Proceedings of the International Symposium on

LAND MANAGEMENT AND BIODIVERSITY IN SOUTHEAST ASIA

September 17-20, 2002
Bali, Indonesia

ORGANIZED BY

Hokkaido University, Sapporo, JAPAN
&
Research Centre for Biology,
The Indonesian Institute of Sciences,
Bogor, INDONESIA

Proceedings of the International Symposium on
LAND MANAGEMENT AND BIODIVERSITY IN SOUTHEAST ASIA

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Editors

Mitsuru OSAKI

Toshio IWAKUMA

Takashi KOHYAMA

Ryusuke HATANO

Koyo YONEBAYASHI

Harukuni TACHIBANA

Hidenori TAKAHASHI

Takuro SHINANO

Seigo HIGASHI

Herwint SIMBOLON

Sehat Jaya TUAH

Hanny WIJAYA

Suwido Hester LIMIN

Hokkaido University, Sapporo, JAPAN and

Research Center for Biology,

The Indonesian Institute of Science, Bogor

March 2003

FOREWORD

As we all may be aware Southeast Asia countries are among the most important areas in terms of land management and biodiversity conservation. In these areas, a myriad of ecosystems and species diversity are harbored, which directly and indirectly relates to the quality of the global environment. Hence, any land mismanagement will lead to environmental destruction and unprecedented biodiversity loss. A recent serious disaster in Southeast Asia that is related to the mismanagement of land was the forest fire of 1997/1998 and 2002, which caused significant damage to natural resources and, hence also to human life.

In addition, Southeast Asia is expected to be an area of major economic development in the 21st century. Therefore, natural resources within this area are being utilized and managed as one of the main sources of capital for economic development. However, in the last few decades, there are some indications of the natural resource mismanagement. It is imperative that wise use and sustainable management of the land's ecological and biological resources be applied while accelerating the economic development of the area. The need for better management and sustainable development has been studied in detail from many aspects by numerous scientists under The JSPS-LIPI Core University Program entitled "Environmental Management of Tropical Wetland Ecosystem in Southeast Asia", which was established in 1997 and will continue until 2006.

To garner needed attention to the pressing issues of sustainable land management and biodiversity conservation, The Graduate School of Environmental Earth Sciences, Hokkaido University and The Research Center for Biology-Indonesian Institute of Sciences jointly organized and hosted the International Symposium on Land Management and Biodiversity in Southeast Asia (TROPEAT2002). The presentations and discussions during the symposium emphasized four important issues: wise use and sustainable management of tropical peatlands, biodiversity and bioresources, aquatic ecosystems and resources, and environmental quality of human settlements in river basins. During the four-day symposium, around one hundred and sixty scientists sat together to discuss the problems we face concerning the mismanagement of natural resources and biodiversity. It was a very successful meeting, with more than 80 oral and 90 poster presentations, which led to very interesting and encouraging discussions. We believe that the scientific knowledge related to the sustainable land management and biodiversity conservation presented in this volume are very useful for scientists, students, as well as decision takers and policy makers, and will also promote more fruitful collaboration in the future.

Motoyoshi IKEDA
Dean,
Graduate School of Environmental
Earth Science, Hokkaido University

Arie BUDIMAN
Director,
Research and Development Center for Biology,
Indonesian Institute of Sciences

PREFACE

Southeast Asia has changed tremendously due to the rapid technological, economic and political developments of the 1980s. The members of the region are now integrated into the international economy. Some countries have already become industrialized and/or more urbanized. However, most countries in the region are still agriculturally-based. As most of the cultivated land is already being used, the people must encroach upon forestlands to increase the production of crops to meet the nation's needs. Economic development in the early stages tends to rely primarily on the extraction of natural resources. However, in the last few decades, mismanagement of natural resources has accompanied the acceleration of economic development. Many natural forests have been exploited for economic development at a very astonishing rate, mostly for agriculture, forest plantations and settlements. Unfortunately, many of these projects have been unsuccessful and have resulted in land degradation and biodiversity loss. The mismanagement of natural resources and biodiversity is indicated by the decrease in environmental quality, expansion of the area of degraded lands and increase in the frequency of flooding and forest fires.

Of course mankind has depended on natural resources to sustain life for many millennium. Natural resources have been defined as living entities, which include genetic resources, organisms and populations, with actual or potential uses to mankind. Meanwhile, biodiversity refers to the variation of life in all forms, levels and combinations. In the past, in general, human population density was low and people had only limited technology with which to acquire resources and change the environment, so humans lived in close harmony with nature and natural resources were plentiful. Increasing population and the development of technology has resulted in the exploitation of natural resources. As a consequence, the environment has inevitably deteriorated, although our dependency on the environment has not diminished. Therefore, new natural resource management approaches are essential. If we are to utilize our resources in a sustainable manner, we must understand the interaction between biological diversity and global processes through research.

The purpose of the International Symposium on Land Management and Biodiversity in Southeast Asia (TROPEAT2002) held in Bali, Indonesia from 17-20 September 2002 was to share results and experiences on environmental systems in this region. The numbers of participants was, to our excitement, larger than expected, so the meeting was divided into oral and poster sessions. Around 160 researchers attended from Japan, Indonesia, Malaysia, Thailand, Australia and some European countries: United Kingdom, Finland, Germany and the Netherlands, to present their most recent findings on various issues of land management and biodiversity conservation in Southeast Asia regions.

This volume consists of 8 different subjects organized according to the sessions of the symposium. Session 1 ("Forest Ecology", 9 papers) includes descriptive studies of vegetation, microclimates, CO_2 flux and throughfall in peat swamp forests, as well as plant adaptation to acid soils, nitrogen sources of some tree species and natural reforestation processes. Session 2 ("Soil Ecology", 12 papers) addresses biochemical and microbial processes and macro fauna diversity in tropical soils. Taxonomic and physiological studies are included along with a report on carbon emissions of peat soils. Session 3 ("Biodiversity", 8 papers), highlights the enormous diversity of flora, fauna and habitats in the tropics. Session 4 ("Agricultural Environment", 10 papers), introduces novel land management strategies for peat soil to enhance crop productivity. The quality of the soil was investigated from a microbiological, hydro-physical, traditional and modern perspective. Session 5 ("Peat Science", 8 papers), examines various unique properties of peat soil. Reconstructing past natural and artificial vegetation changes was undertaken using isotope and lignin signatures. In addition, "Kerangas" grain size distribution was investigated with radio-isotopic dating. In Session 6 ("Peatland and River Technology", 12 papers), the hydrology of peat swamp forests in Indonesia and mires in Japan were investigated. Water quality, mining and forest fire effects, groundwater characterization, restoration and management were all addressed. In Session 7 ("Aquatic

Environment", 14 papers), the macro and micro-faunal composition in rivers and the upper layers and benthic zone of lakes were characterized; phytoplankton and zooplankton diversity in some oxbow lakes and a perian swamp forest was also described in detail. In addition, mercury pollution from illegal gold mining was reported on. Session 8 ("Human dimension, Conservation and Remote Sensing", 12 papers) describes the use of ethnobotany and traditional food usage, recycling and allocation in Kalimantan, characterization of peat with indigenous knowledge, conservation of primates and application of remote sensing and GIS techniques to describe land use patterns and changes.

During the closing session of the symposium, a plan for the final stage of the Core-University Project from 2003 to 2006 was discussed. Conspicuously lacking from the project are detailed and focused studies on the human dimensions of the environmental issues. Therefore, an additional research group is being established, which will focus on the human dimension and any related issues.

In this volume, sustainable land management and biodiversity conservation are assessed and examined from various viewpoints. Many studies were carried out using a multi-disciplinary approach simultaneously in particular sites in Kalimantan, therefore the investigations presented at this symposium are the result of the conscious integration of many fields and bodies of knowledge, making this volume comprehensive and informative. Also, since the investigations carried out were from all over Southeast Asia, comparisons of the ecosystems are possible. It is the wish of this project's collaborators that this information will lead to more collaborative efforts to confront and find solutions to the resource management challenges facing the entire region.

Sapporo, March 2003

Mitsuru OSAKI

Editor-in-chief

CONTENTS

Additionall paper

Appendix

Remark by the Vice Chairman of the Indonesian Institute of Sciences Dr. Suparka on: The International Symposium on Land Management and Biodiversity in Southeast Asia

Dr. Toshio Iwakuma, the representative of Hokkaido University
Dr. Seiichi Tokura, the representative of Kansai University
Mr. Nahson Taway, Vice Governor of Central Kalimantan
Mr. Adi Susmianto, the representative of Forest Protection and Nature Conservation, Department of Forestry

Distinguished guests and researchers,
Ladies and gentlemen,

At first I would like to say, especially for foreign participants, welcome to Indonesia; and welcome to Bali for all of you.

It is indeed my great pleasure to reiterate welcoming address on behalf of The Indonesian Institute of Sciences to the distinguished audience in the occasion of **The International Symposium on Land Management and Biodiversity in Southeast Asia**.

This present international symposium is hosted jointly by The Research Center for Biology-Indonesian Institute of Sciences and The Graduate School of Environmental Earth Sciences, Hokkaido University. Both institutions have been cooperated in the research on biodiversity since 1997 under Japan Society for Promotion of Sciences (JSPS)-LIPI Core University Program on: Environmental Management of Wetland Ecosystem in Southeast Asia. This cooperation will be lasted until 2006.

Distinguish guests
Ladies and gentlemen,

As we all may aware, Southeast Asia countries are included among the most important areas in the broad sense of land management and biodiversity of the earthís subject. In these areas, enormous types of ecosystem and biodiversities are harbored. Hence, any mismanagement on them will lead into environmental destruction and even biodiversity loss.

As an example, Indonesia only covers 1.3% of the total world land. However, it is remarkably accounted to possess about 17 % of the total living species on earth; about 11 % of flowering plants, 12 % of mammals, 15 % of the total reptile and amphibian, 17 % of bird species, 37 % of fish species. And more important to remember is, many of these harbored species are being categorized as the endemic species.

These natural resources have been utilized and managed as one of the main capital for the economic development. However, in the last few decades, there are some indications of mismanagement of natural resources including its biodiversities in the areas. These indications of the mismanagement are related with the acceleration of the economic development.

Distinguish guests
Ladies and gentlemen,

Many areas of natural forests have been exploited for economic development and some others have been converted into other purposes in a very spectacular rate, mostly for agricultural lands or plantations and settlements. Unfortunately, many of them were unsuccessful and creating major land degradation and biodiversity loss.

Some signals on the mismanagement of natural resources and its biodiversity reflected on the degradation of environmental quality, expansion of the number of degraded land, the increasing frequency of floods during the rainy season and forest fire during the dry season.

It is still clear in our mind, the forest fire in 1997/1998. It burnt out about 9.5 million ha land and forest in Indonesia. There were an enormous estimations on the economic value lost, but the estimation of the lost of biodiversity due to the forest fire disaster in 1997/98, is still a big question mark.

Distinguish guests
Ladies and gentlemen,

That was just an example of the impacts of mismanagement on land and biodiversity, and we know that there are many others. I am not going to explain them all here one by one, because we are now still facing many problems that arise as the results of the mismanagement on natural resources and biodiversity

We have to be aware, that based on the present rate of natural forest conversion and destruction, it was estimated that there will no more natural lowland forests remain in Sumatra Island on 2005 and in Kalimantan Island on 2010.

How do we concern about those threats?

Learning from those experiences, I believed that the topic of land management and biodiversity is an important issue to be discussed.

At present, in this symposium, about hundred and fifty scientists are sitting together to discuss the problem we face on the mismanagement of natural resources and its biodiversity. I do believe that all of you will result a fruitful discussion on the subject within two days of symposium. I am also expecting that the results will be beneficial as the valuable input for the decision makers in preparing policy for management of natural resources and biodiversity.

Distinguish guests
Ladies and gentlemen,

I would like to use this opportunity to express my gratitude to JSPS for its continuous support to the research on basic sciences in Indonesia and for the financial support on this symposium. I also would like to extend my gratitude to BPPT, CIMTROP, EUTROP, JICA and STRAPEAT for their kind support on this symposium.

And to Bogor Agriculture University, Palangkaraya University, Bandung Institute of Technology, Hokkaido Institute of Technology, Hokkaido University of Education, Tokyo University of Agriculture and Technology, Kyoto University, University of Shiga Prefecture, Kanazawa University, Kansai University, Tottori University and Kagoshima University for the kindness cooperation in conducting research under LIPI-JSPS Core University Program.

My high appreciation also goes to all of scientists from over the world for their deep concern on the natural resources and biodiversity of the Southeast Asia areas, especially Indonesia. I believe that your scientific findings will be a great input for sustainable management of natural resources and biodiversity of the areas.

Distinguish guests
Ladies and gentlemen,

Allow me to conclude my speech by addressing gratitude and appreciation on behalf of the Indonesian Institute of Sciences to our distinguished guests; those are all of you, for your great contributions, expertise, experience and idea on the land management and biodiversity of the Southeast Asia areas.

Have a nice symposium

Thank you.

DEPARTEMEN KEHUTANAN DIREKTORAT JENDERAL PERLINDUNGAN DAN KONSERVASI ALAM DIREKTORAT KONSERVASI KEANEKARAGAMAN HAYATI

KEYNOTE ADDRESS

Adi Susmianto
Director of Biodeversity Conservation
Gedung Pusat Kehutanan Manggala Wanabakti, Blok VII Lantai 7Jalan Jenderal Gatot
Subroto, Jakarta 10270 - Telp. 5720227 - Fax 5720227

It is my great honor to be with you here pertinent to the symposium in peatland management and biodiversity in South East Asia. As the request by Dr. Arie Budiman, my note would focus on the existing condition at peatland in Indonesia, threats, on the way activities, and recommendation related to the peatland management.

Distinguished participants, Ladies and Gentlemen,

It is currently estimated that peatland in Indonesia covers about 17 million ha which is mainly distributed in Sumatra, Kalimantan and Papua. This represents over 70% of peatland area in Southeast Asia and about 50% of the worldís tropical peatlands. It is also estimated that the remaining total peatland area in Indonesia has decreased from the original peatland area of about 20 million ha (Silvius *et al*, 1987). About 531,000 ha of peatlands in Indonesia have been used for agriculture-based transmigration settlement and by local inhabitants. The use of peatland for cultivation of perennial/ estate crops such as coconut and oil palm is known to be considerably increasing since the last two decade. It is estimated that up to 3 million ha of peatland has been converted or destroyed between 1987 to 2000. Due to development and population pressure, severe degradation to peatland in Indonesia is likely to continue in coming years unless prompt action is taken to safeguard these resource.

Ladies and Gentlemen,
For the illustration, In Sumatra approximately 4.6 million ha of remaining peatlands occur mainly along the east coast of North Sumatra down to South Sumatra. Whereas in Kalimantan, peatland occupies about 3.5 million ha mainly on the west coast of West Kalimantan, in the central part of
Central Kalimantan and some parts of East Kalimantan. In Papua, peatlands occur mostly on the south coast and some fringes on the south-west coast with a total area of 8.7 million ha

It is unfortunate, however, during the forest fires in 1997/98 more than 1.45 million ha of peatlands in Indonesia (about 10% of the total peatland areas) were destroyed by fire or partially degraded. In the studies carried out by Asian Development Bank, fires in the area of peat soils were identified as the major contributors (about 60% of particulates) to the smoke and haze which enveloped some parts of Southeast Asia (Malaysia and Singapore).

Ladies and Gentlemen,

Indonesian peatlands have a broad range of values to the local communities, to the nation, as well as to the global community. Peatlands are important sources of timber and non-timber forest products and also play a key role in the hydrology of surrounding areas such as flood control, flow regulation, water supply and prevention of saline water intrusion. In addition, they are globally significant as carbon storages and sinks, an highly important for conservation of biodiversity.

Indonesian peatswamp forests have been recognized as an important reservoir of plant and relative high in the diversity of tree species. More than 300 tree species have been recorded in swamp forests of Sumatra, some of which are becoming increasingly rare. From Berbak National Park alone, already more than 160 tree species are known . Many of the plants are restricted in distribution or endemic to this habitat. The peat forests of Indonesia provide many commercial timber species including Ramin (*Gonystylus bancanus*), Jelutung (*Dyera costulata*), Meranti (*Shorea* spp.) These forests are also home to many rare and endangered wildlife species such as Sumatran tiger (*Panthera tigris sumatranus*), tapir (*Tapirus indicus*), Sumatran elephant (*Elephas maximus sumatrensis*), Javan rhino (*Rhinoceros sondaicus*) and Sumatran rhino (*Dicerorhinus sumatrensis*) , orang utan (*Pongo pygmaeus*) and hundreds of bird species, including hornbills and cassowaries. Black-water rivers (peatland rivers) in Indonesia are important fish habitats that often have a higher degree of localized endemism than other rivers, and are important source of aquarium fishes.

Indonesian peatlands are significant carbon storage and sinks. Estimate of the carbon content of Indonesiaís peatlands, based upon information on bulk density of different peat types, total areas, mean depths and percentage carbon content, range from 16-39 billion tonnes. Calculation of the annual rate of carbon sequestration by peatland in Indonesia vary from 10 - 93.4 million tonnes. If disturbed by drainage and fires, the carbon is released to the atmosphere contributing to the greenhouse effect. If maintained in their natural state, carbon dioxide is incorporated as organic carbon into dying biomass and stored in the peat moderating greenhouse gas emissions. Forest fire during 1997 and 1998 is estimated to have released more than 750 million tones of carbon dioxide in which over 50% was as a result of combustion of peat, making Indonesia as one of the highest carbon emitting countries in the world.

Ladies and Gentlemen,

Peatlands face the same threats as forest by massive loss of natural habitats due to changing land use and loss of biodiversity through environmental damage and overexploitation of resources. For the illustration, the following are development projects/ activities with significant change and negative impacts to peatlands and associated resources :

* " One million hectare Mega Rice Field" Project, Central Kalimantan, started in 1995 and stopped in 1997. The scheme aimed to establish irrigated rice fields on one million hectares of mainly peat soils.
* Integrated Swamp Development Project (ISDP) (Irrigation Department in Province of Riau, Jambi dan West Kalimantan)
* South Sumatra small-holder Tree Crop Development Project with hybrid coconut planting activities, since 1992 (Directorate General of Estate Crops with funds from IFAD (International Federation Agriculture Development)

Ladies and Gentlemen,

The Government of Indonesia is particularly concerned with the conservation of its natural resources and to ensure the availability of the biological diversity for the welfare of the people. Indonesiaís commitment to conservation is very clear. Conservation needs concerted efforts and shared responsibilities and harmonized partnership between government, scientific institutions, local community, and NGOís. Without these efforts and responsibilities, we may not be able to achieve our goal of sustainable utilization.

In relation with peatlands, some activities in the terms of research, study and projects are underway. Some examples of these activities include :

* Carbon content measures of peat swamp forest areas, in Riau (by TNC-CIFOR)
* Kalimantan Tropical Peat Swamp Forest Research Project (KALTROP), near Sebangau River in the Province of Central Kalimantan (by Univ. Palangkaraya, Univ of Nottingham, Univ. Leicester and Univ. Hokkaido)
* Research and development on the use of peat at Tropical Peat Research Centre (Purigatro), West Kalimantan, since 1991 (by BPPT-Pemda Kalbar joint research).
* The Peat swamp laboratory project to assess the potential of Ramin (*Gonistylus* sp) in West Kalimantan, since 1989 (by Univ. Tanjungpura - Pontianak.
* The Climate Change, Forests and Peatlands in Indonesia (CCFPI) project funded through the Canada Climate Change Development Fund (CCCDF)-CIDA and jointly implemented by Wetlands International Indonesia Program and Wildlife Habitat Canada. The project consists of a range of community-based and policy-level activities related to the protection and rehabilitation of peat swamp forests and peatlands in Indonesia

Ladies and Gentlemen,

Finally, I would like to recommends further development and improvement of the management of peatlands mainly in Indonesia as follows :

* Assess the impact of management options on peat, such as undertake a review of the effect of agricultural drainage/peatland conversion on greenhouse gas (GHG) emissions and biodiversity loss and future management options to address these issues.
* Identify site-specific impact of forest fire on the peat swamp forests.
* Develop strategies and management plan for peat lands including the fire-damaged peat swamp forest area in order to restore its ecological function and conserve biodiversity.
* Initiate coordination among stakeholders involved in the management of peat swamp forest in Indonesia.
* Review peat research activities carried out in Indonesia. Research should be directed towards applied research that can be benefited to local people living within and surrounding the peat areas.
* Enhance awareness and share information regarding the impact of peatland loss on biodiversity and climate change.

* Protect natural peatland systems. Control of drainage, fills, tree cutting, flooding and other threats to the peatlands could, simultaneously, protect peatland carbon reserves in many circumstances and continued carbon accumulation as well. Protection could also protect biodiversity and a broad range of additional functions such as flood storage and conveyance, water quality protection, erosion and sediment control, and other functions.
* Control of fires which can protect both the forest stands and the organic matter contained in peats. Fires are considered to one of the major ways in which peatland carbon stores may be released especially in the tropics.
* Protect low flows and residual water. Efforts by environmental agencies and organizations to protect the low flows of rivers and other water bodies during dry seasons or droughts through "appropriation" of low flow water rights, adoption of regulations or other techniques can prevent de-watering of peatlands which will lead to release of carbon.
* Protection of low flows and other residual water is also needed to maintain oxygen levels and to protect fish, amphibians, and other aquatic organisms. Such efforts will be even more important for areas with increased temperatures and decreased precipitation caused by climate change.
* Blocking of drainage channels or install water control structures. The blocking of drainage channels may be one of the most strategic management interventions as it will help reduce drawdown of water and associated oxidation or burning of peat layers. The installation of water control structures on the outlets to peatlands could not only help maintain water levels in peatlands, but protect carbon reservoirs and increase accumulation. However, water control structures may also fragment peatland/aquatic systems and prevent seasonal fluctuations that may be important to peatland plants and animals.
* Plant trees, other vegetation. The planting of trees and other vegetation in peatlands where vegetation over has been reduced might increase the above ground biomass and, in some instances, the litter and debris layer, increasing the total carbon in peatlands. However, planting should only be of appropriate indigenous species to avoid disturbance to the natural ecosystem.
* Restore and enhance peatlands. Peatland enhancement and restoration (Kusler, 1990; Kentula, 1992) could under certain conditions, enhance the carbon accumulation roles of some peatlands, restore the roles of others, reduce oxidation and release of carbon from partially or wholly drained peatlands. For example, establishment of water control structures in existing peatlands could maintain water levels and allow water level manipulation in the event of summer temperature increases or reduced precipitation and reduce release of carbon. But, stabilization of water levels may also create problems in some instances in terms of accelerated successional sequences or changes in species composition.

Ladies and Gentlemen,

On this note, once again I wish all of you a successful symposium and pleasant stay in Bali.
Thank you.

Peat Swamp Forests in Borneo and Sumatra
-Original state, development and disaster during the past 50 years with a proposal for future eco-resource management-

Isamu Yamada
Center for Southeast Asain Studies, Kyoto University
46 Shimoadachi-cho, Sakyo-ku, Kyoto, Japan
TEL. 075-753-7311, 7362, FAX 075-753-7350, e-mail: yamada@cseas.kyoto-u.ac.jp

ABSTRACT
The tropical peat swamp forests of Southeast Asia are unique and valuable forest types. Because of the difficulty of approaching the interior, these forests remained untouched for many years. In the last two decades, however, development projects and forest fires have caused them serious damage. Drawing from my experience in Sumatra and Borneo from the 1970s to the present, I describe here the original pattern of forests, development typologies, and hazards. I also propose a new concept of ìeco-resources" to promote better preservation and more healthy forms of development. Eco-resources are richest and most diversified in the tropics; shifting to the higher latitudes, they become simplified. As peat swamp forests represent the last frontier of unspoiled nature, a total understanding of the relationship between human activities and nature is inevitably a central issue.

Key word: Sumatra, Borneo, peat swamp forest, Alan, development, eco-resources

INTRODUCTION

Tropical rain forests in Southeast Asia contain the worldís richest resources in terms of biomass and forest structure. Mixed dipterocarp forests and peat swamp forests, in particular, are unique to this part of the world. Peat swamp forests in Sumatra and Borneo are the forest type least touched by development because of the difficulty of access. But even in these remote areas, a wave of development has reached the interior and various ecological problems have occurred in the past two decades. In this paper, I describe the changing patterns of peat swamp forests in these areas according to my experience on the sites and propose an alternative, possibly better, type of development based on the concept of eco-resources management.

1) Sumatra, 1978

My first experience in peat swamp forests was in Sumatra in 1978. During a mangrove survey in south Sumatra, I had a chance to see three types of development in the swampy area of the Musi river basin (Yamada & Sukardjo 1979).

One was the large-scale development of the transmigration project in the major swampy area between Palembang and Sunsang. The project used heavy machines to dig wide canals for drainage and irrigation. The original landscapes were totally transformed into a very flat and devastated land. At the time, the canals were already experiencing problems, causing the water flow to be suspended. The site managers told me they were well aware of the problems, but because it was a government project, no one could stop it. Large-scale development has since proceeded rapidly, changing all the peat swamp forest into cultivation areas.

The second type of development I saw was in the Bugis settlement in Pulau Rimau. The Bugis came from Sulawesi to this part of Sumatra after the large trees were extracted in the early 1970s. They themselves cut the remaining trees, dug small canals, and developed the area little by little. Paddy nurseries were established on the dikes or on the floors of houses to escape damage by inundation. Rice was transplanted twice to ensure a better harvest. Peppers, sugar cane, fruit trees, and coconut palms were planted on higher ground near tree stumps. Although the movement was very slow, the homegrown development and cooperation of the Bugis villagers have changed the situation gradually; several years later, coconut palms had grown big enough to bear fruit and sales of coconut provided the major income in the area. Compared with the first type, this village-level development pattern seemed to adapt better to the difficult environmental problems of peat swamp forests (Furukawa 1994).

The third type of development consisted of individual efforts to open up forest in order to cultivate land. This kind of effort was usually in vain, as cultivators were unable to surmount the environmental challenges of the area. The evidence found in south Sumatra in 1978 is summarized in Table 1.

2) Brunei Forests, 1982-86

Brunei is a small country located on the northwestern coast of Borneo island. Although the area is small, the forests of this country were in fairly good condition because oil and gas production produced enough wealth to spare the forest.

To commemorate the independence of Brunei from the United Kingdom, international cooperation between Brunei and Japan was inaugurated in 1984. The project was called the Forest Research Center Project and included basic

Table 1. Three types of development in the peat swamp forests in Sumatra in 1978.

Level	Individual Household	Village	Company/Government
Scale	Small	Medium	Large
People	Individual	Villager	Company
Labour	Single fighter	Community work	Mechanics
Budget	None	Small	Big
Destruction	Small	Small	Large
Local knowledge	Enough	Enough	Poor
Sustainability	Weak	Fair	Poor
Future Perspectives	No	Yes	No
Ecological balance	Bad	Good	Bad
Integration	No	Good	No

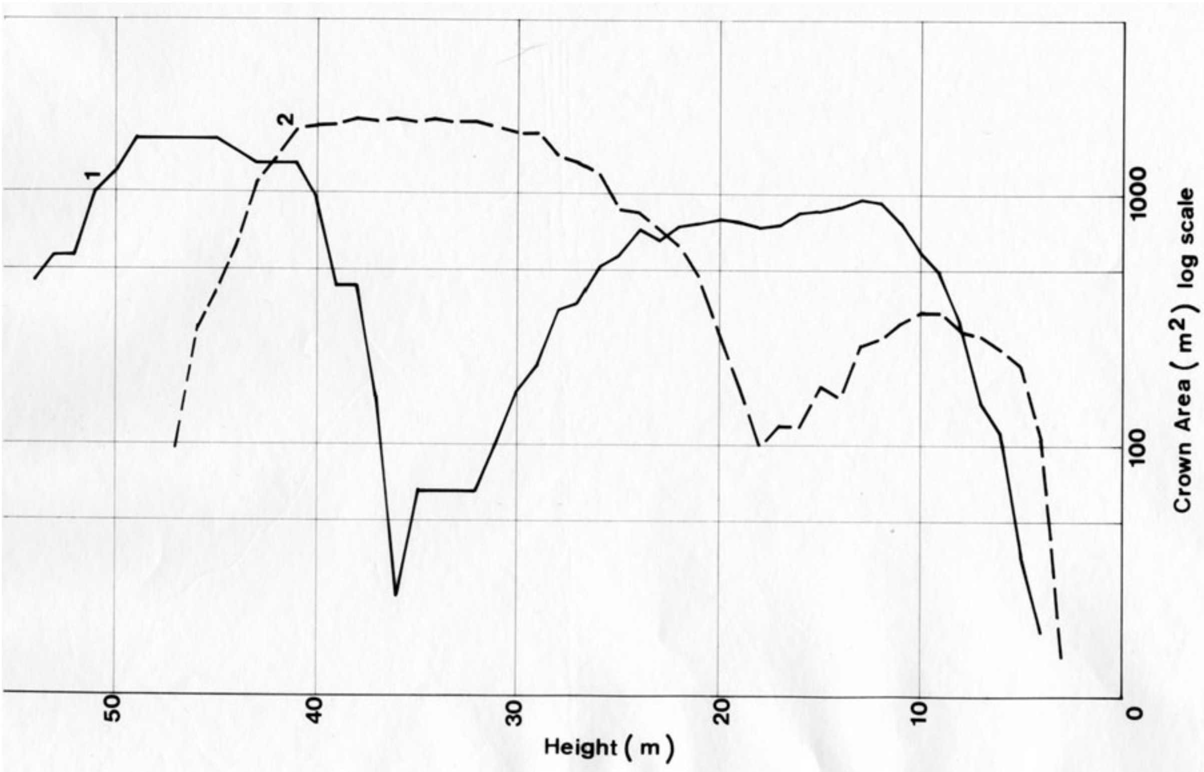

Figure 1. Difference of canopy height of Alan bunga (2) and Alan batu (1).

forest ecological research, afforestation, and genetic resources conservation.

At that time, I was working at the Kanto Forest Tree Breeding Institute, a research institution working for genetic conservation and promotion of tree breeding in Japan. I was dispatched to Brunei from 1984 to 1986 to help establish the cooperative project. During this time, I spent many days in the forests and made extensive surveys of various forest types, of which the peat swamp forests were the most important.

As already reported by Anderson (1961), Brunei and Sarawak have splendid tropical peat swamp forests. The most important species is Alan (Shorea albida), of which there are two important types. One is Alan bunga, a matured pure forest type with a 70-90cm diameter and 50m height; the other is Alan batu, an over-matured forest type with a diameter of at least 100-150cm and a height of 70m. As shown in Fig. 1, the canopy class is quite different in each. Alan bunga has a uniform canopy projection, as shown in Fig. 2. The root system is very big, as shown in Fig. 3, and a pseudo-forest floor is established on the upper surface of the rootmat. Leaves and fruits fall on this pseudo-forest floor and decomposition occurs here. As shown in Table 2, the biomass of peat swamp forest types was as large as that of mixed dipterocarp forests. (Yamada 1997)

Because the Alan bunga grow as a pure stand, most of this area became a target of harvesting. The method of harvest, done by a contractor from Sarawak, was typical, using a small railway and the sliding sledge system. After cutting one site, the rail was removed and set up again in a neighboring logging site. Natural regeneration of Alan is very rare in the forest. The species is weakened by wind and attacks by insects called Ulat bulu and flowering intervals are very long. In 1986, there was gregarious flowering in the Badas Peat swamp area of southern Brunei, but regeneration did not succeed. A plantation trial for this species was conducted in Sarawak, where good growth was observed of 10cm diameter in 10 years. Vegetative propagation in a mist box has proved quite successful. Good reforestation of Alan is one of the most important targets for this area.

Beside Alan, many other species have good reforestation potential in peat swamp forests. Anderson (1961) mentioned several candidates, as shown in Table 3. He also proposed preserving a series of peat swamp forest types and a strict nature reserve. But there are not many locations where we can find a series of each peat swamp forest type. In the Badas peat swamp area, the series was in good condition in the 1980s; it is doubtful whether it is still intact. Even in Brunei, the pressure of private sector logging interests is very high.

In the 1960s and 1970s, peat area studies advanced greatly in Sarawak, leading many scientists to agree that it is better not to develop the deeper peat areas, but to keep it as forest (Tropical Agriculture Research Center 1980).

3) Disasters in the late 1990s in Kalimantan

In 1998, I joined the IITO Forest Fire Prevention Mission to survey conditions in Kalimantan and Sarawak. This mission, organized by IITO Head Quarters in Yokohama, included specialists from India, Nepal, Germany, and Japan. We conducted intensive interviews and observations in the areas studied and found the damaged forest to have many critical problems in the wake of the fires. The forest fires first occurred on a huge scale in 1983 in east Kalimantan where 3 million ha of forest burned. Subsequently, several large fires occurred every 3 to 4 years; the fire in 1997 was especially severe in the peat swamp forest.

Simultaneously, a large-scale development project in central Kalimantan, called the “Mega Rice Project,” started to open up large areas for cultivation. For this purpose, large canals were dug and new transmigrants were sent to the area. As is widely known, this project failed, mainly due to badly designed canal construction.

But other factors kept up the pressure. Large-scale fires spread into the peat area and burned the remaining forest (Guhardja et al 1993). Local autonomy became the dominant trend following the fall of President Suharto, allowing more people access to logging more freely than before. As we conducted surveys in the years 1999 to 2001, we found the effects of these combined factors causing the forests to become more and more degraded.

4) The concept of eco-resources: toward a harmonious life in the future

Bio-science has become an advanced discipline in recent years, and the term “bio-resources” has become very common. As currently used, however, the concept does not include the whole ecosystem in which bio-resources live. Lack of understanding of ecosystems and wide-scale, speedy extraction of these resources has left primary forests devastated in many parts of the world. Obviously, bio-resources will not survive in the absence of suitable environmental conditions in particular ecosystems, but this simple argument has been ignored in the last two decades. If this trend continues, our bio-resources will be seriously threatened with extinction in the near future.

In contrast to this model of extraction and degradation, there are still many minority groups living in the deep forests in Southeast Asia who live daily life in a sustainable manner and with a deep understanding of the natural environment (Rousseau 2000, Sellato 1994). The concept of “eco-resources” emerged from their example and from my research experience in many parts of the world. The general concept is shown in Fig. 4. I divide eco-resources into three broad categories. First are the fundamental resources of atmosphere, soil, and water which form our earth. Second are the so-called bio-resources. Third are eco-human resources, the most important part of eco-resources.

In this category, I include the life resources of agriculture, forestry and fishery. More important are anthropogenic factors such as culture, religion, healing, play, and so forth. Such cultural elements had been excluded from the nature preservation concept for many years, but recent trends have been dramatically changing.

Table 2. Summarized forest biomass in major forest types in Brunei.

Forest type	Plot size (m^2)	No./ha	B.A./ha (m^2)	Species No./plot	Hmax (m)	Dmax (cm)
Agathis	100×50	610	38.4	33	47.0	92.7
Alan batu	100×50	522	42.6	24	57.5	140.0
Alan bunga	100×50	310	43.4	22	51.5	96.6
Alan	50×50	400	50.7	14	51.0	80.5
Padang alan	50×50	872	39.7	17	43.5	63.5
Alan padang	50×50	744	34.5	10	33.0	46.0
Ulat bulu	50×50	1172	32.6	26	30.5	46.5
Mixed peat swamp (1)	50×50	828	36.5	41	36.0	73.3
Mixed peat swamp (2)	100×100	645	33.9	58	47.0	140.0
Mixed dipterocarp	100×100	736	49.4	174	50.0	114.0
Kapor paya	50×50	884	36.7	28	33.5	47.5

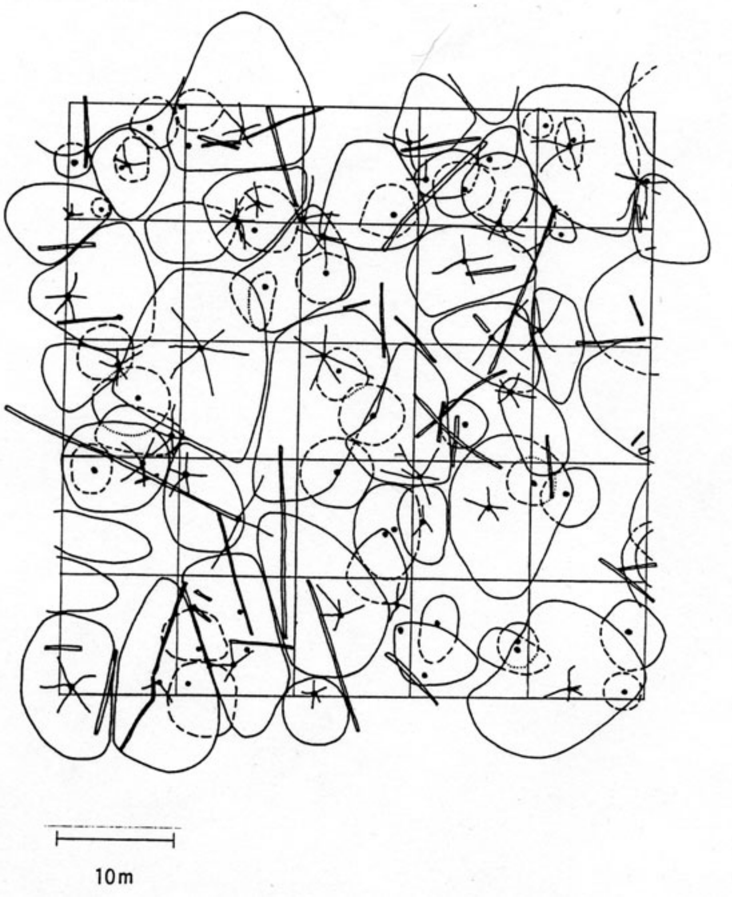

Figure 2. Crown projection of Alan bunga forest type in Brunei.

Figure 3. Large root system of Alan batu

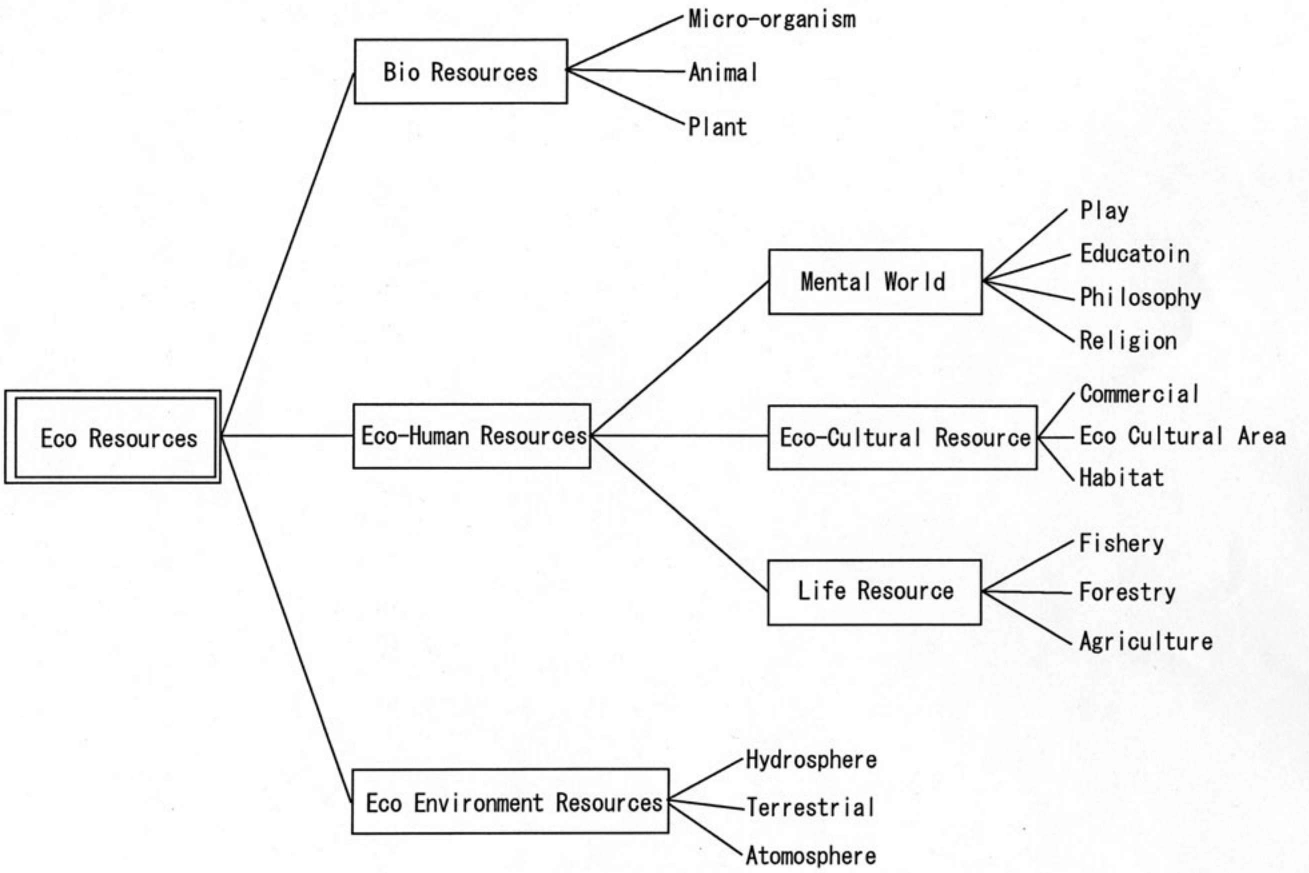

Figure 4. Concept of eco-resources

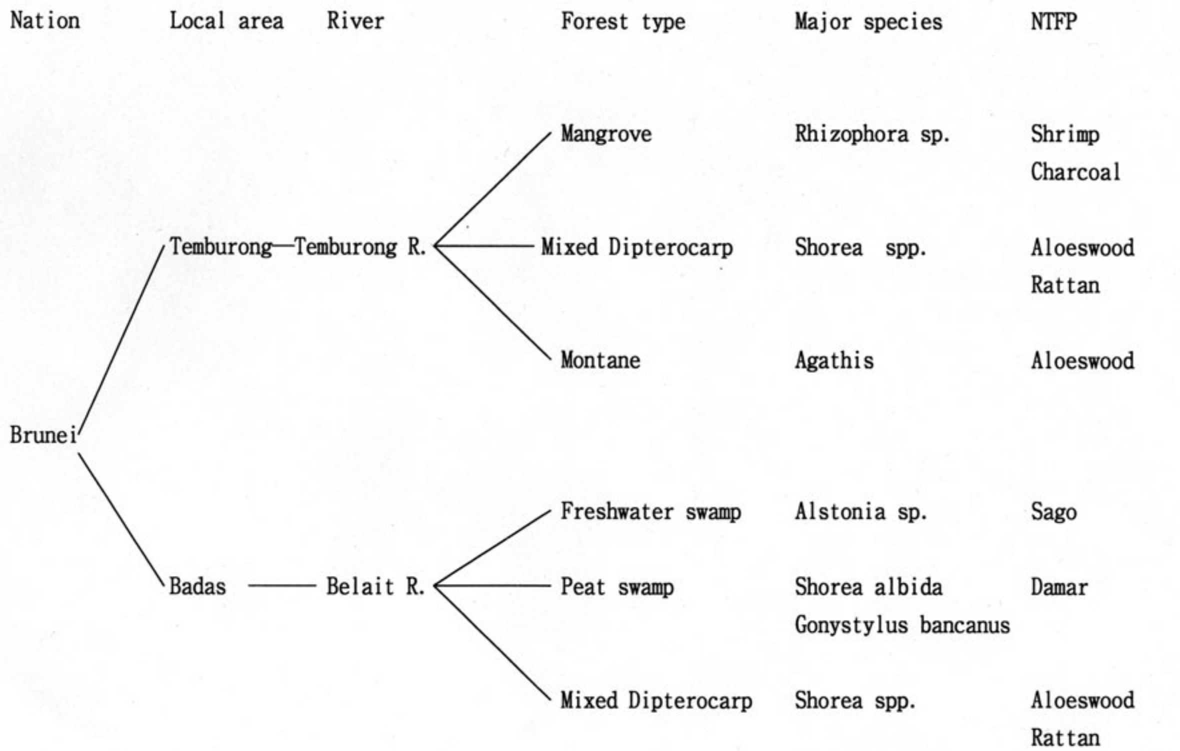

Figure 5. Eco resources chart in Brunei. Only forest related matters are figured.

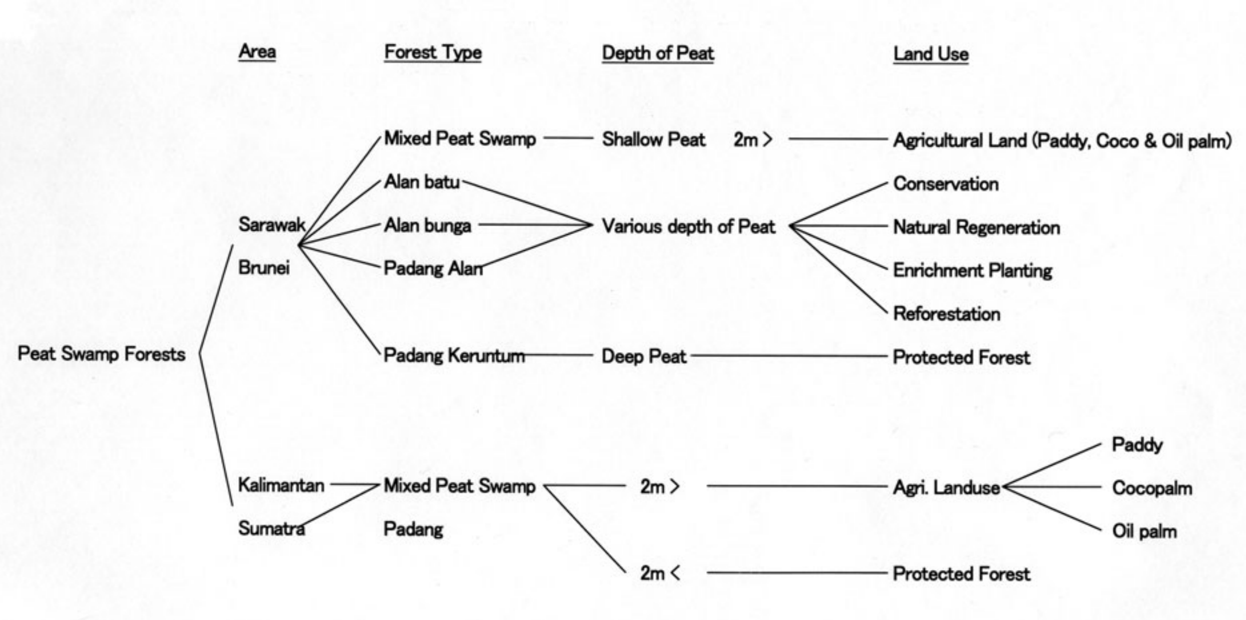

Figure 6. Eco-resources chart for the peat swamp forests in Borneo and Sumatra. Forest types, depth of peat and possible land use.

Table 3. Candidate species for the reforestation of peat swamp forest by Anderson (1961)

Preferred species:	
Ramin	(*Gonystylus bancanus*)
Jongkong	(*Dactylocladus stenostachys*)
Meranti lop	(*Shorea scabrida*)
Meranti lilin	(*Shorea teysmanniana*)
Meranti buaya	(*Shorea rugosa var. uliginosa*)
Meranti paya	(*Shorea platycarpa*)
Kapur paya	(*Dryobalanops rappa*)
Sepetir paya	(*Copaifera palustris*)
Semayor	(*Shorea inaequilateralis*)
Acceptable species:	
Jelutong	(*Dyera lowii*)
Perupok	(*Lophopetalum multinervium*)
Durian burong	(*Durio carinatus*)
Geronggang paya	(*Cratoxylon arborescens*)
Geronggang padang	(*Cratoxylon glaucum*)
Bintangor	(*Calophyllum spp.*)
Terentang	(*Campnosperma coriacea*)

For instance, religion has emerged as an important factor in protecting the forest in many Buddhist countries (Siam Society 1989). Minority group traditions of preserving certain forests near their village as sacred places are also being recognized. And eco- tourism has become more and more attractive as people seek to spend time in natural sites to heal themselves from their exhausting life in the city (Fennell 1999, Yamada 2002).

This trend is completely different from the bio-resources concept we know so far. Production is not important here because what we are seeking is unspoiled nature, not the extraction of bio-resources. The role of the forest has been changed from a source of resources to a preserver of harmonious pure nature. And this trend should be accelerated quickly because the pressure to destroy nature is ever more intense. What remains of pure nature will have elevated importance and value in the future. As shown in Fig. 4, it is important to include the whole ecosystem as well as the cultural and mental elements of human activities.

To see the concept of eco-resources in a particular area, Fig. 5 shows the concrete example of Brunei. This is one example of a small area. Accumulating these data in many parts of the world, we can arrive at a broad view of the worldís eco-resources and identify the fundamental principles of eco-resources as follows:

(1) Eco-resources are basically sustainable resources if no severe disturbance occurs. Once disturbed, however, the cost of recovery is very high.

(2) The most highly diversified and rich eco-resources are found in the tropics. As we move toward the polar regions, eco-resources become uniform and show centralized distribution.

(3) The most fundamental types of eco-resources are found in primary nature, the opposite of which is the city.

(4) Anthropogenic factors are essential to the eco-resources concept in order to understand the relationship between humans and nature.

Looking back on the history of the earth, we see that human beings have been destroying nature for thousands of years. And some of the most severe destruction is ongoing in the peat swamp areas of Southeast Asia. Activities to date in Sumatra and Borneo have mostly destroyed the original system of nature and threaten the lives of people living in and around these areas. These are extremely wasteful activities because the original peat swamp forests were unique and among the most valuable eco-resources in the world.

This should not be disregarded: rehabilitation and protection of what remains is possible. Fig. 6 shows a tentative idea for land use according to peat depth. The integration of many disciplines will be necessary, but I believe that seeking a harmonious relationship between humans and nature in peat swamp areas is a most urgent task.

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Session 1

FOREST ECOLOGY

Chaired by

Takashi KOHYAMA & Herwint SIMBOLON

Adaptations of Tropical Plants to Acid Soils

Jumpen Onthong[1] and Mitsuru Osaki[2]
[1]Faculty of Natural Resources, Prince of Songkla University, Songkhla, Thailand, 90112
[2]Graduate School of Agriculture, Hokkaido University, Kita 9, Nishi 9, Kitaku, Sapporo, 060-8589 Japan
1 Corresponding author: Tel. 66 74 212847, Fax 66 74 212823, e-mail: ojumpen@ratree.psu.ac.th

ABSTRACT

It is known that the tropical pastures or grasses; *Arachis pintoi*, *Brachiaria ruziziensis*, *Panicum maximum*, *Panicum repensi*, *Pueraria phaseoloides*, and *Stylosanthes hamata*, and the tropical trees; *Acacia mangium*, *Anacardium occidentale*, *Hevea brasiliensis*, and *Melaleuca cajuputi* adapt well to acid soils which are low phosphorus (P) and high aluminum (Al). In this study, top soils and sub soils of the highly weathered soils in peninsular Thailand were collected for chemical analysis and phosphorus fractionation, and the adaptive mechanisms of these plants were examined from the aspect of phosphorus utilization efficiency and root exudation of organic acids and acid phosphatase by culturing of plant seedling in complete, deficient phosphorus (-P), high Aluminum (+Al), and deficient P and high Al (-P+Al) solutions. It showed that both available and total P were low, and organic P was the main fraction. Fe-P and Al-P were the dominant inorganic P sources in these soils. The secretion of acid phosphatase increased distinctly in -P treatment only from roots of *Stylosanthes hamata*. Tropical trees that adapt well to these soils were able to secrete oxalic and citric acids to acquire P by the solubilization of Fe-P and Al-P. Whereas, tropical pastures or grasses showed the high P utilization efficiency and high root-shoot ratio by P deficiency.

Key words: P forms, acid soils, acid phosphatase, Al tolerance, P tolerance, organic acids, P utilization efficiency, P acquisition, tropical plants

INTRODUCTION

Acids soils are recognized as Ultisols and Oxisols which widely distribute in the tropical upland. In Southeast Asia, it has been estimated that these soils cover about 212 million ha, or just over 50% of the total land area. In the South of Thailand, they occupy over 3.5 million ha, or 68% of the total cultivated area (Thainugul and Sinthurahas, 1977). These soils contain a large amount of aluminum (Al) which is readily precipitated as the highly insoluble Al-phosphates. Consequently, P deficiency and Al toxicity are major limiting factors for crop production and often appear together in the highly weathered acid soils (Foth and Ellis, 1997). Plants, however, differ greatly in their tolerance of this condition (Hedley et al., 1994; Otani and Ae, 1996; Subbarao et al., 1997a, b). In low available P soils, adaptive plants improve P utilization, allowing high yield per unit P in plant, and improve P acquisition, allowing P greater extraction from soils (Hedley et al., 1994; Rao et al., 1999). It was reported that the secretion of organic acids by roots is not only the mechanism in plants for P acquisition but also the mechanism for Al tolerance. Malic acid secreted from wheat roots created an Al resistance mechanism (Ryan et al., 1995), and citric acid secreted from *Cassia tora* L. roots in response to Al created Al tolerance (Ma et al., 1997). Recently, it was documented that the secretion of oxalic acid from taro roots was stimulated by excess Al, not by P deficiency (Ma and Miyasaka, 1998). Moreover, application of citric and oxalic acid to highly weathered soils increased the release of P (Fox et al., 1990; Onthong et al., 1999)

Previous reports (Osaki et al., 1997; Watanabe et al., 1997, 1998) have elucidated that tropical plants, which have adapted to low pH soils, have a tolerance to Al, or show growth stimulated by Al. In low pH soils, P forms compounds with Al or Fe, then P becomes unavailable to plants. It was expected that tropical plants have a tolerant ability to the low P and high Al soils, and this ability was achieved through root exudation. Recently, it was noted that inorganic P that is freely available to plants, inorganic P associated with positively-charged oxide surfaces and apatite-like P in the rhizosphere of external P efficient tea clones were more greatly depleted than that in the less efficient tea clones (Zoysa et al., 1999). However, adaptation of tropical plants widely found in acid soils in the south of Thailand is not fully understood. To elucidate the adaptive mechanisms of tropical plants to acid soils, it was investigated on (i) the chemical properties and phosphorus status of highly weathered acid soils (ii) the capability of tropical plants to exudate organic acids and acid phosphatase, and (iii) the P acquisition in the rhizosphere of tropical trees.

MATERIALS AND METHODS

Chemical properties and phosphorus status of highly weathered soils:

Top soils and sub soils of two dominant soil series; Kohong (Typic Paleudults; Coarse-loamy siliceous) and Hat Yai (Typic Paleudults; Clayey-skeletal, kaolinitic) in southern peninsular Thailand, were collected for soil chemical analysis. The soil properties were determined as follows: soil pH in 1 *M* KCl (1:5), organic matter (Walkley and Black method; Allison 1965), exchangeable aluminum (1 *M* KCl, atomic absorption spectrophotometry; Shimadzu, AA-6200), exchangeable K, Ca, Mg, and Na (1 *M* ammonium acetate pH 7, atomic absorption spectrophotometry (Shimadzu, AA6400F) for Ca and Mg, and atomic emission spectrophotometry (Shimadzu, AA6400F) for K and Na). The concentrations of available P (Bray and Kurtz, 1945), orginic P (Olsen and Sommers, 1982) and total P (HNO_3-$HClO_4$ digestion) were determined (Molybdenum blue method). P forms (Ca-P, Al-P and Fe-P) in soils were fractionated using a modification of the Sekiya (1983) method.

The response of tropical plants to low phosphorus and high aluminum condition:

Seedlings the tropical pastures or grasses; *Arachis pintoi*, *Brachiaria ruziziensis*, *Panicum maximum*, *Panicum repensi*, *Pueraria phaseoloides*, and *Stylosanthes hamata*, and the tropical trees; *Acacia mangium*, *Anacardium occidentale*, *Hevea brasiliensis*, and *Melaleuca cajuputi* were cultured in the complete nutrient solution (Watanabe et al., 1997). After 2-4 weeks of pre-culturing in this solution (culturing time depended on plant species), the seedlings were transferred into one of the following solutions: (i) control (complete nutrient solution containing 1 mg P L^{-1}), (ii) -P (complete solution without P), (iii) +Al (complete nutrient solution with 10 mg Al L^{-1} as aluminum sulphate), and (iv) -P+Al. At two weeks after treatment application, root exudates were collected by immersing roots into 0.1 m*M* $CaCl_2 \sum 2H_2O$ solution for 24 hours under continuously aeration. The solution was concentrated for analysis of organic acids (oxalic, citric, malonic, succinic, tartaric acid, and so on) using a capillary ion analyzer (CIA, Waters). To measure the activity of acid phosphatase and phytase, it was conducted according to the method reported by Li et al. (1997b). Root and shoot dry weights were measured separately. The nutrient concentrations in the shoots and roots were analyzed after digestion of 100 mg of dried and ground samples using H_2SO_4-H_2O_2. Nitrogen was determined by the semi-micro Kjeldahl method, phosphorus by the vanado-molybdate yellow method, potassium and sodium by atomic emission spectrophotometry (Shimadzu AA6400F), and calcium, magnesium, and aluminum by atomic absorption spectrophotometry (Shimadzu AA6400F for Ca and Mg, and Shimadzu AA-6200 for Al).

Phosphorus utilization in rhizosphere of tropical trees:

Acacia mangium which secreted a large amount of citric acid was cultivated in a rhizobox containing three zones, a root zone with perlite, a rhizosphere zone with Hat Yai soil (consisting of four subzones: 0-0.5, 0.5-1, 1.0-1.5 and 1.5-2.0 mm from the root zone), and a bulk zone with Hy soil as the method of Youssef and Chino (1988). The experiment was replicated 3 times. During the experimental period, soil moisture in the rhizobox was kept at field capacity. After 2 weeks of planting, only 3 seedlings of plants were left to grow until 4 months. At the end of the experiment, all the compartments were dismantled, and soil in each compartment was carefully collected. The concentrations of available P and P forms in soils were also measured.

RESULTS

Chemical properties and phosphorus status of soils:

The highly weathered soils widely distributed in peninsular Thailand were acidic, and the concentration of exchangeable Al was high (Table 1). Phosphorus fertility of the Hat Yai (Hy) and Kohong (Kh) soils was low because the concentrations of available P (1-3.5 mg kg^{-1}) and total P (35-162 mg kg^{-1}) of the surface soil were low. The Hy soil, with a finer texture, contained a higher level of total P (145-162 mg kg^{-1}) than the Kh soil (35-43 mg kg^{-1}). The concentrations of exchangeable Ca, Mg, Na and K were also low.

Most of P in the Hy and Kh soils consisted of organic P (Figure 1) whose content decreased with the soil depth, while the content of occluded P, next in proportion, increased according to the soil depth. Calcium phosphate (Ca-P) accounted for only a small proportion, and the amounts of aluminum phosphate (Al-P) and iron phosphate (Fe-P) were larger.

Table 1 Chemical properties of Kohong (Kh) and HatYai (Hy) soil series

Properties	Kh soil series		Hy soil series	
	Top soil	Sub soil	Top soil	Sub soil
pH (soil :1 M KCl =1:5)	4.18	4.25	4.49	4.16
Organic matter (g kg^{-1})	9.39	5.62	22.26	10.29
Exchageable Al ($cmol_c kg^{-1}$)	0.75	0.79	0.24	1.35
Available P (mg kg^{-1})	3.53	2.24	2.17	1.04
Total P (mg kg^{-1})	43.51	35.23	162.20	145.39
Exchageable Ca ($cmol_c$ kg^{-1})	0.09	0.03	3.25	1.46
Exchageable Mg ($cmol_c$ kg^{-1})	0.07	0.03	0.52	0.18
Exchageable Na ($cmol_c$ kg^{-1})	0.02	0.01	0.04	0.04
Exchageable K ($cmol_c$ kg^{-1})	0.03	0.02	0.07	0.04

The responses of tropical plants to low P and high Al condition:

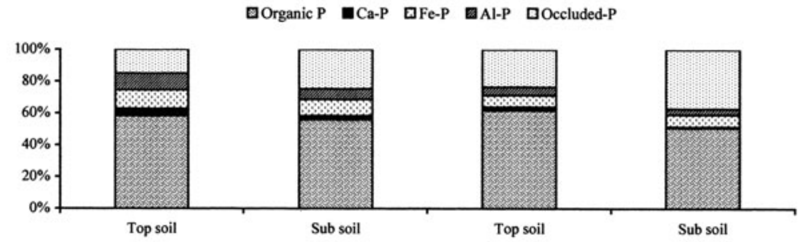

Figure 1. Distribution of P froms in Kohong and Hat Yai soil series

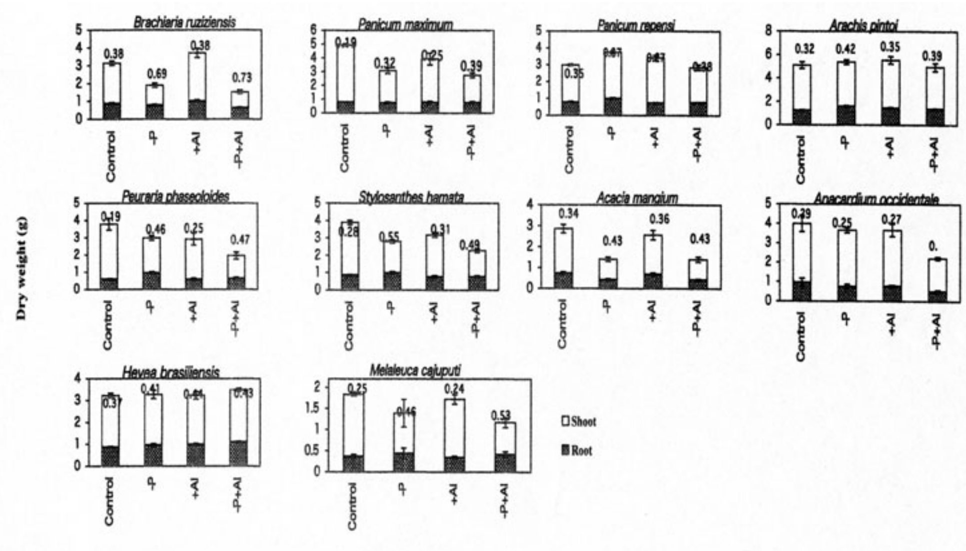

Figure 2. Effect of P and Al treatments on plant dry weight (the number over the bar represent root:shoot ratio). Bars ( ) indicate ± standard error

The shoot dry weight of plants decreased remarkably in -P treatment and decreased further in -P+Al treatment, except in *Panicum repensi* and *Arachis pintoi.* However, root dry weight was slightly effected by -P treatment. Therefore, under P deficient condition, root-shoot ratio was increased obviosly (Figure 2).

The P concentrations both in shoot and roots of plants cultivated in -P and -P+Al treatment became obviously lower than that in the control and +Al treatment groups (Table 2). The P deficient condition also tended to reduce the concentration of K, Ca (except in the case of *M. cajuputi*), and Mg in almost all plants, and this effect was more clearly in plants cultured in the -P+Al solution. However, no effect of P on the concentration of N was clearly observed. Plants cultivated in the +Al and -P+Al treatment accumulated Al mostly in roots, though shoots of *S. hamata*, *P. repensi*, *P. maximum*, and *A. occidentale* also showed Al accumulation. Phosphorus utilization efficiency of plants which is defined as dry weight production per unit P in plant increased remarkably in -P treatment compare with the control, especially in tropical grasses (Table 3).

In most of tropical grasses and legumes, root exudation of organic acids was not found. However, in tropical trees, it was clearly observed. Citric acid exudation was stimulated by +Al in *A. mangium*, oxalic acid by -P in *A. occidentale* and oxalic acid by +Al in *H. brasiliensis* (Table 4). The secretion of acid phosphatase increased distinctly in -P treatment only from roots of *S. hamata* (Figure 3). For the secretion of phytase, it was non-detectable in all plants.

Phosphorus acquisition in the rhizosphere:

The concentration of available P in the rhizosphere zones was slightly changes. In contrast, the concentration of Fe-P in the rhizosphere zone next to the root zone decreased obviously. The concentration of exchangeable Al in the rhizosphere zones decreased with increasing proximity to the root zone (Figure 4).

DISCUSSION

Chemical properties and phosphorus status in highly weathered soils:

Table 2 Effect of P and Al treatments on nutrient concentration (g kg^{-1}) in shoot and roots of plants

		Shoot						Root					
Plant species	Treatment	N	P	K	Ca	Mg	Al	N	P	K	Ca	Mg	Al
Brachiaria ruziziensis	Control	47	14.57	45	1.09	3.79	Trace	35	8.66	23	0.21	3.12	Trace
	-P	50	0.85	20	1.20	3.12	Trace	25	0.84	21	0.22	2.33	Trace
	+Al	48	9.35	45	0.40	2.79	Trace	34	9.49	26	0.23	2.53	5.36
	-P+Al	48	0.73	21	0.77	2.27	Trace	27	0.80	25	0.18	1.82	3.50
Panicum maximum	Control	38	10.59	42	2.33	3.60	Trace	39	5.84	26	1.32	4.31	0.80
	-P	34	0.96	31	1.79	2.55	0.15	27	1.03	25	0.98	1.96	0.68
	+Al	37	8.78	24	1.22	2.41	0.26	32	6.12	18	1.22	2.47	5.69
	-P+Al	32	0.89	33	1.41	1.79	0.29	22	1.00	11	0.96	0.98	4.29
Panicum repensi	Control	29	8.32	26	1.61	1.95	Trace	14	8.04	21	0.59	2.34	0.76
	-P	25	0.76	23	1.28	1.73	Trace	19	0.83	29	0.69	3.75	1.09
	+Al	28	10.32	27	1.14	1.97	0.22	17	11.03	26	0.60	2.20	4.10
	-P+Al	23	0.63	23	1.05	1.47	0.23	18	0.69	28	0.64	2.25	2.45
Arachis pintoi	Control	51	9.89	36	2.76	4.28	Trace	42	16.22	33	0.42	5.69	Trace
	-P	47	2.83	30	2.74	4.44	Trace	40	2.09	35	0.53	2.52	Trace
	+Al	53	12.31	36	1.64	3.90	Trace	41	21.79	29	0.20	3.59	4.46
	-P+Al	49	2.46	27	1.65	3.75	Trace	39	2.40	30	0.46	1.45	2.94
Pueraria phaseoloides	Control	42	5.82	27	4.85	3.69	Trace	41	7.54	46	1.53	4.60	Trace
	-P	47	1.42	13	4.76	4.75	Trace	47	1.78	33	1.56	2.50	0.04
	+Al	46	6.34	32	*2.92*	3.04	Trace	41	8.70	29	1.58	3.57	2.74
	-P+Al	44	1.24	16	3.46	3.48	Trace	40	2.04	19	1.66	2.27	2.19
Stylosanthes hamata	Control	22	8.03	24	5.25	3.70	Trace	23	9.78	29	0.89	1.51	0.11
	-P	25	0.83	21	3.27	2.84	Trace	25	0.88	19	1.26	0.92	Trace
	+Al	18	6.68	24	1.92	2.71	0.13	24	9.88	17	0.86	1.07	3.75
	-P+Al	25	0.74	21	2.25	2.48	0.30	23	0.89	19	0.98	0.87	2.81
Acacia mangium	Control	40	3.57	17	0.47	3.75	Trace	37	7.28	29	0.26	6.34	0.03
	-P	34	0.67	14	0.55	3.24	Trace	25	0.90	20	0.29	4.83	0.39
	+Al	41	3.48	19	0.47	3.65	0.04	34	6.16	30	0.34	6.81	2.76
	-P+Al	31	0.65	14	0.49	3.60	0.52	23	0.78	22	0.22	2.86	2.09
Anacardium occidentale	Control	33	5.88	15	2.15	2.57	0.07	23	4.22	21	1.07	1.84	0.23
	-P	26	2.94	17	1.50	1.90	0.21	17	2.12	22	1.27	1.58	0.71
	+Al	24	4.69	12	1.02	2.18	0.27	16	4.06	16	0.52	1.36	4.38
	-P+Al	41	3.37	20	0.81	2.09	0.66	21	2.19	25	0.45	1.24	3.72
Hevea brasiliensis	Control	21	4.93	17	4.16	2.34	Trace	21	6.36	25	1.22	1.98	0.14
	-P	23	3.63	16	3.63	2.26	Trace	20	3.28	22	1.33	1.99	0.20
	+Al	18	4.86	17	*3.18*	2.27	Trace	16	6.13	16	0.84	1.62	1.29
	-P+Al	26	3.62	16	3.07	2.49	Trace	24	3.47	25	0.83	1.98	1.43
Melaleuca cajuputi	Control	37	3.06	15	0.64	5.89	Trace	20	5.67	17	0.18	1.60	0.17
	-P	24	0.81	14	1.12	6.68	Trace	13	0.91	17	0.28	1.84	0.17
	+Al	31	2.91	15	0.77	5.57	Trace	17	4.00	18	0.28	1.63	2.67
	-P+Al	20	0.66	15	0.92	5.26	Trace	13	0.87	19	0.26	1.50	3.14

Values are means of 3 replicates.

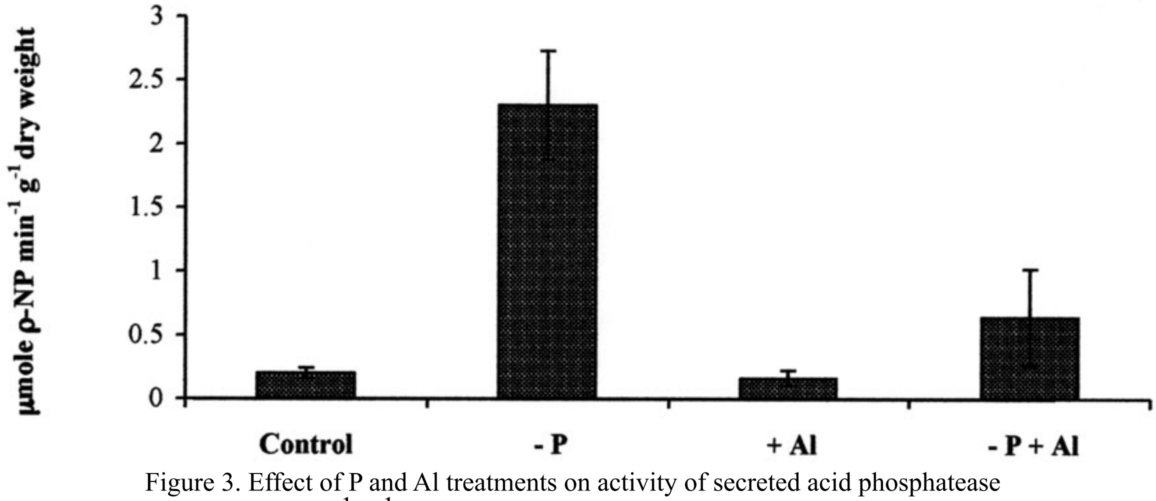

Figure 3. Effect of P and Al treatments on activity of secreted acid phosphatease (mmole r-NP min^{-1} g^{-1} root dry weight) from root. Values are means of 3 replicates ± standard error

The highly weathered acid soils predominant in peninsular Thailand are infertile (Table 1). The Hy and Kh soils were acidic. The concentrations of exchangeable Al were higher in the subsoil than those in topsoil. This causes aluminum toxicity which commonly appears together with P deficiency in tropical acid soils (Foth and Ellis, 1997). Acids soils contain a large amount of aluminum (Al) and iron (Fe), and thus available P is readily precipitated as the highly insoluble Fe- or Al-phosphates which are poor sources of phosphorus for higher plants (Steveson, 1986). It was summarized that

Table 3 Effect of P and Al treatments on P utilization efficiency (g dry weight g^{-1} P) of plants.

Treatment	Plant species									
	Brachiaria ruziziensis	*Panicum maximum*	*Panicum repensi*	*Arachis pintoi*	*Pueraria phaseoloides*	*Stylosanthes hamata*	*Acacia mangium*	*Anacardium occidentale*	*Hevea brasiliensis*	*Melaleuca cajuputi*
control	77±2	102±2	122±7	88±1	165±4	119±3	222±3	201±32	286±18	281±10
-P	1207±96	1023±3	1286±44	283±4	651±5	1186±30	1362±57	363±15	431±29	1006±194
+Al	107±4	121±3	96±3	68±1	148±7	135±5	239±6	220±3	290±20	320±3
-P+Al	1331±55	1087±7	1587±158	413±22	670±24	1271±29	1454±56	327±22	426±28	1346±125

Values are means of 3 replicates ± standard error.

Table 4 Effec of P and Al treatments on organic acid exudation from roots and organic acid concentration in fresh roots

		Root exudation (nmole g^{-1} root dry wt.)		Concentration in roots (nmole g^{-1} root fresh wt)				
Plant species	Treatment	Oxalic	Citric	Oxalic	Citric	Succinic	Tartaric	Malonic
Brachiaria ruziziensis	Control	ND	ND	197±13	793±277	ND	ND	ND
	-P	ND	ND	145±16	768±101	ND	ND	ND
	+Al	ND	ND	181±43	1004±163	ND	ND	ND
	-P+Al	ND	ND	182±36	879±253	ND	ND	ND
Panicum maximum	Control	ND	ND	328±17	293±1	338±19	ND	ND
	-P	ND	ND	395±3	388±2	366±5	ND	ND
	+Al	ND	ND	402±1	637±12	376±9	ND	ND
	-P+Al	ND	ND	431±9	929±35	372±9	ND	ND
Panicum repensi	Control	ND	ND	538±10	484±14	ND	ND	ND
	-P	ND	ND	ND	ND	ND	ND	ND
	+Al	ND	ND	ND	ND	ND	ND	ND
	-P+Al	ND	ND	790±4	669±29	ND	ND	ND
Arachis pintoi	Control	ND	ND	517±8	835±12	ND	ND	ND
	-P	ND	ND	542±7	758±6	1310±94	1031±101	ND
	+Al	ND	478±46	460±0	358±3	ND	ND	ND
	-P+Al	ND	1764±263	650±19	521±18	1424±80	1236±4	ND
Pueraria phaseoloides	Control	ND	ND	463±23	213±47	ND	ND	707±38
	-P	81±11	ND	832±72	254±24	10±1	ND	1185±94
	+Al	ND	ND	640±56	240±81	ND	ND	783±45
	-P+Al	89±4	ND	892±132	322±55	11±1	ND	1465±428
Acacia mangium	Control	28±5	58±17	112±16	454±16	ND	ND	ND
	-P	57±9	73±10	110±9	830±51	ND	ND	ND
	+Al	42±12	154±31	122±3	1029±53	ND	ND	ND
	-P+Al	74±12	268±40	116±4	1148±251	ND	ND	ND
Anacardium occidentale	Control	615±225	ND	2865±590	5345±73	ND	ND	ND
	-P	1559±371	ND	2651±314	4912±136	ND	ND	ND
	+Al	653+146	ND	2854±656	4274±436	ND	ND	ND
	-P+Al	2200+477	ND	3119±71	6941±1104	ND	ND	ND
Hevea brasiliensis	Control	558+161	ND	864±33	1228±136	ND	ND	ND
	-P	ND	ND	1153+44	1937+220	ND	ND	ND
	+Al	1263+323	ND	1064+124	2083+262	ND	ND	ND
	-P+Al	1687+62	ND	1098+1	2393+8	ND	ND	ND
Melaleuca cajuputi	Control	106+16	ND	3451+8	319+2	ND	ND	ND
	-P	132+1	ND	4558+52	1007+36	ND	ND	ND
	+Al	269+36	ND	2564+76	813+119	ND	ND	ND
	-P+Al	137+44	ND	5711+680	1180+5	ND	ND	ND

Values are means of 3 replicates ± standard error.

ND = non-detectable

* As *S. hamata* contained sticky gel-like compounds which interfere to detect organic acids, organic acids were not determined in *S. hamata* .

chemical properties of the Ultisols are poor. They are commonly acidic with the low cation exchange capacity and low content of exchangeable bases and organic matter, but the exchangeable Al is often high (Kheoruenromne, 1990).

The concentrations of total P in the top soil of the Hy and Kh soils were 162 and 43 mg kg^{-1}, respectively (Table 1), while the amount of total P in natural soils is generally 50 to over 1000 mg kg^{-1} (Foth and Ellis, 1997). According to the P fractionation (Figure 1), the concentration of Ca-P, which is considered to be easily available to crops, in the surface of these soils was very low (2-3 mg kg^{-1}); thus this fraction can not supply adequate P for crops. The major inorganic forms of P in these soils were Fe-P and Al-P. Although these forms were widely expected that they can be solubilized due to the complex formation with secreted organic acids from plant roots, resulting the release of P which is available to plants (Bolan et al., 1994; Marschner, 1995; Stauton and Leprince, 1996; Kirk et al., 1999; Neumann and Romheld, 1999; Roa et al., 1999; Zoysa et al., 1999), the amount of both fraction (about 5-10 mg kg^{-1})was only slightly greater than that of Ca-

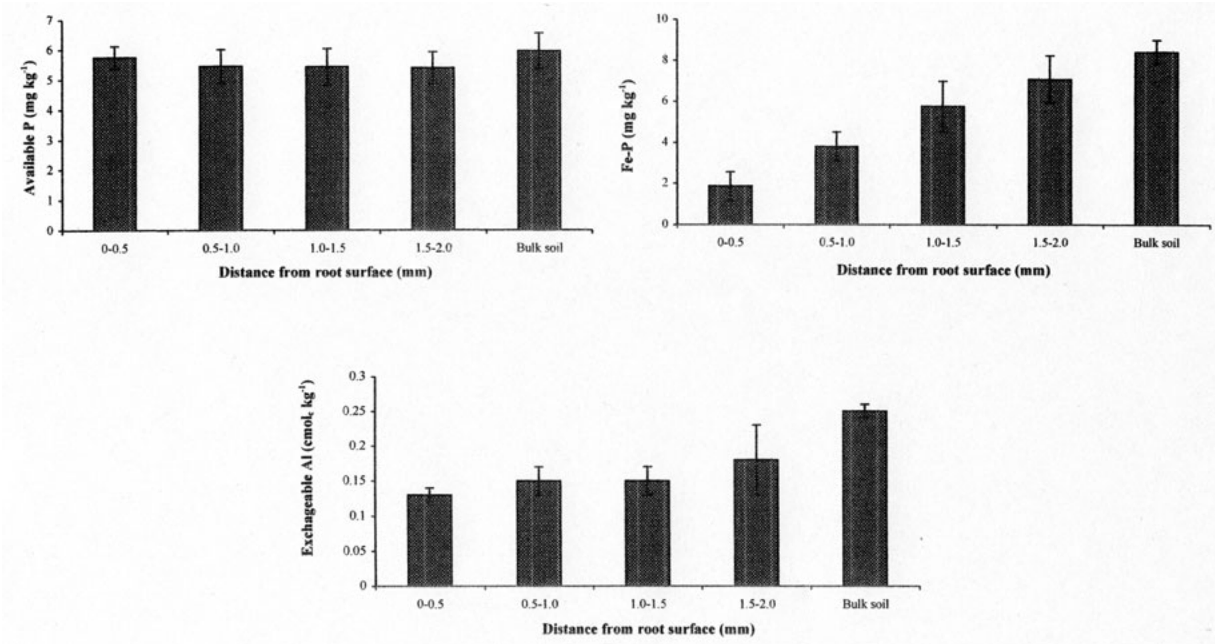

Figure 4. Concentration of available P, Fe-P and exchangeable Al in the rhizophere soil.

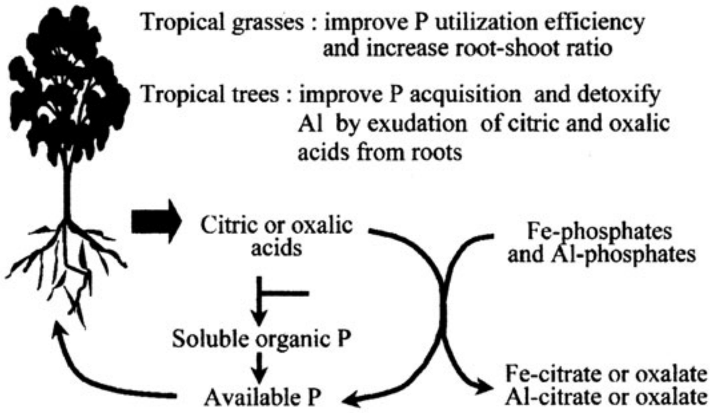

Figure 5. Adptive mechanisms of tropical plants to acid soil.

P. The main fraction of P in these soils was organic P (100 and 29 mg kg^{-1}) which account to about 70 and 60% of the total P in the top soil of the Hy and Kh soils, respectively. Therefore, organic P in the top soil may play an important role as the P source for plants. Recently, it was found that both inorganic and organic P in highly weathered soils can be extracted by the addition of citric or oxalic acid (Onthong et al., 1999). It has also been concluded that organic P in nonfertilizered Ultisols is the primary source of plant available P (Beck and Sanchez, 1994; Linquist et al., 1997). It was calculated that up to 75% of the P uptake of Norway spruce may be derived from the organic P fraction (Firsching and Claassen, 1996). However, the organic P is normally unavailable to plants unless the phosphatase or phytase secreted from plant roots or produced by microorganisms hydrolyze it and liberates orthophosphate which is available to plants. It was documented that the activity of acid phosphatase and phytase in some plants was increased under P deficient condition (Tadano et al., 1993; Li et al., 1997b), and it was also reported that the increase of acid phosphatase activity induced an appreciable depletion of organic P in the rhizosphere of lupin (Li et al., 1997a). Therefore, plants that secrete the enzyme contributing in P mineralization are able to acquire sufficient P even the native of available P in soils of this region is low.

Adaptation of tropical plants to acid soils:

The total dry weight of *B. ruziziensis*, *P. phaseloides*, *S. hamata*, *P. maximum*, *A. mangium*, and *M. cajuputi* grown in -P treatment and in -P+Al treatment became drastically lower than that in the control (Figure 2). However, symptoms of P deficiency were not observed, though the P concentration in the shoot was found to be very low (Table 2). On the contrary, the total dry weight of *P. repensi* increased even when the P concentration in the shoot became very low (0.76

g kg^{-1}), indicating that this plant has a tolerance to very low P concentration in tissue; the mechanism that enables growth under low P condition needs to be further investigated. On the other hand, -P treatment had no effect on the dry weight of *A. pintoi*, *A. occidentale*, and *H. brasiliensis*, assuming that P accumulated during pre-culturing (2.8-3.6 g kg^{-1}) was sufficient for growth after P elimination. The dry weight of *A. occidentale* cultivated in -P+Al treatment was much lower than that in the control, probably due to the concentration of high Al and low Ca in the shoot (Table 2).

A. pintoi, *B. ruziziensis*, and *P. repensi* cultivated in +Al treatment grew slightly better than the control, because the uptake of N (except in the case of *P. repensi*) and P (except in the case of *B. ruziziensis*) was stimulated by Al application (Table 2). This effect is consistent with the findings in a study of the beneficial effect of Al on the growth of plants adapted to low pH soils (Osaki et al., 1997). It has also been reported that *Melastoma malabathricum* and *M. cajuputi* can only slightly absorb N and P without Al (Osaki et al., 1998). On the other hand, Al inhibited the uptake of Ca and Mg in all plants used in this study, as was found in *Melastoma malabathricum* (Osaki et al., 1997). However, because Ca and Mg concentration in tissue is higher than deficient level, Ca and Mg competition with Al is not the main factor to reduce plant growth in this current study.

A. pintoi, *B. ruziziensis*, *P. phaseoloides*, *H. brasiliensis*, *A. mangium*, and *M. cajuputi* cultured in +Al and -P+Al treatment accumulated Al only in roots, though the other plants also accumulated a small amount of Al in the shoot. However, accumulation of Al did not effect plant growth (Figure 2), possibly due to the chelating ability of organic acids from or in roots (Table 2) with Al.

When tropical plants were grown in low P and high Al conditions, P utilization efficiency, which was expressed as dry weight per unit P in plant, was commonly increased in all plants investigated (Table 3), particular in grasses. This finding supports the fact that ruzigrass (*B. ruziziensis*) is widely cultivated in P deficient tropical soils distributed in Thailand without fertilizer in agronomical practice (Masuda et al., 1997). The ability of efficient P utilization is strongly beneficial for plants to grow in the regions that both available and total P are low as commonly found in the south of Thailand. Thus, species and varieties with high efficient P utilization should be investigated in this region. However, the higher phosphorus utilization efficiency (PUE) is, the lower P concentration is. Therefore, care should betaken; otherwise high PUE forage plants may induce malnutrition of animals.

In soils with low available P, plants can also increase P uptake by the abilities as follow: (i) to develop long, fine hairy roots in soil zone containing plant-available P, (ii) to solubilize soil inorganic P through the pH change or the release of organic acids which act as the chelating agents, and (iii) to utilize soil organic P through the release of phosphatase or phytase (Hedley et al., 1994). Root-shoot ratios of *P. phaseoloides*, *S. hamata*, *B. ruziziensis*, and *P. maximum* were greatly enhanced under cultivated in P deficient solution (Figure 2). This trait is the important mechanism of these plants to acquire P from limited-P soils. Exudation of acid phosphatase and phytase from roots is also one of the adaptive mechanisms of plants to acquire P in P-limited soils (Tadano et al., 1993; Li et al., 1997a, b; Gilbert et al., 1999; Neumann et al., 1999). High activity of these enzymes in the rhizosphere is involved in hydrolysis of organic P fraction in soils. In this investigation, secretion od acid phosphatase from roots of *S. hamata* was stimulated by deficient P. Plants having this ability may be significantly important to grow in soils where the majority of the total P consisted of organic P as in the highly weathered soils in the tropics.

In current study oxalic and citric acids were secreted into the root medium, particularly from the roots of tropical trees (Table 4). Oxalic acid secretion from roots of *A. occidentale*, which is widely cultivated in infertile soils and that from roots of *H. brasiliensis*, which is the commonly plantation crop in the south of Thailand, was stimulated by deficient P and excess Al, respectively. In addition, *A. mangium* and *M. cajuputi*, which adapt well to low pH soils, secreted citric and oxalic acids, and oxalic acid, respectively (Table 4). The secretion of organic acids is important not only for the increase of P availability but also for the decrease of Al toxicity. Moreover, the organic acids accumulating in roots are also important for Al detoxification in plants. Therefore, this trait is very substantial for plant adaptation to low pH soils where low available P and excess Al are the major constraint on crop production.

Phosphorus acquisition of tropical plants in acid soils:

Both available and total P in the dominant highly weathered soils in peninsular Thailand were low (Table 1), and the main proportion of total P was organic P (Figure 1). However, P availability in these soils can be increased by the application of citric and oxlic acid (Onthong et al., 1999). These acids were secreted by roots of tropical plants (Table 4). In this investigated, the concentration of available P in the rhizosphere zones was slightly changed, indicating that the P absorption by roots and P solubilization by root exudates is in equilibrium. In contrast, the concentration of Fe-P in the rhizosphere zone close to the root zone decreased sharply (Figure 4), implying that the the large amount of secreted citric acid from roots of *A. mangium* (Table 4) enhances P acquisition in the rhizosphere. The decrease of exchangeable Al in soil fraction close to the root zone (Figure 4) implies that Al form the complex with secreted citric acid, resulting decrease of Al toxicity to roots.

Recently, it was reported citrate-overproducing plants yielded more leaf and fruit biomass when the transgenic tobacco plants that over produce citrate grown under P-limiting condition and required less P fertilizer to achieve optimum growth (Lopez-Bucio, et al., 2000). For this reason, the plants with ability in extracting P from soils are strongly recommended. It is sometimes argued that the plants that are highly efficient in extracting P from soils is dangerous because it will accelerate the depletion of soil P reserves. To avoid this situation in the long run, application of P fertilizer is still required.

CONCLUSION

Tropical plants have different adaptive mechanisms to tolerate to deficient P and high Al conditions (Figure 5). Increase of P utilization is commonly found in all plants investigated. Increase of root-shoot ratio is dominant mechanism on P uptake in *P. phaseoloides, S. hamata*, *B. ruziziensis*, *P. maximum*, *A. mangium*, and *M. cajuputi*. Secretion of acid phosphatase was dominant only in *S. hamata*. The organic acid exudation, which is important in improving P acquisition and Al detoxification, from plant roots were observed in tropical trees, especially citric and oxalic acid by *A. mangium* and citric acid by *A. occidentale*, *H. brasiliensis*, and *M. cajuputi*.

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A Preliminary Study on Vegetation and Habitat Recivery of Peat Swamp Post-Forest Fire in Central Kalimantan, Indonesia

Edi Mirmanto
Botany Devision, Research Centre for Biology - LIPI
Juanda 22 Bogor, Indonesia - 62-251-322035
E-mail: emirmanto @ yahoo.com

ABSTRACT

A study was made in the Central Kalimantan peat-swamp forest areas to compare plants and physical habitat recovery of peat-swamp post-forest fire at sites with different histories. The main aims of this study were investigate whether the soil fertility increased with increasing of undergrowth vegetation, and whether vegetation re-growth differed at sites of age, geographically and peat-depth.

The soil data showed no significant difference in soil chemistry among sites. The composition and biomass of undergrowth (vegetation re-growth) changing up to 4 years after forest fire was largely dependent on age rather then to peat depth and scale of damages.

Key words: peat-swamp forest, post-forest fire, undergrowth, Central Kalimantan

INTRODUCTION

The peat-swamp forests dominated in Central Kalimantan characterized by poor nutritional conditions, occurs on fresh-water marshland with a thick peat layer varying from 0.5 m up to 10 m or more. This forest type is unique and important ecosystems because its roles in many global processes, such as carbon sequestration, hydrological regulation, and biodiversity maintenance. However, it is sensitive to development and fragile, so artificial the extents of these forest types are dependent on the land utilization and conservation measure applied.

In fact the forest disturbance causes the physical damage on plantís habitat but in some cases that disturbance resulted in little environment damage and the forest capable to sustained and maintained for future generation. The different scale of disturbance resulted in different rate of recovery of plants and physical habitats. The rate of plant re-establishment influences the forest recovery as well as physical habitats. The succession has implications for both soil nutrient dynamics and vegetation development. Therefore, the comparative study on recovery of plants and physical habitats at sites with different histories is an important matter.

In the inland of C. Kalimantan, there are many disturbed forests that caused by forest fire and human activities. The data and information on recovery of forest and their habitat is still limited. The present study is a preliminary result on the recovers rate of plants and physical habitats among forest sites with various agesí post-forest fire.

MATERIALS AND METHODS

Study sites

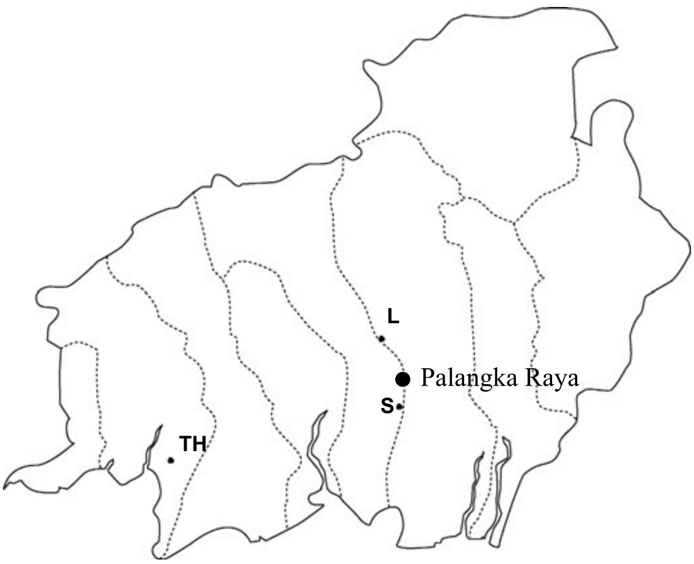

Figure 1. Location of three study sites in Central Kalimantan, Indonesia;. L: Lahei site; S: Sebangau site; TH: Tanjung Harapan

The study has been made in three sites, Sebangau, Lahei and Tanjung Harapan (Figure 1). The Sebangau site is situated at 2˚18’24” S, 113˚55’4.1” E, at about 10 m above sea level. The typical vegetation here is a peat swamp forest, of which peat depth varied from 2 m to 10 m. The Lahei study site is situated at 1˚ 55’15” S, 114˚10’0” E, at about 20 m above sea level. There are at least two types of vegetation, peat swamp forest and heath forest. In the former, peat depth is ca. 2 m, and in the latter, peat depth is 0.6 m. The study site in Tanjung Harapan is situated at 2 º45’45.8” S, 111º 56’41.4” E, at about 10 m above sea level. The land is covered with a heath forest with thin peat less than 1m.

Five plots were selected referencing knowledge of residents to include post forest fire of different ages (1-4 years). I settled three plots in Lahei area (L-1a, L-1b and L-4) and one plot in Sebangau (S-3) and Tanjung Harapan (TH-3) respectively. The plots L-1a and L-1b were one year old after forest fire, but the former suffered heavier damages of forest fire. The plots S3 and TH3 were three years old , and the plot L4 was four years old after forests fire. Unfortunately plots of two years old after forest fire was not found.

Vegetation

In each selected site I set up plots of 30-m x 30-m, and each plot was divided into 9 quadrates of 10 x 10 m. In order to estimate plant cover, each quadrate was then divided into to 25 sub-quadrates of 2 x 2 m. The coverage of each species was obtained for each quadrate by calculating percentages of sub-quadrates from which the species was found. The vegetation was subjected to multivariate analysis using multivariate statistical packed software (Kovach Computing Service, MVSP). Species found in less than three quadrates at a site were excluded from the analysis for that site. After principal component analysis (PCA), a multiple regression analysis was used to examine the relation between two principal components and environmental factors (age, peat depth, disturbance and location) as independent variables.

In order to measure peat depth, I inserted wood poles into the ground, pulled up, and measured depth of the boundary between peat and white sand. In my study sites, sediments below peat were always white sand.

Scale of disturbance was evaluated in the following manners. According to the estimated ratio of canopy trees killed by fire, percentages of disturbance were evaluated at the unit of 10%. If nearly half of canopy trees were killed by fire, percentage of disturbance was 50 %. If no living trees were remaining, percentage of disturbance was 100%. In all plots examined, more than half of canopy trees were estimated to be killed by fire, so percentages of disturbance was always 50% or higher.

Soil analysis

Soil surface sample (0-10 cm) were collected from randomly selected three quadrates of each plot. The samples were air-dried and grounded. Sub-samples for chemical analysis of 150 g in dry weight were taken to Research Center for Soil and Agro-climate.

Biomass and chemical contents of plants

I harvested aboveground parts of living plants within three neighboring quadrates (10 x 30 m) in every plot. However, large standing trees that were estimated to have existed before forest fire and still remaining alive were not cut. Such trees had burnt barks and were much larger in sizes than recovered plants after fire, which were shorter than 1.5 m in the harvested areas.

Harvested plants were sorted into ferns, grasses, herbs and trees, and dried in 90*C for two days Dry samples were weighed, and sub-sample were taken to Research Center for Soil and Agro-climate for chemical analysis.

RESULTS AND DISCUSSION

Soil analysis

Analysis of variance on chemical attributes showed no significant ($p < 0.05$) differences among five sites (Table 1). Although contents of some mineral elements of L-1a were slightly higher than those of L4, the difference was marginally insignificant ($p = 0.056 - 0.068$).

The changes in soil chemistry that occurred after forest fire were slightly different with other report (Riswan & Kartawinata, 1991.). However, no significant differences in soil chemistry among study site similar to that reported by Nagy and Proctor (in press.). The near-significant differences between L-1 and L-4 may indicate that a real decrease in soil fertility during period one year to four year after forest fire. This is may be because a temporary depletion of nutrient was occurring in the L-4, whilst the L-1 was a relatively still enriched in nutrient. Nakano & Syahbuddin (1989) reported that the dynamics of nutrient in forest fallows are characterized by decrease in the early stage (1-4 year) and after that soil reserves will tend to increase from litter-fall.

Table 1. The results of chemical analysis of soil samples (n= 3) collected from five study sites. The averages and max-min in brackets were shown (mg/g for mineral contents). There were no significant differences (P < 0.05) among sites.

	L-1a	L-1b	TH-3	S-3	L-4
pH (CaCl)	4.3 (4.2-4.4)	4.3 (4.2-4.4)	4.3 (4.1-4.4)	4.3 (3.9-4.5)	4.18 (3.9-4.5)
Nitrogen	1.1 (0.99-1.2)	1.1 (0.97-1.2)	1.1 (0.96-1.2)	1.1 (0.87-1.28)	0.92 (0.76-1.1)
Phosphorus	0.090 (0.060-0.11)	0.080 (0.040-0.16)	0.080 (0.05-0.12)	0.07 (0.040-0.11)	0.040 (0.020-0.060)
Potassium	0.050 (0.020-0.080)	0.060 (0.030-0.090)	0.050 (0.03-0.08)	0.05 (0.030-0.080)	0.060 (0.020-0.080)
Calcium	0.26 (0.12-0.41)	0.24 (0.21-0.27)	0.25 (0.19-0.31)	0.24 (0.18-0.32)	0.24 (0.19-0.28)
Natrium	0.015 (0.0090-0.020)	0.013 (0.0060-0.019)	0.012 (0.0080-0.021)	0.013 (0.05-0.023)	0.010 (0.0090-0.014)
Magnesium	0.12 (0.080-0.20)	0.090 (0.070-0.15)	0.090 (0.050-0.12)	0.080 (0.07-0.11)	0.070 (0.050-0.11)

Table 2. Coverage of major species in five study sites. Percentages of 2 x 2 m sub-quadrates that each species were found were shown. In this table, I selected species found in at least seven quadrates (5 x5 m) for at least one site.

	Species	L-1a	L-1b	TH-3	S-3	L-4
Fern						
	Nephrolepis exaltata	23.00	22.00	24.00	10.00	5.0
	Pteridium aquilinum	46.00	30.00	35.00	18.00	9.0
	Stenochlaena pallustris	23.00	25.00	4.60	12.00	0.32
Grass						
	Imperata cylindrica			3.6	3.2	0.36
	Scleria purpuraceus				4.0	1.5
Herb						
	Blumea balsamifera	0.45	1.4	1.6	0.53	0.19
	Blumea lacera	0.30	1.1	1.2		
	Globa sp.	0.11	0.28	2.2	3.5	3.8
Shrub						
	Goniothalamus malayanus	0.20	0.28	0.87	1.0	
	Melastoma malabathricum		6.3	6.1	2.1	4.1
	Rhodamnia cinerea		2.3	3.1	2.1	
Tree						
	Acronychia porteri			0.020	0.17	0.95
	Baccaurea bracteata		0.87	0.64	1.1	5.3
	Calophyllum sp.1			0.27	3.1	5.4
	Calophyllum sp.2			0.90	1.6	2.3
	Cratoxyllum glaucum				3.0	9.7
	Dialium indum			0.23	0.79	1.4
	Diospyros hermaphrodifica	0.71	0.75		0.64	1.3
	Elaeocarpus griffithii	0.54	0.80	0.62	2.5	2.4
	Ganua motleyana			0.18	0.74	1.0
	Garcinia sp.1	0.050	0.15	0.42	2.9	5.3
	Horsfieldia punctatifolia	0.060	0.11	0.09	0.070	3.6
	Ilex cymosa			1.5	2.2	1.5
	Knema intermedia		0.42	0.25	0.43	1.8
	Macaranga triloba	0.73	0.58	0.51	0.38	
	Mezzettia umbellata	1.4	1.5	1.8	2.5	3.4
	Palaquium sp.2				0.19	3.5
	Santiria laevigata	0.32	0.15	0.21	0.36	2.8
	Shorea spp.				1.6	3.0
	Sindora leiocarpa		1.5	1.2	2.0	2.4
	Sterculia coccinea		1.8	1.3	2.3	2.6
	Tristania obovata		0.020	0.42	0.45	1.6

Table 3. The percentages in biomass of ferns, grasses, herbs, shrubs and trees at five study sites.

Life-form	L1-a	L1-b	TH-3	S-3	L-4
Ferns	94.0	80.0	56.0	51.0	21.0
Grasses	0.0	0.0	3.8	8.9	2.8
Herbs	1.0	4.7	7.4	6.0	6.9
Shrubs	2.3	9.0	10	9.6	10.6
Trees	2.6	6.5	19	25	58.7

Table 4. Standardized coefficients of multiple regression values in order to determining PCA scores of 45 quadrates using five environmental factors.

	Dependent variable	
Independent variable	Axis-1	Axis-2
Age (year)	-0.3	0.56 ***
Peat-depth (m)	-0.1	0.0130
Disturbance	0.899 **	).769 ***
Altitude (m asl)	-1.44 **	).944 ***
Gographical	-1.16	0.783 ***
F	18.0	54.6

* p < 0.05, ** p < 0.01, *** p < 0.001

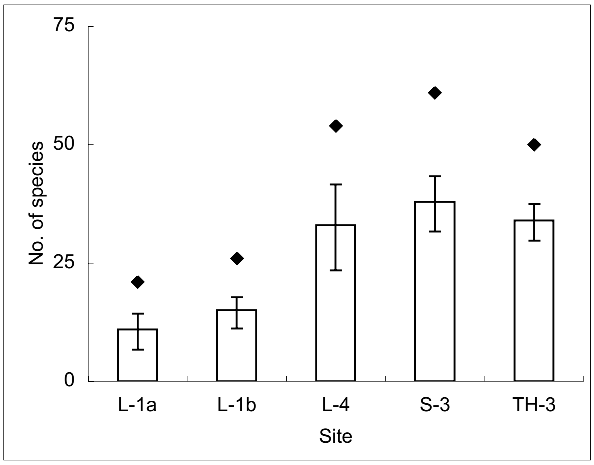

Figure 2. Mean number of species per 5 x 5 m quadrates (n= 9) and standard deviations recorded at five study sites. The diamond-shaped points above the graphs indicate the total number of species found in whole plot (30 x 30 m).

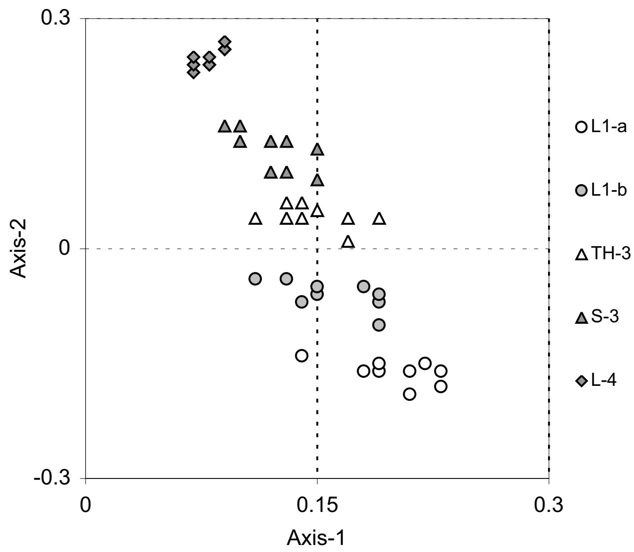

Figure 3. Scatter diagram for PCA of 45 quadrates at five study sites.

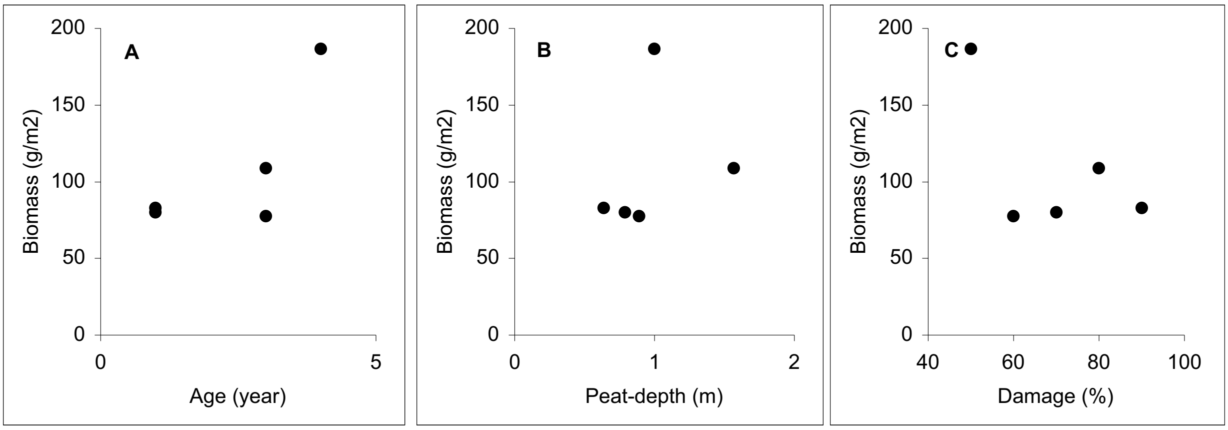

Figure 4. Results of biomass measurements in relation to age (A), peat-depth (B) and percentage of habitat damage (C).

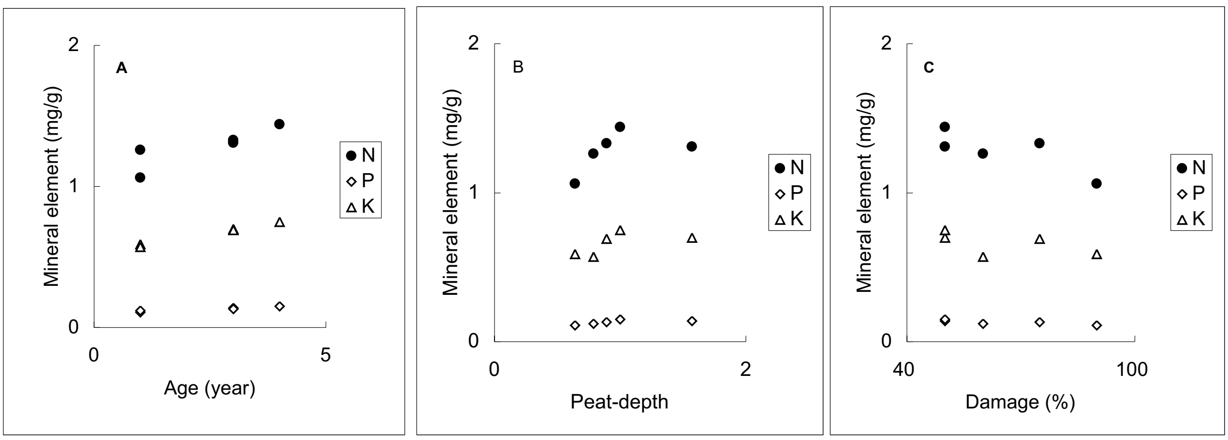

Figure 5. Results of chemical analysis of plants in relation to age (A), peat-depth (B), and percentage of habitat damage (C).

Vegetation

A total of 89 vascular plant taxa were recorded from the five sites: L-1a had 21 species; L-1b, 26 species; L-4, 54 species, TH-3, 54 species and S-3, 61 species (Figure 2). Coverage of some major species for each site was summarized in Table 2. The older vegetation had about twice more number of tree species than youngest vegetation.

According to PCA, the contribution of the first principal component (Axis-1) was 53 %, and the second axis (Axis-2) was 19 %. The first two axes explained 71 % of variation. Figure 3 shows the distributions of quadrates along the two axes. The results of multiple regression analysis suggest that the Axis-2 was strongly correlated with age, disturbance, and location, whereas Axis-1 related to disturbance and altitude less strongly (Table 4). Thus, quadrates located left top in Fig. 3 are older, less disturbed, and at higher altitude.

Biomass and chemical components of plants

In the plots L-1a and L-1b (one year old after fire), the biomass of ferns and herbs was about 87 % of total biomass. The corresponding value for the oldest vegetation (L4) decreased to 21 % (Table 3). Biomass was significantly ($r = 0.87$) related positively to age of vegetation (Figure 4A). In relation with peat depth, biomass tended to be highest at medium peat depth (Figure 4B). Biomass of recovered plants was negatively related with percentages of damages (Figure 4C). Contents of N, P, K of recovered plants were significantly higher in older plots (for N: $r = 0.91$; for P: $r = 0.94$; for K: $r = 0.98$; Figure 5A). However, they were not significantly related with peat depth (Figure 5B) and percentages of damages (Figure 5C).

The study shows that under-growth biomass significantly increase from L-1 to L-4. That means there is positive correlation between ages of forest and vegetation recovery. However, so far the vegetation recovery did not followed by recovery of physical habitat, which indicated, by no significant differences in soil nutrient among study site. In fact, on the other hand the vegetation nutrients content increase with increasing in age of forest. This indicates that there is no or very little nutrient turnover from litter falls to the soil. It is may be characteristic of peat-swamp forest where the rate of decomposition is relatively slow. Another explanation that forest fire may have destroyed the physical habitat and biotic component as well as which will reduce the rate of decomposition (Rahajoe & Kohyama, 2002).

The paper is a results of preliminary data analysis and more detail analysis may still needed. However not significantly differences between youngest and oldest post-forest fire in habitat recovery is interesting point, and may be able to be used as reference for future studies.

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Light and Nitrogen Effect to CO_2 Fluxes: From Leaf to Canopy

Tania June[1], Mitsuru Osaki[2], Takashi Hirano[2], Hendrik Segah[3] and Suwido H. Limin[3]
[1]Bogor Agricultural University, Bogor, Indonesia
[2]Graduate School of Agrigulture,, Hokkaaido University, Sapporo, Japan
[3]Faculty of Agriculture, Palangka University, Palangka Raya, Indonesia

ABSTRACT

Better modelling of canopy photosynthesis is a challenging research area which has been greatly stimulated in recent years by the demand for more accurate carbon budgets in ecosystems in the context of global warming and increasing atmospheric CO_2 concentration. Nowadays, mechanistic modelling of leaf photosynthesis, based on theoretical and experimental framework introduced two decades ago by Farquhar and co-workers, has become a standard to simulate whole leaf photosynthesis in a canopy (Baldocchi & Harley 1995; Leuning et al. 1995; Amthor et al. 1994; Lloyd et al. 1995) and provides a basis for these larger scale predictions. This mechanistic approach has been particularly successful since model parameterisation can be almost fully obtained using conventional gas exchange measurements at the leaf level.

The photosynthetic performance of a whole leaf is a summation of the performance of the individual cell layers. This is also true for a canopy, where the total efficiency of one canopy depends on the efficiency of each layer that build one canopy. Light intensity, as well as its distribution and properties, together with distribution of nitrogen determine overall canopy efficiency.

The manuscript presented here shows how the parameters obtained at the leaf level is scaled up to the canopy level to estimate canopy CO_2 assimilation and efficiency. It shows the effect of the distribution of irradiance, diffuse fraction of irradiance and nitrogen distribution on canopy assimilation rate, its efficiency and the resulted optimum LAI that a canopy can sustain.

INTRODUCTION

A major component of many crop, pasture and ecosystem models is the prediction of the daily rate of net canopy photosynthesis, as canopy photosynthesis is a fundamental component of growth (Monteith 1977; Caldwell *et al*. 1986; Reynolds *et al*. 1987; Norman & Arkebauer 1991; Goudriaan & van Laar 1994; Lloyd *et al*. 1995). Canopy photosynthesis is affected by photosynthetic capacity at the leaf level, light interception by the canopy, nitrogen level and other environmental conditions (temperature, CO_2 concentration) to which the canopy is exposed. The model of Farquhar *et al*. (1980) and Farquhar & von Caemmerer (1982) provides a means of examining the direct and interactive effects of CO_2, light and temperature on the photosynthesis of individual leaves. Although this model is widely used in physiological contexts, its application in crop and ecosystem models for climate change research was until recently fairly limited. Difficulties in parameterisation, and differences in scale between photosynthetic biochemistry and whole-plant processes are thought to be the reasons.

The Big-leaf and the Sun-shade models used parameterisation at the leaf level, which can be done easily with a gas exchange measurement system, to model photosynthesis at the canopy level. The big leaf model treats the canopy as a single big leaf (following Beerís Law), where the properties at the leaf level are matched to the bulk canopy. This model has the advantage of being very simple to parameterise. It however, suffers from the difficulties that is spatial variation in photosynthetic capacity and instantaneous irradiance, that are not in concert. The sun-shade model, on the other hand, separates the canopy into two parts, sunlit and shaded, with different parameters, and each part is then modelled using the big leaf approach.

The aim of this manuscript is to use the sun-shade model (and compare it with the big-leaf model) together with observed climatic data to quantify the effect of irradiance (light) and nitrogen on CO_2 fluxes. Effect of temperature and CO_2 concentration are also examined at the level of an idealized canopy. This model separates the canopy into two parts, the shaded and the sunlit (in contrast to the one big sun leaf of the big leaf model), and each part was modelled by integrating the photosynthetic capacity down through the canopy. Therefore, these separated parts can then be modelled using the Farquhar *et al*. (1980) and the Farquhar & von Caemmerer (1982) C_3 leaf photosynthesis model, using the parameterisation at the leaf level obtained from gas exchange measurement.

The example simulation is summarised in terms of canopy CO_2 assimilation rate as a function of time of day, which depends on irradiance, distribution of nitrogen, the canopy Leaf Area Index (LAI), CO_2 concentration, temperature and the fraction of diffuse irradiance. The proposed canopy assimilation module is suitable for incorporation into existing agricultural/forestry models to improve predictions of canopy assimilation or total biomass production.

MODELLING LEAF PHOTOSYNTHESIS

Leaf photosynthesis can be described by the equations developed by Farquhar *et al*. (l980) and Farquhar & von Caemmerer (1982). The basic assumption underlying the model is that the rate of photosynthesis is controlled by the amount of activated enzyme RuBP carboxylase-oxygenase (Rubisco), the rate of regeneration of RuBP, and the relative partial pressures of CO_2 (c_i) and O_2 at the site of CO_2 fixation. Therefore, under a given set of environmental conditions, the net CO_2 assimilation rate, A, is taken as being either the Rubisco-limited rate, A_v, or the predicted RuBP-regeneration limited rate of photosynthesis, A_j, whichever is the lower at a particular c_i. (This holds for $c_i > \Gamma^*$.) A has units of mmol m^{-2} s^{-1}.

$$A_j = \frac{J}{4}\left(\frac{c_i - \Gamma^*}{c_i + 2\Gamma^*}\right) - R_d \qquad (1)$$

$$A_v = V_{c\max}\left(\frac{c_i - \Gamma^*}{K_c\left(1 + O/K_o\right) + c_i}\right) - R_d \qquad (2)$$

$$A = \min(A_j, A_v) \qquad (3)$$

where c_i = partial pressure of CO_2 in the leaf (µbar); Γ^* = CO_2 compensation partial pressure in the absence of dark respiration (µbar); R_d = dark respiration by the leaf which continues in the light (µmol m^{-2} s^{-1}); O = ambient partial pressure of oxygen (mbar); K_c and K_o are Michaelis-Menten constants for carboxylation and oxygenation by Rubisco (µbar and mbar, respectively); V_{cmax} is the maximum rate of Rubisco activity in the leaf (µmol m^{-2} s^{-1}); and J is the actual electron transport rate (µmol m^{-2} s^{-1}).

The temperature dependence of K_c and K_o follows an Arrhenius function:

$$K_c = K_{c,25}\exp\left[\frac{E_c}{298.2R}\left(1 - \frac{298.2}{(T + 273)}\right)\right] \qquad (4)$$

$$K_o = K_{o,25}\exp\left[\frac{E_o}{298.2R}\left(1 - \frac{298.2}{(T + 273)}\right)\right] \qquad (5)$$

where R is the universal gas constant, 8.3144 J mol^{-1} K^{-1}, and T is temperature in °C. E_c and E_o are the apparent activation energies and the 25 subscript refers to the value at 25 °C.

The effect of temperature on the CO_2 compensation point of photosynthesis in the absence of mitochondrial respiration follows the equation of von Caemmerer *et al*. (l994):

$$\Gamma^* = 36.9 + 1.88(T-25) + 0.036(T-25)^2 \qquad (6)$$

The parameters K_c and K_o indicate the intrinsic kinetic properties of Rubisco. They are relatively constant, varying only with temperature for all C_3 species.

The rate of electron transport, J, follows the equation by Farquhar & Wong (l984):

$$J = \frac{Ia_2 + J_{\max} - \sqrt{(Ia_2 + J_{\max})^2 - 4\Theta I a_2 J_{\max}}}{2\Theta} \qquad (7)$$

where J_{max} is the maximum light-saturated rate of electron transport of the leaf (mmol m^{-2} s^{-1}), Q is the curvature factor of the light response curve that varies from 0 (rectangular hyperbola) to 1 (two straight lines quasi Blackman), a_2 is the quantum yield (in terms of incident PAR) of electron transport at low light and I is the light intensity (mmol m^{-2} s^{-1}) incident on the leaf.

MODELLING CANOPY PHOTOSYNTHESIS

Total Canopy Absorption of Irradiance and the estimation of fraction of diffuse light.

In the following section I used soybean canopy as a study case. The total canopy absorption of irradiance per unit ground area (I_c) is calculated by integrating I_l (leaf absorption of irradiance per unit leaf area) over the whole Leaf Area Index (LAI, L_t). L_t is the total area of leaf surfaces per m^2 of ground.

$$I_c = \int_0^{L_t} I_l dL$$
$$= (1 - P_{cb}) I_{B(0)} (1 - exp(-k_{b'} L_t)) + (1 - P_{cd}) I_{D(0)} (1 - exp(-k_d L_t)) \quad (8)$$

$$P_{cb} = 1 - exp(-2\rho_H k_b / (1 + k_b)) \quad (9)$$

where P_{cb} = canopy reflection coefficient for beam PAR, P_{cd} = canopy reflection coefficient for diffuse PAR (= 0.036), $k_{b'}$ = beam and scattered beam PAR extinction coefficient (= 0.69/*sin*b), $k_{d'}$ = diffuse and scattered diffuse PAR extinction coefficient (= 0.715), $I_{B(0)}$ and $I_{D(0)}$ = beam and diffuse PAR, respectively, in a horizontal plane (mmol m^{-2}s^{-1}), r_H = reflection coefficient of a canopy with horizontal leaves (= 0.041), and k_b = beam radiation extinction coefficient of canopy (Goudriaan l977). The value of 0.75 for k_b*sin*b was used in the simulation. The value was taken from Ito & Udagawa (1971), who did a phytometrical study of soybean canopies by measuring the geometrical structure of the soybean canopy and sunlight penetration. The beam and diffuse PAR (units of mmol m^{-2}s^{-1}) are calculated using these equations:

$$I_{B(0)} = (1 - f_D)S \quad (10)$$

$$I_{D(0)} = f_D S \quad (11)$$

Total Canopy Nitrogen And Photosynthetic Capacity

Leaf nitrogen in the canopy (N_l) is modelled by assuming that N_l decreases exponentially with cumulative *absolute* leaf area index, L, from the top of the canopy. A base level of nitrogen which is not associated with leaf photosynthesis, N_b, is incorporated into the model (Anten *et al*. l995). The equation for the leaf nitrogen distribution is

$$N_l = (N_0 - N_b)exp(-k_{na}L) + N_b \quad (12)$$

where N_o is leaf nitrogen content at the top of canopy and k_{na} is the extinction coefficient for nitrogen in the canopy. This nitrogen distribution results in plants maintaining their nitrogen level on the top of the canopy regardless of their total LAI (L_t). As L increases, the plant leaves have a lower nitrogen content in the lower part of the canopy.

Total canopy nitrogen (N_c) is calculated by integration of the leaf nitrogen concentration per unit leaf area (N_l) over the entire canopy (unit is μmol m^{-2}):

$$Nc = \int_0^{Lt} N_{la} dL = L_t(N_0 - N_b)(1 - exp(-L_t k_{na}))/(L_t k_{na}) + N_b$$
$$= (N_0 - N_b)(1 - exp(-L_t k_{na}))/k_{na} + L_t N_b \quad (13)$$

where N_o is the leaf nitrogen concentration at the top of the canopy (mmol m^{-2}) and N_b is the leaf nitrogen not associated with photosynthesis (residual leaf nitrogen content).

According to Shiraiwa & Sinclair (1993), for soybean leaves the range of leaf nitrogen per unit leaf area in the top leaves of a mature canopy is from about 114.3 to 171.4 mmol m^{-2}, and at the bottom of the canopy it is about 71.4 mmol m^{-2} for LAI = 4.0. This result was compatible with observations of leaf photosynthetic activity in soybean as found by Lugg & Sinclair (l981), where the photosynthetic rate was saturated at a leaf nitrogen content of 157.1 - 171.4 mmol m^{-2}, and dropped to zero at a leaf nitrogen content of 71.4 mmol m^{-2}. The optimum surface leaf nitrogen content for soybean is 186 mmol m^{-2}.

Anten *et al*. (l995), who also worked with soybean, suggested that the decrease in nitrogen is exponential. Recalculated the data of Anten *et al*. (1995), an extinction coefficient for nitrogen in the canopy of k_{na} = 0.3 was obtained.
Assuming a linear relationship between nitrogen content and V_{cmax} in the leaf, the Rubisco capacity (V_{cmax}, μmol m^{-2}s^{-1}) is then calculated from leaf nitrogen.

$$V_{cmax(l)} = \chi_n(N_l - N_b) \quad (14)$$

where χ_n is the ratio of measured Rubisco capacity to leaf nitrogen content. This ratio depends both on how much nitrogen in the leaf is allocated to carboxylation activity and the nitrogen content of Rubisco activity. Pons & Pearcy (l994) measured the leaf nitrogen content of soybean and associated V_{cmax}, and found that at nitrogen contents of 122.6 and 71.6 mmol m^{-2}, V_{cmax} was 149.6 and 66.4 mmol m^{-2} s^{-1} respectively. From these data I calculate χ_n =1.63 μmol mmol^{-1} s^{-1} via a linear fit to Eq. (14), and N_b = 30.9 mmol m^{-2} when V_{cmax} is zero. These are the values chosen for the simulation that follows. The value of N_b is close to that calculated by Anten *et al*. (l995) which was 29 mmol m^{-2}.

The canopy photosynthetic capacity, V_{ca}, is the integral of V_{cmax} of the leaf over the entire canopies:

$$Vc = \int_0^{Lt} V_{cmax(l)} dL = x_n \int_0^{Lt} (N_l - N_b) dL$$
$$= x_n(N_0 - N_b)(1 - exp(-L_t k_{na}))/k_{na} \qquad (15)$$

Canopy respiration

Canopy respiration, R_c, is calculated by integration of the leaf respiration for the whole canopy:

$$R_c = \int_0^{L_t} R_d dL = V_c \frac{R_d}{V_{cmax}} \qquad (16)$$

where R_d is dark respiration at the leaf level, V_c is at the canopy level and V_{cmax} is at the leaf level. The temperature dependence of canopy respiration follows the Arrhenius function.

Canopy net photosynthesis

Canopy net assimilation rate, A_c, is then calculated separately for sunlit and shaded fractions as

$$A_c = \min\{A_j, A_v\} - R_c \qquad (17)$$

where A_j and A_v are calculated according to Eq. (1) and Eq. (2) by changing the variable of V_{cmax} to V_c, R_d to R_c and changing I to I_c in Eq. (7).

MODELLING IRRADIANCE ABSORPTION OF THE SHADED AND SUNLIT FRACTIONS OF THE CANOPY

Irradiance absorbed by the sunlit part of the canopy (I_{csun}) is the integral of the absorbed component of irradiance, i.e. direct, diffuse and scattered, by the sunlit leaf area fraction.

$$I_{csun} = I_{B(0)}(1-\sigma)(1-\exp(-K_b L_t)) +$$
$$I_{D(0)}(1-P_{cd})(1-\exp(-(K_{d'}+K_b)L_t))K_{d'} / (K_{d'}+K_b) +$$
$$I_{B(0)}\left[(1-P_{cb})(1-\exp(-(K_{b©}+K_b)L_t))K_{b©}/(K_{b©}+K_b) - (1-\sigma)(1-\exp(-2K_b L_t))/2\right] \quad (17)$$

where σ is the leaf scattering coefficient of *PAR*, $\sigma = \rho_l + \tau_l$, ρ_l is the leaf reflection coefficient for *PAR* (= 0.10) and τ_l is the leaf transmissivity to *PAR* (= 0.05).

The irradiance absorbed by the shaded part of the canopy (I_{cshade}) is

$$I_{cshade} = (1-P_{cb})I_{B(0)}(1-\exp(-K_{b©}L_t)) + (1-P_{cb})I_{D(0)}(1-\exp(-K_{d©}L_t)) - I_{csun} \qquad (18)$$

For the big leaf model irradiance absorbed by the canopy is denoted as I_c where

$$I_c = I_{csun} + I_{cshade} \qquad (19)$$

MODELLING PHOTOSYNTHETIC CAPACITY OF SUNLIT AND SHADED PARTS OF THE CANOPY

The photosynthetic capacity of the sunlit part of the canopy, V_{csun}, is calculated by integrating the leaf photosynthetic capacity, V_{cmax}, for the whole sunlit leaf area fraction.

$$V_{csun} = \int_0^{L_t} V_{c\max}(L) f_{sun}(L) dL$$
$$= \int_{L_t}^{L_t} X_n (N_l(L) - N_b) f_{sun}(L) dL \qquad (20)$$
$$= \int_0^{L_t} X_n (N_0 - N_b) \exp(-K_{na}L) \exp(-K_b L) dL$$

Note that the sunlit leaf area fraction is given by

$$f_{sun}(L_t) = \exp(-k_b L) \qquad (21)$$

The corresponding photosynthetic capacity of the shaded leaf fraction (V_{cshade}) is

$$V_{cshade} = \int_0^{L_t} V_{c\max}(L) f_{shade}(L) dL \qquad (22)$$

where

$$f_{shade}(\mathrm{L}) = 1 - f_{\mathrm{sun}}(\mathrm{L}) \qquad (23)$$

Net and gross canopy photosynthesis

Canopy photosynthesis can be calculated using Eqs. (1) and (2) for each part of the canopy, the sunlit (A_{csun}) and the shaded (A_{cshade}) fractions, and the total net canopy photosynthesis can then be written as follows:

$$A_c = A_{csun} + A_{cshade} - R_c. \qquad (24)$$

Gross photosynthesis A_{cgross} is

$$A_{cgross} = A_c + R_c \qquad (25)$$

LIGHT USE EFFICIENCY (*LUE*)

Light use efficiency, or canopy efficiency, in this simulation is defined as mol CO_2 assimilated per mol of absorbed light, i.e A_c divided by I_c. Monteith (1977) proposed an attractive approach in estimating the daily rate of carbon accumulation (dC/dt) by terrestrial plant communities, in which dC/dt was expressed as a product of intercepted solar radiation and the light use efficiency. This approach was developed based on his earlier work (Monteith 1972) where he suggested that the daily net assimilation rate of a canopy (A_c) is given by:

$$A_c = LUEI_c \qquad (26)$$

The exact equation that Monteith used was $A = efCR_s$, where in this manuscript $e = LUE$, f is the fraction of PAR absorbed by the canopy, C is a constant factor to convert total radiation to mol quanta (0.5x4.55 = 2.28 mol PAR MJ^{-1}), and R_s is the daily global radiation reaching the surface, which is the same as S used in this manuscript. For more detailed information on how to obtain S and diffuse fraction of irradiance, f, read June (2002).

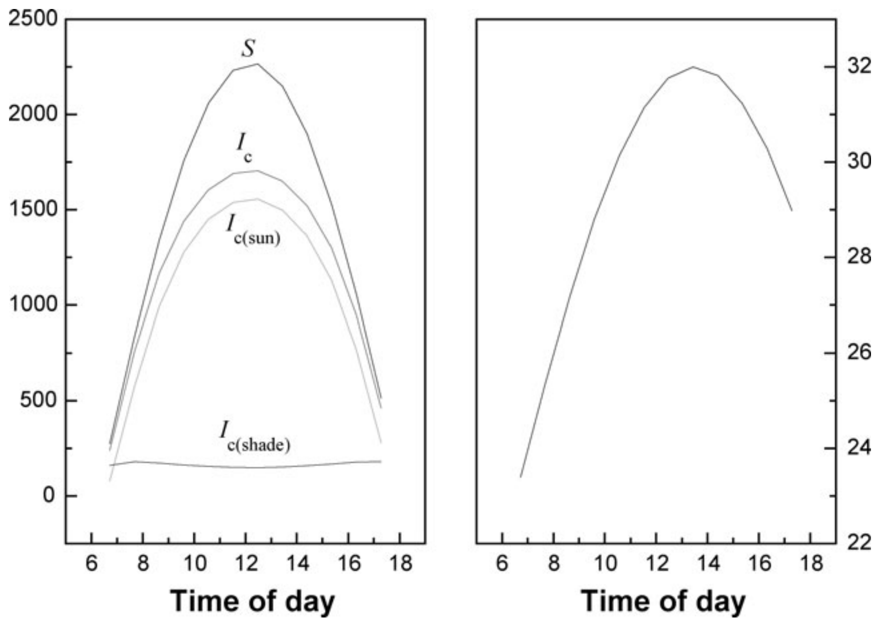

Figure 1. Generated diurnal course of PAR at the top of the canopy (S) for leaf area index of 3, absorbed by the sunlit fraction of the canopy (I_{csun}), absorbed by the shaded fraction of the canopy (I_{cshade}), and absorbed by the whole canopy ($I_c = I_{csun} + I_{cshade}$).

SIMULATION

Example simulation was run for a location in Bogor (106.75°E, 6.67°S and altitude 260 m above sea level). The choice of *DOY*s (days of year, a year 1978 was chosen) was made to get variation in the incoming radiation and fraction of diffuse light.

*Hourly PAR and temperature (*April 10, 1978*)*

A generated diurnal PAR on the top of the canopy (*S*) and the change in temperature over time are shown in Figure 1.

Canopy A_j *and* A_v

The electron transport limited and the Rubisco-limited rates of canopy photosynthesis are shown for the sunlit and shaded part of the canopy in Figure 2.
The result shows that the rates of photosynthesis for the sunlit and shaded parts of the canopy are calculated as the minimum of either the electron transport rate or the Rubisco limited rate. It is apparent from Figure 4. that the shaded part of the canopy is always electron transport limited, that is A_j(shade) < A_v(shade). The sunlit part of the canopy is Rubisco limited (A_v(sun) < A_j (sun)) most of the day, from 8 am to 4 pm. A_v(sun) > A_j (sun) only when absorbed light is very low, i.e early in the morning or later in the afternoon.

Canopy net assimilation rate and efficiency

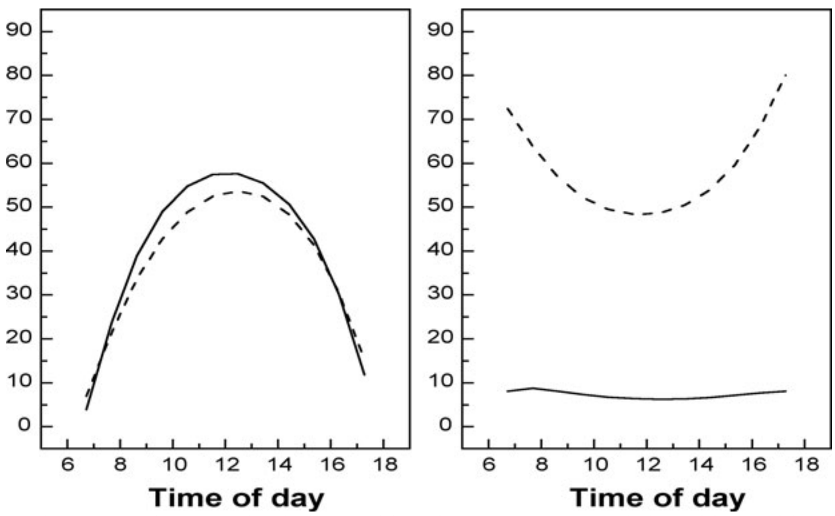

Figure 2. Photosynthesis limited by electron transport (A_j) and by Rubisco (A_v) of the sun and shade parts of a canopy with leaf area index of 3. A_v is indicated by dashed lines and A_j by solid lines (Left: SUN and right: SHADE).

Total canopy net assimilation rate, is the sum of the sunlit and the shaded parts of the canopy (where each of these parts is the minimum of their A_v and A_j), minus canopy respiration. Canopy respiration (R_c) is 9.5 µmol m^{-2} s^{-1} in the middle of the day, which is about 16 % of the gross photosynthetic rate.

Light use efficiency (LUE) of the canopy, which shows how efficiently the canopy converts PAR into carbon, changes during the time course of the day. It is very low at sunrise and sunset, reaching a maximum at about 8 am up to 4 pm and is fairly stable during this period at 0.030 mol CO_2 mol^{-1} quanta.. The value drops slightly in the middle of the day due to increasing light saturation of the canopy as shown by a larger increase in the absorbed light than the increase in A_c.

Table 1 shows the integrated A_c, R_c, I_c and the photosynthetic components values for the whole day and resulted LUE. Results are expressed based on daily integration. It is shown that the shaded part of the canopy operate in a more efficient way than the sunlit part of the canopy resulted in 33 % increase in its LUE value. There is no difference in efficiency between LAI = 1 and LAI = 4, although net canopy assimilation rate increased by 61 %.

THE EFFECT OF PROPORTION OF DIFFUSE LIGHT ON CANOPY ASSIMILATION RATE AND EFFICIENCY

Some of the solar radiation entering the earth's atmosphere is absorbed and scattered. Direct beam radiation comes in a direct line from the sun. Diffuse radiation is scattered out of the direct beam by molecules, aerosols, and clouds. The sum of the direct beam, diffuse (and in some cases ground-reflected) radiation arriving at the canopy surface (or single leaf) is called total or global solar radiation. The ratio between the diffuse and global radiation is defined as the diffuse fraction of radiation. When it is expressed based on PAR part of the spectrum, it is called diffuse fraction of irradiance.

Six *DOYs* with different fraction of diffuse irradiance were chosen for the following simulation. Those are: (1) *DOY* 2 with t_a = 0.406, f_D = 0.71, daily global radiation of 15.6 MJ m^{-2}; (2) *DOY* 63 with t_a = 0.493, f_D = 0.57, daily global radiation of 19.0 MJ m^{-2}; (3) *DOY* 273 with t_a = 0.575, f_D = 0.43, daily global radiation of 21.6 MJ m^{-2} and (4) *DOY* 240 with t_a = 0.658, f_D = 0.29, daily global radiation of 23.0 MJ m^{-2} and (5) *DOY* 96 with t_a = 0.744, f_D = 0.13 and daily global radiation of 27.2 MJ m^{-2}. Simulation was run at different leaf area index, LAI (increasing from 0.5 to 6) using Bernacchi *et al*. (2001) photosynthetic parameters.

Figure 3 shows that as f_D increases, canopy net assimilation rate increases, until f_D reaches 0.57, after which further increase of f_D reduces the net rate. Thus, there is an optimum f_D of about 0.57. The optimum LAI (*i.e.* the LAI with maximum net canopy assimilation rate) increases with increasing f_D and at optimum LAI is around 4 at f_D=0.57.

Table 1. Simulation results for April 10 (DOY100), f_D = 0.13, t_a = 0.75, LAI = 1 and 4.

LAI	1.0	4.0
S (mol m^{-2} day^{-1})	64.5	64.5
I_B (mol m^{-2} day^{-1})	56.2	56.2
I_D (mol m^{-2} day^{-1})	8.3	8.3
Ic (mol m^{-2} day^{-1})	29.9	56.6
Ic_{sun} (mol m^{-2} day^{-1})	28.3	50.1
Ic_{shade} (mol m^{-2} day^{-1})	1.6	6.5
A_{vsun} (mol m^{-2} day^{-1})	0.76	1.44
A_{vshade} (mol m^{-2} day^{-1})	0.40	3.18
A_{jsun} (mol m^{-2} day^{-1})	0.94	1.70
A_{jshade} (mol m^{-2} day^{-1})	0.07	0.26
A_{cshade} (mol m^{-2} day^{-1}) (Gross)	0.07	0.26
A_{csun} (mol m^{-2} day^{-1}) (Gross)	0.76	1.44
R_c (mol m^{-2} day^{-1})	0.15	0.62
A_c (mol m^{-2} day^{-1}) (Net)	0.67	1.08
A_c (mol m^{-2} day^{-1}) (Gross)	0.82	1.70
LUE based on gross A_c		
Sunlit canopy	0.027	0.029
Shaded canopy	0.043	0.040
Total	0.027	0.030
LUE based on net A_c	0.022	0.019

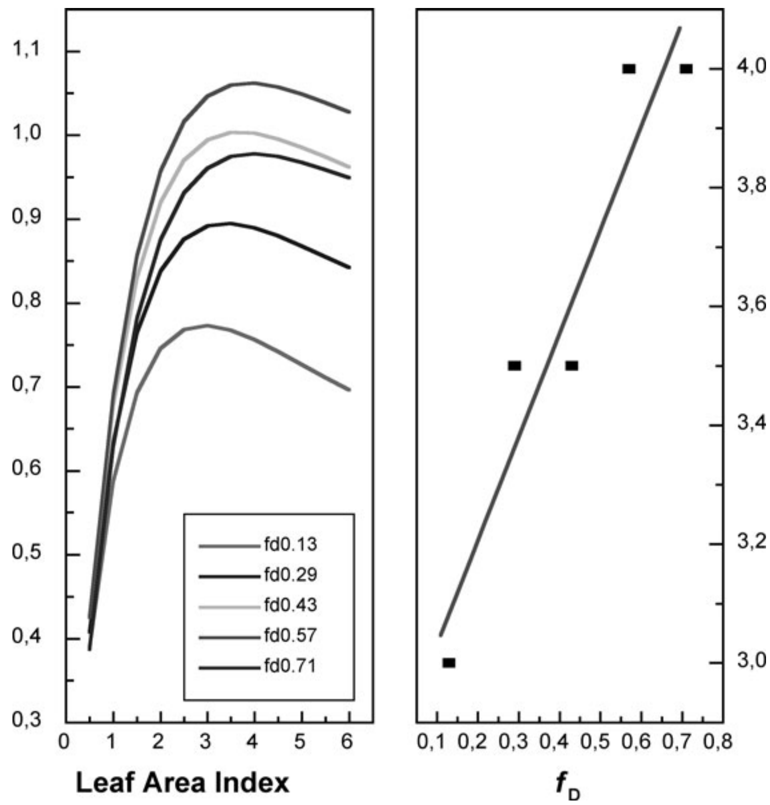

Figure 3. (Left) Integrated canopy net assimilation rate at different LAI and fraction of diffuse irradiance. (Right) Relation between f_D and optimum LAI.

COMPARISON BETWEEN THE SUN-SHADE AND THE BIG LEAF MODEL AT DIFFERENT DIFFUSE PROPORTION OF IRRADIANCE.

The following simulation shows that the overestimation of the big leaf is important under a very bright radiation (Table 2) with differences diminishing with increasing diffuse fraction, *i.e*. the difference between the two models is only 2 % under f_D = 0.71 and increases to 34 % under f_D = 0.14. The difference is influenced by LAI. In tropical region, where diffuse fraction of irradiance is very high, the difference between using the big leaf and the sun-shade is small.

Table 2. Difference in integrated net canopy assimilation rate at fraction of diffuse light f_D = 0.71 and 0.14, using sun-shade and big-leaf models.

LAI	difference (%)	
	f_D = 0.71	f_D = 0.14
0.5	0.56	9.77
1.0	1.68	17.30
1.5	2.27	25.15
2.0	2.51	30.50
2.5	2.72	31.99
3.0	2.70	32.19
3.5	2.63	32.27
4.0	2.48	32.47
4.5	2.37	32.76
5.0	2.26	33.12
5.5	2.01	33.72
6.0	2.04	34.41

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Quantity and Mineral Nutrient Content of Throughfall in Two Types of Peat Swamp Forest in Central Kalimantan, Indonesia

Sulistiyanto, Y[1,2]., Rieley, J.O.[2], Page, S.E.[3] and Limin, S.H[1]

[1)]Centre for International Co-operation in Management of Tropical Peatland, University of Palangka Raya, Palangka Raya, Indonesia (sulistiyanto@palangkaraya.wasantara.net.id)
Telp Number:+62-536-26488

[2)]School of Geography, the University of Nottingham, UK

[3)]Department of Geography, The University of Leicester, UK.

ABSTRACT

Throughfall underneath, and gross precipitation falling upon, peat swamp forest in the upper catchment of the Sebangau River in Central Kalimantan, Indonesia were sampled every two weeks from November 2000 to November 2001 and analyzed for total content of Ca, Mg, K, Na, Fe, Mn, and P. Throughfall was collected in three permanent study plots, 50 x 50 m, which were established in mixed swamp forest (MSF) and low pole forest (LPF). In each plot, throughfall collection vessels were located in a manner (fixed and roving) that enabled statistical analysis to be carried out on the data obtained. Rainfall was collected from above the tree canopy in four rain gauges situated in riverine forest (1), mixed swamp forest (2) and low pole forest (1). Rainfall is slightly acid (pH between 5.02 and 6.92 with average 5.92) with a predominance of Ca and K. Throughfall is enriched in most elements analysed compared to rainfall and its pH values are lower. Throughfall pH ranges from 3.25 to 6.13 (average 4.76) in mixed swamp forest and from pH 2.90 to 6.12 (average 4.37) in low pole forest. Throughfall in LPF was higher than throughfall in MSF at 2136.0 mm (70.1 %) and 1969.4 mm (76.03 %), respectively.

Key words: peat swamp forest, rainfall, throughfall, chemical analysis

INTRODUCTION

Many workers have reported that atmospheric input is the major source of nutrients for forest ecosystems, followed by rock weathering (mineral soil) or organic matter mineralization (peat soil), nitrogen fixation and faunal migration) (Barnes, *et al.*, 1998). The first can be in the form of dust, particles or aerosols and gases from a number of sources, such as, smoke from shifting cultivation (Whitmore, 1989), dust raised by vehicles from roads and dust from agriculture activities, for example, from ploughing and fertiliser application (Ahmad-Shah, 1984).

According to Stinner *et al*. (1984) nutrients in precipitation play an important role in maintaining fertility of certain agricultural soils,especially in the area where soil nutrient availabilityis poor, such as, ombrogenous peatland (Van Breemen, 1995). Similarly, Moore and Bellamy (1973) contend that the continued growth of ombrotrophic bogs is possible only because of nutrient inputs from the atmosphere, coupled with the various adaptive mechanisms of bog plants.

Some of the rainfall reaching a forest is retained by the canopy and this water is re-evaporated back to the atmosphere. The portion of the incident rainfall that reaches the forest floor is referred to as throughfall (Ahmad-Shah, 1984) the amount of which varies with the quantity of rainfall (Edwards, 1982). Aerosols and dust deposited on foliar surfaces through rainfall are eventually carried downwards through the canopy in throughfall, although some may be adsorbed and absorbed by plants or taken up by microorganisms on the surface of leaves and branches (Carlisle *et al*., 1967). Reiners (1972) states that nutrients may also be exuded by plants and leached from foliar surfaces by precipitation enriching further the chemical content of throughfall reaching the forest floor. Consequently, throughfall is an important component of nutrient cycling in forest ecosystems.

METHODS

The study area is in the upper catchment of Sungai Sebangau in Central Kalimantan, Indonesia. Three permanent study plots, 50 x 50 m, were established in two peat swamp forest sub-types, Mixed Swamp Forest (MSF) and Low Pole Forest LPF). In each plot, a combination of one fixed and two roving water sampling gauges (constructed from wood and 25 liter capacity polyethylene containers fitted with 25 cm diameter plastic funnels) were employed for the collection of throughfall. Rainfall was collected in four fixed position rain gauges, of similar construction to the throughfall collectors, situated within the research area, in riverine forest (1 gauge), mixed swamp forest (2 gauges) and low pole forest (1 gauge). Water samples were collected every two weeks from the beginning of November 2000 to beginning of November 2001. Samples were stored in a refrigerator (4 ^{o}C) on the same day, immediately on return to the laboratory. On the following day, pH was determined on the water samples and then they were filtered through glass funnel which was put

Whatman paper and then Ca, Mg, K, Na, Fe and Mn were determined by atomic absorption spectrophotometry (AAS spectra 30).

Nitrite was done by Tachibana method (2000). Take a 25 ml sample, which have been filtered, in Erlenmeyer, add 0.1g of mix powder (made of Sulfanilic acid 1g + Naftil amin 0.1 g + Tartaric acid 8.9 g), mix thoroughly . After 20 minutes measure absorbance at 520 nm but not more than 40 minutes. The standard series is treated in the same way.

Phosphorus was done by Tachibana method (2000). Take A 25 ml sample, which have been filtered, fill in Erlenmeyer, add 4 ml $K_2S_2O_8$ 5 w/ % (by diluting 50 g $K_2S_2O_8$ in distilled water make up to 1 l warm up till 30 - 40 ^oC), close Erlenmeyer by aluminium foil and boiled in autoclave for 30 minutes. After cold, take 20 ml and add 4 ml combination solution (made by mix 50 ml 50 N H_2SO_4 + 5 ml potassium antimonil tartarat solution + 15 Ammonium molybdate solution + 30 Ascorbic acid solution), make up to 25 ml. Colour development is complete after 10 minutes. Measurement absorbance at 882 nm wavelength. The standard series is treated in the same way.

Ammonium-nitrogen was done by indophenol method (Scheiner, 1976). Take 25 ml of the sample which have been filtered in a 50 ml volumetric flask, add 10 ml phenol nitroprusside -buffer reagent (made by $Na_3PO_3.12\ H_2O$ 30 g + $Na_3C_6H_5O_7.2H_2O$ 30g + EDTA 3 g in 1 l distilled water); phenol 60 g in 800 buffer reagent + 0.2 g $Na_2\ Fe\ (CN)_5\ NO.2H_2O$ make up to 1 l by buffer reagent), using burette. Mix by swirling. Promptly add hypochlorite reagent (30 ml NaClO + 400 ml 1 M NaOH filling up by distilled water up to 1 l), make up to 50 ml. Colour development is complete after 45 minutes at room temperature. Measure absorbance at 635 nm. The standard series is treated in the same way.

RESULTS

The Quantity and pH of Rainfall and Throughfall

During the period 10 November 2000 - 10 November 2001 the total amount of rainfall falling in the upper Sg. Sebangau, determined from the rain gauges, was 2809.4 mm while throughfall in MSF and LPF was 1964.4 mm and 2136.0 mm, respectively. The seasonal pattern of the amounts of rainfall and throughfall in four (4) weekly periods thoughout the study period are shown in Figure 1 and variation in pH during the same periods can be seen in Figure 2.

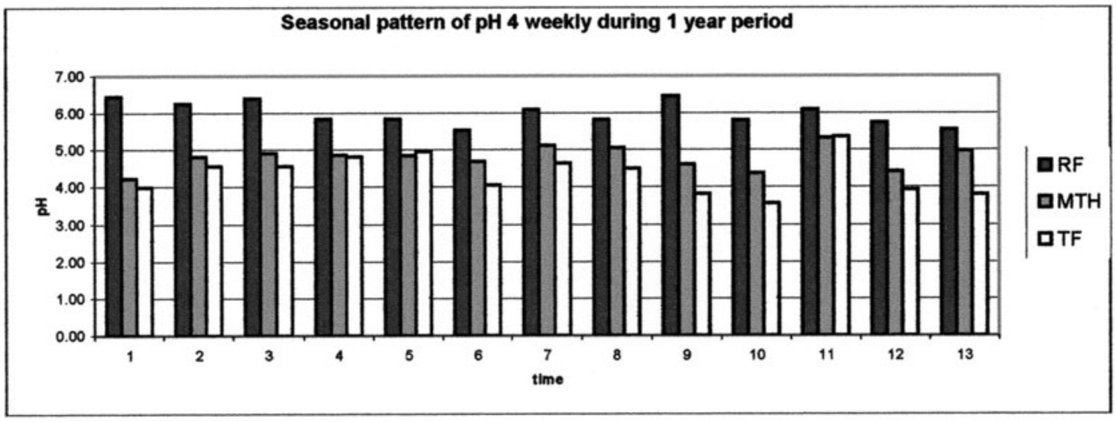

Figure 1. Seasonal pattern of Rainfall (RF), Throughfall in MSF (MTH) and LPF (TF) four (4) weekly during 1 year period.

Figure 1 shows that there is variation in the amount of precipitation falling on the peat swamp forest during the study period. The mean 4 weekly amounts ranged from 24.38 mm to 424.07 mm and the mean over the 1 year period was

No	Time period	No	Time period	No	Time period
1	10 Nov – 8 Dec 00	**6**	1 – 28 April 01	**11**	19 August – 15 Sept 01
2	9 Dec – 5 Jan 01	**7**	29 April – 26 May 01	**12**	16 Sept – 13 Oct 01
3	6 Jan – 3 Feb 01	**8**	27 May – 23 June 01	**13**	14 Oct – 10 Nov 01
4	4 Feb – 7 March 01	**9**	24 June – 21 July 01		
5	8 – 31 March 01	**10**	22 July – 18 August 01		

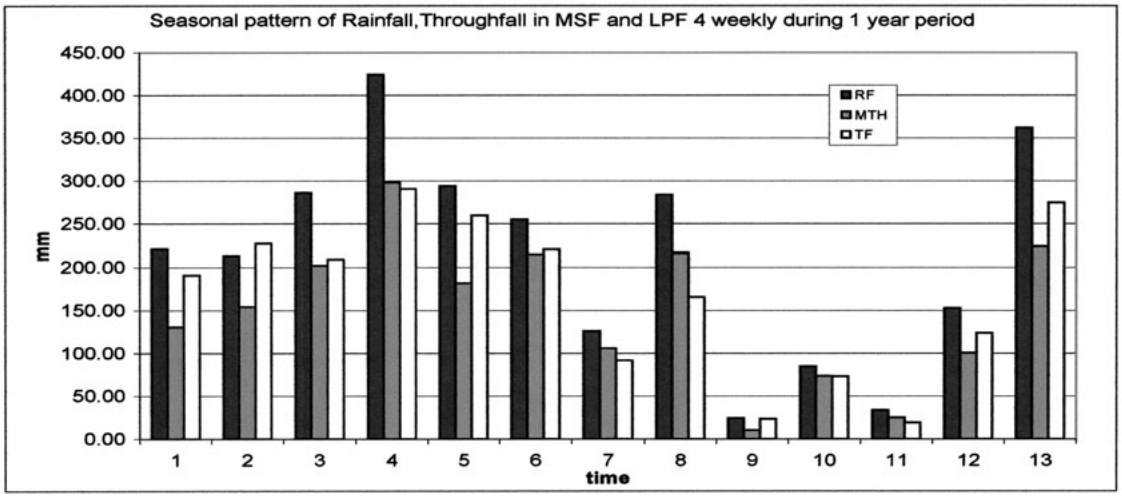

Figure 2. Seasonal pattern of pH value four (4) weekly during 1 year period

212.36 mm with the highest value obtained between 4 February and 7 March 2001) (424.07 mm), followed by 14 October to 10 November 2001 (362.10 mm) both of which occur during the rainy season. In contrast, the lowest amount of water was collected between 24 June and 21 July 2001 (24.38 mm). The highest values for throughfall are almost the same in both MSF and LPF at 298.34 mm and 290.70 mm, respectively. In general, throughfall as a proportion of rainfall is higher in Low Pole Forest (76.0%) than in Mixed Swamp Forest (70.1%) There is a positive correlation between rainfall and throughfall with the latter always less than the former. Correlation between rainfall and throughfall in MSF; rainfall and throughfall in LPF, and throughfall in MSF and throughfall in LPF are 0.97, 0.95, and 0.91 respectively.

The pH of precipitation and throughfall in MSF and LPF varied throughout the study period (Figure 2) with rainfall generally higher than throughfall in both sub-types but with throughfall pH in MSF higher than in LPF. Rainfall pH is slightly acid, ranging from 5.02 to 6.92 (mean 5.92) while throughfall pH ranges from 3.25 to 6.13 (mean 4.76) in mixed swamp forest and from pH 2.90 to 6.12 (mean 4.37) in low pole forest.

Mineral Nutrient Content of Rainfall and Throughfall

Table 1 shows that ammonium-N is the predominant cation in bulk precipitation, followed by calcium, potassium, magnesium, sodium, iron, and manganese which is present in lowest amount. Of the anions, phosphate is highest (4.624 kg ha^{-1}) followed by nitrite (0.54 kg ha^{-1}). In throughfall in Mixed Swamp Forest potassium is the major cation (24.13 kg ha^{-1}), followed by calcium, ammonium, magnesium, sodium, iron and manganese; anions follow the same pattern as rainfall. In contrast, Low Pole Forest throughfall the calcium is the cation present in greatest quantity (22.341 kg ha^{-1}), followed by potassium, ammonium, magnesium, sodium, iron, and manganese; anions follow the same pattern as Mixed Swamp Forest.

Throughfall was enriched in most of these ions during the1 year period (Table 2):

The largest enrichment of nutrients in MSF and LPF throughfall was K with +14.52 and + 11.718 kg ha^{-1}, respectively. The PO_4 nutrient enrichment is the smallest in both type of forest with 0.021 kg ha^{-1} in MSF and 0.413 kg ha^{-1} in LPF. Manganese resulted in decreases of 0.023 kg ha^{-1} in MSF and 0.033 kg ha^{-1} in LPF. Nutrient were enriched in MSF throughfall in the order of K> Mg> Ca> NO_2-N> Fe> Na> PO_4-P. In comparison, nutrient enhancement in LPF throughfall was K> Ca> Mg> Na> NO_2-N> Fe> PO_4-P.

The quantity of (NH_4-N) and Mn in throughfall was lower than in rainfall.

Table 1: Mineral nutrient content of rainfall (RF) and throughfall in MSF (MTH) and PF (TF) during the one year study period in (kg ha^{-1}).

Code	Ca kg ha^{-1}	Mg kg ha^{-1}	K kg ha^{-1}	Na kg ha^{-1}	Fe kg ha^{-1}	Mn Kg ha^{-1}	NO_2-N kg ha^{-1}	PO4 kg ha^{-1}	NH_4-N kg ha^{-1}
RF	15.720	5.788	9.610	5.5204	3.250	0.223	0.540	4.624	16.508
MTH	19.177	9.539	24.130	5.6643	3.945	0.200	3.353	4.645	15.122
TF	22.341	11.606	21.328	7.7478	4.412	0.190	2.198	5.037	13.240

Table 2: Nutrient input in precipitation and throughfall in MSF and LPF reaching the peat surface in Sebangau catchment area, Kalimantan.

Nutrient	Rainfall ($kg.ha^{-1}$)	Throughfall in MSF ($kg.ha^{-1}$)	Throughfall in LPF ($kg.ha^{-1}$)	Enrichment in MSF throughfall ($kg.ha^{-1}$)	Enrichment in LPF throughfall ($kg.ha^{-1}$)	Enrichment factors MSF	Enrichment factors LPF
Ca	15.720	19.177	22.341	3.457	6.621	1.22	1.42
Mg	5.788	9.539	11.606	3.751	5.818	1.65	2.00
K	9.610	24.130	21.328	14.52	11.718	2.51	2.22
Na	5.5204	5.6643	7.7478	0.1439	2.2274	1.03	1.40
Fe	3.250	3.945	4.412	0.695	1.162	1.21	1.36
Mn	0.223	0.200	0.190	-0.023	-0.033	0.89	0.85
NO_2-N	0.540	3.353	2.198	2.813	1.658	6.21	4.07
PO_4-P	4.624	4.645	5.037	0.021	0.413	1.01	1.09
NH_4-N	16.508	15.122	13.240	-1.386	-3.268	0.92	0.80

DISCUSSION

The Quantity and pH of Rainfall and Throughfall

Comparison rainfall data from air port area (Cilik Riwut airport, Palangka Raya, about 15 km from the study site) during study period were slightly different (2809.4 and 2835.4 mm respectively).

This study shows that throughfall quantity in Low Pole Forest is higher than in Mixed Swamp Forest (see figure 1) with a mean of 2135.97 mm (76.0% or incident rainfall) and 1968.42 mm (70.1% of rainfall), respectively, and that there are temporal variations throughout the year in both forest sub-types. Ahmad-Shah (1984); Ahmad-Shah and Rieley (1989) reported similar temporal rainwater (precipitation) and throughfall variations in a study of nutrient fluxes in a forested mire at Chartley Moss, England where throughfall ranged from 68% to 80% of precipitation. Henderson *et al*., (1977) obtained a variation from 83% to 89 % in four type of forest -*Pinus, Liriodendron tulifera, Quercus prinus, Quercus-Carya* , in Tennessee, USA, while Ahmad-Shah *et al*., (1991) reported a range between 55.6 % and 82.7 % in peat swamp forest in Selangor, Malaysia. Moreover, Ahmad-Shah and Rieley (1989) suggest that variations in the amount of throughfall reaching the forest floor may result from differences in intensity and duration of precipitation, differences in the architecture of tree canopies, tree age and size, density, type of bark and foliage.

The pH of rainwater in the Sg. Sebangau catchment is slightly acidic (mean 5.92$\pm$0.32) but that the acidity of throughfall is always higher in both MSF and LPF although the latter is more acid than the former (LPF mean: pH 4.37±0.32; MSF mean: pH 4.76±0.53). In comparison to other worker, the acidity of precipitation at Chartley Moss, England was more acidic than that in Central Kalimantan (mean pH 4.23) and this led to and even higher acidity in throughfall (mean pH 3.53) (Ahmad-Shah, 1984; Ahmad-Shah & Rieley, 1989). Similarly, Martin (1979) found that precipitation at the Bowl, New Hampshire, USA, hardwood forest with spruce and fir, was also very acidic, ranging from pH 3.3. to 5.2 with a mean of 4.0 and Likens & Bormann (1999) reported a pH range for rainfall in the Hubbard Brook Experimental forest during 1965 -1974 of 4.0 to 4.4. The acidity in precipitation is generally due to the presence of SO_4^{2-}, NO_3^- and organic acid and neutralized by Ca^+ and NH_4^+ (Kaya and Tuncel, 1997).

Moreover, Kaya and Tuncel (1997) suggest that variations in the pH value may result from differences in location of research, for example, near or far industrial area, which produce emissions of acid precursor gases, particularly SO_2. Furthermore, (Al Momani *et al*., 1995) state that in agricultural areas, neutralization of acidity in precipitation is could be happened due to atmospheric NH_3 in agricultural areas where NH_4NO_3 and $(NH_4)_2 SO_4$ containing fertilizer intensively used.

Mineral Nutrient Content of Rainfall and Throughfall

Comparison to other study in several places in tropical forest indicated that the amount of atmospheric input reaching the forest floor throughout the study period (Table 3) indicated is near to the highest of the range for calcium while sodium and magnesium are near to below of the range.

It is well known that when water passes over vegetation it is enriched with macronutrients [Carlisle *et al*., 1966). Various reason have been suggested to explain the changes, which occur in the chemical composition of precipitation as it passes through a vegetation canopy. For example, the higher nutrient contents in throughfall compared to rainfall result from the elution of air-borne particles such as aerosols, dust and pollen grains pollens impacted onto the forest canopy as water

Table 3 : Annual fluxes of nutrients in bulk precipitation (R) and throughfall (T) in several places in tropical forests.

No	Location	Rain (mm)	Ca (kg ha^{-1})	Mg (kg ha^{-1})	K (kg ha^{-1})	Na (kg ha^{-1})	NH_4-N (kg ha^{-1})	PO_4-P (kg ha^{-1})	Reference
1	This study (R)	2809.4	15.72	5.79	9.61	5.52	16.51	4.624	This study
	In MSF (T)	1969.4	19.18	9.54	24.13	5.66	15.12	4.645	This study
	In LPF (T)	2135.9	22.34	11.61	21.33	7.75	13.24	5.037	This study
2	Selangor (R)	2665	20.15	5.12	26.36	31.42	18.12	-	Ahmad-Shah et al. 1991
	Malaysia (T)	1986	46.74	13.41	50.87	48.50	17.19	-	
3	New Guinea (R)	3800	3.6	1.3	7.3	-	-	0.5	Grubb&Edwards. (1982)
	(T)	2585	22.6	12.2	78.4	-	-	3.0	
4	Puerto Rico (.R)	3750	21.8	4.9	18.2	57.2	-	-	Veneklaas (1990)
	(T)	2775	34.8	9.2	155.0	83.2	-	-	
5	Colombia (.R)	2115	10.1	3.2	7.9	24.1	18.28	0.72	Veneklaas (1990)
	(T)	1854	27.1	10.7	95.2	26.9	21.45	1.67	
6	Boundary Range	2089	21.3	1.9	2.7	5.4	-	-	Crowther (1987)
	Malaysia (T)		65.0	22.3	92.1	4.5	-	-	

passes through and these are then transferred to the forest floor. It has been suggested that high pollen levels in the atmosphere and pollen *in situ* on trees can be washed down in the throughfall leading to increased concentration of K (Carlisle *et al.*, 1966). This is confirmed in the Sg. Sebangau study area where reproductive parts, including pollen, in litterfall have the highest concentration of K compared to other components, such as, leaves and branches Sulistiyanto *et al.*, (2002). Other authors confirm that enhanced K, Ca and Mg in throughfall and stemflow derives from foliage leaching (Reiner, 1972; Eaton *et al.,* 1973; Puckett, 1991). The quantity of nitrite (NO_2-N) in throughfall was higher than in precipitation and may be due to the enrichment of nitrite within canopy. There is some evidence that trunks and leaves of tree and shrubs are often covered with lichens, algae and bryophytes that give rise to microtopographic epiphytic ësoilí in the canopy that might contain nitrogen-fixing organisms (Edwards, 1982). Increasing concentrations of elements in throughfall could also be as result of dead twigs, branches and bark (Ahmad-Shah *et al.*, 1991). Furthermore, trash fall, such as, bird dropping, and the unclassified part of litterfall collected in rain gauges may also contribute to the increased level of nutrients in throughfall.

The quantity of (NH_4-N) in throughfall was lower than in rainfall. Ahmad-Shah *et al.*, (1991) obtained same result that was from 34.85 mg m^{-2} week $^{-1}$ (rainfall) become 33.06 mg m^{-2} week $^{-1}$(throughfall). Puckett (1991) state that ammonium is strongly retained by canopy. Moreover, Marcos & Lancho (2002) proposed that under nutrient-limited (oligotrophic) conditions, trees maybe able to minimize canopy leaching, and even take up nutrients precipitation, such as, nitrogen, as a conservative mechanism to conserve nutrients.

CONCLUSION

In general, in the upper Sg. Sebangau catchment, Central Kalimantan the concentration of most nutrients in throughfall is higher than in rainfall. Further study of the role of tree canopies, especially associated plant species of branches, leaves and stems (e.g. bryophytes, lichens and other epiphytes and climbers) in nutrient retention and release in peat swamp forest would do much to clarify our understanding of nutrient inputs to the forest floor and their potential availability for nutrient cycling back to the trees.

ACKNOWLEDGEMENTS

This research was part of the European Union INCO_DC Project: Natural resource functions, biodiversity and sustainable management of tropical peatlands (contract no. ERB181C980260). The authors wish to thank Adi, Resae, Sampang, Ary, Alim and Edy for their co-operation during field work and laboratory analysis

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Microclimate of a Tropical Peat Swamp Forest in Central Kalimantan, Indonesia from 2001 to 2002

Takashi Hirano[a], Mitsuru Osaki[a], Hendrik Segah[c], Tania June[b], Suwido H. Limin[c], Ich Kulu[c], Hiroshi Tani[a], Ryuichi Hirata[a], Junichi Mogami[a] and Minoru Gamo[d]
[a] Graduate School of Agriculture, Hokkaido University, Sapporo, Japan
[b] Bogor Agricultural University, Bogor, Indonesia
[c] Faculty of Agriculture, University of Palangkaraya, Palangkaraya, Indonesia
[d] National Institute of Advanced Industrial Science and Technology, Tsukuba, Japan

ABSTRACT

Micrometeorology of a tropical peat swamp forest in a devastated peatland in Central Kalimantan has been measured continuously from July 2001 to November 2002. The existence of the rainy season in southern-hemisphere summer and the dry season in winter was confirmed. The annual sum of precipitation for the first year was 1782 mm. Northern and southern winds prevailed in the rainy and dry seasons, respectively. Although wind was weak throughout a year, wind velocity was higher in the dry season. Air temperature was almost constant with the annual mean of 26.5˚C. However, it decreased below 20 ˚C around dawn by radiative cooling in the dry season of 2002. VPD was low in the rainy season and high in the dry season. Daytime mean VPD was almost 5-15 hPa in the rainy season and 10-20 hPa in the dry season. Large-scale peatland fires occurred around the forest in the dry season of 2002 because of a drought caused by the El Niño event. A large amount of smoke emitted from the fires severely shaded solar radiation between mid-August and late October 2002. In the dry season, albedo and PPFD reflectance increased and NDVI decreased owing to the change in the spectral reflectance of the forest. This NDVI phenology was probably caused by water stress.

INTRODUCTION

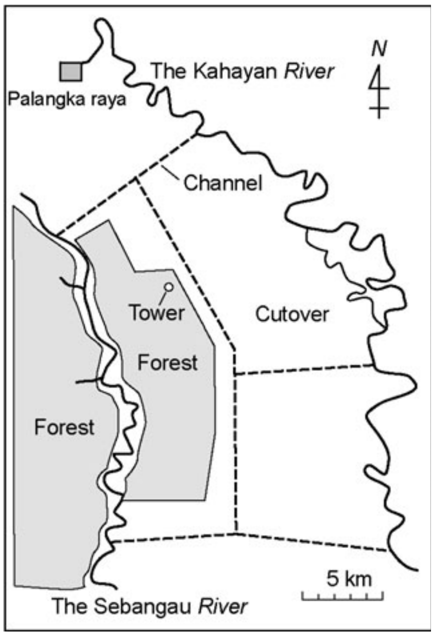
Tropical peatlands exist under the condition of permanent waterlogging and acidification in the tropics. Indonesia contains the largest area of tropical petlands, and Kalimantan has the area of 6.7 Mha in lowlands (Page *et al*., 1999). The peatlands usually coexist a tropical peat swamp forest and have accumulated a large amount of carbon as organic matter for over thousands of years. Recently, however, deforestation in the peatlands is advancing rapidly owing to a growing demand for timber and farmlands. In addition, droughts caused by the El Niño event devastated the peatlands by the promotion of peatland fires (Page *et al*., 2002). In Central Kalimantan a large area of peatlands was deforested to develop farmlands as a national project, the Mega Rice Project, in late 1990's, and channels excavated for drainage dried the peat. The big project, however, was revoked in 1999 mainly by the economic crisis (Riely and Muhamad, 2002). As a result, vast devastated peatlands were left. The devastation of peatlands by deforestation and drainage promotes decomposition of the peat through the disturbance of micrometeorology and water condition. The promoted decomposition increases the release of carbon fixed in the tropical peat to the atmosphere as CO_2, which is the most important green house gas. This suggests that tropical peatlands will be a major CO_2 source for the atmosphere in the near future.

Micrometeorology of a devastated peatland and CO_2 exchange between the peatland ecosystem and the atmosphere have been measured continuously since July and November 2001, respectively, in Central Kalimantan in order to investigate the effect of deforestation, drainage and fires on the CO_2 and energy balances of tropical peatlands. In this study, as the first step we report the microclimate of a tropical peat swamp forest from July 2001 to November 2002. Details of the CO_2 and energy balances are in preparation.

MATERIALS AND METHODS

2.1. Site description

The study site is a tropical peat swamp forest remaining in Area B of the Mega Rice Project near Palangkaraya, Central Kalimantan, Indonesia. The forest is located between the Sebangau *River* and a channel running from north to south (Fig. 1); water table in the forest was zonally reduced near the channel. A tower of 50 m height was constructed about 300 m inside from the northeast corner of the forest (2˚20' 41.6" S, 114˚ 2' 11.3" E) to measure micrometeorology and CO_2 and energy fluxes. Dominant tree species of the forest are *Combretocarpus rotundatus*, *Cratoxylum arborescens*, *Buchanania sessifolia* and *Tetrameristra glabra* (Tuah *et al*., 2000) and rich shrubs grow in the trunk space. The height of the forest canopy is about 26 m, and plant area index (PAI) measured at 1.5 m height with a plant canopy analyzer



Figrue 1. Schematic map of the study site.

(LAI2000, Licor, USA) was 4.5 m^2 m^{-2} in late June 2002.

2.2. Measurements of micrometeorological

The continuous measurement of micrometeorology was started at the middle of July 2001 on the tower. Four components of radiation including downward and upward short- and long-wave radiation were measured at 40.6 m height with a radiometer (CNR-1, Kipp&Zonen, The Netherlands); net radiation (R_n) and albedo were calculated from these components. Downward and upward photosynthetic photon flux densities (PPFD) were measured at 40.6 m with quantum sensors (LI-190S, Licor, USA). Wind velocity and direction were measured at 41.7 m with a cup anemometer and wind vane (03001-5, R.M. Young, USA). Precipitation was measured at 41.0 m with a tipping-bucket rain gauge (TE525, CSI, USA). Air temperature and relative humidity were measured at 41.7 and 2 m with platinum resistance thermometers and capacitive hygrometers (HMP45, Vaisala, Finland); the probe is installed in a non-ventilated radiation shield. Moreover, soil temperature was measured at 5 cm depth with a thermocouple thermometer. Soil moisture was measured between 0 and 20 cm in depth with a TDR sensor (CS615, CSI, USA). Although TDR outputs should be calibrated by the oven drying method for organic soils, the calibration is not yet made. Signals from the sensors were measured every 30 seconds, and 30-min means were recorded using a datalogger (CR10X, CSI, USA). The maintenance of the system and the collection of the data stored in the datalogger were made once or twice a month. Since a commercial electric power is unavailable, the measurement system works with DC power supplied by a solar panel and battery.

2.3. Calculation of NDVI

The normalized difference vegetation index (NDVI) was calculated from the following equation (Huemmrich *et al.*, 1999) using the data measured between 1000 and 1400 in local time when downward short-wave radiation (solar radiation, S_r) was larger than 600 W m^{-2},

$$\mathrm{NDVI} = (r_{OIR} - r_{PAR}) / (r_{OIR} + r_{PAR}) \quad (1)$$

$$r_{PAR} = E_{PARref} / E_{PAR} \quad (2)$$

$$r_{OIR} = (S_{r\text{-}ref} - E_{PARref}) / (S_r - E_{PAR}) \quad (3)$$

$$E_{PAR} = 0.25 \times \mathrm{PPFD},\ E_{PARref} = 0.25 \times \mathrm{PPFD}_{ref} \quad (4)$$

where r_{OIR} is an optical infrared reflectance, r_{PAR} PAR reflectance, E_{PAR} downward PAR, E_{PARref} upward (reflected) PAR, $S_{r\text{-}ref}$ upward (reflected) short-wave radiation, PPFD_{ref} upward (reflected) PPFD. Units of PAR and PPFD are W m^{-2} and mmol m^{-2} s^{-1}, respectively.

RESULTS AND DISCUSSIONS

3.1. Microclimate from 2001 to 2002

Variations in microclimate from late July 2001 to mid-November are shown in Fig. 2, and the monthly values are shown in Table 1. The distribution of wind direction is shown in Fig. 3 for southern-hemisphere summer (February 2002), winter (July 2002) and the first year between August 2001 and July 2002.

In Kalimantan, the rainy season is in summer and the dry season is in winter (Hamada *et al.*, 2002). Semiannual precipitation (P) from October 2001 to March 2002 was 1332 mm, which was 75 % of the annual sum (1782 mm) for the first year (Table 1). Wind direction (WD) also changed seasonally in accordance with the Asian monsson, from the north in summer to the south in winter (Fig. 3). The relative frequency of southern wind (SE-SW) and northern wind (NW-NE)

Table 1. Monthly values of microclimate.

Month	Sr [a)] (MJ m^{-2} d^{-1})	Rn [b)]	PPFD [c)] (mol m^{-2} d^{-1})	Tmean [d)] (C)	Tmax [e)]	Tmin [f)]	VPDmax [g)] (hPa)	VPDmean [h)]	V [i)] (m s^{-1})	P [j)] (mm mo^{-1})	Ts [k)] (C)	WD [l)]
Aug. 01	19.0	13.1	38.9	26.3	31.5	22.4	22.6	14.1	2.1	19		S(27) [m)]
Sep. 01	17.3	12.7	35.3	26.6	31.7	23.0	21.2	12.9	1.7	105		S(13)
Oct. 01	18.6	14.4	40.0	26.5	31.5	23.2	21.7	12.9	1.7	208		NW(9)
Nov. 01	17.0	13.7	36.7	25.4	30.6	22.1	19.8	11.3	1.6	227	26.6	NW(12)
Dec. 01	16.6	13.0	36.7	25.9	30.7	23.0	17.2	9.5	1.6	207	26.6	W(12)
Jan. 02	15.6	12.1	34.2	26.3	30.6	23.6	16.6	8.9	1.6	269	26.7	NNE(10)
Feb. 02	17.0	13.0	36.9	26.7	31.1	23.7	18.2	10.4	1.6	170	26.9	NNE(11)
Mar. 02	15.9	12.5	34.6	26.3	30.6	23.6	15.9	8.3	1.6	251	27.3	NW(9)
Apr. 02	17.4	13.7	37.8	26.9	31.4	23.9	17.5	9.8	1.6	152	27.6	N(9)
May 02	18.9	14.0	40.7	27.8	32.2	24.3	20.8	12.8	1.8	49	27.9	S(20)
Jun. 02	15.7	11.7	33.9	26.3	30.5	23.2	15.9	9.5	1.6	116	27.3	S(20)
Jul. 02	20.3	14.4	42.8	26.8	32.1	22.8	22.5	14.1	2.2	9	27.1	S(35)
Aug. 02	18.9	12.4	37.5	26.3	31.5	22.1	24.0	15.6	2.6	13	26.4	S(32)
Sep. 02	12.2	7.4	21.4	26.7	31.3	23.2	21.5	13.7	2.2	9	27.0	SSW(27)
Oct. 02	13.3	8.5	24.4	27.3	32.1	23.5	24.4	14.9	1.9	128	27.5	SSW(19)
Annual [n)]	17.4	13.2	37.4	26.5	31.2	23.2	19.2	11.2	1.7	1782	27.1	

were 43 and 26 %, respectively, during the first year.

Solar radiation (S_r) and PPFD were high in the dry season (Fig. 2a, c). In spite of the dry season, however, they began to decrease at mid-August 2002. This is due to the shading of the smoke emitted from large-scale peatland fires around the forest. This decrease also occurred for net radiation (R_n), while the difference of R_n between the rainy and dry seasons was unclear (Fig. 2b). Upward long-wave radiation (L_u) depending on surface temperature was almost constant throughout a year at 38.5-40.0 MJ m^{-2} d^{-1} (Fig. 2d). On the other hand, downward long-wave radiation (L_d) depending on sky temperature decreased in the dry season (Fig. 2d); sky temperature depends on the amount of cloud, water vapor and aerosol in the atmosphere. In 2002, however, L_d began to increase in mid-August when S_r decreased. This increase in L_d was caused by the smoke from the petland fires.

Daily mean air temperature (T_{mean}) at 41.7 m height was between 23.0 and 29.5 ˚C with the annual mean of 26.5 ˚C for the first year. For daily maximum (T_{max}) and minimum (T_{min}) air temperature, the range and annual mean were 24.2-34.3 and 31.2 ˚C, and 19.9-25.9 and 23.2 ˚C, respectively (Table 1 and Fig. 2e). The range and annual mean between November 2001 and October 2002 of soil temperature at 5 cm depth were 24.9-28.6 and 27.2 ˚C for daily mean (T_s), 26.0-31.3 and 28.5 ˚C for daily maximum, and 23.1-27.6 and 26.1 ˚C for daily minimum (Fig. 2g). Air and soil temperatures were almost stable throughout a year, while T_{min} decreased below 20 ˚C twice; this will be discussed later. Vapor pressure deficit (VPD) at 41.7 m was low in the rainy season and high in the dry season (Fig. 2f). Daily maximum VPD was almost 15-25 hPa in the rainy season and 20-30 hPa in the dry season. Daytime mean VPD, which was the daily mean VPD under the condition that S_r was larger than 10 W m^{-2}, was almost 5-15 hPa in the rainy season and 10-20 hPa in the dry season. Soil moisture of top soil changed with precipitation (Fig. 2h). It was very low in the dry season of 2002. Wind was weak, while wind velocity increased before and during a squall; daily mean wind velocity (V) at 41.7 m was between 1 and 3 m s^{-1} with the annual mean of 1.7 m s^{-1} (Table 1 and Fig. 2i). V was higher in the dry season when southern wind prevailed.

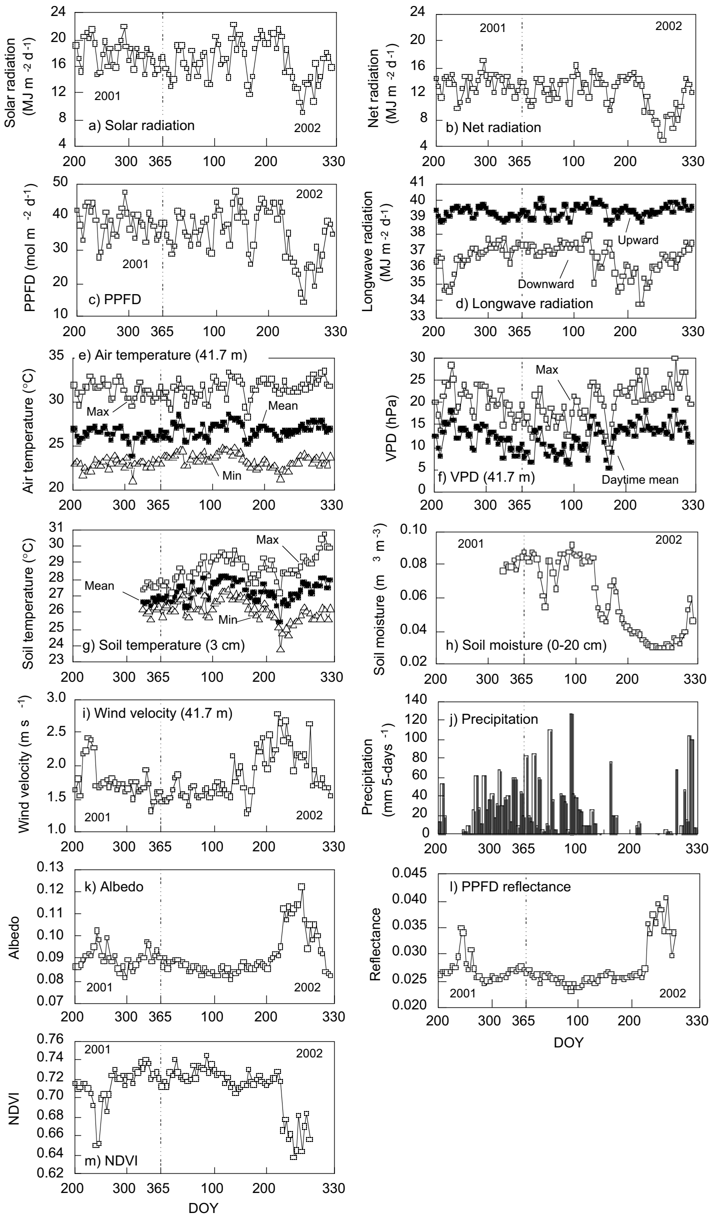


Figure 2. Variation in microclimate from July 2001 to November 2002. Data are five-days mean or sum.

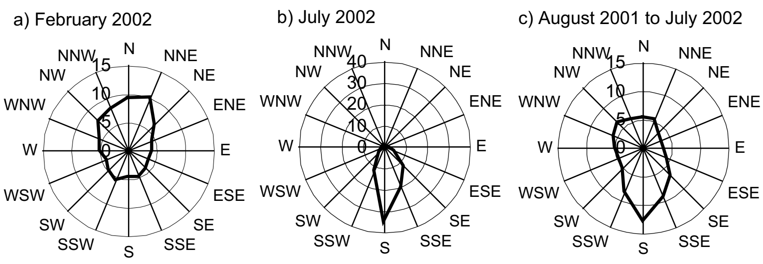


Figure 3. Relative frequency (%) of wind direction in a) February 2002 (summer), b) July 2002 (winter) and c) the first year.

a) daily solar radiation, b) daily net radiation, c) daily PPFD, d) mean air temperature, e) daily maximum air temperature, f) daily minimum air temperature, g) daily maximum VPD, h) daytime mean VPD, i) mean wind

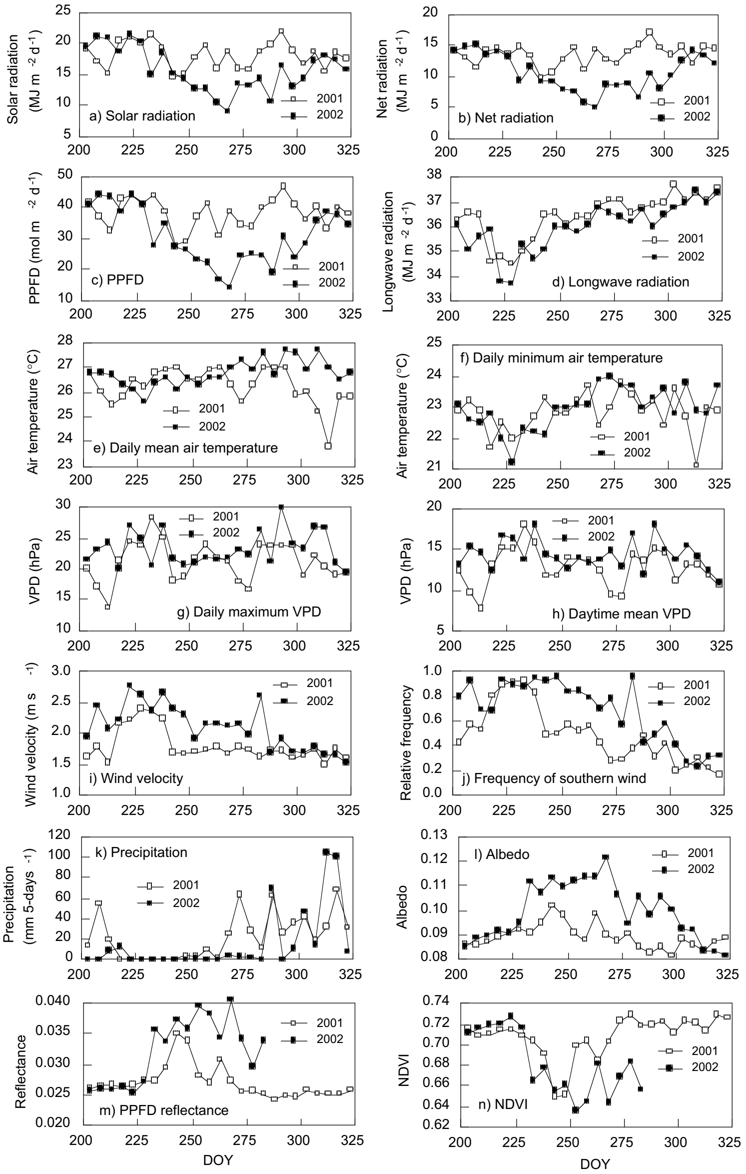


Figure 4. Comparison of microclimate between 2001 and 2002 during the dry season and the early rainy season, from late July to mid-November. Data are five-days mean or sum.

velocity, j) sum of precipitation, k) mean soil temperature, l) most frequent wind direction, m) relative frequency (%), n) annual mean or sum between Nov. 2001 to Oct. 2002 for T_s and between Aug. 2001 and Jul. 2002 for the others.

3.2. Comparison of microclimate between 2001 and 2002

Microclimate is compared between 2001 and 2002 during the dry season and the early rainy season, from late July to mid-November in Fig. 4. Large-scale peatland fires occurred around the forest in the dry season of 2002 because of the long dry season and the consequent drought by the El Niño event.

P was much smaller in 2002 than in 2001; the three-months sum of *P* from August to November was 332 and 150 mm in 2001 and 2002, respectively (Table 1). Moreover, the duration of consecutive dry days was 34 and 50 days in 2001 and 2002, respectively (Fig. 4k). Rain came at the end of the dry season when the frequency of southern wind and *V* decreased (Fig. 4i, j). Although daily maximum VPD frequently decreased below 15 hP with rain events in 2001, it was always over 15 hPa in 2002 (Fig. 4g). S_r and PPFD began to decrease at mid-August in both the year (Fig. 4a, c), and they continued to decrease until late September in 2002; the bottom value of PPFD was only one third as large as PPFD in July. In 2001, however, S_r and PPFD recovered at mid-September. The difference in the variations of S_r and PPFD between 2001 and 2002 was caused by the scale of peatland fires. In Indonesia, farmers start peatland fires for land clearance in the dry season, and the fires are naturally extinguished with rain at the beginning of the rainy season. Thus the fires are naturally controlled within a small scale in a normal year such as 2001. However, the fires spread out in the El Niño year such as 2002 because the beginning of the rainy season is delayed. A large amount of smoke emitted from the large-scale fires severely shaded S_r and PPFD in 2002.

T_{min} decreased to 19.9 ˚C at around dawn on 9 November 2001 in the rainy season and 15 August 2002 in the dry season (Fig. 4f). Since R_n in nighttime decreased below -70 W m^{-2}, radiative cooling occurred on 15 August. Assuming that the emissivity of the forest surface is 0.98, the daily minimum temperature of the forest surface, which consists of the canopy and forest floor was calculated at 24.2 and 19.8 ˚C at the time when T_{min} occurred on 9 November and 15 August, respectively from L_u; 19.8 ˚C is the minimum record of the surface temperature during the measurement. The minimum surface temperature in 2001 was 21.2 ˚C on 15 August. This shows that the land surface is cooled most in the dry season by radiative cooling, and suggests that the cooling is larger in the El Niño year.

3.3. Seasonal variation in albedo and NDVI

Albedo, PPFD reflectance and NDVI were almost constant at 0.08-0.09, 0.023-0.027 and 0.71-0.74, respectively, for the period with rain, from mid-September 2001 to early August 2002 (Fig. 2k, l). Albedo and PPFD reflectance increased up to 0.12, 0.04, respectively, and NDVI decreased to 0.64 in late September 2002 with drying, which appears as the decrease of soil moisture (Fig. 2h). NDVI also decreased to 0.65 in late August 2001. In November 2002, albedo decreased back to the previous level (Fig. 4l). Although there are no data for PPFD reflectance and NDVI, these are expected to return to the previous level from the change of albedo. This NDVI phenology was probably caused by water stress. It seems that there is a threshold in soil moisture for NDVI. In addition, defoliation may occur and resulted in the decrease of leaf area index (LAI) in the dry season.

CONCLUDING REMARKS

The existence of the rainy season in southern-hemisphere summer and the dry season in winter was confirmed in Central Kalimantan. The annual sum of precipitation for the first year from August 2001 to July 2002 was 1782 mm. Northern and southern winds prevailed in the rainy and dry seasons, respectively. Although wind was weak throughout a year, wind velocity was higher in the dry season. Air temperature was almost constant with the annual mean of 26.5 ˚C for the first year. However, it decreased below 20 ˚C around dawn by radiative cooling in the dry season of 2002. VPD was low in the rainy season and high in the dry season. Daily maximum VPD and daytime mean VPD were almost 15-25 and 5-15 hPa in the rainy season, and 20-30 and 10-20 hPa in the dry season, respectively. Large-scale peatland fires occurred around the study site in the dry season of 2002 because of a drought caused by the El Niño event. A large amount of smoke emitted from the fires severely shaded solar radiation between mid-August and late October 2002. In the dry season, albedo and PPFD reflectance increased and NDVI decreased owing to the change in the spectral reflectance of the forest. This NDVI phenology was probably caused by water stress. For understanding the phenology, it is needed to investigate the relationship between NDVI and forest physiology, such as CO_2 exchange and evapotranspiration, which are under analysis.

ACKNOWLEDGEMENTS

This work was supported by JSPS Core University Program, the Grant-in-Aid for Scientific Research (No. 11490001) from MEXT Japan, Heiwa Nakajima Foundation and Showa Shell Sekiyu Foundation for Promotion of Environmental Research.

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A Preliminary Study of Forest Tree Species of Muara Kendawangan Nature Reserve West Kalimantan

Mustaid Siregar
"Herbarium Bogoriense", Research Center for Biology - LIPI
"Eka Karya" Botanical Garden, Bali - LIPI
Bedugul, Bali, Indonesia - 82191 Telp. & Facs. +62 368 21273
E-mail: direkbg@singaraja.wasantara.net.id

ABSTRACT

Four plots, those were: 30m x 100m; 50m x 60m; 20m x 150m and 20m x 70m at dry land forest-Df, hilly forest-Hf, annual peat forest-APf and peat swamp forest-PSf of Muara Kendawangan Nature Reserve, West Kalimantan, respectively were established in order to study the structure and species composition of the forests. In total, within 4 plots (1.04 ha) were recorded 1544 trees (dbh ≥ 5 cm), belonging to 151 species. There are big variations in floristic composition among plots, indicated by relatively low of the similarity indices. The highest Sorensonís similarity index (20.7%) was found between Df and PSf plots, and only three species (*Syzygium laxiflorum, Litsea firma* and *Syzygium laxiflorum*) were distributed at the fourth plots. Total number of species in PSf plot was higher (60 species; diversity index - H'=3.6463) than that of Hf plot (56 species; H'=2.8465), Df plot (49 species; H'=2.9182) and APf plot (34 species; H'=2.2023). Density and total basal area of trees per ha in peat forest plots (PSF and APf) were higher than that of dry land forest (Df and Hf). The most abundance tree species in PSf plot were *Pternandra rostrata, Barringtonia reticulata* and *Myristica elliptica*, whereas in Hf plot were *Haemocharis ovalis, Guioa pubescens* and *Shorea parvifolia*, in Df plot were *Schima wallichii, Lithocarpus blumeanus* and *Pternandra rostrata*, in APf plot were *Shorea balangeran, Pternandra rostrata* and *Combretocarpus rotundatus*. The influence of soil physical condition on structure and species composition will also be discussed.

Key words: preliminary study, tree species, forest structure, species composition and Muara Kendawangan Nature Reserve.

INTRODUCTION

The resort of Muara Kendawangan Nature Reserve which is 150.000 ha wide is located in South West beach area and the Southern part of Kalimantan facing to Kalimantan strait. Administrationally it is located in Ketapang Regency, the Province of West Kalimantan. This resort has some habitat which is different one another that will make a big flora variation. On this Nature Reserve we can find peat swamp forest, dry low land forest and Hilly forest. Some kind of commercial wood like meranti (*Shorea* spp.), Ulin (*Eusideroxylon* zwageri), Jelutung (*Dyera lowii*) inhabit the low land forest in this Nature reserve resort. Some fauna like rusa-deer (*Cervus unicolor*), penyu belimbing (*Dermochellelys coriaceae*), kura gading (*Orlitia borneensis*), bekantan (*Nasalis larvatus*) and some kind of sea birds reported still can be found here. One of the uniqueness that is owned by this Nature Reserve is a thousands hectares of savannah. This savannah is a peace for the deer and other kinds of fauna to feed.

Comparing with the Natural Park which exist in West Kalimantan, This Nature Reserve his not much been done a research yet, so the information about the condition and all the Natural Resources are still very limited. To know more detail about the condition of the vegetation, specially the forestís flora, the research has been done on July 2000 to this resort.

GENERAL CONDITION OF RESEARCH SITE

Peat Swamp Forest - PSf

The result of the measurement on one of the point in the plot using a means of GPS (*Global Position System*), this forest is located in the geographical position of 2°37'50"South latitude and 110°17'23.4" East longitude on 15 m above the sea level. The condition of the land mostly (80%) watery and another parts forming small channels to the south with a very slow stream. The topography of the plot is generally flat. The thickness of peat layer is generally more than 3 m. The down plant is relatively scarce, whereas the trees tend to grow in groups in a bit dry places. However the closing of the treeís canopy is dense and no gaps.

Annual Peat Forest - APf

This plot of forest can the found in the Northern part of peat swamp forest, in the geographical position of 2^o 37'5" South latitude and 110^o 17'28.3" East longitude in the height of 5 m above the sea level. The topography is flat, about a quarter of the plot is watery and the rest is a little watery to a bit dry. The thickness of peat layer less than 1 m. The closing of trees canopy is a bit opened make it possible for the teki (*Cyperus* sp.), *Fimbristylis* sp. and some kind of *Taenitis* sp. to grow in this forest floor.

Dry Land Forest - Df

This forest plot is located in the Northern part of the annual peat forest, in the geographical position of 2^{o}36'33" South altitude and 110^{o}17'12" East longitude in the height of 10 meters above the sea level. It has a flat topography with a relatively dry land. This forest plot is splitted by a small river (Sumbar river). The water flow slowly to the South which is about 50 m depth. The height of the water level in the river is 1.5 meters below the forestís floor surface, the river is about 3 meters wide. The closing of the trees canopy is a bit opened by the gap existence. This gap is caused by the cut of some big trees.

Hilly Forest - Hf

This forest's plot is located in the Northern part of the annual peat forest, in the geographical position about 2^{o}34'36" South altitude and 110^{o}15'16" East longitude in the height of 35-50 m above the sea level. The topography is sloping, with the sloping degree 5^o-20^o facing to the west. It has a dry land. The canopy treeís closing is relatively dense with a little destruction.

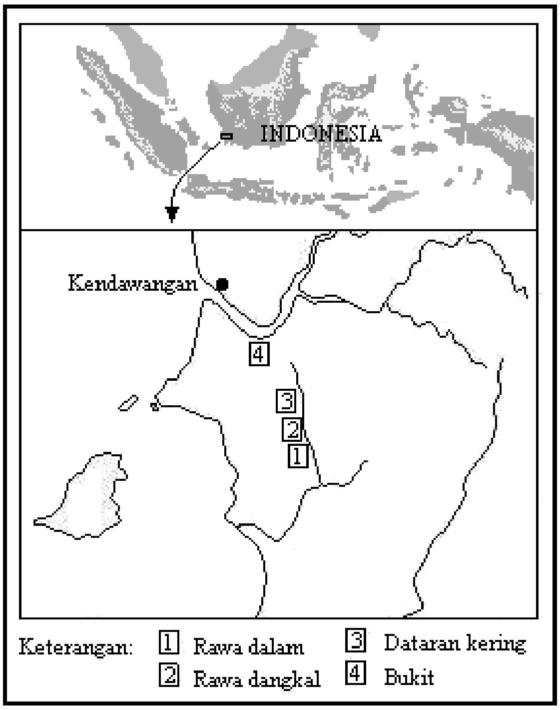

Figure 1. Map of plot study

RESEARCH METHOD

The data citation is done by using a plot method. The plot size in each type of forest vary, the plot of APf 150m x 20m, Df plot 100m x 30m, Hf plot 60m x 50m and PSf plot 70m x 20m. The plotís size is vary because the good forest in each type of forest has narrow and disperses location alternated by a secondary forest and bush. So the total width of the four plot citation is 1,04 hectare.

The fourth mayor plot are divided into some sub plot measures 10m x 10m. all trees species has a diameter breast height (dbh) >5 cm in the sub plot is chopped. The data collected include the name of species, stem diameter, the height of the tree and the height of free branch. The measurement of the stem diameter for all the treeís species are done as high as chest position (130m) from the soil level (dbh.). The voucher specimenís of each tree taken, further more it is identificated in Herbarium Bogoriense, Research center for Biology, LIPI (Indonesian Institute for Science Bogor).

Table 1. Some gathered information on the forest structure from each plot

	Plot			
	PSf	APf	Df	Hf
Number of species	60	34	49	56
Shanon's diversity index	3.6463	2.3023	2.9182	2.8465
Evenness index	0.8870	0.6529	0.7422	0.7041
Number of trees	175	703	261	405
Density /ha	1250	2341	869	1349
Basal area (m^2)	4,3	8,48	6.3	6,79
Basal area /ha (m^2)	30,68	28,24	20,98	22,62
Basal area per tree (m^2)	0,0246	0,0121	0,0241	0,0168

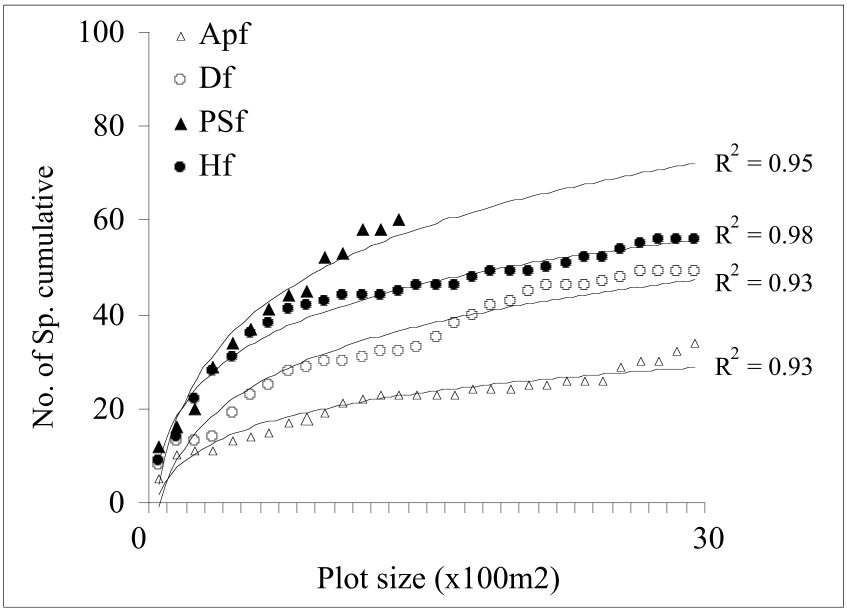

Figure 2. Species area curva

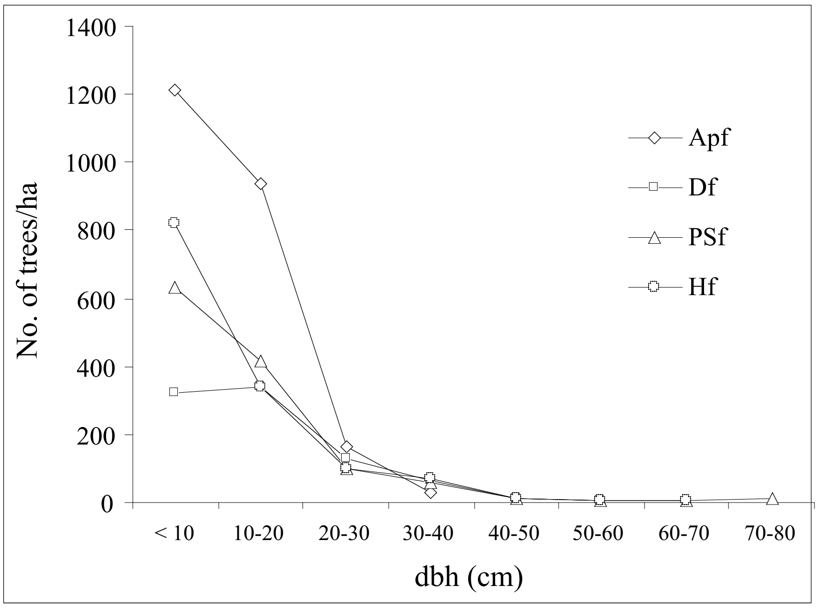

Figure 3. Tree distribution based on dbh class.

RESULT AND DISCUSSION

The total number of the treeís species (dbh< 5 cm) in the four plots of research are 151 species which classified into 90 genus and 38 families. The curveís area species in the four plots of research is served in Figure 2. The total number of species reach 1544 trees with a basal area 25.9 m^2. In Figure 3 showed tree distribution based on dbh class in the each plots.

PSf Plot

The richness of trees species (dbh > 5 cm) in this forest plot is high enough. From the temporary result of identification to all of voucher specimen, there are 60 species of trees with the density 1250 trees per hectare and the basal area 30.68m^2 per hectare (Table 1). Ladi (*Pternandra rostrata*) is the greatest in number 143 treeís per ha, followed by kumpang karut - *Barringtonia reticulata* (114 trees/ha) and Kumpang - *Myristica elliptica* (64 trees/ha).

APf plot

The richness of treeís species (dbh >5 cm) in this forest plot is low. From the temporary result of identification to all of voucher specimen there are 34 species of trees with the density 2341 trees per hectare and the basal area 28.24 m^2 per hectare (Table 1). The greatest number of trees are balangeran (*Shorea balangeran*) with 523 trees/ha followed by ladi (*Pternandra rostrata*) 513 trees /ha and parapat *Combretocarpus rotundatus* (423 trees/ ha).

Df plot

The richness of treeís species (dbh > 5 cm) there are 49 species in this plot with the density 869 trees per hectare and basal area 20.98 m^2 per hectare (Table 1). The greatest number of trees are penaga (*Schima wallichii*) with 193 trees/ha, followed by kempaning - *Lithocarpus blumeanus* (140 trees /ha) and Ladi - *Pternandra rostrata* (127 trees/ha)

Table 2. Number of species, trees and basal area per sub plots (100 m^2)

	PSf	APf	Df	Hf
Jumlah Jenis	9,8 $\pm$ 9,3	7,6 $\pm$ 3,8	5,6 $\pm$ 5,2	7,6 $\pm$ 3,7
Jumlah Individu	12,5 $\pm$ 10,7	23,4 $\pm$ 61,4	8,7 $\pm$ 11,6	13,5 $\pm$ 21,7
Luas bid. dasar (m^2)	0,31 $\pm$ 0,05	0,28 $\pm$ 0,01	0,21 $\pm$ 0,01	0,23 $\pm$ 0,02

Hf plot
The richness of treeís species (dbh > 5 cm) in this plot is noted 56 species with the density 1349 trees per hectare, and basal area 22.62 m^2 per hectare (Table 1) The greatest in number of trees are betapai putih (*Haemocharis ovalis*) with 326 trees/ha followed by nyamnyam - *Guioa pubescens* (210 trees /ha) and penaga *Schima wallichii* (173 trees /ha.).

Table 3. Sorenson's Similarity index from each plot

	PSf	APf	Df
PSf	-		
APf	13.79	-	
Df	20.70	10.17	-
Hf	5.48	5.05	18.62

Diversity
From Table 1 we can see that PSF has the richest species, followed by Hf, Df and APf plot. The similar illustration relatively can be seen from the number of species per sub plot (100m^2) showing the richness of the highest species in PSf plot and the lowest in APf plot and Df plot (Table 2). However the richness of species among sub plot. On PSf plot seen to be more varieties compared with another type of forest as can be seen from a very high basic deviation mark (Table 2).
Based on diversity and evenness indices is known that, the trees of PSf plot has the highest in diversity and evenness indices compared with another plot. In contrary APf plot has the lowest diversity and evenness indices (Table 1).

Another illustration that can also be used to see the diversity and evenness label in a certain plot is by seeing species distribution model. It is done by describing the abundance of the species from the biggest in number to the most rare in each plot (Magurran 1988). From the abundance species model in each plot (Figure 4) generally it shows the same pattern with another tropical forest that is only a small part has abundance species, while another species relatively rare. However if we see from the steepness of its curve, it is seen clearly that APf plot is steeper that shows only a small part of species is dominant. Three species which are abundance in APf plot (*Shorea balangeran, Pternandra rostrata, Combretocarpus rotundatus*) mastering 62.3 % (1459 trees/ha) from all treeís species (2341 trees/ha) in that plot. The mastery of the most abundance of the three species (*Schima wallichii, Lithocarpus belumeanus, Pternandra rostrata*) in Df plot is lower, that is 52.9 % (460 trees/ha) from all the trees species (869 trees /ha) in that plot. So is in Hf plot, the mastery of the most abundance of the three species (*Haemocharis ovalis, Guioa pubescens, Shorea parvifolia*) is noted 52.6 % (709 trees/ha) from all the trees species (1349 trees/ha) in that plot. Whereas on PSf plot the mastery of the three abundance species (*Pternandra rostrata, Barringtonia reticulata, Myristica elliptica*) much lower, that is 26.9 % (336 trees/ha) from all the trees species (1250 trees/ha) in that plot. From the above description it shows that the evenness of the species of trees in APf plot is relatively low and contrary in PSf plot is relatively high.

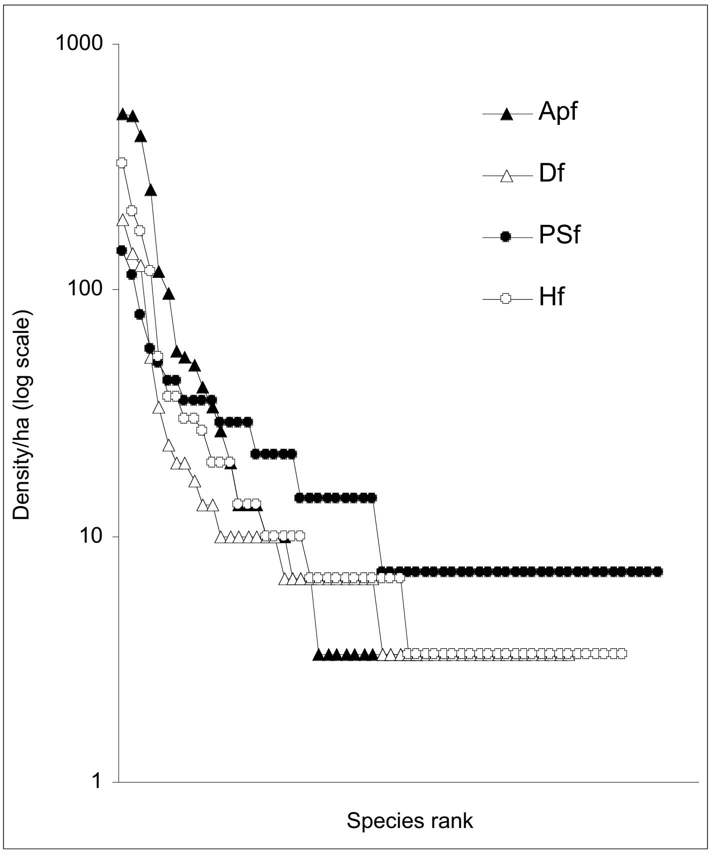

Figure 4. Abundance species model in each plot

If the type of trees in the fourth plot of research compared with one another, there are big enough species variation. This is reflected by the low of similarity index that is counted based on Sorenson's formula (Magurran, 1988;

Mueller-Dombois. and Ellenberg, 1974). The highest of similarity index is only 20.7 % that can be found between Df and PSf plot (Table 3). This result is surprising, because Df plot which is located in the red yellow podsolic land and PSf on the peat land, precisely has the biggest similarity index. *Pternandra rostrata*, *Litsea firma, Lithocarpus blumeanus* and *Barringtonia reticulata*, which are relatively abundance in both plots seem to be the species which are very tolerant to the soil difference. In contrary, *Shorea balangeran, Combretocarpus rotundatus* and *Cratoxylum glaucum* are species which sent to prefer shallow peat land which watered seasonally. Some species which is predicted has specific distribution in the land which has thicker peat layer and permanently watered are *Myristica elliptica, Polyalthia lateriflora* and *Endiandra rebescens*. *Myristica elliptica* and *Polyalthia lateriflora* previously has reported by Simbolon and Mirmanto (2000) as species of swamp forest tree in Central Kalimantan. In contrary the species of *Cotylelobium lanceolatum* and *Guioa fubescens* seem to be the types which are not strong enough with water and inhabate.

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Vegetation Zoning of Sumatran Peat Swamp Forests

Kuniyasu Momose[1] and Tetsuya Shimamura[2]

[1] Faculty of Agriculture, Bogor Agricultural University, Bogor, Indonesia
[2] Graduate School of Asian and African Area Studies, Kyoto University, Kyoto, Japan
[1] Present address: Graduate School of Asian and African Area Studies, Kyoto University, Kyoto, Japan

[1] Corresponding author: tel. 075-753-7837, fax. 075-753-7834, e-mail momose@asafas.kyoto-u.ac.jp.

ABSTRACT

We reconsidered the typology of Sumatran peat swamp forests. The sequential zoning along the distance from rivers starting from mixed peat swamp forests, changing into méranti paya forests, and ending in padang suntai forests was detected. Sequential zoning was also reported in peat swamp forests of Sarawak and Brunei, which have rather peculiar flora compared with the peat swamps of surrounding areas. Despite the differences in flora, forest types were well corresponded between Sarawak / Brunei and Sumatra. Among several measurements, canopy height, peat depth, EC and the amount of litter fall showed significant relations with distances from rivers. Based on this finding, we proposed a hypothesis to explain the formation of vegetation zoning.

Key words: litter fall, nutrient cycle, peat depth, peat swamp forest, vegetation zoning

INTRODUCTION

The most detailed studies about the typology of vegetation in tropical peat swamps of Sarawak and Brunei were carried out by Anderson (1961). However, these areas have rather peculiar flora compared with peat swamps of surrounding areas, including the Malay Peninsula, Sumatra and Kalimantan. Anderson (1976) and Page et al. (1999) also reported on vegetation of peat swamps of Sumatra and Kalimantan. However, the typology they described is too simple and its correspondence with vegetation zoning of Sarawak and Brunei is unclear. We reconsidered the typology of Sumatran peat swamp forests, and found that vegetation zoning is well corresponded with that of Sarawak and Brunei. The result has been partly published (Momose & Shimamura 2002, Momose 2002) in wider contexts of social forestry, but in this paper we present complete data and more detailed discussions focusing on vegetation zoning.

Huge areas of lowland plains of the western Malay Archipelago, except for marginal areas near the foot of hills, where freshwater swamp forests (Whitmore 1982) are dominant, are covered with peat swamp forests (18 million ha, according to Driessen 1978). Flooding does not occur year-round, but small pools sometimes appear when the water table rises. The soil is mineral-poor (the content of organic matter is higher than 75%). The underground water and the water of seasonal pools is acid (pH 3-5) (Anderson 1961, 1964).

When we leave riverbanks of lowland plains for the interior of the peat swamps, we observe remarkable shifts in vegetation. Peat swamp forests found in zones neighboring riverbanks are called mixed peat swamp forests. In mixed peat swamp forests, the peat is less than 2m deep, allowing tree roots to reach mineral soils. In Sarawak and Brunei (Northwest Borneo), this vegetation is characterized by *Dryobalanops rappa* (*kapur paya*, Dipterocarpaceae) (Anderson 1961). In the rest of the western Malay Archipelago, *Koompasia malaccensis* (*menglis* or *kömpas*, Leguminosae) and several species of *Gluta* (*kelakap* or *réngas*, Anacardiaceae) are typical elements, according to a review by Yamada (1991). The forest height is over 40 m.

As we proceed further from the rivers, the peat becomes thicker and thicker (Anderson 1964, Supiandi 1988a, b, 1998, Supiandi & Furukawa, 1986, Furukawa 1992). The vegetation also changes. In Sarawak and Brunei, the vegetation shifts as follows: 1) mixed peat swamp forests, 2) alan batu / alan bunga forests, 3) padang alan / padang médang forests, and 4) padang kerntum forests. According to Anderson (1961), however, some intermediates are recognizable.

Alan batu forests and alan bunga forests are as high as (or sometimes higher than) freshwater and mixed peat swamp forests: over 40 m (sometimes up to 70 m: Anderson 1961). Forest height is lower in padang alan / padang médang forests (30 m) and padang kerntum forests (10-20 m). The dominant species in alan batu and alan bunga forests is *Shorea albida* (*alan* or *empenit*, Dipterocarpaceae). Although these two forest types share a common dominant species, they differ in the species compositions of some minor components and in the wood quality and diameter of *alan* (namely, *alan* of alan batu forests have harder woods and larger diameters). Padang alan forests are also dominated by *alan*, but the trees are much smaller and the minor components differ greatly from alan batu / alan bunga forests. Padang mÈdang forests occur in the same habitat as padang alan forests, and are dominated by *Litsea palustris* (*médang*, Lauraceae). The species composition varies in padang kerntum forests, but there are common important members, such as *Combretcarpus rotundatus* (*kerntum* or *garam-garam*, Rhizophoraceae).

The rest of the western Malay Archipelago has been poorly studied. Anderson (1976) also reported on the vegetation of peat swamps in Sumatra and Kalimantan. He recognized only two forest types, mixed peat swamp forests and padang forests. The typology was too simple in that study, and the correspondence in the vegetation zoning of Sarawak and Brunei is unclear. More-detailed studies on the vegetation zoning of peat swamp forests are required in areas other than Sarawak and Brunei.

MATERIALS AND METHODS

We settled seven plots in Sumatraís Kerumutan Wildlife Sanctuary (KWS), located between the Kampar River and Inderagiri River (N0˚0-8', E102˚27-33') in Riau province. Seven plots were located along a line from the river to the interior of the swamp at intervals of ca. 500 m. The distance was measured by counting steps. In each 40 x 60 m plot, each tree over 10 cm in dbh (diameter at breast height) was identified and its dbh was recorded. In 20 x 20 subplots, each tree over 1 cm in dbh was identified. Voucher specimens were identified in Herbarium Bogoriense (BO) and donated to that herbarium.

The height of the highest tree in each plot was measured trigonometrically. Peat depth was measured in each plot by hand boring. The water quality of each small pool (1-3 m^2) found in each plot was measured at the beginning of April, 2001. pH was measured with a Horiba compact pH meter, B-211. EC (electric conductance) and ORP (oxidation reduction potential) were measured with a Horiba model D21. Concentrations of Cl^-, NH_4^+, NO_2^-, NO_3^-, phosphoric P, and SO_4^{2-} were measured with a Kyoritsu Aquasearch Lambda 8020. Levels of underground water were measured on a single day (24 March, 2001) at 10 points per plot at intervals of 2m along a 20m line within each plot.

The plots were named A, B, C, G from the riverside to the interior. In the plots A, C, E, we settled ten litter traps per plot. The litter traps were 1m in diameter, and with ca.1 mm mesh. They were placed ca. 1m above the ground, at intervals of 5m along the line at the center of each plot. Litters trapped were collected every month for one year from September 2001. They were dried using kerosene stoves for three days (ca. 80˚C) and weighed.

RESULTS

As shown in Fig. 1 and Table 1, the dominant species changed as follows. In the plot nearest the river, *Koompasia malaccensis* and *Durio lowianus* (*durian*, Bombacaceae) were dominant among canopy trees. *Gluta rostrata* was another conspicuous trees near rivers, although it was not found in this first plot. This result corresponds with the typical composition of mixed peat swamp forests reviewed by Yamada (1991).

When we proceeded to ca. 500 m from the river, the dominant species changed. *Shorea teysmanniana* (*méranti onék*, Dipterocarpaceae) was the dominant top canopy species, followed by *Swintonia glauca* (*ongös*, Anacardiaceae). The third plot (ca. 1 km from the river) had similar components. When we reached ca. 1.5 km from the river, the dominant top canopy species were *Palaquium burckii* (*suntai*, Sapotaceae) and *Swintonia glauca*.

Among sub-canopy trees, *Ganua mottleyana* (*boangku*, Sapotaceae) was dominant throughout the seven plots. However, some selected species (*Knema intermedia*, *Mangilietia glauca*, *Neoscortechinia kingii*, and *Stemonuros scorpioides*) showed remarkable changes in dominance as the distance from the river changed (Fig. 1). Species diversity tended to decrease in plots far from the river (Table 2).

Canopy height also decreased as distance from the river increased: it was 46 m in the plot nearest the river and 34 m in the plot ca. 2.5 km from the river (Table 3). The difference in water quality was remarkable only in EC (Table 3), which fell as we moved farther from the river, indicating low cation contents. The peat became thicker as we moved farther from the river (Table 3), as reported in a number of studies (Anderson 1964, Supiandi 1988a, b, 1998, Supiandi & Furukawa, 1986, Furukawa 1992). Other measurements (pH, ORP, contents of Cl^-, NH_4^+, NO_2^-, NO_3^-, phosphoric P, and water table level were not significantly related with distance from the riverbank (Table 3). The amount of litter fall was similar between the plots A and C, but was significantly smaller in the plot E than the in other two plots (Table 4).

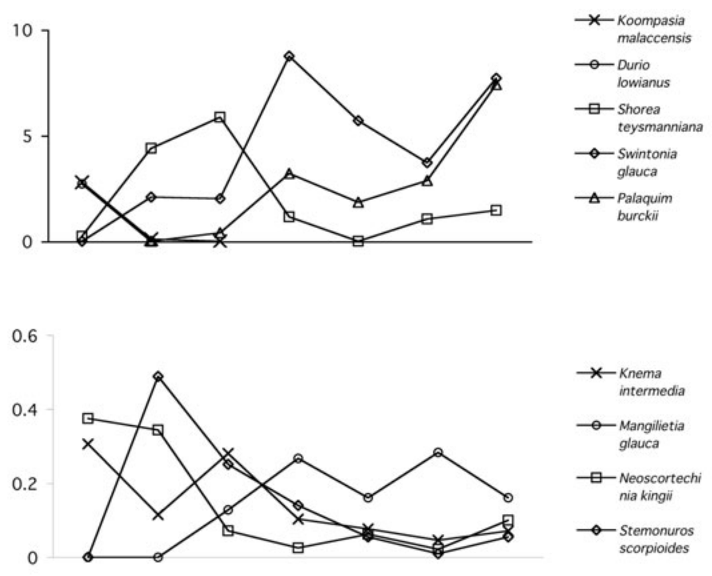

Figure1. Changes in basal areas of dominant species (top) and selected understory tree species (bottom) against distances from the river. Data was partly published in Momose & Shimamura (2002).

As a result of a cluster analysis (based on Euclidean distances calculated from basal areas and connected by the UPGMA method), three clusters were recognizable (Fig. 2). The plot nearest the river (A) was a cluster by itself, the next two plots

Table 1. Species composition of seven forest plots of peat swamp forests that are different in distances from the river. The plot A was located near rivers, and other plots were located at the intervals of 500 m. Data was partly published in Momose & Shimamura (2002).

	% basal area		% basal area
Plot A		Plot D	
Ganua mottleyana Pierre ex Dub.	13.2	*Ganua mottleyana* Pierre ex Dub.	28.7
Koompasia malaccensis Maing. ex Benth.	8.7	*Swintonia glauca* Engl.	22.9
Durio lowianus Sort. ex King	8.4	*Palaquim burckii* H. J. Lam	8.4
Diospyros diepenhorsii Miq.	6.4	*Parartocarpus forbesii* (King) FM Jarrett	5.0
Vatica pauciflora (Korth.) Bl.	6.1	*Xylopia malayana* Hk.f. et Th	4.7
Stemonuros secundiflorus Bl.	4.1	*Stemonuros secundiflorus* Bl.	4.2
Crudia subsimplicifolia Merr.	3.6	*Diospyros diepenhorsii* Miq.	4.1
Pouteria malaccensis (Clarke)	3.3	*Gonistylus bankanus* (Miq.) Kurz.	3.2
Polyalthis glauca (Hassk.) Boerl.	3.3	*Shorea teysmaniana* Dyer ex Brandis	3.0
Knema intermedia (Bl.) Warb.	3.0	*Tetramerista glabra* Miq.	2.7
Plot B		Plot E	
Shorea teysmanniana Dyer ex Brandis	13.1	*Ganua mottleyana* Pierre ex Dub.	24.7
Ganua mottleyana Pierre ex Dub.	12.7	*Swintonia glauca* Engl.	17.8
Gonistylus bankanus (Miq.) Kurz.	8.6	*Stemonuros secundiflorus* Bl.	5.9
Tetractomia tetrandra (Roxb.) Merr.	7.4	*Palaquim burckii* H. J. Lam	5.8
Swintonia glauca Engl.	6.2	*Parartocarpus forbesii* (King) FM Jarrett	5.7
Stemonuros scorpioides Becc.	5.5	*Diospyros diepenhorsii* Miq.	4.8
Tetramerista glabra Miq.	4.1	*Aglaia argentia* Bl.	4.4
Shorea uliginosa Foxw.	4.1	*Tetractomia tetrandra* (Roxb.) Merr.	4.3
Stemonuros secundiflorus Bl.	3.8	*Alstonia angastiloba* Miq.	3.4
Aglaia argentia Bl.	3.6	*Gluta aptera (King)* Ding Hou	3.2
Plot C		Plot F	
Ganua mottleyana Pierre ex Dub.	26.8	*Ganua mottleyana* Pierre ex Dub.	30.7
Shorea teysmaniana Dyer ex Brandis	17.9	*Swintonia glauca* Engl.	12.4
Tetramerista glabra Miq.	13.6	*Palaquim burckii* H. J. Lam	9.6
Swintonia glauca Engl.	6.2	*Parartocarpus forbesii* (King) FM Jarrett	6.6
Stemonuros secundiflorus Bl.	5.1	*Gonistylus bankanus* (Miq.) Kurz.	4.5
Aglaia argentia Bl.	4.3	*Ilex pleiobrachiata* Loes.	4.1
Stemonuros scorpioides Becc.	2.9	*Xylopia malayana* Hk.f. et Th	3.8
Knema intermedia (Bl.) Warb.	2.7	*Shorea teysmaniana* Dyer ex Brandis	3.5
Shorea uliginosa Foxw.	2.5	*Tetramerista glabra* Miq.	3.3
Tetractomia tetrandra (Roxb.) Merr.	2.4	*Stemonuros secundiflorus* Bl.	3.1
		Plot G	
		Swintonia glauca Engl.	21.2
		Palaquim burckii H. J. Lam	20.4
		Ganua mottleyana Pierre ex Dub.	14.4
		Gonistylus bankanus (Miq.) Kurz.	7.7
		Campnosperma coriaceum Ridl.	4.3
		Shorea teysmaniana Dyer ex Brandis	4.0

(B and C) formed another cluster, and the four plots farthest from the river (D, E, F, and G) formed the third cluster. Within the third cluster, the farthest plot (G) was relatively distanced from the other three plots.

DISCUSSION

In conclusion, three types of forests are recognizable. The forest in the plot nearest the river is identical to mixed peat swamp forests. As pointed out in previous studies, mixed peat swamp forests grow in peat shallow enough to allow plant roots to reach mineral soils.

In the next zone, the peat was deeper and the plant roots did not reach mineral soils. However, the canopy was still high and the water was cation-rich. We call this the méranti paya forest. Here, "méranti" is a generic Malay term indicating the species *Shorea*, Section Mutica; and "méranti paya" means "méranti found in swamps". According to the review by Yamada (1991), some Sumatran peat swamp species of méranti are also found in peat swamps of the Malay Peninsula and Kalimantan. Thus, méranti paya forests will be found also in these areas. Anderson (1976) confuses méranti paya forests with mixed peat swamp forests, but these must be clearly distinguished from each other, because méranti paya forests occur in the same habitats as alan batu / alan bunga forests, in which plant roots do not reach mineral soils (Tables

Table 2. Indexes calculated from vegetation census of seven forest plots. Data was partly published in Momose & Shimamura (2002).

Plots	A	B	C	D	E	F	G
[1] No. ind. (dbh≧1cm)	173	322	243	270	303	338	292
[2] No. sp. (dbh≧1cm)	59	54	40	46	47	48	45
[3] Div. index (ind. no.)	3.67	3.41	3.10	2.98	3.26	3.24	3.18
[4] Basal area (m^2/ha)	32.2	33.6	32.7	38.1	31.9	30.0	36.3
[5] No. sp. (dbh≧10cm)	48	45	31	32	34	33	38
[6] Div. index (basal area)	3.32	3.12	2.48	2.40	2.67	2.58	2.63

[1] Number of individuals (dbh≧1cm) found in subplots (20 x 20 m).

[2] Number of tree species (dbh≧1cm) found in subplots (20 x 20 m).

[3] Diversity index, N'. $N' = \Sigma_i (n_i / N) \ln (n_i / N)$, where N is total number of individuals over 1 cm in dbh found in subplots(20 x 20 m), and n_i is number of individuals of species i.

[4] Total basal areas of trees (dbh≧10cm) found in plots (40 x 60 m).

[5] Number of tree species (dbh≧10cm) found in plots (40 x 60 m).

[6] Diversity index, N'. $N' = \Sigma_i (n_i / N) \ln (n_i / N)$, where N is total basal areas of trees (dbh≧10cm) found in plots (40 x 60 m), and n_i is the basal area of species i.

Table 3. Measurements of seven forest plots. Data was partly published in Momose & Shimamura (2002).

Plots	A	B	C	D	E	F	G	r [2)]
Canopy height (m)	46.0	38.6	42.9	41.4	36.0	33.5	36.0	-3.4*
Peat depth (m)	0.4	4.2	4.8	5.3	5.8	6.3	8.5	2.1**
pH	3.3	3.5	3.5	3.4	3.5	3.6	3.4	NS
EC (ms/m)	15.5	11.0	14.3	9.7	10.7	9.0	9.3	-1.9*
ORP (mV)	288	284	164	331	298	293	238	NS
Cl^- (mg/l)	3.3	0.7	1.2	1.8	1.2	1.2	1.1	NS
NH_4^+ (mg/l)	1.3	1.2	1.6	1.5	1.2	1.5	0.9	NS
NO_2^- (mg/l)	0.01	0.02	0.01	0.02	0.01	0.02	0.01	NS
NO_3^- (mg/l)	0.14	0.10	0.07	0.10	0.09	0.10	0.07	NS
phosphoric P (mg/l)	0.12	0.16	0.09	0.09	0.10	<0.1	0.11	NS
SO_4^{2-} (mg/l)	<5	<5	<5	<5	<5	<5	<5	
Water table (cm) [1)]	27.1	37.1	39.1	40.1	30.1	24.2	28.1	NS
	(10.9)	(10.9)	(7.0)	(11.0)	(10.2)	(5.5)	(10.4)	

[1] Average of levels of underground water in March among ten points per plot and SE in brackets.

[2] Coefficient of regression analysis between distance from the riverbank (km) and measurements. NS: coefficient was not significant. *: $p < 0.05$. **: $p < 0.01$.

Table 4. Litter fall in three plots that differ in distances from the river.

Plot	A	C	E
Sample size	10	10	10
Mean litter fall[1] ($g / month / m^2$)	60.9	57.7	37.1
SE	14.2	4.85	14.1

[1] $F = 10.5$, $p < 0.01$ (ANOVA); A vs. C: $z = 0.64$, NS (Bonferroni's LSD); A vs. E: $z = 3.55$, $p < 0.003$ (Bonferroni's, LSD); C vs. E: $z = 4.11$, $p < 0.003$ (Bonferroni's LSD).

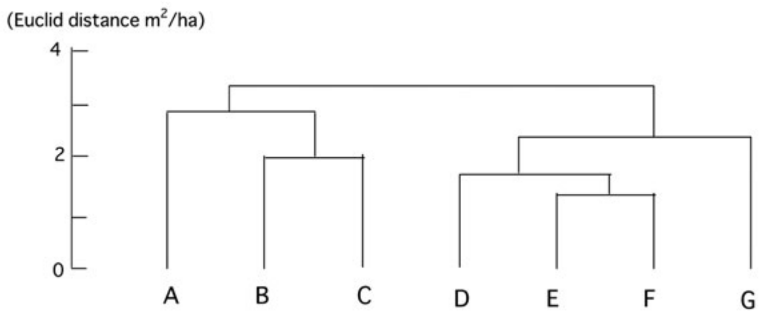

Figure 2. A result of a cluster analysis of seven forest plots of peat swamp forests at different distances from the river, based on Euclidean distances calculated from basal areas, and connected by the UPGMA method.

Table 5. Vegetation zoning of Sumatran peat swamp forests.

Vegetation types	EC (ms/m)	Peat depth	Dominant genera
Mixed peat swamp forests	> 15	< 2m	*Koompasia*, *Durio*
Meranti paya forests	11-15	2-5 m	*Shorea*, *Swintonia*
Padang suntai forests	8-11	> 5 m	*Palaquium*, *Swintonia*

Table 6. Correspondences of forest types between two regions within Western Malay Archipelago, which differ in flora.

	Sarawak, Brunei	Sumatra
zone 1	mixed peat swamp f.	mixed peat swamp f.
zone 2	alan batu / alan bunga f.	méranti paya f.
zone 3	padang alan / padang médang f.	padang suntai f.
zone 4	padang kerntum f.	absent

5, 6).

Forests with lower canopy heights were found in the areas farthest from rivers. Anderson (1976) called them padang forests. If we follow the terminology that Anderson used in Sarawak and Brunei, the forests found in areas farthest from rivers in Sumatra should be called padang suntai forests. Here, ìsuntai” is the Malay name for *Palaquium burckii*, a species characterizing the vegetation. According to Anderson (1976), suntai is also dominated in Kalimantan in the same habitats as Sumatra. This is the forest type that replaces the padang alan / padang médang forests in Sarawak and Brunei (Table 6). In KWS, peat depth was 5 m at the boundary between méranti paya forests and padang suntai (Table 3).

Forests identical to the padang kerntum forests of Sarawak and Brunei are also found in Kalimantan (Anderson 1976). However, forests whose canopy heights are as low as those of the padang kerntum forests were not found in Sumatra, according to our field observation, interpretation of aerial photographs (padang kerntum forests are distinctive in their fine tree crowns), and interviews with local Malays. In the aerial photographs, we sometimes found forests with fine tree crowns near rivers. However, these are flooding forests dominated by *Syzygium*, whose crown sizes are considered to be limited because of heavy flooding. If padang kerntum forests exist, they should be found far from rivers. However, such forests were not found in aerial photographs of three main lowland plains on the Sumatran east coast: the Kampar, Inderagiri, and Batan Hari regions.

For simplification, we apply a single term, padang forests, to refer to padang alan, padang médang, padang suntai, and padang kerntum forests, if it is not necessary to distinguish between them.

Hydrological conditions no doubt have significant effects on vegetation, but the level of the water table was not significantly related with distance from the riverbank (Table 3). Thus, other factors determining vegetation types should be considered. In our hypothesis, the mechanisms by which forest zoning is formed are explained as follows.

When peat starts to accumulate, mixed peat swamp forests cover the shallow peat. Trees absorb nutrients from mineral soils under the peat, and litter containing nutrients is deposited as peat. Thus, minerals are stocked in living plants plus peat, while mixed peat swamp forests cover the shallow peat. When the peat becomes thicker than 2m, tree roots no longer reach mineral soils. Thus, nutrients are circulated between living plants and the peat (a small amount is supplied from rainfall but not from mineral soils or river water). As the peat becomes thicker still, plant roots do not reach the lower parts of it, and nutrients contained there are excluded from circulation. Thus, as the peat thickens, the amount of circulating nutrients becomes smaller. As long as rich nutrients are circulated, the biomass is large, allowing alan batu, alan bunga or mÈranti paya forests to occur. After the peat becomes thick and the amount of circulated nutrients is reduced, the biomass decreases, and thus padang kerntum forests occur. As we move farther from rivers, peat depth increases, and we can observe this vegetation succession, starting from mixed peat swamp forests, passing through alan batu / alan bunga forests or méranti paya forests, and ending in padang kerntum forests. Pollen analysis carried out by Morley (1981) suggested that vegetation succession occurred as peat became thicker.

Although we have not yet measured nutrient flows, the amount of litters changed among vegetation types showing the pattern expected in the above hypothesis. The amount of litter fall was similar between the mixed peat swamp forest (plot A) and the méranti paya forest (plot C), but was significantly smaller in the padang forest (plot E) (Table 4).

Furukawa (1992) suggested a different mechanism. Padang forests occur as a result of the flowing away of nutrients that had been stocked in the peat. It is possible for this to occur. However, as found in Andersonís several study sites and KWS, peat depth usually correlates clearly with vegetation type. Such correlation can be explained by our model only. In any case, the nutrient contents of living plants and peat at various depths, as well as nutrient flows, must be measured to test the above hypothesis, and this work is now in preparation.

ACKNOWLEDGEMENTS

We thank Prof. H. Furukawa, Graduate School of Asian and African Area Studies, Kyoto University, for helpful suggestions including the selection of study sites; Prof. Supiandi Sabiham, our host scientist at IPB (Bogor Agricultural University), and other staff members at IPBís Soil Science Laboratory; all staff members at IPBís Center for Wetland Studies; the Conservation Section, Forest Department of Riau, for research permission in KWS; Mr. Ramli and his family in Lugu Loga, Riau, Indonesia, for their kind hospitality during our stay in the field; the curator and other staff members at the Herbarium Bogoriense, for their kind hospitality during our stay at the herbarium for plant identification.

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Nitrogen Source for Common Tree Species in Peat Swamp Forests, Central Kalimantan inferred from $\delta^{15}N$ Analysis

Takeshi Matsubara[1], Sehat Jaya Tuah[2], Suwido, H. Limin[3] and Mitsuru Osaki[4]

1) School of Business and Environment, The College of Cross-Cultural Communication and Business, Shukutoku University, Saitama 354-8510, Japan. tkm@ccb.shukutoku.ac.jp
2) Department of Forestry, Faculty of Agriculture, University of Palangka Raya, Central Kalimantan, Indonesia. sehat@chem.agr.hokudai.ac.jp
3) Department of Agronomy, Faculty of Agriculture, University of Palangka Raya, Central Kalimantan, Indonesia.
4) Laboratory of Plant Nutrition, Faculty of Agriculture, Hokkaido University, Sapporo 060-8589, Japan. mosaki@chem.agr.hokudai.ac.jp

Corresponding Author: Takeshi Matsubara
School of Business and Environment, The College of Cross-Cultural Communication and Business, Shukutoku University, Saitama 354-8510, Japan.
tkm@ccb.shukutoku.ac.jp
Tel: +81-492-74-1511/ Fax: +81-492-74-1521

ABSTRACT

We measured leaf $\delta^{15}N$ of dominant and common tree species collected at peat swamp and kerangas forests, Central Kalimantan to evaaluate nitrogen sources of the trees. Average plant $\delta^{15}N$ value was most depleted at kerangas forest plot of Lahei (-4.6 ‰) and most enriched at Kalampangan plot 4 (-0.4 ‰). The depleted $\delta^{15}N$ value suggested poor nitrogen availability for plant compare with other type of tropical and temporal forests. But some tree species $\delta^{15}N$ value such as ca -10 ‰ of *Ardisia eliiptica* and *Cratoxylum arborescens* suggested that they could access nitrogen from ect-micorrhiza. In addition, $\delta^{15}N$ of *Combertocarpus rodentatus* (close to 0 ‰ and/or upper than 4 ‰) in all of the study plot collected suggested that this species utilize not only atmospheric nitrogen but also symbiotic with microorganisms proceed denitrofication.

Key words: $\delta^{15}N$, Central Kalimantan, peat swamp forest, Kerangas forest, nitrogen source

INTRODUCTION

Peat swamp forest is a common forest type in lowland at Central Kalimantan. The peat swamp forest have unique ecosystem with various plants and animals, even though under poor nutrient with strong acid condition (cf. Simbolon & Mirmanto, 2000). However, the peat swamp forest has been degraded by unsuccessful land conversion and management in Central Kalimantan. Additionally, massive fire in 1997/98 had burnt huge area of the peat swamp forest.

Under poor nutrient condition with massive fire damage, how plants utilize nitrogen, one of limited resource for plant ? To estimate possible nitrogen sources for plants in fire-damaged peat swamp forest, we conducted nitrogen stable isotope analysis.

Natural abundance of nitrogen stable isotope is recognized as a useful index of plant nitrogen sources (Evans, 2001, Takahashi, 1996). The forms of nitrogen absorbed by plants have different isotopic ratios (Robinson, 2000). For example, Michelsen *et al*. (1996, 1998) reported difference of nitrogen sources of subarctic plants living with mycorrhizal fungi. Hietz *et al*. (2002) investigate nitrogen cycle and nutrition of epiphytic plants. We expect, therefore, ^{15}N natural abundance in peat swamp forests also give us useful information on nitrogen source for plants in the forests.

MATERIALS AND METHODS

Site description

Sample collection was conducted at eight study plots established at Central Kalimantan. Four 1-hectare study plots were established between 2°19' - 2°21' S, and 114°00' - 114°03' E in June 1999. In these four plots, plot 1 and 3 are in a relatively undisturbed peat forest, but water level of plot 3 is lower than plot 1. Plot 2 and 4 are located at repeated fire-damaged area and plot 4 is more dry condition than plot 2 with shallower peat layer (Table 1; cf. Tuah et al. 2000). Additionally we collected plant leaf sample from peat swamp forest and Kerangas forest at Lahei, and two plots in natural peat swamp forest at Setia Alam.

Sample collection and stable isotope analysis

Mature leaf was collected from trees with 10 cm or above in DBH, and from some fern leaf (including shoot) at the each study plot. Target trees were collected based on our previous research at Kalampangan study plots (cf. Tuah et al. 2000). Collected leaves were washed with deionized water, dried in an oven at 80 ˚C for 24h, then ground and homogenized using a tungsten carbide vibrating mixer mill.

Soil sample was also collected at each study plot during July – Augusut, 1999 (Tuah et al. 2000). Collected soil sample was treated as like leaf samples mentioned above.

^{15}N natural abundance of plant and soil samples were measured using CF-IRMS (EA1108-Conflo II-delta-S system). The ^{15}N abundance relative to the standard (atmospheric nitrogen) was expressed as follows:

$$\delta^{15}N=(R_{sample}/R_{N2\text{-}air\text{-}standard}-1) \times 1,000 \text{ (‰)}$$

where R is the ratio $^{15}N/^{14}N$. DL-alanine ($\delta^{15}N$; 1.65 ‰) was used as running standards and normalized to $\delta^{15}N_{AIR}$. More than a hundred replicates using the running standards indicated analytical errors of ± 0.1 ‰ for $\delta^{15}N$ measurements.

RESULTS

Site specific $\delta^{15}N$ characteristics

Average $\delta^{15}N$ of plants is shown in Table 1. Average plant $\delta^{15}N$ value was most depleted at kerangas forest plot of Lahei (-4.6 ‰) and most enriched at plot4 in Kalampangan plot 4 (-0.4 ‰). The average $\delta^{15}N$ is significantly different among study sites ($p < 0.001$; Kruskal-Wallis test).

The $\delta^{15}N$ value was enriched in shallow peat and fire damaged plots in the four Kalampangan plots. The $\delta^{15}N$ value of plot 4, most fire damaged and shallow peat with low water level, was significantly enriched than other three plots (t-test, $p< 0.001$). The $\delta^{15}N$ value of other plots in Lahei and Setia Alam were similar value with Plot 1 (undisturbed with deep peat) and/or plot 3 (undisturbed with shallow peat).

Surface soil $\delta^{15}N$ value of each plot was not so different compare to leaf $\delta^{15}N$ value (Figure 1). It was ranged from 0.0 ‰of Lahei kerangas plot to 1.81 ‰ of Kalampangan plot 2. Nitrogen content of surface soil was ranged from 0.6 % of Lahei kerangas plot to 1.45 % of Setia Alam plot1 (Figure 2).

Species specific $\delta^{15}N$ characteristics

$\delta^{15}N$ value of plants is shown in Table 2. The $\delta^{15}N$ value was varied within inter and intra species from –10.09 ‰ of *Ardisia eliiptica* (Lahei Kerangas) to 7.42 ‰ of *Combretocarpus rotundatus* (Kalampangan plot1). Compare to tree species $\delta^{15}N$ value of fern species varied with relatively small range (-5.06 ‰ to 1.53 ‰).

There was no obvious tendency of $\delta^{15}N$ value among species, family and/or site specific, except *Combertocarpus rodentatus* as mentioned later.

DISCUSSION

The soil $\delta^{15}N$ value was lower than that of average soil world-wide (Shearer & Kohl 1989, Takahashi, 1996). The value was similar to those reported from nitrogen poor environment such as heath and tundra ecosystems (Michelsen *et al*., 1996, 1998) and forest on sandy soil in tropical area (Martinelli *et al*. 1999).

Plant $\delta^{15}N$ value was also lower than that of tropical forests and temperate forest (Martinelli *et al*. 1999). $\delta^{15}N$ of forest ecosystem is depleted less than -2 ‰, if nitrogen source is limited only inorganic nitrogen supplied from precipitation. Average $\delta^{15}N$ of precipitation is reported ca. -5 ‰ for nitrate and -2‰ for ammonium (Takahashi 1996). In present study, the microorganic activity enrich $\delta^{15}N$, such as ammonium volatilization and denitrification, is possibly low due to strong acid environment (pH 2.89 - 3.41; cf. Tuah 2000). That is, depleted $\delta^{15}N$ of plant less than -2 to -5‰ suggest that main nitrogen source is inorganic nitrogen in precipitation in the peat swamp and kerangas forests.

Other factor depleting $\delta^{15}N$ value of plant is symbiosis with mycorrhizal organisms. In this case plants and mycorrhizal associates differ in their $\delta^{15}N$ values as much as 8 ‰ (Evans 2001). As a result, plant $\delta^{15}N$ depleted more than the case of precipitation mentioned above (Hobbie et al. 2000). For example in this study, *Ardisia eliiptica*(-10.09 ‰) and *Cratoxylum arborescens* (-10.47 - -8.51 ‰) at Lahei Kerangas plot suggested that these tree plant uptake organic nitrogen from symbiotic ecto-mycorrhiza (Table 2). But all of individual tree in the same species did not show symbiotic relationship with mycorrhiza.

Another factor affects plant $\delta^{15}N$ is atmospheric nitrogen fixation. $\delta^{15}N$ of plant which utilize atmospheric nitrogen fixed by symbiotic bacteria close to -2 ‰ to 0 ‰ (cf. Takahashi 1996). Some of the tree species in this study with $\delta^{15}N$ of that range might use atmospheric nitrogen through symbiotic nitrogen fixing bacteria.

In these tree species, $\delta^{15}N$ of *Combretocarpus rotundatus* suggested that this tree species has unique nitrogen utilization pattern. $\delta^{15}N$ value of this species in the study plots was close to 0 ‰ and/or more than 4 ‰ (Figure 3). Compare with $\delta^{15}N$ of other species, these $\delta^{15}N$ of *Combretocarpus rotundatus* were more enriched. This difference suggested that this species utilize not only atmospheric nitrogen but also symbiotic with denitrification bacteria.

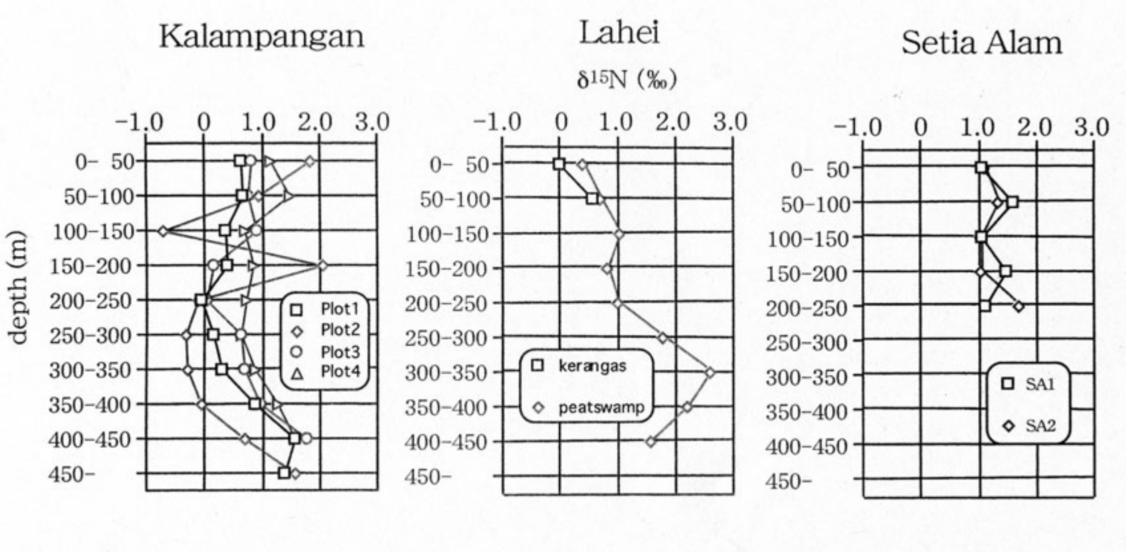

Figure 1. Soil $\delta^{15}N$ of peat swamp and kerangas forests, Central Kalimantan.

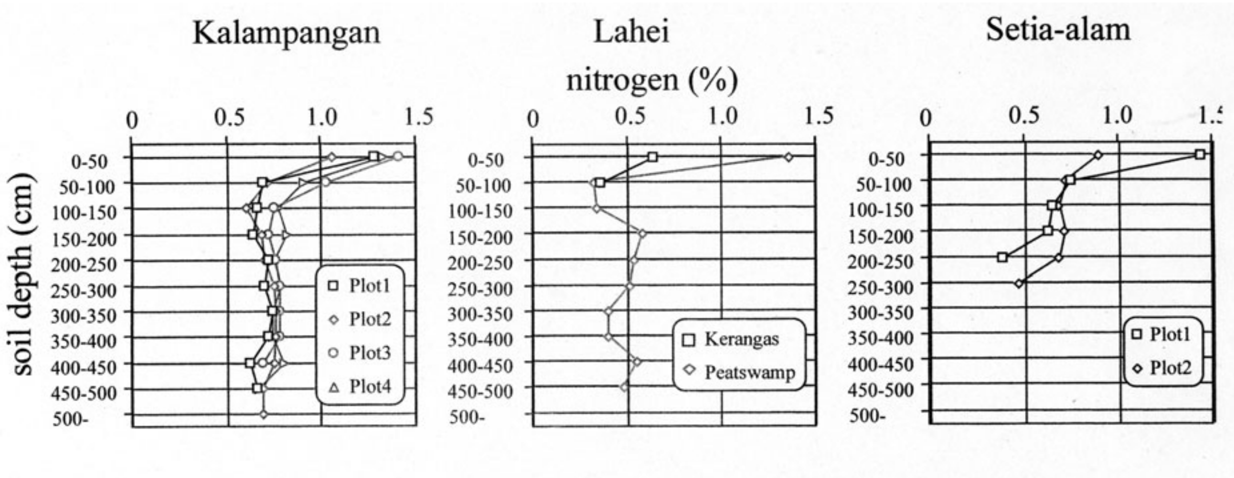

Figure 2. Soil nitrogen content of peat swamp and kerangas forests, Central Kalimantan.

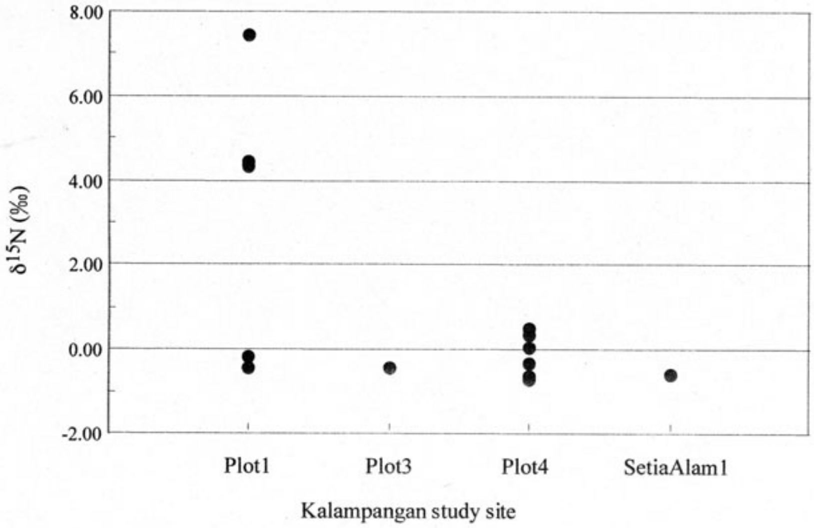

Figure 3. Leaf $\delta^{15}N$ of *Combretocarpus rodendatus* among study sites.

Table.2 $\delta^{15}N$ of plants collected at study plots. Average with sample number and range in parenthesis.

Family	Species	Kalampangan				Lahei		SetiaAlam	
		Plot1	Plot2	Plot3	Plot4	Kerangas	Peatswamp	Plot1	Plot2
Anacardiaceae	Camnosperma coriaceum	-1.59 (2)							-0.63 (1)
		(-1.94 - -1.23)							
	Mangifera sp.	-2.14 (2)							
		(-4.06 - -0.22)							
Anisophylleaceae	Combretocarpus rotundatus	4.14 (7)		-0.43 (1)	-0.04 (7)			-0.59 (1)	
		(-0.44 - 7.42)			(-0.70 – 0.50)				
Annonaceae	Goniothalamus malayanus?						-0.17 (1)		
	Polyalthia glauca	-5.03 (2)							
		(-6.01 - -4.05)							
	Polyalthia hypoleuca	-5.23 (1)							
	Xylopia fusca	-3.52 (1)	-1.74 (1)						
	Ilex cymosa	-5.34 (3)							
		(-6.89 - -3.29)							
Apocynaceae	Dyera costulata		-1.66 (1)	-0.48 (1)					0.14 (1)
Bombaceae	Durio beccarianus							-0.83 (1)	
Caesalpiniaceae	Koompassia malaccensis	-4.42 (6)	-2.84 (1)	-0.50 (3)					-0.13 (1)
		(-7.07 - -1.69)		(-1.28 – 0.39)					
Celastraceae	Lophopetalum multinervium	-4.16 (1)		-1.57 (1)					
Clusiaceae	Calophyllum inophyllum	-2.93 (30)		-2.61 (5)					-1.42 (1)
		(-4.90 - -1.22)		(-4.53 - -0.48)					
	Calophyllum macrocarpum	-5.18 (2)	-0.86 (1)	-0.62 (6)					
		(-6.62 - -3.74)		(-2.64 – 0.87)					
	Calophyllum teysmannii	-3.44 (7)	-3.03 (2)	-2.08 (1)					
		(-4.77 - -1.46)	(-3.34 - -2.72)						
	Garcinia cuspidate	-5.70 (1)	-4.31 (1)					-5.51 (1)	
	G. diocia		-3.90 (1)			-6.19 (1)			-4.33 (1)
Chrysobalanaceae	Parastemon urophyllus						-2.07 (1)		
Crytoteroniaceae	Dactylocladus stenostachys	-2.09 (4)		-6.50 (1)					
		(-5.67 - -0.43)							
Dipterocarpaceae	Cotyleobium melanoxylon						-0.47 (1)		
	Shorea balangeran			-2.36 (1)			-1.45 (3)		
							(-2.50 - -0.42)		
	S. platycarpa	-5.51 (8)	-0.13 (2)	-0.32 (1)		-2.49 (1)			
		(-9.19 - -2.51)	(-0.92 – 0.67)						
	S. retusa	-4.85 (2)	-1.42 (1)	-1.15 (1)		-6.83 (2)			
		(5.21 - -4.48)				(-7.70 - -5.95)			
	S. teysmanniana	-6.23 (1)				-4.27 (1)		-3.14 (1)	
	S. uliginosa		-0.01 (1)						
	Vatica umbonata	-2.88 (3)				-1.84 (1)			
		(-3.94 - -1.07)							
Ebenaceae	Diospyros bandamensis?						2.07 (3)		
							(1.41 – 2.77)		
	D. confertiflora cf.						-2.26 (2)		
							(-3.08 - -1.43)		
	D. hermaphroditica			-0.60 (6)		-6.30 (1)			
				(-1.59 – 0.45)					
Eleocarpaceae	Eleocarpus mastersii	-1.85 (1)		-2.61 (1)		-4.35 (1)			
Euphorbiaceae	Antidesma bunius					-6.86 (1)			
	Baccaurea macrocarpa?						-3.46 (1)		
	Macaranga pruinosa							-1.71 (1)	
	Neoscortechinia kingii	-2.75 (4)	-4.72 (1)						
		(-6.29 - -0.89)							
	Macaranga pruinosa[?]	-4.55 (2)							
		(-5.57 - -3.52)							
Fagaceae	Quercus argentata	-5.24 (2)	-1.73 (1)	-1.84 (1)					
		(-6.49 - -3.99)							
Guttiferae	Calophyllum[bingtangor]					-6.24 (1)			
	Calophyllum[kakar siang]					-1.25 (1)			
	Calophyllum[mahatigan]					-0.12 (1)			
	Calophyllum[matutan]long						1.12 (1)		
	C. pulcherrimum					-4.76 (1)			
	Garcinia. rostrata					-10.07 (1)			
	Mesua marcantha					-7.76 (1)			
Hypericaceae	Cratoxylum arborescens	-4.79 (2)				-9.49 (2)		-5.75 (1)	
		(-4.86 - -4.72)				(-10.47 - -8.51)			
Ixonanthaceae	Ixonanthes reticulata						-1.84 (1)		
Lauraceae	Alseodaphne coriaceae	-6.73 (1)							-7.30 (1)
	Cinnamomum sintoc	-3.56 (1)		-2.93 (1)		-9.06 (1)			
	Dehaasia caesia		-1.63 (3)						
			(-1.66 - -1.61)						
	Endiandra rubescens cf.					-2.98 (1)			

	Litsea ochracea cf.					-7.39 (1)	-1.34 (1)		
Meliaceae	Aglaia odoratissaima cf.					-0.74 (1)			
Moraceae	Artocarpus nitidus					-1.22 (1)			
	Ficus microcarpa								-4.53 (1)
Myristicaceae	Gymnacranthera eugeniiloria cf.					-0.69 (1)	0.01 (1)		
	Mirystica maxima					-4.34 (1)			
Myrtaceae	Eugenia chlorantha cf.						1.45 (1)		
	Syzygium borneense	-3.72 (4)		-2.99 (2)				-2.76 (1)	-2.65 (1)
		(-4.76 - -2.65)		(-3.20 - -2.78)					
	S. cerasiforme			-2.91 (1)					
	S. lepidocarpa			-0.25 (1)					
	S. rugosum	-3.57 (3)						-4.92 (1)	-3.40 (1)
		(-7.4 - -0.71)							
	Syzygium sp.	0.00 (1)						-2.00 (1)	
	Tristania whitiana						-1.34 (1)		
	Tristaniopsis obovata	-4.15 (6)						-4.11 (1)	
		(-4.59 - -3.21)							
Myrs	Ardisia elliptica?					-10.09 (1)			
Olacaceae	Strombosia ceylanica						0.61 (1)		
Polygalaceae	Xanthophyllum ellipticum		-0.13 (1)						
Polygonaceae	Xanthophyllum eurhyncum?					0.44 (2)			
						(-0.15 – 1.02)			
Rubiaceae	Ixora havilandii?					-6.45 (1)			
	Jackia ornate								-4.45 (1)
	Timouis flavescens					-2.07 (1)	-2.80 (2)		
							(-3.22 - -2.38)		
	Tetractomia obovata cf.					0.31 (1)			
Rutaceae	Acronychia porteri	-2.83 (1)	-2.77 (1)	-2.30 (1)					
	Tetractomia obovata cf.						-7.62 (1)		
Sapindaceae	Nephelium maingayi cf.						-2.38 (1)		
Sapotaceae	Isonandra lanceolata					-0.06 (1)			
	Madhuca motleyana			-4.09 (2)					
				(-4.19 - -3.99)					
	Nephelium maingayi							-2.39 (1)	0.06 (1)
	Palaquium cochlerifolium	-2.84 (1)							
	P. leiocarpum	-3.28 (3)	-2.13 (4)						
		(-4.40 - -1.80)	(-2.30 - -1.96)						
	P. ridleyii	-4.13 (2)						-4.92 (1)	
		(-6.63 - -1.62)							
	Payena endertii	-2.97 (1)							
Sterculiaceae	Heritiera albiflora					-3.30 (1)			
	Scaphium longiflorum					-3.13 (1)			
	Sterculia gilva			-2.56 (1)					
Tetrameristaceae	Tetramerista glabra	-3.73 (27)	-1.23 (3)	0.65 (4)	-2.43 (1)		-2.60 (1)	-1.85 (1)	
		(-5.86 - -2.29)	(-1.72 - -0.34)	(-0.08 – 1.44)					
Theaceae	Ternstroemia aneura?					-6.61 (1)			
Thymelaeaceae	Gonystylus bancanus	-3.46 (2)	-1.59 (1)	-1.31 (1)				-4.08 (1)	-0.48 (1)
		(-3.71 - -3.20)							
Tiliaceae	Pentace borneensis?						-1.07 (2)		
							(-1.65 - -0.49)		
Fern species									
Dennstaedtiaceae	Pteridium esculentum		-0.08 (4)		0.84 (7)				
			(-3.33 – 1.52)		(-2.3 – 1.53)				
	Lycopodium cernuum		0.32 (1)						
Nephrolepidaceae	Nephrolepis biserrata		-1.83 (1)		-3.41 (1)				
	N. pectinata		-2.52 (1)						
Polypodiaceae	Polypodium hirsutulum		-3.25 (10)		-0.85 (11)				
			(-5.06 - -2.84)		(-1.63 – 1.41)				

ACKNOWLEDGEMENT

We thank to Mrs. M. Akiho, Dr. A. Sugimoto at Center for Ecological Research, Kyoto University for their assistance of mass spectrometry.

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Preliminary Selection of Fast-growing Tree Species with Tolerance to an Open and Dry Tropical Peat Land in Central Kalimantan: To develop a preceding planting method

Hideyuki Saito[1)], Masato Shibuya[1)], Sehat J. Tuah[1,2)], Kunihide Takahashi[1)], Yahya Jamal[2)], Hendrik Segah[2)], Patricai Erosa Putir[2)], Suwido H. Limin[2)]

1) Graduate School of Agriculture, Hokkaido University, North-9, West-9, Kitaku, Sapporo 060-8589, Japan
2) CIMTROP, University of Palangka Raya, Jl. Yos Sudarso, Palangka Raya, 73112, Central Kalimantan, Indonesia
Corresponding author: Hideyuki Saito, Tel: +81-11-706-2523, Fax: +81-11-706-4176, E-mail: saitoo@for.agr.hokudai.ac.jp

ABSTRACT

Preceding planting tree species in open and dry tropical peat land needs to be fast-growing with tolerance to strong light, drought and high soil temperature conditions. In order to select some tree species for the preceding planting in Central Kalimantan, survivorship and height growth of naturally regenerated tree species were investigated on a top floor of canal bank made of peat soil. The top floor conditions were open, dryer soil moisture content and higher soil temperature conditions than the forest floor. The abundant tree species were Asam-asam (*Mangifera sp.*), Garunggang (*Cratoxylon arborescens*) and Tumih (*Combrecarpus rotundatus*). Their newly regeneration on the canal bank was confirmed during this investigation. Their mortality was very low. These results suggest that Asam-asam, Garunggang and Tumih have tolerance to strong light, drought and high soil temperature conditions in their germination and survivorship. The annual increment of the tree height of the abundances, Asam-asam, Garunggang and Tumih, was 189 to 232 cm, 118 to 289 cm and 27 to 255 cm per year, respectively. Therefore Asam-asam, Garunggang and Tumih are classified into fast-growing tree species. These results suggest that Asam-asam, Garunggang and Tumih is suitable as preceding plant tree species in the disturbed peat swamp land in Central Kalimantan.

Key words: fast-growing tree species, height growth, preceding planting, regeneration, survivorship, tolerance to open and dry land

INTRODUCTION

Tropical peat swamp forest in Central Kalimantan is nowadays one of the most threatened terrestrial ecosystems (Boehm and Siegert, 2001), in which the function is as not only timber production but also global carbon stores and reservoirs of biodiversity (Kobayashi, 1988; Adi Jaya et al., 2001). Since 1979, the peat swamp forest has been drained by many canals channeled between rivers, due to development of agriculture land (Adi Jaya et al., 2001). The agriculture, commercial logging and wildfire have disturbed the drained forest. The burnt forest and abandoned agriculture land are usually covered by herbs, ferns and/or climbers without natural tree species regeneration (Kobayashi, 1994; Kobayashi, 2000). Furthermore, those disturbances degrade the chemical composition of peat soil to low pH and lacking nutrition, where it is considered that the degraded soil conditions inhibit regeneration of trees toward the ecological and commercial-rich forest (Kobayashi, 1994; Kobayashi et al., 1996). Therefore it is necessary to accelerate the rapid rehabilitation after the disturbance. However, in the tropical peat swamp region of Central Kalimantan, no technique of afforestation has been developed yet.

In the case of the afforestation, commercially expensive and ecologically important tree species are usually expected. In Central Kalimantan, Dipterocarp is one of the candidates. However, it may be difficult to plant them in open land, because many species in Dipterocarp are generally believed to be strong light-intolerance. Probably they need underplanting for their establishment.

It is known that an available technique of the afforestation for the strong light-intolerant tree species is preceding plant method (Sasaki & Asakawa, 1994). The preceding plant method is to make a shading umbrella by fast-growing tree species with tolerance to open condition before the planting of the shade tolerance. In the Central Kalimantan, the ecological and physiological characteristics have not been classified, e.g. pioneer or late-successional species, and shade tolerance or shade intolerance. Thus, we need to find out some fast-growing tree species with tolerance to open and dry conditions. It is also necessary that they are native tree species to avoid a disturbance in biodiversity (Sugandhy, 1997).

Our aim is to select some tree species for preceding planting in open and dry peat land in Central Kalimantan. For the immediate selection without large-scale experiment, we focus on naturally regenerated tree species on an open ground floor of canal bank made of dug peat soil. The bank condition seemed to be the most stressful by the strong light, drought and high soil temperature, like the burnt and degraded peat swamp forest. It may be possible to consider that the regenerated tree species on the canal bank conditions have the tolerance to open and dry peat land and have potential as the preceding planting tree species. In this study, in order to clear the canal bank conditions are the stressful, the soil moisture and soil temperature in the bank floor were measured compared with forest floor. In order to select some fast-growing tree species with tolerance to open and dry peat land conditions, the tree species naturally regenerated on the canal bank condition was noted, and their survivorship and height growth were investigated. The availability of the preceding planting by the selected tree species is discussed based on their ecological and commercial characteristics.

STUDY SITE AND METHODS

The study site is located at Kalampangan canal in Palangka Raya, Central Kalimantan, Indonesia (2˚20'S, 114˚2'E). Annual average of air temperature in meteorological center in Parangka Raya airport was approximately 26 to 28˚ C during 1996 to 1999. Warm index presented by Kira (1977) was approximately 260 to 270.

A plot, 10 m by 50 m, was set on a top ground floor of a part of bank of Kalampangan canal in October 2000. The canal bank with 2m height above the ground level and 10 m wide of the top ground floor was made of the dug peat soil in 1995. During 1997, 1998 and 2002, the forest over the canal from studied bank was burnt, and in near side from the bank, the natural forest remained. On the top ground floor of the canal bank, isolated trees, shrubs, herbs and ferns have established themselves. All tree species growing in the plot were tagged for the identification, and the tree height was measured in October 2000, November 2001and November 2002, the beginning of the rainy season. In 2000, the tree density was 1540 per hectare, and the average of tree height was approximately 70 cm.

Environmental conditions of soil temperature and soil moisture in the experimental plot and understory of forest canopy near the plot were measured. The measurement was curried out in midday on a sunny day in October 2000 and November 2002. The soil temperature at the depth of 0.5 and 5 cm from ground level was measured by using thermometer (MF1000, Chino, Tokyo, Japan). The volumetric water content of soil at the depth of around 5 to 10 cm from ground level was measured by using FDR portable sensor (ML2x, Delta-T devices Ltd., Cambridge, England).

RESULTS

The top ground floor of canal bank was almost sunlit all day long in sunny day. The soil temperature at 5 cm depth in the open site was 34.0±1.0∞C, when the soil temperature on the floor of matured forest was 30.1±1.0∞C (Table 1). On the surface of the ground in the top of canal bank, 0.5 cm depth, the temperature reached to over 60∞C under sunlit conditions in the midday. The volumetric soil moisture content was 27.0±13.5%, while that on the forest floor was 47.4±8.1% (Table 1). The soil moisture of ground surface should be drier. Therefore, the environmental conditions of the open floor on the canal bank are stronger light, higher soil temperature, and lower soil moisture than shade understory conditions.

33 tree species occurred on the canal bank floor around the study plot out of 69 tree species identified in the area including the natural forest (data not shown). Tree species occurred in the study plot was shown in Table 2. The abundant tree species were Asam-asam (*Mangifera sp.*), Garunggang (*Cratoxylon arborescens*) and Tumih (*Combretocarpus rotundatus*) among 12 occurring tree species. They are native tree species in Central Kalimantan, and are usually found on the canal banks around

Table 1 Environmental conditions in a top floor of canal bank and forest floor.
Value denotes average±S.D. (n=6). Different letter in the shoulder of the value denotes significant difference (t test, p<0.05). The mesurements were carried out at 14:00 on 6 October 2000. Soil moisture was presented by volumetric soil moisture content estimated by FDR sensor.

	Canal bank	Forest floor
Soil moisture (%)	27.0±13.5[a]	47.4±8.1[b]
Soil temperature (˚C)	34.0±1.0[a]	30.1±0.8[b]

Value denotes average±S.D. (n=6). Different letter in the shoulder of the value denotes significant difference (*t* test, *p*<0.05). The mesurements were carried out at 14:00 on 6 October 2000. Soil moisture was presented by volumetric soil moisture content estimated by FDR sensor.

Table 2 Occurrence, regeneration and mortality of tree species on an open ground floor of canal bank.

Latin Name	Local Name	Number						
		Occurrence			Regeneration		Mortality	
		Oct. 2000	Nov. 2001	Nov. 2002	2000-2001	2001-2002	2000-2001	2001-2002
Adenanthera pavonina	Saga paya	1	1	1	0	0	0	0
Alseodaphne coriacea	Gemur	1	1	1	0	0	0	0
Combretocarpus rotundatus	Tumih	19	16	15	0	2	3	3
Cratoxylon arborescens	Garunggang	15	21	22	8	3	2	2
Elaeocarpus mastersii	Milas	2	1	0	0	0	1	1
Macaranga sp.	Mahang	0	0	0	0	1	0	0
Ploiarium alternifolium	Asam-asam	25	38	64	14	26	1	1
Sterculia sp.	Banitan	1	0	0	0	0	1	0
Sterculia sp.	Kayu kapas	1	1	0	0	0	0	1
Syzygium sp.	Katakau	1	1	0	0	0	0	1
Syzygium sp.	Jambu-jambuan	0	0	1	0	1	0	0
Syzggium spicata	Galamtikus	1	1	1	0	0	0	0

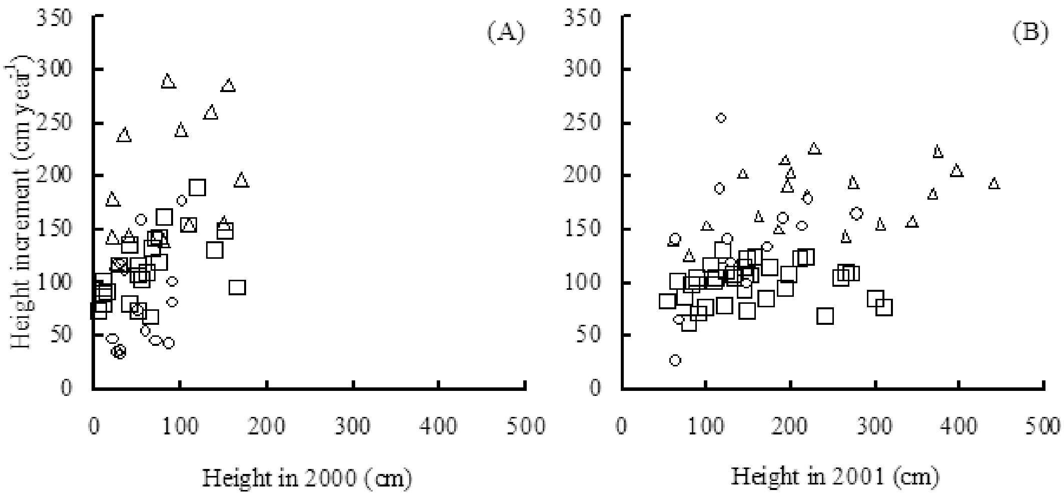

Figure 1. Relationship between tree height and annual increment of the tree height.

Panel (A) and (B) denotes the result from 2000 to 2001 and from 2001 and 2002, respectively. Symbole of square, circle and triangle denotes Assam-assam, Tumih and Garunggang, respectively.

Parangka Raya in Central Kalinantan according to our ground survey.

The newly regenerated tree species was Asam-asam, Garunggang, Jambu-jambuan (*Syzygium sp.*), Mahang (*Macaranga sp.*), Tumih for the investigating 2 years (Table 2). The number of Asam-asam, Garunggang, Jambu-jambuan, Mahang, Tumih was 30, 11, 1, 1 and 2 individuals per 500m^2, respectively. This result indicates that they can germinate on the canal bank conditions.

The most of the trees occurring in 2000 survived throughout the investigating 2 years (Table 2). The number of the mortality of Asam-asam, Garunggang and Tumih was 2, 4, 6 individuals for 2 years, respectively. Their high survivorships in the seedlings regenerated in 2001 were also found out in 2002 (Table 2). These results suggest that Asam-asam, Garunggang and Tumih have a tolerance to bank floor conditions in their survivorship after their germination.

The annual increment of the tree height of the abundant tree species, Asam-asam, Garunggang and Tumih, was 189 to 232 cm, 118 to 289 cm and 27 to 255 cm per year, respectively (Fig. 1). The height increment of Garunggang was the greatest among the abundant three species. Their height increment in the canal bank conditions was higher than understoried tree species in the matured natural forest (Masato Shibuya, unpublished data). Their height growth is also higher than *Shorea* species grown in approximately 30% full sun photosynthetically active radiation (Turner, 1989; Turner, 1990) and grown in sunlit conditions in dry land-plantation (Soda et al., 1997; Istomo et al., 1999). Thus it is considered that the three abundant tree species are classified into fast-growing tree species.

DISCUSSION

Three fast-growing tree species, Asam-asam, Garunggang and Tumih, with tolerance to open canal bank conditions were found out among the native tree species in Central Kalimantan (Table 2 and Fig.1). The environments of the open canal bank floor were drier in soil moisture and higher in soil temperature compared with forest floor conditions (Table 1). Furthermore, it appears that the environments on the canal bank were severe conditions for the regeneration and growth compared with the drained and burnt peat swamp forests in Central Kalimantan. Generally, high temperature and drought conditions inhibit the germination of seed, survivorship and growth of seedlings (Kozlowski & Pallardy, 1997). Therefore it is possible to evaluate that Asam-asam, Garunggang and Tumih have tolerance in their germination, survivorship and height growth under strong light, drought and high soil temperature conditions, and that they have potential as the preceding planting tree in the drained and disturbed peat swamp land.

According to Swaine and Whitmore (1988), tropical tree species may be classified into two distinct groups, which are pioneer and non-pioneer, based on seed germination and seedlings establishment requirements. They suggest that the seeds of pioneer species germinate only canopy gaps open to the sky, whereas the seeds of non-pioneer species can germinate only under canopy shade or in gaps. Our results generally agree that Asam-asam, Garunggang, Tumih, and the other tree species shown in Table 2, which can germinate and/or regenerate under open conditions, are classified into pioneer species.

Although Tumih is classified into pioneer species, Tumih constructs the dominance in matured peat swamp forest together with Dipterocarp species in Central Kalimantan (Sehat J. Tuah, personal communication). The Asam-asam and Garunggang construct as co-dominance within the forest canopy (Sehat J. Tuah, personal communication). Thus it appears that their large planting is lower risk to disturb ecologically and genetically compared with exotic tree species. On the other hand, the commercial price of Tumihís stem-wood is excessively cheaper as timber than Dipterocarpís stem-wood. However the Tumihís stem-wood has been traditionally used for timber of constructing house of local people. The stem-woods of Asam-asam and Garunggang have been traditionally used for fuel of local people, because they are fast-growing tree species with function of sprouting after the logging (Sehat J. Tuah, personal communication). The planting of Asam-asam, Garunggang, Tumih may contribute the timber and/or fuel-wood production for local people. Therefore, Asam-asam, Garunggang, and Tumih have not only ecological but also commercial advantages in their planting.

Their availability of germination in the open and dry condition suggests one additional advantage in their afforestation. That result suggests that it is successful to sow their seeds directly in the disturbed land, not planting the seedlings grown in the nursery. It is well known that the preparation, transporting and planting of the seedlings need very hard work with high cost. Furthermore, it is easy to collect their seed, because their seed production starts at young age and continues every year. If it is possible to sow their seeds directly in the disturbed land, therefore, it may be easy to develop the preceding plant method by using the direct sowing.

As a concluding remark, our results do not mean that the disappeared tree species in Table 2 are not the fast-growing tree species with the tolerances. The composition and abundance of the regenerated tree species on the canal bank depend on the composition of the natural forest and its seed supplying. In this study, it is not enough data to discuss the complete classification of the ecological characteristics of all tree species growing in Central Kalimantan. However it is enough information to select some tree species immediately which are suitable for the preceding planting. Therefore we propose that Asam-asam, Garunggang and Tumih, which are fast-growing tree species with tolerance to open and dry peat land condition, is suitable as preceding planting tree species in the disturbed peat swamp forest in Central Kalimantan.

ACKNOWLEDGEMENTS

Authors thank to Professors Hidenori Takahashi and Mitsuru Osaki in Hokkaido University for organizing this research project. Authors also thank to Dr. Shigeo Kobayashi in Forestry and Forest Products Research Institute for variable discussion. This study was supported by Core University Program sponsored by Japan Society for Promotion of Science.

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Session 2

SOIL ECOLOGY

Chaired by

Ryusuke HATANO & Syaiful ANWAR

Diversity and Ecological Perspective of Soil Yeast in Gunung Halimun National Park

Atit Kanti and I Made Sudiana
Research Center for Biology, Indonesian Institute of Science, Jl. Juanda 18 Bogor 16122.
Tel. 62-251-324006, Fax. 62-251-325854. E-mail: sudianai@yahoo.com

ABSTRACT

Gunung Halimun National Park is the last sub montane forest remained in Java. The present work is conducted to study the population of soil yeast at various altitude (600 m, 1000 m and 1500 m asl), and verifying its ecological role by isolating and characterizing its physiological properties on cellulose hydrolizes and mineralization phosphate. Isolated yeast from soil and rhizosphere sample were purified and tested their ability to grow and to utilize carboxymethyl cellulose as sole carbon sources, and to dissolve $Ca_3(PO_4)_2$. Increased population of soil yeast were observed at higher altitude. About twenty three isolates belonged to genera of *Debaryomyces*, *Pichia, Rhodotorula* and *Candida* were isolated from soil. Nineteen strains have cellulolyitic capacity and 12 strains have ability to dissolve $Ca_3(PO_4)_2$. Yeast were common found in soil and rhizosphere, and they appear to play role on the bio-transformation of organic materials and mineralization phosphate in soil.

Key words: soil yeast, Debaryomyces, Pichia, Rhodotorula and Candida

INTRODUCTION

The GHNP is one of the most conserve forest ecosystems in tropical area with a high diversity of flora and fauna. Though there is incomplete scientific justification, but it is believe that high species richness of flora and fauna is also relevant to that of high microbial diversity

Recently there is growing interest on studying the ecological perspective of yeast in soil ecosystem. It is known that terrestrial yeast is most abundance in plant, animal and soil, but our understanding on its significant ecological influence in its habitat is limited. Wickerman was the pioneer in identification of yeast in 1951, and and Alexander,1961, reported a wide variety of yeast encountered in soil include *Candida, Crytococcus, Debaryomyces, Hansenula, Lipomyces, Pichia, Pullularia, Rhodotorula, Saccharomyces, Schizoblastoporion, Torula, Torulasspora, Torulopsis, Trichosporon* and *Zygosaccharomyces*. Since that the knowledge in yeast taxonomy has growth rapidly, as shown by the increase of identified species tremendously from 500 species to 700 species (Kurzman, 1998). Since the yeast grow readily at pH 4.0, no difficulty is encountered in the enumeration of yeast, and most of the bacteria and fungi could not grow well at low pH. Enumeration of yeast in the presence of the large number of filamentous fungi common to soil, on the other hand is difficult because the later proliferate more readily and tend to overgrow the former. However a medium at pH 3.8 to 4 which contains 0.35 % sodium propionate suppress both the bacteria and mold so that yeast count can be made. The abundance of these organisms varies greatly with the locality understudy. Yeast play role together with other soil microorganism accelerating nutrient cycle. As a decomposer yeast often perform as a fermentative glycolyses, but rather restricted in the nature of the carbon source they may assimilate. They produce extracellular enzyme such as proteinase, cellulase, chitinase and amylase (Anna, 1990). But not many intensive studies conducted to verify which species yeast is ecologically essential and play significant role on ecosystem sustainability. Recently scanning electron microscope (SEM) have been successfully helping taxonomist to look into deeper morphological characteristic of yeast, and here with SEM is used to observe *in-situ* morphological characteristic of soil yeast

MATERIAL AND METHODS

Yeasts isolation

Soil, and rhizosphere soil was collected from several study sites located at GHNP (600 m, 1000 m, and 1500 m) asl. Pre-cultivation was undertaken by shake culture after transferring 10 g of sample into yeast nitrogen base 6.7%, yeast extract 0.1%, malt extract 0.1%, and glucose 20% (pH 6.8). The cultures were then incubated on rotary shaker for three days at 30 ˚C. Isolation was done by plate count methods with three replicates. The isolation medium consisted of yeast extract (3g/L), malt extract (3g/L), bacto peptone (5g/L), glucose (10g/L), agar (20g/L), 0.2% dichloran solution and streptomycin (100U/L), pH 3.7. Cultivation of isolates were performed at 25 ˚C for three days.

Purification

Prior to use, each strain was streaked onto Yeast malt extract agar (YM agar) pH 6.5. This followed by incubation at 25 ˚C for 48 hour. Single well-separated colonies of each form are selected and restreaked onto the same media and reincubated. Twice is generally sufficient to obtain pure culture. After 2 days, the colonies were examined using phase contrast microscope for homogeneity. Homogenous strains were then grown in Yeast malt extract broth, and preserved.

Identification of yeasts

The yeast strains were tested for their characteristics of vegetative reproduction, sexual characteristics, physiological and biochemical characteristics as described by Barnett *et al*.,(1990) and Kurtzman *et al*., (1998).

Morphology of vegetative cells

Yeast cells can be globose, subglobose, ellipsoidal, ovoidal, cylindrical, botuliform, bacilliform, apiculate, lunate or triangular. Definition and illustrations of the various possibilities can be found in Ainsworth and Bisbyís Dictionary of the fungi (Hawksworth *et al*., 1995).

Formation of ascospore

Sporulation studies were performed using modified YM agar and Kowado agar containing (Potassium acetate 1.5%, Glucose 0.02%, glutathion 10mM, and agar 2%). Strain from 48 hour growing slant were streaked to the above-mentioned sporulation media, then incubated at 25 ˚C for 3 days, and examined for the presence of ascospores. Morphological observation of ascospore was also conducted by scanning electron microscope (SEM).

Utilization of carbon compounds

The carbohydrates employed in the assimilation tests included D-glucose, D-galactose, D-xylose, L-arabinose, D-arabinose, L-rhamnose, sucrose, maltose, me-a-D- glucoside, cellobiose, melibiose, lactose, raffinose, melezitose, inulin, starch, erytritol, xylitol, D-mannitol, 2-keto-D-gluconate, D-gluconate, D- glucuronate and citrate. The assimilation media were inoculates with 0.1 ml of a suspension of 2-day-old YM slant culture, and then the tubes were incubated at 25 ˚C. The tests were done on the continuously rotating shaker at 160 rpm, and examined for turbidity during 2 weeks.

Assimilation of nitrogen compounds

The following of nitrogen source are used : potassium nitrate, sodium nitrite, cadaverine dihydrochloride, L-lysine, and glucosamine.

The assimilation media were inoculated with 0.1 ml of a suspension of 2-days-old YM slant culture. Growth was observed after 1 week of incubation at 25 ˚C in rotary shaker. When sign of growth is detected, a second tube was inoculated with one loopful from the first to reconfirm the test result.

Observation of soil yeast by SEM

About 0.5 g soil sample were added with 1 ml cold ethanol for about 1 h, and remove the alcohol and replace it with 2.5 % glutaraldehyde solution for several hours or more at 4 ˚C. Immerse the material into 2 % tanic acid solution for 6 hours at 4 ˚C. Sample washed with buffer for 15 minutes at 4 ˚C, and repeat it 4 times. Immerse into 1 % OsO_4 solution for 3 h at 4 ˚C, and water washed for 10 minutes, and this procedure was repeated 3 times. Gradient dehydration with 50 % , 75 %, 87.5 % ethanol at 4 ˚C, each step was conducted for 20 minutes. Final dehydration with alcohol absolute for 20 minutes at room temperature. The sample was glued on stab, and coated with gold platinum. Observation was conducted using SEM at 5000 x magnification.

Celulolyitic ability. All strains were grown on 1 % CMC containg media (Enari, 1983) and the media was added with 0.1 % congored. Clearing zone formation around growing colony was an indication of cellulolyitc activity (Joson and Coronel, 1986). After 5-day incubation cellulolyitic ability was determined, the ratio the are of clearing zone to colony was calculated**.**

Phosphate dissolving ability *S*train were grown in Pivoskaya medium contained : 5 g l^{-1} $Ca_3(PO_4)_2$ l^{-1} , 10 g l^{-1} glucose, 0.2 g l^{-1} NaCl, 0.2 g l^{-1} KCl, 0.0025 g l^{-1} $MnSO_4.H_2O$, 0.1 g l^{-1} $MgSO_4$ $7H_2O$, 0.0025 g l^{-1} $FeSO_4$ $7H_2O$, 0.5 g l^{-1} yeast extract. Formation of clear zone around growing colony indicate $Ca_3(PO_4)_2$ dissolution.

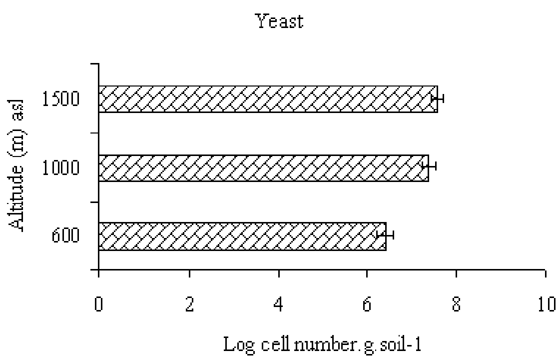

Figure 1. Yeast population in soil.

RESULT AND DISCUSSION

Yeast in soil is dominated by several genera include *Debaryomyces*, *Pichia, Rhodotorula* and *Candida*, which belonged to group imperfect yeasts (*Candida* small globose, *Candida* big globose), Ascomycetous yeasts (*Debaromyces*, *Pichia*) and Basidiomycetes yeasts (*Rhodotorula*). Highest population was observed in 1500 m asl. Altitude appear to affect yeast population and its diversity of Ascomyceteous, Basidiomyceteus and imperfect yeast. Higher population at higher altitude could be due to high acidity of soil at higher altitude (Rahmansyah *et al*., 2002), and yeast is preferable at lower pH, while growth of other organism is suppressed.

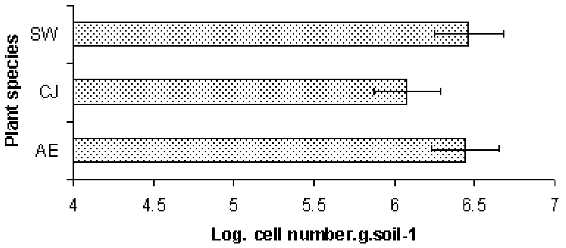

Figure 2. Population of yeast in rhizosphere of *Altingia excellsa* (AE), *Schima wallichii* (SW) and *Castanopsis javanica* (CJ)

Rhizosphere yeast

The population of Rhizosphere yeast was about 275000 till 290000 colony per g.rhizosphere soil. There is no significant different the number of yeast in rhizosphere of *Altingia excellsa*, *Schima wallichii*, and *Castanopsis javanica* (Figure 2). They belonged to genera *Debaryomyces*, *Pichia, Rhodotorula* and *Candida*.

Ecological importance

A wide range distribution of yeast in ecosystem suggest that yeast may create special physical or biochemical mechanism by which they success occupy and sustain maintaining its habitat (Photo 1). In-situ morphological observation of soil yeast appeared yeast devise itself with capsule for physical protection. In the mineral soil horizons, oligothrophic capsule forming yeast occurred. They were not pigmented and were often able to accumulate lipids (Kurzman, 1998).

The existence of yeast that is repeatedly and exclusively from soil, such as *Lypomyces* sp, *Debaryomyces* and certain species of *Cryptococcus* suggest that some habitat specificity may be at play. Some genera of yeast usually found in soil such as *Candida* and *Debaropyomyces* and the presence of yeast usually in accordance with and cellulose decomposition bacteria and soil fungi (Cook, 1958). These all suggested that yeast plays role in acceleration of carbon mineralization and indirectly stimulate element mineralization. But our understanding on which species yeast accelerate transformation of organic substances and which catalyze solubilization of mineral phosphate is still limited. To understand which yeast dissolve phosphate and or hydrolyze cellulose, pure culture of isolated yeast were tested its physiological properties in phosphate mineralization

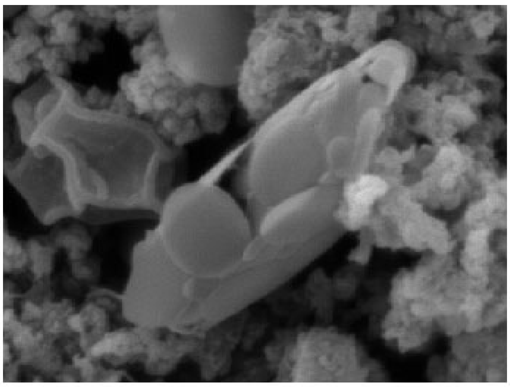

Photo 1. Capsule forming yeast(SEM 5000x)

Cellulolytic capacity

Hydrolyses of cellulose take place due activity of a complex of cellulase enzymes, and some yeast posses that enzymes system. Yet, documentation on the presence of celulolytic yeast in soil is rare. On other hand occurrence of yeast in soil is common (Kurzman, 1998). The presence of soil microflora possessing cellulolyitc enzymes ensure degradation rate of organic material in soil occur at appreciable rate.

Table 1. Cellulolytic capacity of soil yeast after 4 days incubation in cytophaga media

No	Name of species	-/+	Ratio of clear zone
1	S 1 (*Debaryomyces hansenii)*	+	2,5
2	S6 (*Debaryomyces hansenii)*	+	3,6
3	S11 (*Candida* sp)	+	2,5
4	S13 (*Candida sp*)	+	1,8
5	S14 *(Debaryomyces* sp)	+	2,1
6	S16 (*Candida* sp)	+	2,3
7	S 7 (*Pichia membranifaciens*)	+	2.4
8	S8 (*Candida* sp)	+	2.2
9	S 9 (*Candida* sp)	+	2.1
10	S10 (*Candida* sp)	-	Nd
11	S11 (*Candida* sp)	+	2.3
12	S22 (*Candida* sp)	-	Nd
13	S23 (*Rhodotorula minuta*)	+	3.8
14	S24 (*Candida* sp)	+	2.2
15	S25 (*Candida* sp)	+	2.4
16	S26 (*Candida* sp)	-	Nd
17	S27 (*Candida* sp)	+	2.4
18	S28 (*Candida* sp)	+	2.6
19	S29 (*Candida* sp)	+	2.1
20	S30 (*Candida* sp)	+	2.9
21	S31 (*Candida* sp)	+	2.3
22	S32 (*Candida* sp)	+	2.5
23	S33 (*Candida* sp)	+	2.6

Out of 23 isolates testes 19 isolates were able to hydrolyze CMC. Not much report has quantified the ability of yeast to hydrolyze cellulose. Complete degradation of cellulose were executed by cellulase complex enzyme system include exo-b-1,4 glucanase, endo—b-1,4 glucanase, b-glucosidase (Enari, 1983). Hydrolyzes of CMC indicate the activity of endo—b-1,4 glucanase (Enari, 1983). In soil yeast may collaborate and co-exist among the soil microflora component, and its presence may significantly contribute to bioconversion of organic material in soil. The complexity of cellulose molecule of plant origin may affect cellulose degradation rate. Yeast together with fungi and bacteria may produce different cellulose enzyme system and the presence of that organism in soil accelerates decomposition of organic material in soil. And the activity of those complex enzyme is significantly affected by the nature of soil ecosystem include species composition, soil humidity, temperature, the presence inhibitor/stimulator, pH temperature, aeration status and redox potential state of existing environment.

Phosphatase activity

Most of the strain tested solubilize $Ca_3(PO_4)_2$ (Table 2) indicating that they play on mineralization of phosphate in soil. Soil is a source of nutrient and micro and macro element for microorganism and plant growth. Phosphorous is essential element required by microorganism for nucleotide synthesis and for plant photosynthesis (Tisdale *et al*., 1985). Most soil P is unavailable since it is bound to macro element such as $Ca_3(PO_4)_2$, rock phosphate and to organic substances. Most soil consists of organic and inorganic phosphorous. The quantity of inorganic phosphorous in soil mineral is higher than that of organic phosphorous i.e., about 25-90 % of the total soil-P. However in organic soil the quantity of organic-P is in the range of 50-90% (Cosgrove, 1967). The major constituent of organic-P is phytin and inositol. Phytic acid is representing about 60 % of the total phosphorous in soil and mostly accumulated in soil since it is less soluble (Anderson, 1988). The upper layer soil contained more organic-P than subsequent layer.

Soil-P species is mostly pH dependent, and ionic phosphorous is mostly in the form of $H_2PO_4^-$, HPO_4^{2-}, and PO_4- , it is formed from ionization of $H_3PO_4^-$. Ion $H_2PO_4^-$ is easier absorbs by plant. The optimal pH for phosphorous ionization is

Table 2. Clearing formation after 7 days incubation in Pivoskaya

No	Name of species	Phosphatase	Ratio of clear zone
1	S 1 (*Debaryomyces hansenii)*	-	-
2	S6 (*Debaryomyces hansenii)*	-	-
3	S11 (*Candida* sp)	-	-
4	S13 (*Candida sp*)	+	1,8
5	S14 *(Debaryomyces* sp)	+	3.2
6	S16 (*Candida* sp)	-	-
7	S 7 (*Pichia membranifaciens*)	+	2.1
8	S8 (*Candida* sp)	+	2.0
9	S 9 (*Candida* sp)	+	2.1
10	S10 (*Candida* sp)	+	Nd
11	S11 (*Candida* sp)	-	-
12	S22 (*Candida* sp)	-	-
13	S23 (*Rhodotorula minuta*)	+	3.2
14	S24 (*Candida* sp)	+	1.9
15	S25 (*Candida* sp)	-	-
16	S26 (*Candida* sp)	-	-
17	S27 (*Candida* sp)	+	1.9
18	S28 (*Candida* sp)	-	2.2
19	S29 (*Candida* sp)	+	2.4
20	S30 (*Candida* sp)	-	-
21	S31 (*Candida* sp)	+	2.1
22	S32 (*Candida* sp)	+	2.3
23	S33 (*Candida* sp)	-	-

near neutral value and slightly acidic. The presence of soil ionic macroelement such as Fe, Al, Ca and Mn, amount and decomposition stage of organic substances affect solubility of inorganic phosphorous (Brady, 1974).

CONCLUSION

A wide diversity of soil was encountered in GHNP, they belonged *Debaryomyces*, *Pichia, Rhodotorula* and *Candida,* and 19 strain were cellulolytic yeast and 13 isolates were able to solubilize phosphate implying that they have significant role in element mineralization and conversion of organic substances

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Cellulolytic Capacity of *Cellulomonas* sp . Isolated from Peat Soil of Central Kalimantan

I Made Sudiana
Research Center for Biology, Indonesian Institute of Science
Jl. Juanda 18 Bogor 16122, Tel. 62-251-324006, Fax 62-251-325854,
e-mail sudianai@yahoo.com

ABSTRACT

Using Carboxymethyl cellulose as the sole carbon source eleven bacterial species were isolated from peat soil of Central Kalimantan. Five strains were cellulolytic, of those isolates the characteristic of cellulolytic capacity of 1 strain that has highest clear zone to colony ratio its cellulase enzymes was further studied. On the bases of its morphological and physiological characteristic the isolates was belonged to *Cellulomonas* sp. The strain rapidly utilize *carboxymethyl* cellulose as the sole carbon sources at 30 ˚C, with a specific growth rate was 0.319 h^{-1} for glucose augmentation and 0.274 h^{-1} for without glucose augmentation. Whereas Avicell was utilize slowly. CMCase and Avicellase actitvity were 8.2 unit, and 5.9 unit respectively. Glucose augmentation stimulate biomass growth but repress enzyme activity. Km and Vmax of CMCase were 6.25 mM and 15.64 mM.h^{-1} respectively.

Key words: cellulolytic bacteria , Cellulomonas and peat soil

INTRODUCTION

The natural peat contains a considerable number of microorganisms. Owing to its high acidity of peat fungi are encountered to be dominating microflora. Other microorganism such as actinomycetes and bacteria also community member of peat microbes which have been found adapted to this extreme habitat. Peat varies in its chemical and consequently also in its microbiological composition. The microflora of peat consists of a small number of genera and species only. Most of the organisms present are in a dormant or resting state. The microbial activity in bogland is very small and slow. The entire situation is completely changed when the peat is harvested by milling and piled. The more decomposed, humified and carbonised the carbon material in peat, the smaller the content of utilisable compounds and less available they become for microbes. The poorer the quality of peat with regard to its use as fuel, the higher are the figures for microorganisms as obtained by the plate count method. Poor quality is equivalent to low decomposition. Poor peat still contains organic matter which can be used by microorganisms. It has been demonstrated that the less-decomposed layers of high moor contain more hemicelluloses and celluloses than the well-decomposed ones. We can conclude from this that a microbial activity is quite well evolved in less-decomposed peat, this is particularly obvious when remains of the surface layer with root residues are mixed into the peat.

Microflora has a major contribution on the degradation of organic substances in soil. Peat Bacteria are the most second abundant of soil microflora after fungi. Their population is mostly governed by the soil organic content. The sources from which an organism derives its cell-C and energy are useful for describing basic physiological differences among bacteria. Peat composed dominantly by plant materials of which cellulose materials are the major component. Those substances should be hydrolyzed by complex of microorganism, which perform various metabolic patterns.

Aerobic cellulolytic bacteria (ACB) in soil and other environment are quite heterogeneous (Eberson et al., 200; Coughlan and Meyer, 1992; Hiroki and Watanabe, 1996; Gall et al., 1997; Bélaich et al., 1997) and play important role in nutrient cycle (Hiroki and Watanabe, 1996; Verhoven et al., 1983). Other soil microflora like yeast also contribute on the decomposition of organic material in soil (Hatano et al., 1991; Nakase et al., 1994). Forest in Indonesia are of special significance because they form one of the main natural resources and contribute substantially to the national economy through wood, medicinal plant, rotton, and spot for ecological tourism.

Present studies have indicated that cultivable ACB in peat soil are quite heterogeneous both physiologically and morphologically. It has been reported that soil microbes phylogenetiacally consist of quite diverse Eubacteria belonging to sub class of gram negative *Proteobacteria*, gram positive low GC, and high GC DNA content, *Cytophaga* group and many others. A few works have been devoted on studying of cultivable ACB (Coughlan and Meyer, 1992; Hiroki and Watanabe, 1996).

Our present study are trying to isolate diversity of ACB in peat, and to quantify the endo-1,4-β-D-glucanase activity, and determine the characteristic of biomass and pH profile during bacterial growth.

MATERIALS AND METHODS

Media and strains bacteria isolation

Soil samples (1 g dry weight basis) were suspended in 100 ml sterile distilled water by magnetic stirring (500 rpm, 5 minutes) in other to establish dilution series. Replica aliquots (1 ml) were over poured and dispersed by swirling with modified cytophage medium containing $(NH_4)_2SO_4$ 1g, $MgSO_4$ 0.1g, $MnSO_4$ 0.1g, yeast extract 1g, $FeCl_3$ 0.01 g). The medium was adjusted to pH 4.8 prior to autoclaving. Agar plates were incubated for 28 ˚C for 3 to 7 day. The density of culturable cellulolytic yeast was assayed on modified cytophage medium containing 1 % carboxymethyl cellulose (CN-cellulose). After suitable incubation time 5 d, 28 ˚C, congo red was used as an indicator for the detection and enumeration of cellulolytic colonies, as described by Mullings and Parish (1984). For the isolation of cellulolytic yeast, randomly chosen colonies were transferred to modified cytophage, subsequently incubated (3-5 d, 28 ˚C) and finally tested for cellulolytic activity as described above.

Identification

Bacteria identification was done follow Holt et al., 1994.

CMC-ase producing ability

To study the effect of glucose augmentation on cell and enzymes synthesis, 0.1 g glucose was augmented to 1 liter medium, and for control no glucose was added.

Growth on Avicell

The bacteria was cultured on cytophage modified medium namely substituting 1% CMC with an equal amount of *Avicell* with addition or without addition of glucose.

Quantitative determination of CMC

The strain was cultured in liquid modified cytophage medium at 30 ˚C for 4 days, the enzyme activity was determined 0 h, 24 h, 4 days incubation, and its CMCase activity was determined follow Hatano et al., 1991, expressed in unit i.e. mmol glucose equivalent produced. minute^{-1}. ml enzyme^{-1}.

pH determination

Profile of pH during culture growth was determined using pH meter

CMCase determination

A twenty fourth aged culture (5 ml) grown on modified cytophage medium, was inoculated into 100 ml CMC containing media with and without addition of 0.1 g/l glucose, and the culture was observed at interval of 2 h, and its CMC-ase activity was determined follow Joson and Coronel, (1986) expressed in unit i.e. mmol glucose equivalent produced.minute^{-1}. ml enzyme^{-1}.

Km and Vmax

Substrate concentration affect of enzyme activity rate. Km was calculated by analyzing the enzyme activity at various substrate concentrations, and plotted follow the Michaelis Menten equation and further analyzed by Lineweaver-Burk confronting the value of 1/S and 1/V

RESULT AND DISCUSSION

Isolation and identification

Out of 11 strains isolated only 5 strain formed clear zone (Table 1) of which *Cellulomonas* sp was has the highest ratio colony to clear zone Kim 1995 recognized that *Bacillus circulan* has high cellulolytic capacity. Whereas Blackal, 1985 noted that several member of genus *Cellvibrio* are cellulolytic.

Table 1. Cellulolytic ability of ACB 4 days incubation in cytophaga media

No	Name of species	Ability	Ratio of clear zone vs colony
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3	*Bacillus* sp	+	2.6
4	*Bacillus* sp	+	1.9
5	*Bacillus* sp	+	1.7
6	*Bacillus* sp	+	1.5
8	*Bacillus* sp	+	1,3
9	*Pseudomonas* sp	+	1.2
10	*Pseudomonas* sp	-	nd
11	*Bacillus* sp	-	nd

Biomass growth

Glucose rapidly, and they easily converted into biomass as indicated by a rapid increase of cell density (Figure 1). Appear less cell synthesis was observed in media with CMC as the sole carbon source. Denis, 1971 observed that culture

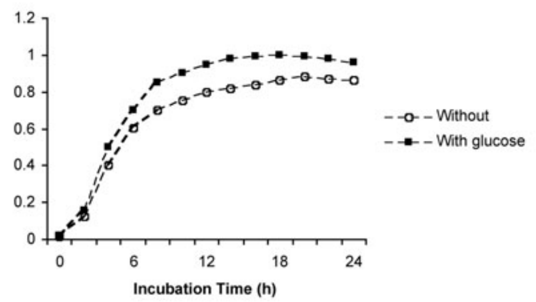

Figure 1. Profile of cell growth of *Cellulomonas* sp in cytophage medium with or without glucose

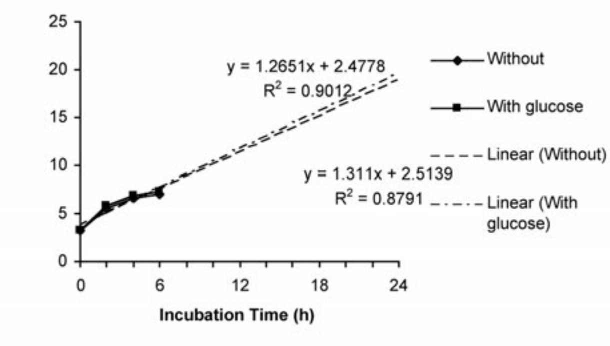

Figure 2. Specific growth rate of *Cellulomonas* sp in cytophage medium with or without glucose

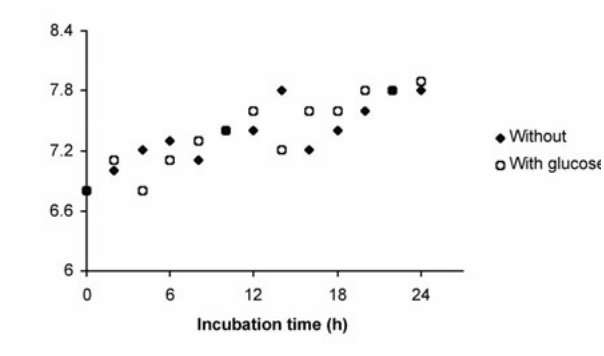

Figure 3. pH profile of culture grown in cytophage medium Activity of endo-1,4-b-D-glucanase (CMC-ase)

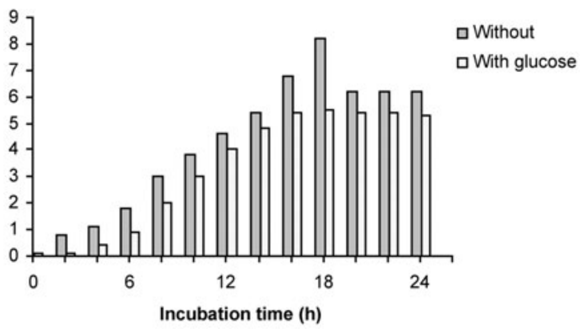

Figure 4. Profile of CMCase activity of *Cellulomonas* sp in cytophage medium with or without glucose

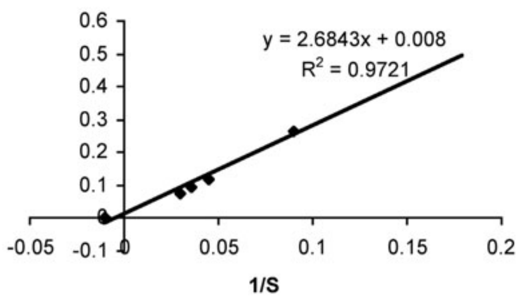

Figure 5. Kurva Lineweaver-Burk, as a substitution of Michaelis Menten for determination of Km and Vmax

growth is concomitant with enzymes synthesis.

A complex of cellulase enzymes act upon organic substrate in peat leading on degradation and mineralization of organic materials. Most of organic materials in peat is of plant origin, and its biodegradation rate is affected by cellulose type. Our present study have indicate that *Cellulomonas* sp has capacity to hydrolize carboxymethyl cellulose. The later substance is used to determined endoglucanase activity (Enari, 1983). The degradation rate of carboxymethyl cellulose is affected by glucose addition (Figure 4). In most cases, during cell cultivation, addition of glucose seem to have lower CMCase activity. Maximum enzymes activity was 6.0 unit for CMC as the sole carbon source observe after 18h incubation at pH 7, whereas at pH 6 and 8 CMCase activity was less than that of pH 7 (Figure 3 and 4). Those indicate that enzymes synthesis was pH dependent.

Km and Vmax

Substrate concentration affect of enzyme activity rate. Km was calculated by analyzing the enzyme activity at various substrate concentrations, and plotted follow the Michaelis Menten equation and further analyzed by Lineweaver-Burk confronting the value of 1/S and 1/V (Figure 5). Km value was 6.25 mM and Vmax was 15.64 mM.h^{-1}

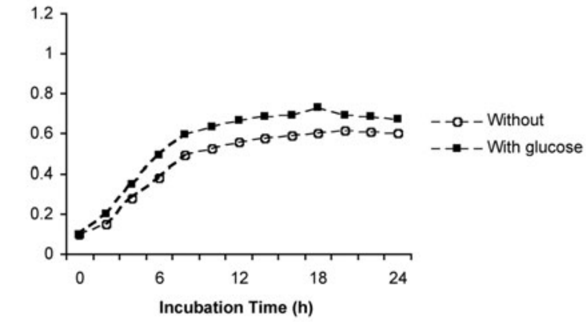

Figure 6. Profile of cell growth of *Cellulomonas* sp in Avicell augmented cytophage medium with or without glucose

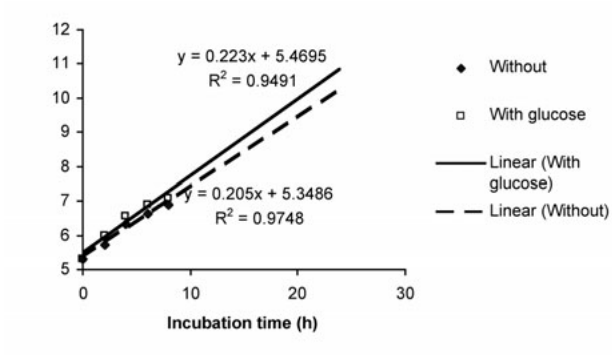

Figure 7. Specific growth rate of *Cellulomonas* sp in Avicell augmented cytophage medium with or without glucose

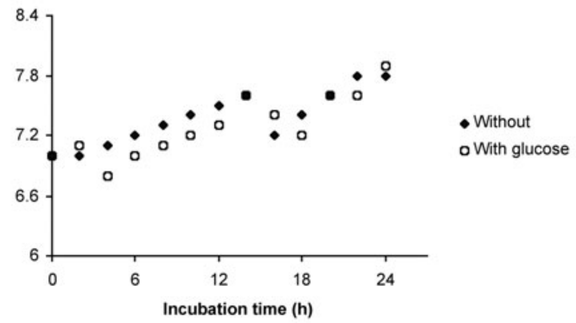

Figure 8. pH profile of culture grown in Avicell augmented cytophage medium

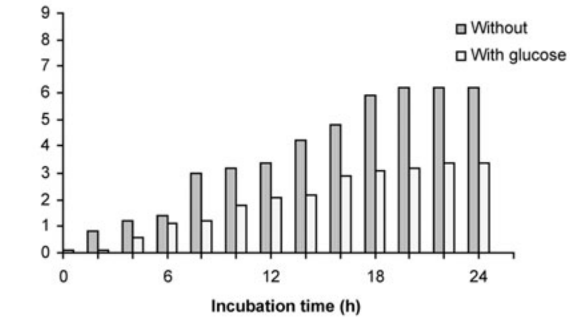

Figure 9. Profile of CMCase activity of *Cellulomonas* sp in cytophage medium with or without glucose

Growth on *Avicell*

Ability cell to grow on Avicell as a sole carbon sources and to produce Avicellase of was observed every . Compared to CMC, Avicell is less suitable for culture growth than that of CMC (Figure 6) indicating that the strain produce less of exo-1,4-β-D-glucanase, C1, (Enari, 1984). Addition of glucose has positive effect on the bacterial growth indicating that the bacteria preferantially utilize glucose as C-source than *Avicell*

Profile of pH

Decreased of pH was observed at the beginning of incubation but then increased after 1 d incubation (Figure 8). The reason for this is unclear, it supposed that degradation of Avicell (crystaline cellulose) occur slowly, and glucose was converted into organic acid, as s reported by Holt et al., 1994. Many factors affect pH of culture such as degradation of protein may have result in basic aminoacid release into bulk solution, complex enzyme and substrate, the presence of inhibitor and culture age (Malik and Singh, 1980).

ACKNOWLEDGEMENT

The authors thank JICA for research grant and Mr. Maman Rahmansyah for fruitfull suggestion to the manuscript.

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Characteristic of CMCase of *Bacillus* sp Isolated from Soil of Gunung Halimun National Park

I Made Sudiana
Research Center for Biology, Indonesian Institute of Science
Jl. Juanda 18 Bogor 16122, Tel. 62-251-324006, Fax 62-251-325854,
e-mail sudianai@yahoo.com

ABSTRACT
Eight bacteria strains were isolated from soil of Gunung Halimun National Park was taxonomically and physiologically studied. Eight strains were cellulolytic, and 1 strain that has highest clear zone to colony ratio was its cellulase enzymes was studied. On the bases of its morphological and physiological characteristic the isolates was belonged to *Bacillus* sp. The strain rapidly utilize *carboxymethyl* cellulose as the sole carbon sources at 30 ˚C, with a specific growth rate was 1.71 d^{-1}, 1.58 d^{-1} and 1.50 d^{-1} at pH 6, 7 and 8 respectively. No significant growth was observed when Avicell was used as sole Carbon sources. CMCase and activity in bulk solution maximum 6 Unit was observed when pH of substrate at the beginning of incubation was adjusted to 7, after 4 days incubation. Maximum cell growth was observed after 4 days incubation. Glucose augmentation stimulate biomass growth but repress enzyme activity. Km and Vmax of CMCase were 10 mM and 2.68 mM.d^{-1} respectively.

Key words: cellulolytic bacteria , Bacillus sp, Gunung Halimun National park

INTRODUCTION

Bacteria are the most second abundant of soil microflora after fungi. Their population is mostly governed by the soil organic content. The sources from which an organism derives its cell-C and energy are useful for describing basic physiological differences among bacteria. The soil organic substances composed dominantly by plant materials of which cellulose materials are the major component. Those substances should be hydrolyzed by complex of microorganism, which perform various metabolic patterns.

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Ecologically the ACB play key central role on the organic carbon turned over in soil which turn have a crucial impact on nutrient availability to plants (Hiroki and Watanabe, 1996). In addition to the later case, conservation of forest ecosystem in relation with green house gas management is a becoming a global issue. Characteristic of microbial biomass of ACB and its activity must be further investigated to fully understand soil C turned over and nutrient dynamic of several ecosystem type of wetland ecosystem. It is also worth to explore the economic potential use of tropical bio-resources. Collecting, studying and depositing of cultivable ACB are worth effort since natural destruction is occurring at alarming stage. Though quantification of the rate of extinct of microbes have not been investigated intensively, but many microbiologist believe that measures on ex-situ conservation should be conducted as soon.

Our present study are trying to quantify the endo-1,4-β-D-glucanase activity, and determine the characteristic of biomass growth and profile of pH during bacterial growth.

MATERIALS AND METHODS

Media and strains bacteria isolation

Soil samples (1 g dry weight basis) were suspended in 100 ml sterile distilled water by magnetic stirring (500 rpm, 5 minutes) in other to establish dilution series. Replica aliquots (1 ml) were over poured and dispersed by swirling with modified cytophage medium containing $(NH_4)_2SO_4$ 1g, $MgSO_4$ 0.1g, $MnSO_4$ 0.1g, yeast extract 1g, $FeCl_3$ 0.01 g). The medium was adjusted to pH 4.8 prior to autoclaving. Agar plates were incubated for 28 ˚C for 3 to 7 day. The density of culturable cellulolytic yeast was assayed on modified cytophage medium containing 1 % carboxymethyl cellulose (CN-cellulose). After suitable incubation time 5 d, 28 ˚C, congo red was used as an indicator for the detection and enumeration of cellulolytic colonies, as described by Mullings and Parish (1984). For the isolation of cellulolytic yeast, randomly chosen colonies were transferred to modified cytophage, subsequently incubated (3-5 d, 28 ˚C) and finally tested for cellulolytic activity as described above.

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Profile of pH during culture growth was determined using pH meter.

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RESULT AND SISCUSSION

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Out of 8 strains isolated only 5 strain formed clear zone (Table 1) of which *Bacillus* sp was has the highest ratio colony to clear zone Kim 1995 recognized that *Bacillus circulan* has high cellulolytic capacity. Whereas Blackal, 1985 noted that several member of genus *Cellvibrio* are cellulolytic.

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7	*Bacillus* sp	-	nd
8	*Clostridium* sp	-	nd

Biomass growth
Glucose rapidly, and they easily converted into biomass as indicated by a rapid increase of cell density (Figure 1). Appear less cell synthesis was observed in media with CMC as the sole carbon source. Denis, 1971 observed that culture growth is concomitant with enzymes synthesis. 1.71 d^{-1}, 1.58 d^{-1} and 1.50 d^{-1} at pH 6, 7 and 8 respectively (Figure 2).

Activity of endo-1,4-b-D-glucanase (CMC-ase)
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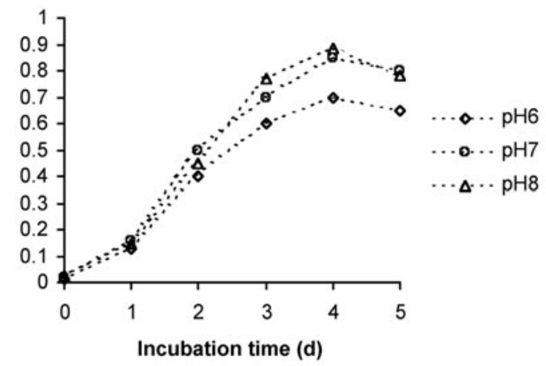

Figure 1. Profile of cell growth of *Bacillus* sp in cytophage medium at various pH

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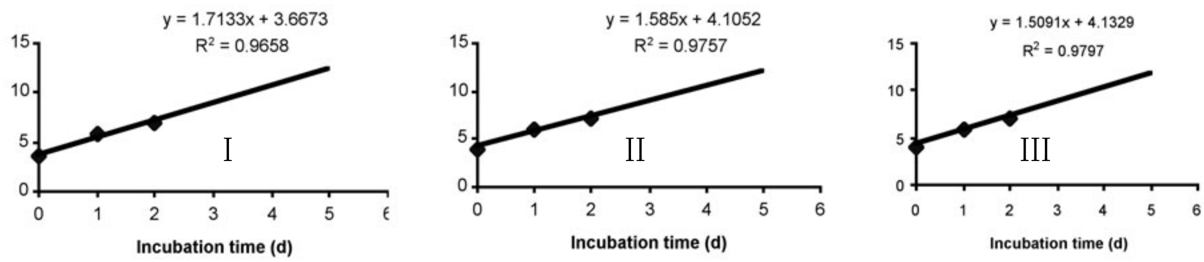

Figure 2. Specific growth rate of *Bacillus* sp in cytophage medium at pH 6 (I), pH 7 (II) and pH 8 (III)

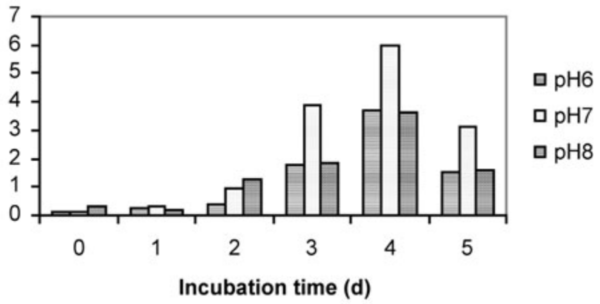

Figure 3. Profile of CMCase activity of *Bacillus* sp in cytophage medium with or at various pH

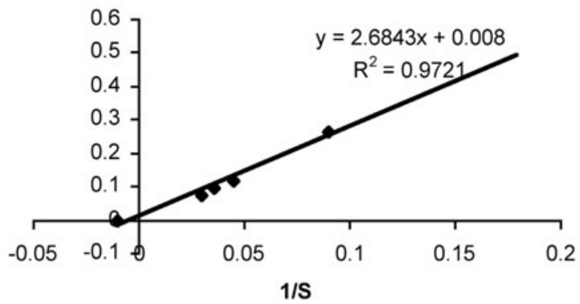

Figure 4. Kurva Lineweaver-Burk, as a substitution of Michaelis Menten for determination of Km and Vmax

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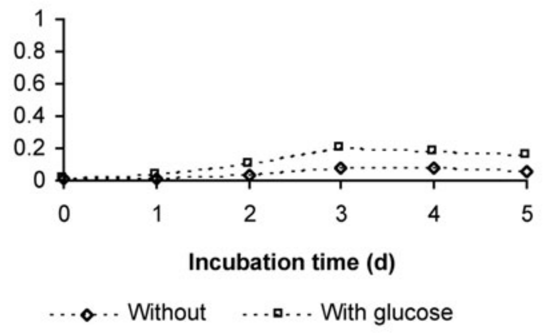

Figure 5. Profile of cell growth of *Bacillus* sp in cytophage medium with or without glucose

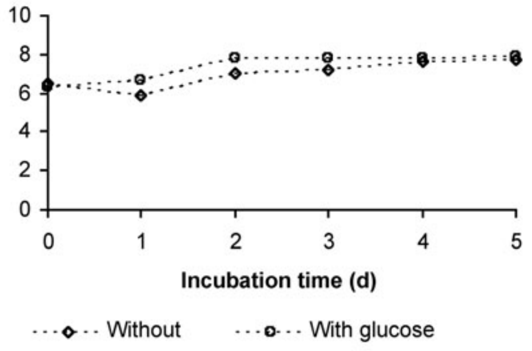

Figure 6. Profile of pH of *Bacillus* sp in Avicell augmented cytophage medium with or without glucose

ACKNOWLEDGEMENTS

The authors thank JICA especially to Dr. Toshinao Okayama for research grant and Mr. Maman Rahmansyah for fruit full suggestion to manuscript.

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A Taxonomic and Physiological Study of Cellulolytic yeast *Candida tropicalis* isolated from Peat Soil

Atit Kanti, I Made Sudiana* and Wellyzar Sjamsuridzal**
*Research center for Biology, Indonesian Institute of Science
Jl. Juanda 18 Bogor 16122, Tel. 62-251-324006, Fax 62-251-325854,
e-mail. sudianai@yahoo.com
**Laboratory of Microbiology, Dept. of Biology, University of Indonesia

ABSTRACT

Two dominating strains of yeast isolated from peat soil of Central Kalimantan was taxonomically and physiologically studied. On the bases of its morphological and physiological characteristic those isolates were belonged to imperfect yeast, and further identified on the bases of D1/D2 domain of large subunit ribosomal RNA gene were identified as *Candida tropicalis*. The two strains have cellulolytic capacity as indicated by its ability to utilize *carboxymethyl cellulose* as the sole carbon sources. Glucose augmentation stimulate biomass growth but repress enzyme activity.

Key words: imperfect yeast, Candida tropicalis and cellulolytic

INTRODUCTION

Microorganism is also commonly found in natural peat. Chemically peat soil is indicated by its high acidity, and thus only acidophilus microbes will dominates microbial community of peat. Multi-cellular and unicellular fungi (yeast) are encountered to be dominating peat microorganism. Other microorganism such as Actinomycetes and bacteria also represent as a community member of peat microbes which have been found to be well adapted to this extreme habitat.

Peat varies in its chemical and consequently also in its microbiological composition. The microflora of peat consists of a small number of genera and species only. Most of the organisms present are in a dormant or resting state. The microbial activity in bog land is very small and slow. The entire situation is completely changed when the natural peat is disturbed. The more decomposed, humified and carbonized the carbon material in peat, the smaller the content of utilizable compounds and less available they become for microbes. The poorer the quality of peat with regard to its use as fuel, the higher are the figures for microorganisms as obtained by the plate count method. Poor quality is equivalent to low decomposition. Poor peat still contains organic matter, which can be used by microorganisms. It has been demonstrated that the less-decomposed layers of high moor contain more hemicelluloses and celluloses than the well-decomposed ones. We can conclude from this that a microbial activity is quite well evolved in less-decomposed peat; this is particularly obvious when remains of the surface layer with root residues are mixed into the peat.

Micro flora has a major contribution in biodegradation of organic substances in soil. Fungi play essential role in biodegradation of organic substances of Peat. Their population is mostly governed by the soil organic content. The sources from which an organism derives its cell-C and energy are useful for describing basic physiological differences among bacteria.

Peat composed dominantly by plant materials of which cellulose materials are the major component. Those substances should be hydrolyzed by complex of microorganism, which perform various metabolic patterns. A few works have been devoted on studying of cultivable yeast in peat ecosystem (Coughlan and Meyer, 1992; Hiroki and Watanabe, 1996). Our present work are trying to study cellulolytic yeast in peat, and to quantify the endo-1,4-β-D-glucanase activity. Characteristic of biomass and pH profile during bacterial growth was also covered.

MATERIAL AND METHODS

Yeasts isolation

Peat Soil was collected from several study sites located at Central Kalimantan. Pre-cultivation was undertaken by shake culture after transferring 10 g of sample into yeast nitrogen base 6.7%, yeast extract 0.1%, malt extract 0.1%, and glucose 20% (pH 6.8). The cultures were then incubated on rotary shaker for three days at 30 ˚C. Isolation was done by plate count methods with three replicates. The isolation medium consisted of yeast extract (3g/L), malt extract (3g/L), bacto peptone (5g/L), glucose (10g/L), agar (20g/L), 0.2% dichloran solution and streptomycin (100U/L), pH 3.7. Cultivation of isolates were performed at 25 ˚C for three days.

Purification

Prior to use, each strain was streaked onto Yeast malt extract agar (YM agar) pH 6.5. This followed by incubation at 25 ˚C for 48 hour. Single well-separated colonies of each form are selected and restreaked onto the same media and reincubated. Twice is generally sufficient to obtain pure culture. After 2 days, the colonies were examined using phase contrast microscope for homogeneity. Homogenous strains were then grown in Yeast malt extract broth, and preserved.

Identification of yeasts

The yeast strains were tested for their characteristics of vegetative reproduction, sexual characteristics, physiological and biochemical characteristics as described by Kurtzman et al., (1998) and Barnett et al.,(2000).

Morphology of vegetative cells. Yeast cells can be globose, subglobose, ellipsoidal, ovoidal, cylindrical, botuliform, bacilliform, apiculate, lunate or triangular. Definition and illustrations of the various possibilities can be found in Ainsworth and Bisby's Dictionary of the fungi (Hawksworth et al., 1995).

Formation of ascospore

Sporulation studies were performed using modified YM agar and Kowado agar containing (Potassium acetate 1.5%, Glucose 0.02%, glutathion 10mM, and agar 2%). Strain from 48 hour growing slant were streaked to the above-mentioned sporulation media, then incubated at 25 ˚C for 3 days, and examined for the presence of ascospores. Morphological observation of ascospore was also conducted by scanning electron microscope (SEM).

Utilization of carbon compounds

Thirty four of carbon sources were used in this study**.** The assimilation media were inoculates with 0.1 ml of a suspension of 2-day-old YM slant culture, and then the tubes were incubated at 25 ˚C. The tests were done on the continuously rotating shaker at 160 rpm, and examined for turbidity during 2 weeks.

Assimilation of nitrogen compounds

The following of nitrogen source are used : potassium nitrate, sodium nitrite, cadaverine dihydrochloride, L-lysine, and glucosamine.

The assimilation media were inoculated with 0.1 ml of a suspension of 2-days-old YM slant culture. Growth was observed after 1 week of incubation at 25 ˚C in rotary shaker. When sign of growth is detected, a second tube was inoculated with one loopful from the first to reconfirm the test result.

Sequencing of D1/D2 region

All methods used for PCR amplification of the D1/D2 region of LSU ribosomal RNA gene were those Sjamsuridzal (2002). The D1/D2 region were amplified by PCR with the following two primers: F63 (5'-GCATATCAATAAGCGGAGGAAAAG-3'), and LR3 (5'-GGTCCGTGTTTCAAGACGG-3'). Purified PCR product were sequenced directly by using Alfexpress pharmacia biotech.

Phylogenetic analysis

The multiple alignments were performed by the program Clustal W (Thompson et al., 1994). The distance matrixes for the aligned sequences were calculated by the two parameter method of Kimura (1980). The neighbor-joining method was used for constructing a phylogenetic tree (Saitou and Nei, 1987).

Celulolyitic ability

All strains were grown on 1 % CMC containg media (Coughlan and Mayer, 1992) and the media was added with 0.1 % congored. Clearing zone formation around growing colony was an indication of cellulolyitc activity (Joson and Coronel, 1986). After 5-day incubation cellulolyitic ability was determined, the ratio the are of clearing zone to colony was calculated.

CMCase determination

A twenty fourth aged culture (5 ml) grown on modified cytophage medium, was inoculated into 100 ml CMC containing media with and without addition of 0.1 g/l glucose, and the culture was observed at interval of 2 h, and its CMC-ase activity was determined follow Joson and Coronel, (1986) expressed in unit i.e. mmol glucose equivalent produced. minute^{-1}. ml enzyme^{-1}.

RESULTS AND DISCUSSION

Phenotypic characteristics

Two dominating yeast were isolated from peat soil. The two isolates were similar in morphology and shared similar physiological characteristics features, as show in Table 1. The strains studied was subglobose measuring from 4 to 5.5 by 6.5 to 9.5 mm. They did not produce ascospore during their life cycle. They produce gas during fermentation of glucose and galactose. They grow well in the presence of glucose, galactose, maltose, soluble starch, D-xylose,D-mannitol and D-glucitol as a carbon sources. The negative results observed in the presence of lactose, mellibiose, raffinose, inulin, L-arabinose, D-arabinose and rhamnose. The isolates did not grow in the presence of sodium nitrate, nitrite and D-glucosamine, hence it grows well in the medium contain cadaverine and L-lysine as a sole nitrogen sources. On the basis of phenotypic characteristics shown in Table 1, we emphasize that those isolates were closely related to *Candida tropicalis*, and identified as this species.

Phylogenetic analysis based on partial sequence D1/D2 region of LSU ribosomal RNA gene, reveals that the strain is the member of the genus Candida and have closely related in the class Hemiascomycetes. Figure 1 demonstrated that strain studied has closely relative with *Candida tropicalis*, which received 97% bootstrap value.

Celulolytic capacity of soil yeast

Strain AG 1and AG 2 were identified as *Candida tropicalis*. They have similar cellulolytic capacity as *Rhodotorula minuta* which was isolated from soil of Gunung Halimun National Park (Figure 2). Few reports have dealt with cellulolytic yeast. The presence of cellulolytic yeast in peat soil will stimulate and enhance the biodegradation of organic substances. In natural environment, yeast may co exist with other microorganism and perform simultaneous hydrolyses of complex polymeric substances (Kurtzman et al., 1998) .

Table 1. Physiological characteristics of yeast strains studied

†	Strain no	†
Physiological test	AG-1	AG-2
Fermentation		
Glucose	+	+
Galactose	+	+
Assimilation		
Glucose	+	+
Galactose	+	+
L-sorbose	-	-
Sucrose	+	+
Maltose	+	+
Cellobiose	+	+
Lactose	-	-
Mellibiose	-	-
Raffinose	-	-
Melezitose	+	+
Inulin	-	-
Soluble strach	+	+
D-xylose	+	+
L-arabinose	-	-
D-arabinose	-	-
L-rhamnose	-	+
Erythitol	-	-
Ribitol	+	+
Galactitol	-	-
D-mannitol	+	+
D-sorbitol	+	+
Glucono-Lactone	-	-
2-ketogluconic acid	+	+
Succinic Acid	+	+
D-glucuronic Acid	-	-
Arbutin	+	+
Xylitol	+	+
Methanol	-	-
Ethanol	+	+
Glycerol	-	-
D-L-Lactic Acid	-	-
Citric Acid	+	+
2.3 butanediol	-	-
Nitrate	-	-
Nitrite	-	-
L-lysine	+	+
Cadaverine	+	+
Glucosamine	-	-

-, negative; +, positive

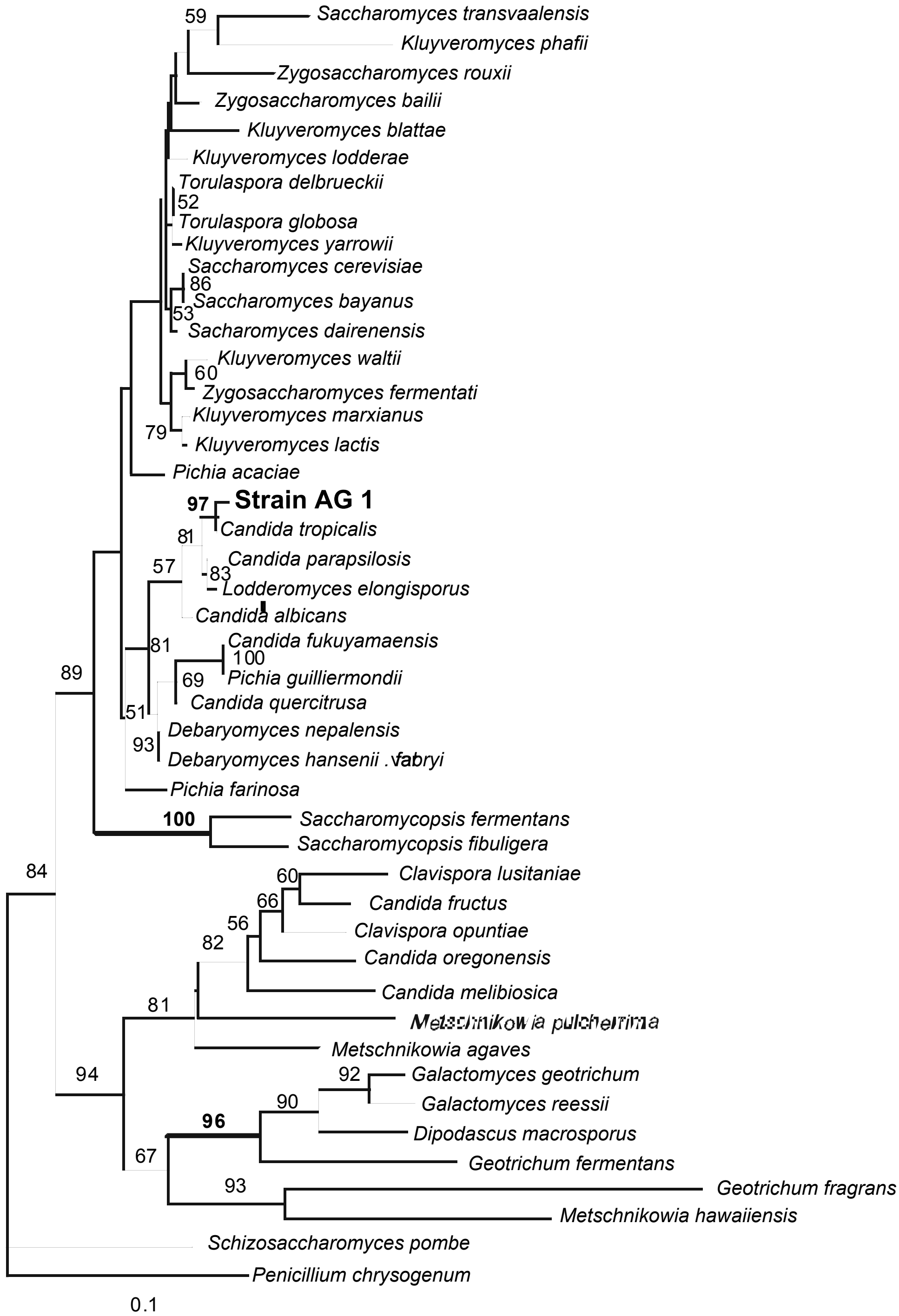

Figure1. Phylogenetic relationships between strain AG1 and closely related species in the class Hemiascomycetes based on partial sequence D1/D2 region of LSU ribosomal RNA gene. The scale bar represents a distance corresponding to 10 base changes per 100 nucleotide positions.

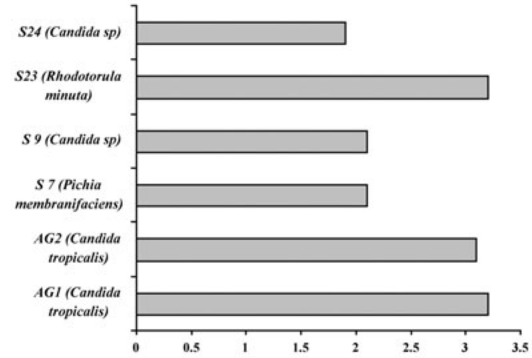

Figure 2. Celulolytic capacity of soil yeast

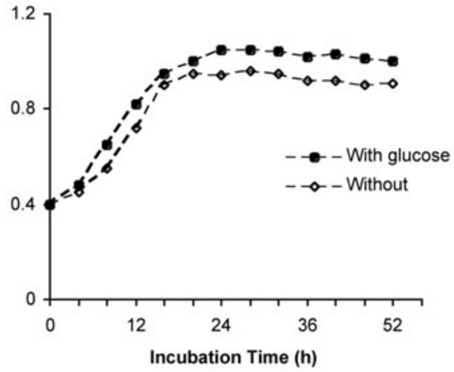

Figure 3. Growth of *Candida tropicalis*

Strain AG1 and AG2 utilize CMC and glucose rapidly as indicated by Figure 2. Biomass syntheses occur under aerobic condition. Glucose augmentation enhanced cell multiplication and result in higher biomass production is achieved when 0.5 % (w/v) glucose was added to CMC contained media. Most yeast assimilate glucose rapidly in oxygen saturated environment (Kurtzman et al., 1998). When media contained glucose in excess cell metabolism appear responded towards DNA synthesis and start stimulate cell multiplication.

As glucose taken up rapidly into cell, and hydrolyses of CMC is taking place due to activity of endo-1,4-b-D-glucanase, and thus result in increase of specific growth rate of yeast cultured in glucose augmented media (Figure 3). This is logical since intracellular glucose will stimulate glicolyses pathway to operate in maximum mode and affect other concomitant metabolism such as three-carboxylic acid pathways and protein synthesis. That all possible metabolisms, finally have affected cell metabolisms as expressed by higher biomass synthesis obtained when glucose is augmented into CMC contained media.

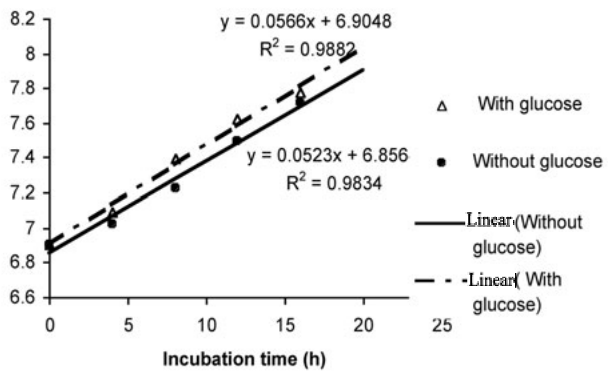

Figure 4. Specific growth rate of *Candida tropicalis* AG1

CMCase activity

Hydrolyses of CMC took place after 4 h incubation, and maximum enzyme activity obtained after 28 h incubation (Figure 5). In contrast to cell synthesis, glucose augmentation result in lower enzyme activity. This phenomenon could be explained by cell controlling mechanism for amount of carbon required for cell metabolism. When glucose is added, cell carbon demand, especially for C6 requiring metabolic pathways, is already fit by available carbon sources, then it is unnecessary for cell to hydrolyse CMC via synthesis of endo-1,4-β-D-glucanase. This phenomenon is indicated by suppressed CMCase activity when glucose is added (Figure 5). Cellulase control activity is complex process and it seems the mechanism by which cellulase is inhibited, suppressed, activated and stimulated are species dependent (Coughlan & Mayer. 1992).

Amino acids and ammonium sulphate were also reported affect cellulase activity (Dees et al., 1995). Appears enzyme activity is correlated with cell growth (Figure 3 and 5). High rate biomass synthesis and enzyme activity were observed during this phase implying that carbon demand affect enzyme activity.

Km and Vmax

Substrate affinity (Km) and maximum enzyme activity (Vmax) of culture augmented (Figure 6) and non-augmented glucose (Figure 7) were slightly different. When glucose was added, Km was 179.65 mM and Vmax was 53.19 unit.d^{-1},

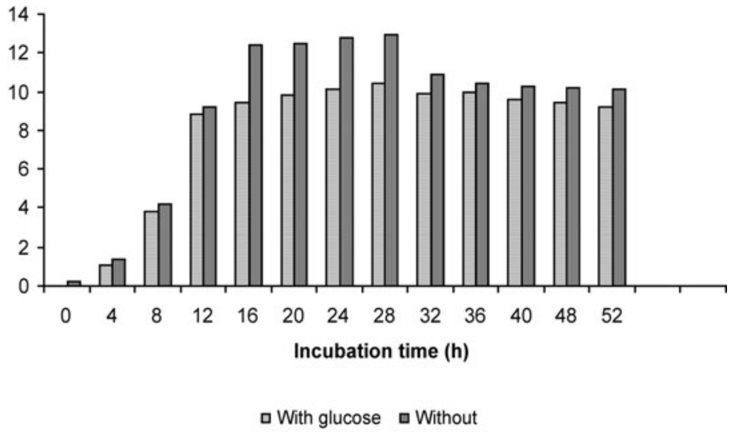

Figure 5. CMCase activity

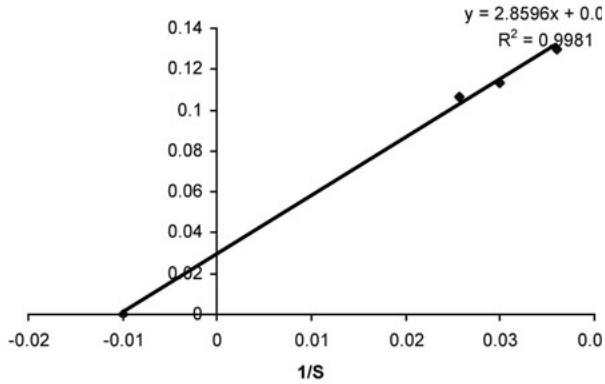

Figure 6. Km and Vmax of CMCase in Cythophage medium with glucose

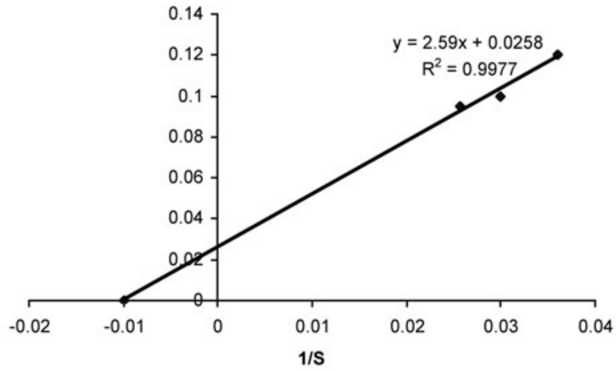

Figure 7. Km and Vmax of CMCase in Cythophage medium without glucose augmentation

whereas non-glucose augmented cultures, Km and Vmax were 157.76 mM and 60.57 unit.d^{-1} respectively. Km value indicating the substrate specificity and Vmax indicates the reaction velocity. The above value indicate that strain AG1 has quite high CMC hydrolyses rate in both media.

CONCLUSTION

Yeast were also found in peat soil, and its presence will accelerate biodegradation of organic material in peat ecosystem. Glucose augmentation accelerates cell synthesis but lower CMCase activity.

ACKNOWLEDGMENTS

The authors thank JICA for research grant, especially to Dr. Toshinao Okayama for his generous help during field survey and chemical reagent donation, and Mr. Maman Rahmansyah for fruitful comment to the manuscript.

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Tropical Peat Soil Carbon Emissions

Jyrki Jauhiainen1,2, Hidenori Takahashi3, Adi Jaya4, Inoue Takashi3, Juha E.P. Heikkinen5, Pertti J. Martikainen6, and Harri Vasander1
1 Department of Forest Ecology, University of Helsinki 00014, Finland
3 Hokkaido University, Sapporo 060-0810, Japan
4 CIMTROP, Palangka Raya 73112, Indonesia
5 Dept. of Env. Sciences, P.O.Box 1627, Kuopio 70211, Finland
6 Dept. of Env. Sciences, P.O.Box 1627, Kuopio 70211, Finland
1 Corresponding author: Fax:+358-9-19158100, Telephone: +358-9-19158152, e-mail:Jyrki.Jauhiainen@helsinki.fi

ABSTRACT

Pristine natural tropical peatland ecosystems have an important role in the global carbon cycle as carbon stores. The SE Asian region comprising areas surrounding the South China Sea and areas in Papua-New Guinea contains the largest expanse of tropical peat deposits. Carbon dioxide (CO_2) and methane (CH_4) fluxes in various peat water table conditions on hummock and lawn peat surfaces were studied in tropical mixed-type peat swamp forest in Central Kalimantan, Indonesia. Flux data was combined with long-term peat water table data in order to produce annual emissions for gas fluxes.

The highest CO_2 emissions were attained during dry season when oxic peat layer is thick due to water table drawdown. Tree root filled hummocks maintained steady CO_2 emission rate independent of the water table in peat. On lawns CO_2 emission rate lowered when the peat water table was near the peat surface. Methane emission rates remained small and were detected only in water-saturated peat. By applying year 1994-1995 water table data, annual carbon emissions from peat swamp forest floor for CO_2 are estimated to be about 985 g C m^{-2} and less than 1 g C m^{-2} for CH_4. Thus, CO_2 seems to be clearly more important in comparison to CH_4 when proportioned to released carbon.

Key words: climate change, water level, CO_2, CH_4, carbon dioxide, methane

INTRODUCTION

Partially decomposed organic matter deposits, *i.e.* peat, is developed in wet places where the annual deposit of dead organic matter is higher than the breakdown and decay. This makes the system a carbon sink.

Estimates of the Worldís wetland area vary between 5.3 Mkm^2 (Matthews and Fung, 1987) and 6.4 Mkm^2 (Lappalainen, 1996). About 75% or 4 Mkm^2 (± 4%) area from the wetlands are peatlands (Armentano and Menges, 1986; Andriesse, 1988). Although peatlands occupy only 3% of the Earthís land area, they can store 525 Gt or up to 24% of the world soil carbon pool (Maltby and Immirzi, 1993).

Tropical peatland cover (0.3 - 0.5 Mkm^2) is approximately 10% of the global peatland area (Immirzi and Maltby, 1992; Maltby and Proctor, 1996; Lappalainen, 1996). The tropical peat carbon store is about 191 - 202 Gt (Rieley and Setiadi, 1997; Post *et al*., 1982), thus representing 15% (Maltby and Immirzi, 1993) to over 30% of the world total peat carbon pool (Jaya *et al*., 2000; Page *et al*., 2000; Siegert *et al*., 2002). Indonesia contains the largest area of peat in the tropical zone with estimates ranging 16 - 27 Mha (RePPProT, 1990; Radjagukguk, 1992; Rieley *et al*., 1996 a, b). Still, tropical peatlands are a major target for development although there are no detailed accounts on their natural resource functions and values, or plans for their sustainable management (Diemont *et al*., 2002). Incessant uncontrolled illegal logging, poorly planned drainage, and disastrous peat fires on heavily disturbed peatlands are just a few examples of the disasters in tropical biodiversity hot-spot and carbon store ecosystem (Page *et al*., 2002).

The age, rate of organic matter accumulation and carbon sequestration, and the amount of carbon stored in boreal and temperate peats is well documented, but peat in the tropics has just recently received more attention as the marked volume of the deposits and the rich flora and fauna is being discovered. This study was carried out in order to estimate tropical peat swamp forest peat surface carbon dioxide (CO_2) and methane (CH_4) emission rates at various water levels, and establish an estimate of the annual gas flux emissions for these gases at actual water levels.

MATERIAL AND METHODS

Study site

Carbon containing greenhouse gas fluxes were studied at mixed type peat swamp forest (Shepherd *et al.,* 1997) located at southern part of Borneo, in Central Kalimantan province of Indonesia. Research site is at the upper Sungai Sebangau catchment, about 20 km from the city of Palangka Raya. Logging concession PT. Setia Alam Jaya has selectively logged the forest area for the commercially most valuable timber prior to year 1998 (Jack Rieley, personal communication). Although there is recent illegal logging activity in the area, the forest in the research area was still in a relatively good condition. Further information about the research area and vegetation can be found in Shepherd *et al.* (1997) and Page *et al.* (1999).

The mean peat depth at the study site varied between 2 and 3 metres, and tree stand density was 1660 - 1793 stem per ha (Shepherd *et al.*, 1997). The forest floor was covered with a nearly continuous about 2 - 5 cm thick layer of fallen tree leaves. The uppermost leaves were brown, hard and seemingly intact by decomposers, but transition underneath debris to peat and roots was hard to detect. Some 20 - 30 decimetres high hummocks and adjoining depressions *i.e.* lawns are typical formations on the forest floor. For the most, hummocks are formed from root plates of living trees. Small tree seedlings and scattered sprouts of grassy vegetation on hummocks are common. During the rainy season water covers about 65 - 80% of the peat surface, *i.e.* interconnected network of lawns, and streams slowly from the interior towards the swamp edges. Lawns are usually vegetation-free, but pneumatophores, special tree root formations, pointing out from lawn surfaces are relatively common.

Data collection and processing

Three sites were selected for the study about 1 km distance of each others. At each site, 3 subplots were selected, and each subplot included 8 CO_2 measurement spots on hummocks and 1 spot for CO_2 and CH_4 flux determination on lawns. Measurements were done in 3 - 5 weeks lasting intensive measurement periods during rainy and dry seasons in 1999 - 2001. Water table (WT) depth was measured with audible buzzer apparatus from wells next to each subplot.

Two methods were applied in the gas flux measurements. Closed chamber technique was applied for measuring CO_2 and CH_4 fluxes in the lawn surfaces (method described in Crill *et al*., 1998; Bubier *et al*., 1998; Heikkinen *et al*., 2002). For sample collection, 20 ml glass vials filled with nitrogen (99.5% N_2) and closed with rubber septa were prepared beforehand. Some days before the measurements were started, vegetation free lawn spots were selected. At each spot, a square shaped open-top aluminium frame with dimensions (W × L × H) 60 × 60 × 30 - 50 cm, equipped with a groove for water sealing on the upper edging, was fitted in peat to a depth at most 15 cm from the lower frame edging.

Prior each measurement the groove was filled with water, and a lid (dimensions W × L × H, 60 × 60 × 10 cm) was placed on the groove of the frame closed the chamber. A fan installed inside the chamber lid mixed air. Gas samples were drawn into 60 ml syringes from the inlet of the chamber lid at 5 min intervals during the 20 min incubation period. Vials were flushed with 40 ml of the sample and over pressurized with the remaining 20 ml. The gas samples were transported to a laboratory for analysis. Hewlett Packard gas chromatograph with a flame ionization detector (FID) using a Hayesek Q was used for CO_2 and CH_4 analyses (Nykänen *et al*., 1998, Heikkinen *et al*., 2002).

Another closed chamber method was used for measuring CO_2 emissions from hummock surfaces. A chamber (Ø 20 cm, height 10 cm) connected to a portable infrared gas analyzer (PP Systems, EGM-2) was placed tightly on the peat surface at the start of the measurement. A small fan mixed air inside the chamber, and soft rubber sealing on the lower edging prevented airflows out from the chamber. Air was circulated between the chamber and the analyzer while the chamber CO_2 concentration was recorded at 1 min intervals during a 5 min measuring period.

In one lawn surface, pressure sensor (Druck Ltd. PDCR830) connected to data logger (Kona System C. Ltd, Kadec-Up) recorded peat WT during 1.9.1994 - 29.6.1995. Average daily WT was calculated from the database. In order to lengthen WT data to cover a period of one year, average daily WT depths were interpolated for the period 30.6. - 31.8.1995 by applying linear equation. In order to build water table data for hummock surfaces in the calculus, the surface height was set to 20 cm above the lawn surface.

Carbon dioxide and methane flux rates were calculated from a linear change of gas concentration inside the measurement chamber as a function of measurement time. The data collected from the three measurement sites was merged together and split into classes in accordance with prevailed peat WT during gas sampling. Each of the WT classes covers 10 cm wide range of WT depths, and is named after the mean WT-value.

In order to produce estimate of gas fluxes integrated over time, the mean flux rate at each WT class was multiplied with the number of days owing that WT range, and the resulted daily fluxes were summed together. For CO_2, effect of hummock-lawn coverage on cumulative fluxes was studied.

RESULTS

Hummock CO_2 flux rates (486 - 622 mg m^{-2} h^{-1}) were relatively uniform at various WT in comparison to flux rates measured in lawns (139 - 877 mg m^{-2} h^{-1}). In lawns, lower CO_2 flux rates were detected especially with WT near the peat surface (Fig. 1). However, with WT depths -20 - -50 cm the flux rates in lawn surfaces were higher than in hummocks. In lawns, small CH_4 fluxes from peat to atmosphere were detected with WT near or at the peat surface, but with low WT the flux direction was reversed (Fig. 1). Even the highest CH_4-C flux rate (0.30 mg C m^{-2} h^{-1}) remained very low in comparison to CO_2-C flux rates (38 - 239 mg C m^{-2} h^{-1}).

When comparing annual CO_2 fluxes with the equal hummock-lawn coverage, hummocks appear to be the stronger CO_2 emission source with steadily rising cumulative emission, while high WT during the rainy season clearly slows cumulative emissions from lawns (Fig. 2a). During the period with WT below the peat surface, *i.e.* from the beginning of July till the end of December, the flux rates are about the same with the equal surface coverage-ratio (Fig. 2a). In reality lawns can be regarded as the primary CO_2 source, as their coverage in forest is higher than hummocks (Fig.

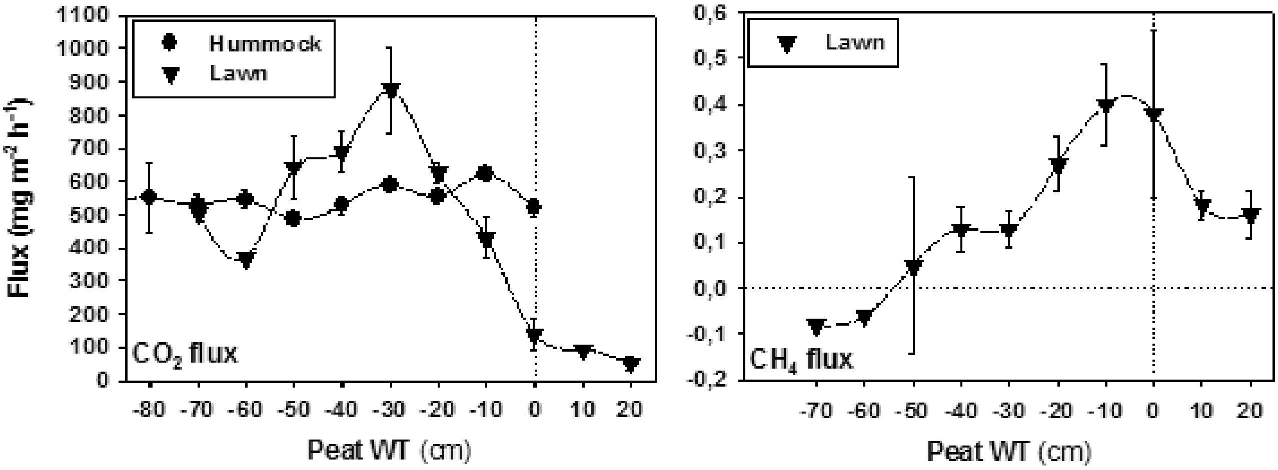

Figure 1. Hummock and lawn CO_2 fluxes (on left), and lawn CH_4 fluxes (on right) in peat swamp forest at various peat water table (WT) depth classes. Average flux rate (mg m^{-2} h^{-1}) with S.E.M. Straight dotted vertical line represents situation when WT is at the peat surface, and horizontal line in CH_4 graph is the zero-flux rate. Note different scales in the graphs

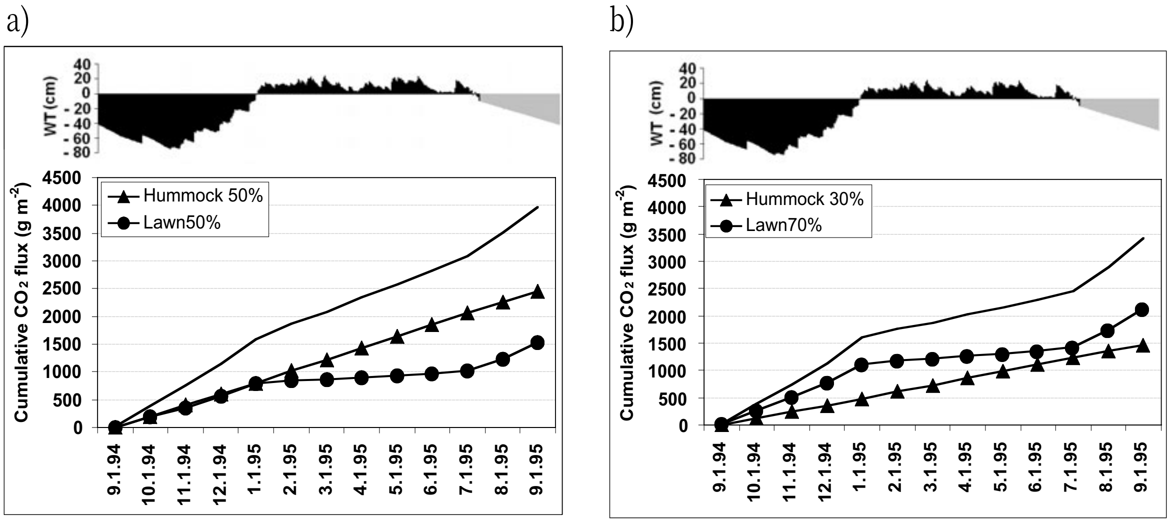

Figure 2. Estimated cumulative carbon dioxide emission (g m^{-2}) from mixed peat swamp forest hummocks and lawns (lines with symbols), and annual emission (line only). Emissions are presented with 2 hummock-lawn coverage-ratios (%). Dates below the graphs are in form m.dd.yy. See text for the details of the calculus.

Table 1. Annual (1.9.1994 - 31.8.1995) CO_2 flux from hummocks and lawns, and annual CH_4 balance of lawns (g m^{-2} a^{-1}) of peat swamp forest. Fluxes are presented with various percentual hummock-lawn coverage.

Hummock and lawn flux	**Hummock – lawn coverage (%)**				
	50/50	**40/60**	**30/70**(*	**20/80**	**0/100**
CO_2 (g m^{-2} a^{-1})	3978	3794	3610	3427	
CO_2-C (g m^{-2} a^{-1})	1085	1035	985	935	
Lawn fluxes only					
CH_4 (g m^{-2} a^{-1})	0.67	0.81	0.94	1.08	1.35
CH_4-C (g m^{-2} a^{-1})	0.51	0.61	0.71	0.81	1.01

(* Observed relative hummock-lawn coverage at the study sites.

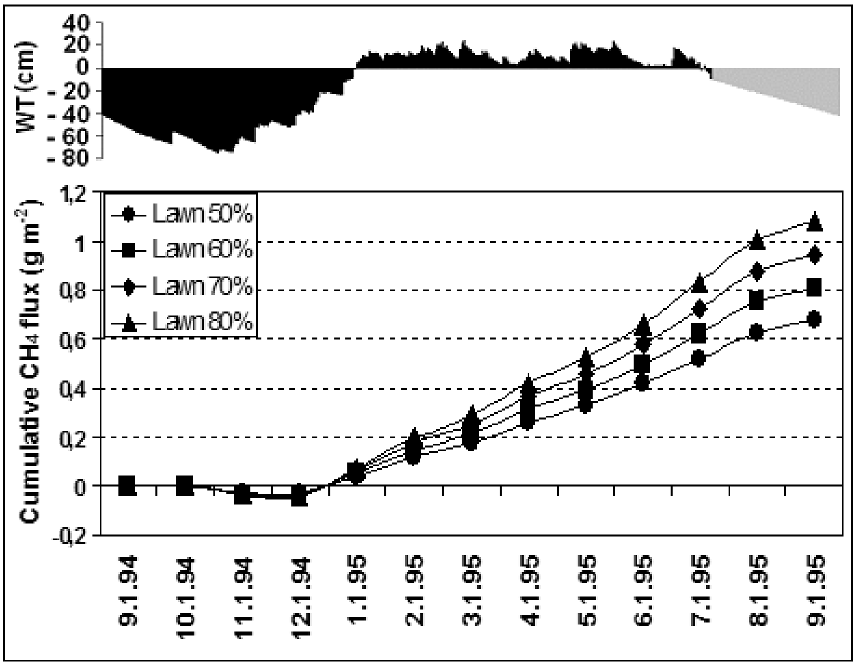

Figure 3. Annual methane emission (g m^{-2}) from mixed peat swamp forest lawns during 1.9.1994 - 31.8.1995. Emission is presented with various percentual coverage. Dates in the graph are in form m.dd.yy. See text for the details of the calculus.

2b). With the 30/70% coverage-ratio between hummocks and lawns at measurement sites, the annual CO_2 outflow is about 3610 g m^{-2} (Table 1, Fig. 2b).

Water prevailed above lawn surfaces in the forest for 6 months and produced favourable waterlogged conditions for methanogenesis, but the resulted cumulative emission remained relatively low, though positive (Fig. 3). Prolonged low WT conditions during the dry season resulted in favourable conditions for CH_4 consumption by the methanotrophic bacteria, and CH_4 flux direction into peat during October - December 1994 (Fig. 3).

With the given WT and with the hummock-lawn coverage-ratio of 30/70, the net annual CH_4 flux from peat to atmosphere is about 0.94 g m^{-2} (Table 1). If both hummocks and lawns would have identical CH_4-flux-WT dependence, the annual emission would remain under 1.35 g m^{-2} a^{-1} (see Table 1) because hummocks are drier habitats. Comparison between cumulative CO_2 and CH_4 fluxes show that production of CH_4-originated C is less than 1 per mille of the CO_2-C in the given WT conditions (Table 1).

DISCUSSION

Data presumptions

Mathematical approach in this study is simple. Establishing a straight the relation between measured gas emission rates to the measured water tables gives relatively reliable estimates of the cumulative gas fluxes over time in the given conditions. However, this approach does not allow predictions in largely differing conditions *i.e.* gas flux estimates in extremely dry- or wet years. Another compromise made in this study is the interpolation of WT data for the period of several weeks during the dry season. The missing fragment of primary WT data is at the beginning of the dry season, and the presented linear decrease in the peat WT is quite possible for the season.

We have been able to measure only the emission of CO_2 and CH_4 from the peat soil. As there is no fixing of CH_4 by the plants, our approach gives the annual balance for CH_4. However with CO_2 the important part of CO_2 fixation to the plant biomass and peat is missing. Then, our approach gives only one part of the annual balance for CO_2. Further studies are urgently needed to cover the other missing part of CO_2 balance in peat swamp forests.

Momentary gas flux rates

In temperate and boreal peatlands production of CH_4 and CO_2 is largely controlled by temperature and substrate availability (Mikkelä *et al*., 1995; Schimel, 1995; Komulainen *et al*., 1998; Kettunen, 2002). Peat temperature in tropical climate (-10 cm in peat, AVE±SD 26±1.6 ˚C, *n*=145, unpublished data from this study) is high and stabile throughout the year (see also Takahashi and Yonetani, 1997). However, the amount of rainfall may vary markedly both daily and annually (Takahashi and Yonetani, 1997). Therefore in the tropics, the prevailing water level is more important than peat temperature in controlling peat gas fluxes.

High input of small roots with poor decomposability is important for tropical peat accumulation (Brady, 1997, 2002). Slightly elevated, tree root filled hummocks are abundant in mixed peat swamp forest floor micro-topography. Hummocks form large part of the peat surface, *acrotelm*, where the WT fluctuations take place and which is chemically and biologically most active. In these aerobic conditions CO_2 is produced in autotrophic respiration of flora, heterotrophic respiration of fauna, and released by micro-organisms in aerobic decomposition of organic matter. Root respiration and litter decomposition in the extensive root mats in hummocks may have contributed much to the detected high CO_2 emission rates. Root respiration may be the principal contributor for the steady remaining CO_2 production rate even in wet conditions. However, in this study root respiration could not analytically be separated from the other peat CO_2 sources. Vegetation-poor lawns probably produce CO_2 and CH_4 mostly from decomposing litter, and emissions are therefore more controlled by the prevailing water table. High WT conditions decreased CO_2 emission rate in lawns, so the forest floor emission rates are at highest during dry season when both hummock and lawn surfaces have deep oxic zones. In comparison, usual summertime CO_2 emission rates from *Sphagnum*-dominated ombrotrophic sites in boreal region seem to remain well below 400 mg m^{-2} h^{-1} (Silvola *et al*., 1996; Nykänen *et al*., 1998)

The permanently waterlogged peat layer under water fluctuation zone is called *catotelm*, and CH_4 is a characteristic product from the decomposition of organic matter in the anaerobic conditions. The ratio between CH_4 production in anoxic and CH_4 consumption in oxic peat determines the gas flux rate (Roulet *et al*., 1993; Shannon and White, 1994). With water tables at about -50 cm or deeper, CH_4 consumption was found to exceed production rate in this study. The phenomenon may occur when the lowered water table in peat leads to less space for CH_4 producing bacteria giving more space for methanotrophic bacteria in the surface peat (Glenn *et al*., 1993; Roulet *et al*., 1993; Martikainen *et al*., 1995; Komulainen *et al*., 1998). Methane emissions increased in high WT conditions in this study, but remained relatively small (maximum about 0.4 mg m^{-2} h^{-1} at -10 cm WT) in comparison to boreal *Sphagnum*-dominated bogs which have been measured to have CH_4 emission rates starting from about 0.8 mg m^{-2} h^{-1} up to 2 mg m^{-2} h^{-1} during summer months (Nykänen *et al*., 1998; Martikainen *et al*., 1995).

Cumulative gas fluxes

The differences in cumulative CO_2 emissions with differing hypothetical surface coverage between hummocks and lawns are of two kinds. On the one hand, increase in lawn coverage has decreasing effect on cumulative CO_2 emissions at high WT conditions during rainy season. On the other hand, increased lawn coverage may lead to higher cumulative emissions from lawns in comparison to hummocks at low WT conditions. However, the results suggest only minor change in the annual CO_2 emission due to different proportional lawn-hummock coverage. The annual CO_2 flux (60 - 200 g C m^{-2} a^{-1}) from boreal *Sphagnum* dominated ombrotrophic bog (Martikainen *et al*., 1995; Silvola *et al*., 1996) remains much smaller in comparison to annual flux measured in this study (about 1000 g C m^{-2} a^{-1}).

Here CH_4 fluxes were measured only from lawn surfaces. As CH_4 is produced only in waterlogged conditions, and WT in lawns is higher compared to hummocks, this should lead to better moisture conditions for CH_4 producing bacteria in lawns. The measured CH_4 fluxes in lawns can therefore be regarded to represent reasonable approximate or be a slight over-estimate for the whole forest floor surface fluxes. The forest lawn surfaces were CH_4 sinks during the dry period, and clearly decreased cumulative CH_4 flux during the dry season. In boreal peatlands, favourable conditions for changing CH_4 flux into peat have usually involved anthropogenic interference (Martikainen *et al*., 1995; Nykänen *et al*., 1997; Nykänen *et al*., 1998). A representative average for undisturbed boreal Finnish bog CH_4-C emissions vary between 2 and 15 g C m^{-2} a^{-1} (Martikainen *et al*., 1995; Nykänen *et al*., 1998; Alm *et al*., 1999). Annual estimate for CH_4-C emissions from tropical peat swamp forest floor (<1g C m^{-2} a^{-1}) can be therefore regarded as low, and to have a minor effect on total C fluxes in peat swamp forest. In terms of the greenhouse effect upholding gases studied here, CO_2 seems to be clearly more important than CH_4 in the amount of released carbon.

Reasons for the surprisingly low CH_4 emissions from tropical peat cannot be revealed in this study. Undefined quantity of CH_4 may have escaped to the atmosphere through tree pneumatophores, which conduit air to roots in waterlogged peat. In temperate and boreal wetlands, vascular plants have been noted to have an important role in substrate supply for methanogenesis, as well as a transport route for CH_4 emissions (Whiting and Chanton, 1993; Frenzel and Rudolph, 1998; Shannon *et al*., 1996; Saarnio and Silvola, 1999; Kettunen, 2002). The role of peat swamp tree structures in producing favourable conditions for methanotrophic bacteria and in gas transportation needs further studies.

Carbon allocation from atmosphere to peat swamp forest ecosystem has not received needed attention yet, thus making tropical peat swamp forest ecosystem C balance estimation difficult or impossible. The amount of CO_2-C bound into vegetation and partly allocated into peat can be assumed to be high in viably growing vegetation (Brady, 1997). At least in some tropical peat swamps the ^{14}C-dated age of acrotelm peat show that deposits are in steady state or expanding (Brady, 2002), which supports high C input rate to the ecosystem. Estimates of carbon accumulation rates in tropical peatlands vary between 0.59 - 1.18 t ha^{-1} a^{-1} (Sorensen, 1993) and 0.61 - 1.45 t ha^{-1} a^{-1} (Neuzil, 1997), which are well above the average rate estimate of 0.21 t C ha^{-1} a^{-1} in bogs and fens at boreal and northern subarctic regions (Clymo *et al.*, 1998).

Carbon accumulation in the future climate

Environmental conditions regulating carbon accumulation from and release back to the atmosphere in peat swamp forests can change because of several reasons; (i) due to the natural ecosystem development, (ii) due to climate change, or (iii) due to human disturbance. In all these cases the balance between the peat hydrology and vegetation is disturbed. According to Clymo (1984), slow fermentation rate of organic substrate in bogs is theoretically shown to lead to ceased growth of the thickening peat domes, and thus limit the final volume of the peat deposit. Geophysically the growth of peat dome demands continued wetness of the surface peat matrix, so the available rainfall and peat hydraulic conductivity need to sustain favourable conditions for the peat-forming vegetation (Ingram, 1982). Many peat swamp forest sites are assumed to be in steady state conditions or in the way of destruction, but in some areas peat depth may well be increasing under favourable environmental conditions (Sieffermann *et al*., 1988; Neuzil, 1997; Moore & Shearer, 1997).

Drainage and forest clearance will rapidly convert peat swamp forest ecosystem from sink and storage to a greenhouse gas source (Andriesse, 1988; Diemont, 1992; Jauhiainen *et al.*, 2002; Rieley and Page, 2002). In selectively logged peatlands, net peat accumulation decreases after harvesting due to decline in organic matter input (Brady, 1997). Plantation or agricultural crops in the developed peat can hardly substitute natural forest vegetation in C-sequestration. Hydrology of peatlands is dependent on the precipitation and temperature. Due to climate change, tropical Southeast Asia is predicted to be highly vulnerable in biodiversity and water resources within the next few decades (Lal *et al.*, 2002). In Indonesia the present rainfall scenarios suggest a change in wet season with -5 to +15% and dry season change with rainfall 0 to +10% before the year 2070 (Whetton and Rutherford, 1994). According to Meehl and Washington (1996), future seasonal precipitation extremes associated with El Niño event are likely to become more intense in tropical Indian Ocean region so that anomalously wet areas could become drier during the future El Niño events. If evapotranspiration exceeds the amount of water input drier conditions follow. This may be due to lower precipitation and/or due to increased evapotranspiration with gradually warming climate. The peat swamp ecosystem can probably adapt to wetter conditions, but extensive droughts are likely to have negative effect on the vitality of the system and function as a carbon sink. Weather extremes, such as hot and dry El Niño years, have found to cause Amazonian basin tropical forests to become net sources of carbon (Tian *et al*., 1998). Although similar studies are not available from Southeast Asian peat swamp forests, long-time lasting low WT conditions during El Niño years (Takahashi *et al*., 2002) can cause C emissions from peat surfaces that may well exceed the amount of C bound to drought-suffering vegetation. However, peat fires spreading out of control, consuming not only the surface vegetation but also the underlying peat and tree roots, may cause the greatest effect at lowered WT. These fires could contribute to the dense haze and cause deterioration in air quality, health problems, and even economy (Page *et al*., 2002).

ACKNOWLEDGMENTS

This study is result of cooperation between the EU INCO-DC program, Natural resource functions, biodiversity and sustainable management of tropical peatlands and Japanese Society for the promotion of science ten-year programme on the ëEnvironmental Management of Tropical Wetlands of SE Asiaí.

During the measurements this project has been partly carried out with financial support from the Dutch Ministry of Foreign Affairs (DGIS) under the Global Peatland Initiative, managed by Wetlands International in cooperation with the IUCN-Netherlands Committee, Alterra, the International Mire Conservation Group and the International Peat Society, and was financially sponsored also by the Ministry of Foreign Affairs (Finland), the Jenny ja Antti Wihuri Foundation, and Suomen Metsätieteellinen Seura (Societas Forestalis Fenniae).

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Production of Bioflocculant by Microbial Isolates from Peat-Soil of Tanjung Puting National Park - Center of Kalimantan

Yati Sudaryati Soeka & Joko Sulistyo
Microbiology Division. Research Center For Biology-LIPI
Jl Ir. H. Juanda No 18 Bogor 16002, Tel. 0251-321038, Fax. 0251325854

ABSTRACT
Development of biodegradable and safer bioflocculants that do not cause problems in environmental pollution and toxicity and have strong flocculation activities are required. We have found that alcohol and sugar are useful carbon sources for its flocculant production. Manitol, sorbitol and starch (29%, 25% and 26%, respectively) were best for flocculant production while methanol and sucrose were the best inducer for cell growth and culture time. The bioflocculant produced on buthanol medium flocculated a wide range of suspended soils. The flocculation activity was increased as increasing of culture time on 6 to 8 days for alcohol and 12 days for polyphenols. The highest bioflocculation activity (57% and 32%, respectively) was exhibited by strain-PS1-2 and PS4-2 when both were stimulated by the addition of $CaCl_2$, and was effective only when the reaction mixture contained an adequate amount of bioflocculant.

Key words: bioflocculant, peat-soil, microbial isolate, alcohol, sugar, polyphenol.

INTRODUCTION

Synthetic flocculants have been used to aggregate colloidal substances in the field of waste water treatment such as activated sludge processes as clarifying agents and they are expected to be used in more fields, such as downstream processing and separation of microbes from cultures in fermentation plants (Nam, *et al*. 1996). However, their usages are restricted since these synthetic flocculants particularly the monomers of organic synthetic high-polymer flocculants, such as acrylamide, were reported have neurotoxic and strong carcinogenic properties, eventhough they exhibited a good performance and strong flocculating activity (Kurane *et al*. 1994).

Recently, a variety of new microbial flocculants have been reported and screened from soil using kaolin clay as the flocculation test material (Kurane and Matsuyama, 1994). Since this naturally occuring flocculants have only weak flocculating activities, therefore, development of biodegradable and safer bioflocculants that do not cause problems in environmental pollution and toxicity and also have strong flocculation activities are required.

This research reports on a study of a bioflocculant produced by microbial isolates from peat-soil of Tanjung Puting National Park, center of Kalimantan.

MATERIALS AND METHODS

Screening of microbial flocculant producer

Screening of microbes from activated sludge was done using phtalic acid assimilation as the indicator. The reason why this specified medium containing phtalic acid is used that *Rhodococcus erythropolis* produces effective bioflocculant. A screening medium, in which phtalic acid was used as a sole carbon source instead of phtalate ester, was used as previously reported. The slime-forming colonies among phtalic acid assimilation microbes such as *Corynebacterium sp., Aspergillus sojae, Dematium sp., Paecilomyces sp., Alcaligenes latas* and *A. cupidus*. were cultured in the production medium and then the flocculating activities were measured by using a suspension of kaolin. The composition of the production medium for bioflocculant was starch (1%), K_2HPO_4 (0,5%), KH_2PO_4 (0,2%) $MgSO_4$, (0,02%), $(NH_4)_2SO_4$ (0,05%), NaCl (0,01%) yeast extrat (0,05%), urea and a carbon source (respectively 0,05%), with a pH adjusted to 8,0.

Measurement of flocculating activity

Flocculating activity was measured from the turbidity of kaolin clay suspension at a constant concentration (5000 ppm) after flocculation with various amount of bioflocculant. Kaolin clay was suspended and $CaCl_2$ was dissolved in 8.9 mM glycine-NaOH (pH 7.0). A reaction mixture in a test tube containing 9 ml of kaolin clay suspension was added with 50 ml of culture broth and 1 ml of 0.5 M $CaCl_2$ solution sequentially was then stirred with a Vortex mixer for 20 seconds and left for 5 minutes. The supernatant was collected and its optical density (OD_{550}) was measured. A control experiment without culture broth was carried out in the same process and the OD $(OD_{550})_c$ was measured. Flocculating capacity was expressed according to following equation $\{D(1/ OD_{550})\}$as $(1/OD_{550})$-$(OD_{550})_c$.

RESULTS AND DISCUSSION

We have screened ten isolated colonies from peat soil those exhibited flocculating activities against kaolin suspension and established methanol as carbon source to produce flocculant using some isolates. Some microorganisms can grow with various carbon sources instead of alcohols and sugars. As shown in Fig. 1, microbial strain-PS1-2 and PS4-2 exhibited the highest flocculating activities whereas strain PS 21 could grew well among the isolated strains. It was apparently that flocculating activities was not much effected with higher cell growth. In another preliminary experiment we have also observed an influence of pH on the cell growth and the flocculating activity. It was found that better medium for producing the bioflocculant was at a mild condition. An extreme alkali and acid pH of medium could considerably affect the flocculating activity (data not shown).

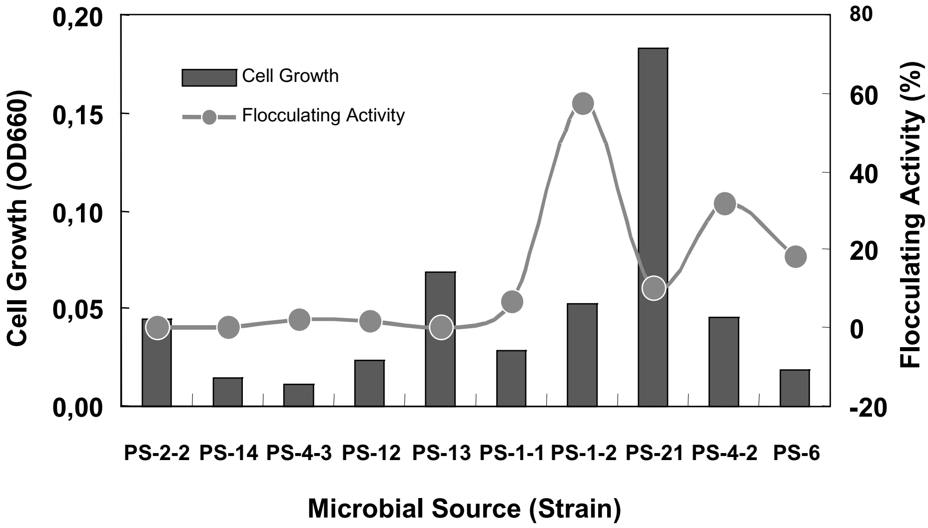

Figure 1. Flocculating activity and cell growth of isolated strains.

We observed that strain PS 1-2 could assimilate almost all the carbon source tested. The flocculating activity was measured with various amount of carbon source included sugars, alcohols and polyphenols at a constant concentration of kaolin clay that could be flocculated at an adequate concentration of flocculant. The flocculating activity even decreased when an excess concentration of flocculant was implemented.

Mannitol, sorbitol and starch were more effective carbon sources than alcohols and polyphenols, while glucose, succrose and maltose were not effective to enhance the flocculating activity. Eventhough the bioflocculant that was produced by the tested strain grown on succrose and methanol media was observely less in flocculating activity, however a higher cell growth was observed on both media and therefore both of glucose and methanol were highly potential carbon source for cell and enzyme production to study of bioflocculant productivity of none tested strain (Fig. 2).

The flocculating activity was stimulated by addition of $CaCl_2$. This is similar to the previous report (Nam *et al.* 1996) in that the flocculating activities of *Alcaligenes cupidus* and *Rhodococcus erythropolis*, and other microbial strains for kaolin clay were stimulated by the addition of cations such Ca^{2+} and Al^{3+}.

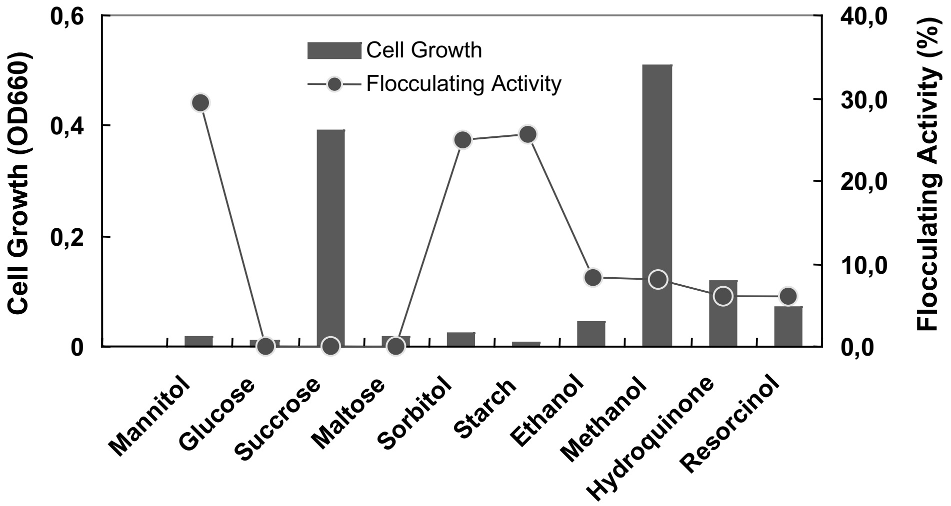

Figure 2. Effects of carbon sources on cell growth and flocculating activities.

It was apparently longer chain of carbon source was more effective for the biofloculant production. In this study, we found that mannitol, sorbitol and starch were more effective than glucose, succrose and maltose. Using longer chain of alcohols as carbon source, it was observed that propanol, butanol and glycerol were the most effective media for the biofloculant production, although methanol and ethanol were not so much effected. It was found that catechin was the most effective medium for production of biofloccullant among the polyphenols media. Maximum flocculating activity was observed in butanol, propanol and glycerol media after 6 days (21%), 8 days (18%), and 10 days (19%) cultivation, respectively. However, less flocculating activity was shown in methanol and ethanol media (Fig. 3).

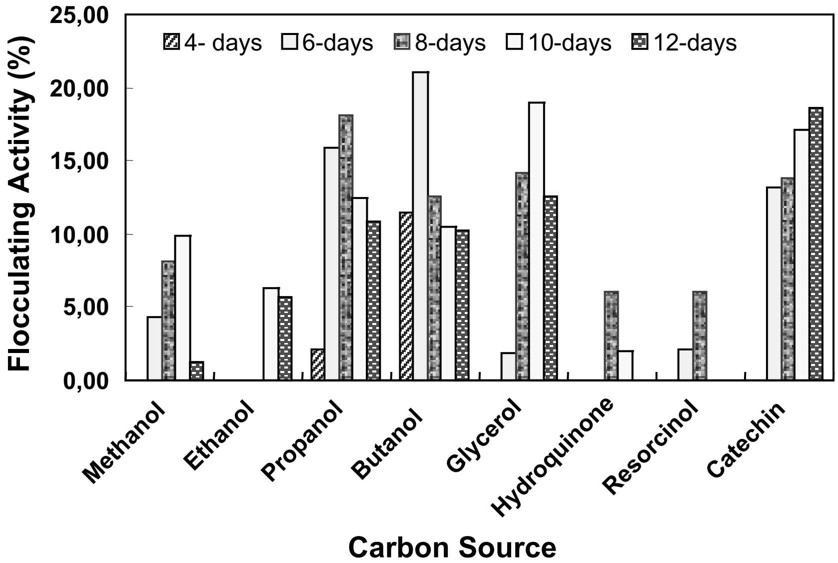

Figure 3. Courses of flocculating activities grown on various alcohols and polyphenols.

Flocculating activity of tested strain in cathechin medium was observely increased as increasing days of cultivation from 6 to 10 days (13 to 19%). However, poor flocculating activity was shown when it was grown on hydroquinone, resorcinol and pyrocathecol media. Almost no activity of flocculation when the strain was cultivated in pyrocathecol medium up to 14 days cultivation (data not shown). These results show that butanol, propanol, glycerol and catechin are the best carbon source of the alcohols and polyphenols tested to produce bioflocculant by using our isolate.

Bioflocculant produced on sugar, alcohols and polyphenols were usable on a variety of suspended solids, especially kaolin clay. This is our preliminary study to show that properties of bioflocculants produced on carbon source of longer chain of sugars, alcohols and polyphenols were considerably similar. It is a suggested to study the effect of organic and inorganic ions in the production of flocculant since we had no observation data on the effect of variety organic and inorganic nitrogen sources. It is also suggested to purify the observed bioflocculant in order to study the properties in detail.

The reason why we implemented polyphenols also in the medium is as the fact we found in the preliminary experiment that glycoside form of catechin could be synthesized enzymatically during cultivating of bioflocculant. This catechin glycoside exhibited not only a preventive effect against toxicity but also showed a reparative effect against damage by O_2^- that caused oxidative damaged to bio-molecules, resulting in cell-lysis and inflamatory on their gizzard and gut of living organism. It is therefore an antitoxic effect could be synthesized during the production of bioflocculant (Sulistyo, *et al*. 2000&2001).

ACKNOWLEDGMENT

The present study was supported by the Research Center for Biology, Indonesian Institute of Sciences, Utilization of Biological Resources Project 2002.

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Arbuscular Mycorrhizas of Plants Grown in Peat Swamp Forest of Central Kalimantan

Tawaraya, K[1]., Takaya, Y[1]., Turjaman, M[2]., Tuah, S.J[3]., Limin, S. H[3]., Tamai, Y[4].,
Cha, J. Y[5]., Wagatsuma, T[1]. and Osaki, M[4].
[1]Faculty of Agriculture, Yamagata University, Tsuruoka, 997-8555, Japan, [2]Forest and Nature Conservation Research and Development Centre, Ministry of Forestry, Bogor, 16610, Indonesia, [3]Faculty of Agriculture, University of Palangka Raya, Palangka Raya, 73112, Indonesia, [4]Graduate School of Agriculture, Hokkaido University, Sapporo, 060-8589, Japan, [5]Wakayama Experimental Forest, Field Science Center for Northern Biosphere, Hokkaido University, Kozakawa, 649-4563, Japan

Corresponding author: Tawaraya, K.
Tel: +81-235-28-2870, Fax:+81-235-25-8578, e-mail: tawaraya@tds1.tr.yamagata-u.ac.jp

ABSTRACT

Arbuscular mycorrhizas (AM) are formed in 80% of land plants and improve growth and nutrient uptake of plants. Little imformation is available on status of AM in tropical soils. The objective of this study was to clarify mycorrhizal colonisation of tree species grown in tropical peat soils. Seedlings of 22 species in 14 families grown in peat swamp forest of Central Kalimantan, Indonesia were collected in 2000 and 2001. Roots were stained with 0.05% aniline blue and arbuscules, vesicles and internal hyphae were observed under compound microscope. Seventeen species in twenty-two species showed AM colonisation. AM colonisation was observed for the first time in roots of *Palaquium gutta* (Sapotaceae), *Calophyllum soulattri* (Guttiferae), *Campnosperma auriculatum* (Anacadiaceae), *Cratoxylum arborescens* (Guttiferae), *Tetramerista glabra* (Tetrameristaceae), *Eugenia* sp. (Mytraceae), *Shorea teysmanniana* (Dipterocarpaceae), *Gonystylus bancanus* (Thymelaeaceae), *Hevea brasiliensis* (Euphobiaceae). No AM colonization was found in *Hopea mengarawan* (Dipterocarpaceae), *Koompassia malacensis* (Caesalpiniaceae), *Tristaniopsis whiteana* (Myrtaceae), *Combretocapus rotundatus* (Rhizophoraceae) and *Dyera costulata* (Apocynaceae). It is suggested that inoculation of AM fungi can improve an early growth of some tree species grown in peat swamp forest and therefore accelerate rehabilitation of peatlands.

Key words: arbuscular mycorrhiza, colonization, peat swamp forest, tropical soil

INTRODUCTION

Peat swamp forests have been decreasing due to conversion of forests into farm land by excessive draining, the use of shifting cultivation on a large scale, illegal logging and forest fire. It is necessary to understand edaphic factors, including the physical, chemical and biological properties of soil, in order to remediate disturbed forests. Of these properties, the biological is least known. Mycorrhizas affect the maintenance of vegetation in various ecosystems, and may play an important role in tropical peat swamp forests. Moyersoen et al. (2001) showed that AM colonization was about 40% in plants grown in heath forests and mixed Dipterocapaceae forest of Brunei Darussalam. AM may be formed even in trees, which grow in the peat swamp forest. It may be possible that AM improves the early growth of tree species and hence has an important role in the rehabilitation of disturbed peat swamp forests if mycorrhizal colonization in these soils is proven. In this study, we collected natural seedlings of representative tree species in peat soil of Central Kalimantan, Indonesia and investigated AM colonization in these plants in order to clarify the status of mycorrhiza in the tropical peat swamp forest.

MATERIALS AND METHODS

Twenty-two species (20 genera) of representative tree were collected in September and October 2000 and November 2001. Identification of tree species was done according to the morphological characteristics at the Forest and Nature Conservation Research and Development Centre, Ministry of Forestry, Bogor, Indonesia. Three replicate plant samples were collected from thirty-six different sites. Roots were separated from shoots while in the field and packed into plastic bags and sent to the laboratory. Roots were washed with tap water to separate them from soil particles. The roots were cleared in KOH (100 g L^{-1}) for 1 hour, acidified with diluted HCl (Phillips and Hayman 1970) and stained with 500 mg L^{-1} aniline blue for 15 min. The percentage mycorrhizal colonization was determined by the grid line intersect method (Giovannetti and Mosse, 1980) under a compound microscope. Presence of arbuscules, internal hyphae and vesicules was recorded from each intersect and expressed as a percentage of total root intersect.

RESULTS

Seventeen species of twenty-two species showed mycorrhizal colonization (Table 1). AM colonization was observed for the first time in roots of *Shorea teysmanniana*, *Shorea balangeran*, *Shorea uliginosa* (Dipterocarpaceae), *Calophyllum* *sclerophyllum*, *Calophyllum soulattri*, *Cratoxylum arborescens* (Guttiferae), *Tetramerista glabra* (Tetrameristaceae), *Palaquium gutta* (Sapotaceae), *Melastoma melabathricum* (Melastomataceae), *Gonystylus bancanus* (Thymelaeaceae), *Hevea brasiliensis* (Euphorbiaceae) and *Campnosperma auriculatum* (Anacardiaceae). No AM colonization was found in *Hopea mengarawan* (Dipterocarpaceae), *Koompassia malacensis* (Caesalpiniaceae), *Tristaniopsis whiteana* (Myrtaceae), *Combretocapus rotundatus* (Rhizophoraceae) and *Dyera costulata* (Apocynaceae).

Table 1 Arbuscular mycorrhizal colonization of tree species

Species	Colonization (%)*	
Shorea teysmanniana	10	5
Shorea teysmanniana	9	8
Shorea balangeran	8	4
Shore uliginosa	17	6
Hopea mengarawan	0	0
Calophyllum soulattri	34	13
Calophyllum sclerophyllum	18	13
Calophyllum sp.	4	3
Cratoxylum arborescens	69	4
Tetramerista glabra	15	7
Palaquium gutta	17	3
Syzygium sp.	12	3
Tristaniopsis whiteana	0	0
Gonystylus bancanus	37	7
Combretocapus rotundatus	0	0
Hevea brasiliensis	60	2
Campnosperma auriculatum	28	7
Ficus sp.	15	9
Koompassia malaccensis	0	0
Acacia mangium	65	4
Melastoma melabathricum	56	9
Dyera costulata	0	0

*: Mean standard error

DISCUSSION

AM colonization was observed in 77% of these plant samples from tropical peat swamp forest of Central Kalimantan and in seventeen tree species colonization was observed for the first time. AM colonization has never been reported in any species of Dipterocarpaceae and Tetrameristaceae. In tropical forests other than peat swamp forests, AM colonization was shown to be present in heath forests (Moyersoen et al., 2001), dipterocarp forests and secondary forests (Metcalfe et al., 1998), monodominant lowland and upland forests (Torti et al., 1997) and lowland rainforests (Bakarr and Janos 1996). In temperate aquatic conditions, AM was also observed in fens (Cornwell et al., 2001) Our results of AM colonization in some genera are consistent with previous reports of Smits (1992) with *Ficus* sp., *Callophyllum* sp., *Palaquium* sp. and *Syzygium* sp. in East Kalimantan and of Moyersoen et al. (2001) with *Callophyllum ferugineum*, *Syzygium bankensis*, *Tristania beccarii* in Brunei Darussalam. There are also reports on AM colonization in other species of Anacardiaceae, Euphorbiaceae, Mimosaceae and Sapotaceae in Cameroon (Onguene and Kuyper, 2001) and Guttiferae and Mytraceae in Brunei Darssalam (Moyersoen et al., 2001) and Mimosaceae in Uruguay (Frioni et al., 1999) and in Sierra Leone (Bakarr and Janos, 1996). AM colonization in *Acacia mangium* has been previously reported in SierraLeone (Bakarr and Janos, 1996). Growth of this species has been shown to improve with the inoculation of mycorrhizal fungi (Habte and Soedarjo, 1995). Along with Dipterocapaceae , these species are also important in Central Kalimantan. It is possible that the early growth of these species in tropical peat soil can also be improved with the inoculations of the AM fungi.

ACKNOWLEDGEMENTS

We are grateful to members of Centre for International Cooperation in Management of Tropical peatland (CIMTROP), University of Palangka Raya for field support.

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Study of Soil Macro Fauna on Different Crop Land Types in Andisol Pasir Sarongge, West Java

G. Djajakirana[1)] and Siswati[2)]
[1)] Center for Wetland Study, Department of Soil Sciences,
Faculty of Agriculture, Bogor Agricultural University
Jl. Meranti, Kampus IPB Darmaga, BOGOR-16680 Indonesia
e-mail: soilipb@indo.net.id

[2)] Formerly Student at Department of Soil Sciences,
Faculty of Agriculture, Bogor Agricultural University

Corresponding author:
Dr. G. Djajakirana
Department of Soil Science, Faculty of Agriculture,
Bogor Agricultural University
Jl. Meranti, Kampus IPB Darmaga, BOGOR-16680 Indonesia
e-mail: soilipb@indo.net.id
phone: 0251-627792
fax: 0251-629358

ABSTRACT

Soil macro fauna has almost the same important role as soil microorganism in affecting soil characteristics. However, the data regarding the population and the biodiversity of soil macro fauna in Indonesia are still rare. The objective of this research is to determine the population and biodiversity of soil macro fauna in various crop land types and soil depth.

The research was conducted at Bogor Agricultural University Field Experiment Station in Pasir Sarongge, Cipanas at four crop land types namely grass, citrus orchard, cerealia, and vegetables. In each crop land type, hand sorting observation method was conducted at four different soil depths: 0-10 cm, 10-20 cm, 20-30 cm, and 30-40 cm. Each observation was replicated four times at different locations.

The total population of soil macro fauna in each crop land type were grass>cerealia>vegetables>citrus orchard. The population were 3.64 x 10^6 organisms/ha, 3.54 x 10^6 organisms/ha, 3.28 x 10^6 organisms/ha, and 3.17 x 10^6 organisms/ha respectively. In all crop land types, the total population of soil macro fauna was decreasing with soil depth. The population of soil macro fauna at 0-10 cm and 10-20 cm were affected significantly by crop land types. The type of crop land had a significant effect on soil macro fauna biodiversity in all soil depth.

The biodiversity of soil macro fauna were vegetables>citrus orchard>cerealia>grass. The biodiversity in all crop land types were decreased with soil depth. The population of earthworm and ants were affected significantly by soil depth in all crop land types, meanwhile the population of termites, centipedes, and beetles were affected by soil depth only in certain crop land type.

Key words: soil macro fauna, biodiversity, earthworm, ants, termites, centipedes.

INTRODUCTION

Biodiversity has relationship with ecosystem variety and life variability of all sorts of animals, plants and microorganism in the world. The difference in energy input and soil physical condition greatly affect the population and biodiversity of soil organisms.

The activities of soil flora and fauna interwoven each other, therefore it is very difficult to study separately. Soil macro fauna together with soil micro organism play an important role in the process of decomposition, namely in chewing and tearing plant tissue and moving the soil organic matter on soil surface from one place to another and often carrying them into the soil. Together with soil micro flora, soil animals utilize the energy content of the plant residues (Brady, 1974).

Although the share of soil biomass (macro, meso and micro organisms) in soil organic matter is small, in nature soil biomass varies between 1 to 5 % of the total soil organic matter, however their activity has long been recognized as a key factor influencing many soil processes such as soil genesis, productivity, and ecosystem. They also play a major role in the biochemical and physical aspect of soil fertility, soil structure, and water relationship (McGill and Cole, 1981; Stevenson, 1986).

Soil is composed of minerals, organic matter, water and gases. Organisms living in the soil vary greatly in kind and size. The difference in the soil biotic components present in the soil depends on food supply in the soil. Interaction between physical and chemical factors causes soil habitat variability in the nature and will affect the composition and activities of soil biota in certain place and time (Killham, 1994). Compared with undisturbed area (*e.g.* nature forest), arable land usually has lower population and soil biomass, especially soil fauna. In general higher population and biodiversity of fauna are found in undisturbed soil such as grassland and nature forest, where they play important role in the food chain (Woomer and Swift, 1994).

Most of researches done in the past few decade dealt with soil microorganism, especially soil bacteria and soil fungi, although soil macrobiotic have also almost the same important role in affecting soil processes as the soil microorganism. This research was done because the data regarding the population and the biodiversity of soil macro fauna in Indonesia are still rare. The data regarding soil macro organisms are needed because the population and soil biotic biodiversity present in the soil will affect soil characteristics. Soil macro fauna greatly affect the distribution of soil particle (*e.g. bioturbation*), water holding capacity, and soil infiltration.

According to Woomer and Swift (1994) organisms that belong to soil macro fauna in general have size bigger than 2 mm. Soil macro fauna that often be found in the soil are earthworm, termites, ants, snail, mites, centipedes, millipedes, insects and small mammals.

The objective of this study was to determine the population and biodiversity of soil macro fauna in various crop land types and soil depth.

MATERIALS AND METHODS

The research was conducted at Bogor Agricultural University Field Experiment Station in Pasir Sarongge, Cipanas (1 200 m above sea level), West Java at the east slope of Mount Gede. This area has an average rainfall 249 mm/month and annual rainfall 2988 mm/year. The soil in this area developed from the Mount Gede Eruption materials in 1747-1748 & 1947-1948 belong to the order of Andisol.

The research use four cropland types as observations site, namely: Grassland, Citrus orchard, Cereals (Corn), and Vegetables (Carrots, Chinese cabbage, Cabbage and Spring Onion). In each site the observations were done at four soil depth: 0-10; 10-20; 20-30; 30-40 cm. Preliminary soil analysis on soil chemical properties (pH, C_{org}., cations, and CEC) was conducted in each site.

To observe and count the soil fauna, hand sorting method was used in this research. In each site the soil was dug by 1 m x 1 m according to the depth determined in the research and the soil was sieved with 5 mm and 2 mm sieves. Then the fauna were collected by hand using tweezers and kept in the small bottles filled with formalin according to its kind and later were counted with the help of loupe. In each observation site four replications were made.

To test the influence of crop land type and soil depth on the population and biodiversity of soil macro fauna, statistical analysis using completely random design with four replications was used.

RESULTS AND DISCUSSION

Soil properties

The soil reaction of the Andisol in each site varies from slightly acid to slightly neutral and also the other chemical properties vary between each site. The difference in soil reaction and other chemical properties were due to management of the crops themselves. The vegetables soil was work more intensively (more tillage and fertilizers), therefore has higher pH, but lower in organic matter content. The cereals soil also relatively was managed more often then grassland and Citrus orchard. The grassland and Citrus orchard were the least managed soil, almost undisturbed, therefore have the higher organic C content (Table 1.)

Because of the differences in the soil chemical properties therefore it can be expected that there will be differences in the soil fauna population and biodiversity. The most important factor that influences the size of population is the food supply which is reflected by the content of the soil organic matter. The second important factor is soil reaction. Other factors that also important influence the size of population is the intensity of disturbance in that particular ecosystem (*e.g.* tillage).

Table 1. Some chemical properties of the Andisol Pasir Sarongge West Java.

Crop land type	pH	C-Org.	Ca-Exch.	Mg-Exch.	K-Exch.	Na-Exch.	CEC
		(%)	meq/100 g				
Grassland	5.70	5.42	7.65	0.52	0.40	0.06	25.91
Citrus Orchard	5.20	5.34	4.66	0.43	0.17	0.15	18.08
Cereals	5.30	4.70	6.90	0.63	0.23	0.34	17.31
Vegetables	6.20	3.89	3.55	1.29	0.45	0.27	25.90

Population of soil macro fauna in each crop land type

In grassland soil, ants and termites were the most dominant fauna throughout the soil depth. In the second layer (10-20 cm), termites have higher population as compared with first layer, because termites usually made their nest in that depth. Earthworm, beetle larvae, and centipedes also were found in relatively high amount. In grass soil, it was found 10 kinds of soil macro fauna (Table 2.). Grassland soil has the highest population of soil macro fauna as compared with other crop land types.

Grassland soil has the highest soil macro fauna population because it was never tilled, therefore the soil organic matter tend to accumulate in the soil surface. It has the highest soil organic matter content (Table 1.), so it has abundance food supply that can accommodate higher soil macro fauna population.

In citrus orchard soil, ants and termites were also the most dominant fauna throughout the soil depth. However, the highest termites population was found only in the surface layer (0-10 cm), and then the population decreases with the soil depth. Centipedes, earthworm, beetle larvae, mole cricket and roach also were found in relatively high amount. In citrus orchard soil, it was found 12 kinds of soil macro fauna (Table 3.). Citrus orchard soil has the highest biodiversity of soil macro fauna as compared with other crop land types. In this soil many fauna still can be found in relatively high number in the depth of 30-40 cm.

Table 2. Means of soil macro fauna population found in grassland soil.

No.	Soil Macro Fauna	Soil Depth (cm)			
		0 – 10	10 – 20	20 – 30	30 – 40
		Means population per m^2			
1.	Earthworm	15	6	3	0
2.	Ant	54	28	31	11
3.	Termite	27	82	35	4
4.	Mole Cricket	3	0	0	1
5.	Centipede	14	12	4	7
6.	Cricket	1	0	0	1
7.	Spider	1	0	1	1
8.	Beetle larvae	15	3	0	0
9.	Small Beetle	2	0	0	0
10.	Roach	1	1	0	0

Citrus orchard soil has different kind of earthworm as compared with others soil. In this soil the earthworm has bigger size and darker color; whereas the others crop land types have relatively the same earthworms. Citrus orchard soil also seldom was tilled, therefore the soil organic matter tend to accumulate in the soil surface. It has the second highest soil organic matter content (Table 1.), however, has the lowest soil reaction so it has also the lowest soil macro fauna population.

Beetle larvae prefer living where the soil organic matter was abundance, therefore in citrus orchard soil mostly was found in the soil surface and the population was the highest among others crop land types. Citrus orchard soil has the second highest centipedesí population. Most centipedes are predator; they prey on other smaller soil fauna. They can move quickly, therefore they can be found throughout the soil depth. Citrus orchard soil has the highest mole cricket population. Mole cricket likes to live in wet or humid environment, and citrus orchard gives that condition. Mole cricket is omnivore, sometime it act also as predator by feeding some smaller soil fauna, but it brings more disadvantages to the plant because it likes to feed on plant roots (Kalshoven and van der Laan, 1981).

Table 3. Means of soil macro fauna population found in citrus orchard soil.

No.	Soil Macro Fauna	Soil Depth (cm)			
		0 – 10	10 – 20	20 – 30	30 – 40
		Means population per m^2			
1.	Earthworm	19	3	1	0
2.	Ant	41	14	10	4
3.	Termite	50	7	4	2
4.	Mole Cricket	18	7	2	9
5.	Centipede	22	13	10	9
6.	Cricket	8	0	0	2
7.	Spider	9	1	0	0
8.	Beetle larvae	19	3	1	1
9.	Small Beetle	2	0	0	0
10.	Caterpillar	7	1	0	0
11.	Roach	11	1	0	0
12.	Snail	7	0	0	0

The result of soil macro fauna counting in the cereals soil can be seen in Table 4. Termites, ants and earthworm were the most dominant macro fauna found in this soil. The earthworms found in this soil have smaller size and have reddish color. This soil has been tilled relatively often, and was also often sprayed with pesticide, therefore disturbed the soil ecosystem. The cereals soil has 10 kinds of soil macro fauna, less biodiversity as compared with other crop land types.

The distribution of termitesí population in this soil was the same as in the grassland soil, namely highest in the second layer (10-20 cm) and then decreases with soil depth. However, the population in the depth 30-40 still the highest as compared with others crop land types. This is due to the tillage, so the distribution of soil organic matter was more evenly in the soil profile till the depth 30-40 cm. Organic matter means food for the soil fauna. When the organic matter can be distributed deeper, then the organisms can also move deeper to find the food.

The result of soil macro fauna counting in the vegetables soil can be seen in Table 5. Centipedes were the most dominant fauna found in this soil, followed by ants, termites, earthworms

Table 5. Means of soil macro fauna population found in vegetables soil.

No.	Soil Macro Fauna	Soil Depth (cm)			
		0 – 10	10 – 20	20 – 30	30 – 40
		Means population per m^2			
1.	Earthworm	22	16	7	0
2.	Ant	38	42	17	6
3.	Termite	32	13	9	4
4.	Mole Cricket	1	8	0	3
5.	Centipede	52	19	6	8
6.	Cricket	1	3	0	1
7.	Spider	1	1	0	0
8.	Beetle larvae	7	3	1	1
9.	Small Beetle	1	1	1	0
10.	Caterpillar	1	1	1	0
11.	Roach	1	0	0	0

and beetle larvae. In vegetables soil, it was found 11 kinds of soil macro fauna.

Vegetables soil also has been tilled relatively often, and was also often sprayed with pesticide, therefore disturbed the soil ecosystem. Intensive tillage has reduced the soil organic matter content. Although this soil has the lowest organic matter content, but it has the highest soil reaction, therefore it will affect the population of the soil macro fauna.

The influence of crop land type on soil macro fauna population and biodiversity

Soil macro fauna population

The total population of soil macro fauna in the depth of 0-40 cm was grassland>cereals>vegetables>citrus orchard (Fig. 1). Grassland soil has the highest soil macro fauna population, because this soil has better soil environment (Table 1.), whereas citrus orchard has the lowest population. Citrus orchard soil though has second highest organic matter content, but organic matter supplied by citrus plant contains a lot of volatile oil that is poisonous to soil fauna, therefore can not be utilized optimally by soil fauna. Beside that, citrus soil also has the lowest pH, no wonder that citrus soil has the lowest population of soil fauna.

Cereals and vegetables soils have intermediate amount of soil macro fauna population. Though these soils have enough litter and plant residue supply and good soil reaction, but were tilled and also applied with pesticide relatively often, therefore have more disturbances to the soil ecosystem as the habitat of the soil macro fauna. As a consequence the total populations were not so high as compared with grassland.

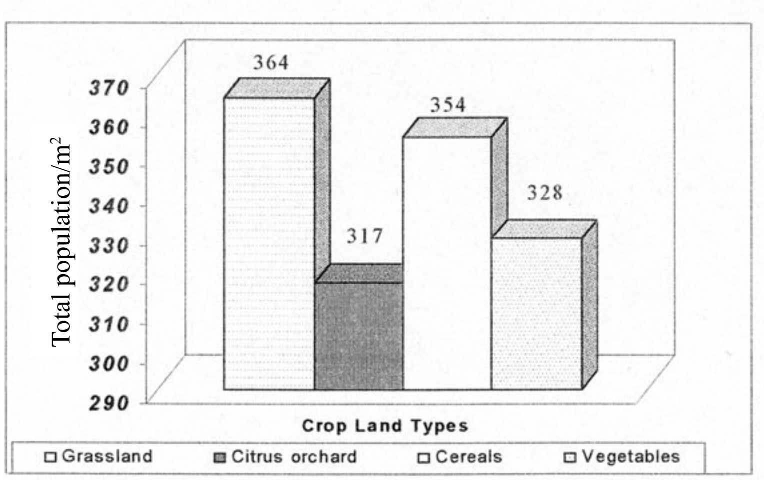

Figure 1. Total population of soil macro fauna in 0 - 40 cm soil depth at four crop land types

Statistical analysis showed that crop land type significantly affected the total population of soil macro fauna in the depth of 0-10 cm and 10-20 cm, but has no significant effect on the depth of 20-30 cm and 30-40 cm (Table 6.).

The total population of soil macro fauna decreased with the soil depth (population in 0-10 cm> 10-20 cm> 20-30 cm> 30-40 cm). In all crop land type surface layer (0-10 cm) has the highest population and the deepest layer has the least population. This phenomenon has relationship with the soil organic matter content. Organic matter content of the soil decreased with the soil depth.

Table 6. Mean population of soil macro fauna as affected by crop land types and soil depth.

No.	Crop Land Type	Soil Depth (cm)			
		0 – 10	10 – 20	20 – 30	30 – 40
		∑/m^2			
1.	Grassland	133 b	132 b	74 cd	25 d
2.	Citrus Orchard	213 a	50 d	28 d	26 d
3.	Cereals	132 b	129 b	69 cd	24 d
4.	Vegetables	156 b	107 bc	42 d	23 d

Note: Number followed with the same letter is not significantly different at 5 % LSD.

Soil macro fauna biodiversity

Statistical analysis showed that crop land type significantly affected the soil biodiversity of the soil macro fauna in all soil depth. Soil depth also significantly affected the soil biodiversity of the soil macro fauna in all crop land type. Soil macro fauna biodiversity in the surface layer was vegetables soil> citrus soil> grassland> cereals soil (Table 7.).

In the surface layer cereals soil has the lowest biodiversity, because the plant coverage was not so high and also organic matter supply of the maize plant was not so high. The soil also was not planted in rotation with other

Table 7. Biodiversity of soil macro fauna as affected by crop land types and soil depth.

No.	Crop Land Type	Soil Depth (cm)			
		0 – 10	10 – 20	20 – 30	30 – 40
		∑/m^2			
1.	Grassland	10 a	8 ef	5 i	6 h
2.	Citrus Orchard	12 b	8 ef	6 h	6 h
3.	Cereals	9 b	8 ef	7 g	6 h
4.	Vegetables	11 a	10 b	7 g	7 g

Note: Number followed with the same letter is not significantly different at 5 % LSD.

plant. On the other hand, vegetables soil has the highest biodiversity; this was due to the fact that in this soil plant rotation between Carrots, Chinese cabbage, Cabbage and Spring Onion was applied intensively. It can not be denied that every crop may has certain macro fauna which likes to live in its vicinity, therefore with this plant rotation, the diversity of the soil macro fauna will increase.

Population of some soil macro fauna on crop land types

In this section some soil macro fauna which have higher population and have important role in the soil ecosystem will be discussed; some of them were earthworms, ants, termites, centipedes and beetles.

Earthworms

Statistical analysis showed that crop land type significantly affected the population of earthworms in the depth of 0-10 cm, 10-20 cm, and 20-30 cm, but has no significant effect on the depth of 30-40 cm (Table 8.). Soil depth significantly affects earthwormsí population in all crop land types.

The earthwormsí population was highest in cereals soil. This was due to the fact that cereals soil has high organic matter content and exchangeable Ca (Table 1.). As already known earthworms need high concentration of Ca in their habitat. Other factor that affected earthwormsí population may be due to the addition of the manure in cereals soil. Russel (1978) has reported that manure addition increased the earthwormsí population in arable soil.

Table 8. Earthworms' population as affected by crop land types and soil depth.

No.	Crop Land Type	Soil Depth (cm)				
		0 – 10	10 – 20	20 – 30	30 – 40	Total
		$\sum/m^2$				
1.	Grassland	15 ab	6 bcd	3 c	0 c	24
2.	Citrus Orchard	19 ab	3 c	1 c	0 c	23
3.	Cereals	20 a	16 ab	13 ab	1 c	50
4.	Vegetables	22 a	16 ab	7 bc	0 c	45

Note: Number followed with the same letter is not significantly different at 5 % LSD.

Citrus orchard soil has the lowest earthwormsí population; this was due to the fact that citrus soil has the lowest exchangeable Ca. Earthworms were rarely found in the soil with low exchangeable Ca and has low pH. Beside the fact that organic matter quality from citrus leaves residue was low because it contains volatile oil that poisonous to some soil fauna.

Ants

Statistical analysis showed that crop land type significantly affected the population of ants in the depth of 0-10 cm, 10-20 cm, and 20-30 cm, but has no significant effect on the depth of 30-40 cm (Table 9.). Soil depth significantly affects antsí population in all crop land types.

Grassland has the highest population. Ants are soil fauna that have fixed nest in the soil; therefore soil tillage will destroy their nest. In the soil that never been tilled liked grassland the antsí population will be high. In vegetables soil although often was tilled, the ants population was high. This may because of most of the ants found here came to this soil only for searching food, but have nest in other places. Many soil fauna lived in the vegetables soil that maybe the food for the ants.

Table 9. Ants' population as affected by crop land types and soil depth.

No.	Crop Land Type	Soil Depth (cm)				
		0 – 10	10 – 20	20 – 30	30 – 40	Total
		$\sum/m^2$				
1.	Grassland	54 a	28 bcd	31 bc	11 e	124
2.	Citrus Orchard	41 ab	14 de	10 e	4 e	69
3.	Cereals	35 b	35 b	15 de	7 e	88
4.	Vegetables	42 ab	42 ab	17 cde	6 e	103

Note: Number followed with the same letter is not significantly different at 5 % LSD.

Termites

Statistical analysis showed that crop land type only affected significantly the population of termites in the depth of 10-20 cm and has no significant effect on other depth (Table 10.). Soil depth significantly affects termitesí population in citrus orchard, grassland and cereals soil, but has no effect on vegetables soil. The termites population was in the order grassland>cereals>citrus orchard>vegetables.

Table 10. Termite population as affected by crop land types and soil depth.

No.	Crop Land Type	Soil Depth (cm)				
		0 – 10	10 – 20	20 – 30	30 – 40	Total
		$\sum/m^2$				
1.	Grassland	27 cde	102 a	35 bcde	4 e	168
2.	Citrus Orchard	50 bcd	7 e	4 e	2 e	63
3.	Cereals	51 bc	69 ab	34 bcde	12 de	166
4.	Vegetables	32 bcde	13 de	9 e	4 e	58

Note: Number followed with the same letter is not significantly different at 5 % LSD.

Grassland and cereals soils have high population of termites. Grass and cereals both belong to the Graminae family. It seems that termites were favorable living in this plant; maybe the supply of organic matter from this kind of plant suited the need of the termites.

Centipedes

Statistical analysis showed that crop land type significantly affected the population of centipedes in the depth of 0-10 cm, 10-20 cm, and 20-30 cm, but has no significant effect on the depth of 30-40 cm (Table 11.). Soil depth significantly affects centipedesí population in citrus orchard, grassland and vegetables soil, but has no effect on cereals soil. The centipedes population was in the order vegetables>citrus orchard>grassland>cereals.

Table 11. Centipede population as affected by crop land types and soil depth.

No.	Crop Land Type	Soil Depth (cm)				
		0 – 10	10 – 20	20 – 30	30 – 40	Total
		∑/m^2				
1.	Grassland	14 cd	12 cde	4 fg	7 fg	37
2.	Citrus Orchard	22 b	13 cde	10 def	9 efg	54
3.	Cereals	6 fg	4 fg	3 g	2 g	15
4.	Vegetables	52 a	19 bc	6 fg	8 efg	85

Note: Number followed with the same letter is not significantly different at 5 % LSD.

The vegetables soil has the highest centipedesí population. Most centipedes lives as predator (Richards, 1978), therefore soil which has higher diversity most likely has higher centipedesí population, because they have more variety on their prey.

Beetles

Statistical analysis showed that crop land type only affected significantly the population of beetles in the depth of 0-10 cm and has no significant effect on other depth (Table 12.). Soil depth significantly affects beetlesí population in citrus orchard, grassland and vegetables soil, but has no effect on cereals soil. The beetles population was in the order citrus orchard> grassland> vegetables> cereals.

Citrus orchard has the highest beetlesí population as compared with others crop land types. Beetles larvae prefer to live in a place rich with organic matter, meanwhile citrus orchard has high soil organic matter content (5.34 %). Although citrus plant residues were not liked by other soil fauna, it seems that beetles larvae were not affected by the low quality of citrus plant residues.

Table 12. Beetle population as affected by crop land types and soil depth.

No.	Crop Land Type	Soil Depth (cm)				
		0 – 10	10 – 20	20 – 30	30 – 40	Total
		∑/m^2				
1.	Grassland	17 a	3 bc	0 c	0 c	20
2.	Citrus Orchard	21 a	3 bc	1 bc	1 bc	26
3.	Cereals	3 bc	3 bc	3 bc	1 bc	11
4.	Vegetables	8 b	4 bc	2 bc	1 bc	15

Note: Number followed with the same letter is not significantly different at 5 % LSD.

Most beetles live in the surface layer of the soil. Any disturbance in this layer will affect the beetlesí population. This is the ground that cereals and vegetables soils have lower beetlesí population, meanwhile citrus orchard and grassland have higher beetles population. In cereals and vegetables soils, the soils were often tilled and applied with pesticide; therefore this practice will disturb their habitat. The soil that was seldom tilled liked citrus orchard and grassland have greater beetlesí population.

Beetles play important role in tearing and mixing organic matter in the soil. Because beetles larvae prefer to live in a place rich with organic matter, they can be used as fertility indicator for soil fertility. Organic matter that has been destroyed through beetle larvae activity will be utilized by soil micro flora and will be decomposed to produce humus substances that are very important for soil fertility.

CONCLUSION

- Crop land types affected population and biodiversity of soil macro fauna. The population of soil macro fauna was grassland>cereals>vegetables>citrus orchard. The biodiversity of soil macro fauna citrus orchard> vegetables>grass=cereals.
- Soil depth influenced the population and biodiversity of soil macro fauna, with soil surface (0 - 10 cm) has the greater population and biodiversity
- The population of earthworm, centipede and beetle were affected by soil management (soil tillage, fertilizer, liming and pesticide)
- Some soil macro fauna live only in the soil surface

ACKNOWLEDGEMENTS

The authors acknowledge the consent of Center for Wetland Studies (CWS), Bogor Agricultural University and Japan Society for the Promotion of Science (JSPS) for their financial support to present this paper in the International Symposium on Land Management and Biodiversity in Bali, 17-20 September 2002.

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Ectomycorrhizas of Peat Swamp Forest Trees in Central Kalimantan

Yutaka Tamai[1], Joo-Young Cha[2], Turjaman Maman[3], Keitaro Tawaraya[4], Masato Shibuya[1], Limin Suwido[5], Mitsuru Osaki[1]

1:Graduate School of Agriculture, Hokkaido University, N-9, W-9, Kita-ku, Sapporo 060-8589, Japan

2:Wakayama Experimental Forest, Field Science Center for Northern Biosphere, Hokkaido University, Hirai, Kozagawa-cho, Wakayama 649-4563,Japan

3:R&D Center for Forest and Nature Conservation, Jl. Gunung Batu 5, Bogor, Indonesia 16610

4:Faculty of Agriculture, Yamagata University, 1-23, Wakaba-cho, Tsuruoka 997-8555, Japan

5:CIMTROP, University of Palangkaraya, Jl. Yos Sudarso, Palangka Raya 73112, Central Kalimantan, Indonesia

ABSTRACT

For restoration of degraded peat swamp forest, the silvicultural techniques using mycorrhizal fungi are necessary. Mycorrhizal symbiotic relationships play many important roles to growth and survive of trees. The objective of this research is to observe the ectomycorrhizal status of typical peat swamp forest tree species in central kalimantan. Sixteen tree species were collected in the peat swamp area of Palangkaraya city, and examined about microscopic characteristics of their roots. Abundant ectomycorrhizal colonizations were observed in *Shorea balangeran*, *S. teysmanniana* (Dipterocarpaceae) and particially colonization were in several species of Myrtaceae. The other species Eighteen species of ectomycorrhizal fungi were collected from the forest floor. Most common species were *Scleroderma* spp.

Key words: ectomycorrhiza, Shorea balangeran, Shorea teysmanniana, arbuscular mycorrhiza, Scleroderma

INTRODUCTION

Peat swamp forest in Central Kalimantan was highly disturbed and destroyed by the development of farmland, illegal logging and wild fire. Such a damaged forest site dose not recover easily, because the damage has an influence to soil condition.

Mycorrhizal association plays an important role for survival and growth of trees. Most of tree species have some symbiotic relationships with mycorrhizal fungi and receive some supports in nutrition uptake and tolerance for environmental factors (Harley & Smith, 1983).

The wild fire on the peat land seems to cause an enormous damage into the native microbial symbiotic system. For the reforestation planting of such a damaged site, utilization of mycorrhizal fungi must be essential to produce vigorous seedlings for plantation. To establish an appropriate nursing method, the purpose of this research was to clarify the ectomycorrhizal status of native and typical peat swamp forest tree species in Central Kalimantan.

MATERIALS AND METHODS

Three plots were set in the peat swamp forests (Kalanpangan, Setialam, Tangirin) of Palangka Raya, Central Kalimantan, where tree seedlings were collected in September 2000. At least three replication of sampling were performed for each tree species. Their scientific names were identified in R&D Center for Forest and Nature Conservation, Bogor. Each root samples were separated into two parts and the half part was used for vesicular-arbuscular mycorrhizal investigation (Tawaraya *et al* 2003). After washing of root samples, they were fixed and stored in FAA fixative (5% Formalin, 5% Acetic acid, 45% Ethyl alcohol) until the microscopic observation. KOH clearing and typanblue staining were used for observation of inner structure of mycorrhiza according to need.

Fruit-bodies were collected from the same plots during rainy season of 2001 (November - March). After observation of macroscopic features, samples were dried in oven and stored. Fungal isolation from fresh fruit-body tissue or spore was tried for some species. Fungal genus and species were identified according to Corner (1972, 1994), Singer (1987), Pegler (1997) and Miller & Miller (1988).

RESULTS AND DISCUSSION

Sixteen tree species were collected according to local name and identified as in Table 1(Soerianegara and Lemmens, 1996). They are typical species in the peat swamp forest of Palangka Raya, and have economically importance for local people. All of sampled seedlings were ranged in height of 30 - 60 cm and stem diameter of 5 - 10 mm, but age was unknown. Root depth reached to 30 - 50 cm in peat soil layer.

Two Dipterocarpaseae species (*Shorea balangeran* and *Shorea teysmanniana*) appeared to form abundant ectomycorrhizas with short, pinnate branched root chips and abundant external hyphae (Figure 1, Table 2). Three *Syzygium* spp. appeared partially to form unbranched, fine ectomycorrhizas with brownish fungal sheath. They may also have coexistent vesicular-arbuscular mycorrhizas in the same root systems. For *Combretocarpus rotundatus* and *Tristaniopsis whiteana*, mycorrhizal formation was seldom observed with undefined features. Further investigation will be necessary to clarify their mycorrhizal status. The other tree species did not form any types of ectomycorrhizas. They seemed to form and depend on vesicular-arbuscular mycorrhizas (Tawaraya *et al*, 2003).

Eighteen species of fruit-bodies were found on the floor of peat swamp forest, which seemed to be ectomycorrhizal fungi (Table 3). Most common species was *Screloderma* sp., which were observed on dried soil surface. Three fungal species (*Screloderma* sp., *Russula* sp.1 and *Boletus* sp.1) have a hyphal connection with *Shorea balangeran*, seemed to make ectomycorrhizal associations. *Scleroderma citrinum* formed ectomycorrhizas with *Acasia mangium*, and the features were described in detail by Cha *et al* (2003). Only one isolate

Table 1. Collected natural tree seedling samples from peat swamp forest in Palangka Raya.

No.	Family	Latin name	Local name	Useage
1	Anacardiaceae	*Campnosperma auriculatum*	Terentang	timber, seed oil
2		*Mangifera sp.*	Asem-asem	construction wood for local use
3	Anisophylleaceae	*Combretocarpus rotundatus*	Tumih	heavy construction wood for local use
4	Clusiaceae	*Calophyllum soulattri*	Bintangor (sp1)	construction wood, latex, medicine, fruits
5		*Calophyllum sp.*	Bintangor (sp2)	construction wood, latex, medicine, fruits
6	Dipterocarpaceae	*Shorea teysmanniana*	Meranti rawa	timber
7		*Shorea balangeran*	Balangeran	timber, walling, resin
8	Ebenaceae	*Diospyros maingayi*	Buring pahe	interior wood
9	Hypericaceae	*Cratoxylum arborescens*	Gerunggang	timber
10	Myrtaceae	*Syzygium sp.(1)*	Jambu-jambuan (sp1)	construction wood for local use, fruits
11		*Syzygium sp.(2)*	Jambu-jambuan (sp2)	construction wood for local use, fruits
12		*Syzygium sp.(3)*	Ehang	construction wood for local use, fruits
13		*Tristaniopsis whiteana*	Pelawan	heavy construction wood
14	Sapotaceae	*Palaquium gutta*	Hangkang	interior wood, latex
15	Tetrameristaceae	*Tetramerista glabra*	Punuk	interior wood, fruits
16	Thymelaeaceae	*Gonystylus bancanus*	Ramin	light constraction wood. incense.

Table 2. Ectomycorrhizal status of collected tree samples from peat swamp forest in Palangka Raya.

No.	Latin name	Characteristics of ECM colonized roots	Abundance	(VAM colonization*)
1	*Campnosperma auriculatum*	None	-	++
2	*Mangifera sp.*	None	-	
3	*Combretocarpus rotundatus*	Unbranched , visible external hyphae, light brown fungal sheath		-
4	*Calophyllum soulattri*	None	-	+++
5	*Calophyllum sp.*	None	-	
6	*Shorea teysmanniana*	Pinnate branched, abundant external hyphae, light to dark brown	+++	
7	*Shorea balangeran*	Pinnate branched, abundant external hyphae, light to dark brown, reddish yellow	+++	
8	*Diospyros maingayi*	None	-	+++
9	*Cratoxylum arborescens*	None	-	+++
10	*Syzygium sp.(1)*	Unbranched, no external hyphae, dark brown	+	
11	*Syzygium sp.(2)*	Unbranched, visible external hyphae, brown	+	
12	*Syzygium sp.(3)*	Unbranched, visible external hyphae, dark brown	+	+
13	*Tristaniopsis whiteana*	Pinnate branched, visible external hyphae, light brown		-
14	*Palaquium gutta*	None	-	+
15	*Tetramerista glabra*	None	-	+
16	*Gonystylus bancanus*	None	-	+++

* Based on observation by Tawaraya et al (2003) with the same samples of this report.

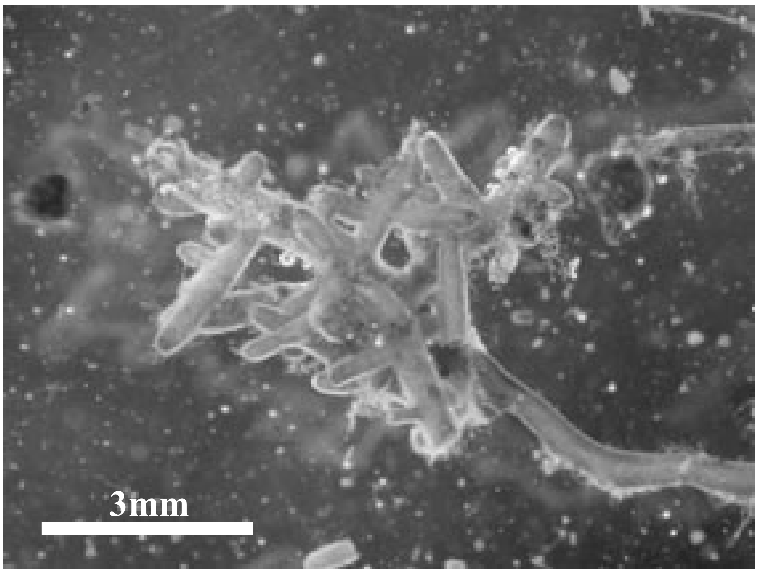

Figure 1. Ectomycorrhizas formed abundantly on the root of *Shorea balangeran*.

Table 3. Ectomycorrhizal fungi collected from the peat swamp forest of Palangka Raya.

No.	Fungus name	Fruit-body features	Host species
1	*Scleroderma citrinum*	gasteroid, yellowish brown, no stipe	*Acasia mangium*
2	*Scleroderma* sp.	gasteroid, grayish brown, leathery peridium, no stipe	*Shorea balangelan*
3	*Laccaria fraterna*	light brown, adnate and distant gills, brownish distorted stipe	*Dryobalanops* sp.
4	*Laccaria* sp.	light pink, adnate and lamellae gills, reddish brown stipe	*unknown*
5	*Russula* sp.1	reddish brown, free and lamellae gills, reddish brown stipe	*Shorea balangelan*
6	*Russula* sp.2	reddish brown, free and lamellae gills, white stipe	*unknown*
7	*Russula* sp.3	light brown, free and lamellae gills, sphaerocyst distinct	*unknown*
8	*Russula* sp.4	white, free and lamellae gills, sphaerocyst distinct	*unknown*
9	*Boletus* sp.1	reddish brown, yellow flesh cyanescent on exposure	*Shorea balangelan*
10	*Boletus* sp.2	reddish brown, yellow flesh cyanescent on exposure	*unknown*
11	*Strobilomyces* sp.1	dark gray, grayish white flesh nigrescent on exposure	*unknown*
12	*Strobilomyces* sp.2	dark gray, grayish white flesh slowly nigrescent on exposure	*unknown*
13	*Rhizopogon* sp.	puffball, white, no stipe	*unknown*
14	*Geastrum* sp.	earthstar, grayish brown,	*unknown*
15	*Amanita* sp.1	light brown, viscid cap, volva	*unknown*
16	*Amanita* sp.2	grayish brown, viscid cap, annules, volva	*unknown*
17	*Calvatia* sp.	gasteroid, yellowish brown, no stipe	*Acasia mangium*
18	*Calostoma fuscum*	gasteroid, grayish white, gelatinous stipe and outer layer	*unknown*

was obtained from the fruit-body tissue of *S. citrinum*, and maintained on the Ohta agar medium (Ohta, 1990). *Calostoma fuscum* forms a unique type of ectomycorrhiza, which has a gelatinous outer layer over the fungal sheath (Figure 2). It may be an adapted structure for wetland condition. The host tree species could not be identified.

To clarify ectomycorrhizal properties of these fungi, inoculation test for *Shorea* species using several fungal species (*Screloderma* spp., *Boletus* sp.1, *Storobilomyces* sp.1 and *Calvatia* sp.) are executing in nursery.

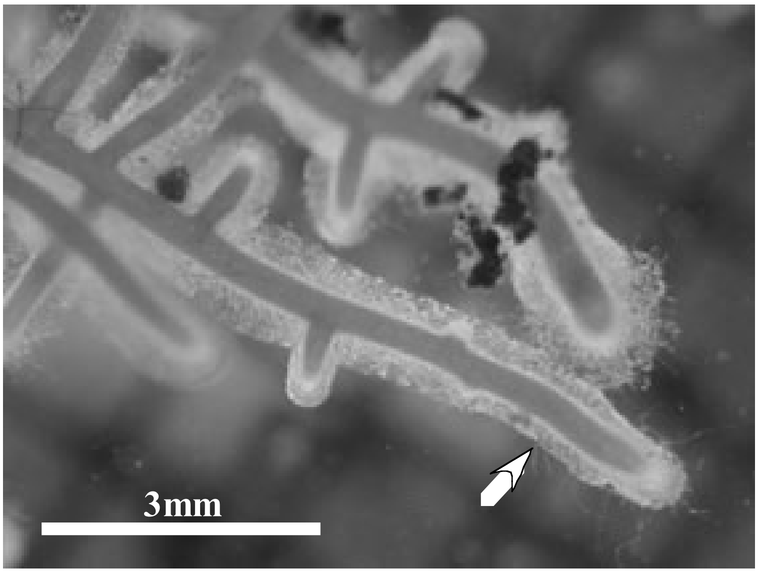

Figure 2. An ectomycorrhiza forming gelatinous outer layer over the fungal sheath.

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Characterization of Free-living Nitrogen-fixing Bacteria Isolated from Rhizoplane of *Melastoma* sp. Inhabiting Acidic Plain Land in Kalimantan and Their Ecological Role

Yasuyuki Hashidoko,[1] Yukako Gotou,[1] Henny Hoo,[1] Mitsuru OsakiI,[1] Erry Purnomo,[2] Limin H. Suwido,[3] and Satoshi Tahara[1]

[1] Graduate School of Agriculture, Hokkaido University, Sapporo 060-8589, Japan. E-mail: yasu-h@abs.agr.hokudai.ac.jp

[2] Center for Tropical Acid Soil Studies, Faculty of Agriculture, UNLAM, PO Box 1028 Banjarbaru, South Kalimantan 70714, Indonesia. E-mail: ctassas@hotmail.com

[3] Faculty of Agriculture, The University of Palangka Raya, Palangka Raya, Central Kalimantan, Indonesia. E-mail: suwido@palangkaraya.wasantara.net.id

*Corresponding author: Yasuyuki Hashidoko. E-mail: yasu-h@abs.agr.hokudai.ac.jp
Tel: +81-11-706-3839. Fax: +81-11-706-4182.

ABSTRACT

Rhizoplane microorganisms of *Melastoma* sp., distributing throughout acid sulfate soil and peat soil in southern Kalimantan, were investigated, using soft gel media of N-free WinogradskyÅfs mixture solidified with 0.3 % gellan gum. Two bacteria, *Sphingomonas rosa* and *Burkholderia cepacia* belonging to subclass of a- and b-Proteobacteria, respectively, emerged in the nitrogen-free medium. Inoculation of *Sphingomonas rosa* in the *Melastoma* sp. seedlings grown in N-free, 1/4 Hoagland's No. 2 medium (pH 3.0) resulted in better growth of the seedlings

Key words: Melastoma sp., rhizoplane bacterium, Sphingomonas rosa, Burkholderia cepacia, acid-sulfate soil.

INTRODUCTION

Many species of genus *Melastoma*, such as *M. malabathricum* L., are known to be Al-accumulators (Watanabe *et al.,* 1998a), and adaptability of *Melastoma* spp. to acid-sulfate soil of very low pH is mainly due to this property. The *Melastoma* sp., distributing throughout Central and South Kalimantans, Indonesia, is a powerful pioneer shrub tree that is able to spread throughout the acid-sulfate soil regions. Since acid-sulfate soil with very low pH (2.5-3.5) has undergone strong leaching, such acid-tolerable plant must employ certain strategy to get nutrient, including N and P. *Melastoma* spp. are also known as ammonia-assimilating plants, preferring NH_4^+ rather than NO_3^- for their nitrogen source (Watanabe *et al.,* 1998b). Bearing in mind these facts, the presence of free-living nitrogen-fixing bacteria on the rhizoplane of the *Melastoma* sp. is thought to be beneficial to their survival in acid-sulfate soil, due to releasing ammonia into the rhizosphere. Not only as a nitrogen source but also as an inorganic base provided via nitrogen-fixation, ammonia is likely a key material in the adaptation of the *Melastoma* sp. to acid-sulfate soil.

MATERIALS AND METHODS

General.

Melastoma sp. used for microfloral investigation in the rhizoplane were collected at ridge of a sulfate acid soil paddock at Serapatbaru in South Kalimantan, ridge of a peat soil field at Kalampangan in Central Kalimantan, respectively. For plant growth, we used a EYELA LTI 600 SD thermo-controlling incubator equipped with red and blue light emitting diode (EYELA LED-red/blue, 40/10 per a board of 30 x 30 cm^2 width) as the illuminant. To a tall-skirted petri dish, 50 ml vermiculite in the bed volume was poured, and wet with approximately 30 ml of a N-free 1/4 Hoagland's No. 2 (pH 3.0) in which molybdenum trioxide (MoO_3) was ten-fold enhanced.

Screening and Identification of Rhizoplane Microorganisms

We used a gellan gum-base soft gel medium for observation and evaluation of the microflora of rhizoplane nitrogen-fixing bacteria as described in our paper (Hashidoko *et al*., 2002). Some bacteria obtained from the root washings were purified on a modified Winogradsky's medium (Winogradsky's mineral mixture, 0.5% mannitol, 0.005% yeast extract and 2% agarose). For identification, 16S rDNA sequences was determined and its homology search was done using DDBJ BLASTN DNA database (http://www.ddbj.nig.ac.jp/E-mail/homology-j.html). Total DNA used for the template for PCR amplification of the 16S rDNA regions was prepared by a DNA extraction kit, Isoplant II (Wako Pure Chemical Industries Ltd.). For the DNA amplification, the PCR kit, Gene *Taq* (Nippon Gene), was used according to its instruction protocol.

Seedling Preparation and Inoculation Assay

Seeds sampled at Central Kalimantan were sown in an autoclaved vermiculite bed wet with sterile N-free 1/4 Hoagland's No. 2 adjusted pH 3.5, and incubated at 23°C under a 16-h light/8-h dark photoperiod. Bacteria grown on an agar plate of modified Winogradsky's medium (containing 0.5% mannitol and 0.005% yeast extract) were scraped with a loop and suspended in 5 ml sterile water and used as the inocula. The seedlings (*S. rosa*-inoculated, *B. cepacia*-inoculated, *S. rosa* plus *B. cepacia*-inoculated and control) were grown under the same condition for 8 weeks to see the effects of the bacterial inoculation on the growth of the seedlings under the N-deficient condition.

RESULTS AND DISCUSSION

Bacterial isolates and their physiological properties

We initially investigated microorganisms constituting of the rhizoplane microflora, particularly those of nitrogen-fixing bacteria. We used a soft gel medium for observation and evaluation of the rhizoplane nitrogen-fixing bacteria, of which method was first developed by a Brazilian microbiologist, Dobereiner and her coworkers at 1980th (Dobereiner, 1995) and we replaced 0.2% agarose used as the gel matrix with 0.3% gellan gum. As shown in Fig. 1, gellan gum was highly transparent, and even thin or highly transparent colonies are visible through the glass tube (Hashidoko *et al.,* 2002).

Two rhizoplane bacteria were isolated from a specimen of *Melastoma* sp. grown along a bank of an acid-sulfate paddock at Serapatbaru, South Kalimantan. Our physiological and 16S rDNA determination led them to identification of *Sphingomonas rosa* and *Burkholderia cepacia*. The former was non-motile and highly aggregative, whilst the latter was highly motile and produced mucilaginous materials around the cells. An unknown *Sphingomonas* sp. was also isolated as the major rhizoplane bacterium of *Melastoma* sp. grown on acid-sulfate clay soil in Paduran, Central Kalimantan. On the contrary, a specimen of *Melastoma* sp. grown on a peat land at Kalampangan, Central Kalimantan, possessed two *Burkholderia* species, and one was tentatively identified as *B. brazilensis*.

All of the rhizoplane bacteria from *Melastoma* sp. showed Type B-behaviors (Hashidoko *et al*., 2003). In particular, bacteria isolated from the specimen sampled at Paduran, developed in the N-free gellan gum-base soft gel medium in which 1% glucose was used as the sole carbon source, turned its medium pH to be alkaline regions. This suggested that bacteria positively released ammonia in the medium.

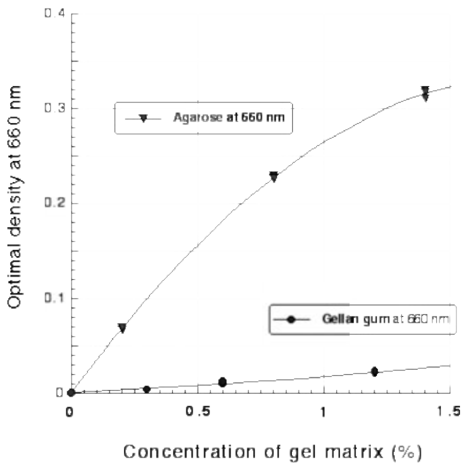

Figure 1. Transparency of gellan gum in comparison with agarose.

Effect of inoculation of rhizoplane bacteria on growth of Melastoma sp. seedlings under acidic, N-free condition

Screening of the rhizoplane epiphytes from a specimen of *Melastoma* sp., grown along a ridge of an acid-sulfate paddock in South Kalimantan, led to isolation of two nitrogen-fixing bacteria of heterotrophs. By some physiological properties and 16S rDNA determination, the two isolates were identified to be *Sphingomonas rosa* and *Burkholderia cepacia*, both of which are known to be a root-associating bacterium (Takeuchi *et al*., 1995; Poole *et al*., 2001). In 0.3% gellan gum medium, *S. rosa* and *B. cepacia* behaved as non-motile with cell-aggregation and highly motile, respectively. Inoculation test of the isolates for the host seedlings was then carried out. The *Melastoma* sp. seedlings were prepared as follows: after 50 ml of the vermiculite beds wetted with N-free 1/4 Hoagland's No2 medium (50 times-enriched Mo as $NaMoO_4$, and adjusted to pH 3.0 with 1 mM $AlCl_3$) were autoclaved, five seedlings of the *Melastoma* sp. grown for 4 weeks on another vermiculite bed wetted with N-free 1/4 Hoagland's No2 medium (50 times-enriched Mo as $NaMoO_4$, pH 5.5) were shortly rinsed with 70% ethanol and then washed with sterile water were transplanted. To the seedlings, *S. rosa* (approximately 1 x 10^8 cells), *B. cepacia* (1 x 10^8 cells), *S. rosa* plus *B. cepacia* (both 1 x 10^8 cells) and control (sterile water) were inoculated.

Growth of the test seedlings was observed in each dish. After incubation for 4 weeks at 23°C under a 16-h light/8-h dark condition, the *S. rosa*-treated seedlings significantly showed a better growth than control seedlings (Fig. 2). In fact, the seedlings in the control dish showed a severe stunting, of which symptom is obviously due to nitrogen-deficiency. Interestingly, neither single-inoculation of *B. cepacia* nor double-inoculation of *S. rosa* and *B. cepacia* showed any positive effect on the seedling growth. This meant that nitrogen-fixation is affected by combination of the bacterial species composing rhizoplane microflora.

The survival frequency of the inocula was respectively investigated. As shown in Table 1, both *S. rosa* and *B. cepacia* survived around the rhizosphere/rhizoplane; however, their effects on the growth of the seedlings were distinguishable. Interestingly, growth stimulation with inoculation of *S. rosa* was completely inhibited in the double inoculation of both *S. rosa* and *B. cepacia.* At Paduran, farmers grew improved rice IR 66, but its harvest was almost nothing for 4 years. Very stunting paddy rice there possessed *Burkholderia* sp. on the rhizoplane but none of *Sphingomonas*.

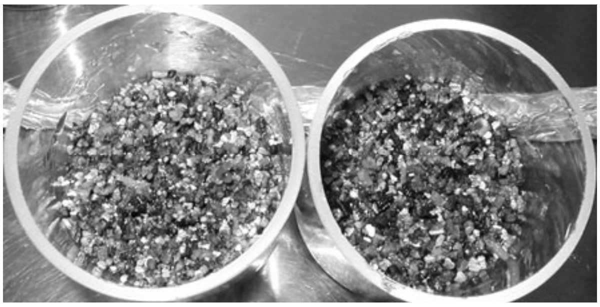

Figure 2. Growth stimulating effect of Sphogomonas rosa R-1 strain after inoculation to Melastoma seedlings grown on N-free medium/vermiculite bed.

This result and our experiment using *Melastoma* sp. seedlings described here suggested different ecological positions of these bacterial species in the rhizoplane microflora.

When the seedlings grown in vermiculite bed wetted with P-free 1/4 Hoaglandís No. 2 (pH 5.5) and $AlPO_4$ powders previously washed with pure water to remove soluble phosphates, only the *B. cepacia*-inoculating dish in the rhizoplane showed a better growth for the seedlings. This indicates a capability of *B. cepacia* to solubilize aluminum phosphate powders in acidic soil.

TREATMENT	Rhizoplane microflora	Effectiveness	
		Aerial	Root
S. rosa inoculated (10^8 cells)	**Survived**	+++	+++
B. cepacia inoculated (10^8 cells)	**Survived**	—	+
S. rosa + *B. cepacia* inoculated (10^8 cells + 10^8 cells)	**Both survived**	—	+
Control (sterilized water)	**None***		

Table 1. Survival and Effectiveness of the Inoculates around the Roots of *Melastoma* Seedlings Grown in N-free 1/4 Hoagland No2 Medium.

* None grew in N-free Winogradsky's media, but certain fungus and saprophytic bacterium were apparent in potato-dextrose agar.

CONCLUSION

Thus, our preliminary experiments showed that sulfate acid-tolerable *Melastoma* sp. possesses functional rhizoplane microflora on its rhizoplane to manage with nutrient deficiency under the strongly acidic conditions. The rhizoplane microorganisms, affording to display their capability on the rhizoplane, may change micro-scale of rhizospheric conditions, and host plant make benefits from them. As known in flavonoids that play a role as signal compounds for rhizobia-symbiosis in leguminous plants, some non-leguminous plants have a strategy in regulating their rhizoplane microorganisms to deliver their maximal capacity by root exudates (Strong & Phillips, 2001). Also in the *Melastoma* sp., phenolic components in the root exudates of the *Melastoma* sp. stimulated the growth and/or cell aggregation of *S. rosa* in the gellan gum medium. Such a chemical signal secreted from the rhizoplane is likely to be involved in cross talk signals among the microorganisms that formed rhizoplane bio-complex to maintain micro-scale of rhizospheric environment.

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Characterisation of lipase-producing yeastlike-fungi isolated from Muara Angke Nature Reserve, Jakarta, Indonesia

Ariyanti Oetari, Wellyzar Sjamsuridzal & Reno Fitri
University of Indonesia Culture Collection (UICC), Department of Biology, Faculty of Mathematics & Natural Sciences, University of Indonesia, Depok 16424, INDONESIA
Tel/Fax: (62)-(021)-78884762; E-mail: a-oetari@makara.cso.ui.ac.id; sjwelly@hotmail.com

ABSTRACT

Mangrove ecosystem covers only 15 million hectares and is distributed in the tropical and subtropical areas. Almost one third of the worldís mangrove areas is found in Indonesia. There is at present very little information on microbial diversity of mangrove ecosystem, and particularly none on microbial mangrove diversity of Indonesia. UICC has conducted an exploration of yeasts from mangrove forests of Muara Angke, Jakarta, on August 2001. Seventeen strains of yeasts and yeastlike-fungi were isolated from several samples of gastropods identified as *Pila scutata* Mousson. The isolates were screened for lipase activity. A modified version of the method from Kouker & Jaeger (1987) was employed using agar plates with Yeast Nitrogen Base (YNB) as a basal medium, olive oil as a substrate, and rhodamine B as an indicator. Lipase activity was determined by the formation of fluorescence zones during a 72 hour incubation period. Two isolates, M 227 and M 228, showed higher lipase activity than the positive control *Yarrowia lipolytica* (UICC Y-16). To identify these isolates, we determined the partial sequence of the Large Sub Unit ribosomal RNA genes from M 227 and M 228. The results from homology search by BLAST using sequences of both isolates as query sequences hit the *Discosphaerina fagi* for M 227 and *Aureobasidium pullulans* for M 228, respectively. The phylogenetic position of both isolates within the ascomycetes lineage will be discussed.

INTRODUCTION

Mangrove ecosystem covers only 15 million hectares and is distributed in the tropical and subtropical areas. Almost one third of the worldís mangrove areas is found in Indonesia. There is at present very little information on microbial diversity of mangrove ecosystem, and particularly none on microbial mangrove diversity of Indonesia.

On August 2001 University of Indonesia Culture Collection (UICC) has conducted an exploration of yeasts from mangrove forests of Muara Angke, Jakarta. Seventeen strains of yeasts and yeastlike-fungi were isolated from several samples of gastropods identified as *Pila scutata* Mousson. Up till now there is very little information, or none at all, on the potentials of yeasts isolated from gastropods in producing lipase.

The gastropod, *Pila scutata*, in Indonesia known as keong gondang undak, lives in freshwater environment (Djajasasmita, 1999). They are generally found in the lakes, marshes, and slow-current rivers. In Indonesia they can be found in the islands of Sumatra, Java, Kalimantan, Sulawesi, Bali, Lombok and Sumbawa. These gastropods eat litters found on the ground, especially those which have been degraded partly by microorganisms.

Lipase enzyme (*triacylglycerol acylhydrolase*: EC: 3.1.1.3) hydrolyzes lipid (triglycerides) at water and lipid interface (*water-lipid interface*). As final products of hydrolysis of lipid by lipase are glycerol and fatty acids (Rapp & Backhaus, 1992; Jarvis & Thiele, 1997).

Kouker and Jaeger (1987) have developed a method for screening of lipase activity from the bacteria using agar plates with olive oil as a substrate and rhodamine B as an indicator. Hydrolysis of lipid by lipase will form orange fluorescent zones around the colonies when the agar plates are exposed under the ultraviolet light at 350 nanometer. A similar method with little modification has been used by Hou & Johnston (1992) to detect lipase activity from the bacteria, yeasts and moulds, and Jarvis & Thiele (1997) to detect lipase activity from anaerobic bacteria.

The formation of orange fluorescent zones around the colonies is due to the hydrolysis of olive oil and formation of the fatty acids-rhodamine B conjugate. The orange fluorescent zones will not be observed if the rhodamine B forms a complex with glycerol (Jarvis & Thiele, 1997).

Investigation were carried out by UICC on seventeen yeast isolates from gastropods of Muara Angke on their ability to hydrolyze lipid. The isolates were tested for their lipase activity using a modified method of an agar plate rhodamine B fluorescence assay from Kouker & Jaeger (1987).

The yeast isolates were grouped into taxonomic classes based on urease activity. Identification of those isolates capable of hydrolizing lipid were carried out by determination of the partial sequence of the Large Sub Unit ribosomal RNA genes. Homology search by BLAST using sequences of those isolates was carried out and the phylogenetic position within the yeast lineage will be discussed.

MATERIALS AND METHODS

Microorganisms

From fourteen samples of gastropods identified as *Pila scutata* Mousson, 17 yeast isolates were obtained. The yeast isolates were investigated for their lipase activity. *Yarrowia lipolytica* UICC Y-16 was used as a positive control, and *Saccharomyces cerevisiae* var. *ellipsoideus* UICC Y-17 was used as a negative control.

Media

Yeast Malt Agar (YMA) plus 1.5 % NaCl was used for isolating single colonies; Potato Dextrose Agar (PDA) plus 1.5% NaCl was used for maintaining yeast isolates; Yeast Nitrogen Base Agar (YNB-A) added with 1.5% NaCl, olive oil and rhodamine B was used for screening of lipase activity; Christensenís Urea Agar (CUA) plus 2% urea was used for determination of taxonomic classes based on the urease activity.

Isolation of Yeasts from Gastropods Samples

The gastropods samples were washed under running tap water until they were cleaned of mud. The gastropod shells were crushed using sterile stone mortar. The intestines were taken out and squashed. The squashed intestines were added with 1 ml sterile aqua dest. and streaked directly onto YMA added with 1.5% NaCl and tetracycline. The mixture was diluted to 10^{-2} with sterile aqua dest. and 0.1 ml of it was spread onto YMA added with 1.5% NaCl and tetracycline. The plates were incubated at room temperature. Colonies were isolated and purified using streak method onto YMA added with 1.5% NaCl and tetracycline.

Screening for Lipase Activity

Yeast cells in YMA + 1.5 % NaCl slant, 48h, were made into suspension in 5 ml sterile aqua dest. Sterile filter paper (diam. 8 cm) was saturated with olive oil. Sterile filter paper (diam. 2 cm) saturated with yeast cell suspension was put onto Yeast Nitrogen base-Agar added with 0.01% rhodamine B in a plate. Amount of 0.025 ml of yeast cell suspension was put onto a sterile filter paper (diam. 2 cm) and put onto Yeast Nitrogen base-Agar added with 0.01% rhodamine B in a plate. The plates were incubated at 28°C for 72 h. An orange fluorescent zone was observed under the UV light at 350ó365 nanometer.

$$\text{Index of lipase activity was determined as} = \frac{\text{Mean of diameter of orange fluorescent zone}}{\text{Diameter of yeast colony}}$$

RESULTS AND DISCUSSION

There were 17 yeast isolates isolated from 14 *Pila scutata* samples. The yeast colonies were observed and the results are shown on Table 1.

Observation of the yeast colonies showed that there were 9 cream-coloured isolates, 4 orange-coloured isolates, 2 white-coloured isolates, and 2 black-coloured isolates. All isolates were tested for their abilities to utilize urea in the urease activity test in order to classify them into the Class Ascomycetes or Basidiomycetes. The results showed that 15 isolates were urease-negative, and they were assumed as Ascomycetous yeasts. Two isolates, M 227 and M 228, were urease-positive and were assumed as Basidiomycetous yeasts.

Out of 17 isolates, 15 showed no lipase activity whilst two isolates, M 227 and M 228, showed orange fluorescent zones on plates. The index of lipase activity is shown in Table 2. The M 227 and M 228 are black yeasts. These isolates showed higher lipase activity than the positive control *Yarrowia lipolytica* UICC Y-16 (syn. *Saccharomycopsis lipolytica*).

Table 1. Yeasts and Yeastlike-Fungi Morphology

No.	Code	Colony Observation (YMA+ 1.5% NaCl; 7d, Room temperature)			Budding & Cell Shape
		Colour	Texture	Surface	
01	M 221	orange	Filamentous, dull	Filamentous, wrinkled	Multipolar, oval to cylindrical
02	M 222	Orange	Filamentous, dull	Filamentous, wrinkled	Multipolar, subglobose to oval
03	M 223	Orange	Filamentous, dull	Filamentous, wrinkled	Multipolar, oval
04	M 224	Orange	Filamentous, dull	Filamentous, wrinkled	Multipolar, subglobose to oval
05	M 225	Cream	Butyrous, dull	Flat, smooth	Multipolar, oval
06	M 226	Cream	Butyrous, dull	Flat, smooth	Multipolar, oval
07	M 227	Black	Butyrous, dull	Raised, rough	Multipolar, subglobose to cylindrical
08	M 228	Pink (young colony); black (old colony)	Butyrous, dull, fringed	Raised, rough	Multipolar, subgolobose to oval
09	M 229	Yellowish white	Butyrous, dull	Flat, smooth	Multipolar, subglobose to oval
10	M 2210	Whitish cream	Butyrous, dull	Flat, smooth	Multipolar, subglobose to oval
11	M 2211	Cream	Butyrous, shiny	Flat, smooth	Multipolar, oval to cylindrical
12	M 2212	Whitish cream	Butyrous, dull	Flat, smooth	Multipolar, oval
13	M 2213	Cream	Butyrous, shiny	Flat, smooth	Multipolar, cylindrical
14	M 2214	Cream	Butyrous, dull	Flat, smooth	Multipolar, cylindrical
15	M 2215	Cream	Butyrous, shiny	Flat, smooth	Multipolar, cylindrical
16	M 2216	Cream	Butyrous, shiny	Flat, smooth	Multipolar, subglobose
17	M 2217	White	Butyrous, dull	Flat, smooth	Multipolar, oval

Table 2. Lipase Activity

No.	Isolate	Incubation time (h)	Fluorescence zone (cm)				
			I	II	III	Mean	L.A.I.
01	M 221-M 226, M 229-M 2217	24	--	--	--	--	--
		48	--	--	--	--	--
		72	--	--	--	--	--
02	M 227	24	2	2	2	2	0
		48	2	2	2	2	0
		72	2.6	2.5	2.7	2.6	0.3
03	M 228	24	2.2	2.2	2.3	2.23	0.115
		48	2.4	2.4	2.6	2.46	0.23
		72	2.47	2.49	2.67	2.54	0.27
04	UICC Y-16	24	2	2	2	2	0
		48	2	2	2	2	0
		72	2.2	2.15	2.14	2.16	0.08
05	UICC Y-17	24	--	--	--	--	--
		48	--	--	--	--	--
		72	--	--	--	--	--

Note: Lipase activity index of yeast isolates grown on YMA+1.5% NaCl, 2 days, room temperature; filter paper (diam. 2 cm) was saturated with cell suspension.

For identification of M 227 and M 228, the results from homology search by BLAST using the partial sequence of the Large Sub Unit ribosomal RNA genes from M 227 and M 228 as query sequences hit the *Discosphaerina fagi* for M 227 and *Aureobasidium pullulans* for M 228, respectively.

Discosphaerina fagi and *Aureobasidium pullulans* are black yeasts and included in the group of Dematiaceous fungi. They have unicellular cells during one phase of their life cycle. These black yeasts are commonly found on plants and litter which are the staple food for some animals, including gastropods. The gastropods *Pila scutata* are commonly found in the freshwater environment, but they might have been brought by the current into the mangrove environment, near the estuary of Muara Angke.

Results of the urease activity test of M 227 and M 228 showed that they were urease-positive. The position of *Discosphaerina fagi* and *Aureobasidium pullulans* in the phylogenetic lineage, however, showed that they are within the Ascomycetes lineage.

CONCLUSION

Two isolates, M 227 and M 228, showed higher lipase activity than the positive control *Yarrowia lipolytica* UICC Y-16. The sequence analysis of M 227 indicates its similarity to *Discosphaerina fagi*, whilst the sequence analysis of M 228 indicates its similarity to *Aureobasidium pullulans*. The isolates, M 227 and M 228, were urease-positive. *Discosphaerina fagi* and *Aureobasidium pullulans,* however, are black yeastlike-fungi and are included in the Class Ascomycetes.

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Oxidation-Reduction Potentials of Tropical Peat as a Factor Controlling the Distribution of Forest Communities in Wetland of Central Kalimantan

Kazuo Yabe* and Takatoshi Nakamura**
*Sapporo School of the Arts, Sapporo 005-0864, Japan (e-mail *yabe@sapporo-sa.ac.jp*);
**Forest Research Station, Field Science Center for Northern Biosphere, Hokkaido University, Nayoro 096-0071, Japan (e-mail *taka@exfor.agr.hokudai.ac.jp*)

INTRODUCTION

In a lowland area of Central Kalimantan, peat swamp forests develop with up to 10 m deep peat around the both sides of the rivers. Because peat makes domed topography through the accumulation process, chemistries of peat water change into ombrotrophic condition with low pH and small amounts of minerals and nutrients. Different from mossy bog in the temperate and boreal regions, the peat swamp forests have a large biomass and high diversity of trees under waterlogged conditions.

Besides the peat swamp forest, some wetland forests and wet grasslands are suppressed in species diversity and biomass of trees. Water table conditions of these communities, which are close to the soil surface, are similar to the peat swamp forest. The object of the present study is to reveal the factors controlling the tree growth and community types of tropic wetlands. In particular, strongly anaerobic soils suppressing the growth of trees due to its toxicity may be easily produced in the high temperature regime of tropical region. Accordingly, to clarify the question, we will compare the oxidation-reduction conditions, nutrients and other hydrological variables of wetland soil.

STUDY SITES

Two study areas were chosen in Central Kalimantan Province, Indonesia. Lahei area is about 40 km northeast of Palangka Raya and within the catchment area of Mangkutub River (a catchment of Kapuas River). The topography rolls gently. Lower parts are covered with wetland forest with various thickness of peat at a surface of soil, whereas higher parts with dry forest of heath on a mineral quartz sand.

We investigated wetland forests within the P-2 quadrat and around P-3 quadrat, both of which have been settled by the JSPS-LIPI Program. The soil of P-2 is well-developed peatland, but that of the P-3 is the mineral quartz material with a thin peat on it.

Setia Alam Jaya area is located in the upper part of the Sebangau River, about 20 km southwest of Palangka Raya. Sebangau River is relatively short compared to the other rivers in Central Kalimantan. We examined a grassland in floodplain of the river and a riparian forest next to the grassland.

4 types of communities can be identified. Two forest types are observed from wetlands in Lahei.

1) Mixed swamp forest: A tall forest with 30 m of maximum canopy height is growing in P-2. The forest community consisted of 73 species and was dominated by *Shorea balangeran*, *Buchanania sessifolia* and *Semecarpus* sp. (Suzuki *et al.* 1998). The peat which accumulates up to 7.5 m contains several clayey layers and carbonized layers (Haraguchi *et al.* 2000), indicating occurrences of river floodings and forest fires. Accordingly the water chemistry is estimated not to ombrotrophic but to weakly minerotrophic. There are many hummocks made by tree roots and their debris, on which trees are standing.

2) Freshwater mangrove. An open woodland community in P-3 consists of 16 species, dominated by *Cratoxylum glaucum* and *Combretocarpus rotundatus* (Suzuki *et al.* 1998). The maximum tree DBH of *Combretocarpus* is 26.2 cm. The canopy height is less than 19.7 m. In and around the woodland, there are many treeless areas, which were temporally submerged with shallow water. Many shoots of *Sphagnum junghuhnianum* are growing in such a submerged condition. Soft lateral roots of *Combretocarpus* and 30 to 40 cm tall vertical pneumatophores of *Dactylocladus stenostachys* are also abundant in the treeless area, showing a similar landscape to that of mangroves in seashore. The surface layer of the soil is a ca. 20 cm thick peat, and the second layer is a 20 cm thick quartz sand, which is underlain by a hard layer of solidified quartz particles. Many tree roots run horizontally in the bottom of the peat layer.

3) Riparian grassland: A 1.5 m tall grassland of *Thorachostachyum bancanum* occupies coasts of Sebangau River. Low bushes of 1 to 2 m tall *Ploiarium altenifolium* are occurred frequently. Peat depth is 0.5 to 2 m.

4) Riparian forest: This forest is located close to the river adjacent to the grassland. Crown is 21 m of *Xylopia* sp. in maximum height and is composed of *Combertocarpus rotundatus*, *Tristaniposis obovata*, *Parastemon spicata* and *Cratoxylon arborescens*, *Xylopia* sp. Peat depth is 1 to 2 m.

METHODS

We examined the hydrochemical conditions of each of the community. In the mixed swamp forest, a 30 m long line was set at two plots in early January 2000 and that of 15 m at two plots in early January 2001. We set a 30 m long line at three plots and a16 m long line at one plot within the early January either 2000 or 2001. Each line ran through the treeless area to the open woodland. Sampling points were set at 2 m intervals along all the lines. In Setia Alam Jaya, a 50 m long line with sampling points at 5 m intervals ran from the grassland to the forest at four plots.

Along each line, ground levels of the sampling points were measured using a construction level and water levels from ground surface (upward +) were recorded.

Hydrochemical envirnment

After driving a porous cup collector into 20 cm deep part of the soil, we depressurized its interior using a portable vacuum pump, and collected the peat-pore water in the pipe. We measured pH *in situ* using a portable pH meter (HM-12P, TOA, Tokyo), and the rest was stored 50 mL of the sampled water in a polyethylene bottle. In the laboratory of Japan the samples were filtered through a 0.45-mmmembrane filter, and the nutrient concentrations, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-} and NH_4^+, were then determined (Japan Society for Analytical Chemistry 1994). Concentrations of minerals such as Na^+, Ca^{2+}, K^+ and Mg^{2+} were examined by atomic absorption spectroscopy (AA-625-11, Shimadzu, Kyoto).

Measurements of Eh

A potentiometer (TOA Co., Tokyo, Japan) equipped with a platinum electrode and a Ag/AgCl (saturated KCl) reference electrode was used for Eh readings of the soil. We used a platinum electrode and reference electrode for the measurements of soil Eh for the investigation of the vertical profile of the Eh. The platinum electrode was polished and rinsed with nitric acid before measurements. Data of Eh were presented as the potential relative to reference electrode. Hence the reference potential was added to the values measured by the potentiometer.

In order to obtain vertical profile of Soil Eh at each sampling point, we vertically inserted the electrode to 10 (5) cm to 40 (50) cm deep surface soil at intervals of 10 cm. When the electrode could insert it only on the way, measurement was stopped in that depth.

Statistical analysis

To detect differences in hydrochemical environments among communities, we used a multivariate technique, canonical discriminant analysis (CDA). CDA is usually used to discriminate between more than three groups with multivariate factors; it finds linear combinations of discriminating variables, which maximize the difference between groups, and allows for interaction between factors. In running CDA, we progressively eliminated ineffective factors (stepwise forward method: F-in >3.0, $P < 0.01$). All statistical analyses were run using STATISTICA 5.1 for Windows (StatSoft 1997).

RESULTS

Hydrochemical variables

Among nutrients and minerals, the concentrations of NO3$^-$, NH_4^+ and Mg^{2+} were highest in the riparian forest (Table 1). The concentration of PO_4^{3-} was higher in the freshwater mangrove and the mixed swamp forest than in the riparian communities, and those of Na^+ and Ca^{2+} in the mixed swamp forest were lower than others.

Acidity showed around pH 4.0 throughout the study plots, and was higher in the mixed swamp forest and riparian forest than in the freshwater mangrove and riparian grassland. A shallow Eh (10 cm deep) showed the significant differences among communities. The Shallow Eh was lowest in the riparian grassland and became higher in the order of the mixed swamp forest, freshwater mangrove and riparian forest. On the other hand, a deep Eh (the deepest position) was lowest in the fresh water mangrove, but highest in the mixed swamp forest. The water levels became higher from the riparian forest through the riparian grassland and fresh water mangrove to the mixed swamp forest. The concentrations of Cl^-, NO_2^-, SO_4^{2-} and K^+ did not differ among the communities.

Table 1. Standardized coefficients of environmental variables in each canonical discriminant function (n = 82).

	Canonical function		
	Axis 1	Axis 2	Axis 3
Eh 10cm deep	-0.224	0.992	0.144
Eh lowest position	0.290	-0.449	0.656
pH	0.755	-0.087	0.550
Na^+	-1.420	-0.150	0.602
SO4^{2-}	0.933	0.418	-0.295
Ca^{2+}	-0.758	0.022	-0.538
Mg^{2+}	0.665	0.235	-0.206
Water level	0.376	-0.124	-0.590
Eigenvalue	6.01	1.92	0.88
Contribution (%)	68.2	21.8	10.0

CDA ordination

Eight variables (shallow Eh, deep Eh, pH, water level, and concentrations of Na^+, SO_4^{2-}, Ca^{2+}, Mg^{2+}) were employed in the CDA, which revealed three canonical functions that discriminated significantly between habitats of the four communities ($P < 0.05$ by chi-square test) and, in total, explained more than 99% of the differences (Table 2). The first canonical function, which contributed almost 70% to the difference, had the largest standardized coefficient for Na^+ (negative) followed by SO_4^{2-} (positive), Ca^{2+}(negative) and pH (positive). This axis segregated the mixed swamp forest from the others (Fig. 1).

Shallow Eh only had a large positive coefficient in the second canonical function (larger than 20% contribution), and scores decreased from the riparian forest, through the fresh water mangrove to the riparian grassland. The third canonical function explained only 10% of the difference, and reflected heterogeneity of habitats from the freshwater

Table 2. Mean± S.D. of environmental variables in each vegetation type. Results of ANOVA are shown as F-values and p-values. In each line, the different superscripts mean significant differences (p< 0.05, Scheffe's multiple-comparison test).

					Riparian communities				
	Freshwater mangrove		Mixed swamp Forest		Forest		Grassland		*F* -value	*P* -value
Cl^- (mg/L)	1.230 ± 1.022		0.799 ± 0.818		1.559 ± 0.803		1.012 ± 0.642		1.95	0.13
NO_2^- (mg/L)	0.000 ± 0.002		0.000 ± 0.000		0.001 ± 0.002		0.001 ± 0.002		0.83	0.48
NO_3^- (mg/L)	0.002 ± 0.004	b	0.006 ± 0.009	b	0.134 ± 0.323	a	0.021 ± 0.021	ab	4.00	0.01
PO_4^{3-} (mg/L)	0.127 ± 0.149	a	0.182 ± 0.129	a	0.000 ± 0.000	b	0.003 ± 0.007	b	9.74	< 0.01
SO_4^{2-} (mg/L)	0.121 ± 0.114		0.115 ± 0.061		0.069 ± 0.064		0.065 ± 0.070		2.05	0.11
Na^+ (mg/L)	0.559 ± 0.230	a	0.231 ± 0.077	b	0.630 ± 0.115	a	0.692 ± 0.132	a	25.67	< 0.01
K^+ (mg/L)	1.429 ± 1.291		0.843 ± 1.037		1.895 ± 0.806		1.301 ± 0.606		2.39	0.08
Mg^{2+} (mg/L)	0.053 ± 0.043	ab	0.035 ± 0.011	b	0.080 ± 0.049	a	0.039 ± 0.015	b	4.31	0.01
Ca^{2+} (mg/L)	0.276 ± 0.187	a	0.092 ± 0.048	b	0.302 ± 0.249	a	0.286 ± 0.230	a	5.50	< 0.01
	(n=36)		(n=20)		(n=10)		(n=16)			
NH_4^+ (mg/L)	0.262 ± 0.184	ab	0.265 ± 0.143	ab	0.371 ± 0.247	a	0.140 ± 0.130	b	3.73	0.02
	(n=12)		(n=12)		(n=10)		(n=16)			
pH	3.98 ± 0.13	b	4.36 ± 0.30	a	4.31 ± 0.33	a	4.06 ± 0.27	b	23.78	< 0.01
Eh 10cm deep (mV)	489.7 ± 94.6	b	382.7 ± 115.5	c	605.9 ± 113.4	a	223.1 ± 118.4	d	45.78	< 0.01
Eh lowest position (mV)	145.7 ± 184.0	c	324.9 ± 132.5	a	302.0 ± 120.7	ab	198.7 ± 68.6	bc	13.65	< 0.01
Water level (cm)	4.8 ± 9.9	b	10.9 ± 10.2	a	-9.7 ± 5.1	c	0.9 ± 2.8	b	21.34	< 0.01
	(n=57)		(n=46)		(n=15)		(n=19)			

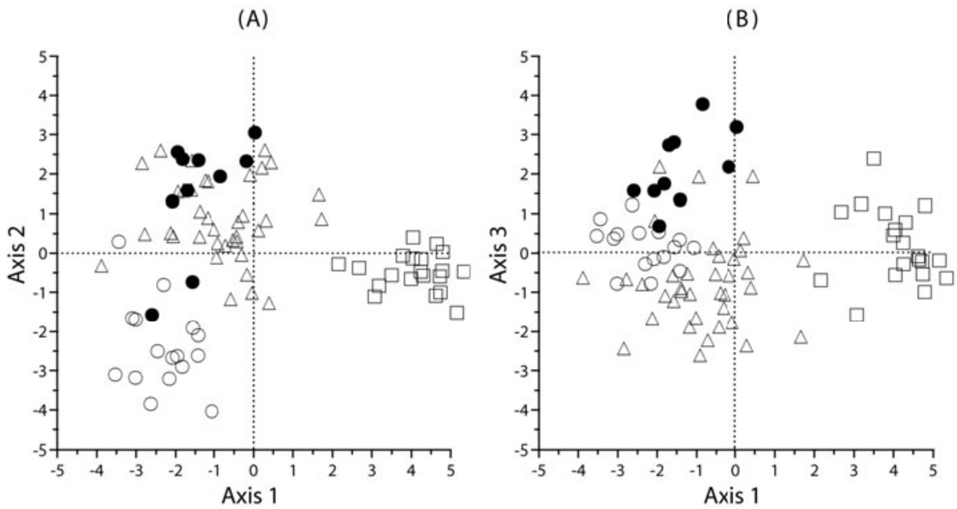

Figure 1. Arrangement of canonical scores for Axis 1-Axis 2 (A) and Axis 1 - Axis 3 (B) by CDA. Open squares: peat swamp forest (n=20), solid circles: riparian forest (n=10), open circles: riparian grassland (n=16) and open triangles: freswater mangrove (n=36).

mangrove to the riparian forest with ascending scores. The function was positively related to deep Eh and Na^+ concentration. Habitats of the other communities were arranged around 0 point of the score.

As expressed in the first function, the most strongly discriminating factor between habitats was the low concentrations of minerals such as Na^+ and Ca^{2+} and the high SO_4^{2-} concentration in the mixed swamp forest. On the other hand, the most strongly discriminating factor between habitats of the other communities was soil Eh.

Profile of Eh values in surface soil

The Eh in the mixed swamp forest changed little from the surface to the depth of 50 cm and the value were within the range of 300 to 400 mV (Fig. 2). Eh in the fresh water mangrove decreases with the increasing depth from the soil surface. Eh in the shallow soil (10 cm deep) was slightly less than 500 mV, whereas it decreased strongly to 150 mV in the deep soil (the deepest part). Between riparian communities, the shallow soil of the grassland was reductive (ca. 200

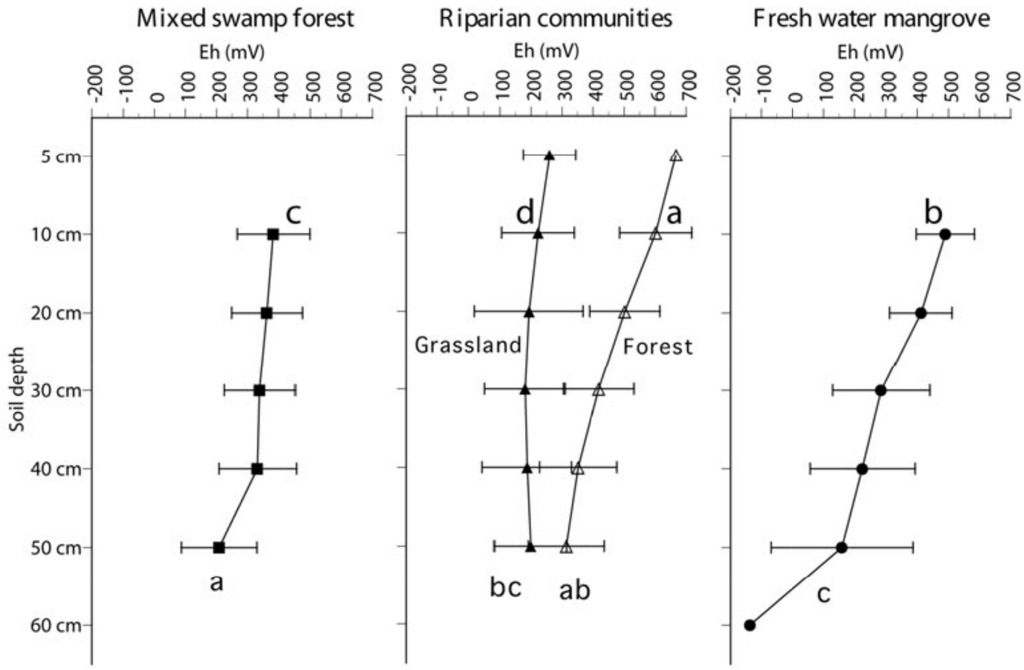

Figure 2. Vertical change of soil Eh.

mV) but that of the forest was oxidative (600 mV). The difference of Eh between both decreased according to the increasing depth, and became insignificant in the deep soil (200 to 300 mV).

DISCUSSION

The present study deals with three forests and a grassland. Among the four communities, the riparian grassland, riparian forest and mixed swamp forest correspond well to ìsedge swamp", ìriverine forest" and "mixed swamp forest" classified by Page *et al.* (1999), respectively.

The submerged peat in the mixed swamp forest is not so reductive. The chemistry of peat-pore water shows the low concentrations of Ca^{2+}, Na^{+} and Mg^{2+}, which indicate weakly minerotrophic or ombrotrophic water conditions. A high concentration of SO_4^{2-} may be also due to acid rains, in which much SO_4^{2-} (0.544 mg/L) was contained. Low mineral concentrations suppress the soil reduction by anaerobes, and trees can grow bigger free from the stresses of anaerobic conditions of soil.

The freshwater mangrove shows almost the same physiognomy and species composition as "very low canopy forest" in central Kalimantan (Page *et al.* 1999), which, in Sarawak of Borneo (Malaysian Kalimantan), is called *Combertocarpus- Dactylocladus* association by Anderson (1983). The very low canopy forests are growing around the peak of highly developed peat domes, where the thickness of peat exceed 10 m, whereas the freshwater mangrove inhabits in a shallow depression with only a 20 cm thick peat. Since tree roots in the freshwater mangrove are limited in the thin peat layer, insufficient thickness of rooting zone can be one of the causes of the tree restriction. However, the fact that similar communities are growing in highly developed peatland implies that thin rooting zone is not the limiting factor for trees in the freshwater mangrove. The present study suggested the anaerobic conditions of soils in the fresh water mangrove restrict the tree growth. Minerals leaching out of underlying sand or hard layer may activate anaerobes to produce anaerobic conditions in the deep part of soil. It is also provable to think that trees in the very low canopy forest are also restricted their growth by anaerobic soils, because, at a surface peat around the peak of peat dome, minerals and nutrients are supplied from decomposing peat through mineralization processes (Page 1999).

The riparian communities would receive minerals and nutrients by inflows of flooding water from the river. It results in reduction of shallow parts of submerged peat, whereas shallow parts of emerged peat are in oxidative conditions owing to the air oxidation. Accordingly, the difference of water level determines the community types, and trees can grow only under oxidative conditions of the forest soil.

The oxidation-reduction conditions of tropical peats are important for determining the establishment of community types, and especially for the distribution of tree species and forest structures in the condition of submerged soil.

ACKNOWLEDGEMENTS

Authors thank Mr. Suwido H Limin and stuffs of the University of Palangka Raya for their great help to our research activities. This work was financially supported under the Core University Program by JSPS.

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Session 3

BIODIVERSITY

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Seigo HIGASHI & Sri SULANDARI

Karyotype of Papua's Rainbowfish (*Melanotaenia maccullochi*)

Djamhuriyah S. Said[1], Hidayat[1], Odang Carman[2], and Abinawanto[3]
[1] Research Center for Limnology-LIPI, Jl. Raya Bogor KM 46,6 Cibinong-Bogor - 16911
[2] Faculty of Fisheries and Marine Science, Bogor Agricultural University
[3] Dept. of Biology, Faculty of Mathematics and Natural Sciences University of Indonesia
E-mail: limno@indo.net.id ; limnologi2002@yahoo.com

ABSTRACT
***Melanotaenia maccullochi* is freshwater fish distributed from the mid of south of Papua/New Guinea to Australia. Attractive color and shape of this species has the economical value as ornamental fish that caused the exploitation of the species so intensified. Some problems in rearing of this fish are low survival rate, growth rate, and male percentage. The other problem is a genetic information (such as chromosome) of this fish is so poor. The aim of the research is to explain the chromosome diversity of the fish. The information is needed for genetic conservation and aquaculture development.**

Cytogenetic study of *M.maccullochi* was focused on karyotype and to find out the information of chromosome. The research was conducted at Laboratory of Fish Breeding and Genetics, Faculty of Fisheries and Marine Science-IPB on June 2000 - May 2001. Chromosome plates were prepared by solid tissue technique (using 150 larvae) and analyzed after staining with Giemza solution. Diploid chromosomes number of *M. maccullochi* is (2N=48). Karyotyping of this fish shown that 48 chromosomes consist of 4 pairs subtelosentrik (ST) (no.1, 2, 3, and 21) and 20 pairs telosentric (T). The sex chromosomes have not yet identified.

Key words: chromosome, freshwater ornamental fish, Melanotaenia maccullochi, Karyotype

INTRODUCTION

Melanotaenia maccullochi is one species of the family Melanotaeniidae, ordo Atheriniformes. The fish is a stream and swamp-dwelling rainbowfish. Distribution northern Australia and southwestern Papua New Guinea wich is very close to the Irian Jaya borders. It probably occurs on the other side of the border (Allen, 1995). This fish is small, growing about 6-10 cm, schooling fish. The adult male has the greatest body depth, silvery white with yellowish tinge, with 6ó8 narrow reddish-brown or black stripe on the side, generally more prominent on male. They have beautiful red fins and are often referred to red-finned Rainbows. Due to the attractive body color and shape it is popular as ornamental fish (fresh water ornamental fish) and has the economical value. Therefore, the exploitation of this fish has been intensified that is concerned to destruct its natural population. Some problems in culture of this fish are low survival rate, growth rate, and male percentage. On the other hand, genetic information such as chromosome of this fish is so poor.

Cytogenetic study or chromosome information is needed to explain the chromosome diversity, closely related study, and for genetic conservation (Albert, 1989). Information of chromosome and sex chromosome is very important to aquaculture development such as to produce a monosex fish, ploidisation, and hybridization. Study of karyotype is generally accepted as a valuable complement to biochemical methods for identification of species, hybrid or more rarely population, and may be of particular importance in the application of polyploidy and gynogenesis in aquaculture (Chevassus et al. 1978, in Moynihan & Mahon 1983).

Several study of chromosome of rainbowfish has been reported such as Nurhayati (1997) on Chilaterina campsi, M. patoti, and M. boesemani, Andriani (2000) on Celebes rainbowfish Telmatherina ladigesi, Said et al. (2001, 2002a,b) on Glossolepis incisus, M. boesemani and M. praecox. The number of diploid chromosome of these fishes is 46 or 48.

The research was foccused to explain the number and type of chromosome, to make a karyotype and to find out the sex chromosome of Melanotaenia maccullochi.

MATERIALS AND METHODS

The research was conducted at Laboratory of Fish Breeding and Genetic, Faculty of Fisheries and Marine Science-IPB on June 2000 - May 2001.

Chromosome plates were prepared by solid tissue technique. The methods are according to Kligerman & Bloom (1977) and Carman (1992) with slight modification.

Tissue preparation

Larvae 150 individual, 21 days old were collected from Research Center for Limnology-Indonesia Institute of Sciences (RC for Lymnology-LIPI). The larvae were exposed to colchicine 0.070 - 0.090 % for 7.5 - 9.0 hour and were allowed to swim in well-aerated to the colchicines solution). Larvae were killed immediately and treated for 90 - 100 minutes with 0.075 M KCl hypotonic solution about 10 times of the tissueís volume. Then the tissue was fixed in two changes (2 x 30 minutes) of Carnoy's solution (ethanol absolute: acetic acid glacial, 3:1), and it was further processed or stored in a refrigerator for several weeks.

Preparat preparation

The tissue (larvae) was removed from fixative and touch-dried on a filter paper to eliminate excess of fixative. It was placed in well of a hollow slide or a watchmaker's and 3-5 drops of 50% acetic acid were added immediately. The tissue was gently minced for about 1 minute by a scalpel to obtain a cell suspension. Using a Pasteur's pipette tip, an appropriate amount of the suspension was withdrawn and expelled on a clean slide glass placed on a slide warmer (45-50^{o}C). The suspension was quickly withdrawn back into the pipette tip leaving a ring of cells approximatelly 1-1.5 cm in diameter on the slide glass and each slide glass could make 1-3 rings respectively.

Staining

Slide were then stained with Giemza solution (Giemza : Phosphate Buffer Saline pH 6,88, 1:30) for 30ó60 min. Slide were rinsed properly with tap- water or distilled water, allowed to dry and observed under a microscope (10x100)

Analysis

Chromosome number analysis was based on the modus of the cells metaphase containing well spread chromosome, and to describe the type of chromosome based on the centromere position, that was according to Levan et al. (1964).

RESULTS AND DISCUSSION

Direct method on fish larvae has been commonly applied i.e. Carman (1992) on some warm-water fish species, Nurhayati (1997) on Irian rainbowfish, Said et al. (2001) on G. incisus. Beside that, Said (1998) studying the chromosome of M. boesemani concluded that the use of larvae gave better preparat than that of some other tissues in growing phase such as egg and embryo in eye-spot phase. According to Kligerman & Bloom (1977) the advantage of the method are relatively easy to get metaphase cell in shorter time with cheaper cost. Other advantage is that it is easy to observe the metaphase cell on the edge of the prepared ring.

The number of chromosome was determined based on the modus of the cells metaphase containing well spread chromosome. The chromosome number of M. maccullochi is 48 (2N) (Figure 2A). The diploid number of 48 was confirmed in 55 cell counts from 75 cells total count (Table 1) that is collected from 15 individuals. In this study only 15 larvae have cells with good spread, which were treated in colchicines solution 0.090% exposured during 7.5 hours, and 90 minutes in hypotonic treatment. Carman (1992) has reported that incubation period of warm-water fish larvae is about 3 - 4 hours in 0,07% colchicines. Nurhayati (1997) found that Ch. campsi larvae required 9 hours exposure period in 0,07% colchicines. Said (2001) reported that 30 days old larvae of G. incisus required exposure period of 8 hour in 0,085% colchicines, and 100 minutes hypotonic treatment. Based on these studies it seems that to make the best preparat, there are some specification in the case of age of larvae, colchicines dosage, incubation period both in the colchicines and the hypotonic solution. According to Flajshans & Rab (1989) in the larval exposing method, not all larvae construct the accurate spread of metaphase chromosome. This is because of different individual response toward the effect of colchicines or may be the colchicines not functioned as the larvae were stressed during the exposure.

Table 1. The number of cells with the number of chromosomes of M. maccullochi

Σ Chromosome	39	44	45	46	47	48	50	88
Σ Cells	1	-	1	5	10	55	-	2

Several species of ordo Atheriniformes have diploid chromosome number of 48 such as reported by Arai & Fujiki, 1978 on Atherian elimus; Arai & Koike, 1980 on Basichlichtis bonariensis (Ojima, 1986), Telmatherina ladigesi (Andriani, 2000); Glossolepis incisus (Said, et al., 2001); M. boesemani, M. praecox (Said, et al., 2002a, b). The fishes have 48 diploid chromosome respectively. On the other hand, Scheel, 1972 (Ojima, 1986) has reported that the Australian rainbowfish M. maccullochi have 46 diploid chromosome number. The differece perhaps caused by technical error in the counting of the chromosome, Similarly, Nurhayati found that M. boesemani has 46 diploid chromosome but without a karyotyping, while Said et al (2002a) found that M. boesemani has 48 diploid chromosome. But Ch. campsi and M. patoti have 48 diploid chromosome number (Nurhayati, 1997). Based on the data, .therefore the diploid chromosome

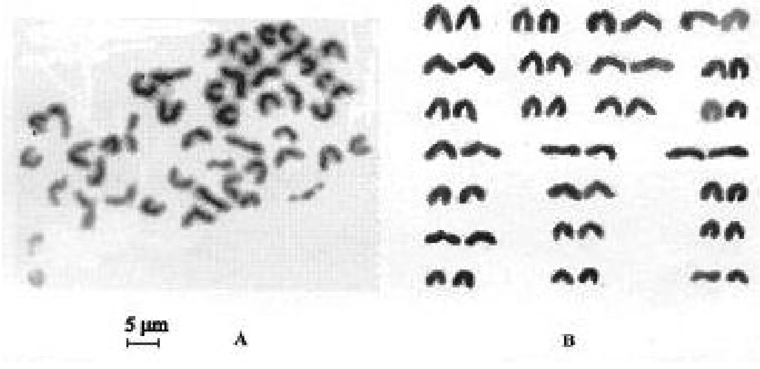

Figure 1. Metaphase Cell (A) and Karyotype (B) of M. maccullochi.

number of Melanotaeniidae (Atheriniformes) trends to 48.

Karyotype of M. maccullochi shown that 48 chromosome (24 pairs), consist of 4 pairs are subtelosentric (ST) (no. 1, 2, 3, & 21) and 20 pairs are telosentric (T). The type of chromosome recording to numeric value of centromere position (NVCP) (Table 2; Figure 1B).

Table 2. Chromosome type of Melanotaenia maccullochi

NO.	1	2	3	4	5	6	7	8	9	10	11	12
NVCP	14.28	20.83	18.18	0	0	0	0	10	0	0	0	5.21
Type	ST	ST	ST	T	T	T	T	T	T	T	T	T
NO.	13	14	15	16	17	18	19	20	21	22	23	24
NVCP	0	0	0	0	0	0	0	0	13.6	0	0	0
Type	T	T	T	T	T	T	T	T	ST	T	T	T

Andriani (2000) found that T. ladigesi has 3 pairs submetasentric (SM), 7 pairs sub telocentric (ST) and 14 pairs telocentric T. Several species of family Malanotaeniidae, such as Chilaterina campsi has 2 pairs ST and 21 pairs T (Nurhayati, 1997), Glossolepis incisus has 7 pairs ST and 17 pairs T (Said, et al., 2001), M. boesemani has 4 pairs ST and 20 pairs T, and M. praecox has 1 pair ST and 23 pairs T (Said, et al., 2002a, b). Based on the data, karyotype of Melanotaeniidae trends to be dominated by telosentric shape. More detailed appearance of the chromosome shape can be seen on the composite idiogram of M. maccullochi karyotype (Figure2). In the idiogram could be seen the differences of the relative length of chromosome and the centomere position of the pairs number respectively.

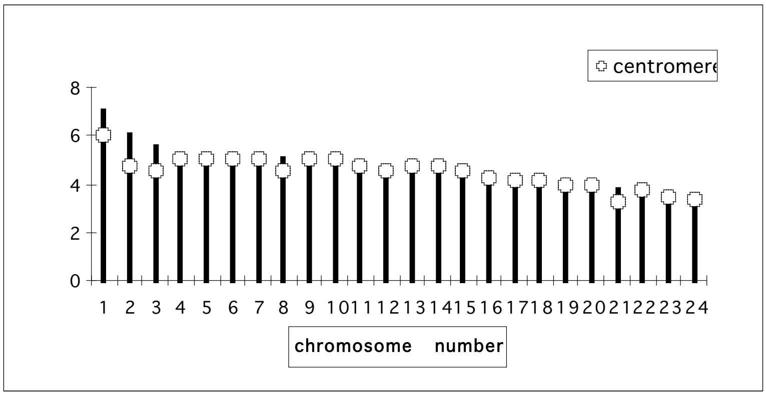

Figure 2. Composite Idiogram of M. maccullochi Karyotype.

Unhomologous chromosome pair, which is assumed as sex chromosome, is not appeared on the constructed karyotype. Therefore, sex chromosome of M. maccullochi has not yet identified. According to Kligerman & Bloom (1977) the weakness of the method is the difficulty to identify sex chromosome.

This study is supposed to give adding value in conservation effort and the fish culturing development. Chromosome Information as baseline data is highly support to development of production technique such as monosex fish production, ploidization, and hybridization.

CONCLUSION

Melanotaenia maccullochi has 48 diploid chromosome, with the karyotype that consist of 4 pairs subtelosentric (no. 1, 2, 3, & 21) and 20 other pairs telosentric. The sex chromosomes of the fish have not yet identified.

ACKNOWLEDGEMENTS

This research was funded by Indonesian Government under the scheme of Terrestrial Organisms Research and Development Project. Special thank to Prof. Dr. Komar Sumantadinata for his support and recommendation in this research.

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Habitat Distribution and Diversity of Plants as Feed Resources on Mouse Deer (*Tragulus Javanicus*) and Barking Deer (*Muntiacus muntjak*) in Gunung Halimun National Park

Wartika Rosa Farida, Gono Semiadi, Tri H. Handayani, dan Harun
Zoology Division., Research Centre for Biology - LIPI
Jl. Raya Bogor-Jakarta KM 46, Cibinong 16911, Bogor
Telp. (62-21) 8765060; Fax (62-21) 8765068, e-mail : wrfarida@indo.net.id

ABSTRACT

An initial study on the habitat distribution and diversity of plants as feed resources on mouse deer (*Tragulus javanicus*) and barking deer (*Muntiacus muntjak*) was conducted at Gunung Halimun National Park. Survey was carried out by visiting places where mouse deer and barking deer are usually seen and taking plant specimen as those animalsí feed. Habitat of mouse deer in Gunung Kendeng is forest until the height of 1100 m asl. Mouse deer prefers the dense of bushes, crevices of rocks or hollows of trees, the dense of tea plantation, and the places with bush dense not far from the river. Habitat of barking deer in Gunung Kendeng is forest until the height of 1100 m asl and in Gunung Botol is forest until the height of 1600 m asl. Barking deer prefers the dense of bushes on the edges of forest. The result showed 50 species of plants as feed resources for mouse deer and barking deer, consisting of 22 families.

Key words: habitat, feed plant, Tragulus javanicus, Muntiacus muntjak

INTRODUCTION

Mouse deer (*Tragulus javanicus*), categorized in family of Tragulidae, and barking deer (*Muntiacus muntjak*), categorized in family of Cervidae, in Indonesia are distributed in Sumatera, Jawa, Kalimantan, and islands around them (Lekagul and McNeely, 1977). Mouse deer, the smallest ruminant found for the first time in Jawa (Van Dort, 1987), does not have horns and the male adult has canine, is dispersed in primary and secondary forest in South East Asia (Medway, 1983), and according to Kudo *et al*. (1987), has a prospect as herbivorous laboratory animals. People has been long time used the meat of this animal as protein resource. Mouse deer, marked by brown-reddish body hair with three white line under its chin, is categorized as endangered species. This condition is caused by the damage of their habitat due to the exploitation of the forest for settlement and plantation, forest fire, and uncontrollable hunting activity. As endangered species, mouse deer is listed in *IUCN Red List of Threatened Animals* (IUCN, 1986).

Mouse deer is generally lived in low land area with the altitude of 600 m above sea level (Payne *et al*., 1985), and according to Adhikerana (1999), this animal is one of tourism asset in Gunung Halimun National Park in West Java. It is urgent to find out the habitat distribution of mouse deer and barking deer and the diversity of forest plants in Gunung Halimun National Park preferred by these animals as their feed resources to maintain the existence of these animals in their habitat (*in situ*). And it is also needed to preserve the existence of plants selected by mouse deer and barking deer as their diet.

Footprint of barking deer is frequently found in Gunung Halimun National Park. The posture of this animal is like deer, and its male has short horn and canine with the body size smaller and slenderer than deer. Barking deer prefers living in bushes and shrubs grown in abandoned, unirrigated agricultural field or teak forest in both low land and mount area with the altitude of 2,400 m above sea level. Its body hair is short and delicate whilst longer hair grow at its ears. The color of body hair is brown-reddish, and this color is faded at the body of female and young barking deer. The color of its back is darker whilst the hair at under part of its chin, neck, and stomach is white. In Thailand, barking deer is still hunted because of the high quality of its meat (Lekagul and McNeely, 1977). Mouse deer and barking deer are solitaire, and both animals coupled at the time of mating only. Their feed activities are done at early morning and night.

The wholeness of the habitat of mouse deer and barking deer and the conservation of feed plants selected by these animals as their diet in Gunung Halimun National Park are need to preserve in order to maintain the existence of these animals in their habitat.

Nutrient contents of the selected plants, which are in the form of young leaves, young trunk, flowers, and fruits is necessary to identify for the purpose of finding alternative feed needed in the case of captivating these animals in the breeding program (*ex situ*), both for research and commercial purposes.

The aim of the research is to find out habitat distribution of mouse deer and barking deer, diversity and nutrients of plants selected by both animals as their feed resources.

MATERIALS AND METHODS

Field survey has been conducted in June 2001 for 14 days with the tracks suggested by forest ranger and local people knowing about the presence of mouse deer in Gunung Halimun National Park. The locations of survey (Table 1) are around Gunung Kendeng (940 m - 1,180 m above sea level) and around Gunung Botol (1,300 m - 1,750 m above sea level). This survey is an initial research done by visiting places where mouse deer and barking deer are frequently found, observing distribution of habitat, and picking forest plants selected by these animals as their diet. The data of location and places preferred by mouse deer and barking deer as their habitat are recorded. These locations and places are known based on the fact that mouse deer and barking deer are frequently found in that places and the tracks of the nests of these animals. For feed plants, the record is done based on types of feed plants and the parts of plants eaten by mouse deer and barking deer (leaf, trunk, and fruit). Observing and recording the data of these animalsí diet, in this research, is limited at bush/shrub, climbing, grass, and herb.

Table 1. Positition of Research Location in Gunung Halimun National Park

LATD	LATM	LATS	DIRLAT	LONGD	LONGM	LONG	DIRLON	ALT (m asll)	LOCATION
6	44	21,1	S	106	31	50,0	E	1090	Loop trail Citalahab, Gunung Kendeng
6	44	14,2	S	106	31	25,6	E	1030	Tea plantation Nirmala, Citalahab
6	44	28,4	S	106	31	50,1	E	1050	Curug, Gn. Kendeng
6	44	55,3	S	106	32	17,4	E	1000	Cikaniki,Gn. Kendeng
6	45	05,4	S	106	32	24,7	E	1000	Canopy trail
6	44	41,9	S	106	32	36,6	E	970	Cikaniki river, Gu- nung Kendeng
6	44	53,0	S	106	32	16,3	E	1060	Loop trail Cikaniki
6	44	46,4	S	106	32	30,6	E	1100	Cikuda paeh, Gu- nung Kendeng
6	44	35,7	S	106	32	19,9	E	1050	Wates Citalahab
6	44	46,4	S	106	32	30,6	E	1030	Forest of wates
6	44	52,0	S	106	32	46,9	E	1040	Out of forest of wates
6	43	39,4	S	106	29	36,0	E	1520	Gunung Botol
6	43	33,4	S	106	29	00,3	E	1720	Top I of Gunung Botol

The parts of plants selected as the diet are picked in order to build herbarium and sample, and then will be analyzed the nutrient of them.

The plants sample which is complete with trunks, branches, leaves, flowers, and fruit (if available) were collected, then, were put between used newspapers, moistened with methylated spirit as preservative in order to avoid from decaying so that the process of identification in Herbarium Bogoriense will be easier.

On the other side, the sample of forest plants in the form of leaves, trunks, flowers, and fruit were dried by putting them under the sun for 1 - 2 days to avoid decaying. The samples were kept in plastic bags waiting for analyzing in laboratory. In the laboratory, all of the plants samples were dried in oven at 60°C for 12 - 18 hours, then milled and kept in closed places waiting for nutrient contents analysis based on Harris method (1970).

RESULTS AND DISCUSSION

During field research, mouse deer has been seen in only two occasions in the daylight period. It is caused by the fact that animal is coward, shame animal, so that it will be difficult to see this animal unless using camera trap. Mouse deer and barking deer are distributed in almost all of research location (Table 1) in the foot of Gunung Kendeng, but not in Gunung Botol, Gunung Halimun National Park, proven by the finding of feces, traces of nests, and jerks traces of feed plants, plus information from local people guiding researchers to the forest during the research.

It is apparently that mouse deer lives in the area with the altitude of 1,100 m above sea level around Gunung Kendeng, whereas some literature mentioned that mouse deer can only be seen in the area with the altitude of 600 m above seal level (Hoogerwerf, 1970; Lekagul and McNelly, 1977). Mouse deer prefers the types of habitats which are thick, protecting bushes, holes at the trunks, holes at the rocks, especially places nearby rivers, or according to Anonymous (1978), mouse deer is tropical animal with habitat of primary and secondary forest, preferring dry land close to springs and dense vegetation. There are plants with jerks done by mouse deer and/or barking deer. It is difficult to find out or to see footprints of both animals because of their little and thin feet. Researchers found some of their feces on the forest floor. Local people informed that mouse deer has frequently be seen coupled in the side of rivers flowing in the area of Gunung Kendeng, even they have ever seen that animal drank water there. Mouse deer and barking deer also have ever be seen under tea bushes grown in Gunung Halimun National Park, and barking deer have frequently be found at the afternoon in open land with young tall, coarse grass.

Feed plants documented during research consist of 50 species grouped in 22 families. Table 2 shows that all plants consumed by mouse deer (44 species) are also consumed by barking deer. However, there are 6 species of feed plants consumed by barking deer, namely *Foorestia glabrata*, *Forrestia* sp., *Ficus grossularioides*, *F. padana*, *F. septica*, and *Imperata cylindrica*, which are not preferred by mouse deer. Medway (1983) reports that in the forest mouse deer is

Table 2. List of Feed Plants of Mouse deer and Barking deer in Gunung Halimun National Park

No.	Family	Scientific name	Local name	Part consumed	Eaten by	Kind of Plants
1	Acanthaceae	*Tetraglochidium bibracteatum*	Peki	Leaf & young trunk	M & B	Climb
2	Amaranthaceae	-	Teklan	Leaf & young trunk, flower	M & B	Shrub
3	Araceae	*Schismatoglottis calyptrata*	Solempat	Young trunk	M & B	Shrub
		Schismatoglottis rupestris	Cariang	Young trunk	M & B	Shrub
4	Asteraceae	*Adenostemma macrophyllum*	Babadotan (wild)	Leaf & young trunk	M & B	Shrub
		Bidens chinensis	Hareuga	Leaf & young trunk	M & B	Shrub
		Clibadium surinamense	Nampong	Leaf, flower, & fruit	M & B	Shrub
		Erechtites valerianifolia	Sintrong	Leaf & young trunk	M & B	Shrub
		Galinsogo parviflora	Semingu	Leaf & young trunk	M & B	Shrub
		Mikania cordata	Capituheur	Leaf & young trunk	M & B	Climb
5	Balsaminaceae	*Impatiens javensis*	Pacar tere	Leaf & young trunk	M & B	Shrub
6	Caryophyllaceae	*Drymaria cordata*	Ibun	Leaf & young trunk	M & B	Shrub
7	Commelinaceae	*Commelina paleata*	Gewor	Leaf & young trunk	M & B	Shrub
		Forrestia glabrata	Tali sahid (red)	Leaf	B	Shrub
		Forrestia sp.	Tali sahid (green)	Leaf & young trunk	B	Shrub
8	Convolvulaceae	*Ipomoea batatas*	Hui areuy beureum	Leaf & young trunk	M & B	Climb
9	Cucurbitaceae	*Cucumis sativus*	Bonteng	Young leaf	M & B	Climb
		Cucurbita moschata	Labu kuning	Young leaf	M & B	Climb
		Sechium edule	Labu siam	Young leaf	M & B	Shrub
10	Cyperaceae	*Carex baccans*	Ilat	Young leaf	M & B	Shrub
11	Euphorbiaceae	*Omalanthus giganteus*	Kareumi	Leaf & young trunk	M & B	Shrub
12	Fabaceae	*Teramnus labialis*	Kakacangan	Leaf & young trunk	M & B	Climb
13	Moraceae	*Ficus grossularioides*	Seuhang	Young leaf	B	Young tree
		F. padana	Hamerang	Young leaf	B	Young tree
		F. septica	Beunying	Young leaf	B	Young tree
14	Onagraceae	*Jussieua linifolia*	Cacabean	Leaf & young trunk	M & B	Shrub
15	Poaceae	*Axonopus compressus*	Jampang sliper	Leaf & young trunk	M & B	Grass
		Digitaria sp.	Kukucayan	Leaf & young trunk	M & B	Grass
		Eleusine indica	Jampang carulang	Leaf & young trunk	M & B	Grass
		Isachne sp.	Bayona (red)	Leaf & young trunk	M & B	Grass
		I. albens	Lameta	Leaf & young trunk	M & B	Grass
		Imperata cylindrica	Alang-alang	Leaf & young trunk	B	Grass
		Lophaterum gracile	Tangkur gunung	Leaf & young trunk	M & B	Grass
		Miscanthus floridulus	Hutamala	Leaf & young trunk	M & B	Grass
		Panicum trigonum	Bayona (green)	Leaf & young trunk	M & B	Grass
		P. repens	Jajahean	Leaf & young trunk	M & B	Grass
		Paspalum conyugatum	Jampang pahit	Young leaf	M & B	Grass
		Setaria barbata	Lamotek	Leaf & young trunk	M & B	Grass
		S. palmifolia	Sawuheun	Leaf & young trunk	M & B	Grass
		Urochloa muticum	Inggris grass	Leaf & young trunk	M & B	Grass
16	Plantaginaceae	*Plantago major*	Kiurat	Leaf, flower & young trunk	M & B	Shrub
17	Polygalaceae	*Polygala paniculata*	Akar wangi	Leaf & young trunk	M & B	Shrub
18	Polygonaceae	*Polygonum chinensis*	Bungbrun	Leaf & young trunk	M & B	Shrub
19	Rubiaceae	*Anotis hirsuta*	Kasimukan	Leaf & young trunk	M & B	Shrub
		Borreria alata	Goletrak	Leaf, flower & young trunk	M & B	Shrub
		Hedyotis auricularia	Kakawatan	Leaf & young trunk	M & B	Shrub
		Mussaenda frondosa	Kingkilaban	Young leaf	M & B	Climb
20	Thelypteridaceae	*Macrothelypteris torresiana*	Pakis beunyeur	Leaf & young trunk	M & B	Herb
21	Urticaceae	*Elatostema sp.*	Kibeling (wild)	Leaf & young trunk	M & B	Shrub
22	Verbenaceae	*Stachytarpheta jamaicensis*	Jarong	Leaf & young trunk	M & B	Shrub

Notes : M = Mouse deer; B = Barking deer

Table 3. Nutrient Contents of Feed Plants of Mouse deer and Barking deer

No.	Local name	Dry matter	Ash	Protein	Fat	Crude fiber	Energy
		%	%	%	%	%	cal/g
1	Kingkilaban	90,43	8,32	13,14	0,78	27,89	3942
2	Nampong	89,91	17,22	22,04	1,54	29,85	3498
3	Kakawatan	90,70	11,59	18,50	0,77	30,39	3839
4	Jampang pahit	92,43	14,53	13,88	0,79	32,58	3923
5	Inggris grass	91,42	13,79	18,55	0,76	30,99	3414
6	Ilat	90,58	13,08	11,92	0,76	46,26	3682
7	Capituheur	89,63	16,25	23,41	0,75	34,25	3565
8	Sawuheun	93,08	11,73	15,47	0,78	46,04	3169
9	Pakis beunyeur	90,52	11,58	24,75	0,97	36,10	4636
10	Pacar tere	91,34	15,60	22,14	0,76	43,95	3336
11	Sintrong	89,79	18,56	28,96	1,50	13,66	3372
12	Tangkur gunung	92,08	8,23	13,41	0,77	43,12	3951
13	Hutamala	91,85	10,30	10,45	0,78	41,62	3535
14	Gewor	91,69	18,64	21,03	0,79	22,51	3467
15	Goletrak	90,25	15,79	31,24	0,79	12,40	2929
16	Jampang sliper	91,46	9,72	12,74	0,75	34,99	3513
17	Lamotek	92,18	14,43	22,15	0,76	23,04	4041
18	Lameta	95,20	8,07	15,73	0,77	36,04	3554
19	Kakacangan	93,89	8,85	24,82	0,78	31,70	3529
20	Bayona (green)	95,74	9,06	14,43	0,77	32,17	3643
21	Bayona (red)	91,48	7,64	17,71	0,76	21,84	3701
22	Hui areuy bereum	95,73	10,56	27,77	0,78	16,49	3808
23	Kasimukan	93,32	15,53	20,23	0,75	26,23	3557
24	Babadotan (wild)	93,29	14,59	21,81	0,93	12,81	4307
25	Teklan	90,35	11,40	18,95	0,96	19,58	3362
26	Semingu	90,29	14,18	23,10	0,78	25,28	3403
27	Akar wangi	93,32	5,21	22,46	0,76	19,07	3575
28	Hareuga	90,47	11,54	28,54	0,94	13,91	3214
29	Bungbrun	90,18	8,77	21,53	0,94	17,89	3155
30	Kareumi	91,94	6,75	24,14	0,85	11,11	3502
31	Kukucayan	92,57	14,50	21,24	0,76	30,68	3160
32	Kibeling (wild)	90,78	15,32	21,00	0,91	18,14	3606
33	Tali sahid (grenn) :						
	- Leaf	92,41	8,91	21,57	0,95	19,48	3300
	- Young trunk	92,64	17,14	19,41	0,95	24,92	3608
34	Tali sahid (red) :						
	- leaf	90,82	13,08	20,23	0,98	24,95	3464
35	Peki	92,30	8,53	18,00	1,47	29,28	3162
36	Jampang carulang	92,63	9,77	16,77	0,79	38,12	3394
37	Jarong	92,75	6,43	17,16	0,83	16,85	3469
38	Jajahean	91,11	8,71	14,89	0,76	32,87	3925
39	Cacabean	91,69	7,67	22,93	0,77	9,55	3601
40	Cariang (young trunk)	90,64	32,90	10,80	0,82	19,42	4213
41	Solempat (young trunk)	86,14	27,48	10,27	0,79	25,97	2576

very selective in consuming plants, such as bushes, some types of grasses, and forest fruit laid on forest floor, whilst according to Kay *et al.* (1980), based on selection of species, mouse deer prefers leaves containing water, seeds, and fruit easy to digest, so that mouse deer is categorized in the grouped of browser or concentrate selectors (Agungpriyono, 1992). On the other side, for barking deer, although also categorized in the group of browser or concentrate selectors, the number of grasses types consumed is more than mouse deer do, and barking deer also consumes leaves, bushes, herbs, and forest fruit (Leakagul and McNeely, 1977).

Barking deer is different from other ruminants because this animal does not like grasses in the phase of vegetative and prefers young buds growing after burned such as tall, coarse grass. For barking deer and deer from family of Cervidae, the willingness to consume young buds of tall, coarse grass in the burned field is linked with the effort to meet their needs for mineral resources, especially for male animal with growing velvet (Semiadi, 1998).

There are some plants consumed by barking deer which are not selected by mouse deer as diet resources. This fact is seemingly caused by the fact that the plants contain alkaloid which is can not be approved by mouse deer. It is known that some plants protect their leaves toward herbivore by producing compounds such as tannin and phenol. Mouse deer with its sharp sense of smell avoids such plants and prefers plants and leaves not containing compound (Kinnaird, 1995). Table 2 shows that all kinds of leaves consumed by mouse deer and barking deer are young leaves plus their young trunks because they are still soft and palatable, easy to digest, and contain low level of tanin and lignin (Waterman, 1984). The report of Kudo *et al*., (1997) states that the content of cellulotic microbe in the digestive organs of ruminants is high enough so that mouse deer can consume high fiber feed. It is reported that for rough fiber of 12.7 %, mouse deer is able to digest at 63.7% (Nolan *et al*., 1995). Considering that this research indicates that the content of rough fiber consumed by mouse deer is higher (Table 3), it is necessary to observe the optimum capability of this animal in consuming rough fiber. On the other side, because the information on morphology of the digestive organs of barking deer is very little, it is needed to conduct a research on anatomy and morphology of the digestive system of this animal.

Nutrient content of the plants as diet resources of mouse deer and barking deer in their habitat (Table 3) seems having variation. Ash (mineral) content ranges from 5.2% to 32.90% (average 91.70% $\pm$ 1.76), protein from 10.27% to 34.35% (average 19.90% $\pm$ 5.79), fat from 0.72% to 2.93% (average 0.90% $\pm$ 0.34), rough fiber from 9.55% to 46.26% (average 26.41% $\pm$ 9.92), and energy from 2,576 cal/g to 4,691 cal/g (average 3,493.54 cal/g $\pm$ 456.24).

The result of nutrient analysis shows that feed plants selected by mouse deer and barking deer as their diet resources have vary value ranges for the content of protein and rough fiber. This condition will make easier the effort of supplying and selecting the types of alternative feed in the case of captivating those animals in breeding program (*ex situ*), for both research and commercial purposes.

CONCLUSION

The research concludes that mouse deer exists in all of foot areas of Gunung Kendeng with the height up to 1,150 m above sea level, but does not exists in the foot area of Gunung Botol, whereas barking deer distributes in both areas. The types of habitats preferred by mouse deer are dense and protected bushes such as under tea bushes, holes at trunks, holes at rocks, nearby rivers, whilst barking deer prefers protected bushes in the forest side and unirrigated field. This research also resulted a documentation of 50 species including in 22 families forest plants selected by mouse deer and barking deer as their diet resources.

ACKNOWLEDGEMENT

Financial support for this research was provided by Biodiversity Conservation Project (JICA) in Indonesia, a joint project with LIPI, PHPA, and JICA.

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Genetic Diversity of Slow lories (*Nycticebus coucang*) Based on Mitochondrial DNA

Wirdateti[1], Toshinao Okayama[2] & Hellen Kurniati[1]
[1] Museum Zoologicum Bogoriense, R & D Center for Biology-LIPI
[2] Biodiversity Conservation Project, JICA-LIPI
E-mail : [1]mzb@indo.net.id, [2] Lox@indo.net.id

ABSTRACT
Genetic diversity of slow lories (*Nycticebus coucang*) based on mitochondrial 12S rRNA gene. The research of genetic diversity on slow lories *Nycticebus coucang* (kukang) was carried out. The collection samples 12 individuals os slow lories from three locations (Sumedang and Jember in Java, and Lampung in Sumatera. Total DNA was extracted from blood and tissue.

The mitochondrial 12 S rRNA nucleotide sequences were determined to investigate genetic diversity of this species. The amplified this region with use L1091 and H1478 primers by PCR. As a result of the analysis for 386 bp sequence, five haplotipes were found, two from Java and three from Sumatra.

Keyword : slow lories, Nycticebus coucang, genetic diversity, mitochondrial DNA

INTRODUCTION

Slow lories *(Nycticebus coucang)* is a species from genus Nycticebus with its distribution ranged from South Asia to Southeast Asia (Lekagul & Mcneely, 1977). This species in Indonesia is distribution in Sumatera, Jawa and Kalimantan.The wild population has been declining quit significant due to poaching, hunting to be sold as pet animal and degradation of their habitat (IUCN, 1987). The status of this species were protected based on ìUndang-undang dan Peraturan Perlindungan Binatang Liar" 1931 and currently under CITES convention is in Appendix II (Anonymous, 1996).

Taxonomically, in Indonesia *N. coucang* is known to have three subspecies, which spread from Kalimantan (*N.c. menangensis*), Jawa (*N.c. javanicus*) and Sumatera (*N.c. coucang)* (Groves, 1971; PHPA, 1978). However, morphological review indicates that some authors put the animal into six subspecies (Strein, 1986; Corbet and Hill, 1992, and Chasen, 1940). Based on morphological data that overlap will difficult for determine or difference in classification of subspesies in Indonesia, therefore in this animal trade difficult for determine from original locations each individuals. There is not permanent characteristics on each subspesies will difficult in conservation oh this animal in nature. . For that was important to do the exploration of particular marker the genetic characteristic on each subspecies with molecular DNA. For this will do research genetic analysis on *N. coucang* based on mitochondria 12S rRNA gene is determine genetic diversity and difference nucleotide of each populations.

MATERIALS AND METHODS

Sampling locations

Sample collection were at the five locations of three subspecies *Nycticebus coucang* which representative that is in Sumedang (6), Jember (2), Lampung (4), Jambi (2), and Kalimantan (1).

DNA extractions

Total DNA was extracted from blood, tissue (liver, kidney, pulmo and heart) following standard procedures (Sambrook *et al*, 1989) with phenol - chloroform.

Amplification and Sequencing

Amplification using the PCR was performed in 50 ul reactions, containing buffer 10x 5 ul, 10mM dNTP 4 ul, 2pm Primer (L&H) 5 ul, Taq polymerase 1.25 U 1 ul, DNA template 1-2 ul and destilation water 29 ul. The amplification with PCR using the following thermal cycles in a 9600 Perkin Elmer machine was performed by denaturation; 95°C for 30 sec., annealing 55°C for 30 sec, and extension 72°C for 30 sec with 40 cycles and use H1478 and L1091 primers described by Kocher *et al*. (1989). Amplification products were resolved by electroforesis in a1% Seakem agarose gel in 1X Tris-Acetate EDTA (1xTAE) buffer and stained with ethidium bromide to visualize the DNA.

Sequencing

Sequence determine of PCR product with use sequencer automatic. PCR products were purified using spin column (Amersham-Pharmacia) following the manufacture,s protocol . Direct sequencing was performed using Thermosequenase dye primer cycle sequencing kit (Amersham-Pharmacia) with ALFred DNA sequencer. The sequencing reaction were run at 50% stock Long Ranger™ gel solution Acrylamide for 12 hours (over night).

Data analysis

386 base-pair sequence nucleotide were for analysis. Alignment sequences were using Clustal X (Jeanmougin *et al*., 1998). For estimated haplotype diversity (*h*) and nucleotide diversity (*p*) intra and inter populations following Nei (1987). Phylogenetic tree was constructed using Neighbor in PHYLIP program (Felstein, 1995).

RESULTS AND DISCUSSION

Of the 15 individuals obtained, there were only 12 that could be sequenced as long as 386 base-pair nucleotide. The other three individuals from Jambi and Kalimantan could not be either sequenced or analyzed. Thus, the genetic variety of one individuals from Kalimantan (*N.c. menangensis*) and the two from Jambi (*N.c. coucang*) could not be calculated.

Variation of DNA Sequence

The sequence alingment of 386 bp of gen 12S rRNA DNA Mitokondria from the 12 *Nycticebus coucang* can be seen in Figure 1. There are 9 varied sites (polimorphic sites). All variations of the sites indicate transitional event and each of the positions underwent one or more base change. This condition is in accordance with Greenberg *et al* (1983) stating that in a closely connected population, the variation in the sequence is expected to be dominated by transitional event.

Genetic Variation

From the nine polymorphic sites, there were 5 haplotype found (JA, JB, SA, SB, and SC) shown in Table 1. The haplotype frequency and genetic variation can be seen in Table 2. In individuals derived from Sumedang, the haplotype found were JA and JB, and the two individuals from Jember had the same haplotype (JB). Meanwhile, in the Lampung population consisting of 4 individuals, 3 haplotypes were founds i.e SA, SB and SC. The result of haplotype frequency calculation (Nei, 1987) indicates that the frequency of JB haplotype (0,500) is higher compared with the other four haplotypes. JB haplotype is the dominant charateristics of Javanese slow lories.

This result indicates that genetic variation of Java slow lories (*h* = 0,242) is lower than that of Lampungs (*h* = 0,714) characterized by 2 haplotype from the 8 individuals (Table 2.). This obvious difference is also indicated in the nucleotid difference between the population from Java and that from Sumatra (Lampung) i.e p = 0.00205, while individuals from Jember indicates monomorf population from 2 individuals (temporary result). Decrease in genetic variation of Java slow lories can be of several causes, which are, among others, destruction and exploitation of their habitat for plantation, which tend to increase every year (Mackinnon, 1987). In addition to that, uncontrolled illegal hunting can decreased the population in nature, which in turn will decrease Effective Population Size, in which individuals inside have the role in the breeding of that animal. Nursahid (2000), reported that the selling of slow lories in black market and malls is the third position of primate species, and these markets are generally found in Java. Based on the slow lories survey in animal markets, there are more Javanese slow lories sold there than those of Sumatra and Kalimantan. High frequency of hunting has been in West Java areas (Sumedang and Malimping). Hence, there should be some control over the habitat and the haversting of these animals in nature.

Genetic variation in the population coming from Lampung indicates that there are high levels of variation and nucleotide differences (Table 2.). This result has been supported by the same criteria having the morphology of the four slow lories individuals from Lampung. One individuals indicated almost these same body size as that from Java (*N.c. javanicus*), while the stripe patterns on the head and back are similar to those from Sumatra (*N.c. coucang*). The characteristics of these individuals might indicate that these slow lories have been the result of crossbreeding between those from Java *(N.c.javanicus*) and slow lories from Sumatra (*N.c.coucang*). This crossbreeding can possibly occur considering a close distance between Java and Lampung where slow lories from Java are accidentally taken to Sumatra and other hand by animals traders or privately. The other three individuals have the body size , spot and stripe patterns similar to those from Sumatra found in Lampung. These criteria are in accordance with the kind slow lories from Sumatra as reported by Chasen (1940), Strein (1986), Corbet and Hill (1992). The results of their research based on the morphological data indicated that, slow lories in Sumatra consisted of 4 subspecies distributed in Riau, Jambi, South Sumatra including Lampung, Tebing Tinggi (East Sumatra) and Tanah Datar (West Sumatra).

The Philogeny tree (Figure 2) indicates that there are different haplotypes between the population in Java and Sumatra. However, there is one ambigious haplotype from Lampung. In which it is closer to the population from Java than it is from Lampung. This haplotype is different in two bases from JA haplotype and three bases from JB (Java), and with SB and SC the differences are five and six bases respectively (Lampung).

CONCLUSION

From this research, there are 5 haplotypes found (JA,JB,SA,SB,SC); two of them (JA,JB) are found in the Java population and three (SA,SB,SC) are in the Sumatra population. The genetic variation between those from Java and Sumatra is *h* = 0,709, and that of Lampung (*h* = 0,714).

SUGGESTION

As the samples of each subspecies in this research were very limited, there should be futher research having more samples in each location and there should be some additional locations of each subspecies in order to obtain complete information regarding the existence of slow lories in nature.

CLUSTAL X (1.8) multiple sequence alignment

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SM4         -TTGCCCTATTCAATTAAGCTCTCTATTCTTAATTTACTTCTAAATCCGCCTTAATCACT
SM1         ATTGCCCTATTCAATTAAGCTCTCTATTCTTAATTTACTTCTAAATCCGCCTTAATCACT
SM2         ---GCCCTATTCAATTAAGCTCTCTATTCTTAATTTACTTCTAAATCCGCCTTAATCACT
JM1         ---GCCCTATTCAATTAAGCTCTCTATTCTTAATTTACTTCTAAATCCGCCTTAATCACT
SM3         ------------------------------------TTACTTCTAAATCCGCCTTAATCACT
LP3         ---------TTCAATTAAGCTCTCTATTCTTAATTTACTTCTAAATCCGCCTTAATCACT
SM5         --------ATTCAATTAAGCTCTCTATTCTTAATTTACTTCTAAATCCGCCTTAATCACT
JM2         -------TATTCAATTAAGCTCTCTATTCTTAATTTACTTCTAAATCCGCCTTAATCACT
SM6         -----CCTATTCAATTAAGCTCTCTATTCTTAATTTACTTCTAAATCCGCCTTAATCACT
LP2         ------------------------------------TTACTTCTAAATCCGCCTTAACCACT
LP1         ---GCCCTATTCAATTAAGCTCTCTATTCTTAATTTACTTCTAAATCCGCCTTAACCACT
LP4         --TGCCCTATTCAATTAAGCTCTCTATTCTTAATTTACTTCTAAATCCGCCTTAACCACT
                                                                   *

SM4         TTTTTCATAAGGGGTGGCGTTAATTGTTCTGTGAAGATAGAAAATGTAGCCCATTTCTTC
SM1         TTTTTCATAAGGGGTGGCGTTAATTGTTCTGTGAAGATAGAAAATGTAGCCCATTTCTTC
SM2         TTTTTCATAAGGGGTGGCGTTAATTGTTCTGTGAAGATAGAAAATGTAGCCCATTTCTTC
JM1         TTTTTCATAAGGGGTGGCGTTAATTGTTCTGTGAAGATAGAAAATGTAGCCCATTTCTTC
SM3         TTTTTCATAAGGGGTGGCGTTAATTGTTCTGTGAAGATAGAAAATGTAGCCCATTTCTTC
LP3         TTTTTCATAAGGGGTGGCGTTAATTGTTCTGTGAGGATAGAAAATGTAGCCCATTTCTTC
SM5         TTTTTCATAAGGGGTGGCGTTAATTGTTCTGTGAAGATAGAAAATGTAGCCCATTTCTTC
JM2         TTTTTCATAAGGGGTGGCGTTAATTGTTCTGTGAAGATAGAAAATGTAGCCCATTTCTTC
SM6         TTTTTCATAAGGGGTGGCGTTAATTGTTCTGTGAAGATAGAAAATGTAGCCCATTTCTTC
LP2         TTTTTCATAAGGGGTGGCGTTAGTTGTTCTGTGAGGATAGAAAATGTAGCCCATTTCTTC
LP1         TTTTTCATAAGGGGTGGCGTTAGTTGTTCTGTGAGGATAGAAAATGTAGCCCATTTCTTC
LP4         TTTTTCATAAGGGGTGGCGTTAGTTGTTCTGTGAGGATAGAAAATGTAGCCCATTTCTTC
                                  *           *

SM4         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTGGTTCTCCTGCTTACTATG
SM1         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTGGTTCTCCTGCTTACTATG
SM2         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTGGTTCTCCTGCTTACTATG
JM1         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTGGTTCTCCTGCTTACTATG
SM3         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTGGTTCTCCTGCTTACTATG
LP3         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTAGTTCTCCTGCTTACTATG
SM5         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTGGTTCTCCTGCTTACTATG
JM2         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTGGTTCTCCTGCTTACTATG
SM6         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTGGTTCTCCTGCTTACTATG
LP2         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTAGTTCTCTTGCTTACTATG
LP1         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTAGTTCTCTTGCTTACTATG
LP4         CCACCTCATAGACTACACCTTGACCTAACGTTTTAATGTGTGGTTCTCTTGCTTACTATG
                                                     *      *

SM4         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
SM1         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
SM2         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
JM1         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
SM3         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
LP3         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
SM5         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
JM2         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
SM6         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
LP2         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
LP1         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
LP4         GGTCCTTGACAGGGTTTGCTGAAGATGGCGGTATATAGGTTGAATTAGAAAGAGGTGGTG
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SM4     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTGTAAAGCACCGC
SM1     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTGTAAAGCACCGC
SM2     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTGTAAAGCACCGC
JM1     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTGTAAAGCACCGC
SM3     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTGTAAAGCACCGC
LP3     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTGTAAAGCACCGC
SM5     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTGTAAAGCACCGC
JM2     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTGTAAAGCACCGC
SM6     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTGTAAAGCACCGC
LP2     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTATAAAGCACCGC
LP1     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTATAAAGCACCGC
LP4     AGGTTTATCGGGGTTTATCGATTATAGAACAGGCTCCTCTAGGGGGGTATAAAGCACCGC
                                                        *

SM4     CAAGTCCTTTGAGTTTCGAGCTGTTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGGTAT
SM1     CAAGTCCTTTGAGTTTCGAGCTATTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGGTAT
SM2     CAAGTCCTTTGAGTTTCGAGCTATTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGGTAT
JM1     CAAGTCCTTTGAGTTTCGAGCTATTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGGTAT
SM3     CAAGTCCTTTGAGTTTCGAGCTATTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGGTAT
LP3     CAAGTCCTTTGAGTTTCGAGCTATTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGGTAT
SM5     CAAGTCCTTTGAGTTTCGAGCTGTTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGGTAT
JM2     CAAGTCCTTTGAGTTTCGAGCTATTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGGTAT
SM6     CAAGTCCTTTGAGTTTCGAGCTATTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGGTAT
LP2     CAAGTCCTTTGAGTTTCGAGCTATTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGATAT
LP1     CAAGTCCTTTGAGTTTCGAGCTATTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGATAT
LP4     CAAGTCCTTTGAGTTTCGAGCTATTGCTTGTAGTACTCTGGCGAGTAGCATTGTTGGTAT
                              *                                  *

SM4     GCTACTTTAGTTTACGGTTAAGCATAG---------------------
SM1     GCTACTTTAGTTTACGGTTAAGCATAGTGGGG----------------
SM2     GCTACTTTAGTTTACGGTTAAGCATAGTGGGG----------------
JM1     GCTACTTTAGTTTACGGTTAAGCATAGTGGGGTATCTAAT--------
JM3     GCTACTTTAGTTTACGGTTAAGCATAGTGGGGTDATCTG---------
LP3     GCTACTTTAGTTTACGGTTAAGCATAGTGGGGTATCTNAT--------
SM5     GCTACTTTAGTTTACGGTTAAGCATAGTGGGGTATCTTTATCCCAGTT
JM2     GCTACTTTAGTTTACGGTTAAGCATAGTGGGGT---------------
SM6     GCTACTTTAGTTTACGGTTAAGCATAGTGGGGTATCTAAT--------
LP2     GCTACTTTAGTTTACGGTTAAGCATAGTGGGGTATC------------
LP1     GCTACTTTAGTTTACGGTTAAGCATAGTGGGG----------------
LP4     GTTACTTTAGTTTACGGTTAAGCATAGTGGGG----------------
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Figure 1. Sequence alignment 386 bp of 12S rRNA mtDNA gene. Asterisks mark shown on 9 polymorphoics sites position.

Table 1. Polymorphic positions between Slow loris haplotypes. A period denotes A maching base with the top-most sequence.

Haplotype	Base Position								
	22	49	61	129	135	255	289	323	328
JB	T	A	A	G	C	G	A	G	C
JA	.	.	.	.	.	.	G	.	.
SA	.	.	G	A	.	.	.	.	.
SB	C	G	G	A	T	A	.	A	.
SC	C	G	G	.	T	A	.	.	T

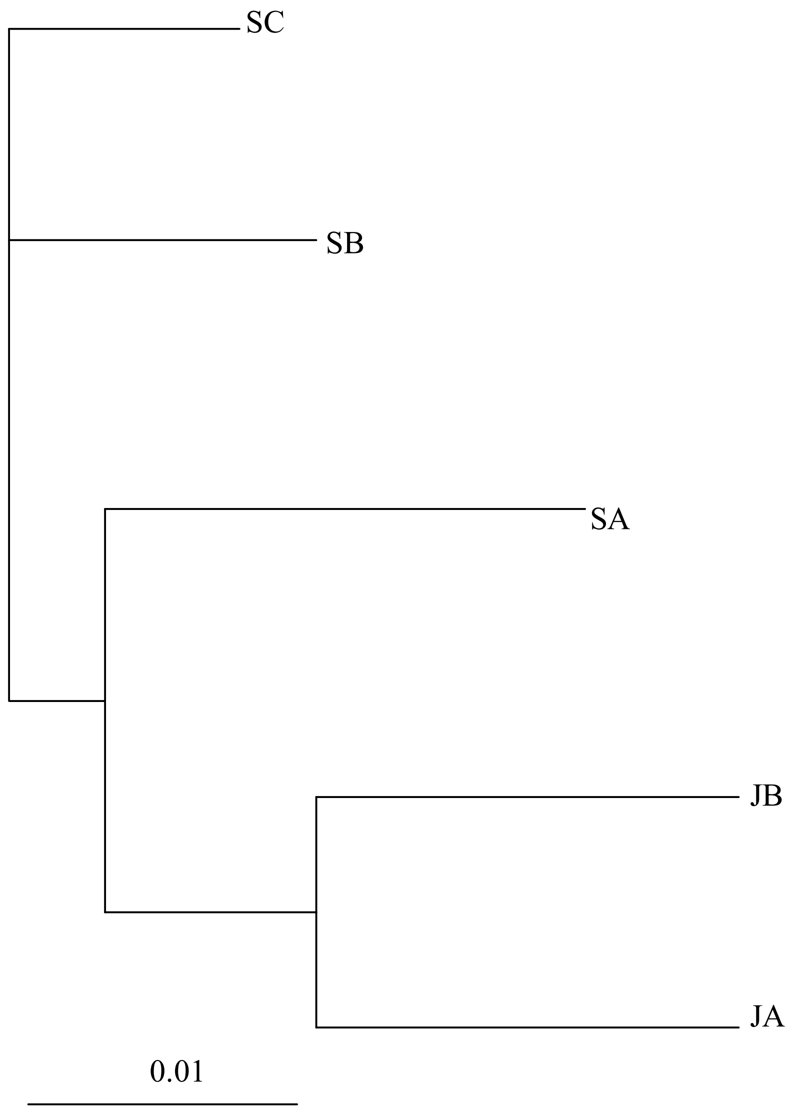

Figure 2. Phylogenetic tree (Neighbor - joining method).
JA, JB = Haplotype from Java
SA, SB, SC = Haplotype from Lampung (Sumatra)

Table 2. Haplotypes frequencies, genetics variations (h) and nucleotide differences (π) on three locations

Location	Haplotype Frequency					h	π	n
	A	B	C	D	E			
Lampung	-	-	0.50	0.25	0.25	0.714	0.00129	4
Sumedang	0.333	0.667	-	-	-	0.484	0.00063	6
Jember	-	1	-	-	-	0	0	2
Jawa-Sumatera	0.167	0.500	0.0183	0.167	0.167	0.709	0.00205	12

ACKNOWLEDGEMENT

This study was a part of research activities of the Biodiversity Conservation Project - JICA (Japan International Cooperation Agency and APPERI.

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Tree Population Change of a Disturbed Protection Forest in Jampang - Sukabumi, West Java

Edy Nasriadi Sambas and Mustaid Siregar*
Research Center for Biology, The Indonesian Institute of Sciences
Jalan Juanda 22, Bogor 16122, Indonesia, E-mail: herbogor@indo.net.id
* Present Address : Eka Karya Botanic Garden - Bali
Candikuning, Baturiti, Tabanan, Bali 82191 E-mail: direkbg@singaraja.wasantara.net.id

ABSTRACT

Tree population change of a 1 Ha (100 m by 100 m) plot in a disturbed protection forest was studied at Jampang, Sukabumi Regency, West Java. The censuses were carried out in 1998 and 2000. During two years, the forest lost 25 species and 93 individual trees mostly due to illegal cutting and only gained 2 recruiting individual trees. Number of species and density of trees (diameter > 10 cm) in 1998 and 2000 were 136 species (belonging to 86 genera and 46 families) and 408 trees/ha, and 111 species (belonging to 79 genera and 43 families) and 307 trees/ha respectively. The most abundant trees were *Schima wallichii*, *Gironniera subaequalis*, *Macaranga lowii*, and *Pentace polyantha*. While the most diverse families were Euphorbiaceae (10 genera, 14 species), Lauraceae (8 genera, 15 species), and Rubiaceae (5 genera, 6 species). The food crisis in 2000-2001 and lack of supervision from the forest guards caused local people to convert most part of the forest to upland rice field.

Key words : disturbed protection forest, illegal cutting, tree population change, Jampang, West Java.

INTRODUCTION

The utilization of natural resources such as gold mining eventhough manually will cause social and environmental impacts, either positively (positive gainings) or negatively (negative gainings). The land formerly mining area tends to undergo degradation that is becoming less fertile/nutrient deficiency. Therefore, it needs rehabilitation on that degraded land. Land and bioresources conservation is supposed to be implemented along with mining activity so that the fertility recovery is not as difficult as if it is not an effort at all.

The main purpose of this study is to expose the status and condition of a forest ecosystem at the traditional gold mining area, Jampang, West Java, so that it can be a reference in land reclamation activity on that area specifically and for other similar areas in Indonesia.

STUDY SITE AND METHODS

The study was conducted at the protected forest of Jampang, Waluran village, Sukabumi Regency, West Java in August 1998 and February 2000 (Fig. 1). The annual precipitation at Jampang varies around 2000-3800 mm. Geographically it is located on 7 and 10.747 South ; 106 and 37.244 East. Topographical condition was hilly with a slope of 15 - 40. The altitude is 600 - 770 m above sea level. Soil type is dominated by latosol and yellowish red podzol with clayed soil texture. PH ranges 4.5 - 5.5 and humidity of 78 % (depending on the season).

A plot of 100 m by 100 m (1 Ha) was established . The plot was divided into 100 subplots of 10 m by 10 m, and those trees with dbh of more than 10 m were enumerated their species, measured their diameter, total height and height of the first live branch. Some chemical contents of soil sample were presented in Table 1.

Table 1. Quantitative data of the analytical results of the soil sample

Parameters	Quatitative measurements	Notes
pH	4.77	
N- total	0.041 %	Medium
P-Bray 2	0.059 ppm	Very low
K	0.222 me/100 g	Medium
CEC	15.624 me/100 g	High
Al dd	12.606 me/100 g	

RESULTS AND DISCUSSION

Density and diversity

Number of species in 1998 was 136 species belonging to 86 genera and 46 families (Appendix 1) while that of 2000 was 111 species belonging to 79 genera and 43 families. The list of species disappeared within two years is listed on Appendix 2. List of twenty tree species with highest important value at the research plot in 1998 and 2000 are presented in Table 2 and Table 3.

From Table 2 and Table 3 it can be seen that the species composition and structure between data of 1998 and 2000 was still similar. Some main species dominating were *Schima wallichii*, *Gironniera subaequalis*, *Macaranga lowii*, and *Pentace polyantha*. S. *wallichii* was recorded as the dominant species with highest frequency, density and basal arae compared to other species. This species grows naturally, but its dominance is not directing to homogenous forest type (Sambas and Siregar 1999). The composition of twenty tree species having largest individual numbers in 1998 and 2000 were still similar although the ranks were different. Tree individual number of S. wallichii decreased sharply from 41 to 23 trees per Ha or decreasing 44% wirth a reducing basal area 0f 2.43 m2. From the observation in the field, that was caused by illegal cutting. Cutting seemed to be directed to tree individuals having diameter > 50 cm (Figure 2). However, from field observation, trees of smaller diameter were also cut to make easy the access in taking the log. Some small trees were fallen as a side effect of tree falling. This caused individual number of small diamter trees also decreased (Figure 3). Some tree individuals having diameter > 50 cm that still exist are also subject to be cut seeing from the sign on the trunk. This indicates that although protected forests, yet it is sensitive to felling generally implemented openly. *Macaranga lowii* had the stabile densuty compared to ther species, it only lost one individual. This was probably due to its low wood quality especially for constraction material, so that not as object of tree felling.

Table 2. List of the Twenty species with Highest Important Value at the Study Plot in 1998

	Species	Family	Freq. (%)	Density /Ha	Basal Area (m2/Ha)	Imp. Value
1	*Schima wallichii*	Theaceae	31	41	9.15	52.57
2	*Gironniera subaequalis*	Ulmaceae	20	29	0.85	15.71
3	*Pentace polyantha*	Tiliaceae	15	21	1.09	13.29
4	*Macaranga lowii*	Euphor.	17	24	0.56	12.59
5	*Castanopsis tunggurut*	Fagaceae	7	8	0.44	5.50
6	*Blumeodendron tokbrai*	Euphor.	8	8	0.27	5.14
7	*Sterculia oblongata*	Stercul.	6	7	0.44	4.99
8	*Lithocarpus indutus*	Fagaceae	4	6	0.56	4.65
9	*Adina trichotoma*	Rubiaceae	6	7	0.35	4.65
10	*Polyalthia rumphii*	Annon.	7	9	0.13	4.59
11	*Dysoxylum densiflorum*	Meliaceae	5	6	0.32	4.02
12	*Prunus arborea*	Rosaceae	5	5	0.31	3.75
13	*Xerospermum noronhianum*	Sapind.	5	7	0.14	3.60
14	*Nyssa javanica*	Nyssaceae	4	4	0.37	3.45
15	*Ficus fistulosa*	Moraceae	4	5	0.25	3.25
16	*Lithocarpus sundaicus*	Fagaceae	4	4	0.31	3.23
17	*Horsfieldia glabra*	Myrist.	4	4	0.22	2.89
18	*Polyalthia lateriflora*	Annon.	4	5	0.13	2.80
19	*Meliosma nitida*	Sabiaceae	4	4	0.07	2.33
20	*Diospyros* sp.	Ebenaceae	4	4	0.07	2.33

Table 3. List of the Twenty Species with Highest Important Value in the Study Plot in 2000

	Species	Family	Freq. (%)	Density /Ha	Basal area (m2/Ha)	Imp. Value (%)
1	*Schima wallichii*	Theaceae	21	23	6.72	48.20
2	*Gironniera subaequalis*	Ulmaceae	17	24	0.56	16.59
3	*Macaranga lowii*	Euphor.	15	23	0.53	15.40
4	*Pentace polyantha*	Tiliaceae	13	15	0.54	12.15
5	*Dysoxylum densiflorum*	Meliaceae	5	6	0.36	5.49
6	*Blumeodendron tokbrai*	Euphor.	6	7	0.20	5.38
7	*Polyalthia rumphii*	Annon.	7	7	0.10	5.24
8	*Adina trichotoma*	Rubiaceae	4	6	0.34	5.05
9	*Lithocarpus indutus*	Fagaceae	4	5	0.29	4.48
10	*Castanopsis tunggurut*	Fagaceae	4	4	0.34	4.40
11	*Xerospermum noronhianum*	Sapind.	5	6	0.13	4.35
12	*Sterculia oblongata*	Stercul.	3	5	0.33	4.33
13	*Nyssa javanica*	Nyssaceae	3	4	0.38	4.24
14	*Lithocarpus sundaicus*	Fagaceae	3	3	0.31	3.58
15	*Ficus fistulosa*	Moraceae	3	4	0.23	3.50
16	*Polyalthia lateriflora*	Annon.	2	5	0.14	3.02
17	*Diospyros* sp.	Ebenaceae	3	4	0.08	2.76
18	*Prunus arborea*	Rosaceae	2	2	0.13	1.99
19	*Meliosma nitida*	Sabiaceae	2	2	0.04	1.55
20	*Horsfiledia glabra*	Myrist.	1	2	0.11	1.55

Tree number on 1998 census was 408 trees/Ha, while that of 2000 was 307 trees/Ha, decreasing 101 individuals (24.8%). During last 1.5 years, number of trees dead and cut was far higher (103 individuals) compared to the new recruitments (two individuals) i.e. *Blumeodendron tokbrai* and *Lithocarpus indutus*. All dead tree can be causee by illegal cutting.

In the growth process, the chance of each individual tree to occupy dead trees are not same.Generally, the recruitent psrocess of each individual to become a mature tree is through natural selection competitatively. After 1.5 years, there was a population change by reducing the individual number and density, if the security of the forest is not enhanced, the protected forest will be more damaged especially the good quality trees for construction material, and will only replaced by low quality ones.

With the status of a protected forest, the study plot is categorized as highly degraded forest. Therefore, it needs reboisation with origin species. The successful reboisation of this area will support reclamation activity on land formerly gold mining area at Jampang and surrounding. Besides, that forest needs protection from illegal cutting having impression of no prevention due to lack of forest guards and low awareness of some people (illegal cutting network) on forest function. The illegal logger should be given alternative jobs so that forest destruction will not be worsened.

Tree species richness in the research area was high. The tree diversity level was also showed by the number of trees per species. In 1998, as many as 124 species (91.18 %) only represented by 1 - 5 trees, and 77 species (56.62 %) represented by only one tree. While in 2000 there were 102 (91.89 %) species represented by 1 - 5 trees and 62 species (55.86 %) represented by only one tree.

Based on diameter class, Figure 1 showed tree distribution, while that of 2000 is shown in Figure 1.

Tree distribution of 4 main species in the study plots are presented in Figure 2 (1998) and Figure 3 (2000)

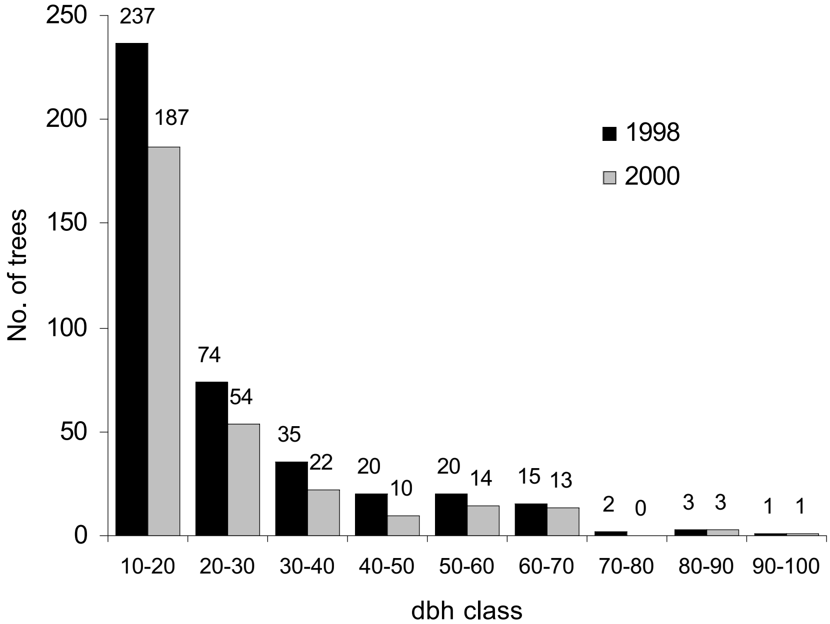

Figure 1. Tree Distribution Based on dbh Class in the Study Plot in1998 and 2000

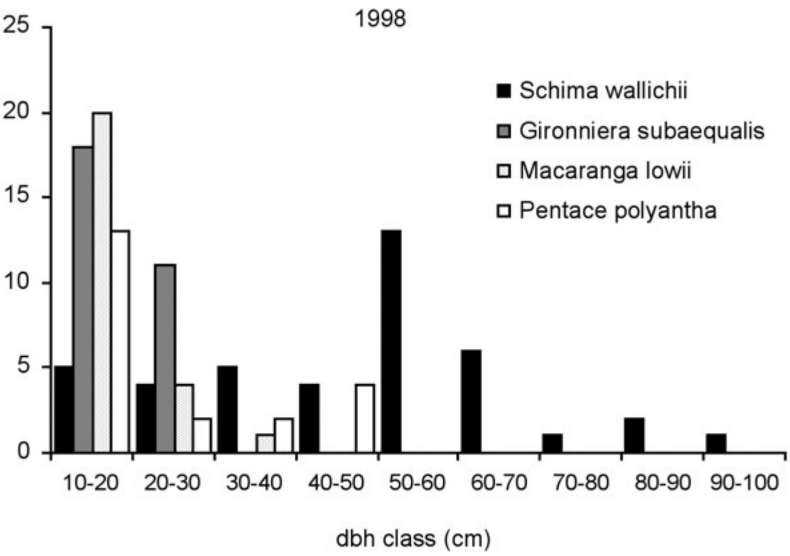

Figure 2. Tree Distribution of Four Main Species in the Study Plot in 1998.

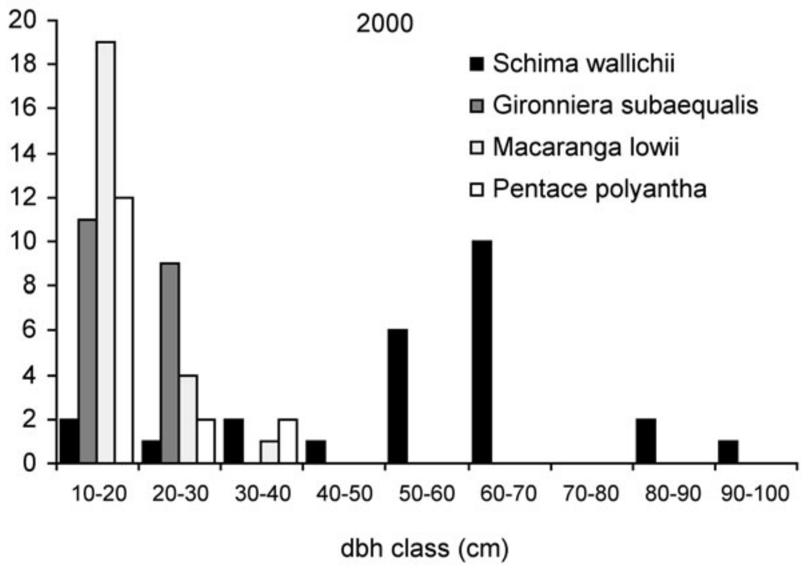

Figure 3. Tree Distribution of Four Main Species in the Study Plot in 2000.

Table 4. Family Importance Value in the Study Plot in 1998

No	Family	No. of Genera	No. of Species	No. of Trees	Basal Area (m2/Ha)	Family Importance Value (%)
1	Theaceae	1	1	32	9.150	52.57
2	Euphorbiaceae	10	14	50	1.768	32.43
3	Fagaceae	2	8	24	2.154	20.43
4	Ulmaceae	1	1	25	0.850	15.71
5	Lauraceae	9	18	24	0.734	15.14
6	Myrtaceae	4	7	18	1.361	14.10
7	Meliaceae	3	8	16	0.939	11.77
8	Myristicaceae	3	7	15	0.654	10.19
9	Rubiaceae	5	6	14	0.680	9.50
10	Annonaceae	1	2	14	0.275	7.39
11	Melastomataceae	2	6	10	0.435	6.79
12	Rosaceae	2	2	8	0.494	5.98
13	Sterculiaceae	1	2	8	0.444	5.79
14	Sapotaceae	3	3	5	0.787	5.52
15	Moraceae	3	3	7	0.291	4.70
16	Elaeocarpaceae	1	5	6	0.341	4.37
17	Crypteroniaceae	1	2	2	0.879	4.31
18	Aquifoliaceae	1	1	5	0.426	4.17
19	Ebenaceae	1	4	8	0.226	4.0
20	Sapindaceae	2	2	7	0.161	3.90
21	Nyssaceae	1	1	4	0.367	3.44
22	Clusiaceae	3	3	5	0.205	3.35
23	Sabiaceae	1	2	5	0.085	2.90
24	Cornaceae	1	2	4	0.062	2.30
25	Saxifragaceae	1	1	3	0.077	1.84
26	Icacinaceae	2	3	3	0.036	1.68
27	Aceraceae	1	1	1	0.251	1.45
28	Burseraceae	1	1	2	0.109	1.44
29	Magnoliaceae	1	1	2	0.091	1.37
30	Symplocaceae	1	2	2	0.067	1.28
31	Olacaceae	2	2	2	0.065	1.28
32	Fabaceae	1	1	2	0.122	1.22
33	Bignoniaceae	1	1	2	0.021	1.11
34	Thymelaeaceae	1	1	2	0.019	1.10
35	Pittosporaceae	1	1	1	0.039	0.66
36	Loganiaceae	1	1	1	0.037	0.65
37	Bombacaceae	1	1	1	0.027	0.62
38	Anacardiaceae	1	1	1	0.020	0.59
39	Simaroubaceae	1	1	1	0.019	0.59
40	Flacourtiaceae	1	1	1	0.016	0.58
41	Rhamnaceae	1	1	1	0.014	0.57
42	Rhizophoraceae	1	1	1	0.013	0.57
43	Proteaceae	1	1	1	0.012	0.56
44	Staphyllaceae	1	1	1	0.009	0.55
45	Connaraceae	1	1	1	0.009	0.55
46	Tiliaceae	1	1	19	1.090	13.29

Table 5. Family Importance Value in the Study Plot in 2000

No	Family	No. of Genera	No. of Species	No. of Trees	Basal Area (m2/Ha)	Family Importance Value (%)
1	Theaceae	1	1	24	6.740	48.20
2	Euphorbiaceae	9	12	41	1.386	34.66
3	Fagaceae	2	7	16	1.449	17.57
4	Lauraceae	8	15	20	0.674	16.90
5	Ulmaceae	1	1	18	0.599	16.59
6	Meliaceae	3	7	13	0.879	13.17
7	Tiliaceae	1	1	15	0.513	12.15
8	Rubiaceae	5	6	13	0.663	11.75
9	Myrtaceae	4	4	11	0.555	9.50
10	Myristicaceae	3	6	12	0.323	9.38
11	Annonaceae	1	2	12	0.242	9.33
12	Ebenaceae	1	4	8	0.226	6.54
13	Melastomataceae	2	6	7	0.276	6.11
14	Sapotaceae	2	2	3	0.727	5.64
15	Moraceae	3	3	6	0.282	5.47
16	Sapindaceae	2	2	7	0.161	5.19
17	Sterculiaceae	1	1	5	0.325	5.00
18	Nyssaceae	1	1	4	0.367	4.53
19	Aquifoliaceae	1	1	4	0.313	4.26
20	Rosaceae	2	2	4	0.138	3.40
21	Crypteroniaceae	1	1	1	0.537	3.34
22	Cornaceae	1	2	4	0.062	3.02
23	Clusiaceae	3	3	4	0.060	3.01
24	Sabiaceae	1	2	3	0.051	2.29
25	Magnoliaceae	1	1	2	0.091	1.81
26	Olacaceae	2	2	2	0.065	1.68
27	Elaeocarpaceae	1	1	1	0.192	1.63
28	Fabaceae	1	1	2	0.122	1.61
29	Saxifragaceae	1	1	2	0.033	1.52
30	Thymelaeceae	1	1	2	0.019	1.45
31	Symplocaceae	1	1	1	0.052	0.94
32	Pittosporaceae	1	1	1	0.039	0.87
33	Bombacaceae	1	1	1	0.027	0.81
34	Simaroubaceae	1	1	1	0.019	0.77
35	Loganiaceae	1	1	1	0.037	0.86
36	Flacourtiaceae	1	1	1	0.016	0.76
37	Rhizophoraceae	1	1	1	0.013	0.74
38	Bignoniaceae	1	1	1	0.011	0.73
39	Icacinaceae	1	1	1	0.010	0.73
40	Connaraceae	1	1	1	0.009	0.72
41	Staphyllaceae	1	1	1	0.009	0.72
42	Anacardiaceae	1	1	1	0.020	0.78
43	Burseraceae	1	1	2	0.109	1.90

ACKNOWLEDGEMENT

We would like to thank Ismail for assisting in the field and identifying the species. The project leader of Research and Development Center for Biology LIPI of 1998 - 2000 is thanked for providing logistics.

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Appendix 1. List of Tree Species in the Study Plot in 1998

Aceraceae
Acer laurinum

Aquifoliaceae
Ilex cymosa

Annonaceae
Polyalthia lateriflora
P. *rumphii*

Anacardiaceae
Semecarpus glaucus

Bignoniaceae
Radermachera gigantea

Bombacaceae
Durio zibethinus

Burseraceae
Canarium denticulatum

Clusiaceae
Calophyllum venolusum
Cratoxylum sumatranum
Garcinia sp.

Connaraceae
Ellipanthus tomentosus

Cornaceae
Mastixia rostrata
M. trichotoma

Crypteroniaceae
Crypteronia griffithii
C. *paniculata*

Ebenaceae
Diospyros buxifolia
D. *frutescens*
D. *hermaphroditica*
Diospyros sp.

Elaeocarpaceae
Elaeocarpus floribundus
E. *oxypyren*
E. *petiolaris*
E. *sphaericus*
Elaeocarpus sp.

Euphorbiaceae
Aporosa frutescens
Aporosa sp.
Baccaurea javanica
Blumeodendron elatriospermum
B. *tokbrai*
Bridelia glauca
Claoxylon longifolium
Cleidon spiciflorum
Cleistanthus sp.
Croton argyratus
Drypetes macrophylla
Macaranga lowii
M. *semiglobosa*
M. *subglobosa*

Fabaceae
Cassia fistulosa

Fagaceae
Castanopsis argentea
C. *javanica*
C. *tunggurut*
Lithocarpus blumeanus
L. *indutus*
L. *javanica*
L. *javensis*
L. *sundaicus*

Flacourtiaceae
Flacourtia rukam

Icacinaceae
Gomphandra javanica
Stemonurus secundiflorus
Stemonurus sp.

Lauraceae
Actinodaphne angustifolia
A. procera
Alseodaphne umbelliflora
Cinnamomum iners
C. javanicum
C *sintoc*
Cryptocarya costata
C. *densiflora*
C. *ferea*
Dehaasia cuneata
Lindera bibracteata
Litsea grandis
L. *lanceolata*
L. *mappacea*
L. *resinosa*
Litsea sp.
Neolitsea casseafolia
Persea rimosa

Loganiaceae
Fagraea elliptica

Meliaceae
Aglaia aspera
A. dookko
A. eusideroxylon
A. odoratissima
Chisocheton sp.
Dysoxylum arborescens
D. densiflorum
D. *excelsum*

Magnoliaceae
Michelia montana

Melastomataceae
Memecylon costatum
M. *edule*
M. *floribundum*
M. *myrsinoides*
M. *oligonorum*
Pternandra azurea

Moraceae
Ficus fistulosa
Paratocarpus sp.
Artocarpus elasticus

Myristicaceae
Horsfieldia glabra
Knema cinerea
K. *intermedia*
K. *latericia*
K. *latifolia*
K. *laurina*
Myristica iners

Myrtaceae
Rhodamnia cinerea
Rinorea cinerea
R. *javanica*
Eugenia acuminatissima
E. fastigiata
E. *lineata*
Syzygium sp

Nyssaceae
Nyssa javanica

Olacaceae
Anacolosa frutescens
Olea javanica

Proteaceae
Helicia serrata

Pittosporaceae
Pittosporum ferrugineum

Rubiaceae
Adina trichotoma
Canthium sp.
Ixora paludosa
Nauclea lanceolata
Nauclea sp.
Plectromia didyma

Rosaceae
Atuna racemosa
Prunus arborea

Rhamnaceae
Maesopsis eminii

Rhizophoraceae
Gynotroches axillaris

Simaroubaceae
Ailanthus integrifolia

Sapotaceae
Chrysophyllum roxburghii
Madhuca macrophylla
Payena leerii

Staphyllaceae
Turpinia sphaerocarpa

Sabiaceae
Meliosma lanceolata
M. *nitida*

Sapindaceae
Nephelium lappaceum
Xerospermum norohianum

Saxifragaceae
Polyosma integrifolia

Sterculiaceae
Sterculia cordata
S. *oblongifolia*

Symplocaceae
Symplocos fasciculata
S. *odoratissima*

Tiliaceae
Pentace polyantha

Theaceae
Schima wallichii

Thymelaceae
Gonystylus macrophyllus

Ulmaceae
Gironniera subaequalis

Appendix 2. List of Disappearing Species within 1998-2000 in the Study Plot

No	Species	No	Species
1	*Acer laurinum*	14	C. *javanicum*
2	*Crypteronia griffithii*	15	*Aglaia odoratissima*
3	*Baccaurea javanica*	16	*Knema intermedia*
4	*Macaranga subglobosa*	17	*Rinorea javanica*
5	*Elaeocarpus oxypyren*	18	*Eugenia fastigiata*
6	E. *petiolaris*	19	E. *lineata*
7	E. *sphaericus*	20	*Helicia serrata*
8	*Elaeocarpus* sp.	21	*Chrysophyllum roxburghii*
9	*Lithocarpus javensis*	22	*Xerospermum noronhianum*
10	*Gomphandra javanica*	23	*Sterculia cordata*
11	*Stemonurus secundiflorus*	24	*Symplocos fasciculata*
12	*Alseodaphne umbelliflora*	25	*Maesopsis eminii*
13	*Cinnamomum iners*		

Preliminary Phylogeny of the Two Closely- Related Genera, *Agrioglypta* Meyrick and *Talanga* Moore (Lepidoptera: Crambidae; Spilomelinae), Based on Nucleotide Sequence Variation in Mitochondrial Cytochrome Oxidase II and Morphology

Hari Sutrisno[1,2*], Azuma Noriko [2], Seigo Higashi [2]
[1]Museum Zoologicum Bogoriense, Cibinong, PO. Box 25 Bogor, Indonesia
[2]Graduate School of Environmental Earth Science, Hokkaido University Sapporo 060-0810 Japan.
*Author to whom correspondence should be addressed at present: Graduate School of Environmental Earth Science, Hokkaido University, Sapporo, 060 0810, Japan. E-mail: hari@ees.hokudai.ac.jp.

ABSTRACT

The phylogeny of the two closely- related genera, *Agrioglypta* Meyrick and *Talanga* Moore, was inferred from nucleotide sequence variation across a 687-bp region in the cytochrome oxidase II gene and from morphology. Seven species representing the two genera and two outgroup genera (*Sameodes* Zeller and *Metallarcha* Meyrick) were included in parsimony analysis based on 64 molecular characters and 20 morphological characters that were potentially informative. The most parsimonious relationships based on molecular data showed substantial congruence with the species relationships indicated by the morphological variation. Separate and combined analyses of the molecular and morphological data sets showed that *Agrioglypta* possibly formed a paraphyletic assemblage while *Talanga* was a monophyletic group.

*Key words: morphological variations**,** molecular phylogeny, moth*

INTRODUCTION

Agrioglypta Meyrick, 1932, and *Talanga* Moore, 1885, are medium-sized moths (20-30 mm) that are common and widespread in tropical regions especially in South East Asia with some species penetrating into subtropical areas (Common, 1990; Robinson *et al*., 1994). These genera are small groups with the known species numbering 17 for *Agrioglypta* and 12 for *Talanga*. Both genera belong to the Spilomelinae, a large lepidopteran subfamily, comprising 220 species in 86 genera from North America (Hodges *et al*., 1983), more than 300 species represented by 47 genera in South East Asia (Robinson *et al*., 1994), and about 360 species in about 125 genera in Australia (Shaffer *et al*., 1996). Compared with other Spilomelinae, *Agrioglypta* and *Talanga* are less studied not only in terms of their taxonomy but also their relationships and their biological aspects (Robinson *et al*., 1994). The recent preliminary study on the relationships of some genera of the Australian Spilomelinae based on adult moths showed that *Agrioglypta* is a sister group of *Talanga*, but the relationships among species within each genus are still unresolved (Sutrisno, 2002a).

Agrioglypta was described by Meyrick, 1932 for the single species *Agrioglypta enneactis* Meyrick. A little information is available on diversity and distribution of this genus. Robinson *et al.* (1994) estimated that this genus contains more than 17 species ranging from Taiwan and India to Samoa. Shaffer *et al.* (1996) recorded five species from Australia. The only biological information is Commonís (1990) record that the larvae of *A. excelsalis* (Walker) feed on the leaves of sandpaper figs (*Ficus coronota* Spin and *F. opposite* Miq, Moraceae), either folding the leaves or joining adjacent leaves with silk.

Talanga was described by Moore, 1885, based on several species including *Oligostigma sexpunctata* Moore, an incorrect subsequent spelling of *Oligostigma sexpunctalis* Moore (1877). Hampson (1896) subsequently designated *O. sexpunctalis* as the type species of the genus. This genus contains about 12 species distributed from India and Taiwan to the Solomon Islands and Australia (Robinson *et al*., 1994). Based on material deposited in Australian National Insect Collection, Canberra, Australia, there are three species in Australia (*T. tolumnialis* (Walker) and *T. sabacusalis* (Walker), *T. sexpunctalis* Moore) but only the first two species were listed in the Checklist of the Australian Lepidoptera (Shaffer *et al*., 1996). The biology of this genus is little known. Common (1990) reported that the larvae of *T. tolumnialis* is a common pest of cultivated figs in Queensland and New South Wales. The larvae normally feed on the young foliage of native figs (*Ficus* spp, Moraceae).

As for nearly all pyraloids in the Oriental/Australian region, these two genera are poorly defined since the previous taxonomic studies, largely from early this century (Hampson, 1896, 1898, 1899), were based on external characters only (Common, 1990). Several characters previously used to describe these two genera, such as scaling of the labial and maxillary palpi, shape of the segments of labial and maxillary palpi and body shape, often lead to confusion since these characters vary considerably within species or even according to the condition of the specimen. Therefore, the monophyly of each genus and the relationships among species within each genus need to be tested, preferably by cladistic analysis based, not only on external character but also genital characters and molecular data. The latter are useful to phylogenetic studies of Lepidopetra, as has been shown in studies of the moth taxa *Greya* Busck (Prodoxidae) (Brown *et al.*, 1994); phylogeny of *Ostrinia furnicalis* GuenÈe and allied species (Pyralidae) (Kim *et al*., 1999) and phylogeny of *Papilio* Linnaeus (Papilionidae) (Caterino *et al*., 1999). All of these studies utilized the mitochondrial gene, cytocrhrome oxidase II (mtDNA CO II), which displayed appropriate variation for resolving relationships species within genus. There is no doubt that including other mitochondrial genes and nuclear genes in the analysis may give more appropriate result to reconstruct the relationships among taxa at generic level, as has been shown in the study of the phylogeny of *Polygonia* H¸bner, *Nympalis* Kluk and related butterflies (Nympalidae) (Nylin *et al*., 2001).

The present study aims to reassess the monophyly of both *Agrioglypta* and *Talanga* and to estimate the relationships among species within each genus based on morphological data and nucleotide sequence variation in mtDNA CO II gene. Due to the difficulty of collecting fresh materials for molecular study, only four species of *Agrioglypta* and three species of *Talanga* are included in the present study.

MATERIAL AND METHODS

Moth specimens

Specimens for molecular study were collected during 1999-2002 from various localities in Indonesia and Australia (Table 1). Adult moths were collected by using light traps and were preserved in absolute alcohol (99.5% ethanol). Morphological study was conducted based on specimens deposited in Museum Zoologicum Bogoriense, Bogor (MZB) and Australian National Insect Collection (ANIC).

The two genera *Sameodes* and *Metallarcha* were chosen as the outgroup in this study since the preliminary study on the relationships among genera of the Australian Spilomelinae showed that both genera are more primitive than *Agrioglypta* and *Talanga* (Sutrisno, 2002a).

Table 1. Species selected for molecular study.

Genera	Species	Locality	Date of collection
Agrioglypta	*excelsalis*	Menado, Sulawesi	April, 2001
	eurytusalis	Pangrango NP, West java	September, 2000
	itysalis	Halimun Np, West Java	April, 2001
	naralis	Halimun NP, West Java	March, 2002
Talanga	*sabacusalis*	Patunuang, Sulawesi	April, 2001
	sexpunctalis	Bantimurung, Sulawesi	April, 2001
	tolumnialis	Bucasia, Queensland	April, 2001
Sameodes	*cancellalis*	Sorong, Irian Jaya	March, 2002
Metallarcha	*aureodiscalis*	Bucasia, Queensland	April, 2001

DNA Extraction

An individual thorax was ground in a 1.5 ml microcentrifuge tube containing 600 µl CTAB buffer with 4% polyvinyl pyrrolidone and incubated at 55 ˚C for 2 hours. The solution was extracted several times with phenol saturated with TE buffer (10 mM Tris-HCL, pH 8.0, 1mM EDTA); once with one volume of phenol: chloroform: iso-amyl alcohol (25:24:1). Then, the solution was again extracted twice with chloroform: iso-amyl alcohol. The aqueous phase was transferred to a new tube, then 1.5 volume of isopropanol was added to precipitate DNA and left at -20 ˚C for more than 1 hour. The DNA precipitant was pelleted by centrifugation at 13,000 rpm for 20 minutes. The DNA pellet was washed with 70% ethanol, air dried and dissolved in 50 µl l of TE buffer.

Sequencing of mtDNA CO II gene

PCR was carried out by using a Takara Thermal Cycler MP (Takara) at the following cycle profiles: 30 s at 94 ˚C, 60 s at 47 ˚C and 120 s at 72 ˚C for 35 cycles. The primers used to amplify the mtDNA CO II gene were O-tLEU (5-TAGTGCAATGGATTTAAACC-3) and B-tLYS (GTTTAAGAGACCAGTACTTG-3) (Kim at *al*., 1999).

The PCR products were purified using QIAquick PCR Purification Kit (Qiagen, USA). Sequencing of the purified PCR product was performed using an ABI PRISM Dye Terminator Cycle Sequencing Ready Reaction Kit (Perkin-Elmer) on ABI PRISM model 310 Genetic Analyzer (PE Applied Biosystems). The sequences were aligned using BioEdit Sequence Alignment Editor (Hall, 1999).

Morphological characters

The following 20 characters were observed on pinned specimens under a stereoscopic dissecting microscope and/or on mounted body parts under a compound microscope. Several terms for characters used here are following Sutrisno (2002b). All characters were treated as ordered (Wagner Parsimony) with the exception of characters: 2, 9, 10, 12, and 14 which were treated as unordered. The data matrix of characters state for taxa that was subjected to cladistic analysis is given in Appendix 1.

The 20 characters used are as follows:

1. Triangular marking at middle of forewing costa: (0) absent; (1) present.
2. Post medial line of forewing: (0) absent; (1) slightly curved, not interrupted medially; (2) curved, interrupted medially.
3. A small triangular spots at tornus of hindwing: (0) absent; (1) present.
4. Two small spots, surrounded by metallic marking at outer margin of hindwing: (0) absent; (1) present.
5. Hair pencils on lateral margin of male sixth tergum: (0) absent; (1) present.
6. Bundle of long hair on lateral margin of male T8: (0) absent; (1) present.

7. Shape of anterior edge of male eighth sternum: (0) rounded; (1) angled.
8. Length of ductus ejaculatorious: (0) short; (1) narrow long.
9. Apex of uncus:(0) apex not flat without neck; (1) apex truncate; (2) flat, paddle shaped.
10. Shape of tegumen:(0) narrow, nearly spindle shaped, fused with base of uncus; (1) subtriangular to ovate, fused with base of uncus; (2) broadly rounded depressed at apex.
11. Sclerotization of base of tuba analis: (0) absent; (1) U-shaped, but outer margin ventrally with wide, angled keels and well sclerotized.
12. Transtilla: (0) U-shaped, weakly sclerotised; (1) curved, medially weakly sclerotised; (2) V-shaped with wide subtriangular arm, medially with only membranous connection.
13. Shaped of juxta: (0) wide, without sclerotised medial rod; (1) narrow dorsal half curved anteriorly, with short well-sclerotised rod like medial processes with its tip curved ventrally.
14. Shape of vinculum: (0) simple; (1) nearly onion shaped, dorsal half subparallel ventral half transversely ovate with a ventro-medial depression containing a round extension; (2) U-shaped or broadly rounded with complex ventral expansion including an inclined transverse ventral plate.
15. Plate in middle of valva: (0) absent; (1) present.
16. Costa of valva: (0) without any process; (1) with a small knob-like process.
17. Coremata: (0) simple in basal structure, with scattered broad long scales; (1) simple in basal structure with lamellate scales fused to form a large valva-like processes.
18. Hair pencil on base of ear lobe coremata (basal structure): (0) absent; (1) present.
19. Sclerotized ring anterior to ostium: (0) absent; (1) present.
20. Sculptured hair at middle of coremata: (0) absent; (1) present.

Phylogenetic Inference

Phylogenetic analyses were performed with PAUP* version 4.0b.10 for 32-bit Microsoft Windows (Swofford, 2001). Maximum Parsimony analysis were applied for morphological and molecular data either separately or combined. All searches of the data matrix were performed with the exhaustive search.

The numbers of nucleotide substitutions per site of the mtDNA CO II gene were estimated based on Tamura and Nei (1993) model using MEGA. 1.0. The statistical confidence of a particular clade in the MP tree was evaluated by the Bootstrap test (Felsenstein, 1985).

RESULTS

Morphological Phylogeny

An exhaustive search in PAUP resulted single MP tree (length= 26, CI= 0.89, and RI=0.93). The MP tree resulted from the analysis based on morphological characters with bootstrap support is presented in Fig. 1A.

The numbers of the synapomorphy characters are presented only for the two major groups, *Agrioglypta* + *Talanga* and *Talanga*. The monophyly of the group *Agrioglypta* + *Talanga* is supported by the following character and states: 1(1), 2(0), 3(1), 6(1), 7(1), 8(1), 9(0), 10(1), 12(1), and 14(1), while the synapomorphy characters states for *Talanga* are 4(1), 9(2), 10(2), 11(1), 12(2), 13(1), 14(2), 15(1), 17(1) and 20(1).

mtDNA variation

Sequences of seven species of *Agrioglypta* and *Talanga* and two species outgroups were aligned using BioEdit Sequence Alignment Editor (Hall, 1999), with no evidence of indels (aligned sequences are available from the corresponding author on request). Over the entire 687-bp region, 76.12 % of the nucleotide positions were constant, 14.55 % were uninformative (i.e., any variants were found in single sequence), and 9.31 % were informative. Third positions of codon were most variable, whereas second positions were least variable (Table 2). The mtDNA CO II sequences of the seven species of *Agrioglypta* and *Talanga* had high proportions (77%) of A + T, with A + T bias particularly pronounced (94%) at the third position (Table 3).

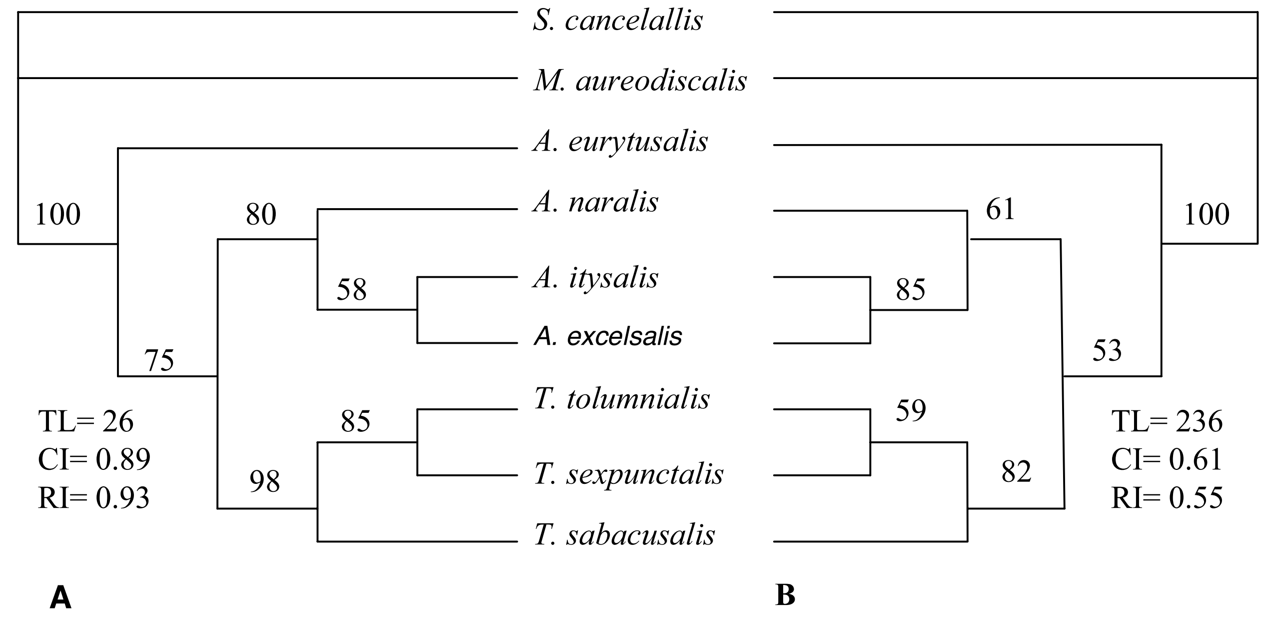
Estimated sequences divergence

Since the existence of substantive composition bias (0.366 A, 0.119 C, 0.109 G and 0.0409 T) occurred in the nucleotides, the Tamura and Nei (1993) method was applied to estimate nucleotide divergence for all pairwise combination of the seven species of *Agrioglypta* and *Talanga* (Table 4, above the diagonal). Distances based on all substitutions range from 1.48% to 9.13% for comparison within the *Agrioglypta* and 3.36% to 5.94% within *Talanga*.

The ratios of transitions to transversions for all pairwise species comparison range from 0.534 to 4.00. The highest ratios are between closely- related species: for example *A. itysalis* (Walker) - *A. excelsalis* (Walker). The lower ratios are for comparison between the genera.

Phylogenetic analyses of mtDNA CO II sequences

An exhaustive search using equal weighting of all nucleotides substitutions resulted in a single MP tree (length= 236, CI= 0.805, and RI=0.589) which is similar to the tree resulting from analysis of the morphological data (Fig. 1B). When



Figures 1 A-D. MP trees: (A) based on morphological data, (B) based on CO II using all substitution, (C) only transversion (a strict consensus of the two MP trees), (D) combination morphological data and CO II using all substitution. Bootstrap values (percentage of 1000 replicates) are shown at each node of MP tree. In the MP trees, total tree length (TL), consistency index (CI), retention index (RI) are also shown.

transversions only were included, there were two MP trees which differed only on the position of *A. eurytusalis*. The topology of the first tree was exactly similar to the MP tree resulted from the morphological data, whereas in the second tree, *A. eurytusalis* occupied the basal of the genus *Talanga* and separate from the rest of *Agrioglypta*. The strict consensus tree of these two MP trees is presented in Fig. 1C. When substitution weighting was applied to the analyses, giving transversion from twice to five times the weight of transitions, the analysis resulted in the same topology as the MP tree from morphological data as well as when giving the first codon position was weighted from twice to five times the weight of other codon position.

When mtDNA CO II sequences were translated into amino acid, 21 (9.1 %) of 229 amino acids were variable across the 9 sequences. Since only 14 of these variable positions were informative, an exhaustive search resulted in 12

MP trees that agreed only on the clade formed by *A. itysalis* and *A. exelcalis*.

Combination of the two data sets, morphology and mtDNA CO II gene with equal weighting or only transversion data included in the analysis, resulted in a single MP tree with similar topology from those based on separate data. The MP tree based on combination of the two data sets with the bootstrap support value shown is presented in Fig. 1D.

Table 2. Percent variable sites by codon position, across *Talanga*, *Agrioglypta* and two outgroup species

	1^{st}-codon	2^{nd}-codon	3^{rd}-codon
Constant (%)	86	94.7	47.1
Uninformative (%)	7	2.6	33.6
Informative (%)	6	2.6	19.2
No of sites	229	229	229

Table 3. Proportion of each nucleotide in protein coding regions (by codon position) in the CO II region

	Codon position			
	First	Second	Third	Mean
A	0.2882	0.3643	0.4376	0.3664
C	0.1761	0.1407	0.0402	0.1190
G	0.1256	0.1824	0.0174	0.1085
T	0.4100	0.3124	0.5046	0.4090

Table 4. Interspecific divergence in CO II gene sequences in the *Agrioglypta* and *Talanga*

Species	1	2	3	4	5	6	7	8	9
1. *S. cancelallis*		12.46	10.52	9.66	9.82	12.07	11.35	10.99	11.17
		0.673	0.941	0.967	1.00	1.313	0.919	0.816	0.892
2. *M. aureodiscalis*	6.41		14.77	13.45	13.42	15.71	15.69	14.53	15.19
	14		0.607	0.566	0.566	0.696	0.610	0.534	0.736
3. *A. eurytusalis*	5.93	8.85		6.17	5.82	9.13	6.31	5.99	7.64
	13	19		1.105	1.00	1.591	0.952	0.95	0.96
4. *A. itysalis*	6.89	9.85	2.22		1.48	6.09	6.62	5.15	6.14
	15	21	5		4.00	2.546	0.954	0.619	1.00
5. *A. excelsalis*	6.89	9.85	2.22	0.80		5.38	6.60	4.52	6.29
	15	21	5	2		1.692	0.792	0.429	0.864
6. *A. naralis*	6.89	9.85	4.05	2.67	2.67		9.38	7.95	8.56
	15	21	9	6	6		1.185	0.821	1.348
7. *T. tolumnialis*	5.93	8.85	2.22	2.22	2.22	3.13		3.36	5.94
	13	19	5	5	5	7		3.400	2.167
8. *T. sexpunctalis*	5.93	8.85	2.22	17.7	17.7	2.67	0.44		4.26
	13	19	5	4	4	6	1		1.154
9. *T. sabacusalis*	5.93	8.85	3.13	2.67	2.67	1.77	1.32	0.88	
	13	19	7	6	6	4	3	2	

a. Above diagonal pairwise DNA sequences divergence are given (substitutions/100 sites; Tamura and Nei method) (top no. in each entry) and transition/transversion ratio (bottom no. in each entry).

b. Below the diagonal amino acid divergence are given (inferred replacement/100 codons) (top no. each entry) and number of replacement (bottom no. in each entry).

DISCUSSION

Phylogeny of Agrioglypta and Talanga

The result of the present study showed that the genus *Agrioglypta* is a paraphyletic group while *Talanga* is a monophyletic group. This result agreed in general with Shaffer *et al*.'s (1996) opinion except for the position of *A. eurytusalis* which is separate from the three remaining species of *Agrioglypta*, and therefore, this genus was shown to be paraphyletic. Shaffer *et al*. (1996) listed three of the four species of *Agrioglypta* included in the present analysis in the checklist of the Australian Lepidoptera in a possible sequence of divergence: *A. eurytusalis* as the most primitive and the two species *A. itysalis* and *A. excelsalis* as the more derived.

The monophyly of *Talanga* is well supported by at least 10 synapomorphic morphological character states and 10 molecular substitutions. The bootstrap test also showed that this genus has high support (98%) on the MP tree resulting from the combination of the two data sets. This indicates that there is enough evidence to be confident that this genus is a good monophyletic group. The relationships among the three included species is clearly resolved with *T. sexpunctalis*, the hypothesized sister species of *T. tolumnialis* and *T. sabacusalis* as sister group to the other two species.

The present study showed that the two data sets, morphology and mtDNA CO II gene, produced similar topology in inferring the relationships of the two genera, *Agrioglypta* and *Talanga*. These two data sets provide the strongest achievable evidence that this proposed phylogeny is accurate. It is well accepted that when several independently derived data sets agree, producing the same cladogram, it means that the result has high confidence (Miyamoto and Cracraft, 1991).

Variation in substitution frequencies in the mtDNA CO II genes

The extreme bias in base composition appears to be typical of the mtDNA CO II gene in insect; in 13 species representing 10 different orders, the mean proportion of A+T at third base positions in the CO II gene is 87% (Liu and Beckenbach 1992). The present study also revealed a similar phenomenon (94%) which is comparable also with other lepidopteran (Brown *et al*., 1994). The bias in base composition is greatest at the third-base positions, perhaps because first- and second-base positions are more constrained by the amino acid composition of the encoded protein. De Salle *et al*. (1987) stated that this assumes that there is continuous selection for A+T nucleotides, which is opposed by selection against some nonsynonymous substitution which increase the representation of A or T but have deleterious consequences for protein functions.

The discovery of strong transition bias of the mtDNA CO II gene in *Agrioglypta* and *Talanga* moths is consistent with observations from several groups of closely- related species and within species of insects (e.g. Beckenbach *et al*., 1993; Sperling and Hickey, 1994; Brower and De Salle, 1998; Kim *et al*., 1999). The strong bias for transitional substitutions is present in pairs of closely- related species, with a loss of this bias in those more distantly- related species, presumably due to strong biases in both base composition and substitution patterns.

All the findings in the present study may allow us to treat the three clades [(*A. eurytusalis*, (*A. itysalis* + *A. excelsalis* + *A. naralis*), and (*T. tolumnialis* + *T. sexpunctalis* + *T. sabacusalis*) as independent genera, or to synonymize *Talanga* with *Agrioglypta*. However, such nomenclature change should be made only after an analysis with additional species from wider range of distributional areas to avoid a further production of paraphyletic taxa or production of very many genera, each consisting of a small number of species.

ACKNOWLEDGMENTS

Grateful thanks are due to Dr. P. J. Gullan (University of California, Davis) for her critical reading of the early manuscript and her assistance in English. We thank the following colleagues for their help: Mr. E. Cholik, Mr. R. Sofyan and Mr. Darmawan (Museum Zoologicum Bogoriense, Bogor) for collecting specimens in Indonesia, Dr. M. Horak (CSIRO) and Mr. Ken J. Sandery for collecting and sending the specimens from Australia, Dr. H. Suzuki and Mr. Sato (Hokkaido University) for technical support, especially in sequencing. The study was supported in part by the Grand-in-aid from the Japan Ministry of Education, Science and Culture.

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Appendix 1. Data matrix for morphological characters

Species	No. of Characters			
	1	6	11	16
S. cancelallis	00000	00000	00000	00000
M. aureodiscalis	00000	00000	00000	00000
A. eurytusalis	11101	1?11?	0?0?0	0?000
A. exelsalis	12100	11111	01010	00110
A. itysalis	12100	11111	01010	00110
A. naralis	11100	11111	01010	00110
T. sabacusalis	11110	11122	12121	01101
T. sexpunctalis	11111	11122	12121	11101
T. tolumnialis	11111	11122	12121	11101

The Diversity and Abudance of Bats from Lore Lindu National Park, Central Sulawesi, Indonesia: Associations with altitude, land systems, vegetation and habitats

Ibnu Maryanto[1)] and Mohamad Yani[2)]
1) Museum Zoologicum Bogoriense, Jl. Raya Cibinong KM 46, Cibinong Bogor, Indonesia. E-mail: mzb@indo.net.id ; ibnu_mar@yahoo.com.
2) Current address: The Nature Conservancy. Jl. Karajalemba No.1 Palu, Central Sulawesi. E-mail: yanibat@yahoo.com

ABSTRACT

The long-term study of bats was carried out on March 2000 to July 2001 in Lore Lindu National Park, Central Sulawesi, Indonesia. All 11 major vegetation types and 8 major land system types an altitudinal range of around 200 to up 2355 meters ASL and habitat types was describe as combination of them were surveyed using the same standardized mist netting. The survey site was sampled for 4 days using 5 mist-nets a night for a total of 20 mist-nets night/each location. The total of 31,233.6 m^2 of mist-nets night area were set during this survey.

A total 16 species of Megachiroptera (fruit bats) and six Microchiroptera (insectivorous bats) have been identified in the Park. A total of 3822 bats were captured in these nets at an average capture rate of 12.24 individuals /100 m^2/night. The highest Fisher alpha diversity index for habitat diversity for bats was laid in the Marsh vegetation type, Lower Montane Forest on Bukit balang habitat type, or in the elevation 1200-1499 m ASL. There also appeared to be a trend for the bat species to partition resources along the altitudinal gradient, such that peak relative abundances of bats were spread out between the various altitudinal groupings in the Park.

To assist prepare management strategies for the Park it is important, in addition to considering species diversities and species abundance in the various altitudinal, vegetation, habitat or land system types, because they contain very similar assemblages of bats.

INTRODUCTION

Lore Lindu National Park (LLNP) has a total area of approximately 231,000 ha; it is one of the biggest National Park in Sulawesi. The Park has a rugged topography with an altitudinal range of around 200-2355 m Above Sea Level (ASL) and theyíre laid at 10 land system types and 11 major vegetation types (Lore Lindu National Park 2001). Wirawan (1981) identified that national park generally mountainous with 90% of the park area being above 1000 meters ASL; the area below 1000 m is found along the western and northern boundaries of the park. Furthermore, Bynum (1999) classified that the lowland forest in Lore Lindu have five significant variables that are best at detecting anthropogenic disturbance in the low land. Those are stumps, exotic trees rattan>3 meters, rattan<3 meters, and moss line. Musser and Dagosto (1987) stated that more than 1300 m ASL in Central Sulawesi, the lowland evergreen forest gives way to lower montane rain forest, decreases in canopy height, species diversity, buttressed trunks, woody climbers and ambient temperature. Whitmore (1984) argued that the decreasing of the biologically diversity generally along with increasing elevation

Little was known of the chiropteran (bat) fauna in the Park prior to the 2000-2001 surveys. However, Sulawesi and closely related smaller islands is known to be rich in pteropodid (fruit bat) species with at least 21-26 species having been recorded, including several endemic species (Bergmans and Rozendaal, 1988; and van Strien, 1986; Suyanto *et al.*1997). All these studies indicated a general absence of habitat types preferred by these bats and any detailed information on their distribution, particularly along altitudinal gradients, habitat, and land system and vegetation types. Heaney *et al.* (1989) and Medway (1972) reported that the species richness of pteropodid fruit bats in Southeast Asia typically decreased at higher elevations. This is also the situation in Lombok Island and elsewhere in the Lesser Sunda, Indonesia (Gunnel *et al.*1996; Kitchener 1998).

These paper reports on observations and interpretations of diversity of bat based on elevation, habitat, vegetation and land system type categories.

METHODOLOGY

Sampling areas

The bats survey of the Park was carried out March 2000 to July 2001. A total of 40 sites representative of the geography and vegetation of the Park were sampled for mammals. Their location is shown in Table 2. Each of the mist nets were geolocated using Garmin 12 GPS units, and the altitude of the plot recorded using an altimeter. All 11 major vegetation types and 8 major land system types were surveyed using the same standardized.

Vegetation types surveyed were:
- Cloud forest,
- Upper montane,
- Montane,
- Lower montane,
- Lower montane moist,
- Marsh,
- Mix garden,
- Monsoon,
- Swamp forest,
- Low land forest, and
- Degraded lowland forest.

These vegetation types lay on eight-land system types that are classification by RePPProt (1989) (Table 1). The habitats represent also the eight major land systems (Table 1) and vegetation that lain in altitudinal range of 350 to up 2100 meters ASL.

Seven altitudinal groupings recognized for later interpretation of both the mammal species and assemblage distributions. These were: 300-599 m, 600-899 m, 900-1199 m, 1200-1499 m, 1500-1799 m, 1800-2099 m and up 2100 m ASL.

Table 1.Land system types in Lore Lindu National Park

Land System Type	Land and Rock Types
Telawi (TWI)	Precipitous oriented mountain ridges on acid igneous rocks, granite, granodiorite, rhyolite.
Bukit Balang (BBG)	Irregular mountain ridges on intermediate basaltic, volcanics, andesite, basalt breccia
Kototinggi (KTT)	Moderately sloping non volcanic alluvial fans
Bukit Baringin (BBR)	Very steep ordered hills on acid igneous rocks, rhyolite, granite
Bukit Pandan (BPD)	Precipitous oriented metamorphic ridges, quartzite, schist, gabbro, granite, serpentinite
Pendreh (PDH)	Assymetric broadly dissected ridges on sandstone and mudstone
Batang Anai (BGA)	Long very steep ridges over metamorphic rocks
Lindu (DLU)	Lacustrine Plains

Capture techniques

Bats were recorded using standard monofilament mist nets. The total 40 survey sites were already done in that national park and each location of survey site was sampled for 4 days using 5 mist-nets a night for a total of 20 mist-nets night. The mist nets used were made of polyester 75d/2 ply and 31mm and all were set in the lower canopy or 6 to 20 meters above the ground. The nets used most commonly had four shelves and varied in length from 6, 9, 12 and 18 meters; all were 2.7 meters high. On occasions, smaller nets were used in caves. Nets were frequently changed positions between nights because of the facility of bats to recognize their position after initial contact with a net.

Trapping sites were visited two times 9.00 PM and every morning.

Data analysis

Indices of species diversity used were: Simpsonís, Shannon, and Fisher's a (Krebs 1989). The results of the survey were entered into a Microsoft Access database linked to an Arcview 3.2 geographical information system. Diversity indices were calculated using an Ecological Methodology computer package was produced using calculations from NTSYSpc 2.10p.

Table 2. Bats survey locations.

Survey Site	Location name	Vegetation Type	Altitude range (m)	Landsystem
Baku bakulu	Bbakulu	Degraded forest	850-1055	TWI
Dodolo	Dodolo	Montane	1500-1600	BBR
Hanggira 1	Hanggira1	Cloud Forest	212-2250	TWI
Hanggira 2	Hanggira2	Montane	1520-1755	TWI
Kadidia 1	Kadidia1	Lower Montane	665-820	TWI
Kadidia 2	Kadidia2	Lower Montane	730-865	PDH
Kamarora	Kamarora	Lowland	640-700	TWI, KTT
Kanawu 1	Kanawu1	Swamp Forest	995-1005	DLU
Kanawu 2	Kanawu2	Lower Montane	1040-1050	PDH
Kanawu 3	Kanawu3	Lower Montane	1070-1420	PDH
Kanawu 4	Kanawu4	Upper Montane	1655-1835	PDH
Lempe 1	Lempe1	Cloud Forest	2000-2120	TWI
Lempe 2	Lempe2	Cloud Forest	2000-2135	TWI
Lindu 1	Lindu1	Mixed Garden	910-1065	TWI, DLU
Lindu 2	Lindu2	Lower Montane	985-1170	TWI
Lindu 3	Lindu3	Marsh	984-990	DLU
Lindu4	Lindu4	Swamp Forest	990-1000	DLU
Nokilalaki 1	Nlalaki1	Upper Montane	1605-1914	TWI
Nokilalaki 2	Nlalaki2	Lower Montane	795-1420	TWI
Nokilalaki 3	Nlalaki3	Cloud Forest	1905-2290	TWI
Pointoa	Pointoa	Upper Montane	1810-2005	TWI
Rorekatimbu 1	Rkatimbu1	Upper Montane/Cloud	1895-2015	BPD, TWI
Rorekatimbu 2	Rkatimbu2	Upper Montane/Cloud	1990-2520	BPD, TWI
Rorekatimbu 3	Rkatimbu3	Montane	1695-1980	TWI
Rompo	Rompo	Upper Montane - moist	1195-1200	BBR
Sibalaya 1	Sibalaya1	Monsoon	345-620	TWI
Tababuru 1	Tababuru1	Lower Montane	1100-1190	BBR,TWI
Tababuru 2	Tababuru2	Lower Montane	890-1090	BBR
Uwebiro 1	Uwebiro1	Montane	1300-1320	BBR
Uwebiro 2	Uwebiro2	Montane	1195-1250	BBR
Watubose	Watubose	Lower Montane	815-965	BBG
Watumaeta	Watumaeta	Lower Montane	1185-1195	KTT
Wuasa 1	Wuasa1	Lower Montane	1230-1500	BBR
Wuasa 2	Wuasa2	Montane	1384-1515	BBR
Toro 1	Toro 1	Montane	1455-1510	BPD
Toro 2	Toro 2	Upper Montane	1600-1970	BPD,TWI
Bulu Kalumea 1	Kalumea 1	Montane	1545-1675	BGA
Bulu Kalumea 2	Kalumea 2	Upper Montane	1710-1950	BBR
Ooperese	Ooperese	Low Land	600-745	BGA
Tuare	Tuare	Lower Montane	790-1135	BGA

RESULTS

Chiroptera (bats) captured

Total 16 species of Megachiroptera (fruit bats) and six Microchiroptera (insectivorous bats) have been identified in the Park. This included an unidentified *Rousettus*. We have since described the Rousettus as a new species (see attachment). The taxonomic status of the *Thoopterus* is under review.

Megachiropterans caught in this Park were:

- *Cynopterus brachyotis* (Mueller, 1838)
- *C. luzoniensis* (Peters, 1862).
- *C. minutus* Miller, 1906.
- *Chironax melanocephalus* (Temminck, 1825).
- *Dobsonia exoleta* Andersen, 1909.
- *Thoopterus nigrescens* (Gray, 1870).
- *Nyctimene cephalotes* (Pallas, 1767).
- *Pteropus alecto* Temminck, 1837.
- *Styloctenium wallacei* (Gray, 1866).
- *Rousettus amplexicaudatus* (Geoffroy, 1810).

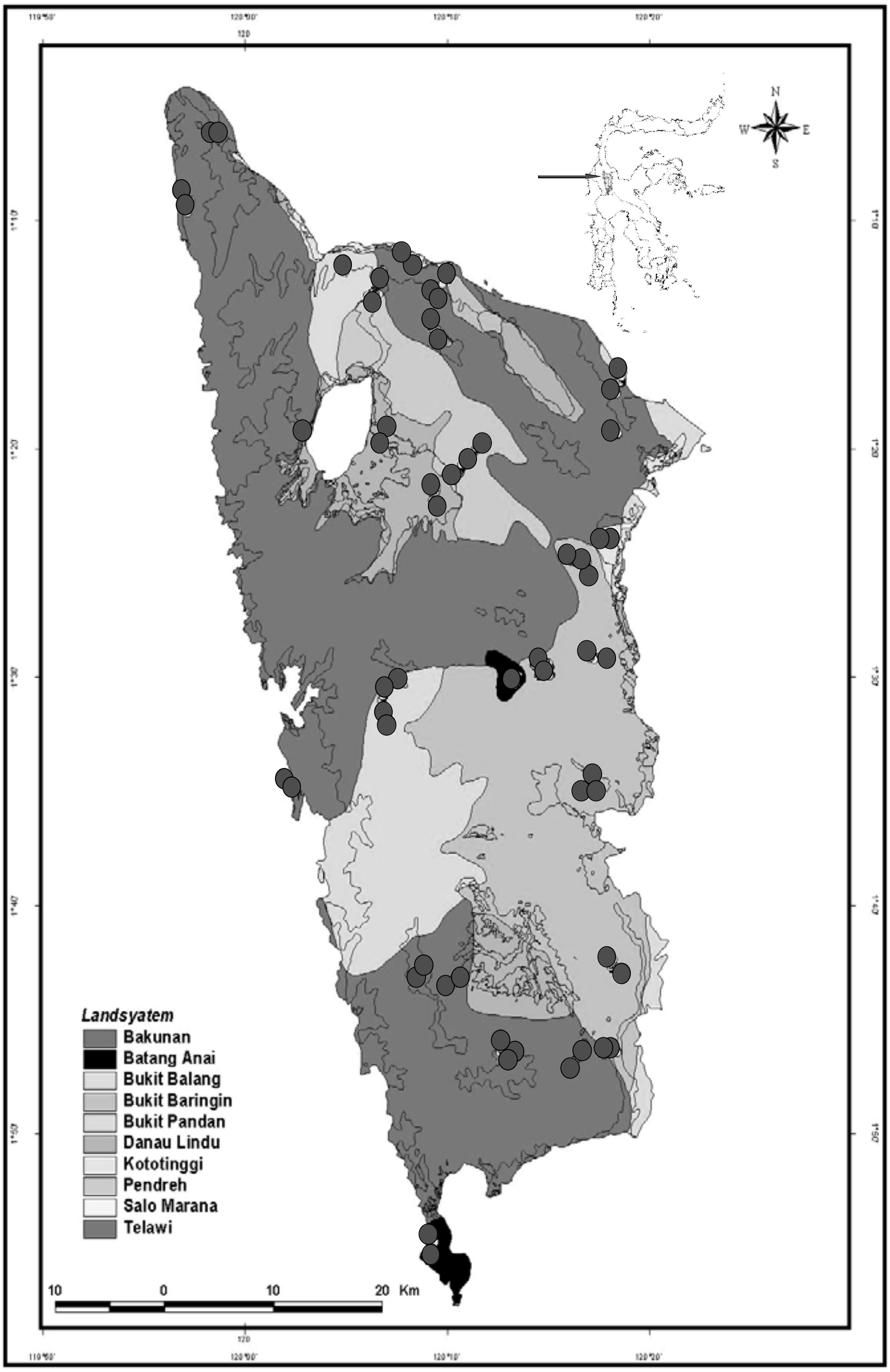


Figure 1. Map of the small mammalís survey locations

- *R. celebensis* Andersen, 1907.
- *R. linduensis* sp. nov. Ibnu Maryanto and Mohamad Yani (2001).
- *Boneia bidens* Jentinck, 1879.
- *Eonycteris spelaea* (Dobson, 1871)
- *Macroglossus minimus* (Geoffroy, 1810)
- *Harpyionycteris celebensis* Miller and Hollister, 1921

The microchiropterans were rare in the Park. Some were mist netted in the forest and some collected in caves. They comprised the following species:

- *Rhinolophus celebensis* Andersen, 1905.
- *Rhinolophus sp.*
- *Hipposideros diadema* (Geoffroy, 1813).

- *Megaderma spasma* (Linnaeus, 1758).
- *Myotis adversus* (Horsfield, 1824).
- *Pipistrelus javanicus* (Gray, 1838).

The latter species unfortunately died in the cage traps before they could be released.

Trapping Effort

A total of 31,233.6 m^2 of mist-nets night were set during this survey. A total of 3822 bats were captured in these nets at an average capture rate of 12.24 individuals /100 m^2/night. This catching effort for each ltitudinal grouping, vegetation and habitat types is presented in Table 3a-d, respectively. The tables showed that *Rousettus celebensis* and *Thoopterus nigrescens* were the most abundant bats by far throughout the Park.

Altitudinal grouping:

The greatest relative abundance of bats was 15.75 individuals between 1800-2100 m ASL. However, the highest numbers of species (19) was between 900-1200m.

There is also a trend for the maximum relative abundance of species to occur at different altitudes, perhaps suggesting some measure of resource partitioning by this bat community. The greatest overlap is at the altitude between 600-900m where six species attain their maximum abundance. For example, maximum abundances of *Cynopterus*

Table 3a. Relative index of abundance of bat species in LLNP for each altitudinal grouping (numbers caught/100 m^2 mistnets/night).

Species	Sex	Altitude grouping (m, ABL)						
		300-599	600-899	900-1199	1200-1499	1500-1799	1800-2099	>2100
MEGACHIROPTERA								
Boneia bidens	Female			0.01			0.16	
	Male						0.02	
Chironax melanocephalus	Female		0.10	0.06	0.06	0.05		
	Male		0.08	0.09	0.24	0.07		
Cynopterus brachyotis	Female		0.04					
	Male	1.29	0.72	0.43	0.04	0.02		
Cynopterus luzoniensis	Female		0.84	0.53	0.04	0.02		
	Male		0.66	0.30	0.02			
Cynopterus minutus	Female	0.51	0.26	0.12	0.02			
	Male	0.26	0.28	0.20	0.02	0.02		
Dobsonia exoleta	Female	0.26	0.18	0.25	0.02			
	Male		0.30	0.15		0.02		
Eonycteris spelaea	Female		0.02					
Harpyionycteris celebensis	Female		0.12	0.06	0.06	0.16	0.07	
	Male		0.02	0.07	0.11	0.05	0.07	
Macroglossus minimus	Female	0.26	0.32	0.53	0.28	0.30	0.13	0.25
	Male		0.30	0.25	0.33	0.19		
Nyctimene cephalotes	Female		0.04	0.02	0.02	0.02		
	Male		0.02	0.04	0.02			
Pteropus alecto	Female			0.01				
Rousettus amplexicaudatus	Female	0.77	0.08	0.01				
	Male		0.08					
Rousettus celebensis	Female	5.66	5.06	3.46	0.69	0.44	0.04	
	Male	2.06	3.21	2.27	0.35	0.26		
Rousettus linduensis	Male			0.04				
Styloctenium wallacei	Female	0.26		0.02		0.02		
	Male			0.03	0.02			
Thoopterus nigrescens	Female	0.51	0.94	1.37	1.88	6.46	7.71	5.11
	Male	0.51	1.59	1.35	1.82	6.04	7.51	2.87
Microchiroptera								
Hipposideros diadema	Female			0.01				
	Male				0.02			
Megaderma spasma	Male			0.01	0.04			
Murina sp	Male						0.02	
Myotis adversus	Female		0.04					
	Male		0.08					
Pipistrellus javanicus	Female				0.04			
	Male				0.04			
Rhinolophus celebensis	Female			0.01	0.04		0.02	
	Male			0.02				
Rhinolophus sp	Female			0.01				
	G.Total	12.35	15.35	11.71	6.18	14.54	15.75	8.23

Table 3b. Relative index of abundance of bat species in LLNP for each vegetation types (numbers caught/100 m^2 mistnets/night).

Species	Sex	Marsh	Lower Montane	Low. Monta-ne Moist	Lowland Forest	Montane	Upper Montane	Swamp Forest	Degraded Lowland	Monsoon	Mixed Garde n	Cloud
Megachiroptera												
Boneia bidens	Female						0.14					
	Male	0.15					0.02					
Chironax melanocephalus	Female		0.07	0.39	0.11	0.06	0.04					
	Male		0.17	0.39		0.08	0.08	0.06				
Cynopterus brachyotis	Female			0.02								
	Male	0.15	0.40	0.90	0.93	0.02	0.02	0.28	1.03	0.91		
Cynopterus luzoniensis	Female		0.46	0.39	1.31	0.02		0.28	1.26	0.46	0.76	
	Male	0.31	0.34	0.13	1.15			0.06	0.57	0.11	0.11	
Cynopterus minutus	Female		0.09	0.39	0.33	0.02			0.23	0.69	0.22	
	Male		0.12	0.13	0.55	0.02	0.02	0.17	0.57	0.34	0.33	
Dobsonia exoleta	Female	0.62	0.08		0.38	0.02		0.06	0.23	0.11	1.53	
	Male	0.31	0.06		0.60	0.02		0.11	0.23		0.98	
Eonycteris spelaea	Female				0.05							
Harpyionycteris celebensis	Female		0.07		0.16	0.12	0.14	0.11			0.11	
	Male		0.06	0.13		0.14	0.04	0.17				0.04
Macroglossus minimus	Female	2.31	0.26	0.13	0.60	0.29	0.16	1.11	0.91	0.11	0.22	0.11
	Male	0.93	0.16	0.13	0.49	0.29	0.06	0.83	0.23		0.11	
Nyctimene cephalotes	Female		0.02		0.05	0.02			0.11		0.11	
	Male	0.15	0.03		0.05						0.11	
Pteropus alecto	Female	0.15**										
Rousettus amplexicaudatus	Female		0.01		0.16				0.11	0.34		
	Male		0.03							0.11		
Rousettus celebensis	Female	0.77	2.36	0.26	8.08	0.75	0.08	4.32	9.37	4.80	7.65	
	Male	2.31	1.59	0.51	5.30	0.23	0.20	3.43	3.09	2.06	4.26	
Rousettus linduensis	Male							0.22				
Styloctenium wallacei	Female		0.01			0.02		0.06		0.11		
	Male		0.01					0.11			0.11	
Thoopterus nigrescens	Female	0.15	1.40	1.80	0.71	3.75	8.30	1.05	1.49	0.46	2.08	4.65
	Male	0.15	1.42	2.31	0.66	3.75	7.25	1.22	2.63	0.69	3.61	4.65
Microchiroptera												
Hipposideros diadema	Female		0.01									
	Male		0.01									
Megaderma spasma	Male					0.04		0.06				
Murina sp	Male						0.02					
Myotis adversus	Female		0.02									
	Male		0.04									
Pipistrellus javanicus	Female					0.04						
	Male					0.04						
Rhinolophus celebensis	Female		0.01			0.02						0.04
	Male		0.02									
Rhinolophus sp	Female		0.12**									
	G. Total	8.49	9.45	7.99	21.69	9.75	16.59	13.67	22.06	11.32	22.29	9.48

brachyotis, Cynopterus luzoniensis, Macroglossus minimus, Chironax melanocephalus, and *Thoopterus nigrescens* were recorded at 300-599, 600-899, 900-1199, 1200-1499 and 1500-1799 m ASL, respectively (Table 3)

Vegetation types:
The greatest relative abundance of bats was in Lowland Forest, including Degraded Forests (index, 21,69 and 22.06, respectively) and Mixed Gardens (index, 22.29) with *Rousettus celebensis* dominant (index, 13.38, 12.46 and 11.91 respectively). The greatest number of species (16) was recorded in Lower Montane Forest. (Table 3)

Land systems:
The Kototinggi Land system type had the highest relative abundance of bats with an index of 16.66. However, the number of species in that land system was less (12) than was recorded in the Danau Lindu and Telawi systems, which have 15 and 14 species, respectively. (Table 3)

Habitat types:
Lowland Forest on KTT had the highest relative abundance of bats with an index of 46.64. However, Lower Montane Forest on PDH had the highest species richness (13 species). (Table 3)

Species diversity
Diversity measures required for estimating of species importance in the community. There are many methods to measure of diversities in the community like Simpsonís, Shannon and Fisher’s a. Three indices gave similar results, however for anticipated large number of specimens that are informed that some of few common species were abundance or inverse

that are rare; we used Fisher's a for measured the diversities in the every elevation, vegetation, habitat land system. For comparing we also measured diversities by Simpsonís and Shannon methods.

Diversity in Altitude Groups:
The bat fauna shows little change in Fisher's a diversity between altitudes of 300 and 1500 m (index 2.74-3. 239); however above about 1500 m their diversity declined to 1.698 and reached a low value of 1.08. Only two species of bats were recorded above 2100m and we cannot to detect diversities by Fisher's a (Table 4, Figure 2).

Table 4a. Bat diversity against altitudinal range types

	300_599	600_899	900_1199	1200_1499	1500_1799	1800_2099	>2100
N	8	13	19	15	10	7	2
Sum	48	771	1294	329	611	703	66
Simpson's	0.60	0.67	0.69	0.61	0.21	0.07	0.06
Shanon	1.91	2.27	2.32	2.00	0.76	0.29	0.20
Fisher's alpha	2.74	2.22	3.16	3.24	1.70	1.08	
Fisher's alpha ST error	0.74	0.07	0.30	0.41	0.22	0.02	

Table 4b. Bat diversity against vegetation types

	Cloud Forest	Upper Montane	Montane	Lower Montane	Lower Montane Moist	Marsh	Swamp Forest	Monsoon	Mixed Garden	Lowland Forest	Degraded Lowland
N	4	9	14	16	8	9	12	9	9	12	9
Sum	265	902	426	972	62	55	247	99	204	397	193
Simpson's	0.04	0.07	0.50	0.72	0.70	0.72	0.63	0.61	0.64	0.60	0.64
Shanon	0.16	0.31	1.65	2.38	2.27	2.18	2.04	1.99	1.89	2.04	2.01
Fisher's alpha	0.67	1.44	2.78	2.72	2.45	3.05	2.75	2.41	1.93	2.33	2.15
Fisher's alpha ST error	0.02	0.04	0.34	0.08	0.58	0.77	0.39	0.48	0.32	0.10	0.35

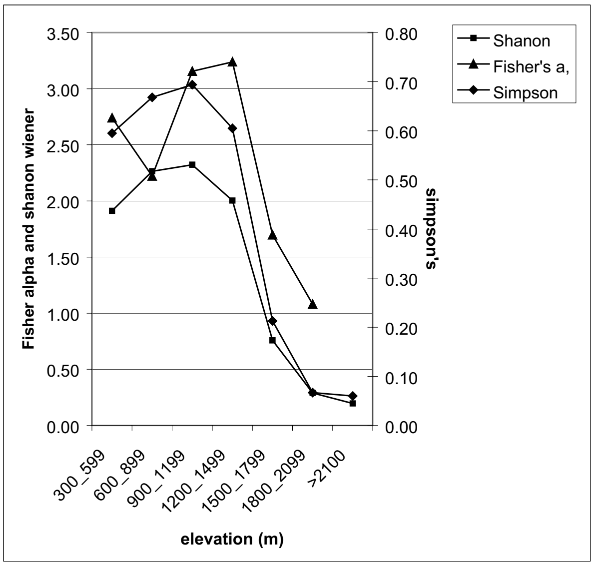
Table 4c. Bat diverstity against land system types

	BGA	BBG	BBR	BPD	DLU	KTT	PDH	TWI
N	11	11	15	7	15	11	13	14
Sum	327	73	537	148	369	253	403	1712
Simpson	0.66	0.72	0.48	0.32	0.69	0.74	0.66	0.59
Shanon	2.05	2.28	1.75	1.07	2.27	2.38	2.18	1.78
Fisher's alpha	2.20	3.60	2.86	1.65	3.14	2.35	2.57	2.09
Fisher's alpha ST error	0.31	0.79	0.33	0.31	0.39	0.35	0.33	0.21

Table 4d. Bat diverstity against habitat types

	Cloud_BPD	Cloud_TLW	UPPER_MONTANE_TLW	UPPER_MONTANE_BBR	UPPER_MONTANE_BPD	Upper Montane on PDH	MONTANE_BAA	Montane_BBR	MONTANE_BPD	MONTANE_TLW	Degraded_forest_TLW	Lower_montane_moist_BBR	Lower_montane_BBG	Lower_montane_BBR	LOWER_MONTANE_KTT	LOWER MONTANE_PDH	LOWER_MONTANE_TLW	LOWER_MONTANE_BAA	Low_land_KTT	LOW_LAND_TWI	Lowland_Forest_BAA	Mixed Garden on DLU	Mix_garden_TLW	Moonson_TLW	Marsh_LDU	Swamp_LDU
N	1	4	5	5	3	3	7	12	7	4	9	8	11	9	9	13	10	8	9	9	10	6	9	9	9	12
Sum	6	259	535	207	62	98	104	198	80	44	193	62	73	68	151	305	296	79	102	149	146	67	137	99	55	247
Simpson		0.04	0.06	0.11	0.10	0.04	0.49	0.56	0.50	0.25	0.64	0.70	0.72	0.78	0.72	0.75	0.57	0.69	0.73	0.62	0.45	0.70	0.56	0.61	0.72	0.63
Shanon		0.16	0.26	0.43	0.32	0.16	1.45	1.85	1.50	0.77	2.01	2.27	2.28	2.55	2.22	2.49	1.84	2.01	2.38	2.05	1.50	1.83	1.71	1.99	2.18	2.04
Fisher's alpha		0.67	0.76	0.92	0.69	0.59	1.69	2.81	1.80	1.07	2.15	2.45	3.60	2.78	2.10	2.76	2.0	2.22	2.38	2.11	2.43	1.60	2.16	2.41	3.05	2.75
Fisher's alpha STE		0.14	0.13	0.18	0.20	0.16	0.35	0.43	0.40	0.32	0.35	0.58	0.79	0.63	0.37	0.37	0.29	0.48	0.47	0.37	0.42	0.38	0.39	0.48	0.77	0.39

A)



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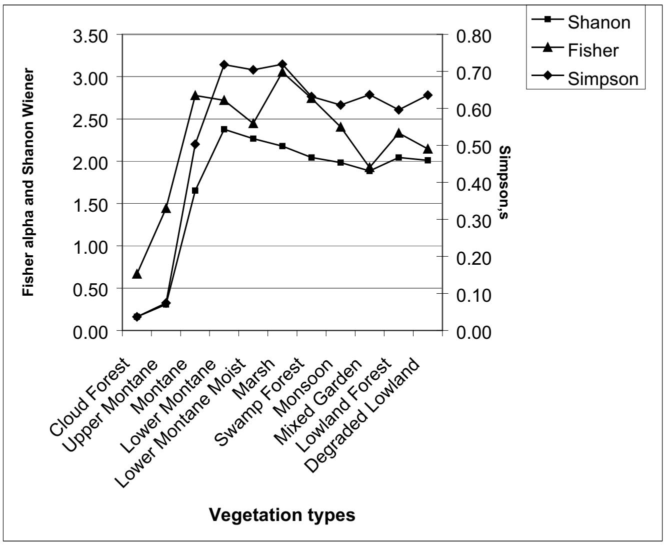

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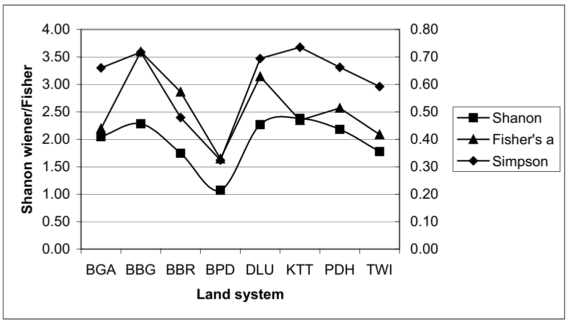

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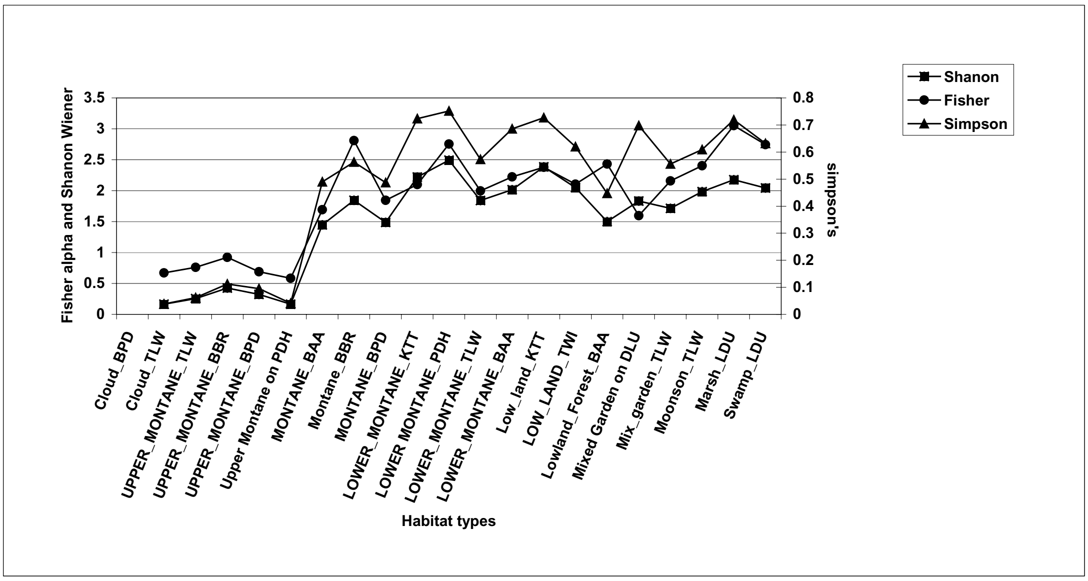

Figure 2. The comparing Fisher alpha, Shanon-Wiener and SimpsonÅfs diversity index based on (a) altitude range, (b) vegetation types, (c) Land system type and habitat types.

Diversity in Vegetation types:

A fishers alpha diversity indices shows that the highest bat diversity is in Marsh (3.054). But, the diversity over most vegetation types is similar (ranging from 1.926 to 2.778). Only in upper montane and cloud forest is there a marked fall off of diversity to an index of 1.442 and 0.668 respectively. The Simpson index values mirror those presented as do those of Shannon- with the exception that Shannon also showed a decline in the lower montane (Table 4, Figure 2).

Table 5. Linear regression and correlation coefficients calculated between pair of Simpson's Shannon and Fisher's α indices

		Shannon	Fisher's α
Altitudinal			
	Simpson's	Y=3.26X+0.03; R^2 = 0.99	Y=2.85X+1.01; R^2 = 0.78
	Shannon		Y=0.87X+0.96; R^2 = 0.77
Vegetation			
	Simpson's	Y=3.09X+0.07; R^2 = 0.98	Y=2.40X+0.96; R^2 = 0.73
	Shannon		Y=0.78X+0.89; R^2 = 0.74
Habitat			
	Simpson's	Y=3.08X+0.04; R^2 = 0.98	Y=2.86X+0.54; R^2 = 0.77
	Shannon		Y=0.95X+0.47; R^2 = 0.81
Land system			
	Simpson's	Y=2.91X+0.15; R^2 = 0.95	Y=2.49X+1.04; R^2 = 0.31
	Shannon		Y=0.95X+0.69; R^2 = 0.42

Diversity in Habitat Types:
The diversity using Fisherís alpha was low, ranging (0.585 to 3.596). The highest diversity is in Low Montane Forests BBG, while the lowest is in Upper Montane PDH. On the cloud forest BPD, we cannot to account of diversity index because we catch only one species and six individuals. The Simpson and shanon index of the highest and lowest index values mirror to those Fishers alpha (Table 4, Figure 2)

Diversity in Land system:
Modify along the lines recommended above. The lowest indices at Bukit Pandan for bat across land system types are fairly similar. Furthermore the highest indices for bat at Kototinggi for Simpsonís and Shannon and at Bukit Balang for Fisher's a indices (Table 4, Figure 2).

DISCUSSION
Whitmore (1984) observed that diversity in tropical plant rain forest decrease with increasing elevation. Heaney *et al*. (1989) and Medway (1972) also showed that diversity of Pteropodid fruit bats also typically decreased at higher elevations. Little is known in Indonesia of changes in either species richness or species diversity of mammals with the increasing of altitude. Gunnel *et al*. (1996) reported that in Lombok Island, Nusatenggara, Indonesia, bat species diversity declined between 200 - 400 m.

This trend bat diversity is lowest value in the Cloud Forest. The highest for habitat diversity for bats was in Marsh in Danau Lindu land system type, Lower Montane Forest on BBG (elevation 1200-1499m ASL). It is interesting that on highest bat diversity is in Marsh and Montane Forest respectively. At the Marsh habitat that are very few for plantation, its possible that habitat as primer roosting place for bat and differ with montane forest for feeding ground.

The three diversity indices used in this study (Fisher's a, Simpsonís and Shannon-Weiner indices) did not always indicate the same trends in diversity, although in general they did so. Indeed, correlation coefficients calculated between pairs of indices for each of the four datasets generally show weak association, with R^2 values typically higher than 0.7 except for association between Simpson, Shanon cross by Fisher's a indices for the land system dataset have R^2 = 0.31 and R^2 = 0.42 respectively. Furthermore that, actually the bat flight havenít based on land system type but it is flight based on vegetation, altitudinal range or habitat that are have height correlation association in the value of indices.

Six teen (16) fruit bats were collected, but even with this large sample, in some altitude groups or vegetation, land system or habitat types a single animal represented some species that were trapped. Also, because of the timeframe of this study, it is unlikely that the mammal census in any of the sites surveyed is complete. It can be argued on the basis of a discussion of the major indices in Krebs (1989) that Fishería method of estimating diversity is appropriate but really concordance between the various methods used in this study is the most reliable estimate that trends may be biologically. In this study, while three were observed between the three methods of estimating species diversity, overall the trends were similar. Furthermore, by mist-netting approach used in this study indicated that the value of standard error of Fisher's a indices very low and it was perhaps the Fisher's a appropriate method to apply to our data

For example, the highest diversity for bats using Fisherí a was at 1200-1499 ASL, in the Marsh vegetation type, BBG land system type and Lower Montane BBG habitat type by the standard error for each type categories were 0.41, 0.76, 0.78 and 0.78, respectively. However, in Marsh diversity indices peaked using both Simpson and Fisherí a diversity- but not with the Shannon index, which peaked in the altitude grouping 600-900 m. Peet (1974) stated that the Shannon index was most sensitive to changes in the abundance of rare species and de-emphasized the importance of common species. Because rare species are probably poorly sampled by the trapping approach used in this study, the Shannon index was the least appropriate method to apply to our data.

The difference between the standard errors range of the estimates of the values for species diversity of bats compared to rodents undoubtedly relates to the fact that far fewer individuals of each species of rodent were collected than was the case with bats. With bats, the evenness factor was much higher in the numbering of sample (Ibnu Maryanto and M. Yani 2001).

Furthermore, bat extensive fruit bat assemblage, which tend to be generalist feeders and live in a wide variety of situations in the Park nevertheless depend on the timing of fruiting and flowering of tree and shrub species throughout the Park. Perhaps this is one of the reasons that we were able to detect that altitude appeared to be a more important factor associated with bat species diversity than vegetation, habitat or land system types. Our data shows that the bat assemblage is clearly divided into those species that occur above and below an altitude of 1800 m ASL- and that few species bats live in the Cloud Forests at the highest altitudes. There also appeared to be a trend for the bat species to partition resources along the altitudinal gradient, such that peak relative abundances of bats (Table 3) were spread out between the various altitudinal groupings in the Park. For example, the peak relative abundance of *Cynopterus luzoniensis* was at altitude 600-900 m ASL while that of *Macroglossus minimus* was at 900-1199 m ASL. Interestingly, the relative abundance of the two most dominant species was significantly associated when related to altitudinal groupings ($r= 0.99$. $P<0.05$) with *Rousettus celebensis* more dominant below 1200m and *Thoopterus nigrescens* more dominant above 1200m.

ACKNOWLEDGMENTS

We were indebted to Duncan Neville, The Nature Conservancy Program Manager at Palu, and Dr. Darrell Kitchener, TNC Director of Conservation for their organization of the mammal survey on Lore Lindu National Park and the comments this manuscribe. Mr. Edward Polard, Managing programs for conservation TNC Palu branch office. We also gratefully acknowledge the support of Ir. Banjar Yulianto Laban MSc, the Director of Lore Lindu National Park, who provided us with great assistance in the field.

Thanks are extended our field assistance Mohamad Annas, Hariyanto and Thius, Jacson, who assisted us to develop the trapping procedures adopted in the field. Thanks also to Drs. Martin Hadianto for his support and preparation of the Lore Lindu National Park map. Expedition cost were met by on grant to The Nature Conservancy Indonesia program from the USAID /NRM2 program Jakarta, Indonesia.

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Fauna of Cerambycid Beetles from Gunung Halimun National Park

Woro A. Noerdjito*, Hiroshi Makihara** and Sih Kahono*
*Bidang Zoologi, Puslit BiologiLIPI, **FFPRI, Tsukuba, Japan

ABSTRACT

More than 500 specimen about 128 species cerambycid beetles collected by Museum Zoologicum Bogoriense (MZB=Bidang Zoologi, Puslit Biologi-LIPI) in 1997-2002 from Gunung Halimun National Park (GHNP),100 species (78%) were identified. Of this species treated, 47 species (47%) are endemic in Java. From 53 non endemic Java species live in GHNP, 38 (38%) occur in Sumatera, 40 (40%) in Kalimantan, 20 (20%) in Malay Peninsula, 7 (7%) in Thailand, 10 (10%) in Laos, 5 (5%) in Sulawesi, 4 (4%) in Philippines and 1 (1%) in PNG. Compare with them small areas in Sumatera (Benakat) and Kalimantan (Campus Univ. Mulawarnan, Samarinda, Bukit Suharto and Bukit Bangkirai) which are already well known, Cerambycid fauna in GHNP differs much. It is supposed two reason: (1) GHNP is highland (1000-1500 m asl), while this areas in Sumatera and Kalimantan are lowland (less than 100 m above sea level). (2) Cerambycid fauna of Java is different them of Sumatera and Kalimantan. To clarify in these points, we should survey on cerambycid beetles in lowland Java.

INTRODUCTION

Gunung Halimun National Park is the largest and last submountane tropical rain forest in Java. The park is known as one of the best biologically conserved area in Java which is assumed to support high diversity of flora and fauna. Since the Biodiversity Diversity Conservation Project in Gunung Halimun National Park was started in 1995, many biological researches have been carried out under the projects (see publications in the series of Research and Conservation of Biodiversity in Indonesia). Although the diversity in the number of species and life forms or ecological roles in tropical forests as well as in any biota on the earth is most striking in insects, a few investigations have been done on the insect fauna in Gunung Halimun National Park (Ubaidillah et al., 1998).

Among insect orders, the Coleoptera is one of the four largest orders in terms of species and shows the most divergent life forms. There are 350 000 named species of Coleoptera in the world, more species than there vascular plants or fungi and 90 times as many as there are mammals. Beetles occupy virtually every non-marine habitat in the world and are enormously diverse in structure and in size; the larges of them (The Cerambycidae *Titanus giganteus* from South America and *Xixuthrus heros* from Fiji) attain a length of 200 mm, almost 800 times greater than that of the smallest ones (*Nanosella* and related genera in the family Ptiliidae) (Lawrence and Britton, 1994).

During the last two years (started in March 2000) intensive and regular collections of insects have been made on and around the canopy trail in the Research Station at Cikaniki, Gunung Kendeng and Gunung Botol, in the Gunung Halimun National Park using various traps, such as the light, Malaise, yellow-pan, window, and pitfall traps. The study site, time and collecting method indicated in Table 1 and Figure 1, and the specimens preserve and accumulated in the collection of the Zoology Division, Research Center for Biology - LIPI, were sorted out to the family-level according to (Lawrence and Britton, 1994).

The cerambycid beetles consist of three families, Disteniidae, Vesperiidae and Cerambycidae in Asia. Among them, the family Cerambycidae constitutes one of the largest groups of wood boring insects. Of approximately 35,000 species that have been described, most are wood scavengers, but many are injurious to living forest, plantations, orchid trees and shrubs. That is cerambycid beetles are typical forest insect. Did the environmental changes influence to the cerambycid fauna? We try to constraction with cutting and removing tree for food of Cerambycidae (*Artocarpus* sp. and *Ficus* sp.) to explain the impact of human activities and environmental condition at surrounding Gunung Halimun National Park.

MATERIALS AND METHODS

Materials examined were MZB collection from Gunung Halimun National Park from during 1997-2002, with the most material from intensive and regular collections (started in March 2000) concentred in Cikaniki and Gn. Botol area. The Cerambycid specimens mostly collected by Malaise, light, hanging trap with chemical atractants, and bait (branch *Arthocarpus* sp., *Ficus* sp. and *Pasiflora* sp. cutting) traps and Beating methods. The distribution of traps and time setting in the intensive collecting shown in Fig.1 and Table 1.

RESULTS AND DISCUSION

Until now we notes 150 species of cerambycid beetles collected from Gunung Halimun National Park and 128 species shown in (Makihara and Noerdjito, 2002. From these species, 100 species (78 %), identified including described 2 new species, *Trypodryas nigricollis* and *Acalolepta disparoides* and 1 new rediscribed, *Cacia* (*Ipocregyes*) *subfasciatus* Schwarzer (will be publish soon in separate journal). We also notes there are 8 species as new record for Java (see Tab. 2).

Fauna of cerambycid beetles in GHNP

Tabel 1. Time and site setting traps

No.	Methods	Setting	Site and collecting
1	LT (Light traps); LTA (on canopy) and LTB (under canopy) trail	March, 2000	Every month and continuous for 3 time collection
2	MT (Malaise traps) A1, 2 (on canopy); B1, 2 (under), and T1, 2 (middle) canopy trail	March, 2000	Weekly sampling and continuous
3	MT3, MT4, MT5, MT6, MT7, MT8, MT9 (broken in December 2001)	April, 2001	Weekly sampling and continuous
4	Hanging traps: HTP (white) and HTH (black), with specisial atrractant.	April, 2001	Weekly sampling and continuous
5	Beating and sweeping	Incidentally	In Cikaniki and Gunung Botol area
6	Bait branch cutting of *Arthocarpus* sp. and *Ficus*	April, 2001 (only near canopy trail) and April 2002 bait setting a long the main route from the gate to Gunung Botol.	Sampling done a week after hanging than weekly sampling until the branch decay (about a month)

From 100 (100%) described species from GHNP (Gunung Halimun National Park), 47 species (47%) are endemic in Java. Of the known distribution of the 53 jenis non-endemic Java species live in GHNP, 38 (38%) in Sumatera, 40 (40%) in Kalimantan, 20 (20%) Malay Peninsula, 7 (7%) in Thailand, 10 (10%) in Laos, 5 (5%) in Sulawesi, 4 (4%) in Philippines and 1 (1%) in PNG (Fig.2). It is obvious that many species occur in the Western side of Wallaceís Line and many members come into the fauna of Malay region. According to Breuning Lamiinae (more than 50% of Cerambycidae are Lamiinae group) cataloque (1958-1967), recorded in Java 297 species (Lamiinae), indicated that 201 endemic (67.7%) with 96 species (30.3%) non-endemic; in Sumatera 368 species, 198 endemic (54%) and170 non-endemic (46%); in Kalimantan 547 jenis, 380 species endemic (69,5%) and 167 (30.5%) non-endemik. Until know we identified 95 species (47,3%) Lamiinae live in Gunung Halimun National Park.

Cerambycidae fauna of GHNP, compare with them of small areas in Sumatera and Kalimantan which are already well known as well as Benakat of South (Makihara, 2001, un publish), Campus of Mulawarna University in Samarinda, (Sugiharto, et. all. 2001), Bukit Suharto, Education Forest of Mulawarman University (Makihara 1999), and Bukit Bangkirai Forest, INHUTANI I, (Makihara et. all. 2002), in Kalimantan. As a result of comparing with each other, fauna in GHNP differs much from another areas of Sumatera and Kalimantan. From 128 species identified in GHNP, 13 species (13/128 %) found in Benakat, 15 species (15/128) in Bukit Suharto, 21 jspecies (12/128) in Bukit Bangkirai and 3 species in Samarinda.

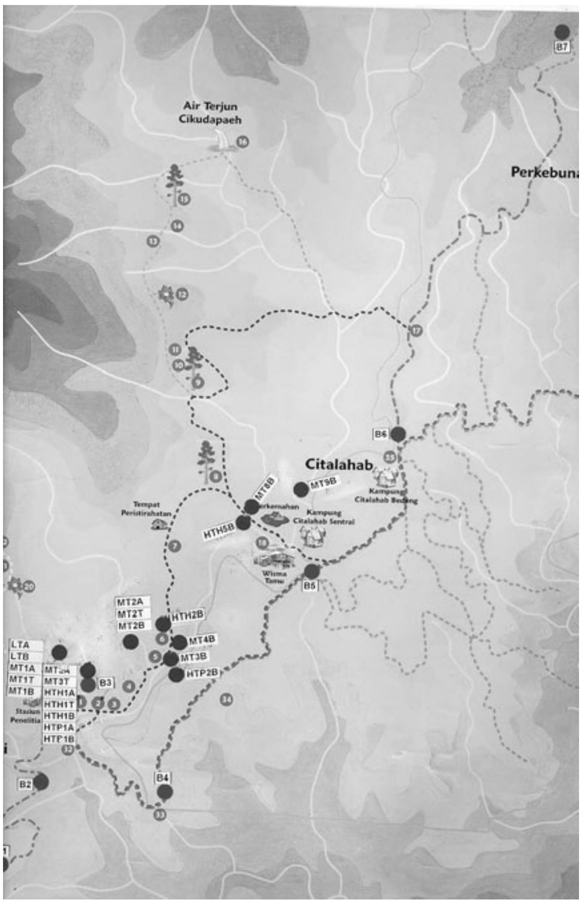

Figure 1. Map of the distribution of traps in Gunung Halimun National Park (MT=Malaise traps; LT=Light traps; B=habit traps. *Artocarpus* sp. and *Ficus* sp.).

Table 2, shown list of 8 species of the new record of Cerambycid beetles in GHNP.

No.	Species	Former record
1.	*Trypodryas chalybeata* (Pascoe)	Borneo, Malay Peninsula
2.	*Psilomerus procerus* Holzschuh	Thailand
3.	*Mimosybra mediomaculata* Breuning	Borneo, Malay Peninsula
4.	*Celosterna stolzi* Ritsema	Sumatra, Borneo
5.	*Acalolepta laevifrons* (Aurivillius)	Sumatra, Borneo
6.	*Parasophronica albomaculata* Breuning	Sumatra
7.	*Nyctimenius varicornis* (Fabrticius)	Sumatra , Borneo, Malay Peninsula
8.	*Glenea (Macroglenea) nympha* Thomson	Sumatra , Borneo, Malay Peninsula

Cluster analysis based on NSC (Nomura simpsonís Coeficient) ìSpecies similarity" analysis by UPGMA Methods. It is supposed two reasons: One is that GHNP is highland (1000-1500m above sea level), while these areas in Sumatera and Kalimantan are lowland (less than 100m above sea level). Another one is that Cerambycid fauna of Java is different them of Sumatra and Borneo. To clarify in this point, we should survey on Cerambycid in lowland Java (Makihara & W.A. Noerdjito. 2002).

New record

In table 2, shown that we noted 8 species as new record of cerambycid beetles for Java, 6 species belong to sub famili Lamiinae. Two others species *Trypodryas chalybeata* (Pascoe) belong to family Disteniidae and *Psilomerus procerus* Holzschuh was Lepturinae.

New species and rediscribed

We described 2 new species are *Stenodryas nigricollis* sp. nov. and *Acalolepta disparoides* sp. nov. (Makihara et W.A. Noerdjito, 2002) will be publish in Coleopterist in this year. Genus *Stenodryas* species are known to about 10 species (Tabel 3) from South East to East Asia. This new species distinguishable from them in having the prothorax black (Figure 2).

Acalolepta disparoides sp. nov, until know this new species treated as the same species as *Acalolepta dispar* (Pascoe) (Fig.3) from Borneo island. However the result of our detail investigations, these two were each other closely related but different species. And this *Acalolepta disparoides* sp. nov, is distinguishable from *A. dispar* by the following point.

Acalolepta disparoides sp. nov,,: Antennae long, 1.9 times as long as body in male (Fig, 3A); inferior eye lobe deeper than wide; prothorax with a median longitudinal carina and with a posterior transverse groove; scutellum trapeziform (Fig. 3A); leg long, for tibiae 0.25 times as long as body in male.

Acalolepta dispar (Pacoe): Antennae short, 1.6 times as long as body in male (Fig. 3B); inferior eye lobe as deep as wide; prothorax subrounded swelling with two posterior transverse grooves; scutellum semicirculer (Fig. 3B); legs short, for tibiae 0.23 times as long as body male.

Cacia (*Ipocregyes*) *subfasciatus* Scharzer was described from Sipora island. After that this species was recorded from Sumatra (Palembang) and Java (Sukabumi). In this time, we had a chance making on investigation of *Cacia* (*Ipocregyes*) *subfasciatus* from gunung Halimun National Park, West Java. This species is similar to *Cacia* (*Cacia*) *confusa* Pascoe from Borneo island and *Cacia (Ipocregyes)newmani* (Pascoe) from Borneo Island too, but distinguish from them. Difference of subgenus *Ipocregyes* and *Cacia* is third antennal segment without or with apical spibnes. But *Cacia* (*Ipocregyes*) *subfasciatus* and *Cacia* (*Cacia*) *confusa* Pascoe are not only similar, but also closely related. *Cacia* (*Ipocregyes*) *subfasciatus* Scharzer is similar to *Cacia (Ipocregyes) newmani*, but not related species.

ACKNOWLEDGEMENTS

We wish to express our sincere thanks to the following persons: Dr. Arie Budiman (Director of Puslit Biologi-LIPI) and Dr. Siti Nuramaliati Prijono (Head of Bidang Zologi, Purlit Biologi-LIPI) for their encouragement and giving an opportunity to study this subject. Messrs. Endang Cholik, M. Rofik Sofyan, Sarino, Darmawan and Rina Rahmatiah for their assistance in the field work activities and manage the specimens. Finally we wish to thank our research collegues to staff of this project in Cibinong, JICA office in Jakarta and Tokyo, FFPRI in Tsukuba for their support and help. his study was conducted with the partnership by JICA-BCP project in Indonesia and Government of Indonesia.

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1

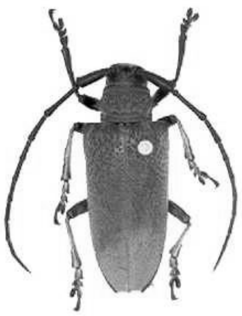
Trypodryas chalybeata (Pascoe)
(New record of Java)

21

Psilomerus procerus Holzchuh
(New record of Java)

55

Mimosybra mediomaculata Breuning
(New record of Java)



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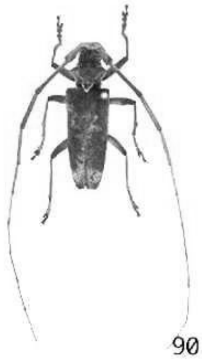
Celosterna stolzi Ritsema
(New record of Java)



90

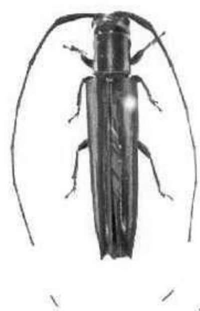
90'

Acalolepta laeviforns Aurivillius
(New record of Java)

100

100'

Parasophronica albomaculata
(New record of Java)



103

112

Nyctimenius varicornis Fabricius
(New record of Java)

Glenea (Macroglenea) nympha Thomson
(New record of Java)

11

11'

Stenodryas nigricolis sp. Nov.
(Makihara et W.A. Noerdjito. 2002)

85

88

Acalolepta disparoides sp. nov.
(Makihara et W.A. Noerdjito. 2002)

Acalolepta javanica (Breuning)

37

37'

Cacia (Ipocregyes) subfasciatus Schwarzer
(rediscription)

Diversity of Birds at Gunung Halimun National Park, West Java-Indonesia in Comparison with Other Javan National Parks

Dewi M. Prawiradilaga
Division of Zoology, Research Centre for Biology-LIPI
Jalan Raya Bogor Km 46, Cibinong 16911, INDONESIA
Telephone: +62 - 21 - 8765056/7 Fax: +62 - 21 - 8765068
E-mail: Dewi Prawiradilaga <mzb@indo.net.id>; d_prawiradilaga@yahoo.com

ABSTRACT
There are a number of national parks gazetted on Java island, Indonesia. From those parks, Gunung Halimun National Park is the largest remaining tropical rainforest block in the island and located between 6˚36'– 6˚52' S and 106˚16' – 106˚38' E. It covers an area of 40,000 ha with altitudinal variation ranges from 570 to 1,929 m and mountaineous landscape streches from 900 to 1,500 m altitude. In order to determine the importance of this national park for bird conservation, the richness of its bird species has been assessed by reviewing the bird research in the area and collecting information from previous reports. The results show that there are 244 bird species (50% of total Java-Bali species) recorded in the area. Among those species, 84% (31 out of 37 species) have restricted range of distribution as indicated by the BirdLife International. These results were then compared with the richness of bird species at Ujung Kulon National Park, Gede-Pangrango National Park, Meru Betiri and Baluran National Parks. The richness of bird species at Gunung Halimun National Park is similar with Gede-Pangrango National Park, however the other parks are poorer.

Key words: Diversity, bird species, richness, restricted range of distribution, national park..

INTRODUCTION

Gunung Halimun National Park is the largest remaining tropical rainforest block on Java island, Indonesia. Since the Gunung Halimun National Park is the youngest park (see Table 1), the bird species from this area are not well explored and the bird studies developed late. A preliminary list of bird species from the area was based on the museum specimens (MacKinnon, 1988). The first bird study was conducted by students from University of East Anglia, UK and the Biological Science Club, National University-Jakarta, Indonesia at Ciusul-Western Halimun region in 1994 (UEA, 1994). The following study concentrated on altitudinal distribution at G. Kendeng-Centre of the national park by Dr. Asep Adhikerana *et al*. from The Indonesian Institute of Sciences (LIPI) in collaboration with Mr. S. Komeda from the Yamashina Institute for Ornithology, Japan under the Biodiversity Conservation Project-JICA conducted between 1996 and 1998 (Adhikerana *et al*., 1998). Recent studies have focused on regular monitoring of the bird community on the forest floor and canopy layer at G. Kendeng as well as surveying non-surveyed areas (Prawiradilaga *et al*., 2000, 2001, 2002). The paper aims to show the richness of bird species at Gunung Halimun National Park and its importance for bird conservation; and to compare its bird diversity with other national parks on Java island: Ujung Kulon National Park (UKNP), Gunung Gede-Pangrango National Park (GPNP), Meru Betiri National Park (MBNP) and Baluran National Park (BNP) especially on endemic species which have restricted range of distribution

METHODS

The study was carried out by compiling the results of bird research at Gunung Halimun National Park (UEA, 1994; Adhikerana *et al*., 1998; Prawiradilaga *et al*., 2000, 2001 and 2002; Prawiradilaga, 2001) and previous lists made by MacKinnon (1988). Available information on the bird species of other Javan national parks including: Ujung Kulon NP (Hoogerwerf, 1970; PHPA, 1986; ANZDEC, 1995; Whitten *et al*., 1996; Rombang and Rudyanto, 1999), Gunung Gede-Pangrango NP, Meru Betiri NP and Baluran NP (PHPA, 1986; ANZDEC, 1995; Whitten *et al*., 1996; Rombang and Rudyanto, 1999) was also reviewed. Comparison was made between the birds of Gunung Halimun National Park and of the other Javan National Parks in particular on restricted range of endemic species.

Study Area

Gunung Halimun National Park (GHNP) is located in West Java (Fig. 1) between 6˚36'– 6˚52' S and 106˚16' – 106˚38' E. The park covers an area of 40,000 ha: with altitudinal variation ranges from 570 to 1,929 m. Mountaineous landscape streches from 900 to 1,500 m altitude. Habitat types consist of primary forest, secondary forest, agriculture land and tea plantation.

Review on other Javan national parks

Ujung Kulon National Park (UKNP) is located in the west tip of Java island (Fig. 1) at 6˚38'- 6˚51 S and 105˚12' - 105˚30' E (Widiyanti, 2001). It is composed by Ujung Kulon peninsula, Handeuleum island, Peucang island, Krakatau

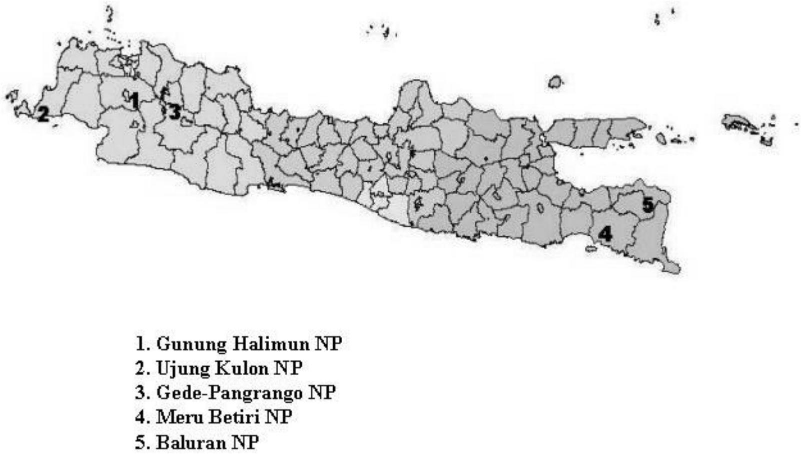


Figure 1. Location of Javan National Parks

islands, Panaitan island, and G. Honje. The total size of the area is 120,551 ha cosisting of 76,214 ha terrestrial and 44,337 ha marine (ANZDEC, 1995). The altitude ranges between 0 and 623 m. The vegetation types include coastal forest, mangrove, monsoon fresh water swamp forest, lowland secondary rainforest, primary rainforest, savanna or grasslands and plantation of introduced species.

Gunung Gede-Pangrango National Park (GPNP) is located in West Java (Fig. 1) at 6˚41' - 6˚53' S and 106˚51' - 107˚02' E (Widiyanti, 2001). The park covers an area of 15,000 ha and altitudinal variation ranges from 500 to 3019 m. The vegetation includes submontane forest, montane forest, alpine moss forest and grassy plains (ANZDEC, 1995; Whitten *et al*., 1996).

Table 1. Information on gazetted Javan national parks

No.	Park	Date of Designation	Supported Decree
1	GHNP	26 February 1992	Minister of Forestry Decree No. 282/Kpts-II/1992
2	UKNP	17 April 1958	Minister of Agriculture Decree No. 48/Kpts/Um/4/58
3	GPNP	14 October 1982	Minister of Agriculture Decree No. 736/Mentan/X/1982
4	MBNP	14 October 1982	Minister of Agriculture Decree No. 736/Mentan/X/1982
5	BNP	6 March 1980	Minister of Agriculture Declaration

Table 2. Comparison between Javan national parks: Habitat types

Park	Size (Ha)	Montane forest	Lowland forest	Coastal Forest	Mangrove forest	Agricultureland/ Crop	Production forest	Savanna (grass land)
GHNP	40,000	√	√	-	-	√	√	-
UKNP	75,000	√	√	√	√	√	-	√
GPNP	15,295	√	√	-	-	√	√	√
MBNP	58,000	√	√	√	√	√	-	√
BNP	25,000	-	-	-	√	-	√	√

Table 3. Comparison between Javan national parks: Bird species

No.	National Park	∑ Bird species	∑ restricted range spec.
1	G. Halimun	244 [1)]	31 [1)]
2	Ujung Kulon	234 [2)]	8 [5)]
3	G. Gede-Pangrango	245 [3)]	31 [5)]
4	Meru Betiri	> 180 [4)]	5 [5)]
5	Baluran	> 160 [4)]	6 [5)]

Sources:

1) Prawiradilaga (unpublished data)
2) Hoogerwerf (1970)
3) Whitten *et al.* (1996)
4) ANZDEC (1995)\
5) Rombang and Rudyanto (1999)

Note:

Total Restricted Range Species on Java–Bali islands: 37 species (Sujatnika *et al.* 1995)

Meru Betiri National Park (MBNP) is located in the south coast of East Java (Fig. 1) between 8˚22'16" – 8˚32'05" S and 113˚37'51" – 113˚57'06" E (PHPA, 1986). The size of park is 50,000 ha with altitudes between 0 and 1223 m (ANZDEC, 1995; Rombang and Rudyanto, 1999). The vegetation includes lowland rainforest, mangrove, swamp forest, coastal forest and crop plantation (PHPA, 1986; ANZDEC, 1995).

Baluran National Park (BNP) is located in East Java (Fig. 1) between 7˚29'10" – 7˚55'55" S and 114˚29'10" – 114˚39'10" E (PHPA, 1986). The park covers an area of 25,000 ha with altitudinal variation ranges between 0 and 1,250 m. It has the driest climate on Java with less than 1,000 mm rainfall in a year concentrated between December and

Table 4. Restricted range of endemic bird species at Javan national parks (from Hoogerwerf 1970, MacKinnon *et al.* 1992, Sujatnika *et al.* 1995, Rombang and Rudyanto 1999, Prawiradilaga *et al.* unpublished data)

No.	Species	Status	GHNP	UKNP	GPNP	MBNP	BNP
1	*Spizaetus bartelsi*	EJ	√	√	√	√	
2	*Arborophila javanica*	EJ	√		√	√	√
3	*Charadrius javanicus*			√			
4	*Treron oxyura*		√		√		
5	*Ptilinopus porphyreus*		√		√		
6	*Ducula lacernulata*		√	√	√		
7	*Otus angelinae*	EJ	√		√		
8	*Caprimulgus pulchellus*				√		
9	*Hydrochous gigas*		√		√	√	
10	*Aerodramus vulcanorum*	EJ	√		√		
11	*Harpactes reinwardtii*	EJ	√		√		
12	*Centropus nigrorufus*			√			
13	*Megalaima corvina*	EJ	√		√		
14	*Megalaima armillaris*	EJB	√	√	√		
15	*Pericrocotus miniatus*		√		√		
16	*Pycnonotus bimaculatus*		√				√
17	*Hypsipetes virescens*		√		√		
18	*Cinclidium diana*		√		√		
19	*Enicurus velatus*		√		√		
20	*Cochoa azurea*	EJ	√		√		
21	*Stachyris grammiceps*	EJ	√	√	√		
22	*Stachyris thoracica*	EJ	√		√		
23	*Stachyris melanothorax*	EJB	√	√	√	√	√
24	*Macronous flavicollis*		√	√		√	√
25	*Garrulax rufifrons*		√		√		
26	*Alcippe pyrrhoptera*	EJ	√		√		
27	*Crocias albonotatus*	EJ	√		√		
28	*Tesia superciliaris*	EJ	√		√		
29	*Seicercus grammiceps*		√		√		√
30	*Rhipidura phoenicura*	EJ	√		√		
31	*Rhipidura euryura*	EJ	√		√		
32	*Psaltria exilis*	EJ	√		√		
33	*Aethopyga eximia*	EJ	√		√		
34	*Lophozopterops javanicus*	EJB	√		√		
35	*Serinus estherae*				√		

Note:

√ = presence; EJ = Javan endemic; EJB = Javan and Bali endemic

February. The main vegetation type is wooded savanna. Invasive *Acacia nilotica* to prevent forest fire has dominated some part of savanna vegetation (personal observation, Whitten *et al*., 1996).

RESULTS AND DISCUSSION

Birds of Gunung Halimun National Park

The recent researches have added 25 species to the list of birds in the area. They are *Pernis ptilorhynchus*, *Elanus caeruleus*, *Accipiter gularis*, *Hieraeetus kieneri*, *Falco moluccensis*, *Otus brookii*, *Batrachostomus cornutus*, *Pitta guajana*, *Alcedo euryzona*, *Eurylaimus javanicus*, *Erithacus cyane*, *Acrocephalus orientalis*, *Gerygone sulphurea*, *Rhinomyias brunneata*, *Muscicapa dauurica*, *Muscicapa ferruginea*, *Dicaeum cruentatum*, *D. trigonostigma*, *D. trochileum*, *D. sanguinolentum*, *Zosterops montanus*, *Zosterops palpebrosus*, *Lophozopterops javanicus*, *Erythrura prasina*, and *Lonchura leucogastroide*s. Even some species including *Batrachostomus cornutus*, *Rhinomyias brunneata* and *Muscicapa dauurica* are new records for Java island (Prawiradilaga *et al*. in prep.).

So far, there are a total of 244 bird species (Tables 3) from 47 families recorded at G. Halimun National Park which took about 50% of total bird species in Java and Bali (MacKinnon, 1988). From this number, 31 species (84% of the total 37 species as indicated by the BirdLife International-Indonesia Programme (Sujatnika *et al*., 1995)) are restricted range of endemic species (Tables 3 and 4) and 23 species are migrants.

Birds of other Javan national parks

Ujung Kulon National Park has 234 bird species (Table 3). Among those species, there are only eight restricted range and endemic species recorded in the area (Tables 3 and 4). In addition, the Ujung Kulon National Park is a home of vulnerable species including *Leptotilus javanicus*, *Pavo muticus*, *Pycnonotus zeylanicus* and *Padda oryzivora* (Rombang and Rudyanto, 1999).

Gunung Gede-Pangrango National Park has 245 bird species (Table 3) in which 31 are restricted range and endemic species (Tables 3 and 4). It is also the habitat of vulnerable species including *Pavo muticus*, *Pycnonotus zeylanicus* and *Padda oryzivora* (Rombang and Rudyanto, 1999).

Meru Betiri National Park has approximately 180 bird species (Table 3) and five of them are restricted range of endemic species (Tables 3 and 4). There are also two vulnerable species: *Pavo muticus* and *Padda oryzivora* recorded in this park (Rombang and Rudyanto, 1999).

Baluran National Park has approximately 160 bird species (Table 3) and six of them are restricted range of endemic species (Tables 3 and 4). There are also three vulnerable species: *Leptotilus javanicus*, *Pavo muticus* and *Padda oryzivora* recorded in this park (Rombang and Rudyanto, 1999).

Comparison of bird diversity

Table 3 shows that the number of bird species at Gunung Halimun National Park and G.Gede-Pangrango National Park is high and almost similar. Although the number of bird species at Ujung Kulon National Park is lower than at Gunung Halimun National Park and G.Gede-Pangrango National Park which are all located in West Java, it is higher than at Meru Betiri National Park and Baluran National Park located in East Java. Possibly, this is because the habitat of the three national parks in West Java (UKNP, GHNP and GPNP) could be richer or more diverse than that of in East Java in particular at Baluran National Park. As Sutherland (2001) argued that the diversity of birds usually follow the diversity of plants or vegetation. However, further detailed study should be carried out to see the relationship between the diversity of plants and the diversity of birds in West and East Java.

One of the criterias being used to assess an important bird area is the number of restricted range of endemic species as an indicator (Stattersfield *et al*., 1998 in Rombang and Rudyanto, 1999). Tables 3 and 4 indicate that the number of restricted range of endemic birds at Gunung Halimun National Park is high (84% or 31 species out of 37 species) and similar with G.Gede-Pangrango National Park. Therefore, both parks can be considered as important habitat for Javan birds.

CONCLUSIONS

1. Gunung Halimun National Park is an important habitat for Javan birds.
2. The number of bird species and restricted range of endemic species at Gunung Halimun National Park is high
3. The richness of bird species at Gunung Halimun National Park is similar with G.Gede-Pangrango National Park

ACKNOWLEDGEMENTS

I am grateful to the Research Centre for Biology-LIPI and the Biodiversity Conservation Project-JICA for funding the research at Gunung Halimun National Park and attendance the International Symposium on Land Management and Biodiversity in South-East Asia in Bali, Indonesia. Bapak Ir. Sudarmadji, the Head of Gunung Halimun National Park provided research permit to work in the area. I would like to thank Alwin Marakarmah, Satrio Wijamukti, T. Ozawa, Apud and Emad for assisting the fieldwork.

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Session 4

AGRICULTURAL ENVIRONMENT

Chaired by

Mitsuru OSAKI & Clara M. KUSHARTO

Utilization of Steel Slag in Wetland Rice Cultivation on Peat Soil

Suwarno
Department of Soil Science, Faculty of Agriculture, Bogor Agricultural University
Jalan Meranti, Kampus IPB Darmaga, Bogor, Indonesia
Telp.: 0251-629360; Fac.: 0251-629358; e-mail: soilipb@indo.net.id

ABSTRACT
An incubation experiment in laboratory using peat soil from Lagan, Jambi was conducted to study the effect of steel slag on chemical properties of peat soil. In addition, a pot experiment using the same peat soil was carried out to investigate combination effect of steel slag and NPK, saprodap, or standard fertilizers - urea, SP-36, and KCl - on growth and yield of wetland rice. Application of steel slag on peat soil significantly improved the availability of Si as well as increased soil pH and exchangeable Ca and Mg. On the other hand, it significantly decreased soil organic matter content, total N, and the availability of Fe, Mn, and Zn. Moreover, the effect of steel slag on the availability of Cu was not significant. Wetland rice grown on peat soil highly responded to steel slag application. The number of productive tiller, number of panicle, and weights of filled and total spikelets were significantly raised with steel slag application. Interaction of steel slag with NPK, saprodap, or standard fertilizers also had significant effect on those rice yield variables. In combination of steel slag and NPK fertilizer, steel slag 2.5 % produced the highest rice yield. However, in combination of steel slag and saprodap or standard fertilizers, the highest rice yield was achieved at dosage of steel slag 5.0 %. In general, combination of slag 2.5 % and NPK fertilizer produced the highest rice yield. Increasing the growth and yield of rice after application of steel slag was associated with increasing the availability of Si, soil pH, and exchangeable Ca and Mg as well as reducing toxic organic acids.

Key words: peat soil, steel slag, wetland rice

INTRODUCTION

Staple food of Indonesian people is rice, so rice is the most important crop in this country. Since 1960ís Indonesian Government have implemented various efforts to meet rapid increase of rice demand, such as intensification and expansion of rice land areas. These efforts succeeded in improving rice production and since 1984 Indonesia has successfully achieved self-sufficient level of rice production. However, the population grows so fast that the demand of rice keeps on increasing. Consequently, the rice production must be increased annually to maintain the self-sufficient level. Unfortunately, non-agricultural sectors are using up more and more arable lands. Therefore, the availability of fertile lands for rice is declining and rice lands are pushed onto infertile lands.

One infertile land potentially for expansion of wetland rice is peat soil, because these soils are flat and level, permanently water saturated - with cheap gravity drainage easily possible - and not yet occupied for agriculture or other purpose (Driessen, 1978). These soils are mainly distributed along the eastern coast of Sumatra, the southern and western coasts of Kalimantan, and the southern coast of West Irian (Driessen and Soepraptohardjo, 1974). They cover about 24 million hectares, corresponding to 12.6% of total land resources of Indonesia (Muljadi and Soepraptohardjo, 1975). Peat soils vary from extremely poor to very rich, depending on the kind and composition of the organic materials. In particular, they have low content of total silicon, and micronutrient deficiencies such as copper and zinc deficiencies occur frequently. Moreover, wetland rice on deep peat suffers from male sterility (Driessen, 1978).

Silicon is a beneficial mineral element for rice growth by maintaining erect leaves (Balasta *et al*., 1988; Yoshida, Navasero, and Ramirez, 1969); promoting the growth, strong culms and roots, and early panicle formation; increasing the number of spikelets per panicle and percentage of matured grain (De Datta, 1981); decreasing transpiration rate (Matoh, Murata, and Takahashi, 1991); increasing the resistance to fungi, insects, and mites (Ishizuka and Hayakawa, 1951; Volk, Kahn, and Weintraub, 1958); diminishing the unfavorable action of nitrogen on the resistance to lodging, stem borer, and diseases such as blast (Idris, Hossain, and Chounhury, 1975; Ota, Kobayashi, and Kawaguchi, 1957) and alleviating Mn or Fe toxicity or both (Horiguchi, 1988; Okuda and Takahashi, 1962).

The most common material used as a source of Si for rice cultivation in many countries for example Japan, Korea, Taiwan, and China is steel slag containing calcium silicate, a by-product formed in the process of steel manufacturing (De Datta, 1981; Ma and Takahashi, 1993). At present, Indonesia produces annually about 350 000 tons of steel slag; however, it has not been used yet in agriculture. Besides has high content of Si, Indonesian steel slag also contains much Ca, Mg, and Fe as well as relatively high micronutrient (Suwarno and Goto, 1997a). It is necessary, therefore, to explore the effects of this slag on the growth and yield of wetland rice grown on peat soil.

The objectives of this experiment were: (i) to evaluate effects of steel slag on the chemical properties of peat soil and (ii) to evaluate effects of steel slag on growth and yield of wetland rice grown on the peat soil.

MATERIALS AND METHODS

Experiment I. Incubation experiment in laboratory using peat soil from Dendang, Jambi was carried out to evaluate effect of steel slag on chemical properties of peat soil. Peat soil equivalent to 10 g oven dry basis was placed in 200 ml of plastic bottle to which steel slag in size less than 2 mm in dosage of 0, 2.5, 5.0, 7.5, and 10 % of soil weight, respectively, was added and mixed thoroughly. The bottles were incubated for two months and then the chemical soil properties: pH, exchangeable Ca and Mg, available Si, Fe, Mn, Cu, and, Zn, total N and organic matter content were analyzed.

Experiment II. Pot experiment in greenhouse using the same peat soil was conducted to evaluate combination effect of steel slag and three kinds of fertilizer on growth and yield of wetland rice grown on peat soil. Each pot contained 2 kg oven dry basis of peat soil. Steel slag in size less than 2 mm was applied in three dosage levels: 0.2.5, and 5.0 % of soil weight and combined with three kinds of fertilizer: NPK (15-15-15), saprodap (16-20-0), and standard fertilizer (urea, SP-36, and KCl). These fertilizers were applied in dosage of 500 ppm N, 500 ppm P_2O_5 and 500 K_2O. Moreover, all pots were received 5 ppm Cu of $CuSO_4.5H_2O$ as basal fertilizer. Four plants of twenty one days-old of IR 64 rice variety were transplanted into all pots. This plant was harvested at maturity. Plant variables measured were numbers of productive tiller and panicle; weights of filled, unfilled, and total spikelets as well as percentage of filled spikelets.

To evaluate the effects of treatment, the data of soil chemical properties as well as plant growth and yield variables were analyzed by analysis of variance. Furthermore, the means of treatment were analyzed by w-Tukey Test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Effects of Steel Slag on Chemical Properties of Peat Soil

As shown in Table 1, soil pH, exchangeable Ca and Mg, and available Si were significantly increased after application of steel slag. The values of these variables were increased with increasing the amount of steel slag. On the other hand, organic matter content, total nitrogen, and available Fe and Zn were significantly decreased with application of steel slag. The magnitudes of these soil chemical properties were decreased as the amount of steel slag was increased. Available Mn was increased after application of steel slag; however, the availability of Mn was decreased as the amount of steel slag was increased from 2.5 % to 10 %. In addition, steel slag had no significant effect on available Cu.

In peat soil, steel slag reacted with H_2O containing CO_2, producing base cations (Ca^{2+}, Mg^{2+}, Na^{+}) and other cations in addition to base conjugate (hydroxide, silicate, and carbonate) and other anions, thus increased concentration of these cations and anions in soil solution. The $Ca^{2+}$and Mg^{2+} then replaced for exchangeable acidity (exchangeable Al and H) on adsorption sites. As a result, application of steel slag increased exchangeable Ca and Mg as well as increased available Si. This result was agreed to that obtained by Suwarno and Goto (1997b) on mineral soil.

At the same time, the hydroxide (OH^-) and silicate ($H_3SiO_3^-$) reacted with H^+, resulting in H_2O and H_4SiO_4. These processes reduced exchangeable H, which in turn increased soil pH value. Consequently, application of steel slag increased pH value of peat soil.

Increasing pH value of peat soil due to application of soil amendment increased decomposition of organic matter (Andriesse, 1997). During decomposition process, organic matter were attacked by microorganism, resulting in simple products such as carbon dioxide, water, ammonia, ammonium, nitrites, nitrates, elemental nitrogen, sulfides, sulfates, inorganic phosphates, and cations for examples Ca^{2+}, Mg^{2+}, and K^+ (Brady, 1990). Increasing rate of decomposition increased the amount of decomposed organic matter, which in turn increased the amount of simple decomposition products. As a result, application of steel slag to peat soil - which increased pH soil pH - reduced organic matter content.

Total nitrogen is total of organic and inorganic nitrogen in the soil (Tan, 1996). During decomposition of organic matter, organic nitrogen is mineralized into inorganic nitrogen. Total nitrogen in the soil is constant during decomposition process if there is no release of gaseous nitrogen to the atmosphere. Result of nitrogen total analysis in

Table 1. Effects of Steel Slag on Chemical Properties of Peat Soil from Dendang, Jambi

No	Treatment	pH (H_2O)	Organic Matter	Total N	Exch.Ca	Exch.Mg	Available Si	Available Fe	Available Mn	Available Cu	Available Zn
			………(%)……..		….(cmol(+)kg^{-1})….		……………………(mg kg^{-1})………………………				
1	Slag 0 %	3.8 a	95.98 e	0.52 c	1.17 a	1.15 a	71 a	14.49 c	1.03 a	1.39	1.88 c
2	Slag 2.5 %	5.3 b	84.22 d	0.49 c	5.31 ab	5.20 a	224 ab	6.99 b	6.44 c	1.11	1.61 bc
3	Slag 5.0 %	6.2 c	76.22 c	0.41 abc	9.04 b	11.67 b	582 b	2.65 a	4.41 b	0.96	0.65 ab
4	Slag 7.5 %	6.7 d	60.40 b	0.35 ab	20.27 c	15.22 bc	1 695 b	2.20 a	2.08 a	0.93	0.46 a
5	Slag 10 %	6.8 e	52.04 a	0.33 a	23.81 c	16.90 c	2 128 c	1.93 a	1.59 a	0.88	0.44 a
	Tukey $_{0.05}$	0.3	5.15	0.12	7.24	4.78	416	1.93	1.53	NS	1.14
	Tukey $_{0.01}$	0.4	6.81	0.16	9.56	6.31	549	2.55	2.02	NS	1.50

Note: NS = Not significantly different
Means followed by the same letter were not significantly different by w-Tukey Test at 5 % level of difference.

Table 1 indicated that nitrogen total was decreased with application of steel slag. Ratio of C/N in steel slag treatments of 0, 2.5, 5, 7.5, and 10 % were 107.7, 101.5, 108.9, 98.4, and 91.9; respectively. This result indicated that in decomposition of organic matter there was released gaseous nitrogen to the atmosphere. The amount of gaseous nitrogen released to the atmosphere was increased with increasing the dosage of steel slag.

Table 2. Chemical Composition of Steel Slag (Suwarno dan Goto, 1997a)

Composition	Unit	Content
Fe_2O_3	%	42.6
CaO	%	21.6
SiO_2	%	14.6
MgO	%	11.6
Al_2O_3	%	7.21
P_2O_5	%	0.37
MnO	%	1.55
K_2O	%	0.18
Na_2O	%	0.33
Neutralizing Value	%	67.6

Steel slag applied in this experiment contained total iron 42.6 of Fe_2O_3; however, application of this material to peat soil significantly decreased availability of iron. Although this steel slag contained very high total iron, result of mineral identification indicated that most of iron minerals was present as iron oxide mineral - wuestite, magnetite, and di-calsium ferrite (Suwarno and Goto, 1997a). According to Lindsay (1979), solubility of these minerals was extremely low in the pH range of soils and also affected by redox potential of soil. Consequently, those minerals did not affect the availability of iron in soil applied steel slag. Mineral containing iron in steel slag which could supply iron was apparently only forsterite feroan ($(Mg,Fe)_2SiO_4$) (Suwarno and Goto, 1997a). However, iron released from this mineral was precipitated as iron hydroxide with increasing soil pH after application of steel slag (Foth and Ellis, 1988; Lindsay, 1979). In addition, iron has high affinity to humic substances to form chelates (Tan, 1998). Formation of these chelates reduced available iron - amount of iron extracted with 0.05 N HCl - in peat soil.

The increase in soil pH might have shifted the equilibrium between soluble Mn^{2+} and insoluble MnO_2 toward insoluble MnO_2 (Adam, 1965), thus reduced available Mn. Moreover, Mn also could form chelates with humic substances (Tan, 1998). Formation of these chelates reduced the availability of Mn. On the other hand, reaction of steel slag in the peat soil also yielded Mn^{2+} ions, because this material contained 1.55 % of MnO_2 (Table 2). Apparently, the amount of Mn^{2+} produced by steel slag in this experiment was slightly higher than that of converted into MnO_2 and formed chelates with humic substances. As a results, available Mn was increased with application of steel slag; however, the availability of Mn was decreased with increasing the dosage of steel slag.

Available Zn significantly decreased with steel slag application, and the availability of Zn was decreased with increasing the dosage of steel slag. Availability of Zn in the soil was decreased with increasing soil pH (Lindsay, 1979). In addition, Zn could form chelates with humic substances resulted from decomposition of organic matter (Tan, 1998). Because application of steel slag increased soil pH and decomposition rate of organic matter, application of this material reduced availability of Zn in peat soil.

Table 3. Effects of Steel Slag Combined with Various Fertilizers on Growth and Yield of Wetland Rice Grown on Peat Soil from Dendang, Jambi

No	Treatment	Productive Tillers	Panicles	Weight of Spikelets			Percentage of Filled Spikelet
				Filled	Unfilled	Total	
		(no.pot^{-1})	(no. pot^{-1})	………………(g pot^{-1})………………			(%)
1	Slag 0 % + NPK	0.0 a	0.0 a	0.00 a	0.00 a	0.00 a	-
2	Slag 0 % + Saprodap	0.0 a	0.0 a	0.00 a	0.00 a	0.00 a	-
3	Slag 0 % + Standard	4.3 ab	8.3 ab	3.55 ab	0.53 ab	4.08 ab	87.1
4	Slag 2.5 % + NPK	29.7 de	33.7 de	47.62 e	0.89 ab	48.51 e	98.2
5	Slag 2.5 % + Saprodap	18.0 cd	22.0 cd	7.71 ab	1.16 b	8.87 ab	87.4
6	Slag 2.5 % + Standard	14.0 bc	18.0 bc	22.93 cd	1.02 ab	23.95 cd	95.5
7	Slag 5.0 % + NPK	30.0 e	34.0 e	34.07 d	0.75 ab	34.83 d	97.8
8	Slag 5.0 % + Saprodap	16.7 c	20.7 c	15.03 bc	0.64 ab	15.66 bc	96.0
9	Slag 5.0 % + Standard	18.0 cd	22.0 cd	26.51 cd	0.75 ab	27.25 cd	97.2
	Tukey $_{0.05}$	11.8	11.7	12.00	1.12	12.07	
	Tukey $_{0.01}$	14.7	14.7	15.00	1.40	15.08	

Note: Means followed by the same letter were not significantly different by w-Tukey Test at 5 % level of difference.

Response of Wetland Rice to Combination of Steel Slag and NPK, Saprodap, or Standard Fertilizers

Growth of rice plant was very poor without application of steel slag. On treatments of steel slag 0 % + NPK fertilizer and steel slag 0 % + saprodap fertilizer, rice plant failed to produce panicle. As shown in Table 3, application of steel slag on peat soil significantly improved numbers of productive tiller and panicle as well as weights of filled and total spikelets. Combination of steel slag and NPK fertilizer produced higher numbers of productive tiller and panicle than combination of steel slag and saprodap or standard fertilizers. Weights of filled and total spikelets also higher with the former combination. In combination of steel slag and NPK fertilizer, steel slag 2.5 % produced the highest rice yield (weight of filled spikelets). However, in combination of steel slag and saprodap or standard fertilizers, the highest yield was achieved at dosage of steel slag 5 %. In general, among those combinations, combination of steel slag 2.5 % and NPK fertilizer produced the highest rice yield.

The very poor rice growth on pots untreated steel slag might be associated with the very low soil pH value, the low exchangeable Ca and Mg, and the low available Si as well as the presence of toxic organic acids. At pH value less than 4.0, hydrogen ions had a significant influence on absorption of many inorganic ions (Jackson, 1967), so inhibit the growth of rice plant. The presence of toxic organic acids in peat soil is also the problem that has to be solved in utilizing of peat soil for wetland rice cultivation.

The low exchangeable Ca and Mg in this soil also restricted the growth of rice plant, therefore they had to be noticed in wetland rice cultivation on peat soil. According to De Datta (1981), the functions of Ca in rice plant are as: a constituent of cementing material of plant cells, an important constituent of calcium pectate, which strengthens the cell wall, maintainer of turgidity of cell walls, and promoter of normal root growth and development. The functions of Mg in rice plant are as: a constituent of chlorophyll molecule, a component of several essential enzymes, and functions similar to Ca.

Silicon has various beneficial effects in rice plant such as: promotes the growth, strengthens culms and roots, favors early panicle formation, increases number of spikelets per panicle and percentage of matured grains, increases the resistance to attack of fungi, insects, and mites, and deminishes the unfavorable action of nitrogen on the resistance of rice to diseases such as blast. Therefore, the low availability of Si has to be corrected in cultivation of wetland rice on peat soil.

Application of N, P, and K fertilizers as urea, SP-36, and KCl - called as standard fertilizers - only improve the availability of N, P, and K nutrients; therefore the growth of rice was poor. Application of steel slag to peat soil that increased soil pH, exchangeable Ca and Mg, and available Si as well as reduced toxic organic substances improved growth and yield of IR 64 rice variety. These results were agreed to that obtained by Snyder, Jones, and Gascho (1986). However, the increasing yield obtained in this experiment was far higher.

In this experiment, interaction effect of steel slag with NPK, saprodap, or standard fertilizers was significance. In combination with NPK fertilizer, steel slag 2.5 % produced higher rice yield than steel slag 5.0 %. On the other hand, in combination with saprodap or standard fertilizers, steel slag 5.0 % produced higher yield. Apparently, it was associated with the ability of the three kinds of fertilizer in supplying N, P, and K nutrients as well as condition resulted from their reactions in peat soil.

CONCLUSION

Application of steel slag on peat soil significantly improved the availability of Si as well as increased soil pH and exchangeable Ca and Mg. On the other hand, it significantly decreased soil organic matter content, total N, and the availability of Fe, Mn, and Zn. Wetland rice grown on peat soil highly responded to steel slag application. The numbers of productive tiller and panicle as well as weights of filled and total spikelets were significantly increased with steel slag application. Interaction of steel slag with NPK, saprodap, or standard fertilizers also had significant effect on those rice yield variables. In combination of steel slag and NPK fertilizer, steel slag 2.5 % produced the highest rice yield. However, in combination of steel slag and saprodap or standard fertilizers, the highest rice yield was achieved at dosage of steel slag 5.0 %. In general, combination of slag 2.5 % and NPK fertilizer produced the highest rice yield. Increasing the growth and yield of rice after application of steel slag was associated with increasing the availability of Si, soil pH, and exchangeable Ca and Mg as well as reducing toxic organic acids.

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Soil Nitrogen Supply and Nitrogen Uptake for Local Rice Grown in Unfertilized Acid Sulfate Soil in South Kalimantan

E Purnomo[1], T Hasegawa[2], Y Hashidoko[2] and M Osaki[2]

[1] Center for Tropical Acid Soil Studies, Faculty of Agriculture, Unlam PO Box 1028 Banjarbaru, South Kalimantan, Indonesia (70714), E-mail: ctassas@hotmail.com
[2] Crop Science Laboratory, Graduate School of Agriculture, Hokkaido University, Sapporo, Japan. E-mail: thase@res.agr.hokudai.ac.jp

ABSTRACT

Most of acid sulfate soil areas in South Kalimantan are recommended for growing rice. Due to unfortunate soil condition such as low pH and unpredictable water level , farmers grow local rice varieties. The farmers use a multiple transplanting system not only to multiply the seedling population but also to coop with the condition. In addition, most farmers do not apply fertilizer after the last transplanting, however, they got a reasonable yield. Where are the nutrients for the crop coming from? This work focuses on investigating the supply nitrogen (N) from the mineralization of organic N for the crop.

The experiment took place in Tambaksirang Baru (03 26 31S, 114 35 29E), Gambut District South Kalimantan. Two farmersí paddocks separated by a village road were chosen for the study. The N mineralisation measurements were carried out on monthly basis after the planting. At each sampling date plant, top and root were collected for biomass and N content determination.

At the end of the growing season, we observed that the biomass, N uptake and release from the soil were 9.5 and 7.1 Mg DM ha^{-1}; 36.0 and 27.8 kg N ha^{-1}; and 13.37 and 8.32 kg N ha^{-1} for plot 1 and 2 respectively. The higher N in the crop than that supplied by soil indicates that there are other sources of N for local rice grown in acid sulfate soil.

Key words: Nitrogen mineralisation, Siam Unus variety, multiple transplating

INTRODUCTION

Tidal swamp area in South Kalimantan is quite large and unique. According to Ismangun and Karamah (1994) the area is around 200,000 ha. As far as the area is concerned, it is important for rice growing area. The tidal swamp area is characterized by poor chemical properties and deep water level. The poor chemical properties include low soil pH and high in Fe and Al concentration. Combination of high rainfall and effect tidal movement make this area have excessive water in a certain period of the year.

This condition force the farmer in this area to selective rice variety that not only tolerant the acidic environment but also taller one to avoid flooding. Most farmers grow local rice varieties that proven to be adaptive to the condition. In addition to that, the local rice varieties are less responsive to fertilizer application. This will enhance the use of such varieties.

Given the fact that minimum fertiliser is used, the farmers still gaining a reasonable rice yield. The yield was varied from 2.6 to 3.7 ton ha^{-1} (Hasegawa et al. 2001). This raises question about nutrient supply for this variety. The study focuses on N supply for a local variety.

MATERIALS AND METHODS

Site

The experiment was carried out in a farmerís paddock. The paddock is in Tambak Sirang Baru Village (GPS 03 26 31S, 114 35 29E). The soil was classified as gleysols (Deckers et al. 1998). The paddock has been cultivated for rice for more than 20 years.

Planting system

The paddock was grown with a local rice variety called Siam Unus. The farmer used a multiple transplanting system in preparing the seedling. The multiple transplanting system included seedling stage in early October 2000, followed by first transplanting in early December 2000, the second transplanting in January 2001 and finally, last transplanting (planting) in early April 2001. Detail of such unique cultural practice was explained in more detail in (Hasegawa et al. in this issue).

Paddock preparation

Approximately a month prior to planting, farmer prepared the paddock. To prepare the paddock, farmer cut the weeds using a special hand hoe and let the weed to decompose. Before planting the un-decomposed weeds were dragged to the edge of the paddock. No fertilizer was applied during the growing season.

Selected soil properties

The soil samples were collected from a depth of 25 cm from 3 sites within the area of the paddock and were obtained from the first sampling period. The soil from each replicate was air-dried, ground to < 2mm and stored prior to analysis. The properties of the soil are shown in Table 1.

Table 1. Selected Soil Properties at plot 1 and plot 2

Selected soil properties	Plot 1	Plot 2	Category[a)]
Organic C (%)[b]	6.72	5.92	very high
Organic N (%)[c]	0.55	0.44	high
C/N ratio	12.37	13.75	medium
P Bray 1 (mg P kg^{-1})[d]	0.29	0.96	very low
pH (H_2O)[e]	3.83	3.87	very acid
Exchangeable Ca [cmol(+) kg^{-1}][f]	0.88	0.84	very low
Exchangeable Mg [cmol(+) kg^{-1}][f]	0.13	0.19	very low
Exchangeable K [cmol(+) kg^{-1}][f]	1.43	0.82	very high and high, respectively
Exchangeable Na [cmol(+) kg^{-1}][f]	0.38	0.41	medium
Exchangeable Al [cmol(+) kg^{-1}][g]	3.96	3.54	
CEC [cmol(+) kg^{-1}][h]	39.82	38.81	high
Base saturation (%)	7.1	5.8	very low
Al saturation (%)	9.9	9.12	very low

Note: Methode used were described in: [a)] Djaenuddin *et al.* (1994); [b)] Yeomans and Bremner (1986); [c)] Bremner and Mulvaney (1982); [d)] John (1970); [e)] McLean (1982); [f)] and [h)] Hidayat (1978); and [g)] Barnhisel & Berstch (1982), respectively.

Experiment procedures

In this experiment N mineralisation and plant N uptake were measured through out the growing season (14 April-28 August 2001). Nitrogen mineralisation was measured by inserting 2 PVC tubes (internal diameter of 10 cm) into 25 cm depth. The arrangement of the tubes is shown in Figure 1.

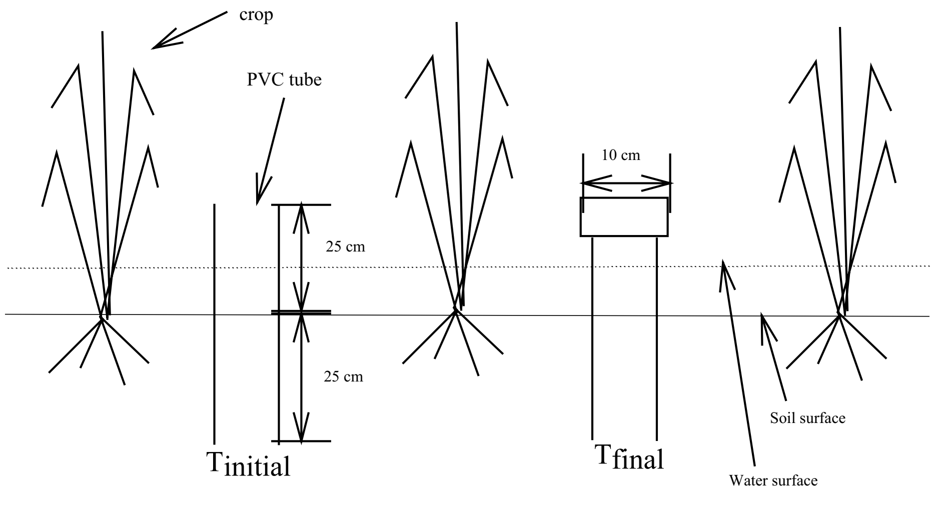

Figure 1. The PVC arrangement in the field

The first tube was excavated on the same day and the other tube was kept in the field for 4 weeks with the lid on. After excavating the tubes, mineral N ($NH_4^+ + NO_3^-$) was determined. Detail of the procedures were explained else where (Purnomo et al. 2000). These activities were replicated 3 times for each plot. The N mineralisation measurement was conducted in every 4 weeks interval through out the growing season.

In each soil sampling period, crop biomass (plant top + root) was also sampled. The plant samples were randomly taken from 3 hills out of 15 hills around the tube. The plant top and root were washed; oven dried 70^o C, ground and determined their N content.

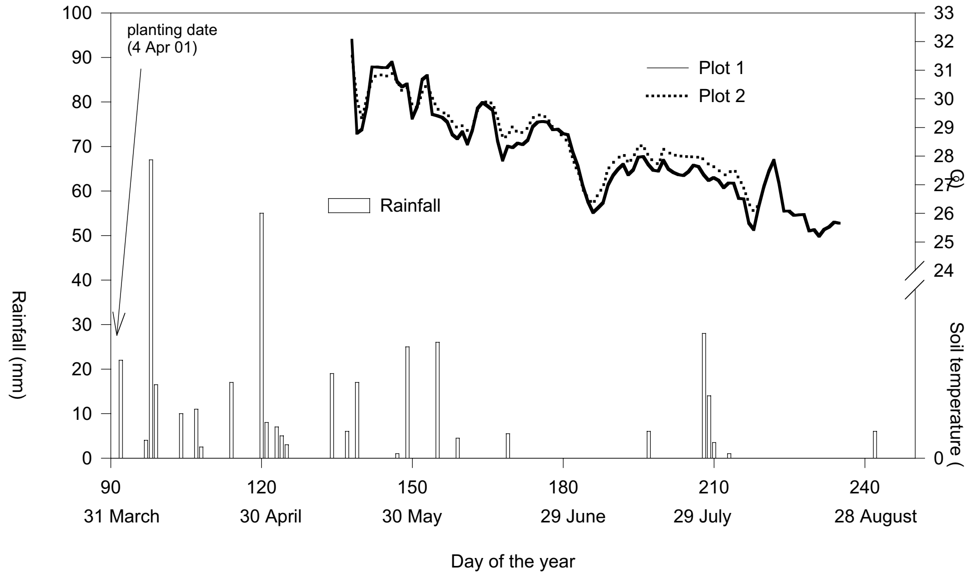

Figure 2. The rainfall distribution and soil temperature during the growing season

Soil and plant analysis

The NH_4^+ and NO_3^- concentrations were determined following extraction of approximately 40 g of fresh soil in 200 mL of 1 M KCl for 1 hour. The NH_4^+ concentration in the extract was measured colorimetrically (Kempers and Zweers 1986). The concentration of NO_3^- in the extract was measured colorimetrically (Yang et al. 1998).

The N content of the plant material was determined by digesting the plant material using kjeldahl reagent. The N content in digest was measured by distillation.

Calculation and data analysis

Nitrogen mineralisation for each *in situ* incubation period was calculated using a formula:

$$\text{N mineralisation} = [\text{N mineral}]_{final} - [\text{N mineral}]_{initial}$$

Variations of data obtained were shown using standard error of mean.

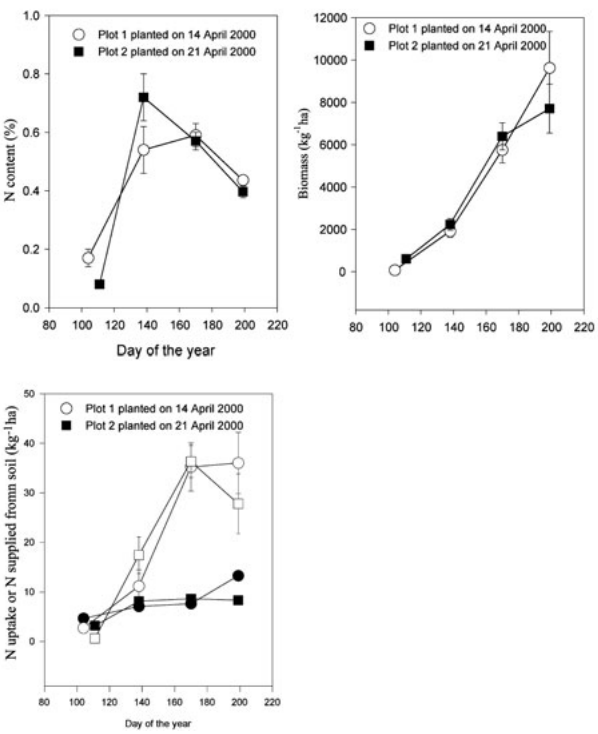

Figure 3. The biomass, N content and N uptake through out the growing season

RESULTS AND DISCUSSION

Soil properties

The selected soil properties of plots use for the experiment are shown Table 1. Both plots have very similar properties.

Rainfall and soil temperature

The rainfall and temperature soil data through out the growing season are presented in Figure 2. Total rainfall through out the growing season was 390 mm. This amount was less than the average of last 10 years (1991-2000) which was 766 mm. It was observed that the soil temperature decreased toward the growing season. The decrease was associated with the coverage the crop canopy.

Biomass production

The course of biomass production of the rice crop is shown in Figure 3a. There was significant increase of biomass production up to panicle initiation stage. At the end of the growing season, the dry matter accumulation was 7.1 - 9.5 ton ha^{-1}. It is important to note that no fertiliser was applied after the last transplanting.

N content

N content of the plant tissue in the growing season is presented in Figure 3b. The maximum N content was 0.6 and 0.8% for plot 1 and plot 2, respectively. The N content increased up to the tillering stage and the decreased toward harvest time. The N content in comparable to the modern rice variety (Doberman and Fairhurst 2000).

Nitrogen mineralisation

N mineralisation during the growing season is shown in Figure 3c. It was observed that in a growing season, N derived from the mineralisation of organic N was 8 and 13 kg N ha-1, for plot 1 and plot 2, respectively. This amount is much lower that found by Purnomo et al (2000) in soil under wheat crop in south-eastern Australia. They found that N mineralised during growing season was 140 kg N ha^{-1}. The lower N mineralised in the present study may be due low quality of organic material or reduce condition.

N uptake

The course of N uptake for the growing season is demonstrated in Figure 3c. The N uptake by crop increased up to the panicle initiation stage and steady after that. The highest N uptake was 36 kg N ha-1. It can be seen also that after the tillering stage, N uptake was higher than N released from the soil organic N. This indicates that there may be some sources of N other than N from the soil organic N, such as the role of N fixing bacteria (see paper by Hashidoko et al. in this issue).

CONCLUSION

From the study area we found that without fertiliser after last transplanting there a huge accumulation crop biomass. Surprisingly, N uptake of the local rice exceeded the N originated from the release of the organic N. It may be N fixing bacteria contributed to the remaining N in the crop.

ACKNOWLEDGEMENTS

We thank Hokkaido University for financing the research.

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Tidal Peat Swamp Management for Agriculture by Fork Irrigation Model at Central Kalimantan Indonesia

Nuryani.H.U. S [1] ., A. Rosmarkam [1]., R.E.K. Kurniawan [2]
1 Faculty of Agriculture, Gadjah Mada University,Yogyakarta, Indonesia
2 Graduate Program Soil Science Department, Faculty of Agriculture, Gadjah Mada University,Yogyakarta, Indonesia (ruly_kusuma@Lycos.com)

ABSTRACT

Total swamps include tidal peatswamps land in Indonesia is about 20,07 million hectares and distributed mainly in costal land of Sumatra, Kalimantan, and Irian Jaya.

According to Soil Taxonomy (USDA,1992) the soil can be classified in the order of Histosols.
For agricultural purposes there many constraints e.g. very low pH, high pyrit contents, high available Al^{+++} and Fe^{+++}, deep organic layers (more than 200 cm thick). One of those properties very low pH is the dominan constraints.

Since 1968 these areas are used for transmigration project mainly for ressetlement and agriculture. Until now the total area that had been reclamed is about 1.3 million hectares.

The reclamation of the tidal peatswamps land in Central Kalimantan was carried out by making irrigation and drainage canal. Primary canals are 40-50 m wide and 4-5 deep, secondary canals are 15-20 m wide and 3 m deep and tertiary canals were 1 m wide and 1 m deep. At the end of secondary canals tide water pond by 300 m wide and 400 m long were built to collect the toxic water. Because of the irrigation scheme like fork, so the name of irrigation system is *"fork model irrigation"*.

The result of this fork model tidal peatswamp reclamation showed increasing the land capability and productivity because of increasing pH and decreasing toxicity of Al^{+++} and Fe^{+++}.

Key words : peat, swamp, management, fork irrigation model

INTRODUCTION

Tidal peat swamp land is land influenced by tide of water from sea. This tidal swamp is occupied by peat soil. Which is dominated by soil organic matter. Total peat and swamp peat area in Indonesia is very large about 39 million hectares and occupied the 4th in the world, distributed in some island. Three island that occupied tidal and swamp are Sumatera, alimantan and Papua (Figure 1)

Figure 1. Distribution of tidal swamp and swamp land in Indonesia

According Rosmarkam (1992), soil ordo (USDA taxonomy) of this area consists of Entisol, Inceptisol and Histosol. Acid sulphate soil and potential acid sulphate soil (pH 3.5 or less) content pyrite, occupied 32.4 % of total area in this tidal swamp area. This area is not suitable for agricultural purpose. So to manage this area needs reclamation.
Table 1. Total area territorial and swamps in Sumatera, Kalimantan and Papua (x 1000 ha)

The taxonomy of this soil tidal swamp and swamp area consist of great group Entisol, Inceptisol and Histosol (USDA,1994). Some chemical properties of Entisol (Typic Sulfaquent), Inceptisol (Typic Udiaquept) and Histosol (typic Sulfosaprist) from Centre kalimantan could be shown on table 2.

Table 1. Total area territorial and swamps in Sumatera, Kalimantan and Papua (x 1000 ha

Island	Total area	
	Territorial	Tidal swamps
Sumatera	34.361	13.211
Kalimantan	53.946	12.764
Papua	42.198	12.98
Total	143.505	38.955

(Sources : Soedibyo,1996)

Table 2. Chemical properties tidal swamp and swamp from Central Kalimantan

Elements	Entisol (Typic Sulfoaquent)	Inceptisol (Typic Udiaquept)	Histosol (Typic Sulfohemist)
pH	3.4	4.5	3.4
Organic mater (%)	29.5	5.48	32.96
Total N (%)	0.8	0.41	0.73
C/N	21	7.8	20.6
P_2O_5 (ppm)	44.3	59.6	73.3
CEC (me%)	86.28	75.52	67.6
K (me%)	0.33	1.53	1.55
Ca (me%)	1.88	1.5	2.7
Na (me%)	1.42	1.3	6.85
Mg (me%)	0.21	1	0.4
Zn (ppm)	13	14.7	46.07
Cu (ppm)	64.12	46.36	91.2
Mn (ppm)	156.23	18.51	362.21
Al (ppm)	681.4	86.5	114
Fe (ppm)	331.9	2839.4	937

(Source : Anonim 1980)

Table 2. Chemical properties tidal swamp and swamp from Centre kalimantan

Current and economic uses

Tidal swamps forest consist of mangrove forest, swamps and peaty swamp forest which is important natural resource environtmental and economic value in Indonesia. Special commercial tree species are lodged including ramin (Gonystylus bancarnus) and several marantis (Shorea sp). These timbers are dominant forest production and be exported as teak wood, triplex etc. itís carried out selectively and productively by about 35 years cycle.

Development of tidal swamps area by Indonesian Government has not fully realized for agricultural purposes (manly to sustain self supporting rice) but also for resettlement transmigration project.

Transmigration

Since 1968, the increase transmigration in Indonesia moved transmigrate from Java to another island that dry land (upland) and wet land (swamps/tidal swamps) of Sumatera, kalimantan, Sulawesi and Papua.

In the first period reclamation 1968-1985 tidal swamps that had been conversed to agricultural purpose and resettlements is about 1,300,00 hactare. About 550,000 families or 1,700,000 men/women were reselfmanted.

In second period reclamtion 1996-2001, one million hectare of tidal swamps/swamps area would be reclaimed for wet land rice field at Centra Kalimantan. In this program government would moved 316,000 families or 1,200,000 men/women from Java to this area.

Management tidal swamp

The management tidal swamps by fork irrigation model was carried out based on assumtion that tiding water is better than original water, so original water be substituted by tiding water from the big river.

According of the assumtion irrigation model canals be constructed. There are three kind canals they are : a) primary canal, b) secondary canal, tertiery canal, and d) tiding water pond

a). Primary canals.

Primary canal is canal that be built from the big river. The fumction of this canal is to irrigate fresh tidal water from the big river to substitute original water of land that be reclaimed. The other function of this canal to drainage original water and leach to move the big river. The width of the canal is 40-50 meters and the depth is about 5 meters. The length of primary canal varies depend on the total area bew managed. This primary canal is branch into 3 or 3 secondary canals. Beside for irrigation and drainage, the primary can be used for water transportation such as sloop, boat, little ships.

b). Secondary canals

Branches of primary canals are secondary canals. The width of secondary canal is about 10-20 meter and the depth is about 3 meter. The fucntion of secondary is the same with the primary canals. At the end of secondary canals are occurred tidal water ponds

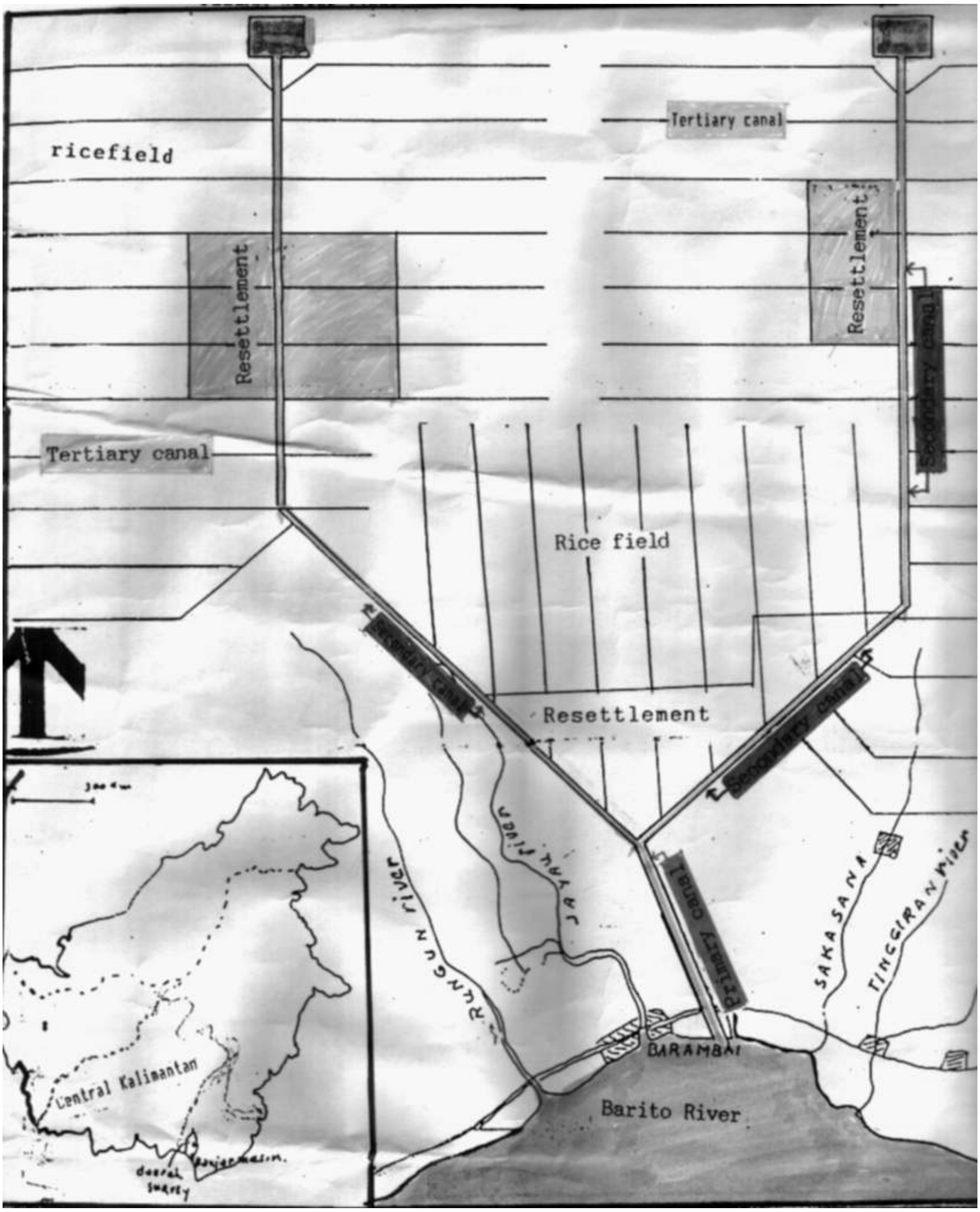

Figure 2. Fork Irrigation Model at Central Kalimantan (1968)

c). Tertiary canals
Secondary canal has many tertiary canals. Genarally the tertiary canal is perpendicular to secondary canal. The function of secondary canal is to distribute tide water to area/land between tertiary canals. The width of tertiary canal is 1 meter wide and the depth 1 meter. The distribution of tide water only from tertiary canal (not distribute from secondary canal or primary canal)

d.). Tiding water pond
Tiding water at the end of secondary canals is digging soil for collecting toxic water from original water are built at the end of secondary canals that be drainage in the next tide. Size the water pond is 300 meter width and 4000 meter length and 5 meter depth.

By management water with used primary, secondary and tertiary canals tidal peat land increased their productivity step by step and the chemistry and physically more better than before be manage by this fork irrigation model.

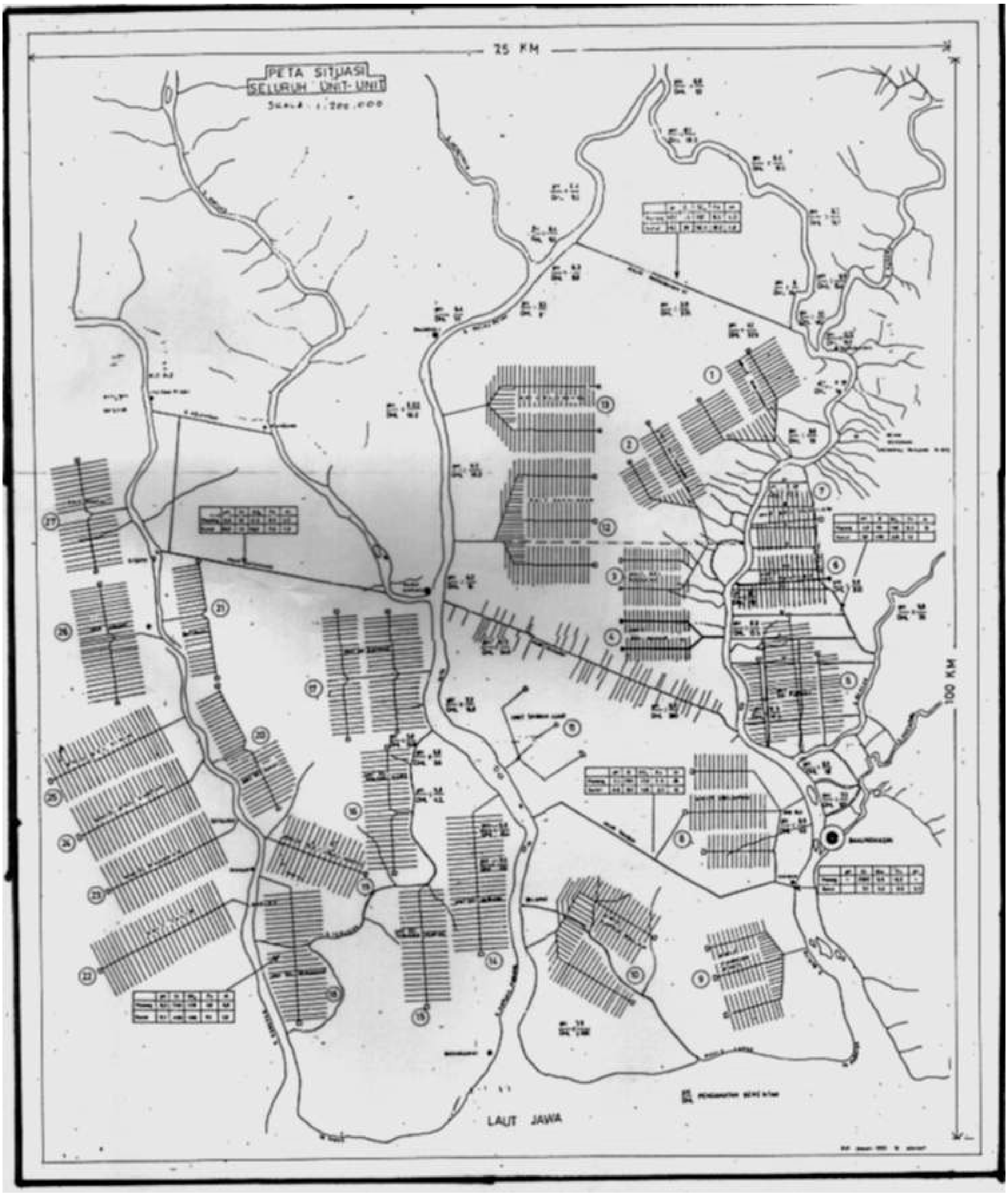

Figure 3. Showed 27 units that had been managed in the 1st period reclamation at Central and South Kalimantan (1968-1985)

RESULTS

The result showed that reclamation by fork irrigation model to the soil of this area could produce rice, corn, at medium level.

Original population cultivated this area by planting native crop rice and traditional cultivation produced about 0.8 to 1.2 ton per hectare and one time harvest annually (Sastrosoedarjo,1996). It is relativity low when be compared with transmigration cultivated at reclaimed land by simple cultivation (without high intensification and twice harvesting annually). Table 3 showed the production of rice since 1977-1993.

Table 3. Yield grain rice at South, Centre and West Kalimantan 1977-1993 (ton/ha)

Test farm Research Gadjah Mada University by chemical analysis showed that reclamation by fork irrigation model capable to decrease limiting factor for example increasing pH, decreasing toxic elements such as Al^{+++}, Fe^{+++},Cl^{-},

Table 3. Yield grain rice at South, Centre and West Kalimantan 1977-1993 (ton/ha)

Years	South Kalimantan	Centre Kalimantan	West Kalimantan	Average
1997	1.86	1.46	1.74	1.69
1981	2.3	1.97	2.04	2.1
1985	2.43	2.18	2.18	2.26
1989	2.68	2.17	2.36	2.4
1993	2.89	2.39	2.43	2.57
Increasing	2.09%	2.54%	1.97%	2.20%

(Source: Darwanto,1996)

SO4. By intensification management the yield of rice is about between 4.0-5.0 ton/ha per harvesting or it is produce 9.0-10.0 ton/ha per annually (Sastrosoedarjo,1996).

CONCLUSION

1. Fork irrigation model on peat tidal swamps land can increasing productivity appraising the land for agriculture purposed step by step
2. For increasing rice production, in tertiary rice field area, completely substituted and leached original water should be done.

AKNOWLEDGEMENTS

Thank you to Leader and Secretary Centre Study of Land Resources, Miss Ari Affiani and Mr R.E.K. Kurniawan for completing this paper about her computerising

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Impact of Development and Cultivation on Hydro-Physical Properties of Tropical Peat Soils

A. Kurnain[1]; T. Notohadikusumo[2]; and B. Radjagukguk[2]
[1]Department of Soil Science, University of Lambung Mangkurat, Banjarbaru 70714, Indonesia
[2]Department of Soil Science, University of Gadjah Mada 55281, Yogyakarta, Indonesia

ABSTRACT
Restoration and proper agricultural use of tropical peatlands require knowledge of the physical properties of peat soils. Some physical properties related to changes in hydrological potential of peat soils as affected by agricultural development were investigated. Selected parameters obtained in selectively logged peat swamp forest were compared with those obtained in clear-cut and maize-cultivated peatlands. In all cases changes in selected hydro-physical properties were evidently in the top 0-15 cm layer of peat soils as in developed sites the top layer of peat soils was subjected to more decomposed as shown by an increase of bulk density and a decrease of fibre contents. Bulk density of the top 0-15 cm layer was in average 0.14, 0.29, and 0.19 kg dm^{-3} in selectively logged peat swamp forest, clear-cut and maize-cultivated peatlands, respectively. Unrubbed fibre contents were in average 74, 35, and 58% volume basis in selectively logged peat swamp forest, clear-cut and maize-cultivated peatlands, respectively. Potential of water release, at low suction (high matric potential), was significantly reduced in the top layer. Based on the three parameter equation reducing potential of water release was attributed by decreasing a rate constant of water release (k_{wr}) and maximum volume of water release (V_{max}). Values of k_{wr} and V_{max} in the top 0-15 cm layer of undeveloped site were 0.0346 cm^{-1} and 47.69%, whilst in clear-cut and maize-cultivated sites they were respectively 0,0135 cm^{-1} and 44.03%, and 0.0363 cm^{-1} and 41.50%. This three parameter model of potential of water release may further be developed to estimate available water for growing crops on peat soils at different heights of water table. At high matric potential there was more water volume over air volume of peat soils under developed sites compared with undeveloped site. This implies that as a growing medium the quality of peat soils decreases with agricultural development. Based on correlation analysis changes in selected hydro-physical properties of peat soils were significantly related to changes in bulk density and fibre contents, and so related to progress of peat decay.

Key words: tropical peat soils, potential of water release, bulk density, fibre content, available water

INTRODUCTION
In their natural state peatlands have important values involving sequestration of carbon, regulation of hydrological and biogeochemical cycles, maintainance of biodiversity, and socio-economic values. On the other side petlands are viewed as fragile ecosystems and sensitive to disturbances. Once the natural peatland is developed, its values will be changed.

In the tropical zone the pressure for conversion of the natural peatland for economic development is increasing. Almost 20% of the natural peatland of Indonesia has been developed, in particular for agriculture (Rieley *et al*., 1997). While in Malaysia about 32% of Malaysian peatland has been used mainly for oil palm, sago and pineapple plantations (Ahmad-Shah & Soepadmo, 1989; Mutalib *et al*., 1992; Ambak & Melling, 2000). More recently, the pressure on the natural peatland has intensified, for example, the ill-fated Mega Rice Project in Central Kalimantan. The project initially involved construction of drainage and irrigation channels, and by 1998 4,618 km of the channels had been constructed (Notohadiprawiro, 1998).

The obvious impact of the channel system on the peatland hydrology is to lower the water table (Takahashi *et al*., 2002). Decreasing water table, will in turn, influence the distribution of moisture contents over the profile of peat soils. Change in peat moisture contents evidently relates with some physical properties of peat soils (McLay *et al*., 1992). Impact of agricultural development on peat physical properties relevant to moisture measures includes decreasing in field moisture content, bulk density, total porosity, and available water (Radjagukguk, 2000). Although the study on peatland hydrology particularly in South East Asia has been increasing (Stahlhut & Rieley, 2002; Takahashi *et al*., 2002), there is lack of information regarding water storage capacity of reclaimed peat soils. The need to proper management of peatland require a knowledge of hydro-physical properties of peat soils. This paper will give a few information of peat physical properties related to water storage capacity of peat soils.

METHODOLOGY
Study sites
Study sites were located in Central Kalimantan, Indonesia. An area of 10 x 15 km^2 of peatland was established to collect peat samples which are representative to undeveloped and developed sites. Undeveloped site was represented by a selectively logged peat swamp forest which is located in east of the River Sebangau. The forest canopy is covered about

70% and dominated by *ramin* (*Gonystylus bancanus*), *tumih* (*Combretocarpus rotundatus*), and *belangeran* (*Shorea balangeran*) (Tuah, *et al*., 2000). The shrub layer is characterized by members of the families Pandanaceae, Orchidaceae, Arecaceae, and Nephetaceae. During peat sampling in the late rain season of 2001, the water table was positioned near the surface.

Developed area is being used for agriculture and located in the Kalampangan village. Local inhabitants have cultivated the area since the 1980s mostly for vegetables, pineapple, and maize. Peat samples were collected in maize-cultivated area in which maize is being cultivated by most local inhabitants. The water table in this area varied between 30 and 60 cm below the surface during peat sampling. As well as maize-cultivated area one site of clear-cut peatland was selected in an adjacent area of cultivated peatland which is mostly overgrown by *alang alang* (*Imperata cylindrica*).

Peat sample collection and laboratory analysis

Peat sample collection was conducted during the late rain season of May 2001. Two kinds of soil samples were collected. Firstly, bulk peat samples were taken from the 0-15 cm, 15-45 cm and 45-100 cm layers of the profile. Secondly, peat cores collected by a metal cylinder with 5 cm in diameter and height were taken from the 5-10 cm, 25-30 cm and 55-60 cm layers of the profile. Prior to introducing into the laboratory peat cores were covered on both sides with their plastic caps and coated with wax to prevent dewatering during transfort and storage. Each sample for each layer was analysed individually.

Peat properties determined included field moisture content, bulk density, fibre content, and some properties related to the hydro-quality of peats. Field moisture content and bulk density were determined using peat cores, and other peat properties were determined using peat bulks. Field moisture content was determined gravimetrically after oven drying at 105^{o}C for at least 4 hours (Houba *et al*., 1986). Values of the field moisture content were expressed in volume %. Bulk density was determined by oven-drying peat cores at 105^{o}C to constant mass. Dry bulk density was calculated as the oven-dried mass divided by the field volume of each peat core and expressed in kg dm^{-3} (Black, 1965). This bulk density is so called as field bulk density (Andriesse, 1988). Fibre content was determined volumetrically following the procedure proposed by Linn *et al*. (1974). Fibre content was calculated as volume % of fibres before and after rubbing.

On the basis of determination of moisture retention at some levels of water suction (matric potentials) together with of bulk density, the hydro-quality of peats was calculated and expressed as air volume, easily available water, water buffering capacity, and available water. Pore distribution could also be calculated and expressed as range of equivalent diameter, total porosity, macro and micro pores. All calculation were run using the procedure described in Puustjarvi (1973) and Verdonck *et al*. (1973).

Processesing data

Comparison of field moisture content, bulk density, and fibre content of peat soils under undeveloped and developed sites was analysed using one-way analysis of variance (Anova) with land use types as fixed effects (Sokal & Rohlf, 1969). All data were previously tested for variance homogeneity using Bartlett Test at $P < 0.01$. When the test indicated that raw data violated the assumption of variance homogeneity, the data were transformed using logaritmic transformation. The Duncan Multiple Range Test was used for comparison tests of means. The data were presented in means and their standard deviation.

The strength of associations between bulk density and fibre content regarding as physical indices of peat decay (Blackford & Chambers, 1993; Brady, 1997) and the hydro-quality of peats was analysed using analysis of correlation and its results were expressed in Pearson correlation coefficients. Significance test in correlation was confirmed using *t*-Test (Sokal & Rohlf, 1969).

Water release capacity of peat soils under different land use types was curved as a function of suction height of water column. The three paramater equation was produced to fit the curve:

$$\mathbf{V}_{wr} = \mathbf{V}_{max}\,\mathbf{e}^{-kwr} + (\mathbf{1} - \mathbf{V}_{max})\mathbf{e}^{-kwrh} + \mathbf{V}_s$$

where $\mathbf{V}_{wr}$ is volume of water release (%), $\mathbf{V}_{max}$ is volume of maximum water release (%), $\mathbf{V}_s$ is volume of peat particles (%), $\boldsymbol{k}_{wr}$ is rate constant of water release (cm^{-1}), and $\boldsymbol{h}$ is suction height of water column (cm).

Hydro-quality of peat soils as a medium of grown crops was evaluated by construction of air:water ratio curve (Verdonck *et al*., 1973).

RESULTS AND DISCUSSION

Physical indices of peat decay

Comparison of several peat physical properties including bulk density, and unrubbed and rubbed fibre contents over land use types at three peat layers was presented in Table 1. The properties provide the basis for describing the progress of peat decay. In general the properties significantly changed in the top 0-15 cm layer and followed the order of peat decay.

Bulk densities in the study sites ranged from a minimum of 0.12 kg dm^{-3} of the top 5-10 cm layer in the undeveloped site, to a maximum of 0.31 kg dm^{-3} of the top 5-10 cm layer in the clear-cut site. The results were in general agreement with those of Driessen and Rochimah (1977). They surveyed Indonesian peat soils and showed that the bulk densities of peat soils sampled from the peat swamp forest in the River Sebangau, Central Kalimantan ranged from 0.10 to 0.21 kg dm^{-3}. While the bulk densities of peat deposits in South Sumatra and Riau varied from 0.07 to 0.22 kg dm^{-3} (Brady, 1997). Wood-based peat deposits are in general characterised by a higher bulk density, as evidently proved in this study. The study showed that the bulk density of peat soils, especially in the top layer under the developed sites were significantly higher than that under the undeveloped site. In the developed peatland peat materials are commonly more decomposed and subsequently fine materials are resulted in. Arrangement of fine materials into the intrinsic peat structure results in closer contact among particles and in turn lower total pore space. The lower the total pore space is, the higher the bulk density is resulted in.

Table 1. Comparison of physical indices of peat decay under undeveloped peatland (I), maize-cultivated peatland (II), and clear-cut peatland (III) at three different peat layers

Peat Properties	Peat Layer (cm)	Peatland Type		
		I	II	III
Bulk density (kg dm^{-3})	5 - 10	0.15(.02)a	0.19(.01)a	0.29(.03)b
	25 - 30	0.15(.02)a	0.23(.06)a	0.19(.02)a
	55 - 65	0.17(.04)a	0.16(.03)a	0.18(.00)a
Unrubbed fibre content (%,v/v)	0 - 15	74.0(6.3)a	58.0(5.9)b	35.0(5.0)c
	15 - 45	56.9(9.7)a	62.0(7.1)a	52.3(2.7)a
	45 - 100	60.6(3.6)a	61.5(5.0)a	62.7(3.0)a
Rubbed fibre content (%,v/v)	0 - 15	36.9(6.0)a	35.0(10.5)a	11.7(2.7)b
	15 - 45	24.6(7.7)a	33.0(6.6)b	22.0(4.4)a
	45 - 100	26.3(2.4)a	36.0(6.5)b	36.3(2.7)b

* Data presented as means and their standard deviation. Values followed by the same latter for each row are not significantly different after Duncan Multiple Range Test at $P < 0.05$.

Unrubbed fibre contents in the study sites varied from 30% of the top 0-15 cm layer in clear-cut site to 84% of the top 0-15 cm layer in undeveloped site. Fibre contents of peat soils were significantly lower in the top layer of developed sites compared to those in undeveloped site. Based on the criteria of USDA (Soil Survey Staff, 1975), humification degree of peat material in the 0-100 cm layer of undeveloped site is classified as fibric in the top 0-15 cm layer, followed as hemic in the lower layer. In developed sites peat materials are classified as hemic in the 0-100 cm layer of maize-cultivated site, and as sapric and hemic respectively in the top 0-15 cm layer and the lower layer of clear-cut site. Unrubbed fibre contents are evidently good agreement with bulk density as physical indices of peat decay.

Hydro-physical properties of peat soils

Table 2 shows the strength of associations between physical indices of peat decay and some hydro-physical properties of peat soils. All selected hydro-physical properties of peat soils except for water buffering capacity significantly correlate with fibre content and bulk density of peat soils. This implies that with progress of peat decay some hydro-physical properties of peat soils including field moisture content, air volume, available water, macro pores and total porosity decreased and micro pores increased. As peat materials were more decomposed as a result of cultivation, finer materials and closer contacts among peat particles were resulted in.

Table 2. Pearson's correlation coefficient (r) between physical indices of peat decay and selected hydro-physical properties of peat soils

	Bulk Density	Unrubbed Fibre Content
Total Porosity	-0.7733***	0.5024***
Macro Pores	-0.8290***	0.6318***
Micro Pores	0.6865***	-0.6111***
Air Volume	-0.6578***	0.6375***
Easily Available Water	-0.5333***	0.2704^{ns}
Water Buffering Capacity	-0.0990^{ns}	0.0725^{ns}
Available Water	-0.6307***	0.3360*

Significance test of r was carried out by t-test (n = 45). The r values followed by asterisk of * and *** indicate respectively significant association among appropriate pairs of data at $P < 0.05$ and $P < 0.001$. Those followed by asterisk ^{ns} indicate not significant association at $P < 0.05$.

Potentials of water release

Cultivation and development of peatland evidently influenced water release potentials of peat soils at high matrix potentials. Potentials of water release were described by the three parameter equation. Results of fitting water release data with the proposed model are presented in Figure 1. Potentials of water release of peat soils under clear-cut and maize-cultivated sites were lower than those under undeveloped site. Reducing potentials of water release was attributed by decreasing rate constant of water release (k_{wr}) and maximum volume of water release (V_{max}). Values of k_{wr} and V_{max} in the top 0-15 cm layer of undeveloped peatland were 0.0346 cm^{-1} and 47.69%, whilst in clear-cut and maize-cultivated peatlands they were respectively 0.0135 cm^{-1} and 44.03%, and 0.0363 cm^{-1} and 41.50%.

Changes in k_{wr} and V_{max} were consistent with changes in some hydro-physical properties of peat soils. They showed negative correlation with bulk density and in turn, negative correlation with micro pores and positive correlation with total porosity and macro pores. This signifies that the rate constant and maximum volume of water release decreased with the progress of peat decay.

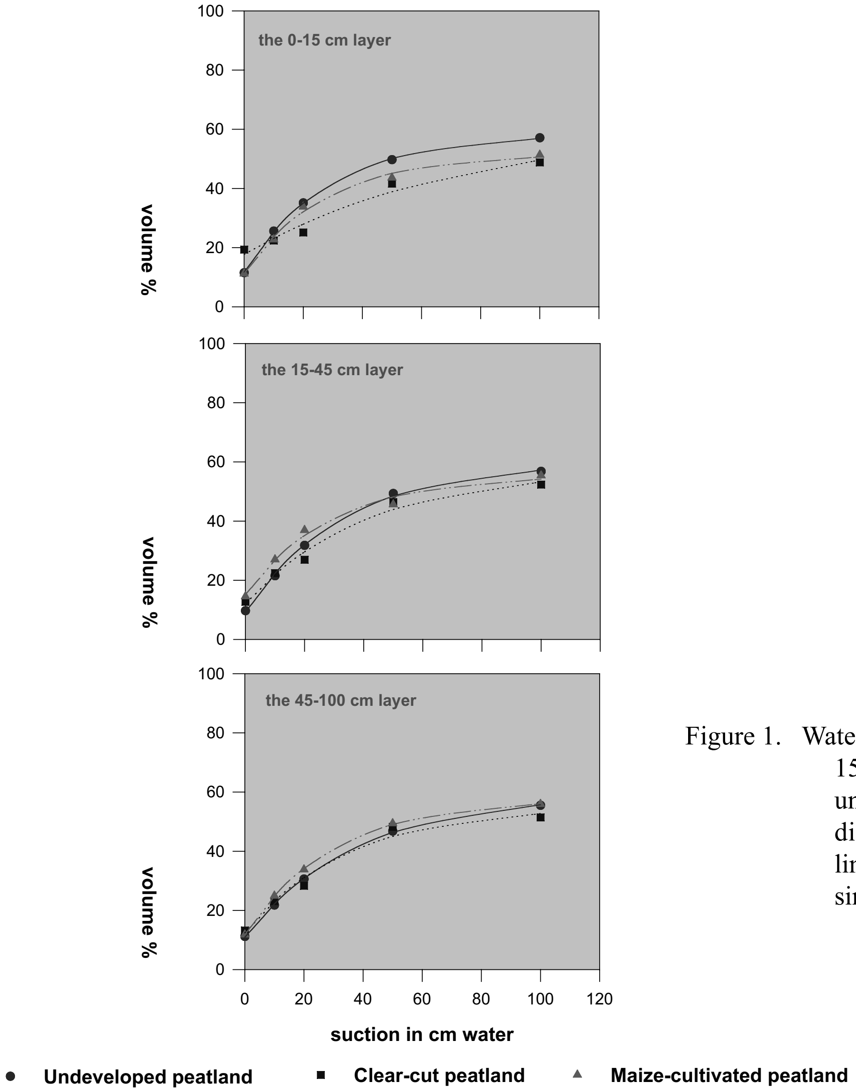

Figure 1. Water release of three peat soil layers (a) 0-15 cm, (b) 15-45 cm, and (c) 45-100 cm under three different land use systems at different suction heights. Syimbols and lines respectively represent observed and simulated data based the proposed model

Air: water ratio

The ratio of air and water volumes at high matric potential values (low suction) is very important. The suction at which the volume of air is equal to the volume of water is shown by the intersection of the volume % of air and water curves (Figure 2). The position of this point indicates the quality of peat (Verdonk *et al*., 1973). Compared to developed sites the suction on which the intersection occurs is lower in undeveloped site. This implies that the quality of peat soils under developed sites reduced.

CONCLUSION

1. Development and cultivation changed physical dimensions of the peat soil including an increase in bulk density and a decrease in fibre contents. This, in turn, changed some hydro-physical properties of peat soils.
2. Decreasing k_{wr} and V_{max}, attributed reducing potential of water release. They changed consistently to the progress of peat decay and changes in some hydro-physical properties of peat soils.
3. At high matric potential there was more water volume over air volume of peat soils under developed site compared with undeveloped site. This implies that as a growing medium the quality of peat soils decreased with agricultural development.

ACKNOWLEDGEMENTS

The study was part of the Eutrop Research Project: Natural resource functions, biodiversity and sustainable management of tropical peatlands (Contract Number: ERB18IC980260). The authors wish to thank Mr. Sajarwan and his brothers for their help during field works, and Mas Bowo and Mas Klik for their laboratory works.

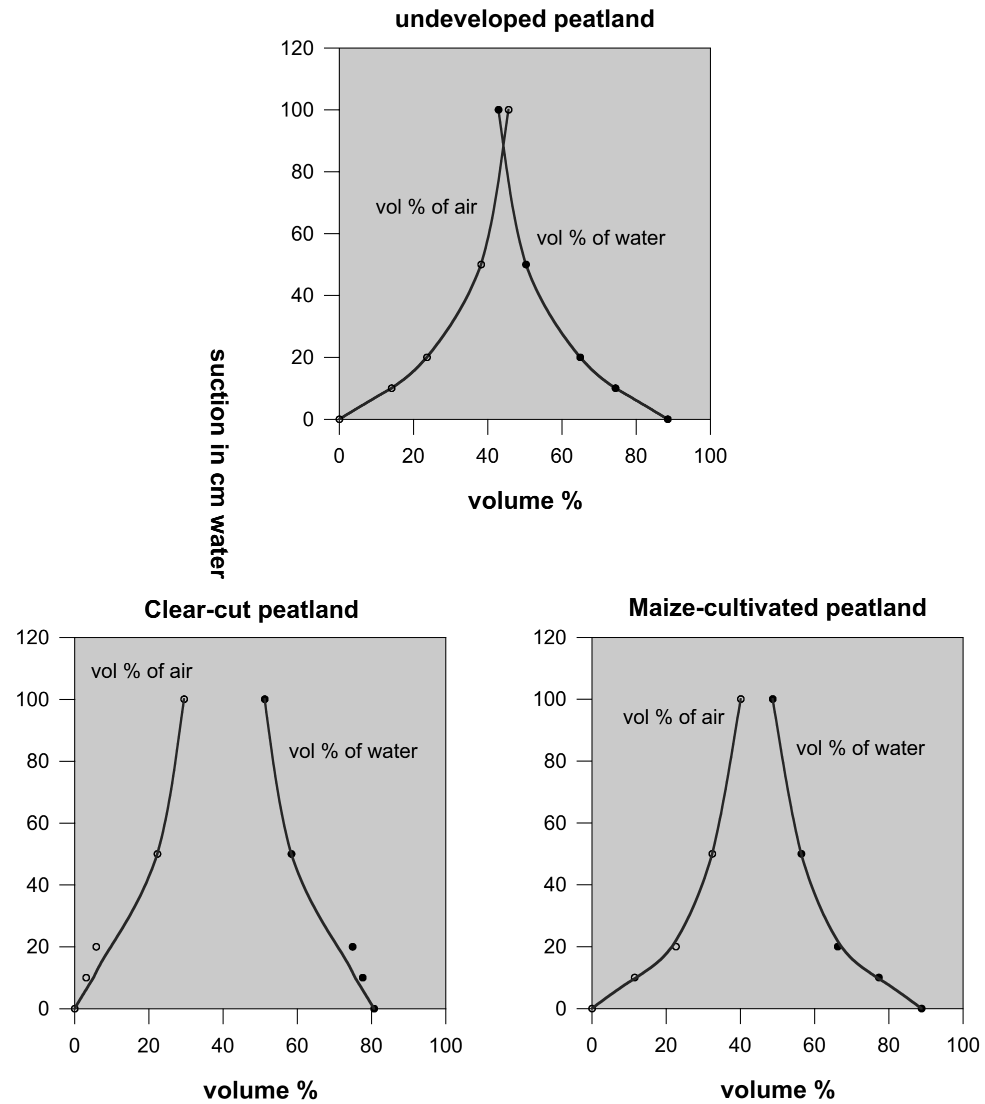

Figure 2. Water:air volume ratio of the top 0-15 cm peat layer at different suction heights under (a) undeveloped peat forest, (b) maize-cultivated peatland, and (c) clear-cut peatland. Symbols and lines respectively represent observed data and fitted data.

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Polyphenol in Peat Soil, and Growth and Yield of Rice (*Oryza sativa* L.)

Nyahu Rumbang
Department of Agronomy, Faculty of Agriculture
University of Palangkaraya, Indonesia
e-mail: rumbank@yahoo.com

ABSTRACT

The study aimed to express effect of polyphenol on growth and yield of rice. Its effect was related to N availability. The study was carried out in two experiments. The first experiment was carried out to measure polyphenol in peat soil using Completely Randomised Design. Treatments tested involved combination of liming and N-fertilisation. The combination composed of 0, 22.5, and 45.0 g lime pot^{-1}, and 0, 2.14, and 4.28 g N pot^{-1}. The second experiment was carried out to study effect of polyphenol on growth and yield of rice var. Membramo. The experiment was designed following Completely Randomised Design with two factors as the first experiment. The study showed that polyphenol content in field conditions was much higher (1,121.33 mg.kg^{-1}) than that in pot conditions (487.30 mg.kg^{-1}). Application 45.0 g lime pot^{-1} was able to increase peat pH of 1.2 units. There was interaction between lime and N on growth and yield of rice in peat soil. Rice grown on peat soil without lime and N showed poor growth and lower yield. The highest weight of dry-paddy (48.48 g. clump^{-1}) was obtained at application of 22.5 g lime.pot^{-1} and 4.28 g N.pot^{-1}.

Key words: polyphenol, peat soil, rice

INTRODUCTION

Peat decomposition process in anaerobic condition produces various organic acids including an aliphatic group such as acetic acid, formic acid, propionic acid, and butiric acid, and an aromatic group including phenolic acids such as hydroxybenzoic, ferulic, coumaric, and vanillic acids (Flaig *et al.*, 1975; Hartley & Whitehead, 1985; Saragih, 1996). Phenolic compound that mostly inhibit the growth of crops is *p*- hydroxybenzoic acid (Stevenson, 1982; Hartley & Whitehead, 1985).

Amount of phenolic compound that is toxic for crops depends on kinds of phenolic and crops. Concentration of 0.01-3 mM is toxic ranges for most crops (Hartley & Whitehead, 1985; Sabiham *et al.*, 1995; Saragih, 1996). Phenolic compound results in damages due to its ability to form complexes with protein through hydrogen bonding (Harborne, 1996) and protein, in turn, is difficult to be decomposed by decomposer organisms and enzymatic activities are reduced (Handayanto, 1994). Tannin inhibits the growth or the function of decomposer organisms through enzymatic retention and subsequently nitrogen becomes unavailable (Palm & Rowland, 1997).

Effect of phenolic acids on crops involves inhibited seedlings, dwarf crops, damaged root systems, inhibited nutrient uptake, chlorosis, wilted and death. Direct effect of phenolic compound on crop growth is damages on metabolism processes such as respiration, synthesis of nucleic acid or protein (Sabiham, 1993). This study was to express effects of polyphenols on rice growth in peat soils, by which their effect was related to nitrogen availability.

MATERIALS AND METHODS

The study composed of two experiments carried out in laboratory and glass house. Peat soil used was hemic peat from Kalampangan village, Central Kalimantan. Indicator crop is rice crop var. Membramo. Polyphenol determination applied methanol extraction method (Anderson & Inggram, 1993).

First experiment

This experiment was carried out to measure polyphenol in peat soil using Completely Randomised Design. Treatments tested involved combination of liming and N-fertilisation. The combination composed of 0, 22.5, and 45.0 g lime pot^{-1}, and 0, 2.14, and 4.28 g N pot^{-1}. Weight of 0.3 kg of air-dry peat was added into pot, mixed with lime and Urea fertiliser according with treatment applied. Peat with its contents was flooded and incubated during 3, 6, 12, 24, and 48 days.

Second experiment

The second experiment was carried out to study effect of polyphenol on growth and yield of rice. The experiment was designed following Completely Randomised Design with two factors. Factors and their levels were equal to those in the first experiment. An amount of 3.5 kg of air-dry peat was added into container. Two weeks before planting, lime was added, mixed, and incubated in flooded condition. Urea fertiliser was added in two times namely 2 and 6 weeks after planting. To all containers triple superphosphate (TSP), KCl and micro fertilisers were added together with the first time N fertilisation. Height of water in containers was maintained at 10 cm above peat surface, and one week before harvesting the surface was dried.

RESULTS AND DISCUSSION

Polyphenol

Dynamics of polyphenol release into flooding water in pot that was added by single N or combination N and lime showed similar trends during 48 days of incubation time (Fig.1). Polyphenol concentration increased rapidly to reach a maximum point at 20 days of incubation time, and after next decreased rapidly. This indicates that polyphenol released from peat into flooding water was lost or changed to non-extractable form. Polyphenol concentration obtained in this study was much lower than that in field-flooding water, 556-811 mg kg^{-1}. This can be explained that water used in this study was distilled water. After 48-day incubation time, total polyphenol contained in peat and flooding water was lower than that in initial peat sample, 866-1,412 $mg.kg^{-1}$. This implies that during storage of sample and incubation extractable polyphenol was lost or changed.

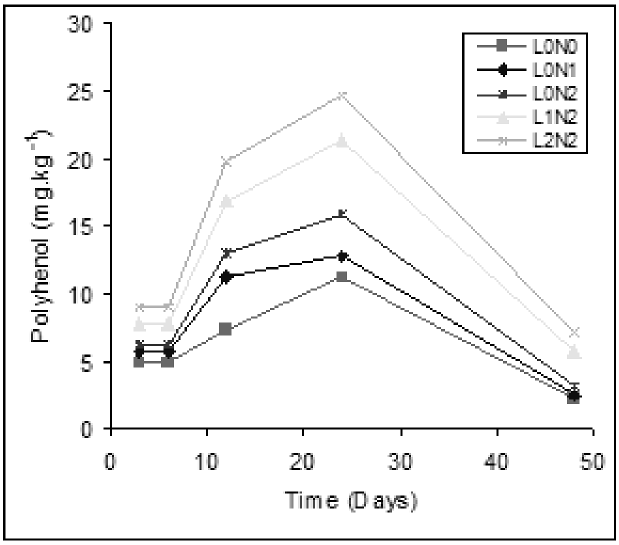

Figure 1. Release of peat polyphenol into flooding water during 48 days of incubation time. Symbols of L0, L1, and L2 represent 0, 22.5, and 45.0 g $lime.pot^{-1}$, and N0, N1, and N2 represent 0, 2.14, and 4.28 g $N.pot^{-1}$.

Application of N fertiliser and lime influenced on polyphenol contents in flooding water. Until 24 days of incubation time, polyphenol content increased with increasing N doses (without lime), and also with increasing lime doses with N fertilisation of 4.28 g N pot^{-1}. Liming with higher doses resulted in higher content of polyphenol at 12 and 24 days of incubation time. In contrast, after 48 days polyphenol content was not influenced by N fertilisation without liming. Similar result was also obtained from N fertilisation of 4.28 g N with liming 22.5 g lime pot^{-1}. However, at application of 4.28 g N and 45 g lime polyphenol content of peat decreased almost 38.71% after 48-day incubation.

In the second experiment interaction between application N and lime at harvesting time (Fig.2) influenced polyphenol content of peat grown by rice crop. Polyphenol content of peat decreased with increasing lime doses without N fertiliser.

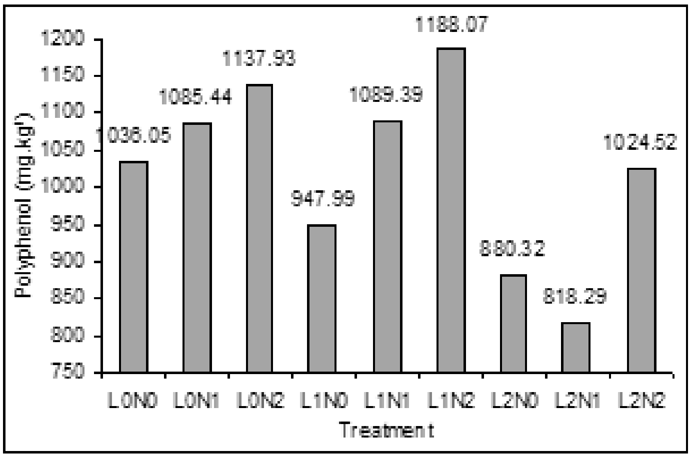

Figure 2. Effect of application of lime and N on polyphenol content of peat soil measured at harvesting time. Legends are referred to Fig.1.

Total nitrogen

In the first experiment total N content in flooding water changed as a result of treatments during incubation (Fig.3). There was a decrease in total N content at all treatments with increasing time of incubation. Total N content of peat (peat + flooding water) after 48 days of incubation was lower than that in initial peat sample, 1.61% (Table 1). Application of lime did not influenced on total N content of flooding water during incubation time. This may be related with limited ability of lime to increase pH and shorter incubation time. However, application of 45.0 g lime pot^{-1} increased pH from 2.8 to 4.0, microorganism activities were still lower. In the second experiment, total N content of peat at harvesting time was affected by interaction between liming and fertilisation.

pH

Treatments tested in the first experiment affected pH of flooding water during incubation (Fig. 4). pH of flooding water increased significantly with increasing lime doses up to 45.0 g lime pot^{-1}. Application of 4.28 g $N.pot^{-1}$ did not affected peat pH after 48 day incubation time, but such peat pH was still lower (pH 2.8) than that of initial peat pH (pH 3.6). Application of 45.0 g lime pot^{-1} increased peat pH to pH 4.0. In the second experiment, peat pH at harvesting time was not influenced by interaction between lime and N, but single liming affected significantly on peat pH (Fig.5).

Chlorophyll and paddy yield

Table 1. Means of total N content (%) and pH (pH H_2O) of peat soil and polyphenol content ($mg.kg^{-1}$) of peat soil and flooding water after 48 days of incubation time with application of lime and N

Treatment	Total N of peat	pH of peat	Polyphenol		
			peat	water	total
L0N0	0.88 a	2.80 a	766.11 b	2.23 a	768.34
L0N1	0.97 ab	2.70 a	763.75 b	2.45 a	766.20
L0N2	1.00 b	2.73 a	794.66 b	3.09 a	797.75
L1N1	1.01 b	3.90 b	665.57 b	5.67 b	671.24
L2N2	1.06 b	4.00 b	469.53 a	7.12 b	476.65

Notes: Polyphenol content of peat initially used is 1,121.33 $mg.kg^{-1}$. Means followed by the same letter are not significantly different at LSD 5%

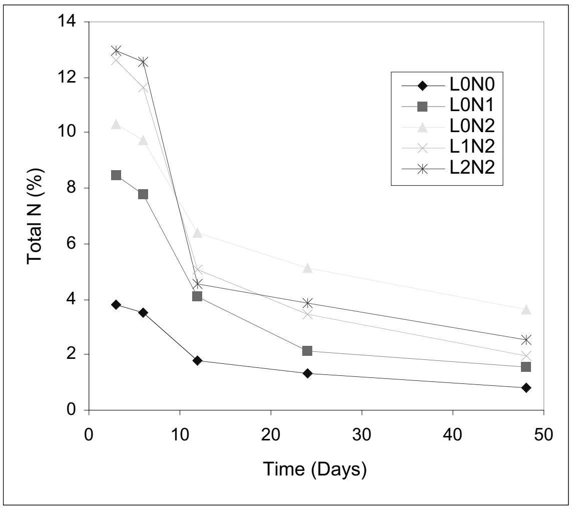

Figure 3. Release of total N into flooding water during 48 days of incubation time. Legends are referred to Fig.1.

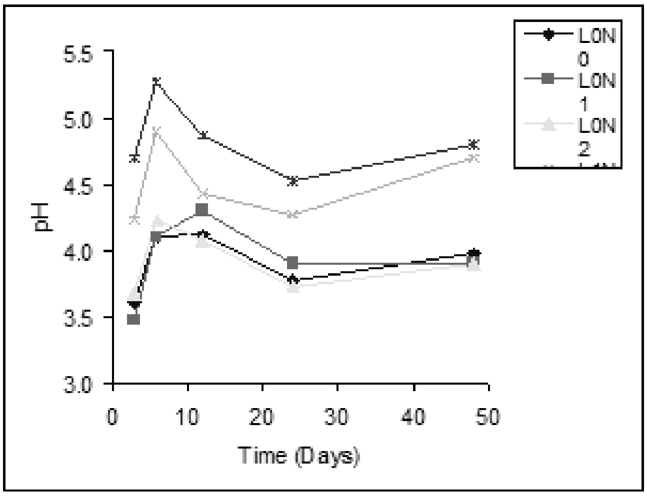

Figure 4. Change in pH of flooding water during 48 days of incubation time. Legends are referred to Fig.1.

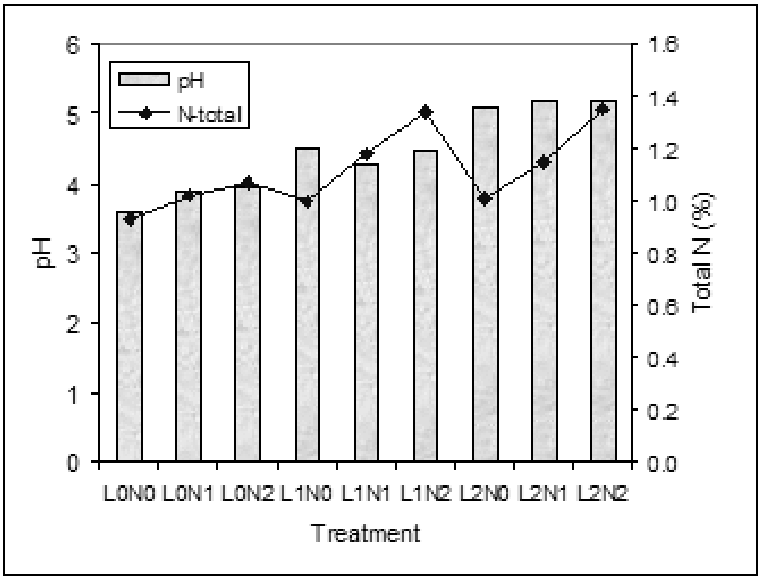

Figure 5. Effect of applicaton of lime and N on pH and total N content of peat soil measured at harvesting time. Legends are referred to Fig.1.

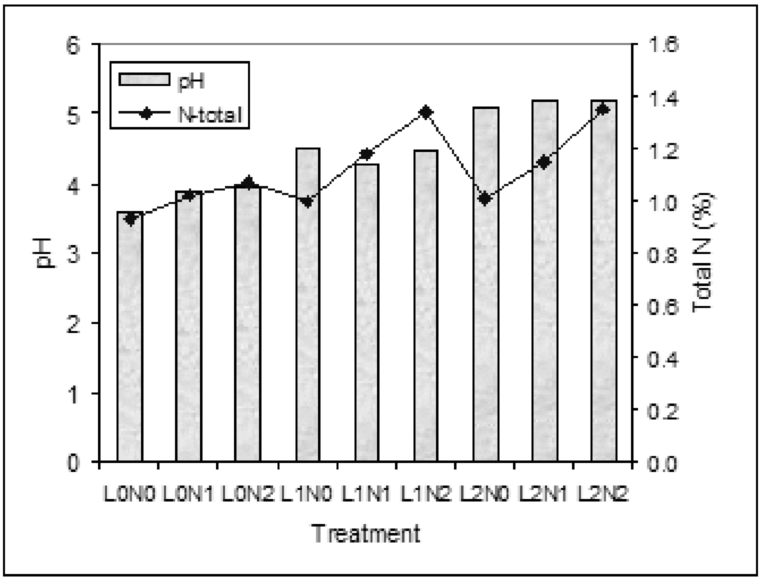

Figure 6. Effect of application of lime and N on chlorophyll in paddy leaves and yield of rice. Legends are referred to Fig.1.

Interaction between lime and N affected contents of chlorophyll-a, chlorophyll-b, and total chlorophyll contained in paddy leaves. The highest contents were obtained at application of 4.28 g N pot^{-1} and 22.5 g lime pot^{-1}. Interaction between lime and N also affected dry-paddy yield per clump, and the highest yield was obtained at application of 4.28 g N pot^{-1} and 22.5 g lime pot^{-1} that also resulted in previously the highest contents of chlorophyll (Fig.6).

CONCLUSION

1. Field polyphenol content was much higher (1,121.33 $mg.kg^{-1}$) than that in pot conditions (487.30 $mg.kg^{-1}$).
2. Application 45.0 g lime pot^{-1} was able to increase peat pH of 1.2 units.
3. Interaction between lime and N affected growth and yield of rice in peat soil. Rice grown on peat soil without lime and N showed poor growth and lower yield. The highest weight of dry-paddy (48.48 g. $clump^{-1}$) was obtained at application of 22.5 g $lime.pot^{-1}$ and 4.28 g $N.pot^{-1}$.

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A Concept of Spatial Arrangement in Peat Land Management Based on Traditional Peat Land Management System in Indonesia

Suwardi[1], Basuki Sumawinata[1], Budi Mulyanto[1], and Dedy Kusnadi[2]
[1]Member of Center for Wetland Studies, Dept. of Soil Science, Bogor Agricultural University, Email: soilipb@indo.net.id
[2]Fac. of Agricultural Engineering, Bogor Agricultural University

Corresponding author: Dr. Suwardi
Center for Wetland Studies
Dept. of Soil Science, Bogor Agricultural University
Jl Meranti, Kampus IPB, Darmaga, Bogor 16680, Indonesia
Email: soilipb@indo.net.id
Phone o251-627792 Fax: 0251-629358

ABSTRACT

Peat land area is a unique and fragile ecosystem so that the management of the peat land area needs comprehensive understanding components of peat land ecosystem and their relationships in the ecosystem. Development of agricultural area on the peat land needs specific techniques, particularly in water management. Application of inappropriate techniques cause the peat layers disappeared. Many places leading to catastrophe, because the agriculture systems are not based on the peat layer but on mineral materials. Under organic material of peat dome contains brackish sediment that normally compose of sulfidic materials. Over drainage of peat land containing brackish sediment causes acidic.

The reclamation of peat land area by government mostly still used open drainage system with long and large canals without considers ecosystem boundaries and spatial arrangement of land use. Consequently large areas of cultivated area are abandoned. Dealing with the above experiences this paper will discuss about the concept of peat land management system that regarding environmental aspects of peat land ecosystem. This system believes that the island or delta is an ecosystem unit of the peat land; therefore the management of peat land has to consider the boundaries of island or delta. The landscape of the island or delta should be analyzed to determine the position of conservation areas and cultivated areas. We suggest the conservation area is located on the inland of peak dome whereas the cultivated on the foot slope and riverside area.

The proportion of conservation area and the cultivated area can be calculated based on the balance of water surplus that retained by the conservation area to the amount of water that needed for irrigation and maintaining water level of the production area during the dry season. The appropriate special arrangement can reduce deforestation of conservation area, plantation crops such as coconut, oil palm, rubber, and forest plantation threes should be developed by government or private companies. The area for plantation is designed between cultivated area and conservation area. This system will reduce significantly the illegal logging practices penetrate to conservation area.

Key words: peat land management system, spatial arrangement, water management technique

INTRODUCTION

Development of peat land area in Indonesia has been started since the year 1920 by some traditional ethnic groups such as Chinese, Banjarese, and Bugise using very simple closed drainage system (Sumawinata, 1992). They developed 3 to 5 km long from the rivers that still influenced by tidal water. They conserve natural forest as source of fresh water in the dry season. These traditional agricultural practices still exist until nowadays. Unfortunately, many reclaimed areas become abandoned due to extensive conversion of forest in the peat dome area to enlarge cultivated area. Up to now, government has difficulties to control the conversion of peat land forest to cultivated area.

In the year 1970 the Indonesian government with the support of the World Bank tried to develop relatively large scale coastal peat land area in Kalimantan and Sumatra mainly for cultivation of rice. However, most of the island or delta is planned to convert into cultivated of rice without planning for conservation area. With this system the peat layer continue to disappear due to subsidence process is inevitable, ultimately the sustainability will be disturbed. The reclamation carried out using open drainage systems with long and large canals without consider ecosystem boundaries. Open canals system causes the difficulty of controlling the water table. Consequently, water and soil of the peat land becomes acidic due to oxidation of pyrite mineral. Nowadays most of the areas are unproductive and abandoned.

Around the year 1990 the private sectors also participate in the development of coastal peat land area to develop plantation of coconut, oil palm, and industrial forest plantation for supporting industries. They use closed drainage system and consider the ecosystem boundaries. This system is relatively success to enlarge plantation area in the coastal peat land. Therefore plantation crops are the other alternative crop rather than rice that has been developed until nowadays.

According to the above history, there are various problems following the conversion of peat land to cultivated land. The most important problems is water management system that allow the management of some areas for cultivation of food and the other areas for source of fresh water for irrigation and flushing of acid water in the cultivated areas. The other problems are how to arrange agricultural crops and natural forest in the peat land and how to calculate the proportion of cultivated area and conservation area in the island or delta in order to maintain the balance of ecosystem. This paper will discuss the concept of peat land management by using water management system and land use management techniques. If this system practices properly, it will guarantee of the maintaining natural forest from deforestation of human being.

WATER MANAGEMENT CONCEPT

Most of peat land management is not successful due to mismanagement of water. In natural condition peat land absorb water stagnant. Reclamation of peat land should be prepared by managing water with drainage system. Basically there are two drainage systems, those are open drainage system and close drainage syatem. The reclamation of peat land designed by government are carried out using open drainage systems with long and large canals without consider ecosystem boundaries. These canals use both for drainage water and transfortation facility. Long and large canals system causes the difficulty of controlling the water table. Consequently, water and soil of the peat land becomes acidic due to excessive oxidation of pyrite mineral. Most of cultivated areas become abandoned.

We suggest using close drainage system rather than open drainage system. This system allow the reclamation of peat land area to cultivated area should be accompanied by conservation of water resources area in the forest carefully and appropriately. Conservation area is managed by reliable basic science and more applied of local knowledge such as fire control and wise utilization of water. The drainage system should consist of shallow drains and narrower spacing instead of deep drain with large pacing (Ritzema et al., 1998). This system allow easier to control water level across the drain. This system is also facilitated by water gate with stop lock system.

The water management system shoul consider that island or delta is managed under one water management. Fragmentation of water management system in the same island or delta will causes the destruction of peat land ecosystem. Many locations, island and delta is developed by many water management systems due to different province or district in that area. In that case the management of water should be discussed together involving all stakeholders in that island. Two questions should be answered to manage the water system of peat land in the island. Firstly, where will be developed the cultivated area and conservation area? Secondly, what the proportion of both cultivated and conservation areas?

According to traditional agricultural practices, the cultivation area is selected near the sea or rivers and foot slope where tidal water still influenced. Usually the distance of 3 to 5 km from the rivers is still favorable for cultivation area. In big island such as Pulau Petak in South Kalimantan, within that definition only a small area can be developed for cultivation area. Such that case the development of canals can be made to increase the cultivation area. On the other hand, the location of conservation area is selected in the peat dome. Peat dome area that functions as water storage for lower region is usually located in the middle of island. The altitude of peat dome area is higher than cultivated area. Two functions of peat dome area are as follows. (1) As water storage for supplying water in the dry system and to conserve area from flooding in the wet season. (2) As conservation area to conserve the water level and biodiversity.

The proportion of conservation and cultivated area is calculated based on the balance of water surplus that retained by the conservation area to the amount of water needed by the cultivated area during the dry season (Figure 1).

The amount of maximum water holding capacity (WHC) of peat dome can be calculated by equation (1) as follows:

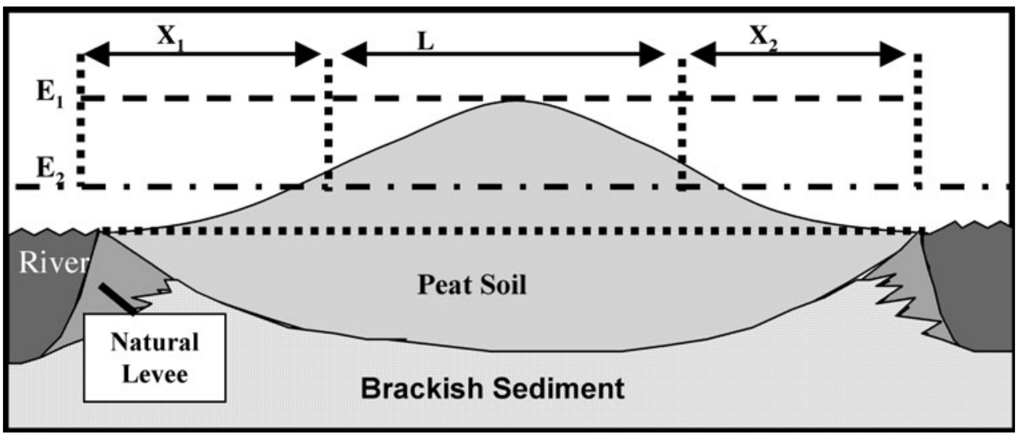

Figure 1. Schematic of peat dome as conservation area and foot slope as cultivated area.

$$WHC = (E1-E2) \times 0.6 \times L \times 0.9 \text{ .... (1)}$$

where L: width of conservation area (m), X1 and X2: foot slope area, E1: elevation of peat dome (m), E2: water elevation in the canal (m), where 0.6 is geometric-form factor, and 0.90 is the average porosity of peat. The unit of WHC is m^3. The water content of peat during field condition is about 45%(v/v). Therefore, the water capacity will be release during dry season is about 50%. The water flux through subsurface can be calculated by equation (2) and (3) as follows:

$$(X1+ X2) \times \text{water deficit} \leq (E1-E2) \times 0.6 \times L \times 0.9 \times 0.5 \text{ …..... (2)}$$

$$\text{Water flux } [q(m^3/day)] = ((E1-E2)/0.5\ L) \times \text{permeability …… (3)}$$

LAND USE MANAGEMENT CONCEPT

The basic concepts of peat land management have been applied by many traditional inhabitants of Indonesian. In the tidal zone, they reclaim by digging of drainage channels inland from the river and sea. This concept allows advantage to drain acid water and use tidal water for irrigation. They also conserve the forest in the peat dome as source of fresh water resources for irrigation in the dry season. This design is effective for cultivation of paddy and upland crops.

The success of traditional inhabitant to reclaim the peat land for agricultural cultivation forces the use peat land excessively. Peat layers are destroyed by burning resulting in devastation of land that is not suitable for growing crops. Deforestation and intruding of human community causes the loss of not only peat land on the foot slope but also forest on the peat dome that function as water reservoir. Efforts to reduce deforestation in the conservation area from illegal logging are always unsuccessful due to economical reason of human live around the conservation area.

To reduce deforestation of conservation area, the following land use management technique is recommended. Four points of this concept are noted as follows. (1) Rice is not the only crop recommended in the peat land but perenial crops such as coconut, oil palm, rubber, acacia, etc are the suitable crops cultivated in the peat land. (2) Rice that needs high nutrient requirement is cultivated in shallow peat in the river side whereas plantation is cultivated on the foot slope area. (3) Annual crops such as rice is cultivated intensively by farmers while plantation is cultivated by private company. (4) Plantation area is designed between conservation area and cultivated area.

If the above land use management concept is applied consistently, we hope that illegal logging will decrease because conservation area and cultivated area is separated by plantation that managed by private company. Private company can control channels by water gates so the canals can not use by illegal loggers for transferring their logs. In this system, government just encourages private company for maintaining conservation area by monitoring of landsat images. It is clear that the water management system will sustain because plantation has to control the water level and water quality for sustainability of its crops. Consequently drainage water from plantation area can be used for rice cultivation on the downstream. The example of water management system has been proposed to used in peat land on industrial forest plantation at Bukit Batu, Riau such as illustrated in Figure 2.

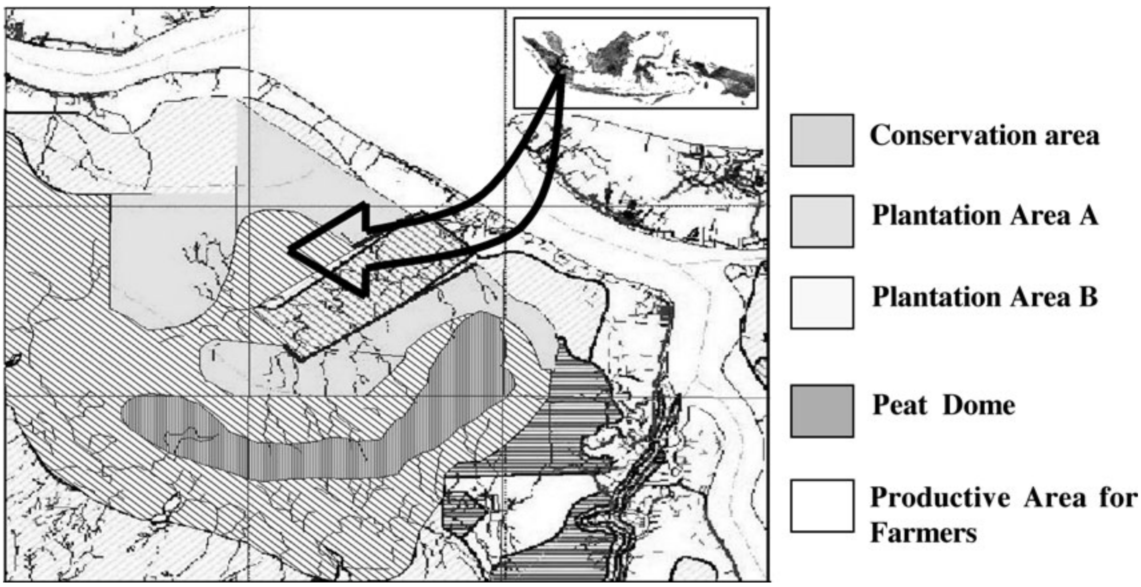

Figure 2. The example of land use management of peat land in Bukit Batu, Riau.

CONCLUSION

The management of peat land for agricultural uses has to consider that island or delta is one unit of ecosystem. The reclamation of peat land area for cultivation crops should be considered water management system especially fresh water from conservation area. The location of conservation area is located on the peat dome and its surrounding whereas the cultivated area is in the foot slope and river side. The proportion of conservation area can be calculated based on the balance of water surplus. To reduce deforestation by illegal logger, the plantation area managed by private company is allocated between conservation area and cultivated area.

ACKNOWLEDGMENTS

The authors acknowledge the consent of Center for Wetland Studies (CWS), Bogor Agricultural University and Japan Society for the Promotion of Science (JSPS) for their financial support to present this paper in the International Symposium on Land Management and Biodiversity in Bali 17-20 September 2002.

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Nitrogen Budgets in Different Types of Agricultural Systems in Central Kalimantan, Indonesia

Ryusuke Hatano [1,2], Mitsuru Osaki [2] and Suwido H. Limin [3]
1) Field Science Center for Northern Biosphere, Hokkaido University
2) Graduate School of Agriculture, Hokkaido University
3) Faculty of Agriculture, University of Palangka Raya
hatano@chem.agr.hokudai.ac.jp

ABSTRACT
Field surplus nitrogen (N) and farm disposal N are major sources of water pollution in farming systems. These sources are estimated from N budgets in fields and whole farms, which are associated with the production and consumption of food and feed. This study was conducted to investigate N budgets to estimate magnitude of pollution sources in 4 villages with different types of agricultural activities, soils and surrounding conditions, in central Kalimantan, Indonesia. Questionnaire survey for estimating N budgets was conducted to the head of 4 villages of Bukit Rawi (mixed cultivation of rice and upland crops at inland podzolic soil area associated with lake), Kalampangan (mixed vegetable cultivation and animal husbandry at inland peat soil area), Seberang Pasar II (rice cultivation at coastal peat-lost clay soil area) and Pangkoh IV (mixed vegetable cultivation and animal husbandry at coastal peat-losing clayey soil area).

Field surplus N was less than 30 kgN ha^{-1} y^{-1} in 3 villages other than Pangkoh IV where that was 109 kgN ha^{-1} y^{-1}. Less than 103 kgN ha^{-1} y^{-1} of field surplus N was estimated to maintain optimal drinking water quality. There was a significant positive correlation between the averaged field surplus N and averaged N application rate. Chemical fertilizer N application rate in Pangkoh IV was 110 kgN ha^{-1} y^{-1} which was almost equal to the field surplus N.

Disposal N was estimated as 15 kgN ha^{-1} y^{-1} to 160 kgN ha^{-1} y^{-1}. All human excreta was discarded in all villages, which ranged from 13 kgN ha^{-1} y^{-1} in Seberang Pasar II to 112 kg N ha^{-1} y^{-1} in Bukit Rawi. Although there was no animal manure in Seberang Pasar II, only 30 kgN ha^{-1} y^{-1} was used for manure in Kalampangan and Pangkoh IV. However, almost all livestock excreta of 89 kgN ha^{-1} y^{-1} was used for fish feeding in Bukit Rawi. The sum of disposal and field surplus N as total N pollution source was 28 kgN ha^{-1} y^{-1} in Seberang Pasar II, but it ranged from 114 kgN ha^{-1} y^{-1} in Bukit Rawi to 250 kgN ha^{-1} y^{-1} in Pangkoh IV. This was due to high proportion of purchased food N and grazing N in total input N. If farmers quit chemical fertilizer application, total N pollution source can exceed 103 kg N ha^{-1} y^{-1}.

Key words: N cycling, nitrate leaching, tropical peat, water pollution

INTRODUCTION

Chemical N fertilizer and the cultivation of leguminous crops account for 60% and 25% of total N increased by human activity, which have been seriously unbalancing the N cycling in both regionally and globally (Vitousek et al., 1997). Generally, many of plant species living in natural ecosystems are adapted to the soils with low levels of available N. Modern agriculture has increased crop yield by intentional application of chemical N fertilizer as well as manure N to maintain soil fertility and well-adapted plant species to the soils with high level of available N. While intentional N applications in agricultural fields have increased crop productivity locally, surplus N occurred in agricultural fields has diffused to atmosphere and aquasphere regionally and globally. Furthermore, trade of food and feed has drove N among regions of the world and much of N has been disposed of in intensive livestock farm as well as urban area.

A comprehensive approach to estimate field surplus N and disposal N based on the calculation of N flow associated with production and consumption of food, together with biological processes for N transformation, has been developed and used to determine the impact of N cycling in farm, community and regional systems (Guo & Bradshaw, 1993; Hatano et al., 2002; Matsumoto, 2000; Matsumoto et al., 1992 a, b, c; Nagumo & Hatano, 2000; Watson & Atkinson, 1999; Zebarth et al., 1999). Watson and Atkinson (1999) suggested that ignorance of biological N transformations such as denitrification and ammonia volatilization led to more than a 50% overestimate of field surplus N. Matsumoto et al. (1992 a, b, c) and Matsumoto (2000) showed that the disposal N in a Japanese urban area was considerably larger than field surplus N due to the human diet. Nagumo and Hatano (2000) reported that the annual disposal N of 2713 kg N ha^{-1} in another Japanese urban area became a point source of N pollution of stream water through the sewage treatment facility, while field surplus N ranged from 69 to 99 kg N ha^{-1} y^{-1}. On the other hand, Guo and Bradshaw (1993) showed that all human and livestock excreta was applied to paddy fields in a small Chinese village together with other manure composed of water plants or mud from fish ponds and chemical fertilizer, and the surplus N of 155 kg N ha^{-1} accounted for 69% of N derived from water plants and mud from fishponds. This indicates that water plants and phytoplankton play a significant role in recycling N discharged from fields. Hatano et al (2002) showed that field surplus N in upland fields in another small Chinese village ranged from 10.1 to 463 kg N ha^{-1} and there was a significant positive correlation between the field surplus N and N application rate.

Some recent studies have indicated that the estimated field surplus N is almost equal to the N discharged from the fields (Barry et al., 1993; Goss & Goorahoo, 1995; Hayashi & Hatano, 1999). However, the amounts of discharged N measured for the large-scale watersheds were significantly less than the estimated field surplus N, probably due to denitrification and N uptake by trees in the riparian zone (David et al., 1997; Jordan et al., 1997). Therefore, field surplus N may help only in an estimation of potential N leaching. From the N budget study in the small Chinese village, Hatano et al (2002) suggested that the N application rate of 160 to 185 kg N ha^{-1} was the maximum N input within a environmental capacity to sustain optimal N cycling because N application rate more than 160 kg N ha^{-1} increased field surplus N to an extent greater than crop uptake N, and a N application rate of more than 185 kg N ha^{-1} increased the potential nitrate-N concentration to more than 10 mg N L^{-1} which is critical level for drinking water.

Woli et al., 2002 showed that increase of animal disposal N and field surplus N increased of N concentration in stream water. N concentration in stream water was positively correlated with upland field ratio (Tabuchi et al., 1995). Regional N cycling influences not only water quality but also air quality. Ammonia volatilization occurs from manure processing and field application. (Barry et al., 1993) showed that 28% of total manure N was volatilized as NH_3 during manure processing and 10% of manure N applied to the field was volatilized. Increase of NH_3 volatilization increases atmospheric NH_4^+ deposition even in natural ecosystems. (VanBreemen et al., 1983) suggest that the NH_4^+ deposited contributes to soil acidification through nitrification releasing double equivalent amount of proton in the oxidation of NH_4^+ to NO_3^-. Bobbink et al., 1998 indicate that air borne N (NOx and NH_3) can alter primary production and nutrient cycling and cause significant reductions in biological diversity in terrestrial ecosystems.

Tropical peatland are categorized two major types; topogenous (fresh water swamps) and ombrogenous (rain-fed, nutrient poor bogs)(Page et al., 1999), indicating that the peatland have been strongly influenced by N deposition.

The purpose of this study was to estimate the impact of agricultural activity on the regional N cycling in central Kalimantan.

MATERIALS AND METHODS

Study Site

Following 4 villages in Kahayan river basin in central Kalimantan, Indonesia was investigated in this study; Bukit Rawi, Kalampangan, Seberang Pasar II and Pangkoh IV. Bukit Rawi is located at 12km north from Palangka Raya (S 3˚8'18", E114˚29'14), where in the area of podzols on Kerangus Terrace associated with some lakes. Kalampangan Village is located at 15km Southeast from Palangka Raya (S 2˚15', E114˚01'), where is in the peatland area with about 4 m thickness of peat layer. Seberang Pasar II village is located at 150 km south east from Palangka Raya and 17km south east from Kuala Kapuas (S 3˚8'18", E114˚29'14"), where is in the peat-lost lowland clay soil area. Pangkoh IV village is located at 30km west from Kuala Kapuas (S 2˚53'8", E114˚9'41"), where is in the lowland clayey soil area with peat mixed in the top 30 cm layer. These villages had different in land use. In Bukit Rawi there were paddy fields along the shore of the lakes and maize fields on the terrace. Pigs were fed and latan and rubber were harvested in the surrounding forest. In Kalampangan, the many kinds of vegetables and fruits were cultivated and also large number of livestock was fed. Seberang Pasar II was the typical paddy area in central Kalimantan. Pangkoh IV was the area cultivating vegetables and pulses and also animal husbandry.

N flow model

Field surplus N estimating potential N leaching and disposal N affecting N concentration in stream water were calculated as a budget in crop field and in whole farm, respectively. Figure 1 shows the N flow model for calculating the N budget. Ammonia volatilization was also estimated in the model.

Field surplus N was calculated as the difference between sum of the N inputs and the N outputs in crop field. N is input to the crop fields through the N flows of manure application, chemical fertilizer application, atmospheric deposition and N fixation. And also N is output from the crop fields through crop N uptake, denitrification and NH_3 volatilization. Surplus N was calculated as the difference between sum of the N inputs and the N outputs in crop field.

Disposal N was also calculated as a difference between the sum of the N inputs and N outputs in whole farm. The N inputs to whole farms are chemical fertilizer application, atmospheric deposition, N fixation and purchased food and feed. The N outputs from whole farms are denitrification, NH_3 volatilization, N leaching and sale for agricultural products. N flows in the model include N flows through human and natural activities. In order to calculate the N flows through human activities, the population of human and livestock, human dietary, live stock husbandry, trade of agricultural products, land use, area of fields, manure and chemical application rate and crop yields are obtained by questionnaire survey to the head of the villages.

On the other hand, to estimate natural activities, unit values were cited from the literatures or the data books. Atmospheric deposition was assumed to be 10 kgN ha^{-1} y^{-1} (Bouwman & VanVuuren, 1999). N fixation was assumed to be 30 kgN ha^{-1} y^{-1} for paddy, 10 kgN ha^{-1} y^{-1} for non-legume, 50% of total N uptake of legume crop, 15 kgN ha^{-1} y^{-1} for grassland (David et al., 1997; Ledgard & Giller, 1995; Yoshida, 1981). Denitrification was estimated as 18 % of chemical N fertilizer application rate and 1.5 % for manure application rate (Hauck, 1971; Koshino, 1976). Ammonia volatilization was also estimated as 28 % of manure N stocked in manure barn and 10 % of field applied manure (Barry et al., 1993)

Excretion rate was assumed to be 44 kgN ha^{-1} y^{-1} for cattle; 8 kgN ha^{-1} y^{-1} for goat; 5.5 kgN ha^{-1} y^{-1} for pigs; 0.6 kgN ha^{-1} y^{-1} for chicken (Mckown et al., 1991; Arthun et al., 1992; Hirschfeld et al., 1996). However, human excretion rate was 95 % of intake N (Holmes, 1971). N contents of foods and feeds were obtained from Standard tables of food composition; Feed composition table (RC-STA, 1982; AFFRCS-MAFF, 1995)

Estimation of potential nitrate-N concentration

Assuming that all the field surplus N in upland fields is leached away after mineralization and nitrification each year, the annual mean nitrate-N concentration in drainage water from fields was predicted by dividing the amount of field surplus N by drainage water volume. Drainage water volume was approximated as the difference between mean annual precipitation (2705 mm) and evapotranspiration. Mean annual evapotranspiration was estimated by using climatic data observed at Palangka Raya. The average monthly air temperature, humidity, wind speed, and rainfall data from 1998 to 2001 were used to estimate monthly evapotranspiration by the Penman method (Penman, 1948) and mean annual evapotranspiration was obtained as 1677 mm by summing up the monthly values. From these values, drainage water volume was estimated to be 1028 mm.

Although N leaching is generally related to soil processes, such as denitrification, immobilization, mineralization, ion exchange, hydrodynamic dispersion or diffusion, such reactions were not taken into consideration. Therefore, the prediction should be termed the potential nitrate-N concentration in drainage water.

RESULTS

Characteristics of the villages surveyed

The area of the village was almost same, which was about 1000 ha (Table 1). However, the land use pattern in the each village was considerably different. In Seberang Pasar II, crop lands accounted for 82 % of the whole area, especially rice paddy area accounted for 98 % of total crop land area. On the other hand, in other villages, crop lands accounted for less than 10% of whole area. However, in Bukit Rawi, rice paddy accounted for 68 % of total crop land area, while in Kalampangan and Pangkoh Ö¢, more than 70 % of total crop land area was cultivated by pulses and vegetables.

Population of human ranged from 1974 in Bukit Rawi to 3163 in Pang IV (Table 2). However amount of human excreta N was highest in Seberang Pasar II, which is due to higher amount of human dietary in Seberang Pasar II than in Pang IV (Table 2). Total amount of excreta N ranged from 11208 kg N in Bukit Rawi to 68637 kg N in Kalampangan. Livestock excreta N accounted for 93 %, 75 % and 61% of total excreta N in Kalampangan, Pang IV, and Bukit Rawi, respectively, but it accounted for only 3 % in Seberang Pasar II. In Kalampangan and Pangkoh IV cattle and chickens were the predominant livestock husbandry, and also pigs were predominant in Bukit Rawi. In Seberang Pasar II, only chickens grazed in the fields.

Table 1 Land use in the four villages surveyed in Central Kalimantan

Villages	Land use (ha)							
	Rice	Maize	Roots	Pulses	Vegetables	Fruits	Others	Total
Bukit Rawi	20	4	0	0	0	5	1071	1100
Kalampangan	0	3	5	47	54	21	1249	1378
SeberangPasar Ⅱ	900	0	5	0	13	0	208	1125
Pangkoh Ⅳ	0	0	3	30	46	2	999	1080

Table 2 human and livestock excreta N in the villages surveyed in Central Kalimantan

Village	Human kgN	Cattle kgN	Goat kgN	Pig kgN	Chicken kgN	total kgN
Bukit Rawi	4343 (1974)	0 (0)	0 (0)	2489 (1240)	45 (73)	6877
Kalampangan	4750 (2794)	20814 (1296)	49 (20)	100 (50)	7252 (10335)	32965
SeberangPasar	12900 (3000)	0 (0)	66 (0)	0 (0)	2360 (585)	15325
Pangkoh	7591 (3163)	6745 (420)	657 (200)	84 (42)	1678 (2720)	16756

The number in the parenthesis indicates population

Field N budget

Chemical fertilizer N and manure N were mainly applied in the maize, vegetable and pulse fields (Table 3). Especially in Pangkoh IV, chemical fertilizer N of 138 kg N ha^{-1} y^{-1} was applied in the vegetable fields. In the maize fields in Kalampangan and in pulse fields in Pangkoh IV, N was also applied at a rate of more than 100 kg N ha^{-1} y^{-1}. These resulted in large amount of averaged total input N of 180 kg N ha^{-1} y^{-1} in Pangkoh IV and of 96 kg N ha^{-1} y^{-1} in Kalampangan due to high proportion of vegetable and pulse fields in land use in these villages. However N uptake by vegetables in Pangkoh IV was only 18 kg N ha^{-1} y^{-1}, which was considerably lower than the input N. This decreased averaged crop uptake N in Pangkoh

Table 3 N budget in the field in the villages survayed in Central Kalimantan

Village	Ccrop	Input N (kgN ha^{-1} y^{-1})						Output N (kgN ha^{-1} y^{-1})				
		Chemical fertilizer	Manure	Atmospheric deposition	N fixation	Irrigation	Total input	Crop uptake	NH_3 volatilization	Denitrification	Field surplus	Total output
Bukit Rawi	Rice	0	0	10	10	5	25	16	0	0	9	25
	Maize	17	0	10	10	0	37	60	0	3	-26	37
	Roots	-	-	-	-	-	-	-	-	-	-	-
	Pulses	-	-	-	-	-	-	-	-	-	-	-
	Vegetables	-	-	-	-	-	-	-	-	-	-	-
	Fruits	0	0	10	10	0	20	20	0	0	0	20
	Average	3	0	10	10	3	26	23	0	0	2	26
Kalampangan	Rice	-	-	-	-	-	-	-	-	-	-	-
	Maize	83	30	10	10	0	133	157	3	15	-43	133
	Roots	0	0	10	10	0	20	59	0	0	-39	20
	Pulses	22	38	10	94	0	164	167	4	5	-12	164
	Vegetables	18	31	10	10	0	69	54	3	4	8	69
	Fruits	0	0	10	10	0	20	11	0	0	9	20
	Average	17	28	10	41	0	96	91	3	4	-2	96
Seberang Pasar	Rice	0	0	10	10	5	25	12	0	0	13	25
	Maize	-	-	-	-	-	-	-	-	-	-	-
	Roots	0	0	10	10	0	20	18	0	0	2	20
	Pulses	69	0	10	97	0	175	173	0	12	-10	175
	Vegetables	70	0	10	10	0	90	16	0	13	61	90
	Fruits	-	-	-	-	-	-	-	-	-	-	-
	A	1	0	10	11	5	27	14	0	0	13	27
Pangkoh	Rice	-	-	-	-	-	-	-	-	-	-	-
	Maize	-	-	-	-	-	-	-	-	-	-	-
	Roots	0	0	10	10	0	20	127	0	0	-107	20
	Pulses	83	25	10	54	0	172	87	2	15	67	172
	Vegetables	138	42	10	10	0	200	18	4	25	152	200
	Fruits	0	0	10	10	0	20	18	0	0	2	20
	Average	110	33	10	26	0	180	47	3	20	109	180

IV to 47 kg N ha^{-1} y^{-1} and resulted in large amount of field surplus N of 109 kg N ha^{-1} y^{-1}. On the other hand, in Kalampangan, each crop uptake N was well balanced with input N. This resulted in field surplus N of almost 0 kg N ha^{-1} y^{-1}.

No chemical fertilizer N was applied in the paddy fields, and N fixation and atmospheric N deposition were main N inputs in the paddy field. Therefore, in Bukit Rawi and Seberang Pasar II with high proportion of paddy field in the land use, averaged total N inputs were less than 30 kg N ha^{-1} y^{-1}. Consequently, crop uptake N was 23 and 14 kg N ha^{-1} y^{-1} respectively, and field surplus N was 2.5 and 13 kg N ha^{-1} y^{-1}, respectively.

Village N budget

Total input N into Seberang Pasar II was only 38 kg N ha^{-1} y^{-1} (The values were presented as the amount of N per unit crop land area), which was due to small amount of purchase of food and chemical fertilizer and of grazing (Table 4) . Even in Bukit Rawi, where was also rice cultivating village as Seberang Pasar II (Table 1), purchased food N of 94 kg N ha^{-1} y^{-1} and grazing N of 99 kg N ha^{-1} y^{-1} were input into the village (Table 4). Although input N through purchased food was only 24 kg N ha^{-1} y^{-1} in Kalampangan, input N through grazing N was 242 kg N ha^{-1} y^{-1} which was considerably large due to animal husbandry. In Pangkoh IV, chemical fertilizer N as well as purchased food N and grazing N accounted for large proportion of total input N. Therefore, total input N in these two villages was 340 and 349 kg N ha^{-1} y^{-1}, respectively (Table 4).

Total output N ranged from 32 kg N ha^{-1} y^{-1} in Seberang Pasar II to 343 kg N ha^{-1} y^{-1} in Pangkoh IV, which was slightly small in all villages because of N accumulation in human and livestock body (Table 4). Total disposal N from human and livestock ranged from 15 to 160 kg N ha^{-1} y^{-1}. All human excreta was discarded in all villages, which ranged from 14 kg N ha^{-1} y^{-1} in Seberang Pasar II to 148 kgN ha^{-1} in Bukit Rawi, depending on amount of purchased food N (The

Table 4 N budget in whole village surveyed in Central Kalimantan

Village	Input (kgN ha^{-1} y^{-1})								
	Purchased food N	Fishing N	Purchased feed N	Chemical fertilizer N	Grazing N	Atmospheric deposition N	N Fixation	Irrigation	Total input N
Bukit Rawi	94	18	0	3	99	10	10	3	237
Kalampangan	29	1	0	17	242	10	41	0	340
SeberangPasar	8	0	0	1	3	10	11	5	38
Pangkoh Ⅳ	79	0	0	110	124	10	26	0	349

Village	Output (kgN ha^{-1} y^{-1})									
	Sold crop N	Sold animal N	Fish Feed N	Field Surplus N	Human Disposal N	Animal Disposal N	Denitirification	NH_3 volatilization (application)	NH_3 volatilization (processing)	Total output N
Bukit Rawi	0	0	89	2	112	0	0	0	24	228
Kalampangan	50	0	6	-2	36	124	4	3	61	282
SeberangPasar	3	0	0	13	13	2	0	0	1	32
Pangkoh IV	16	21	0	109	93	48	20	3	32	343

value of excreta N was calculated as the amount of N per unit crop land area by using the data shown in Table 1 and 2). Livestock was fed by grazing and crop residue application. Livestock excreta N was 3 kg N ha^{-1} y^{-1} in Seberang Pasar II, while 86 to 219 kg N ha^{-1} y^{-1} was produced in other villages. Almost all livestock excreta of 90 kgN ha^{-1} y^{-1} was used for fish feeding in Bukit Rawi, although only 30 kgN ha^{-1} y^{-1} was used for manure in Kalampangan and Pangkoh IV (Table 3).

Potential nitrate-N concentration

Potential nitrate-N concentration in drainage water from the field ranged from 0 mg N L^{-1} in Kalampangan to 10.6 mg N L^{-1} in Pangkoh IV (Table 5). Potential nitrate-N in Pangkoh IV exceeded 10 mg N L^{-1} as nitrate-N concentration limit for drinking water. As potential nitrate-N concentration was calculated by dividing the amount of field surplus N by drainage water volume of 1028 mm as mentioned above, potential nitrate-N concentration in drainage water should be 10 mg N L^{-1} when field surplus N was 103 kg N ha^{-1}.

Table 5 Potential nitrate-N concentration in field drainage water in the villages surveyed in Central Kalimantan

Village	NO_3-N (mg N L^{-1})
Bukit Rawi	0.2
Kalampangan	0.0
SeberangPasar	1.2
Pangkoh	10.6

DISCUSSION

The previous N budget study in British Columbia, Canada (Zebarth et al., 1999), Hokkaido, Japan (Nagumo & Hatano, 2001) and whole, central and southern China (Zhu, 1997; Abe et al., 1999). Hatano et al., (2002) showed that the increase of N application rate increased field surplus N significantly although there was a slight variance in the relationship between them (Fig. 1). The variance probably related to the effects of soil fertility, crop species and micrometeorology. The relationship between field surplus N and N application rate in the present study was in the range of the variance in the previous study (Fig. 1). Therefore, the present data was reliable enough to evaluate N budget.

The surplus N in Central Kalimantan ranged from -107 to 152 kg N ha^{-1} y^{-1} (Table 3), while it ranged from -24 to 238 kg N ha^{-1} y^{-1} in Canada, from -95 to 675 kg N ha^{-1} y^{-1} in Hokkaido and from -19 to 567 kg N ha^{-1} y^{-1} in China. This clearly indicates that field surplus N in Central Kalimantan was small compared with other countries. However, the field surplus N was different in different village. Although Pangkoh IV and Kalampangan had similar agricultural activities characterized by upland cultivation and animal husbandry, whole field surplus N in Pangkoh IV was considerably higher than that in Kalampangan. This may be due to the difference of trading activities between these villages. Pangkoh IV was located in the lower Kahayan river basin extending high population area, while Kalampangan was in the upper Kahayan river basin surrounding peat swamp forest. Therefore, farmers in Pangkoh IV have intensively increased chemical fertilizer application rate to increase the supply of agricultural production to urban area. However, crop productivity was lower in Pangkoh IV than in Kalampangan. This is probably due to soil acidification associated with depletion of thin peat layer in the lower basin near the coast. The deeper clay soils in the coastal area generally includes pyrite which releases sulfuric acid with proceeding of oxidation (Golez & Kyuma, 1997). On the other hand, the field surplus N in Seberang Pasar IVwas low due to paddy cultivation although the village was in similar location to Pangkoh IV. In general, paddy soil reduces soil acidification by ion transformation. The field surplus N in Bukit Rawi cultivating rice was also low. These facts indicate that field surplus N depends on economy and nature conditions surrounding the village as well as agricultural activities inside the village.

Zebarth *et al.* (1999) showed that the annual field surplus N required to obtain optimal N cycling in British Columbia, Canada, was below 50 kg N ha^{-1} y^{-1}. On the other hand Hatano *et al.* (2002) estimated the optimal field surplus N in Quibainong, southern China from 73 kg N ha^{-1} y^{-1} for obtaining optimal crop yield to 91 kg N ha^{-1} y^{-1} for obtaining potential nitrate-N concentration less than 10 mgN L^{-1}. In present study, the optimal field surplus N of 103 kg N ha^{-1} y^{-1} was estimated for obtaining potential nitrate-N concentration less than 10 mgN L^{-1}. As mentioned previously, potential nitrate-N concentration can be estimated as one tenth of drainage water volume in unit of mm (Barry *et al.*, 1993; Goss and Goorahoo, 1995; Hayashi and Hatano, 1999). The difference between optimal surplus N values in the previous studies and the present study was due to the differences in dilution effect depending on amount of precipitation. The field surplus N in only

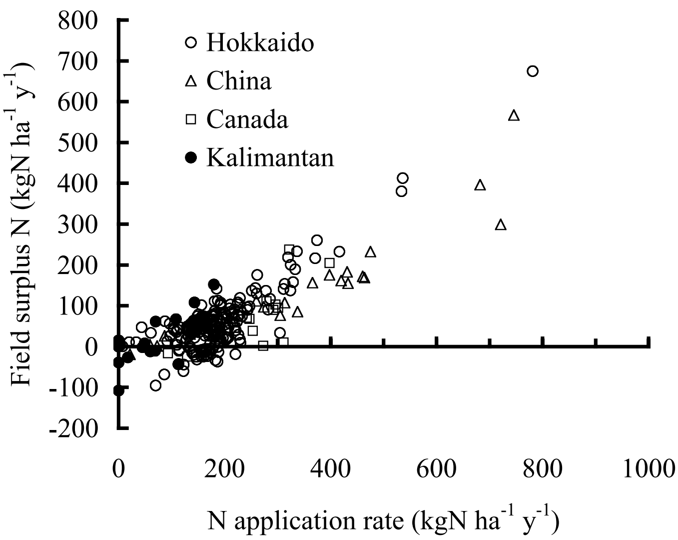

Figure 1. Relationship between N application rate and field surplus N.

Pangkoh IV exceeded the optimal field surplus N of 103 kg N ha^{-1} y^{-1}, which was 109 kg N ha^{-1} y^{-1}. The chemical fertilizer application rate in 110 kg N ha^{-1} y^{-1} corresponding to field surplus N, which indicated that chemical fertilizer application is not necessary in Pangkoh IV.

If disposal N would be also discharged to aquasphere together with the field surplus N, the sum of disposal N and field surplus N as total N pollution source in Bukit Rawi and Kalampangan as well as Pangkoh IV exceeded 103 kg N ha^{-1} y^{-1} as optimal surplus N, which reached to 114, 158 and 250 kg N ha^{-1} y^{-1}, respectively (Table 4). If farmers in the villages other than Seberang Pasar II quit chemical fertilizer application, total N pollution source will exceed 103 kg N ha^{-1} y^{-1}. There was a tendency that disposal N increased with increasing purchased food and feed N (Fig. 2). Especially in Hokkaido, very high disposal N was observed due to high purchased food and feed N. In this study, there was no purchased feed N but grazing N was input in the villages. Although grazing N was only 3 kg N ha^{-1} y^{-1} in Seberang Pasar II, it ranged from 99 kg N ha^{-1} y^{-1} in Bukit Rawi to 242 kg N ha^{-1} y^{-1} in Pangkoh IV (Table 4). Purchased food N was also very low in Seberang Pasar II, which was 8 kg N ha^{-1} y^{-1}. In Kalampangan it was 29 kg N ha^{-1} y^{-1}, which was not so high. On the other hand , it was 94 kg N ha^{-1} y^{-1} in Bukit Rawi and 79 kg N ha^{-1} y^{-1} Pangkoh IV, which accounted for 64% and 81 % of total food N in the villages. Therefore, these high proportions of N input by purchased and grazing N increased disposal N in the villages, especially in Pangkoh IV.

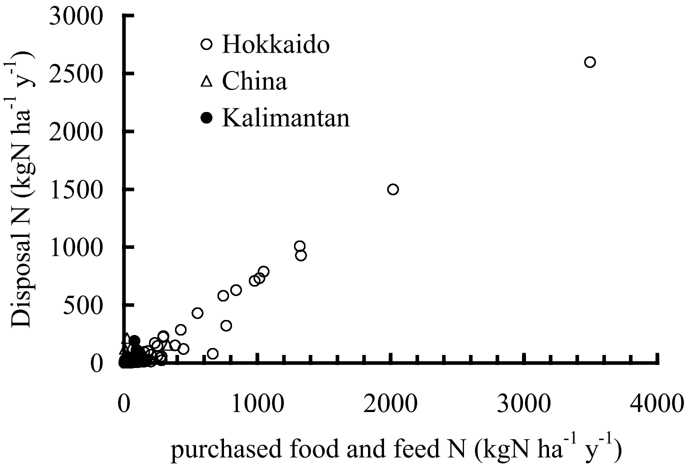

Figure 2. Relationship between purchased food and feed N and disposal N.

As total of surplus and disposal N in all villages except for Seberang Pasar II was estimated to exceed optimal N level if quit chemical fertilizer application, it should be decreased to prevent from water pollution. In Bukit Rawi, all animal excreta applied to grow fish and farmers ate the fish by themselves (Table 4). Furthermore, rice production in Bukit Rawi might be influenced by the manure application, because paddy fields were constructed in the lake where fish was caught. This is similar to the result in a previous study from a small village in the Lake Tai region, southern China, which indicated N cycling between fields and the lake (Guo and Bradshaw , 1993). Although in the present study, we could not clarify the significance of phytoplankton quantitatively, survey for quantity and quality in primary production in ponds, lakes and rivers influenced by N discharged from agricultural fields will be important to establish good agricultural practice in future.

CONCLUSION

Field surplus N depended on economy and nature conditions surrounding the village as well as agricultural activities inside the village in central Kalimantan. Chemical fertilizer was intensively applied to the fields in the village with high-populated urban area surrounding village, and vegetable and upland crop cultivation in the peat-lost acid clay soil to sell to the urban area. However, the yields were lower than in peatland village. There was more than enough amount of disposal N to alternate chemical fertilizer N due to large amount of purchased food N and grazing N. Intensive production and consumption of food and feed seem to destroy peat soil, reduce crop yield, and pollute water quality.

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The Use of Fly Ash as Ameliorant to Improve The Chemical Properties of Peat Soil in Pulau Muda, Riau Province

Iskandar[1], G. Djajakirana[1], and R. Marolop[2]
[1] Department of Soil Science, Bogor Agricultural University
Jl. Meranti, Kampus IPB Darmaga, BOGOR-16680 Indonesia
e-mail: soilipb@indo.net.id
[2] PT. Indah Kiat Pulp and Paper Tbk.
Jl. Raya Minas- Perawang Km.26
Perawang, Kab. Siak - Riau 28772

Corresponding author: Dr Iskandar
[1] Department of Soil Science, Bogor Agricultural University
Jl. Meranti, Kampus IPB Darmaga, BOGOR-16680 Indonesia
e-mail: soilipb@indo.net.id
issi.isk@bogor.wasantara.net.id
phone: 0251-627792 fax: 0251-629358

ABSTRACT

Chemical properties of peat soils are generally low in: pH, exchangeable cations (K, Na, Ca, and Mg), base saturation, and micronutrients. To improve these chemical properties, fly ash was used as ameliorant. However, fly ash contains not only both macro- and micronutrients, but also elements potentially harmful to the environment. The objective of the study was to observe the effect of fly ash that was used as ameliorant on chemical properties of peat soil planted with Acacia, quality of water from control wells, and some chemical composition of Acacia plant leaf. Fly ash was added around the tree at the rate range from 5 kg/tree to 10 kg/tree. Six months after the addition of fly ash, samples of peat soil, water from control well, and Acacia leaf were collected from the study area.

Chemical analysis of soil samples showed that soil pH, exchangeable cations, available P and base saturation of the soil treated with fly ash were higher than those of the control treatment. Heavy metals content of the treated soil showed that only Fe content increase significantly, whereas the other heavy metal elements such as Ni, Pb, Cd and Cr have no different with the control peat soil.

Plant analysis of the Acacia leaf showed that there are an increase in absorption of Ca, Fe, Cu, and Zn of the plant after addition of fly ash, but decreasing content of Mn and B.

Analysis of water from control wells at the area treated with fly ash showed only increasing in P and Fe content as compared with the water taken from the untreated peat soil.

Key words: ameliorant, fly ash, heavy metal, peat soil, pollution

INTRODUCTION

Fly ash is major particles as a result of modern coal-fired power plants and collected by means of electrostatic precipitators or fabric filter. Chemical analysis showed that fly ash contains several nutrients such as K, Ca, Mg, B, S, *etc*. that make it potential to be used as ameliorant to increase the soil fertility. However, fly ash also carries heavy metals, such as Cd, Cu, Pb, As, *etc*. that have to be observed because they can pollute the environment.

Researches about the use of fly ash as soil ameliorant have been conducted generally in mineral soils (Elseewi *et al*., 1980; McCarty *et al*., 1994; Stuczynski *et al*., 1998a; Stuczynski *et al*., 1998b). For example, Stuczynski *et al*. (1998a) studied the effect of fly ash and bed ash on nitrogen mobilization, meanwhile Stuczynski *et al*. (1998b) studied the effect of fly ash and bed ash on carbon mobilization in soil profile. Both researches were conducted on mineral soils Mollic Hapludalf and Typic Hapludalf. Their results showed that the use of fly ash at a rate till 80 g/Kg soil did not change the C and N content of the soil. However, decreasing of C and N contents occur on the use of bed ash as a result of decreasing amino acid content in soil organic matter related to increasing of soil pH. In other research, Taets and Rayburn (1996) observed that maize which was grown on soils amended with the recommended agronomic rates of fly ash was not affected negatively by the addition of fly ash.

One of the soil types in Indonesia that need to be improved with an ameliorant is peat soils. Peat land in Indonesia covers an area about 13.2 mio. ha. (Subagyo *et al*., 2000). Chemical properties of peat soils are generally low in: soil pH, exchangeable cations (K, Na, Ca, and Mg), micronutrients, and base saturation. To improve the chemical properties of peat soils, fly ash derived from multifuel boiler (fueled with peat, bark, saw dust, chip and palm oil seed shells) has been used and studied as ameliorant.

The objective of the research was to study the effect of fly ash used as ameliorant on chemical properties of peat soil, quality of water from control wells, and some chemical composition of the Acacia plant leaf.

MATERIALS AND METHODS

Peat soils in Pulau Muda, Riau was planted with *Acacia crassicarpa*. Fly ash derived from multifuel boiler (fueled with peat, bark, saw dust, chip and palm oil seed shells) was added around the tree at the rate range from 5 kg/tree (T-2) to 10 kg/tree (T-6). As addition, chemical fertilizers: FMP, KCl and NPK, each at the rate of 100 g/tree were applied (total fertilizers were 300 g/tree). The basic treatment as control was added only with chemical fertilizers (T-1). Six months after addition of fly ash, the peat soil samples were taken in control area (T-1) and the area with the greatest dosage of fly ash (T-6) at the depth of 0-20, 20-40, 40-60, 60-80, and 80-100 cm. The chemical analysis was conducted on pH, total organic C, total N Kjeldahl, CEC, available P, exchangeable cations and some heavy metals, such as Fe, Cu, Zn, Mn, Cr, Ni, Pb, Cd. Heavy metals was extracted with 0.05 N HCl.

To observe the quality of water in the treated area, water samples were taken from control well and were analyzed for some element. The same observation was conducted on Acacia plant leaf. The samples of plant leaf were taken in control area (T-1) and the area with the greatest rate of fly ash addition (T-6).

RESULTS AND DISCUSSION

The results of chemical analysis of the fly ash derived from multifuel boiler (fueled with peat, bark, saw dust, chip and palm oil seed shells) showed that it contain both macro- and micronutrients, such as K, Ca, Mg, P, S, B, Cu, Zn, *etc*. in relatively high concentrations that are beneficial for plant growth. It has also very alkaline reaction (pH 11.5), therefore it is potentially good to be used as ameliorant. However, fly ash contains also several potentially harmful elements such as Al, As, Cd, Cr, Ni, *etc*. (Table 1). The concentration of Cr and Ni has to be taken into consideration, because these elements are harmful to the environment if accumulate in high concentration.

Six months after addition of the fly ash, peat soil samples taken from the treated area have higher soil pH, exchangeable cations (K, Na, Ca, and Mg), available P and base saturation percentage than those of the basic treatment (Fig. 1). The mobility of the exchangeable cations is shown by a vertical movement in the soil profile till the depth of about 40-60 cm. Chemical analysis on heavy metals showed a significant increase in Fe content and slightly increase in

Table 1. Chemical properties of the fly ash that was used as ameliorant

Parameter	Value	Parameter	Value
pH H_2O	11.5	Mn (ppm)	200
C (%)	3.50	B (ppm)	50
N-total (%)	0.20	Zn (ppm)	24.3
C/N	44	Cu (ppm)	7.90
P-total (%)	0.18	Co (ppm)	1.40
K (%)	1.05	Mo (ppm)	1.80
Ca (%)	5.01	Se (ppm)	<0.003
Mg (%)	0.57	Pb (ppm)	0.40
Na (%)	0.19	Cr (ppm)	18.7
S (%)	0.77	Cd (ppm)	0.20
Fe (%)	1.28	Ni (ppm)	30.4
Al (%)	2.28	Hg (ppm)	<0.01
		As (ppm)	0.90

Zn content throughout the soil profile after the treatment with fly ash (Fig. 2), whereas the concentration of other heavy metal elements Ni, Pb, Cd, and Cr have no different with the control treatment.

The increase of Fe and P content of the soil samples in the area treated with fly ash is in accordance with the increase of the same elements in the water samples. Analysis of the water sample from control wells in the plot which received fly ash addition showed only increase in P and Fe content as compared with the water from the basic treatment (Table 2).

Therefore it can be said that addition of the fly ash as ameliorant in peat soil is relatively safe to the peat soil environment. This is due to the high CEC of the peat soil, so it can bind the element in its absorption site, so as has been shown in these results, most of the elements were bonded in the absorption site. With the addition of fly ash, the soil pH is also increase as shown in the Fig. 1, and in the peat soil which has mostly dependent charge in its absorption site, increasing soil pH mean increasing its CEC, therefore more elements will be bonded in the absorption site.

Plant analysis of the Acacia leaf showed that 6 months after addition of fly ash, relatively no significant different of the elements concentration between plant that received fly ash with the plant without fly ash (Table 3). The variants

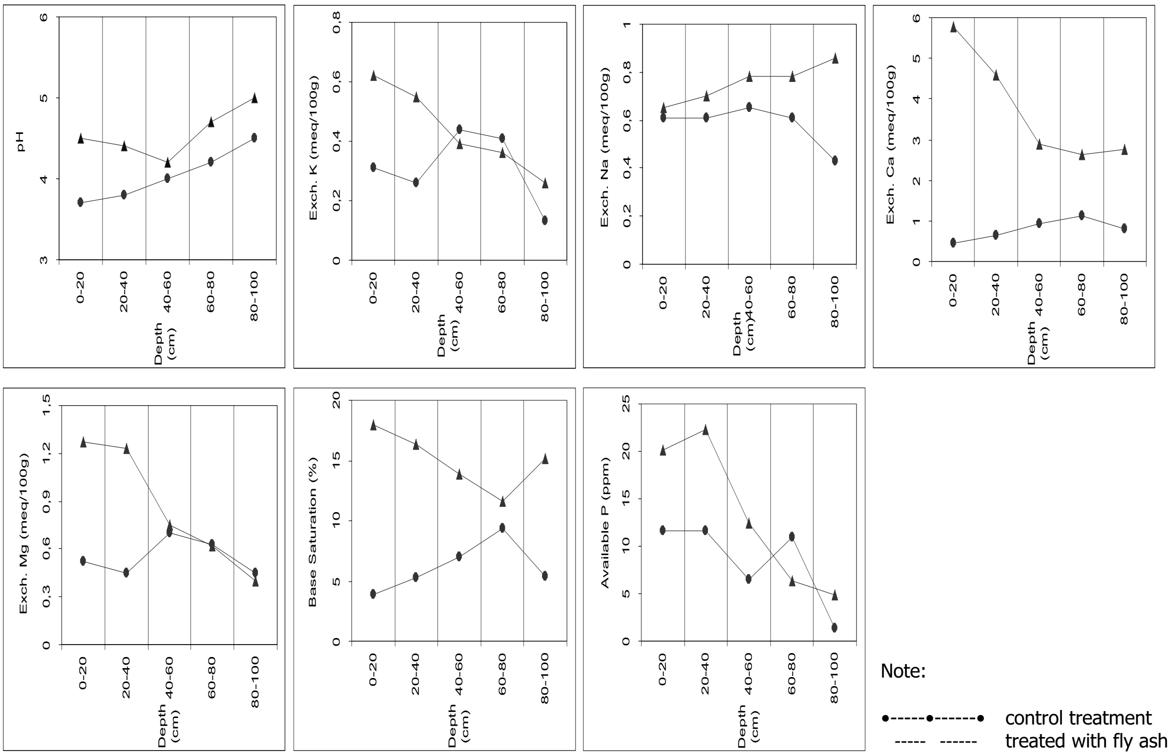

Figure 1. Effect of fly ash application on some chemical properties of peat soil.

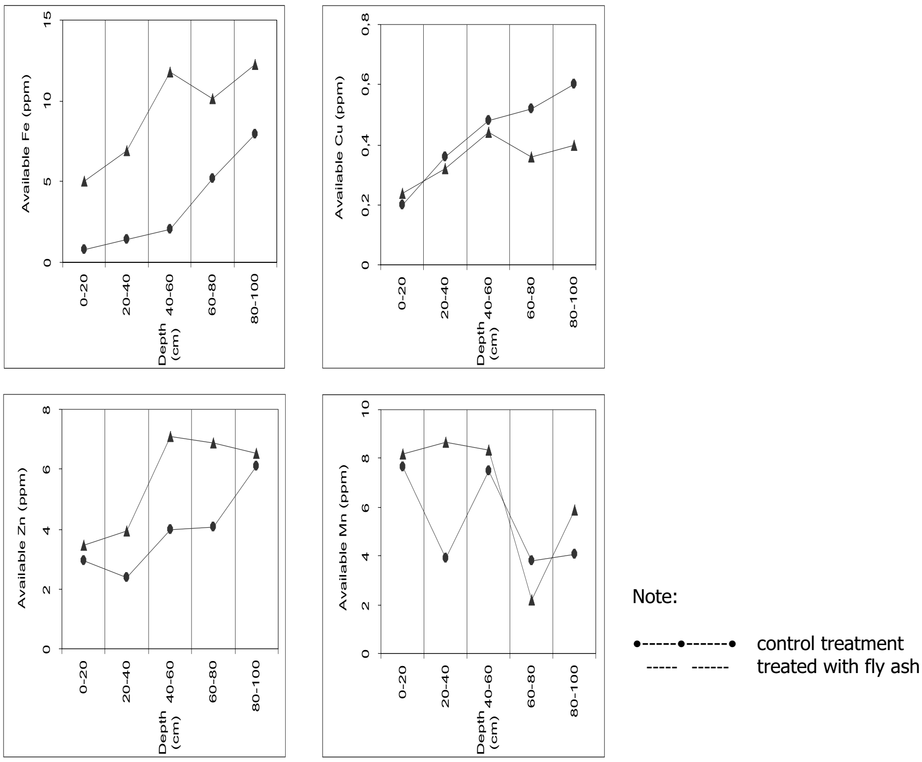

Figure 2. Effect of fly ash application on available of some heavy metals in peat soil.

that occur in the concentration of the element between plant with and without fly ash such as Ca, Fe, Zn*, etc*. are still in the limit of normal plant absorption of those elements. Some elements such as N, P, K, B, *etc*. even lower in the plant that received fly ash. This is due to dilution effect, because plant that received fly ash grows better and bigger, so it has higher plant biomass. Fly ash as ameliorant has improved the growth environment, therefore plant will grow better and faster.

Table 2. Chemical analysis of water taken from control well in plot treatment

Parameter	T-1 (0 kg Fly Ash/tree)	T-6 (10 kg Fly Ash/tree)
pH	4.00	3.70
NO_3	tr*	tr
P	0.06	1.25
Na	5.00	5.00
K	5.50	4.50
Ca	0.70	0.78
Mg	0.50	0.50
Fe	2.56	6.40
Cu	Tr	tr
Zn	1.92	1.12
Mn	Tr	tr
Cr	0.138	0.138
Ni	0.008	tr
Pb	Tr	tr
Cd	Tr	tr

*tr = trace

Table 3. Chemical analysis of Acacia plant leaf

Element	T-1 (0 kg Fly Ash/tree)	T-6 (10 kg Fly Ash/tree)
N (%)	2.47	2.25
P (%)	0.25	0.16
K (%)	1.50	1.25
Ca (%)	0.69	0.96
Mg (%)	0.27	0.31
Na (%)	0.40	0.38
Fe (ppm)	134.8	148.8
Cu (ppm)	5.2	9.7
Zn (ppm)	18.4	24.9
Mn (ppm)	275.3	219.9
B (ppm)	16.0	6.0
Cr (ppm)	0.01	tr*
Pb (ppm)	tr	tr
Cd (ppm)	0.01	tr
Ni (ppm)	0.01	0.02

*tr = trace

Based on the results above it can be said that the use of multifuel fly ash as ameliorant in the peat soil of Pulau Muda has no significant effect on peat soil environment, water quality as well as on plant that grows on that soil. Therefore multifuel fly ash can be used as ameliorant safely in the peat soil as long as the dosage of that fly ash do not exceed 10 kg/tree which this study has proved it. Dosage of fly ash more than 10 kg/tree has not been tried, therefore it is not recommended. It has to be studied more intensively to know how many kg/tree is the maximum dosage that still safe to the environment, water quality and plant growth.

CONCLUSION

1. Addition of fly ash in peat soil after 6 months increase the soil pH, exchangeable cations, available P, and percentage of base saturation.
2. Addition of fly ash slightly increases in Fe and Zn availability of these elements in soil environment, but did not significantly change the soil environment.
3. Plant leaf analysis showed no significant effect of fly ash addition on plant elements concentration. The variants in plant elements content are still in the limit of normal plant absorption of those elements.
4. Water analysis showed no significant effect of fly ash addition on water quality, only slightly increasing in P and Fe content in the water samples taken from the area treated with fly ash

AKNOWLEDGEMENTS
The authors would like to thank the Center for Wetland Studies (CWS), Bogor Agricultural University and Japan Society for the Promotion of Science (JSPS) for their financial support in attending the International Symposium on Land Management and Biodiversity in Southeast Asia conducted in Bali, 17-20 September 2002, and to the Management of PT. Indah Kiat Tbk for its permission to publish the paper.

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Growth Stimulation of *Shorea pinanga* Scheff. and *Shorea seminis* (de Vriese) Slooten. Seedlings Inoculated with *Pisolithus arhizus* (Pers.) Raus. and *Scleroderma* sp. in Nursery Stage

Turjaman M.[1]*, Tawaraya K.[2], Cha J.Y.[3], Tamai Y.[3], Segah H.[4], Limin S.H[4], Osaki M.[3]
[1]Forest and Nature Conservation Research and Development Centre, Ministry of Forestry, Indonesia
[2]Faculty of Agriculture, Yamagata University, Japan
[3]Graduate School of Agriculture, Hokkaido University, Japan
[4]Faculty of Agriculture, Palangkaraya University, Indonesia

*Corresponding author. Mailing Address : Forest Microbiology Laboratory, Forest and Nature Conservation Research and Development Centre (FNCRDC), Ministry of Forestry, Jalan Gunung Batu No.5, Bogor, 16610, Indonesia; E-mail : maman@forda.org

ABSTRACT

An experiment was conducted to investigate the effect of ectomycorrhizas on growth and nutrient uptake of dipterocarps seedlings in peat soils. Two ectomycorrhizal fungal species *Pisolithus arhizus* (Pers.) Raus. and *Scleroderma* sp were isolated under *Pinus merkusii* and *Shorea leprosula*, respectively and two types of inoculum (enbeaded mycelium and spore inoculum) were prepared. *Shorea pinanga* Scheff and *Shorea seminis* (de Vriese) Slooten were inoculated with spores or enbeaded mycelium per seedling and grown in a pot containing with sterilized peat soil at nursery. Percentage of ectomycorrhizal colonization of *Shorea pinanga* and *S. seminis* were 35- 87 %. Both ectomycorrhizas improved height, diameter, leaf number, shoot fresh and dry weight, shoot N and P content of seedlings 7 months after inoculation.

Key words: Shorea pinanga, Shorea seminis, Ectomycorrhiza, Pisolithus arhizus, Scleroderma sp, spore inoculum, and enbeaded mycelium.

INTRODUCTION

Continues disturbances/pressures on forest resources will inevitably lead to desertification of forest soil. Desertification of terrestrial ecosystems is claiming several million hectares annually (Warren *et al.,* 1996). Factors that may accelerate the desertification of forest soil in Central Kalimantan (Indonesia) include illegal logging, forest fire, land mining as well as plotting of one million hectares irrigated field rice. Disturbances of the Tropical Rain Forest (TRF) by logging and other practices disrupts the nutrient cycling processes. Substantial losses in nitrogen, calcium, potassium and magnesium may be evident even two years after logging of a virgin forest (de la Cruz, 1995). By eliminating the disturbance, calcium, potassium and magnesium levels may be restored 16 years after felling (Whitmore, 1990; de la Cruz, 1995). Restoration of the nitrogen content to its original level, however will require more than 16 years. The removal of bases, such as potassium, calcium and magnesium, also reduces soil pH which can cause the solubilization of acid forming metals such as alumunium and iron. These in turn may fix phosphorus leading to the reduction of available phosphorus in the soil. Phosphorus is one of the most unavailable element in the tropical soils (Whitmore, 1990; de la Cruz, 1995).

At present, dipterocarps are high-quality, wood producing trees that are widely distributed in the TRF of Southeast Asia. The Dipterocarpaceae dominate the canopy of the lowland TRF of Malay Peninsula, Sumatra, Borneo, and the Philippines. Unfortunately, their present status is in danger because of uncontrolled deforestation. In Indonesia, major deforestation taking place during the past 30 years has reduced this resources to millions hectares of old growth dipterocarps forest. Recently, novel forest management policies have been introduced to rehabilitate denuded sites as well as enhancing growth of current regeneration (Mayer, 1988; Whitmore, 1989).

Shorea pinanga and *S. seminis* produce tengkawang kernel or Illipe nuts. Kalimantan is an important source of tengkawang kernel. However most of the tengkawang kernel production from this island has been destined for export. Further processing of the raw material within Indonesia is actually possible, as tengkawang kernel is rich in fatty substance, which after extraction and purification can be used as edible oil known as cacao butter. Other possible uses of the fat are for the manufacture of candle, soap, cosmetics and dissolving. Some species were cultivated by local people, generally along the river banks and rivulets, i.e. *Shorea pinanga, S. seminis*, *S. stenoptera*, *S. macrophylla*, and *S. splendida* (Anderson J.A.R., 1975; Wiyono B, 1989).

Dipterocarps has been identified of having specific symbiosis with ectomycorrhizal fungi (ECM) in which the fungi build symbiotic tissues that assist the plant in uptaking and assimilating minerals. Typical dipterocarp ECM are short, pyramidal or racemously branched and variously coloured (e.g. brown, black, white, yellow). A fungal sheath (mantle) characteristic of the fungal partner surrounds the host root. Underneath this sheath lie the radially elongated epidermal cells between which are located the hyphae of the Hartig net (Lee *et al*., 1997). This activity is a key component of the nutrient cycle in the forest floor, hence bigger stem biomass could be achieved (Bakshi, 1974; Hadi & Santoso,1988; Smits, 1994). The most common ECM species found in warmer temperate and tropical forest ecosystems are the Sclerodermatales which can exist either as saprotrophs or as ectomycorrhizal symbionts of several economically important families of trees, including the Eucalypts, the Pinaceae, and the Dipterocarpacea (Sims *et al*., 1997). Ectomycorrhizal fungi may therefore serve as reliable indicators of forest disturbance, but also have a great potential for regeneration of tropical tree species (Lee, 1990; Smits, 1994). Dipterocarp ECM may be important for succesfull seedling establishment and for enchanced uptake of nutrients by mobilizing plant water and nutrient uptake via hyphae and increasing resistance to environmental stress (Lee, 1990). Although much has been documented about the effects of ECM infection on plant growth and uptake nutrients, especially nitrogen and phosphorus, little of this information concerns tropical tree species (Harley and Smith, 1983) and even less is known about dipterocarps (Lee, 1990).

There are a few document reports of improved *Shorea* spp (dipterocarp) seedling growth due to ECM inoculation. *Shorea leprosula*, *S. acuminata* and *Hopea odorata* grown in sterile soil inoculated with root fragments obtained from 1-year-old *S. leprosula* plants were two and half times taller than uninoculated plants after 7 months in nursery stage (Lee, 1991;Yazid *et al*., 1994). Turner *et al.* (1993) reported that *Shorea macroptera* seedlings may only be responsive to fertilizer addition when grown at very low nutrient availabilities, and that ECM infection may be of great importance to seedling growth under such condition. In view of the current international interest in tropical rain forests and the potential of dipterocarps in re-forestation, information about the relative importance of inoculum source in forests, and the degree of ECM dependence or responsiveness, of dipterocarps is needed to assess the role of ECM in forest regeneration and recovery (Lee and Alexander, 1996).

The aim of this study was to investigate the effect of controlled ECM inoculation of *P. arhizus* and *Scleroderma* sp. fungi entrapped in Ca-alginate beads and tabletting spores on the growth stimulation of *S. pinanga* and *S. seminis* in nurseries. The use of alginate beads or spores as inoculum is a viable proposition for low technology nurseries currently producing seedlings for outplanting in developing countries.

MATERIALS AND METHODS

Seeds Germination and Peat Soil Preparation

Peat soils were collected from Kalampangan, Central Kalimantan and fried-sterilized over fiery woods for 1 hour**.** Seeds of *Shorea pinanga* and *S. seminis* were collected from Carita Beach Experimental Forest Site, West Java. These seeds were gently washed with running water and transferred to polybags containing 500 g of sterilized peat soils. Polybags containing seeds of each of species were placed in the nursery of Palangkaraya University, Central Kalimantan. The nursery was 9 blocks and each block was 800 polybags. Polybags were placed under 75 % shading net intensity to minimize solar radiation because both species of *Shorea* require shady condition.

Preparation of ectomycorrhizal fungi

Alginate-Beads: Two ECM species used in this experiment were *Pisolithus arhizus* (Pa) and *Scleroderma* sp (Sc). *P. arhizus* and *Scleroderma sp.* were isolated from Central Aceh (Sumatra Island) under *Pinus merkusii* and Haurbentes Experimental Forest Site (West Java) under *Shorea leprosula*, respectively. The inoculum was grown in Pachlewski liquid medium (Pachlewski and Pachlewska,1974) in 2-liter Erlenmeyer flasks and were placed in shaker for 1 month at 100 rpm. The growing inoculant were kept in a dark room at room temperature (28-30^{o}C) until complete mycelial colonization of the fungi was achieved. The mycelia were harvested and rinsed with sterile distilled water and were cut to obtain homogenous fragments in length (about 1-3 mm in size). Five % of mycelia were then mixed with 15% of coco peat in an aqueous suspension of 2 % sodium alginate (w/v). Then, the inoculant paste as transferred to 5 % calcium chloride solution by passing the paste through a 4 mm mesh sieve to obtain granular calcium alginate-entrapped inoculant. The granular forms were soaked in 5 % calcium chloride solution for 5 minutes and were rinsed subsequently with sterile distilled water. For storage, the beads were soaked in sterile distilled water in a clean capped container to maintain humidity at room temperature (Le Tacon *et al*., 1983; Mauperin *et al*., 1987).

Tablet: Basidiospores were collected in the field under established plantations of pines and dipterocarps. The spores of ECM were processed, mixed in a clay and peletized in a tabletting machine. Weight of tablet was 0.4 g and containing 1 % spores (w/v) (Turjaman and Santoso, 1999).

Inoculation

Inoculation was carried out 10 days after seed germination. ECM spore tablets were applied (1 tablet per seedling) in polybags whereas two ECM alginate beads added near seedling roots (de la Cruz, 1995). In addition, 0.5 g per polybag of Slow Release Fertilizer (SRF) was added as a basic fertilizer (14 % N, 13 % P_2O_5, and 13 % K_2O). The *Shorea* seedlings were irrigated by watering manually daily and weeds were eliminated.

Growth measurement and harvest

A fully Randomised Completely Block Design (RCBD) was applied with five treatments that included control and seedlings inoculated by *Pisolithus arhizus* or *Scleroderma sp.* mycelia each entrapped in calcium alginate beads or spores in tablet. Each was replicated three times. Each assay replication contained 50 seedlings. The effect of growth response was measured at 30 days intervals in height, diameter, fresh and dry weight. The data were subjected to general analysis of variance/two-way ANOVA and the siginificant data were grouped using Duncan Multiple Range Test (DMRT). The plants were harvested 7 months after seed germination. Individual shoot dry weights (80^{o} C) were measured.

The shoot portions of each species in each treatment were bulked for the determination of N and P content. Ground shoots were digested in a H_2SO_4 solution. The N and P contents in the digested solution were determined by the semi-micro Kjeldahl method and vanado molybdate yellow method, respectively.

Ectomycorrhizal infection

Roots were examined for ECM infection. Confirmation of ECM infection was obtained by free-hand section examination of root tips under the light microscope for the presence of mantle and Hartig net (Brundrett *et al.*, 1996). The level of infection was determined by counting the number of infected root tips. To determine the percentage of ECM infection, the root systems were spread on trays and the total number of root tips and the number of ECM short roots were counted and examined under stereo microscope.

RESULTS

Shoot Growth

S. pinanga

Mycorrhizal inoculation of *S. pinanga* using spores and mycelium of both *P. arhizus* and *Scleroderma* sp increased plant height and diameter, leaf number, and shoot dry shoot weight (Table 1).

S. seminis

Inoculation of *S. seminis* using *P. arhizus* and *Scleroderma* sp increased height, diameter, leaf number, fresh and shoot dry weight. There were no differences in these parameters between spore inoculum and mycelium inoculum. Growth stimulation was similar for seedlings inoculated with *Scleroderma* sp. and *P. arhizus* (Table 2).

Table 1. Shoot growth of *S. pinanga* inoculated with *P. arhizus* and *Scleroderma* sp (spore or mycelium) after 7 months in the nursery.

Treatment	shoot growth of *S. pinanga*				
	Height (cm)	Diameter (mm)	Leaf number (/plant)	Fresh weight (g/plant)	Dry Weight (g/plant)
control	42.00a	5.33a	8.67a	13.70a	4.35a
P. arhizus-spore	78.00b	7.67b	22.67b	38.60b	12.99b
Scleroderma-spore	71.67b	7.67b	14.33ab	33.73b	10.97ab
P. arhizus-mycelium	71.33b	7.67b	13.00ab	31.47b	9.90ab
Scleroderma-mycelium	71.00b	7.67b	11.00a	32.87b	11.16ab

*Treatment means showing different letter subscript are significantly different as determined by Duncan Multiple Range Test (DMRT) at the 5 % confidence level

Ectomycorrhizal infection

S. pinanga

Both *P. arhizus* and *Scleroderma sp.* formed ectomycorrhiza in *S. pinanga* seedlings. Ectomycorrhizal infection was higher than 80% in inoculated seedlings. There was no difference of percentage infection between spores and mycelium inoculum. Control seedlings were colonized infection of 30 % by indigenous ECM fungi (Fig. 1).

S. seminis

P. arhizus and *Scleroderma* sp. also formed ECM on *S. seminis* seedlings, but the percentage of infection was lower than *S. pinanga*. Mycorrhizal infection of seedlings inoculated with spore inoculum was higher than those inoculated with mycelium inoculum. Control seedlings were also infected (19 %) by indigenous ECM fungi (Fig. 1).

Table 2. Shoot growth of *S. seminis* inoculated with *P. arhizus* and *Scleroderma* sp (spore or mycelium) after 7 months in the nursery.

Treatment	shoot growth of *S. seminis*				
	Height (cm)	Diameter (mm)	Leaf number (/plant)	Fresh weight (g/plant)	Dry Weight (g/plant)
control	36.67a	4.67a	4.00a	6.07a	2.19a
Pa-spore	57.00b	6.33a	10.00ab	15.67b	5.50b
Sc-spore	43.00ab	5.67a	10.00ab	12.97b	4.64ab
Pa-mycelium	53.33ab	8.33b	8.33ab	18.90b	6.98b
Sc-mycelium	48.00ab	6.67ab	13.67b	16.03b	6.08b

*Treatment means showing different letter subscript are significantly different as determined by Duncan Multiple Range Test (DMRT) at the 5 % confidence level.

Shoot nutrient content

S. pinanga

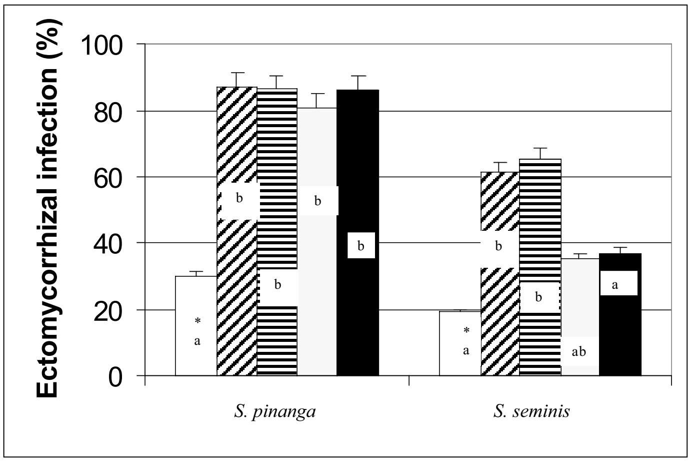

Figure 1. Percentage of ECM infection of *S. pinanga* and *S. seminis* after 7 months in the nursery : control ( ), Pa-spore ( ), Sc-spore ( ), Pa-mycelium ( ), Sc-mycelium ( ).

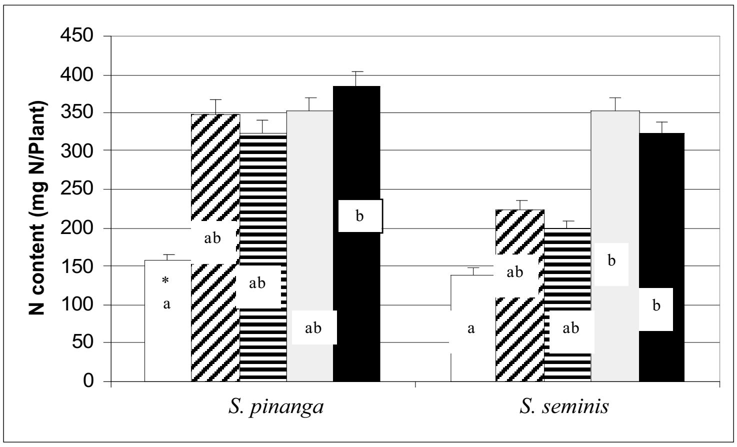

Figure 2. Shoot N uptake of *S. pinanga* and *S. seminis* seedlings after 7 months in the nursery : control ( ), Pa-spore ( ), Sc-spore ( ), Pa-mycelium ( ), Sc-mycelium( ).

*Treatment means showing different letter subscript are significantly different as determined by Duncan Multiple Range Test (DMRT) at the 5 % confidence level.

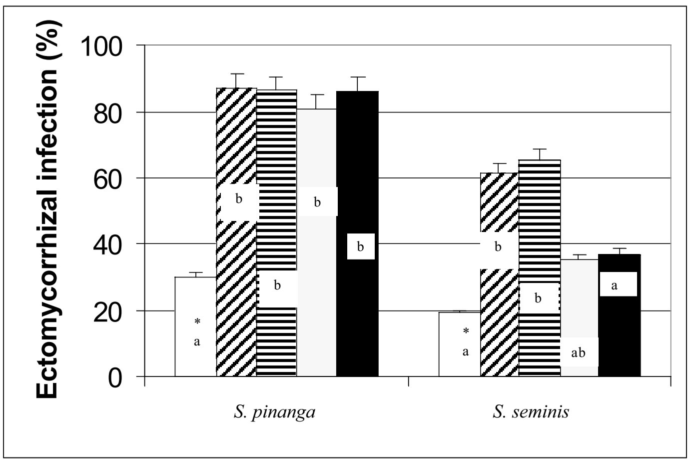

Figure 3. Shoot P uptake of *S. pinanga* and *S. seminis* seedlings after 7 months in the nursery : control ( ), Pa-spore ( ), Sc-spore ( ), Pa-mycelium ( ), Sc-mycelium( ).

*Treatment means showing different letter subscript are significantly different as determined by Duncan Multiple Range Test (DMRT) at the 5 % confidence level.

Shoot N content of *S. pinanga,* inoculated using *P. arhizus* and *Scleroderma* sp. (spore and mycelium treatments) was higher compared to those of controls (349 vs 353 mg N/plant, respectively) (Fig. 2).

P. arhizus inoculation (spores or inoculum) increased shoot P content compared to those of control by 77 and 71 mg P/plant, respectively. Incontrast, shoot P content of *S. pinanga* inoculated with *Scleroderma* sp was lower than those of control (Fig. 3).

S. seminis

Shoot N content of *S. seminis*, inoculated using spores of mycelium either *P. arhizus* or *Scleroderma* sp. Was higher (384 mg N vs 353 mg N). Shoot N content of *S. seminis* inoculated with *P. arhizus* or *Scleroderma* sp spores was also high compared to those of controls (Fig. 2).

Inoculation using *P. arhizus* spore or mycelium increased shoot P content of *S. seminis* compared to those of controls, that is 31 and 68 mg P/plant, respectively. Shoot P content of *S. seminis* inoculated with *Scleroderma* sp mycelium was higher compared to those of controls (Fig. 3).

DISCUSSION

Pisolithus arhizus (Pa) and *Scleroderma* sp. (Sc) inoculum succesfully formed ectomycorrhizas on *S. pinanga* and *S. seminis* seedlings ans mycorrhized plants showed improved height, diameter, leaf number, fresh and shoot dry weight (Table 1), percentage of ectomycorrhizas colonization (Fig. 1) , N and P shoot content (Fig. 2 and 3) after 7 months in the nursery stage.

Percentage of ECM colonisation on individual plants ranged from 81 to 87 % for *S. pinanga* and from 35 to 65 % for *S. seminis*. While unidentified local ECM fungi were observed on control *S. pinanga* and *S. seminis* seedlings (infection rate : 29.79 % and 19.35 %, respectively) they appeared to give no significant effect to the overall results (Fig. 1). Local ECM infection in control treatment was high probably because polybags were placed in a direct contact with the nursery floor made from peat soil. Therefore, it was possible that local ECM fungi persisted in the peat floor slowly reached the seedling roots and formed ECM. However, the significant difference of all parameters ($P<0.05$) between controls and inoculated plants indicated that both ECM inoculants, Pa and Sc, could prevent invasion of local ECM fungi providing that Pa and Sc had an opportunity to initiate infection at first. Further, it was also shown that Pa and Sc inoculant were perhaps more dominant than indigeneous fungi. But the local ECM could not compete with those inoculated with Pa and Sc. In the first our survey, some local ECM species existing in peat-swamp forest included *Laccaria* sp, *Scleroderma* sp, *Russula* sp, and *Boletus* sp. The presence of *Laccaria* sp and *Scleroderma* sp were high, probably, these two fungi were dominant in the nursery stage. Some survey have been made for about six years in Wanariset (East Kalimantan) to identify the fungi associated with dipterocarps. 172 species from 36 genera were identified (Supriyanto *et al*., 1993). *Laccaria*, *Pisolithus*, *Rhizopogon* and *Scleroderma* species were the most common ECM fungi used for experiment and reforestation (Supriyanto *et al*., 1993 and Zarate *et al*., 1993). However, it is surprising that Pisolithus was not identified in dipterocarps forests of Indonesia. In Indonesia, *Pisolithus* sp was found in *Pinus merkusii* (Aceh Province), *Eucalyptus urophylla* and *E. alba* (East Nusa Tenggara) (Turjaman and Santoso, 1999). In Malaysia Peninsula, Watling and Lee (1995) identified *Pisolithus aurantioscabrosus* Walt.nom.prov. associated to *Shorea parvifolia* and *S. acuminata* in lowland dipterocarp forests in Pasoh (Malaysia).

It has been shown that early infection of dipterocarp seedlings is highly dependent on contacts with living ECM roots of adult trees (Alexander *et al*., 1992). This suggests that controlled inoculation of dipterocarp seedlings in the nursery with selected efficient ectomycorrhizal fungal strains should be introduced in forest regeneration programmes. The growth stimulation measured in the present experiments with an exotic ectomycorrhizal fungus shows that a fungal strain isolated from a non-dipterocarp host outside the natural distribution of the Dipterocarpaceae could form perfectly functional ectomycorrhizas with two *Shorea* species. These results suggest that in terms of specificity dipterocarps most probably behave like most temperate tree species, i.e. a particular tree being receptive to numerous broad host range species (Yazid *et al.,* 1994).

Nitrogen content was heigher in shoots of inoculated (or mycorrhizal) plants than in the controls (Fig. 2), indicating that ECM infection improved nitrogen uptake by both *S. pinanga* and *S. seminis*. There was a significant difference in shoot P content of ECM seedlings. *P. arhizus* spores or mycelium could increase shoot P content of *S. pinanga* compared to those of control by 77 and 71 mg P/plant, respectively (Fig 3). For shoot P content of *S. seminis*, *P. arhizus* spores or mycelium inoculum could increase shoot P content compared to those of controls, that is 31 and 68 mg P/plant, respectively (Fig. 3), indicating that ECM infection also improved phosphorous uptake by both *S. pinanga* and *S. seminis* seedlings. Uptake by uninfected root is related closely to rooting intensity and the volume of soil contributing nutrients to the root and root hairs, where they occur. In poorly rooting species there are still considerable volumes of soil between the roots which are not being used. The outgrowth of the ECM fungus into soil far beyond the root or the root hair zone considerably increases the volume of soil being used as the fungus absorbs the poorly mobile nutrients and translocates it back to the root (Bowen and Haselwandter, 1996).

Lee and Alexander (1994) reported that ectomycorrhiza infection in *Hopea odorata* plants increased shoot P concentration and increased shoot and total dry weight to the same or greater extent than those of uninfected plants growing on P amended soil. Yazid *et al.* (1994) reported that growth of two dipterocarp species, *H. odorata* and *H.*

helferi was stimulated by inoculation with a strain of *Pisolithus tinctorius* in pure culture. Phosphorus uptake in the seedlings was also improved by ectomycorrhizal infection.

The tablets containing spores of the mycorrhizal *P. arhizus* and *Scleroderma* sp. contained clay soil as the carrier. Seedlings can be conveniently inoculated by simply dropping one tablet per polybag. Mycorrhizal spore tablets are under pilot testing in Perhutani Ltd. (Java Island) for their effectiveness in increasing growth of *Pines, Eucalypts,* and *Shorea* seedlings. Significant height, diameter, biomass, level of compatibility, survival rate, planting success and fructification of ectomycorrhiza in the field were observed on inoculated of *Pinus merkusii*, *Shorea leprosula*, and *Eucalyptus* spp. The biggest problem in using spores is the inherent genetic diversity of the inoculum. Basidiospores of *P. arhizus* collected from different sporophores and locations may have different genetic traits. Event different species as *Pisolithus tinctorius* is a species complex *P. albus*, *P. microcarpus*, etc. Genetic variations would be greater if basidiospores from sporophores collected from many geographical areas and different tree hosts were combined into a single inoculum (Turjaman and Santoso, 1999). Results revealed that both ECM (*P. arhizus* and *Scleroderma* sp.) can be utilized and are compatible for accelerating growth of *S. pinanga* and *S. seminis* in the nursery.

Both ECM species entrapped in alginate beads could form between 35-36 % of ECM colonization. It means that the percentage of ECM colonization from alginate bead inoculum was lower compare to those of ECM in spore tablet treatments. This is probably the result of different, The amount of mycelia in alginate beads. However, the risk of introducing pathogens, or other uncontrolled microorganisms, is eliminated with mycelium (pure culture) inoculation. The genetic potential of the introduced selected fungal strain can also be determined. Rodrigues *et. al.* (1999) studied the viability of fragmented mycelium of *P. arhizus* entrapped in calcium alginate gel to determine the efficacy of this method of producing ectomycorrhizal fungus inoculum. *Pisolithus arhizus* attained its highest viability (55%) for to 20- to 40-day-old mycelium and gel-entrapped *P. arhizus* mycelium, viability was highest when stored at 25^o C in 0.7 M $CaCl_2$. Liquid industrial fermentation process can be developed. Entrapping the mycelium produced in fermenter with ground peat in alginate is a very suitable method for use in commercial nurseries (Le Tacon *et al.,* 1985; Kuek *et al*., 1992). Alginate beads inoculant could be utilized in large scale nursery production of *Shorea* seedlings to be used for rehabilitation of marginal lands. The process of making alginate beads can be carried out at all time of the year regardless of the season. In contrast, growth of ECM fruiting body as source of spores in tropical climate is relatively unpredictable. On the other hand, tablet of spores can still be used as alternative to that of mycelium entrapped in alginate beads. Both types of inoculum can replace soil inoculum in large scale. In these experiments, we did not find symptoms of root or leave diseases on both Shoreas after 7 months in the nursery.

Up to present, the utilization of soil inoculant have revealed to be inconsistent in achieving a high percentage of ECM infection level. In addition, outbreaks of root and leave diseases have also been encountered in the nursery. Therefore, using soil inoculant are likely to be in practical and ineffective that also require vast volume of soil occupant, are costly, also soil contain unidentified ECM fungal, can not be stored for long term and most importantly massive exploration of topsoil could damage mature stand in exploration site.

Studies on the mass production of infective spore tablets or alginate bead entrapped mycelium are under way as these would efficient procedures to generate ECM inoculum for general applications in rehabilitating peat-swamp forest. Experiments are presently being conducted to determine the optimal amount of some ECM species inoculum needed for successful ectomycorrhizal inoculation of *Shorea balangeran* seedlings originating from peat-swamp forests. Experiments are also being conducted to compare the effect of some local fungal isolates, the emphasis in inoculation programmes for dipterocarps should be on the build-up and use of pure culture ECM strain collections obtained from native dipterocarp forests, i.e. *Scleroderma* sp and *Laccaria* sp. The predominance of *Scleroderma* and *Laccaria* species within these forests suggest that they are potential strains for the young stage and climax stage in the development of forest plantation or natural forests.

ACKNOWLEDGMENTS

Financial support from the Core University Program of the Hokkaido University, Japan Society for the promotion of Science (JSPS) is gratefully acknowledged. We are also grateful Dr. Francis Martin (INRA-Nancy, France) for his critical reading of the original manuscript.

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Rhizoplane pH and Rhizoplane Microflora of Local Rice Varieties Grown on Acid Sulfate Soil in South Kalimantan

Yasuyuki Hashidoko[1*], Toshihiro Hasegawa[1], Erry Purnomo[2],
and Mitsuru Osaki[1]
[1] Graduate School of Agriculture, Hokkaido University, Sapporo 060-8589, Japan.
[2] Center for Tropical Acid Soil Studies, Faculty of Agriculture, UNLAM, PO Box 1028
Banjarbaru, South Kalimantan 70714, Indonesia.

*Corresponding author: Yasuyuki Hashidoko. E-mail: yasu-h@abs.agr.hokudai.ac.jp
Tel: +81-11-706-3839. Fax: +81-11-706-4182.

ABSTRACT
We preliminarily investigated correlation between productivity of rice and diversity of free-living nitrogen-fixing bacteria on its rhizoplane in paddocks of local rice varieties tolerable to acid-sulfate soil in South Kalimantan. We also screened ammonia-releasing factors from the chemical constituents in the root of a local rice variety, Siam Unus. To understand how the local variety of paddy rice tolerable to acid-sulfate soil manage with very low soil pH (2.5-3.5), studies of such free-living, root-associating nitrogen-fixing bacteria on the rhizoplane are likely to be important.

Key words: Oryza sativa L., rhizoplane bacterium, Sphingomonas, rhizoplane pH, acid-sulfate soil.

INTRODUCTION
Since tropical peat swampy forests, distributed throughout lowland area of Central Kalimantan, had been opened for farming, emergence of acid-sulfate soil on the farmland came into a major problem. Drastic decrease of crop production within several years in the domestic agricultural management forced the farmers to abandon their farmlands, and this often leads them to illegal logging. After the logging activity, the forests are burned for clearing to open new farmlands where repeatedly turn into acid-sulfate soil after several years. Accordingly, vast area of tropical peat swampy forests has been destroyed. To avoid deforestation in Kalimantan, it is quite necessary to cut such a vicious circle chain. So, establishment of agricultural methods for sustainable crop production and field management on the acid-sulfate soil land is a solution of the pressing problem. We, hence, focused on acid-tolerable wild plants and crops to understand function of their root systems which are involved in the acid-adapting strategy of the plants.

Main problem of acidic soil for plants is a toxicity of aluminum cation (Al^{3+}). Acid-sulfate soil showing approximate pH 2.5-3.5 releases a large amount of Al^{3+} that directly or indirectly disturbs nutrient assimilation from the roots. Some acid-sulfate tolerable plants, such as *Melastoma* sp., *Juncus* sp. and *Melaleuca cajuputi*, however, can manage with such excess Al^{3+} and are able to regenerate on such strongly acidic soil lands. As the representative acid-tolerant plants, genus *Melastoma* including *M. malabathricum* L. and tea plant (*Camellia sinensis*) are known to be Al-accumulators, while *Juncus* spp. and *Melaleuca cajuputi* are representative Al-excluders paddy rice (*Oryza sativa*) comparatively tolerable to acid-sulfate soil is a member of Al-excluders (Watanabe and Osaki, 2002). Since acid-sulfate soil with very low pH (2.5-3.5) has suffered serious leaching, such acid-tolerable plant must employ certain strategy to acquire nutrients, including N and P. The rice production, so far we investigated, reached to 3-4 t/ha, without any fertilization nor lime-input (Hasegawa *et al*., 2002a). Since we regarded the high yield performance of rice in the acid-sulfate paddock as a good model for LISA, three paddocks were chosen as monitoring plots to monitor chemical properties of the soil, rhizoplane microflora and its rice productivity were investigated in each paddock (Hasegawa *et al*., 2002b).

Since paddy rice is known as ammonia-assimilating plants that prefer NH_4^+ rather than NO_3^- for their nitrogen source, the presence of free-living nitrogen-fixing bacteria on the rhizoplane of the local rice varieties is thought to be beneficial for them to survive in acid-sulfate soil land. Releasing ammonia into the rhizosphere may also play a role in neutralization of the rhizospheric soil to reduce toxicity of aluminum, so our idea was that ammonia produced from free-living nitrogen-fixing bacteria on the rhizoplane are a key factor in the adaptation of local paddy rice to acid-sulfate soil. So far our preliminary investigation, free-living nitrogen-fixing bacteria were frequently isolated from the rhizoplane of the local paddy rice. In this paper, we report rhizoplane pH of the local rice varieties and investigation of their rhizoplane microflora, particularly those of nitrogen-fixing bacteria, and further discuss on micro-ecological role of those diazotrophic bacteria.

MATERIALS AND METHODS
Preliminary Measurement of Rhizoplane pH on Several Acid-tolerant Plants and Soil pH
For preliminary, simple pH measurement for rhizoplane of the acid-tolerant plants inhabiting acid-sulfate soil, peat soil or sandy spodozol-like soil, a portable pH meter (ORION model 250A, USA) equipped with a glass microelectrode (9863 BN, ORION), a half of which stainless cover to protect the tip has been removed. The soil attached to the surface of fresh root was washed out with pure water using a handy spray bottle. With a soft polyurethane foam, free water on the

root was absorbed, and enhold the root and bare glass electrode with the polyurethane foam. The pH value was recorded until the pH meter indicate stable numeric over 10 seconds. After measured rhizoplane pH of 8-10 numbers of the samples, the highest and the lowest data were both eliminated and then calculated the mean and standard deviation (SD) for remaining ones. For soil pH, a raw soil (ca. 1 cm^2) was put in a plastic bag and added double volume of pure water. Suspending the soil into the water for 10 min, the soil water was directly measured by the handy pH meter. In the case of paddock soil, microelectrode was directly attached on a wet soil cake, and hold it until pH value became stable for 10 seconds.

Screening Method for Rhizoplane Microorganisms
We used a gellan gum-base soft gel medium for observation and evaluation of the microflora of rhizoplane nitrogen-fixing bacteria (Hashidoko *et al*., 2002). Solidifying with this gel matrix (0.3%), a nitrogen-free medium (Winogradsky's salt medium) with 1% glucose as sole carbon source (Tchan and New, 1984) was initially used. The root fragment (1 cm long) was washed several times with 20-25 ml of sterile water, and finally vortexed for 30 sec. in 10 ml of sterile water in an 18-cm test tube. The resulting washings were used as the inocula, regarding that it contains rhizoplane bacteria. For inoculation, generally 100 μl of the washings was added to the liquefied soft gel medium and briefly vortexed 3-times.

Physiological Properties of Emerging Bacteria in the Soft Gel Medium
Bacteria developed in the soft gel medium showed some patterns of the colony emergence, according to the factors as follows: a) respiratory type, b) motility and oxygen adaptability, and c) population of bacterial cells. By patterns of the colony emergence in the soft gel medium, it was possible to know such physiological characters of the dominant nitrogen-fixing bacteria on the rhizoplane of investigating plants. When BTB, a pH indicator, was added to be final concentration of 40 ppm, it is also capable of monitoring ammonia or organic acid accumulation on real time in the soft gelled medium. For the medium pH monitoring, *Klebsiella pneumoniae* IFO 3318 and *Beijerinkia indica* subsp. *indica* IFO 3744 were used as the reference bacteria.

Identification of the rhizoplane bacteria
Some bacteria were purified on a modified Winogradskyís medium (Winogradskyís mineral mixture, 0.5% mannitol, 0.005% yeast extract and 2% agarose), and their phenotypic and physiological characters were investigated. For identification, 16S rDNA sequences determination was done. Total DNA used for the template for PCR amplification of the 16S rDNA regions was prepared by Isoplant II (Wako Pure Chemical Industries Ltd.). For the reaction, the PCR kit, Gene *Taq* (Nippon Gene), was used according to its instruction protocol. The first amplification for 16S rDNA region with universal forward (5í-AGARTTTGATCCTGGCTCAG-3í, 27f) and reverse (5í-AAAGGAGGTGATCCAGCC-3í, 1525r) primers (Hiraishi, 1992) was done as 30 cycles of 94 ^{o}C for 1 min, 53 ^{o}C for 1 mim and 72 ^{o}C for 1 min. The PCR product was diluted 10 times with pure water, and directly used as the template for the second amplification with forward (5í-CTACGGGAGGCAGCAGT-3í, 357F) and reverse (5í-ACGAGCTGACGACA-3í, 1076R) primers under the same reaction conditions above (Weisburg et al., 1991), and the resulting PCR product was sequenced by ABI PRISMÆ 310 Genetic Analyzer with BigDye Terminator Cycle Sequencing, FS (Applied Biosystems). The sequence homology was then searched on the database program, BLASTN, provided by DDBJ on its web site.

RESULTS AND DISCUSSION

Rhizoplane pH
Rhizoplane pH of several varieties of paddy rice, including Japanese Koshihikari and Hoshitaro grown in Hokkaido University Experimental Paddock, was preliminary measured with the microelectrode. All of the root in any type of paddocks showed their rhizoplane pH almost at 7.0 or so. When whole hill had died, rhizoplane of the dead roots indicated more acidic pH values, push to the soil pH. For more precise measurement of rhizoplane pH, fluorescent pH-indicator or other technique should be applied for these acid-tolerable plants.

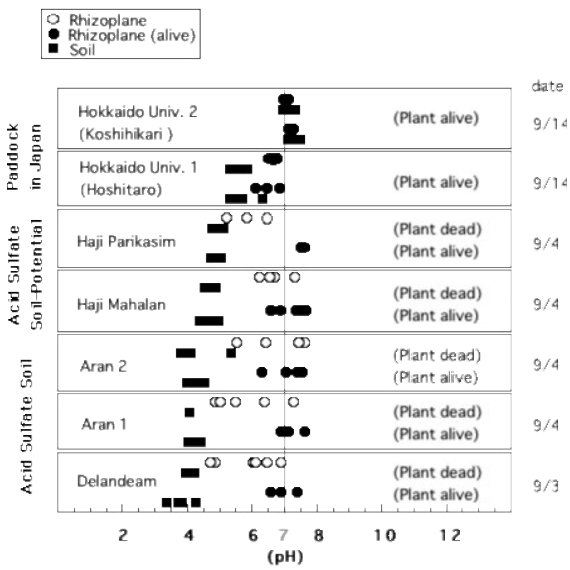

Figure 1. Rhizoplane pH of paddy rice grown in acid-sulfate or other type of Soil. (n=4~6)

Screening Method
We used a soft gel medium for observation and evaluation of the microflora of rhizoplane nitrogen-fixing bacteria, of which method was first developed by a Brazilian microbiologist, Dobereiner and her coworkers at 1980th (Dobereiner, 1995). The soft gel method was convenient method for sampling of rhizoplane nitrogen-fixing bacteria during outfield investigation. Dobereiner originally used

agarose as gel matrix at low concentration (0.2%); however, we found some inconvenience of the gel matrix, namely less transparency, inflexible gel structure and rapid solidifying nature. To overcome these inconvenient natures of agarose, we replaced agarose with 0.3% gellan gum that is originated from bacterial polysaccharide and usually in use for plant tissue culture. Solidifying with this gel matrix (0.3%), a nitrogen-free medium (Winogradsky's salt medium) with 1% glucose as sole carbon source was initially used.

Physiological Properties of Emerging Bacteria in the Soft Gel Medium

Bacteria developed in the soft gel medium showed some patterns of the colony emergence, according to the factors as follows: a) respiratory type, b) motility and oxygen adaptability, and c) population of bacterial cells. By patterns of the colony emergence in the soft gel medium, it was possible to know such physiological characters of the dominant nitrogen-fixing bacteria on the rhizoplane of investigating plants. In addition, free-living nitrogen-fixing bacteria mix-cultured in the soft gel medium showed certainly combined patterns (e.g. from lumps/ sparse to lumps or cloud to layer) (Hashidoko et al, 2002). When BTB, a pH indicator, was added to be a 40 ppm concentration, it is capable of observing ammonia or organic acid accumulation in the half-gelled medium, on real time. In many plants we tested, the root washings rapidly turned the media into acidic along with development of the colony (type A), but inocula from the local paddy and other acid-sulfate soil- tolerable plants kept culture media to be neutral, despite of their fine emergence of the colony. Some of them eventually inclined pH of the medium to be alkaline region after 3- or 4-week-incubation.

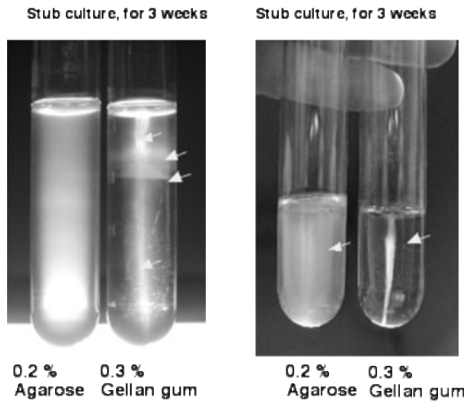

Figure 2. Bacterial colonies developed in N-free soft gel saccharose medium solidified with agarose and gellan gum.

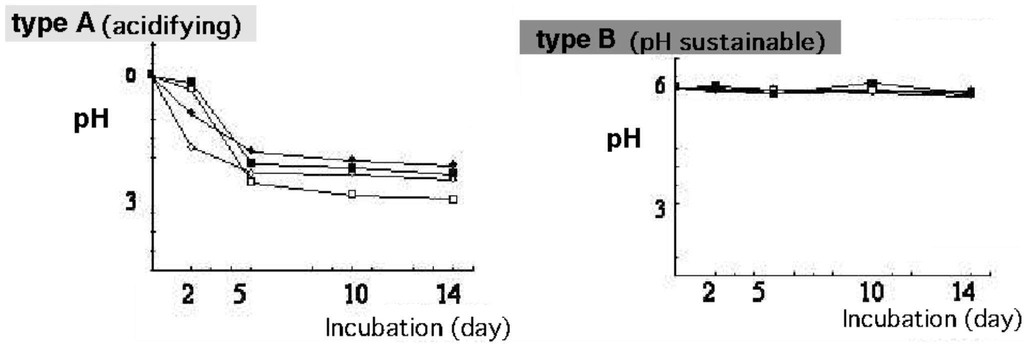

Figure 3. Visualized pH change in the BTB-containing N-free medium that had been inoculated rhizoplane bacteria of some plants sampled at Central and South Kalimantan.

Diversity of N-Fixing Bacteria on Rhizoplane of Local Rice Varieties

Free-living nitrogen-fixing bacteria on rhizoplane of Gramineae plants often show a simple, thin layer as their colony pattern; however, those from local varieties of paddy plant in South Kalimantan frequently formed multiple layers. Because layer-forming bacteria are highly motile, they are probably able to move into more profitable conditions, particularly with demands toward appropriate concentration of dissolving oxygen, and they are probably able to share niche to occupy large part of the rhizoplane/rhizosphere.

Therefore, we further focused on correlations among diversity of the rhizoplane microlflora, ammonia supply, and rice production. In fact, nitrogen-fixing bacteria from *Melastoma* sp. and local varieties of paddy plants able to grow on acid-sulfate soil showed relatively high diversity.

Characterization of Sphingomonas sp. as Rhizoplane Bacteria from Local Paddy Rice

Among rhizoplane microorganisms cultured in the half-gel medium, those from local rice varieties inhabiting acid-sulfate soil paddocks in South Kalimantan, showed highly diverse microflora. After isolation of the bacteria composed of the microflora, all of the bacterial isolates were investigated their 16S rDNA sequence of by PCR technique. Homology search (with BLAST system at NRIGA) led to identification of these isolates from local varieties to be *S. rose, S. adhaesiva, S. parapaucimobilis, S. melonis* and three unknown *Sphingomonas* sp. The major isolates were surprisingly all *Sphingomonas* bacteria. We have yet no direct evidence whether theses *Sphingomonas* spp. are involved in a group of free-living nitrogen-fixing bacteria, and there is only one reliable report about nitrogen fixation by *Sphingomonas* sp.

(Adhikari et al., 2001). However, their highly frequent appearance from the acidic soil-tolerable plants, including local paddy rice strongly suggested characteristic function of *Sphingomonas* sp. on the rhizoplane under acidic soil conditions.

CONCLUSION

Based on the results from our preliminary investigation, we estimated certain contribution of rhizoplane bacteria to the acid-tolerant plants in their adaptability to acid-sulfate soil. It is hence significant to study further those rhizoplane *Sphingomonas* sp. on the paddy rice in nursery pot and container experiments. Moreover, effects of root exudates on behaviors of root-associating nitrogen-fixing bacteria, which involves their role in regulating rhizoplane pH, should be examined. All of the phenomena that we observed in productivity and physiological behaviors of local rice varieties are likely to be highly linked with their functional rhizoplane microflora, which regulate rhizospheric conditions.

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Session 5

PEAT SCIENCE

Chaired by

Koyo YONEBAYASHI & Mashhor MANSOR

Factors Acidifying Peat in Central Kalimantan, Indonesia

Akira Haraguchi[1], Midori Akioka[2], Sawahiko Shimada[3], and Tsutomu Iyobe[4]
[1]The University of Kitakyushu, Hibikino 1-1, Wakamatsu, Kitakyushu 808-0135, Japan
[2]School of Development, University of East Anglia, Norwich NR4 7TJ, UK
[3]Faculty of Regional Environment Science, Tokyo University of Agriculture, Sakuraoka, Setagaya, Tokyo 156-8502, Japan
[4]Graduate School of Science and Technology, Niigata University, Ikarashi 2-8050, Niigata 950-2181, Japan

Corresponding Author: Akira Haraguchi, The University of Kitakyushu, Hibikino 1-1, Wakamatsu, Kitakyushu 808-0135, Japan. Tel. 093 695 3291; Fax. 093 695 3383; e-mail sphagnummire@hotmail.com

ABSTRACT

The chemical properties of peat pore water in the basin of the Sebangau River and Lahei district, Central Kalimantan, Indonesia, were studied with reference to the data for Cape Ochiishi Mire and Furen Mire, eastern Hokkaido, Japan. We analyzed the major ions, pH, electrical conductivity (EC) and redox potential (Eh) of the peat pore water with reference to their vertical profile. Correlations between sulfate concentration and pH in peat pore water exhibited differences between the mires. A negative correlation between pH and sulfate concentration in the Paduran site implies a contribution of sulfuric acid on pH produced by pyrite oxidation originating from the underlying sediment. However, a positive correlation between pH and sulfate concentration was found in Lahei and the upper Sebangau sites. The present findings suggest that sulfuric acid production by pyrite oxidation is not the dominant acidification process of the peat pore water in the peat lands in the upper basin.

Key words: acidification, proton, pyrite, redox potential, tropical peat

INTRODUCTION

Peat is the accumulated organic remains of dead plants, and now peat lands are regarded as an important carbon pool which regulates green-house gases in the atmosphere (Shimada et al., 2001). The basin of the Sebangau River and the Lahei district, Central Kalimantan, Indonesia, belongs to the tropical forest zone and has very high precipitation in the rainy season, which impedes plant decomposition as a result of the high water table and the consequent anoxicity in the peat layer. Rain forests are established on peat lands in tropical areas, and hence tropical peat contains higher amounts of woody plant material than circumpolar herbaceous peat lands with grasses, and the acidity of tropical peat is much higher than the circumpolar peat (Anderson, 1983; Clymo, 1983; Haraguchi et al., 2000). The soil of this area is characterized by Spodzol with an extensive bleached horizon composed of white sand and silt of quartz (Djuwansah, 1999), and this is due to the high acidity of the peat. A problem caused by the destruction of the peat layer in the coastal region of Central Kalimantan is the oxidation of pyrite in the sediment underneath the peat layer. After destruction of a peat layer occurring with pyrite-containing sediments, the sulfuric acid concentration will increase in the soil, and a large proportion of nutrients will be lost. Also, the sulfuric acid leached from the soil causes acidification of river water and consequent effects on the estuarine areas. In this study we tried to accumulate fundamental data for evaluating how the acidity of peat pore water is affected by pyrite oxidation.

MATERIALS AND METHODS

Study Area

We surveyed five sites in the Central Kalimantan, Indonesia during the dry season, the lowest precipitation of the year (Kurasaki, 2000). The study site in Lahei is in the upper basin of the Mangkutup River (Haraguchi et al., 2000). Three sites, Setia Alam Jaya, Bakung and Rasau, were in the upper basin of the Sebangau River. Another site in Paduran was in the lower basin of the Sebangau River (Fig. 1). Site characteristics are summarized in Table 1.

For comparative purposes in our analysis of tropical peat, we used data from Cape Ochiishi Mire and Furen Mire in eastern Hokkaido, Japan (Table 1).

Methods

We took peat core samples from the peat top to the mineral surface with an Edjelkamp peat sampler. Peat pore water was collected from bulk peat samples by filtering though nylon mesh (ca. 0.2 mm). Samples were taken at every 10-25 cm interval of the core.

The pH, electrical conductivity (EC) and redox potential (Eh) of the peat pore water were measured immediately after sampling. The concentrations of cations (ammonium, sodium, potassium, magnesium, calcium) and anions (chloride, nitrate, nitrite, sulfate and phosphate) were analyzed using an ion chromatograph (TOA, Tokyo, Japan and

Dionex Japan, Osaka, Japan) after samples had been filtered through a 0.45 mm cellulose ester membrane filter (ADVANTEC TOYO, Tokyo, Japan).

Spearman's correlation analysis was used to test the correlation between pH and other chemical parameters of the peat pore water.

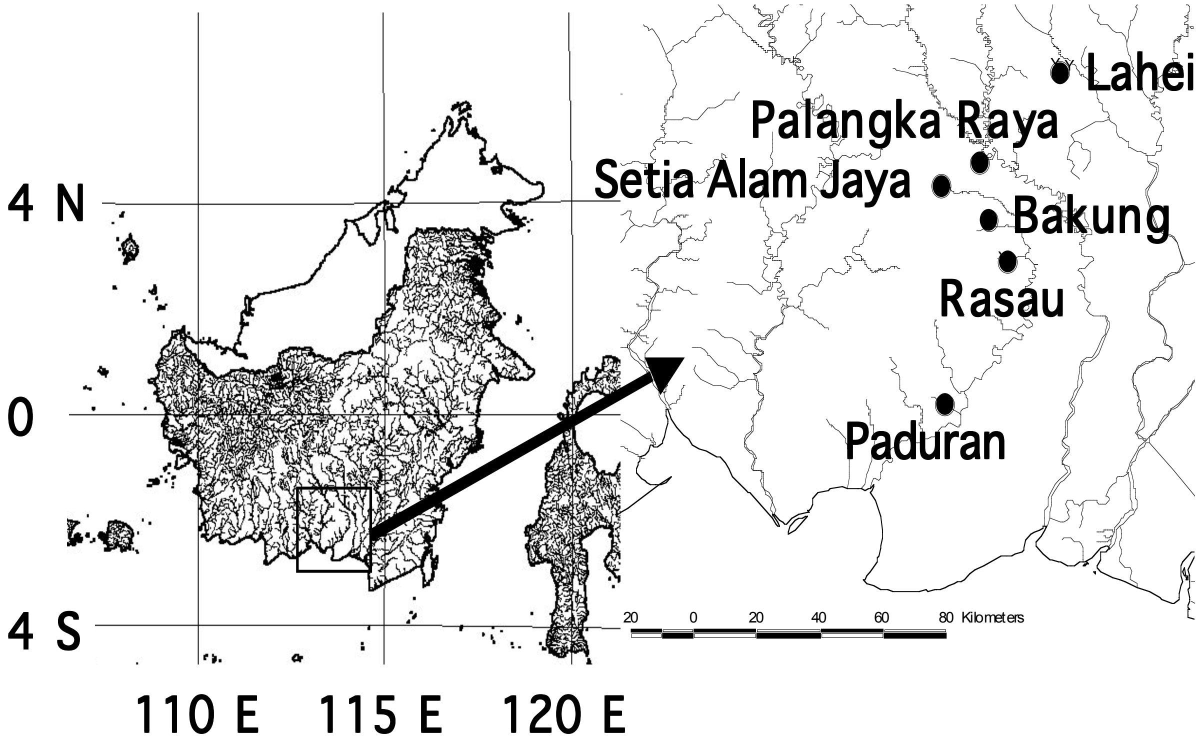

Figure 1. Map of the study sites in Central Kalimantan, Indonesia

Table 1. Characteristics of the study sites.

Area	Location	Altitude	Land use	Sediment
Lahei	1°55'S, 114°10'E	43m	natural forest mire	sand
Setia Alam Jaya	2°18'S, 113°55'E	12m	natural forest mire	sand
Bakung	2°24'S, 113°56'E	12m	natural forest mire	sand
Rasau	2°30'S, 113°59'E	12m	natural forest mire	clay
Paduran	2°53'S, 113°46'E	9m	paddy field, natural forest mire	clay
Cape Ochiishi Mire	43°10'N, 145°31'E	50m	ombrotrophic mire, forest mire	clay, silt
Furen Mire	43°17'N, 145°15'E	10m	minerotrophic and ombrotrophic mire	clay

RESULTS AND DISCUSSION

At the Lahei study site, the pH of the peat pore water showed significant positive correlations with redox potential, and with potassium, ammonium and sulfate concentrations, and it showed a significant negative correlation with nitrate concentration (Table 2).

At the three study sites in the upper basin of the Sebangau River, the pH of the peat pore water showed significant positive correlations with calcium, ammonium and sulfate concentrations (Table 2).

At the Paduran study site, the pH of the peat pore water showed significant positive correlations with potassium, nitrate and chloride concentrations, and it showed a significant negative correlation with sulfate concentration (Table 2).

At the Cape Ochiishi Mire in eastern Hokkaido, the pH of the peat pore water showed significant positive correlations with calcium and nitrate concentrations, and it showed significant negative correlations with redox potential, and with

Table 2. Spearman's correlation coefficient between pH and other chemical parameters of the peat pore water in mires in Central Kalimantan, Indonesia. EC: electrical conductivity, Eh7: redox potential corrected at pH = 7.0, n: number of data. Significance level of correlation: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, NS not significant $p > 0.05$.

Site	Lahei n = 46	Upper Sebangau n = 75	Paduran n = 22
EC	0.065 NS	-0.211 NS	0.184 NS
Eh_7	0.583 ***	0.038 NS	-0.098 NS
Na^+	0.230 NS	0.197 NS	0.159 NS
K^+	0.389 **	0.098 NS	0.525 *
Mg^{2+}	-0.032 NS	0.119 NS	-0.049 NS
Ca^{2+}	-0.262 NS	0.236 *	-0.244 NS
NH_4^+	0.590 ***	0.236 *	0.149 NS
NO_3^-	-0.510 ***	-0.051 NS	0.679 ***
Cl^-	0.258 NS	0.064 NS	0.515 *
PO_4^{3-}	0.119 NS	0.027 NS	0.360 NS
SO_4^{2-}	0.555 ***	0.277 *	-0.487 *

Table 3. Spearman's correlation coefficient between pH and other chemical parameters of the peat pore water in mires in Eastern Hokkaido, Japan. EC: electrical conductivity, Eh7: redox potential corrected at pH = 7.0, n: number of data. Significance level of correlation: *** $p < 0.001$, ** $p < 0.01$, NS not significant $p > 0.05$.

Site	Cape Ochiishi Mire n = 390	Furen Mire n = 43
EC	0.037 NS	0.545 ***
Eh_7	-0.547 ***	-0.536 ***
Na^+	-0.039 NS	0.462 **
K^+	-0.295 ***	-0.274 NS
Mg^{2+}	0.060 NS	0.549 ***
Ca^{2+}	0.295 ***	0.415 **
NH_4^+	0.049 NS	-0.539 ***
NO_3^-	0.170 ***	0.282 NS
Cl^-	-0.153 **	-0.596 ***
PO_4^{3-}	-0.027 NS	0.099 NS
SO_4^{2-}	-0.294 ***	0.458 **

potassium, chloride and sulfate concentrations (Table 3).

At the Furen Mire, the pH of the peat pore water showed significant positive correlations with electrical conductivity, and with sodium, magnesium, calcium and sulfate concentrations, and it showed significant negative correlations with redox potential, and with ammonium and chloride concentrations (Table 3).

As indicated by the correlation analysis, the determinant factors of the pH of the peat pore water were different among study sites. Among the chemical parameters, redox potential showed a significant correlation with pH at the Lahei site, Cape Ochiishi Mire and Furen Mire; however, the correlation was quite the opposite between tropical peat and temperate peat. At the Lahei site, reduced soil condition is related to the acidic condition. The redox potential of the peat pore water, however, constantly showed a value > 100 mV vs. NHE, and hence the anoxic decomposition of organic substances should not be considered the determinant process which makes the peat pore water acidic. High nitrate concentration accompanied acidic conditions, and hence decomposition under oxic conditions would promote acidification in Lahei peat. In Ochiishi Mire and Furen Mire, on the other hand, high redox potential accompanied acidic conditions. The redox potential of the peat pore water, however, constantly showed a value > 100 mV vs. NHE as at Lahei, so the temperate peat also showed oxic conditions from the top to the bottom. Low concentrations of nitrate in Ochiishi Mire and high concentrations of ammonium in Furen Mire accompanied acidity of the peat pore water. These imply somewhat reduced conditions would produce organic acids in peat which would acidify the peat.

Sodium and magnesium, major components in sea salts, showed positive correlations with pH in Furen Mire. Furen Mire is a coastal mire with low elevation and the mire should experience frequent sea water inundation. These correlations imply that the supplied sodium and magnesium ions were exchanged for protons in organic substances, and the protons contributed to the acidification of the peat pore water.

Potassium and chloride concentrations showed different correlations with tropical and temperate peat. In tropical peat, low concentration of these ions relates to low pH. Negative correlation of chloride concentration and pH in Furen Mire would be explained by the effects of sea salt on acidification. Chloride is also supplied by sea water inundation. Only cations, however, were exchanged for protons in organic substances, and anions remained in the peat pore water. Consequently, low concentrations of sea water cations and high concentrations of chloride accompanied acidity in coastal peat. Cape Ochiishi Mire is also in a coastal area, but it was established on a coastal terrace 50 m a.s.l. As a result, atmospheric deposition, rather than direct inundation, is the dominant sea salt supply process for the peat in the Cape Ochiishi Mire. Although the correlations of sodium and magnesium with pH were not significant, the significant negative correlation of chloride with pH suggests a contribution of sea salt to the lowering of the pH of the peat in Cape Ochiishi Mire.

Low calcium concentration accompanied low pH in both the tropical and temperate mires. Although there is no calcareous water supply for these mires, calcium supply should be one of the neutralizing factors for peat pore water at all the studied mires.

Sulfate showed different correlations among the mires studied. Low concentrations of sulfate accompanied low pH at the Lahei site, the three sites in Upper Sebangau and at Furen Mire. This implies that sulfuric acid should not be considered the determinant factor in acidification of peat pore water in these mires. At the Paduran site and Cape Ochiishi Mire, however, high concentrations of sulfate corresponded to low pH. This implies that sulfuric acid is possibly the determinant factor for low pH at these two mires. It is evident that the mineral subsoil in Paduran contains high concentrations of pyrite, so pyrite oxidation and the consequent diffusion of sulfuric acid to peat pore water possibly acidifies the peat pore water. The redox potential of the peat pore water was > 100 mV even at the bottom layer of peat, so the peat redox condition is oxic enough for the oxidation of pyrite even at the bottom layer. At Cape Ochiishi Mire, sulfate would be supplied from sea salt via atmospheric deposition. This could be explained as following the same process as chloride.

Although a contribution to the acidification of peat by sulfuric acid produced through pyrite oxidation originating in the underlying sediment was found at Paduran, the lower basin of a river, sulfuric acid production by pyrite oxidation is not the dominant acidification process for peat pore water in the tropical peat lands in the upper basin.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Suwido H. Limin and Mr. Sapariono of the University of Palangka Raya for their support in the field work, and Dr. Seiichi Nohara of the National Institute for Environmental Study for analytical work. This work was financially supported by the Core University Program of the JSPS and the Sumitomo Foundation for Environmental Research.

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Isotope and Lignin Signatures in Tropical Peat Core (Rawa Danau, Indonesia): An spproach to reconstruct past vegetation and climate changes

Shafi Mohammad Tareq[1*], Keiichi Ohta[2], Noriyuki Tanaka[3,4]
[1]Division of Earth and Environmental Sciences, Graduate School of Environmental Studies, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8601, Japan
[2]Hydrospheric Atmospheric Research Center, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8601, Japan
[3]Graduate School of Environmental Earth Science, Hokkaido University, Sapporo 060-0810, Japan
[4]Frontier Research System for Global Change, International Arctic Research Center, University of Alaska, Fairbanks, USA

ABSTRACT

Peat samples from a 3.60 m core collected from Rawa Danau, West Java, Indonesia, were studied to reconstruct past vegetation and climate changes. The study carried out combining visual observations, elemental analyses, stable carbon and nitrogen isotope analyses as well as CuO oxidation of lignin residues. Variations of total organic carbon (TOC: 55.53 - 3.18 %, mean 23.31%), total nitrogen (TN: 2.52 - 0.06 %, mean 0.94%) and water content (WC: 46.8 - 93.2 %, mean 79.0 %) with core lithology reflected dry and wet cycles. Vertical profiles for TOC, TN, WC and core lithology also had signatures of heavy precipitations and consequent land sliding at the abrupt change of climate (wet cycles). Variations of $(C/N)_a$ (15 – 93, mean 27) and $\delta^{13}C$ (-27.0 to -30.1 ‰, mean -28.5 ‰) of organic matter (OM) in the peat core indicated that the organic material was comprised of terrestrial C3 plant material. The direct input of aquatic plant matter was small or overwhelmed by high terrestrial input, although changes in lake productivity due to decreasing/increasing nutrient availability were reflected in $\delta^{15}N$ profile. At low elevations in the tropical area, a large shift in vegetation zones was not likely observed. Most species might persist at the site when small-scale localized environmental changes and human disturbances or natural forest fires occurred, but the abundances of particular species might change, depending on the natural conditions in which a species could grow. However, vegetation changes associated with periodical sequence of dry and wet microenvironment were inferred from the total lignin phenol (TLP) profile.

Key words: isotope, lignin, peat, tropical, wetland, vegetation and environment.

INTRODUCTION

Histosole (peat soil) contains a considerable amount of organic matter (OM) and provides a verity of indicators that can be used to reconstruct the past depositional environment and paleoclimate (Cerling et al., 1989; Aucour et al., 1999; M¸ller and Voss, 1999; Choi, 2001). The types of vegetation that existed at a locality at different times in the past can also be estimated from compositions of OM in different age's peat layers. Tropical lowland peat deposits are often dominated by trees and shrubs (Phillips and Bustin, 1998; Wüst and Bustin, 1999). Peats from Malaysia, Indonesia, Irian, Java and Thailand have large amounts of woody material and amorphous matrix (Wüst et al., 2001). The amorphous matrix contains residues and fragments of fibers, leaves, roots, spores, pollen, diatom, hard wood and partially decayed wood tissues. Tropical peats are therefore rich in lignin with significant amounts of cellulose, hemicelluloses, protein and water-soluble compounds which are partially lost during early microbial activities (Orem et al., 1996; Kuder and Kruge, 1998). A wealth of environmental and ecological information preserved in peat can often be obtained from stable isotope analyses (Rundel et al., 1989; Bowen, 1991). The natural variations in stable isotope ratios of both carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) are extremely useful in tracing and quantifying sources, sinks and flux within the biogeochemical cycles (Filley et al., 2001).

In the present study, an attempt has been made to reconstruct the past vegetation and climate changes in tropical area, Rawa Danau, West Java, Indonesia, using $\delta^{13}C$, $\delta^{15}N$, atomic $(C/N)_a$ ratios of OM together with lignin phenol composition (CuO oxidation) of a peat core. The principals behind using these parameters for this purpose are; (1) significant differences of $\delta^{13}C$ values in different plant types depend on photosynthetic pathway [C3 plant: -23‰ to -34 ‰ (-27‰) C4 plant: -9‰ to -17‰ (-13‰) and CAM plant: -10‰ to -30‰; Deines, 1980; O' Leary, 1988; Farquhar et al., 1989], (2) source plant can be identified by lignin phenol compositions (gymnosperm plant: vanillyl phenols, angiosperm plants: vanillyl and syringyl phenols, nonwoody plant: vanillyl, syringyl and cinnamyl phenols; Hedges and Mann, 1979; Orem et al., 1997) as well as lignin enrichment of peat sample, and (3) the isotope and lignin composition of the OM in peat is similar to the isotope and lignin composition of the vegetation cover from which it derived.

MATERIALS AND METHODS

Study Area

The Rawa Danau lies in an ancient caldera of Danau volcanic complex on the north-western tip of West Java, Indonesia, at an elevation of around 100 m above sea level (asl), at 6˚11'S and 105˚59' E (Fig. 1). The catchments include the steep hills and mountains forming the wall of the caldera. The surrounding caldera rim is at an altitude about 140 m asl, and the adjacent high volcanic terrain is mostly between 400-700 m asl, but the Mt. Karang, some 15 km to the southeast, reaches 1778 m asl. Two hundred years ago, there was a substantial lake in the caldera, the size of which is unknown, and it does not exist at present as its original form (Endert, 1932). Rawa Danau occupies a few km^2 and the deepest part is the crater bottom which is largely occupied by swamp. Early of the last centaury, it covered approx. 50 km^2 and artificial attempts had been made to drain the lake and reclaim the land for agriculture purpose by lowering the base of the outlet channel (Endert, 1932). The northern part is still a morass and regarded as an important nature reserve because of its unique flora. The Danau area is drained by three rivers namely Ci danau, Ci kalumpang and Ci bojang. Among them Ci danau catchments covered major portions (72 km^2) of caldera that originated on the northern lower slopes of Karang volcano. The danau volcanic complex is of plio-pleistocene age and formed in a number of eruptive phases. It appears that all other volcanic centers are presently dormant. The geomorphology of the inner caldera is indicative of the youngest sedimentation. Nearly all sediments are derived from the southern volcanic slopes and deposited in alluvial fans and fluvial system in the caldera. A survey of the swamp deposit by Indonesia Geological Survey (IGS) shows that deeper basin deposits (> 6 m depth) consist of fine-grains (organic silt-clay) with minor intercalations of peat and fluvial sands (Rimbaman, 1994). Peat deposits prevail in the central swamp area with sequences up to 4-5 m thickness just below the surface.

Climate of the Java Island in Indonesia is driven by the Asian monsoon system. This system produces both dry and wet

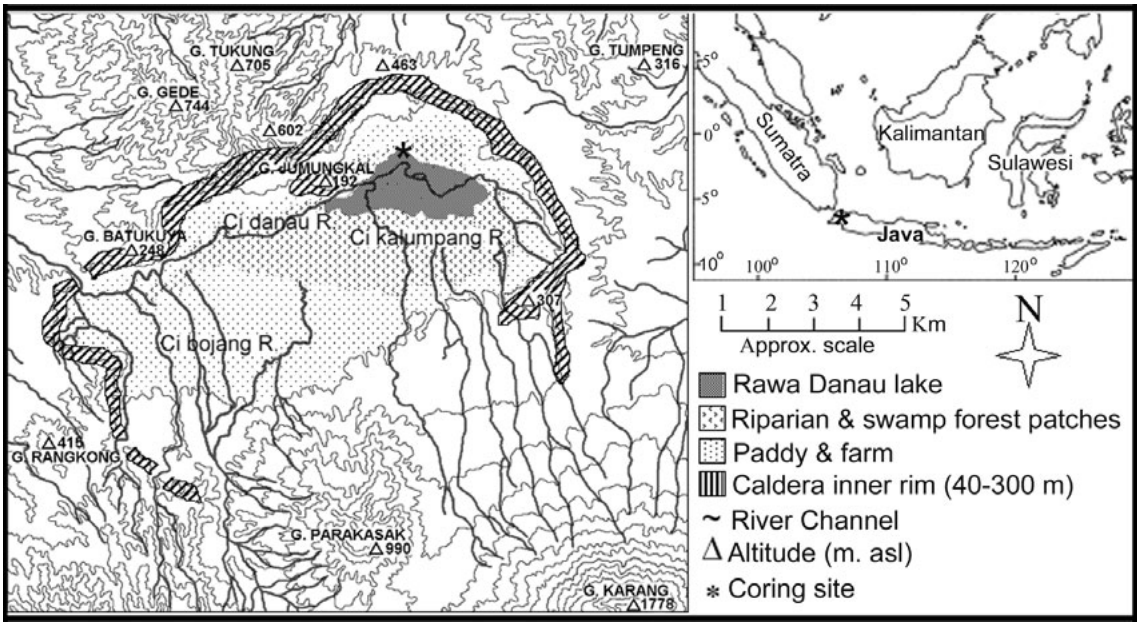

Figure 1. Map of the coring site

monsoon climates. The mean yearly temperature for all of Java is approx. 27.5 ˚C and does not vary systematically along the longitudinal moisture gradient. Van Steenis (1965) documented a pronounced floristic gradient across the island correlated with the change in climate. Vegetation of Rawa Danau explained else where in detail (Kaars et al., 2001). Briefly, the main vegetation types of Rawa Danau are mixed forest swamp, *Ficus retusa* swamp forest, open herbaceous swamp and dry land largely deciduous (Stujts, 1993; Kaars et al., 2001; references therein). On the slope of the hills and mountains, the lowland tropical rain forest is gradually replaced by sub-mountain and mountain forest. The swamp vegetation in the northern part is partially replaced by rice field, but the signature of original swamp forest is still common at the edge of remaining fresh water swamp. Agriculture farm (mainly rice field) and villages are developed in southern part of the Danau where the original vegetation is cleared or replaced. A mosaic of secondary and deciduous high forest vegetation dominates the hilly northwestern slopes of the caldera.

Sampling

After analyzing three test cores from Rawa Danau, the main core (RD-1), 3.60 m deep and 10 cm diameter, was collected by piston coring in September 2001. Since piston coring disturbed upper portion of the main core, a gravity sub-core of 32 cm was collected to maintain sedimentary sequence. The peat cores were divided into slice approx. 2 cm thick, sealed in polyethylene bag and transported to laboratory. The material was freeze-dried, homogenized with mortar and pestle, passed through a 300 µm sieve and finally preserved for subsequent analysis.

Elemental and isotopic analyses
The water content (WC) was determined gravimetrically using weight differences between wet and freeze-dried samples and expressed in %. Weight percentage of total organic carbon (TOC) and total nitrogen (TN) were measured by Thermo Quest elemental analyzer of model NA2500 NCS. Samples were combusted at 1000^0C to CO_2 and NO_x gas and a subsequent Cu-packed column reduced NO_x to N_2 gas at 750^0C. The CO_2 and N_2 gases were separated chromatographically, detected using a thermal conductivity detector (TCD), and the resulting signals were digitized, integrated and mathematically processed along with results based on standard. Alanine was used as a standard for TOC and TN determination using peak areas recorded by shimadzu RA6 integrator. During each measurement, standard alanine samples were inserted after 10 natural samples intervals in an auto-sampler to check the analytical results. A few selected samples run several times for estimating the reproducibility of the measurements and found that the deviation is less than ±5% for both TOC and TN.

Stable carbon and nitrogen isotope compositions were determined by the method involving automatic combustion in a elemental analyzer (Thermo Quest NA 2500 NCS) interfaced via a Finnigan CONFLOW II system to a Finnigan MAT 252 mass spectrometer (Finnigan, 1995). Half the samples were analyzed at least in duplicate with a maximum difference of ±0.2‰ between replicates. The performance of the automatic EA-CONFLOW II - MS system was evaluated by running the working standard alanine samples of known δ^{13}C (-21.56 ‰) and δ^{15}N (-5.25 ‰) values and the accepted values were obtained for both of carbon (±0.07‰) and nitrogen (±0.21 ‰) within samples size ranges 7-100 µg carbon and 100-300 µg nitrogen for the measurements.

Lignin analysis
About 30 mg of bulk lipid free peat was oxidized with CuO at 170 ˚C for 3 hours in 2N NaOH containing ferrous ammonium sulfate [$Fe(NH_4)_2(SO_4)_2.6H_2O$] (Hedges and Ertel, 1982). After adding known amount of ethyalvanilline and cinnamic acid as internal standards and adjusting the pH to1 by adding 6N HCl, lignin phenols were extracted with peroxide-free diethylether. The quantification of lignin phenol monomers were performed by GC (Shimadzu14B) equipped with DB-1 (60 m x 0.25 mm, id). Details of the procedures were described elsewhere (Tareq et al., 2002).

RESULTS AND DISCUSSION
Core lithology and sedimentation rate
The core (RD-1) of 360 cm in total length collected by 380 cm core tube insertion indicated only less than 5% compaction during coring operation. The upper 50 cm of the core was a mixture of grass-woody peat and partially decayed plant tissues except for the depths of 8-12 cm that were enriched by silty-sand-clay. Visual inspection during sample processing indicated that rest of the core (50 - 360 cm) was mainly composed of woody peat. A few numbers of silty-sand-clay enriched layers were detected at different depths (9, 115, 175, 225, and 280 cm). Perhaps, these silty-sand-clay layers are the signature of upper mountainous erosion due to heavy precipitation or changing water level of the lake. No decreasing trend with depth was observed in water content (WC) profile, rather it was correlated with core lithology, TOC and TN as shown in Fig.2. It was also clear from the WC profile that compaction effect was not pronounced during sedimentation. Macroscopic observation of detritic materials indicated that this mineral faces deposited in a calm deposition milieu. There was no trace of current activity within sediments.
Nine conventional radiocarbon (^{14}C) dates on bulk sediments are available for the core RD-1 sequence. Dates were

Table1. Calibrated radiocarbon ages* of the core RD-1.

Sample code	Depth (cm)	Uncalibrated ^{14}Cage± SD (BP)	Cal. Age in BP		Cal. Age in AD/BC	
			(1)	**(2)**	**(1)**	**(2)**
RDT2	22	410±240	423(*0.78*)	353	AD 1527(*0.78*)	AD 1600
RDT3	55.5	880±220	820(0.94)	858(*0.97*)	AD 1130(0.94)	AD 1098(*0.97*)
RDT4	66.9	1040±280	954(*0.93*)	974(*0.98*)	AD 996(*0.93*)	AD 976(*0.98*)
RDT5	99	1400±260	1305(*0.95*)	1310	AD 645(*0.95*)	AD 640
RDT6	123.2	1600±290	1547(*0.97*)	1548	AD 404(*0.97*)	AD 402
RDT7	137.6	1740±350	1672	1704	AD 278	AD 246
RDB1	175.3	3030±260	3169	3287(*0.98*)	BC 1220	BC 1338(*0.98*)
RDB2	188.3	3500±360	3813(*0.98*)	3800(*0.98*)	BC 1861(*0.98*)	BC 1851(*0.98*)
RDB3	207.7	4020±360	4429(*0.96*)	4455(*0.97*)	BC 2480(*0.96*)	BC 2506(*0.97*)
Bottom	360	6529 (Cal.)	7428	7428	BC 5479 *(0.79)*	BC 5479 *(0.79)*

*Ages are calibrated in both years B. P. and A.D./B.C., and expressed at one sigma (68.3% confidence) and two sigma (95.4% confidence) ranges. Where multiple intersections of the calibration curve occur, the largest relative area of the probability distribution in each case was chosen to represent the most probable age range (probability values shown in brackets and *italicized*). Age values are meadian age of the two sigma calibrated ranges.

calibrated by CALIB rev. 4.3 (Stuiver et al., 1998), and are presented in Table 1. The age/depth relationship ($r^2 = 0.93$) indicated a coherent sequence of increasing age with depth. Based on the calibrated radiocarbon dating results of the bottom, the average sedimentation rate of the core was 0.048 cm/y. This rate is lower than those of mangrove and other sub-recent coastal sedimentation in the tropics, but comparable to other tropical wetland (Ledru, 2001). However, rate of sedimentation of this lake was not uniform for all depth. Grass peat showed higher rate of sedimentation (0.079 cm/y) than that of woody peat (0.031 cm/y). The organic matter preserved at the bottom section of the core represented Holocene materials (7.4 ka BP). The low accumulation rate observed after 1.7 ka BP made the interpolated ages somewhat uncertain in comparison to the much better resolution of the overlying sections.

Distribution of organic carbon and nitrogen

The TOC content remained high throughout the all depths with some sharp peaks at different depths as usually observed for the accumulation of OM from terrestrial sources (Aucour et al., 1999; Bourdon et al., 2000, references therein). A vertical profile of TOC showed variation between 3.18 and 55.53 % with an average of 23.31 %. The major sources of OM in the peat land are the detritus of land plants that have covered the coring site and upper mountainous catchment areas. Detritus form phytoplankton and algae can be an important additional contributor to the OM in peat of tropical wetland.

The vertical distribution of total nitrogen (TN) with depth of peat core is shown in Fig.2. The TN ranged from

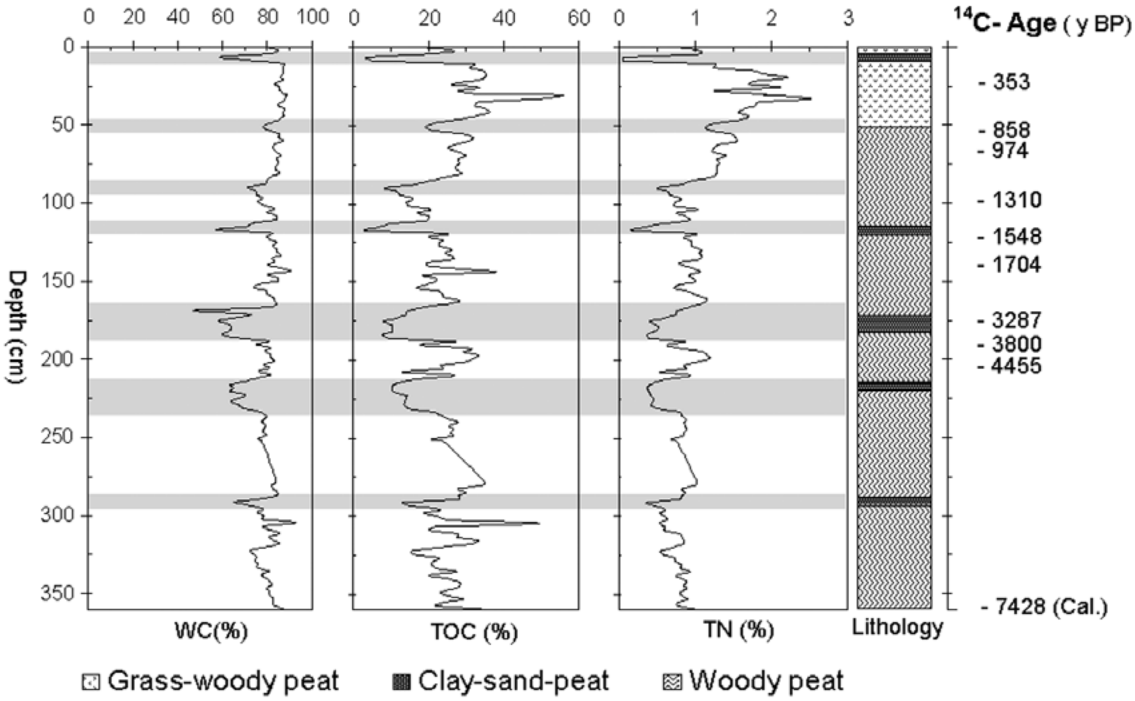

Figure 2. Vertical distributions of total organic carbon (TOC), total nitrogen (TN) and water content (WC) with calibrated ^{14}C-age. Shaded areas indicate different hydrological regimes.

0.06 to 2.52 % with an average value 0.94% for overall the depths. In relation to TOC content, TN also showed peaks at the same depths. There was a significant correlation (Fig.3; $r^2 = 0.66$) between TOC and TN which could be attributed to the possible unique source signature overall the accumulation period. Although TN showed similar trend, the concentrations were a factor of 8-10 lower than that of TOC. Both TOC and TN contents were higher in woody peat layer than the clay-silt-sand enriched layers. The atomic ratios of carbon to nitrogen $(C/N)_a$ varied frequently (15 - 93) with an average value 27. The $(C/N)_a$ ratio is widely used to identify the source of OM (Meyers, 1994; Herczeg et al., 2001). Vascular land plant has C/N ratios higher than 20 (C/N > 20) due to comparatively high cellulose content whereas non-vascular sources like algae and phytoplankton have C/N ratios from 4 to 10 (Meyers, 1997). Most of the layers of core RD-1 had $(C/N)_a > 20$ indicating vascular plant sources, but few layers at different depths had $(C/N)_a$ 20 - 10 due to complex heterogeneous contributions of the terrestrial plant sources and in-situ developed aquatic species such as algae, phytoplankton, and other protein enriched sources under an optimized environmental condition. The hydrological variations may be results of land use changes and river regulations. A large scale natural/artificial diversion of three major rivers in caldera could reduce water discharged of pre-regulation amount which influenced swamp vegetations.

Isotopes signature

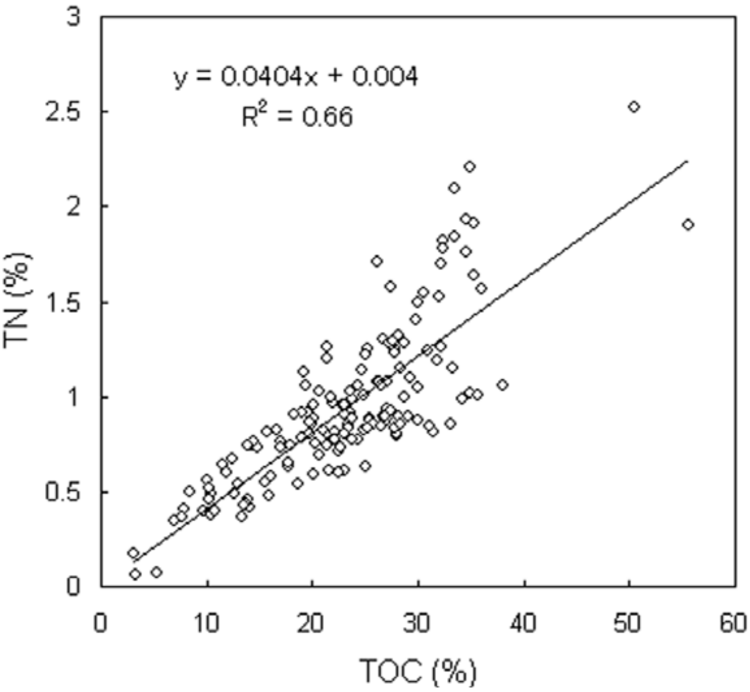

Figure 3. Correlation between TOC and TN of the RD-1 core

The $\delta^{13}C$, $\delta^{15}N$ and (C/N)a values for the whole core are plotted versus depth in Fig.4 along with calibrated time scale for the 7.4 ka BP (^{14}C age). The $\delta^{13}C$ displayed a small range of fluctuation between -27.0 and -30.1 ‰. This shift apparently should be caused at least by selective loss of the isotopically heavy carbohydrate fraction (compare to lignin) of total OM (Spiker and Hatcher, 1984). Diagenetic effect usually induces minor $\delta^{13}C$ depletion in buried OM (>2 ‰ ; Macko et al., 1991; Meyers, 1994) and can be considered as a secondary factor for the observed variability. Moreover, the core did not show any strong downward trends for diagenetic signature in $\delta^{13}C$ as well as $(C/N)_a$. Despite of the possibility of a diagenetic overprint on the isotopic compositions, the overall changes in $\delta^{13}C$ values from -27.0 to -30.1 ‰ in the peat core would reflect changes of environmental factors that influenced the isotopic discrimination during photosynthesis of the primary biomass producers.

The average values of $\delta^{13}C$ (-27.2 ‰) and C/N ratio (27) is a signature of the dominance of C3 terrestrial plants though the

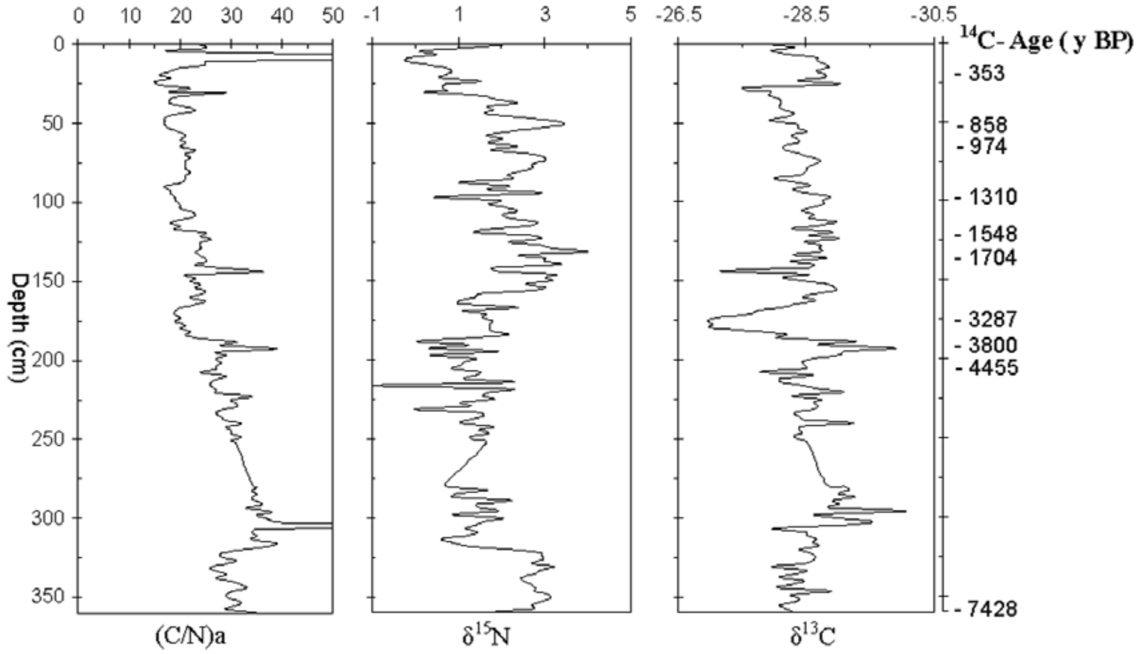

Figure 4. Vertical profiles of (C/N)a, $\delta^{13}C$, $\delta^{15}N$ with calibrated radiocarbon age

isotopic signature of C3 land plants can not be distinguished from that of fresh water algae (Meyers, 1994). The natural difference in stable carbon isotope ratio of different plants provides fine resolution spectrum of vegetation succession in tropical wetland (Chmura et al., 1987; DeLaune, 1986) and has the potential to provide valuable evidence of changing hydrological regime and climate. In Rawa Danau, the vegetation was not completely altered during peat development, but only relative abundances of different plant species (angiosperm, gymnosperm, nonwoody plants) changed as was shown by lignin phenol compositions (Tareq et al., 2002). The irregular changes of $\delta^{13}C$ values at different depths were more likely due to isotopic fractionation in changing relevant climatic parameters including precipitation and air temperature. Stewart et al., (1995) suggested a co-efficient for eastern Australian climate covering a large range of precipitation (350-1500 mm) and open vegetation. They measured a decrease of 0.33 ± 0.07 ‰ per 100 mm increase in precipitation, but the control of temperature on $\delta^{13}C$ plant was poorly constrained. It is difficult in a natural environment to separate its influence from other parameters. The variation of $\delta^{13}C$ in the peat core reflects the changes water availability results in a complex balance among precipitation, annual distribution, evaporation, water runoff and drainage.

Variation of $\delta\, ^{15}N$ values of peat core RD-1 was between -1.0 and 4.0 ‰ with mean of 2.0 ‰, indicating the change in composition of source materials and relevant environmental parameters. Algal and land plant sources of OM have distinct values of $\delta^{15}N$ due to the different isotopic composition of inorganic nitrogen taken by aquatic and land plants. Hydrological changes can also affect the $\delta^{15}N$ value of peat of the tropical wetland. Meyers et al. (1998) noted a 2 â shift towards higher values due to lowering of the water level in Pyramid lake, Nevada, that was caused by partial diversion of Truckee river for agricultural use. This is caused by a decreasing nutrient availability in lake as runoff (due to low precipitation) from the catchment area decreases. During periods of high productivity, phytoplankton may be forced to fully utilize available dissolved inorganic nitrogen (DIN) and tend to be more enriched in ^{15}N than during periods of low productivity (Meyers et al., 1998). The major rivers in Rawa Danau shifted several times artificially and/ or naturally, and it might play an important role in shifting the $\delta^{15}N$ values. The chronological information derived from ^{14}C indicated that the enrichment of $\delta^{15}N$ in the peat core began in mid Holocene when the lake became shallow (From diatom records; Kaars et al., 2001) and $\delta^{15}N$ was depleted again from the late Holocene. Vertical profile of $\delta^{15}N$ should reflect changing in aquatic productivity of the wetland. Both $\delta^{13}C$ and $\delta^{15}N$ values of the peat core documented several times of shift probably due to the relative productivities of structurally and functionally-distinct components of tropical ecosystem in response to human use or natural environmental variation. The elemental carbon record indicated frequent forest fire from mid-late Holocene and $\delta^{13}C$-elemental carbon showed a positive correlation with $\delta^{13}C$-TOC (H. Tsuji, personal comm.). The forest fire events documented by the elemental carbon record concur with dry climatic conditions of periodical wet and dry cycles (as shown in Fig.2). It can be postulated that the local climate has been influenced by long term oscillation as we observed like ENSO events for last few decades in tropical zone. However, geochemical records from a single peat core are insufficient to precisely predict such changes.

Lignin signature

Figure 5 gives a representative gas chromatogram of the CuO oxidation products of Rawa Danau peat. Eleven lignin

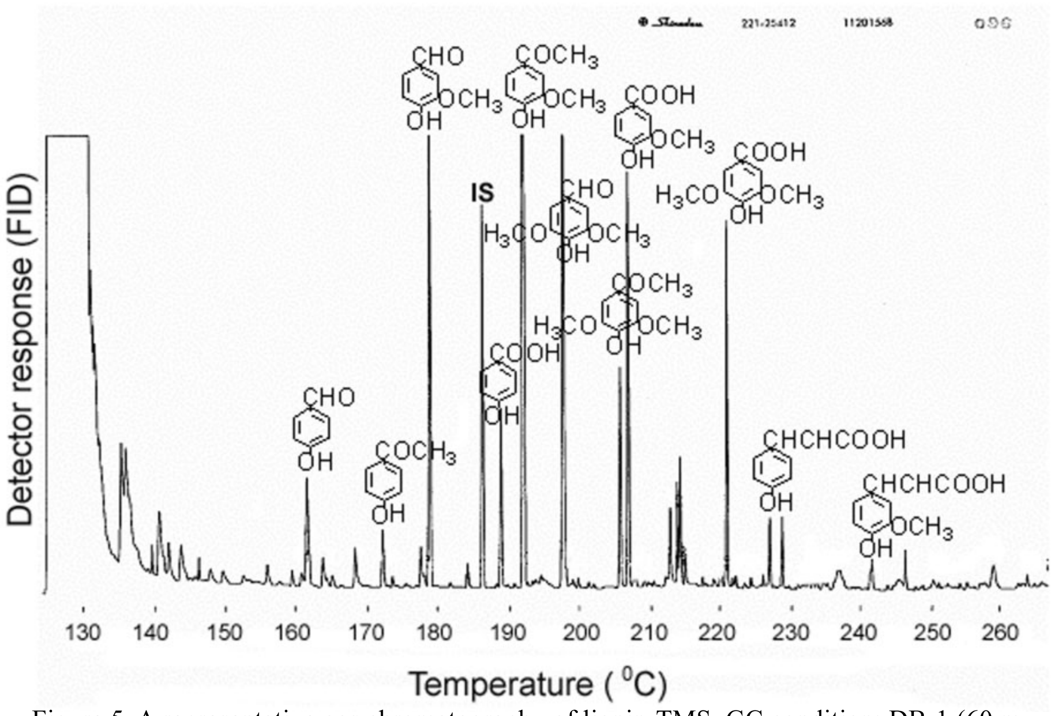

Figure 5. A representative gas chromatography of lignin-TMS, GC condition: DB-1 (60 m x 0.25 mm i.d.), 120^{0}C to 290^{0}C at the rate of 2^0/min, ethyalvanillyl used as GC internal standard.

phenol monomers (p-hydroxybenzoic, vanillyl, syringyl and cinnamyl phenols) were determined among CuO oxidation products of 24 pre-selected samples. Vanillic phenols are derived from the coniferyl lignin and both vanillic and syringic phenols are from sinapyl moieties of lignin. They consist of aldehydes, ketones and acids. The p-coumaric and ferulic acids (cinnamic unit) linked to cellulose by ester bonds are generated from the cinnamyl alcohol-derived moieties. p-Hydroxybenzoic phenols were also determined, but this group can be partly derived from other sources than lignin (Hedges and Parker, 1976; Hedges and Ertel, 1982). Total lignin phenol (TLP) in mg/g dry peat is calculated as the sum of the four groups (p-hydroxybenzoic, vanillyl, syringyl and cinnamyl phenols).

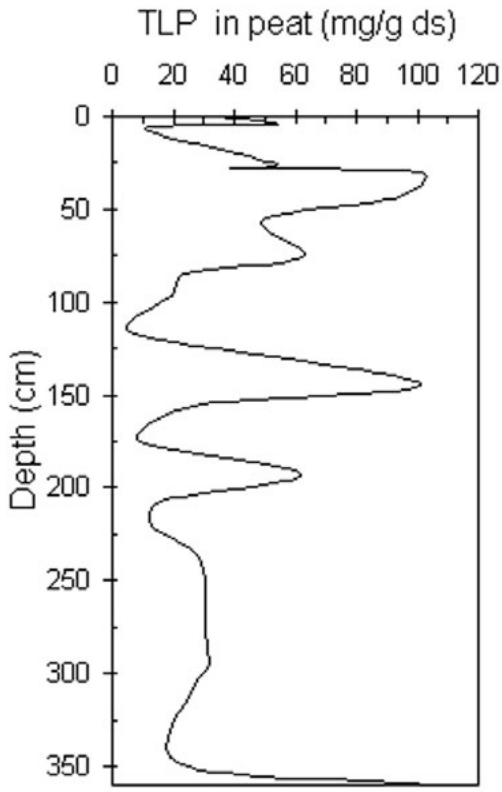

Figure 6. Vertical distribution of total lignin phenols (TLP in mg/g dry peat) of the core RD-1

Total lignin phenol (TLP) concentrations of peat core (RD-1) from Rawa Danau were generally higher than those from other sediments and more comparable to those observed in other tropical peat land (Bourdon et al., 2000). The high concentrations of TLP reflect high vascular plant contribution to the wetland in Rawa Danau as suggested by the high atomic (C/N)a ratio. The vertical distribution of TLP of the core RD-1 (Fig.6) showed increasing vascular plant component in OM at the calibrated age of 1, 1.5, 3.5, 4.5 and 7.5 ka BP. However, this pattern can be influenced by rapid sedimentation and selective degradation of lignin under oxic conditions. It can be inferred from alternative variations of TLP that the terrestrial vegetation of Rawa Danau strongly influenced by the hydrological changed as indicated in Fig.2. The detail of the vegetation change history is discussed else where (Tareq et al., 2002) depending on composition of lignin monomers and newly defined lignin phenol vegetation change index (LPVCI).

We also analyzed CuO oxidation lignin monomers of the four most dominated plant species (*Polypodiaceace, Cyperaceae, Pandanus and Gramina*) around the coring site. The materials from the living plants showed high lignin contents comparable to the value previously obtained for tropical nonwoody plants (Bourdon et al., 2000). The cinnamic group composed of both p-coumaric and ferluic acid dominated (Table 2). By comparison with fresh plants, small fraction of cinnamic phenols was found in the surface of the wetland (Table 2) and the amount of lignin substantially decreased, indicating post-depositional diagenetic loss of cinnamic group is higher than that of syringic and vanillic groups. The loss of cinnamyl phenols can be attributed to early diagenetic nature of cellulose ester bonds and thus C/V ratio can be used as indicator of degree of early diagenesis of OM in wetland.

A comparison of average values of lignin phenol parameters between fresh plants and the surface peat is illustrated in Fig.7. In every phenol family, peat yielded less aldehyde and proportionately more acid than fresh plant tissues did. These compositional differences are sensitively reflecting the post depositional oxidatative degradation of lignin. Comparison of lignin phenol ratio parameters (S/V, C/V and p-H/V) between fresh plants and surface peat concurred with the results of earlier discussion on the rate of post-depositional diagenetic loss (cinnamic > syringic > vanillic). Average values of TLP and λ_8 ($\sum$vanillic, syringic, and cinnamic in mg/100 mg OC) of peat are higher than those of fresh plants due to early diagenetic loss of non-lignin components of OM in the tropical wetland.

Table2. Lignin phenol composition (mg/g of dry samples) of the plant samples collected from coring site and relevant lignin parameters with mean values of surface peat.

Name of species	% OC	p-H	V	S	C	S/V	C/V	p-H/V	(Ad/Al)V	(Ad/Al)S	(Ad/Al)p-H	TLP	$_8$
Polypodiaceac	41.1	8.2	11.3	12.7	6.5	1.12	0.58	0.73	0.27	0.25	0.22	38.7	7.4
Pandanus	43.3	17.3	7.2	10.1	6	1.4	0.83	2.4	0.26	0.23	0.25	40.6	5.4
Cyperaceae	42.1	12.2	17	20	10.6	1.2	0.62	0.72	0.2	0.25	0.37	59.8	11.3
Gramina	41.5	10.5	10.3	18.2	8.6	1.8	0.83	1.02	0.26	0.2	0.38	47.6	9
Average (plants)	42	12.5	11.5	15.3	7.9	1.4	0.72	1.22	0.25	0.23	0.3	46.7	8.3
±SD	± 0.84	± 3.35	±3.54	± 4.01	± 1.83	± 0.25	± 0.12	± 0.70	± 0.03	± 0.02	± 0.07	± 8.27	± 2.2
Average (surface peat)	26.4	11.3	16.3	15.8	2.1	1.03	0.13	0.73	0.52	1.28	0.37	45.5	14
±SD	± 7.73	± 1.70	± 4.73	± 1.72	± 0.42	± 0.24	± 0.03	± 0.15	± 0.18	± 0.40	± 0.15	± 8.11	± 4.6

Abbreations: OC: organic carbon, p-H: p-hydroxybenzoic phenols, V: vanillyl phenols, S: syringyl phenols, C: cinnamyl phenols, (Ad/ Al): acid/ aldehyde, TLP: total lignin phenols in mg/ g dry peat, $_8$ (lamda): sum of vanillyl, syringyl and cinnamyl phenols per 100 mg organic carbon

Human dimension and environment

Vegetation in a landscape can be disturbed by both of human activities and environmental changes. At a glance, the vegetation in Rawa Danau, West Java, Indonesia is apparently remained constant during Holocene, in which relative abundances of different species are established as a function of local topography, hydrology and climate. Anthropogenic disturbances are dominated by human social and economic processes and are more variable than natural disturbances. Charcoal is commonly present in tropical rainforest soils (Sanford et al., 1985; Saldarriaga and West, 1986). However,

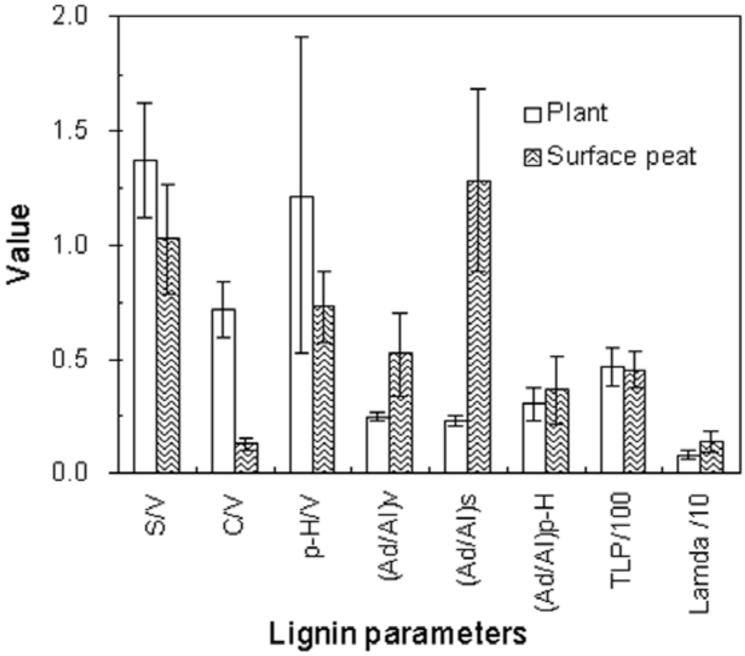

Figure 7. Bar chart of the mean of the lignin parameters of four living plants and surface peat of Rawa Danau (Vertical bars represents ±SD).

the implications of these data are unclear because we do not know whether the charcoal was produced by natural forest fires or by human activities. People clearly had a large impact on the vegetation development in Rawa Danau area during the last few hundred years as evidenced by increased burning, the appearance of food crops, the apparent opening of the vegetation with many grasses, sedges and ferns and presence of weeds (Kaars et al., 2001). Once the vegetation is disturbed by human impact and/or natural forest fire, the original forest is usually replaced by grasses and sedges with occasional shrub or trees. The pollen data suggested that the vegetation of west Java dominated by gymnosperms prior to approx.12 ka BP and marked decline of gymnosperms is evident after 10 ka BP and by 8 ka BP have disappeared from the area (Stuijts, 1993). However, lignin phenols compositions (S/V > 0.50) reflected the presence of gymnosperm during last 7.4 ka BP and dominated during forest fire events (Tareq et al., 2002). It is quite difficult to distinguish between the human dimension and climate forcing on the vegetation changes at mid Holocene time (during 3.5-7.4 ka BP). Large scale vegetation changes/intensive forest fire occurred during 3.8 - 4.5 ka BP, but our data were unable to identify whether that changes caused by human dimension (through forest clearance or burning) or natural climatic changes (ie. drought). But it is clear from our records that the recent vegetation changes/forest fires were caused by human activities that enhanced the periodical ENSO events.

CONCLUSION

Variations of $(C/N)_a$, $\delta^{13}C$ and $\delta^{15}N$ of OM in the peat core indicated that the organic material was comprised of terrestrial C3 plant material, and the direct input of aquatic plant matter was small or overwhelmed by high terrestrial input. Excursions in the isotopic abundances of 5 ‰ in $\delta^{15}N$ and -3.1 ‰ in $\delta^{13}C$ are not artifacts of diagenetic processes but were caused by changes in sources of organic matter. Although, , it was difficult from small scale excursion of stable isotope values to identify paleovegetation and environmental changes, lignin phenols together with other geochemical data (like elemental carbon, TOC, $\delta^{13}C$) were able to indicate small scale shift of terrestrial vegetations. The TLP concentrations of core RD-1 varied with depth due to the changes in composition of terrestrial plant of Rawa Danau in response to climate changes.

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A Study of Phosphorus Soil Test Criteria for Tropical Ombrogenous Peat Soil

Radjagukguk. B [1]., R.E.K. Kurniawan [2]., N.W. Yuwono [1]., and A. Sajarwan[3].
[1] Faculty of Agriculture, Gadjah Mada University, Yogyakarta, Indonesia
[2] Graduate Program, Soil Science Department, Faculty of Agriculture, Gadjah Mada University, Yogyakarta, Indonesia *(ruly_kusuma@ Lycos.com)*
[3] Faculty of Agriculture, Palangkaraya University, Palangkaraya, Indonesia

ABSTRACT

A glasshouse experiment was conducted with a suitable phosphorus (P) soil test method to determine phosphorus availability criteria for tropical ombrogenous peat soil, using maize (*Zea mays,* L) as the test plant. The peat soil used was taken from the top 30 cm layer at the Kalampangan Region, Central Kalimantan. Prior to treatment application, basal dressings were applied to the soil, consisting of the equivalent of 10 ton.ha^{-1}of lime, and complete macro and micro nutrients, except phosphorus. Phosphorus as treatment was applied in the form of NaH_2PO_4 at 10 rates, ranging from the equivalent of 0 to 640 kg.ha^{-1}. The extractant tested was the Bray II method and the plants were harvested at the maximum vegetative growth stage (55 days from planting). The results showed that highest total plant dry weight of 32.6 g.pot^{-1} was obtained at the rate of 640 kg.ha^{-1} NaH_2PO_4 (the equivalent P fertilizer rate of 788 kg.ha^{-1} TSP). The critical Bray II-extractable P wich gave 90% of maximum total plant dry weight (29.3 g.pot^{-1}) was found to be 155.7 µg.g^{-1}. There was a fairly linear relationship between Bray II-extractable P and P application rate.

Keyword : soil test criteria, phosphorus, peat soil

INTRODUCTION

Indonesia has 20.07 million hectares of peatland distributed mainly in the islands of Sumatera (8.25 M ha), Kalimantan (6.79 M ha), and Irian Jaya (4.62 M ha), with the remainder found in Sulawesi, Halmahera and Seram islands (0.41 M ha) (Bellamy,1995 ; Radjagukguk,1991 and 1995). Constraints encountered on the tropical peat soils for agriculture are the low chemical fertility, low pH, and impleded drainage. The availability of most plant nutrients, including P, are low due to the prolonged decomposition under a high rainfall regime (Radjagukguk, 1991). No study, as yet, has been carried out on P soil test method for ombrogenous peat soil.The study was aimed to disclose the effect of increased P application on the growth of maize, the relation between maize growth and available P extracted by Bray II extractant in ombrogenous peat soil

METHODS

Glasshouse experiment contained sapric peat soil soil on Laboratory of Soil Chemistry and Fertility, Department Soil Science, Faculty of Agriculture, Gadjah Mada University. Prior to treatment application, basal dressings were applied to the soil, consisting of equivalent 10 ton.ha^{-1} of lime, and complete macro- and micro nutrients, except phosphorus. Phosphorus as treatment was applied in the from NaH_2PO_4 at 10 rates, ranging from the equivalent of 0 to 640 kg.ha^{-1}. The extractant tested was the Bray II method and the plants were harvested at the maximum vegetative growth stage (55 days from planting). Experimental design used was completely randomized design with three replications.

RESULTS

Results of the experiment showed that increasing the NaH_2PO_4 fertilizer rate effected plant dry weigth and available P in the sapric peat soil and the rate of 160 kg.ha-1 NaH_2PO_4 the optimum values. Optimum plant dry weigth and available P were 29.71 g.pot^{-1} and available P for Bray II extractant 68,18 ppm, respectively.

Increasing the quantity of fertilizer P suppied increased the plant dry weigth of maize (Suryanto, 1994). Optimum plant dry weigth the treatment of fertilization equivalent 160 kg.ha^{-1} NaH_2PO_4 in the plant were 29.71 g.pot^{-1}. Fertilizer suppied more than 160 kg.ha^{-1} NaH_2PO_4 not significant increasing for plant dry weigth for maize in sapric peat soil.

Results of the experiment showed that increasing the NaH_2PO_4 fertilizer rate effected for available P for Bray II extractant and optimum available P the treatment of fertilization equivalent 160 kg.ha^{-1}. $NaH_2PO_{4,}$ in the available P 68,18 ppm, respectively.

Increasing the quantity of fertilizer P supplied increased the available P in the sapric peat soil used Bray II extractant. In contras to mineral soil, peat soil has low phosphorus (Erich,1991). Phosphorus losses from peat are determined by the solubility of P fertilizer, P leaching and influenced by soil acidity (Duxbury and Peverly,1978)

Available P used Bray II extractant were 68.18 ppm and plant dry weigth were 29.71 g.pot^{-1}. Corelation increasing available p in the sapric peat soil significant for plant dry weigth. In the experiment, relationship between plant dry weigth and soil test value was established. (Jordan *et al.*, 1966).

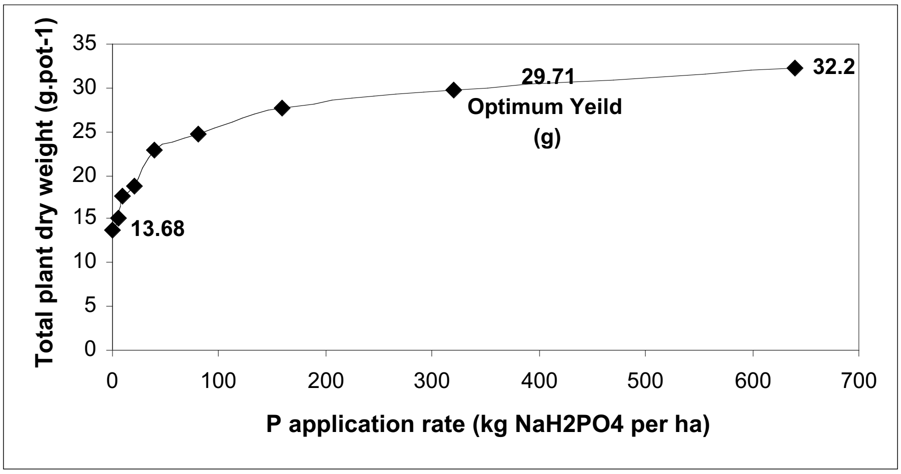

Figure 1. Plant dry weight (g.pot^{-1}) of maximum vegetative stage
(Treatment : the rate of 0 to 640 kg.ha^{-1})

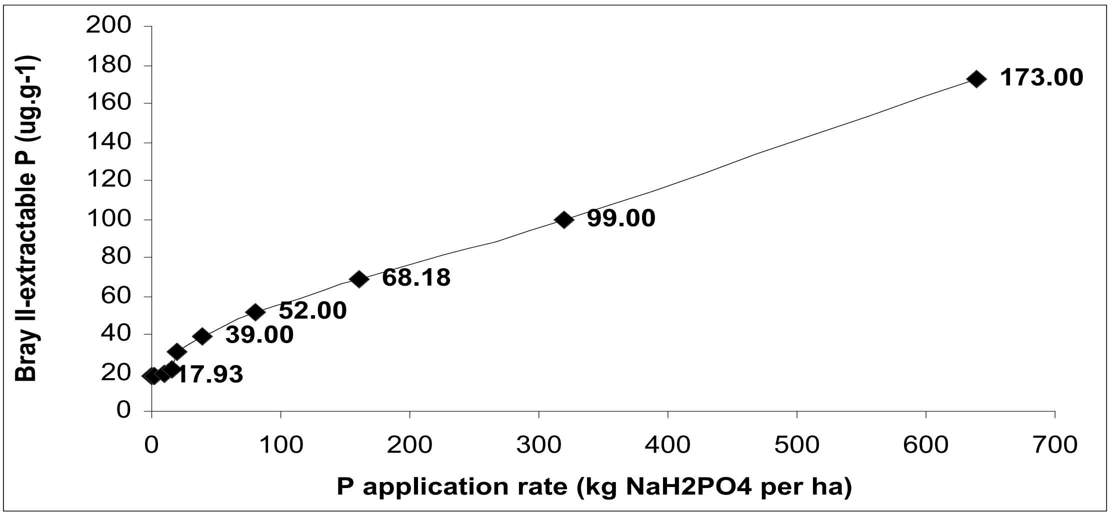

Figure 2. Available P in the sapric peat soil for Bray II method
(Treatment : the rate 0 to 640 kg.ha^{-1})

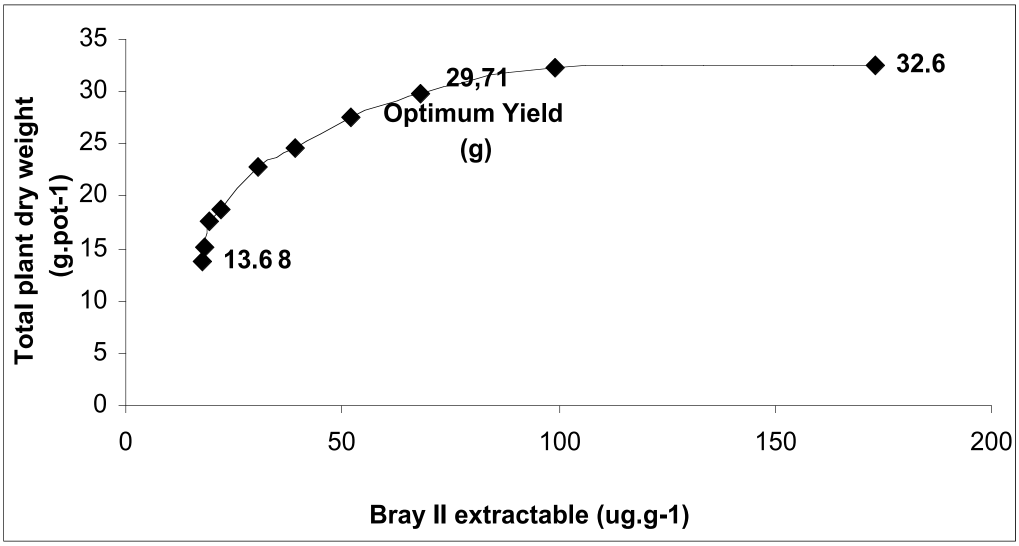

Figure 2. Available P in the sapric peat soil for Bray II method
(Treatment : the rate 0 to 640 kg.ha^{-1})

CONCLUSIONS

Increasing the quantity of fertilizer P suppied increased the plant dry weigth of maize and increased the available P in the sapric peat soil. Relationship between plant dry weigth and soil test P used Bray II extractant in the sapric peat soil for maize value was established. Based on the maximum vegetative stage (55 days for planting) it was estimated that the rate P fertilizer application required to optimum total dry weigth 29.71 $g.pot^{-1}$ was obtained at the rate of 160 $kg.ha^{-1}$ NaH_2PO_4 (equivalent of P fertilizer rate of 150 $kg.ha^{-1}$ SP-36). Available P at application of 160 $kg.ha^{-1}$ NaH_2PO_4 extracted with Bray II was 68.18 ppm and agronomic aspect.

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Effect of Dolomite Application on Soil pH Change of Inland Peat

Untung Darung, Mirae Setiawati, Herry Redin and Salampak Dohong
Department of Agronomy, Faculty of Agriculture,
University of Palangka Raya, Indonesia

INTRODUCTION

The inland peat is a type of soil categorized as marginal soil, which is less fertile for the plant growth; therefore, it needs specific treatment to improve its potential and usefulness to the growth of plant. Using a proper technology for the inland peat management can do this (Radjagukguk, 1991; Salampak, 1999).

The effort for handling of plant growth failure within the inland peat by solely adding nutritional content through the fertilization was considered not effective because the lack of nutritional content was not the main cause of plant growth failure. Nevertheless, the main cause was the content of inland peat that consisted of colloid material of peat soil. This was mainly because colloid consists of organic acid matter, especially those of phenolic acids, which is showed by low of soil pH and high concentration of phenolic acids in peat soil (Tadano *et al*., 1990; Saragih, 1996; Salampak, 1999).

This research was aimed to studying the soil pH changes on the inland peat resulted from dolomite adding, within a certain period of incubation.

MATERIALS AND METHODS

The experimental design used in this research was Complete Randomized Design with single factor and four replicates. The factor studied was the dolomite adding. Dolomite was applied at rates of 0 (D0), 2 (D1), 4 (D2), 6 (D3), 8 (D4), and 10 ton/ha (D5). Each treatment was incubated at 2, 4, 6, 8, and 10 weeks.

RESULTS AND DISCUSSION

The result of this research indicated that the application of dolomite significantly affected the soil pH changes within the time of incubation 2, 4, 6, 8, and 10 weeks. The supply of dolomite within 2, 3, 4, 6, 8, and 10 ton/ha was able to improve inland pH in linear manner. The increase of pH became higher in line with the incubation period. The effect of dolomite application and incubation period on soil pH changes was expressed by regression equation as follow:

$$Y = 3.094 + 0.2335X_1 + 0.0458X_2 + 0.0282X_1X_2 - 0.002X_1^2 \quad (r^2 = 9.59)$$

(X_1 = dosages of dolomite, and X_2 = incubation period)

Figure 1 showed the regression pattern of dolomite application and incubation period on soil pH change. The supply of 10 tones of dolomite lime/ha had resulted in pH increase within 2, 4, 6, 8 and 10 weeks periods of treatment, higher than in other treatment. The changes of pH were 5.61; 5.99; 6.10; 6.57 and 6.68. From this research, it was found out that to achieve the same level of soil pH, the dolomite application with lower doses would need longer incubation period compared to the application of higher doses of dolomite (Table 1).

CONCLUSIONS

The application of dolomite significantly affected the soil pH changes and the soil pH became higher in line with the incubation period.

The dolomite application with lower doses would need longer incubation period compared to the application of higher doses of dolomite to achieve the same level of soil pH.

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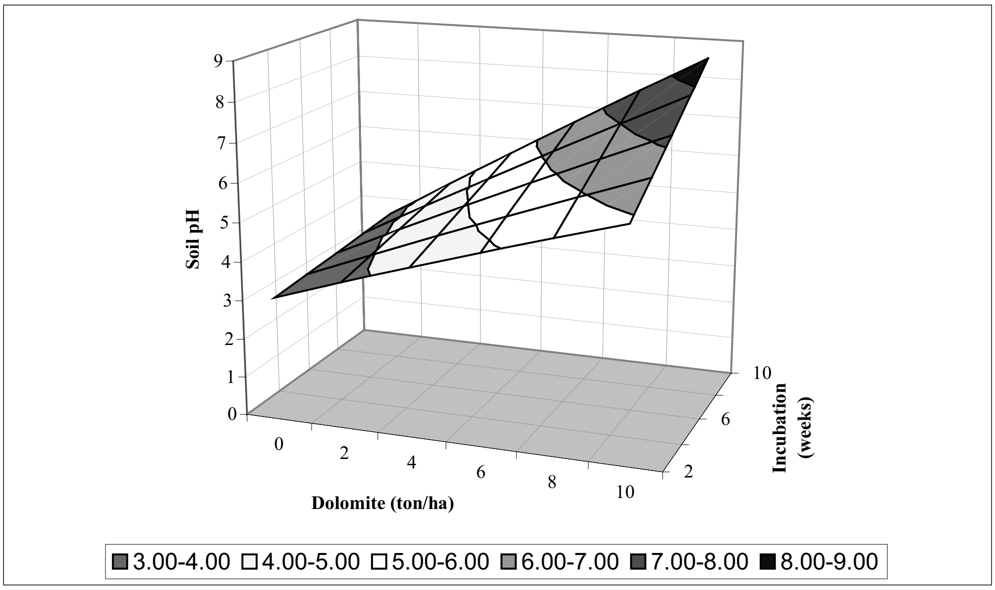

Figure 1. The regression pattern of dolomite application and incubation period on soil pH

Table 1. Effect of dolomite application and Incubation time on soil pH value

Dolomite (ton/ha)	Incubation time (weeks)				
	2	4	6	8	10
0	3.06	3.17	3.32	3.42	3.44
2	3.71	4.00	4.22	4.48	4.58
4	4.31	4.73	4.91	5.23	5.31
6	4.89	4.97	5.2	5.47	5.56
8	5.12	5.53	5.7	5.98	6.03
10	5.61	5.99	6.1	6.57	6.68

** to achieve the same level of soil pH, the dolomite application with lower doses would need longer incubation period compared to the application of higher doses of dolomite*

Effects of pH on the Surface Activity of Humic Acid: Aspects on Adsorption Behavior at Air-Water Interface

Motoki Terashima[1], Masami Fukushima[2] and Shunitz Tanaka[1*]
[1] Division of Material Science, Graduate School of Environmental Earth Science, Hokkaido University, Sapporo 060-0810, Japan
[2] National Institute of Advanced Industrial Science and Technology (AIST), 16-1 Onogawa, Tsukuba 305-8569, Japan

Author to whom the correspondence should be addressed: telephone; +81-11-706-2219, fax; +81-11-706-2219, e-mail address; shunitz@ees.hokudai.ac.jp

ABSTRACT

The pH effects on the surface activity of humic acid (HA) were investigated by surface tension measurements under various pH conditions. The surface tension of HA was depressed with decreasing in pH with an inflection point at around pH 5.5. This can be attributed to the protonation of the acidic functional groups of HA, followed by the accelerated accumulation of HA at the air-water interface. In addition, two break points were observed in the surface tension curve at pH 4 and 5, whereas the one break point was observed in that at pH 6 and 7. Since the apparent solubility of pyrene as a function of HA concentration provided the one liner relationships under the examined pH conditions, all break points observed in this study were not a critical micelle concentration (CMC). On other hand, the area occupied with a HA molecule (A) was decreased with decreasing in pH. From the results described above, it was concluded that, based on the protonation, the interfacial adsorption of HA was accelerated with the alteration in the adsorption state of HA at the air-water interface.

Key words: humic acid, surface activity, surface tension, CMC, pH, dissociation, pyrene, PAH, solubilization, dynamic light scattering.

INTRODUCTION

Humic acid (HA) is the most widespread natural polyelectrolyte in all terrestrial and aquatic environments as well as tropical peat lands (Schnitzer and Khan, 1972). HA has an amphiphilic nature on the basis of the presence of both hydrophilic and hydrophobic moieties in the structure. Based on the amphiphilic nature, HA can depress the surface tension of its aqueous solution to form the micelle-like aggregate in similar manner as a surfactant (Hayano et al, 1982; Shinozuka and Lee, 1991). Since the surface activity of HA can influence strongly the interfacial phenomena in the environments, such as an adsorption of it onto the surface of clay mineral (Terashima et al, 2003), a solubilization of hydrophobic organic pollutants (HOPs) (Tanaka et al, 1997), and a bio-availability for HOPs (Holman et al, 2002), the fundamental understanding on the surface activity of HA is one of the most important subjects.

The surface activity of HA depends on the solution conditions such as a temperature, a concentration and kind of co-existing ions, respectively. Especially, the co-existing cations influence remarkably the surface activity on the basis of screening the negative charge of the HA colloid (Tombácz and Regdon, 1994). The proton is one of the most affective counter cation for screening the charge on the HA colloid because of the protonation of the acidic functional groups. It can be expected that the protonation of HA accelerate the accumulation at the interface and also the micelle-like aggregation in the bulk to affect the fate of HOPs in the environment. However, the pH effects on the surface activity of HA had not been proposed in detail.

In the present study, we evaluated the accumulation of HA at air-water interface and the micelle-like aggregation in the bulk solution on the basis of both the surface tension curves (surface tension as a function of the concentration of HA) and the solubility enhancements of pyrene into the HA solutions under various pH conditions.

MATERIAL AND METHODS

Humic acid (HA) used in this study was extracted from peat soil (Bibai, Hokkaido: BHA) and purified according to a protocol recommended by the International Humic Substances Society (IHSS) (Swift, 1996.). The functional groups analyses (Schnitzer and Khan, 1972) were resulted in 6.04 ± 0.56 meq g^{-1} for the total acidity, 2.76 ± 0.01 meq g^{-1} for the carboxylic groups, and 3.28 ± 0.01 meq g^{-1} for the phenolic hydroxyl groups, respectively.

The surface tensions of the aqueous solution of BHA were evaluated by using the surface tensiometer equipped with thermostat jacket (Kr¸ss Co., Ltd). The Wilhelmy method, where the Pt porous plate was used as the probe, was employed. The surface tension was recorded after allowing to stand for 36 hours, at which the adsorption of BHA had reached to the equilibrium at the air-water interface. The temperature on the surface tension measurements was keep at 25.2 ± 0.1℃. The aqueous solutions of BHA were prepared by diluting the 5000 mg L^{-1} stocked solution in 0.01 M NaOH. The aqueous solution of NaCl was added to control the concentrations of sodium ion in the aqueous solution, and the pH was adjusted with HCl or NaOH.

RESULTS AND DISCUSSION

The surface tension curves (surface tension as a function of HA concentration) of HA at various pH conditions were shown in Figure 1. In neutral pH conditions (pH 6 and 7), the surface tensions depressed linearly with increasing the logarithmic concentration, and showed the break point at around 100 mg L^{-1} of HA. On the other hand, when pH is decreased from pH 6 to 4, the surface tension curves were depressed with decreasing in pH. As expected above, this indicates that the protonation of the acidic functional groups of HA leads it to the more hydrophobic molecule to accelerate the accumulation at the air-water interface. Moreover, two break points were observed in the surface tension curves at acidic conditions (pH 4 and 5). These break points were summarized in Table 1. To confirm whether the break points observed in the surface tension curves are in agreement with the critical micelle concentration (CMC) or not, we performed the solubility experiments of pyrene under various pH conditions. As reported by Shinozuka and Lee (1991), when HAs form the micelle-like aggregate with a hydrophobic interior, the aggregate can solubilize the hydrophobic compounds into the interior to enhance remarkably the apparent water solubility of the compounds. The apparent water solubility of

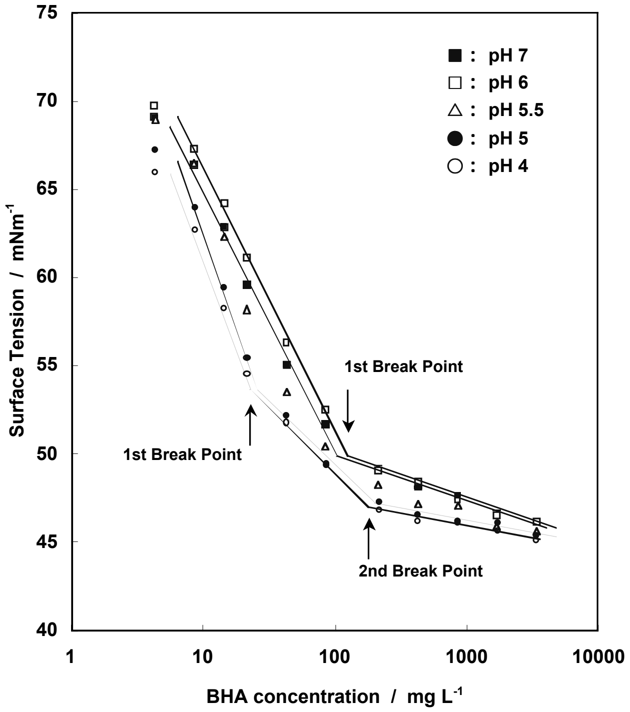

Figure 1. Surface tension as a function of BHA concentration at 0.01M sodium ion, 25℃, and 4 – 3400 mg L^{-1} BHA concentration.

pyrene as a function of BHA concentration is shown in Fig. 2. Since the remarkable enhancement in the apparent water solubility of pyrene was not found under any pH conditions (Fig. 2), it is shown that all break points observed in this study do not correspond to the CMC. From this result, it can be considered that these break points are attributed to the alteration on the interfacial adsorption state of BHA molecule.

To clarify the interfacial adsorption for BHA, the surface excess (Γ) and the area per HA molecule (A) were estimated on the basis of the Gibbsís equation as follows;

$$\Gamma = -\frac{1}{RT} \times \frac{d\gamma}{d\ln[\mathrm{HA}]} \quad [1]$$

$$\mathrm{A} = \frac{1}{\Gamma \times N_\mathrm{A}} \quad [2]$$

where γ, R, T, and [HA] denote a surface tension (mNm^{-1}), the gas constant, the absolute temperature, and a concentration of HA (mol L^{-1}), respectively. In addition, N_A denotes Avogadroís number. In this study, the mole concentration of HA was calculated on the basis of the average molecular weight (16,779 ± 51 g mol^{-1}) determined by gel permeation chromatography (GPC). The Gibbsís equation was applied to the region around the first break point (Fig. 1). The estimated [Γ] and A values at each pH are shown in Table 1, and are plotted in Fig. 3. As shown in Fig. 3, the A values as a function of pH were decreased with decreasing in pH, indicating the sigmoid relationships with the inflection point at around pH 5.5. In addition, this inflection point can be apparently recognized to the dissociation constant (pK_a) at the interface

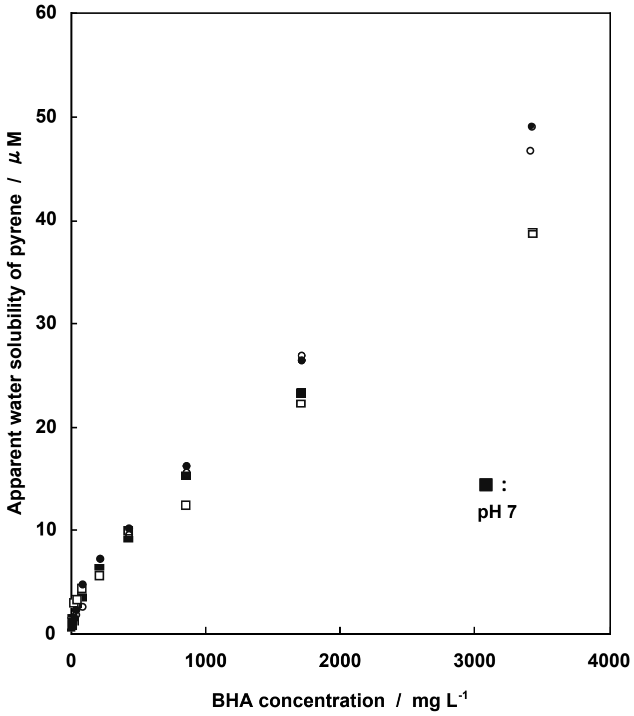

Figure 2. Enhancements of apparent solubility of pyrene as a function of BHA concentration at 0.01M sodium ion, 25℃, and 4 – 3400 mg L^{-1} BHA concentration.

(Spildo and Høiland, 1999). Therefore, it indicated that the adsorption state of BHA at the air-water interface could be changed with the protonation of the acidic functional groups. For the decrease in A value with the protonation, three likely interpretations were assumed as follows; i) the structural transition of HA molecule, ii) the heterogeneous adsorption on the basis of the distribution of the dissociation constant and the molecular weight, and iii) the decrease in the electrostatic repulsive force between HA molecules at the interface. In order to clarify the change in the colloidal state of BHA molecule under various pH conditions, the apparent particle diameter of BHA colloid were evaluated by means of the dynamic light scattering (DLS). Fig. 4 represents the apparent particle diameter of HA colloid as a function of pH. As shown in Fig. 4, the apparent particle diameter of HA colloid was found to be nearly unchanged over the range from pH 3 to 10. This indicates that the structural transition of BHA does not occur with the protonation. Since HA is a polydisperse polymer and a mixture, the heterogeneous adsorption can occur at the interface under all solution conditions. In addition, the distance between HA colloids at the interface can decrease with the protonation because of the decreasing in the electrostatic repulsive force. Therefore, the decreased A with the protonation could be attributed to both the heterogeneous adsorption and the decrease in the electrostatic repulsive force between HAs. Based on these interpretations, the first break points in the surface tension curves under acidic conditions (pH 4 and 5) can also be explained as the concentration at which the interfacial adsorption of BHA is saturated with the heterogeneously and closely packed state. On other hand, Hayano et al. (1982) proposed that the large molecular fraction of HA, which is polydisperse polymer and mixture, can

Table 1. Surface active parameters evaluated by the surface tension curves of BHA under various pH conditions.

pH	Break Points (mg L^{-1})		Surface Excess* (mol cm^{-2})	Area per Molecule* (Å^2)
	1st	2nd	_	A
4.0	23	204	3.55 _ 10^{-10}	46.8
5.0	26	186	3.75 _ 10^{-10}	44.5
5.5	69	—	3.30 _ 10^{-10}	50.3
6.0	126	—	2.64 _ 10^{-10}	62.9
7.0	105	—	2.61 _ 10^{-10}	63.6

*** The mole concentration of BHA was calculated on the basis of the average molecular weight determined by GPC measurement.**

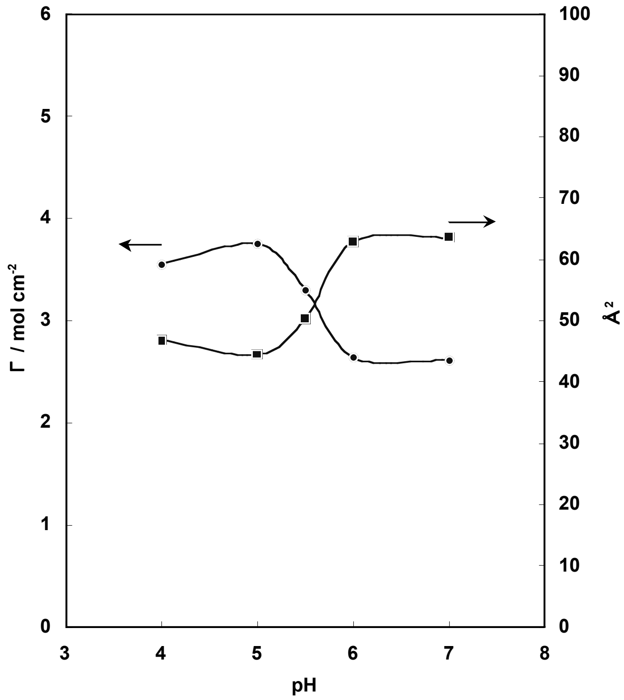

Figure 3. Surface excess (Γ)and area per molecule (A) as a function of pH.

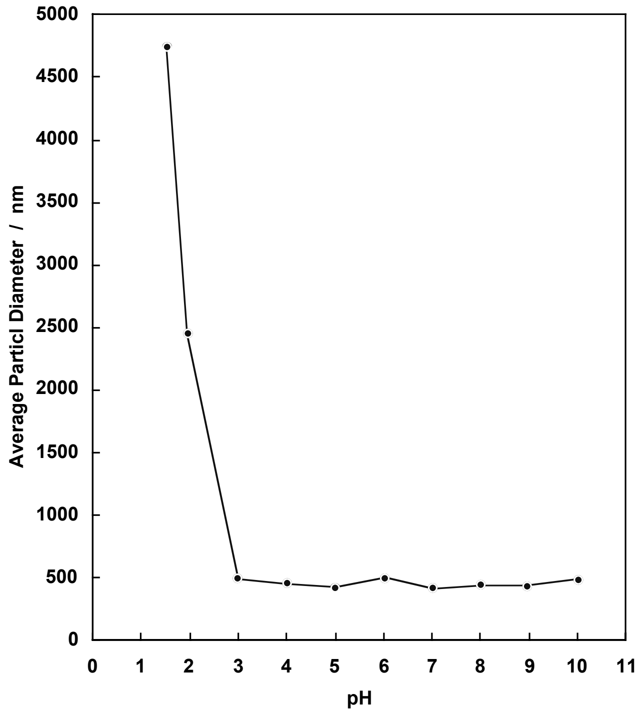

Figure 4. Apparent average particle diameter as function of pH at 0.01M sodium ion, 25℃, and 50 mg L^{-1} BHA concentration. The DLS measurements were performed by the following conditions; light source: 75-mW Ar Laser (488 nm), scattering angle: D 90˚.

accumulate predominantly at the air-water interface to reflect overall surface activity of HA. In addition, this indicates that the large molecular fraction of BHA can be substituted for the small one at the air-water interface. Therefore, for the first break points at pH 6 and 7, and the second break points at pH 4 and 5 (Fig. 1), it can be reasonable interpretation that the interfacial adsorption of BHA was saturated at the break point by the large molecular fractions.

CONCLUSION

The pH effects on the surface activity of HA were examined by surface tension measurements and solubilization experiments of pyrene. From the results, we can result that the surface tension of BHA depresses with proceeding in the protonation of the acidic functional groups of HA, reflecting the accelerated accumulation at the air-water interface. In addition, it was presented that the interfacial adsorption of BHA involved the alteration of the adsorption state with the protonation. Moreover, it could be concluded that the break points observed in this study were followed by the alteration in the adsorption state of HA at the air-water interface. Now we are planning to compare the surface activity of tropical humic acid with BHA.

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Electrokinetic Remediation of Contaminated Soil With Hazardous Organic Matters using Humic Substances or Fenton Reaction

Tomoyuki Kimura, Akira Sawada and Shunitz Tanaka*
Graduate School of Environmental Earth Science, Hokkaido University, N10, W5, Kita-Ku, Sapporo, Japan

*To whom correspondence should be address
The corresponding authorís telephone number and Fax number
Shunitz Tanaka, Tel. & Fax: +81-11-7062219
e-mail address: shunitz@ees.hokudai.ac.jp

ABSTRACT

Electrokinetic remediation (ER) is a process for removing pollutants from clayey soils on the basis of electrokinetic phenomena. ER can move charged species by electrophoresis and electrically neutral species by electroosmotic flow if they are soluble in water. However, water-insoluble and neutral species can not be removed by ER. In this work, the utility of humic acid (HA) as a surfactant for the removal of insoluble and neutral species such as copper (II)-oxinate ($Cu(OX)_2$) in clayey soil by ER was investigated. The utility of Fenton reaction in order to convert insoluble species to soluble species was also investigated. HA has a negative charge at a neutral pH, however, the HA moved to the cathodic chamber. This shows that the driving force of HA in this system is predominantly due to electro-osmotic flow. The amount of $Cu(OX)_2$ removed in the presence of HA is 3 times larger than that in its absence. The solubilization of $Cu(OX)_2$ with HA seemed to enhance the amount of $Cu(OX)_2$ removed by ER. Bisphenol A was not moved by ER without Fenton reaction because bisphenol A is neutral and water-insoluble species, but the presence of Fe(II) and hydrogen peroxide decompose bisphenol A by Fenton reaction to convert it to soluble species. Therefore, the combination of Fenton reaction with ER facilitated to remove bisphenol A from clayey soil.

Key words: soil, copper(II)-oxinate, bisphenol A, electrokinetic remediation, humic acid and Fenton reaction

INTRODUCTION

Contaminated soils lead to the subsequent contaminations of river and ground water if they are left behind without adequate treatment. Therefore, the development of technologies for cleaning up the contaminated soil is important from the view point of environmental protection. Electrokinetic remediation (ER) is a process for removing pollutants from clayey soils on the basis of electrokinetic phenomena (Probstein, 1993 and Alshawabkeh, 1992).

This method is performed under a low-level DC voltage between two electrodes, which are inserted in the vicinity of the contaminated sites. The ER can move charged species by electrophoresis and electrically neutral species by electro-osmotic flow (EOF) if they are soluble in water. However, water-insoluble and neutral species can not be removed by ER.

It is well known that humic substances (HSs), such as humic acid (HA) and fulvic acid, are weak-acid polyelectrolytes and are widely distributed in the environment. HAs have vari functions, such as the complex formation ability with metal iron, the reduction, and surface active ability (Uhle. 1999). Although, $Cu(OX)_2$ can be slightly soluble in water, its water solubility is increased by several folds in the presence of HA. These functions of HA seems to be effective for removing insoluble pollutants by ER.

On the other hand, it has been reported that Fenton reaction is useful for the degradation of various harmful organic pollutants in wastewater and soil. Hydrogen peroxide and Fe(II) used in the Fenton reaction produce hydroxyl radicals by the following reaction, which attack organic pollutants to decompose them (Watts, 1999).

$$Fe(II)+H_2O_2 \rightarrow Fe(III)+HO\cdot+OH^-$$

The EK by using Fenton reaction has been used to the in situ treatment of organic compounds in soils, but not applied to water-insoluble organic pollutants (Gordon, 2001).

In this work, the utility of humic acid (HA) as a surfactant for the removal of insoluble and neutral species such as copper (II)-oxinate ($Cu(OX)_2$) in clayey soil by ER was investigated. Moreover, the utility of Fenton reaction in order to convert insoluble species to soluble species was also investigated.

MATERIALS AND METHODS

In order to investigate the behavior of pollutants in soil by ER, an apparatus having a small migration chamber (3.0 cm i.d. and 10 cm length) and two electrode chambers was prepared (Fig. 1). Commercial kaolin, which mainly consists of kaolinite, obtained from Wako Pure Chemical Co. (Tokyo, Japan) was used as a model of soil. Since this kaolin contains trace of iron, the kaolin with was shaken 0.1 M HCl (w/w=1:4) for 24 hr to remove iron. The pH of the model soil was adjusted to 7 by addition of aqueous 0.1 M NaOH and then the kaolin was dried for 24 hrs. The water content of the soil was set at 30% using a buffer solution (pH=7, 0.1 M NaH_2PO_4/NaOH buffer). The total weight of the soil in the migration chamber was 118 g. As shown in Figure 1, two meshed Pt/Ti electrodes were inserted into each chamber, and the cathodic chamber was filled with a buffer solution (Sawada, 2003). A constant DC voltage of 2.2 V cm^{-1} was applied through the soil for 30 or 48 hrs.

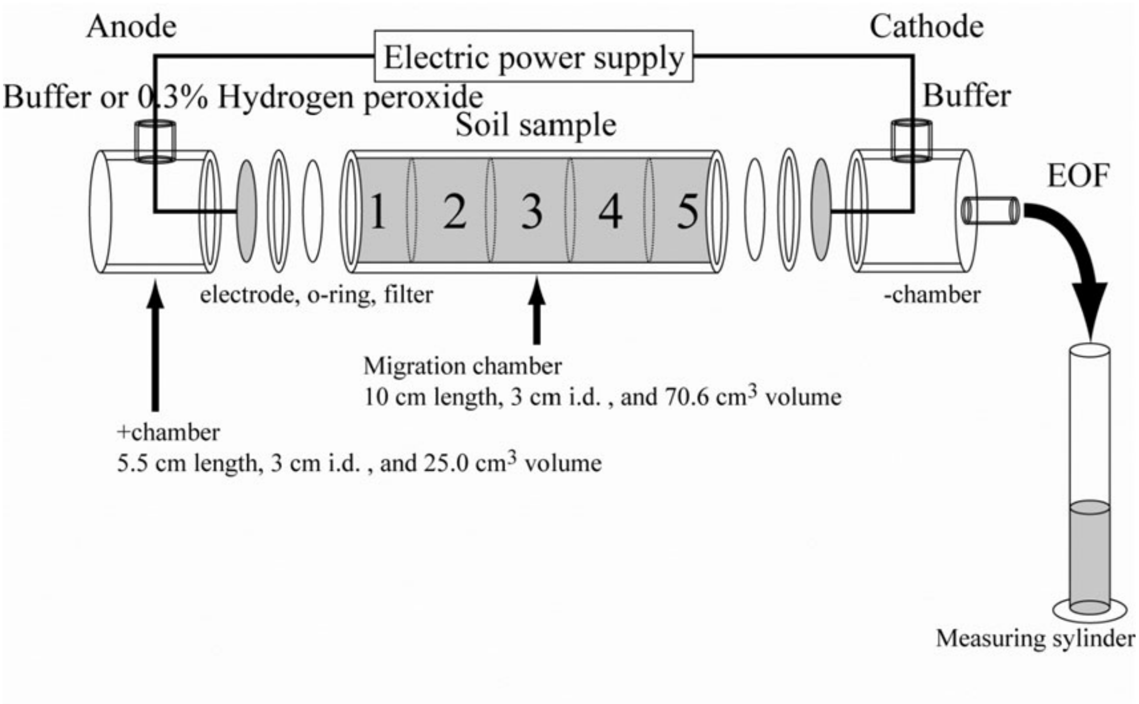

Figure 1. Schematic diagram of electrokinetic apparatus.

RESULTS AND DISCUSSION

Effect of HA by electrokinetic remediation

In order to confirm the effect of the surface active utility of HA on the removal of hydrophobic compound by ER, the layers of kaolin containing HA and $Cu(OX)_2$ were set in the migration chamber as shown in Fig.1. The kaolin containg HA (kaolin + HA) was prepared by mixing 11 g of the pretreated kaolin and 1 g of HA. The kaolin containg $Cu(OX)_2$ (kaolin + $Cu(OX)_2$) was prepared by mixing 12 g of the pretreated kaolin and 4 g of $Cu(OX)_2$. The arrangement of the soil samples in the migration chamber was kaolin / kaolin + HA / kaolin / kaolin + $Cu(OX)_2$ / kaolin.

The pH of the solution in the anodic chamber was maintained at 7.0. After applying the voltage, the analysis of HA and $Cu(OX)_2$ were performed for the solutions in the cathodic chamber and the effluent in the measuring cylinder. The concentrations of HA were determined by means of an ultraviolet-visible absorption spectrophotometer at a wavelength of 450 nm. The amount of $Cu(OX)_2$ in soil and two electrode chambers was measured by atomic absorption spectrophotometer.

Although HA has a negative charge at a neutral pH, the HA moved to the direction of the cathodic chamber. This shows that the driving force of HA in this system is predominantly due to EOF. HA was detected in the cathodic chamber after the retardation for 60 ml of the effluent volume, which corresponds to the ER treatment for 17 hr. Figure 2 shows the amount of the removed $Cu(OX)_2$ as a function of the treatment time. In the absence of HA, the removed $Cu(OX)_2$ increased slightly with time. However, the amount of $Cu(OX)_2$ removed in the presence of HA is 3 times larger than that in its absence. The water solubility of $Cu(OX)_2$ was clearly enhanced by the presence of HA because HA has a surface active ability. Therefore, the enhancement of the removal of $Cu(OX)_2$ by

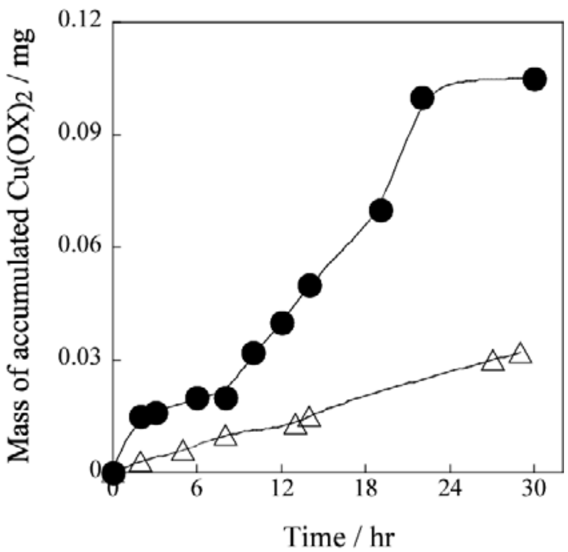

Figure 2. Mass of accumulated $Cu(OX)_2$ as a function of time in the presence or the absence (Sawada. 2003). (●) presence HA, (△) absence HA.

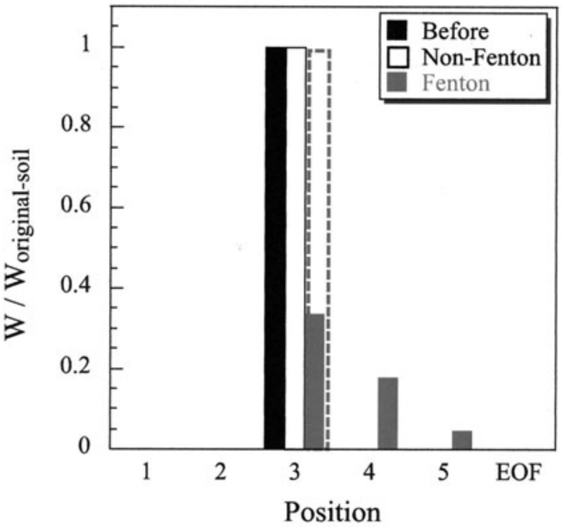

Figure 3. The removal of bisphenol A from contaminated soil by electrokinetic-Fenton remediation, analyzed by HPLC. applied voltage 2V/cm, applied time 48hr.

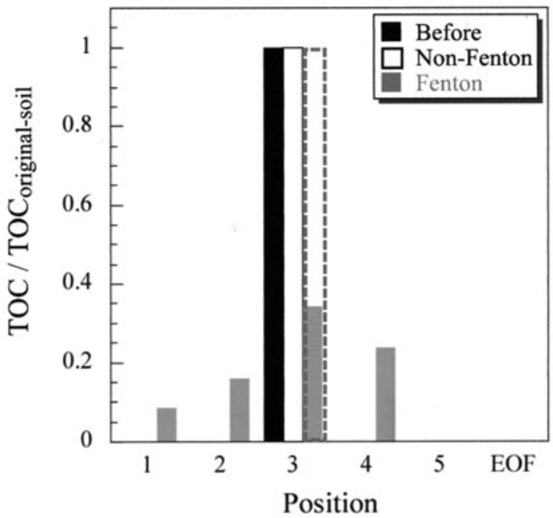

Figure 4. The distribution of bisphenol A from contaminated soil by electrokinetic-Fenton remediation, analyzed by TOC. applied voltage 2V/cm, applied time 48hr.

ER is due to the solubilizing effect of HA for hydrophobic compound.

Effect of Fenton reaction by electrokinetic remediation

Soil containing Fe(II) was set in the migration chamber, and the kaolin containg bisphenol A (kaolin + bisphenol A) was prepared by mixing 23.6 g of the pretreated kaolin and 6 mg of bisphenol A. This soil was set in the position of no.3 in the migration chamber. To curry out Fenton reaction, hydrogen peroxide was introduced by electroosmotic flow from the anodic chamber. The amount of bisphenol A in soil and two electrode chambers was measured by HPLC. Total organic carbon (TOC) in soil was also measured by TOC for solid.

Before the treatment by ER, all bisphenol A was remained in no.3 of position. Without Fenton reaction, bisphenol A could not be removed by ER because the bisphenol A was neutral and water-insoluble. Figure 3 shows the results after the treatment by Fenton reaction. About 70% of bispenol A could be removed from no.3 of the original position to other positions. The mechanism of conversion for bisphenol A by Fenton reaction is not clear in detail, however, it was confirmed that the bisphenol A can be removed by in situ ER combined with Fenton reaction.

In order to trace the movement of organic matters by ER, total organic carbon(TOC) in the soil after ER was measured. Figure 4 shows the removal of bisphenol A from contaminated soil by ER using Fenton reaction as the change of TOC in the soil. By using Fenton reaction, TOC was detected in the 1-4 positions of the migration chamber. From the evidence that TOC was distributing in the side of anode, it is suggested that the presence of Fe(II) and hydrogen peroxide decompose bisphenol A by Fenton reaction to convert it to negative charge species such as organic acid. The identification of the reaction products by Fenton reaction in soil is now under progress.

CONCLUSIONS

The solubilization of $Cu(OX)_2$ with HA enhanced the amount of $Cu(OX)_2$ removed by ER. The presence of Fe(II) and hydrogen peroxide decompose bisphenol A by Fenton reaction to convert it to soluble species. Therefore, neutral and water-insoluble bisphenol A could be removed by ER. The utility of HA and the combination of Fenton reaction with ER was confirmed.

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Mimosa pigra: A Potential Threat to Abandoned Peatlands

Asyraf M. and Mashhor Mansor
School of Biological Sciences, Universiti Sains Malaysia
11800, Minden, Penang. MALAYSIA.

Corresponding author: Asyraf M.
School of Biological Sciences, Universiti Sains Malaysia
11800, Minden, Penang, MALAYSIA.
Tel:604-6533888 ext. 3518
Fax:604-6565125
Email:asyraf_m@yahoo.com

ABSTRACT

The invasion and colonization of weeds and alien species into a disturbed area is a major threat to the natural ecosystem. A recent survey on a vast abandoned peat swamp forest in Central Kalimantan, the Mega Rice project revealed that certain parts of the area especially in Block B area has been infested by *Mimosa pigra*. Several colonies of this species have been observed on some parts of Kahayan River and the main water gate at Block B. The colonies, up to the date however are restricted to the water margin area and have not been detected further into the inland area. Although new colonies have not been detected in nearby area, the possibilities of *Mimosa pigraís* expending colonization are most probably very high along the riverbank of Kahayan River. The immediate threat of this invasion is to the endemic and local plant species in the area.

Key words: Mimosa pigra, infestation, disturbance, abandoned peatland, management.

INTRODUCTION

Mimosa pigra has been considered as one of the most semi-aquatic invasive plant species in the world. This Giant Cat Claw or Giant Mimosa has been a major nuisance in Kakadu National Park, Australia and it has been found the infestations can nearly double in just over one year and on average every 6 years (Lonsdale and Farrell 1998, Lonsdale *et al.* 1995, Lonsdale 1993b). Many parts of the South East Asianís countries, namely Thailand, Indonesia and also Malaysia are also facing this problem.

This species belongs to the Mimosae group and has the ability in displacing local plant species once colonization had started. This species is usually overlooked in the first stage of succession and would not be considered as pest species until the colonization has reached the carrying capacity of the area. Up to this point, the vegetation of the area would be dominated by *M. pigra*.

The invasions of new and exotic species into disturbed areas are most probably due to their abilities in adapting to the environment, utilizing larger number resources and producing higher number of progeny thus suppressing other local species from regenerating. Apart from natural disturbances, human induced disturbances including the removal of native vegetation for activities such as farming, timber extracting and mining would provide an open niche for alien invasiveness due to lack of competition and altered soil structure, availability of moisture (by irrigation), and nutrients (Randall & Marinelli 1996).

The main objective of this survey is to assess the degree of invasion by *Mimosa pigra*, a noxious semi-aquatic species belongs to the group of legume in the abandoned Mega Rice Project, Central Kalimantan, Indonesia and to recommend the management options to control this species.

MATERIALS AND METHODS

Site description

A vegetation survey was conducted between 26 - 30 March 2002 on *Mimosa pigraís* distribution and colonies along Kahayan River and main water channel in Block B of Mega Rice Project (MRP) area (Figure 1). Detail description on the vegetation and geographical history on this area has been described elsewhere (Bˆhm, 1998; Bˆhm *et al.*, 1997; Rieley *et al.*, 1992)

Survey on population of Mimosa pigra

The species distribution and composition within the area were assessed using belt line transect. Boat was used to conduct areal survey and the size of each colony size was estimated using quadrat with 5x $5m^2$ in dimension.

RESULTS

The colonization of Mimosa pigra was recorded higher in the water channel and main water gate for Block B of MRP. The largest population of this species was observed at the entrance of main water gate from Kahayan River into the Block

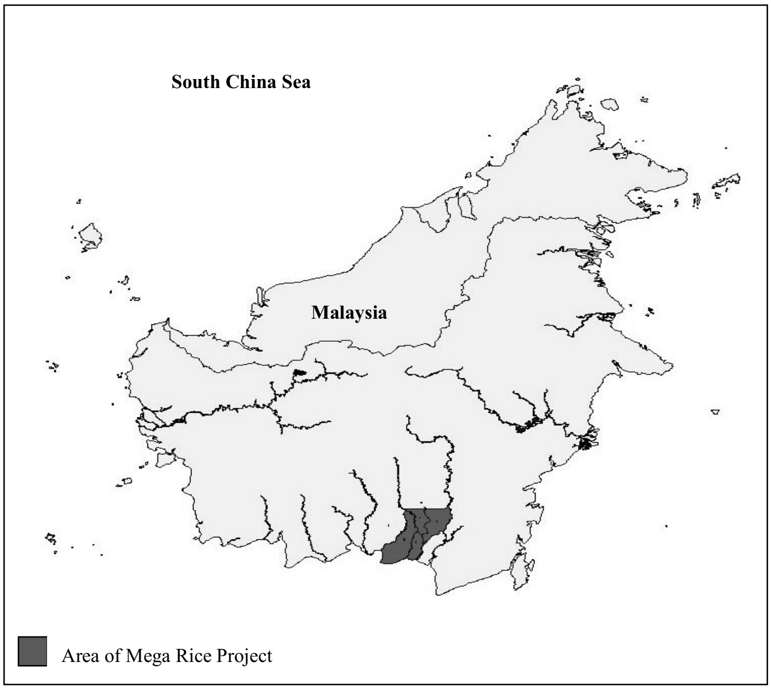

Figure 1. The location of Mega Rice Project in Central Kalimantan, Indonesia. (Source: Boehm and Siegert, 1999)

B area (Figure 2). This could be the main population for the *M. pigra* within the area. Other satellites population were also been observed further into the abandoned peat area. However, the populationís distribution seems to be confined in the main water gate area and not into further abandoned peat swamp area.

Only one site of Kahayan River has been infested by *M. pigra*. The site located approximately 5 km from the main colonies of *M. pigra*

.

DISCUSSION

Current Situation

The first colonization of *Mimosa pigra* is probably within the abandoned peat swamps and believed to have spread to new sites by water. The construction of MRP using heavy machineries brought from other areas which have already infested with *M. pigra* was believed to have started the infestation. Seed banks logged in the soils which was carried in by the machineries

The colonies of *M. pigra* were observed only in several locations and seems to be isolated from each other. This might suggest the possibility of unrelated distribution from different main colonies. The satellite colonies have not been observed during the sampling activities which probably due to low seed production and dispersals. This condition also probably due to the age of the main plant, which is still probably at younger age. Lack of dispersal agent especially the flood cycle might also caused the satellite colonies to be restricted near to the main colony. However further study would be carried out to determine the actual situation of the area concerned.

Future condition

The concentration of *Mimosa pigra* is strongly believed to expand along the Kahayan River downstream and would further colonize into the terrestrial area. Thus making any attempt to eradicate this species a major constraint. Disturbed areas has ever since provide suitable conditions for exotic species and the magnitude of disturbances would further restrict the endemic and local species which would thrive in the new conditions. High magnitudes of disturbance would allow only compatible and highly adaptive species to survive in the harsh conditions. With the ability to produce up to 9,000 seeds per plant annually, a small population of this species would colonize a large area in relatively such a short period.

There are many factors contributing to the invasiveness of certain species such as lacking of natural competitors and the abilities to grow and proliferate in the new surrounding. The inability of native species to out-cast the aliens are because they are not co-evolved with them. The native species would only succeed to suppressed other local competitors are due to long time involvement of the species. This would explain the non effective defense mechanisms posses by local species against the new comers. The abilities to suppress other plant species would ensure the successfulness of the invasive species.

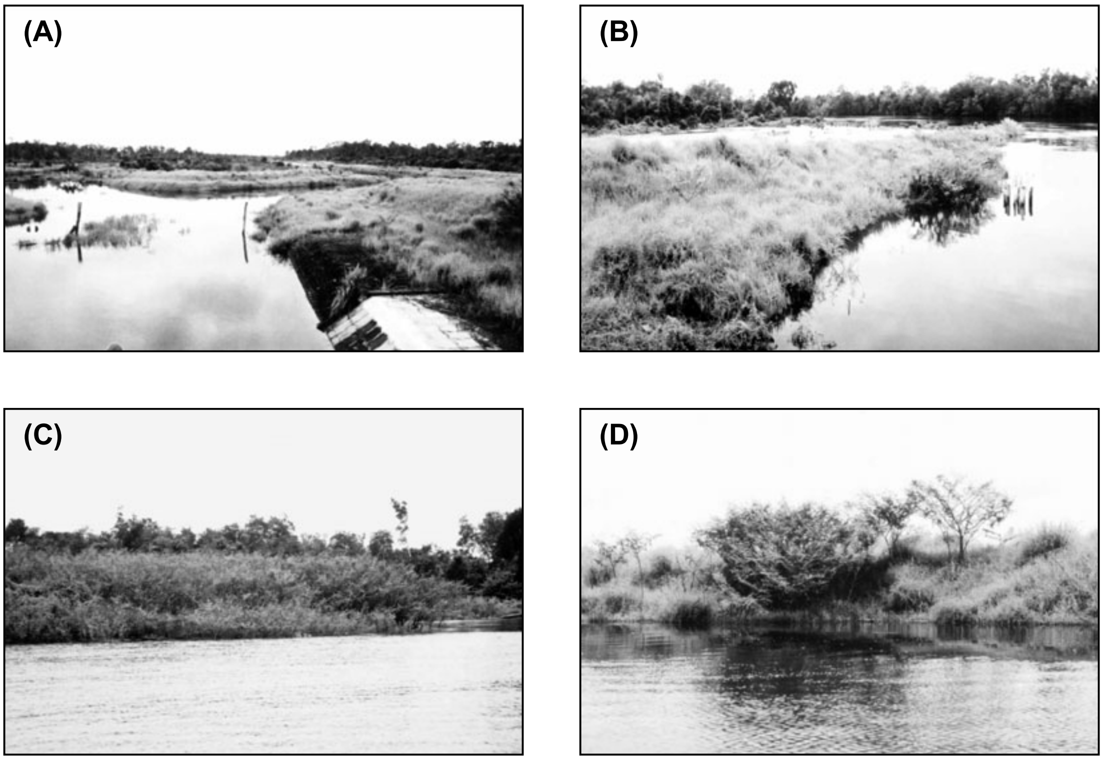

Figure 2. The colonies of *Mimosa pigra* recorded at the water gate (A & B) to the abandoned Mega Rice Project and river bank of Kahayan River, Kalimantan, Indonesia (C & D).

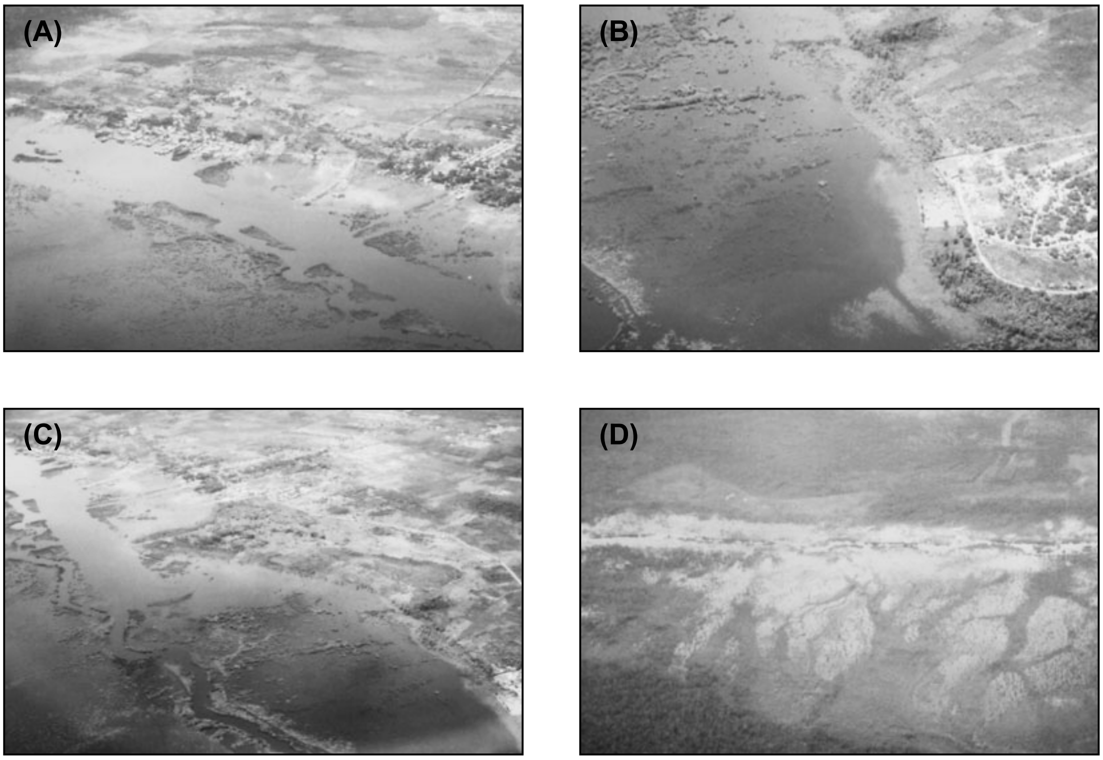

Figure 3. The flood plain areas of Kahayan River, with high possibilities of infestation by *Mimosa pigra*.

Impact of Invasiveness

The loss of domestic and endemic biodiversity is one of important impact brought by invasive problem. The inability to consume and the impalatability of *M. pigraís* leaves to mammalian herbivores (Lonsdale *et al.* 1995) and the high reproductive output by this species will continue to make *M. pigra* as a noxious species in any areas it invades.

Management and Recommendation

The lost of natural vegetation within disturbed areas should be considered as a threat to the biodiversity of flora and also fauna. The genetic erosion would reduce the gene pool of natural and endemic species. Thus making the invasion of exotic and alien species a bigger threat to local species.

The eradication of *M. pigra* should include combinations of various techniques which would include biological, chemical and mechanical controls. To manage this species, a considerable effort should be taken to minimize the satellite population of *M. pigra* since the main colony is relatively easier to control (Moody and Mack 1988). Mechanical control would be concentrating in weeding the plant using tools and machines. Burning of the plant has been considered as ineffective method since this the seeds can tolerate and almost resistant to fire and using fire alone may actually increase mimosa densities by means of plant regrowth and enhancing seed germination (Miller and Lonsdale, 1992). However, combination of burning and applying herbicides such as 2,4,5-T, tebuthiuron (Graslan 20PÆ), fluroxypyr (StaraneÆ) and hexazinone (VelparÆ) which are among the principal chemicals used to control *M. pigra* (Miller and Siriworakul, 1992), has been found to be effectively minimized the population sized.. Although mechanical control is only temporary control option when dealing with *M. pigra* since regrowth will occur unless a suitable herbicide (as suggested above) is immediately applied (Siriworakul and Schultz 1992), it is still an applicable method especially for smaller infestation.

Biological control using insects has been used in Australia and has been found that only 13 species are endophagous on *M. pigra*. This would mean that the mimosa flowers, fruit, and seed were largely uneaten by these species (Wilson *et al.* 1990). Another survey in Central and South America has discovered 441 species of phytophagous insect on *M. pigra* and seven of those are specialists (Harley *et al.* 1995).

Continuous monitoring and further development on techniques to control and better management strategies would help to prevent the further spread of *M. pigra*. Another practical approach is the usage of GIS as now being used in Kakadu National Park to monitor the spreading of this species is also possibly helpful. The effort in controlling this species at their minimal infestation would be highly recommended.

ACKNOWLEDGEMENTS

The School of Biological Sciences, Universiti Sains Malaysia, MALAYSIA, Centre for International Cooperation in Management of Tropical Peatland (CIMTROP), University of Palangka Raya, Central Kalimantan, INDONESIA, and the Kalimantan Peat Swamp Forest Research Project (KALTROP) University of Nottingham, Centre for Environmental Management, School of Geography, UNITED KINGDOM are truly acknowledge.

This survey was made possible by the EU Grant ìStrategies for Implementing Sustainable Management of Peatlands in Borneo *(PI ICA 4-2000-10331)*

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Characteristics of Grains Size Distribution of "Kerangas" in Central Kalimantan

Yoshimasa Kurashige[1] and Kazuomi Hirakawa[2]
[1]School of Environmental Science
The University of Shiga Prefecture
Hikone 522-8533, Japan

[2]Graduate School of Environmental Earth Science
Hokkaido University
Sapporo 060-0810, Japan

Corresponding author: Yoshimasa Kurashige
Tel: +81-749-28-8314 Fax: +81-749-28-8477
e-mail: kurashig@ses.usp.ac.jp

ABSTRACT

Grain-size distribution of Kerangas in Central Kalimantan was tested at around Palangkaraya City. The grain-size distributions were classified into two types, i.e. the coarse type whose median diameter ca. 0.75 mm and the fine type with median diameter of ca. 0.4 mm. The grain-size distributions were further separated into four lognormal distributions. The grain-size distributions of levee and present river-bar deposit were also separated into four subpopulations. Good similarity was found between the subpopulations of fine type Kerangas and those of levee deposit, showing that the fine type Kerangas is alluvium and was transported and deposited under present hydrological condition.

Key words: Kerangas, grain-size distribution, subpopulations, alluvium

INTRODUCTION

In Central Kalimantan we can find widely distributed "Kerangas", which is composed of white barren sandy materials. Rivers undercut plateau of Kerangas, and swamps are formed in the undercut valley as well as in wide lowland south of the Kerangas plateau.

In a previous study by Sieffermann (1988), peat in Central Kalimantan was considered to cover widely the southern range until the hill top between rivers. In contrast, topographical and geomorphological observation by Hirakawa Kurashige (2000) indicates that small swamps are sporadically distributed on the Kerangas plateau, in particular where small depressions are formed, and peat locates only in these depressions. This geomorphological feature indicates that the formation and distribution of the Kerangas plateau strongly controls the formation of swamps and, accordingly, peatland in Central Kalimantan. Process of the Kerangas plateau formation should be revealed to consider the peat production in Central Kalimantan.

Hirakawa and Kurashige (2000) stressed that terraced landforms with residual hills widely occupy the Central Kalimantan Plain, and the terraced sediment is composed of Kerangas. This geomorphological feature clearly indicates that Kerangas is alluvium, and comparison between terraced Kerangas sediment and present river sediment will be informative to consider the Kerangas plateau formation. In this study, as the first step, grain size distributions of terraced Kerangas sediment sampled around Palangkaraya city were tested, and were compared with grain-size distribution of present river-bar sediment and that of levee sediment.

STUDY AREA AND METHOD

Sediment was sampled at 8 sites around Palangkaraya City (Fig. 1). The terraced Kerangas sediment was sampled at six sites (Sites A, B, C, D, G and H), whereas old levee sediment and present river sediment were sampled at Sites E and F, respectively. At some sites where several sediment strata were found, sediment of each stratum was sampled (Sites A and G).

Grain-size distribution of sampled sediment was examined by sieving method (for grains coarser than 45 μm) and by centrifugal settling method (for grains finer than 45 μm). The grain-size distribution was further plotted on a probability paper, and was separated into several log-normal subpopulations by Inokuchi and Mezaki (1974) method (Figs. 2 and 3).

RESULTS

Representative grain-size distributions plotted on probability paper are shown in Figs. 2 and 3. Each grain-size distribution was separated into four lognormal subpopulations. Median (Mϕ), standard deviation (σϕ) and percentage of each lognormal subpopulation are shown in Table 1. In contrast, Table 2 shows median size of original grain-size distribution, and sand percent, silt percent and clay percent are also shown here.

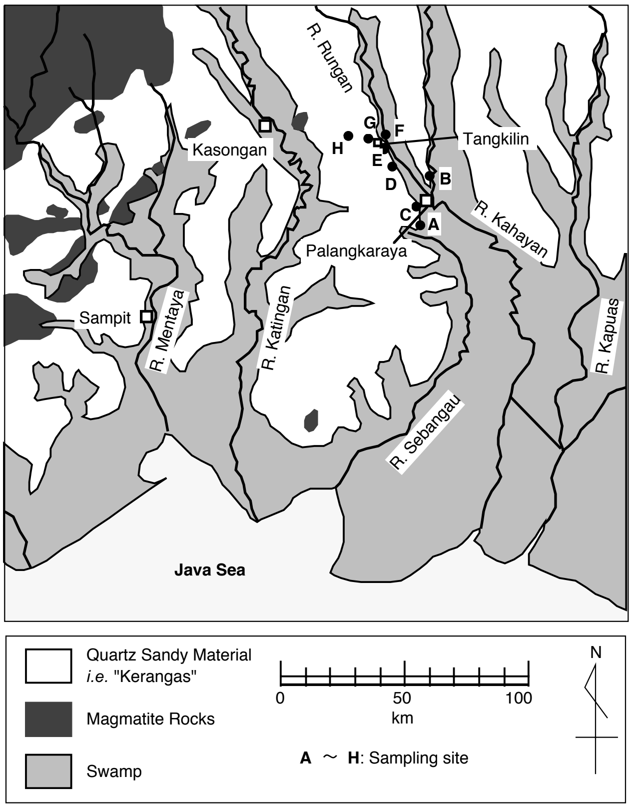
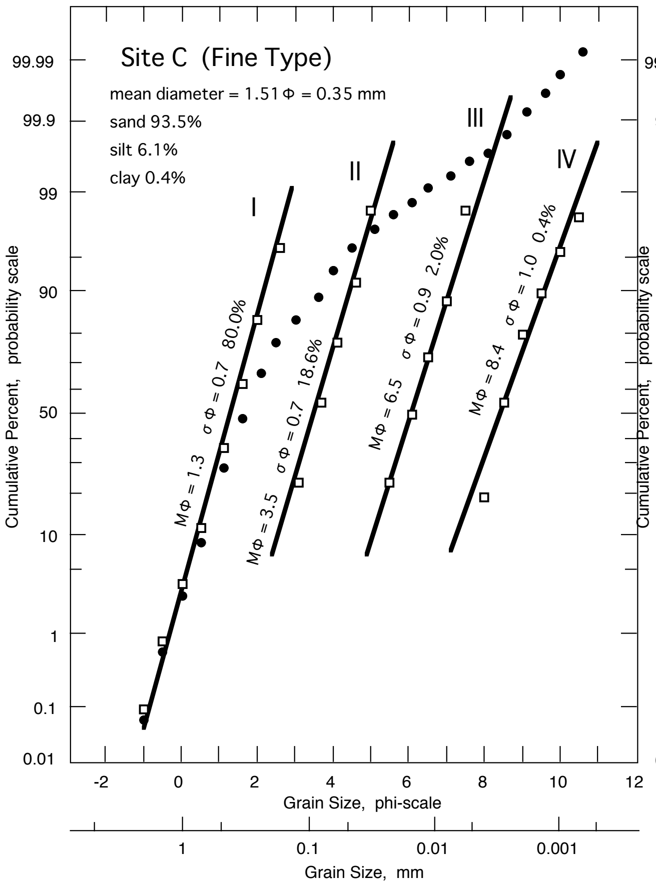


Figure 1. Map and surface geology of Central Kalimantan. Solid circles indicate the locations of sampling site.



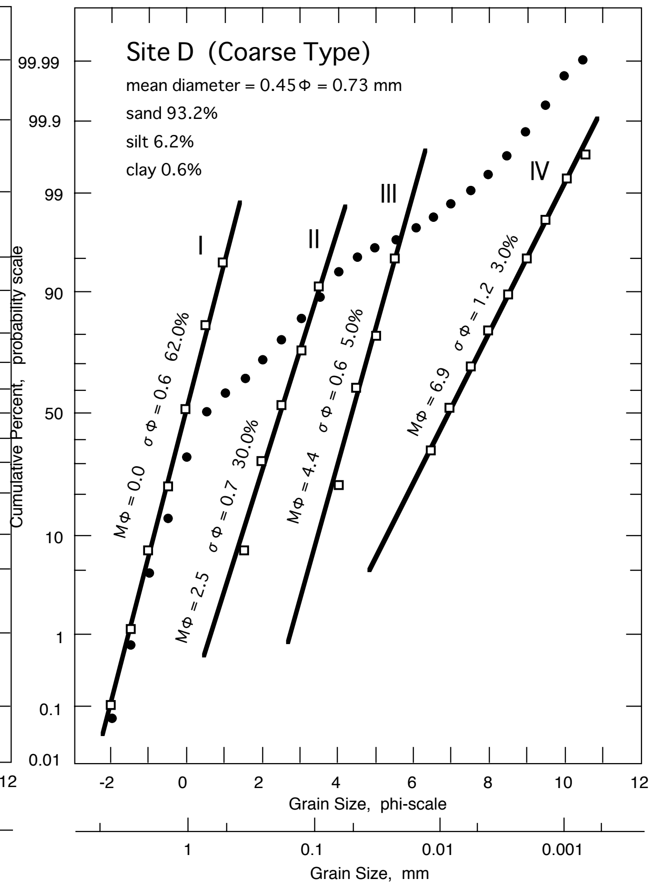


Figure 2. Representative grain-size distribution of the fine-type Kerangas plotted on probability paper. Solid circles indicate original grain-size distribution. Open squares and solid lines indicate lognormal subpopulations separated from the original distribution.

Figure 3. Representative grain-size distribution of the coarse-type Kerangas.

The grain-size distributions were classified into two types: coarse type and fine type. The coarse type Kerangas had median diameter of ca. 0.75 mm, whereas fine type had around 0.4 mm (Table 2). Except laterite sampled at Site G, sand percent exceeded 90%.

Table 1. Mean size, standard deviation and percentage of subpopulations separated from each grain-size distribution of Kerangas in Central Kalimantan

	I			II			III			IV				
Site	Mϕ	σϕ	%	Mϕ	σϕ	%	Mϕ	σϕ	%	Mϕ	σϕ	%	Type	Remarks
A	1.1	0.6	74.0	3.0	0.8	25.3	6.0	0.7	0.5	8.6	1.1	0.2	fine	
	0.8	0.8	83.0	3.7	0.7	15.3	6.0	0.6	1.3	8.3	0.9	0.4	fine	
B	0.9	0.8	84.0	3.5	0.7	13.4	6.5	0.9	2.3	8.8	0.9	0.3	fine	
C	1.3	0.7	80.0	3.5	0.7	18.6	6.0	0.8	2.0	8.4	1.0	0.4	fine	
D	0.0	0.6	62.0	2.5	0.7	30.0	4.4	0.6	5.0	6.9	1.2	3.0	coarse	
E	1.3	0.8	88.8	3.9	0.7	9.9	6.5	0.7	1.0	9.1	1.2	0.3	fine	levee
F	0.9	0.4	8.0	2.3	0.6	91.9	6.2	0.5	0.05	8.4	0.9	0.05	fine	present bar
G	-0.1	0.5	57.0	2.8	0.7	36.4	4.9	0.8	3.6	7.4	1.2	0.3	coarse	below podzol
	0.7	0.6	50.4	2.8	1.0	39.6	5.3	0.9	9.8	8.8	0.9	0.2	fine	laterite
	1.5	0.8	87.4	3.8	0.7	10.8	6.2	0.6	1.5	8.6	0.6	0.3	fine	podzol
H	1.0	0.8	88.0	3.5	0.8	11.2	6.3	0.8	0.6	8.5	0.8	0.2	fine	

Mϕ : mean size in phi scale. σϕ : standard deviation in phi scale.

Phi scale ϕ is defined as $\phi = -\log_2 d$, where d is the diameter in mm.

Table 2. Mean diameter and sand-silt-clay content of sampled Kerangas

Site	median diameter (mm)	sand%	silt%	clay%	Type	Remarks
A	0.40	96.5	3.3	0.2	fine	
	0.54	93.4	6.4	0.2	fine	
B	0.47	94.3	5.4	0.3	fine	
C	0.35	93.5	6.1	0.4	fine	
D	0.73	93.2	6.2	0.6	coarse	
E	0.41	94.9	4.7	0.4	fine	levee
F	0.23	99.62	0.34	0.04	fine	present bar
G	0.78	92.2	6.6	1.2	coarse	below podzol
	0.31	85.5	14.3	0.2	fine	laterite
	0.31	94.3	5.5	0.2	fine	podzol
H	0.47	96.8	3.1	0.1	fine	

Each of the coarse and fine type had characteristic subpopulations (Table 1). Median of each subpopulation of the coarse type sediment (population I: Mϕ = ca. 0.0, population II: Mϕ = ca. 2.5, population III: Mϕ = ca. 4.8, population IV: Mϕ = ca. 7.5) was coarser than that of the fine (population I: Mϕ = ca. 1.0, population II: Mϕ = ca. 3.6, population III: Mϕ = ca. 6.2, population IV: Mϕ = ca. 8.7). Each subpopulation of the levee deposit was similar to that of the fine type (population I: Mϕ = 1.3, population II: Mϕ = 3.9, population III: Mϕ = 6.5, population IV: Mϕ = 9.1). Subpopulations of the present river-bar sediment (population I: Mϕ = 0.9, population II: Mϕ = 2.3, population III: Mϕ = 6.2, population IV: Mϕ = 8.4) were fairly similar to those of the fine type except population II.

Median diameter of both podzol and laterite (ca. 0.3 mm) was smaller than those of the coarse and fine type Kerangas (0.35 to 0.78 mm) (Table 2). On the other hand, the sub-populations of podzol (population I: Mϕ = 1.5, population II: Mϕ = 3.8, population III: Mϕ = 6.2, population IV: Mϕ = 8.6) were similar to those of the fine type Kerangas, whereas those of laterite (population I: Mϕ = 0.7, population II: Mϕ = 2.8, population III: Mϕ = 5.3, population IV: Mϕ = 8.8) were not so well similar to those of the coarse type and fine type (Table 1). Silt percent of the laterite (14.3%) was much larger than that of the coarse and fine type Kerangas (3.1 to 6.6%) (Table 2).

DISCUSSION

Similarity between the grain-size distributions of fine type Kerangas and those of levee sediment indicates that the fine type Kerangas is alluvium which were transported and deposited under present alluvial condition. In contrast, the subpopulations of coarse type Kerangas were coarser than those in the fine type. This suggests that the coarse type Kerangas was transported under higher stream-power condition, possibly during last glaciation when sea level was lower than present.

Small median diameters of both podzol and laterite (ca. 0.3 mm) and large silt percent of the laterite may indicate that their grain-size distributions are affected by weathering process at the site.

The fine type Kerangas could be found widely around the sampling area, and this sediment was transported under present alluvial condition. This indicate that levee and floodplain sequence had been formed on the Kerangas Plateau, and the floodplain between levee and higher hill can be stagnant to form swamp and accordingly peat on the terraced Kerangas.

CONCLUSION

Kerangas could be classified into two types due to its grain-size distribution: i.e., the coarse type and fine type. The fine type Kerangas widely distributes on the Kerangas plateau, and this fine type Kerangas was transported under present condition.

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Session 6

PEATLAND AND RIVER TECHNOLOGY

Chaired by

Harukuni TACHIBANA & Nyoman SUMAWIJAYA

Estimation of Ground Water Level in a Peat Swamp Forest as an Index of Peat/Forest Fire

Hidenori Takahashi[1)], Aswin Usup[1)], Hiroshi Hayasaka[2)] and Suwido H. Limin[3)]
[1]Graduate School of Environmental Earth Science, Hokkaido University, Sapporo 060-0810, Japan, Telephone: +81-11-706-2221, e-mail: htaka@ees.hokudai.ac.jp
[2]Graduate School of Engineering, Hokkaido University Sapporo 060-0812, Japan
[3]Faculty of Agriculture, University of Palangka Raya, Palangka Raya, Central Kalimantan, Indonesia

ABSTRACT

Hydrological information, such as water balance, ground water level and soil moisture are very important not only for plant ecology but also for the estimation of wild fire disasters in a tropical peat swamp forest. Ground water level in a tropical peat swamp forest was measured for 10 years from 1993 in the catchment of Sebangau River, Central Kalimantan. The ground water level in the forest was between 10 cm below and 20 cm above the ground during the rainy seasons and dropped to 100 cm below the ground surface during dry season in 1997 and 2002. Dry seasons of those two years related to the serious forest/peat fires in Central Kalimantan.

The annual change of ground water levels in the forest were estimated with an one dimensional model of water balance in the peat soil of the forest. The results of estimation of ground water level showed the importance of rain-fall data close to the observation point of ground water level.

INTRODUCTION

Long-term observation of the ground water level in a tropical peat swamp forest have provided much information on the hydrological conditions of such a forest. The daily actual evapotranspiration from a tropical peat swamp forest was estimated from the daily change of ground water level in a forest (Takahashi et al., 1997). The actual evapotranspiration estimated from the daily change of ground water level has a linear relation ship with the daily solar radiation (Takahashi, 1999). A half of gross rain fall is used for the evapotranspiration in a tropical peat swamp forest (Kayama et al.,2000) . But the seepage ratio of ground water has small change with depth of ground water (Takahashi et al., 2000).

Ground water levels in dry season for ten years were compared with the total damaged area by forest/peat fire. Diurnal change of ground water level in the forest were estimated in this study.

STUDY SITE AND METHODOLOGY

The tropical peat swamp forest selected for this study is situated in the NATURAL LABORATORY which was established in a forest on the upper catchment of River Sebangau, about 10 km from Palangka Raya. Observation point (Plot 1B) in the forest is located inside of designated "germ plasm" biodiversity conservation area in the marginal tall forest zone, 2km from the river along the logging railway. The depth of peat near the plot is approximately 3 meters (Rieley, J.O., 1997) . The open site (Camp) is located at the edge of forest in the intermediate point between Plot 1B and the river. The meteorological observatory (UNPAR) was set up in a campus of University of Palangka Raya.

Ground water levels were measured at Plot 1B with a pressure sensor (Druck Ltd, PDCR830) and a data logger (Kona System, Kadec-Mizu). Integrated solar radiation with one hour interval and were measured at sites Camp and UNPAR with a solarimeter (Prede Co. Ltd., PC-100) and a tipping-bucket rain gauge respectively from September 1993 to September 2002. Data loggers (Kona System, Kadec-Up and Kadec-PLS) were used in the both sites.

RESULTS AND DISCUSSIONS

Relation between the damaged area and the ground water level in a forest

The ten years record of ground water level in the peat swamp forest is shown in Fig.1.

The ground water level were above the ground surface during wet season from November to April in the most of wet season of each ten years. But minimum ground water level were largely different year by year. Those minimum ground water level in each year has a relation to the total burned area (Indonesia Ministry of Environmental-UNDP 1998) of forests in Indonesia with a third order regression equation and a high regression coefficient of 1.0.

The ground water levels are expressed as a distance from the ground surface in this regression. According to the regression curve in Fig. 2, the gradient of curve of the burned area against the depth of the lowest ground water level from the ground surface increased when ground water level drop to lower than 40 cm. If the lowest ground water level is 40 cm, total burned area is less than 200 km^2, but if the lowest ground water level drops deeper than 80 cm from the ground surface, the burned area will increase to 2,000 km^2.

The lowest ground water levels in 1995, 1996, 1998 and 1999 were higher than 40 cm in depth from the ground surface. In the case of such a humid dry season with high ground water level, the possibility of big forest/peat fire will be low. But if the lowest ground water level is deeper than 40 cm below the ground surface, the possibility of forest/peat fire will

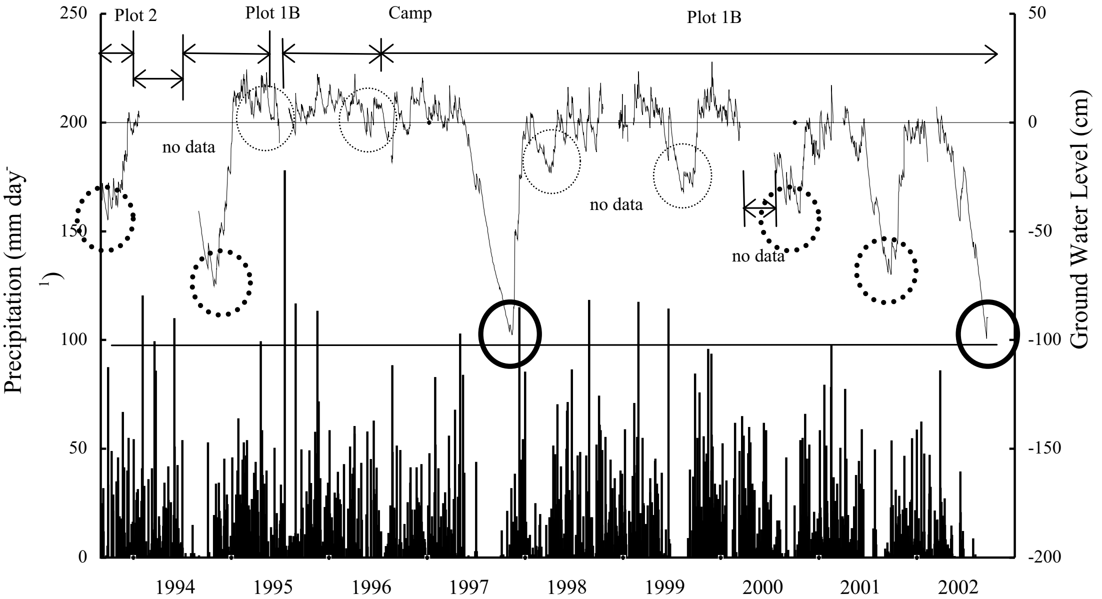

Figure 1. The long tem records of the ground water level at Plot 1b in the forest and the rain fall at open sites, Camp and UNPAR. The bold close circle: seriously dry season, the bold dot circle: mild dry season, and the thin dot circle: humid dry season.

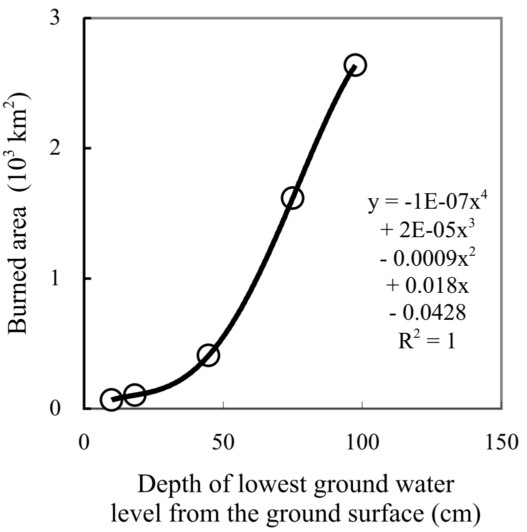

Figure 2. Relation between minimum ground water level in a year at Plot 1b and the total burned area of forest in Indonesia

increase with lowering of lowest ground water level. The burned area of the seriously dry season in 1997 reached to 2.64◊10^3 km^2 in Indonesia. Then two years of 1997 and 2002 in which the lowest ground water level were lower than 80 cm are categorized to the serious dry season and the possibility of serious forest/peat fire will be very high.

Estimation of the ground water level change

Evapotranspiration from the vegetative surface usually has a good linear regression with solar radiation and affects on the diurnal changes of ground water level in mires. Diurnal change of ground water level (Δh, mm day^{-1}) is calculated with next water balance equation.

$$\Delta h = C_{gw}(R + E_t) + h_{sp} + h_{in} + h_{out} \qquad \text{Eq. 1}$$

where C_{gw}: response coefficient of ground water table against rainfall, R: rainfall (mm day^{-1}), E_t: evapotranspiration (mm day^{-1}), h_{sp}: seepage ratio (mm day^{-1}),, h_{in} and h_{out}: inflow and outflow ratios (mm day^{-1}),.

The study plot was set up in a flat and homogenous forest, then the value (h_{in} + h_{out}) was assumed to be zero. The relationship between the daily total of solar radiation and the daily actual evapotranspiration, which was estimated from diurnal change of ground water level was linear (Eq. 2) in this study plot (Takahashi et al., 1999).

$$Et = 0.199Sr + 0.36 \qquad \text{Eq. 2}$$

where E_t: evapotranspiration from the forest (mm day^{-1}), S_r: solar radiation (MJ m^{-2} day^{-1}).

The seepage ratio h_{sp} of ground water level changed linearly with the depth of ground water level (Takahashi et al., 2000). But the regression equations were different with the ground water level were above the ground surface or not. Following two equations were used for estimation of seepage ratio.

$$h_{sp} = 1.31L_{gw} + 8.8 \quad L_{gw}>0 \qquad \text{Eq. 3a}$$

$$h_{sp} = 0.0116L_{gw} + 5.1 \quad L_{gw}<0 \qquad \text{Eq. 3b}$$

where L_{gw} (cm) is depth of the ground water level from the ground surface being minus below the ground surface.

The response coefficient, C_{gw}, at the study site were reported as C_{gw}=2.1 ,when ground water level is below the ground surface, and C_{gw}=1.3 when ground water level is above the ground surface (Kayama et al., 2000).

The ground water level was estimated using Eq. 1 with the daily data of solar radiation and rainfall and shown in Fig.3 with measured one.

The process of the ground water level dropping in the estimation has a good similarity with measured one. But

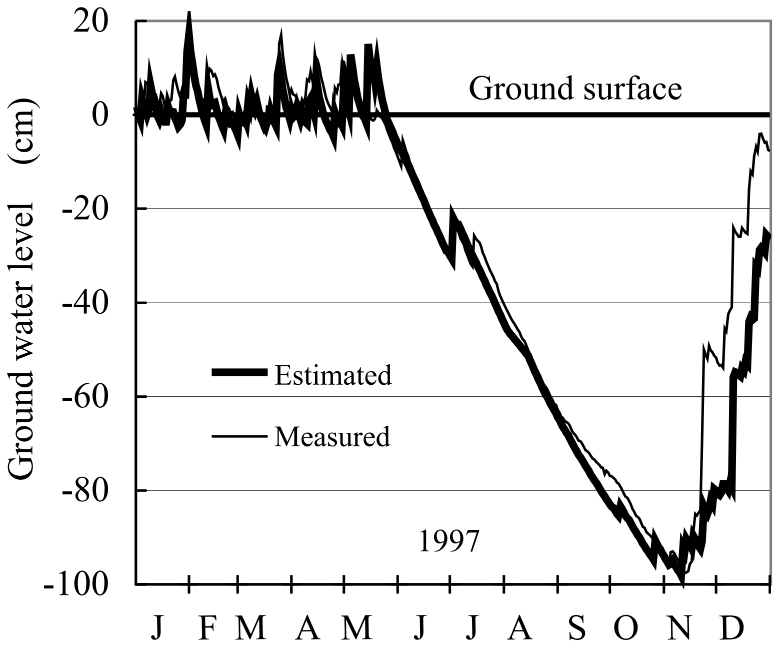

Figure 3. Measured and estimated ground water level in the study plot in 1997.

response of the estimated ground water level on rainfall is not so good. Because rainfall data used in the estimation was the measured one in the Palangka Raya airport and the campus of University of Palangka Raya which are located more 10 km far from the observation point, Plot 1B. And rainfall in a tropical area has a locality. Therefore, the estimated ground water level could not response on the rising process of ground water level in the beginning of rainy season.

Sensitivity of the model against the response coefficient C_{gw} and the seepage ratio h_{sp}

The hydrological parameters of the soil and ground where the ground water level was measured are important to estimate an annual change of ground water level. Those parameters used in the model were measured at the same point with ground water level observation. Then the results,

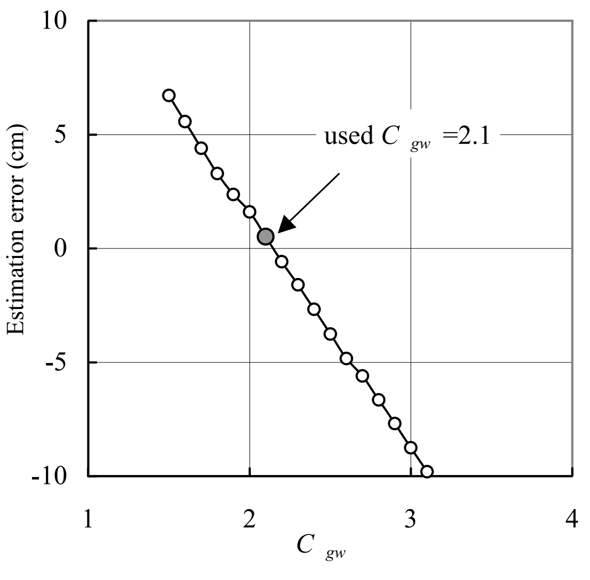

Figure 4. Estimation error of the lowest ground water level with the deviation of C_{gr}

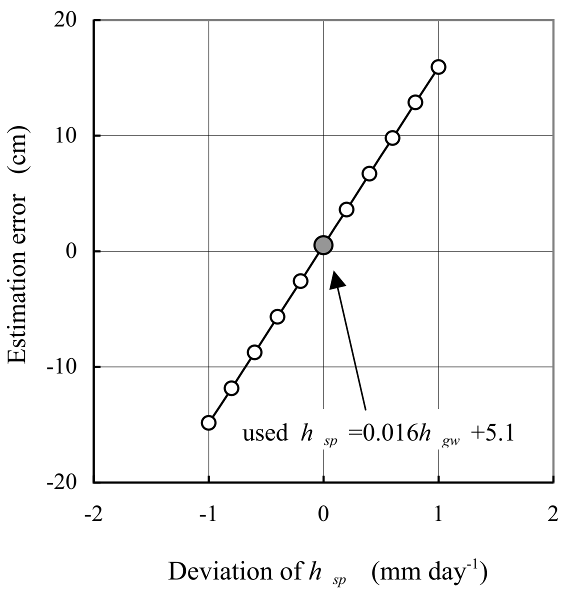

Figure 5. Estimation error of the lowest ground water level with the deviation of h_{sp}

especially the estimated lowest ground water level in the year had a good agreement with measured one.

The effect of the deviation of the response coefficient C_{gr} on the estimated lowest ground water level was checked and shown in Fig. 4. If the value of C_{gr} increases from 2.1 to 2.6, the lowest ground water level is estimated 5 cm lower which is 5% of total lowering of ground water level from the beginning of the estimation, January 1st, 1997. On the other hand , if the value of C_{gr} decreases from 2.1 to 1.6, the estimated lowest ground water level is estimated 5 cm higher.

The effect of deviation of the seepage ratio h_{sp} on the estimated lowest ground water level was checked and shown in Fig. 5. If the value of h_{sp} increases 1 mm day^{-1} from the original value which is calculated with Eq.3b, the lowest ground water level is estimated 15 cm higher which is 15% of the total lowering of ground water level in a year.

The two parameters of the soil and ground, C_{gr} and h_{sp}, have some important roles on the estimation of the lowest ground water level in dry season of a year.

CONCLUSION

1. From the ten years record of the ground water level in a peat swamp forest, the level of drought of forest was categorized to the serious dry years, 1997 and 2002. The lowest ground water levels were lower than 80 cm from the ground surface in those years. Four years, 1995, 1996, 1998 and 1999, were categorized to the humid dry season with their higher ground water levels than 40 cm below the ground surface.
2. The total burned area of the forest in Indonesia has a relation to the lowest ground water level in each year with a high regression coefficient. So the ground water level is a very good index for the forest/peat fire forecasting in the tropical area.
3. The annual change of ground water level estimated using a one dimensional water balance model with the daily data of solar radiation and rainfall showed a good similarity with the measured one excepting the rainy season.
4. The response coefficient C_{gr} of peat soil against rainfall and the seepage ration h_{sp} of the ground are important for estimation of the lowest ground water level in the peat swamp forest.

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Ten Years Peat Mining in Indonesia

Nyoman Sumawijaya[1) and Ketut Budhi Junaedi [2)
[1)Research Center for Geotechnology - LIPI;
Address: Komplek LIPI,
Jl. Sangkuriang Bandung 40135 Indonesia
Phone : +62-22-2503654
Fax : +62-22-2504593
Email : nyomas@geotek.lipi.go.id

[2)PT Arara Abadi, Riau

ABSTRACT

Peat can be used either in place such as for forestry, agriculture, water retention, settlement or extractive use such as for energy source, horticultural, and industrial peat. To use the peat as an extractive material, mining activities must be done.

Following the result of a cooperative work of the Department of Mine and Energy, the Republic of Indonesia and Finland Government in Central Kalimantan to use peat as energy source the Indonesian government gave a mining permit to PT Arara Abadi in Riau to mine peat and use for generating electricity in 1991. The peat in the area can be classified as medium grade humification (H5 - H6 of van Post scale) and has an average 5.587 K.cal /kg (dry bases) and low of ash and sulfur content. In an area of 1800 hectares with thickness ranges from 0.5 m to > 6.0 m the peat deposit is estimated 7.9 million tones and; with production rate 400,000 ton per year the deposit can be exploited for 21 years.

Peat mining (ìharvesting") is done by milling the peat naturally ëdryí ($\pm$ 50% water content) the granular or powder peat is collected or striping the upper most layer of peat for 1 - 1.2 cm and left for naturally ëdryí. After using ëridgerí and transported into stockpile using ëpeccoí transporter. The minimum thickness of peat left is 1.5 - 2 meters, to ensure that the drainage condition is still functioning well at the end of mining period; there will no any hydrology problem in the ex-mining area. The ex-mining area is then planted with *Acasia mangium* and *Acacia crassicarpa* as an estate plantation (sustainable development).

INTRODUCTION

Peat land in Indonesia is the fourth biggest peat spreading area and deposit in the world. It is estimated about 27 million hectares with varying depth from less than 1 meter to more than 10 meters peat land found in Indonesia. Peat land mostly occur in the lowland of Sumatera and Kalimantan. This big natural richness can be used for a number of purposes such as forestry, agriculture, and many types of extractive uses. At present condition most of its utilization are for forestry (logging) and agriculture, and limited extractive use (energy source).

To use the peat as a material (energy source, horticultural, and industrial material) mining should be done. Some countries have been using peat as material and so mining of peat such as Finland, Russia and Germany. Peat mining in Indonesia was started in 1987 in Palangkaraya - central Kalimantan, in cooperative work of the Department of Mine and Energy, the Republic of Indonesia and Finland Government. This experimental mine was then followed by issuing one mining permit (pilot project) in Perawang - Riau in 1991. After ten years since the first mining permit issued, until today there is no new peat mining in operation.

There are many problems should be solved for the success of peat mining, mainly water management and environment. Indonesian peat is mostly found in the lowland area which is characterized by waterlogged almost all days of the year. Indonesia peat is also considered as the huge world carbon stock and having unique biodiversity.

The government policy in (reasons of) using peat as energy source are : its energy content, low ash and sulfur content (<1%) (environmentally clean). And also in line to the government general energy policy : fulfillment the energy demand for any development sectors and diversification in energy sources. Peat is considered as one of the many alternatives energy sources in Indonesia. In term of emission, peat is considered clean energy source compared to coal and oil due to its low sulfur content. Fossil fuel such as coal and oil are preference for transportation fuel and export commodity.

GOVERNMENT POLICY

The government policy and regulation in relation to utilization of peat as energy source and peat mining is based on the government general policy on energy. The Government of Indonesia energy policy are : fulfillment of any type of energy demand, diversification of energy sources, conservation of fossil fuel, fossil fuel mostly for transportation use and export commodity. In line to this policy, the Ministry of Mine and Energy issued decree no. 507 K/20/M.PE/1989 which state that peat is a mining commodity. So that, exploitation of peat as a material is regulated on the basis of Mining Regulation. Beside the above policy that put peat as energy source, in contrast in 1990 the Central Government issued President

Decree no. 32 regarding management of the protected areas. The decree stated that, among others, peat land located in the upper stream and swamps area of thickness more than 3 meters is classified as protected area, no mining and any other development allowed.

Base on the above mentioned government policy on peat, the Indonesian Government (1991) gave one mining authority to PT Arara Abadi in Pearwang, Riau (Sumatera) to do peat mining and use the peat as energy source for its Pulp and Paper industry. Base on company calculation, the utilization of peat as energy source is economically competitive with other energy sources (coal, wood, and oil). Beside for energy use, peat is also used by PT Arara Abadi for nursery media. However, after ten years of the first mining authority, there is no other mining authority given by the government.

Why ?., what is the problem ?. If the mining of peat is considered not met the environmental regulation; why peat mining by PT Arara Abadi still in operation until today. And if peat mining can meet the environmental requirement, why there is no other peat mining in operation. There is some unclearness between the mining sector and the environmental sector policy.

Peat mining, as any other development program is controlled by Indonesia Environmental Regulation. The other regulation is Government Regulation no. 5/1990 regarding natural resources conservation.

Peat mining should meet the following requirement :

- mining activities will not deteriorate the hydrology of the peat-land and surrounding area
- minimum distance 3 Kms to the nearest river bank,
- elevation of after mined peat minimum 1 meter above the maximum river water level during the heavy rain,

Peat for electricity generating criteria :

- there is no other alternative source
- cost effective
- local use (in place electricity generation)
- peat is classified as medium to high grade humification (H_{5-10} of van Post scale), calorific value > 4,700 K.cal/Kg, ash content < 3.3%, and sulfur <1%.

Peat on the Kerangas (heath) forest with the following characteristics /conditions is not recommended to be mined :

- peat deposit is underlain by quartz sand
- flat lying area
- thickness less than 3 meters

THE NEED AND DEVELOPMEN OF PEAT MINING

The need for peat mining

- energy source : high calorific value, low ash and sulfur content, requirement for remote area (far from electricity line). There are a lot of Indonesia population living in the remote area without enough energy and electricity supply.
- seeding media, soil conditioning : easy handling, low density, high porosity,
- used for industrial materials such as cosmetic, drilling mud, medicine (its humic acid)
- mining technology : relatively simple, equipment available, human resources available,

There are big demand on tropical peat such as for energy source, soil improvement and growing media. The Indonesia Government policy (1989) that classified peat as mining commodity had been once followed by some export order from Taiwan, Melbourne - Australia, and South Korea for soil conditioner and seeding media.

The history of peat mining in Indonesia was started in 1982 - 1985 by the promotion of government policy on peat mining. This policy was then followed with a join research between Indonesia and Finland Government to mine peat in Palangkaraya Central Kalimantan (by 1985 - 1987) mainly for the purpose of energy use (electricity generation). This research conclude that Indonesian peat can be used as energy source and electricity generation. However the Palangkaraya project can not be continued due to minimum electricity demand of the area (in that time) which can not meet the smallest power plan unit using peat as energy source. In that time the smallest unit was 20 MWhour.

Following the success of the Palangkaraya research the government issue Ministry of Mine and Energy Decree No. 507K/20/M.PE/1989 which classified peat as mining commodity. Based on this decree the government give one mining authority to PT Arara Abadi to mine and use peat in Perawang as an energy source and seeding media. This mining authority was then followed by other mining authority. Until the year 1995 there were 10 companies holding mining authority (Kuasa Pertambangan - KP) for peat mining. But then most of them, for many reasons stop their activities (exploration) and only PT Arara Abadi continuing his mining activity. Mostly the problems related to environmental management standard and government policy. There many conflicting government policy in relation to peat.

Worldwide peat mining

Peat mining and energy use have been done since more than 200 years ago. Russia, Finland, Sweden, Germany and United Kingdom, US, Ireland have their long history on peat mining (Pozdnyakova, 2002, web communication).

- Finland : peat share 20% of heat and power energy source, producing 25 million m3 peat per year (energy and growing media)
- Ireland : about 385 MW electricity generated from peat, 320.000 ton peat briquettes, and 800.000m3 horticultural peat.
- USA : peat for growing media and soil conditioner (horticultural)
- Indonesia : about 400.000 m3/year (energy and growing media).

Table 1 : Some characteristics of peat as energy source

Parameter	Unit	Value
Calorific value	Kcal/kg	4200 - 5920
Ash content	%	0.5 – 4.0
Sulfur content	%	0.15 – 0.90
Density (dry)	Ton/m3	0.08 – 0.10

(Source : ***Company report on study of Peat Mining***,)

PEAT MINING IN PERAWANG - RIAU

Peat mining started in 1992 by PT Arara Abadi (Indah Kiat group of company). The company got mining authority on a 2000 Ha in Perawang. At present condition; 642 Ha of which have been done and reclamation and re-forestation is undergoing. Peat is used for energy source (Indah Kiat - Pulp and Paper Industry) and for growing media (forestry).

The peat in the area is part of the so called Siak Kanan peat deposit which cover an area of about 1400 km^2 (Supardi, Subekty A.D., and Neuzil SG, 1993) located between Siak River and Kampar River and about 60 Km Northeast of Pakanbaru (capital of Riau Province) (Figure 1). The elevation is between 5 meters to 7 meters above maximum river water level. Peat thickness ranges between 0.5 - 2.0 meters in the hilly areas and in the swampy area thickness may up to 6.0 meters. The topography is relatively flat with average slope about 1: 2000 meter into the Siak River .

In the basis for energy resources, the peat in the area is in average quality. Some chemical and physical characteristics of the peat are shown in Table 1. In the dry basis, the colorific value of the peat ranges from 4200 kcal/kg to 5920 kcal/kg, however in the daily practice the water content of the mined peat ranges from 45% to 55% and the related calorific value ranges from 2,689Kcal/kg to 2,094Kcal/kg. The wood content (non decomposed tree components) is rather high 15% - 20%. In Perawang peat for energy source is mixed with coal and wood chip (multi fuel boiler).

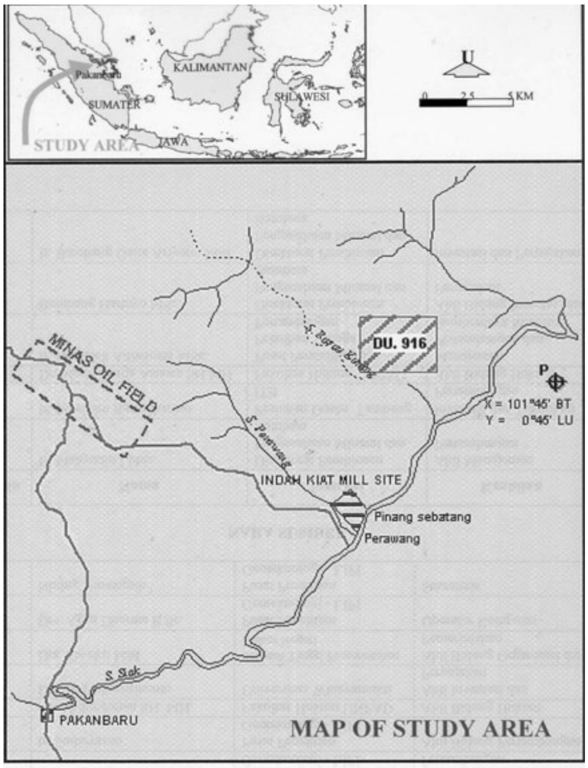

Figure 1. Location of Perawang Peat Mining

Peat Mining Process

Peat mining method and technique is a development of farming technology, so for many people peat exploitation is called as ëpeat harvestingí. Three methods commonly used in peat production Vacum, Haku, and Pecco Harvesting method. The choice of mining method is based on type of peat, terrain condition and the utilization of peat. Peco method is applied in Perawang.

Peat mining process involved land clearing, ditch and canal construction, field preparation, and peat production. As any other mining project, before mining process can be done, exploration, feasibility study and environmental impact assessment should be done (see Figure 2).

The mining process is started by the construction of drainage canal. The purpose of the canal is to lower the water level and improve bearing capacity of the field to support the load of mining equipment. This stage is then followed by land clearing (cutting all the trees), and preparing working area. Preparation of the working area include deep milling, profiling, and leveling. Deep milling is aimed to remove the trunk and stumps. Profiling is to create a working field that the middle of the strips have an elevation about 20 - 40 cm above the edge. This profile is intended to allow the surface rain water to flow into the ditch. One working strip is 20 meters width and 1000 meters length.

In the PCO peat production a powdery peat is produced. The peat is cut in thin layer (1.5 - 2 cm) using “peat miller”. This thin layer peat is left in the field for naturally air dry for about 3 hours (when good sun shine). After 3 hours the “powdery” peat is turn over, to make the other side projected to sun shine. When the peat dry enough (40% - 50% water content) the powdery peat is collected using peat “ridger” and then transported into the stockpile using “PECO TRANSPORTER”, a side dumping truck. This cycle will last for about 2 - 3 months in one working field, depend on the thickness of the peat.

When some working strip finished, reclamation program is began. Base on the environmental impact assessment document and result of forestry experiment the ex-mining area is used as plantation forest (production forest). *Accasia crasicarpa* and *Accasia mangium* are planted. The wood of *Accasia crasicarpa* and *Accasia mangium* will be used as raw material for the pulp and paper industry. So there is a continuous production and activities in this area.

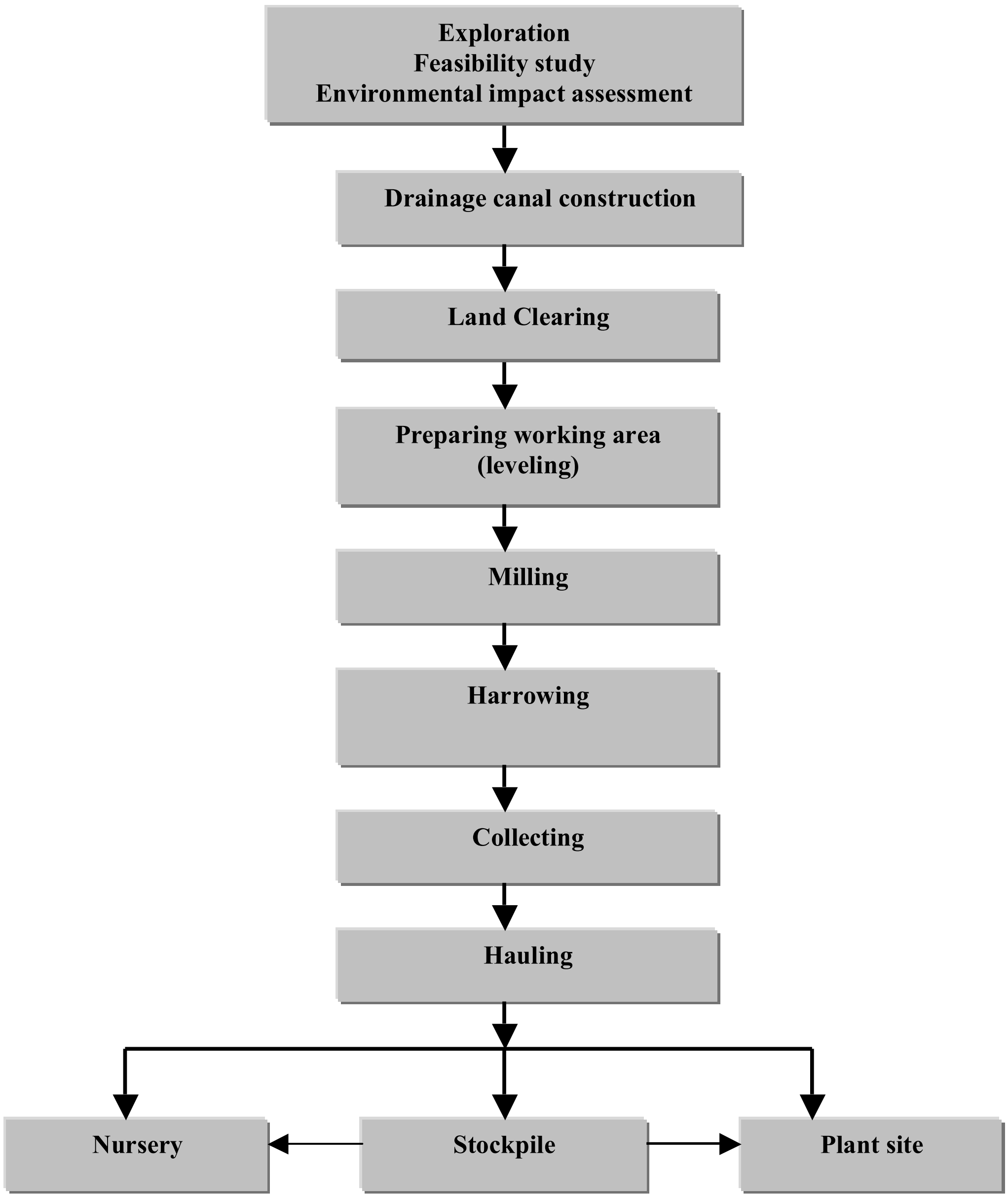

Figure 2. Flow Sheet of Peat Mining/Production

If good forestry treatment and management apply, 10 years old *Accasia crasicarpa* and *Accasia mangium* can be harvested.Figures 3, 4, 5, and 6 (photo of *Accasia crasicarpa* and *Accasia mangium)*

Some Environmental program conducted by the company are :

- minimizing suspended solid in the run off water by constructing settling pond
- fire prevention facility
- maintaining working condition : do not mine when the floor wet. When the rain intensity more than 5 mm a day, mining work will be done on the second day.
- dust control : cover the hauling box
- reclamation of cut-over peat : plantation forest (Accasia crasicarpa and Accasia mangium)
- Use of ash : ash produced from peat burning can be used as soil conditioner (fertilizer ?). Some experiment show that Accasia grow much better using ash as soil conditioner.

Figure 3 : Accasia one year old (floor is clean from grass, yellowish leaf colour)

Figure 5 : Accasia crassicarpa, 5 years old.

Figure 4 : Accasia 3 years old

Figure 6 : Accasia, 7 years old (secondary forest but no mining of peat)

CONCLUSION
About 27 million hectares of Indonesian land covered by peat, and about 5 million hectares having thickness more than 3 meters. Indonesia peat is in average quality for energy sources, have low sulfur and ash content. Peat mining should be considered as one alternative of peat utilization in Indonesia

Most of the peat-land areas are less developed area, low income family, and low educational level. Utilization of peat for Indonesia is not basically based on a want but based on a need. There is big need to use peat as an extractive material (energy sources and others).

Utilization of peat as energy source will solve the problem of energy shortage for some remote areas of Indonesia. There are many residential areas out of energy supply. When peat is available in that area, utilization of

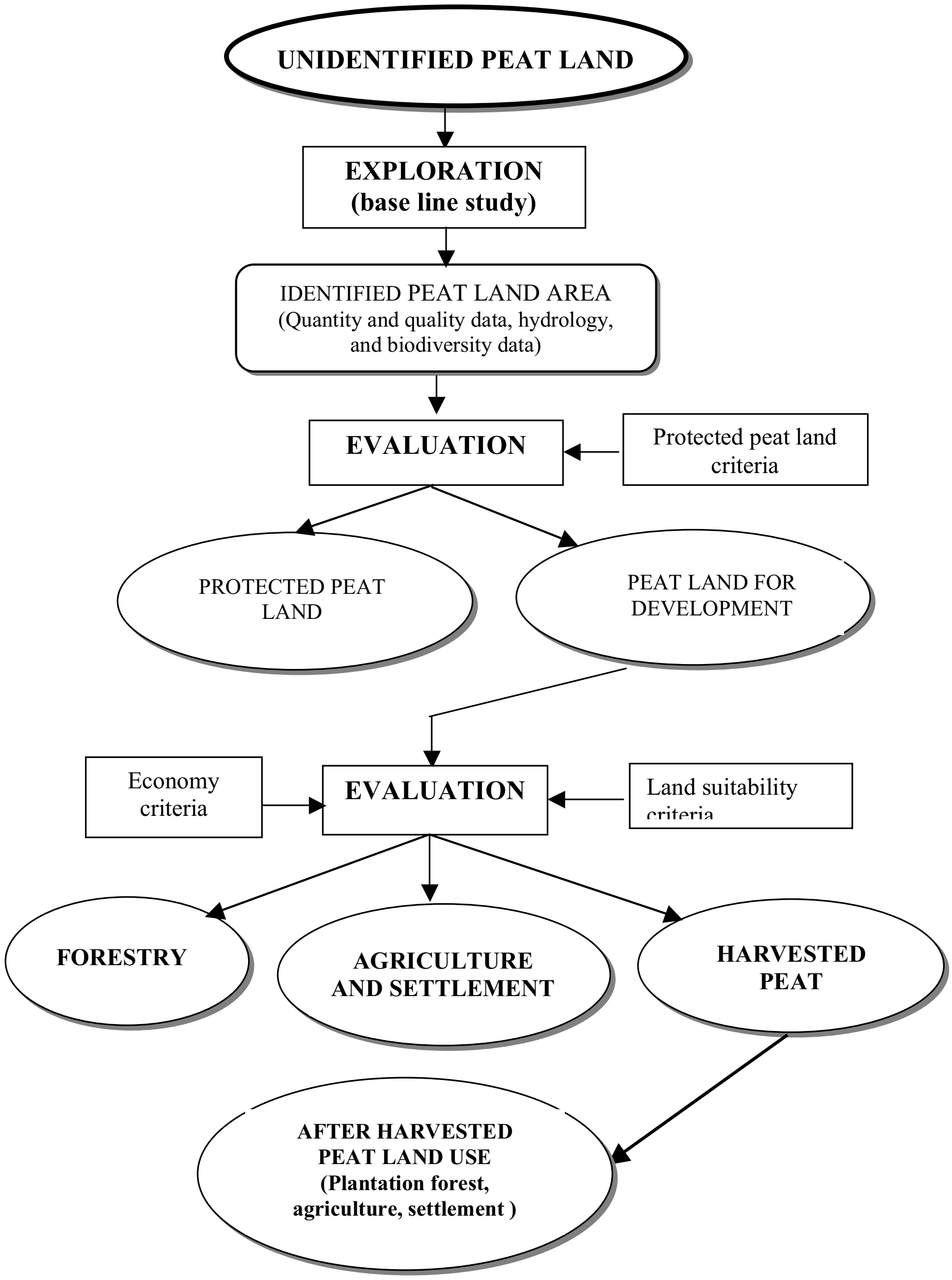

Figure 7. Peat and Management Scenario

peat as energy source will give economical benefit for the area and helping the government program in energy fulfillment.

There are some environmental problems related to peat mining such as changes of biodiversity, disturbing hydrology of the area, and water and air pollution. With technology and management system the environmental impact should be minimized without ignoring the potential use of the resources.
Wise use of peat

- preserved in natural condition as a wetland : control, local community, forest fire
- proportional mined area (10% ?) and block system of mining : minimize microclimate effect, biodiversity loss
- plan after-mine use of land before final removal
- developing restoration technology of the cut-over peat land : estate plantation (forestry), grass land, agriculture

To use the peat-land wisely, a peat-land management scenario is proposed (Figure 7). With this scenario, for any peat-land development plan, a base line study should be done before any other process. In the base line study the data collected not only peat data but also biodiversity and hydrology. Base on the data collected and conservation criteria evaluation is made. In this stage decision is made, either the area will be developed or classified as conservation area for specified purposes.

When the conservation criteria stated that the area can be developed, then socio-economic data is collected and the second evaluation is made. In this evaluation socio-economical criteria are used to decide the type and scale of development without ignoring the environmental concern.

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Shallow Groundwater Chemistry of Podzols in Central Kalimantan

M. Djuwansah*) & D. Suherman*)
*) Research Centre for Geotechnology - LIPI.

ABSTRACT

Chemistry and solutes composition of shallow groundwater have been studied in order to understand the percolation mechanism within podzols profile. Shallow groundwater studies have been carried out at peat station in Kalampangan Central Kalimantan. Water samples have been taken from auger holes at depths of 1.5, 3.5, 5.5 and 8.5 meters which were located at A0. A2, B2 and C Horizons respectively. Water sampling have been carried out 24 hour after auger drilling and pumped out of water table. Chemical parameters that have been measured directly are: pH, EC, and temperature. Whereas composition of solutes have been determined by laboratory analysis for Na, K, ca, Mg, H^+ HCO_3^-, CO_2, SO_4^-, Cl^-, Fe, PO_4-P and Permanganate Value. Peat influence on shallow groundwater is very significant at the layers above B2 horizons, whereas below B2 the influence does not appear physically but value of pH is still low. Permanganate value that represents potassium permanganate oxydable organic matter shows a maximum in peat (O) horizon, decrease in A2 horizon and drop below B21(or placic) horizon to 20 % of peat water content. The results of stiff diagram examination shows that the water in every horizons are of type different. The rate of percolation (vertical movement) of water within podzols profile is very low that water have sufficient time to interact with surrounding substance and results particular composition of solutes for every soil horizon. B-horizons performs as semi confined layer that impede vertical movement of water due to high content of fine particles that block soil porosity. The upper part of B Horizons behaves as well as filter of organic matter that accumulate here as organic complexes and form Placic B horizon.

INTRODUCTION

Any activity concerning land development in the lowland of Kalimantan always deal with the problem of hydrology either quality aspects such as peat water chemistry or quantity such as flood control and high water table. Eventhough, by its geographical situation, it seems that this area is the most appropriate to be developed in Kalimantan since lowlands coverage occupies the important part of the islands. The extensive utilization of Kalimantan lowlands started at the early of 1970' s by timber exploitation, followed by transmigration settlements started at the early of 1980's. The biggest projects was the reclamation of one million hectares of peatlands for rice fields at the middle of 1990's. So far, the success of these projects is not always as has been expected due to several constraints derived mostly from natural problems mentioned above. Even though in the future, the development of lowlands in Kalimantan looks will be still essential due to growth and increasing activity and necessity of population. On the other hand, measures have also to be done to rehabilitate the excessively devastated area.

Physiography of lowland in Kalimantan essentially consist of peat lands and wetlands. Kalimantan is also characterized by high rainfall, where the average of annual precipitation in most part is about 3000 mm. Under natural condition, lowlands of Kalimantan are characterized by thick peat deposit under heath forest overlying deep weathering profile of mineral horizons known pedologically as podzols profile. Surface water shows the characteristic of peat water with dark brownish color and low pH. The upper part of soil profile may reach 4 m thick consist of (1) prominent quartz sands-rich blanched A2 Horizon, lying above (2) sandy clay B Horizon. C horizon consist of coarser sands originated from weathering of unconsolidated parent materials.

The objective of this study is to gain a better understanding of hydrology and hydrochemical properties of shallow ground water in podzols terrain of Kalimantan, mainly that of percolation mechanisme and shallow groundwater flow .

MATERIALS AND METHODS

Shallow groundwater studies have been carried out at peat station in Kalampangan Central Kalimantan, near to the peat mining experiment station belong to Ministry of Mining and Energy. Water samples have been collected from auger holes at depths of 1.5, 3.5, 5.5 and 8.5 meters which were located at the levels of A0. A2, B2 and C Horizons of podzols profile respectively. Augerhole was drilled for 5" diameter. Cassing was made of PVC tube and screened at desired depth. Holes washing was effectuated by pumping out of water table until the entire cassing tube was filled of water originated from the screen. Water sample was collected 24 hour after pumping. Chemical parameters that have been measured directly are: pH, EC, and temperature. Whereas composition of solutes have been determined by laboratory analysis for Na, K, ca, Mg, H^+ HCO_3^-, CO_2, SO_4^-, Cl^-, Fe, PO_4-P and Permanganate Value.

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RESULTS

Water temperature profile within soil stabilizes after 48 hours of drilling and pumping. The stabilized water temperature (fig. 1) vary at 28 to 31°C shows slight increase from surface to the midle part of the profile and gradually decrease to the bottom. The stabilization of EC and pH values after drilling and washing disturbance is more rapid. The Electrical conductivity of the water shows a significant stratitfication according to soil horizon. The highest Electrical conductivity is found at surficial peat (A0) horizon, decrease in A1 and A2 Horizons where the value is almost the same. EC decrease sharply at B Horizon and from this horizon until the bottom of the profile the variation of EC value is small. The similar pattern of starification was appear as well for the pH.

Decreasing value of EC was proportionally related to the incerasing pH

Stratification within the profile appear also at the major soluble ions. The content of cations species at the peat horizon is $Ca^{2+} > K^{+} = Na^{+} > Mg^{2+}$ (fig. 2). The content of Ca^{2+}, K^{+} and Na^{+} increase at A2 Horizon, decrease at AB horizon and reach a minimum at Bh Horizon. From Bh to C horizon, the contents of these ion species remain constant and slightly increase at the bottom. For Mg^{2+}, the profile of the content showing an opposite pattern to the other cation, mainly below Bh. Horizon where the content sharply increase and reach the maximum untill C Horizon and began to decrease again at the bottom. For Anions and soluble CO_2, the contents of soluble $CO_2 > Cl^- > SO_4^{2-} > HCO_3^-$, at peat level. The contents of soluble CO_2, Cl^- and SO_4^{2-} constantly varied by descending and reach the minimum at Bh Horizon. This minimum content was still remain until the upper part of C horizon and slightly increase at the bottom. Whereas the pattern of HCO_3^-, eventhough the content is smaller than other anions and soluble CO_2, its pattern of content profile was showing the opposite to the others. The content of soluble organic matter was analyzed and expressed as permanganate value represents the total content of soluble organic matter could be oxydized by potassium permanganate (Tebbutt, 1983). At peat horizon level, permanganate value is fairly high. This value decrease at A2 horizon and increase to reach the maximum at Bh. Horizon. From this horizon, permanganate value decrease sharply to the bottom of the profile. Plotting the major ions content on stiff diagram (fig. 4) was showing that the composition is different between water above below Bh Horizon. According to the predominant cations and anions, the water above Bh horizons is the type of Ca^{2+} - Cl^- containing SO_4^{2-}, whereas below Bh horizon was the type of Mg^{2+}- Cl^- containing HCO_3^-.

The above results could indicate that Bh horizon have an important role as the limit of water chemistry between above and below this horizon. Whereas the soluble ions composition of water suggest the presence of several reaction of percolated water in this horizon: (1) Accumulation of organic matter, (2) precipitation of $Ca^{2+}$and SO_4^{2-} and (3) Dissolution of Mg^{2+} and HCO_3^-.

DISCUSSION

Previous study of podzols profile (Djuwansah, 2000) have suggested that the permeability of podzols is very low due to the development of illuviated (Bt and Bh) horizons by which water infiltration to deeper layer is hampered. In most studied podzols profile in Kalimantan shows that sand fraction dominate soil texture in all depth of the profile. Normally high sand fraction content related to high porosity. However, in fact Kerangas Forest soil has a bad drainage property that inundation and flooding usually happen after rainfall. The amount of water infiltration into the soils, in fact, is determined

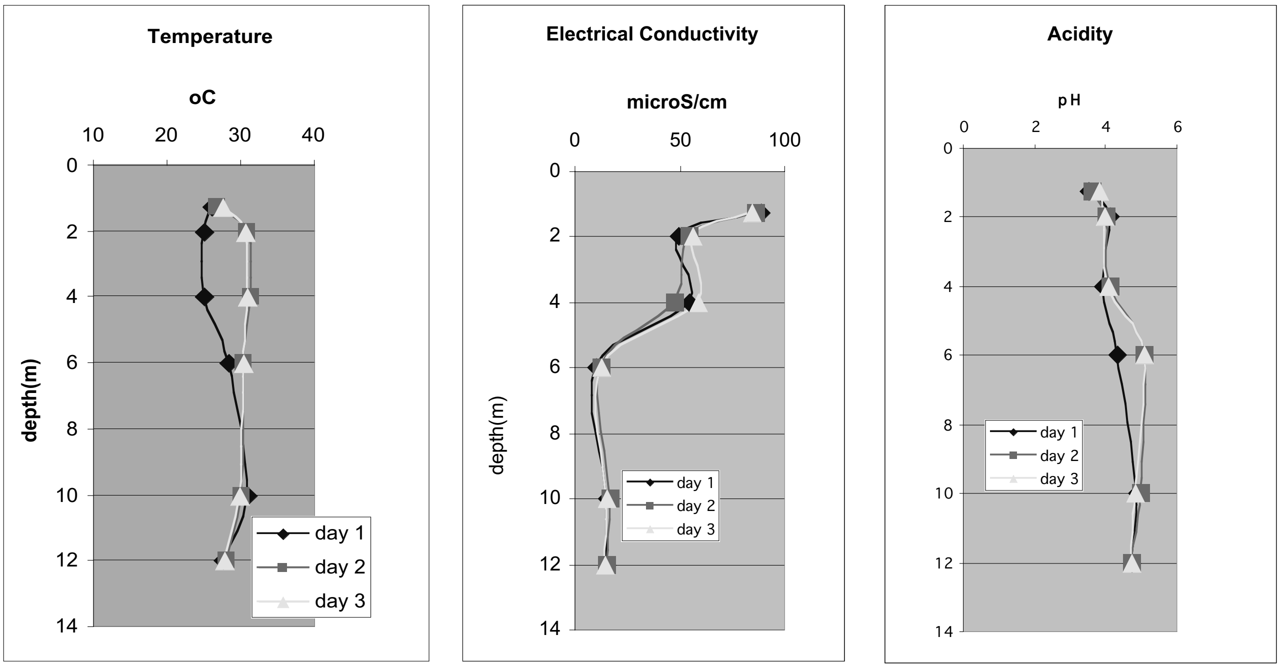

Figure 1. Water Temperature, Electrical Conductivity and Acidity profile in Podzols of Kalampangan.

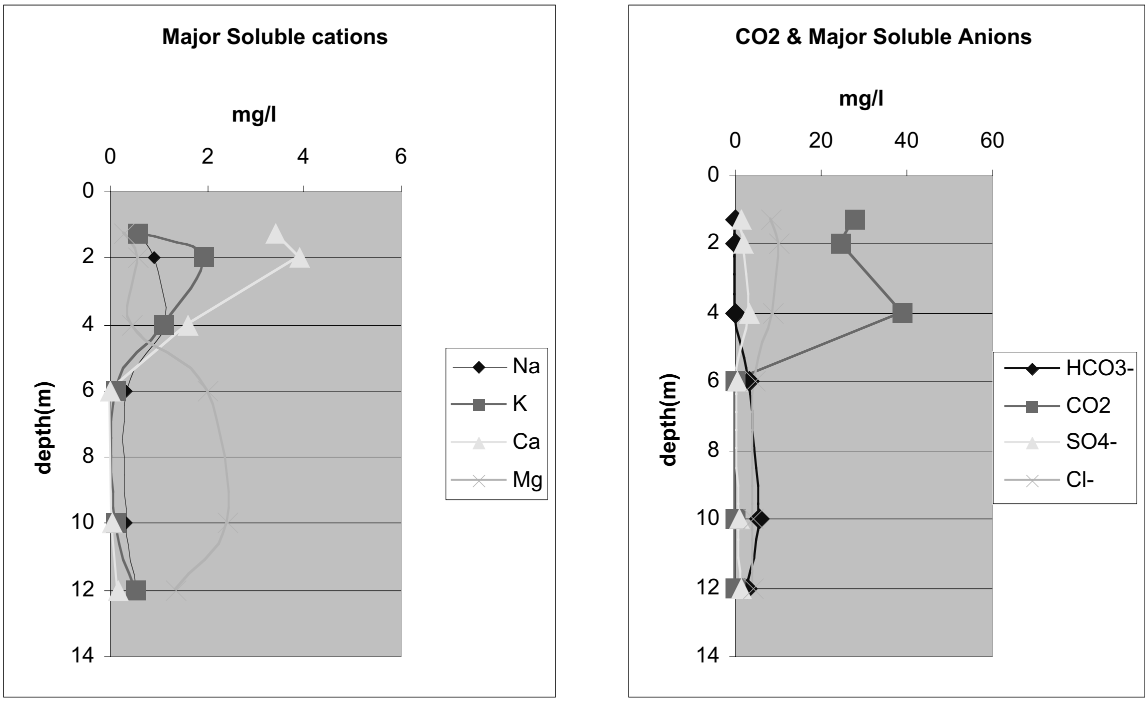

Figure 2. Profile of major soluble ions and CO_2

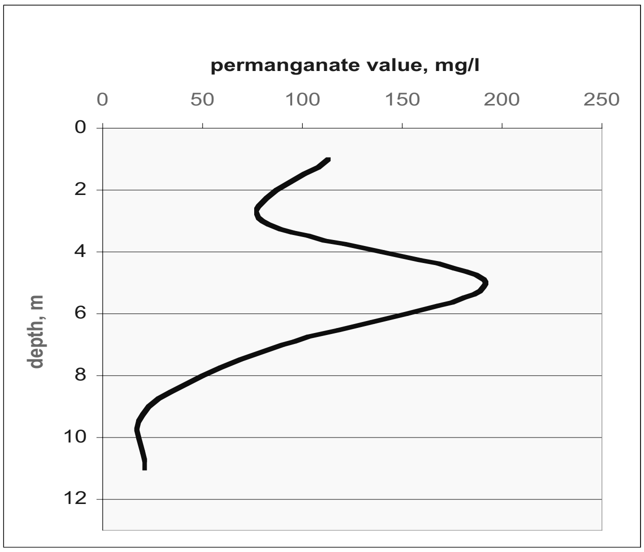

Figure 3. Profile of Organic matter content expressed by Permanganate value.

by the least permeable layers within the soils. In these case of podzols, eventhough the major constituents of mineral fractions are sands, the accumulation of iron and alluminum organic complex in Bh horizon and Clay in Bt-horizon has diminished the porosity, therefore these horizons is became the major restraints for water infiltration. The solis absorbs only water above these horizons. Movement of this shallow groundwater will occur at the direction of either sufficial slope or the sloping spread of these impermeable layer. Since the Podzols of kalimantan occupy mainly flat to gently sloping area, the sub-surface water movement will be weak, even stagnant. When the upper part of the soils has already been sturated, therefore all rainwater that reach soil surface will be transformed into surface run off or inundation water. Recent study conducted by Kayama et. al. (2000) on water balance in the upper catchment of Sebangau river, shows that most of rainwater was transformed into surface run off (59,8%) and evapotranspiration, whereas groundwater storage (10 %) was transformed into water table level change.

The study of isotopic hydrology (Tanaka, 1999) of water collected from rain water, lake water, river water, ground water from peat ponds, and wells shows that groundwater was found to be isotopocally lightest among the water samples, and rain water collected in both dry and rainy seasons was heaviest of all. Its indicate that ground water has to be originated from the water supply other than the local precipitation. This study concluded that in situ rainwater recharges negligible amount to the ground water. Most of groundwater originated from the remote recharge area in the upstream of the area, mainly of the high altitude as shown by isotopically light characteristics.

CONCLUSION

The results of this study confirm the hypotheses that the vertical movement of water is very slow in such a way that water have sufficient time to interact with surrounding soil materials. Illuviated (Bh and Bt) horizons is, in fact, is not olly reduced the infiltration capacity of water, but behave as well as filter of organinic matter and the location of ion transfert.

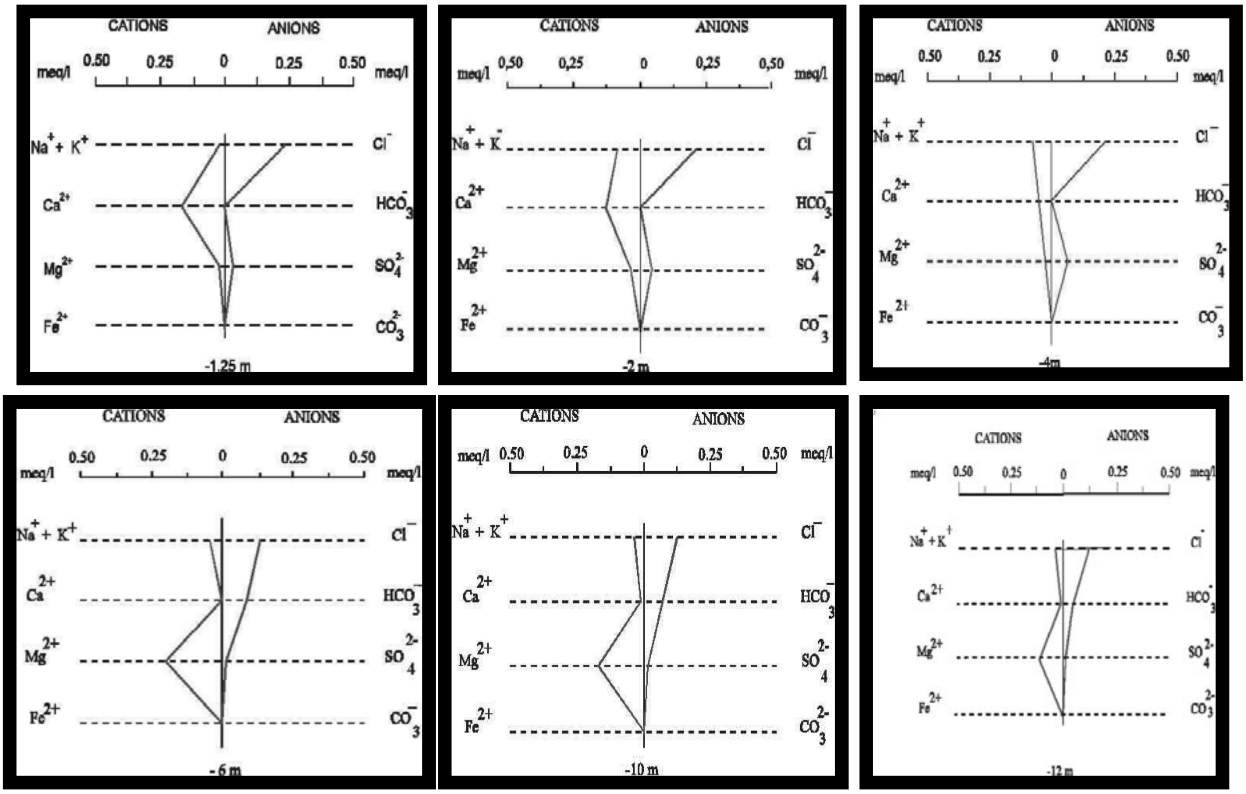

Figure 4. Stiff diagrams of water above (1.25m, 2m and 4m depth) anbelow (6m, 10m, and 12m depth) B horizon.

The great extent of Podzols in kalimantan may influence the hydrology of all wetlands and coastal area in this island. Podzols terrain supply high amount of surface and subsurface run off mainly consist of peatwater to the lower elevated wetlands ant coastal area. Under vegetation cover, due to the high humidity, podzols terrain is still favorable for peat accumulation that characterize chemical properties of water by high humus and acidity. Whereas under open condition,high water flow may cause severe erosion due to the loose property of sandy A2 horizons, mainly when covering peat as removed. The particular hydrological properties of podzols terrain and its surrounding recommends that water resources management concept of the area require a special approach adapted to characteristics of the enviromnent. therefore groundwater exploitation in this area is to be evaluated, mentioning that podzols is not a good recharge area. Surface and sub surface water is still to be considered as the most important resources.

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Water Quality Restoration for The Conservation of Sarobetsu Mire

Rofiq Iqbal(1)*, Tatsuo Shimizu(1), Stefan Hotes(2), Ryo Nakagawa(1),
Saori Akimoto(1), and Harukuni Tachibana(1)
(1) Division of Environmental Resources Engineering,
Graduate School of Engineering, Hokkaido University
North 13 West 8 Kita-ku Sapporo, Hokkaido, JAPAN
Phone +81-11-706-6276 Fax +81-11-706-6277
(2) Graduate School of Environmental Earth Science,
Hokkaido University,
North 12 West 5 Kita-ku Sapporo, Hokkaido, JAPAN

*Corresponding author, e-mail: iqbal@eng.hokudai.ac.jp

ABSTRACT

The shrinking of high-moor bogs around the globe has become an important problem, because these areas are ecologically valuable but very vulnerable to external impact.

Sarobetsu Mire is a case in point. Its ecosystem is gradually losing its natural state because of human perturbations at surrounding area which caused the water level to decrease, and threatens to change the entire mire ecosystem. As a consequence, a new non-native fauna, *Sasa* sp., is growing rapidly and invading areas of natural species.

It is already shown from previous research that the groundwater quality and groundwater level in Sarobetsu Mire have relationship with the vegetation, especially with the change of species, from sphagnum to Sasa sp. Point E where sphagnum as natural plants still remain dominant and the groundwater level is still high, inorganic nutrients available for plants to grow is less. On the contrary, the WW and the NC points where sasa already invaded, have high nutrients contents. Especially at point NC, which is suspected to be affected by inflow from outside of the mire, the water quality shows a great difference with the natural condition of bog-mire as Sarobetsu with high pH and high nutrient contents. In this research we installed dams in the natural channel and we found that by increasing the water level, the mineralization by micro-organic activities can be restrained and the sasa growth can be minimized. It also proved that the sasa growth, which was prompted by mineralization by micro-organic activities and enhanced by soil dryness and migration, could be hindered by increasing water level.

Key words: bog mire, restoration, water quality, water level, ombrotrophic, nutrient, dam.

INTRODUCTION

The shrinking of high-moor bogs around the world has become an important issue, because these areas are ecologically valuable but very vulnerable to external impact. (Bragg and Tallis, 2001; Tachibana et al., 1999; Nakamura et al., 1997). The conservation of those areas is necessary due to some reasons: they provide natural filtration and storage of water (water recharge); they aid in flood reduction and control; they are natural sink for pollutants; and they provide wildlife habitat for plants and animal, including some rare and endangered species. (Anon, 1995).

Sarobetsu Mire, a mire of fen and bog in northern Hokkaido, is a case in point. Its ecosystem is gradually losing its natural state because of destruction by human perturbations, such as drainage, changes in waterways, and the development of agricultural land and tourist resorts. These artificial activities have caused the water level to decrease, which threatens to change the entire mire ecosystem. As a consequence, a new non-native fauna, *Sasa senanensis*, the Japanese dwarf bamboo, is growing rapidly and invading areas of natural species. This species can endanger the diversity of the community due to its characteristics to inhibit tree generation and reduce the richness and abundance of forest floor plants. (Nagaike et al., 1999).

Previous studies in Sarobetsu Mire have investigated the main causes of the changes in the natural vegetation (from sphagnum to sasa). These studies have identified the factors contributing to sasa growth as the decrease in groundwater level, mineralisation by increased microbial activity promoted by soil dryness, the inflow of water from another water system and the mixing of mineral soil (Tachibana et al., 1999).

In this study, we installed small plywood dams to prevent excessive water flow and preserve rainwater in the natural channel. Previous works in the rehabilitation and conservation of raised mires commonly required water levels to be raised in order to reinstate Sphagnum-based raised mire vegetation, (Joya and Pullina, 1997) since the hydrologic parameters control the chemical and biotic processes in peatlands and may be the most important process regulating wetland function and development, including interactions among vegetation (Reeve et al., 2000).

We studied how the dams affected the water quality by retaining rainwater and increasing the water level. We compared the data from the dam site with data that had been collected continuously during the past 5 years. We also studied the effect of water quality restoration at the dam site on the growth of Sasa. It was found possible to use the growth rate of invading sasa as a variable for Mire Management and Conservation, since ecological conservation in this study was considered to be the maintenance of natural mire conditions toward supporting the continued existence of native plant species.

SITE DESCRIPTION AND METHODS

Study site

Sarobetsu Mire is in northern Hokkaido. The mire consists of both bog and fen and measures 23,000 hectares. The thickness of the peat layer ranges from 5 to 7 meters, and the surface elevation is mostly less than 10 meters above sea level. The mire contains relatively large amounts of mineral matter, as a result of river flooding and the presence of volcanic ash (tephra). Part of the area has become grassland, and another part (the study area) has been conserved in its natural state as a national park.

The height of central mire area is about 6 m a.s.l. and drops down to 4 m a.s.l. on the banks of Sarobetsu River. But the height of the dam site is only around 2.5 m a.s.l.

Sampling points

The investigation was performed in Sarobetsu National Park. We built one dam and then another 5 meters downstream of it, to hold water in the natural channel. We established a sampling point at each of the dam, those are upstream and downstream point.

The installation of dam for the purpose of sasa elimination was tentatively conducted in 1984. But after three years, in 1987, the water storage examination of the dam was stopped (Environmental Conservation Bureau, 1993).

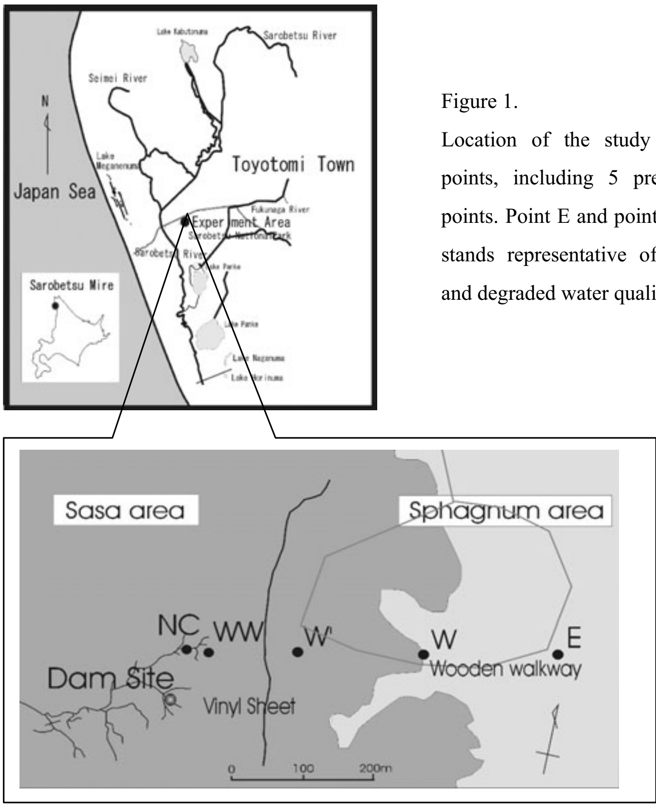

Figure 1.
Location of the study site and sampling points, including 5 previously established points. Point E and point NC were chosen as stands representative of having unchanged and degraded water quality, respectively.

Groundwater level measurement

We installed a water logger at each sampling point to monitor the change of water level on an hourly basis and calculated the average value and standard deviation to show the fluctuation of the groundwater level.

Water analysis

Samples were collected at monthly intervals during May - August 2001. Physical variables were measured in the field and all the chemical analysis were conducted in the laboratory according to The Hokkaido Branch of Japan Society of Analytical Chemistry (2000) after filtration with 0.45 µm filter. The variables studied were nitrogen, phosphorus, silicate, and main inorganic ions, using ion chromatography.

Sasa growth measurement

The effect of the dam on the growth of sasa was measured using the stalk height, the amount of plants per 100 cm^2 and leaf area index as variables. Measurement was performed near the upstream point, close the downstream point, and at the backside of downstream's dam.

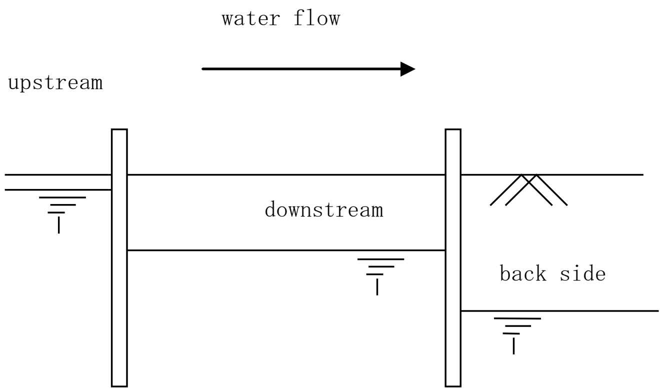

Figure 2. Schematic figure of sampling points.

2.6. Study of the vegetation

The vegetation was studied at each point during April - November 2001. Plant species list was drawn up on the basis of the work of Hotes (2002).

RESULTS AND DISCUSSION

General condition of the water quality

Table 1 compares the recent data from this study with the average water quality during the past 5 years of two extreme stands in terms of water quality. Point E in Fig 1. represents Sphagnum area with unchanged mire water quality, and point NC represents Sasa area with degraded water quality (see Fig. 1).

Point NC is almost neutral in pH, i.e., it no longer shows the characteristics of wetland. Water at that point also has high electrical conductivity, which correlates with high concentration of minerals and high content of nutrients, nitrogen and phosphorus. The irregularity of point NC is attributed to outside effects on that point (Tachibana et al., 1999). The natural channel in Sarobetsu Mire seemed to flow to Sarobetsu River in the past, but the human perturbations around this area might change the natural ecosystem. Because of the construction of drainage, the groundwater level has declined, enabling inflow from surrounding areas. This inflow may be transporting soil and sediment that contain high concentrations of minerals, and it may be this that is causing such change of water quality. The decline of water level may also be causing the drying of the mire, and also may be increasing the nutrient concentration, which would lead to further changes in groundwater quality.

On the contrary, water at the dam site (both upstream and downstream) still showed wetland characteristics, with low pH and low nutrient content, even though the dams are near point NC and have physical conditions similar to those at point NC. The silicate concentration also is low, and is unaffected by the growth of sasa in this area. It seemed that in almost every aspect, the dam succeeded in restoring the water quality to its previously undisturbed condition. As shown from the study area in Figure 1, the dam site closely correlate with point NC, both of which points are natural channel. After dam construction, however, this stand showed great differences from point NC.

The water at the dam site shows characteristics similar to rainwater. Previous studies by Tachibana et al. (1996) showed that groundwater of high-moor bog region where Sphagnum sp. are dominant is increased only by the addition of rainwater.

Table 1. Chemical properties of water at dam site compared with those of water at stands E and NC.

Points		E	NC	May		June		July		August	
		(n=42)	(n=30)	up	down	up	down	up	down	up	down
pH		4.5	6	4.5	4.6	4.4	4.4	4.4	4.5	4.3	4.3
EC	µS/cm	70.1	230.7	63.5	61.1	68.7	63	70.1	74.3	74.1	69.8
DN	mg/L	0.98	3.31	1.8	1.46	1.22	1.66	1.85	2.19	1	1.18
NH_4^+-N	mg/L	0.23	2.12	0.11	0	0	0	0.01	0.01	0.01	0
NO_2^--N	mg/L	0	0	0	0	0	0	0	0	0	0
NO_3^--N	mg/L	0.18	0.51	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
DIN	mg/L	0.41	2.64	0.12	0.01	0.01	0.01	0.02	0.02	0.02	0.01
DON	mg/L	0.57	0.68	1.69	1.45	1.21	1.65	1.83	2.17	0.98	1.17
TP	mg/L	0.01	0.519	0.08	0.04	0.25	0.07	-	0.13	-	0.07
DP	mg/L	0.01	0.06	0.01	0.01	0.01	0.01	0.021	0.02	0.01	0.013
DRP	mg/L	0	0.034	0	0	0	0	0.003	0	0	0
DOP	mg/L	0	0.026	0.01	0.01	0.01	0.01	0.018	0.02	0.01	0.013
Na^+	mg/L	11.7	25.8	7.9	7.6	7.9	7.6	7.5	7.7	7.1	7.1
K^+	mg/L	1	3.6	0.4	0.9	0.2	0.5	0.4	1.9	0.2	0.4
Ca^{2+}	mg/L	1.4	5.8	1	1.3	0.8	0.8	1.2	1	0.9	0.8
Mg^{2+}	mg/L	2	9.4	1.6	1.6	1.4	1.5	1.6	1.6	2.1	1.6
Cl^-	mg/L	15.6	18.6	13.3	14.2	12.5	12.9	11.6	12.5	11	10.9
SO_4^{2-}	mg/L	2.4	3.5	0.7	0.5	0.4	0.3	0.5	0.3	0.3	0.2
SiO_2	mg/L	7.3	26.5	1.9	1.8	0.4	-	1.9	1.8	0.3	0

Nutrient form

Previous research showed that at point E, nitrogen and phosphorus exist mainly in organic form. There is less inorganic nutrient available to promote sasa growth than at other stands. In contrast, point NC is high in inorganic nitrogen and reacted phosphor (Tachibana, 1994). This means that mineralization has already occurred and promotes sasa growth.

Our study showed a similarity between water at the dam site and that at point E, regarding nitrogen and phosphorus: These components still existed mostly in organic form. This result, which already reported by Nakagawa et al. (2001), also shows the success of the dam in restoring the water quality of the mire, because it demonstrates that mineralization by microorganisms was hindered.

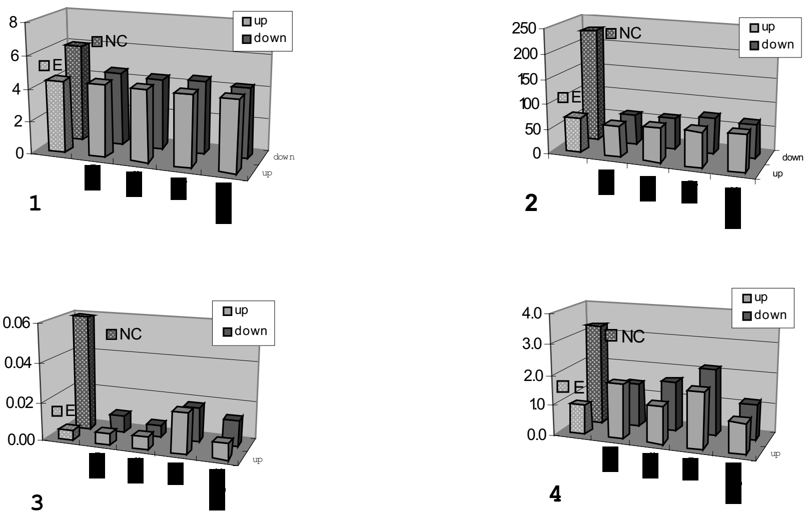

Figure 3. Distribution of water quality, with points E and NC as comparative values

1. pH 2. elec. conductivity (μS/cm) 3. dissolved phosphate (mg/l) 4. dissolved nitrogen (mg/l)

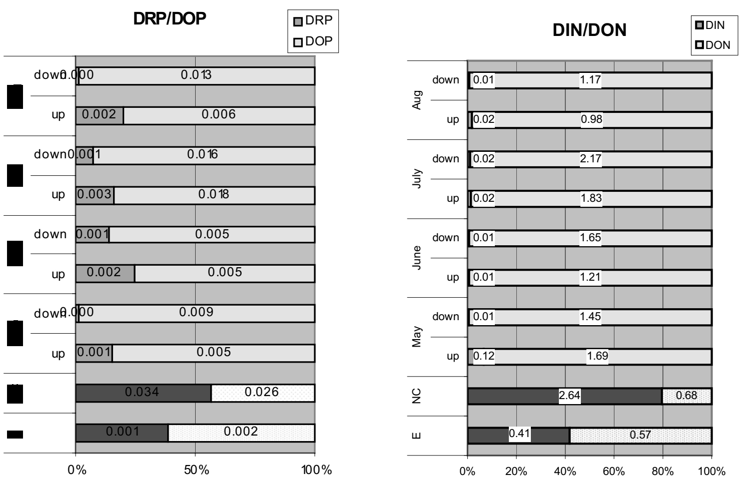

Figure 4. Comparison of nutrient form between inorganic and organic nitrogen and between reacted and organic phosphate. The values at the bar represent the concentration of each parameter in mg/l.

Groundwater level

Groundwater level was relatively stable after April, with the difference between high and low water within 20 cm. The high water level in early April may have been caused by snow melting.

As reported by Inoue et al. (1992), the fluctuation of water level at point E (undisturbed stand) was smaller than at the changed stand. At point WW, which considered as disturbed stand, almost equal with point NC, the difference between high and low water level reached up to 100 cm during August - September, but was less than 20 cm at point E, almost equal to what we had at dam site.

The retention of rainwater by the dam and the relatively constant water level seemed to be factors in hindering mineralization at the dam site. The data on nutrient form showed the effect of high water level at this point. Deeper underwater, the relative scarcity of oxygen tends to inhibit the activity of microorganisms, meaning that nutrients remain in their organic state.

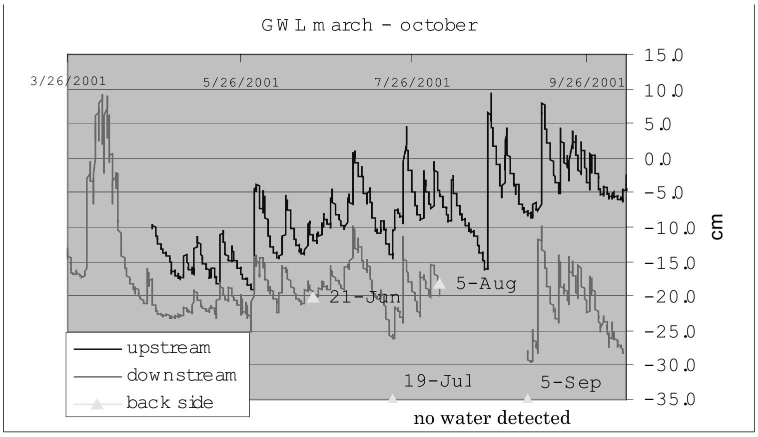

Fig. 5. Groundwater level fluctuations at the dam site. The value shows the water depth from surface. Average water level of upstream and downstream point and standard deviation of each point are -8.087, -18.374, 5.726 and 6.172. respectively. The backside of downstream was measured manually every sampling. At July and September sampling, no water detected at this point.

Sasa growth rate

The effect of the dam on sasa growth is shown in figure 5. The growth of sasa seemed to have been influenced by dam installation. We noticed that the raise of water level, which lead to prevent mineralization by organisms, have good effect to minimize sasa growth.

At backside point, where only remains little water flow or even no water flow at all (see Fig. 4), sasa grew easily. The deficiency of water had effect to increase the sasa growth. On the contrary, the storage waters both at upstream and downstream diminishes sasa plants efficiently. During August-October, the leaf area index at upstream and downstream decreased gradually from 13.1 to 6.1 and from 1.3 to 0.2.

The storage water at upstream and downstream also showed its effect in minimizing the amount of sasa plants and their stalk height. At upstream and downstream, where much water can be collected, the sasa heights are lower than at backside.

Vegetation

In this section, plant species lists including rough abundance estimates (+++ dominant; ++ subdominant; + recedent; - present, low cover value) are presented.

The three areas show differences in their plant species composition that may be related to different hydrological regimes. From the present short-term survey that is based only on four visits during a year, however, no tendencies for plant succession can be derived, as no data on the state of the vegetation before the dam installation or changes during previous years are available.

CONCLUSIONS

Human perturbations have changed the natural ecosystem of Sarobetsu Mire. This phenomenon started with the decline of groundwater level, which was followed by soil drying in the mire and increased nutrient concentration caused by mineralization resulting from microorganism activity in shallow water. Later, the change in groundwater quality is also influenced by inflow from outside of the mire, which is thought to cause migration of soil and sediment that contain high concentrations of nutrients and minerals.

The small dam installed in the natural channel successfully hindered mineralization. The high water level may also prevent inflow from outside the mire and soil migration, as happened at the other natural channel (point NC). The decrease in sasa growth around the dam also showed the dam's effect.

These results suggest ideas for future research on the management of wetland ecology. Mire conservation can start from retaining rainwater that is similar in characteristics to the water of natural wetlands, such as in having low pH and low mineral content. Retention of this rainwater keeps the water level in the natural channel high, which in turn prevents inflow from outside and soil migration, and hinders mineralization.

Table 2. Plant species list and abundance estimates

Upstream	*Moliniopsis japonica*	+++	Downstream	*Sasa senanensis*	++
	Drepanocladus cf. *exannulatus*	++		*Sphagnum riparium*	++
	Carex lasiocarpa var. occultans	+		*Carex lasiocarpa* var. *occultans*	+
	Phragmites australis	+		*Moliniopsis japonica*	+
	Hemerocallis middendorffi	+		*Iris laevigata*	+
	Sanguisba tenuifolia	+		*Hemerocallis middendorffi*	+
	Myrica gale var. *tomentosa*	+		*Rubus chamaemorus*	+
	Phalaris arundinacea	-			
	Scirpus wichurae	-	Back side	*Sasa senanensis*	+++

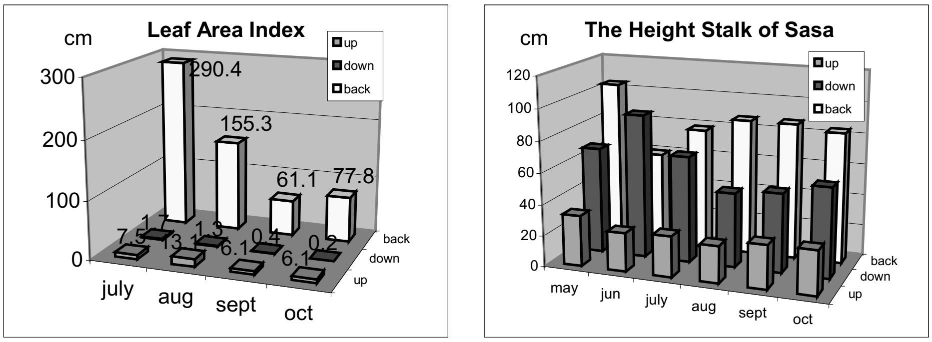

Figure 6. Effects of the dams on Sasa growth.

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Key Aspects of Water Management in Sustainable Development of Peatlands in Borneo

J.H.M. Wösten and H.P. Ritzema

Alterra Green World Research, P.O. Box 47, 6700 AA Wageningen, the Netherlands
(j.h.m.wosten@alterra.wag-ur.nl)

ABSTRACT

Coastal zones of Sarawak are identified as a major region for agricultural development, this development will be partly on peat. At the same time it is recognised that the characteristic flora and fauna give the peat swamps in this zone the status of unique ecosystems, which are internationally recognised as valuable wetlands. As a consequence, a balance needs to be established between agricultural development and wetland conservation of these peat swamps. Water management is a key issue in this respect as the challenge is to achieve suitably low water levels to enable optimal crop production and sufficiently high water levels to minimise peat subsidence. The proposed integrated water management approach shifts from an exclusive emphasis on drainage of excess water, to water conservation emphasising drainage in wet periods and water storage in dry periods. In this contribution, values for typical peat characteristics such as subsidence and hydraulic conductivity are presented. Insight is provided on sustainability of different types of peatland use by showing how these characteristics are related to the imposed water management regime, which in turn, is dictated to a large extent by the envisaged type of land use.

Key words: peat swamp; subsidence; oxidation; CO_2 emission; bearing capacity; water management

INTRODUCTION

The lowland peat swamps in Sarawak are waterlogged during practically the whole year (Tie & Kueh, 1979). Drainage is needed to make these waterlogged swamps suitable for agriculture use (Andriesse, 1974). Depending on the envisaged type of land use, different optimal water table depths for crop production need to be defined. Yield versus water table depth curves are established for a number of crops whereas they are still not well known for other crops (Department of Irrigation and Drainage, 2001). For the purpose of this study, examples are presented of oil palm and sago cultivation on peatlands. The optimal water table depth for oil palm cultivation is assumed to be 50 cm and for sago cultivation 25 cm below soil surface. The effects are discussed of these two types of land use on the sustainability of the peatland ecosystem.

Until now, the existing water management practice is almost exclusively focused on fulfilling the drainage requirement aiming at avoiding flooding by evacuating excess rainfall within a certain period of time (Department of Irrigation and Drainage, 1973; Tan & Lim, 1999). Despite the fact that the measured physical characteristics of peat and mineral soils differ greatly, the drainage design principles for the two soils are still often assumed to be similar. An overview is presented of the physical characteristics of peatland and the consequences are discussed if these values are not used in the design of the drainage system.

Assuming an oil palm and a sago land use system and taking into account the measured physical characteristics of peatland, this paper quantifies its effects on subsidence (and associated CO_2 emission) and bearing capacity of peatlands. Finally, a number of principles are defined with respect to the water management of peatlands aiming at their most sustainable agricultural use.

Physical characteristics of peat

Based on an review by PS Konsultant and LAWOO (Department of Irrigation and Drainage, 2001) the main physical characteristics of peat can be summarised as follows:

Infiltration capacity. The infiltration capacity of intact peat domes is always sufficient to prevent overland flow of rainfall. Only when the complete peat body is saturated with water, additional rainfall may cause flooding.
Drainable pore space. Peat deposits contain a high percentage of raw and woody material that is 80-90% porous and highly permeable. Drainable pore space, or the storage coefficient, can be as high as 0.8.

Hydraulic conductivity. Hydraulic conductivity of peat soils is very high, generally exceeding 1 m/d. Conductivity of fresh peat moss can be over 100 m/d. Conductivity varies considerably with the type of peat and the degree of humification.
Capillary rise. Capillary rise in peat soils can be considerable: up to 2 mm/d is possible in humified peat with a water table depth as low as 50 cm. However, experiments indicate that evapotranspiration can be restricted when the water table drops below 30 cm. Capillary rise depends very much on the degree of humification.

Bulk density. Bulk density can be higher than 0.1 g/cm^3 in the more decomposed hemic topsoil, whereas it is below 0.1 g/cm^3 in the less decomposed fibric subsoil. The dry bulk density of a peat soil is only 7-8 % of the bulk density of a mineral soil, which implies that peat soils have a high water storage capacity.

Plant-available water. Depending on the degree of humification, plant-available water may vary from 10-20 mm per 10 cm of peat. The relatively low available water capacity, in combination with a low capillary rise implies that periods of drought of 10 or more days may reduce crop yields in peat.

Due to its physical characteristics, the water storage capacity of peat is large compared to mineral soil (Ritzema *et al.,* 1998). If this fact is ignored, as is often the case, water management systems in peatlands are often over-dimensioned resulting in deep water table levels with the following negative consequences:

- Irreversible drying of surface peat, producing hard granules that are sterile and non-productive;
- Excessive subsidence rates and loss of peat by oxidation;
- Uneven land surface topography creating overall sub-optimal water levels;
- Water stress during prolonged dry periods.

To correct these negative effects a new, integrated approach in water management is requested in which the emphasis in water management shifts from drainage to water conservation.

Subsidence

Subsidence is defined as the continuous lowering of the level of the soilís surface. Peat soils show a characteristically different subsidence behaviour from the mineral soils clay and sand. Over time, subsidence of mineral soils will stop, first with sands and then with clays. Subsidence of peat soils, however, continues over time, albeit at decreasing rates. Furthermore, subsidence of peat soils is caused to a large extent by oxidation which leads to considerable CO_2 emissions. To understand the complex relationship between total subsidence and drainage, it is useful to divide peat subsidence into an early, rapid consolidation component and in an ongoing oxidation and shrinkage component (DID & LAWOO, 1996). An existing model can quantify the oxidation and shrinkage component of total subsidence in Sarawak (Wˆsten *et al.*, 1997). To quantify the oxidation component, it is necessary to know the organic matter decomposition rate. Measured bulk densities of initial and residual organic matter are necessary to calculate the volume reduction due to shrinkage.

Based on limited data it is estimated that total initial, rapid subsidence in the 2 years following drainage of a virgin peat in Sarawak will be approximately 1 m. In the following years, this rate decreases to approximately 5 cm per year (Figure 1). The initial rapid subsidence occurs because of consolidation. It results in compression of permanently saturated peat layers without a permanent loss of peat.

Analogue to the situation in Western Johore (Wˆsten *et al.*, 1997) it is assumed that in Sarawak also 60% of the total subsidence occurring after the first two years is caused by oxidation. Projections of peat subsidence rates in Sarawak are around 5 cm per year as compared to 2 cm per year in Western Johore. Notwithstanding these differences in subsidence rates, CO_2 emissions in the two regions are assumed to be comparable and of the order of 26 tonnes per hectare per year. This assumption is justified by the fact that the temperature and humidity regimes in the two regions are comparable. It needs to be stipulated that these are indicative figures only, which need to be substantiated by measured data.

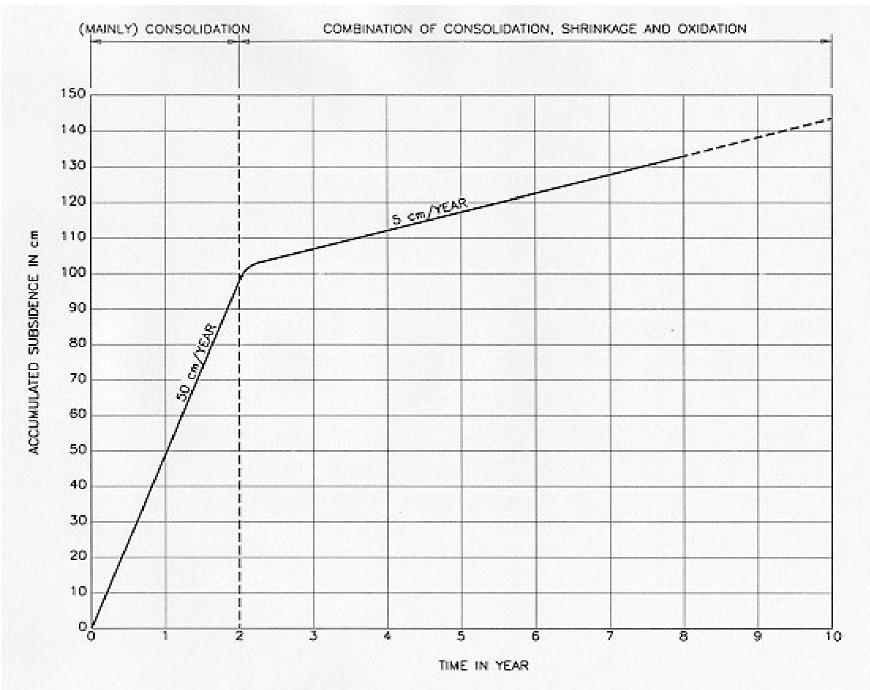

Figure 1. Projected relation between accumulated subsidence and time after drainage of virgin peat in Sarawak.

Subsidence - water table depth relationship

Recognising that the subsidence rate depends on the depth of the water table and considering that:

- The average annual subsidence rate in Sarawak (5 cm) is 2.5 times the average annual rate in Western Johore (2 cm).
- The relationship between the subsidence and the water table depth in Western Johore (DID & LAWOO, 1996) can be described as follows:
  Subsidence rate (cm per year) = 0.04 * depth of the water table (cm).

The following equation is considered to be the best possible prediction of the subsidence - water table depth relationship for Sarawak.

Subsidence rate (cm per year) = 0.1 * water table depths (cm)

The above equation is a key parameter in the interrelationship between land use, water management and peat subsidence. For example, the rate of subsidence of peat under sago cultivation with an optimal water table depth of 25 cm will be only half the rate of subsidence of peat under oil palm cultivation with an optimal water table depth of 50 cm. Assuming an optimal water table depth for a specific crop and knowing the thickness of the peat layer, the equation can be used to assess the sustainability of the peat soil. As an example the lifetime of peats with different thickness is calculated for the situation of oil palm and sago cultivation (Table 1).

Table 1 shows that the choice of the cultivation practice by its associated optimal water table depth has a strong influence on the sustainability of the peat ecosystem. Furthermore the mineral substratum underlying the peat soils is often sulfidic in nature. As such the peat layer acts as a protective wet sponge that keeps the underlying mineral subsoil in a wet anaerobic condition. If peat disappears the mineral subsoil will surface and if this subsoil is situated above the water table, available pyrite will oxidise and problematic acid sulphate soils with very low pH values may be formed.

Table 1. Lifetime of peat as influenced by the choice of cultivation practise.

Peat depth (cm)	Elapsed time spans (years) for peat disappearance	
	Oil Palm (water table depth 50 cm)	Sago (water table depth 25 cm)
Shallow peat (< 150)	< 10	< 20
Anderson 1 (150 – 200)	10 – 20	20 – 42
Anderson 2 (200 – 250)	20 – 30	40 – 60
Anderson 3 (>250):		
250 – 500	30 – 80	60 – 160
500 – 1000	80 – 180	160 – 360
1000 – 1500	180 – 280	360 – 560
1500 – 2000	280 – 380	560 – 760
>2000	> 380	> 760

CO_2 emission as a result of subsidence

The peat subsidence rates in Figure 1 are related to CO_2 emission rates. An average subsidence rate of 1 cm per year results in a peat volume reduction of 100 m^3 per hectare per year. A bulk density of 0.1 gram per cm^3 and an average subsidence due to oxidation of 60% will lead to 6 tonnes of decomposed peat per hectare per year. If the carbon content of the peat is 60%, 6 tonnes of decomposed peat will produce 3.6 tonnes of carbon per hectare per year, which, in turn, will result in a CO_2 emission of 13.25 tonnes per hectare per year. So every centimetre of peat subsidence results in a CO_2 emission of approximately 13 tonnes per hectare per year. These values are approximations and further measurements are necessary to underpin this finding.

Figure 2 uses the relationship between subsidence rates and CO_2 emission to illustrate how the CO_2 emission is related to water table depths in peat soils. It is clear from the figure that lowering the water table depth in peat soils causes a dramatic increase in the release of CO_2.

Water Management

Agricultural use of peatlands requires lowering of the water table for crop cultivation, on-farm transport and infrastructure. However, to avoid excessive subsidence and to reduce water stress in dry periods it is also necessary to control the water table. Thus a water management system in peatlands has to perform several functions:

- Remove excess surface and subsurface water
- Control the water table
- Conserve the water.

These functions do conflict. On one hand, the removal of excess water requires unrestricted outflow conditions. Yet on the other hand, it is only by restricting the outflow that it is possible to control the water table and conserve water. To complicate the situation further, the water management system must perform these functions at different times of the year. For example, it must control the level of the water table the whole year around but remove excess water only during periods of excess rainfall and conserve water only during prolonged dry periods. As a consequence, a new integrated water management approach has to be adopted. Until now the focus was on the removal of excess water. The new approach integrates the above mentioned functions and is based on experiences obtained in the utilisation of peat land in Peninsular Malaysia (DID & LAWOO, 1996), The Netherlands (Ven, 1996) and other parts of the world (de Bakker & van den Berg, 1982). The new approach has the following consequences for the design, implementation and operation of the system (Ritzema *et al.*, 2001):

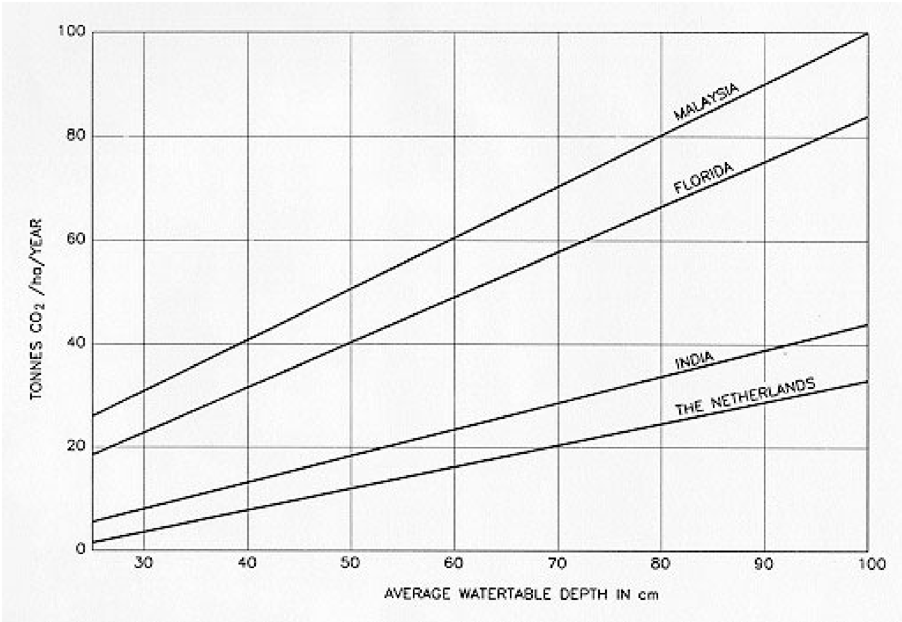

Figure 2. CO_2 emission rates as a function of water table depths in peat soils for different areas in the world.

- The design of the system should take into account the specific soil hydraulic characteristics of peat, i.e. the very high infiltration rate, storage capacity and permeability. Because of these unique characteristics, excess rainfall will not be removed as surface runoff but mainly as groundwater runoff (Figure 3).
- Water levels in the system will fluctuate with the seasons. During the rainy season a lower level will have to be maintained to increase the discharge capacity while during the dry season a higher level will be maintained to conserve water. Consequently, structures are needed to control water levels in the system. Because of the high permeability of peat a cascade of closely spaced structures with small differences in head is recommended. This results in a water management system with narrowly spaced drains in combination with an intensive network of control structures.
- The layout of the water management system should make use of the dome-shape topography of peat lands. Field drains should be located parallel to the contour lines and collector drains perpendicular to these. Water storage is needed to replenish the groundwater during prolong dry periods. The best place to store water is the centre of the peat dome.
- To minimise the effects of rapid initial subsidence in the first years after the use of peat swamps, a two-phase approach in the implementation of the water management system is recommended. In the first phase, the area is opened and the main drainage system is installed. During the second phase, the field drainage system is installed. A time delay of at least 1 to 2 years is recommended between the two phases.
- The hydrological characteristics of the peat swamps determine to a large extent the design of the water management system. The drainability of these swamps should not only be based on the elevation of the mineral subsoil, as is currently the case, but also on the elevation of the peat itself. These two aspects need to be considered to prolong the live of the peat.
- As demonstrated, different types of land use require different water levels. This in combination with the high permeability of peat, means that subsidence can be reduced by assigning only a single specific type of land use to each independent drainage basin.

CONCLUSIONS

The Government of Sarawak has identified the populated coastal zone of Sarawak as a major region for agricultural development (Department of Irrigation and Drainage, 2001). Overall, 2 million hectares, of which almost one-quarter is on peat, will be developed for growing oil palm, forest, sago, aquaculture, paddy and miscellaneous crops including vegetables. At the same time peat swamps are recognised as valuable wetlands. These developments require an integrated water management approach that is based on the unique physical characteristics of peat. Compared to mineral soils, peat has a high infiltration capacity, drainable pore space and hydraulic conductivity, but lower capillary rise, bulk density and plant-available water. Furthermore, the subsidence behavior in peat is also fundamentally different as it is never-ending and partly the result of oxidation. For the peatlands in Sarawak the oxidation-component leads to a CO_2 emission of about

13 tonnes per hectare per year per cm subsidence. Eventually this continuing subsidence can result in a situation that the land surface is below sea level. Under these circumstances agriculture is only possible when drainage is achieved by costly pumping. To avoid excessive subsidence and to reduce water stress in the dry periods a water management system in peatlands has to perform several functions: removal of excess water, control of the water table and water conservation. This implies a shift from the existing practice that is almost exclusively focused on fulfilling the drainage requirement. A further refinement of this approach and its implementation is a process that will take several years. Knowledge of the different aspects of water management is certainly a prerequisite to arrive at a wise use of Sarawakís precious lowland peat swamps.

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Physical Properties of Peat in Central Karimantan

Kamiya Mitsuhiko and Kawabata Sinichiro
Dept. Civil Engineering, Hokkaido Institute of Technology
7-15, Maeda, Teine-ku, Sapporo, 006-8585 JAPAN
Phone & Fax. 81-11-688-2262, E-mail: kamiya@hit.ac.jp

ABSTRACT

We carried out geotechnical survey and soil test soil in Central Karimantan, and compared with the characteristics of peat in Hokkaido, northern Japan.

In peatland of Karimantan, fallen shrub formed the skeleton of the ground and the decomposed foliage of the paste state fills its void.

Mean value of ignition loss of the peat is 96%, specific gravity is 1.46, water content is 391%, the degree of saturation is 61% and the water content-ignition loss ratio is 6 from 5. From this fact, the peat of Karimantan hardly include the component of the mineral matter, and it is seems that strongly received the compression and drying history.

Compression index get from the consolidation test is 3.5 from 1.9, and it is smaller than Hokkaido. Coefficient of consolidation is observed larger than it of Hokkaido that the water content is almost equal. Therefore, the ground settlement rate of peatland of Karimantan can be estimated with that it is rapid than Hokkaido.

Key word: peat, specific gravity, ignition loss, water content, void ratio, degree of decomposition, compression index, coefficient of consolidation

INTRODUCTION

The engineering property of peat is different by depositional environment and land use. On the peatland of cold region like Hokkaido, northern Japan, Plant such as sedge and Sphagnum moss was bases of the condition of the low-temperature high-humidity and it piled up over the multiyear as the decomposition inadequate, while in the tropical peatland, fallen shrub formed the skeleton of the ground and the decomposed foliage of the paste state fills its void. Therefore, though in cold region, the mechanical behavior of the peaty ground can be estimated from the result of laboratory test, in tropical zone, it is difficult to know the behavior of the peatland from test result of small sample. In the application of the experimental result to in site, there was such difference.

In this study, Physical and consolidation characteristic are compared on the peat collected from the surface layer in the ground. The used sample on the analysis was collected 2 sites of Central Karimantan, Parangka Raya and Kalampangan, 23 sites in Hokkaido and 4 sites in Ruoergai, Sichuan Province China. We carried out ignition loss test, specific gravity test, water content test, density test, degree of decomposition test and consolidation test.

CORRELATION BETWEEN PHYSICL PROPERTIES OF PEAT

Ignition loss

The solid part of peat is composed of mineral matter and plant in decomposition process. Since they have the properties in which differs engineeringly, the characteristics of peat is often discussed by using ignition loss as a parameter in which shows the organic content.

The relationship between specific gravity and ignition loss of the peat is shown in Fig. 1. Since comparing with the specific gravity of the plant that constitutes the peat and mineral soil matter, the former is small, when ignition loss increase, the specific gravity of the peat becomes smaller. Therefore, the unique relation has been established between both.

It is possible to show the specific gravity of the peat by following equation, when the peat is regarded as mixed mineral matter and organic matter in the simplicity.

$$G_p = \frac{G_s \cdot G_o}{\left(G_s - G_o\right) \cdot L_i / 100 + G_o} \quad (1)$$

where,

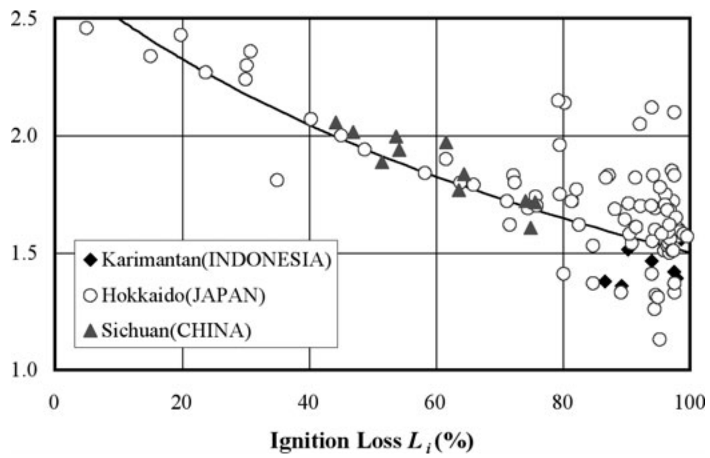

Figure 1. Relationship between ignition loss and specific gravity of peat.

G_p : specific gravity of peat

G_s : specific gravity of soil mineral

G_o : specific gravity of organic matter

L_i : ignition loss (%)

It is shown like the curve of the relation between specific gravity of the peat and ignition loss of the peat being, when G_s=2.70 and G_o=1.50.

The specific gravity of the peat is in the vicinity of the curve within ignition loss being small, and the dispersion increases, when the ignition loss exceeds 80%.

The ignition loss of the peat of Central Karimantan is observed as 99 from 88%, so the component of the mineral matter hardly is included for this peat. The specific gravity of this peat is 1.58 from 1.36, and it is smaller than it of Hokkaido. This reason is estimated that the bubble is included for the stem of the intactness plant fiber.

The relationship between ignition loss and water content of the peat is shown in Fig.2. Since water retention increases by the increase of organic matter, it is usually to show high water content as ignition loss is larger.

In Hokkaido, the mean value of degree of saturation of the peat is about 95% because samples are collected near the groundwater surface. However, on the peat of Karimantan, it is about 60%, since they are collected in the dry season. Therefore, the calculaed water content in which the degree of saturation is 95% is also shown in the figure, on peat of Karimantan and Sichuan. The relationship between the following equation is proposed between natural water content and ignition loss

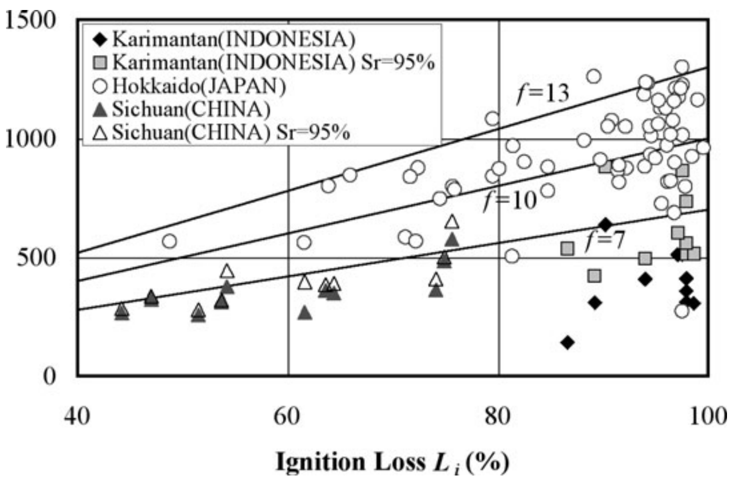

Figure 2. Relationship between ignition loss and water content.

$$w_n = f \cdot L_i \qquad (2)$$

where, w_n : natural water content (%)

f: constant (water content - ignition loss ratio)

In the virgin peat the value of f , in 10, compression peat , 7 is reported(Miyakawa,1957). While the peat of Hokkaido is distributed in f=10 vicinity, the peat of Karimantan and Sichuan are f=7 or less, and it is shown that the history of compression and drying is being received by land use.

The relationship between ignition loss and void ratio of the peat is shown in Fig.3.

The void ratio is obtained according to following equation using G_p and ρ_d of measured value.

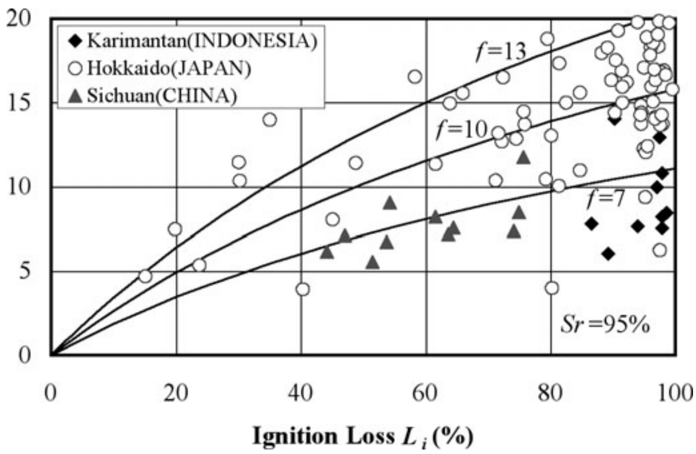

Figure 3. Relationship between ignition loss and void ratio.

$$e = \frac{G_p \cdot \rho_w}{\rho_d} - 1 \qquad (3)$$

where, e: void ratio

ρ_d : dry density (g/cm^3)

ρ_w : density of water (g/cm^3)

The lines of the figure are calculated using the following equation which substituted equation (1) and (2), using as G_s=2.7 and G_o=1.5 and S_r=95% which are a representative value of the peat, on case of f=8,10,13.

$$e = \frac{w \cdot G_p}{S_r} \qquad (4)$$

where, S_r : degree saturation (%)

The peat of Karimantan is distributed for f=7 or less as well as Fig.2.

Water content

The natural water content is the value which changes according to drainage and compression history, and it can not become a peculiar parameter of the soil unlike ignition loss and specific gravity. However, the measurement of water content is easy, in order to generally control characteristics of the soil, in making the water content to be a parameter, it is often related of the other with the soil modulus.

The relationship between water content and void ratio is shown in Fig4.

The line in the figure estimated the value of f most suited using the measured value of the average degree of saturation. In the peat of Hokkaido, the value of f is about 10, and in Karimantan, it is 5 or 6. Therefore, the peat of Karimantan is seems that strongly received the compression and drying history.

The relationship between water content and dry density is shown in Fig5. The line in the figure is obtained as G_s=2.7, G_o=1.5 and S_r=95%.

The dry density of the peat is generally small, there is within 0.05Å`0.3g/cm^3. When the water content increases, the dry density becomes smaller. As the degree saturation of the peat of Karimantan and Sichuan is made to be 95%, unique relationship is almost obtained between water content and dry density . For this relation the effect by f almost regard.

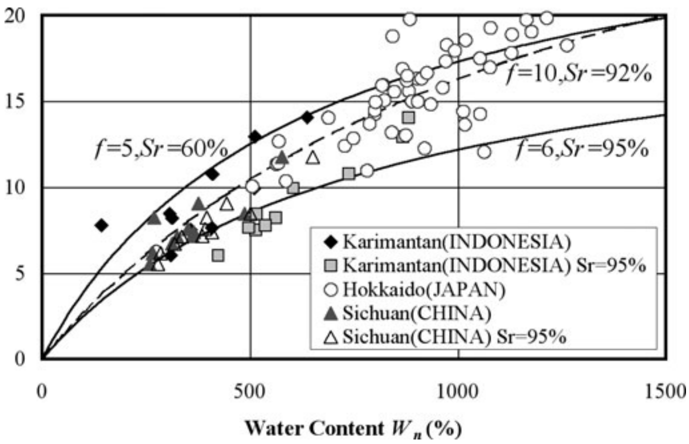

Figure 4. Relationship between water content and void ratio.

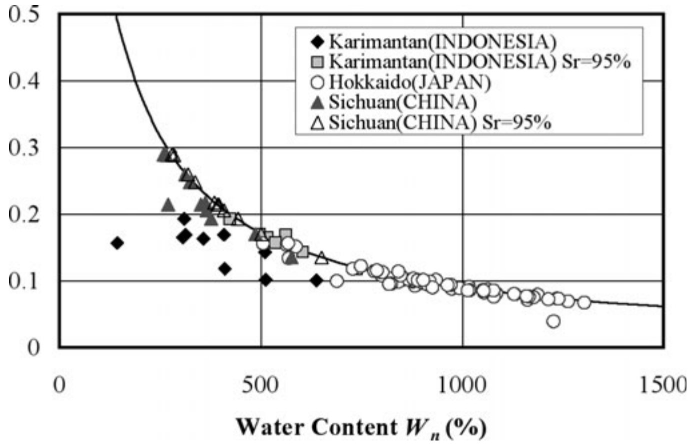

Fig.5 Relationship between water content and dry density

Degree of decomposition

Though the engineering property of the peat is related to the organic content within low ignition loss, the effect of the form of the organic matter becomes remarkable, as the organic content increases.

In this study the index which shows the form of organic matter, is used the degree of decomposition by sieve analysis. The degree of decomposition by sieve analysis is the proportion of the intactness plant fiber of which remains 0.105mm screen.

The relationship between water content and degree of decomposition is shown in Fig.6. Though there is the dispersion on this relation, the water content lowers, as the decomposition increases, and it is shown the tendency in which the water retention becomes small. In comparison with the mean value of Hokkaido, peat of Karimantan and Sichuan show large decomposition. This is estimated with that in Sichuan Province, there is much inclusion of the soil particle of fine grain, since it is fen mire, and in Karimantan, it promotes the decomposition for the high temperature.

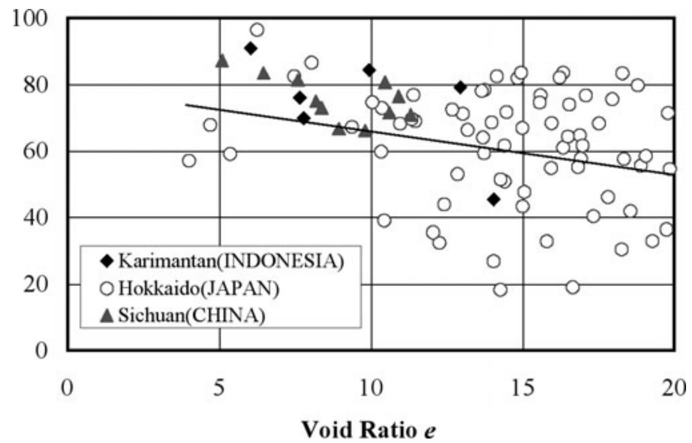

Figure 6. Relationship between void ratio and degree of decomposition.

CARACTERISTICS OF CONSOLIDATION

Compression index

The peat is not only compressed void of particle such as clay, but also composition material itself is compressed. Therefore, the consolidation behavior unlike the clay is shown.

The relationship between ignition loss that is one of the indexes of peat, and compression index is shown in fig.7. Within ignition loss being small, ignition loss and compression index show the proportional connection, but when it is larger, the dispersion of the measured value increases, and the tendency is not determined.

As the ignition loss was made to be a parameter, compression index of Karimantan is observed very smaller than Hokkaido.

The relationship between consolidation index and void ratio is shown in Fig.8. The void ratio is the most general index in which evaluates soil structure. Therefore, the void ratio is well used as the factor of which controls the compression index, and many correlation equations are proposed. Authors propose the following equation on the peat of Hokkaido, and this is shown in the straight line in the figure (Kamiya et al., 1994).

$$C_c = 0.47e + 0.05 \quad (5)$$

In the peat of Sichuan Province, this relational equation can be almost applied, and the peat of Karimantan shows small compression index. This is seemed that forming plant of peat differs from cold region and the effect of compression and drying history are received.

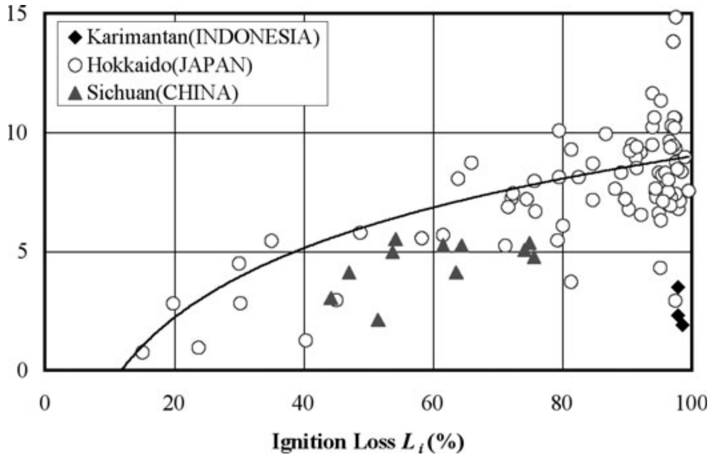

Figure 7. Relationship between ignition loss and compression index.

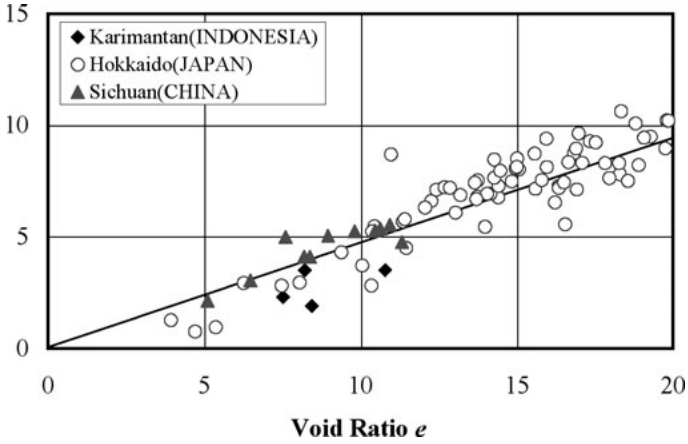

Figure 8. Relationship between void ratio and compression index.

Coefficient of consolidation

The coefficient of consolidation is an index for estimating settlement rate of the ground. Though coefficient of consolidation is obtained utilizing Terzaghiís consolidation theory, but in the peat, there is some a problem of not agreeing with itís theory such as compressing plant fiber under consolidation.

The relationship between mean consolidation pressure and coefficient of consolidation of the representative sample is shown in Fig.9.

Generally, though coefficient of consolidation of the clay seems to be constant regardless of the consolidation pressure. In the peat, as the consolidation pressure increases, coefficient of consolidation decreases, it is more remarkable on this tendency, as the water content increases. Coefficient of consolidation of Karimantan is observed larger than it of Hokkaido that the water content is almost equal, and the rate of lowering of coefficient of consolidation is also small by the increase of the consolidation pressure. Therefore, the ground settlement rate of peatland of Karimantan can be estimated with that it is rapid than Hokkaido.

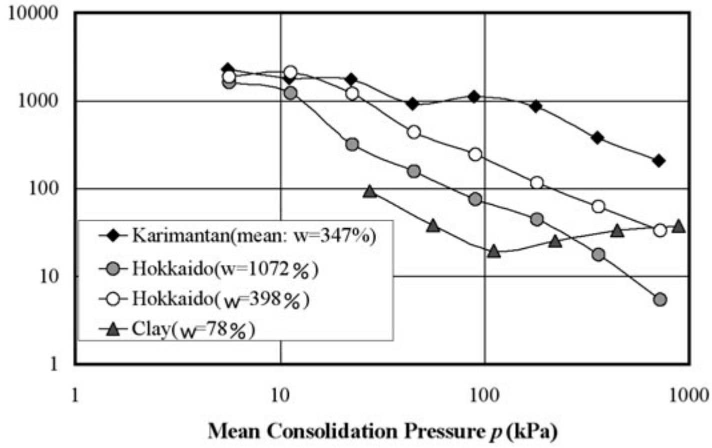

Figure 9. Relationship between mean consolidation pressure and coefficient of consolidation of the representative sample.

CONCLUSIONS

We carried out geotechnical survey and soil test in Central Karimantan, and following conclusions are got in comparison with the peat of the cold region.

1) In peatland of Karimantan, fallen shrub formed the skeleton of the ground and the decomposed foliage of the paste state fills its void.

2) Mean value of ignition loss of the peat is 96%, so the component of the mineral matter hardly is included for this peat. The mean value of specific gravity is 1.46, smaller than it of Hokkaido.
3) Mean value of water content is 391%, the degree of saturation is 61% and the water content-ignition loss ratio is 6 from 5. From this fact, the peat of Karimantan is seems that strongly received the compression and drying history.
4) As the degree of decomposition is observed in the relationship between the water content, it of Karimantan shows large decomposition. This is estimated with that it promotes the decomposition of the minute foliage for the high temperature.
5) Compression index get from the consolidation test is 3.5 from 1.9, and it is smaller than Hokkaido. This is seemed that forming plant of peat differs from cold region and the effect of compression and drying history are received.
6) Coefficient of consolidation is observed larger than it of Hokkaido that the water content is almost equal. Therefore, the ground settlement rate of peatland of Karimantan can be estimated with that it is rapid than Hokkaido.

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Water Environmental Research Study in Palangka Raya Region
- A test of general bacteria and coliform group using a simple test paper -

Kohken Utosawa[1],Harukuni Tachibana[2] , Rofiq Iqbal[2] ,Nyoman Sumawijaya[4],
Suwido H. Limin[5],Salampak Dohong[5],Untung Darung[5],Takanobu Inoue[3],
Saori Akimoto[2], Ai Kano[2]
[1]Hokkaido Institute of Tecnology,Sapporo,006-8585 Japan
E-mail:utosawa@hit.ac.jp
[2]Graduate School of Engineering,Hokkaido Univercity,Sapporo,060-8628 Japan
[3]Graduate School of Engineering,Gifu Univercity,Gifu,501-1193,Japan
[4]Research and Development Center for Geotechnology,LPI,Bandung,Indonesia
[5]University of Palangka Raya,Palangka Raya,Centoral Kalimantan,Indonesia

ABSTRACT
It has surveyed water quality since 1999, groundwater and river water in the Palangka Raya Region. Especially, the test result of general bacteria and coliform group is described this time. Still, the test is a simple test method using the paper.

The groundwater of the 12m depth removed the part, and there was no problem.

However, many general bacteria and coliform group were detected from the water revealed in the air. And, nitrate nitrogen and general bacteria and coliform group were also detected from the tap water of some hotel.

From the Kahayan river levee, considerable general bacteria and coliform group . It detected even in the region in the upstream in the Kahayan river.

In the future, it is important to ensure the good drinking water source with population growth of the Palangka Raya region.

Key words: general bacteria , coliform group, simple test method

RESEARCH METHODS

The location of water sampling in Central Kalimantan are shown in figure -1. The water sample are sampled from the well, river and water supply. Ground water, tap water and river surface water were used for general bacteria, coliform group, chlorine ion, ammonia nitrogen, nitrate nitrogen, total nitrogen, orthophosphoric acid, total phosphorus, metal and measurement of total organic carbon (TOC) in present investigation. The simple test paper was used in the measurement of general bacteria and coliform group. 14 kinds of elements were measured by Inductively Coupled Plasma Spectrometry method (ICPS). TOC meter using gas chromatography was used the total organic carbon (TOC) measurement. Other item was measured using R/2010 of HACH Co.. Still, the test water was all filtered in membrane filter of 0.45 μm except for general bacteria and coliform group test, pH, EC, total nitrogen, total phosphorus and residual chlorine.

Usage of the simple detection paper **(Suzuki)**

1) To begin with, by twisting the upper chuck of the plastic bag, after the hand is made clean, the mouth is opened.
2) Paper in the plastic bag is pushed up from the outside of the bag, and it puts the part of the perforation out on the outside.
3) Paper is drawn by not picking the part in the outside of the perforation in the finger.
4) It spreads in the sample differently prepared the part of the bottom from the perforation and it is taken at once and drop of the extra are dropped.
5) It is let in so that the part of the perforation may consist for the bottom of the chuck.
6) By holding the paper from the outside of the bag, the part over the perforation is cut off in the finger
7) In order to press in the inner surface of the finger, after paper is put in the flat, and it let air out of b after paper is put in the flat, and it let air out of blat, and it let air out of bt air out of bag. The chuck is closed with the adherence of the paper with the bag.
8) Puts and cultivates stuffed paper in es stuffed paper in paper in r in n 35˚C - 37˚C incubator
9) It takes out after culture after culture ulture re 20 - 24 hour, paper from the incubator, and the red colony number of the surface and inside is counted. The number of the coliform group is shown from the red colony number as per ml. By multiplying the red colony number by the dilution multiple, when the sample has been diluted, it is calculated.

General bacteria and coliform groups are very conveniently examined by qualitative analysis. That these fungi are detected means that the handling in which the sample is dirty was received. Even if the coliform group is detected, danger can not always. However, existence of the coliform group and the number become a scale in the health maintenance. This simple detection method is very convenient, personnel expenses, equipment cost, etc. can be saved. It is possible to utilize as a later date education material, because the coliform group leaves red colony, when the detection paper dries

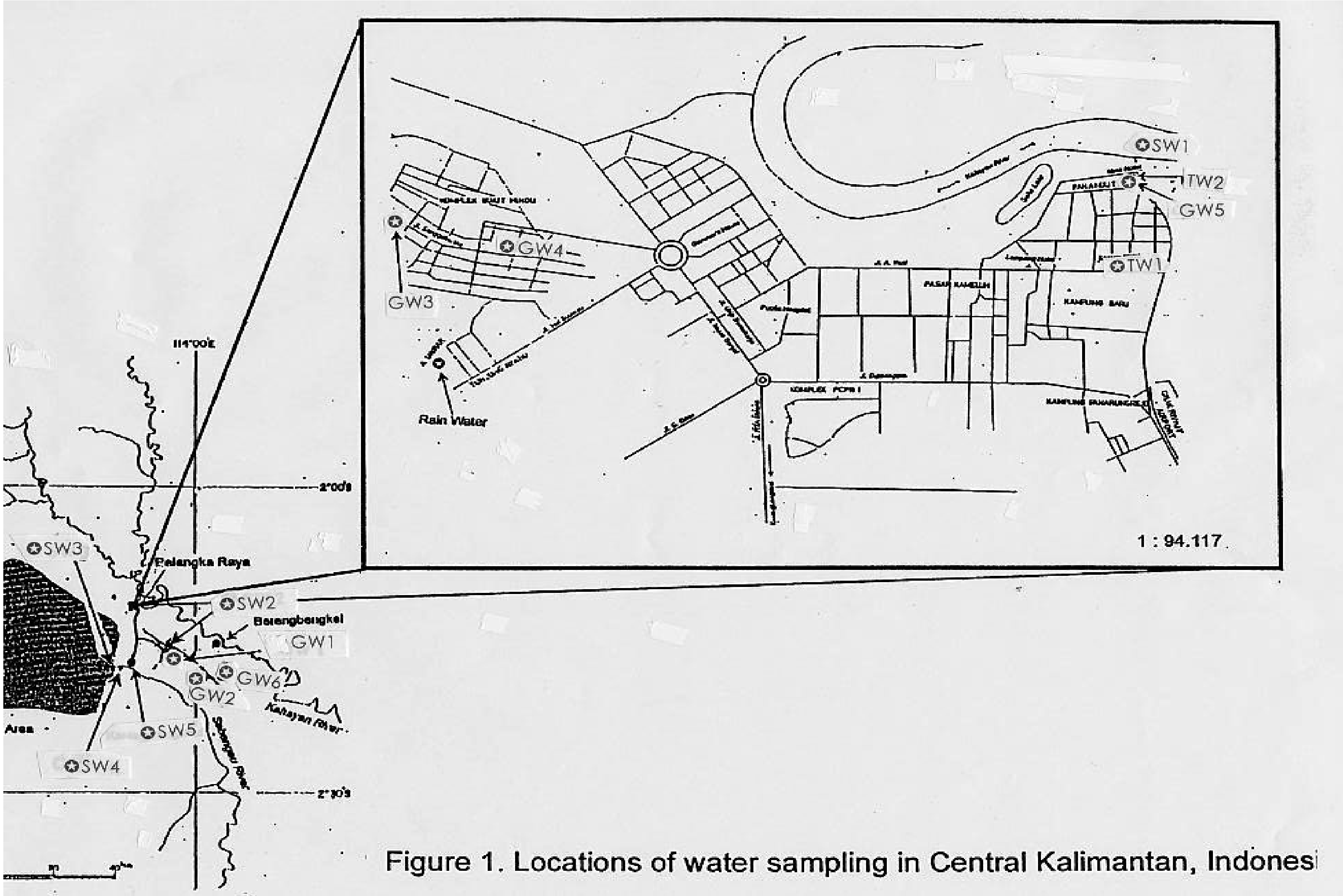

Figure 1. Locations of water sampling in Central Kalimantan, Indonesi

around 60℃, and because it fixes.

Table 1. Data of coliform group ,general bacteria on ground water and surface water samples,Central Kalimantan,Indonesia (SW1= Kahayan River;SW2 = Mining office River;SW3 = Sebangau River(KYA);SW4 = Sebangau River(_);SW5 = Sebangau Rver(Kereng Bangkirai);GW1 = Mining office;GW2 = Eko wells;GW3 = E.H.Gohng wells;GW4 = Jumuri wells;GW5 = Mina wells;GW6 = Juni wells;TW1 = Sakura H.;TW2 = Mina H.)

Date		Surface water					Ground water						Tap water	
		SW1	SW2	SW3	SW4	SW5	GW1	GW2	GW3	GW4	GW5	GW6	TW1(S)	TW2(M)
	Sanple point depth (m)	0.1	0	0.1	0.1	0.1	12.0	12.0	12.0	3.0	16.0	12.0		
1999 Coliform group N/1ml	Number of sample	6	3	6	3	7	3	3	3	6	3	3	2	3
	mean	233	16	17	14	37	0	0.6	0.3	285	1	1	0	0.3
	min.	170	11	13	12	22	0	0	0	220	0	0	0	0
	max.	360	20	21	18	54	0	2	1	360	3	2	0	1
2000 Coliform group N/1ml	Number of sample			6		6	3						11	
	mean			13		36							20	
	min.			2		18	8						9	
	max.			30		56	19						31	
2000 General bacteria N/1ml	Number of sample			3		3	3						4	
	mean			9		17	6						25	
	min.			7		15	6						16	
	max.			12		20	7						31	
2001 Coliform group N/1ml	Number of sample	5				2	2	3	3	3(12 m)	3	3	2	
	mean	66				75	36	2	0	0	2	0.3	72	
	min.	41				70	35	0	0	0	1	0	68	
	max.	※				80	36	3	0	0	4	1	76	
2001 General bacteria N/1ml	Number of sample	3					2	3	3	3(12 m)	3	3		
	mean						39	0	0.3	0	0	0		
	min.	※					38	0	0	0	0	0		
	max.	※					39	0	1	0	0	0		
2002 Coliform group N/1ml	Number of sample	3		3		2	3	3	3	3(12 m)	3	3	3	
	mean	1513		68		75	65	8	3	13	0	0	7	
	min.	612		51		70	56	3	0	5	0	0	2	
	max.	2091		83		80	73	17	9	29	0	0	14	
2002 General bacteria N/1ml	Number of sample	3		3			3	3	3	3(12 m)	3	3	2	
	mean	1462		41			0	1	0	0	0	0	5	
	min.	1071		20			0	0	0	0	0	0	3	
	max.	1938		52			0	4	0	0	0	0	7	

※ : It is too many, the number count it

RESULTS AND CONSIDERATION

The population in fiscal 2000 of the Palangka Raya City is the about 165000 person. Though population supplied is uncertain, the water consumption is 4484m^3 daily. The result of the investigation is according to table of 1. General bacteria and coliform group in the home which pumped up the water of underground 12m were about and coliform group in the home which pumped up the water of underground 12m were about up the water of underground 12m were aboutground 12m were aboutwere aboutaboututt 0 - 29 N/ml. However, it appeared from the tank exposed to the outside for the aeration at general bacteria to the outside for the aeration at general bacteriaration at general bacteriaeral bacteriacteriariaa 0 - 39 N/ml, coliform groupsiform groupsgroupsupss 0 - 73 N/ml . In the shallow well for the gardening of underground 3m, coliform group was very abounding in the average with 285. Survey results of tap water of a hotel are as follows. Investigated first coliform group 0. On the second year, coliform group Survey results of tap water of a hotel are as follows. Investigated first coliform group 0. On the second year, coliform group ted first coliform group 0. On the second year, coliform group the second year, coliform group coliform group m group oup p 19 - 31 N/ml . Other water quality item also showed the large value this time. It increased on the coliform group with the lue this time. It increased on the coliform group with the n the coliform group with the group with the th the he 68 - 76 N/ml in the year

Table - 2 Transition of population and water supply in Palangka Raya

year	population	water supply (m^3/year)	Daily average water consumption per capita iter
1986	92,170		
1987	94,412		
1988	104,911		
1989	110,969		
1990	113,624		
1991	118,130		
1992	122,741		
1993	126,449		
1994	131,628		
1995	133,840		
1996	137,789		
1997	141,539	1,263,899	24.5
1998	144,364	1,291,227	24.5
1999		1,583,085	
2000	164,906	1,636,717	27.2

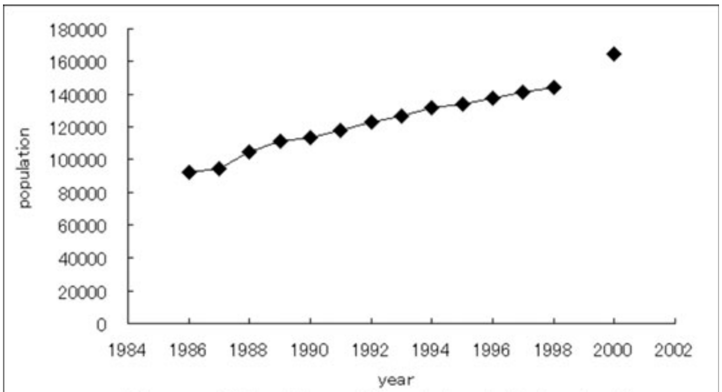

Figure - 2 Trasition of Population in Palangka Raya

Table - 3 The standard on the tap water quality(microorganism)

		WHO	USEPA	
	standard value	guide line	MCLG(mg/l)	MCL(mg/l)
General bacteria	under 100/1ml			
Coliform group	not detected	0/100ml	0	E.coli +5%
heterotrophic bacterium				TT
virus			0	TT
giardia intestinalis			0	TT
legionella			0	TT

MCLG : Maximum Contaminant Level Goal
MCL : Maximum Contaminant Level
TT : correspondent by Treatment Technology

the third year, and there was the fluctuation at other water quality item. In the different hotel, the coliform group changed at theater quality item. In the different hotel, the coliform group changed at thetel, the coliform group changed at theroup changed at theed at the thehee 0 - 1 N/ml, and value 28mg/l in which the nitrate ion was very high in the investigation the third year was shown. The residual chlorine was not detected even in either year from tap water of the hotel. General bacterian. The residual chlorine was not detected even in either year from tap water of the hotel. General bacteriaer year from tap water of the hotel. General bacteriahe hotel. General bacteriaeral bacteriacteriariaa 7 - 52 N/ml, coliform group were them group were thewere the thehee 2 - 83 N/ml in the Sebangau River upstream. The coliform group was as large as the 1 The coliform group was as large as the 1as as large as the 119 - 2091 N/ml in Kahayan River which adjoined for Palangka Raya, and in the upstream, general bacteria and coliform group were and in the upstream, general bacteria and coliform group were cteria and coliform group were orm group were p were re 19 - 25 N/ml and l and nd 11 - 50 N/ml each. There was some a position where the coliform group appeared over 100 in the tributary which flows in Kahayan River from the city. They were each 100 in the tributary which flows in Kahayan River from the city. They were each an River from the city. They were each ty. They were each were each each h 17 - 50 N/ml, 39 - 100 N/ml near the water resource on general bacteria and coliform group. The security of the good water source in water supply becomes the importance, because the population of the Palangka Raya City gradually increases, the future. It is also necessary to cleanly keep the circumference of the water supply faucet.

ACKNOWLEDGMENTS

We thanks Drs.Tadaoki Itakura, Hidenori Takahashi, Akio Mori, Kazuyoshi Hasegawa and Sprihanto Notodarmojo

REFERENCE

A.Suzuki, Coliform group simple test paper, Coliform group simple test paper-usage and the application-, Japan Food Hygiene Association

Forest Fires in Kalimantan

Hiroshi Hayasaka[1], Aswin Usup[2] and Hidenori Takahashi[2]
[1]Graduate School of Engineering,
Hokkaido University, N13W5, Kita-ku Sapporo, 060-8628, Japan.
[2]Graduate School of Environmental Earth Science,
Hokkaido University, N10W5, Kita-ku Sapporo, 060-0810, Japan.

Address correspondence to: Hiroshi Hayasaka
Graduate School of Engineering,
Hokkaido University, N13W5, Kita-ku Sapporo, 060-8628, Japan.
Phone: (011) 706-6784 Fax: (011) 706-6784
E-mail: hhaya@eng.hokudai.ac.jp

ABSTRACT

From the previous researches, it is well known that large forest fires in Indonesia occur under the severe drought condition due to the generation of the El Nino. In this paper, the detailed analysis was carried out using forest fire data and climate data (air temperature and precipitation) in order to clarify a relationship between climate and fire. The analysis results clearly show that large forest fires occurred in 1982-1983 and 1997-1998 were due to not only severe drought in the dry season but also exceptional drought in the wet season. In addition, unstable fluctuations in precipitation that lasted about two years were found just before large fire years of 1982-1983 and 1997-1998.

Key words: forest fire, El Niño, climate, drought, precipitation

INDONESIA AND CLIMATE

Selected cities for Research in Indonesia

The west of Indonesia is shown in Figure 1. This map in Figure 1 is originally made by JICA (2002). Hot spots (fires) in April 2002 are shown in Figure1.

Four selected cities and Palangkaraya in Kalimantan are shown in Figure 1. Padang in Sumatra, Pontianak, and Balikpapan in Kalimantan are chosen just because of their locations at near the equator and their long-term climate data (Rika Nenpyo, 2001). For Jakarta, there are no special reasons except capital and dense population. Palangkaraya is chosen because of the authorsí interest in peat fires around Palangkaraya and climate data from 1979 to 1988 and 1991 and 2001.

Air temperature in Indonesia

Monthly air temperature at various places are shown in Figure 2. Jakarta, Balikpapan, and Palangkaraya have a similar change trend of air temperature. Apparent two peaks are found in their change curves. One peak appears in May. This peak is higher than second peak appeared in October.

On the other hand, change trends for Pontianak and Padang are a little bit different from the two peaksí curve. Especially, Padang has a unique curve. In Padang, air temperatures from January to June are higher than the rest of months. These different tendencies may come from the location of both cities. Namely, Pontianak and Padang are located at the west side of Sumatra and Kalimantan islands.

From Figure 2, it will be found that Jakarta has higher air temperatures than those of other cities have except January and February. There is some difference between two mean air temperature curves for Jakarta. New mean air temperatures from 1971 to 2000 are apparently higher than these from 1961 to 1990. Maximum temperature difference found in August is about 0.5˚C. This temperature rise may be due to heat island and global warming phenomena. The temperature rise for other cities is not clear due to the lack of weather data. In general, temperature rise due to global warming will increase forest fire occurrence in the Southeast

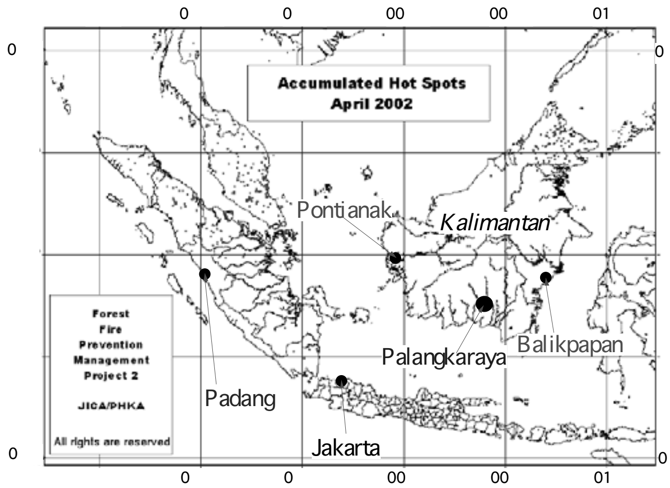

Figure 1. Indonesia, Kalimanta and Fire (Hot spot)

Asia.

Precipitation in Indonesia

In Figure 3, monthly precipitation changes at various places are shown. From Figure 3, you will notice that Jakarta has lowest precipitation amount and Padang has highest precipitation amount on the contrary. This tendency is reverse trend of the air temperature in Figure 2. Namely, Jakarta has the highest air temperature and Padang has the lowest.

The above-mentioned general tendencies are explained in the following. Precipitation has negative relationship with the air temperature. It is because a rain cloud absorbs heat from the sun. When a rain cloud covers a sky, the air temperature tends to drop. Rain also cools the air directly.

Thus, Jakartaís lowest precipitation is related to the highest air temperature. Padangís highest precipitation results in the lowest air temperature, especially from July to December.

There is no remarkable increase and decrease in precipitation between new and old Jakarta data as seen in Figure 3. Two curves in Figure 3 have the same tendency and precipitation amount.

Palangkaraya is located in the south of the Kalimantan island. Only Palangkaraya is about 120km away from the sea. Other four cities are located in the seaside. A precipitation curve for Palangkaraya in Figure 3 is apparently different other three cities except Jakarta. Palangkaraya may have a weak dry season from July to October. In other words, Palangkaraya may have a continental climate. This weak dry season will be one of an important trigger of forest fires in Indonesia.

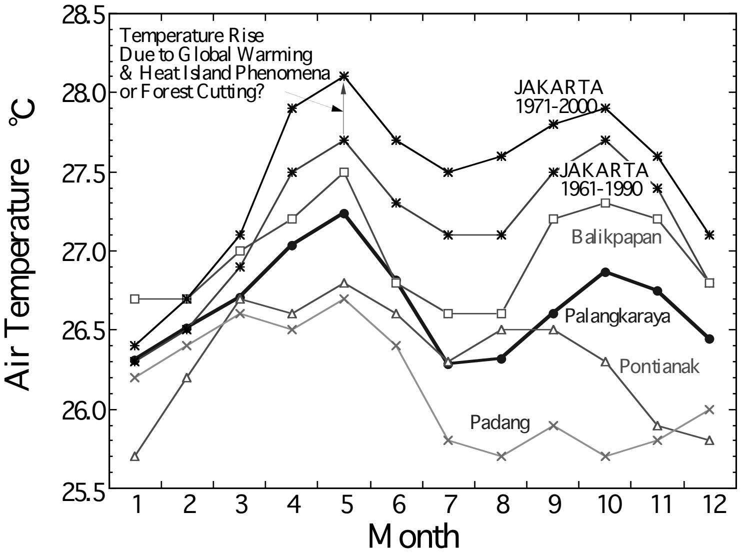

Figure 2. Air Temperature in Various cities in Indonesi

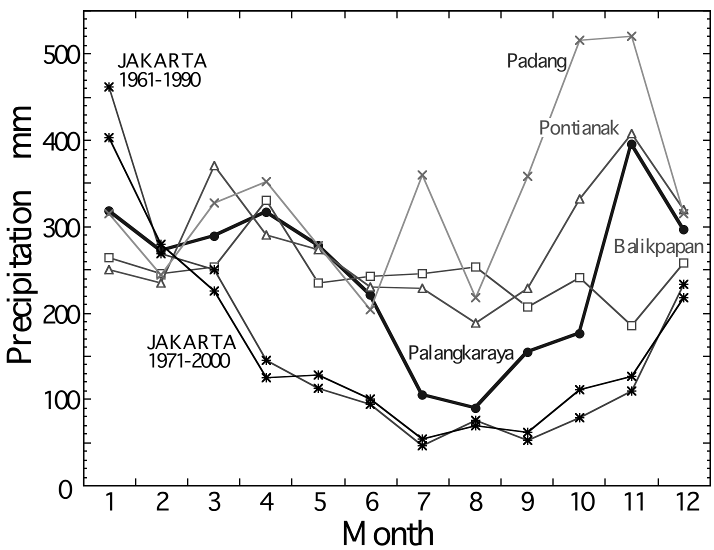

Figure 3. Precipitation in Various Cities in Indonesia

Fires in Indonesia

The recent two large fires in Indonesia

In Indonesia, the Ministry of Forest began to announce the official annual burnt area just after the big fires occurred in east Kalimantan from 1982 to 1983. The burnt area in 1982 to 1983 is still unknown. Rona Dennis (1999) reported forest fires in Indonesia in detail in his review. According to his report, burnt area of primary forest in 1982 was estimated at about 8,000 km2 by Lennertz and Panzer (1983) .

The annual burnt area from 1984 to 2001 is shown in Figure 4. The official burnt areas in Figure 4 may have some error due to the definition uncertainty of burnt area. Precipitation in Palankaraya is also shown in Figure 4 for reference.

From Figure 4, it is found that there are two big fires, the above-mentioned 1982-83 fires and the 1997-98 fires. Annual precipitation in the fire starting year of 1982 and 1997 were below average. Especially, precipitation in 1997 was lowest.

Climate in 1990ís and large fires

Maximum air temperature and precipitation in Palangkaraya from 1991 to 2001 are shown in Figure 5 and from 1994 to 1998 in Figure 6. Figures 5 and 6 clearly show that severe drought period in 1997 started from June and ended in October. This corresponds with the above-mentioned 1997-98 fires. The precipitation amounts in June, August, and September in 1997 were almost zero. The many large fires in 1997 occurred during this severe drought period. It began to rain in November and December in 1997. But the drought came back soon again in January in1998 and lasted until March in 1998. The second drought is an exceptional drought occurred in the rainy season in Palangkaraya. Thus, catastrophic fires in Indonesia occurred during these two consecutive drought periods in 1997 and 1998.

One more peculiar phenomenon is found in maximum air temperature in 1997 and 1998 in Figures 5 and 6. Abnormal high temperature period started in November in 1997 and lasted until May in 1998. The maximum temperature in January 1998 was almost 35 ˚C and it is 3 ˚C higher than mean temperature. This temperature rise together with low humidity due to drought will help to make violent fires.

Other fire years found in Figure 4 were 1991 and 1994. Both years also had drought periods in dry season. However drought periods were shorter than that in 1997. Further, fortunately both years did not have the exceptional drought occurred in the rainy season. As a result, burnt areas in 1991 and 1994 were smaller than that in 1997 and 1998.

Unstable precipitation period before large fires

Finally, the authors noticed that there is an unstable precipitation period just before the occurrence of the droughts in 1997 from Figure 6. Monthly precipitation amounts in 1995 and 1996 increase and decrease at an interval of a few months. In other words, there are no apparent dry season in 1995 and 1996. This trend makes a saw tooth wave form in Figure 6.

The unstable precipitation period started just after the end of drought in 1994 and lasted just before the

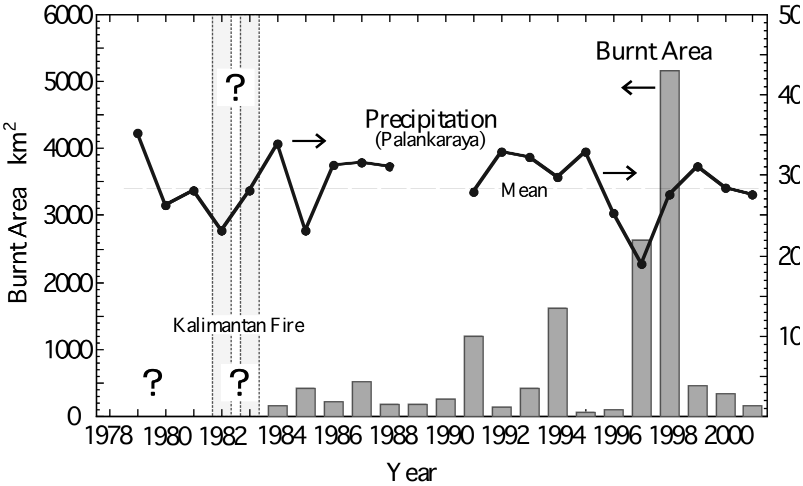

Figure 4. Fire History of Indonesia and Precipitation in Palankaraya

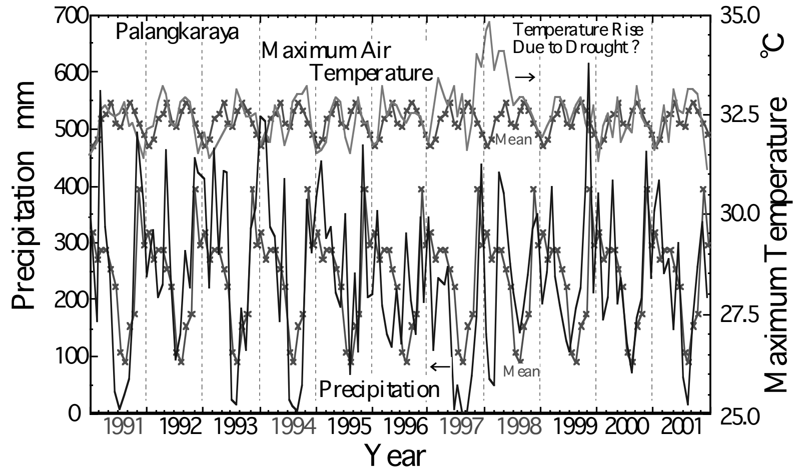

Figure 5. Precipitation and Maximum Air Temperature in Palankaraya(1991-2001)

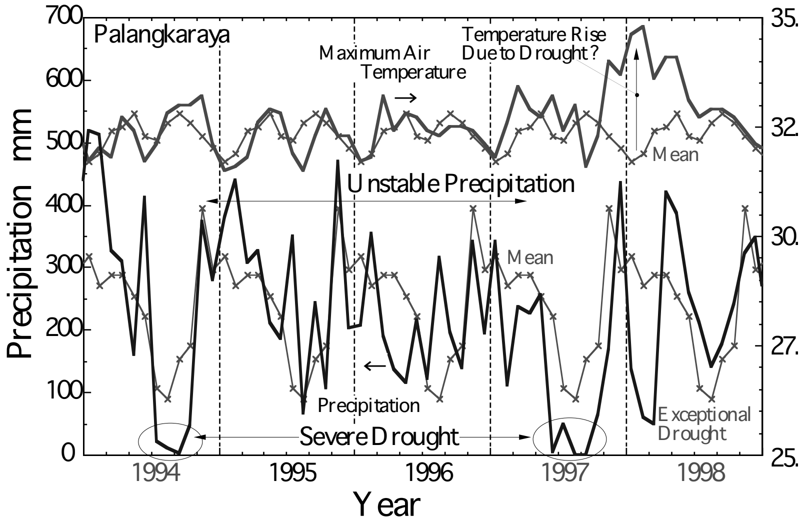

Figure 6. Precipitation and Maximum Air Temperature in Palankaraya(1994-1

beginning of drought in 1997. The unstable precipitation period just before 1997 lasted about two years.

To verify this trend, an additional figure was made for the large fires in 1982 and 1983. Figure 7 clearly shows that there is an unstable precipitation period just before the occurrence of the drought in 1982. Similar saw wave curve is found in Figure 7. The unstable precipitation period also lasted about two years.

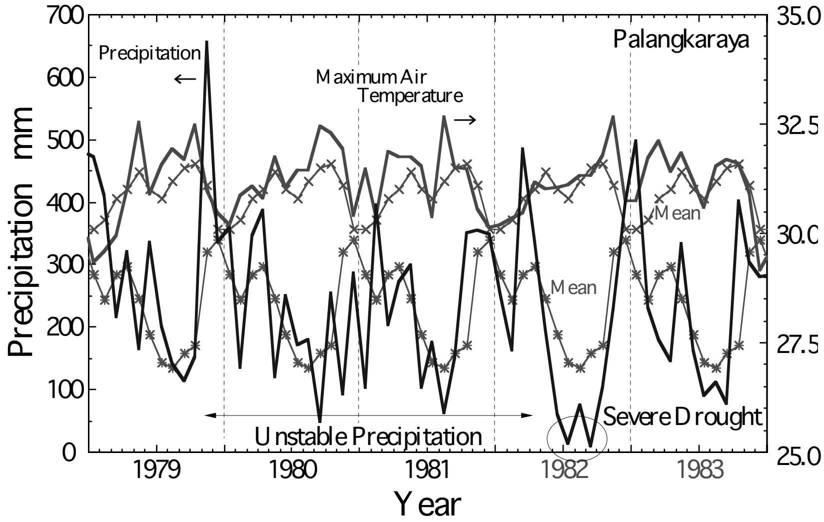

Figure 7. Precipitation and Maximum Air Temperature in Palankaraya(1979

CONCLUSIONS

The authors analyzed forest fire data and climate data (air temperature and precipitation) in Indonesia. Discussion on the results may allow these conclusions in the below.

1) The analysis results clearly show that large forest fires occurred in 1982-1983 and 1997-1998 were due to not only severe drought in the dry season but also exceptional drought in the wet season.

2) Unstable fluctuations in precipitation that lasted about two years were found just before large forest fire years of 1982-1983 and 1997-1998. This trend in precipitation may improve accuracy of forecast for large forest fires in Indonesia.

ACKNOWLEDGEMENT

This research is partly sported by the Grant-in Aid for Scientific Research (A) of Japan Society for the promotion of Science.

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Design of Water Cleaning System by Biodegradable Fiber

Hiroshi Tamura[1], Shinobu Okazaki[1], Katsunori Yamamoto[2] Haruko Kuniyasu[2] and
Seiichi Tokura[1]*
[1] Faculty of Engineering, Kansai university and HRC, Suita, Osaka 564-8680, Japan
[2] Chitosan Kowa Co. Ltd., Hachioji, Tokyo192-0071, Japan

*Corresponding author: Seiichi Tokura
Tel : +81-6-6368-0868 Fax : +81-6-6330-3770
E-mail : stokura@ipcku.kansai-u.ac.jp

ABSTRACT

Living thing doesnít alive without clean water. A water cleaning system is asked to make clean water for general life on the earth. Biodegradable or environmentally friendly materials are requested to compose water cleaning system to avoid water and air pollution.

Chitosan derived from chitin, one of natural abundant muco-polysaccharides, is known to adsorb organic materials and heavy metal ions from polluted water as flocculent. Chitosan is also known as biodegradable polymer in nature within a short period and a cationic polysaccharide. The affinity for mercury ion, especially, is reported to be predominant property of chitosan comparing with synthetic polymeric ion exchange resin. Although the market price off chitosan is comparably higher than other ion exchange resin due to chemical treatment to derive it from chitin, the specific affinity for mercury ion and biodegradability in nature are of remarkable advantage to apply for water cleaning system.

On the other hand, alginate, one of anionic natural polysaccharide from Algae, is known to be calcium ion sensitive polymer to form hydro-gel. The spinning of alginate filament has been reported under mild condition such as 3% aqueous calcium chloride solution. Though we have found a much milder condition to spin a chitosan filament than those methods reported previously, the preparation of chitosan coated alginate filament successfully under very simple solvent composition for the coagulation of alginate aqueous solution such as 3 % aqueous calcium chloride containing a slight amount of chitosan. Resulted filament showed higher tensile strengths with smooth surface and softness. Since the advanced properties of chitosan has been confirmed to restore of remarkable adsorption property for metal ions even after regeneration into coated fiber, the fiber was proposed to apply for the design of water cleaning system together with environmentally friendly materials such as bamboo charcoal to adsorb smells, peat moss and sand.

Keywords : chitosan fiber, chitosan coated alginate fiber, bamboo charcoal, peat moss, water cleaning system

INTRODUCTION

The stabilization of water management would be the heaviest tusk among various peat land operations. The construction of systematic water supply is first thing to keep human environment clean including animals. However, rather high cost performances are requested to construct systematic water supply especially in the sparsely-populated area. A possible solution is to built up small scale water cleaning system applying low cost materials such as recycled or wastes from normal livelihood. The biodegradability of applied materials for water cleaning system is also requested to keep environment clean together with high adsorption ability for contaminants.

On the these points of view, bamboo is one of candidates to construct simple water cleaning system because of rich in tropical zone, easy to become charcoal or active charcoal for adsorption of water contaminates and smells and easy to adapt for environment as life waste.

Chitosan derived from chitin, one of natural abundant muco-polysaccharides from Crustacean, Insects and Mushrooms, are known to be biodegradable, to adsorb metal ions and organic contaminates in water even if in the shape of powder (Masuri, 1974.). Chitosan is also known as biodegradable polymer in nature within a short period and a cationic polysaccharide. The affinity for mercuric ion, especially, is reported to be predominant property of chitosan comparing with synthetic polymeric ion exchange resin. Although the market price of chitosan is comparably higher than other ion exchange resin due to chemical treatment to derive it from chitin, the specific affinity for mercuric ion and biodegradability in nature are of remarkable advantage to apply for water cleaning system.

On the other hand, alginate, one of anionic natural polysaccharide from Algae, is known to be calcium ion sensitive polymer to form hydro-gel. The spinning of alginate filament is reported to be achieved under mild condition such as 3% aqueous calcium chloride. Though we have found a much milder condition to spin a chitosan filament than those methods reported previously, the preparation of chitosan coated alginate filament successfully under very simple solvent composition for the coagulation of alginate aqueous solution such as 3 % aqueous calcium chloride containing a slight amount of chitosan. Resulted filament showed higher tensile strength with smooth surface and softness. As the advanced properties of chitosan such as remarkable adsorption property for metal ions has been confirmed to restore even after regeneration into coated fiber, the application of the fiber was intended to design of water cleaning system. A peat moss is also one of participants to construct water cleaning system to filtrate out the water contaminates together with fine sands mainly consisted of silica in the lower layer of peat land.

We would like to propose to construct a simple water cleaning system applying several popular materials in environment. The main product, bamboo charcoal, was supported by ìHirakata Bamboo Project", at Camp Hirakata (Out Door Activities Center of Hirakata), Hirakata, Osaka 573-0114, Japan where bamboo distribution is trying to qualify on the adjustment of woods in Ikoma National Park area.

MATERIALS AND METHODS

Bamboo Charcoal: Bamboo charcoal has been supplied kindly from Camp Katano that was produced following to dry up of waste bamboo applying hand made furnace and used without activation.

Preparations of chitosan fiber and chitosan coated alginate fiber

Chitosan powder: Chitosan powder was prepared from Shrimp shells according to the method of Hackmann (Hackman, 1958). Molecular weight of chitosan ($4.0X10^4$) was estimated applying viscosity measurement and degree of deacetylation (93%) was estimated from infra-red absorption spectrum as reported previously (Tokura, 1995). Alginate powder was kindly supplied from Yaezu Suisan Co. Ltd.

Spinning of fibers: 70g of chitosan powder was dissolved in 1000ml of 10% aqueous acetic acid solution under stirring at room temperature. Chitosan solution was then filtrated through flunnel and spun into calcium chloride saturated 50% aqueous methanol as 1st coagulation bath at around 15°C applying platinum nozzle (0.1mmf X 50 holes). Fiber was passed through 2nd coagulation bath consisting of 50% aqueous methanol with a slight amount of alkaline to remove acetic acid salt from chitosan filament followed by extensive rinsing with methanol until neutral condition (Tokura, 2001).

Chitosan coated alginate fiber was prepared to spin of 10% alginate aqueous solution into 3% calcium chloride aqueous solution containing 0.01-0.07% of chitosan acetic acid salt (w/v) through platinum nozzle (0.1mmf X 50 holes). A slightly alkaline 50% aqueous methanol containing 8mM of glutaraldehyde as crosslinker was applied as 2nd coagulation bath followed by extensive rinsing with methanol after heat treatment to make chitosan coated alginate fiber water insoluble and then dried in air (Tamura, 2002).

Quantitative analysis of adsorbed metal ions: Various metal ion nitric acid solutions were mixed to prepare 10ppm of final concentration and then adjusted pH to 6.18 before applying adsorption test. 50mg of fibers were immersed in metal ion solution for 24 h. The adsorbed ions was estimated quantitatively from the ion concentration of supernatant by IPC method.

Bamboo charcoal: An air dried bamboo was put then into furnace to fire under oxygen free system to prepare charcoal for a week as shown in Figure 1 and applied directly to construct water cleaning system.

Peat moss: Peat moss was rinsed with water to remove contaminates before drying in air. Sand was also rinsed with water before drying air.

Figure 1. Preparation of bamboo charcoal.

RESULTS AND DISCUSSION

Adsorption of metal ions to chitosan: The metal ion adsorption profiles of chitosan powder and fiber were investigated and specific adsorption for several metal ions were shown as seen in Figure 2. The adsorption of mercuric ion was suppressed abnormally both for chitosan powder and fibrous forms in the case of mixed ion system. As a mixed type of adsorption profile was shown on chitosan coated alginate fiber even after cross linking, application of chitosan coated fiber is proposed to apply for water cleaning system.

Application of bamboo charcoal: Since the adsorption of color and smells is hard to expect on chitosan fiber or chitosan coated alginate fiber, bamboo charcoal or bamboo active charcoal was expected to apply. The advantage of bamboo charcoal over other origins would be the hardness to resist against mechanical breaking forces.
Thus we would like to propose a model system to clean water as shown in Figure 3. consisting of bamboo charcoal, chitosan coated alginate fiber, sands of various grain size and peatmoss.

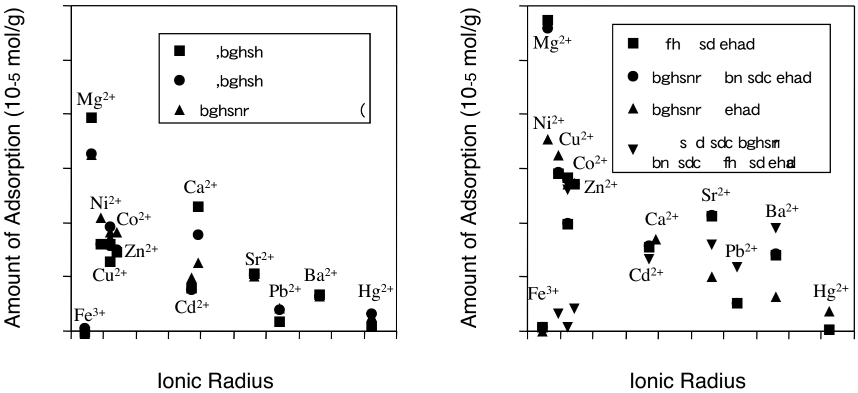

Figure 2. Metal ion adsorption profile of biodegradable fibers
(A) is metal ion adsorptions for powder form. (B) is those for fiber form.

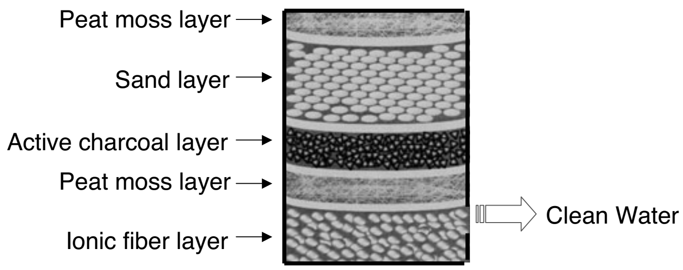

Figure 3. Proposed water cleaning system.

ACKNOWLEDGEMENT

A part of this research was financially supported by the Grant-in-Aid for Scientific Research (14350504).

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Chemical Characteristics of Water at the Upper Reaches of the Sebangau River, Central Kalimantan, Indonesia

Harukuni Tachibana*, Rofiq Iqbal, Saori Akimoto, Mutsuko Kobayashi,
Koichi Ohno, Akio Mori, Tadaoki Itakura
Graduate School of Engineering, Hokkaido University

Hidenori Takahashi
Graduate School of Environmental Earth Science

Kohken Utosawa
Hokkaido Institute of Technology

Nyoman Sumawijaya
Indonesian Institute of Science (LIPI)

Salampak Dohong, Untung Darung, Suwido Limin
University of Palangka Raya (UNPAR)

*Phone & Fax: +81-11-706-6277; e-mail: harukuni@eng.hokudai.ac.jp

ABSTRACT

Seasonal discharge measurement and water sampling were carried out at the upper reaches of the Sebangau River in Central Kalimantan, Indonesia. The samples were analyzed for chemical content and total suspended solid, toward clarifying the relationship between river discharge (flux) and water chemistry. The river runs through tropical peat forest in Palangka Raya, Central Kalimantan. Flux of the Sebangau River was divided into dry season flux and rainy season flux, according to flow quantity. Water quality and runoff load did not differ greatly between the two fluxes. The great rainfall-retentiveness of tropical peat bog may contribute to the stability of the runoff load factor. In a tropical peat bog, the quality of underground water and the changes that are peculiar to that water were found to contribute to the stability the bog ecosystem.

Key words: tropical peat forest, water quality, runoff of chemical components, Central Kalimantan

INTRODUCTION

Peatland formed by the active growth of tropical forests distributes widely in Kalimantan, Indonesia. Few studies have addressed the flow characteristics and water quality of rivers in this area. The Sebangau River can be classified as a mid-size river, based on its width, length, depth, and discharge. This Sebangau flows through the peat area of Palangka Raya, Central Kalimantan. Recently, some of the forest in this catchment has been converted to logging concession, agricultural use and settlement use. Changes in a catchment area influence water quality, and the natural environment of the Sebangau catchment is likely to change in the near future. Currently however, it is observed that the brown color of humic acid that flows into the river changes very little between rainy season and dry season, despite the dramatic difference between the flux of the two seasons. The water quality seems to be largely unaffected by flux We report the water quality and runoff characteristics at the upper reaches of the Sebangau River, based on a joint study by Hokkaido University and University of Palangka Raya of Indonesia.

METHODS

Research area: The geography of the Sebangau catchment is shown in Figure 1. The Sebangau River flows southward through tropical peatland in the western part of Central Kalimantan. The catchment area above KYA Station (Lat. 02˚18' 03.1" S, Long. 113˚52'44.4" E) measures about 600 km^2, and the length of the Sebangau River upstream of that station is about 27 km. The watershed of the upper Sebangau is distributed with tall forest on deep peat. The forest contains commercially important timber species, including several that are specific to peatland, such as ramin (*Gonystylus bancanus*). The forest also supports a number of mammalian, avian and reptilian species. However some of the riparian forest near KYA Station has been logged, legally and illegally, and burned, and then replaced by low vegetation predominantly of *Cyoeraceae* and *Pandanceae* (Shepherd, 1997).

Research period: This research has been carried out since 1998. As of 2000, continuous sampling at KYA Station became possible through cooperation with University of Palangka Raya (UNPAR). This study clarified the water quality based on analyses of eight sampling excursions conducted from September 1998 through September 2000.

Research method: On each sampling excursion we measured the flow flux and sampled the water. Some of the analysis

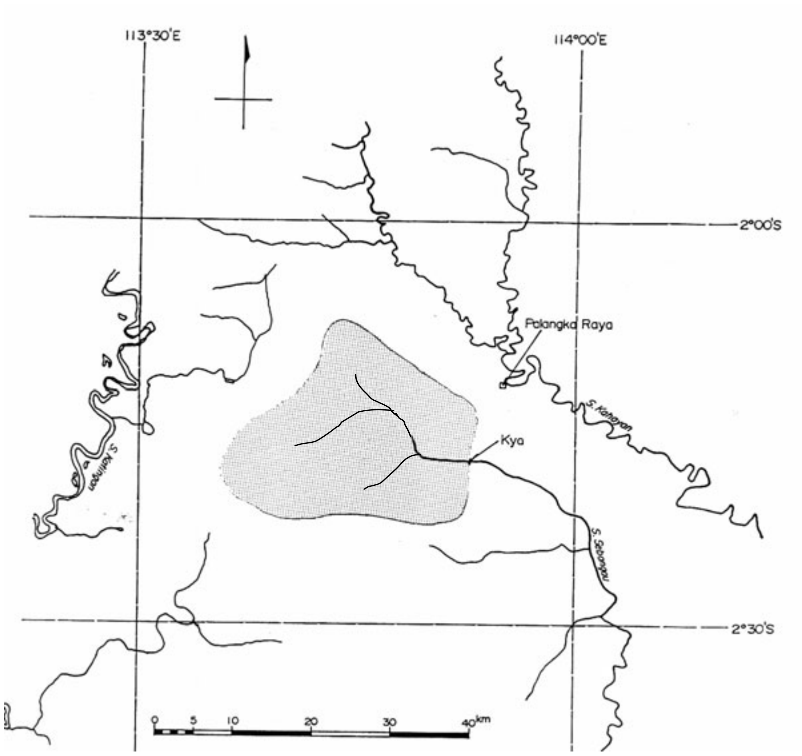


Figure 1 Watercatchment of Sebangau River

Table 1 Average water quality
C.V.: coefficient of variation

n = 8

	Average	C.V.
	mg/l	mg/l
Q	19.25	0.49
pH	3.84	0.03
EC	52.66	0.04
TOC	39.82	0.09
DOC	37.56	0.10
POC	2.26	0.36
TN	0.77	0.14
DN	0.76	0.15
PN	0.01	1.11
NO3--N	0.01	1.09
NH4+-N	0.06	0.44
TP	0.01	0.30
DP	0.00	0.35
DRP	0.00	0.13
Na+	0.79	0.38
Cl-	0.71	0.23
SiO2	15.23	0.06
TN/TP	145.86	0.37
TIN/DN	0.09	0.44

Table 2 Relationship between specific flux and specific load of chemical components
$L/A = C \cdot (Q/A)^n$ L/A: g/s/km^2, Q: m^3/s, A:km^2, C,n: constant coefficient

	Sebangau R.				Ishikari R.			
	N	R	n	C(=10^C)	N	R	n	C
EC	8	0.91	1.07	64.6				
SS	5	0.92	0.62	0.523	21	0.97	1.68	810
TOC	8	0.93	1.06	47.4	21	0.9	1.04	10.4
DOC	8	0.87	1.07	46.7	21	0.93	0.72	1.35
POC	8	0.60	1.01	1.746	21	0.85	1.29	12
TN	8	0.98	1.06	1.037				
DN	8	0.98	1.05	0.897				
PN	8	0.62	1.97	0.139				
NO3--N	8	0.12	0.26	0.0002	21	0.95	1.23	0.80
NH4+-N	8	0.29	0.28	0.004	21	0.55	0.65	0.086
TP	8	0.65	0.52	0.0010				
DP	8	0.70	0.72	0.0009				
PP	8	0.10	0.26	0.0002				
DRP	8	0.98	1.18	0.006				
PP	8	0.31	0.2581	0.0002				
Na+	8	0.40	0.40	0.079				
Cl-	8	0.78	0.87	0.415	21	0.96	0.76	4.03
SiO2	8	0.85	1.06	17.6	21	0.89	0.65	4.35

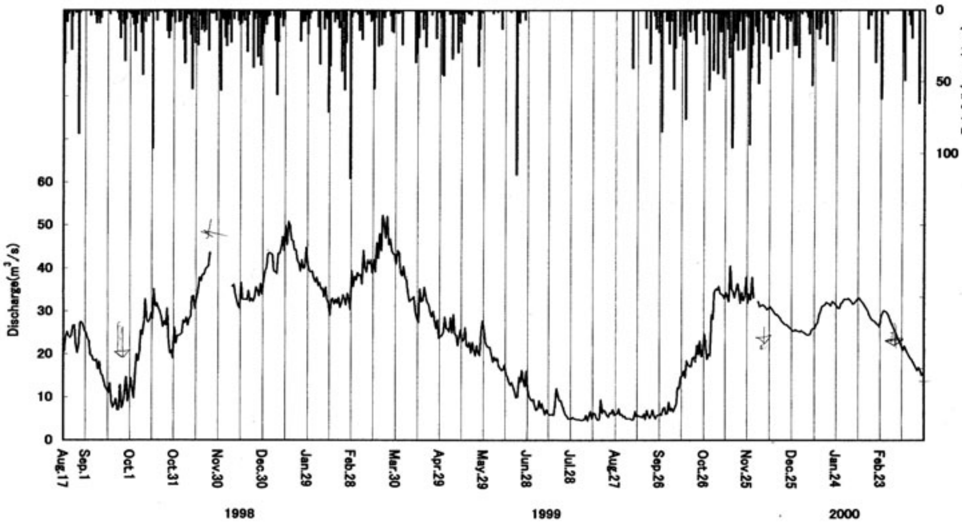


Figure 2 Rainfall and flux at KYA Stn

items were measured onsite, and others were measured in samples kept frozen for later chemical analysis.

RESULTS AND DISCUSSION

Changes of flux at KYA Station

Temporal changes of daily precipitation and mean daily flux at KYA Station from August 1998 through March 2000 are shown in Figure 2. We analyzed the flux data according to two periods: dry season (June through October) and rainy season (November through May) (Itakura, 2001). Data are not provided for some periods of 2000 because a water level meter was stolen. If the water level trends of each year are assumed to be consistent, we can estimate the results of the water quality surveys during the period in which the data are not available. This gives us results for four water quality surveys in the dry season (September 1998, and June, July, and September 2000) and four water quality surveys in the rainy season (November 1999, and April, June and July 2000). The flux data based on these eight surveys are presented in the water quality analysis table (Table 2).

Average water quality of the Sebangau River

An example of the mean values and coefficients of variation (standard deviation / mean value) for each component obtained in the 8 sampling excursions is shown in Table 1. As tends to be true for groundwater at high moor peat bogs in Japan (Tachibana, 1999), the concentration of organic matter such as TOC is high, and that of other general inorganic matter and nutrients is very low. The coefficient of variation is small, which is characteristic of peatland. The coefficient of variation for TOC, which is present in high concentration, is small. This suggests that peatland has great water-retentiveness. The concentration of phosphorus is relatively low, with a TN/TP value of 145.8. Much of the nitrogen compound is organic. It can be said that in rivers of tropical peatland, inorganic matter is utilized in a short time and biological activities are limited by the concentration of phosphorus. Figure 3 shows a key diagram according to the concentration of general inorganic compounds. The figure indicates that the water in the survey area is in the non-carbonate alkali group (Type 4), which is a unique type of peat land water.

Runoff characteristics of chemical water components

Water quality is affected by the characteristics of the water's area of origin. We tried to clarify the runoff characteristics of chemical components from the relationship between specific water flux (Q/A) and specific runoff load of chemical components (L/A).

$L/A = C \cdot (Q/A)^n$ L : runoff load of chemical components in g/s, Q: flux in m^3/s, A: watershed area in km^2,
C, n: constant coefficient
$L = c \cdot Q$, c: concentration of chemical component in mg/l

When n>1 (increasing concentration of chemical component), the water component is of washout type. When n=1, the concentration is stable. When n<1, the concentration is decreasing and is of dilution type. Table 2 shows the constant coefficients C, n and R with the case of the Ishikari River in Hokkaido, northern Japan (Tachibana, 2001). R is the correlation coefficient between log (L/A) and log (Q/A). Figure 4 shows the relationship between specific flux and specific runoff loads of TOC, TN, and TP. From Table 2, it is known that the Sebangau River water concentration is stable (fixed concentration), as the value of n is approximately 1 for SS, POC, and other components. This means that underground water is recharged in the peat bog for a certain period and flows out of the bog as water whose components are homogeneous. In addition, the SS value (0.82) is smaller than that of Ishikari River (1.82), and POC is small (1.01). The soil of the peat bog is of stable

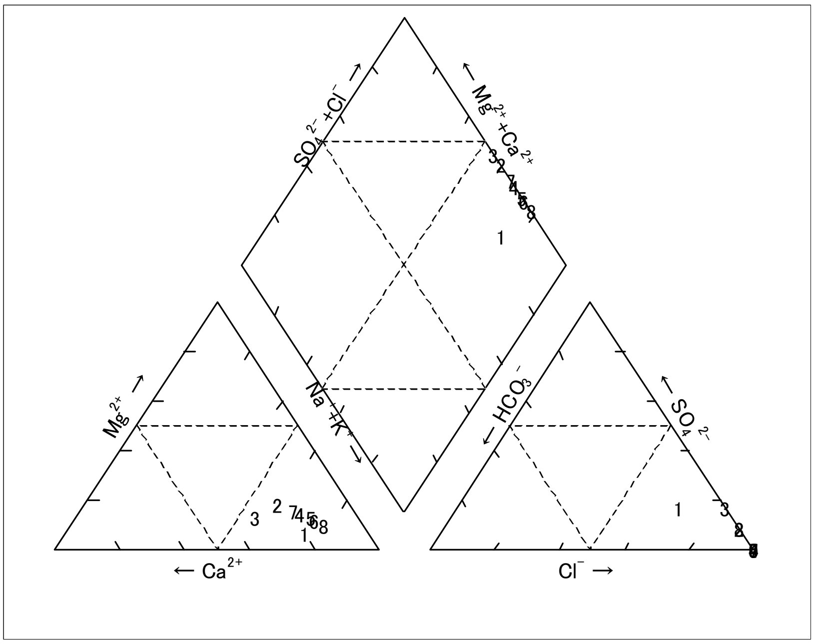
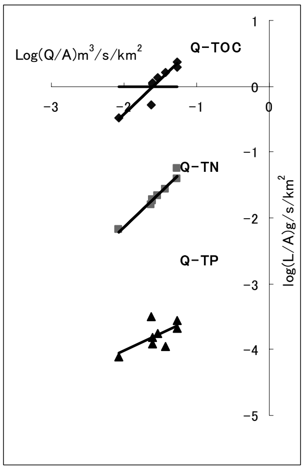


Figure 3 Key diaguram of water components of KYA Stn.
(Chemical equivalent %)
Number in Figure3 shows the sampling (8 times)



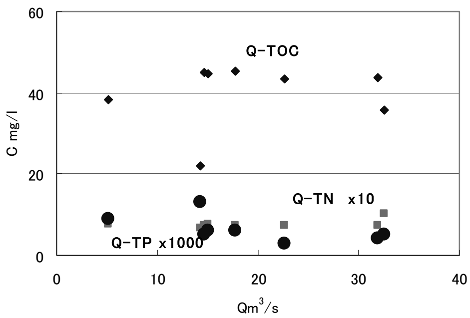


Figure 5 Relationship between flux and concentration of TOC,TN,TP
TN : Actual concentration * 10 TP: Actual concentration * 100

Figure 4 Relationship between specific flux and specific load of chemical components
$L/A= C\cdot(Q/A)^n$ L/A: g/s/km^2, Q: m^3/s, A:km^2, C, n: constant coefficient
(Regression eqation of each line: see Table 2)

structure, so organic matter does not easily wash out. This suggests a rich ecology that is not prone to destruction by changes in the natural environment. The n value of phosphorus is small, and as shown in Figure 5, the TP concentration decreases as flux increases. This means that there is a limit to phosphorus runoff and that phosphorus may have more of a controlling influence on the amount of biomass production does nitrogen. General inorganic components such as sodium and chloride ions are of dilution type (n<1). These components are present in low concentrations, seemingly due to seawater and polluted runoff.

CONCLUSION

This study has shown that the chemical components and runoff concentration at the upper reaches of the Sebangau River vary only slightly between dry season and rainy season. There is great seasonal change in river flux but not in water quality. For water components, the washout during rainy periods that is seen in ordinary rivers is not seen at the upper reaches of the Sebangau River. The great water-retentiveness of tropical peat bog seems to moderate changes in water quality of ground and surface water. The concentration of phosphorus, as well as other nutrients, is relatively low compared to that of nitrogen and it decreases as the flux increases. Phosphorous sources in this area seem limited, which seems to restrict biological activities. As general inorganic compounds exist in extremely low concentrations, the water quality of this tropical peatland is controlled by rainwater and peat soil.

Water quality and its abovementioned changes that are peculiar to tropical peat bog may contribute to the stable ecosystem of tropical peat bog. Toward conserving the ecosystem of a tropical peat bog, it is crucial to maintain a stable environment.

ACKNOWLEDEMENTS

This study was undertaken jointly by The Indonesian Institute of Sciences (LIPI) and Hokkaido University, Japan, as part of the JSPS-LIPI Core University Program on wetland ecosystems. The authors wish to express their appreciation for the support of the University of Palangka Raya during the survey.

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Flood Plain Management in the Lower Ishikari River

Hajime Yamaguchi and Mikio Kuroki
:Minami 1,Nishi7,Chuowku,Sapporo 060-0061,Japan
E-mail:yamaguchi-h@hkd.kasen.or.jp
:Kita 13,Nishi 8,Kitaku Sapporo 060-8628,Japan
E-mail:Kuroki@eng.hokudai.ac.jp

ABSTRACT

The extensive plains along the Ishikari River were formerly entirely covered with marshs, and the water level in the river was high, making the utilization of this land impossible. In 1868, the Government of Japan established "Hokkaido Kaitakushi" empowered to start development of Hokkaido, but the trackless marshs continued to make human settlement impossible along the Ishikari River. The main cause preventing development was flood inundation, which repeated annually, and high groundwater levels of the marshs. The first river improvement works were aimed at converting the marshs into habitable land. These river improvement works played a leading role in regional development, and are different from river improvement work in other areas of Japan where the main objectives were to protect existing inhabitants from disasters. The Ishikari River was completely surrounded by marshs, and the improvement methods could be selected without restraints by existing land utilization. Hence, the flood control philosophy adopted in the river improvement projects were aimed at " Safety of the flood plains" and "Stability of the watercourse," and this resulted in the development of flood control technology peculiar to ihe Ishikari River. To secure the safety of the flood plains, the facilities aimed at eliminating inundation by lowering the flood levels of small and medium tributaries, and preventing inundation by continuous embankments along river channels to protect against major floods. Lowering the water level in rivers accelerates the drawdown of marshes and turns marshs into a fertile plains which make them inhabitable. This report details the development of the river improvement works, mainly the cut-off channels along the Ishikari River, and also the economic impact of improvement works.

Key words: cutt off works,regional development, Ishikari River

HISTORY OF CUT-OFF CHANNEL WORKS

Old river channels

The Ishikari plains extend from Kamuikotan, a bottle-neck of the Ishikari River, and toward the lower reaches there is much wide and flat land with lower gradients than other river plains in Japan,The Ishikari River, the large river flowing through the center of the plains is also a slow flowing river, and used to be much like a large lake forming an unbroken expanse.

The Ishikari River is known for its extreme meandering river channel, and also for causing bank erosion at the bends, devastating the farmland or causing natural shortening, and leaving "oxbow lakes." The old river chan- nel still appears clearly in topographical maps (surveyed 1955 to 1956). The old river channel course can be seen as (1) cliffs at the outer edge of the bends in the river channel, (2) tributaries along the bent river channel parts, (3) oxbow lakes with standing water, and other features. The changes in the river channel are significant in the upstream section near Bibai (at present 60 km from the river mouth) The banks on the downstream side are composed of silt and not easily eroded; there is vertical rather than lateral erosion with few changes in the river channel.

The flood-prone area downstream from Kamuikotan may reach 167,944 ha, or 71% of the total flood plain area 237,798 ha of the Ishikari River system. The flood plain is mainly on the lower reaches of the river. To prevent flooding here extensive work has been carried out, and the cut-off channel and the continuous embankment spacing of 910m are typical. These have greatly changed the river region. The old 29,060 ha Ishikari River has remained the center of the river channel in the flood plain with 13,850 ha of the river channel currently enclosed by embankments and hence the 15,210 ha difference is the remaining flood plain. This newly freed space is a productive green tract of land while the 23 oxbow lakes are effectively utilized for their water, cultivation of freshwater fish, and as a water source. Some of the specific conditions of the Ishikari River are pointed out below, even though the question might arise about appropriateness of the current Ishikari River capacity for the Ishikari plains.

1) The river width of the low-flow channel has to be maintained within certain limits to stabilize the river channel. If the width is enlarged beyond these limits to discharge flood flows, the bed shear stress will be reduced, causing sedimentation with resulting rises in the river-bed level. As a result, the cross- section will remain unchanged, not affected by the widening, and the horizontal changes in the river channel will have the potential for future devastation.

2) Torrential rain and changes in land use on the upper reaches have increased flood flows.
However, the flood levels in the Ishikari River have been lowered despite the increased flood flows because the discharge capacity in the river channel is assured through the adoption of cut-off channel work.

3) Widening the embankment interval to cope with the increased flood flow may need to be considered. With the slow water flow in the high water channel embankment exten- sions and enlargement over long distances to the river mouth will be required, and decreases in river bed levels cannot be expected in areas where the land is being used. This is the background for adopting the cut-off channel method for the Ishikari River.

4) The Ishikari River covers vast river areas, with favorable natural conditions, and oxbow lakes which remain in the

productive green tracts of land, adding much to the pastoral landscape. It is therefore necessary to work to preserve this nature and maintain the attractive environment along the Ishikari River.

Cut-off channels

When the cut-off channel work was adopted for the Ishikari River in 1917, works on the Oyafuru cut-off channel started.

Further excavation of cut-off channels upst- ream was also started, and in 192l the Shinoro No.2 cut-off channel was the first to be opened to flowing water. Since then, 29 cut-off chan- nels were completed over 52 years with the Sunagawa cut-off channel the last to be brought into service in November 1969, shortening the length of the Ishikari River by a total of 58. 1 km. The cut-off channel work was implemented at various places from the lower to the upper reaches of the river as shown in Fig.1, and the order of the work, from the lower reaches, ensured the success of the cut-off channel work. The tributaries like the Yubari, Toyohira, Ikushunbetsu, Bibai, Uryu and other Rivers were also provided with cut-off channels.

The river improvement work of the Ishikari River started in 1910, and nine years later the cut-off channel work started. Thereafter it was the main work of the river improvement projects, the excavated soil was used for embankments. All the cut-off channels were completed 52 years after excavation began on the upstream side. Embankment work con- tinued even after the cut-off channels were opened.

Fig.1 Location map of cutoff works in the Ishikari River(1916)

EFFECT OF CUT-OFF CHANNELS

Changes in Flood Flows

The original objective of the cut-off channel work was (1) to increase the discharge capacity for flood flows by shortening the river channel and so increasing the river channel gradient, and (2) to increase the bed shear stress to enable a degradation of the river bed and enlarge the cross-sectional area, and also to lower the flood level by enlarging the river width by dredging. A second object was to reclaim the Ishikari plains for agricultural land by lowering the water levels. The conseq- uences were the following:

The size of the flood flow in the river channel is primarily governed by the amount of rainfall in the catchment area. However, in the Ishikari River, floods by snow melting in early spring caused disasters because of the enormous snowfall during winter. The flood flows in the Ishikari River depend on the annual rainfall and snowfall which fluctuate widely. The following will demonstrate how the peak water level (annual maximum flood level) of the most severe flood in any year has changed.

Fig.2 shows changes in the annual maximum water level. The open circles ○ , indicate the maximum water level due to snow melting, while the solid circles ●, the highest water level due to rainfall in summer. During the observation period the snowmelt floods dominate at most gauging stations in almost all areas. However, the five annual maximum water levels at each gauging station was caused by rainfall in summer, showing a tendency for medium floods to be caused by snow melting, and severe floods by rainfall.

The variations in the annual maximum flood levels show that the water level dropped at all gauging stations. This drawdown was rema- rkable particularly after 1955, and this tend- ency became greater upstream. This change is clear from the five-year moving average values.

The number of floods may differ due to the observation period, and it is difficult to make a quantitative evaluation. Between 1904 and 1981, the flood level dropped at all gauging stations: 0.26 m at Ishikari Oh-hashi, 1.80 m at Tsukigata, 3.85 m at Naie, 2.25 m at Suna- gawa (1932 to

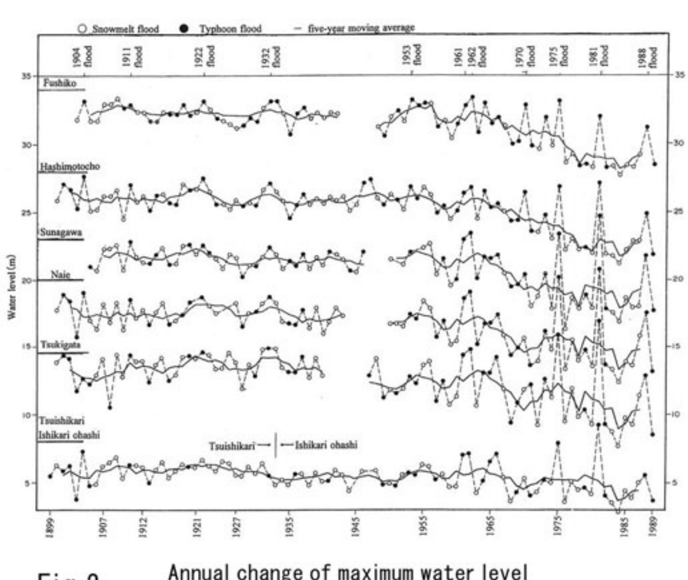

Fig.2 Annual change of maximum water level in the Ishikari River

1981), 2.99 m at Hashimoto -cho, and 3.16 m at Fushiko, and the draw- down was greater upstream.

The rate of drawdown has increased since 1962 at all gauging stations. This is because the effects of the cut-off channels appeared after 1964 as can be seen in the variations of annual water levels to be mentioned later, and the increase of discharge capacity due to the degradation of the river bed. These decreases of flood levels greatly reduced the frequency of flood inundation. The scale of floods in which inundation occurred in the Ishikari River is represented by the flood discharge at the Ishikari Oh-hashi as shown in Table 1.

Table.1 Changes of Flood Scale before and after Cut-Off Works Implemented

	Water level at start of flooding	Discharge at start of flooding
Before the construction of cut-off channels	5.50 m	2,000 m^3/s
After completion of the cut-off channels and embankments (1981)	6.20 m	4,500 m^3/s

Flooding occurred when the river channel discharge reached 2,000 m^3/s in the Ishikari River before improvement works started. At that time the water level at Ishikari Oh-hashi was about 5.50 m. After the completion of cut-off channels to increase the discharge capacity, embankments and tributaries works to control flood flow more easily, both the flood level and the discharge became greater. According to the records of the 1981 flood, the water level at the beginning of inundation was 6.20 m, and the discharge at that time was about 4,500 m^3/s; the discharge capacity of the low-flow channel was greatly increased.

Changes of the Flood Plains

To charge marsh in flood plains into farmland, it was necessary to lower the water Level of the marshes and also prevent inundation and flooding. To achieve this, cut-off channels were constructed and the cross-section of the low-flow channel was enlarged to lower the water level of the river.

Variations in the water level of the river were investigated with the annual mean water level of the main Ishikari River and some tributaries. The results are shown in Fig.3.

For the main Ishikari River, the shortening of river channel due to the cut-off channels are illustrated. For convenience of explanation the ratio of the length shortened downstream from the observation point to the length of the old river channel is shown for the six gauging stations at Fukagawa, Fushiko, Hashimoto-cho, Naie, Tsukigata, and Ishikari Oh-hashi. Over 87 years from 1899 to 1986, a drop of about 3.5 m has occurred upstream from Tsukigata, and about 1.5 m at Ishikari Oh-hashi on the lower reaches. The rate of dropping has reduced with time, but further dccreases in water levels can still be expected. By 1931, three cut-off channels were completed in the lower reaches, and since then the mean water level become lower. By 1955, twenty-five of 29 cut-off channels were complete and the decrease in water level since then has been significant.

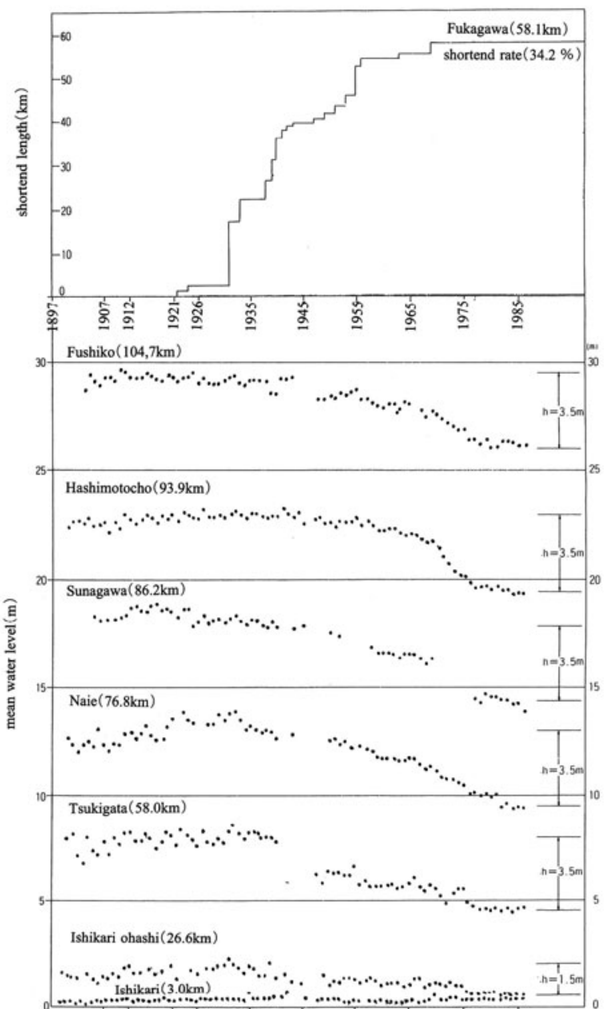

Fig.3 Annual change of mean water level in the Ishikari River

On the river, as well as a network of new drainage canals covering the plains, to accelerate drainage of storm water and to lower the groundwater level in the area. The drainage canals helped lowering the water level in the river and accelerated the lowering of the groundwater level within the plains. In the Bibai plains on the middle rcachcs of the Ishikari River, there was a clear relationship between the advance in land utilization and the construction of drainage canals. The construction of the drainage canals lowered the groundwater level greatly. where the decrease of about 2.5 m is observed.According to the arguments of the First Colonization Plan, land reclamation aimed to increase utilization by turning large areas of marsh and peat into arable land with con- venient transportation. As a consequence, considerable development can be expected after the completion of improvement work inclu- ding the construction of trunk drainage ditches. The ditches were designed to “lower the ground water level by 90 cm.” These trunk drain ditches were connected to the main Ishikari River via the tributaries, and it was impossible to lower the ground water in the marsh and peat regions without lowering the water level in the main Ishikari River.

Extension of land utilization

The cultivation of the Ishikari plains has been carried out as a central object in the development of Hokkaido, and it was promoted by the strong wishes of the settlers there. However, the plains occupied widely distri buted swamy deposits and flooding took place every year, so cultivation could only progress with difficulty. For this reason, improvements of the Ishikari River started to pioneer the best ways of land utilization. During the early half of the improvement works, there wasmainly a creation of farmland and productionpotential, rather than what is today called, conservation of resources.

The major policies pursued to develop the Ishikari plains are listed in a chronological order.

1869 Establishment of regulations to assist settlers
1872 Establishment of regulations for selling and renting land
1874 Establishment of regulations for soldier farmers
1877 Issuing deeds of title for Hokkaido
1886 Establishment of regulations for land disposal by government
1886 Start of selection settlements
1889 tart of partitioning settlements
1897 Establishment of law for disposing unexplored land owned by Hokkaido government

The settlement of the Ishikari plains advan- ced rapidly under these policies, and some examples are described below:

Establishment of soldier farmer villages
Kotoni village (1875)
Yamahana village (1876)

Selection settlements
1886 Along the Chitose River
(93,160 chobu)
1887 Ishikari River areas (109,773 chobu)

Partitioning settlements
Shintotsukawa (1889, 1890) Naie (1890)
Yubari and Sorachi (1891)
Yubari and Chitose (1892) Tsukisamu (l893)
Karugawa (1893) Bannaguro (1893)
Oyafuru (1893) Shinotsu (1893)
Tobetsu (1893) Chitose (1893)
Kamibibai (1894) Shinotsu (1894)
Tobetsu (1894) Sorachi River (1894)
Nopporo (1894)

Fig.4 Land use of the Ishikari Plains(1896)

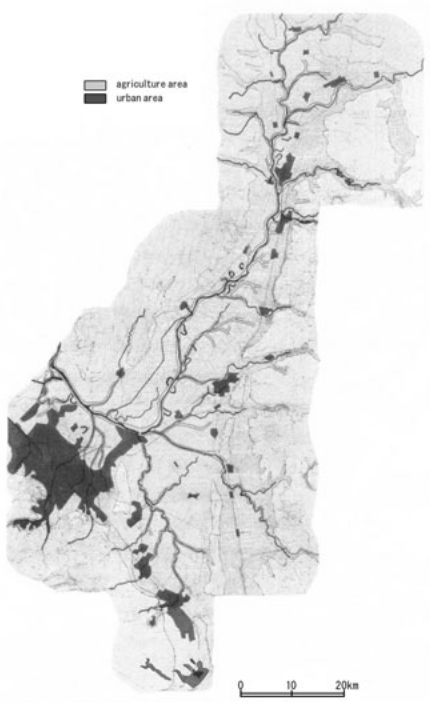

Fig.5 Land use of the Ishikari Plains(1985)

These policies by the Commission of Colonization and others advanced settlement and greatly increased the area of farmland. The population increased from 99,000 in 1880 to 2,842,000 in 1985.

Topographic maps (scale 1/50,000) were used to analyze the progress of land utilization in the Ishikari plains.

According to the 1896 topographic map, the Ishikari plains was covered completely with marsh and forests in parts along the banks. Land utilization started with the upstream gr- avel zone where there were no marshes. Land partitioning started earliest in soldier farmer villages and Shintotsukawa (see Fig.4).

Around 1985, land utilization had expanded over the entire Ishikari plains which had been transformed to "a fertile plains." At that time, the urban area around Sapporo City had expanded, and development onto the flood plains had advanced. Under these circum- stances, the river improvement plans were reviewed to deal with new situations, e.g., "dispersion of flood flows" and "compre- hensive flood control measures" (Figs.5).

CONCLUSION

The cut-off channel work on the Ishikari River may be regarded as one of the world's successful examples for improvement works. The cut-off works that brought about such good results may be summarized as follows:

(1) Improvement works on the Ishikari River started as flood control measures to reclaim an untouched plains and turn it into arable land suitable for settlement.

(2) Cut-off channel works was adopted as the main method for the improvement works. Cut-off channels were capable of lowering both the flood levels and the low-flow water level. This reduced the frequency of inund- ation due to floods and turned moors into arable and fertile plains suitable for habitation.

(3) The cut-off channel work accelerated the degradation of river bed, and the width of river channel was controlled to stabilize the river channel, attaining the original purpose.

(4) The cut-off channel and embankment works made the flood hydrographs narrower and more peaked. The hydrograph of water level was reduced by increasing the discharge capacity due to degradation. Damage due to inundation outside the river channel was red- uced by shortening the flood duration.

(5) From the experience of the latest and most severe flood, dispersion of the flood energy is being achieved by the construction of dams, retarding ponds, flood ways, etc., considering stabilization of river channels.

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Combustion and Thermal Characteristics of Peat/Forest Fire in a Tropical Peatland in Kalimantan, Indonesia

Aswin Uusp Graduate School of Environmental Earth Science, Hokkaido University, N10 W5, Kita-ku, Sapporo 060-0810, Japan
Yoshihiro Hashimoto Fire Science laboratory, Sapporo Fire Bureau, 3-1, 10 W13, Hachiken, Nishi-ku, Sapporo 063-0850, Japan
Hidenori Takahashi Graduate School of Environmental Earth Science, Hokkaido University, N10 W5, Kita-ku, Sapporo 060-0810, Japan
Hiroshi Hayasaka Graduate School of Engineering, Hokkaido University, N13 W5, Kita-ku, Sapporo 060-8628, Japan

ABSTRACT

Wildfires in peat swamp forests have become a serious problem over the past 20 years with adverse effects not only on the forests themselves but also on the global environment due to emission of carbon into the atmosphere. This study focused on peat and forest fires and aimed to clarify some aspects of fire behavior, combustion characteristics of fuel materials in a peat forest and the thermal regime of fire in peat layers. The study site was located on the roadsides of the Trans Kalimantan Highway from Palangka Raya to Pulang Pisau, and nine fire events were used for study plots. Biomass fuels, such as glasses and trees on ground surface in the study site ranged from 15.4 to 39.6 t ha^{-1}. The ratios of fresh to dead materials in the biomass fuels were 52% and 48%, respectively.

Two types of peat fire front were identified: one type, surface layer fire, burns in a shallow layer (from the surface to 10-20 cm in depth) of the peat layer, and the other type, deep layer fire, burns in a deep peat layer (about 20-50 cm in depth). The speed, at which the first type of fire front spread, was 3.8 cm h^{-1} on average, about three-times faster than the speed of the second type of fire front, 1.3 cm h^{-1}.

The critical temperature for ignition of peat soil differed depending on the type of peat. The ignition temperature of coarse peat material in the top layer (from the surface to 40 cm in depth) was 250 ^{o}C, while that of fine and well-decomposed peat material in the layer below 40 cm in depth was 280 ^{o}C. The calorific value of peat in a primeval peat swamp forest was larger than that in a secondary forest but lower than that in bare farmland.

Key words: tropical peat, peat fire, combustion characteristics, fire behavior

INTRODUCTION

The scale of wildfires in tropical areas and the extent of damage to forest and peat caused by fire have been increasing since 1984. Prolonged droughts caused by El Nino in recent years have increased the risk of fire in tropical peat swamp forests and peatlands. Most of the fires that have occurred in recent years in Kalimantan, Indonesia have been concentrated in areas extending from grasslands to forests and in upland areas (Indonesia Ministry of Environmental-UNDP, 1998). But fire is still widely used by smallholders to convert forest to farmland and for other purposes such as burning peat for fertilization (Kanapathy, 1976).

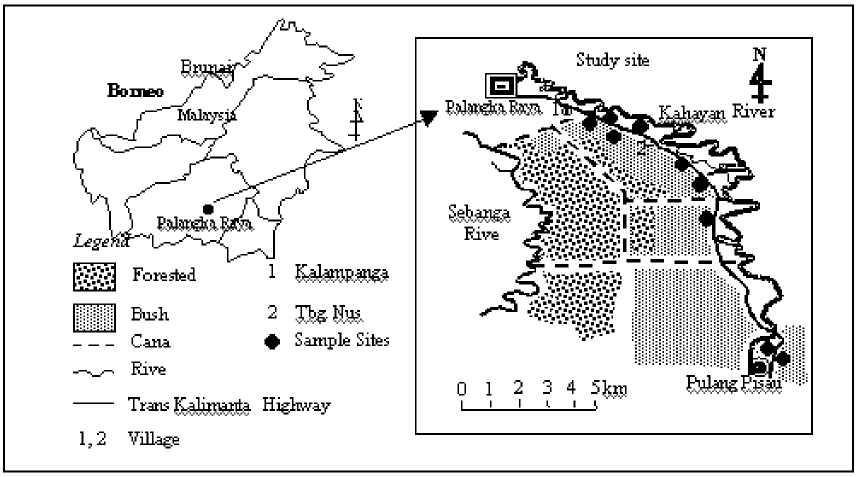
Forest fires cause changes in the ground structure above and below the surface as well as changes in the function of and processes occurring in peatland ecosystems (Neary et al., 1999). In the case of peat swamp forests, however, the impact of forest fire is not limited to the forest ecosystem; the impact extends to the global environment due to the release of carbon from burning peat. There have been few studies on the impact of fire in peat swamp forests in tropical areas. Studies carried out in Indonesia have shown that a wildfire that occurred in a peat swamp forest in Central Kalimantan in 1997 resulted in erosion of the peat surface to depths of 40-100 cm, with a loss of peat soil of about 7.97 x 10^{9} m^{3} in volume (equivalent to about 797,000 ha), and in release of about 0.81 to 2.57 Gt of carbon into the atmosphere (Boehm et al., 2001; Page et al., 2002).

The aim of this study was to clarify various aspects of wildfire in a tropical peat forest. Especially, we focused to the behaviors of fire front, such as the speed of fire spread, the fire temperature and combustion completeness in the field. The rate of fuels above and below the ground surface also measured in the field. Ignition temperature and release of heat from peat combustion were measured in the laboratory.

STUDY SITE AND METHODOLOGY

Study site

The study site was located along the Trans Kalimantan Highway between Palangka Raya and Pulang Pisau in Central Kalimantan, Indonesia. Many wildfires have occurred along the highway because of the prolonged dry season due to El Nino in 2002. Nine plots along the highway were selected for field observations of wildfire in peatland in the fluvial plain of Kahayan and Sebangau Rivers (Fig. 1). The depths of the peat layer in the nine plots were 1-3 m. The principal vegetation in the plots was cinnamon fern (*Osmunda cinnamomea*, pakis), vegetable fern (*Diplazium esculentum*, kalakai)



Location of research plots

Plot-1 : 02° 17' 18.5" S, 114° 01' 57.4" E
Plot-2 : 02° 19' 57.7" S, 114° 04' 23.7" E
Plot-3 : 02° 20' 28.6" S, 114° 04' 57.8" E
Plot-4 : 02° 21' 27.1" S, 114° 06' 05.6" E
Plot-5 : 02° 21' 51.0" S, 114° 06' 33.1" E
Plot-6 : 02° 25' 28.8" S, 114° 10' 05.0" E
Plot-7 : 02° 31' 58.5" S, 114° 11' 22.4" E
Plot-8 : 02° 41' 28.2" S, 114° 18' 04.3" E
Plot-9 : 02° 45' 52.2" S, 114° 17' 11.2" E

Fig.1 Geographical map of study area and location of research plots along a highway from Palangka Raya to Pulang Pisaau.

and bracken fern (*Pteridium*, Gleditsch hawuk) ranging from 1 to 3 m in height. The poor vegetation in the plots was caused by logging of commercial trees and conversion of forest land into farmland. Due to the poor tree canopy cover, solar radiation reaches the ground, making the biomass material on the surface dry.

Climate observatory
A climate observatory has been established in an open area of 30 square meters in a wildfire experimental station belonging to Palangka Raya University. The observatory is located about 2 km east of the main campus of the university. Air temperature and humidity were measured at a height of 1.5 m in a weather shelter using a platinum electronic resistance sensor and a capacitive thin-film polymer sensor (HMP-5D, Visala). Amount of rainfall was measured at a height of 1.2 m using a tapping bucket type of rain gauge (34-T, OTA Keiki). Wind speed and direction were measured at a height of 4 m using a wind vane (WS-05103, Young). Global radiation was measured at a height of 1.5 m using a thermocouple sensor (PCM-01, Prede). Soil temperatures were measured at depths of 0 cm (surface), 10 cm, 20 cm and 40 cm using platinum electronic resistance sensors. All data were recorded in a data logger (Kadec, KONA System) at one-hour intervals.

Amounts of biomass fuel above and below the ground surface
Five quadrates, each one square meter, were established near the burning area in each plot. All grass and litter were collected, and divided into two fuel types, fresh plants and others. These fuels were weighed separately before and after oven-drying at 80 ℃. Three quadrates were used for surveying materials in the peat layer from the ground surface to a depth of 0.5 m. The materials in the peat layer were separated into wood debris, tree root, grass root and peat matrix. The wood debris, wood root and grass root were classified according to size and weighed before and after oven-drying. The peat matrix was classified into two sizes using a sieve of 2 mm in mesh size after air-drying for 2-3 days.

Fire temperature
Chromel-alumel thermocouples of 0.5 mm in diameter with a stainless steel sheath and a 6-channel data logger (KADEC-US, KONA System Co. Ltd, Japan) were used to measure fire temperatures above and below the ground surface. A thermocouple sensor was set at a height of 1 m above the ground surface to measure air and flame temperatures. Thermocouple sensors were set at depths of 0, 5, 10, 15 and 20 cm in the peat layer at a point 5 cm from the fire front. The data logger was buried at a depth of more than 30 cm to prevent the damage caused by the high temperature of the fire. Another set of a thermocouple and a 6-channel data logger was used to measure reference soil temperatures at 4-5 m from the fire front.

Rate of burned material

Five quadrates, each of one square meter in size and marked with four iron rods at the corners, were set near the fire front to estimate the rate of the burned materials in the quadrate. All unburned material from the surface to a depth of 50 cm in each quadrate was weighed after the fire had been extinguished. The total amounts of peat before burning were measured in another five undisturbed quadrates, each of one square meter in size. The rate of burned material (η_{sf}) in each quadrate was calculated using the following equation:

$$\eta_{sf} = \frac{M_{fsdry} - M_{fl}}{M_{fsdry}}$$

where η_{sf} is the rate of burned material in the quadrate, M_{fsdry} is the amount of dried peat material to a depth of 50 cm in the quadrate, and M_{fl} is the amount of material remained to a depth of 50 cm in the quadrate after the fire had been extinguished.

Speed of fire spread

The speed of fire spread in peat soil was measured in the three 3 m^2 quadrates. Iron rods were placed in the ground in each quadrate on grid points of 50-cm intervals to calculate the speed of spread of the fire front.

Ignition temperature and calorific value of peat

The peat ignition temperature was determined using a thermo-gravimetric differential thermal analyzer (TG-DTA: Jasco type A 6300). Peat samples weighing 0.20 to 0.35 grams were combusted in a silica tube with temperature increased at at a rate of 10 ^oC min^{-1} from 30 ^oC to 500 ^oC. Samples were taken from peat layers in the study site at depths of 0-20 cm, 20-40 cm and 40-60 cm. Each peat sample was separated into large and small peat matrixes by using a sieve of 2.0 mm in mesh size. The calorific value was determined using a bomb calorimeter (model C7000) with energy input up to 30,000 joules and ambient temperature ranging from 18 to 30 ^oC.

RESULTS AND DISCUSSION

Weather in the dry season

Monthly total amount of rain in 2002 were normal from January to April as shown in Table 1a. But that in May was so small being one fifth of normal year then the ground water level lowered to 35.5 cm deep from ground surface which was deeper than that of May in 1997, a extremely dry year (Table 1b). The monthly rainfall in June in 2002 recovered to the normal level but the ground water level still lowered deeper. Drought in July and August in 2002 was very serious because total rainfall was only 2.0 mm in two months. Ground water level lowered more and more and reached to 81 cm deep on the end of August, 2002. Such a deep ground water level conduced the grass and litters on the ground and the surface layer of peatland to be very dry and to ignite easily.

Relative humidity of air was also very low in July and August, being 40% and 34% in monthly minimum air humidity respectively (Table 1e). Such a extremely dry weather of dry season might accelerate expansion of the peat/forest fire in 2002.

Table 1 Climatic condition in 2002 at Palangka Raya

(a) Monthly amount of rainfall (mm)
Mean(1978-2000) and 1997: at Air Port Station, Jan.-May in 2002: at Kalampangan, June-August in 2002: Climate observatory in Univ. Palangka Raya

Month	1	2	3	4	5	6	7	8	9	10	11	12
Mean	332.7	271.4	303.1	327.4	256.1	184.5	120.9	113.5	147.2	183.2	348.1	336.8
1997	341.0	110.0	236.0	226.0	257.0	4.0	48.0	1.0	0.0	64.0	168.0	436.0
2002	269.4	170.4	251.4	152.1	49.0	244.0	2.0	0.0	-	-	-	-

(b) Monthly deepest ground water level (cm) from the ground surface in the forest (after Takahashi *et al.* , 2003)

Month	1	2	3	4	5	6	7	8	9	10	11	12
1997	0.0	-2.7	-3.7	0.3	-8.9	-30.1	-40.3	-62.8	-76.9	-94.3	-97.6	-53.9
2002	-9.9	0.0	-4.7	-13.5	-35.5	-45.2	-57.2	-81.1	-	-	-	-

(c) Daily maximum of 10 minute average wind speed (m s^{-1}) in 2002

Month	1	2	3	4	5	6	7	8	9	10	11	12
Mean	-	-	2.5	2.4	2.2	2.3	2.5	-	-	-	-	-
Max.	-	-	4.5	4.2	4.0	3.8	3.0	-	-	-	-	-

(d) Monthly means of daily mean and maximum air temperatures in 2002

Month	1	2	3	4	5	6	7	8	9	10	11	12
Mean	26.4	26.7	-	-	28.1	26.9	27.2	27.0	-	-	-	-
Max.	32.1	32.6	-	-	33.8	32.2	36.5	33.2	-	-	-	-

(e) Monthly mean and minimum of daily minimum humidity in 2002

Month	1	2	3	4	5	6	7	8	9	10	11	12
Mean	-	-	-	-	51.7	60.2	51.7	44.3	-	-	-	-
Max.	-	-	-	-	44.9	48.8	40.4	34.1	-	-	-	-

Characteristics of the fire front

Surface fuel materials such as litter, grass and woody debris on the ground were burned first and then surface peat was ignited. Pyne et al. (1996) reported that surface fuel materials included trees up to 6 feet in height, shrubs, fallen leaves and branches, and woody debris on the forest floor. Surface fire plays an important role in ignition of the peat layer, because vaporization of water in surface peat was accelerated by strong radiation from surface fire (Keetch and Byram, 1968).

Based on the observations of fire behavior in the nine study plots, the fire front in peat soil could be categorized into two types (Fig. 2). One type is a surface layer fire in which the peat layer from the surface to a depth of 10-15 cm is burned. This type of fire occurs mainly when the peat layer is shallow or the ground water level is not deeper than 30 cm from the ground surface. The main characteristics of this type of fire is a fast zigzag movement of the fire front with several projection parts of the fire front line of 10-50 cm in width (Fig. 3). The speed and direction of movement of the head of the fire front line was difficult to predict because of the dependence on peat moisture and wind direction. The main fuel materials were roots of grasses such as vegetable fern (*Diplazium esculentum*) and cinnamon fern *(Osmunda cinnamomea*). This type of fire has two functions: to ignite peat and to become a kindling charcoal for other fires.

The second type of fire is a deep layer fire in which the peat layer between 30 and 50 cm below the ground surface is penetrated by the fire front. This fire spread into the peat dome, hammock, and areas surrounding tree roots. The fire also burned the peat heaps or peat piles on both sides of the highway and the canal. This type of peat fire is the most hazardous, giving rise to black smoke and releasing pollutants into the atmosphere. Once the deep peat layer has been ignited, it is difficult to distinguish even a heavy rainfall. Cristjakov *et al.* (1983) reported that the concentration of bitumen per unit weight of peat soil increased after the peat had dried, and that particles of dry peat responded to water with resin, and even if the rain water penetrated into the peat through cracks, it was not absorbed by peat materials.

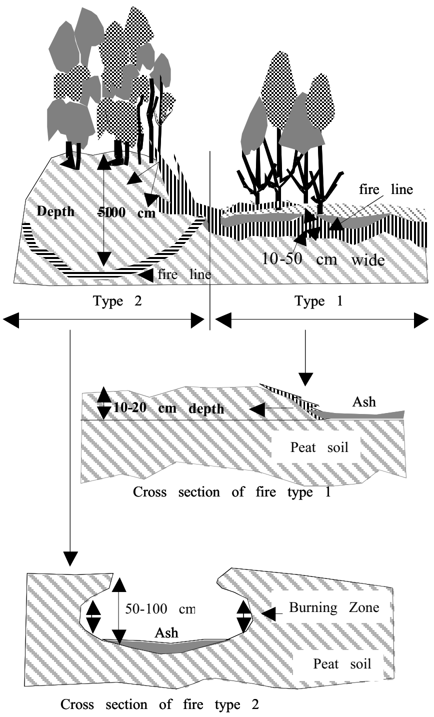


Fig. 2. . Two types of combustion process in (a) the shallow peat (type 1) and (b) the deep peat (type 2) layers of tropical peat.

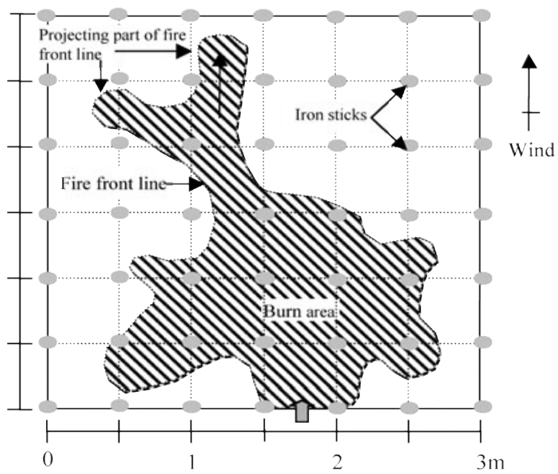


Fig. 3. A typical horizontal distribution of burned surface peat layer with several projection parts of the fire front line at Plot-2 on August 10, 2002.

Fuels of tropical peat

The important factors of surface fuel are not only the amount of fuels but also moisture of fuels. According to the National Fire Danger Rating System (NFDRS) in the United States, the such a standard is used for moisture of plant residuals on the ground that moisture 1% is "extremedry" with

Table 2. Type and height of vegetation of research plots for fire events along the high way. Weight of fresh and dead plants on the ground were measured after oven dry.

Items	Plot number in study site								
	1	2	3	4	5	6	7	8	9
Vegetation type	Bush	Bush	Bush	Bush	Bush	Bush	Bush	Bush	Bush
Vegetation high (m)	2 - 5	1 - 6	1 - 5	2 - 5	1 - 2	2 - 4	2 - 5	2 - 5	2 - 8
Ratio of fresh/died plants (%)	66/34	60/40	41/59	47/53	61/39	38/62	55/45	53/47	48/52
Surface fuels (t ha^{-1}))	34.2	39.6	20.1	34.4	23.9	20.5	20.5	15.4	19.6

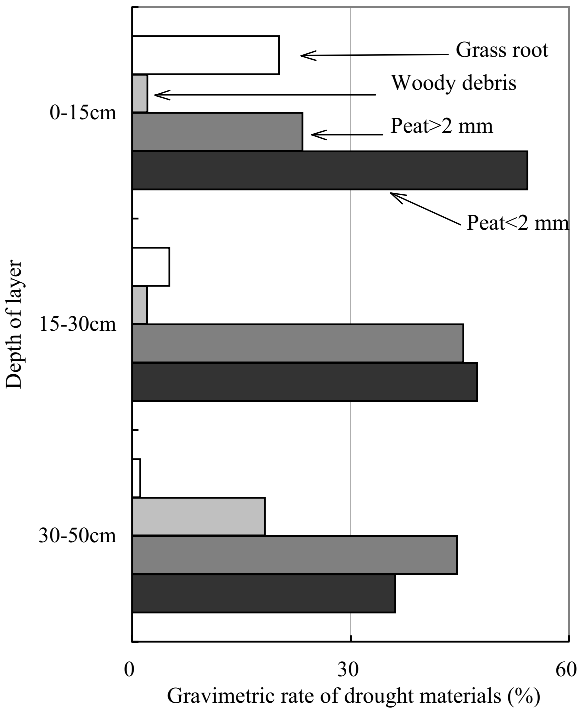


Fig.4. Composition of furel types in peat layers from surface to 50 cm in depth in a one meter square quodrate in study site.

dangerous of fire spread, and moisture 25-40% is "very wet" and there is no danger of fire spread. However the moisture of fresh plant ranges from 30%, "very dry" to larger than 300%.

Table 2 shows the types and heights of vegetation, the dry weight ratio of live and dead materials, and the weight of surface fuel in each study plot. Surface fuel on the ground ranged from 15.4 to 39.6 t ha^{-1} and was 25.3 t ha^{-1} on average. The ratio of live to dead materials ranged from 38/62 to 66/34 and was 52/48 on average.

The characteristics of fuels on the ground are very important for fire behavior same as weather condition and landform. The characteristics of fuels on the ground surface are influenced by various factors such as the drought period, natural diseases and insect infestation. In addition, the fuels on the ground are supplied by timber harvesting, naturally fallen trees, and the slash and cut down system.

The fuels in the peatland were classified into four basic components: (1) peat soil with decomposed material sifted through the sieve with a mesh size of 2.0 mm, (2) peat soil with partially decomposed material remaining on the sieve, (3) wood/root debris, and (4) grass roots. The ratios of wood/root debris to total weight of fuel in each peat layer were small: 3% at a depth of 0-15 cm and 2% at a depth of 15-30 cm. However, the ratio at a depth of 30-50 cm was relatively large (5%). In contrast, the ratio of grass roots to total weight of fuel was large (19%) in the upper layer (depth of 0-15 cm) but small in deeper layers (5% at a depth of 15-30 cm and 1% at a depth of 30-50 cm) (Fig. 4). These findings suggest the grass roots are generally distributed in the surface layer and that wood/root debris is generally distributed in a deeper layer (depth of more than 30 cm).

Field observations of the fire behavior of peat in the study plots indicated that the peat matrix could not be burned without the presence of other fuel materials such as grass roots and wood/root debris. These fuel materials in a peat layer are important for support of fire propagation in peatland, because they easily cause loss of moisture and are highly ignitable under conditions of dry weather or high air temperature and strong radiation from flames. In addition, wood/root debris provides many chinks and gaps in the peat layer through which air can circulate when the peat is burning.

Table 3. Numbers of woody debris counted with different sizes in different layers from surface to 50 cm in depth at the one meter square quadrates in Kalampangan and Tumbang Nusa. WN: number of woody debris.

Size diameter	Peat depth and wood numbers					
	0 - 15 cm		15 - 30 cm		30 - 50 cm	
cm	WN*	(%)	WN*	(%)	WN*	(%)
0.1 – 0.9	139	60	98	53	142	72
1.0 – 1.9	70	30	42	23	24	12
2.0 – 2.9	16	7	17	9	12	4
3.0 – 3.9	8	3	11	6	0	0
4.0 – 4.9	0	0	0	0	0	0
5.0 – 5.9	0	0	9	5	0	0
6.0 – 6.9	0	0	8	4	10	4
7.0 – 7.9	0	0	0	0	0	0
8.0 – 8.9	0	0	0	0	8	4
Total	233	100	185	100	196	100

Wood debris in each layer in each quadrate was counted and sorted according to diameter (Table 3). There was no wood debris in the surface peat layer (0-15 cm in depth) larger than 4 cm in diameter, and 92% of the debris in the surface peat layer was less than 2 cm in diameter. Larger wood debris (4.0-6.9 cm in diameter) was found in the peat layer of 15-30 cm in depth, and much larger wood debris (8.0-8.9 cm in diameter) was found in the peat layer of 30-50 cm in depth. The main reason for the difference in sizes of wood debris at different depths of the peat layer is thought to be cultivation by the farmer.

Fig. 5 shows typical vertical profiles of soil moisture in the peat layer in plot 1 and plot 2 sampled on August 8, 2002. Peat moisture of around 100% in gravimetric water content near the surfaces in plots 1 and 2 means that the surface of the peat layer was very dry at that time. The peat moisture content increased sharply with increase in depth from the surface to 10 cm in depth in plot 1 and to 20 cm in depth in plot 2. However, the gradients decreased in layers deeper than these surface layers. The peat was even dry at a depth of around 30 cm in plot 1 and at a depth of around 40 cm in plot 2. The peat moisture content increased again at layers deeper than the comparatively dry layers in both plots. The existence of these comparatively dry layers below subsurface layers in both plots might be a consequence of the chinks and gap formation by the wood/root debris in these layers. These comparatively dry and porous layers play an important role in the expansion of the fire front below subsurface layers as shown in Fig. 2.

Driessen and Rochimah (1976) reported that the porosity of tropical peat is dependent primarily on the bulk density of the material. For example, fibric peat has a total porosity of 90 percent by volume, whereas the porosity of sapric peat is less than 85 percent (Boelter, 1974). The high degree of porosity of tropical peat and the air mass in the deeper layer can cause smoldering in deep peat layers. Hungerford *et al.* (1995) reported that the smoldering of peat soil was ignited in cracks or depressions, or in woody material on the ground surface and burned downward and laterally to find a favorable condition. Moisture of materials was the most important factor for control of ground fires (Pyne et al., 1996).

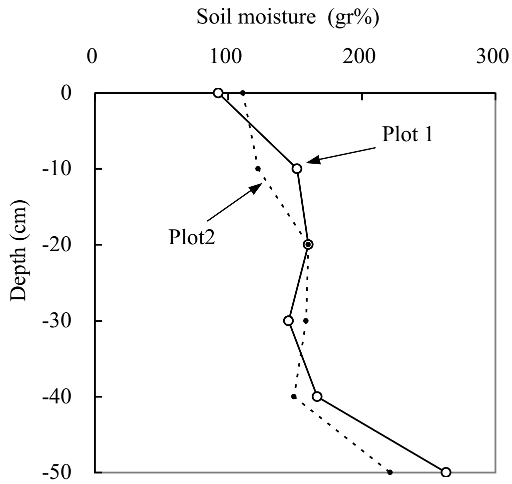


Fig.5. Soil moistute, gravimetric %, profiles in peat layers at Plot 1 and Plot 2 sampled on August 8, 2002.

Speed of fire spread

Table 4 shows the speed of spread of the fire front in the tropical peatland measured at depths of 0-10 cm (type 1 fire) and 30-50 cm (type 2 fire) in the study plots. In shallow peat soil (0-10 cm in depth), the average speed of fire spread was 3.83 cm hr^{-1} (being equivalent to 92 cm day^{-1}), maximum speed was 6.49 cm hr^{-1} (155 cm day^{-1}), and minimum speed was 1.73 cm hr^{-1}(42 cm day^{-1}). The average speed, maximum speed and minimum speed of fire spread in the deeper peat layer, 1.29 cm hr^{-1} (29 cm day^{-1}), 2.50 cm hr^{-1} (60 cm day^{-1}) and 0.50 cm hr^{-1} (12 cm day^{-1}), respectively, were a half to one third slower than the speeds of fire spread in the shallow layer. These speeds of fire spread in the tropical peatland were not greatly different to those reported for different types of peat and different regions, for example, 0.5-10 cm hr^{-1} in Russian peat, 4.2 cm hr^{-1} in Australian peat and 3-12 cm hr^{-1} in Canadian peat (Wein, 1983). The speed of fire spread has been shown to have a linear relationship with the wind speed (Momoh et al., 1996; Fernandes, 2001), but the relationships of speed of fire spread in a peatland with soil moisture and wind speed are still not clear.

Table 4. Speed of fire front expansion on the surface, 0-10 cm deep and in the subsurface peat layer, 30-50 cm deep. SD: standard deviation, N: number of samples.

Peat depth (cm)	Average (cm h^{-1})	Max. (cm h^{-1})	Min. (cm h^{-1})	SD (cm h^{-1})	N
0 – 10	3.83	6.49	1.73	1.41	20
30 – 50	1.29	2.5	0.5	0.64	20

Rate of burned material

The rate of burned material is defined as the total amount of biomass material loss in a fire event. The value of combustion efficiency depends on the type of fuel, fuel moisture content and fuel bed, although fire efficiency is a difficult variable to quantify accurately in estimation of biomass burning (Fearnside et al., 1993).

Table 5 shows the burned areas and the percentages of surface fuel and peat fuel losses by fire in the study plots. The surface fuel loss by fire ranged from 40 to 60%, while the peat fuel loss ranged from 15 to 30%. The percentages of burned fuels in these study plots were higher than those in our previous study on slash and burn of secondary peat forest. Nevertheless 36% of the surface fuel was burnt, the surface peat layer was not ignited (Usup, 2002). One possible reason for this difference is that surface fuel in the present study was sufficiently dry and more suitable for fire propagation. On the other hand, there was abundant wood debris on the peat surface, which remained on the ground without burning in a fire that occurred in 1997. The small amount of rainfall from May to September in 2002 (Table 1) made the fuels on the peatland very dry, thus providing good fuels for combustion in this area.

Table 5. Bernt area in each research plot and rates of burned area of surface and peat fu the three meter square quadrates.

Items	Plot number in study site						
	1	2	3	4	5	6	7
Burned area (ha)	2.0	3.0	1.2	2.6	1.4	5.0	1.2
Surface fuel (%)	60	50	40	60	45	40	55
Peat fuel(%)	15	20	20	25	30	30	30

The rate of burned material never reaches 100%; it has been reported to range from 50 to 95% in wildfire areas (Pyne et al., 1996) and to be 27.4% in a forest subjected to slashing and burning for conversion into pasture land (Fernside, 1993). On the other hand, it has been reported that 90% of trunks and large branches above ground were burned (Seiler and Crutzen, 1980). The rate of burned material ranged from 42-57% in a slashed area of primary tropical forest in the Brazilian Amazon (Kauffman et al., 1995) and was estimated to be about 25.1% in Manuas region (Carvalho et al., 1995).

According to the results of previous studies on tropical forest in the Amazon, the combustion efficiency of tropical peat forest in Kalimantan is not significantly different to that of tropical forest in the Amazon.

Peat fire temperature

The temperature of the peat surface in the study plots peaked at 270 ^{o}C at about 10 a.m. on August 22 (Fig. 6a) and a temperature of more than 125 ^{o}C continued for two hours (Fig. 6c). The surface peat layer (2-3 cm in depth) was burned, and the fire was extinguished in the afternoon after several hours of smoldering. The temperature of the peat soil at a depth of 10 cm rose gradually up to 70 ^{o}C with a lag time of several hours. The temperatures of peat soil at depths of 20, 30 and 40 cm also rose very slowly. The surface temperature rose again in daytime on August 23, but the peak of surface temperature was not so high than that of one day before. The sensor of the thermometer set on the surface might have been exposed to air with the first smoldering of surface layer on the first day. However, the surface temperature did not rise to a high level as it did one day before, because the sensor was not in contact with the peat surface layer due to lowering of ground surface by burning. The lowering of the ground surface reduced the depth of the sensor, which was buried at a depth of 10 cm from the original ground surface. Therefore the smoldering on the surface peat layer affected more clearly to the temperature at 10 cm deep on August 23.

Fig. 7 shows the dynamic changes in temperature profiles in the burning peat layer that contained an abundance of dry wood debris. The surface temperature of the peat layer had risen slightly at 5 minutes, but the temperature of the layers at a depth of more than 5 cm did not change. The surface temperature had risen to 400 ^{o}C 30 minutes later. The temperature at a depth of 5 cm had also risen to 100 ^{o}C at that time, but this temperature was not sufficiently high for ignition. The temperature of this layer had risen to 210 ^{o}C at 40 minutes later. This temperature was not sufficiently high to ignite the dry wood debris of this layer. The temperature at a depth of 5 cm remained high for 60 minutes. However, the surface temperature had dropped to less than 200 ^{o}C after 60 minutes. The temperatures at depths of more than 10 cm deep remain lower than 100 ^{o}C during this fire event.

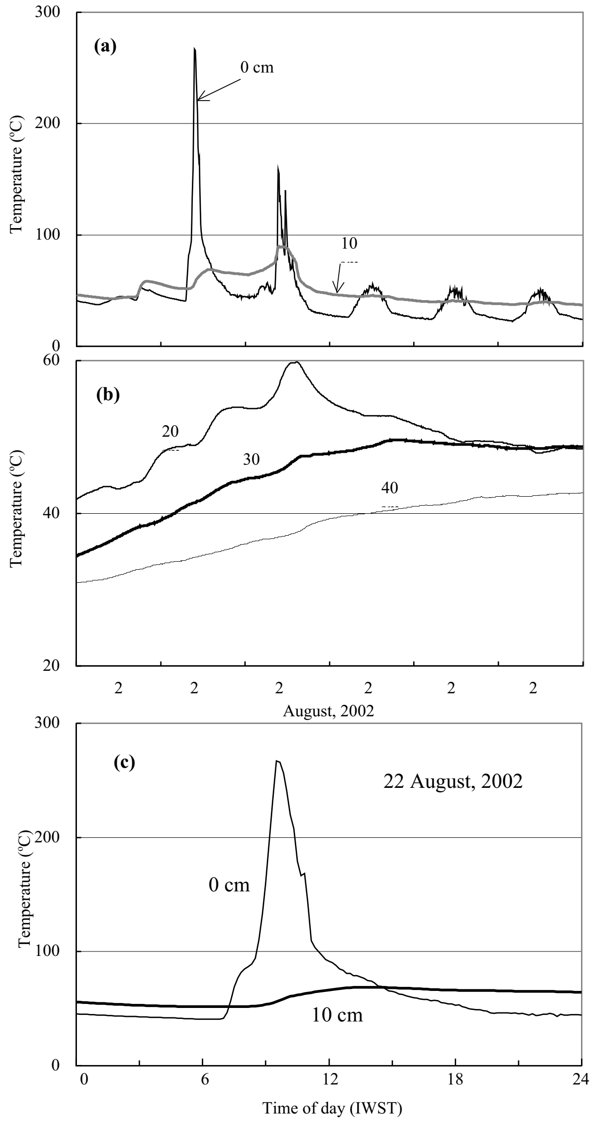


Fig. 6. Temperaterues in peat layers during fire event from August 21 to 26, 2002 in Kalanpangan. (a) at ground surface and 10 cm deep from surface, (b) at 20, 30, 40 cm deep, (c) diurnal temperature changes of ground surface and 10 cm deep on the first day of fire event, August 22, 2002.

Penetration of high temperature from the burning surface layer to deeper layers is governed by many factors such as temperature level and duration of high temperature, moisture content of the peat, and quality of the peat matrix. The ground water level is the most important factor determining the depth to which the peat is burned, because water supplied from ground water to the peat layer just above it will keep the peat sufficient wet to prevent it from igniting.

Peat ignition temperature

Weight losses from samples of peat matrix were measured under the condition of rising ambient temperature using a thermo-gravimetric differential thermal analyzer, and the results are shown in Fig. 8. Peat samples obtained at depths of 0-20 cm, 20-40 cm and 40-60 cm in the study site were used for this analysis. The peat matrix was classified into two sizes, coarse and fine matrixes, by sifting the peat through a sieve with mesh size of 2 mm. The weight loss processes of the coarse peat matrix were different with three layers (Fig. 8a). Generally, the process of weight loss of organic materials caused by heating has three stages. The sample loses weight quickly with release of water vapor until the sample becomes dried-up. A latent energy of 334 J g^{-1} is required to evaporate water from a sample. The temperature of the sample rises up to about 100 ℃ in this stage. Some volatile compounds are released as gasses and are burnt in the second stage. Weight loss of the sample is not so large in this stage. In the third stage, weight of material decreases rapidly with combustion of solid materials.

The weight of the coarse matrix of the surface layer (0-10 cm in depth) was reduced by 20% in the first stage. This weight loss was not as large as the weight losses in deeper layers because of the small amount of water in the sample. The weight losses of the coarse matrix at depths of 20-40 cm and 40-60 cm were 35% and 55%, respectively. The ignition temperatures of three peat matrixes at depths of 0-20 cm and 20-40 cm were estimated from the figure to be around 250 ^{o}C, and that at a depth of 40-60 cm was estimated to be 280 ^{o}C. The processes of weight loss of the small matrixes in the three different layers were the same and were similar to the process of weight loss of the coarse peat matrix in the deepest layer (Fig. 8b). These samples ignited at a temperature of about 280 ^{o}C after weight loss of 60%. Moisture content is a key factor affecting peat combustion. For example, the coarse peat material with particles of larger than 2.0 mm in diameter had a low moisture content and was easy to burn. Nugroho (1997) reported that coarse peat material could burn at 1/3 atmospheric pressure and that most of the energy from the fire was used to decrease moisture content of fuel materials before burning. In other words, ignition and combustion processes occurred under the endothermic and exothermic reactions.

Wright and Bailey (1982) reported that the ignition temperature depended on moisture content, mineral density, specific heat, material thickness and heat source intensity. Frandsen (1997) suggested that the heat input should be sufficient to dry up the moisture and dry bulk peat material (both organic and inorganic) up to ignition temperature.

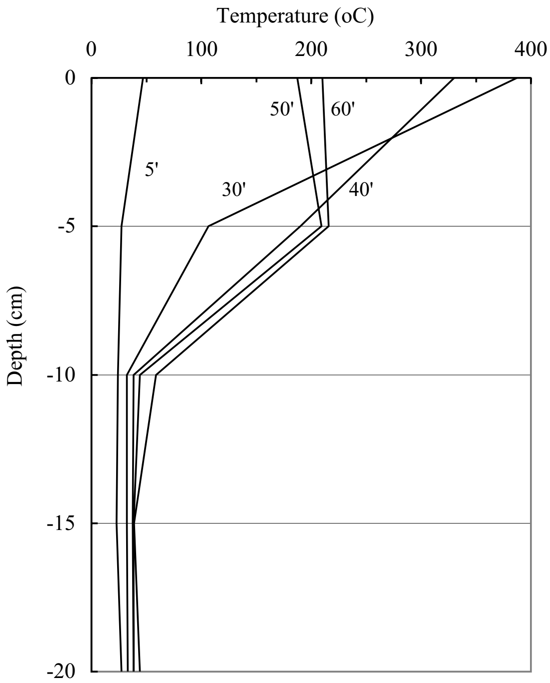


Fig.7. Change of temperature profiles in peat layers during burning of woody debris on the ground surface at Kalampangan on August 6, 2002.

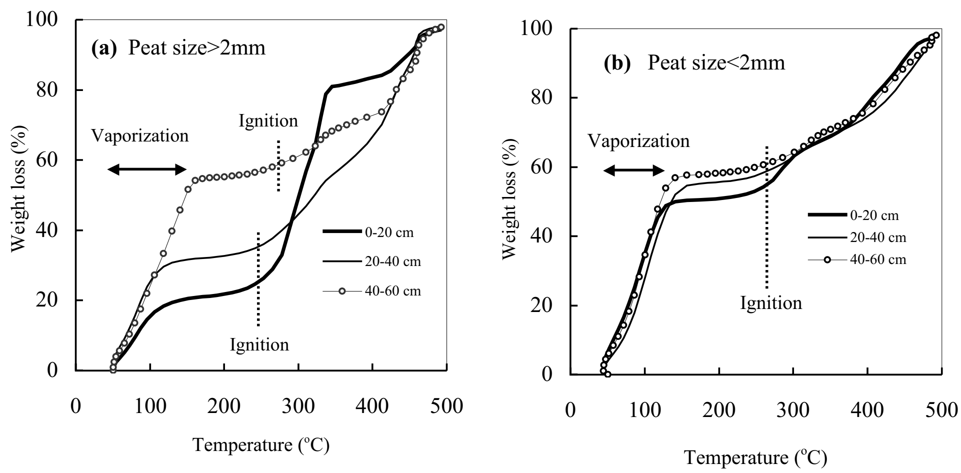


Fig.8. Weight loss processes of peat materials different in size and sampled from different peat layers.

Calorific value

The calorific values of tropical peat are shown in Table 6. The calorific value was measured twice for each peat sample, and the results of measurement were almost the same. The discussion is therefore based on the average values. The root and wood in both layers of 0-5 cm and 5-10 cm in depth in a pristine peat forest had almost same calorific values, 21.1 and 21.5 KJ g^{-1}, which were 2-3 KJ g^{-1} larger than those in a secondary peat forest. The calorific values of peat matrix in layers of 0-5 cm and 5-10 cm in depth in a pristine peat forest were 20.5 and 21.0 KJ g^{-1}, respectively, which were 1 KJ g^{-1} larger than those in a secondary forest but 4 KJ g^{-1} smaller than those in farmland. The surface layer of farmland is sometimes burned to obtain fertilizer from peat, and many carbonized particles remain in the peat layer. This abundance of carbonized particles might be a reason for the high calorific value of surface peat in farmland.

The calorific values of tropical peat, 19.6 - 23.4 KJ g^{-1}, were larger than those of boreal peat, 8.3 - 17.7 KJ g^{-1} (Tokyo Astronomical Observatory, 1998). Tropical peat matrix is usually formed from wood, whereas boreal peat is formed from sphagnum and grasses. Thus, the difference between calorific values of tropical and boreal peatlands might be caused by the difference in their plants of origin.

CONCLUSION

Field survey and temperature measurements were carried out in fire sites in Central Kalimantan, Indonesia in 2002. Some physical properties were measured in laboratories. Some characteristics of peatland fire in a tropical area were

clarified in this study. The results of the present work are summarized as follows:
1) The process by which a fire front spread in peatland can be categorized into two types: surface layer fire (from the surface to 10-15 cm in depth) and deep layer fire (20-50 cm in depth). Deep layer fire is very hazardous because it spreads out into the peat dome, hammock and areas surrounding tree roots.
2) Wood/root debris in the deeper peat layer (30-50 cm in depth) plays an important role in fire propagation by lowering low moisture content of peat and creating a porous matrix structure of the peat layer.
3) The speed of fire propagation in the surface layer was 92 cm day^{-1} on average and ranged from 42 to 155 cm $day-^{1}$, while that in the deeper layer was 29 cm $day-^{1}$ on average and ranged from 12 to 60 cm day^{-1}.
4) According to the weight losses of peat samples, which were measured by a thermo-gravimetric differential thermal analyzer, the ignition temperatures of the coarse matrix of the surface layer (0-10 cm in depth) and the deeper layer (20-40 cm in depth) were around 250 ^{o}C, and those of the fine matrix in the same layers and the coarse and fine matrixes in the layer of 40-60 cm in depth were around 280 ^{o}C. These ignition temperatures coincide roughly with the smoldering temperature of peat in the field.
5) The calorific values of tropical peat, 19.6-23.4 KJ g^{-1}, were larger than those of boreal peat, 8.3-17.7 KJ g^{-1} because tropical peat matrix is usually formed from wood.

ACKNOWLEDGEMENTS
The authors are grateful to the many people who cooperated and assisted in field and laboratory activities, particularly to Miss Makiko Tamari and Mr. Kazumasa Hanazono from the Sapporo Fire Bureau, Japan and Mr. Yukiyasu Yamakoshi from Hokkaido Industrial Research Sapporo Japan. Special thanks are due to Prof. Kazuomi Hirakawa, Mr. Suwido Limin and Mr. Tampung Saman, staff of CIMTROP, University of Palangka Raya. This research was supported in part by the JSPS-LIPI Core University Program 1997-2006.

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Session 7

AQUATIC ENVIRONMENT

Chaired by

Toshio IWAKUMA & Gadis Sri HARYANI

Experimental Studies on The Growth of *AZOLLA* as Biofertilizer for Acid Water System

Fifi Widjaja[1] and Hany Handajani[2]
[1]Aquatic Resources Mangement, Faculty of Fisheries and Marine Science, Bogor Agricultural University (IPB), Bogor, West Java, Indonesia phone /Fax : 0251 - 336389;
e - mail : fifi@bogor. Wasantara net. id
[2]Faquaculture of Fisheries Departement, Faculty of Animal Husbandry and Fisheries, University of Muhammadiyah Malang (UMM), Malang,
East Java, Indonesia phone /Fax : 0341 - 464318 exp : 175; Fax : 0341 - 460782,
e - mail : hhandajani@yahoo.com.

ABSTRACT

Nitrogen is one of the most important minerals for living organisms and the main source is from the atmosphere. Azolla is known as a small water fern, which can fix nitrogen through the symbiotic association with the blue-green algae Anabaena.

Experimental studies were carried out in the glass house investigating the growth of *Azolla* using different levels of nitrogen and phosphorus in the media. The experiment used 12 treatments with 3 levels of nitrogen (0,5 and 10 mg atom/1) and 4 levels of phosphorus (0, 10, 20 and 30 mg atom/I) in the factorial design with 3 replicates. The result show that the highest biomass for fresh weight (13.28 g), dry weight (1.126 g) and the fastest doubling time (7.71 days) were found in combination of 10 mg atom N/1 and 30 mg atom P/1. While the highest protein content was found in combination of 5 mg atom N/1 and 20 mg atom P/1. After the third day heterocyst cells in Anabaena could only be found in those two combinations, but the highest heterocyst cell was found in the lower N and P combination similar to the highest protein content.

The observations of the ecological factor show that Azolla tend to grow in low pH. Further experiment is suggested to introduce *Azolla* as biofertilizer for acid water system such as peatland water.

Key word : Azolla, nitrogen, phosphorus.

INTRODUCTION

Nitrogen is one of the important minerals for living organisms, besides hydrogen, oxygen and carbon. The main source of nitrogen is from the atmosphere. Nitrogen can't be used directly by the plants; it should be converted into nitrate or ammonium through certain process. The symbiotic ability of *Azolla* sp. and *Anabaena azollae* can transform atmospheric nitrogen to become ammonia through enzyme called nitrogenase. The amount of nitrogen fixed is luxury for both plants, i. e. 4-5% dry weight basis or equal to 22-37% protein. This plant is very potential as biofertilizer or used as substitute of protein for animal feed.

Azolla is a small water fern, which belongs to phylum Pteridophyta. In Indonesia, this plant called "kayu apu dadak" (in Sunda), "ganepo" (Sumatra) and *Azolla* is well known by the farmers in Yogyakarta and East Java (Fig. 1). *Azolla* can live throughout the year, distribute from lowland to 2200 m highland. Ideal condition for *Azolla* are temperature 20-30 ^{0}C, pH of water 4-7 and light 25-50% (Lumpkin, 1987). Reproduction is very efficient through vegetation processes,

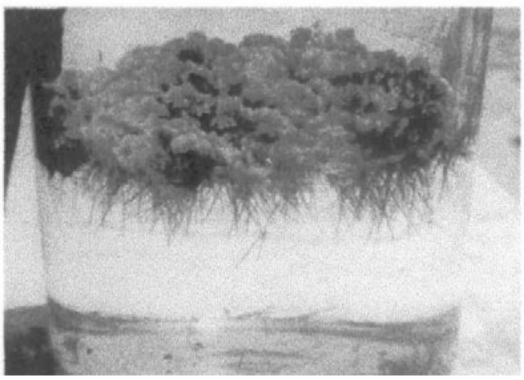

Figure 1. *Azolla microphylla* were used in observation

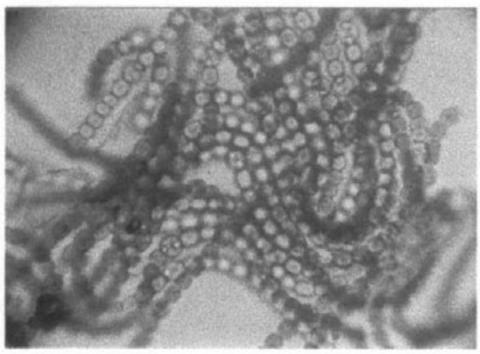

Figure 2. *Anabaena azollae* were used in observation

however it occasionally forms spores.

Anabaena belongs to the blue-green algae within the division Cyanophyta (Fig. 2). The cells of *Anabaena* consist of 3 types: vegetative cells are primarily for photosynthesis, heterocysts are the cells which can fixed nitrogen, and akinetes usually have thick-walled resting spores. Multiplication of *Anabaena* is through binary vision similar to bacteria.

According to Hawab (1982), association of *Azolla-A. azollae* can produce 1 ton green manure/ha/day, which consist 3 kg of nitrogen fixation which equal to 15 kg of ammonium sulfate or 7 kg of urea. This plant is very potential as biofertilizer, it's therefore important to investigate further of *Azolia* and its symbiont.

Association of *Azolla* and microsymbiont *A. azollae* are related to nutrients in the media, therefore this experiment is carried out in the glass house investigating the growth of *Azolla* using different levels of nitrogen and phosphorus.

MATERIALS AND METHODS

The research was conducted in a glass house and Tissue Culture Laboratory, Center for Agricultural Biotechnology, University of Muhammadiyah Malang, from February until June 1999. Alga-free *Azolla microphylla* was collected from paddy field around the University and used in this experiment.

Culture were grown in medium MAC (modified liquid artificial) (Maftuchah, 1998). The experiment needed 3 levels of nitrogen (0, 5 and 10 mg atom 11) and levels of phosphorus (0, 10, 20 and 30 mg atom/1) in a randomized

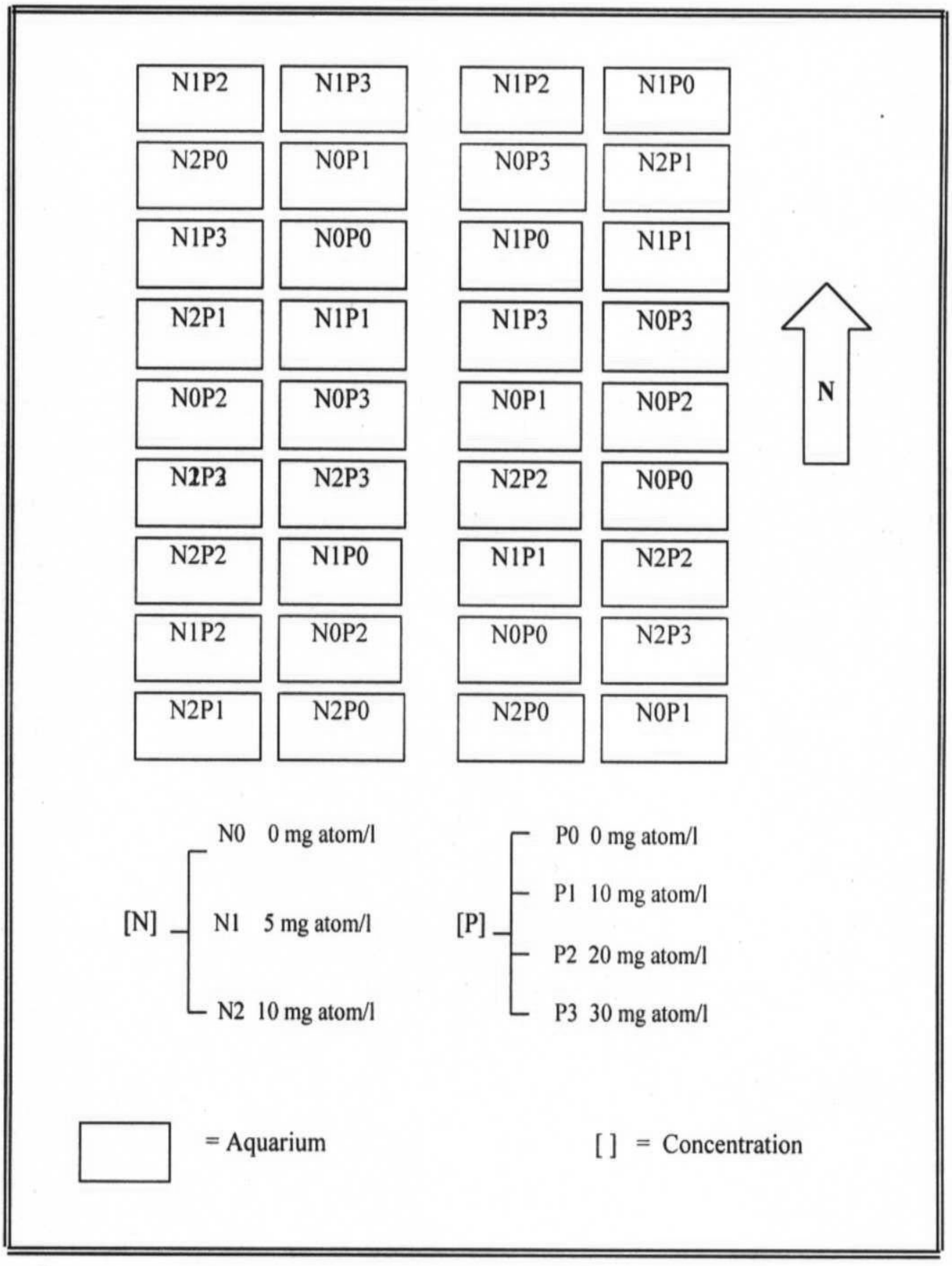

Figure 3. The design of aquariums placement

factorial design. Each treatment used 3 replicates, and the experiment thus consisted of 36 experimental aquariums (40x30x30 cm) (Fig. 3).

Planting was done by inoculation of seed *A. microphylla* 2 g/aquarium (Lumpkin and Plucknett, 1982) and *A. azollae* with 2 different cells, heterocyst cells 57500/ml and vegetative cells 1332500/ml. During the observations, the water level was kept at 5 cm high, considering that the longest root of *A. microphylla* is found 2.5 cm. Each aquarium was filled with 6 liters of growth media.

Azolla microphylla is cultured for 2/days and observations on the leaves is done every day for the first 5 days to check whether heterocyst cells or vegetative cells of symbiotic association already occurred during the time and alternate days afterwards. Observations for pH and light intensity were done every 2 days. Harvesting was done after 21 days.

RESULTS AND DISSUCION

Biomass and doubling time

Result shows interaction between nitrogen and phosphorus treatment on fresh weight, dry weight, and doubling time of *A. microphylla* (Fig. 4a and 4b). It is found that the combination treatments of N2P3 give the highest fresh weight and dry weight, and the fastest for doubling time with the values of 13.28 g, 1. 126 g and 7.71 days. While combination of N2P0 shows the lowest value for fresh weight, dry weight, and the longest doubling time of 3.426 g, 0.290 g and 35.3 days. It seems that phosphorus is the limiting factor for *A. microphylla* growth.

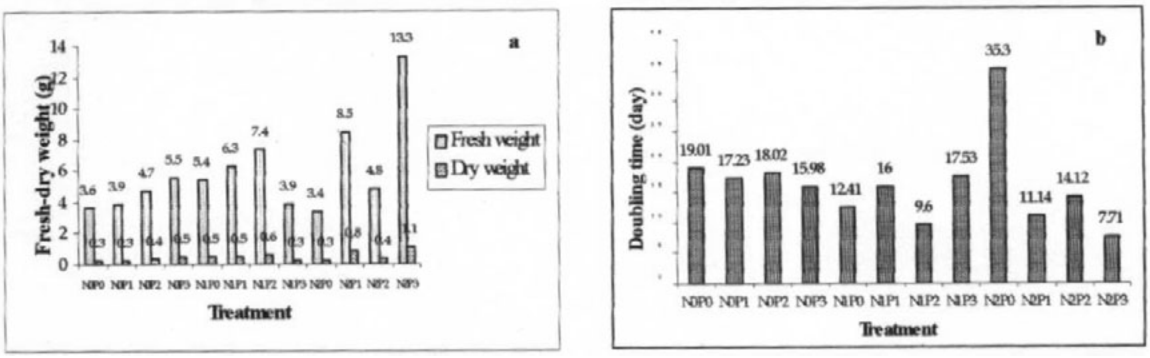

Figure 4. Different treatment combination, a: Fresh weight and dry weight; b: Doubling time

Treatment combination of nitrogen and phosphorus can increase the biomass of *A. microphylla* and also accelerat the doubling time. Maftuchah (1994) neutioned shows that phosphorus 40 ppm treatment as the maximum biomass of *A.* microphylla and harvest on day 3 0. However, Cary and Weerts (1982) show with different species *Azolla pinnata* the highest dry weight biomass was found in phosphorus 20 Mg PO_4-P/1 and the biomass decreased at phosphorus 40 Mg PO_4-P/l.

The fastest doubling time recorded at 7.706 days. These confirm the research of Maftuchah (1998) with the same species at concentration of phosphorus 20-40 ppm found doubling time for 6.08-24.75 days.

Using the different species, Cary and Weerts (1982) calculated doubling time 2.883.21 days using concentration 20-40 Mg PO_4-P/1 for *A. pinnata.* Brotonegoro and Abdulkadir (1976) also found doubling time within the range of 2-5 days for *A. pinnata.*

Research from Ito and Watanabe (1985) showed the fastest doubling time ever recorded 1.9 days. Maximum biomass for most *Azolla* needs 13-23 days after inoculation. Phosphorus is the most important factor to support the growth of *Azolla;* the low concentration of phosphorus can prevent growth.

At harvest, the fresh weight and dry weight were determined. Number of leaves in each aquarium were counted As a measure of growth rates. Doubling time were obtained by dividing In 2 log relative growth rate (Reynolds, 1990). Percentage of the leaves which has A. *azollae* (X) was calculated using the equation:

$$X = \frac{n}{N} \aleph 100\,\%$$

Where X is percentage of leaves with *A. azollae;* n is the number of leaves with *A. azollae;* N is the number of leaves in 10 g sample of *A. microphylla,*

Protein content in *A. microphylla* and in the growth medium was analyzed with Lowry methods (Winberg, 1971).

Leaf number

Fig. 5 shows the concentration without nitrogen gives the highest leaf number until day 11 and then drop. Only on day 19 and 21 there is highest leaf number given by treatment combination of N1P1 (5 mg atom/1 N_2 and 10 mg atom /1 P_2O_5) with low biomass gained. Leaf number in 10 g sample can not be used to measure the biomass. It seems that the area of the leaves is much smaller and limits the photosynthesis.

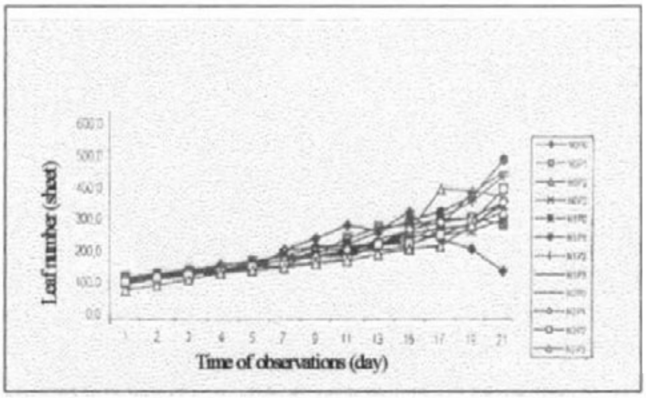

Figure 5. Leaf number of *A. microphylla* in different time of observations

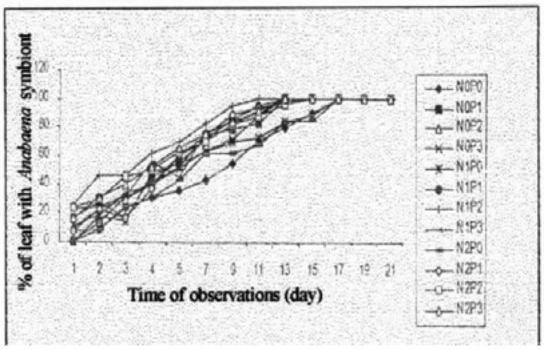

Figure 6. Percentage of *A. microphylla* leaf with *A. azollae* symbiont in different time of observations

Percentage of leaf with A. azollae symbiont

Fig. 6 shows that on day 17, 19 and 21 all treatments contain *100% Anabaena azolla.* Low values were found in N0P0 and very slow having symbiont for N1P0. The Highest value was found combination of 5 mg atom/1 N_2 and 20 mg atom/1 P_2O_5.

Fig. 6 also shows that N1P2 is the best media, low of nitrogen is more effective on association of *A. microphylla-A* azollae. Nitrogenase activity dependes on the condition of the growth media especially phosphorus. which can limit the growth and development of *Azolla.*

Heterocyst cells

Heterocyst started to grow from day 4 until dav 21. Fig. 7 shows that treatment N1P2 has the highest cells. The number of cells accelerates nitrogenase activity, so fixation is faster and nitrogen as protein in plant tissue is also increased.

In low nitrogen, the process of nitrogenase in *A. azollae* is more active so producing more heterocyst, while in high nitrogen, fixation is blocked.

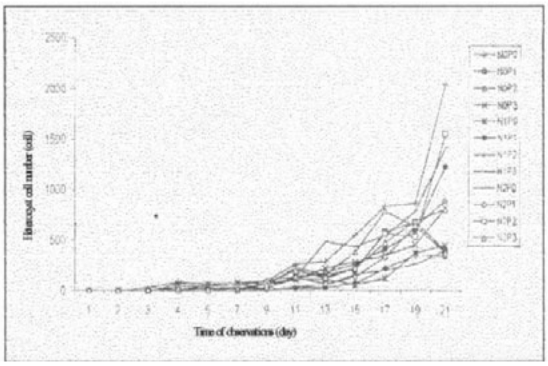

Figure 7. Heterocyst cell number of *A. azollae* in different time of observations

Protein content

Table 1 shows that the highest protein content is found in combination treatment of N1P2.at 39.62% and 21.2 1 % in growth media and the lowest in N0P1 at 13.10% and only 3.56% in growth media. *Azolla* has been proven to be able to synthesize nitrogen and transform in the form of protein, even though the growth media has a low value of nitrogen.

Phosphorus is important to accelerate the fixation process, other wise the process will be blocked, because the ATP energy is needed in nitrogenase process. According to Khan (1988), the lack of phosphorus in the media will decreased the biomass 22% and total nitrogen content decreased until 16% because of the decrease of nitrogen fixation.

pH and light intensity

Table 2 shows the highest pH recorded are N1P0 of 7.5 in day 1. The lowest pH was found in N2P3, which are 4.3 in day 21. At harvest, highest biomass and highest doubling time were found in this pH concentration. The highest leaf number was found in N1P1 with pH of 5.7. Percentage of *A. azollae* symbiont, heterocyst cells and protein contents were found high in N1P2 with pH of 5.0.

Table 1. Protein content of *A. microphylla* and growth media in different treatment

Treatment	Protein content (%) in	
	A. microphylla	Growth media
N0P0	18.53	7.11
N0P1	13.10	20.17
N0P2	28.12	7.11
N0P3	32.59	7.43
N1P0	20.45	8.39
N1P1	21.41	3.56
N1P2	39.62	21.21
N1P3	24.60	7.47
N2P0	30.99	4.51
N2P1	32.91	15.34
N2P2	33.07	21.09
N2P3	15.98	12.70

Table 2. Average pH of growth media in different time of observations

Treatment	Time of observations (day)										
	1	3	5	7	9	11	13	15	17	19	2.1
N0P0	6.8	6.8	6.5	6.6	6.8	6.8	6.6	6.9	6.7	7.2	6.6
N0P1	6.8	6.7	6.6	6.7	7.2	6.7	6.7	6.7	6.7	7.2	5.9
N0P2	6.8	6.7	6.7	6.5	6-8	6.4	6.4	6.9	6.9	6.8	6.2
N0P3	7.0	6.7	6.3	6.3	6.4	6.4	6.4	6.6	6.6	6.4	5.9
N1P0	7.5	7.1	6.6	6.2	6.7	6.6	6.6	6.5	6.5	6.7	5.8
N1P1	7.0	6.9	6.6	6.4	6.6	6.3	6.3	6.7	6.7	6.6	5.7
N1P2	6.9	7.0	6.7	6.1	6.8	5.5	5-5	5.6	5.6	6.8	5.0
N1P3	6.9	7.0	6.6	6.9	6.9	6.6	6.6	6.6	6.6	6.9	6.4
N2P0	6.7	7.1	6-8	6.8	7.1	6.3	6-3	6.7	6.7	7.1	5.8
N2P1	7.4	7.0	6.6	6.3	6.6	5.7	5.7	5.8	5.8	6.6	4.5
N2P2	6.7	6.7	6.6	6.5	6.6	6.2	6.2	6.2	6.2	6.6	4.8
N2P3	6.6	6.6	6.4	6.0	6.6	5.6	5.6	5.9	5.9	6.6	4.3

The pH of growth media tends to decrease following the length of time of observation. The pH range has between 4.3-7.5. According to Lumpkin (1987), optimum pH for *A.-olla* growth is in the range of 4-7, but *A olla* can still survive at pH 3.5- 1 0.

In this experiment light intensity measured is 24418 ± 4845 lux and range between 2033.9 Klux. Virgilius (1986) found the optimum of light intensity for *Azolla* within the range of 20-50 Klux, however the range between 5-100 Klux can still be tolerated.

Contaminant

During the experiment other micro-algae were also found in the growth media. Twenty-two genera were recorded since this was not an aseptic one.

Combination treatment

The selection of all treatments gives the best 3-combination treatment as shown in Table 3. Treatment of N1P2 (5 mg atom N/1 and 20 mg atom P/1) shows the highest value of 3 variables, i.e. percentage of leaves containing *A. azollac,* heterocyst cell number and protein content, so this combination is considered the best growth media for *A. microphylla.*

This research shows that optimum combination for biomass production (N2P3) is different from the requirement of nitrogen and phosphorus to increase the protein content in *A. microphylla and A. azollae (NIP2)*

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CONCLUSION

Combination treatment with low nitrogen in growth media with 5 mg atom N/1 and 20 mg atom P/1 produce the highest protein content of 39.62% in *A. microphylla* and 21.21% in growth media. This treatment also produces the highest cells as respond of association of *A.microphylla and A. azollae.*

High blomass as fresh weight, dry weight and high doubling time were found in N2P3 combination of 10 mg atom N/1 and 30 mg atom P/1, didn't follow with high protein content.

Environment factor shows that *A. microphylla* has a tendency to grow in water with low pH which could be suggested to be introduce as blofertilizer for acid water system such as peatland water.

Table 3. Rank of the best of combination treatment for all variables

Variables	The best of combination		
	I	**II**	**III**
Weight	N2P3	N2P1	N1P2
Doubling time	N2P3	N1P2	N2P1
Leaf number	N1P1	N1P2	N0P2
		N2P0	N2P2
% of leaf with *A. Azollae*	N1P2	N1P1	N0P2
		N2P1	N1P3
			N2P3
Heterocyst cell number	N1P2	N2P2	N1P3
Protein content	N1P2	N2P2	N2P1

ACKNOWLEDGEMENTS
We thank to Mr. Ir. Pong Suwignyo, M. Sc. and Mr. Dr. Ir. Djokosetlyanto for guidance; Mrs. Ir. Maftuchah, W and Mr. Ir. Aris Winaya, MM for discussion; the rector of UMM and Dean of Faculty of Animal Husbandry and Fisheries, University of Muhammadiyah Malang for support of this experiment. Thank is due to Diah Prabandani for typing the manuscript.

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Proposed Set Points for Conservation Management of Malili Lakes, South Sulawesi Based on Several Physico-Chemico Limnological Characters

Dede Irving Hartoto, Awalina
Research Center for Limnology LIPI
LIPI Life Science Center Cibinong, Jln. Raya Jakarta-Bogor km.46 Cibinong. Bogor 16911. Indonesia
Phone:+62-21-8757071 Fax: +62-21-8757076
E-mail:lhartoto@indo.net.id, Awalina.Satya@lipi.go.id

ABSTRACT

From 1992 until 1997, several data of physico-chemico limnological characters were collected in three oligotrophic lakes in Malili lakes area, South Sulawesi that consisted of respectively L. Matano (altitude 382 m asl, A=164.1 km^2, Z_{max} =590 m), L. Mahalona (altitude 310 m asl, A=24.4 km^2, Z_{max} =60 m) and L. Towuti (altitude 293 m asl, A=561.1 km^2, Z_{max} =203 m) the observed parameters were Dissolved Oxygen (DO), Oxydative Reductive Potentials (ORP), Conductivity, pH, Biological Oxygen Demand (BOD_5), Total Phosphorus (TP), Total Nitrogen (TN), ortho-Phosphate (o-PO_4^{3-}), Nitrogen- Nitrate(N-NO_3^-) , Nitrogen-nitrite (N-NO_2^-), Nitrogen-Ammonia (N-NH_4^+), Chemical Oxygen Demand (COD), Alkalinity, free Carbondioxyde (free CO_2), Temperature, Secchi depth and total Hardness. The objective of the study is to reveal the vertical profiles of some physico-chemico limnological characters of those oligotrophic lakes as the background for the development of the set points in the process control of their water quality management. Water samples taken by stratification according to each maximum depth. The results indicated that ortho-Phosphate (o-PO_4^{3-}), Nitrogen-nitrite (N-NO_2^-), Nitrogen-Ammonia (N-NH_4^+), Chemical Oxygen Demand (COD), free Carbon dioxyde (free CO_2), Total alkalinity, Secchi depth, Conductivity, and water temperature, show significantly different both in dry and wet seasons in among of those three lakes. Meanwhile ORP, Total P and Total hardness only in L. Mahalona and Towuti. Mostly the average of some physico-chemico limnological characters were tended to be higher in wet seasons namely Conductivity, ortho-Phosphate (o-PO_4^{3-}), Nitrogen-Ammonia (N-NH_4^+), Alkalinity, free Carbondioxyde (free CO_2),and Secchi depth, and temperature in L. Matano. Meanwhile in L. Mahalona the average of Dissolved Oxygen (DO), Oxydative Reductive Potentials (ORP), Conductivity, ortho-Phosphate (o-PO_4^{3-}), Chemical Oxygen Demand (COD), Alkalinity, free Carbondioxyde (free CO_2), Temperature, Secchi depth and total Hardness were increased in wet seasons. In L. Towuti the average of Conductivity, ortho-Phosphate (o-PO_4^{3-}), Nitrogen-Ammonia (N-NH_4^+), Chemical Oxygen Demand (COD), Alkalinity, free Carbondioxyde (free CO_2), Temperature, Secchi depth and total Hardness were also tended to be enhanced in wet seasons. Depth profiles of each lakes show that at certain water depth deserved to be noticed but it was depending on each physico-chemico limnological characters, generally as follows: 200-300 m (in L. Matano), 20-40 m (in L. Mahalona), and 100-200m (in L.Towuti). The unique characteristics of the lakes suggested to be used as the parameter for the set points is discussed.

Key words: set points, conservation, management, physico-chemico limnological characters, Oligotrophic lakes.

INTRODUCTION

The limnology of the lakes in Indonesia, more over which are located on the eastern part of Indonesia, such as the thirteen lakes in Sulawesi and Papua, is to a great extent unknown. Malili lakes is a chain of oligotrophic lakes that located on South Sulawesi Province, consisted of respectively L. Matano (altitude 382 m asl, A=164.1 km^2, Z_{max} =590 m), L. Mahalona (altitude 310 m asl, A=24.4 km^2, Z_{max} =60 m) and L. Towuti (altitude 293 m asl, A=561.1 km^2, Z_{max} =203 m).

Lake Matano with water volume of 92 million m ^{3} and only 56 draw down is regarded as one of the most beautiful (Whitten, et.al, 1987) and mentioned as the eight deepest lake in the world, well known as the deepest lake not only in Indonesia but also in South East of Asia (Hutchinson, 1957). The most unique feature of this lake is only one in Asia which have a *cryptodepression* depth (Z_c) up to 238 m. The geological characteristics of the lake watersheds is define of two type rock formation which are serpentine and peridot. Lake Mahalona is the smallest lake in this chain while Lake Towuti is the second largest lake in Indonesia (Fernando, 1984 in Whitten *et al.*). Malili lakes ere lakes of tectonic origin, are found on the low section of Matano faults zone (Figure 1), and estimated developed around 1.6 million years ago due to flooded rift valley (graben) formation and a more complex faulting. These lakes are suggested to be under ocean water during the late tertiary and early quartener. Lake Towuti and Lake Matano has 26 and 10 small rivers inlet respectively (Wardoyo, 1978 in Whitten *et al.*) and they are mostly surrounded by pristine forests. A nickel mining company (INCO) which is located near L. Matano have already conducted a strip mining operation since 1990ís. The mining sites is only separated by one rows of small hills with the lakes. Matano, Mahalona and Towuti lakes lies on udic climatic region which is characterized by condition of permanently moist with one month of less than 100 mm rainfall. In this condition, presumably the smoke from smelting process of nickel mining eventually would fall down to the lakes carried by rain fall or mist.

Lake Matano is suggested to be managed and used as a part of water conservation systems. In this system, L. Matano is recommended as a core zone, while L. Mahalona as a buffer zone and L. Towuti as an area of ecotourism. Figure 1 describe the implementation of control process approach to manage one natural system for any purpose of human needs. In this approach, beside a definable systems, set points which are going to be used for evaluation of monitoring data is always crucial (Hartoto, 1994). In related to this, to enrich the basic limnological references for development of set points for the process control in conservation management, a physico-chemico limnological study was conducted in L. Matano, L. Mahalona, and Towuti during 1992-1997.

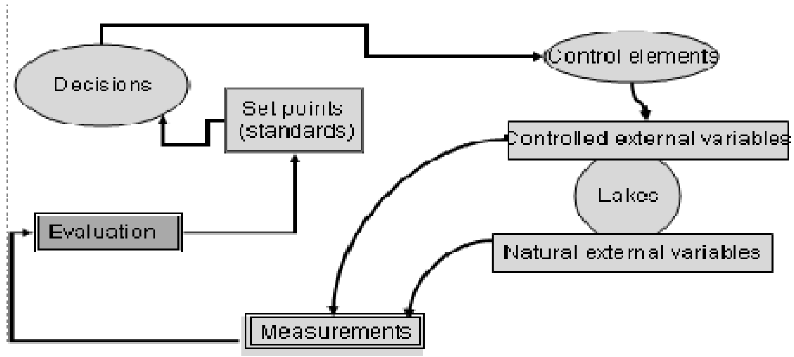

Figure 1. Control process approach for manage aquatics natural ecosystems (Haroto, 1994)

The objective of this study is bring to light the depth profiles of some physical and chemical characters of the lake waters. The parameters observed were Dissolved Oxygen (DO), Oxydative Reductive Potentials (ORP), Conductivity, pH, Biological Oxygen Demand (BOD_5), Total Phosphorus (TP), Total Nitrogen (TN), ortho-Phosphate (o-PO_4^{3-}), Nitrogen-Nitrate(N-NO_3^-) , Nitrogen-nitrite (N-NO_2^-), Nitrogen-Ammonia (N-NH_4^+), Chemical Oxygen Demand (COD), free Carbondioxyde (free CO_2), and total Hardness.

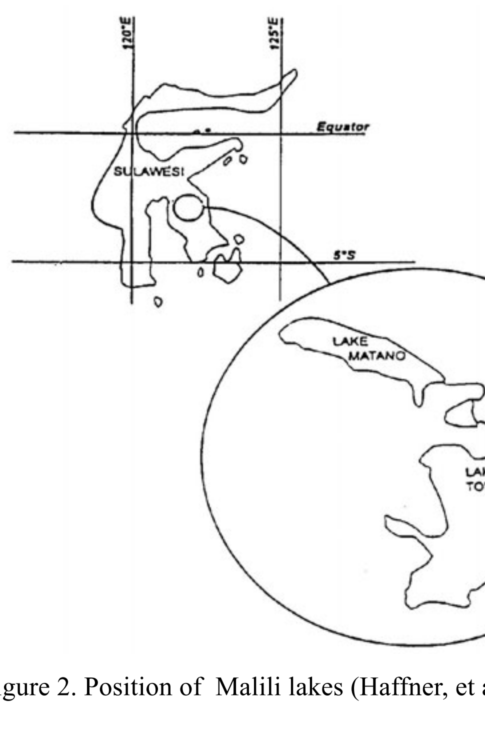

Figure 2. Position of Malili lakes (Haffner, et al. 2001)

MATERIALS AND METHODS

The study was conducted in 25 Sept 1992, 4 December 1994, 26 November 1995, and 26 January 1997 (represents wet seasons) and 24 August 1993, 5 July 1994, 4 September 1995, and 7 August 1996 (represent dry seasons). Water samples were taken using a Kemmerer Bottle sampler which was lower down to predetermine depths according to each maximum depth, which were Lake Matano (m depth): 0, 2, 5, 15, 20, 30, 60, 100, 200, 300, 400, 580, while Lake Mahalona (m depth): 0, 2, 5, 8, 20, 30, 40, 50, 60, and Lake Towuti (m depth): 0, 2, 5, 10, 20, 40, 80, 100, 150, and 250.

Exception for L.Matano in 25 Sept samples only taken until 100m and L.Towuti only till 155 meter (above sediment interface). Sampling point in each location is on the deepest part of the lake that was exactly on S2˚27'.438" E 121˚17'.756" in L. Matano, S2˚35'.156" E 121˚29'.203" in L. Mahalona and S2˚50'.044" E 121˚27'.736" in L. Towuti . The water samples were preserved according to the parameters to be analyzed, that consisted of Biological Oxygen Demand (BOD_5), Total Phosphorus (TP), Total Nitrogen (TN), ortho-Phosphate (o-PO_4^{3-}), Nitrogen-Nitrate(N-NO_3^-) , Nitrogen-nitrite (N-NO_2^-), Nitrogen-Ammonia (N-NH_4^+), Chemical Oxygen Demand (COD), free Carbondioxyde (free CO_2), Total alkalinity, and total Hardness. Those parameters were determined according to methods of APHA (1976) which listed in Table 1 below. Some parameter such as Secchi depth (measured using Secchi disk), Dissolved Oxygen (DO), Oxydative Reductive Potentials (ORP), Conductivity, pH, water temperature, was measured

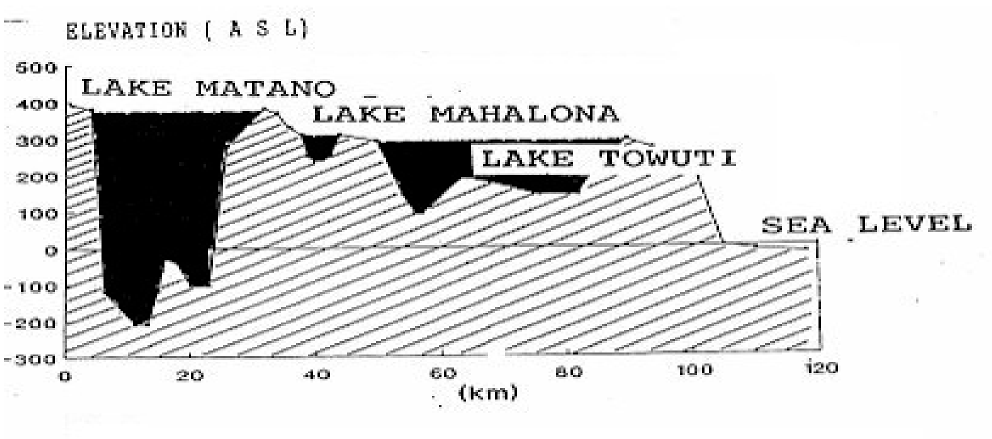

Figure 3. Vertical section of Malili lakes (Hehanussa, 1994)

directly in the lake using different instruments. The read out was recorded after 30 seconds to one minute immersion of the probes. Since during 8 sampling periods DO and ORP probes sometimes out of order, so those relevance parameters can not be measured. Table 2 present the recapitulation of the data collections. For the purpose of the set points development, the natural variation of the parameter was calculated. Statistical test of significant difference was executed by using Excell-xp.

Table 1. The methods and instruments for water parameter measurements in the study

Parameters	methods
Dissolved Oxygen	Iodometric methods (1995-1997) with DO probe in 1992-1994
Biological Oxygen Demand (BOD_5)	5 days incubation and then titration with Winkler Methods
Total Nitrogen (TN)	Digestion with oxidizing reagent, and then analysis for $N\text{-}NO_3^-$ spectrophotometrically with Brucine Methods
Total Phosphorus (TP)	Digestion with oxidizing reagent ($NH_2S_2O_8$, NaOH, and H_2SO_4) using autoclave and then analysis for $o\text{-}PO_4^{3+}$ spectrophotometrically with Ascorbic acid Methods
	Spectrophotometry using Nessler methods
Nitrogen-Ammonia ($N\text{-}NH_4^+$)	Spectrophotometry using Ascorbic acid methods
ortho-Phosphate ($o\text{-}PO_4^{3-}$)	Spectrophotometry using Brucine methods except of 1994 samples analyzed using Cd
Nitrogen- Nitrate($N\text{-}NO_3^-$) ,	reduction methods
	Spectrophotometry using Sulfanilamide methods
Nitrogen-nitrite ($N\text{-}NO_2^-$),	Titrimetric with EDTA
	Titrimetric with Acid (HCl or H_2SO_4) using mix
total Hardness	Bromochresol Green-methyl red Indicator to pH
Total alkalinity	4.6
	Permangano metry
	Volumetry with NaOH as titrant
Chemical Oxygen Demand (COD)	
free Carbon dioxyde (free CO_2)	
Secchi depth	Measured with Yokogawa Model PH82, with appropriate probe
Oxydative Reductive Potentials (ORP), water temperature and pH,	Measured with Yokogawa Model SC82 Conductivity meter
Conductivity,	

RESULTS AND DISCUSSION

The average values of some limnological characters and their test of significant differences in the dry and wet seasons in L. Matano, L. Mahalona, and L. Towuti is presented in Table 3, 4, and 5. The distribution of the water quality in those time is discussed based on the location as below.

In Table 3, 4, and 5 showed that NSD results mostly appeared in L. Matano those were Average of DO, ORP, pH, BOD_5 , TP, TN and Total hardness.

The different pattern on DO level between two seasons was not observed in L. Matano. In whole years, DO in L. Matano was similar and had average 5.11 mg/L. On the contrary, DO in L. Mahalona and L. Towuti were not same between two seasons whereas tended to be higher in wet seasons (6.992 mg/L and 13.31 mg/L) than in dry seasons (3.161 mg/L and 3.161 mg/L). This occasion might be affected by the differences of morphological shape among the lakes, as note L. Matano known had crypto depression (Z_c = 208 m) somewhat this case rise differences on geochemistry among the lakes. Figure 8 show that in each lake water depth that deserve to be noticed were 0-100 m (in L. Matano), 40-60 m (in L. Mahalona), and 100-150 m (in L. Towuti). In these depth frequently observed fluctuation due to DO quantity.

It was interesting, among of the three lakes found that the pH and BOD_5 were not change both in wet and dry seasons. Respectively in L. Matano those average were 7.77 and 2.15 mg/L, 7.67 and 1.84 mg/L in L. Mahalona, while in L. Towuti 7.86 and 3.60 mg/L. It clear from the values of pH and BOD_5 in L. Towuti, according to Wetzel (2000) those parameter related to the allochthonous input of decomposable organic matter, physical condition, and biotic inputs and biotic consumption. Not only the length of shore lines is longer compare to L. Matano moreover L. Mahalona, but also

Table 2. Recapitulation of data collections of the three lakes during 1992-1997

Parameters	Lake Matano		L.Mahalona		L.Towuti	
	Wet seasons (times)	Dry seasons (times)	Wet seasons (times)	Dry seasons (times)	Wet seasons (times)	Dry seasons (times)
Dissolved Oxygen	3	4	2	2	3	4
Biological Oxygen Demand	3	3	2	1	3	3
(BOD_5)	4	3	2	1	4	3
Total Nitrogen (TN)	4	4	2	2	4	4
Total Phosphorus (TP)	4	3	2	1	4	3
Nitrogen-Ammonia ($N\text{-}NH_4^+$)	4	4	3	1	4	4
ortho-Phosphate ($o\text{-}PO_4^{3-}$)	4	3	2	1	4	2
Nitrogen- Nitrate($N\text{-}NO_3^-$) ,	2	3	2	1	2	3
Nitrogen-nitrite ($N\text{-}NO_2^-$),	4	2	2	1	3	3
total Hardness	3	3	3	2	4	3
Total alkalinity	3	3	2	1	3	3
Chemical Oxygen Demand (COD)	4	3	3	1	4	3
free Carbondioxyde (free CO_2)	4	4	2	1	4	4
Secchi depth	4	3	3	2	4	3
Oxydative Reductive Potentials (ORP),	4	3	3	2	4	3
water temperature	4	4	3	2	4	4
pH,	4	4	3	2	4	4
Conductivity,	4	4	3	2	4	4

Table 3. The results test of significant differences in dry and wet seasons of several physico-chemico limnological parameters in Lake Matano during 1992-1997

Parameters	Units	Dry seasons average	Significant test of differences results on P>0.05	Wet seasons average	Lake average
Dissolved Oxygen (DO)	mg/L	4.79	NSD	5.42	5.11
Biological Oxygen Demand (BOD_5)	mg/L	2.29	NSD	2.01	2.15
Total Nitrogen (TN)	mg/L	4.02	NSD	2.09	5.07
Total Phosphorus (TP)	mg/L	0.677	NSD	0.178	0.428
Nitrogen-Ammonia ($N\text{-}NH_4^+$)	µg/L	181.8	SD	331.6	*
ortho-Phosphate ($o\text{-}PO_4^{3-}$)	µg/L	17.532	SD	31.345	*
Nitrogen- Nitrate($N\text{-}NO_3^-$) ,	mg/L	0.810	SD	0.425	*
Nitrogen-nitrite ($N\text{-}NO_2^-$),	µg/L	15.731	SD	1.303	*
total Hardness	mg/L	100.01	NSD	67.62	*
Total alkalinity	mg/L	3.66	SD	2.54	83.82
Chemical Oxygen Demand (COD)	mg/L	9.214	SD	5.019	*
free Carbondioxyde (free CO_2)	mg/L	10.39	SD	23.878	*
Secchi depth	meter	14.7	SD	17	*
Oxydative Reductive Potentials (ORP),	mV	158.26	NSD	143.93	*
water temperature	ºC	27.1	SD	28.4	151.1
pH,		7.69	NSD	7.85	*
Conductivity,	µS/cm	200.17	SD	239.1	7.77

Note: NSD is Not significant different, SD is Significant different, * is no lake average since the average of two seasons are significantly different

Table 5. The results test of significant differences in dry and wet seasons of several physico-chemico limnological parameters in Lake Towuti during 1992-1997

Parameters	Units	Dry seasons average	Significant test of differences results on P>0.05	Wet seasons average	Lake average
Dissolved Oxygen (DO)	mg/L	6.36	SD	13.31	*
Biological Oxygen Demand (BOD_5)	mg/L	4.396	NSD	113.9	3.60
Total Nitrogen (TN)	mg/L	18.010	SD	0.661	*
Total Phosphorus (TP)	mg/L	3.55	SD	0.194	*
Nitrogen-Ammonia ($N\text{-}NH_4^+$)	µg/L	82.855	SD	163.216	*
ortho-Phosphate ($o\text{-}PO_4^{3-}$)	µg/L	0.383	SD	36.022	*
Nitrogen- Nitrate($N\text{-}NO_3^-$) ,	mg/L	1.476	NSD	0.392	0.934
Nitrogen-nitrite ($N\text{-}NO_2^-$),	µg/L	82.855	SD	2.854	*
total Hardness	mg/L	41.89	SD	87.2	*
Total alkalinity	mg/L	3.38	SD	42.43	*
Chemical Oxygen Demand (COD)	mg/L	7.82	SD	163.216	*
free Carbondioxyde (free CO_2)	mg/L	9.980	SD	6.565	*
Secchi depth	meter	10	SD	21.30	*
Oxydative Reductive Potentials (ORP),	mV	190.3	SD	113.9	*
water temperature	ºC	27.9	SD	29.06	*
pH,		7.88	NSD	7.85	7.86
Conductivity,	µS/cm	144.1	SD	173.45	*

Note:

NSD is Not significant different, SD is Significant different, * is no lake average since the average of two seasons are significantly different

Figure 3 . Accasia one year old (floor is clean from grass, yellowish leaf colour)

Figure 5. Accasia crassicarpa, 5 years old.

Figure 4 . Accasia 3 years old

Figure 6. Accasia, 7 years old (secondary forest but no mining of peat)

more crowded inhabitant that relies their live on this lake. So it can be said that L. Towuti as the second biggest lake in Indonesia and because of its location that lies on the lowest part of Malili lakes system receive and load more allochthonous input of decomposable organic matter from its surround than others. Figure 6 show that in each lake water depth that deserve to be noticed were 0-100 m (in L. Matano), 20-40 m (in L. Mahalona), and 150-250 m (in L. Towuti). In these depth frequently observed fluctuation due to pH quantity. Mean while also in Figure 6 show that in each lake water depth that deserve to be noticed were 200-400 m (in L. Matano), 0-10 m, then 20-50 m (in L. Mahalona), and 100-200 m (in L. Towuti). In these depth frequently observed fluctuation due to BOD_5 quantity

Only in L. Matano and L. Mahalona average Total N was not distinct both in dry and wet seasons, which average lake respectively 5.070 mg/L and 3.435 mg/L. In other side L. Towuti was tended to be more average Total N in dry seasons (18.010 mg/L) than in wet seasons (0.661 mg/L). Commonly, in unproductive oligotrophic lakes which nitrogenous compounds input is mainly comes from precipitation, by the way its depending on the local meteorological condition, wind pattern, and the location of lake with respect to industrial and agricultural out puts (Wetzel, 2000). This matter is probably match for the L. Towuti case, since in this lake watershed, the agricultural - domestic, and some small scale home industry activities such as sawmilling, freshwater dried fish, rice milling, etc were more rapid develops than other parts of L. Mahalona and L. Matano. Figure 7 show that in each lake water depth that deserve to be noticed were 200-400 m (in L. Matano), 20-40 m (in L. Mahalona), and 100-200 m (in L. Towuti). In these depth frequently observed fluctuation due to TN quantity.

Both in dry and wet seasons, the average nitrate content was similar in L. Mahalona (0.547 mg/L) and L. Towuti (0.934 mg/L). Higher Nitrate in L. Towuti might be caused by the same reasons as mentioned in previous paragraph (TN case). On the other hand, L. Matano showed diverge feature, which was in dry seasons average Nitrate (0.810 mg/L) was higher than in wet seasons (0.425 mg/L). This fact probably can be explained by the reasons that dry fall out or atmospheric precipitation as a main source of $N\text{-}NO_3^-$ for L. Matano. Figure 7 show that in each lake water depth that deserve to be noticed were 100-200 m (in L. Matano), 30-50 m (in L. Mahalona), and 50-150 m (in L. Towuti). In these depth frequently observed fluctuation due to $N\text{-}NO_3^-$ quantity.

Only L. Matano show the similarity both in dry and wet seasons the average of ORP. Total hardness. Average values of each parameter in whole years respectively 151.1 mV. Mean while average ORP in L. Mahalona was higher in wet seasons (113.9 mV) than in dry seasons (99.72 mV). ORP in L. Towuti was opposite of L. Mahalona which was higher in dry seasons (190. 3 mV) than in wet seasons (113.9 mV). The ORP is important to be observed here since by some the reasons that stated by many researcher for example by Wetzel, according to him the changes of ORP is regulate the biogeochemical cycling of essential inorganic micronutrients in aquatic system, which are governed largely by photosynthetic and bacterial metabolism (Wetzel, 2000). As mentioned on early paragraph, seemingly there was differences of biogeochemical cycling pattern among three lakes based on the seasons whereas L. Matano is not influenced by the seasons while two other lakes were influenced. In addition, L. Mahalona was more ìoxidized" in wet seasons than in dry seasons that was opposite with L. Towuti. Probably, it caused by the differences of environmental depression in each lake watershed or in another word the explanation is same as TN case. Figure 8 show that in each lake water depth that deserve to be noticed were 0-100 m (in L. Matano), 50-60 m (in L. Mahalona), and 100-200 m (in L. Towuti). In these depth frequently observed fluctuation due to ORP values.

Both in L. Mahalona and L Towuti, the amount of Total P was tended to be higher in dry seasons (1.228 mg/L and 3.55 mg/L) than in wet seasons (0.203 mg/L and 0.194 mg/L).This is on the contrary with L. Matano that show no significant differences both dry and wet seasons with average in whole year was 0.428 mg/L. Likely, in Total P case the lakeís morphology, vegetative cover and land use are give strong influences here. L. Towuti and L. Mahalona because of those reason may had more deposit of sediment in the bottom as result of load input. Dry seasons turn over kinetics of Phosphorus generally extremely rapid (Wetzel, 2000), so at this period these two lakes appeared the highest TP content. Figure 9 show that in each lake water depth that deserve to be noticed were 200-300 m (in L. Matano), 0-10 m (in L. Mahalona), and 100-200 m (in L. Towuti). In these depth frequently observed fluctuation due to quantity of TP .

Total Hardness in L. Matano showed average and 83.820 mg/L whole in years since was no significant difference both in dry and wet seasons. Meanwhile in L. Mahalona and L Towuti were tended to be higher in wet seasons (104.334 mg/L and 87.2 mg/L, respectively) than in dry seasons (3.612 mg/L and 41.89 mg/L, respectively). This fact is no wonder because of in this area the type of basin rock mainly is basaltic rocks. By the way Hem (1975) stated that according to American Water works Association, the ideal quality water should be contain no more than 80 mg/L. So, it seems that for ordinary domestic purpose, water from L. Matano should be softened. It also need to be conducted to L. Towuti and L. Mahalona even only in wet seasons. Still in Figure 9, shows that in each lake water depth that deserve to be noticed were 100-200 m (in L. Matano), 0-10 m (in L. Mahalona), and 100-200 m (in L. Towuti). In these depth frequently observed fluctuation due to quantity of total hardness.

Parameter in average that show significantly different in dry and wet seasons

According to Table 3, 4 and 5 not less than eight parameter that consisted of ortho-Phosphate ($o\text{-}PO_4^{3-}$), Nitrogen-nitrite ($N\text{-}NO_2^-$), Nitrogen-Ammonia ($N\text{-}NH_4^+$), Chemical Oxygen Demand (COD), free Carbon dioxyde

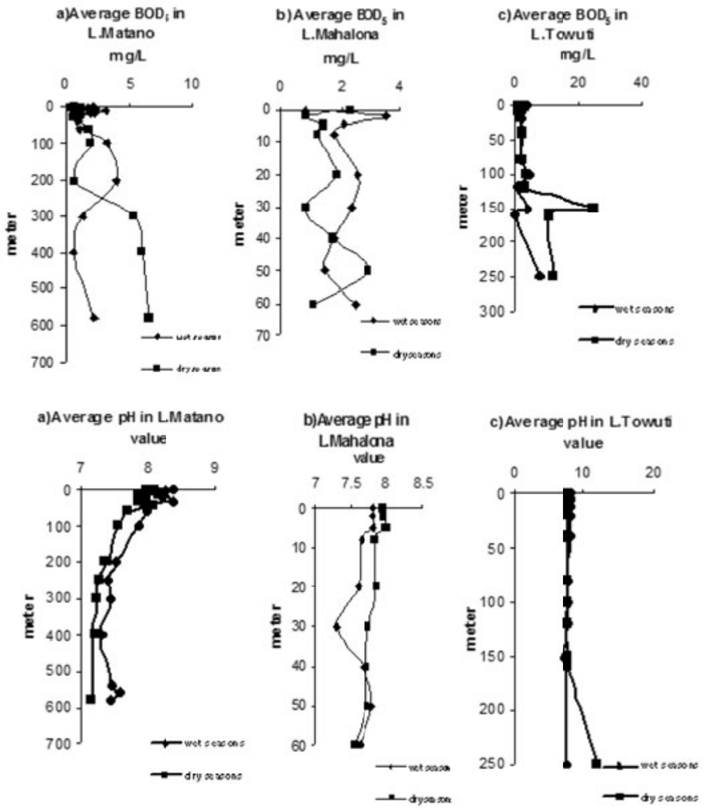

Figure 6. The profiles of the parameters that showed not significant different in threelakes both in dry and wet seasons

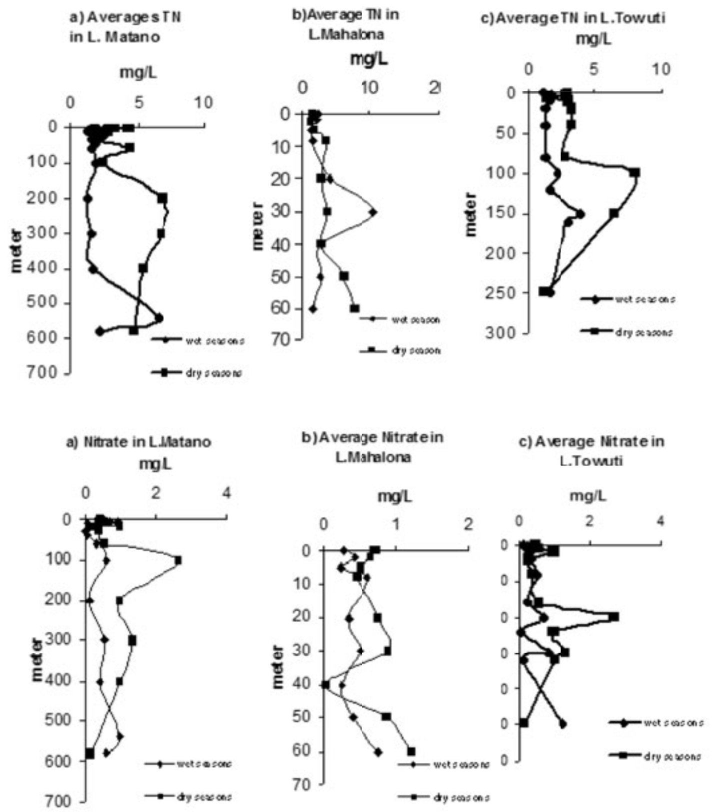

Figure 7. Profiles TN and Nitrate in three lakes. Note that TN only NSD in L. Mahalona & L. Towuti, while Nitrate only NSD in L. Mahalona & L. Towuti.

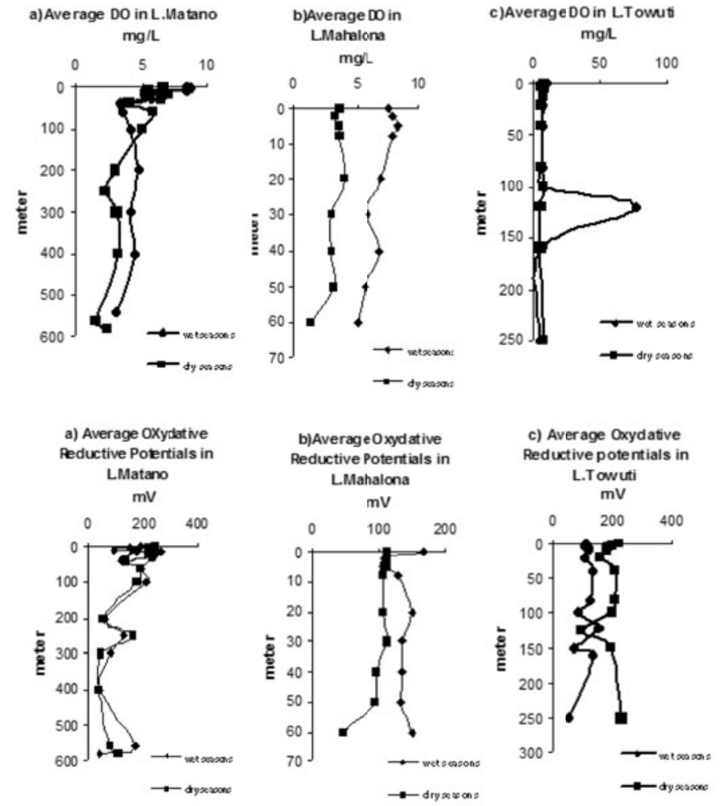

Figure 8. The profiles of DO & ORP in three lakes, DO average was NSD only in L.Matano and L.Towuti, while average ORP was NSD only in L. Matano.

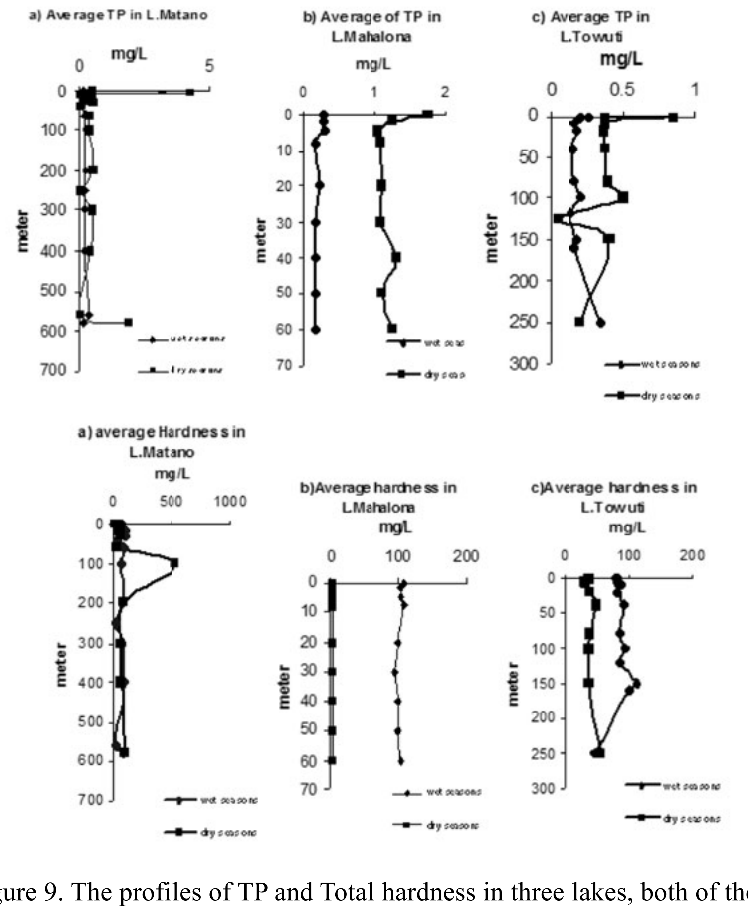

Figure 9. The profiles of TP and Total hardness in three lakes, both of them only appeared NSD in L. Matano.

(free CO_2), Total alkalinity, Secchi depth, Conductivity, and water temperature, that show significantly different both in dry and wet seasons in among of those three lakes.

The average conductivity was tended to be higher in wet seasons in L. Matano (239.1 µS/cm), L. Mahalona (271.96 µS/cm), and L. Towuti (173.45 µS/cm) than in dry seasons respectively 200.17 µS/cm, 174.9 µS/cm, and 144.1 µS/cm. Clearly, that the highest conductivity found in L. Mahalona and next followed by L. Matano. The explanation of these facts is probably caused by the highest allochthonous input that carried out not only by run off water and then received by L. Matano but also by such as ìseepages" or probably springs (?) that only occurs in L. Matano. This ìseepages input" contains ionic material mostly belong to alkaline ions. It was indicated from the conductivity depth profile which was the highest average conductivity values was found at 200-300 and 520 m water depth (Fig. 10). For two other lakes, Figure 10 show that in L. Mahalona 0-50 m water depth was deserved to notice, while in L. Towuti was at 0-50 m .

The average of Secchi depth was tended to be higher in wet seasons (17 m in L. Matano, 8.75 m in L. Mahalona, and 21.30 m in L Towuti) than in dry seasons (14.7 m in L. Matano, 6.10 m in L. Mahalona, and 10 m in L Towuti). This occasion is typical of the oligotrophic lakes, which is Secchi transparency usually high (Lehmusluoto, *et al.* 1995) . Wetzel (2000) noted that Secchi transparency measurements is associated to the concentration of particulate suspensoids.

The alkalinity average were tended to be higher in wet seasons in L. Mahalona (71.62 mg/L) and L. Towuti (42.43 mg/L) than in dry seasons which were respectively 2.47 mg/L and 3.38 mg/L. The opposite was L. Matano which tended to be higher in dry seasons (3.66 mg/L) than in wet seasons (2.54 mg/L). According to Wetzel (2000) alkalinity in water results from any dissolved species, usually weak acids anion, that can accept and neutralize protons or this referred to the buffering capacity of carbonate system in water. Since L. Mahalona had the most highest average alkalinity then followed by L. Towuti, it can be said that L. Mahalona received the highest allochthonous input that mostly consisted of organics material from its surrounding. While alkalinity in L. Matano seemingly derived from organics that originated by domestic waste. Figure 13 show that in each lake water depth that deserve to be noticed were 100-300 m (in L. Matano), 0-10 m (in L. Mahalona), and 100-200 m (in L. Towuti). In these depth frequently observed fluctuation due to alkalinity average quantity.

Discussing nutrient input in lake , one can not ignore the average concentrations of ortho-Phosphate (o-PO_4^{3+}) . The average of o-PO_4^{3+} showed significant differences both in dry and wet seasons in among three lakes. . Whereas, in wet seasons (31.345 µg o-PO_4^{3+}/L in L. Matano, 51.141 µg o-PO_4^{3+}/L in L. Mahalona and 36.022 µg o-PO_4^{3+}/L) were tended to be higher than in dry seasons (17.532 µg o-PO_4^{3+}/L in L. Matano, 15.802 µg o-PO_4^{3+}/L in L. Mahalona and 0.383 µg o-PO_4^{3+}/L). The average of Nitrogen-Ammonia (N-NH_4^+), also showed significant differences both in dry and wet seasons in three lakes. In wet seasons the average N-NH_4^+ in L. Matano (331.6 µg /L) and L. Towuti (163.126 µg /L) were higher than in dry seasons respectively 181.8 µg /L and 82.855 µg /L. On the contrary, L. Mahalona in dry seasons (0.645 µg /L) was higher than in wet seasons (0.202 µg /L). These facts are probably correspond to higher allochthonous input of nutrients that carried out by the run off water in wet seasons for L. Matano and Towuti. The quantity of nutrients contained in inflowing water seemingly depending on not only the width of opened area (not covered by forest anymore) but also the width of lake surface area, it could be seen from those mentioned average content in wet seasons in each lake. As a note, during data collections (1992-1997) deforestation were rapidly conducted on the vicinity of L. Mahalona and L. Matano for any reasons. Figure 12 show that in each lake water depth that deserve to be noticed were 100-300 m (in L. Matano), 10-30 m (in L. Mahalona), and 100-250 m (in L. Towuti). In these depth frequently observed fluctuation due to the average concentrations of ortho-Phosphate (o-PO_4^{3+})quantity. Meanwhile Figure 11 show that in each lake water depth that deserve to be noticed were 200-300 m (in L. Matano), 30-50 m (in L. Mahalona), and 100-200 m (in L. Towuti). In these depth frequently observed fluctuation due to the average of Nitrogen-Ammonia (N-NH_4^+) quantity.

The average of Nitrogen-nitrite (N-NO_2^-) were significantly different both in dry and wet seasons whereas in dry seasons L. Matano (15.731 µg/L), L. Mahalona (8.294 µg/L), and L. Towuti (82.854 µg/L) respectively higher than in wet seasons whereas L. Matano (1.303 µg/L), L. Mahalona (2.139 µg/L), and L. Towuti (2.854 µg/L). Possibly it is not only caused by the same factor with Nitrogen-Ammonia (N-NH_4^+) case, but also caused by the stronger turbulence that took place in these lake in wet seasons than in dry seasons. Figure 11 show that in each lake water depth that deserve to be noticed were 0-100 m (in L. Matano), 50-60 m (in L. Mahalona), and 150-250 m (in L. Towuti). In these depth frequently observed fluctuation due to the average concentrations Nitrogen-nitrite (N-NO_2^-)

The average COD significantly different both in dry and wet seasons in these three lakes. Only in L. Matano and L. Towuti the average COD in dry seasons (9.214 mg/L and 9.980 mg/L) was higher than in wet seasons (5.019 mg/L and 6.565 mg/L). In the other hand, L. Mahalona showed different pattern that was average in wet seasons (3.540 mg/L) was higher than in dry seasons (0.111 mg/L). Seemingly the influence of temperature to COD kinetics in L. Matano and L. Towuti were greater than in L. Mahalona. Another reason that could be fit is L. Mahalona received higher ionic materials derived from allochthonous input than other two lakes, since its position and environmental condition (e.g. the occurrence of out flow from Ni smelter plant as one of inlet L. Mahalona beside of small river that flows down from L. Matano). Figure 6 show that in each lake water depth that deserve to be noticed were 200-400 m (in L. Matano), 0-10 and

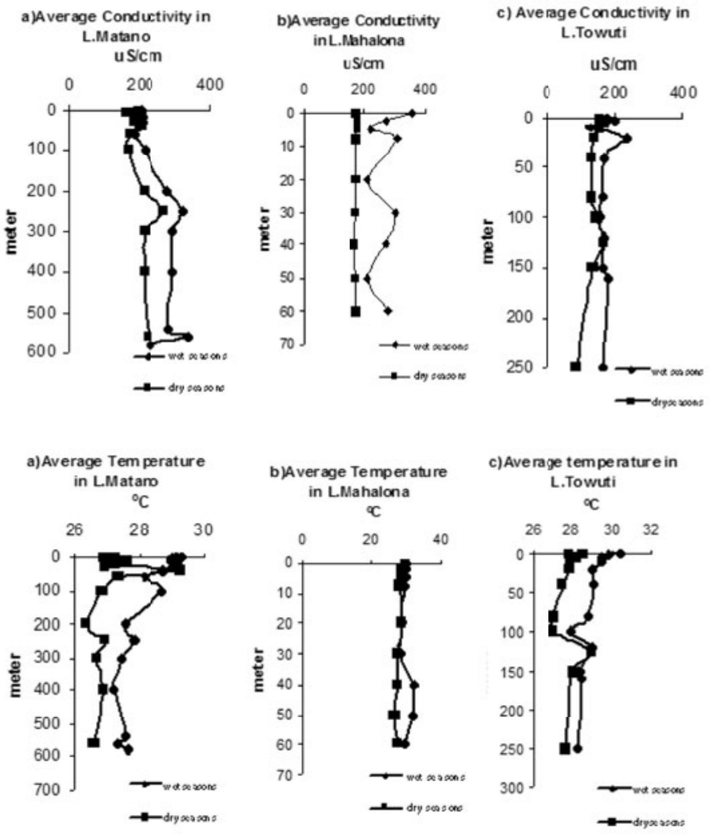

Figure 10. The depth profiles of Conductivity and water temperature in three lakes. Note that the both parameter were Significantly Different in wet and dry seasons.

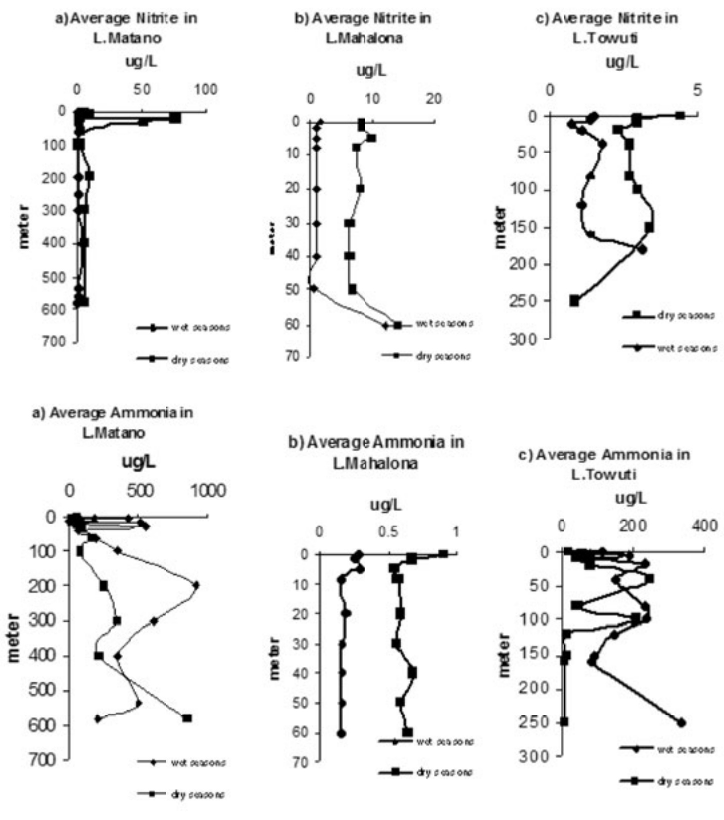

Figure 11. The depth profiles of Nitrite and Ammonia in three lakes. Note that the both parameter were Significantly Different in wet and dry seasons.

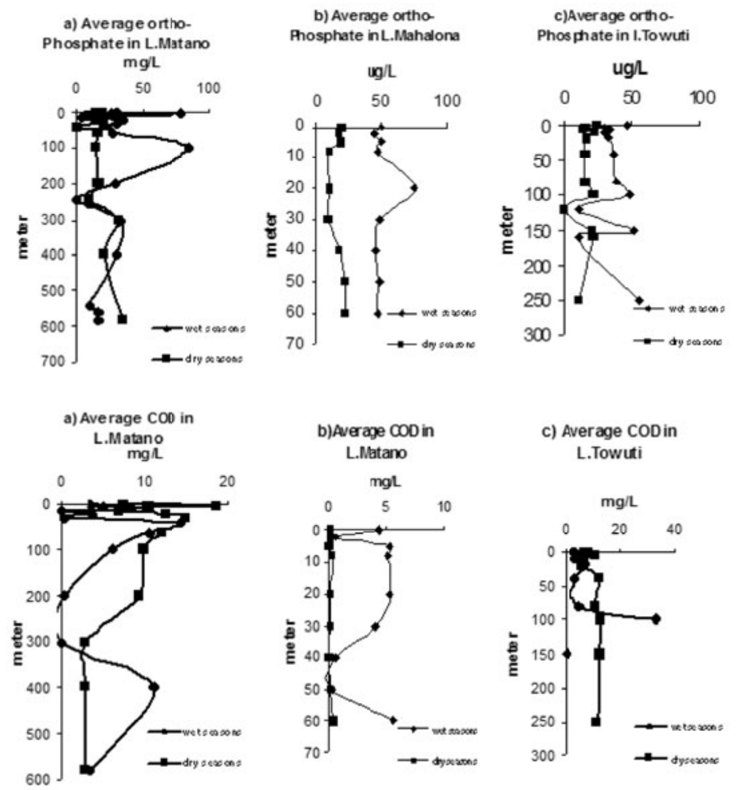

Figure 12. The depth profiles of ortho phosphate and COD in three lakes. Note that the both parameter were Significantly Different in wet and dry seasons.

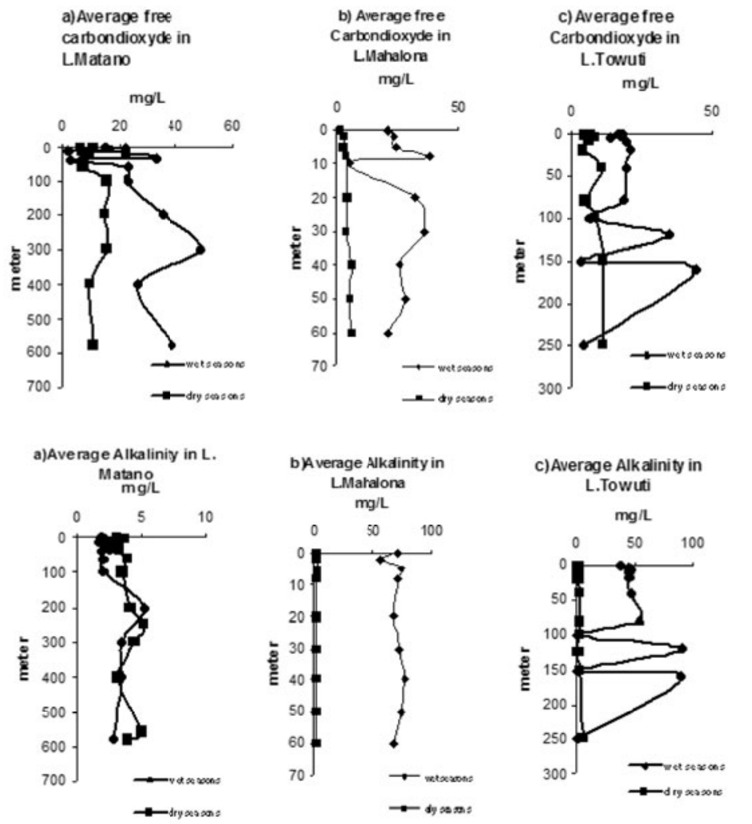

Figure 13. The depth profiles of free carbon dioxyde and Alkalinity in three lakes. Note that the both parameter were Significantly Different in wet and dry seasons.

20-50 m (in L. Mahalona), and 100-200 m (in L. Towuti). In these depth frequently observed fluctuation due to the average concentrations COD

Free Carbon dioxyde (free CO_2) levels in three lakes were tended to be increased in wet seasons, it showed in L. Matano that average of free CO_2 was increased from 10.39 mg/l in dry seasons to be 23.878 mg/L in wet seasons. It also similar with L. Mahalona and L Towuti which rise from 3.951mg/L and 7.815 mg/L to 26.75 mg/L and 18.316 mg/L respectively. Wetzel (2000) mentioned that the solubility of CO_2 increases markedly in water that contains carbonate. A definite amount of free CO_2 will remain in solution after equilibrium is reached between calcium, bicarbonate, carbonate, and un dissociated calcium carbonate. The amount excess CO_2 required to maintain stability of $Ca(HCO_3)_2$ in solution increases very rapidly with increasing content of bicarbonate in the water derived from carbonates. In wet seasons, inflowing water that enter to those lake is rich of carbonate since Malili lakes are located on the basaltic rock type or limestone area, so the mechanism probably have same manner with Wetzel explanation. Figure 13 show that in each lake water depth that deserve to be noticed were 200-300 m (in L. Matano), 20-40 m (in L. Mahalona), and 100-200 m (in L. Towuti). In these depth frequently observed fluctuation due to the average concentrations free CO_2.

The average of water temperature in L. Matano, L. Mahalona, and L. Towuti were lower in dry seasons (27.1 ∫C, 28.34 ∫C, and 27.9 ∫C) if compared to wet seasons (28.4 ∫C, 29.97 ∫C, and 29.06 ∫C). Pattern like this is somewhat common in tropics region since it related to the climatic condition. In the wet seasons, the sky is frequently cloudy, so the heath releasing mechanism during the night is inhibited by the clouds, so there is no cooling down effect working on the water mass of the lakes. Figure 10 show that in each lake water depth that deserve to be noticed were 0-100 m and 200-300 m (in L. Matano), 30-50 m (in L. Mahalona), and 100-150 m (in L. Towuti). In these depth frequently observed fluctuation due to the average concentrations free CO_2.

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Spatial and Temporal Distribution of Phytoplanktonn in Lake Maninjau, West Sumatera

Sulastri
Research Center for Limnology, Indonesian Institute of Sciences
Komplek LIPI Cibinong, Jl. Raya Bogor-Jakarta, Km 46,
Cibinong, Bogor. Tel: 021-8757071, Fax: 021-8757076
E-mail: lastri@indo.net.id

ABSTRACT

Study on spatial and temporal distribution of phytoplankton in Lake Maninjau was conducted in May, September and October 2001 as one ofthe program in controlling the symtom of eutrophication. Eutrophication in this lake was indicated by the occurrence of *Microcystis aeruginosa* blooming in 2000. The study was aimed to reveal the impact of flushing through its natural outlet (Batang Antokan) to phytoplankton community structure.The result showed that there was no a significant differences in the species composition between stations in the lake. The abundance of phytoplankton was higher in Southern basin compared to other part of the basin. Vertical distribution of phytoplankton indicated that phytoplankton were concentrated at upper 20-m layer with the maximum of abundance at subsurface layer. There was a change of phytoplankton composition during obsevation. The blue green algae were abundant in May with *Aphanocapsa sp* as the dominant species, while green algae was abundant in September with *Staurastrum sp* as dominant species. In October diatom was abundant and dominanated by *Synedra ulna*.

Key words: lake, phytoplankton, distriburion, spatial and temporal.

INTRODUCTION

Lake Maninjau is one of eutrophic lakes in Sumatera, located at 462 m above sea level, with the surface area (A_o) 9,737,50 ha, the average depth (z) 105,5 m and the maximum depth (Z_{max}) 165 m (Fachrudin *et al*, 2002). Eutrophication in this lake indicated by the occurrence of *Microcystis aeruginosa* blooming in 2000. The problem of eutrophication was reported because of the natural outlet Batang Antokan was closed and moved the outflow into the intake to gave a power of electricity. Lake Maninjau has been utilized to generate electric power since 1983. Since that year, the lake waters rarely flow through its natural outlet Batang Antokan. The change of this natural flushing rate is suspected to have an impact the natural purification capacity. Hydrological study repoted that closing its natural outlet and flushing lake water through the intake change the outflow from surface layer to 6 until 10 m depth (Fachrudin *et al*, 2002). The other problem of eutrophication in this lake was also reported because of cage aquaculture activity. In 1990, cage aqualuture was started to be developed and reach its peak in 1996. Then in 1997, *Microcystis aeruginosa* was bloom and hundred tons of fish were killed (Syandry, 2000). The cage aquaculture was suspected to increase the organic material as as fish feed that loss and drop into the water. The input of organic material could increase nutrient content in the lake and stimulate the blue green algae growth such as *Microcystis*.

This eutrophication problem rose a quite serious social disturbance and economic loss in that area. In March 2001, the water from the lake was also discharged through its natural outlets as a method to control algae bloom of *Microcystis*. This study was aimed to reveal the impact of flushing through its natural outlet (Batang Antokan) to phytoplankton community structure.

MATERIALS AND METHODS

The study was conducted in May, September and October 2001. Phytoplankton data was collected at some stations include the area near intake, northern part of the basin (DM2), the midle of the basin (DM4), Southern part of the basin (DM7, DM8, and DM10) as presented in figure 1. Phytoplankton samples were collected by filtering 2 L water through the plankton net no 25 (40 m m mesh size) at different depth namely 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20. 40, 60, 80, 100, 120 and 140m (base on the depth of each station), Then samples were preserved with one (1) % lugol lution for taxonomix study in the laboratory. Phytoplankton species was identified according to Prescott (1951), Prescott (1963), Scott and Prescott (1961) using a Microscope Olympus Model with magnification of x 400. Quantitative analysis of phytoplankton counted using Lackey Drop Microtransect Method as presented in Standard Method (1976). The other parameters such as water temperature, water transparency, total nitrogen, total phosphorous, ammonium and nitrite were also observed at the same station and depth of phytoplankton sampling site. Water temperature data collected using Water Quality Checker Horiba U-10 and Data Logger YSI 6000. While the water transparency data was collected by meauerement of Secchi depth. Water samples for ntrient analysis were preserved according to Standard Method (1995). While total phosphorous, total nitrogen, ammonium and nitrite content were determined by spectrophotometric method as presented in standard Method (1995).

RESULTS AND DISCUSSION

The data of temperature showed that Lake Maninjau is stratified water thermally with the mixing layer or epilimnion zone found until 10 and 20 m. Thermocline layer between stations showed a different during observation. In May, thermocline layer was occurred between 5 to 20 m at station DM4. While the deeper layer of thermocline found in October at station DM2 (Figure 2). The differences of thermocline between stations and observation period may be related with the site season. According to Ruttner (1952) that the water temperature profile has strong correlation with the inflow-outflow relation, form, size and location of the lake basin. According to Weizel (2001) in the stabile column water and hot weather thermocline could occur near the surface layer and when the epilimnion zone is exposed by srong wind, thrmocline layer extent to the deeper column. Ocober is transition season between dry and rainy season that usually indicated by strong wind in that season. This condition may be affected the position of thermocline layer that was deeper in October.

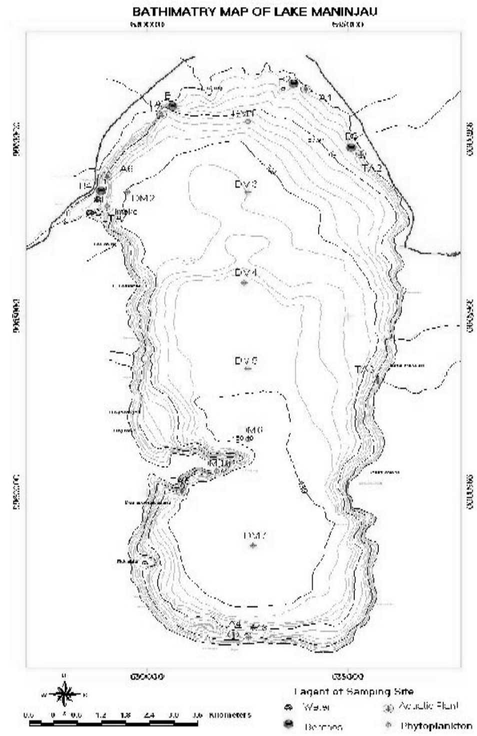

Figure 1. Map of sampling site

The range value of secchi depth of Lake Maninjau from 2.9 to 3.8 m and the rang value of euphotic zone from 7.83 to 10.26 m (Table 1). This range value of secchi depth is lower compared to Lake Ranau, a mesotrophic lake located at South Sumatera and Lake Matano, Towuti and Poso a oligotrophic lake located at South and Center Sulawesi. The range value of Secchi depth in Lake Ranau between 5.0 to 7.15 m (Sulastri *at al*, 2002) While Secchi depth in Lake Matano, Towuti and Poso 22.12; 22.22 and 10.82 m respectively (Okino *at al*, 1992). The euphotic zone was restricted between 7.83 to 10.26 m. The highest of phytoplankton abundance could influence of light penetration and decrease of euphotic zone in Lake Maninjau.

The average value of nutrient content of Lake Maninjau is presented in figure 3. The lower value of total nitrogen was accurred at station DM4 and higher value was occurred at station DM2 and DM7. Station DM2 is located near outlet, therefore organic materials from other sites accumulate before flowing out to the outlet and give an impact to total nitrogen concentration in that station. Station DM7 is located at Southern part and deepest part of the basin (Fachrudin at al, 2002). The posision of station DM7 may cause the organic materials stay longer and accumulate in that station and increase the nutrient content. The average value of total nitrogen decreased during observation. Losses of nitrogen occur

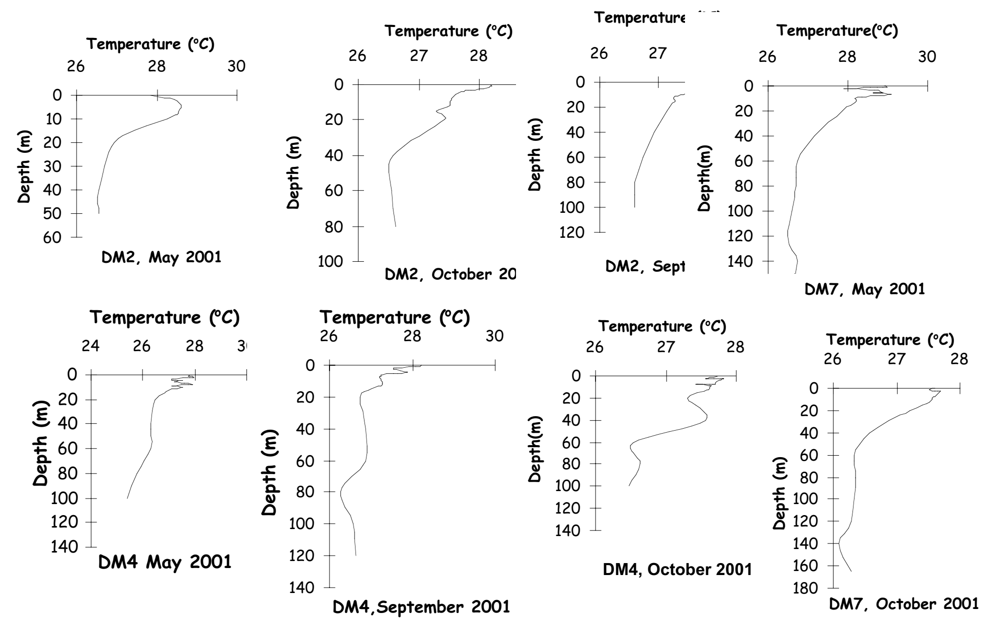

Figure 2. Vertical distribution of water temperature in Lake Maninjau.

Table 1. The value of Secchi depth (Z_{SD}, meter) and Euphotic zone (Z_{eu}, meter).

	May.01				Sep.01						Oct.01				
	DM2	DM4	DM7	Intake	DM2	DM4	DM7	DM8	DM10	Intake	DM2	DM4	DM7	DM10	Intake
Z_{SD}					3.23	2.9	3.8	3.31	3.28	3.23	3.1	3	3.3	3	3.32
Z_{eu}					8,72	7.83	10.26	8.94	8.86	8.72	8.37	8.1	8.91	8.91	8.68

by effluent outflow from the basin, reduction by bacteria and sedimentation of inorganic and organic compounds to the sediment (Wetzel, 2001). Reducing of total nitrogen in this observation may because of flushing the lake water to its natural outlet. The flushing of lake water through its natural outlet increase the average outflow 1.83 m^3/second (Fachrudin at al, 2002).

The same phenomenon was found in total phosphorous concentration that indicate the average value of total phosphorous concentartion was lower at station DM4 and the higher value was found in station DM2 and DM7 (Figure 3). While the average value of total phophorous increase in October. The higher value of total phosphorous in October could relate with increasing of loading input from surrounding of the lake and relase from the sediment. October is starting for rainy season therefore some nutrients from surrounding area enter into the lake together with the run off. On the other hand, in a eutrophic lake such as Lake Maninjau was characterized by rich of organic material in the sediment. In a stratified lake such as Lake Maninjau indicated by anaerobic condition in the hypolimnion zona and sediment then the organic material will decompose and phosphorous release to the column water.

The range value of TN/TP from 19.39 to 30.81; 13.43 to 27.58 qnd 5.70 to 8.83 in May, September and October respectively. It seems that ratio of TN/TP decreased during observation (Figure 3). The value of TN/TP >12 occurred in May and September, indicate that phosphorous is limiting factor while the value of TN/TP < 12 occurred in October indicate that nitrogen is limiting factor related with algae growth (Jorgensen, 1980).

The average value of ammonium was fluctuated during observation (Figure 3). In May, average value of ammonia is lower compared to average value found in September and October. The distribution of ammonia is highly variable seasonally and spatially depend upon the level of productivity and and the extent of pollution of organic mater (Wetzel, 2001). The lower value of ammonium in May could relate with the nitrification processes by nitrifying bacteria that capable of the oxidation of ammonium to nitrite. It is also indicated by the higher value of nitrite concentration in that month (Figure 3). In October, ammonium concentration decrease compared to ammonium value in September. The higher of phytoplankton ppopulation in October cause the utilization of ammonium increase in that month.

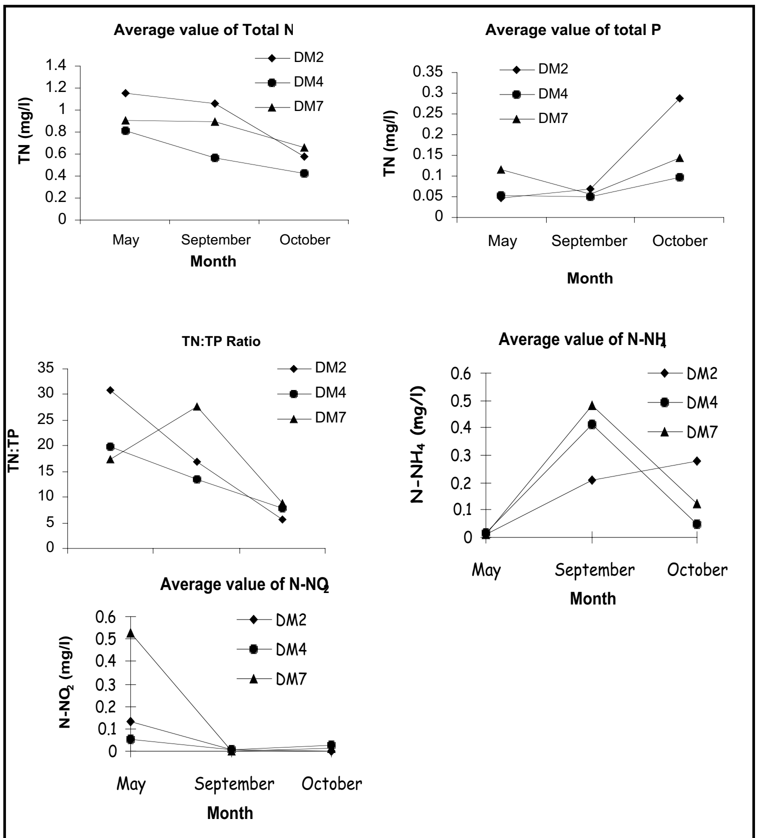

Figure 3. Nutrient concentration of Lake Maninjau.

Phytoplankton composition of Lake Maniniau consist of some species belong to the group of Chrysophyta, Chlorophyta, Cyanophyta, Phyrrophyta and Euglenophyta (Table 2). The composition of phytoplankton was characterized with some of large species such as *Synedra ulna*, *Staurastrum sp.*, *Microcystis aeruginosa*, *Dictyosphaerium sp.*, *Oocystis lacustris* and *Nephrocytium lunatum*. A small spcies was found such as *Crucigenia sp*, *Tetraedron minimum*, *Scenedesmus* and *Quadrigula sp*. *Aphanocapsa sp*, *Staurastrum* sp and *Synedra ulna* are dominant species. *Microcystis aeruginosa* that bloom in 2000 was not dominant species in this observation. *Microcystis* is a group of ohytoplankton that has a buoyancy on the surface water (Reynold, 1984). Therefore, opening the natural outlet and flushing the lake water through the natural outlet caused *Microcystis* flow out together with the surface water flow from the lake.

There was no a significant differences of phytoplanton composition between stations. It seems that individual species of phytoplankton are distributed horizontally over the entire basin. Distribution of phytoplankton like this may be related with the morphology of lake and weither such as strong wind make the lake circulate all

Table 2. Composition of phytoplankton in Lake Maninjau.

	Intake	DM2	DM4	DM7	DM8	DM10
Chrysohpyta						
Cymbella				+		+
Fragillaria	+	+		+	+	+
Navicula	+	+		+	+	+
Denticula	+	+		+		+
Melosira		+		+		+
Synedra ulna	++	++	++	++	++	++
Surirella						
Chlorophyta						
Asterococus		+				
Cosmarium	+	+	+	+	+	+
Crucigenia	+	+	+	+	+	+
Coelastrum		+	+	+	+	+
Chrysocapsa	+	+		+		
Closterium					+	+
Dictyosphaerium	+	+	+	+	+	+
Franceia	+	+	+	+		
Nephrocytium	+	+	+	+	+	
Oocystis		+	+	+	+	+
Quadrigula		+	+	+	+	+
Scenedesmus	+	+	+	+	+	+
Staurastru sp	++	++	++	++	++	++
Tetraedron					+	+
Cyanophyta						
Aphanocapsa	++	++	++	++	++	++
Chrooccocus	+	+	+	+	+	+
Coelospaerium		+	+	+	+	+
Gomposphaerium	+	+	+	+	+	+
Microcystis		+	+	+	+	+
Oscillatoria	+	+	+	+	+	+
Spirulina	+	+	+	+	+	+
Pyrrophyta						
Glenodinium			+	+		
Peridinium	+	+	+	+	+	+
Euglenophyta						
Euglena				+	+	
Phacus		+	+	+	+	+
Trachelomonas.	+			+		

over the basin. According to local people, there is a phenomenon of a strong wind make the lake water mixing and circulating at certain period.

There was a change of phytoplankton composition during observation. The Blue green algae (Cyanophyta) was abundant in May with the *Aphanocapsa sp* as dominant species, while green algae (Chlorophyta) was abundant in September with *Staurastrum sp* as dominant species. In October, diatom (Chrysophyta) was dominant and dominated by *Synedra ulna* (Figure 4 and 5). The change of dominant species could be affected by hydrologycal factor, physical and chemical factors such as water temperature, supply of nutrient and variation of pH (Reynold, 1993). It was reported that occurrence of *Aphanocapsa* in the water is usually together with *Microcystis* bloom (Presccot, 1951). Therefore *Aphanocapsa* rises with high population after flushing and decreasing of *Microcystis* population. While in early flushing of lake water, the other species still have not opportunity to grow with high population because in the condition of phytoplankton bloom is commonly one species dominate and grow with high population. While the others species could not compete to grow with high population. It was also indicated by the lower phytoplanton abundance in May or in early flusing the lake water (Figure 5). The second observation or in September *Staurastrum sp* was a dominant species. Staurastrum is a group of Chlorophyta or desmid or that abundant in water with rich of nutrient on dry season of September.

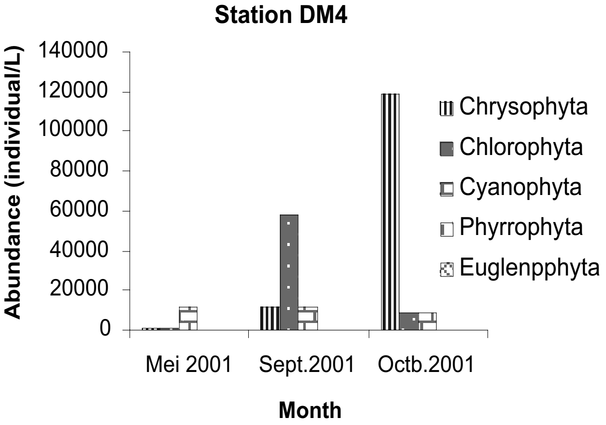

Figure 4. Composition of phytoplankton change.

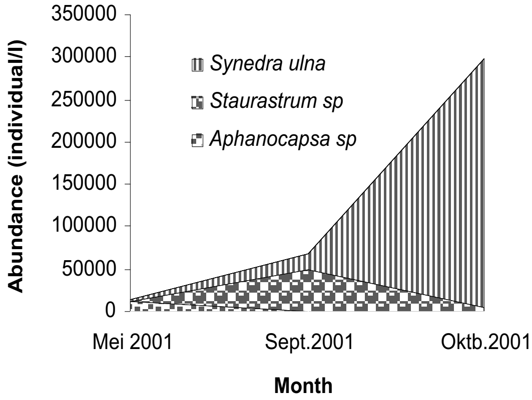

Figure 5. Dominant species of phytoplankton change

As reported that eutrophic lake is characterized with rich of dessolved of organic matter and abundance of desmid in summer (Wetzel, 2001). In October the green algae was replaced by group of diatom with *Synedra ulna* as a dominant species. The higher of *Synedra ulna* abundance in the season may be related with increasing of total phosphorous and change of TN/TP ratio. The change of nutrient related with phytoplankton composition are commonly observed in many lakes as reported in upper Great Lake characterized by phosphate-limited. As the loading of phosphorous increase, diatom bloom and reduce the silica until limiting levels rapidly (Wetzel, 2001).

The distribution of *Microcystis aerugnosa* and a dominant species were presented in figure 6. The highes abundance of *Microcystis aeruginosa* was found in station DM10. While *Synedra ulna*, *Aphanocapsa sp* and *Staurastrum sp* were abundant in station DM8, DM8, DM10 respectively. The deepest part of the basin in found in Southern part of the basin specially station DM 7. . It means the water in this area is not change quickly and the water column is more stabile cause the phytoplankton is not flowing out quickly to the outlet. Conversely, the station intake near outlet has lower

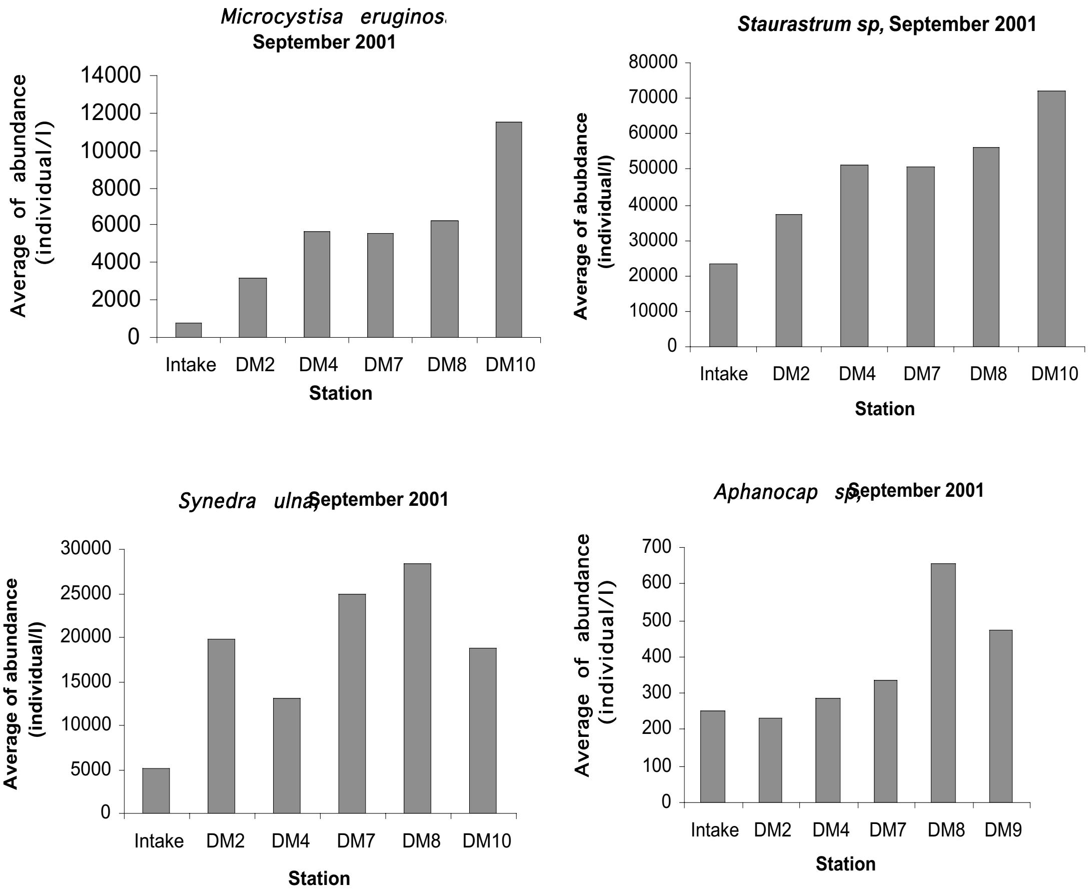

Figure 6. Some dominant species distribution of phytoplankton in Lake Maninjau.

average abundance of Microcystis and dominant species. It can be understood that station intake is in front of the outlet cause the water and phytoplakton is quickly flowing out to the outlet.

Vertical distribution of phytoplankton seems that phytoplankton was concentrated upper 20-m layer with the maximum anundance occured at subsurface layer or 5 m depth (Figure 7). It seems that phytoplankton was abundant until mixed layer. There are many factors controlling the vertical distribution of phytoplankton in the lake such as biotic factor which influence the life processes and mechanical factor such as sinking rate of organism and water movement (Ruttner, 1952). Temperature and light are regarded as the most effective regulator of vertical distribution of phytoplankton. Therefore phytoplankton is commonly abundant in euphotic zone. This observation show that phytoplankton was concentrated until mixed layer or a little below euphotic zone. It was reported that in the eutrophic lake or rich nutrient lake phytoplangkton is abundant until mixed layer as long as the mixed layer is not much deeper than euphotic zone (Ruttner, 1952 and Harris, 1986). The maximum of phytoplankton abundance was found in subsurface layer do to the presence the dominant of *Synedra ulna*, *Staurastrum sp* and *Aphanocapsa sp*, which is more resistance in the column water (Ruttner, 1952).

CONCLUSIONS

1. There was no significant diffrences of phytoplankton composition between stations in the lake.
2. There was a change of phytoplankton composition from blue green algae to green algae and then the diatom.
3. *Aphanocapsa sp* is a group of blue green algae abundant in May, while *Staurastrum sp* is agroup of green algae abundant in September. In October diatom was abundant, with the dominant species *Synedra ulna*.
4. The abundance of phytoplankton was higher in Southern basin compared to other basin.
5. The abundance of phytoplankton is concentrated at upper 20-m layer with the maximum abundance at subsurface layer.

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Phytoplankton Communities in a Group of Oxbow Lakes around Sigi Village, Central Kalimantan.

Ardianor and Evi Veronica
Education staff of Aquatic Resources Management of Fisheries Department, Agricultural Faculty, University of Palangka Raya (UNPAR)
phone : office 0536-28524; home 0536-34428; e-mail : ardianorirmsi@yahoo.com, ardianor@lycos.com

ABSTRACT
This study was in a group of oxbow lakes with different limnological features along side of Kahayan River and aimed to collect more information on the phytoplankton communities and its relation to the physico-chemical parameters as a limnological features of tropical region, particularly peat land ecosystem.

The four subject lakes were Tehang, Bunter, Hurung and Batu located about 19 km from Palangkaraya. Observation and samples collection were made during June to August 2002. Environmental factors were measured monthly. Phytoplankton of each lakes were collected with plankton-net (open mesh = 20 micron) and chlorophyll-a were by filtering lake's water with a glass fiber filter (Whatman-GF/F), analysed spectrophotometrically.

As a results, a total of 25 species were identified in the observed oxbow lakes consist of 8 classes, Cryptomonadidae, Euglenidae, Ochromonadidae and Vorticellidae belong to protozoan and Bacillariophyceae, Chlorophyceae and Cyanophyceae belong to algae. The dominant species were *Euglena*, *Phacus, Trachelomonas* and *Pediastrum.* From June to August 2002 chlorophyll-a content of the observed lakes were varied greatly. It have ranged between 4 and 36 ug/l with average of 20.1 ug/l. The highest chlorophyll-a content of 54.2 ug/l was found in Tehang in month of July while the lowest was being in Lake Bunter of 4.5 ug/l. Among the observed lakes, Lake Tehang was the highest chlorophyll-a content of 28.5±24.3 ug/l, however, Lake Batu of 16.5±0.9 ug/l was lowest. During higher water level season only small number of phytoplankton found, but in low water level season was vice versa. The increasing of phytoplankton number of each lakes observed were followed by the increasing of chlorophyll-a content.

Key words : oxbow lakes, phytoplankton.

INTRODUCTION

Oxbow lake is a flood-plain lake and most of them are distributed in the catchment area of Kahayan River, Central Kalimantan. Some oxbow lakes studied were Sabuah (Torang, 1985; Buchar, 1986; Ardianor *et al*., 2000, Gumiri *et al*., 2000); Tundai (Gumiri *et al*. 2000; Komatsu *et al*. 2000), Takapan (Hartoto, 2000); Lutan (Sulastri and Hartoto, 2000) and Rengas (Awalina and Hartoto, 2000; Sulastri and Hartoto, 2000). Those studies were consist of physico-chemical parameter, phytoplankton, zooplankton, benthos and fishes. With respect to phytoplankton, it has been only small number of studied lakes. Consequently, there are required more information on fate of phytoplankton and its relation to the physico-chemical parameters as one of the limnological features of tropical peat land ecosystems.
The present study was in a group of oxbow lakes with different limnological features along side of Kahayan River.

Study was aimed to collect more information on the phytoplankton communities and its relation to the physico-chemical parameters as a limnological feature of tropical region, particularly peat land ecosystem.

STUDY SITES

The four subject lakes of this study are located along the Kahayan River about 19 km from Palangkaraya, the capital city of Central Kalimantan Province-Indonesia (Figure 1). Lake Tehang (02°01'10.8" S, 113°55'43.7" E) is an oxbow lake which has open connection to Kahayan River at the northern part and at the southern part is connected to Lake Bunter. Water color in Lake Tehang is yellowish-brown either in lower or higher water level season. In dry season this lake has large drawdon, about half of total lakeís length. Lake Bunter (02°01'45.8" S, 113°55'36.2" E) is still part of Lake Tehang where in south-point is directly connected to Kahayan River. Because of Lake Bunter is very closed to Lake Tehang, physical feature is also relatively similar. Lake Hurung (02°00'57.2" S, 113°54'48.0" E) is also oxbow lake which is located at left-side of Kahayan River up stream direction. This lake is connected to Kahayan River merely via one channel during higher water level season. Water color in a 75% part of Lake Hurung is dark indicating the higher humic substance accumulated in lakeís water and this occur in both lower and higher water level seasons. Lake Batu (02°00'57.4" S, 113°56'54.9" E) is an oxbow lake, separated from Kahayan River and only connected to Lake Tehang in higher water level season. Geometric-shape of this lake is rather circular and different to the other lakes which is elongated and slender. Water color in both higher and lower water level seasons were dark. Also, this lake has small inlet from two watercourses. Lake Batu was the deepest about 7 m in lower water season.

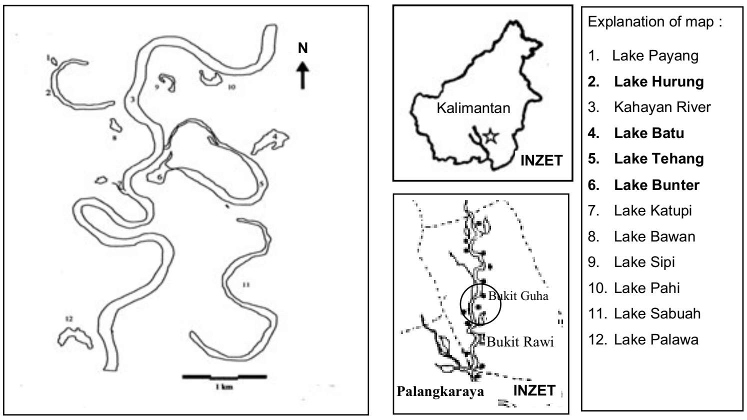


Figure 1. Map showing the observed oxbow lakes (bold-font)

METHODS

Sample collecting and measuring

Physico-chemical parameters :

Observation and samples collection were made during June to August 2002. Environmental factors were measured monthly. Depth of lake-waters were measured at center of lakes. Some physico-chemical parameters, namely temperature, pH, DO and free-CO_2 were sampled only from the surface water layer and measured in situ of each lakes with Horiba Water Checker U22, Orion pH-meter, YSI 55 Dissolved Oxygen and Na_2CO_3 - titration, respectively.

Phytoplankton :

Phytoplankton samples of each lakes were collected by filtering a 45 liters of lakeís water with plankton-net (open mesh = 20 micron) and placed into a 10 ml plastic-bucket. In laboratory samples were analyzed with a binocular photo-microscope (Olympus) and images were taken using Nikon Camera and also identified by using Edmondson (1959); Prescott (1970) and Mizuno (1979). Abundance and diversity of phytoplankton were estimated with formula of Hardy (1939) and Simpsons diversity index (Sournia, 1988), respectively. The identified phytoplankton species were classified and grouped until family..

Chlorophyll-a :

The chlorophyll-a content of each lakes were measured by passing a 300 mL of lakeís water through a glass fiber filter (Whatman-GF/F, not precombusted) and placed in a 15-ml polypropylene centrifuge tube with 8 ml of pure methanol. These tubes were wrapped with aluminum foil and stored in a freezer until analysis. Later the tubes were centrifuged at 3500 rpm for 20 minutes and absorbances of the supernatant was determined at 750 and 664 nm with spectrophotometer. Chlorophyll-a concentration was calculated according to Marker *et al*. (1980):

Chlorophyll-a = [13.4 v(ABS664 - ABS750)]/(Vd)

Where :

V = Sample filtered (L)
v = Volume of methanol (8 mL)
d = Cuvett diameter (1 cm)

Data Analyses

No statistical analysis performed, the data were merely revealed in tables and graphs, and compared one of each other and to the time.

RESULTS AND DISCUSSION

Physico-chemical Parameters

Water level or depth of lakes from month of June to August showed to decrease as in Lake Bunter and Lake Hurung (Figure 2a and 2b). In Lake Tehang and Lake Batu, depths were not reveal to decrease due to merely by no permanent of sampling points, however, totally of water level of the observed lakes were decrease due to the rain from month of June to August frequently decreased. Average of depth of Lake Tehang, Bunter, Hurung and Batu were 5.3, 3.7, 3.6 and 3.4 m, respectively (Table 2). Among the observed lakes, Lake Batu was the deepest.

Table 1. The measured physico-chemical parameters at the observed lakes on June, July and August 2002

Physico-chemical Parameters	Lake Tehang			Lake Bunter			Lake Hurung			Lake Batu		
	June	July	Aug.	June	July	Aug.	June	July	Aug.	June	July	Aug.
Sampling time	13.00	14.15	10.20	12.20	13.15	08.30	11.20	10.45	15.00	13.30	12.50	11.00
Transparency (cm)	18	17.5	20.5	16	22.5	18.5	26	28	42	36	17.5	48
Depth (x 100 cm)	4.6	3.7	7.4	5.6	3.8	1.8	6.4	2.7	1.8	1.0	4.1	5.0
Temperature (^oC)	28	33	28	29	33	28	25	31	32	27	33	31
DO (mg/l)	2.3	4.9	3.2	3.3	7.4	3.9	0.5	3.9	3.7	0.7	6.2	4.4
Free-CO_2 (mg/l)	4.8	7.9	10.0	6.4	4.8	8.0	6.4	6.4	10.0	8.0	4.8	8.0
pH	4.7	5.5	6.0	4.1	3.5	6.5	4.7	4.9	3.8	5.6	3.8	4.7

ransparency from month of June to August at all of the observed lakes increased (Table 1 and Figure 2), where the highest was in Lake Batu (avg. 33.8 cm) and the lowest was in Lake Hurung (avg. 18.7 cm). The low transparency in Lake Tehang and Lake Bunter were due to its highly open to the Kahayan River which is usually turbid. Water temperature at the observed lakes were totally increase from month of June to August 2002. Its values varied where maximum

Table 2. Average and standard deviation (SD) of measured physico-chemical parameters at the observed lakes on June, July and August 2002

Physico-chemical Parameters	Lake Tehang		Lake Bunter		Lake Hurung		Lake Batu	
	Avg.	SD	Avg.	SD	Avg.	SD	Avg.	SD
Transparency (cm)	18.7	1.6	19.0	3.8	32.0	8.7	33.8	15.4
Depth (x 100 cm)	5.3	1.9	3.7	2.3	3.6	2.5	3.4	2.1
Temperature (^oC)	29.7	2.9	30.0	4.0	29.3	3.8	30.3	3.1
DO (mg/l)	3.5	1.3	4.9	3.5	2.7	1.9	3.8	2.8
Free-CO2 (mg/l)	7.6	2.6	6.4	1.6	7.6	2.1	6.9	1.8
pH	5.4	0.6	4.7	1.5	4.5	0.6	4.7	0.9

occurred in month of July and minimum was in June. The lower water temperature in June (27.2 ± 1.5 ^oC) was because of the end of rainy season and higher water temperature in July (32.5 ± 0.9 ^oC) was due to the already hot season (Table 1 and Figure 2). In month of August smoke or haze has already covered the atmosphere inhibiting the penetration of light to the lakes. As a result, lower temperature was occurred in August.

Dissolved oxygen (DO) in almost of the observed lakes varied greatly where the highest was in Lake Bunter (avg. 4.9 mg/l) and the lowest was in Lake Hurung (avg. 2.7 mg/l) (Table 2). During observation, in month of June very low oxygen concentration occurred in Lake Hurung and Lake Batu were 0.5 and 0.7 mg/l, respectively. On the other hand, the highest oxygen concentration of 7.4 mg/l occurred in Lake Bunter on month of July 2002 (Table 1). Free-carbon dioxide (CO_2) revealed no significant different among the observed lakes during observation. The highest value found in Lake Tehang and Lake Hurung that of 7.6 mg/l and however, the lowest of 6.4 mg/l was in Lake Bunter (Table 2).

From month of June to August 2002 pH showed the different patterns among the observed lakes. In Lake Tehang and Bunter pH increased from June to August, whereas in Lake Hurung and Batu showed to decrease (Figure 2a and 2b). Average value of pH in Lake Tehang, Bunter, Hurung and Batu were

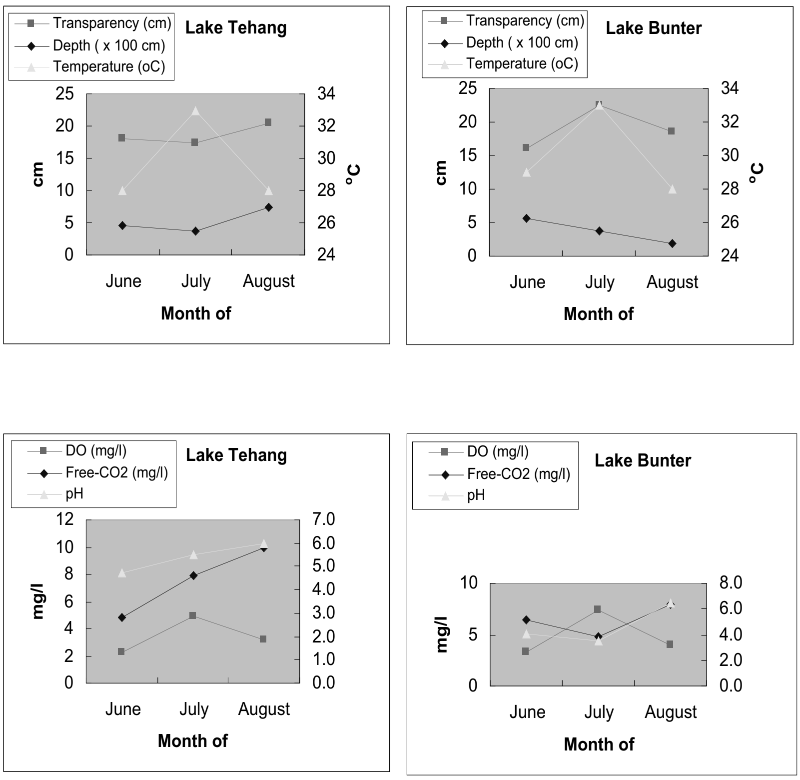


Figure 2a. Graphs showing trend of some physico-chemical parameters at Lake Tehang and Bunter on month of June, July and August 2002

5.4±0.6, 4.7±1.5, 4.5±0.6 and 4.7±0.9, respectively. There was no significant correlation between pH value and free-CO_2 concentration.

The important that during higher water level season, on June 2002, DO and pH were higher then during low water level season (July and August). However, in lake Bunter, Hurung and Batu were no significant different.

Phytoplankton

A total of 25 species were identified in the observed oxbow lakes consist of 8 classes, Cryptomonadidae, Euglenidae, Ochromonadidae and Vorticellidae belong to protozoan and Bacillariophyceae, Chlorophyceae and Cyanophyceae belong to algae. The dominant species belong to Euglenidae were *Euglena*, *Phacus* and *Trachelomonas* and the only other one belong to Chlorophyceae was *Pediastrum*. Completely species or genera found is revealed in Table 3.

The abundance of phytoplankton species in Lakes Bunter, Hurung and Batu in June 2002 were relatively similar. Lake Tehang on month of July and August were dominated by *Euglena* and *Phacus*. Temporal distribution of 3 dominant classes, Euglenidae, Bacillariphyceae and Chlorphyceae showed a difference, where Euglenidae occurred in all of the observed lakes on month of July. However, Bacillariophyceae was only in Lake Bunter and Lake Batu on month of June.

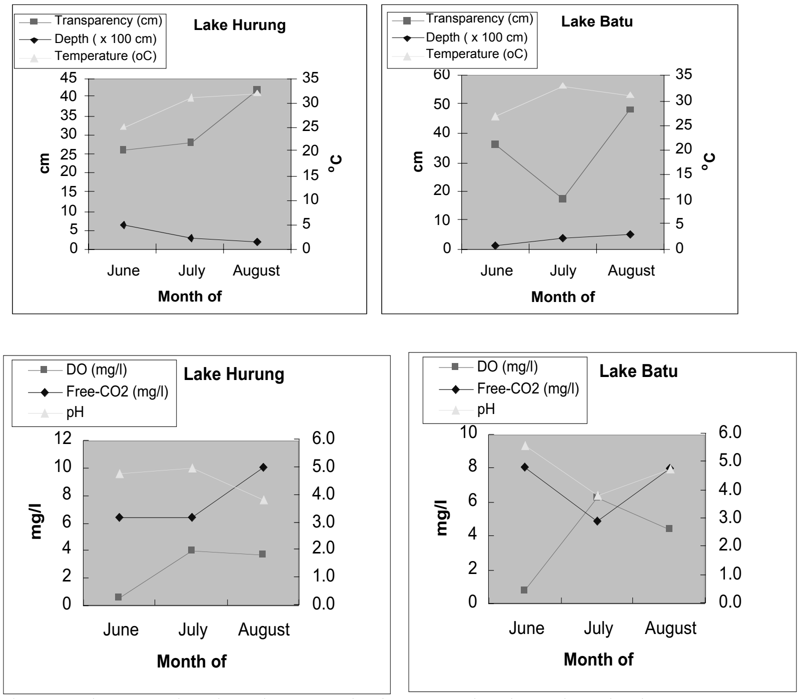
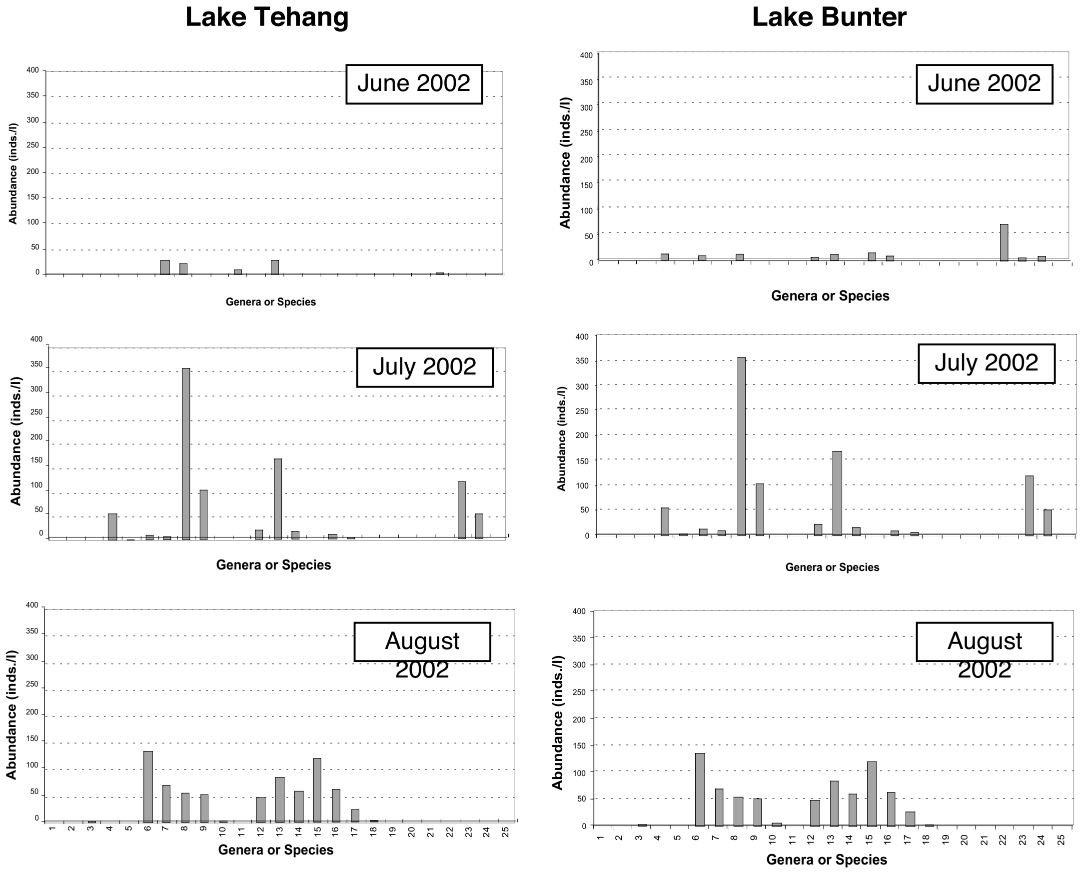


Figure 2b. Graphs showing trend of some physico-chemical parameters at Lake Hurung and Batu on month of June, July and August 2002

Table 3. Abundance of phytoplankton at the observed oxbow lakes from month of June to August 2002

No.	Genera	Lake Tehang			Lake Bunter			Lake Hurung			Lake Batu		
		June	July	Aug.	June	July	Aug.	June	July	Aug.	June	July	Aug.
1	*Cryptomonas sp.*							5					
2	*Cyclotella*						3				29		
3	*Cymbella*			3					8		18		
4	*Dictyosphaerium sp.*		56		13	115	25					60	5
5	*Dynobrion sp.*		2										
6	*Euglena acus*		11	136	7	103	224	24		29			13
7	*Euglena deses*	27	8	69			92	24					12
8	*Euglena gracilis*	22	357	55	13	368		22	61	49		64	17
9	*Euglena geniculata*		102	52		200	113						8
10	*Naviculla*			4							9		
11	*Oedogenium*	9								4			4
12	*Pediastrum sp.*		20	47	5	81	89					67	
13	*Phacus acuminatus*	29	167	84	11	103	105				16		9
14	*Phacus curvicaudatus*		17	60			59		11			20	
15	*Phacus longicauda*			119	15		35		93	88			13
16	*Phacus unguis*		10	61	9		51				7		
17	*Scenedesmus sp.*		5	25			13		24	21			7
18	*Spirulina*			3							5		
19	*Spirogyra sp.*									3			
20	*Staurastrum sp.*											4	3
21	*Surirella sp.*						19		5				
22	*Tabellaria*	4			69						25	3	3
23	*Trachelomonas ensifela*		120		5	280			105			56	
24	*Trachelomonas oblonga*		52		7	309			12	37			
25	*Vorticella sp.*										5		
	Total	91	928	717	155	1559	828	75	320	232	116	275	95

Abundance of phytoplanton expressed in inds./l



1	*Cryptomonas sp.*	6	*Euglena acus*	11	*Oedogenium*	16	*Phacus unguis*	21	*Surirella sp.*
2	*Cyclotella*	7	*Euglena deses*	12	*Pediastrum sp.*	17	*Scenedesmus sp.*	22	*Tabellaria*
3	*Cymbella*	8	*Euglena gracilis*	13	*Phacus acuminatus*	18	*Spirulina*	23	*Trachelomonas ensifela*
4	*Dictyosphaerium sp.*	9	*Euglena geniculata*	14	*Phacus curvicaudatus*	19	*Spirogyra sp.*	24	*Trachelomonas oblonga*
5	*Dynobrion sp.*	10	*Naviculla*	15	*Phacus longicauda*	20	*Staurastrum sp.*	25	*Vorticella sp.*

Figure. 3a . Phytoplankton abundance of lake Tehang and Bunter on month of June, July and August 2002

In Lake Bunter in month of July the species dominant were *Euglena*, *Phacus* and *Trachelomonas*. However, the same lake in August were dominated by *Euglena* and *Phacus*. In month of July and August 2002, Lake Hurung and Batu were no species dominant. Temporal composition of phytoplankton species of the observed lakes are shown in Table 3 and Figure 3a and 3b.

The total abundance of phytoplankton from June to August 2002 tended to fluctuate as shown in Figure 4, where highest occurred in month of July for all the observed lakes. The maximum abundance was 1557 inds./l in Lake Bunter on July 2002, on the other hand the minimum was in Lake Hurung of 75 inds/l on June 2002. The higher number of phytoplankton species were found in Lake Tehang on July and August of 13 genera. However, the lowest was only 4 species found in Lake Hurung on June 2002.

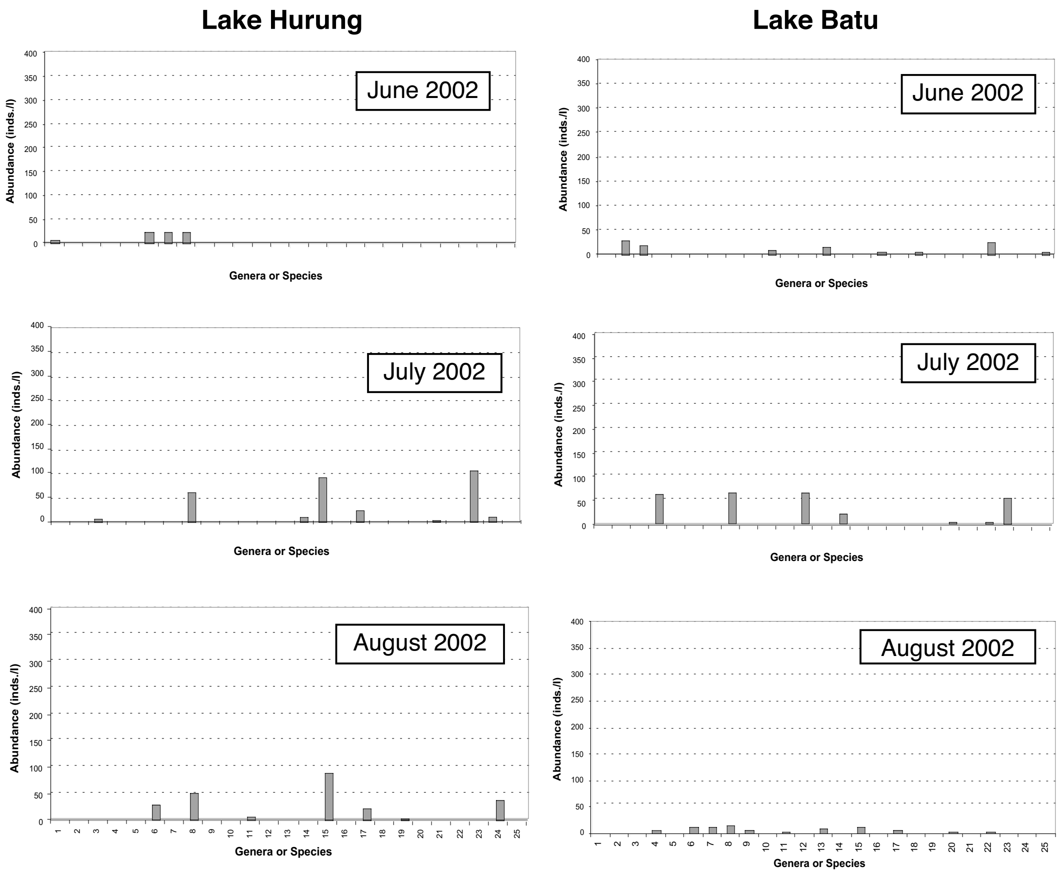
The species diversity all of the observed lakes showed to increase from June to August 2002, in which the highest value was 0.89 found in Lake Tehang on August 2002. The lowest diversity found in Lake Hurung of 0.71. Diversity index of the observed lakes was close related to the number of species, where the increasing of species number was followed by increasing of diversity index (Table 4 and Figure 4).

From June to August 2002 chlorophyll-a content of the observed lakes were varied greatly. It ranged between 4 and 36 ug/l with average of 20.1 ug/l. The highest chlorophyll-a content of 54.2 ug/l was found in Tehang in month of July while the lowest was being in Lake Bunter of 4.5 ug/l. Among the observed lakes, Lake Tehang was the highest chlorophyll-a content of 28.5±24.3 ug/l, however, Lake Batu of 16.5±0.9 ug/l was vice verca (Table 5).

As we know since phytoplankton containing various pigment, the chlorophyll-a is the highest. So that its amount can be a indicator of phytoplankton biomass in aquatic ecosystems. Increasing of chlorophyll-a content is usually followed the increasing of number of phytoplankton.

The chlorophyll-a content of observed lakes revealed to increase with increasing of phytoplankton abundance during months of June to August, except on July in Lake Bunter and Lake Hurung were vice versa (Figure 5).

According to the chlorophyll-a content of 25.4 and 52.4 mg/m^3 in month of July and August 2002 where based on the criteria by Henderson-Seller and Markland (1987) range 10 - 100 mg m^{-3} chlorophyll-*a* , Lake Tehang was being an eutrophic lake. It was also indicated by the highest abundance of phytoplankton species, i.e. *Euglena*, *Phacus* and



1	*Cryptomonas sp.*	6	*Euglena acus*	11	*Oedogenium*	16	*Phacus unguis*	21	*Surirella sp.*
2	*Cyclotella*	7	*Euglena deses*	12	*Pediastrum sp.*	17	*Scenedesmus sp.*	22	*Tabellaria*
3	*Cymbella*	8	*Euglena gracilis*	13	*Phacus acuminatus*	18	*Spirulina*	23	*Trachelomonas ensifela*
4	*Dictyosphaerium sp.*	9	*Euglena geniculata*	14	*Phacus curvicaudatus*	19	*Spirogyra sp.*	24	*Trachelomonas oblonga*
5	*Dynobrion sp.*	10	*Naviculla*	15	*Phacus longicauda*	20	*Staurastrum sp.*	25	*Vorticella sp.*

Figure. 3b . Phytoplankton abundance of lake Hurung and Batu on month of June, July and August 2002

Table 4. Trend of abundance, species number and diversity index of phytoplankton of the observed lakes from June to August 2002

Genera	Lake Tehang			Lake Bunter			Lake Hurung			Lake Batu		
	June	July	Aug.	June	July	Aug.	June	July	Aug.	June	July	Aug.
Abundance (x 10 inds./l)	9.1	92.8	71.7	15.5	155.9	82.8	7.5	32.0	23.2	11.6	27.5	9.5
Number of species	5	13	13	10	8	12	4	8	7	8	7	11
Diversity (Simpsons)	0.74	0.79	0.89	0.78	0.85	0.86	0.71	0.76	0.76	0.84	0.79	0.88

Trachelomonas. Those species were also belong to flagellates (heterotrophic flagellates), where according to Kusakabe *et al*. (2000) was a dominant group identified in Lake Sabuah.

CONCLUSION

During higher water level season only small number of phytoplankton found, but in low water level season was vice versa. The increasing of phytoplankton number of each lakes observed were followed by the increasing of chlorophyll-a content.

ACKNOWLEDGEMENTS

We are grateful to Prof. Toshio Iwakuma, Graduate School of Environmental Earth Science, Hokkaido University for his advice, help and support. To Pak Suwido H. Limin, University of Palangka Raya, thank for his advice and support. To

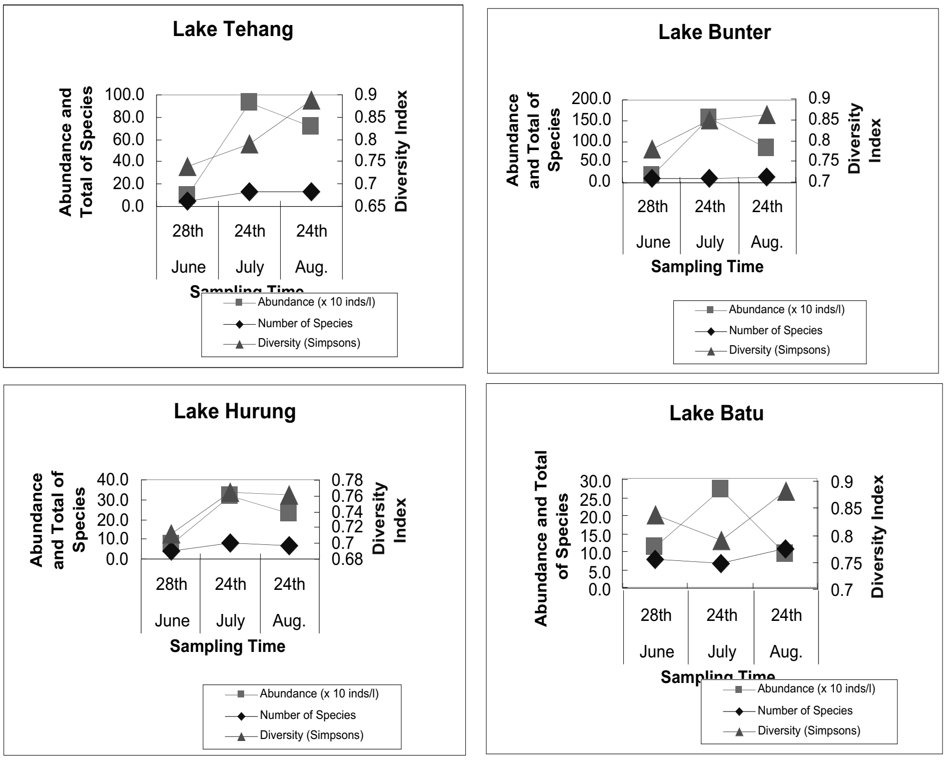


Figure 4. Temporal change of abundance, species number and diversity index of phytoplankton

Table 5. Relationships between abundance and chlorophyll-a content of phytoplankton of the observed lakes

		Lake Tehang			Lake Bunter			Lake Hurung			Lake Batu		
		June	July	Aug.	June	July	Aug.	June	July	Aug.	June	July	Aug.
1	Phytoplankton (inds./l)	91	928	717	155	1559	828	75	320	232	116	275	95
2	Chlorophyll-a (ug/l)	5.8	54.2	25.4	13.6	4.5	37.2	3.6	7.9	38.9	16.6	17.5	15.7

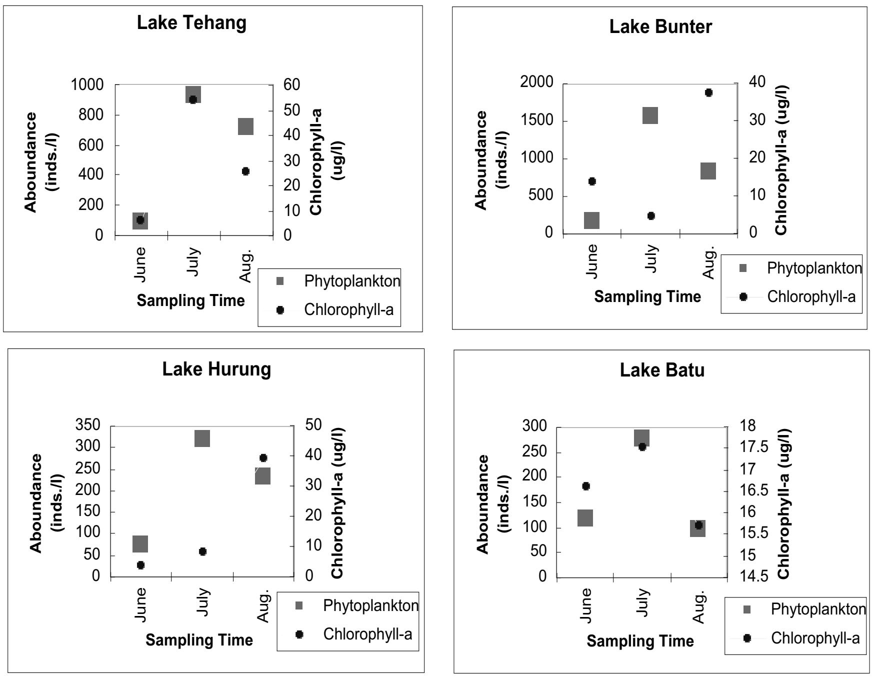


Figure 5. Graphs showing the relationships between abundance and chlorophyll-a content of phytoplankton of the observed lakes

our colleagues, Dr. Sulmin Gumiri (now training in zooplankton at the Ghen University, Belgium), Pak Tariono Buchar, Ibu Linda Wulandari, Sdr. Yantrinata, Yurenfri, Trisliana, and Roy Hariwinata thank for your help and support.

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Structural Community of Macrozoobenthos in Several Oxbow Lakes of Central Kalimanta

Linda Wulandari[1], Yulintine[1] and Toshio Iwakuma[2]
[1]Aquatic Resources Management of Fishery Department, Agricultural Faculty,
Palangka Raya University, Linda_160172@yahoo.com
[2]Graduate, School of Environmental Earth Science, Hokkaido University, Sapporo,
060-0810, Japan, iwakuma@ees.hokudai.ac.jp

INTRODUCTION

The freshwater in peat swamp areas of Central Kalimantan is approximate 23,330.77 km^2 that consist of lakes, rivers, swamps and pools (Biro Pusat Statistik, 2000). There are several oxbow lakes that occur because of breaking of water flow (Throp and Covich, 1991). That was formed from isolated loops of meandering, mature stream (Cole, 1988), and a surface water body that develops due to change in river water course in geological time scale (Hartoto, 2000). Several lakes to research around Sigi village are oxbow lakes and still have connection to both Payang and Kahayan river.

Lakes and rivers in tropical peat swam area have unique limnological features of high concentrasion of humic materials which make the water color brownish, low pH, low transparency and subsequent low dissolved oxygen concentration (Iwakuma. et al. 2000).

Some oxbow lakes observed have showed the richness of many fish species (Komatsu et al. 2000) and high zooplankton diversity (Gumiri and Iwakuma, 2000). The seasonal composition and biomass of Phytoplankton have been also studied by Kusakabe et al. 2000; Sulastri and Hartoto, 2000, however, the information of macrozoobenthos communities is still little know in lakes of this region.

The aim of this study was to determine abundance and diversity of macrozoobenthos of five oxbow lakes in around Sigi village, Central Kalimantan.

STUDY SITES

Macrozoobenthos samples were collected in the bottom zones of :

- lake Hurung (02^{o}00'57.2"S, 113^{o}54'48.0"E)
- lake Bunter (02^{o}01'45.8"S, 113^{o}55'36.2"E)
- lake Tehang (02^{o}01'09.5"S,113^{o}56'54.9"E)
- lake Batu (02^{o}00'57.4"S, 113^{o}56'54.9"E) and
- lake Payang (02^{o}00'39.1"S, 113^{o}54'22.6"E)

The sample were collected at the Center of the lake nearby Sigi village, Central Kalimantan.

MATERIALS AND METHODS

A total of 34 samples were monthly collected during 4 months period (from May to August 2002). Two replicate bottom sediment samples were collected with an Eckman-Birge Grab (15 cm x 15 cm). The sediment were washed using nylon sieve mesh size 0.3 mm to remove fine particles and then the organism were preserved with 5 % formalin solution and alcohol 70 %.

The benthos organisms were identified to the level family or genera according to Pennack (1978); Thorp and Covich, (1991); Merrid and Cummin (1996). The analysis of diversity of macrozoobenthos organism were measured by using Shannon-Wiener diversity index (Krebs, 1989).

On each sampling, measurements of physic and chemist parameters such as depth, temperature, dissolved oxygen, pH and CO_2-free were conducted in situ using secchi disk, thermometer, DO meter YSI Model 55, Orion pH meter and Sodium Carbonate Titration.

RESULTS AND DISCUSSION

Result on the Abundance, Index of Diversity, Index of Evenness and Index of Domination of macrozoobenthos were revealed in Table 1.

Phyllum of Annelids, Molusca and Arthropoda (class Insects) were found in lake Tehang and lake Bunter, while in lake Hurung and lake Payang there were Annelids and Insects. Nevertheles, there was zero of Macrozoobenthos in lake Batu.

In lake Hurung, there were 2 taxa, namely *Chironomus* and *Naidium*, whereas *Chironomus* was the highes (88 ind/m^2) on May 2002.

In lake Bunter, there were 7 taxa belonging to 6 families (Aelosomatidae, Naididae, Tubificidae, Corbiculidae, Spaeriidae and Ceratopogonidae). *Branchiura* (Tubificidae) was the highes (1022 ind/m^2), followed by *Naidium* (266 ind/m^2) from family Naididae on June 2002. In addition, Mollusca and Insect were also found. *Corbucula* was the highes (222 ind/m^2), followed by *Pisidium* (44 ind/m^2). *Dasyhelea* (44 ind/m^2) was taxa of insect found only from family of Ceratopogonidae. Phyllum of Mollusca were found enough abundance at lake Bunter then lake Tehang and their only

Table 1. Values of Abundance, Index of Diversity, Index of Evenness and Index of Domination on Several Oxbow Lakes in Central Kalimantan.

ORGANISM	LAKES																			
	HURUNG				BUNTER				TEHANG				BATU				PAYANG			
	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
ANNELIDA																				
Aelosomatidae																				
Aelosoma	0	0	0	0	44	0	0	0	176	44	0	0	0	0	0	0	88	0	0	0
Naididae																				
Dero	0	0	0	0	0	0	0	0	88	44	0	0	0	0	0	0	0	0	0	0
Naidium	44	44	0	44	88	266	88	44	444	355	88	88	0	0	0	0	0	0	0	0
Tubificidae																				
Branchiura	0	0	0	0	44	1022	355	44	7289	4000	711	222	0	0	0	0	0	0	0	0
Tubifex	0	0	0	0	0	133	88	0	4844	2711	88	44	0	0	0	0	0	0	0	0
MOLUSCA																				
Corbiculidae																				
Corbicula	0	0	0	0	222	133	44	88	0	0	88	0	0	0	0	0	0	0	0	0
Sphaeriidae																				
Pisidium	0	0	0	0	44	0	0	44	0	0	0	0	0	0	0	0	0	0	0	0
INSECTA																				
Diptera																				
Chironomidae																				
Chironomus	88	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	88	0	0	0
Diccotendipes	0	0	0	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0	0	0
Ceratopogonidae																				
Dasyhelea	0	0	0	0	0	44	44	44	0	0	0	44	0	0	0	0	0	0	0	0
TRICOPTERA	0	0	0	0	0	0	0	0	0	44	0	0	0	0	0	0	44	0	0	0
Average of Abundance	55				719.9				2541.6				0				55			
Indeks of Diversity (H')	1				2.392				1.647				0				No complet data			
Indeks of Evennes (E)	1				0.852				0.494				0				No complet data			
Indeks of Dominant (D)	0.5				0.234				0.420				0				No complet data			

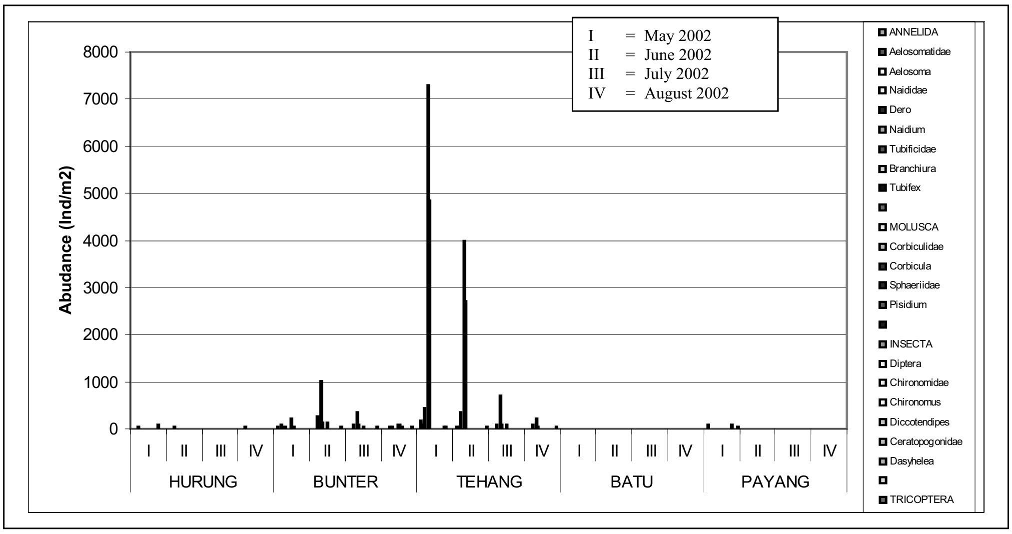

Figure 1. Abundance of macrozoobenthos at a five of oxbow lakes.

were found on two lakes that. When the position of two lakes are near and still have connection with a canal. If at the center only were found 2 species of Mollusca where as based result of research and measured abundance of Mollusca at side lake were found 5 species when 1 species from class Gastropoda (*Vivivarus* 16 ind/m^2) and 4 species from class Pelecypoda (*Corbucula, sp* 320 ind/m^2; *Pisidium* 32 ind/m^2; *Lampsilis* 32 ind/m^2; and *Ligumia* 266 ind/m^2). Seldom were found that species at the center lake because like snails, bivalves are most abundant in the shallows, expecially in waters less than two meters deep (Pennack, 1978).

In lake Tehang, there were found 10 taxa that were dominated by family of Tubificidae such as *Branchiura* (7289 ind/

Table 2. Abundance of Mollusca Collected in Draw down of Lake Bunter (inds./m^2)

ORGANISM	TRANSECK	
	25 cm x 25 cm	50 cm x 50 cm
PELECYPODA		
Corbiculalidae		
Corbicula sp	144	320
Sphaeriidae		
Pisidium	16	32
Unionidae		
Lampsilis sp	16	32
Ligumia sp	16	16
GASTROPODA		
Vivivarus sp	16	16
TOTAL	224	400

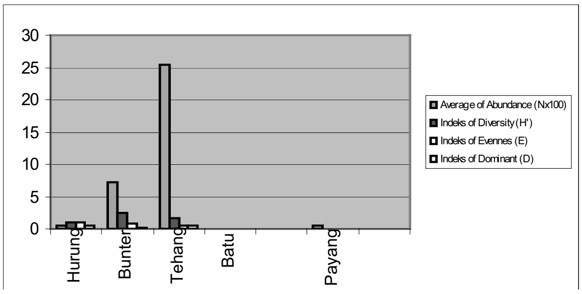

Figure 2. Abundance, inndex of diversity, index of evenness and index of domination on several Oxbow lakes studied.

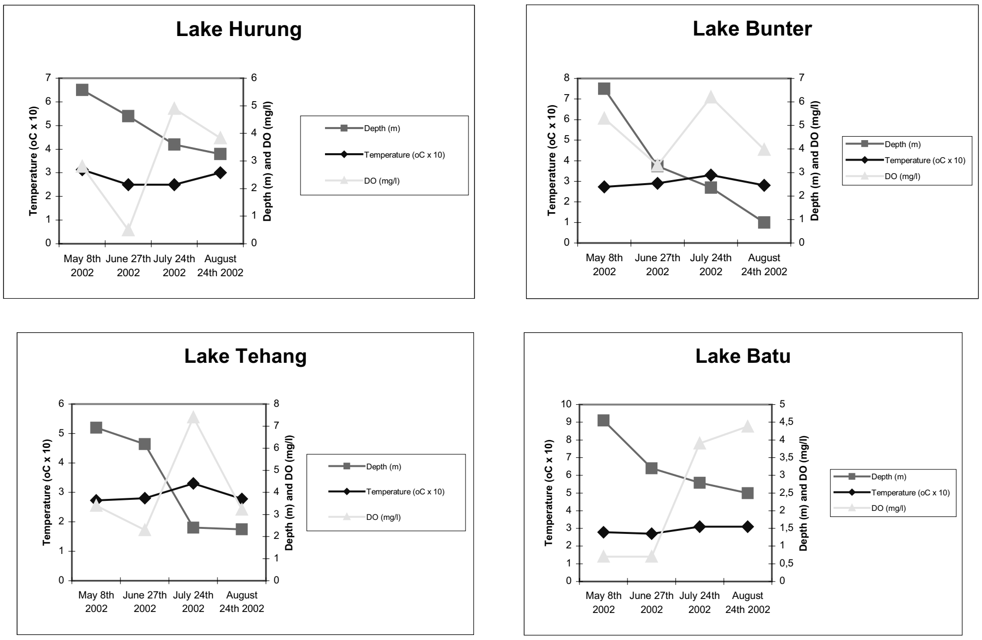

Figure 3. Some physico-chemical parameters measured.

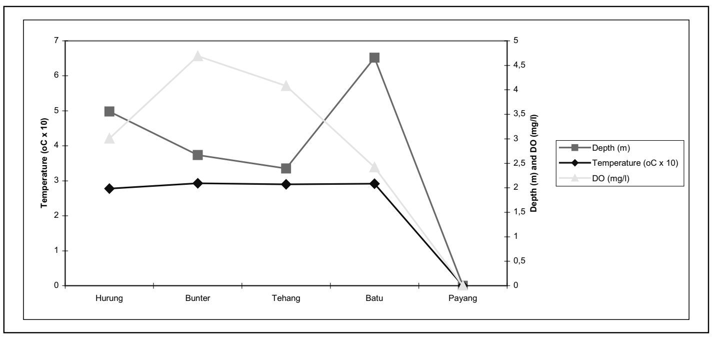

Figure 4. Average of water's depth, temperature and dissolved oxygen in several lakes observed.

m^2), and family Naididae (*Naidium :* 444 ind/m^2)on May 2002, while only *Curbicula* (44 ind/m^2) was from phylum Molusca. There was also found only *Tricoptera* (44 ind/m^2) from class Insecta.

On the other hand, in lake Batu, there was found no Macrozoobenthos that might be due to very low dissolved oxygen (0.7 mg/l).

In lake Payang, there was no data in June until August 2002 because of dried lake. There were 3 taxa, namely *Aelosoma* (88 ind/m^2), *Chironomus* (88 ind/m^2) and *Trichoptera* (44 ind/m^2) on May 2002.

The abundance of Macrozoobenthos in each lake from May to August 2002 decreased. It might be that caused by a decrease water level. Macrozoobenthos might not adapt the lowes water level almost dry because of high temperature of water, as result of death. This was supported that there were found several organisms from Pelecypod groups on dry water in lake Tehang and lake Bunter.

Index of Diversity (H1) and Index of Evenness (E) are indices that are used to evaluate freshwater ecosystems. If freshwater acosystem in balance shown by no dominance of species. Index H' in several lakes ranged low (1 to 2.392), the highest peak was 2.392 in lake bunter. However, Index E ranged from 0.494 to 1 (Intermediate class), the lowest was in lake Tehang. Index of Dominance (D) ranged from 0.234 to 0.5.

It seemed that Macrozoobenthos were various in several oxbow lakes. There were more family of Tubificidae in lake Tehang and lake Bunter than other lakes. In lake Bunter there was the highest found Gastrophods and Pelecypods. These might be due to high of dissolved oxygen in lake Tehang and lake Bunter.

CONCLUSION

- There were found 3 taxa phylum (Annelida, Mollusca and Arthropoda class Insecta) belonging to 8 family or 11 taxa. The highest numbers of taxa was found in lake Tehang.
- Annelids were more various and highest abundance, especially family of Tubificidae such as *Branchiura*.
- Gastropods and Pelecypods were discovered only in lake Bunter and lake Tehang.
- Based on structural community of Macrozoobenthos showed that lake Bunter and lake Tehang were suitable for living due to high dissolved oxygen.

ACKNOWLEDGMENTS

I would like to Professor T. Iwakuma for advice and financial support for this study. I also would like to thank our team and our students for help sampling. I would like to thank and pray may best fiend who studies abroad that has helped and encourage me during this research.

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Apendix 1. Value of Water Quality on Several Oxbow Lakes in Central Kalimantan

Lakes Hurung

	PERIODE SAMPLING			
	May 8th 2002	June 27th 2002	July 24th 2002	August 24th 2002
Time of Sampling	01.30pm	11.20am	11.55am	02.30pm
Secchi disk	36.5 cm	26 cm	17.5 cm	15.5 cm
Depth	6.5 m	5.4 m	4.2 m	3.8 m
Temperature	31.3°C	25°C	25°C	30°C
DO (mg/l)	2.8	0.5	4.9	3.83
CO2 (mg/l)	9.99	7.99	9.99	9.99
PH	5.48	4.73	5.52	5.9

Lakes Bunter

	PERIODE SAMPLING			
	May 8th 2002	June 27th 2002	July 24th 2002	August 24th 2002
Time of Sampling	04.10pm	12.20pm	12.50pm	08.30am
Secchi disk	16.5 cm	16 cm	17.5 cm	18.5 cm
Depth	7.5 m	3.74 m	2.7 m	1 m
Temperature	27.3°C	29°C	33°C	28°C
DO (mg/l)	5.3	3.3	6.2	3.97
CO2 (mg/l)	4.99	7.99	4.99	7.99
PH	6.15	4.99	3.79	6.5

Lakes Tehang

	PERIODE SAMPLING			
	May 8th 2002	June 27th 2002	July 24th 2002	August 24th 2002
Time of Sampling	01.35pm	01.00pm	01.15pm	10.20am
Secchi disk	15.5 cm	18 cm	12.5 cm	20.25 cm
Depth	5.2 m	4.64 m	1.8 m	1.75 m
Temperature	27.3°C	28°C	33°C	27.8°C
DO (mg/l)	3.4	2.3	7.4	3.22
CO2 (mg/l)	5.99	5.99	4.99	9.99
PH	6.05	4.72	3.47	6.0

Lakes Batu

	PERIODE SAMPLING			
	May 8th 2002	June 27th 2002	July 24th 2002	August 24th 2002
Time of Sampling	03.05pm	01.30pm	10.45am	11.30am
Secchi disk	39.5 cm	36 cm	28 cm	48 cm
Depth	9.1 m	6.4 m	5.58 m	5 m
Temperature	27.8°C	27°C	31°C	31°C
DO (mg/l)	0.7	0.7	3.9	4.38
CO2 (mg/l)	9.99	9.99	7.99	7.99
PH	4.80	3.57	4.94	4.7

Lakes Payang

	PERIODE SAMPLING			
	May 8th 2002	June 27th 2002	July 24th 2002	August 24th 2002
Time of Sampling	11.00pm	-	-	-
Secchi disk	38.0 cm	-	-	-
Depth	2.5 m	-	-	-
Temperature	28.8°C	-	-	-
DO (mg/l)	1.9	-	-	-
CO2 (mg/l)	19.98	-	-	-
PH	4.78	-	-	-

Zooplankton Communities in Various Freshwater Bodies Surround Palangka Raya City, Central Kalimantan - Indonesia

Yantrinata[1], Sulmin Gumiri[1], Kartika Bungas[1] and Toshio Iwakuma[2]
[1]Departement of Aquatic Resources Management, Faculty of Agriculture - The University of Palangka Raya, Indonesia, Yantrinata@yahoo.com and Sulmingumiri@yahoo.com
[2]Graduate School of Environmental Earth Science, Hokkaido University, Sapporo, 060 - 0810, Japan
Iwakuma@ees.hokudai.ac.jp.

INTRODUCTION

Palangka Raya as the capital city of central Kalimantan has a fresh water bodies approximate 57,300 Ha that consist of 10,000 Ha rivers ; 1,300 Ha lakes ; and 46,000 Ha swamps (Laporan Dinas Perikanan, 1999). These water bodies formed either naturally or manmade. Several human activities that create fresh water bodies in this region are digging canals, sand mining and also land fire on peatland.

Zooplankton is one major diet of tropical freshwater fishes especially for newly hatched fishes (Fernando *in* Gumiri, 2001), a study on zooplankton. Ecology is urgently necessary in order to verify the role of zooplankton in supporting high fish diversity and production in freshwater ecosystems of this region.

The main objective of the present study is to investigate the zooplankton communities in various freshwater bodies surround Palangka Raya city, with study aims to observe the diversity and abundance of zooplankton communities in relation to environmental factors.

Key Words : Freshwater Bodies, Zooplankton Communities, Diversity And Abundance.

STUDY SITES

The present study was carried out at six various freshwater bodies surround Palangka Raya city at Central Kalimantan, Indonesia during June to August 2002, with location :

- Bengaris swamp (02˚13.447'S and 113˚58.074'E)
- Kereng Bangkirai (02˚17.775'S and 113˚54.338'E)
- Canal of Kalampangan (02º15.678'S and 114º01.795'E)
- Lake Tahai (02º01.775'S and 113º46.778'E)
- Lake Bunter (02º01.701'S and 113º47.464'E)
- Excavation of sand mining (02º05.712'S and 113º46.620'E)

MATERIALS AND METHODS

The environmental factors, namely transparency, temperature, dissolved oxygen & pH. was measured insitu with secchi-disk, thermometer, oxygenmeter (Hanna instruments) & orion pH-meter, resfectively ; and for measured concentration of chlorophyll a were determined with a centrifugal and spectrophotometer (Clements instruments).

Zooplankton was collected from surface to 1 meter depth by using plankton net with 40 µm mesh opening. Filtration were done 3 replicate vertical way to strecth the plankton net from defth 1 m to surface, with rapidness 1 ms^{-1}.

The samples were then preserved in lugol for laboratory analysis. In the laboratory, zooplankton was counted and classified into four different groups : juvenil copepod, adult copepods, cladoceran and rotifers. Rotifers were then identified according to Koste (1978), and general zooplankton were identified according Thorp and Covich (1991) and Pennak (1978). Zoplankton diversity was calculated by Shannon-Weanerís in Magurran (1991) and abundance of zooplankton was calculated by Lakeyís in Hariyadi (1992).

RESULTS AND DISCUSSION

Value of index diversity showed variously, between 1,89 to 2,69 with lowest at excavation of sand mining and highest at lake Tahai (Fig 1). Value of abundance showed variously to, between 4 to 59 ind/l with lowest at Bengaris swamp and highest at Kereng Bangkirai (Fig 2). Based on those value, all of the location belonging to the poor of nutrient aquatic and low diversity level.

From five environmental factors were measured, just concentration of chlorophyll-a has a negative significant correlation with index of diversity (Hí) of zooplankton, were R^2= 0,82. This result indicated that high species diversity of zooplankton will be create the stability ecosystem. Usually, high value of diversity has a long and complex food chain, and it has a many case was happen, so it made homeostasis environmental with prevent biologys system and more stable toward the destruction of environmental.

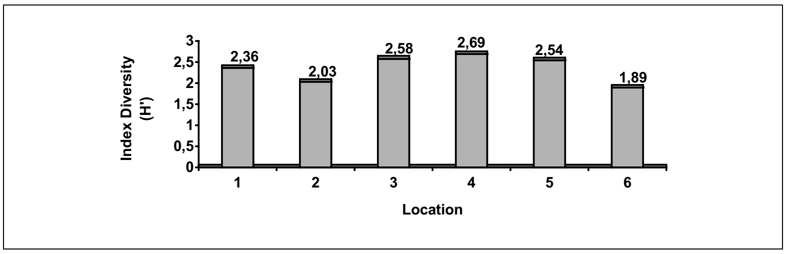

Figure1. Index diversity of zooplankton at six freshwater bodies.

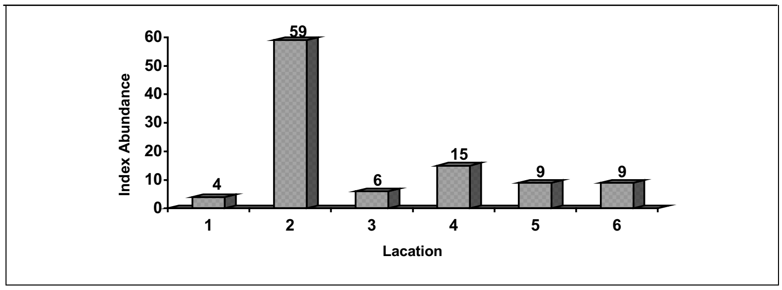

Figure 2. Abundance of zooplankton at six freshwater bodies.

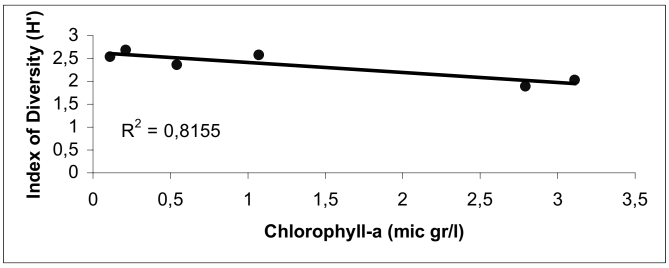

Figure 3. Negative significant correlation between value od chlorophyll-a and index of diversity (H').

The research was founded zooplankton species in six freshwater bodies surround Palangka Raya city consist of 61 species of rotifers; 11 species of cladocerans; aand 4 species of copepod. Rotifers were the most abundance zooplankton group whereas cladocerans were the second most aabundance and copepods were the third most abundance. The dominance of small sized zooplankton like rotifers indicated that larger sized zooplankton i.e. copepods and cladocerans are continouly predated by zooplanktivorous fishes.

Some kind of species of zooplankton can be prevent toward the extreme environmental, like *Ilyocruptus sordidus* was founded at low pH location; *Diurella dixonnutalli* was founded at low transparency and concentrtion of chl *a* locatin; *Eudaactylota eudactylota*was founded at low DO location; *Colurella uncinata* was founded at the location with less then 30°C temperature; and *Lecane signifera* was founded at high temperature and high concentration of chl *a.* On the other hand, some species were founded in every location i.e. *Asplachna brigwelli, Bosminopsis deitersi, Mesocyclops* and *Nauplii.*

CONCLUSION

Based on this research were found several specific species towards physico-chemical aquatic like *llyocruptus sordidus; Diurella dixonnutalli; Eudactylota eudactylota* and *Colurella uncinata* ; resfectively tolerant towards value of pH, DO; Chl-a and low temperature.

Value of simple regression correlation showed negative significant correlation between concentration of chl-a with value index of diversity (H') R^2 = 0,82.

Value of abundance ; diversity index and concetration of chl-a were showed the freshwater bodies arround Palangka Raya city belonging to oligotropic aquatic because content of nutrient is poor.

Table 2. Species of zooplankton according physico-chemical factors and chlorophyll-a

Taxa	Physico-chemical Factors																													
	Transparency (cm)						Temperature (oC)						DO (mg/l)						pH						Chl a (mic gr/l)					
	33,5	38,5	45,0	66,0	66,5	67,5	28,9	30,7	31,5	32,7	39,1	39,6	0,4	1,8	2,5	2,6	2,9	3,8	2,82	3,50	3,77	4,02	4,41	4,53	0,11	0,21	0,54	1,07	2,79	3,11
ROTIFERA																														
Anuraeopsis fissa	x	-	x	-	x	x	-	x	x	-	x	x	x	-	x	x	x	-	-	x	x	x	-	x	x	x	x	-	-	x
Asplachna brigwelli	x	x	x	-	x	x	x	x	x	-	x	x	x	x	x	x	x	-	-	x	x	x	x	x	x	x	x	x	-	x
Colurella obtusa	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Colurella uncinata	-	x	-	-	-	-	X	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-
Dicranophorus, sp	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Diurella cavia	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Diurella dixonnutalli	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-
Diurella stylata	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Euchlanis dilatata dilatata	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Euchlanis dilatata f. lucksiana	-	x	-	-	-	-	X	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-
Euchlanis triquetria	x	-	x	-	-	-	-	x	x	-	-	-	-	-	-	x	x	-	-	x	-	x	-	-	x	x	-	-	-	-
Eudactylota eudactylota	-	-	-	-	-	x	-	-	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-
Gastropus minor	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Hexarthra intermedia braziliensis	-	-	x	-	x	x	-	x	-	-	x	x	x	-	x	-	x	-	-	x	x	-	-	x	-	x	x	-	-	x
Hexarthra mira	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Hexarthra propingua	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Ilyocruptus sordidus	-	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	-	x	-
Keratella cochlearis	x	-	x	-	x	x	-	x	x	-	x	x	x	-	x	x	x	-	-	x	x	x	-	x	x	x	x	-	-	x
Lecane braumi	-	x	-	-	-	-	X	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-
Lecane curvicornis	-	-	x	-	-	x	-	x	-	-	x	-	x	-	-	-	x	-	-	x	-	-	-	x	-	x	x	-	-	-
Lecane elsa	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-

Taxa	Faktor Fisika Kimia																													
	Transparency (cm)						Temperature (C)						DO (mg/l)						PH						Chl-a (mic gr/l)					
	33,5	38,5	45,0	66,0	66,5	67,5	28,9	30,7	31,5	32,7	39,1	39,6	0,4	1,8	2,5	2,6	2,9	3,8	2,82	3,50	3,77	4,02	4,41	4,53	0,11	0,21	0,54	1,07	2,79	3,11
Lecane latissima	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-
Lecane leontina	-	x	-	-	-	-	X	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-
Lecane luna	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Lecane papuana	x	x	-	-	-	x	X	-	x	-	x	-	x	x	-	x	-	-	-	-	-	x	x	x	x	-	x	x	-	-
Lecane rudescui	-	x	-	-	-	x	X	-	-	-	x	-	x	x	-	-	-	-	-	-	-	-	x	x	-	-	x	x	-	-
Lecane signifera	-	-	-	-	x	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x
Lepadella favorita	-	-	x	-	x	-	-	x	-	-	-	x	-	-	x	-	x	-	-	x	x	-	-	-	-	x	-	-	-	x
Lepadella imbricata	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Lepadella ovalis	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Macrochaetus collinsi f. Braziliensis	-	x	-	-	-	-	X	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-
Macrochaetus sericus	x	x	-	-	-	-	X	-	x	-	-	-	-	x	-	x	-	-	-	-	-	x	x	-	x	-	-	x	-	-
Monommata appendiculata	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Monommata dentata	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-
Monostyla bulla	-	x	x	-	x	x	X	x	-	-	x	x	x	x	x	-	x	-	-	x	x	-	x	x	-	x	x	x	-	x
Monostyla closterocerca amazonica	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Monostyla lunaris var. constricta	-	x	x	-	x	-	X	x	-	-	-	x	-	x	x	-	x	-	-	x	x	-	x	-	-	x	-	x	-	x
Monostyla pyriformis	-	x	x	-	x	-	X	x	-	-	-	x	-	x	x	-	x	-	-	x	x	-	x	-	-	x	-	x	-	x
Paranoreopsis quadriantennata	x	x	-	-	x	-	X	-	x	-	-	x	-	x	x	x	-	-	-	-	x	x	x	-	x	-	-	x	-	x
Philodina, sp	-	x	x	-	-	-	X	x	-	-	-	-	-	x	-	-	x	-	-	x	-	-	x	-	-	x	-	x	-	-
Platyias quadricornis var. Brevispinus	-	x	x	-	x	-	X	x	-	-	-	x	-	x	x	-	x	-	-	x	x	-	x	-	-	x	-	x	-	x
Proalides digitus	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-
Rotaria neptuna	-	-	-	-	-	x	-	-	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-
Scaridium bostjani	-	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	-	x	-
Scaridium longicaudatum	-	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	-	x	-
Synchaeta pectinata	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-
Synchaeta stylata	-	-	-	x	-	x	-	-	-	x	x	-	x	-	-	-	-	x	x	-	-	-	-	x	-	-	x	-	x	-

Taxa	Physico-chemical Factors																																			
	Transparency (cm)						Temperature (oC)						DO (mg/l)						pH						Chl a (micgr/l)					
	33,5	38,5	45,0	66,0	66,5	67,5	28,9	30,7	31,5	32,7	39,1	39,6	0,4	1,8	2,5	2,6	2,9	3,8	2,82	3,50	3,77	4,02	4,41	4,53	0,11	0,21	0,54	1,07	2,79	3,11
Synchaeta, sp 1	-	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	-	x	-
Synchaeta, sp 2	-	x	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-
Testudinella brevicaudata	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-
Tetramastix oppoliensis	-	-	x	-	x	-	-	x	-	-	-	x	-	-	x	-	x	-	-	x	x	-	-	-	-	x	-	-	-	x
Trichocerca elongata elongata	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Trichocerca fusiformis	-	x	x	-	-	-	x	x	-	-	-	-	-	x	-	-	x	-	-	x	-	-	x	-	-	x	-	x	-	-
Trichocerca inermis	-	-	-	-	x	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x
Trichocerca longiseta	x	-	x	x	x	-	-	x	x	x	-	x	-	-	x	x	x	x	x	x	x	x	-	-	x	x	-	-	x	x
Trichocerca ornata	x	-	x	-	-	-	-	x	x	-	-	-	-	-	-	x	x	-	-	x	-	x	-	-	x	x	-	-	-	-
Trichocerca rattus	-	x	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-
Trichocerca rosea	-	x	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-
Trichotria tetractis	-	-	-	x	-	x	-	-	-	x	x	-	x	-	-	-	-	x	x	-	-	-	-	x	-	-	x	-	x	-
Brachionus patulus	-	x	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-
CLADOCERA																														
Alona monacantha	x	-	-	-	-	x	-	-	x	-	x	-	x	-	-	x	-	-	-	-	-	x	-	x	x	-	x	-	-	-
Alonella diaphana	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-
Bosmina longirostris	x	x	x	-	-	-	x	x	x	-	-	-	-	x	-	x	x	-	-	x	-	x	x	-	x	x	-	x	-	-
Bosminopsis deitersi	x	x	x	x	x	-	x	x	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	-	x	x	-	x	x	x
Ephemeroporus a.	x	-	x	-	-	-	-	x	x	-	-	-	-	-	-	x	x	-	-	x	-	x	-	-	x	x	-	-	-	-
Chidorid, sp 1	x	-	x	-	-	-	-	x	x	-	-	-	-	-	-	x	x	-	-	x	-	x	-	-	x	x	-	-	-	-
Chidorid, sp 2	-	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	-	x	-
Chidorid, sp 3	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-
Disparalona, sp	x	-	-	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	x	-	-	x	-	-	-	-	-
Leydigia acanthoides	-	-	x	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	x	-	-	-	-	-	x	-	-	-	-
Macrothrix rosea	-	x	-	-	-	-	x	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-	x	-	-	-	-	x	-	-
Mesocyclops	x	x	x	x	x	-	x	x	x	x	-	x	-	x	x	x	x	x	x	x	x	x	x	-	x	x	-	x	x	x

Taxa	Physico-chemical Factors																																			
	Transparency (cm)						Temperature (oC)						DO (mg/l)						pH						Chl a (micgr/l)					
	33,5	38,5	45,0	66,0	66,5	67,5	28,9	30,7	31,5	32,7	39,1	39,6	0,4	1,8	2,5	2,6	2,9	3,8	2,82	3,50	3,77	4,02	4,41	4,53	0,11	0,21	0,54	1,07	2,79	3,11
COPEPODA																														
Laophontidae	x	x	-	x	-	x	x	-	x	x	x	-	x	x	-	x	-	x	x	-	-	x	x	x	x	-	x	x	x	-
Nauplii	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Tropocyclops	-	-	-	x	-	-	-	-	-	x	-	-	-	-	-	-	-	x	x	-	-	-	-	-	-	-	-	-	x	-

ACKNOWLEDGEMENTS

We are grateful to Mr Ardianor and Mrs Linda Wulandari for help and give suggestion during this research and also for Roy Hary Winata, Trisliana, Yurenfri and Jhon Indra C.D. for collection and help in every sampling.

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Benthic Macroinvertebrates Community Structures and Their Functional Status in Lake Singkarak, West Sumatera - Indonesia

Yoyok Sudarso, G. P. Yoga, Tri Suryono
Research Center for Limnology - Indonesian Institute of Sciences

ABSTRACT

Lake Singkarak is a tectonic lake, which is located in West Sumatera. Nowadays the lake is facing serious problems such as lowering water discharge, decreasing indigenous species of fish population, and mesotropic water quality condition of the lake. Those conditions cause adverse effects to the endemic fish such as ikan bilih (*Mystacoleucus padangensis*) and other aquatic biota especially macroinvertebrates. The aims of this study are: 1). To know the composition and diversity of the maroinvertebrate in lake Singkarak, 2). To elucidate the correlation between environmental variabels and the spatial distribution arrangement of the maroinvertebrate in lake Singkarak, 3). To understand the functional feeding status of the maroinvertebrate in lake Singkarak. Samples were taken in September 2001 on 9 locations. Shannon-Wiener biodiversity index was used to calculate the macroinvertebrates diversity. Multivariate analysis using PCA and RDA were conducted to discover environmental variables, which characterize species composition. It was shown from the calculation of diversity index, that benthos diversity of lake Singkarak tends to be classified as medium level (H'= 1,847 to 2,4931). Functional feeding status of benthos in the lake generally was dominated by the scraper (mollusks) except St 1 (Sumpur) which was dominated by gatherer-collector. The result from multivariate analysis using PCA and RDA showed that *Melanoides tuberculata* tend to be characterized by high level of suspended solid, Total nitrogen, Total Phosphate, and Dissolved oxygen

Key Words: Benthos, fungsional feeding status, multivariate, diversity

INRODUCTION

Lake Singkarak is a tectonic lake located in West Sumatera. The lake covers the area of 13.011 acres, while latitude and longitude of the lake are 0° 31í 46" S, and 100° 26í 15" E, respectively. Nowadays the lake is facing serious problems such as lowering water discharge, decreasing indigenous species of fish population, and mesotropic water quality condition. Those conditions cause adverse effects to the endemic fish, i.e. ikan bilih (Mystacoleucus padangensis), and other aquatic biota, especially macroinvertebrates. The presence of benthic macroinvertebrates depends on water quality, sediment type, and other physical factors. Decreasing water quality or other disturbance in aquatic habitat cause disappearance of sensitive species, and then they will be changed by tolerant species. Karr (1999) said that decreasing or lacking of biodiversity is a bigger disaster than other disasters that appear in regional and global scale, such as acid rain, global warming, pollutions, ozone hole, etc. Therefore physical, chemical, and biological monitoring are needed to conserve lake and minimize the adverse effects that are caused by nature, as well as anthropogenic activities in aquatic environment.

Benthic macroinvertebrates community has long been used as bioindicator in a freshwater, for detecting disturbances or aquatic freshwater stresses (Lenat, 1983). Itís noted in 1909, Kolkowitz and Marsson introduced Saprobien System, which is the first method that uses benthic macroinvertebrates for detecting organic pollutant. Generally, benthic macroinvertebrates is defined as organisms without back bone and live in the bottom of the aquatic ecosystem. These organisms usually have minimum size 0.5 mm, but Davis and Lathrop (1995) suggested 0.3 mm as the minimum size. United States, UK, and Australia have used these kinds of organisms for determining the status of aquatic ecosystem Health, and based on the status guidelines for the environmental management is made.

This research was aimed: 1). To know the composition and diversity of the macroinvertebrates in lake Singkarak, 2). To elucidate the correlation between environmental variables and the spatial distribution arrangement of the macroinvertebrates in lake Singkarak, 3). To understand the functional feeding status of the macroinvertebrates in lake Singkarak. The possibility of benthic macroinvertebrates usage as bioindicator of aquatic pollution is the expected result of this research.

METHODOLOGY

Benthic macroinvertebrates organisms were sampled on september 2001 using ekman grab sampler with 225cm^2 opening width. Five replications was taken in each sampling sites based on rerefraction of previous test data. Sampling sites were determined purposively and based on water input/output in lake singkarak. There were nine sampling sites namely: Sumpur (St1), Malalo(St2), outlet of power plant (st3), Paninggahan (st4), Sumani(st5), tanjung muara (st6), Batang ombilin(st8), and Batu tebal (st9). Bathimatry maping and the sampling locations can be seen in figure 1. Formaldehyde 4% solution was used for sample Preservation. The organisms were sorted on research center for limnology-LIPI. Alcohol solution 70% is used for Preservation of the organism after sorting phase. Oligochaeta worm and diptera chironomidae were mounted using CMCP-10 solution (Polyscience Inc).

Water samples were taken for measuring water quality parameters such as Disolved Oxygen (DO), Conductivity, and pH which were measured using water quality checker Horiba U-10. While, Total Nitrogen (TN) and Total Phosphate (TP) were measured by spectofotometer method (APPHA standard, 1976).

Functional feeding status of benthic macroinvertebrates was based on Barbour et al. (1999) and Vannote et al., (1980). Collectors are difined as benthic organism eats fine particulate from organic material (FPOM) such as leaf fragmentation, microbes, sediment deposition, and fecal pellet from other aquatic organisms. Collectors usually are divided more specificly into two feeding mechanism. Filtering C. such as clam and diptera simulidae, while gathering C. such as oligochaeta worm, ephemeroptera, chironomidae, and trichoptera larva. Predator is benthos eat directly other aquatic organism such as megaloptera and odonata larva. Scrapers are benthos eat algae that attach on stone or the others surface such as coleoptera psepheniidae, limpet, and gastropods, and ephemeroptera larva. Shredders are benthos eat coarse particulate organic matter (CPOM) such detritus of leaf, wood, algae, and root. The organism is very important to break down coarse organic to fine particulate organic such plecoptera, trichoptera larva, gammaridae, asellidae (Westcott, 1999).

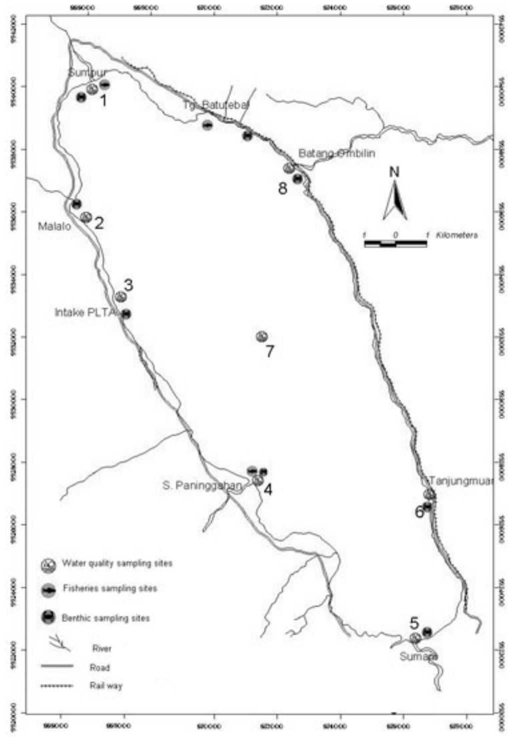

Figure 1. Water quality, and benthic sampling sites in Lake Singkarak

Data analysis.

Benthos Diversity from each sampling site was determined using Shannon-Wiener index (Pielou, 1969) such as:

$$H' = \Sigma\, n_i/N \log_2 n_i/N$$

where H'= diversity index, n_i = number of organisms on one species, and N= total number of each species organisms. Diversity Index Calculation used Spesies Diversity and Richness version 2.65 (*Pisces Conservation*). Abundance data were transformed into log (X+1) before analyses to reduce extreme dominance species (Norris and Georges, 1992). If abundance data range is narrow i.e: 1-100 indvidu, therefore, transformation is not needed (Marchant,1999).

Procedure for choosing multivariate analysis was based on Van Wijgaarden et al (1995). If calculation of gradient length of Detrended Corespondence Analysis (DCA) that expressed in standard deviation unit (SD) ≥ 3, therefore species ordination used Correspondence Analysis (CA), otherwise, if SD < 3 then principal component analysis (PCA) was used. Direct ordination among species, site, and environment variables was conducted using Redundancy analysis (RDA) if PCA was used for species ordination, while canonical Correspondence analysis (CCA) is used if species ordination uses CA. Variable selection is conducted using test multicollinearity. Variable is not analyzed furthermore if R^2 value more than 0.8. DCA, PCA, CA were calculated using CAP software version 2.04, while RDA, CCA, and test multicollinearity were calculated using ECOM software version 1.36 (Pisces Conservation).

RESULTS AND DISCUSSION

Figure 2 shows benthic macroinvertebrates diversity in lake Singkarak, which in medium range according to Suryadiputra *et al* (1999), that categorized diversity index (Hí) as low, medium and high when the Hí scores are lower than 1, within 1 to 3, and higher than 3, respectively. The highest diversity score (2.4931) was found in Paninggahan, while the lowest score were found in Sumani and Tanjung Muara, 1.8147 and 1.8391, respectively. The diversity of Paninggahan was high, possibly because of nutrien and organic materials input from unpolluted Paninggahan River. Substrate type of that area was sandy and stoney which dominated by coble that has diameter 3 to 10 cm. Sediment size is a reflection of erosion and deposition level caused by waves and current (Barton, 1988a). According to that description, Paniggahan was estimated has low erosion, and supported optimum colonization of benthic macroinvertebrates in that area. Invertebratesí abundance and taxa richness tend to raise according to the raising of the substrate particle size. Progressive elevation of total amount and biomass occur within particle size of sand (1.5 - 3 mm) and rubble (30 - 200 mm), but further particle size elevation up to bedrock/boulder cause benthicí amount and biomass decrease (Pennack and Van Grippen, 1947).

Besides substrate size, depth is the other critical factor of benthic macroinvertebrates distribution in lake. Region that has rough sediment type and shallow water (0 - 5 m) tend to produce small amount of taxa, while the richest amount of taxa can be found in a region that has depth between 6 and 10 m (Barton, 1988a). Disturbance from Anthropogenic activities and depth were factors that cause low diversity of station 5 and 6. Benthos samplings were conducted at the depth of 1-5 meters, which tend to be affected by current, comes from the waves, which has role in species arrangement. Sumani is an area that covers paddy field, sand mining area, and human settlement. Activities come from those area increase organic nutrient concentration, pollutant concentration, as well as other suspended materials in the Lake and cause low biodiversity of that area. Tanjung Muara is a tourist area located in bank of the Lake Singkarak. Pollutant in that area mainly comes from the Boat's fuel residue and from domestic waste sewerage. The indication of organic pollution in those two areas could be seen in the elevation of the three parameters of organic pollution, i.e. Total Nitrate (TN), Total Phosphate (TP), and Suspended Solids (SS), which the the levels were 0.875-0.971 mg/l, 0.5855-1.009 mg/l, and 10.25-26.75 mg/l. These concentrations were two fold higher than the other sampling sites.

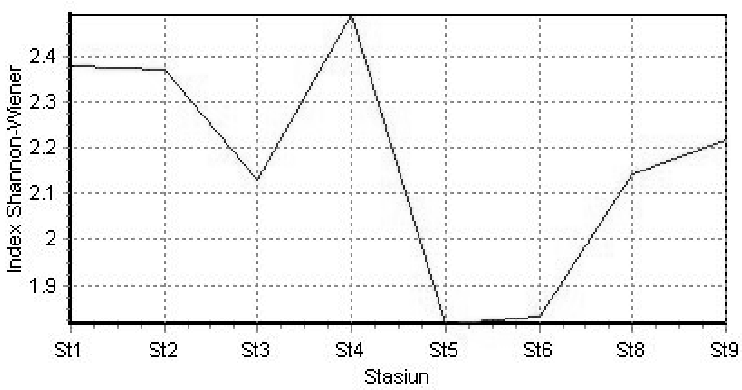

Figure 2. Shannon-Wiener diversity index in each sampling sites

State of functional feeding Determination was based on nutrient dynamic and merely used in evaluation of organic enrichment effect, and cannot be used in toxic chemical evaluation (Reynoldson and Metcalfe-smith, 1992). Relative contribution of benthic macroinvertebrates functional feeding is heavily affected by habitat. Benthic macroinvertebrates, which live in sediment, usually are dominated by gathering collector type, (oligochaeta, and Chironomidae), and micro filtering collector (bivalvia, clamp, and shell), (Benke and Meyer, 1988). Benthic Functional feeding status in Lake Singkarak generally was dominated by mollusk, which has role as scraper/grazer, except Sumpur, which was dominated by gatherer-collector. The scraper domination in lake Singkarak was happened because basalt stone dominates substrate type of Lake Singkarak. This condition is favorable for mollusk, which graze on bryophyte and algae that live on surface of that stone (Marwoto and Djajasasmita, 1985). Oligochaetes from family of Naididae, and Tubificidae, which have role as gatherer-collector, were on the second rank of the functional feeding status of benthic macroinvertebrates in Lake Singkarak. According to the River Continuum theory (Vannote et al., 1980), gatherer-collector domination indicates accumulation of fine particles, which covers Fine Particulate Organic Matter (FPOM) and Ultra Particulate Organic Matters (UPOM) that have diameters 50 μm-1mm, and 0.5 μm-50 μm, respectively. Specifically on Sumpur, which is domestic tourist area like Tanjung Muara, however that area has shallow beach with sand substrate type. This type of substrate is a preference substrate for gatherer-collector, filterer-gatherer, and filterer-collector; therefore the populations of those functional feeding types were higher than the scraper type on Sumpur. Benthic macroinvertebrates functional feeding status category in each sampling site is showed in figure 3.

The result of species ordinance using Detrended Correspondence Analysis (DCA) showed that gradient length, which is expressed as Standard Deviation (SD) and (eigenvalue), on the three major axes are 1.415 SD (0.2055), 1.123 SD (0.095), and 0.85 SD (0.012), respectively. That result shows that benthic species data tends to follow monotonic/linear relationship along environmental variable gradient, therefore PCA is the most appropriate analysis to be used in further multivariate analysis of those data.

Site/species biplot from Principal Component Analysis of the data was shown in figure 3. Eigenvalues of the two major axes were 27.956 and 14.21, and total cumulative described major axes variant was 53.245%. From the

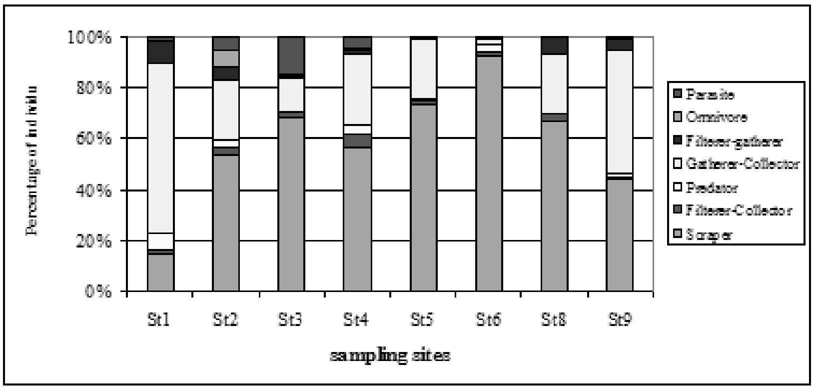

Figure 3. Site/species biplot from Principal Component Analysis of the data

figure, there were found three main groups, which are:

Group 1: Sumpur has sandy substrate and was dominated by Trichoptera (*Oxyesthira* sp.), and Oligochaetes worm that consists of two families, i.e. Naididae (*Dero digitata, Dero furcata, Stephensoniana trivandrana*), and Tubificidae (*Aulodrilus piqueti*). This type of substrate is preferred by *Dero sp.* (Verdonschot, 1984).

Group 2: Sumani and Tanjung Muara have sandy -mud substrate, and were dominated by mollusks (*Melanoides tuberculata, Melanoides granifera, Gyraulus feunerboni, Thiara scaba, Corbicula moltkeana*) and Diptera (*Procladius* sp., *Chiromnomus* sp.). Habitat preference of Chironomidae is strongly determined by the size of substrate, type of particles, organic materials sedimentation (Rae, 1985). The elevation of Chironomus abundance usually indicates the elevation of organic pollution in that area (Lindegaard, 1995).

Group 3: Batu Tebal, Paninggahan, and Malalo have stony and sandy substrates and were dominated by Oligochaetes, i. e. Naididae (*Dero* sp., *Pristina bisserata, Pristinella* sp. *Pristina aequiseta*), Tubificidae (*Limnodrilus* sp., *Branchiura sowerbyi*), Coelenterata (*Hydra* sp.), and Molusk (*Melanoides* sp.). According to the study in Great Lakes, the dominance of Limnodrillus and Tubificidae indicates that silt content in sediment is higher than 10%, and the condition tends to be eutrophic (Barton 1988).*Branchiura sowerbyi,* is distributed widely around the world, and usually lives in a still water with silt-typed substrate. This worm can survive at the estreme pH and DO conditions, like peat water (Verdonschot, 1984). The complete species ordinance using PCA is shown in figure 4.

Analysis Redudancy (RDA) is a direct ordinance using linear response model. Relationship between species and environmental variables using this analysis are plotted along ordinance axes 1 and 2. Since goodness of fit of RDA was limited to environmental variables, therefore the eigenvalues of the ordinance axes 1 is lower than the value of the PCA. The result of direct ordinance of the data using RDA showed that 2 canonical eigenvalues in axes 1 and 2 were 2.85 and 1.814, respectively, and described cumulative % variance was 6.638%.

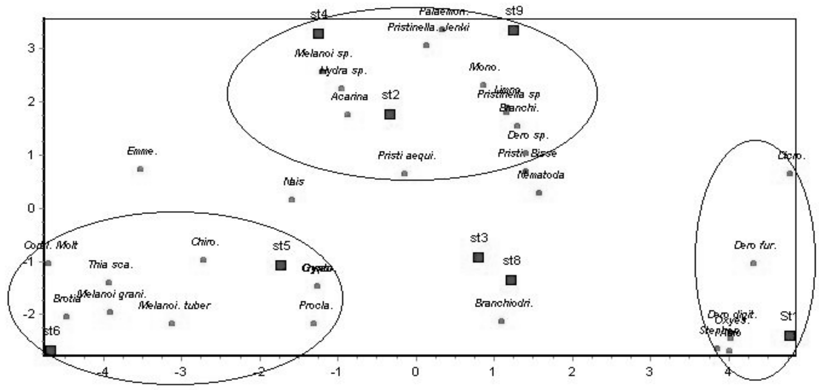

Figure 4. Species/sites Biplot graph from Principal Component Analysis (PCA).

Figure 5 shows triplot graph of species, sites, and chemical variables. From that figure it is seen that *Melanoides tuberculata* was abundantly found in Sumani, and Tanjung Muara, and tend to be characterized by high level of water quality variables such as suspended solids (SS), Total Nitrogen (TN), total Phosphate (TP), and Dissolved Oxygen (DO), on the contrary, in Sumpur, intake of the power plant, Batang Ombilin, and Batu tebal, were characterized by Dero furcata, Dicrotendipes, and Dero digitata, which their abundance were low when those water quality variables were high. The abundance of *Melanoides Tuberculata* in Sumani and Tanjung Muara were possibly caused by nutrients (TN and TP) enrichment, which stimulate algal growth in the surface of sediment and stones. Algae are food source for grazer-typed mollusks such as Melanoides tuberculata, and other mollusk, so that the productivity of that species in those sites were higher than in other sites.

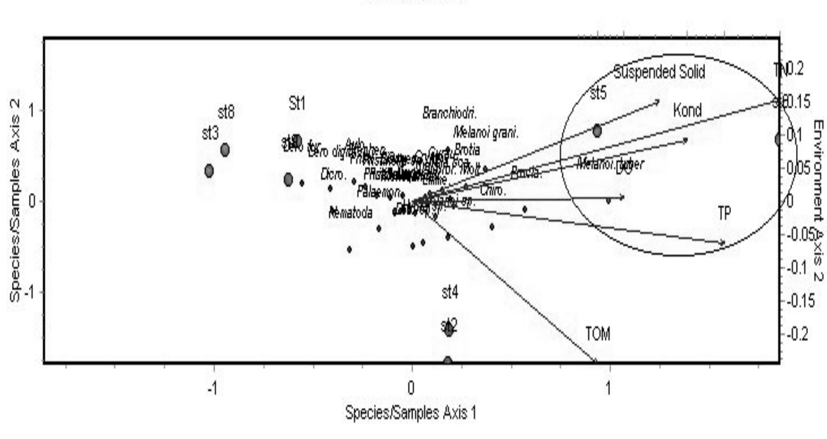

Figure 5. Triplot graph of species, sites, and chemical variables from Redudancy Analysis of benthic macroinvertebrates data

CONCLUSION

The following conclusions were drawn from this research :

1. Based on Shannon-Wiener diversity Index, the diversity of benthic macroinvertebrates were categorized as low to intermediate. The highest diversity was found in Paninggahan, while the lowest ones were found in Sumani and tanjung Muara
2. Functional feeding status of benthic macroinvertebrates in Lake Singkarak was dominated by scraper, which were represented by mollusks
3. PCA and RDA can be applied to describe the dominant variables that has role in species distribution in Lake Singkarak.
4. Melanoides tuberculata prefers to live in aquatic environment with high concentration of Suspended Solids, Total Nitrate, total Phosphate, and Dissolved Oxygen.

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Faunal Composition of Meio- and Macroinvertebrates Associated with Aquatic Macrophytes in Central Kalimantan and West Java, Indonesia, with Special Reference to Oligochaetes

Akifumi Ohtaka[1], Dede Irving Hartoto[2], Yoyok Sudarso[2], Tariono Buchar[3], Fifi Widjaja[4], Toshio Iwakuma[5], and Hidenobu Kunii[6]

1 Department of Natural Science, Faculty of Education, Hirosaki University, Hirosaki 036-8560, Japan

2 Research and Development Center for Limnology, Indonesian Institute of Sciences, Cibinong 16911, Indonesia

3 Department of Fisheries, Faculty of Agriculture, University of Palangka Raya, Palangka Raya 73112, Central Kalimantan, Indonesia

4 Faculty of Fisheries and Marine Science, Bogor Agricultural University, Campus IPB, Darmaga, Bogor 16680, Indonesia

5 Graduate School of Environmental Earth Science, Hokkaido University, Sapporo, 060-0810, Japan

6 Research Center for Coastal Lagoon Environment, Shimane University, Matsue 690-8504, Japan

Corresponding author: Akifumi Ohtaka, Department of Natural Science, Faculty of Education, Hirosaki University, Hirosaki 036-8560, Japan
Tel & Fax +81-172-39-3369, e-mail. ohtaka@cc.hirosaki-u.ac.jp

ABSTRACT

Composition of meio- and macroinvertebrates associated with aquatic macrophytes was compared between acid waters in the peat swamp area of Central Kalimantan (CK) and neutral waters in West Java (WJ). Among the invertebrate assemblages, cladocerans and/or copepods dominated in both regions. On the other hand, relative abundances of chironomids and ostracods were significantly higher in CK and WJ, respectively. Eighteen taxa of oligochaetes were recorded from the regions, of which 14 ones belong to the family Naididae. The oligochaete composition was largely different between CK and WJ, in that *Pristina* and/or *Pristinella* species dominated in CK, while *Stylaria fossularis* dominated in WJ. WJ harbored more diverse oligochaetes than CK. The difference in oligochaete composition can be related with acidity in waters.

Key words: aquatic invertebrate, macrophyte, Central Kalimanta, West Java, Oligochaeta

INTRODUCTION

It has been widely recognized that macrophytes in lakes and rivers play important roles for aquatic ecosystems. They offer many microhabitats for invertebrates, where various kinds of animals live, feed, oviposit, and hind, creating diverse communities. Invertebrates associated with aquatic macrophytes are important as a natural food for fishes and other higher consumers.

In addition to neutral freshwaters, tropical regions often have acidic waters derived from tropical peat. They are often brownish colored, and called “blackwater”. Similar acidic waters are also widely found in *Sphagnum* bog mires in cool climate regions. In general species diversity of larger animals is very low in *Sphagnum* bog waters, and major animal groups are poorly represented or often lacking there (Wetzel, 1983). On the other hand, characteristics in invertebrate structures including meiofauna have been poorly studied in acid waters in tropical peat swamp area.

In the present study, to clear the invertebrate faunal differences between acid and neutral waters in tropical Asia, composition of meio- and macro invertebrates associated with aquatic macrophytes were compared between several acid waters in the peat swamp area of Central Kalimantan and neutral waters in West Java, with special reference to oligochaetes.

STUDY SITES AND METHODS

The material was collected at six vegetated sites in the peat swamp area of Central Kalimantan (CK) during 11-14 December 1998, and three ones in Bogor, West Java (WJ) during 2-4 March 2001 (Fig. 1). The CK sites covered two canals (CK 1 and CK 2) and a fish farm pond (CK 3) in the basin of Kapuas River, a littoral Lake Tundai in the basin of Kahayan River (CK 4), upper Sebangau River (CK 5), and a canal in the suburb of Palangka Raya (CK 6). The WJ sites covered a pond in Bogor Botanical Garden (WJ 1), and littorals of two small and eutrophic lakes, L. Bojongsari (WJ 2) and L. Cikaret (WJ 3).

Every surveys was performed in the daytime. Specimens were randomly collected by scooping with a dipnet with the opening 190 µm (NXX 7) on and among variable macrophytes in water, which include both primarily aquatic forms (submerged parts of emergent plants, submerged plants, and roots of freely floating plants), and sinking terrestrial weeds in water. Animals collected were immediately fixed in a 10 % formalin solution. Water temperature and pH value were measured at each sampling site. Limnological data in CK sites were partly given in Iwakuma (1999).

To determinate the faunal composition, 300-900 individuals of meio- and macro invertebrates for each sample were randomly identified in phylum, class, order, or family revels. Based on these compositions, Simpson's index of diversity (SID; Kimoto and Takeda, 1989) was calculated for each site, and a dendrogram using average-linkage cluster analysis was depicted for grouping the sites, on the basis of similarity indexes, Pianka's (1973) α (Kimoto and Takeda, 1989). Invertebrates less than 190 µm long, for example protozoans and rotifers, were not examined in the present study because they were almost come out from the dipnet sieve used.

Oligochaetes collected were examined specifically for wholly mounted specimens on slides either in CMCP-10 (Polysciences Inc.) or Canada Balsam after being dehydrated in a graded series of ethanol and water solutions, and then cleared in methyl salicylate. For determinating the oligochaete composition, 10-90 worms were randomly identified and assigned to the following nine specific, generic or familial groups; *Stylaria fossularis*, *Pristina* and *Pristinella*, *Nais*, *Branchiodrilus hortensis*, *Allonais*, *Dero* and *Aulophorus*, other Naididae, Tubificidae and Enchytraeidae. SID in each site was calculated and a dendrogram was depicted for oligochaetes by the above-mentioned methods. Significances of differences in the faunal composition and SID were tested by ANOVA between CK and WJ.

The specimens used in the present study are deposited in the in the Department of Natural Science, Faculty of Education, Hirosaki University, Hirosaki, Japan.

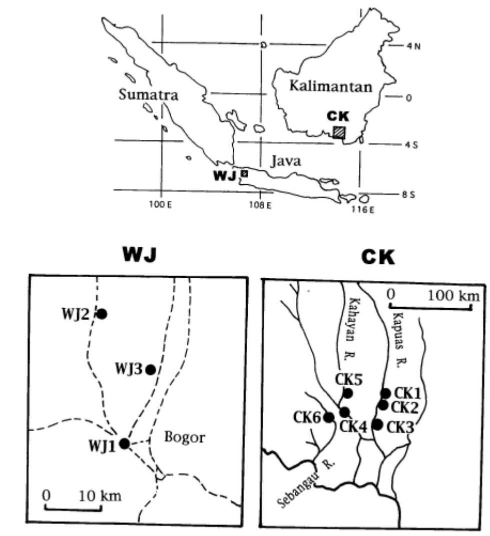

Figure 1. Locations of study areas, Central Kalimantan (CK) and West Java (WJ), with showing study sites.

RESULTS

Faunal composition in Central Kalimantan

Waters of all CK sites were brownish colored and acidic with the pH ranging from 2.9 to 4.2. The temperatures ranged from 28.8 to 34.3 ˚C.

Sixteen taxonomic groups of invertebrates were found in the CK sites studied, of which three ones, Cladocera, Copepoda, and Chironomidae were common to occur in all the sites (Table 1). Among them, cladocerans were the most dominant in all sites except for CK 2 where copepods exceeded the former; these two taxa combined accounted for more than 63 % of whole invertebrates in all CK sites. Chironomids were the next dominant animals, accounting for from 5.0 to 24.9 % of whole invertebrates. Hemipterans in which notonectids surpassingly dominated, attained 14.1 % of whole invertebrates in CK 3. Nematods, turbellarians, oligochaetes, acarinas, ostracods, odonates, ephemeropterans, trichopterans, lepidopterans, and dipteran ceratopoginids, culicids, chaoborids were found from one to three CK sites with the proportion of less than 10% of whole animals. The SID ranged from 1.4 to 3.7 with the mean value of 2.5 (Table 2).

Oligochaetes were collected in all six CK sites but CK 5. Nine taxa were found in the samples (Table 3). All species but enchytraeids belonged to the family Naididae. They includes four *Pristina* species (*P. longiseta*, *P. aequiseta, P. biserrata* and *P. poboscidea*) and one *Pristinella* species (*P.* sp.). *Pristina proboscidea* was the most dominant, and *Pristina* and *Pristinella* species combined occupied from 67 % (CK 4) to 100% (CK 1and CK 6) of whole oligochaete assemblages (Fig. 2). The SID in oligochaetes ranged from 1.0 to 2.0, with the mean value of 1.5 (Table 2).

Faunal composition in West Java

In the three WJ sites studied, the waters were nearly neutral with the pH ranging from 6.5 to 7.2. The water temperatures ranged from 28.6 to31.1 ˚C.

Sixteen taxonomic groups of invertebrates were found in the WJ sites studied (Table 1). Among them, cladocerans were the most dominant, occupying more than 48.3% of whole animals in all the sites. Copepods and ostracods were the second dominant groups, ranging from 19.8 to 33.8 % and from 1.9 to 24.6% of whole animals, respectively. As well as these thee groups, oligochaetes, decapods, odonates ephemeropterans, and chironomids were common to occur in WJ sites. In addition, hydrozoans, mollusks, conchostracans, and decapods were occur in some WJ sites. The SID in all invertebrates ranged from 2.8 to 3.4, with the mean value of 3.1 (Table 2).

Fifteen taxa of oligochaetes were found (Table 3). They were composed of 11 species belonging to 7 genera of the family Naididae, three species of Tubificidae, and one enchytraeid. A naidid, *Stylaria fossularis*, dominated in all WJ sites, accounting for 25-60% of whole oligochaetes (Fig. 2). The SID in oligochaetes ranged from 2.6 to 5.7, with the mean value of 4.2 (Table 2).

Table 1. Relative abundance (%) of meio- and macroinvertebrates associated with macrophytes in Central Kalimantan (CK) and West Java (WJ).

CK 1: Cannel 1 in Dadahup area in the basin of the Kapuas River, CK (11 Dec. 1998)
CK 2: Cannel 2 in Dadahup area in the basin of the Kapuas River, CK (11 Dec. 1998)
CK 3: Fish culture pond in the basin of the Kapuas River, CK (11 Dec. 1998)
CK 4: Littoral Lake Tundai in the basin of Kahayan River, CK (12 Dec. 1998)
CK 5: Upper Sebangau River, CK (14 Dec. 1998)
CK 6: A canal in Belengbenkel area, Palangka Raya, CK (14 Dec. 1998)
WJ 1: A pond in Bogor Botanical Garden, Bogor, WJ (2 Mar. 2001)
WJ 2: Littoral Lake Bojongsari, Bogor, WJ (3 Mar. 2001)
WJ 3: Littoral Lake Cikaret, Bogor, WJ (4 Mar. 2001)

Vegetation: EM, emargent plant; SM, submerged plant; FF, freely floating plant

	CK 1	CK 2	CK 3	CK 4	CK 5	CK 6	WJ 1	WJ 2	WJ 3
Water temp.(C)	31.0	34.3	34.1	31.0	28.8	30.8	31.0	28.6	31.1
pH	2.9	2.9	4.2	4.5	3.6	3.9	6.5	6.5	7.2
Vegetation	SM	SM	SM	FF	EM	SM	SM	SM, FF	SM, FF
No. examined	756	806	481	659	305	612	825	663	832
Hydrozoa	0	0	0	0	0	0	0.2	0	0.2
Nematoda	0	0	9.4	0.3	0	0	0	0	0
Turbellaria	0	0	0.2	0	0	0	0	0.3	0
Mollusca	0	0	0	0	0	0	0	0	0.2
Oligochatea	0	7.1	7.1	1.6	0	0.5	8.7	2.6	2.9
Acarina	0	0.2	0.2	0.5	0	0	0.2	0	0
Conchostraca	0	0	0	0	0	0	0	9.5	0.1
Cladocera	76.0	19.9	53.6	36.1	83.3	65.7	43.9	48.3	47.9
Copepoda	8.7	47.6	10.4	31.3	7.5	28.2	27.1	33.8	19.8
Ostracoda	0	0	0	0.2	0	0	14.5	1.9	24.6
Decapoda	0	0	0	0	0	0	0.2	0.3	0.5
Odonata	0.1	0.2	0	0	0	0	0.5	0.3	0.6
Ephemeroptera	0	0	0	6.7	2.3	1.0	0.7	1.4	1.0
Hemiptera	0	0	14.1	3.8	0	0.2	0.1	0	0
Trichoptera	0	0	0	0.2	0.7	0.2	0	0	0
Lepidoptera	0	0	0	0	0.3	0	0	0	0
Chironomidae	12.2	24.9	5.0	19.3	5.6	3.8	3.9	1.6	2.2
Ceratopogonidae	3	0	0	0	0.3	0.2	0	0	0
Culicidae	0	0	0	0	0	0.2	0	0	0
Chaoboridae	0	0.1	0	0	0	0	0	0	0

Table 2. SID (Simpson's index of diversity) values for whole invertebrate and oligochaete communities associated with aquatic macrophytes in Central Kalimantan (CK) and West Java (WJ). No oligochaete was collected from CK 5.

	CK 1	CK 2	CK 3	CK 4	CK 5	CK 6	WJ 1	WJ 2	WJ 3
Invertebrates	1.6	3.0	3.0	3.7	1.4	1.9	3.4	2.8	3.0
Oligochaetes	1.0	1.7	1.8	2.0	—	1.0	4.3	5.7	2.6

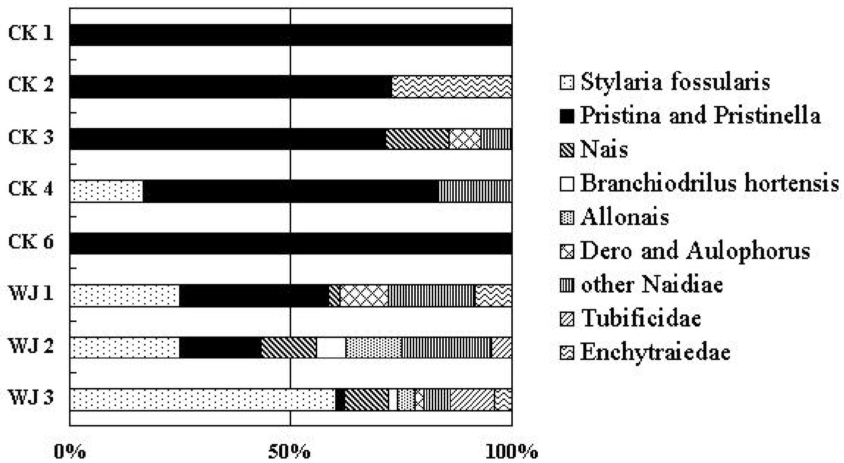

Figure 2. Dendrogram resulting from an average-linkage cluster analysis of invertebrate communities associated with macrophytes in 9 localities studied.

Comparison of faunal composition and diversity between CK and WJ

Diversity indexes (SID) for whole invertebrate communities studied were not significantly different between CK and WJ. It is common to both regions that relative abundances of cladocerans and/or copepods were highest among the invertebrate assemblages, and the proportions of these two groups of animals combined among the whole invertebrates were not significantly different between the two regions. On the other hand, the relative abundance of chironomids was

Table 3. Comparison of oligochaete fauna associated with aquqatic macrophytes between Central Kalimantan (CK) and West Java (WJ).

+ , occurrence; ++ most dominant taxon

	CK 1	CK 2	CK 3	CK 4	CK 5	CK 6	WJ 1	WJ 2	WJ 3
Family Naididae									
Chaetogaster diaphanus (Gruithuisen, 1828)								+	+
Nais pardalis Piguet , 1906							+	+	+
Allonais pectinata (Stephenson, 1910)								+	+
A. paraguayensis (Michaelsen, 1905)								+	
Dero digitata (Müller, 1773)							+		
Aulophorus furcatus (Müller, 1773)			+						
Branchiodrilus hortensis (Stephenson, 1910)								+	+
Pristina longiseta Ehrenberg, 1828		+				+	+	+	
P. aequiseta Bourne, 1891	+						+		
P. biserrata Chen, 1940			+	++				+	+
P. proboscidea Beddard, 1896	++	++	+	+		++			
Pristinella sp.			++						
Stylaria fossularis Leidy, 1852				+			++	++	++
other naidids			+				+	+	+
Family Tubificidae									
Limnodrilus hoffmeisteri Clapar`ede, 1862								+	+
Branchiura sowerbyi Beddard, 1892								+	
other tubificids									+
Family Enchytraeidae									
Enchytraiedae non det.		+					+		+

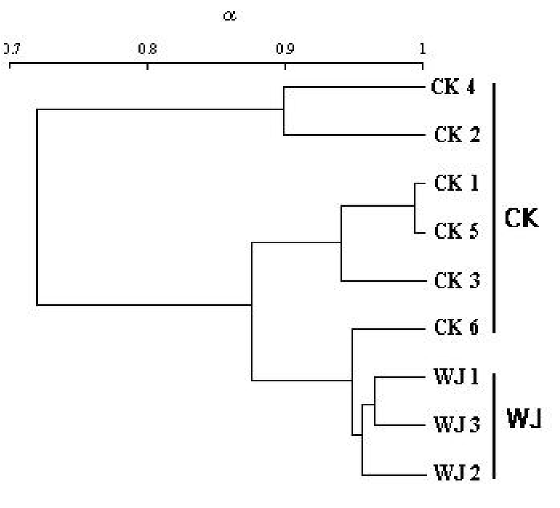

Figure 3. Relative abundances of oligochaetes associated macrophytes in 9 localities studied.

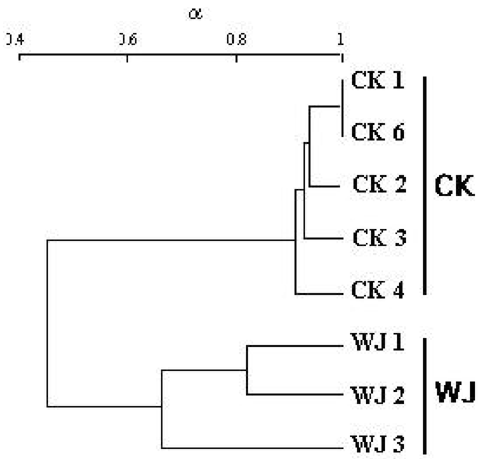

Figure 4. Dendrogram resulting from an average-linkage cluster analysis of oligochaete communities associated with macrophytes in 8 localities studied.

significantly higher in CK ($0.01<p<0.05$), whereas that of ostracods was significantly higher in WJ ($0.01<p<0.05$). The invertebrate structures were not so clearly distinguished as oligochaete structures (below mentioned) between study sites, although three WJ sites made up a single cluster (Fig.3).

A total of eighteen taxa of oligochaetes were recorded from the two regions in the present study. Although relative abundances of oligochaetes among invertebrate communities were not significantly different between CK and WJ, species composition was largely different from each other. That is, the number of taxa recorded was twice higher (16) in WJ than in CK (8), and *Pristina* and *Pristinella* species dominated in CK, while *Stylaria fossularis* dominated in WJ. The SID for oligochaetes was significantly higher in WJ (mean 4.2) than in CK (mean 1.5) ($0.01<p<0.05$). The oligochaete compositions in CK and WJ sites were clearly distinguished from each other as distinct clusters in which the similarity values α were higher than 0.9 and 0.6, respectively (Fig. 4)

DISCUSSION

It has been recognized that chemistry of inland waters is much variable in southeast Asia. Johnson (1967a) once pointed out that blackwaters in southern Malaya are characterized by having low pH with high concentration of sulphuric acid, low alkalinity and lacking in calcium, and they are differ widely in their chemistry from waters in Java and Bali reported by Rutnner (1931). Quantitative and qualitative differences in freshwater biota between different areas in southeast Asia may, therefore, largely depend on water chemistry as well as zoogeographical differences, as suggested in the prawns (Johnson, 1966), fish (Johnson, 1967b) and odonates (Furtado, 1969) communities. However, information of freshwater invertebrate faunal differences within southeast Asian freshwaters is still remained in restricted groups of animals.

By the viewpoint of oligochaete fauna, the Indo-Malayan subregion of the Sino-Indian zoogeographical region, which includes both Kalimantan and Java, is characterized by numerous species of Naididae (Timm, 1980). Thirty-five oligochaete species have so far been recorded from Sumatra, Kalimantan, Java and Bali (Michaelsen & Boldt, 1932; Ohtaka and Usman, 1997; Ohtaka et al., 2000), of which naidids dominated in every islands. The naidids became diverse in vegetated area (Learner et al., 1978), and their predominant occurrence in epiphytic macrofauna has been founded not only in tropical Asia but also in temperate region (Ohtaka and Morino, 1986). The present study points out that oligochaete diversity is significantly lower in CK, and the specific composition is largely different between CK and WJ, although many of the species show potentially wide distribution (Brinkhurst & Jamison, 1971) and CK and WJ close to each other in the common zoogeographical subregion. Therefore, the faunal differences between CK and WJ might be related with water qualities.

Acid waters are generally characterized by low species diversity and low productivity (Welch, 1952), and major animal groups are poorly represented or often lacking there (Wetzel, 1983; Ward, 1992). These tendencies have been demonstrated mainly in *Sphagnum* bog waters in cool climate regions. Ohtaka (2000) recorded 17 oligochaetes from acidic *Sphagnum* bog waters in Ozegahara Mire, central Japan, where the pH ranged 4.6-5.3. In his survey, *Pristina aequiseta* most frequently occurred among naidids, and no *Stylaria fussularis* were found, although the latter species is very common in neutral waters in surrounding areas (Ohtaka, unpubl.). Such faunal characteristics resemble those in CK sites of the present study in that *Pristina* and/or *Pristinella* species are predominant and *Stylaria* is rarely found. Therefore, faunal composition as well as low diversity in CK might be related with low pH in the waters.

In the present study, diversity index for whole invertebrates and relative abundance of every higher taxonomic groups except for chironomids and ostracods were not significantly different between CK and WJ. However, it is highly probable that the species composition is really different form each other in many higher taxonomic groups, as the case in oligochaetes. Taxnomic studies are badly needed for many groups of invertebrates to make faunal characteristics clear in detail.

ACKNOWLEDGMENTS

This study was a part of the Core University Program between Hokkaido University, Japan and R & D Center of Biology, LIPI, Indonesia, sponsored by Japan Society for the Promotion of Sciences.

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Speciation Analysis of Mercury in River Water in West Java-Indonesia

Yustiawati[1], M. Suhaemi Syawal[2], Motoki Terashima[1], Shunitz Tanaka[1*]
[1]Division of Material Science, Graduate School of Environmental Earth Science,
Hokkaido University, Sapporo 060-0810, Hokkaido, Japan
[2]Research Center for Limnology, Indonesian Institute of Sciences

Correspondence author:
Shunitz Tanaka,Tel/Fax: +81-11-7062219
Email address: shunitz@ees.hokudai.ac.jp

ABSTRACT

Cikaniki river and Cidikit river have been contaminated by mercury because the gold mining process. Mercury speciation was studied in these rivers. Sampling was carried out in October 2001 and September 2002. It is well known that humic acid has the ability to bind metal ion, this aspect is important for environment because the toxicity and the movement of mercury might be changed by complex formation.

In all sampling sites, high concentration of mercury was found out in suspended particles. The image of suspended particles observed by Scanning Electro Microscope and the elemental analysis data by X-Ray spectroscopy showed that the suspended particles were like clay mineral. The cationic and anionic species of mercury were also found in the sample water but the concentration was relatively low. Since the presence of humic acid was observed in the river water, anionic species of mercury seemed to be the complex of mercury with humic acid. The total concentration of mercury in Cikaniki River was higher than the maximum tolerable concentration (0.002 mg/l), based on Indonesian Government regulation for river water. In Cidikit River, the concentration is less than maximum tolerable concentration. The concentration of humic acid was also measured to reveal the relation between the distribution of mercury and humic acid; however, the relation is not clear up to the present.

In laboratory, the conditional stability constant and the complexing capacity of humic acid and mercury were estimated by Scatchard plot, at pH 6, with 5 mg/l of humic acid and mercury (II) solution in the concentration 0 to 0.6 µM. The obtained conditional stability constant between mercury (II) and humic acids is log Kí= 6.5 at pH 6 and the complexing capacity of mercury (II) is 0.38 µM.

Key words: mercury speciation, humic acid, stability constants, complexing capacity

INTRODUCTION

In West Java Indonesia, there are several rivers that have been contaminated by mercury, because of many gold mining activities where elemental mercury is used to extract gold from soil containing gold ore. Mercury is discharged into the river as elemental form from various processes of gold mining activities, but this elemental mercury will be transformed to other forms such as inorganic, organic mercury and adsorbing mercury on suspended particles, etc. In other hand, humic substances are widely distributed in natural water and soils (M.Schnitzer and S.U.Khan, 1972). It is well known that humic substances (humin, humic and fulvic acid) have a substantial capacity to complex heavy metal ions and cationic organic molecules (Ying-Jie Zhang *et al.,* 1996). This aspect is important for environment because the toxicity and the movement of mercury might be changed by the complex formation. The presence of organic acids such as humic acid in soils and sediment of rivers increases the solubility of mercury (0) by the mechanisms involving solubilization and formation of complex, this process considerably with time (Melamed *et al*., 2000).

In this study, the mercury contamination level in two rivers in west Java, Cikaniki and Cidikit River, and the mercury speciation in river water were investigated as well as the complex formation between humic acid and mercury. The conditional stability constant and the mercury complex capacity of humic acid were also estimated.

METHODS

Location

This study was conducted at Cikaniki and Cidikit River, west Java, Indonesia. Samples were taken two times in October 2001 and September 2002. Three sampling sites in each river were chosen from upstream to down stream.

Separation Method

The mercury in sample water was divided into four species; adsorbing mercury on suspended particles, total dissolved mercury, cationic and anionic species such as complex with humic acid. The water sample was at first filtered by 0.45 µm membrane filter. The undissolved Hg, adsorbing mercury on suspended particles remained on the membrane filter. cation resin C-25 was added into the solution containing dissolved Hg to separate cationic and anionic species. The cationic species adsorbed on the resin and the anionic species such as HA-Hg complex remained in the supernatant. Each species was measured by Mercury Analyzer (Hiranuma HG-300) after decomposition of organic matter in the solution.

Decomposition Methods

To the prepared samples were added 1 ml of H_2SO_4 (1:1), 1 ml of HNO_3 concentrate, and 2 ml of $KMnO_4$ (50g/l), after shaking for 15 minutes, then 1ml $K_2S_2O_8$ was added. These sample solutions were heated at 95°C for 2 hours, to complete the decomposition process. After cooled at the room temperature, 1 ml of hydroxylamin chloride was added to neutralize the excess of $KMnO_4$, and the solution was diluted to 50 ml with a volumetric flask and then measured by Mercury Analyzer.

Mercury complexing ability of humic acid

The two set of the mercury solutions in the range 0 to 6 μM Hg were prepared at pH 6. The humic acid of Jangraga was added to the second set of the mercury solution, where the concentration of humic acid in each solution was 5 mg/l, and pH was adjusted to 6. 0.2 g of resin C-25 was added to all the solution, followed by shaking for 30 minutes. The cationic Hg species will adsorb on the resin, and the anionic HA-Hg species will remain in the supernatant. The free Hg concentration in the solution with and without humic acid was measured by Mercury Analyzer. These data were used for a Scatchard plot (Fukushima, 1993). The conditional stability constant of HA-Hg and complexing capacity of humic acid for Hg could be calculated.

RESULTS AND DISCUSSION

The distribution of three mercury species in Cikaniki and Cidikit river was shown in Fig.1 and 2. In all sampling sites, high concentration of mercury was found out in suspended particles. This results were similar with Loire and Seine river in France that was observed by Coquery,M (1997). It indicated that mercury in river water mostly presents as adsorbing species on suspended particle. The image of suspended particles observed by Scanning Electro Microscope and the elemental analysis data by X-Ray spectroscopy showed that the suspended particles were like clay mineral. The cationic and anionic species of mercury were also found in the sample water but the concentration was relatively low.

The total concentration of mercury in Cikaniki river in 2001 was higher than the maximum tolerable concentration (0.002 mg/l), based on Indonesian Government regulation for river water. However, in 2002 the concentration has been decreased drastically.

This situation probably related to the decrease of the number of gold mining process in Cikaniki river. It is due to the government effort, that is the government prohibited gold mining in this river.

The distribution of mercury in Cidikit River is shown in Fig.2. The contamination with mercury was also found, however the concentration of mercury was less than maximum tolerable concentration. The average concentration of Hg in 2001 and 2002 did not indicate the significant difference.

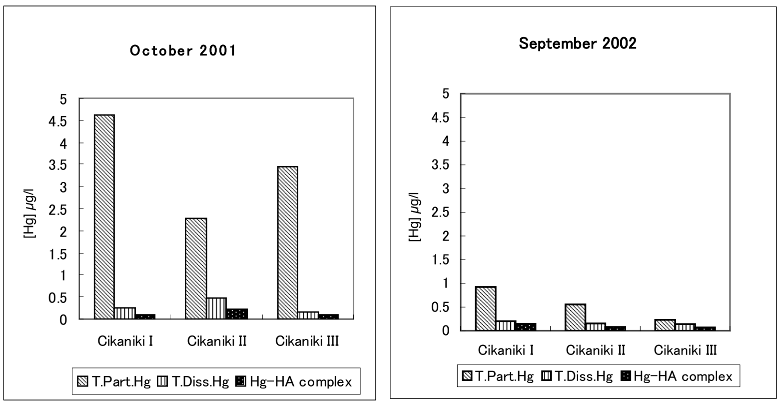

Figure 1. Mercury speciation in Cikaniki river.

The stability constants and the complexing capacities of humic acid to heavy metal ions are the quantitative indicators for the interaction between heavy metal ions and humic acid. In this study, the conditional stability constant and the complexing capacity of humic acid of Jangraga with mercury were estimated by Scatchard plot, at pH 6, with 5 mg/l of humic acid, and mercury (II) solution in the range of the concentration 0 to 0.6 μM. The obtained conditional stability constant between mercury (II) and humic acids and the complexing capacity of mercury (II) are shown in Table 1.

The concentration of humic acid in river water was also measured to reveal the relation between the distribution of mercury and humic acid, unfortunately the relation is not clear up to the present (Table 2).

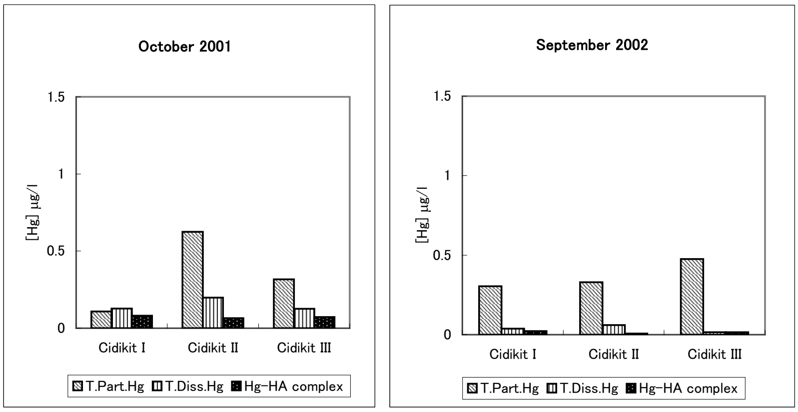

Figure 2. Mercury speciation in Cidikit river.

Table 1. Conditional stability constant (K') and Hg (II) complexing capacity (C_L) of humic acid at pH 6.

Humic Acid (mg l^{-1})	Log K'	C_L (μM)
Jangraga Humic Acid (5 mg l^{-1})	6.5	0.38

Table 2. Total mercury species and humic acid level.

	Location	Total Mercury (ug/l)		Hg-HA complex (ug/l)		[Humic Acid]* ppm		[TOC] ppm	
		2001	2002	2001	2002	2001	2002	2001	2002
1	Cikaniki Station 1	4.864	1.128	0.085	0.148	1.000	1.188	5.768	4.714
2	Cikaniki Station 2	2.743	0.715	0.228	0.083	1.093	1.250	4.642	3.707
3	Cikaniki Station 3	3.630	0.370	0.107	0.073	0.465	1.188	3.396	4.008
4	Cidikit Station 1	0.236	0.342	0.073	0.023	1.0930	0.271	2.167	3.074
5	Cidikit Station 2	0.823	0.390	0.065	0.008	1.000	0.416	2.454	4.200
6	Cidikit Station 3	0.443	0.490	0.443	0.015	0.628	0.354	2.723	5.243

*Reference standard: Humic acid Jangraga

CONCLUSION

Because of gold mining activities, mercury concentration in Cikaniki river in 2001 is over then maximum tolerable concentration (0.002 mg/l), based on Indonesia Government regulation for river water. By decreasing number of gold mining process, the concentration of Hg in Cikaniki river also decreased in 2002.

In river water, the concentration of mercury as adsorbing species on suspended species is highest compared to other species of mercury. The concentration of humic acid in Cikaniki and Cidikit river is low, therefore it is difficult to clarify the relation between Humic acid and mercury in river.

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Influence of Illegal Gold Mining on Mercury Levels in Cikaniki River in Pongkor Area, West Java - Bogor, Indonesia

Muhamad Suhaemi Syawal[1], Dede Irving Hartoto[1] and Tri Pandji[2]
[1)] Research Center for Limnology, Indonesian Institute of Sciences
Life Science Center Jl. Raya Jakarta Bogor KM 46 Cibinong, Bogor 16911 Indonesia
Tel: +62-21-8757071 Fax: +62-21-8757076
E-mail: syawalms@yahoo.com; lhartoto@indo.net.id
[2)] Faculty of Sciences Pakuan University, Bogor, Indonesia

Correspondence author:
Muhamad Suhaemi Syawal, Tel/Fax: +81-11-7062219
Email address: syawalms@ees.hokudai.ac.jp and syawalms@yahoo.com

ABSTRACT

River is a part of inland water system with potential resource of drinking water, irrigation and aquatic living thing. Degradation of surface water has now been threatening the purpose and even sustainability. One of the rivers getting such a threat is River Cikaniki that located in Nanggung (Pongkor), a sub district of Bogor, which flows and terminated Cisadane River. Mercury pollution from illegal gold mining operations represents a serious environmental problem in this river. The illegal gold mining activities occurred in the upstream segment of the river, causes erosion, sedimentation, and the disposal of mercury as waste of gold ore processing into the river. The mining activities highly influenced water quality of the river, which is used for domestic purposes by the surrounding community. The aims of this study were to reveal physico-chemical water quality and include mercury level in the river body, the rate of pollution and location of pollution. The study was carried out in September to December 1999 by collecting and analyzing physical and chemical parameters in four observations and at different time in Cikaniki. Primary parameters that were observed are pH, DO, BOD, COD, NH_3-N, and Total mercury. Supporting parameters such as current, temperature, conductivity and turbidity were also taken. The result showed that majority of water quality parameters of Cikaniki River are still under tolerable value based on Indonesian Government regulation for river water (PP No. 20 1990). Some other parameters that showed values outside the maximum limit are BOD (0.97 - 4.49 mg/l), COD (8.78 - 59.43 mg/l), NH_3-N (0.001 - 0.086 mg/l) and T-Hg (0.0023 - 0.1743 mg/l). Based on the observation on the mentioned parameter, it is concluded that pollution has occurred in every station and time of observation. Mercury had average concentration as high as 35 times of its maximum limit stated for group C (0.002 mg/l). Based on the result, some parameters have to be taken in to account and need direct mitigation of the pollutant, especially the impact of mercury pollution.

Key words: illegal gold mining, mercury, Cikaniki River - Pongkor

INTRODUCTION

Cikaniki River is located at Nanggung District, approximately 45 km west of Bogor, West Java, Indonesia. Almost all people who live in surrounding area use Cikaniki River for domestic purposes such as washing, bathing and others, but for drinking water they use shallow well water.

In the upper stream, there are illegal gold mining that already develop since 1992. At the end of 1996, it was noted that about 3000 people was working there. The illegal gold mining caused some impacts to environment such as deforestation, erosion, water pollution and air pollution. Direct impacts of illegal gold mining to Cikaniki river are the changed of physical characters and chemical composition of water body. It is clear that the contamination source are from the gold extracting process. Related to the local people utilization style of Cikaniki River water that was for domestic purposes, this study is limited to the water quality aspects.

The principal objectives of this study were to evaluate the seasonal variability of the physico-chemical water quality, level and location of pollution in the river segment. This information is necessary in order to assess pollution status of the river with reference to permissible level and to provide baseline data for future studies.

MATERIALS AND METHODS

Location

The samples were collected in seven stations or villages along the Cikaniki River between September until December 1999 (four times). The villages are located at 06°37' - 06°34' S and 106°32' - 106°33' E. The names of the villages are (1) *Curug Bitung Hulu*, (2) *Curug Bitung Hilir*, (3) *Pondok Peucang*, (4) *Bongas,* (5) *Lukut*, (6) *Pasir Gintung* and (7) *Panjaungan* (Fig. 1). Station 2 and 4 are the sites where the river water are used by the illegal gold miners as power source and washing agent for processing the gold ore, while in other stations the processing was done using electricity as source of energy. The main features of the sampling stations are summarized in Table 1.

Sample analysis

Methods of analyzed and collecting sample have been described by Standard Methods of American Public Health Association *et al*. (1997) and were carried out at Hydrochemistry laboratory - Research Center for Limnology. Water samples for heavy metal analyses were collected in glass bottles that were previously washed in nitric acid and the other water samples were contained in non-acidified polypropylene bottles.

Some parameters such as pH, dissolved oxygen (DO), temperature, conductivity and turbidity were directly measured in the field Horiba U-10 Water Quality Checker. Water Currents and position were measured using current meter and GPS - Garmin L 400 respectively. Dissolve Oxygen and Biological Oxygen Demand concentration were determined using titrimetric Winklerís. Chemical Oxygen Demand concentration was determinated by Spectrophotometer HACH DR 2010 with dichromate method. Ammonia concentration was determinated by Spectrophotometer UV-21 Shimadzu with phenate method. Mercury concentration in were measured by cold-vapour atomic absorption spectrophotometer (CV-AAS) with cold vapour methods.

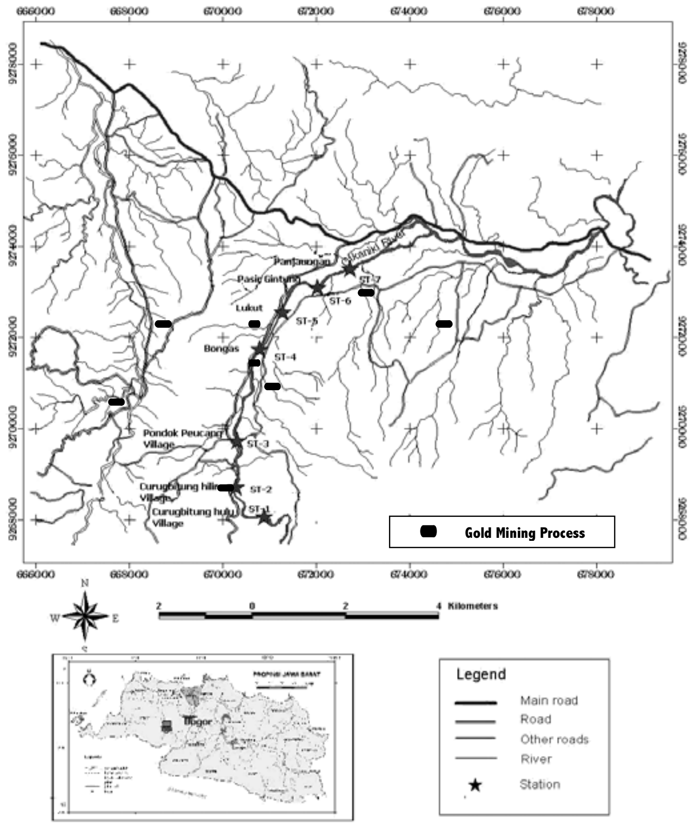
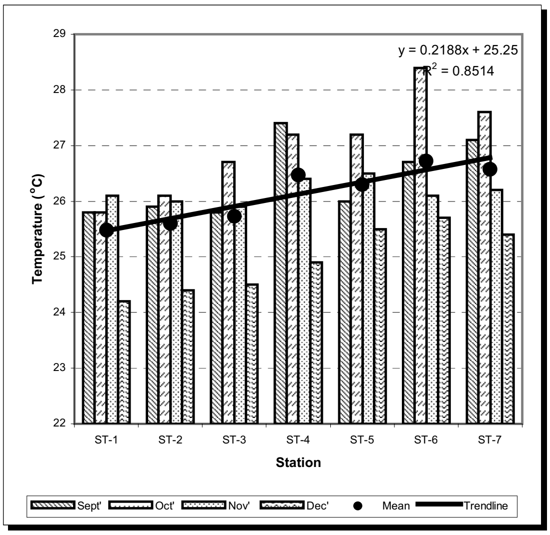


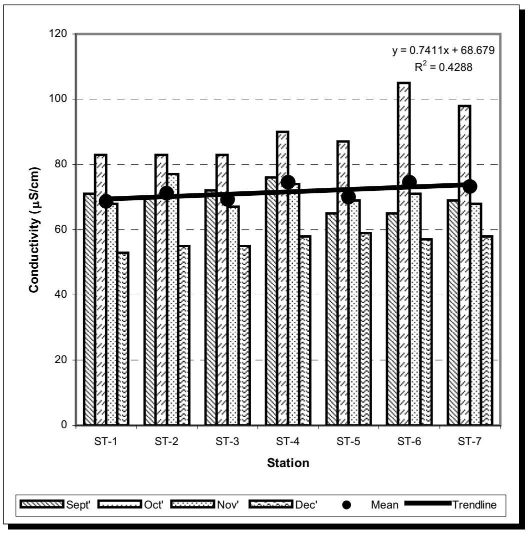
Figure 1. Location of study area showing the distribution of Illegal Gold Mining Activities

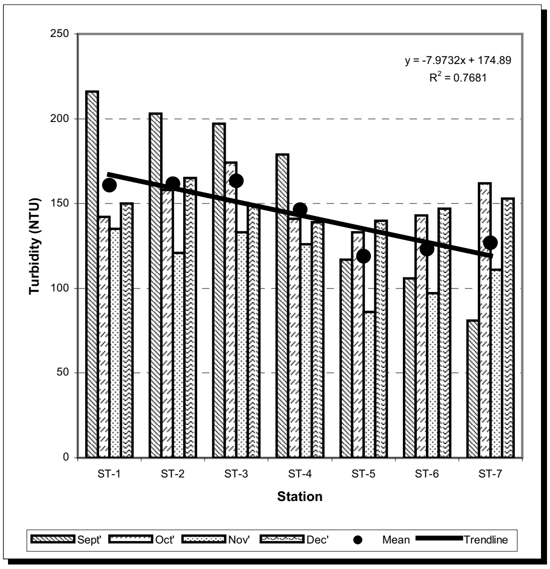
Table 1. Main features of sampling stations in Cikaniki River

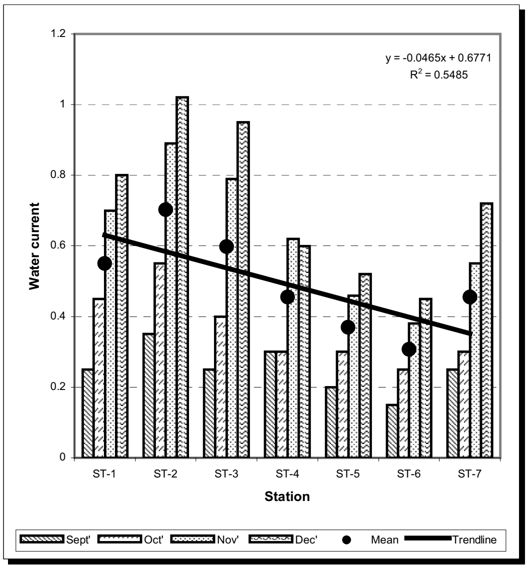
Sampling stations	Distance*	Villages	Position	Depth (m)	Width (m)	Character
ST - 1	0	Curug Bitung Hulu	S: 06° 37' 05.6" E: 106° 32' 32.1"	1.1 - 1.8	65	◊ Slow current ◊ Rocky ◊ Bathing & washing
ST - 2	400	Curug Bitung Hilir	S: 06° 37' 01.7" E: 106° 32' 31.4"	1.0 - 1.5	15	◊ Ore Processing at river segment ◊ Strong current ◊ Rocky
ST - 3	2950	Pondok Peucang	S: 06° 36' 17.8" E: 106° 32' 27.7"	1.5 - 2.2	27	◊ Slow current ◊ Ore processing at home ◊ Rocky ◊ Traditional Market
ST - 4	4775	Bongas	S: 06° 35' 15.5" E: 106° 32' 37.5"	1.0 - 1.3	45	◊ Ore Processing at river segment ◊ Strong current ◊ Rocky ◊ Bathing & washing
ST - 5	6400	Lukut	S: 06° 34' 47.8" E: 106° 32' 50.0"	0.60 - 1.1	33	◊ Ore processing at home ◊ Slow current ◊ Rocky
ST - 6	7950	Pasir Gintung	S: 06° 34' 18.5" E: 106° 33' 31.1"	1.5 - 2.0	15	◊ Slow current ◊ Ore processing at home ◊ Irrigation Dam
ST - 7	9150	Panjaungan	S: 06° 34' 12.3" E: 106° 33' 46.1"	0.8 - 1.1	27	◊ Slow current ◊ Ore processing at home ◊ Rocky ◊ Bathing & washing

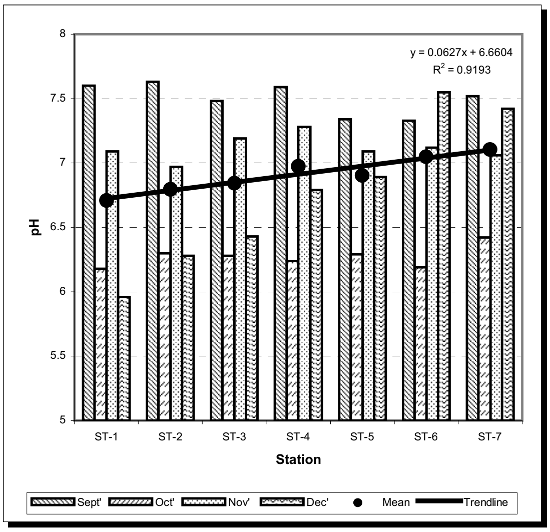
*Distance from the uppermost sampling station

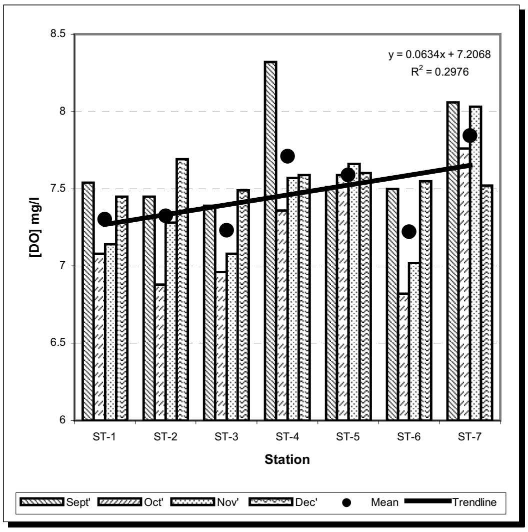

y = 0.2188x + 25.25
R^2 = 0.8514
Temperature (°C)
Station
ST-1 ST-2 ST-3 ST-4 ST-5 ST-6 ST-7
Sept' Oct' Nov' Dec' Mean Trendline


y = 0.7411x + 68.679
R^2 = 0.4288
Conductivity (µS/cm)
Station
ST-1 ST-2 ST-3 ST-4 ST-5 ST-6 ST-7
Sept' Oct' Nov' Dec' Mean Trendline


y = -7.9732x + 174.89
R^2 = 0.7681
Turbidity (NTU)
Station
ST-1 ST-2 ST-3 ST-4 ST-5 ST-6 ST-7
Sept' Oct' Nov' Dec' Mean Trendline


y = -0.0465x + 0.6771
R^2 = 0.5485
Water current
Station
ST-1 ST-2 ST-3 ST-4 ST-5 ST-6 ST-7
Sept' Oct' Nov' Dec' Mean Trendline


y = 0.0627x + 6.6604
R^2 = 0.9193
pH
Station
ST-1 ST-2 ST-3 ST-4 ST-5 ST-6 ST-7
Sept' Oct' Nov' Dec' Mean Trendline


y = 0.0634x + 7.2068
R^2 = 0.2976
[DO] mg/l
Station
ST-1 ST-2 ST-3 ST-4 ST-5 ST-6 ST-7
Sept' Oct' Nov' Dec' Mean Trendline

Continued:

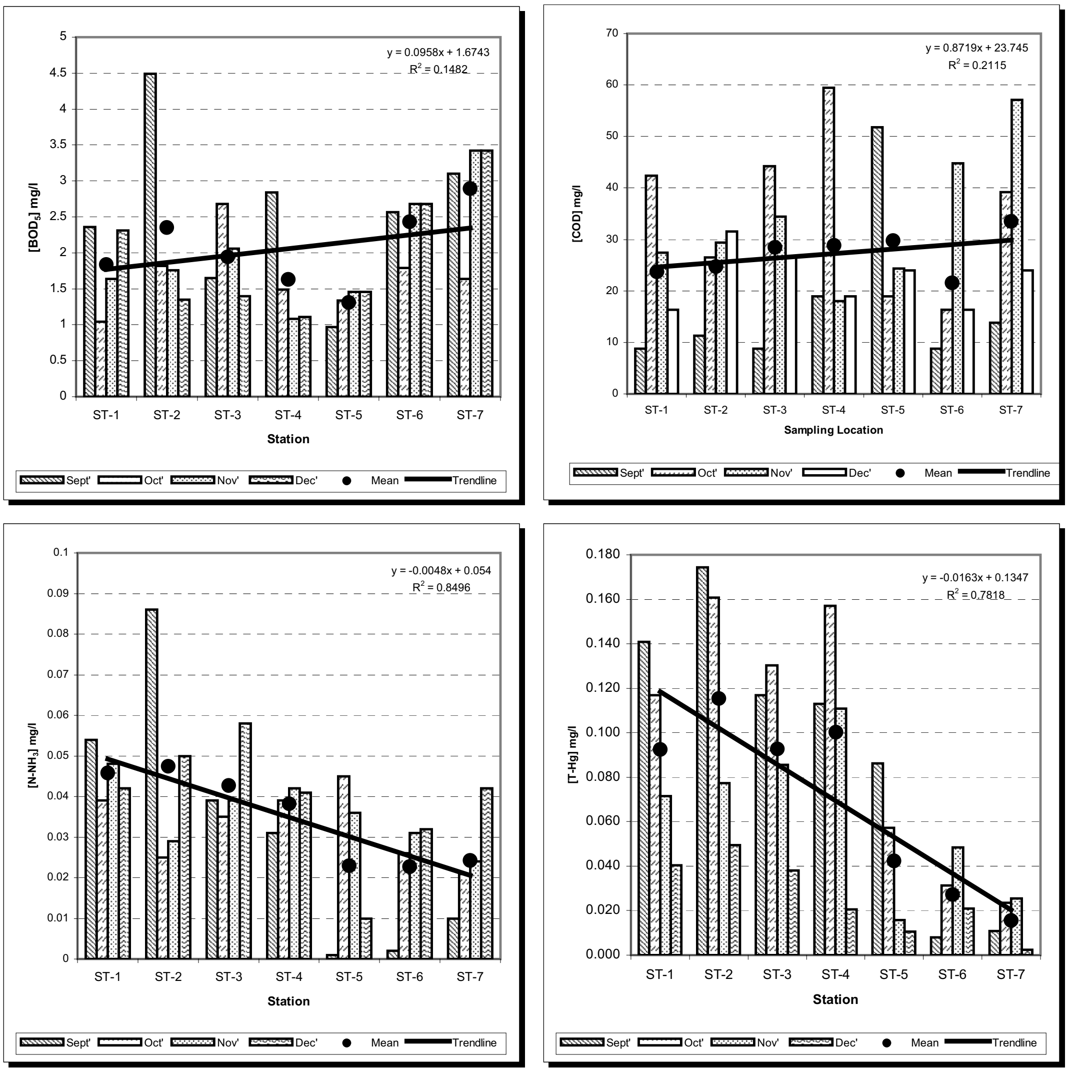


Figure 2. Annual average values of temperature, conductivity, turbidity, water current, pH, DO, BOD_5, COD, $N\text{-}NH_3$, and total mercury at seven stations Water Quality Monitoring in Cikaniki River.

RESULTS AND DISCUSSION

The water quality parameters in this river varied over the course of season, responding to varying hydrological and climatic conditions. In rainy season (December 1999), soil inputs from surface erosion and bank sloughing during hydrological events resulted in elevated levels.

The distance of river which observed is about 9.15 km with 2.2 m maximum depth. During observation, water temperature was 24.2 to 28.4 ^{o}C. In water body, many stones occurred along the river, the water current was relatively torrent in the average 0.49 m/sec. In some parts of the river, small dams were made by miners for rotating drums that contained the mixture of the soil and mercury. This activity caused the increasing of turbidity with range is 81 to 216 NTU.

The range of pH in this river was in 5.96 - 7.63 and the average is 6.91. The lowest pH observed in station 1, probably it caused mineral area that contained pyrite (FeS_2) in this vicinity. Canter (1977) said that tolerable limit of pH for aquatic organism is variable; depend on some factor such as temperature, DO, anion and cation. The pH in ideal aquatic is in range 6.5 - 8.5. Generally, pH in Cikaniki River was still in normal level.

During observation, DO concentration was in the range 6.8 - 8.06 mg/l. It indicated DO concentration in this river was good condition. The physical conditions of Cikaniki river that has high current and many stones occurred, can involve aeration in the water body.

Biological Oxygen Demand (BOD_5) concentration was in the range 0.97 - 4.49 mg/l. It indicated Cikaniki River has been contaminated with organic waste in medium level, according to the criteria of water quality in Indonesia (1990). Fluctuation of BOD concentration is influenced by undegradable organic waste that loading into the river from domestic

Table 2. Average Data Physico-chemistry Water Cikaniki River from September until December 1999

Parameters	Units	Sampling Location and Distance between station (meter)						
		ST-1 0	ST-2 400	ST-3 2950	ST-4 4775	ST-5 6400	ST-6 7950	ST-7 9150
Temperature	^{0}C	24.2 - 26.1 (25.5)	24.4 - 26.1 (25.6)	24.5 - 26.7 (25.7)	24.9 - 27.4 (26.5)	25.5 - 27.2 (26.3)	25.7 - 28.4 (26.7)	25.4 – 27.6 (26.6)
Conductivity	μS/cm	53 - 83 (68.8)	55 - 83 (71.3)	55 - 83 (69.3)	58 - 90 (74.5)	59 - 87 (70.0)	57 - 105 (74.5)	58 - 98 (73.3)
Turbidity	NTU	135 - 216 (161)	121 - 203 (162)	133 - 197 (163)	126 - 179 (146)	86 - 140 (119)	97 - 147 (123)	81 - 162 (126)
Water Current	m/sec	0.25 - 0.80 (0.55)	0.35 - 1.02 (0.70)	0.25 - 0.95 (0.60)	0.30 - 0.62 (0.46)	0.20 - 0.52 (0.37)	0.15 - 0.45 (0.31)	0.25 - 0.72 (0.46)
pH	-	6.0 - 7.6 (6.7)	6.3 - 7.6 (6.8)	6.3 - 7.5 (6.8)	6.2 - 7.6 (6.9)	6.3 - 7.3 (6.9)	6.2 - 7.5 (7.05)	6.4 - 7.3 (7.11)
Dissolved Oxygen	mg/l	7.08 - 7.54 (7.30)	6.88 - 7.69 (7.33)	6.96 - 7.49 (7.23)	7.36 - 8.32 (7.71)	7.51 - 7.66 (7.59)	6.82 - 7.55 (7.22)	7.51 - 8.03 (7.84)
BOD_5	mg/l	1.04 - 2.36 (1.84)	1.35 - 4.49 (2.36)	1.40 - 2.68 (1.95)	1.08 - 2.84 (1.63)	0.97 - 1.46 (1.31)	1.21 - 2.68 (2.43)	0.69 - 3.42 (2.90)
COD	mg/l	8.79 - 42.3 (23.74)	11.31 - 31.57 (24.70)	8.78 - 44.20 (28.49)	18.0 - 59.4 (28.81)	18.9 - 51.83 (29.78)	8.78 - 44.8 (21.59)	13.9 - 57.1 (33.52)
NH_3-N	mg/l	0.039 - 0.054 (0.046)	0.025 - 0.086 (0.048)	0.035 - 0.058 (0.043)	0.031 - 0.042 (0.038)	0.001 - 0.045 (0.023)	0.002 - 0.032 (0.023)	0.01 - 0.042 (0.024)
Mercury (Hg)	mg/l	0.041 - 0.141 (0.092)	0.049 - 0.174 (0.115)	0.038 - 0.130 (0.093)	0.025 - 0.157 (0.100)	0.011 - 0.086 (0.042)	0.008 - 0.048 (0.027)	0.002 - 0.023 (0.016)

( ): Average
Location: ST - 1: Curug Bitung Hulu ; ST - 2: Curug Bitung Hilir; ST - 3: Pondok Peucang; ST - 4: Bongas; ST - 5: Lukut; ST - 6: Pasir Gintung; ST - 7: Panjaungan

waste. Chemical Oxygen demand (COD) in this river was in the range 8.78 to 59.43 mg/l, it indicated this river has been heavy polluted.

The range of ammonia concentration during observation was 0.001-0.086 mg/l. The main source of this contamination was from domestic waste. Canter (1977) suggested that ammonia concentration in tropical aquatic environment must be not more than 1 mg/l because it will inhibit oxygen absorption by hemoglobin, that cause fish and other animal will be died. In the other hand, limit tolerable of ammonia concentration for river water in the criteria of water quality in Indonesia (1990) is 0.02 mg/l; therefore, it indicated that this river has been contaminated by ammonia.

Mercury concentration is in range 0.002 - 0.174 mg/l. The highest concentration observed in September and October while the gold mining activities was very high in that time. Residue, leaching and waste mercury from gold mining activities directly loaded into the river. In December, concentration of mercury decreased because of dilution by heavy rainy and also the decreasing the number of gold mining. Based on The Indonesian Government Regulation for river water (PP. 20/1995), the limit tolerable of mercury is 0.002 mg/l; therefore, it indicated that Cikaniki River has been heavy polluted with mercury.

CONCLUSION

Some parameters such as temperature, conductivity, turbidity, pH, DO were still under limit
tolerable value of water quality for river water. Others parameter of water quality indicated that Cikaniki River has been polluted, those parameters are:

- Mercury (Hg): average concentration of Total Hg is 35 times higher than limit tolerable value (0.002 mg/l) of Indonesian Government Regulation No. 20, 1990.
- BOD and COD: BOD was not so high but COD is high, it indicated there was toxic pollution in the Cikaniki River.
- Ammonia concentration is higher than limit tolerable value (0.02 mg/l).

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Epiphytic Algae of Aquatic Macrophytes from Some Oxbow Lakes of Central Kalimantan

Sulastrilastri, D.I.Hartoto and Sugiharti
Research Center for Limnology, Indonesian Institute of Sciences,
Kompleks LIPI Cibinong, Jl. Raya Bogor-Jakarta, Km 46,
CIBINONG-BOGOR. 16911.
Tel: 021-8757071, Fax: 021-8757076.
E-mail: lastri@indo.net.id

ABSTRACT

Epiphytic algae of aquatic macrophytes were studied in Lake Tabiri, Lake Takapan and Lake Rengas in 2002. The study was conducted to reveal the composition and abundance of epiphytic algae in immersed parts of some aquatic macrophytes in humic lakes. Epiphytic algae were studied from *Salvinia molesta*, *Eichhornia crassipes*, *Cyrtococcum sp* as representatives of floating aquatic macrophytes and *Polygonum lapathifolium* as a submerged macrophytes that grow from the bottom reaching to the surface of the lake. Diatoms or Bacilllariopyceae group dominated the epiphytic algae community. Beside diatom, a group of desmids are commonly found in this community of epiphytic algae. The abundance of epiphytic algae collected on *E crassipes* range from 1,790,036 to 286,898,867 cell/m^2, while the abundance of epiphytic algae collected on *Cyrtococcum* sp range from 2,793,424 to 123,984,278 cell/m^2. The abundance of epiphytic algae colleted on *S. molesta* and *P. lapathifolium* were 1,731,767 and 119,022,754 cell/m^2 respectively. The abundance of epiphytic algae is higher in Lake Tabiri compared to the abundance of epiphytic algae collected from the same species of aquatic macrophytes found in Lake Takapan and Lake Rengas. The highest abundance of epiphytic algae in Lake Tabiri may be influenced by some environmental factors such as pH, conductivity and Secchi depth that were found in higher in that lake. The architecture of aquatic macrophytes seems influence the abundance of epiphytic algae in Lake Tabiri.

Key words: epiphytic algae, aquatic macrophytes, humic, oxbow lake.

INTRODUCTION

Aquatic macrophytes such as water hyacinth (*Eichhornia crassipes) and* water fern *(Salvinia molesta)* are common found blooming in eutrophic inland waters of Java and Sumatera. These aquatic macrophytes are also found in humic floodplain and oxbow lakes of River Kahayan such as Lake Tabiri, Lake Takapan and Lake Rengas in Central Kalimantan. These lakes have the range of pH value from 5.50 to 5.80, 5.01 to 5.55 and 4.50 to 5.31 respectively**.**

Study on phytoplankton abundance in some humic oxbow lakes of Central Kalimantan such as Lake Lutan, Takapan and Rengas showed that the abundance of phytoplankton was relative low, with the range of phytoplankton abundance 441-3495 individuals/L, 149 -3337 individual/L and 293 - 2948 individual/L respectively (Sulastri & Hartoto, 2000). It is possibly that the direct contribution of phytoplankton as food resources for aquatic organism such as fishes is low in that humic oxbow lake ecosystem. Beside the insects, food resources of aquatic organisms also come much from allochthonous material and aquatic macrophytes in that humic oxbow lake ecosystem. Aquatic macrophytes are also habitat for macroinvertebrates and epiphytic algae because of the plant partly play as a kind of detritus filter and rich in nutrient. Gallanti and Romo as cited in Cattaneo (1998) reported that epiphyton contribute significantly to supply the carbon and food resources of fish in Italian lake ecosystem. This study was conducted to reveal the composition and abundance of epiphytic algae in immersed parts of some aquatic macrophytes found in Lake Tabiri, Lake Takapan and Lake Rengas.

MATERIALS AND METHODS

The study was conducted in Lake Tabiri, Lake Takapan and Lake Rengas, as a part of the floodplain system of River Kahayan (Figure 1). Samples of epiphytic algae were collected from the submerged part of aquatic macrophytes such as *Eichhornia crassipes; Salvinia molesta* and a member of Poligonaceae

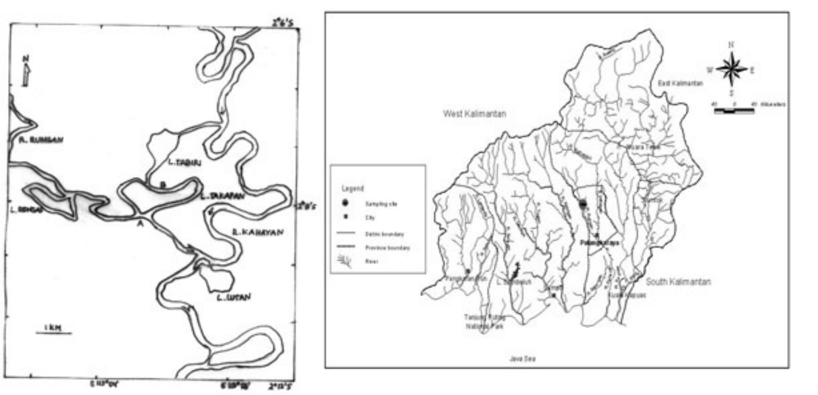

Figure 1. Position of sampling sites.

family that is locally refer as *"Kumpai lengo"* (*Polygonum lapathifolium* L) and "*Kumpai batu"* (*Cyrtococcum sp*) in Lake Tabiri, Lake Takapan and Lake Rengas, June 2002. *Eichhornia crassipes*, *Salvinia molesta* and *Cyrtococcum* SP are floating aquatic macrophytes. *P. Lapathifolium* is a submerged of aquatic macrophyte that grow from the bottom reaching to the lake surface. Epiphytic algae were collected from a part of root especially for *Eichhornia crassipes and Cyrtococcum sp.* and all part of aquatic macrophytes for *S. molesta*. Epiphytic algae collected from *P. laphatifolium* were from the part of plant that immersed in the water.

Samples of epiphytic algae were collected by harvesting all individual of aquatic macrophytes in 50 x 50 cm plots, and then the plant is weighed to know the total biomass. Sub samples were taken from the total biomass. Immersed parts of the plant sub samples are cut and washed with 1000 ml of tap water and then shaken manually for around ten minute. After shaking of samples, the water was filtered using plankton net no 25 (40 mm mesh size) and the sample was preserved with 1 % Lugol solution for identification in the laboratory.

Total number of cells of epiphytic algae at each sub sample of plant was accounted using Lackey Drop Microtransect Method (Anonymous, 1976). Epiphytic algae species was identified according to Prescott (1951), Prescott (1963) and Scott and Prescott (1961). The total cell of epiphytic algae at each square meter of aquatic macrophytes was accounted by some calculations as follow:

1. Epiphytic algae collected from part root of plant
   The first is determining the total cell of epiphytic algae from total sample of root (total weight of root/g sub sample of root x total cell at each sub sample of root = y cell/L). The following step is determining the percentage of total weight of root from total weight of plant (total weight of root/total weight of plant x 100% = x %). From this calculation would obtain the total cell of epiphytic algae /g of biomass of plant (Y x X = Z). Therefore the total cell of epiphytic algae at one square meter of macrophytes (cell/m^2) = 10,000/2500 x Z x total weight of plant at each plot.

2. Epiphytic algae collected from all part of plant.
   The first is determining total cell of epiphytic algae from sub sample of plant (y cell/L). The following step is determining the percentage of sub sample of plant from total weight of plant (total weight sub sample of plant/total weight of plant x 100% = X %). From this calculation would obtain total cell of epiphytic algae/g of biomass of plant (Y x X = Z). Therefore total cell of epiphytic algae at one square meter of macrophytes (cell/m^2) = 10,000/2500 x Z x total weight of plant at each plot.

The water quality parameter such as water temperature, turbidity, conductivity, pH and dissolved oxygen (DO) was measured using Water Quality Checker Horiba U-10. The data for nutrient concentration in the water column was obtained from examination of water samples collected from the lake. Analyses of ammonium, nitrite, nitrate, total nitrogen and total phosphorous were performed according to the method proposed by Anonymous (1995).

RESULTS AND DISCUSSION

Some water quality parameters of Lakes Tabiri, Lake Takapan and Lake Rengas were presented in Table 1 and 2. The water quality condition showed a little different between these lakes, especially pH, conductivity and Secchi depth. In Lake Tabiri, the pH, conductivity and Secchi Depth values were higher than those parameters in Lake Takapan and Lake Rengas. Lake Tabiri is a floodplain lake of Kahayan River that exchange water with River Kahayan and River Rungan River through Lake Takapan. Lake Takapan is always exchanging water with River Rungan, a tributary of the Kahayan River, but in the high water time the lake also exchange water with River Kahayan. Lake Rengas is located south west of L. Takapan and exchange water with River Rungan. Rungan River is a humic river with the average of pH and conductivity 4.72 and 0.005mS/cm respectively (Hartoto, 2000). The higher value of pH and conductivity of Lake Tabiri is may affected by the position of Lake Tabiri that receive the water beside from Rungan also receive from Kahayan river with the higher value of pH and conductivity 5.48 and 0.014 mS/cm (Hartoto, 2000). The average value of nutrient content such as nitrite, ammonium, and total nitrogen and total phosphorous was higher in Lake Takapan than those parameters found in Lake Tabiri and Lake Rengas. The higher

Table 1. The average values of some physical and chemical parameters in Lake Rengas, Lake Takapan and Lake Tabiri.

Station and position of sampling site	pH	Conductivity mS/cm	Turbidity NTU	DO mg/L	WT °C	Secchi Depth cm
Lake Rengas						
A : S 02°08'55.1" ; E 113°53'48.3"	5.11	0.009	25.1	4.95	29.6	16.0
B : S 02°08'55.6" ; E 113°53'39.1"	5.18	0.010	14.3	3.00	29.1	17.0
C : S 02°09'08.3" ; E 113°53'16.1"	4.50	0.010	17.0	3.94	29.4	17.5
D : S 02°08'54.9" ; E 113°53'15.7"	5.40	0.008	33.2	5.28	29.2	12.0
E : S 02°08'54.1" : E 113°53'23.9"	5.31	0.007	31.5	5.5	29.3	13.5
Average	5.25	0.008	24.2	4.53	29.3	15.2
Lake Takapan						
A : S 02°09'14.0" ; E 113°54'48.1"	5.30	0.008	29.6	4.55	29.7	15.5
B : S 02°08'33.9" ; E 113°55'26.1"	5.55	0.010	14.7	4.28	29.5	19.0
C : S 02°08'47.9" ; E 113°54'49.6"	5.27	0.009	8.6	3.40	29.8	22.0
D : S 02°08'44.0" ; E 113°54.'15.7"	5.01	0.029	6.3	3.19	29.4	33.5
E : S 02°09'01.9" : E 113o54'32.2"	5.05	0.009	12.1	3.10	29.6	27.0
Average	5.24	0.013	14.3	3.70	29.7	23.4
Lake Tabiri						
A : S 02°08'33.7" ; E 113°55'21.7"	5.55	0.016	14.9	0.69	30.4	33.0
B : S 02°08'32.7" ; E 113°55'18.0"	5.53	0.013	12.8	1.56	31.3	30.1
C : S 02°08'28.0" ; E 113°55'18.3"	5.80	0.015	17.7	3.87	33.8	21.0
Average	5.61	0.014	2.04	2.08	31.8	28.2

level of nutrient concentration in Lake Takapan is presumably due to the existence of cage aquaculture system in the lake and the water it receives from River Kahayan.

The composition and abundance of epiphytic algae is presented in Table 3 and 4. Diatom or Bacillariophyceae group dominated the community of epiphytic algae. This group is commonly found in humic lake ecosystem because the cell wall is more resistant to acid water. It was also reported that there is a relationship between pH and composition of diatom (Harris, 1986). Furthermore it was reported that the remains of diatom population preserved in the lake sediments have been used to reconstruct the history of acidification. Beside diatom, the group of desmids such as *Cosmarium*, *Closterium*, *Gonatozygon* and *Euastrum* are commonly found in this community of epiphytic algae. Payne (1986) have reported that another group of green algae common in rather acidic water are desmids that often have constrictions at the centre of the cells.

Table2. Average value of nutrient concentration in Lake Rengas, Lake Takapan and Lake Tabiri.

Sampling site and position	$N\text{-}NO_2$ mg/l	$N\text{-}NO_3$ mg/l	$N\text{-}NH_4$ mg/l	TN mg/l	TP mg/l
Lake Rengas					
A : S 02°08'55.1" ; E 113°53'48.3"	0.031	0.043	0.078	0.079	0.065
B : S 02°08'55.6"; E113°53'39.1"	0.032	0.486	0.194	0.690	0.076
C: S 02°09'08.3"; E 113°53'16.1"	0.035	0.490	0.102	0.759	0.063
D: S 02o08'54.9"; E113°53'15.7"	0.042	0.046	0.164	1,413	0.047
E: S 02°08'54.1" ;E 113°53'23.9"	0.048	0.312	0.141	2,132	0.034
Average	0.038	0.275	0.136	1.015	0.057
Lake Takapan					
A:S 02°09'14"; E 113°54'48.1"	0.038	0.358	0.189	1,188	0.072
B: S 02°08'33.9"; E 113°55'26.1"	0.081	0.301	0.276	1,249	0.045
C: S 02°08'47.9"; E 113°54'49.6"	0.026	0.477	0.211	0.978	0.082
D: S 02°08'44.0"; E 113°54'15.7"	0.021	0.343	0.273	1,114	0.078
E: S 02°09'01.9"; E 113°54'32.2"	0.031	0.449	0.278	2,492	0.071
Average	0.039	0.386	0.245	1.404	0.069
Lake Tabiri					
A: S 02°08'33.7'; E 113°55'21.7"	0.048	0.472	0.088	1,258	0.036
B: S 02°08'32.7"; E 113°55'18"	0.036	0.397	0.13	1.09	0.037
C: S02°08'28.0"; E 113°55'18.3"	0.017	0.372	0.107	1.30	0.050
Average	0.034	0.413	0.109	1.216	0.042

The abundance of epiphytic algae found on the stand of E. *crassipes* range from 1,790,036 to 286,898,867 cells/m^2, while the abundance of epiphytic algae found on *Cyrtococcum sp* stand range from 2,793,423 to 123,984,278 cells/m^2. The abundance of epiphytic algae on *P lapathifolium* stand that was only found in Lake Tabiri are 119,022,754 cells/m^2, while on *S. molesta* that was only found in Lake Rengas 1,731,767 cells/m^2.

In Lake Tabiri, the abundance of epiphytic algae found on *E. crassipes* was higher at Station B compared to the abundance found on *E. crassipes* located at Station C. In station C of Lake Tabiri, the value of Secchi Depth was lower compared to the ones found in station B. The lower value of Secchi Depth indicates a lower light penetration into the

Table 3. The abundance of epiphytic algae from some aquatic Macrophytes in Lake Tabiri.

	Station B		Station C	
Plant species	*E. crassipes*	*E. crassipes*	*P. lapathifolium*	*Cyrtococcum sp*
Taxonomical group	Abundance cells/m^2	Abundance cells/m^2	Abundance cells/m^2	Abundance cells/m^2
Chrysophyta		cell/m^2	cell/m^2	cell/m^2
Cymbella	932492	75947	397839	7956777
Diatoma	71842706	310449	47500341	65245579
Ephitemia	731261	555538		
Eunotia	70483264	133690	13799687	11068762
Fragillaria	75089834	411988	7284511	7956777
Frustulia	297150	131702	90918737	
Navicula	58133937	541952	9764103	7956777
Pinnularia	1215947	40260	2417886	3182711
Synedra	752508	91411	4070947	3182711
Suriella	221929	26512	4959184	
Pleurosigma	62682			
Chlorophyta				
Ankistrodesmus	11093			3182711
Cosmarium	899319	2938		
Cladophora	303863		1591356	
Closterium	1132614	40265	3306122	
Euastrum	210248	3573		
Gonatozygon				
Netrum	590412			
Meugotia	715197			
Scenedesmus	590412	7089		
Spirogyra	590412			3182711
Staurastrum		3358		
Ulotrix	1317847	20612	1591356	
Cyanophyta				
Oscillatoria	476219	67341	8013973	11068762
Hapalosiphon		2626		
Euglenophyta				
Euglena	234839	35818	826531	
Phacus		23028	826531	
Total cell/m^2	286898867	2547881	119227754	123984278

Table 4. The composition and abundance of epiphytic algae from some aquatic macrophytes in Lake Takapan and Lake Rengas.

	Lake Takapan	Lake Rengas	
	Station B	Station D	
Plant species	*E. crassipes*	*S .molesta*	*Cyrtococcum sp.*
Taxonomical group	Abundance cells/m^2	Abundance cells/m^2	Abundance cells/m^2
Chrysophyta			
Cymbella	24094	49091	76255
Diatoma	133564	107079	517439
Ephitemia	204671		
Eunotia	71979	122147	36892
Fragillaria	138313	148436	341909
Frustulia	41252	605091	174191
Navicula	157293	101282	199382
Pinnularia	13079	32727	76256
Synedra	31391	26273	67160
Suriella	6027		
Chlorophyta			
Ankistrodsmus	16072		
Cosmarium		42679	83112
Cladophora	672777	35509	
Closterium	23688	47587	429741
Euastrum	26368	28389	
Gonatozygon	30134		
Netrum	3767	32727	
Meugotia	42959		
Cyanophyta			
Oscillatoria	116236		461274
Hapalosiphon		215430	215430
Euglenophyta			
Euglena	28838		
Phacus	7523		38127
Trachelomonas			76256
Total cell/m^2	1790036	1731767	2793424

water column and suspected to limit photosynthesis activity and growth of epiphytic algae in station C.

In station C of Lake Tabiri, the abundance of epiphytic algae was higher on *Cyrtococcum sp* compared to the abundance found on *E. crassipes* and *P. lapathifolium*. Cattaneo *et al.* (1998) have reported that architecture of aquatic macrophytes significantly affects the abundance and communities of epiphytic alga.

Cyrtococcum sp is a floating aquatic macrophyte that has leaves that are thin, providing sufficient light for photosynthesis and the growth of epiphytic algae attached in its root. The root has a role to filter excess detritus and provides suitable nutrient-rich habitat for epiphytic algae, while *E. crassipes* have wider leaves cause limited light intensity penetrating into the water. The light mainly utilized by the plantís leaves for photosynthesis. *P. lapathifolium* is a plant with different architecture compared with *E. crassipes* and *Cyrtococcum sp*. The part of *P. lapathifolium* immersed into the water is mostly the stem. It means that epiphytic algae attached on the stem have little supply of detritus and nutrient. This condition might have caused lower of abundance of attached algae on the *P. lapathifolium* than on *Cyrtococcum sp*.

In Lake Takapan, the abundance of epiphytic algae from *E crassipes* was lower compared with the abundance of epiphytic algae from the same species found in Lake Tabiri. In Lake Takapan, especially in Station B showed that the value of Secchi Depth and conductivity is lower compared to those parameters found in station B and C in Lake Tabiri (Table 1). The lower of Secchi depth in Lake Takapan indicate lower light penetration into the water that in its turn also limit photosynthesis activity of epiphytic algae On the other hand the value of conductivity in Lake Takapan was also lower compared with the value of conductivity found Lake Tabiri. The value of conductivity show lower level of ion that also can influence the abundance of epiphytic algae in Lake Takapan. There were two species of aquatic macrophyte *Salvinia molesta* and *Cyrtococcum sp* found in Lake Rengas. The abundance of epiphytic algae grew on *Cyrtococcum sp* was higher compare to the ones live in *S. molesta* in this lake. *S. molesta* has wider leaves, which are probably affect the existence of epiphytic algae.

The abundance of epiphytic algae in Lake Tabiri was higher compared with the abundance of epiphytic algae in Lake Takapan and Lake Rengas especially the epiphytic algae attach on the same species of aquatic macrophytes. Lake Tabiri has higher value of pH, conductivity and Secchi Depth compared with those value parameters found in Lake Takapan and Lake Rengas (Table 1). Higher level of these parameters probably causes higher influence of epiphytic algae in Lake Tabiri.

CONCLUSION

Diatom or Bacillariophycea group dominated the community of epiphytic algae in the three humic lakes. Beside diatom, a group of desmids are also commonly found in the epiphytic algae community of the lakes. The highest epiphytic algae abundance was found on *E crassipes* collected from Lake Tabiri. The abundance of epiphytic algae in Lake Tabiri was higher compared to the abundance of epiphytic algae collected from the same aquatic macrophyte species found in Lake Takapan and Lake Rengas.

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Primary Production of Phytoplankton in Lake Batu, a Tropical Oxbow Lake of Central Kalimantan

Evi Veronica and Ardianor
Education staff of Aquatic Resources Management of Fisheries Department, Agricultural Faculty, University of Palangka Raya (UNPAR)
phone : office 0536-28524; home 0536-22457; e-mail : eviveronica@yahoo.com

ABSTRACT

The present study was to observe the primary production of phytoplankton and its vertical profile in Lake Batu (02°00’57.4” S, 113°56’54.9” E) on August, 24th 2002, a tropical oxbow lake.

The primary production of phytoplankton at depths of 0, 25, 50, 75, 100, and 150 cm were analyzed using oxygen method (dark and light bottles) and chlorophyll-a content at the same depths were measured by filtering the amount of lake water with GF/F and analyzed spectrophotometrically. Light intensity and waterís transparency were measured using light meter (Extech Instruments) and Secchi-disk. Incubation time was about 4 hours (10.00 - 14.00).

Result showed that the primary production of phytoplankton, viz. respiration (R), gross primary production (GPP) and net primary production (NPP) were 20.5, 12.8 and 7.7 mgC/m²/h, respectively. Lake Batu status was still an oligotrophic where carbon assimilation value was below 100 mgC/m²/day.

Key words : tropical oxbow lake, primary production, oligotrophic.

INTRODUCTION

Since the start of the JSPS-LIPI Core University program ìEnvironmental Management of Wetland Ecosystem in Southeast Asia”, the limnological information has been intensively collected from lakes and river of Central Kalimantan, Indonesia. Freshwater ecosystem in this region have been recognized to be rich in fresh water fish (Komatsu *et al*. 2000) and high zooplankton diversity (Gumiri *et al*., 2000). Although the seasonal composition and biomass of phytoplankton have been observed (Kusakabe *et al*. 2000; Sulastri and Hartoto, 2000), the primary production of phytoplankton is still little known (Ardianor *et al*., 2000) in lakes of this region.

The present study was to observe the primary production of phytoplankton and its vertical profile in Lake Batu, a tropical oxbow lake.

STUDY SITE

Research was conducted in situ at Lake Batu (02°00’57.4” S, 113°56’54.9” E) on August, 24th 2002 (Figure 1). Lake Batu was an small oxbow lake that is located right site of Kahayan River up stream direction, about 19 km northern Palangka Raya, the capital city of Central Kalimantan Province, Indonesia. Hydrological condition showed that the water color in both higher and lower water level seasons were dark. The lake has 2 small inlets from the watercourses. In higher water level season this lake is connected to the other lake, Lake Tehang which is directly opened to Kahayan River, via a small channel. The maximum depth was about 7 m in lower water level season.

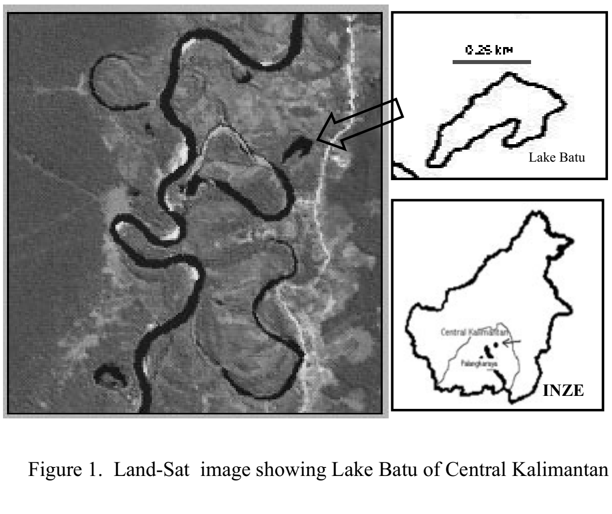

Figure 1. Land-Sat image showing Lake Batu of Central Kalimantan

METHODS

Before the incubation some of physico-chemical parameters, viz. waterís depth, transparency and temperature and pH and free-carbon dioxide (CO_2) were measured in situ. For those parameters samples were taken from water column with thickness of about 50 cm with plastic bucket.

The rate of primary production of phytoplankton at depth of 0, 25, 50, 75, 100, and 150 cm were measured using Oxygen Method (Dark and Light Bottle) (Wetzel and Likens, 2000). The depths were fixed in situ based on current water transparency or Secchi-depth value. To adjust those depths, a constructed wooden-hanger was performed to hold the dark and light bottles (Figure 2 A).

Based on changes in dissolved oxygen, water samples from those depths were enclosed both in transparent (ìlight”) and completely opaque (ìdark”) bottles. The incubated bottles were a pyrex-bottles of 250 ml in volume. Dark bottles were made by covering them with a double layer of first of a aluminum foil and then of black plastic electricianís tape to completely exclude light. To take samples from various depths to be incubated, a constructed fiber-oil hand pump (Figure 2 B) was used. Therefore, dark and light bottles were attached to a hanger and lowered to water column and then fixed to a bamboo-stick which is embedded to the lakeís bottom. Incubation time was about 4 hours, started from 10.00 until finish of 14.00. The changes in dissolved oxygen during incubation time as a rate of production of phytoplankton were recorded and then calculated according to Wetzel and Likens (2000) follows :

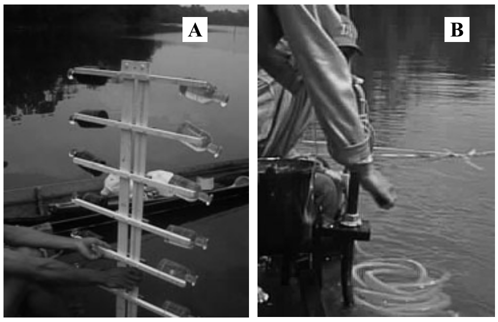

Figure 2. (A) Dark and light bottles attached to the constructed wooden-hanger
(B) A constructed fiber-oil hand pump to suck water from each depths

Gross photosynthesis (mgC/m^3/h) = {[(O_2,LB)-(O_2,DB)](1000)(0.375)}/(PQ(t)
Net photosynthesis (mgC/m^3/h) = {[(O_2,LB)-(O_2,IB)](1000)(0.375)}/(PQ)(t)
Respiration (mgC/m^3/h) = {[(O_2,IB)-(O_2,DB)](RQ)(1000)(0.375)}/(t)
Where : LB = light bottle; DB = dark bottle; IB = initial bottle
0.375 = conversion factor of oxygen to carbon; t = incubation time;
PQ = 1.2 and RQ = 1.0.

The chlorophyll-a content of same depths were measured by passing a 300 mL of lakeís water through a glass fiber filter (Whatman-GF/F, not precombusted) and placed in a 15-ml polypropylene centrifuge tube with 8 ml of pure methanol. These tubes were wrapped with aluminum foil and stored in a freezer until analysis. Later the tubes were centrifuged at 3500 rpm for 20 minutes and absorbances of the supernatant was determined at 750 and 664 nm with spectrophotometer (DMS-100). Chlorophyll-a concentration was calculated according to Marker *et al*. (1980):

Chlorophyll-a = [13.4 v(ABS664 - ABS750)]/(Vd)

Where :
V = Sample filtered (L)
v = Volume of methanol (8 mL)
d = Cuvett diameter (1 cm)

Light intensity was measured using Light Meter (Extech Instruments) during a day (12 hours) at surface water. To estimate the light under water of fixed depths, the light attenuation and changes in light intensity above water surface were based on the Beer-Lambert formula with knowing current extinction coefficient of water previously. To calculate the rate of photosynthetic productivity through the water column of the euphotic zone below one square meter of water surface, the values of mgC/m^3/h were plotted against depth. The area of the curve was integrated by a grid enumeration analysis and then compared to known area on the same graph of known mgC/m^3/h versus known depth (Wetzel and Likens, 2000).

RESULS AND DISCUSSION

Some physico-chemical parameters measured, depth, transparency, temperature, pH and free-carbon dioxide (CO_2) in Lake Batu were 5.2 m, 53 cm, 31 ^{o}C, 4.8 and 7.9 mg/l, respectively. It showed that those values were no significant different to the value of the same parameters measured on August, 27 2002 where depth, transparency, temperature, DO, pH and free-CO_2 were respectively 5.0 m, 48 cm, 31^{o}C, 4.4 mg/l, 4.7 and 8.0 mg/l.

The primary production of phytoplankton, viz. respiration (R), gross primary production (GPP) and net primary production (NPP) were 20.5, 12.8 and 7.7 mgC/m^2/h, respectively. Those values were lower compared to Lake Sabuah where GPP, NPP and R were 31.2, -39.2 and 70.4 mgC/m^2/h, respectively (Unpublished data, presented in the 66th Japan Limnological meeting in Sendai on October 2001 by Ardianor and the study was conducted on September 2001). Also, the primary production of those two

Table 1. Light intensity, chlorophyll-a concentration and primary production by depth in Lake Batu

Depth	LI (lux)		Primary Prod. (mgC/m^3/h)			Chl-a mg/l	mgC/mgChl-a/h		
(m)	12 h	4 h	R	GPP	NPP		R	GPP	NPP
0	20890703	11586250	6.8	14.3	8.7	0.0175	0.118	0.251	0.152
0.25	5837509	3237557	8.2	15.5	8.6	0.0182	0.150	0.282	0.157
0.5	455802	252794	7.3	13.7	7.7	0.0222	0.161	0.304	0.170
0.75	9945	5516	0.8	1.9	1.2	0.0222	0.019	0.042	0.026
1	61	34	3.0	6.1	3.6	0.0189	0.056	0.116	0.069
1.5	0.03	0.02	4.1	0.0	-3.4	0.0125	0.051	0.000	-0.043

lakes are very low compared to Lake Kasumigaura (Takamura *et al*. 1986; Takamura *et al*. 1990). According to Henderson-Seller and Markland (1987) Lake Batu status was still an oligotrophic where carbon assimilation value was below 100 mgC/m^2/day. A comparative data of light intensity, chlorophyll-a content and primary production by depths revealed in Table 1.

Vertical distribution of gross production (GPP) and net production (NPP) revealed the same pattern as shown in Figure 2. Respiration (R), however, showed the different pattern and tend to increase with depth, particularly after 100 cm (Figure 2). At a depth of 150 cm, NPP showed a negative value due to the higher respiration and inadequate light supporting photosynthesis.

A compensation depth where the photosynthesis was equal to respiration (the junction of NPP and R line) occurred at a depth of about 105 cm as pointed by the dashed-line in Figure 2. It was shown that the compensation depth in this study is about two times of water transparency value.

By plotting data of the relatif light intensity (I/Ik) to the relatif photosynthesis (P/Pmax) in Table 2, the exponential saturation curve was got (Figure 3 (A)).

According to the mathematical formula, P = Pmax [1-exp(-I/Ik)], after Webb et al. (1974) *in* Iwakuma and Yasuno (1983), some estimated parameters were found, namely Ik = 4.87E+6 ± 8.96E+06 lux and Lmax = 2.9 ± 2.3 mgC/mgChl-a/day.

Moreover, the photoinhibition exist was indicated by net primary productivity (NPP) curve in Figure 2, pointed by dot-line. However, its shown was very small, pointed by vertical dot-line at NPP curve.

Table 2. Relatif value of photosynthesis (P/Pmax) taken from NPP and light intensity (I)

Depth of	0 cm	25 cm	50 cm	75 cm	100 cm	150 cm
LI (lux)	20890703	5837509.23	455802	9945	61	0.03
NPP (mgC/mgChl-a/day)	1.8	1.9	2.0	0.3	0.8	0.0
P/Pmax	0.91	0.94	1.02	0.16	0.41	0.00
I/Ik	1.000	0.283	0.022	4.8E-04	2.9E-06	1.4E-09

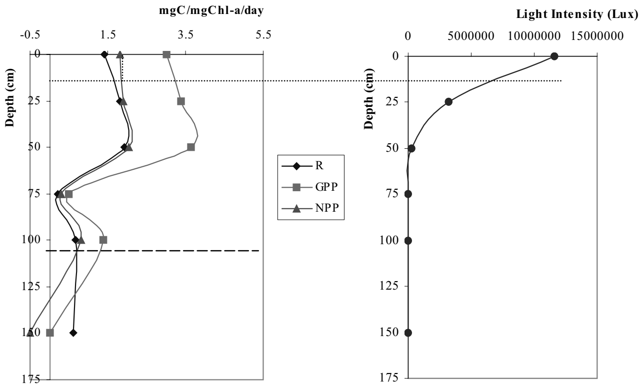

Figure 2. Vertical profile of primary production of phytoplankton and light intensity

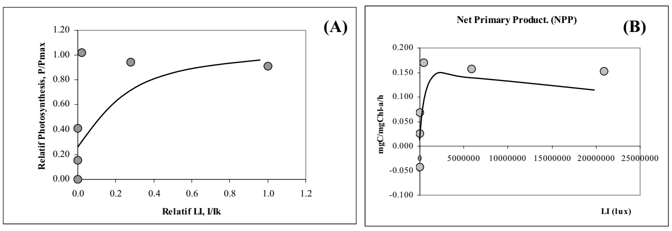

Figure 3. (A) Exponential saturation curve of photosynthesis and (B) photosynthesis-light curve of sample in Lake Batu

CONCLUSSION

From this simple study we can conclude that Lake Batu was an oligotrophic lake which very low carbon assimilation. Net primary production was only 12.8 mgC/m^2/h. More studies with respect to primary production of phytoplankton is essential to study a limnological phenomenon of tropical oxbow lakes.

ACKNOWLEGMENT

We are grateful to Prof. Toshio Iwakuma, Graduate School of Environmental Earth Science, Hokkaido University for his advice, help and support. To Pak Suwido H. Limin, University of Palangka Raya, thank for his advice and support. To our colleagues, Dr. Sulmin Gumiri (now training in zooplankton at the Ghen University, Belgium), Pak Tariono Buchar, Ibu Linda Wulandari, Sdr. Yantrinata, Yurenfri, Trisliana, Jhon Indra and Roy Hariwinata thank for your help, advice and support.

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Leaf Expansion Rate and Life span of Floating Leaves in *Victoria amazonica* (Poepp.) Sowerby Growing in Kebun Raya, Bogor, Indonesia

Hidenobu Kunii[1], Senny Sunanisari[2], Haruo Fukuhara[3], Takuo Nakajima[4] and Fifi Widjaja[5]

[1] Research Center for Coastal Lagoon Environments, Shimane University, Matsue 690-8504, Japan

[2] Research and Development Center for Limnology, Indonesian Institute of Sciences, Cibinong 16911, Indonesia

[3] Laboratory of Hydrobiology, Faculty of Education and Human Sciences, Niigata University, Niigata 950-2181, Japan

[4] Lake Biwa Institute, Otsu 520-0806, Japan

[5] Faculty of Fisheries and Marine Science, Bogor Agricultural University, Campus IPB, Darmaga, Bogor 16680, Indonesia

Corresponding author: Hidenobu Kunii
tel.: +81-852-326439 fax.: +81-852-326099 E-mail: kunii@soc.shimane-u.ac.jpkunii@soc.shimane-u.acd.jp

ABSTRACT

We investigated the growth and life span of floating leaves in *Victoria amazonica* (Poepp.) Sowerby growing in a shallow pond of the Bogor Botanical Garden, West Java, Indonesia. In a pond, five plants were selected and the diameter of each leaf was measured for two weeks at two-day intervals to detect the fate of each individual leaf. A visual observation of lost (decayed) area was also done at each date to evaluate the percentage of decayed leaf area. Leaf life span was estimated from the time interval for the emergence of new leaves, provided that number of leaves per plant was constant. It was shown that maximum value in leaf diameter was 2.35 m (4.34 m^2 in area) and mean value was 1.6-1.7 m. Each plant was composed of 10 to 15 floating leaves and while the total leaf area per plant differed considerably (minimum value 12.1-17.2 m^2, maximum value 27.6-31.2 m^2), minimum and maximum values in time interval of new leaf emergence and in leaf life span showed quite similar values (2.78 and 2.88 days and 30.8 and 39.7 days, respectively) among the five plant observed. Specific leaf weight (mg•cm$^{-ÇQ}$) was 7-9 for young leaves and 10-12 for mature leaves, respectively.

Key words: growth, giant water lily, floating plant, leaf life span, SLW, Victoria amazonica

INTRODUCTION

The giant water lily, *Victoria amazonica* (Poepp.) Sowerby, is an attractive aquatic macrophyte having large floating-leaves and big entomophilous flowers, and it has been a subject of interest in plant ecologists for many years. It is native to equatorial Brazil where it grows in calm waters along the Amazon River, in ox-bow lakes, and in flooded grasslands. Although there is much literature on the floral biology (e.g. Prance and Arias, 1975), morphology (Gessner, 1969; Kaul, 1976), chemical composition (Cowgill and Prance, 1982) and gas flow (Grosse, 1996) of this plant, few describe the growth and life span of floating leaves (but see Funke and Bartels (1937) for petiole growth).

Up to the present, many data have been accumulated on the life span and production of floating-leaved plants (e.g. Brock et al., 1983; Tsuchiya, 1991; Kunii and Aramaki, 1992). However, most of these are for the plants of the temperate regions and only a few for those of the tropical or sub-tropical regions; Center and Spencer (1981) observed on a free-floating *Eichhornia crassipes* (Mart.) Solms. and Ikusima and Gentil (1993) on a semi-emergent *Eichhornia azurea* Kunth. We thus conducted a field observation on *V. amazonica* to provide additional information on the growth and life span of floating leaves of tropical floating-leaved aquatic macrophytes.

SITE AND METHODS

Field observations and measurements of the plants were made in a shallow pond near the entrance gate of the Bogor Botanical Garden (06˚ 36'S, 106˚ 48' E), located about 60 km south of Jakarta, West Java, Indonesia. Air temperature and precipitation of Bogor is reported as c.20-30 ˚C and c.4,000 mm, respectively (Kato, 1982; Darnaedi, 1989), which are comparable to those in its original habitat.

At the pond, we selected five plants growing at different water depths (see Table 1) and measurement on leaf diameter and visual observation of % decay or lost were done at two-day intervals for two weeks from 8 March to 22 March 1993 to detect the fate and expansion of each leaf. We set the reference line at 50 cm in diameter and then calculated the time interval for the emergence of new leaves. Leaf life span was thus estimated by multiplying number of leaves per plant by time interval of new leaf emergence, provided that number of leaves per plant was nearly constant throughout the observation period. In March 2001, we sampled c.10◊10 cm leaf piece from the middle of each individual leaf-blade of two plants to obtain specific leaf weight (mg•cm^{-2}).

RESULTS AND DISCUSSION

Figure 1 shows leaf growth in diameter (left figures) and in area (right figures) for each newly developed leaves in each individual plant. Leaf expanded logistically and reached the plateau within about a week. Maximum record was 235 cm of no.4, which corresponds to 4.34 m^2 in area. New leaf emerged periodically and its interval was estimated to be 2.8 days on average. The averaged maximum value in diameter differed considerably among plants; nos.1 and 5 were c.140 cm while nos.2, 3 and 4 were c.170 cm (Fig.2).

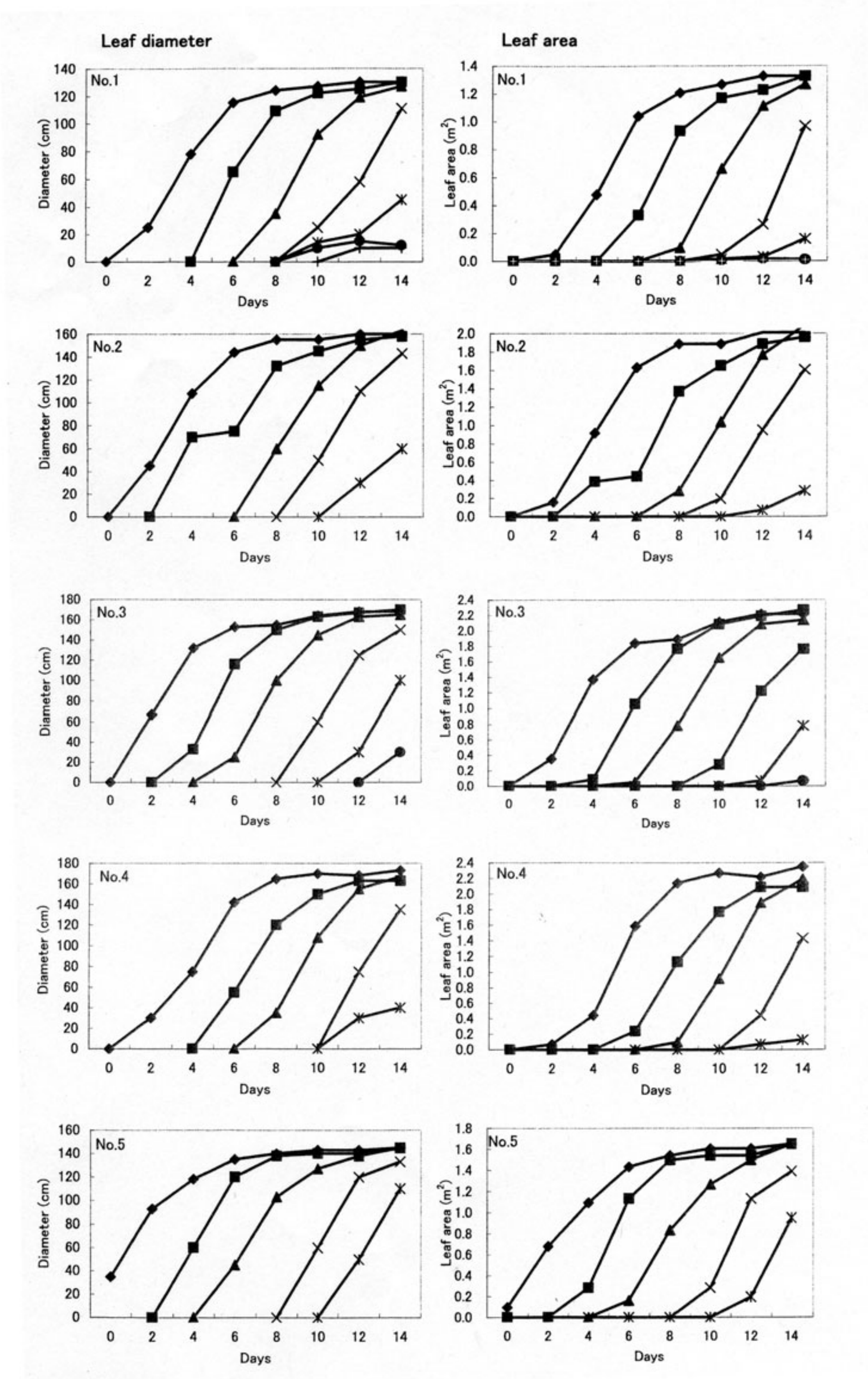

Figure 1. Time trend in leaf growth of newly emerged floating leaves in *Victoria amazonica*. Leaf and right figures show growth in leaf diameter and in leaf area, respectively.

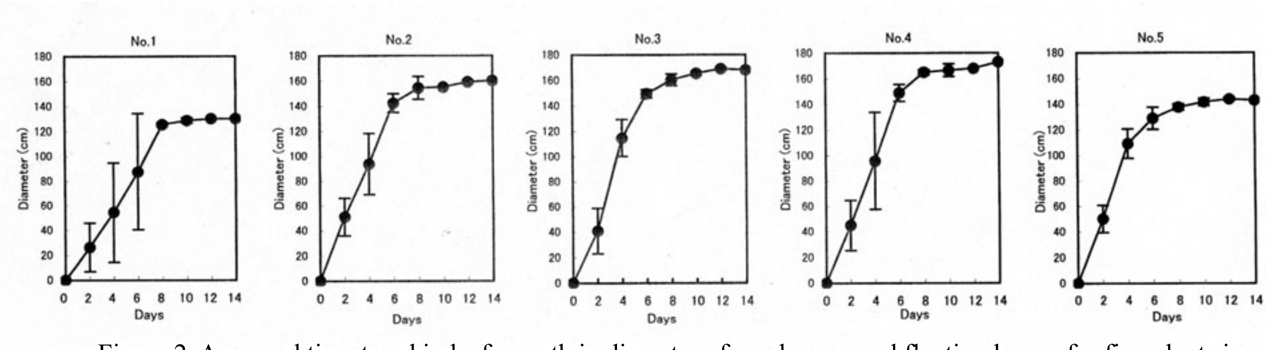

Figure 2. Averaged time trend in leaf growth in diameter of newly emerged floating leaves for five plants in *Victoria amazonica*.

Table 1. Profile of floating leaves in *Victoria amazonica*

	Leaf area/plant (m^2)	Leaf number/plant*	Leaf emergence interval (days)	Estimated leaf life span (days)	Water depth (cm)
No.1	15.5−18.7	12.5±0.9 (11−14)	2.87±0.23	35.4	20
No.2	27.6−31.2	14.6±1.7 (12−17)	2.78±0.39	39.7	65
No.3	18.5−25.3	12.4±0.7 (11−13)	2.78±0.32	34.2	136
No.4	25.3−30.4	13.6±1.2 (12−15)	2.80±0.17	37.5	78
No.5	12.1−17.2	10.8±1.2 (9−12)	2.88±0.54	30.8	53
Mean±SD	19.8±6.5〜 24.5±6.5	11.6±1.1〜 14.0±2.0	2.82±0.33 (n=18)	35.5±3.4 (n=5)	

*; Leaf number was counted if only the lost area was less than 50% and mean of 8 measurements are shown.

Total leaf area and leaf number per plant, time interval for the emergence of new leaves and estimated leaf life span are shown in Table 1. While the total leaf area per plant differed markedly, leaf number per plant and time interval of new leaf emergence showed quite similar values. Minimum and maximum values in leaf life span was estimated to be 30.8 and 39.7 days, respectively, and total mean value was 35.5 days. Since the values in leaf life span are within a range from 10 to 55 days reported for many temperate floating-leaved aquatic macrophytes (Tsuchiya, 1991; Kunii and Aramaki, 1992), the value estimated for *V. amazonica* is within this range. Using the data on leaf life span, the turnover of leaves (length of the vegetation period divided by mean leaf life span) can be calculated as 10.3, assuming that the plant continuously grows all the year round (that is 365 days). Specific leaf weight (SLW) increased from the younger to the older leaves and the maximum value was 12.3 (Table 2). These data should be used to further determine the production of *V. amazonica* under field conditions.

Table 2. Specific leaf weight (SLW) of *Victoria amazonica* measured on 1 March 2001. Results of two plant samples are shown.

	Dry weight (mg)	Area (cm^2)	SLW (mg/cm^2)
I-1	301.9	33.2	9.09
I-2	1155.8	110.8	10.43
I-3	972.6	104.4	9.32
I-4	1224.7	103.6	11.82
I-5	1365.0	110.9	12.31
II-1	807.1	109.4	7.38
II-2	988.3	114.2	8.65
II-3	1216.0	129.0	9.43
II-4	1274.5	110.3	11.55
II-5	1258.9	113.5	11.09
II-6	1010.8	107.2	9.43

ACKNOWLEDGMENTS

This work was done when H.K., H.F. and T.N. were ordered to Indonesia by Japan International Cooperation Agency (JICA) as JICA experts. We thank Dr. Nobutada Nakamoto of Shinshu University for his providing us the opportunity and Dr. Dedy Darnaedi of Bogor Botanical Garden for his permission of the sampling of leaves in the garden. Thanks are also due to all the staffs of LIPI-Limnology. This manuscript was developed based on preliminary results of a presentation at the annual meeting of Water Plant Society, Japan (Kunii et al., 1993).

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A Study of PT ITCI'S Perian Swamp Forest in East Kalimantan, Indonesia

I Nyoman N. Suryadiputra, Prianto Wibowo,Lili Muslihat, Herry Noveriawan, Budi Suriansyah, Dandun Sutaryo, Irfan Mudofar and Euis Nursetiya

ABSTRACT

A bio-physical and socio-economic study of wetlands in PT ITCIís Perian Forest was made on the basis of a survey carried out from 23 March to 17 May 2000, by a survey team from Wetlands International - Indonesia Programme and field assistants from PT ITCI. This was followed by an additional survey during 20 - 30 July to obtain further information on the distribution of peatlands, in particular deep peat (> 3 m). This was further supported by a study of the literature. The overall aim of these studies was to provide the management of PT ITCI with recommendations for managing the Perian Forest in East Kalimantan.

This study report (Wibowo, P. et al., 2000) is written in three main parts: <u>Results and Discussion</u> (which discusses all the bio-physical aspects covered during the survey, including information on climate conditions, soil, water, vegetation, biodiversity and cultural-socio-economics contained in the Perian Forest), <u>Evaluation, Analysis and Management of Perian Forest</u> (this evaluates and analyzes all the bio-physical, socio-economic and legal aspects which subsequently will form a reference for proposing the most appropriate management model for the Perian Forest), and <u>Conclusions and Recommendations</u> (This section outlines the main points of the whole report, and the measures that need to be taken for the management of Perian Forest, specifically by PT ITCI).

WI-IP wishes to thank the PT ITCI management in Jakarta, Balikpapan and at the base Camp in Kenangan (Kecamatan Sepaku-Kaltim) for the financial support and other facilities which they provided for the WI-IP Survey Team throughout the duration of this study.

Keywords: bio-physical and socio-economic study of wetlands in PT ITCI's Perian Forest for the purposes of sustainable management

PHYSICAL CONDITIONS OF PERIAN FOREST

Perian Forest (total area 53,680 ha) comprises dry upland and wetlands which occur mainly in depressions to lowland plain with a slope of less than 3%. The types of wetland (according to *Ramsar Convention Manual 1971*, in Davis 1994) encountered in Perian Forest include: 11 lakes with individual areas ranging from 1.6 ha to 750 ha (total area 1,604 ha), 11 rivers with an area of 4,273 ha (this includes only those parts of the rivers and their tributaries which are within the border of Perian Forest and its boundaries), freshwater swamp (12,720 ha), freshwater peat swamp (21,720 ha) and rice paddies (837 ha). The total area of wetlands within Perian Forest is 40,814 ha (or 76% of the total area of the Perian Forest).

As regards the general physiographical conditions, Perian Forest contains four Land Systems (Tanjung, Mendawai, Klaru, and Beliti; RePPProT, 1987) which can be categorized as swampland which is inundated seasonally or permanently (see Map 1). The two other Land Systems (Lawanguang and Teweh) are categorized as relatively dry (not inundated).

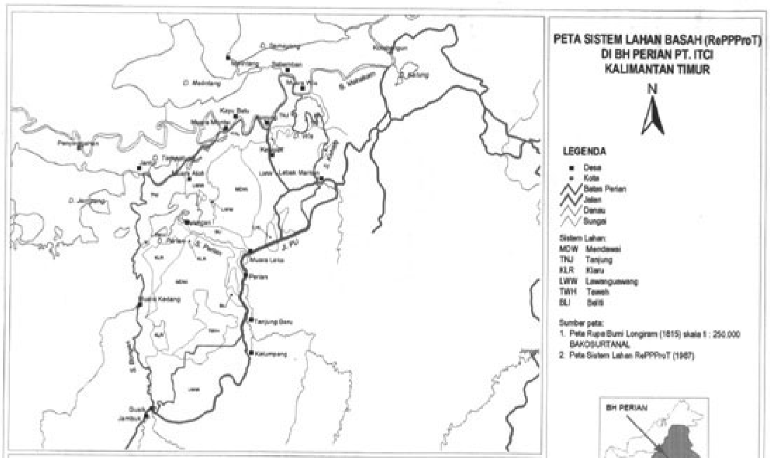

Figure 1. Map of Wetlands System based on RePPProT (1987) at PT ITCI's Perian Forest, East Kalimantan

The Tanjung Land System, which is flat alluvial riverside, is found along the Bongan river extending northwards as far as Danau Perian Lake and the sides of the Mahakam river. This Land System comprises open freshwater swamps and is part of an extensive alluvial plain which includes the flood plains of the Mahakam river. The Klaru Land System, generally comprised of swamp forest and scrub flood plains which are permanently inundated with water, is found near Muara Kedang and south of the Perian river. The Mendawai system comprises shallow peatswamp which is found in the southern part of the Perian river and swamp forest north of this river.

The Beliti Land System, consisting of swampy floodplains in narrow valleys, is found along the Perian river and south of Perian village. The dryland systems of Perian Forest are generally of the Lawanguang (i.e in the vicinity of Lebak Mantan valley and near Gusik village) and Teweh (i.e. in the western part of Tanjung Baru and Kelumpang villages) Land System type. The vegetation in both these systems is thick scrub and lowland forest (see Figure 2).

As regards their physical quality, the waters in Perian Forestís wetlands are generally slightly turbid to very turbid. The concentration of suspended solids in the swamp waters (4-34 mg/l) was generally found to be almost the same as that of the lake waters (4-38 mg/l). However, the Bongan river was exceptionally turbid (344-542 mg/l), as also was the Perian river (6-130 mg/l). The load of suspended solids measured in the Perian river during the survey ranged between 165 - 3,319 ton/day, while that in the Bongan rivers was 370 - 22,288 ton/day. The suspended solids from the Perian river are thought to settle in Perian lake, the herbal/grassy swamps of Perian and the lower reaches of Perian river, whereas those in the Bongan river settle in the swamps of the Kedang estuary, Jempang lake and some also in the Bongan river itself. This siltation causes a shallowing of the lake habitat and increases the area subject to inundation in the wet season in the swamp areas of Kedang estuary and south of Perian river.

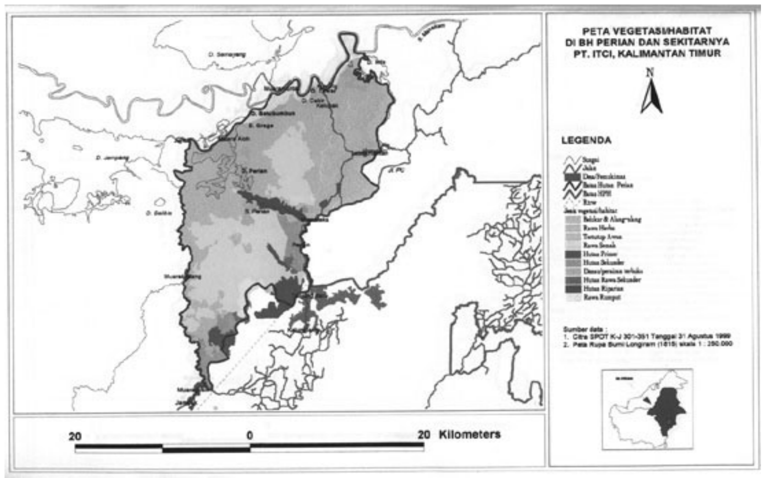

Figure 2. Map of Vegetation Habitat at PT ITCI's Perian Forest, East Kalimantan.

Regarding their chemical quality, Perian Forestís waters were found to be generally soft (< 50 mg/l $CaCO_3$), poor in nutrients and dissolved salts/minerals (Electrical Conductivity < 100 µmhos/cm, except for the swamps of Kedang estuary which were a little higher, between 110-115 µmhos/cm), rather acidic (pH 5.20 - 6.85) in the swamp waters of Perian and Muara Kedang, ranging to slightly alkaline (pH >7 - 8.25) in the Bongan river, and the lakes Wis, Aloh, Batubunbun, Tawar and Gerege Kecil. The amount of organic material and dissolved oxygen content varied within acceptable limits.

The type of soil in Perian Forest was found to be predominantly organic (Histosols), generally in the freshwater swamp plains covering an area of about 35,700 ha (66.86% of Perian Forest), with small amounts of mineral soils, i.e. Entisols and Inceptisols on flat and hilly (gradient 3 to 45 %) dryland. Based on this soil survey, 16 Soil Map Units (Satuan Peta Tanah or SPT) were obtained in Perian Forest (see Figure 3).

In general, the soil ranged from acidic (pH 4.5 - 5.5) to very acidic (pH < 4.5), which will affect the soilís fertility in that its supply of nutrients. P_2O_5 and K_2O ranges from very low to moderate, its Cation Exchange Capacity low to very high, and its alkaline saturation very low to low.

Soil aeration and drainage pores were found to be moderate in Kambisol and low in Podsolic soil. The water content was quite high for all types of soil, especially in the rainy season. Permeability was slow in all types of soil, indicating a high clay content. Soil fertility was generally moderate in alluvial land and poor to very poor in swamp plains and dryland. The low fertility of this soil is due to the very low supply and retention of nutrients. Such conditions were indicated also in the low fertility of waters in the survey area.

THE IMPORTANCE OF PERIAN FOREST

The wetlands encountered in the Perian area possess a variety of important values, not only from the aspect of ecosystem, hydrology, biodiversity, vegetation and land potential, but also as regards to socio-economics and culture.

Ecosystem. The wetlands of Perian Forest form a unique ecosystem representative of the types of wetlands in the Mahakam river plain of East Kalimantan. Ecologically, the status of the Perian wetlands is extremely important to the Mahakam ecosystem as a whole. The position of the wetlands, which protrude inland forming part of the central Mahakam catchment (more precisely, the Perian sub-catchment) greatly supports the habitats for breeding, feeding and shelter from predators for a wide variety of aquatic fauna (such as fish, turtles, etc) and also aerial fauna (like birds). In theory, the peatswamp forest in this region also plays a significant role as a natural Carbon sink. In addition, there are indications of coal reserves in the Perian Forest, particularly near Lebak Mantan, which could be exploited.

Hydrology. The swamp and lake habitats of Perian Forest function to mitigate flooding of the Mahakam river and/or to prevent seawater intrusion in coastal areas (such as Samarinda). However, the high level of erosion (e.g. in the Bongan and Perian rivers) as a result of logging in the upper stretches of these two rivers has caused an increase in the turbidity of the river waters and a shallowing of the lakes Perian and Jempang.

Biodiversity. Perian Forest possesses a variety of wetland ecosystems which support a diversity of flora and fauna (Table 1). Fauna include at least 185 species of bird (including 29 water bird species), 98 species of fish, 49 of mammals, 32 of large reptiles, 4 species of amphibian and around 347 plant species (including 42 aquatic plant species). Some of the fauna encountered in this region are endemic to Borneo, such as the 'Bekantan' or proboscis monkey (*Nasalis larvatus*), the Alap-alap Dahi Putih (*Mirohierax latifrons*), burung Sikatan kalimantan (*Cyornis suberbus*), burung Bondol Kalimantan (*Lonchura fuscans*), and the fishes *Gastromyzon lepidogaster* (*Balitroidae*) and *Betta akarensis* (Belontiidae). A number of rare and protected species (protected by Indonesian law. No. 7, 1999, and/or internationally under Appendix I & II CITES, IUCN *Red Data Book*) are also found in the Perian Forest and its vicinity; these include the Sambar deer (*Cervus unicolor*), Lesser Mouse Deer (*Tragulus javanicus*), Narrow headed softshell turtle (*Chitra indica),* freshwater turtles *(Callagur borneoensis* and *Siebenrockiella crassicollis*), Sinyulong crocodile (*Tomistoma schlegelii*), Lesser Adjutant (*Leptoptilos javanicus*), Wallaceaís Hawk Eagle (*Spizaetus nanus*) and Chinese Egret (*Egreta eulophotes*).

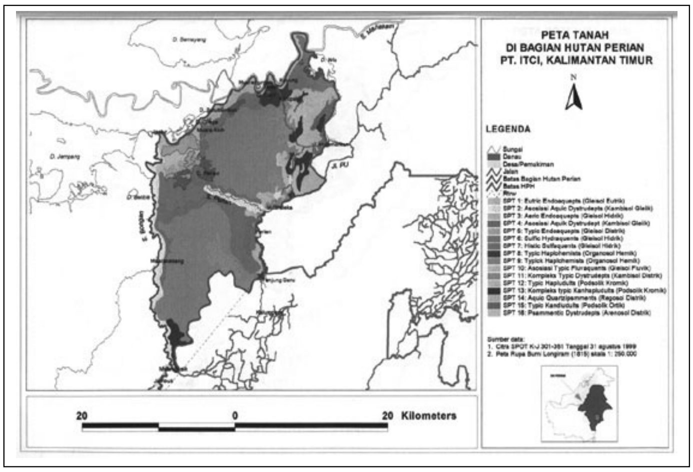

Figure 3. Map of Soil Units (Satuan Peta Tanah, SPT) at PT ITCI's Perian Forest, East Kalimantan

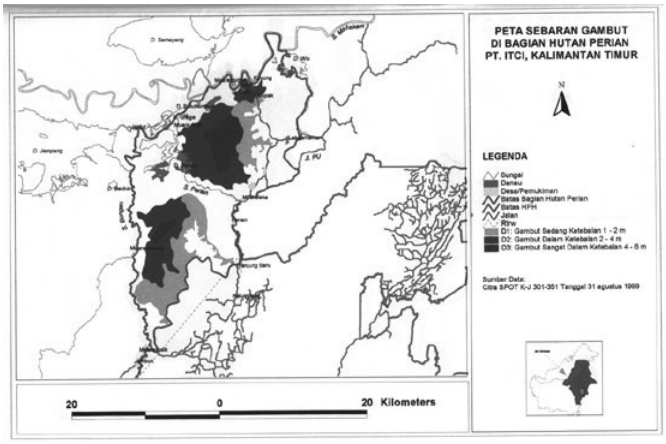

Figure 4. Map of Peat Distribution at PT ITCI's Perian Forest, East Kalimantan

As regards the species diversity of zoo- and phytoplankton in the various types of wetland in Perian Forest, about 12-45 species of plankton were found in river waters, 34-36 in swamp waters and 16-165 in lake waters. From the amounts of plankton species found in the waters of Perian Forest, it can be seen that Perian swamp (near Perian lake) is more fertile than Muara Kedang swamp, Perian river is more fertile than Bongan river, and all the lakes in Perian Forest are categorized as being of medium to high fertility. This fertility analysis also reflects the high productivity of fisheries in Perian Forest. The variety of plankton in these waters can also indicate the levels of pollution by organic material. Pollution levels were found to have been high (polysaprobik) in the Perian. Tempatung, Aloh and Batubumbun lakes, and moderate (mesosaprobik) in the other types of wetland (e.g. Bongan and Perian rivers). The high level of pollution in these four lakes is thought to be due to nearby human settlements, which are fairly densely populated, such as: the villages of Muara Aloh (24 persons/km2), Muara Muntai (49 persons/km2). The other villages in Perian Forest are generally sparsely populated (< 5 persons/km2).

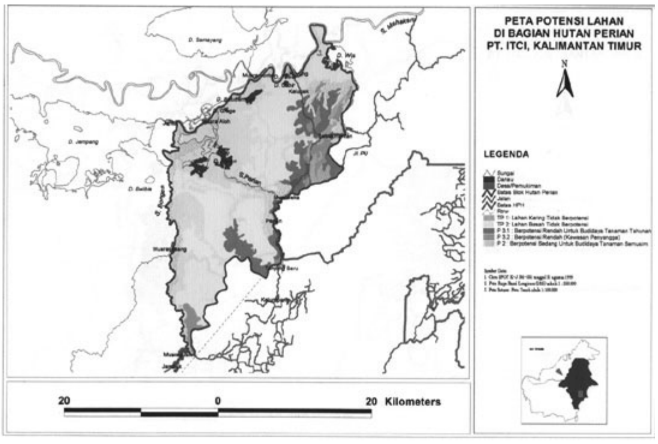

Figure 5. Map of Land Potential at PT ITCI's Perian Forest, East Kalimantan

Vegetation. The types of vegetation found in Perian Forest can be categorized as riparian/marginal swampforest, dwarf swampforest, lowland forest, (maccaranga) *kerangas*, secondary forest, alang-alang, swamp scrub, floating meadow, lake bed vegetation, and cultivated vegetation (see Figure 4). An analysis of the vegetation in Perian Forest obtained no fewer than 182 species of tree and 123 species of undergrowth. 38.6 % of these tree species can be utilized for their timber, while the remaining 61.4 % comprises fruit trees, trees used only for their leaves, roots or bark and for firewood, as well as several species whose use is not yet known. Measurements of tree volume indicate that this is not sufficient for commercial exploitation. Most of the trees are non-commercial species and fruit trees. In Perian Forest and its surroundings there are only three locations which show significant timber potential: one near Perian Village (timber volume 85 m3/Ha; forest area 1,291 Ha), another at Tanjung Baru (245 m3/Ha; area 2,324 Ha) and the third nearby M. Gusik (244 m3/Ha; area 1,980 Ha); whereas all the other locations show very small potential with volumes of below 100m3/Ha.

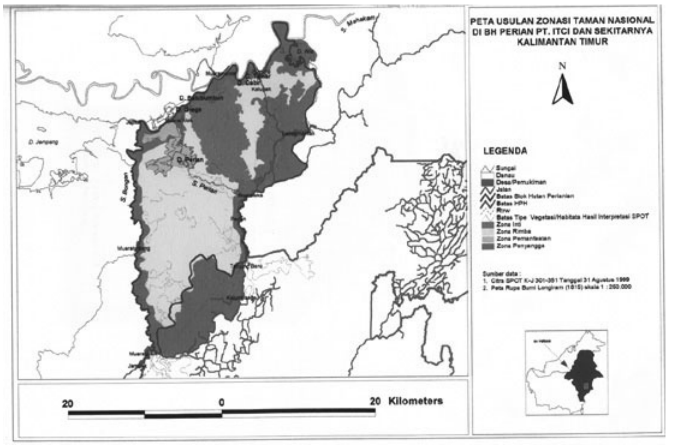

Figure 6. Zoning Proposal at PT ITCI's Perian Forest, East Kalimantan, (if the area can be designated as National Park)

Land Potential. Although Perian Forest possesses a number of vegetation types, not all of these have clear boundaries nor distinct habitat characteristics. Species which it was hoped could act as indicators for specific habitats were not found. Therefore, it is difficult to make firm recommendations as to which types of vegetation would be suitable for the habitats or land types existing in Perian Forest. Based on land suitability assessment, recommendation to cultivate wetlands vegetation (such as paddy, kenaf and abacca banana) is marginally suitable (S3b) and this can be implemented in SPT 1, 2, 4 and 10 within a total area of 7,420 ha (or 13.90% of the total Perian Forest area). However, the conditions above have a limiting factor in the form of pools and seasonal flooding which must be taken into careful account. Moreover, SPT 1 and 2 are riverbanks which are protected by Presidential Decree 32/1990, so the cultivation of these SPT will need to be managed well to prevent any disturbance to their function

Table (1) Biodiversity at Perian Swamp Forest Area.

Taxa	Total Spp. in Borneo	Total Spp. Found at Perian area	% Borneo	Spp. Endemic Borneo	Spp.# status Red List IUCN	Spp.# listed under CITES	Spp.# protected by Indonesian Government
Freshwater Fishes	394	98	24.9	2	1	-	-
Amphibian	91	4	4.4	-	-	-	-
Reptilian	254	32	12.6	1	5	5	3
Mammalia	502	49	9.8	1	2	10	27
Birds	502	185	31	3	4	40	53
-Water birds	54	29	53.7	-	2	8	15
Flora							
- Trees	3.000	182*	6	-	-	-	-
- Aquatic plants	281	42	9.6	-	-	-	-
- Rattan	137	10*	7.3	-	-	-	-
- Dipterocarp.	267	8*	3	-	-	-	-
- Flowering plants	10.000	250*	2.5	-	-	-	-
- Ferns	?	15	?	-	-	-	-

as protected area (note: in recommendations for the zoning of National Parks, it is proposed that SPT 1 & 2 be a buffer zone if Perian Forest becomes a National Park), see Figure 5 and 6.

The SPT 11, 12 and 13 with a total area of 10,950 ha or 20.4% of the total Perian forest are categorized as a marginally suitable (S3rfn) for the cultivation of dryland crops and perrenial/estate crops (fruit, oil palm, coffee, rubber). But these areas have limiting factors such as low nutrient availability and low effective depth as well as low nutrients retention.(note: These three SPT locations are proposed to be a buffer zone, if Perian Forest becomes a National Park).

Land which is not suitable for either agricultural development or forestry, limiting factors being pools and seasonal flooding, maturity and thickness of peat and hillsides, is found at SPT 3, 5, 6, 7, 8, 9, 14, 15, 16 totaling 35,310 ha or 66%. These types of land are considered to have no potential for cultivation, so it would be best that their utilization focus on efforts towards land conservation (note: if at some time Perian Forest becomes a National Park, it is proposed that SPT 3, 5, 6, 7, 9 and 14 be designated as core zone, wilderness zone and utilization zone; while SPT 15 and 16 be a buffer zone which, because of their high slopes, should be assigned the function of protected area).

Socio-economics. The population in the vicinity of Perian Forest numbers 15,440 people (density varies from 2 - 49 persons/km2), the majority of whom work as farmers and fishermen. An economic analysis of a variety of natural resources utilized directly by the local population (Table 2), gives a total value of Rp 8,128,141,017 (over 8 billion rupiah). Of this, the largest contribution (70%) is from the fisheries sector (Rp 5,7 billion), followed by the forest sector which breaks down into: gathering firewood (12.5% or equivalent to Rp 1 billion), timber for building materials (10% or Rp 800 million) and for roof shingles (5% or Rp 565 million), while the remainder at less than 1% each comes from trade in wild animals (e.g. pigs: deer, birds, etc). From these figures it can be seen that the local inhabitantsí income is derived mostly from taking natural products, not from cultivating agricultural or estate lands. This is likely to be a limiting factor on the success of the PMDH programme applied by PT. ITCI in the field, which basically attempts to help improve the economic conditions of the villagers in Perian Forest by assisting in the creation of paddyfields (178 ha), and by providing seeds and farm animals. In addition to the failure of these paddyfields due to rats and wild pigs, also poor irrigation facilities, it is difficult to change the cultural attitude of the community who are accustomed to gathering from nature. It will be a challenge for PT ITCI to find a way of getting them to understand that the natural resources in Perian Forest will run out one day (especially if they are harvested in ways which ignore the principles of conservation) and that it is therefore imperative to put serious effort into cultivating crops.

Table (2) Production Volume and Economic Benefit from Direct Utilization of Forest Products from Perian Forest during 2000.

No.	Type of Forest Product	Production Volume		Annual Economic Benefit (Rp)	Contribution to Total Benefit (%)
1	Building timber	2,843.30	M^3	852,991,200	10.49
2	Firewood	439,799	bundles	1,011,538,648	12.45
3	Multipurpose wood	754	Lengths	565,740	0.007
4	Wood roof shingles	51,534	Packs	386,507,430	4.76
5	Bamboo	14,569	Lengths	4,370,669	0.05
6	Rattan	164,273	Lengths	62,423,719	0.77
7	Damar	222.91	Kg	144,893	0.002
8	Medicinal plants	10,345	Lengths	14,896,829	0.18
9	Deer	168	Individuals	82,484,465	1.02
10	Pigs	71	Individuals	5,313,600	0.07
11	Pangolin	1	Individual	37,786	0.00
12	Dollar bird (Burung Tiung)	1	Individual	94,464	0.001
13	White rumped shama (Burung Murai Batu)	41	Individuals	614,016	0.008
14	Bluecrowned hanging parrot (Burung Telisak)	1	Individual	2,390	0.00
15	Common Lora (Burung Punai)	301	Individuals	452,049	0.006
16	Fish	2,852,851.56	Kg	5,705,703,120	70.20
			Total	8,128,141,017	100

EVALUATION, ANALYSIS AND MANAGEMENT OF PERIAN FOREST

Stakeholdersí Site Values

From an analysis of the value which various stakeholders (i.e. Regional Government, Central Government and local community) place on the Perian Forest site, using several indicators, such as: the designation of Perian Forest as a Non-forest Cultivation Zone (‘KBNK’) by Regional Government, as a Forestry Concession (‘HPH’) by central government, and the use of its natural resources by local communities with disregard for the principles of conservation, it can be deduced that all these parties consider Perian Forest ës economic value to be much more important than any others (such as the value of its ecosystem, hydrology and biodiversity). To the international community, on the contrary, Perian Forest is valued as a unique wetland habitat which supports a relatively high biodiversity and therefore meets the criteria to become a Ramsar site.

Even though the site's value in the eyes of the stakeholders is not fixed and could change, it should at least be used as a reference to show that the value ascribed to a site is subjective and may differ considerably according to the different perceptions of different parties!

CHANGES AND THREATS TO SITE VALUES

The perceived site value of Perian Forest (as described above) may change, and this can be shown by there being a change regarding the value of the ecosystem (in the form of degraded habitat), hydrology (increase in flooded area due to shallowing of rivers and lakes), biodiversity (reducing due to overexploitation of natural resources) and vegetation (reduced due to repeated forest fires). Such conditions can not only alter the value of the Perian Forest, but can also pose a serious threat to its whole ecosystem. An analysis of activities which threaten the existence of Perian Forest identified the following sources of threat: fisheries (the numbers and type of fishing equipment are considered to be excessive thus threatening the size of fish populations in Perian's waters), the existence of paddyfields on lake land during the dry season, animal husbandry, water transportation and human settlement activities (which tend to leave contaminating materials in the waters), the hunting of wild fauna (tortoises, crocodiles, snakes, deer, etc.) and the harvesting of forest products (wood, rattan, etc.).

MANAGEMENT AND CONSERVATION

From a study of the *site value of Perian Forest* (covering the ecosystem, hydrology and water quality, biodiversity and cultural-socio-economic values), *site value priorities* and *tendency for site values to change* and *threats to existing site values* through a number of activities both within and around Perian Forest, and taking into consideration the policy and legal aspects and the existing institutions, it can be seen that it is necessary to have an area conservation management effort for Perian Forest, in order to preserve the current site values, especially as a life support system. In addition, based on the spatial planning (Law UU RI No. 24 of 1992, Government Regulation PP No. 47 of 1997, and Presidential Decree No.32 of 1990), a large part of the Perian Forest area (± 35,570 Ha; 66%) fits the criteria for protection zone which includes forest areas classed as slopes/hillside >15% (± 960 Ha), peatland (± 24,860 Ha), riverside [*sempadan sungai*] (± 6,560 Ha) and lakeside [*sempadan danau*] (± 3,190 Ha), see Figure 5; so the management of Perian Forest needs to focus on the purposes of a protection zone. A repeat study is therefore needed of the areaís status based on the spatial planning, much of it having been designated as Non-Forestry Cultivation (KBNK).

If Perian Forest is perceived as a life support system which needs to be preserved, steps must be taken to conserve this area, and in view of its relatively small potential for timber production, this presents a challenge for PT. ITCI, being a private company and concession holder (HPH) for the Perian Forest area, to choose whether to continue to operate the area as a forestry concession or to relinquish its rights there. Its decision will have a chain of repercussions for both Perian Forest and PT. ITCI.

So long as Perian Forest remains a forestry concession, its management by PT ITCI must be in line with an understanding of conservation (protection, preservation and utilization) to maintain its current site values. Although the survey indicated relatively small timber potential in Perian Forest, it is still possible that this area could be utilized by PT ITCI for non-timber forest products, including environmental services, based on the principles of conservation. It is hoped that the management of a conservation zone within a forestry concession could provide a new model for the management of conservation areas in Indonesia.

The management of the Perian Forest and surrounding area is closely linked to existing development plans drawn up by the local community, regional government and other related institutions. The participation of all stakeholders in such management will better guarantee its success.

To guarantee Perian Forestís status as a conservation area, of the various forms of Conservation Area applied in Indonesia the one which would appear to be appropriate to the conservation management of Perian Forest and its surroundings is that of National Park, based on Indonesian Law UU RI No.5 of 1990. It is proposed that Perian Forest become a National Park with a zonation pattern which comprises core zone (± 6,998 Ha), wilderness zone (± 24,943 Ha), and utilization zone (± 2,347Ha). In addition, the vicinity of the proposed National Park (both within and around Perian Forest) needs to be managed as a buffer zone (± 23,184 Ha).

This buffer zone would cover about 8,090 Ha of dryland which has potential for development as an area for the cultivation of perennial crops, and 7,440 Ha for seasonal crop agriculture. It would also include protected area in the hills and along the riverbanks.

Nevertheless, the proposal of a National Park and zonation for Perian Forest and its surrounding area will need to take into further consideration a chain of aspects including forest authority status, forest utilization, and the communityís perceptions and their involvement in the planning and management of the area, as well as the process of establishing the National Park (see Figure 6).

The Perian Forest wetlands are an internationally important habit because they fulfil the Ramsar criteria. On this basis, Perian Forest can be proposed for designation as a Ramsar Site or a wetland site of international importance. However, before being proposed as a Ramsar Site, it is advisable that this site should possess a certain conservation status at national level (e.g. as a National Park) so as to strengthen its legal position as a conservation area.

CONCLUSION

1. Regarding ecosystem and ecosystem function, the Perian Forest wetlands constitute an ecosystem which is unique and representative of the types of wetland in the lowland plains of the Mahakam River, East Kalimantan. Perian Forest also functions as a life support system in the form of habitat for a number of species of flora and fauna. Moreover, according to theory, the freshwater peatswamp in this area (Figure 4) has an important function as a natural carbon sink. There are indications of potentially exploitable coal deposits in Perian Forest, especially near Lebak Mantan.
2. The Perian Forest wetlands play an important role in the hydrological processes of the Mahakam River lowland plain, The results of water quality analysis indicate that the Perian wetlands have a significant effect on the lakes in this plain.
3. Perian Forest possesses a relatively high diversity of flora and fauna in Borneo, especially of species of water-birds, fish and reptiles. A number of the species found in Perian Forest are endemic to Kalimantan, as well as species which are protected at both national and international level.
4. Perian Forest provides a high economic value, especially in the fisheries sector. Perianís total economic value comprises a tangible value of over Rp. 8 billion/year and an intangible value which is mostly linked to the current site values.
5. The amount of timber in the remaining forest of Perian is of relatively low potential and not suitable for exploitation, but still functions as pockets and corridors for wildlife.
6. The bulk of Perian Forest swamps contain peat with a depth ranging 1-6 meters. Biodiversity encountered in this peat habitat was relatively high.
7. The site values of Perian Forest depend heavily on the perceptions of the stakeholders, and these perceptions need to be changed to determine priorities for area conservation.
8. The site values of Perian Forest tend to be negative due to the threats resulting from human activities.
9. In order to maintain the life support system and values of Perian Forest wetlands, they need to be managed using an area conservation approach.
10. Applying the criteria for determining a protected area based on spatial planning, it transpires that a large part (66%) of Perian Forest meets these criteria.
11. Although Perian Forestís timber potential is relatively low, the possibility still remains of utilizing the area and its non-timber forest products sustainably.
12. The conservation of the area within PT ITCIís forest concession is possible, taking into consideration the three aspects of conservation, i.e.: protection, preservation and utilization of natural resources.
13. Of the various forms of conservation area in Indonesia, that of National Park would seem appropriate for Perian Forest.
14. The proposal of National Park status for Perian Forest needs to take into consideration a number of important aspects, which include the determination of zones, the question of authority in the area, utilization of the forest, the perceptions of the community, and the process of establishing the National Park.
15. The proposed National Park would comprise the following zones within Perian Forest: 6,998 Ha core zone, 24,943 Ha wilderness zone, 2,348 Ha utilization zone. In addition, it is proposed that the surrounding area become a buffer zone covering an area of 23,185 Ha (see Figure 6).
16. The proposed buffer zone contains approximately 8,090 Ha dry land with potential for the cultivation of perennial crops, 7,440 Ha with potential for the development of agriculture and seasonal crops. The buffer zone also includes protected areas in the hills and along the river banks (Bongan, Mahakam, and. Keham rivers).
17. Based on the Ramsar criteria, Perian Forest can be proposed as a Ramsar Wetland Site of international importance.

RECOMMENDATIONS

1. ***Conservation management of Perian Forest is essential to preserve the current site values and life support system.*** This is necessary considering that the site values important as a life support system are under threat and tending to decline (heading towards deterioration of natural resources, reduced potentials, etc.). Conservation management must include the protection of the life support system, preservation of biodiversity and the sustainable utilization of the natural resources contained therein.

2. ***If PT. ITCI wishes to keep Perian Forest as part of its forestry concession (HPH), it would be advised to apply a conservation management approach to the utilization of the areaís non-timber forest products.*** This is because the timber potential of the remaining forest in this area is relatively low and not suitable for exploitation. Moreover, these forest remnants are more useful as pockets and corridors for wildlife (particularly in riparian Perian, . Bongan and Keham rivers; and the forest around Tanjung Baru and Muara Gusik).

3. ***In order to utilize the area and forest products (excluding timber), PT. ITCI should alter its forestry licence (HPH) into a permit to utilize the forest area and its products,*** particularly in view of the new law (UU RI No. 41 1999), which contains stipulations concerning the utilization of forest areas and forest products.

4. ***PT. ITCI is expected to be pro-active in the conservation management of Perian Forest, considering the fact that this area is part of the forestry concession worked by PT. ITCI.*** This could start with PT. ITCI adopting the principles of <u>conservation of biodiversity resources</u> (as stated in Indonesian Law No.5 of 1990) and applying them to the drawing up of a Perian Forest Management Plan (in both 5 year and one year plans), involving the local community and related institutions. Besides, if it is difficult to apply the National Park model to Perian Forest, it is hoped that PT ITCI will be able to create an alternative conservation management model which is different from those already existing in Indonesia (based on Indonesian Law No.5, of 1990)..

5. ***So long as Perian Forest remains within PT. ITCI's forestry concession (HPH) or utilization license, this company is expected to develop ecotourism and non-timber forest products as alternative sources of income for the company and the local community.*** Perianís timber potential is relatively small, but its natural beauty, accessibility and biodiversity have good potential for the development of ecotourism. Depending on the soil conditions, several places are suitable for the cultivation of wetland and dryland plants. Another alternative is the management of fisheries.

6. ***If PT.ITCI relinquishes Perian Forest from its forestry concession (HPH), the Regional and Central Governments will consider taking measures to conserve Perian Forest and its surrounding area,*** in view of its important values and life support system which need to be preserved, besides the fact that a large part of Perian Forest fulfils the criteria for protected area. These conservation considerations should also be used to review Perian Forestís Non-forest Cultivation Zone [*KNBK]* status.

7. ***One Form of Conservation Management proposed for Perian Forest is the National Park.***. This is based on the understanding that the National Park is a form of conservation area which is protected under Indonesian Law, with a type of management which can be applied in Perian Forest. However, if Perian Forest does become a National Park, attention will need to be paid to several aspects, in particular: the areaís authority status, zonation, the process to establish the area to become national park, governmental readiness, and the involvement of the local community and related institutions in the planning and management process.

8. ***The proposed zonation of Perian Forest presented in this report on the study by the Wetlands International Asia Pacific-IP team should be used as reference material for the areaís management, especially if Perian Forest is designated as a National Park. Nevertheless, a more detailed zonation study will still need to be undertaken, in which all stakeholders (especially the community) should participate***. The proposed zonation is that considered best based on the results of this study, which takes into consideration the aspects of protection and preservation of habitat which supports important biodiversity, the potential for utilization, and land use planning at the time of the study. This zonation proposal is accompanied also by a proposal for a buffer zone whose management would require special attention, in view of the fact that part of this zone is protected area, and part also is land which can be utilized.

9. ***If Perian Forest is designated as a conservation area (e.g. National Park) by the Government, PT. ITCI should be given the opportunity to participate in its management,*** in view of the fact that PT.ITCI is an important stakeholder in Perian Forest and that, the Perian area being part of its forestry concession, the company is also responsible for its future conservation.

10. ***If the status of the Perian Forest area is ratified (whether as a National Park or something else) further steps should be taken promptly, in particular the drawing up of a detailed Management Plan***. A management plan is essential as one of the factors in ensuring the sustainable utilization of living/biological natural resources. All the stakeholders should be involved in the process of drawing up this Management Plan.

11. ***Community participation in the management of the conservation area must be facilitated by the managing unit, in order to ensure the sustainability of such management.***. Whatever type of conservation area is assigned to Perian Forest, the local community must be involved in the whole process of planning and area management, because their activities are encountered throughout almost the whole of the Perian Forest and the large part of their livelihoods still depends on the utilization of biological resources.

12. ***In efforts to manage the conservation of the Perian Forest area, it is necessary to clarify strictly the form of protection for existing protected areas (forest area with a slope class factor >15% covering ± 960 Ha, peat area ± 24,860 Ha, river riparian and lake riparian), as well as the utilization of areas suitable for the development of cultivation.*** This is based on the typology of habitats existing in Perian Forest which, according to current law and regulations on spatial planning, fulfil the criteria for protected areas. The protection of peat areas is especially important to Perian Forest, as peat swamp covers the largest area, has an important hydrological function for the lowland plain of the Mahakam river, and can function as a natural carbon trap. . .

13. ***Action need to be taken to rehabilitate marginal land (in particular the alang-alang covered hills near Lebak Mantan valley), and cultivating it with indigenous species. The selection of indigenous species should be a main priority in the rehabilitation of forest and land.*** The replanting of native species will, it is hoped, restore the vegetation to its original condition, and also be of economic benefit. Species suitable for dry land include rubber (*Havea brasiliensis*), meranti (*Shorea* spp.), rattan and Jambon (*Anthocephalus cadamba*). Species suitable for wetland include Kedemba merah (*Mitragyna speciosa*), Sungkai (*Peronema canescens*), Kahuy (*Shorea belangeran*), and Jelutung (*Dyera* sp.).

14. ***The indigenous species listed above should be investigated further as regards their silviculture and their suitability for the land which is to be rehabilitated.*** Rehabilitation using indigenous species is usually constrained by a lack of adequate supplies of seedlings, and a shortage of seedlings obtained from natural rejuvenation [*permudaan alam*].

15. ***When the Perian Forest has received national recognition as a conservation area (e.g. as a National Park) this area can then be submitted (by DitJen PKA-DepHutBun) to the Ramsar Bureau in Switzerland for nomination as a Ramsar site.***. This proposal that the Perian Forest become a Ramsar site is necessary because this area meets the Ramsar criteria, meaning that it is a wetland of importance not only locally and nationally but also internationally. Perian Forestís status as a conservation area needs to be recognized by the government, who have the right to propose Ramsar sites in Indonesia. Formal recognition of Perian Forest as a conservation area (e.g. National Park) will strengthen its legal status.

16. ***It is requested that the results of this study by the team from Wetlands International - Indonesia Programme be distributed to all the stakeholders in Perian Forest, in particular to the central government, regional government levels I and II, in order to reach a similar perception of the significance of conserving the Perian Forest area as a life support system.*** The management of Perian Forest must be integrated, with good cooperation among the stakeholders. Relevant government institutions, especially at regional government level, are an important group of stakeholders in the development of this area, particularly since the implementation of regional autonomy.

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MORE INFORMATION

Detailed report can be obtained from:
Wetlands International Indonesia Programme
Jl A. Yani No 53 Bogor
P.O. Box 254/BOO, Bogor 16002
Jawa Barat Indonesia
Ph/fax +62-251-325755
e-mail: admin@wetlands.or.id

Session 8

HUMAN DIMENSION, CONSERVATION AND REMOTE SENSING

Chaired by

Hidenori TAKAHASHI & Suwido Hester LIMIN

Primate Responses to Observer Related to Habitat Disturbances in Gunung Halimun National Park, West Java, Indonesia.

Jito Sugardjito and M.H.Sinaga
Research Center for Biology-LIPI and Fauna & Flora International-IP

ABSTRACT

The response behaviour of different species of primates to a field observer was studied in populations of three species: *Hylobates moloch, Presbytis comata* and *Trachypthecus auratus* in Gunung Halimun National Park, West Java, Indonesia. Data were collected on behavioural response patterns and its sighting distances. All three species showed a significantly higher fleeing response in disturbed forest habitats than in undisturbed ones. In contrast, freezing response was exhibited less in disturbed habitats than in undisturbed ones. Sighting distances in disturbed and undisturbed habitats were also compared. Detection distances were found to be significantly greater in disturbed habitats than in undisturbed habitats. These results suggest that different habitat conditions may vary behavioural response patterns in primates to perceived degree of threat from human presence.

Key words: behavioural response, primates, sighting distance.

INTRODUCTION

Behavioural studies are often considered to be of limited value to conservation because the different focus between the disciplines of behavioural and conservation biology. However, behavioural response exhibited by animals can be useful in assisting park managers to develop nature tourism planning. Therefore, to identify nature tourism sites surveys to ascertain animal populations should be complimented by studies of viewing feasibility and target animals response to human presence.

Primates are an ideal group on which to conduct this kind of study because they are arboreal, diurnal and usually easier to see than most tropical animals. They are present throughout the tropics utilizing a large range of habitats and often occurring in relatively high densities.

Primates commonly engage in a number of behavioural patterns to avoid predators and conspecific animals. These include vigilant scanning, seeking safe spots, avoidance through hiding or fleeing. Many previous studies of arboreal primates report that unhabituated animals react to a perceived threat from human observers by displaying aggressively, vocalizing, hiding, or fleeing (Rijksen, 1978; Rodman, 1979; Galdikas, 1979; van Schaik *et.al*., 1983). The avoidance and type of response exhibited by primates when first encountering an observer maybe determined by the conditions of the habitats in which they live. The intensity of threats or human activities in these habitats will also affect behavioural response. The behavioural response of animals to the presence of observer can therefore be used as an indicator for identifying the level of habituation within a population.

In the present study three questions were posed:

- Do animals show different responses in the presence of observer?
- Do these responses depend on their habitat conditions?
- Do the sighting distances vary in different habitat conditions?

The aim of this study was to quantify how unhabituated primates in Gunung Halimun National Park react to threat from human presence in order to explore whether the sites are feasible for observing animals. A comparison is made between the behavioural response patterns of the three primate species to observers in the area where the Park management plans to develop nature tourism sites.

MATERIALS AND METHODS

The study was conducted in the Gunung Halimun National Park (GHNP), West Java (6 45í S and 106 E). The GHNP region covers approximately 40,000 hectares of continuous primary forest within an altitude of 700 - 1900 m asl. The Park hosts the worldsí largest population of Javan gibbon *Hylobates moloch* (Sugardjito and Sinaga, 1999) and provides good habitat for grizzled and ebony langurs *Presbytis comata* and *Trachypithecus auratus*.

With reference to the forest habitat conditions, we categorised habitats qualitatively into two types: disturbed situations when > 50% of the big trees more than 60 cm dbh were lost due to selective logging (John, 1986), and primary forest undisturbed by logging. Disturbed habitat featured in the areas surrounding Gunung Ciawitali, Gunung Malang, Gunung Kendeng-Bapang, and Gunung Cimara, while undisturbed forest remains around Cikaniki, Gunung Botol, Gunung Andam, and Gunung Panenjoan (see figure 1). Data were collected between June and September 2000.

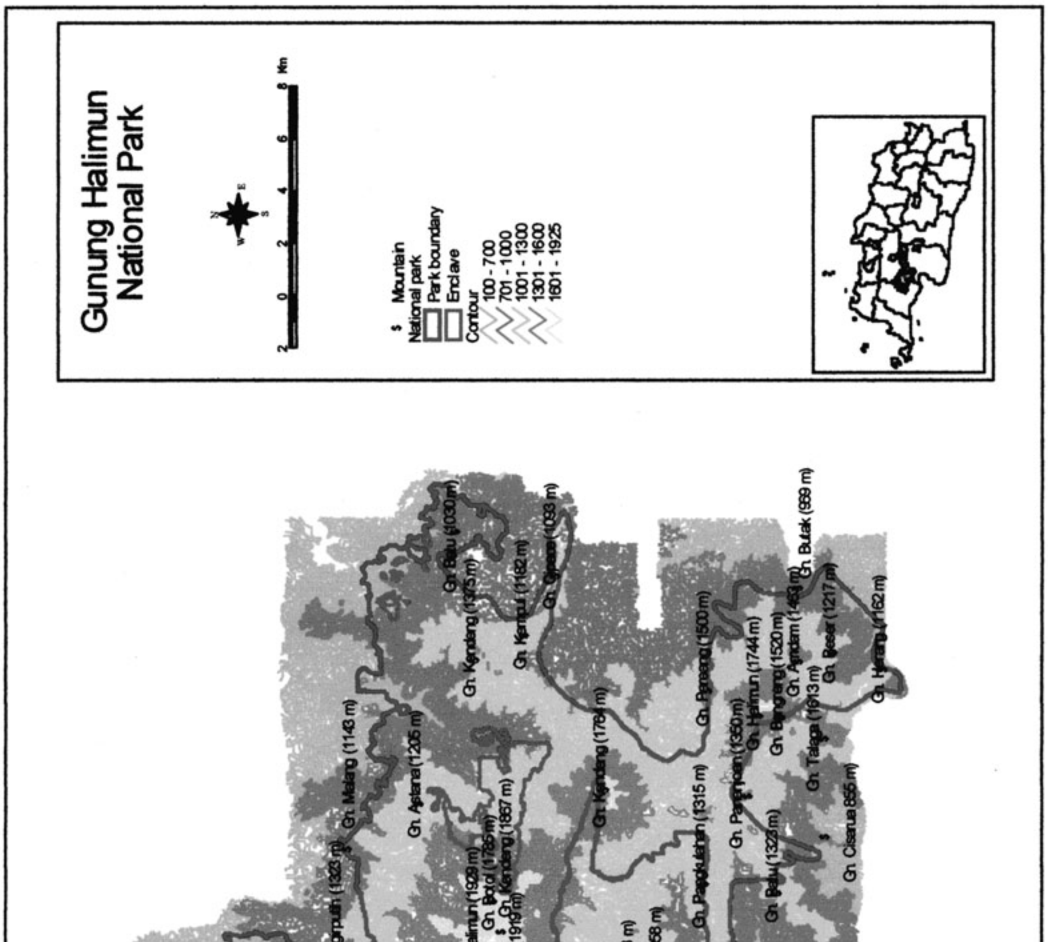
Gunung Halimun
National Park
Km
Mountain
National park
Park boundary
Enclave
Contour
100 - 700
701 - 1000
1001 - 1300
1301 - 1600
1601 - 1925

Figure 1.

We conducted surveys for three species of primates: Javan gibbon, grizzled langur and ebony langur. We used line transects method that is commonly applied to estimate primate densities in difference habitats (National Research Council, 1981; Whitesides *et al*., 1988; Sen, 1982). The transect method depends upon the detection of animals on one or both sides of the survey path. It has been employed for survey work, where rapid estimates of populations in inaccessible terrain or in widely different geographic areas, are required (Payne and Davies, 1982; Sugardjito and Sinaga, 1997). Sighting distances were measured between the observer and animals. Surveys were conducted twice daily, between 0600h and 1000h and 1400h and 1800h, the periods when diurnal primates are most active. Forest walks have been completed for 11 transects covering 51,50 km in disturbed forest habitats while it was ended for 87 km covering 13 transects in undisturbed forest habitats.

The data recorded included the number of encounters and the initial behavioural response to the observers. Response behaviour was collected for one minute following first sighting.

Response behaviour was categorised into three classes:

- Flee: animals moved quickly 10 m or more from the first encounter spot, usually by leaping, jumping, or running.
- Hide: animals move quietly less than 10 m from the first encounter spot by walking quadrapedally or bipedally.
- Freeze: animals show no response to the observer.

Critical assumptions to the methods are:

- Animal detects observer first.
- Human disturbance to the habitat has affected behaviour.
- Different species of primates show different pattern of responses.

We used the nonparametric statistics test (Siegel, 1956) for data analysis to detect any significant differences of behaviour during the study. Since the data consist of frequencies in discrete categories, the Chi-square test will be used to determine the significance of differences between two independent groups. Therefore, in order to detect whether any differences occur between first contacts in the two different habitat conditions in terms of sighting distance, we have tested the sighting distances of encounters with animals using Chi-square test for independent samples.

RESULTS AND DISCUSSION

In total 300 encounters were made. Frequency of species encounters was as follows: 131 Javan gibbon, 88 grizzled langur, and 81 ebony langur.

The total numbers of encounters with Javan gibbons were almost equal for those two different habitat categories. It is shown that 51 % occurred in disturbed habitats, while 49 % were in undisturbed habitats. In contrast, the total number of encounters with grizzled langurs was 62 % for disturbed habitats and 38 % in undisturbed habitats. The total numbers of encounters with ebony langurs was 60 % in disturbed habitats and 40 % in undisturbed habitats. The frequency of species encounters for the three primates species can be seen in figure 2.

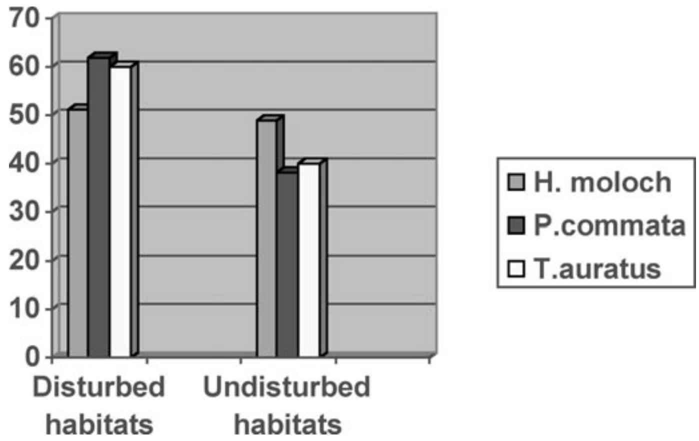

Figure 2. Percentage frequencies of encounters with three species of primates in Gunung Halimun National Park (N=300)

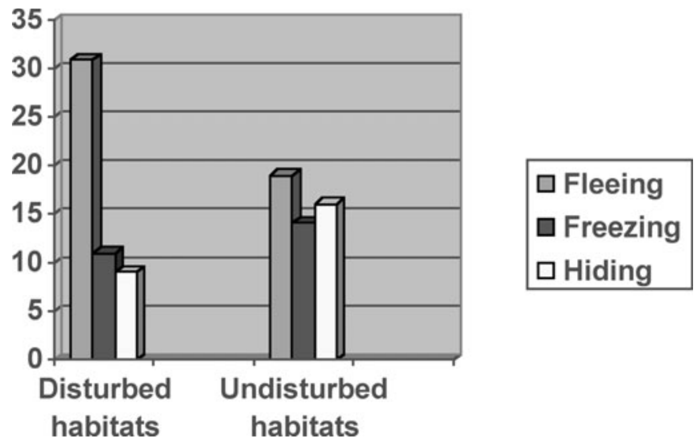

Figure 3. Percentage frequencies of behavioral responses of Javan gibbons when first encountered with an observer (N=131)

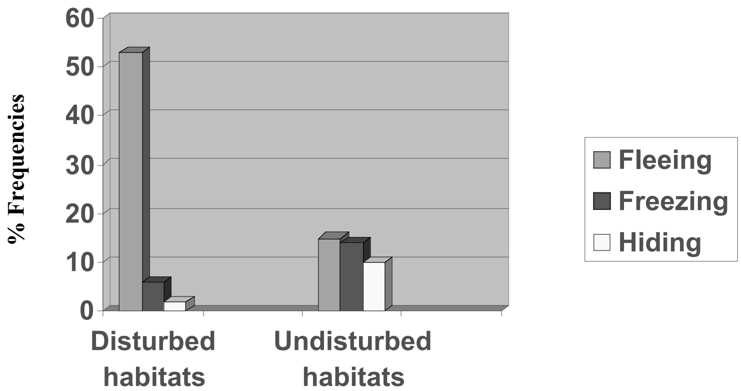

Figure 4. Percentage frequencies of behavioral responses of grizzled langurs when first encountered with an observer (N=88)

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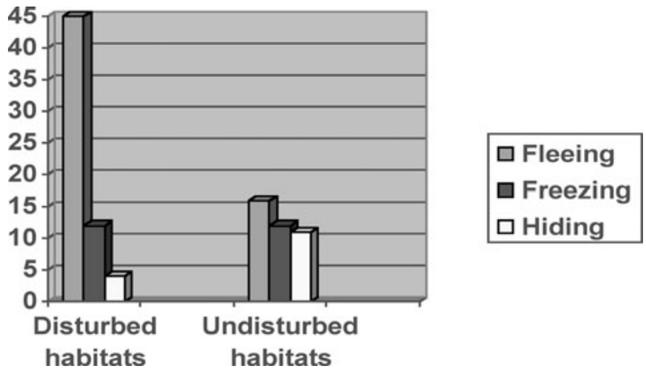

Figure 5. Percentage frequencies of behavioral responses of ebony langurs when first encountered with an observer (N=81)

We can see that observing primates in disturbed habitats was generally easier than in ones that remain undisturbed. In addition, animals showed different behavioural responses in the two habitat types. Response in undisturbed habitats was more likely to be by hiding or freezing, with few animals fleeing. In disturbed habitat primates were more likely to respond to human presence by fleeing. Increase in hiding and freezing in undisturbed habitats would probably lead to a decrease of group detection because animals were more silent and therefore harder to detect. Figure 3 shows the difference between responses of Javan gibbon during first encounter in the two habitats. Figures 4 and 5 show differences for the two species of langurs. The data indicates that response behaviour in the primates differed in the two habitats. All three species showed greater degree of fleeing response in disturbed habitats than in undisturbed habitats. In contrast, all of them have shown freezing and hiding categories less in disturbed habitats than in undisturbed habitats.

Chi square tests showed: *H.moloch*, $\chi^2 = 6.16$ $p<0.05$ df=2; *P.comata*, $\chi^2 = 23.38$ $p<0.001$ df=2; *T.auratus*, $\chi^2 = 10.84$ $p<0.01$ df=2.

For first encounters in disturbed habitats 44 % were made at a distance of more than 20 meters, while only 24 % occurred in undisturbed habitats. Whereas first encounters in disturbed habitats at a distances of less than 20 meters produced a rate of 15 % against 17% undisturbed habitats ($\chi^2 = 7.67$ $p<0.01$ df=1).

The chi square tests showed that the distances of first encounter with primates in disturbed habitats are farther than in undisturbed habitats (Fig. 6). This suggests that response depends on visibility.

In the northern part of GHNP the habitats have been disturbed by human activities fragmenting the canopy and allowing both primates and observers to be seen more easily. In the southern part of the Park the undisturbed habitat provided the opposite scenario. Increased visibility has probably lead to these differences in behavioural response. The implication of this study could be used for the planning in the development of tourism site in GHNP. The northern areas of the Park in which still containing wild primates can be used as a tourism sites providing that these areas should be protected from human interference.

ACKNOWLEDGEMENTS

We wish to thank the Biodiversity Conservation Project of LIPI-PHKA-JICA for supporting this study, particularly, Dr. T. Okayama and Mr. K. Mori. We also greatly appreciate the assistance of Mr. Sudarmadji, the Director of the Gunung Halimun National Park particularly in facilitating the field study. Mr. Jeremy Holden was appreciated for editing the English.

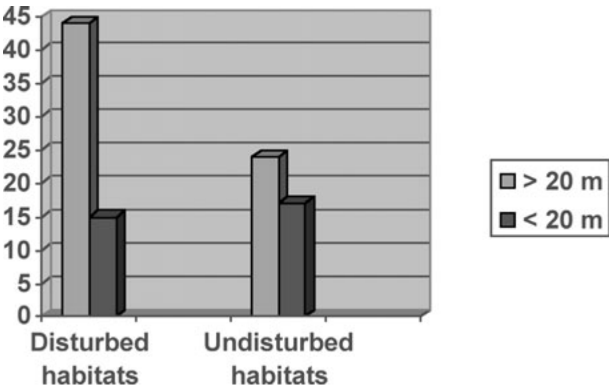

Fig. 6 Percentage frequencies of sighting distances when first encountered with three primate species in two habitat conditions (N=300)

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Potentia Use of Peat Swamp Forest by Dayak Kendayan Society in Pontianak Regency, West Kalimantan

Siti Susiarti & Edi Mirmanto
Botany Devision, Research Centre for Biology - LIPI
Juanda 22 Bogor, Indonesia - 62-251-322035
E-mail: herbogor @ indo.net.id

ABSTRACT

A study of potential use of peat swamp forest by Dayak Kendayan Society was carried out in Pontianak regency, West Kalimantan. Eight sample plots of 0.2 ha were set up to record floristic composition, forest structure and the potential use of some tree species. There were 119 tree species belonging to 70 genera and 33 families were recorded within the study area. The most abundant tree species were temau (*Cratoxylum glaucum*), ombing burung (*Elaeocarpus griffithii*), meranti batu (*Shorea smithiana*), tarenjo (*Nephelium maingayi*) and kenanga (*Litsea* sp. 1). Some species were also found to have important timber value for its strength and workability such as *Koompassia malaccensis*, *Shorea smithiana* and *Cratoxylum glaucum*. Nevertheless, the main use of the forest resources by Dayak Kendayan Society was limited to food and timber products.

Keywords: useful plant, peat swamp forest, Dayak Kendayan, West Kalimantan

INTRODUCTION

Indonesia is rich in plant species with a high degree of diversity. It has been estimated that about one third of the Malesian flora occur in Borneo. Indonesia has 25000 flower plant species and approximately 4000 tree species which are potentially useful for timber. So far about 400 species recognized have economic value and 260 species out of them classified as commercial timbers (Sastrapradja et al., 1992; Soerianegara & Lemmens, 1994; Atmosuseno & Duljapar, 1996).

Timber is very important resource in South-east Asian countries for their economic development. Malaysia and Indonesia are the two greatest exporting countries of tropical timber. In Indonesia timber is the second most important export product after oil. During period of 1985- 1987 the annual export value of tropical hardwood (logs, sawn timber and plywood) reach up almost US $ 1750 million in average. From 1988- 1992 the value of the exported timber was increased by levies, moreover, several tropical countries prohibited the export of non processed wood, to favour the domestic wood- processing industry. This has made prices of exported timber increase considerably in recent years, and the export of sawn timber, veneer and plywood is currently an very important source of foreign exchange. For instance, from 1988 to 1989 the value of the export of plywood in Indonesia increased by 27 %. The main importers of Malaysian and Indonesian timbers are Japan (46 %), other countries in East Asia (42 %), the European Community (7 %) and the United States (3 %) (Soerianegara & Lemmens (1994).

Although the peat swamp forest community is not as rich as that of the dry land forest, it contains many interesting species of flora restricted to this special habitat. The peat swamp forest has potency not only forest product with high economic value but hopefully also in sustainable and well- balanced ecosystem. For exampleThe peat swamp forests in Pontianak regency, for example, is one of the interesting areas that should be conserved in order to maintain their biodiversity

STUDY SITES

The study was conducted at some sites in Pontianak regency, West Kalimantan that were Sungai Pinyuh District (Galang), Mandor District (Mandor National Park; Kopiang, Mianas); Sangah Tumila District (Saham) and one study site in Tayan District (Lais) which is a part of Sanggau regency. The site is up to 60 meters above sea level. Dayak Kendayan society lives commonly in West Kalimantan such as Mandor district, Sangah Tumila district and vicinity.

METHODS

An eight- sample plot of 0.2 ha was established on a peat swamp forest in each study sites with the goal of recording floristic composition, forest structure and potential use of all tree species. The plot was divided into 100 subplots of 10 m by 10 m and all trees with DBH greater more than 10 cm within each plot were identified to species. Plant species encountered from the plot and during exploration were recorded. In addition interviewing with local people was carried in order to understand of local name, potential used of all the plant species. Herbarium specimens were collected, treated with alcohol, then sent to Herbarium Bogoriense, Research Center for Biology-LIPI in Bogor for further identification.†

RESULTS AND DISCUSSION

There were 119 tree species belonging to 70 genera and 33 families were recorded within the study area. Dipterocarpaceae, Myrtaceae, Euphorbiaceae, Sapotaceae, Sapindaceae, Hypericaceae, Elaeocarpaceae, Anacardiaceae are recorded as the commonest families with relatively high in Family Importance Value (Mirmanto et al., 1993). The

Table 1. List of plant species in the observed sites

Local name	Species	Family	Uses
Mensira	Alangium sp.	Alangiaceae	
Terentang	Campnosperma coriaceum	Anacardiaceae	E
Rengas darat	Gluta renghas	Anacardiaceae	E
Rengas	Mangifera applanata	Anacardiaceae	G
Pinyaho		Annonaceae	E; H
Mengkoyang gunung	Xylopia cf altissima	Annonaceae	
Pelaik	Alstonia scholaris	Apocynaceae	E; C
Jelutung	Dyera costulata	Apocynaceae	E
Marwas	Arthrophyllum diversifolium	Araliaceae	
Antapong	Vernonia arborea	Asteraceae	
Pangkok	Santiria griffithii	Burseraceae	B
Raba-raba	Santiria laevigata	Burseraceae	E; B
Cemara	Casuarina cf nobilis	Casuarinaceae	J
Seromet		Celastraceae	I
Bintangur dn. halus		Clusiaceae	B
Bintangur bekakal		Clusiaceae	I
Bintangur dn. Panj. berbulu	Calophyllum austrocoriaceum	Clusiaceae	A
Bintangur bekakal	Calophyllum cf sclerophyllum	Clusiaceae	E;D;A
Bintangur bulat	Calophyllum hosei	Clusiaceae	
Bintangur dn. pendek	Calophyllum sclerophyllum	Clusiaceae	A
Bintangur tadung	Calophyllum sclerophyllum	Clusiaceae	E
Bintangur bulan	Calophyllum soulattri	Clusiaceae	E;D;A
Bintangur sendok	Calophyllum sp (3)	Clusiaceae	E;D;A
Manggis hutan	Garcinia cf bancana	Clusiaceae	B
Manggis hutan	Garcinia cuspidata	Clusiaceae	B
Manggis hutan	Garcinia parvifolia	Clusiaceae	B
Birantang burung		Connaraceae	B
Keranji padi		Connaraceae	B
Medang keran	Dactylocladus stenostachys	Crypteroniaceae	E
Madang keladi	Dactylocladus stenostachys	Crypteroniaceae	E; A
Ancaneng		Dipterocarpaceae	E
Paning-paning		Dipterocarpaceae	A
Penyaho rebung	Anisoptera marginata	Dipterocarpaceae	H
Rasak durian	Cotylelobium burckii	Dipterocarpaceae	E
Keladan	Dryobalanops fusca	Dipterocarpaceae	
Empedu	Dryobalanops keithii	Dipterocarpaceae	E
Rasak jawe	Hopea pentanervia	Dipterocarpaceae	E
Rasak tanjung	Hopea pentanervia	Dipterocarpaceae	E
Rasak air	Hopea pentanervia	Dipterocarpaceae	E; F
Tengkawang tikus	Shorea macrophylla	Dipterocarpaceae	E;B (oil); A
Mabang	Shorea pachyphylla	Dipterocarpaceae	E; F
Meranti bunga	Shorea parvifolia	Dipterocarpaceae	E
Meranti rawa	Shorea parvifolia	Dipterocarpaceae	E
Meranti gambir	Shorea smithiana	Dipterocarpaceae	E
Meranti batu	Shorea smithiana	Dipterocarpaceae	E; F
Meranti papak	Shorea smithiana	Dipterocarpaceae	E; F
Rasak lilin	Vatica umbonata	Dipterocarpaceae	E
Kayu malam	Diospyros sp.	Ebenaceae	J
Ombing burung	Elaeocarpus griffithii	Elaeocarpaceae	B
Ombing	Elaeocarpus sp.	Elaeocarpaceae	
Ringkapok		Euphorbiaceae	J
Tampi	Baccaurea bracteata	Euphorbiaceae	B
Kayu tampi	Baccaurea lanceolata	Euphorbiaceae	B
Raratih	Baccaurea sp. (1)	Euphorbiaceae	N
Gatah	Hevea brasiliensis	Euphorbiaceae	L
Marikubung	Macaranga gigantea	Euphorbiaceae	J
Mahang	Macaranga hypoleuca	Euphorbiaceae	E
Porang	Macaranga triloba	Euphorbiaceae	N
Kudengkang	Archidendron clypearia	Fabaceae	J

Tulang ular	Archidendron sp (1)	Fabaceae	J
Kempas	Koompassia malaccensis	Fabaceae	G, D
Patai	Parkia sumatrana	Fabaceae	B
Siapak	Sindora	Fabaceae	E
Ampaning kulup	Lithocarpus caudatifolius	Fagaceae	F
Temau	Cratoxylum glaucum	Hypericaceae	E
Tamau besi	Cratoxylum sp.	Hypericaceae	E;
Monte	Engelhardtia serrata	Juglandaceae	N
Madang abo	Artocarpus sp (1)	Lauraceae	E; A
Medang lendir	Litsea	Lauraceae	E; C
Medang ayu	Litsea brachystachya	Lauraceae	E; A
Kenanga	Litsea sp (1)	Lauraceae	N; J
Mipis kulit	Memecylon myrsinoides	Melastomataceae	M
Ubah jambu	Pternandra rostrata	Melastomataceae	E
Pantu		Meliaceae	E; N
Amih	Aglaia sp. (1)	Meliaceae	M
Langsat hutan	Aglaia triplex	Meliaceae	B; D
Parak	Amoora rubiginosa	Meliaceae	F
Angubi	Artocarpus nitidus	Moraceae	E;B
Geronggang	Ficus lepicarpa	Moraceae	J
Kayu ara sendok	Ficus sp (3)	Moraceae	A
Kayu ara	Ficus sp (4)	Moraceae	A
Kumpang	Myristica	Myristicaceae	B; J
Sapi-sapi		Myrsinaceae	M, G
Pasir-pasir bawah	Ardisia sp (3)	Myrsinaceae	D
Pasir-pasir	Ardisia sp.(2)	Myrsinaceae	J
Ubah	Rapanea sp.	Myrsinaceae	
Ubah takok		Myrtaceae	
Mancira kenanga		Myrtaceae	J
Ubah menjalin	Syzygium	Myrtaceae	B
Ubah pelanduk	Syzygium	Myrtaceae	E
Ubah besi	Syzygium cf atenuata	Myrtaceae	E
Ubah air	Syzygium sp (a)	Myrtaceae	E; A
Ubah nilas	Syzygium sp (b)	Myrtaceae	E; B
Ubah nasi	Syzygium sp (c)	Myrtaceae	B
Ubah pamok	Syzygium sp (f)	Myrtaceae	J
Ubah lumut	Syzygium sp (g)	Myrtaceae	E; B; A
Pansi	Syzygium sp (h)	Myrtaceae	E; B; A; J
Ubah kakok	Syzygium sp.	Myrtaceae	B; A
Bunyalitn		Polygalaceae	B
Bait=Kelatik kering		Polygalaceae	N
Kamuning		Rhamnaceae	E; B
Sendok-sendok	Combretocarpus rotundatus	Rhizoporaceae	D; K
Mentibu	Petunga microcarpa	Rubiaceae	E
Tarak manuk	Timonius flavescens	Rubiaceae	I
Nyarampang	Euodia sp.	Rutaceae	K
Mentibu		Sapindaceae	E; C
Tarenjo	Nephelium maingayi	Sapindaceae	B; A
Redan	Nephelium maingayi	Sapindaceae	B
Keranji batu	Nephelium sp. (1)	Sapindaceae	
Sarigoja	Nephelium sp. (2)	Sapindaceae	B
Kasei	Pometia pinnata	Sapindaceae	I
Sibun-bun		Sapotaceae	E; D
Nyatuk jungkang	Palaquium cf gutta	Sapotaceae	E; A
Nyatuk tulang	Palaquium gutta	Sapotaceae	E
Melaban odang	Palaquium sp (a)	Sapotaceae	F; M
Kabaca		Theaceae	E; G
Jingir	Ploiarium alternifolium	Theaceae	D, K
Jempari tawang	Gonystyllus brunescens	Thymelaeaceae	E
Tamasuk	Gonystyllus sp (a)	Thymelaeaceae	E
Ampaning burung			A

Notes: A= The fruit is edible for animal ; B= The fruit is edible; C= The wood is for case; D= The wood is for light construction; E= The wood is for chip wood; F= The wood is for wooden tile; G= The wood is for material of pining of gold; H= The wood is for material to construct traditional boat; I= The wood is for medicine & fish poison; J= The wood is for firewood; K= The leaves are for vegetable; L= The sap of plant is for latex; M= The wood is for agriculture tool; N= Others most abundant tree species were temau (*Cratoxylum glaucum*), ombing burung (*Elaeocarpus griffithii*), meranti batu (*Shorea smithiana*), tarenjo (*Nephelium maingayi*) and kenanga (*Litsea* sp. 1). The forest products are used for general utility including sawn timber, foods and animal food by Dayak Kendayan Society.

The societies are use timber for chip wood, pole, wooden tile, material construction, case and boat. Species of Dipterocarpaceae such as rasak durian (*Cotylelobium burckii*), keladan (*Dryobalanops fusca*), empedu (*D. keithii*), rasak jawe (*Hopea pentanervia*), mabang (*Shorea pachyphylla*), meranti bunga (*S. parvifolia*), meranti batu (*S.smithiana*), rasak lilin (*Vatica umbonata*) are usually used for chip wood, pole, wooden tile. Penyaho rebung (*Anisoptera marginata*) is used for boat and it is also used for house building in Peninsular Malaysia (Peng & Ibrahim, 2001). Dipterocarpaceae is usually found the big tree include 9 genus namely: *Anisoptera, Cotylelobium, Dipterocarpus, Dryobalanops, Hopea, Parashorea, Shorea, Upuna and Vatica* and 7 genus of them are found in this study area.

Both *Dryobalanops fusca* and *Dryobalanops keithii* are called commercial name as kapur. Kapur is an important construction timber. It is used for both heavy and light construction. *Hopea pentanervia*, the wood is frequently used for hewn posts in heavy construction and is also popular for the keels of boats. *Shorea smithiana* , the timber is one of the chief sources of light red meranti in north-eastern Borneo. The wood yields a light brown dammar of good quality. *Shorea macrophylla*, the timber is called as a light red meranti and being one of the most important sources of illipe nuts. *Shorea pachyphylla* ,the timber is valuable dark red meranti. *Shorea parvifolia* ,the timber is the main source of light red meranti in South-East Asia. *Vatica umbonata*, the timber is called as resak for construction of houses, bridges and wharfs and other purposes requiring strength and durability (Soerianegara & Lemmens ,1994).

Some species were also recorded to have important timber value because of their strength and durability. *Shorea smithiana* has specific gravity 0.50, the strength of wood class III - II and durability class IV- III, *Dryobalanops fusca* has specific gravity 0.84, the strength of wood class II and durability class II-III, *Calophyllum soulattri* has specific gravity 0.54, the strength of wood class III and durability class II-IV, *Palaquium gutta* has specific gravity 0.71, the strength of wood class II and durability class III- IV, *Cratoxylum glaucum* has specific gravity 0.50, the strength of wood class III - II and durability class IV- III.

The timber class grouping is based on its specific gravity, strength, durability and resistant against termites. Class I refers to the highest specific gravity, strength, durability and resistant against termites whereas class II until Class V shows the lower specific gravity, strength, durability and resistant against termites. An example of this can be found in kempas (*Koompassia malaccensis*) which has specific gravity 0,95; the strength of wood class I- II and the durability class III- IV. Further more the dry wood resistant against termites is class IV whereas the resistant of this species against wood decomposer fungi is class II-IV (Martawijaya *et al*., 1989[a,b]; Seng, 1990).

In traditional gold mining area the children especially elementary school often swimming and panning gold by using small wood dishes which is made from kempas wood after school.

There are some edible fruits tree species namely tarenjo (*Nephelium maingayi*), pangkok (*Santiria griffithii*), raba-raba (*Santiria laevigata*), manggis hutan (*Garcinia cuspidata, G.* cf *bancana, G. parvifolia*), tampi (*Baccaurea bracteata*), kayu tampi (*Baccaurea lanceolata*), langsat hutan (*Aglaia triplex*), angubi (*Artocarpus nitidus*), ubah (*Eugenia* spp.) and one low palm is asam payak (*Eleidoxa conferta*). Oil extrated from seeds of tengkawang tikus (*Shorea macrophylla*) of Dipterocarpaceae may be used for cooking.

Tarak manuk (*Timonius flavescens*) only is used for medicinal. Dayak Tunjung society in East Kalimantan and Bugis society in South Sulawesi are also used for medicinal (Siagian, et al., 1993).

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Prediction of the Hydroperiod and Phenology of a Peat Swamp Forest in Central Kalimantan using MODIS Data.

Sawahiko Shimada[1], Hidenori Takahashi[2], and Suwido H. Limin[3]
1 Department of Bioproduction and Environment Engineering,
Tokyo University of Agriculture
Sakuragaoka 1-1-1, Setagaya-ku, Tokyo 156-8502, Japan
Phone: +81-3-5477-2767, Fax: +81-3-5477-2620, e-mail: shima123@nodai.ac.jp
2 Graduate School of Environmental Earth Science, Hokkaido University
N. 10, W. 5, Kita-ku, Sapporo 060-0810, Japan
Phone: +81-11-706-2221, Fax: +81-11-706-2221, e-mail: htaka@ees.hokudai.ac.jp
3 Faculty of Agriculture, University of Palangka Raya
Jl. Yos Sudarso, Central Kalimantan, Indonesia
Phone: +62-536-25728, Fax: +62-536-25728, e-mail:
suwido@palangkaraya.wasantara.net.id

ABSTRACT

In this study, in order to monitor the seasonality of the function in peat swamp forests by remotely sensed data, we attempted to predict the hydroperiod and phenology of a peat swamp forest in Central Kalimantan using multi-temporal TERRA-MODIS data. We developed a niche method to compress the monthly NDVI images of one-year period into four seasonal NDVI images. The four seasonal periods were discriminated by using the degree and aspect of the local groundwater level. Five phenology types, i.e., Dry-philous, Dry-phobous, Wet-philous, Wet-phobous, and Mixed phenology type, were classified from the seasonal fluctuation in NDVI values. The water-deficit stress of vegetation during the dry season in the Dry-phobous forest phenology type, and the water-flooding stress of vegetation during the wet season in the Wet-phobous forest phenology type were indicated. The forest phenology is clarified to be strongly affected by the hydroperiod in the peat swamp forests.

Keywords:Central Kalimantan, hydroperiod, peat swamp forest, phenology, TERRA-MODIS

INTRODUCTION

Tropical peat swamp forests (PSFs) play important roles in many global processes, such as carbon sequestration, hydrological regulation, and biodiversity maintenance. A lot of studies have been done to evaluate the importance of PSFs in such functions at the scale of local level. However, it is still in the process of development to extend the scale and link with the wide areal information such as GIS data and remotely sensed data. In this study, in order to monitor the seasonality of the function of PSFs by remotely sensed data, we attempted to predict the hydroperiod and phenology of a PSF in Central Kalimantan using multi-temporal vegetation index data of TERRA-MODIS.

The Normalized Difference Vegetation Index (NDVI), has been reported to have correlations with many physical, physiological characteristics of vegetation, e.g., vegetation cover ratio, leaf area index LAI), biomass, chlorophyll amount, absorbed photosynthetic photon flux density (PPFD), transpiration, and photosynthetic rate (Nishida *et al*., 2000). The NDVI is calculated by the following equation:

$$\text{NDVI}=\frac{\text{NIR-RED}}{\text{NIR+RED}} \qquad \text{eq(1)},$$

where NIR and RED are radiative reflectance value at the wavelength of near-infrared and of visible red, respectively. In this study, we used this NDVI value as an index of vegetation activity, and traced the seasonal fluctuation through one-year period (Feb. 2001 - Jan. 2002) in order to decide phenology types.

MATERIALS AND METHODS

Deriving Smoothed Monthly NDVI Images

The multi-temporal 16-days composite vegetation index datasets (L3 GLOBAL 500M ISIN GRID V003) of MODIS over Central Kalimantan area were acquired via Earth Observing System (EOS) Gateway (http://edcimswww.cr.usgs.gov/pub/imswelcome/). The monthly composite NDVI images (Jan. 2001 - Feb. 2002) were made by combining these 16-days composite NDVI images. The 12 monthly NDVI images (Feb. 2001 - Jan. 2002) were, finally, made after smoothed by the time series filter of 3-month moving median in order to eliminate cloud and noise. Erdasís Imagine 8.5 software was used in all the process dealing with the MODIS images.

Topographic indices and extent of the study area

Being considered the areal extent of PSF based on Land system map and Land use Map of RePPProT (1985) (Shimada *et al*., 2001), the one-year mean NDVI value ($NDVI_{1yr}$) of 0.9 were determined as the threshold value to divide forested area (PSF; $NDVI_{1yr} \geq 0.9$) and non forested area ($NDVI_{1yr} < 0.9$) (Fig. 1-B). The phenological classification was conducted

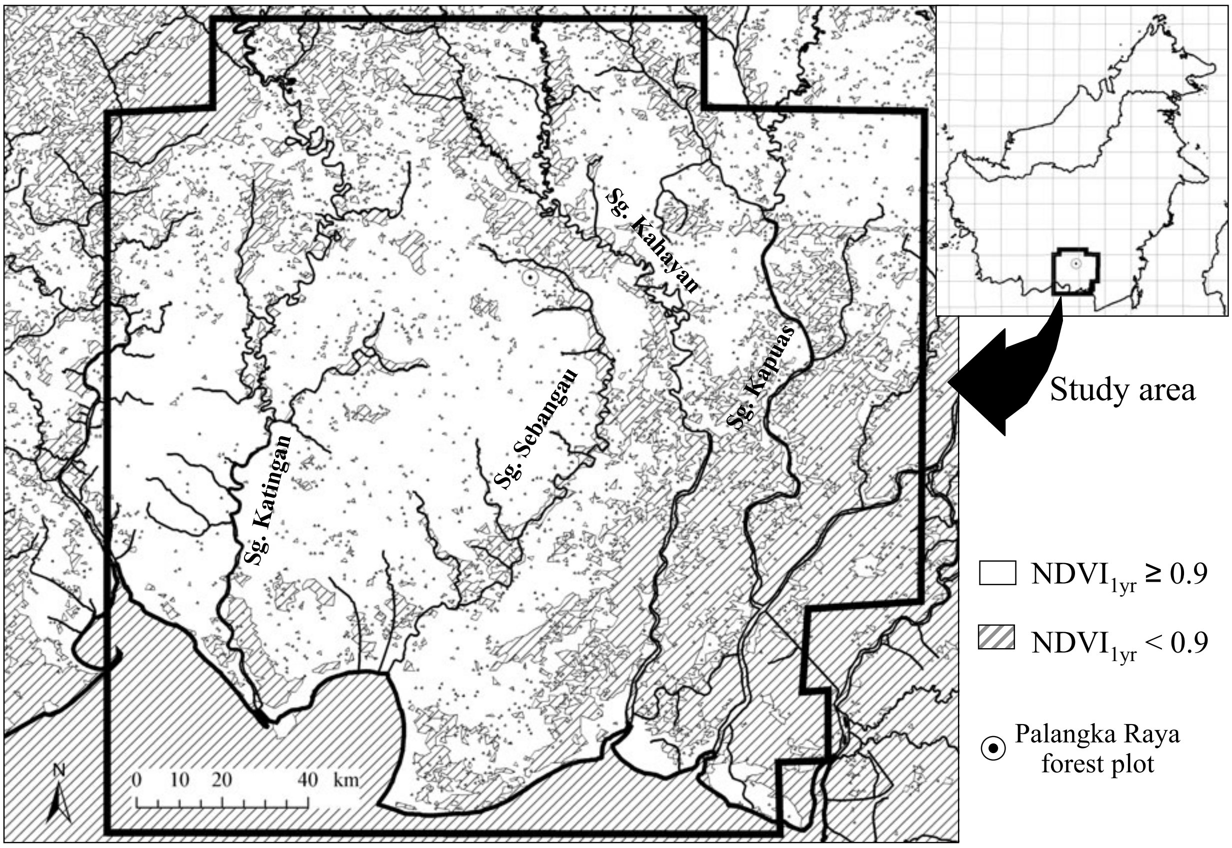

Figure 1. Classified land cover map of peat swamp forest ($NDVI_{1yr} \geq 0.9$) and non forested area ($NDVI_{1yr} < 0.9$) in Central Kalimantan superimposed by the areal extent of the study area for analysis.

both the forested and not forested area, then compared the difference in the characteristics between the two land cover types.

In this study, in order to examine the effect of the topographic location on the vegetation phenology, digital elevation model (DEM) of 500-m ◊ 500-m and digitized line data of river drainage of Central Kalimantan were derived from BAKOSURTANAL (1997) (cf. Shimada *et al*., 2000). Three topographic indices, i.e. slope, convexity index (CVI; Fig. 2-A), and cost weighted distance to the nearest drainage system (CWD_{dr}; Fig. 2-B), were calculated using ESRIís ArcGIS 8.1 software. The CVI was defined as the following equation:

$$CVI = h_{Mean} - \frac{h_{Max} - h_{Min}}{2} \qquad \text{eq(2)},$$

where h_{Mean}, h_{Max} , and h_{Min} are maximum, minimum, and mean elevation value, respectively, within a circle of 2-km radius from the focal point. The absolute value of CVI represents the degree of convexity (CVI > 0) and concavity (CVI < 0). The CWD_{dr} was calculated by setting the elevation as the cost value. The least accumulated cost (i.e., elevation) to get to the nearest river or sea was determined first, and then the cost weighted distance was calculated. This value is the combined index of elevation and distance from drainage system. Since the areal extent of the DEM is limited, the study area was modified within where DEM data exists (Fig. 1).

Discrimination of Seasonal Period

Typically, the PSFs of Central Kalimantan region has a dry season (evapotranspiration exceed precipitation) of ca. 2-3 consecutive months in a year (Neuzil, 1997). The vegetation of the PSF might be affected by this seasonality, especially the fluctuation of groundwater level. The monthly data of precipitation and groundwater level, which period is same with the multi-temporal MODIS data (Feb. 2001 -Jan. 2002), were obtained in the filed of Palangka Raya forest plot (Plot-1B; Fig. 1, Fig. 3-A). Since the evapotranspiration of this plot is reported to be ca. 3.5 mm day^{-1} (Kayama, 2000), 3 month-period of June- August can be defined as the dry season of 2002 in terms of rainfall deficit. However, the fluctuation of the groundwater level seems to react a few months after the alteration of the precipitation rate (Fig. 3-A). In order to trace the vegetation sensitivity to the fluctuation of the groundwater level, in this study, the seasonal periods were divided based on the degree or aspect of the groundwater level. For this reason, one-year period was divided into 4 seasonal periods (i.e. S1, S2, S3, and S4) consist of 3 consecutive months, respectively, as shown in Fig. 3-B. The seasonal period of S1 and S4 are the seasons of high groundwater level, S2 is the transitional season when the groundwater level is in

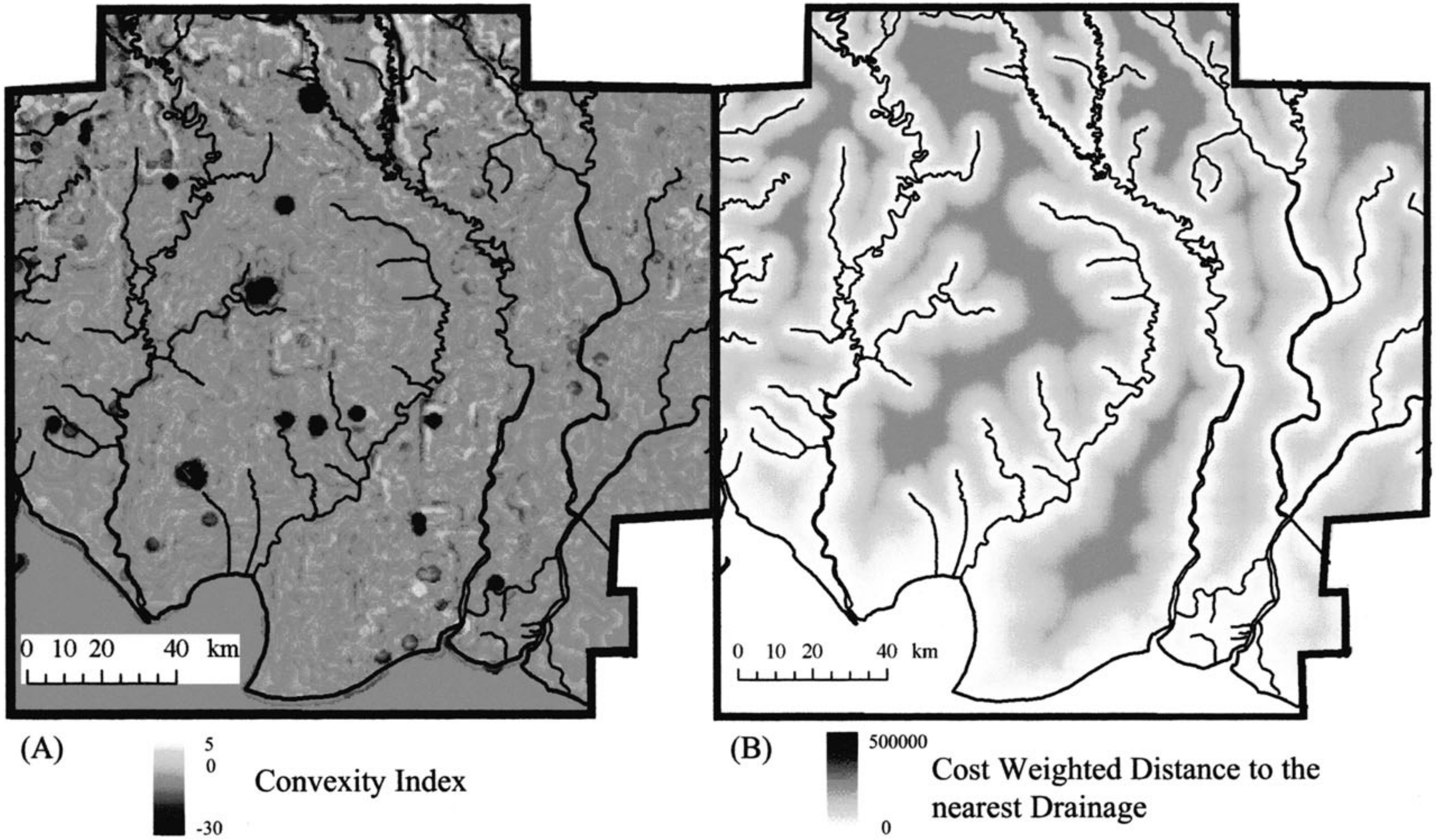

Figure 2. Map of (A) convexity index (CVI) and (B) cost (elevation value) weighted distance to the nearest drainage system (CWD_{dr}) within the study area of Central Kalimantan.

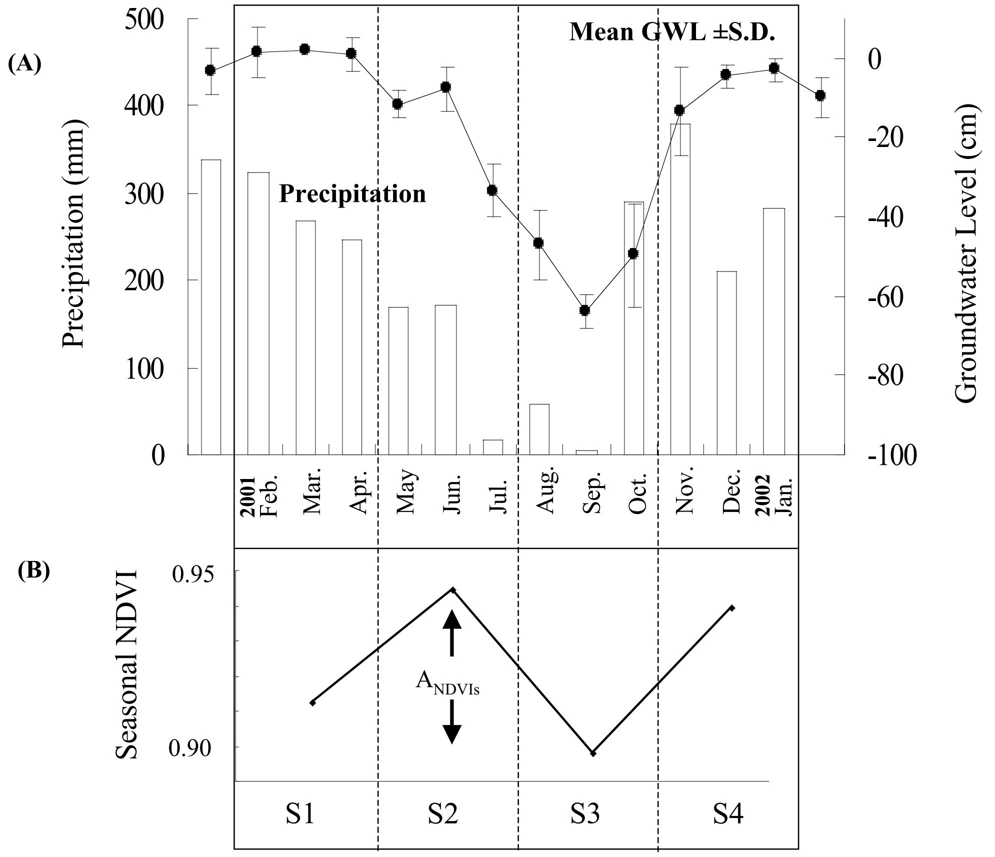

Figure 3. (A) Monthly precipitation and monthly mean groundwater level (±S.D.) and (B) seasonal NDVI fluctuation at Palangkara Raya forest plot (cf. Fig. 1). $NDVI_{S\text{-}Max}$=$NDVI_{S2}$, $NDVI_{S\text{-}Min}$=$NDVI_{S3}$ is clear and this plot can be classified to be “Dry-phobous” (cf. Fig. 4). Seasonal NDVI amplitude (A_{NDVIs}) can be calculated by $NDVI_{S2}$ $NDVI_{S3}$.

Phenological Classification

We calculated the mean NDVI values of the 4 seasonal periods ($NDVI_{S1}$, $NDVI_{S2}$, $NDVI_{S3}$, and $NDVI_{S4}$), for all the 500 m x 500 m pixels, from the 12 monthly NDVI images. For each pixel, the fluctuation of seasonal NDVI can be seen (cf. Fig. 3-B). We, then, calculated the following 3 phenological indicators for all the pixels; i.e., the maximum and minimum seasonal NDVI ($NDVI_{S\text{-}Max}$ and $NDVI_{S\text{-}Min}$, respectively) within the 4 periods, and the Amplitude of seasonal NDVI (A_{NDVIs}: $NDVI_{S\text{-}Max}$ - $NDVI_{S\text{-}Min}$) (cf. Fig. 3-B).

Focusing on the only dry season of S3 (cf. Fig. 3-B), we selected the pixels that contain $NDVI_{S\text{-}Max}$ and $NDVI_{S\text{-}Min}$ in the S3 period, and classified such pixels as “Dry-philous” and “Dry-phobous” phenology type, respectively. The other pixels that werenít classified either of the two were, then, divided into 2 types, focusing on the $NDVI_{S\text{-}Max}$ and $NDVI_{S\text{-}Min}$ occurred in the wet season (S1 or S4), and were classified as “Wet-philous” and “Wet-phobous” phenology type, respectively. There, still, exist pixels that werenít classified into any of the above 4 phenology types. We classified such pixels as “Mixed” phenology type. Finally, the derived phenology map was smoothed by the focal majority filter in order to eliminate the small patches such as < 4 pixels (i.e., < 1 km^2) (Fig. 4). The relationships of these topographic indices and phenology types were analyzed.

RESULTS AND DISCUSSION

Fig. 5 shows the areal distribution of the phenology types in both land cover types. Most in the study area of the PSF (i.e., $NDVI_{1yr} \geq 0.9$) seems to be dominated by the vegetation type that is not active in the wet season (i.e., Dry-philous and Wet-phobous phenology type), in other words, the ombrophobous type. The Dry-phobous type occupies almost the half of the non forested area ($NDVI_{1yr} < 0.9$) in the study area. It should be noted that the large area of cultivated land around the lower catchment of River (Sg.) Kapuas (cf. Fig. 1) contribute largely on the characteristics of whole the non forested areas.

The non forested areas are anticipated to consist of cultivated lands, floodplain areas, residual hills, urban areas, and burnt forests. The significantly greater ($P<0.01$, Scheffe’s test) value of the A_{NDVIs} at non forested area (Fig. 6-A) can be explained by the planting and harvesting in cultivated lands. The significantly ($P<0.01$) lower value of CWD_{dr} in non forested area (Fig. 6-D) indicates that PSFs exist or remain farther inside watersheds, where deeper peat layer exists. The residual hills can be detected by the extremely lower value of convex index (Fig. 2-A). The residual hill, the place of high degree of concavity (inverse value of CVI) and slope, tends to be classified as Wet-phobous within non forested land

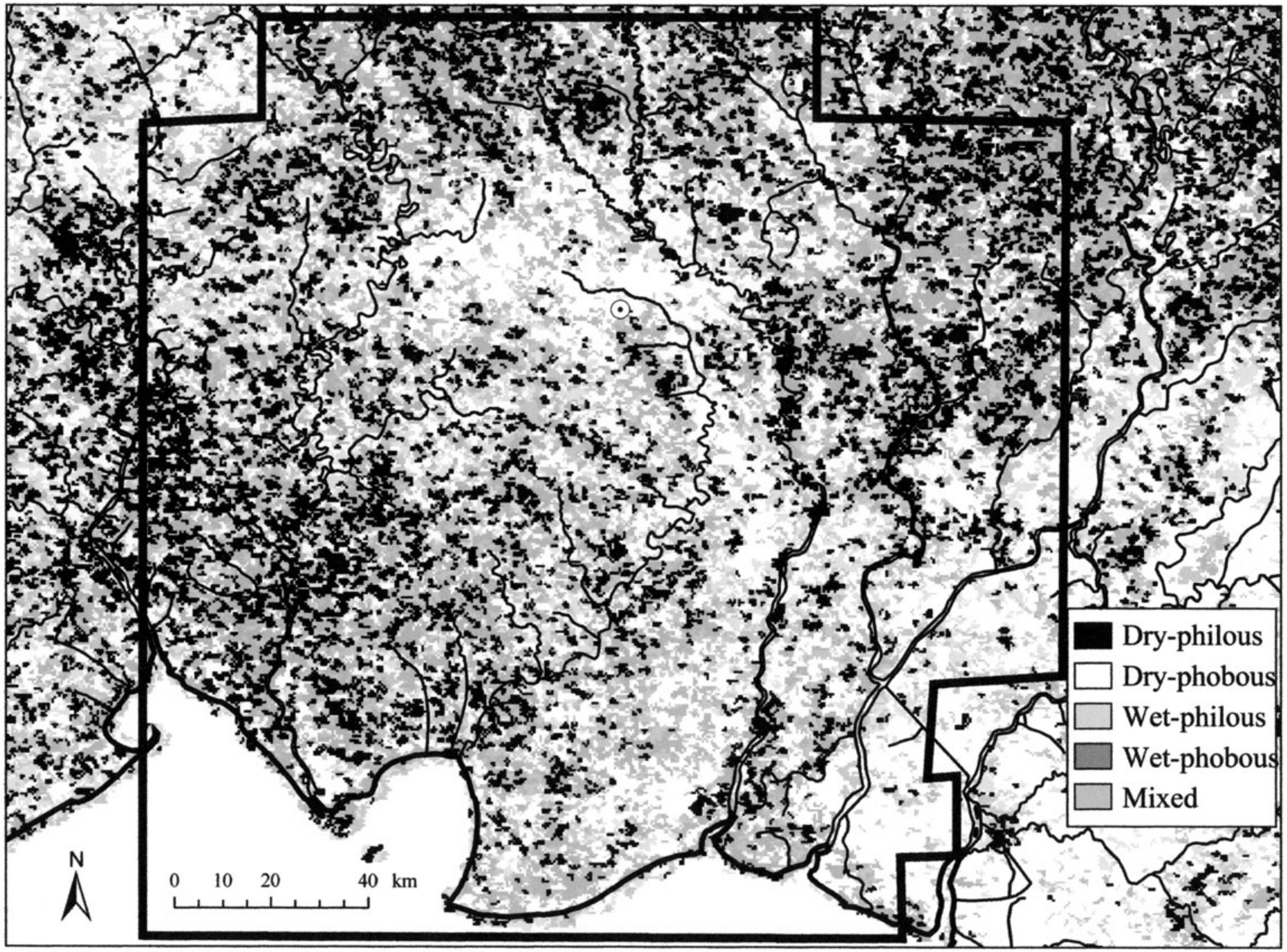

Figure 4. Classified map of phenology type in Central Kalimantan superimposed by the areal extent of the study area for analysis.

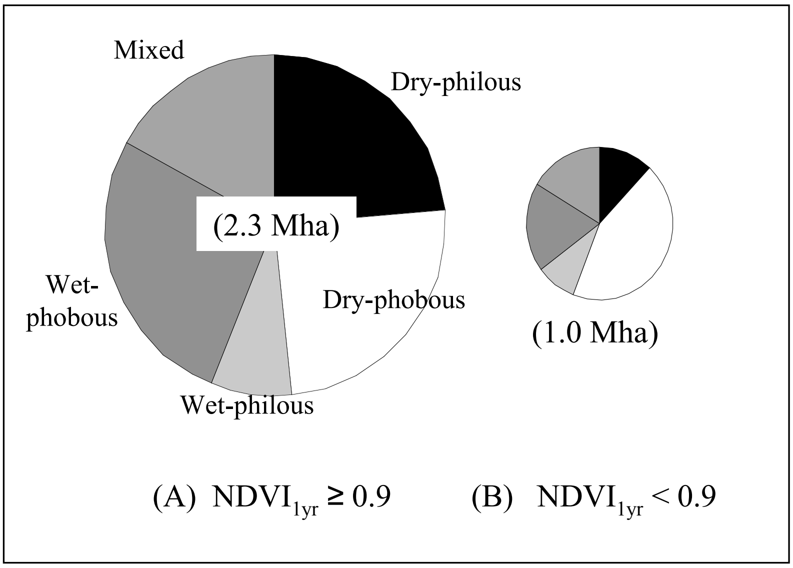

Figure 5. Areal distribution of the phenology types in both (A) forested area ($NDVI_{1yr}$ ≥ 0.9) and (B) non forested area ($NDVI_{1yr}$ < 0.9). The size difference of the two pie charts reflects the areal ratio between both land cover types.

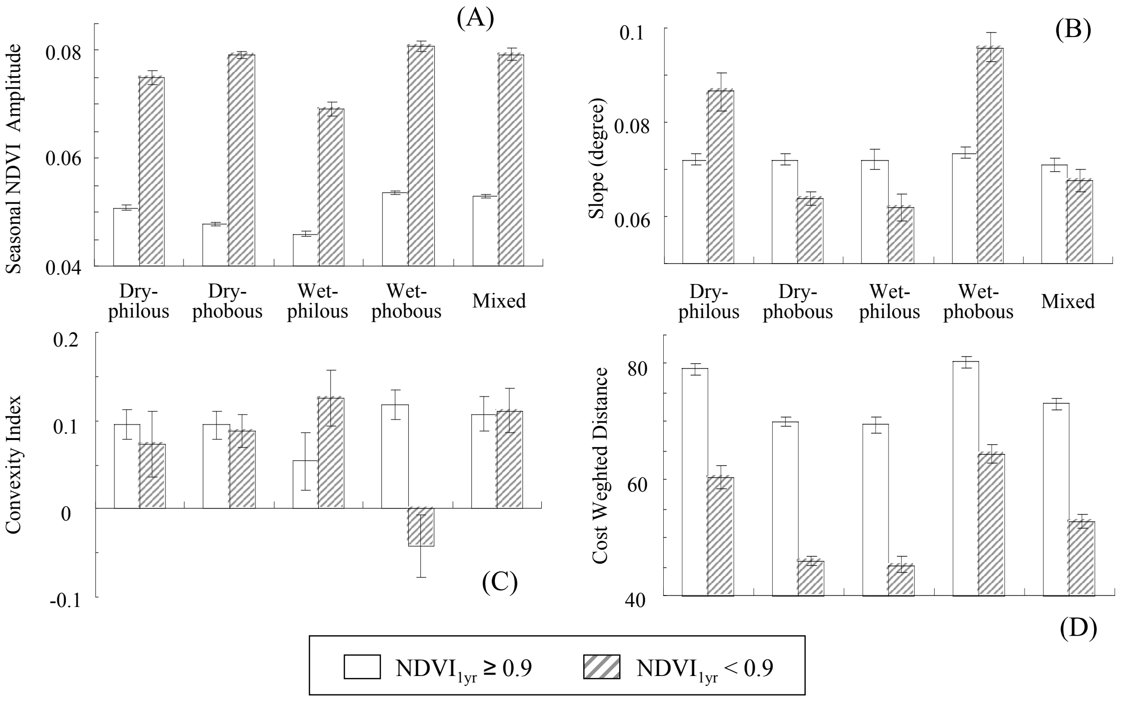

Figure 6. Mean (±95% confidence interval) values of (A) seasonal NDVI amplitude (A_{NDVIs}), (B) topographic slope, (C) convex index (CVI), and (D) cost (elevation value) weighted distance to the nearest drainage system (CWD_{dr}) among the phenology types and land use types.

cover type (Fig. 5-B, -C).

The mean A_{NDVIs} values between PSF phenology types are significantly different (P<0.05) expect between Wet-phobous and Mixed type, which mean A_{NDVIs} values are significantly (P<0.01) greater than the other types (Fig. 5-A). According to the significantly (P<0.01) lower value of mean A_{NDVIs} in Wet-philous PSF phenology type, the vegetation activity is relatively constant during one-year period. No significant difference (P>0.05) is found in any mean slope values between PSF phenology types (Fig. 5-B). The significant difference (P<0.01) in mean CVI value can be found only between Wet-philous and Wet-phobous PSF phenology types (Fig. 5-C). The mean CWD_{dr} values are not significantly different (P>0.05) between Dry-phobous and Wet-philous PSF phenology types, and between Dry-philous and Wet-phobous PSF phenology types (Fig. 5-D). The mean CWD_{dr} values between the two pooled types of similar phenology types, i.e., Dry-philous + Wet-phobous (ombrophobous type), and Dry-phobous + Wet-philous type (ombrophilous type), are significantly different (P<0.01). These results indicates that the ombrophobous PSF types tend to occur relatively nearer to the watershed than the ombrophilous types and have relatively greater degree of fluctuation in vegetation activity.

According to the fluctuation of seasonal NDVI at the Plot-1B in relation to the groundwater level (Fig. 3), the depression of the vegetation activity in S3 period seems to be caused from the water-deficit stress affected by the low groundwater level. A big patch of Dry-phobous PSF phenology type lies around the upper catchment of Sg. Sebangau (Fig. 1, 4) including Plot-1B. These places are anticipated to have a similar hydroperiod to Plot-1B and the vegetation is under the water-deficit stress during the dry season. While, the PSF phenology type of Wet-phobous is anticipated to be located on the place that groundwater level is relatively high so that the vegetation is constrained to be under water-flooding stress in the wet season.

These analyses, reported here, on predicting hydroperiod and phenology in PSFs are still on the rough scale. However, the method used in this study can be applied to the multi-temporal images of much higher resolution remote sensing sensors, i.e., TERRA-MODIS (250-m resolution) and TERRA-ASTER (15-m resolution). Yet, more field data on vegetation physiology, hydrology, and the spectral characteristics of vegetation in PSFs are needed for the further study.

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Household Food Security and Food Habits of The Communities Live at Surrounding Peatland and Areas in Central Kalimantan

Emmy U. Antang[1], Clara M. Kusharto[2], Hartoyo[2], M. Osaki[3]
[1] Faculty of Agriculture, University of Palangkaraya
[2] The Department of Community Nutrition and Family Resources, Bogor Agricultural University (IPB)
[3] Graduate School of Agriculture, Hokkaido University
1 Corresponding author: TEL. +62-(0)536-25645, e-mail: emmyantang@yahoo.com

ABSTRACT

Household food insecurity is still a major problem in Central Kalimantan. Although the average of the supply of calorie is higher than the average of energy allowance, but still about 29 percent of rice imported from the areas outside Central Kalimantan. It is indicated that food security, particularly at household level might still become a problem. The study was intended to identify householdsí food security level and food habits of the communities live at surrounding peatland areas and to analyze selected factors affecting the householdsí food security level.

Design of study was cross-sectional survey and covered of three villages, i.e., Bukit Rawi village (Sub-District of KahayanTengah, Kapuas); Basarang Jaya village (Sub District of Basarang, Kapuas); and Kalampangan village (Sub district of Pahandut, Palangkaraya). Subjects were farmerís households who have an under-five child and were selected randomly. Subjects represent three different ethnic groups, i.e., Dayak tribe (Bukit Rawi), Balinese (Basarang), and Javanese (Kalampangan). Total subjects were 103 households (31 Dayak tribe, 37 Balinese, and 35 Javanese). Structured Interview was conducted at each subjectís home. A cut-off point 70 percent of energy allowance was used as an indicator of household food security. Logistic regression analysis was employed to predict the factors affecting the household food security.

Selected subjects are characterized by young families with two children, belong to families with less educated (50% of household head were graduated from junior high school), and have lower income (the average of monthly income is about Rp. 600,000.00). The source of income is come from on-farm activities. Javanese households are more rely on off-farm activities. About 40 percent of their income is come from off-farm activities.

The study found that about 35 percent of total households faced with ìfood insecurity" problem. The proportion of Javanese households with food insecure (51.4 %) is higher than Dayak Tribe (35.5 %) and Balinese (18.9 %). The probability of the household being in food security is influenced significantly ($p<0.05$) by the household size, household income, and dummy variable for Balinese (positive influence). Furthermore, the finding indicate that households with greater household members and less household income, particularly with ethnic background other than Balinese tend to be considered as vulnerable groups and have a greater likelihood for being food insecure. Staple food consumption pattern of Dayak tribe and Javanese households is rice, whereas Balinese is mixed rice-cassava. Dayak communities consumed more indigenous food as compared to Javanese and Balinese. Types of indigenous food that were usually consumed by the communities, i.e., *puhing , saluang, pantik, baung, tapah, patin, sepat, gabus, betok, tambakan, lais, bajey, kalakai, terung asam, lampinak, umbut rotan, umbut kelapa, and bakung.*

It is recommended that for the food insecure households to improve their food patterns by consuming more variety of food and suggested to utilize local or indigenous foods to improve their food security; and since food security is strongly affected by household income, it is important to generate income by introducing appropriate technology and improving intensive farming practices with consideration of existing social, cultural, and ecological aspects.

Key words: food security, food habits, indigenous foods, peatland

INTRODUCTION

Food security is defined as access by all people at all times to the food needed for a healthy life. A household is food secure when it has access to the food needed for a healthy life for its entire member (ACC/SCN, 1991; Braun, 1992; Maxwell & Smith, 1992). Two major factors affecting food security are food availability and food access (Braun, 1992; Kennedy & Haddad, 1992; Smith, 2000).

In 1998, the average supply of calorie, i.e.: 2,261 calorie/caput/day (BPS Kalteng, 2000) is higher than average energy allowance, i.e.: 2,150 calorie/caput/day (Muhilal, 1998). This condition reflected province food secure; nevertheless, 29.05 percent of rice supplied from outside The Central Kalimantan. The rice supply from outside areas shows that food production is low because of the low of soil fertility. The Central Kalimantan is dominated by peatland area that has relatively low soil fertility.

Food security indicators could be identifying from food system which correlated with food habits that are determined by ecological, social, cultural, and economic aspects. Central Kalimantan is dwelled by native community, i.e.: Dayak tribe; and resettled communities, i.e.: Javanese and Balinese. The social-culture differences of the communities caused the differences on food habits, and finally caused the differences on household food availability and food security.

Objectives of study are as follows; 1) to determined a level of household food security and observed food habits among the three type of communities who lived at surrounding peatland area, and 2) to analyze selected factors affecting the household food security.

METHODS

Design, Time, and Place of Study

Design of the research was cross-sectional survey; Survey was conducted from September until December 2001. While data analysis and writing a manuscript was completed at end of October, 2002 and presented in Post-Graduate Students Seminar in November 21, 2002. This article is a part of thesis submitted to the Graduate School of Bogor Agricultural University, in partial fulfillment of the requirements for the degree of Master of Science (in Community Nutrition and Family Resources) in December, 2002.

The research covered of three villages, i.e.: a) Bukit Rawi Village, Sub-District of Kahayan Tengah, District of Kapuas, represent a Dayak tribe; b) Basarang Jaya Village, Sub-District of Basarang, District of Kapuas, represent a Balinese; and c) Kalampangan Village, Sub-District of Pahandut, District of Palangkaraya, represent a Javanese.

Subjects, and Data Collecting Method

The research subjects were farmerís households who had child under five years old. Total samples were 103 households, composed of 31 Dayak tribe, 35 Javanese, and 37 Balinese households.

Data was collected by interviewed, and both father and mother were filled the questionnaire. The data collected were: a) households characteristics, i.e.: family size, fatherís and motherís age, years fatherís and motherís educational attainment; b) household income and expenditure; c) household food habits, i.e.: food consumption pattern and food taboo; and d) household energy consumption.

Data Analysis

Householdís characteristics, household income and expenditure, and household food habits data were analyzed by descriptive analysis.

The household food security level was determined based on energy adequacy criteria. The cut off point for classification of household food security was 70 percent of energy adequacy (FAO/WHO, 1992; Eele, 1994; Haddad, 1994), the households whose energy adequacy ≥ 70 percent were categorized as household food secure, and the households whose energy adequacy < 70 percent were categorized as household food insecure. Stated as food secure = 1, Stated as food insecure=0.

The factor affecting household food security is analyzed by logistic regression analysis, because of the dependent variable is dichotomous (Agresti & Finlay, 1986; Afifi & Clark, 1996). The model for analyze factors affecting household food security is:

$$\log\left(\frac{\partial}{1-\partial}\right) = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + d_1D_1 + d_2D_2 + u$$

Where:

π

α = Intercept

β, δ = Regression coefficient

X_1 = Family size (person)

X_2 = years fatherís educational attainment (years)

X_3 = years motherís educational attainment (years)

X_4 = Household income (Rp)

X_5 = Household expenditure (Rp)

D_1 = Dummy Variable for type of the community

$D_1 = 1$, if Javanese

$D_1 = 0$, if others

D_2 = Dummy Variable for type of the community

$D_2 = 1$, if Balinese

$D_2 = 0$, if others

U = error

RESULTS

Household Characteristics

Family size was not differ among the three communities, the average members for each family, i.e., 4.4 for Dayak tribe and 4.5 for Javanese and Balinese.

Table 1. General Characteristics

Characteristics	Dayak	Javanese	Balinese
Household size (man)	4.4	4.5	4.5
Age of father (years)	35.32	35.31	31.65
Age of mother (years)	29	29.11	28.95
Father's educ. Attainment (years of schooling)	10.23	7.89	8.65
Mother's educ. Attainment (years of schooling)	10	8.2	5.92
Household income (Rp)	794,824.19	758,763.80	464,042.78
Household expenditure(Rp)	627,109.84	662,797.80	396,548.35

The average of Balinese fatherís age (31.6 years) is lower than Dayak (35.3 years) and Javanese (35.3 years). The average of motherís age was not different among Dayak tribe, Javanese, and Balinese, i.e. about 29 years.

Fatherís educational attainment of Dayak household (10.2 years) is higher than Balinese (8.6 years) and Javanese (7.9 years). Whereas the average of motherís years of schooling for Dayak tribe is 10.0 years, it is higher than Javanese (8.2 years) and Balinese (5.9 years).

Household income was different among the three communities, the average of Dayak household income (Rp. 794,824.19) is the highest, Javanese (Rp. 758,763.80) is the second, and Balinese (Rp. 464,042.78) is the lowest. The source of income is from on-farm activities; Javanese households are more rely on off-farm activities. The major income sources of the Dayak tribe are from harvesting secondary forest, i.e.: rattan, natural rubber, and logging; and fishing. Whereas the Javanese and Balinese major income sources are vegetables and fruits cultivation.

Food Habits

Traditionally, Dayak communities suffice food by subsistence food production. Rice produce by shifting cultivation, fish and vegetable are harvested from the nature. But since 1997, the people due to extended drought and fires did not implement shifting cultivation. Hence, household food availability depends on food availability in the market to fulfill the needed of food.

Balinese communities faced the same problems with Dayak communities; household did not produce food due to drought. Household depends on food availability in the market to suffice the needed of food.

Different from Dayak tribe and Balinese, Javanese households did not produce rice by themselves, availability depend on market supply. Households planted vegetables either to fulfill their need or to sell in the market.Dayak tribe and Javanese households have single staple food consumption pattern, i.e., rice; Balinese households have mix staple food consumption pattern, i.e., rice - cassava. Food consumption pattern is reflected by food frequency, Table 2. shows household food frequency.

Table 2. Household Food Frequency

Group of foods	Dayak	Javanese	Balinese
Fish	5	3	4
Chicken	2	2	2
Meat	2	1	0
Egg	3	4	3
Tofu/Tempe	3	5	4
Vegetable	4	5	4
Fruits	1	2	3

Dayak tribe more frequent consumed fish than Balinese and Javanese, meanwhile Javanese most frequent consumed tofu and Tempe. Javanese more frequent consumed vegetable than Dayak tribe and Balinese, and Balinese more frequent consumed fruit than Javanese and Dayak tribe. In general, Dayak tribe households consumed much more food types than Javanese and Balinese, either indigenous food or common food. Table 3. Show the types of food for each group of food.

Dayak tribe, Javanese and Balinese households still practice some food taboos. Although only few households practiced food taboo, but the practiced group is the vulnerable group, and the type of food taboos are some kind of food that content of rich nutrient. The types of Food taboo and the reason are shown in Table 4.

Household Food Security

The amount of food secure household is higher than food insecure household. The amount of food insecure household is 34.9 %, and proportion of Javanese with food insecure households (51.4 %) is higher than Dayak tribe (35.5%) and Balinese (18.9 %).

Table 3. The types of Food Were Consumed by Dayak Tribe, Javanese and Balinese

Group of foods	Type of foods		
	Dayak	Javanese	Balinese
Staple foods	Rice	Rice	Rice –
Fish	*Puhing*, saluang*, pantik*, tapah*, patin*, sepat*, gabus*, betok*,biawan*, lais*, baung ,** kembung, ikan mas, cumi, lele.	Kembung, udang, *sepat*, gabus ** , ikan mas, tongkol, *patin*, betok** , *saluang*, biawan** , lele	*Sepat ** , lele, *betok*, gabus** , layang, kembung, mujair.
Vegetables	*Lampinak*, kalakai, pakis*, umbut rotan*, umbut sawit*, umbut kelapa*, bakung*, terung asam*, jamur*,* keladi, daun singkong, bayam, pare, *daun pare ** , bayam, kangkung, daun pepaya, kacang panjang, terung, timun, rebung, labu, nangka muda, oyong, terung, sayur manis	keladi, daun singkong, bayam, kangkung, sayur manis, kacang panjang, daun melinjo, labu, kol, pare, terung, buncis, jagung muda, wortel. Kentang, kol, daun pepaya, tomat, rebung, timun, nangka muda, oyong, *kalakai**	Keladi, daun singkong, bayam, kacang panjang, jagung muda, nangka muda, rebung, terung, daun pepaya, sayur manis, buncis, oyong, *kalakai ** , labu, kangkung, keladi, katuk, kentang, wortel, kol.
Fruits	Nenas, pepaya,pisang	Nenas, pepaya, pisang, semangka	Pisang, nenas, salak, pepaya.

*) indigenous foods

Table 4. Food taboo and The Reason that Practiced by Dayak Tribe, Javanese, and Balinese Communities

Type of foods	Practice group	Reason
Dayak Tribe:		
Fish without Scale	Pregnant and nursing mother	Bleeding
Balinese:		
Pineapple	nursing mother	Miscarriage and Bleeding
Pumpkin leaves	nursing mother	Difficulties at Laboring
Javanese:		
Pineapple and sugarcane	Pregnant women	Miscarriage and Bleeding
Fish	Pregnant women	Breast Milk with Fish Odor

Table 5. Logistic Regression Analysis for the Factors Affecting Level of Household Food Security.

Dependent variables	β	Exp.β	Sig.
Constant	- 0,325	0,722	0,840
Family size (X_1)	- 0,639	0,528	0,003
Mother's educational attainment (X_2)	0,047	1,048	0,582
Household income (X_3)	0,005	1,005	0,000
D_1 (Javanese=1; lainnya=0)	- 0,764	0,466	0,249
D_2 (Balinese=1; lainnya=0)	2,939	18,899	0,002

Independent variables which had strong correlation with each others were not included in the analysis. The result of logistic regression analysis shows the factors influence food security significantly is family size, household income, and dummy variable for Balinese.

The model for the factors affecting household food security shown as follows:

$$\log\left(\frac{\partial}{1-\partial}\right) = -0.325 - 0.639X_1 + 0.047X_2 + 0.005X_3 - 0.764D_1 + 2.939D_2$$

Family size has negative influence on household food security that means family with greater number of members has a greater likelihood for being food insecure. The probability for being food insecure if family size is more than 6 person for Dayak tribe, more than 5 person for Javanese, and more than 8 for Balinese.

In contrary, Household income have positive influence on household food security, family with greater household income have a greater likelihood for being food secure. The probability for being food secure if household income is greater than Rp. 533,000.00 for Dayak tribe, and much more than Rp. 715,820.00 for Javanese.

DISCUSSION

Household food habits are the ways in which the household members choose, consume, and make use of available foods in response to social, culture and economic pressure (Hartog, 1995). Food consumption pattern which reflect food habits is manifestation of family culture and a result of interaction among social, culture, and environment (Suhardjo, 1989). The finding indicates that ecology, social, and culture affected food habits which was reflected by food consumption pattern. Javanese and Balinese are less frequent consuming fish than Dayak tribe; and even though fresh water fishes are more available than salty water fish, Javanese and Balinese tend to consume more salty water fishes. According to Sumarno (1997), the communities live outside Java tend to consume more fresh water because their habits of living at by the river.

Balinese households are more food secure than Dayak and Javanese households. The finding indicates that food habits, in particular staple food consumption pattern, affect household food security. Balinese households tend to consume more variety of energy source food. Cassava that was consumed with rice by Balinese contributed a high amount of energy that could fulfill their necessity.

Two factors are proved to influence household food security in the study indicate that the affect of food availability and food access on household food security. Households with greater members need more food than those with smaller members. Households with greater members could provide insufficient food for itsí members; these households are likely to expose in food insecure. By reviewing several studies, Haddad (1994) summarizes that household size is a good predictor of household energy sufficiency; and Rose (1999) concluded also that household size influence the household insecurity level; households with higher size need higher income to meet their food necessity.

Household ability to fulfill food for its member is important and critical factor that determines the household food security level. The ability of household may reflect the accessibility of household to food depends on householdís purchasing power. Several studies indicate that household food availability depends on market food supply; and therefore, household food security is influenced by household income. The result of logistic regression analysis supports this statement; Household income has a negative and significant influence to household food security level. This finding is basically consistent with Foster (1992), Braun (1992) and Maxwell (1996). They stated that the root of food insecurity in developing country is a lack of people ability to increase food access due to poverty. Furthermore, Braun 1992; Kennedy and Haddad, 1992; Lorenza and Sanjur, 1999; Rose, 1999; Smith 2000 explained that food access for household with food availability depends on market food supply reflect from household purchasing power; and household income is one proxy of purchasing power.

CONCLUSION

1. Food habits which is reflected by food consumption pattern is different among Dayak tribe, Javanese, and Balinese. Dayak tribe and Javanese have mono- staple food pattern, i.e. rice; while a Balinese has mix staple food pattern, i.e. rice - cassava. Dayak tribe consumed more varies of food, and more frequent consumed fish (more often fresh water fish) than Javanese and Balinese. In contrast, Javanese more frequent consumed vegetables than others.
2. About 35 % of households are considered to be food insecurity; the proportion of Javanese households with food insecurity (51.4%) is higher than Dayak tribe (35.5 %) and Balinese (18.9 %).
3. Household size and income, and dummy variable for Balinese influence household food security significantly. Family size has negative influence and household income has positive influence, that means family with greater number and less household income, particularly with ethnic background other than Balinese, is vulnerable to household insecurity.

RECOMMENDATION

Since food security is strongly affected by family size and household income, it is important to generate income by introducing appropriate technology and improving intensive farming practices considered to social, cultural, and ecological aspect of the communities.

The limitation of the study is relating to sampling frame in which is limited only to the households with under-five year children. These groups are not a main observation in study about Food Security and Food Habits. Restriction in sampling frame might limit data variation, and in turn, in generalization of the findings. Therefore, it is suggested that to broaden sampling frame for next study, not only to those who have under-five year children but also to the population, in general.

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Appendix. Local Names and Scientific Names of Foods Were Consumed by Dayak Tribe, Javanese, and Balinese Households

No.	Local Name	Scientific Name
Staple foods:		
1	Beras	*Oryza sativa*
2	Singkong	*Manihot esculenta*
Fish:		
1	Baung	*Macrones nemurus*
2	Betok	*Anabas testudineus*
3	Cumi-cumi	*Loligo, sp*
4	Gabus	*Ophiochepalus stiatus*
5	Ikan mas	*Cyprinus carpio*
6	Kembung	*Scomber kanangurta*
7	Lais	*Cryptopterus, spp*
8	Layang	*Decapterus ruselli*
9	Lele	*Clarias batrachus*
10	Mujair	*Oreochromis mossambicus*
11	Pantik	*Mystus negriceps*
12	Patin	*Pangasius pangasius*
13	Puhing	*Cyclochcilichts janthochir*
14	Saluang	*Puntius fasciatus*
15	Sepat	*Trichogaster pectolaris*
16	Tabakan	*Helostoma temminckii*
17	Tapah	*Wellago leerii*
18	Tongkol	*Euthynus alleteratus*
19	Udang	*Palaemon, sp*
Vegetables:		
1	Bajey	*Diplazium esculentum*
2	Bakung	*Lily, sp*
3	Bayam	*Amaranthus hibridus*
4	Buncis	*Paseolus vulgaris*
5	Daun melinjo	*Gnetum gnemon*
6	Daun pare	*Momordica charantia*
7	Daun pepaya	*Carica papaya*
8	Daun singkong	*Manihot esculenta*
9	Jagung muda	*Zea mays*
10	Kacang panjang	*Vigna unguiculata*
11	Kalakai	*Stenochlaena palutris*
12	Kangkung	*Ipomoea aquatica*
13	Katuk	*Sauropus androgynus*
14	Keladi	*Colocasia esculenta*
15	Kentang	*Solanum tuberosum*
16	Kol	*Brassica oleracea*
17	Labu	*Cucurbita moschata*
18	Lampinak	*Euphorbiaceae, sp*

Appendix. Continuation

No.	Local name	Scientific Name
19	Nangka muda	*Artocarpus integra*
20	Oyong	*Luffa acutangula*
21	Pare	*Momordica charantia*
22	Rebung	*Bambusa, sp*
23	Sawi hijau	*Brassica rapa*
24	Terung	*Solanum melongena*
24	Terung asam	*Solanum ferox*
26	Timun	*Cucumis sativus*
27	Tomat	*Solanum lycopersicum*
28	Umbut kelapa	*Cocos nucifera*
29	Umbut rotan	*Calamus, sp*
30	Umbut sawit	*Elauis guineensis*
31	Jamur	*Auricularia, sp*
32	Wortel	*Daucus carota*
Fruits:		
1	Nenas	*Ananas comosus*
2	Pepaya	*Carica papaya*
3	Pisang	*Musa parasidisiaca*
4	Salak	*Zalacca edulis*
5	Semangka	*Citrullus vulgaris*

Land Use Change in Central Kalimantan over the Period 1991 - 2001 including Impacts of Selective and Illegal Logging, MRP Establishment and Fires

Hans-Dieter Viktor Boehm[1], Florian Siegert[1], Suwido H. Limin[2] and Adi Jaya[2]
[1]Kalteng Consultants
Kirchstockacher Weg 2, 85635 Hoehenkirchen near Munich, Germany
Tel.: (49) 8102-774848, Fax: (49) 8102-774850, Mobile: (49) 170-316-1199
Email: viktorboehm@t-online.de; http://www.rhc.at/kalteng
[2]CIMTROP and University of Palangkaraya
Jalan Yos Sudarso, Palangka Raya 73112
Central Kalimantan, Indonesia

ABSTRACT

In Central Kalimantan grows on plain areas a lot of Peat Swamp Forest (PSF) from the coast at the Java Sea up to the north of the provincial capital Palangkaraya. PSF is among the earth's most endangered ecosystem. Peatland has a huge carbon storage capacity and is extremely fragile (Page et al. 2000 and 2002). Local communities have used them extensively for centuries with no significant effect on the environment. This changed in 1995/1996 when a programme of massive peatland conversion, the so-called Mega Rice Project (MRP), was initiated with the aim of converting one million hectares of peatland into rice fields. Approx. 4000km of drainage and irrigation channels were constructed in the area designated for the MRP in two years (Notohadiprawiro 1998). Many people were able to access the previously inaccessible interior of this peatland landscape to exploit the residual timber resources, mostly doing this on illegal logging basis and using fire in the process. In summer 1997 deforestation was initiated by means of fire clearance as the most economical method. Enhanced by the El NiÒo Southern Oscillation (ENSO) in 1997, many of these fires set for land clearing spread into opened forest areas where they continued to burn with greater intensity.

The detailed multi-temporal analysis of eight LANDSAT TM images acquired between 1991, 1994, 1996, 1997 (before the fires), 1998, 2000 (2x) and 2001 shows the quick change of the sensitive peatland and high rates of deforestation. Two TM images, 118-61 and 118-62, with 5.4 million ha were compared for 1991, 1997, 2000 and 2001. It was found by Remote Sensing (RS) and Geographical Information System (GIS) technology that from the TM 118-62 with approx. 2.4 Mha in 6/1991 1.560.377ha (64.8%) was covered with forest while in 5/1997 1.377.442ha (57.5%); res. 7/2000 1.110.151ha (45.7%) was covered with forest. Strong logging and illegal-logging took place (Boehm and Siegert, 2001).

Legal/selective logging operation prepared the ground for further degradation of the forests by fire, illegal logging and farming. More than 11,000km of logging railways were mapped in an area of 25,000km≤. Illegal logging could be often discriminated from selective logging operation in Landsat ETM images by its specific spatial pattern. The logged over area increased by 44% between 1997 and 2000. Field and aerial surveys showed that most of this increase could be attributed to illegal logging. Additionally land use changes as shifting cultivation mosaics, dry and swamp grassland, plantations, bushland, rivers and urban areas will be reported in the paper. The reduction of the forest between 1991 and 1997 is approx. 1.9% / year. Between 1997 and 2000 logging is increased for this three years of approx. 6.5% / year, this includes the fires in 1997, the illegal logging and the MRP activities. As summery the deforestation between 1991 and 2001 is at average approx. 3.3% / year.

If the situation continues as for the years 1991 to 2001 there is a very high risk that most of the PSF resource in Central Kalimantan will be destroyed within few years with grave consequences for the hydrology, local climate, biodiversity and livelihood of the local people. Unless land use policies are changed to control logging and the drainage of the peatland will be stopped recurrent fires will lead to an irrecoverable loss of this unique rainforest ecosystem, compare the last strong fires in 2002 (Boehm et al. 2003).

INTRODUCTION

Approximately half of the study site (2 million hectares) around Palangkaraya, the provincial capital, is covered by peatland that supports the natural vegetation of peat swamp forest. In recent decades the size of the peat area has been shrinking continually due to land-use conversion. High amounts of stored carbon were thus released into the atmosphere. Their huge carbon storage capacity is well known (Page et al. 2000 and 2002). The age of peat varies from several hundred years to 15,000 years (Anderson 1983, Sieffermann et al. 1988, Rieley et al 1996, Diemont et al. 1997).

Peat water is dark-brown to a murky black, and is acidic (pH-value 3 to 4). Peat accumulates in domes with a depth of 8 to 12 metres and flows from watersheds into the main rivers. Peat swamp forests (PSF) have a specific atmosphere and many different animal sounds are heard. Large, undisturbed PSF still contain strong Orang Utan populations. Temperatures within the forests are moderate and under closed canopies seldom exceed 28 ˚C. There is a noticeable wind circulation in the afternoon. Soil and water have a constant temperature of approx. 23 ˚C - 24 ˚C. Tree types and fish species have adapted to the acidic water. Special roots protrude out of the water to absorb oxygen (Rieley and Page 1996 and 1998, Boehm and Siegert 2000).

The peatland area around Palangkaraya is widely extended and the forest is of a PSF type if not cleared. The peatland is located mainly on quartz sand (podzol), from the Java Sea and up to the heath forest belt in the northern area, covering a PSF belt of approx. 150km to 200km (Sieffermann et al. 1988). The landscape is very flat and partly affected by coastal flood plains in which the northward tide from the Java Sea has effect up to 50km - 80km inland. Highland dipterocarp forests begin where the soil changes and the ground become hilly. Along the main rivers Dayaks exercise a slash and burn (ladangs) technique for rice cultivation on alluvial soil. The forest in general is secondary, logged and many areas clear-cut. Only the northern mountain region has greater locations of untouched primary tropical forests. Adjacent in the north are large areas of heath forest, which grows on extremely nutrient-poor siliceous soils. Further north in the direction of the Schwaner and Muller Mountains typical lowland and hill dipterocarp forest are to be found (Sieffermann 1988). Between 1991 and 1996 deforestation was predominately relegated to logging operations and land clearing along newly built roads.

Tropical rainforests often grow on very poor soils, which allow only 1-3 years of farming in every 20 years. If these forests are removed, either by large scale cutting or by uncontrolled forest fires, as happened in 1982/83, 1987, 1994, 1997 and 2002 in Kalimantan (Barber and Schweithelm 2000, Boehm et al. 2003), it will take centuries for a new forest with a similar species diversity to revive. In moderate climates, in contrast, a forest with a similar species composition and diversity as before will regenerate within 10-30 years even after clear felling. In many areas the exploitation and conversion of tropical rain forest proceeds uncontrolled by illegal logging and at an increasing rate (Rieley and Page, 1996, Boehm and Siegert, 2001). To analyse changing land use patterns to date mainly optical and radar satellite images and aerial photos have been evaluated. In this paper we compare optical Landsat images only.

The large-scale sawah rice field “Mega-Rice-Project” was initiated in 1995 by Presidential Decree No. 82: Development of “One Million Hectares of Peatland for Food Crop Production in the Province of Central Kalimantan, Peat Reclamation” (Notohadiprawiro,. 1998). Local communities have traditionally cultivated rice in that part of Central Kalimantan for many years, albeit on shallow peatland, on a very limited scale and without significantly affecting the environment. This land-use conversion through the 1 Million ha (Mega)-Rice-Project for rice cultivation, including transmigration, was started by the Indonesian government with a feasibility study and, in April 1996, with the digging of irrigation channels into the peat swamp. The development of an area of one million hectares in Central Kalimantan, situated between the River Sebangau in the west, the River Kahayan, River Kapuas and River Barito in the east, and the Java Sea in the South, was planned and realised. The total area of impact is 1.5 million hectares within the Blocks A, B, C, D and E, see Fig. 3.

In 1997 and 2002, Central Kalimantan was one of three main regions in Indonesia where forests and peatlands were on fire (Barber and Schweithelm 2000, Boehm et al. 2003). The “Mega-Rice-Project” was in a major location of “hot spots” because burning for land clearance had been started at the onset of the dry season. In June 1997, months before fires and smog had become a serious health hazard to millions of people in Southeast Asia, the areas upstream of the reclamation project already suffered serious food shortages. A marked drop in the water level of major rivers, combined with poor visibility due to smog, hindered food transport, and a lack of water for irrigation made the planting of crops impossible. Droughts, forest fires and famine were the logical results. Famine in the entire area was reported in September/ October 1997 and in 2002.

We have used LANDSAT TM (Thematic Mapper) images. The project was funded partly by an European Union project with 8 international partners with the title: *Natural Resource Functions, Bio-diversity and Sustainable Management of Tropical Peatlands* and partly by a TREES-project (Tropical Ecosystem Environment Observation by Satellite).

METHODS

Multi-temporal LANDSAT TM images 118-61 and 118-62 were analysed for four time periods: 1991, 1997, 2000 and 2001, see Fig.1 and 2, to estimate with a Geographical Information System (GIS) land use classes, change detection and to calculate the deforestation rate. Objectives of the work is to get inputs for land use planning and conservation of the remaining peat swamp forest resources.

Basic image processing was done using ENVI 3.5. Raw image files were imported into ENVI and bands 3, 4 and 5 were selected to produce a colour RGB image. Band assignment was 5,4,3 = RGB. Each channel was interactively contrast enhanced in a reference LANDSAT TM5 image (118-61, 1991) in order to maximise overall image contrast. This band combination proved to be the best in this region. It allowed to separate more than 20 vegetation and land use classes. Using the result of a histogram analysis of the reference image the adjacent scene (LANDSAT TM5 118-62, 30.6.1991) was adapted in contrast and colouring to the reference image. This procedure was applied to LANDSAT TM5 scenes 29.5.1997, TM7 scenes 16.7.2000 and TM7 scenes 20.8.2001. Additional Landsat scenes 118-62 from 24.7.1994, 10.5.1996, 29.3.1998 (after the fires) and 7.2.2000 are available for analysisís.

The two adjacent scenes 118-61 and 118-62 were mosaiked using 15 ground control points (GCP) in the overlapping image parts. We used a set of more than 2000 GPS measurements (shp files) acquired during several ground and aerial surveys conducted in 1998, 1999 and 2000. GPS points were collected using the continuous track mode of the GPS acquiring measurements every 10s to 30s (aerial surveys) or 20s to 60s (ground surveys).

Figure 1. Area of interest located on the island Borneo in Central Kalimantan (grey colour), Indonesia. Landsat images 118-61 and 118-62 taken from the time period 1991 to 2001.

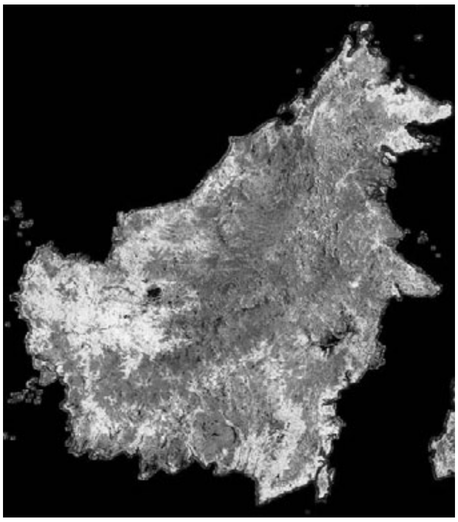

Figure 2**.** Spot-Image Vegetation of Borneo: yellow and red colours are opened areas, different types of green colour describes the remaining forest and black colour are water bodies. Courtesy of ESA

40 Geographical Information System (GPS) measurements distributed across the Landsat TM scene were used for georeferencing the enhanced, mosaiked LANDSAT TM5 reference image (118-62, 1991) and stored into the GIS database ArcView 3.3. Accuracy was better than one pixel (30m) for the study area. The 1997, 2000 and 2001 LANDSAT TM5 res. TM7 scenes were co-registrated to the reference image from 1991 in ENVI using 35 GCPís (mean RMS smaller than 1).

To achieve higher resolution of images for this publication we have selected an area of 43.65km x 96km including Palangkaraya and the southern region for analysis.

RESULTS AND DISCUSSION

Figure 1 and 2 describe the location of the study area in Kalimantan on the island Borneo. In this quick look of Spot vegetation image the remaining forest are shown in green colour.

The elevation of the peatland rises gradually from the Java Sea to the north end of the MRP area by approx. 12m, which means that the channels essentially create paths for water from the peatland to drain into the sea. Tidal influences can be monitored to approx. 6m - 8m and have affected up to the north of Kuala Kapuas. In addition, water levels in the areaís major rivers vary greatly and depend on domes of up to 8m - 12m high between the main rivers. In a cross-section Figure

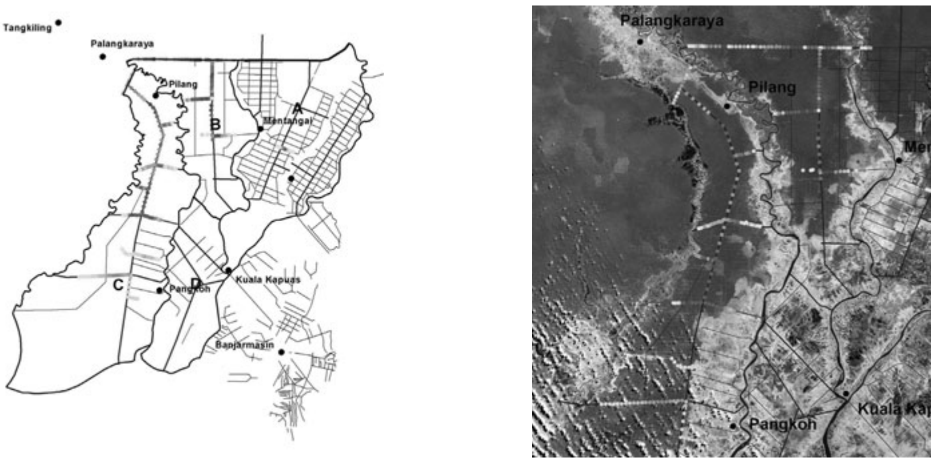

Figure 3. A shows the MRP blocks A+B+C+D, the MRP channels and the location of peat drillings in Kalteng (Yellow and red points) and B is the Landsat TM 29.5.1997 (right) image superimposed with peat drillings (yellow and red points) done be staff of University of Palangkaraya.

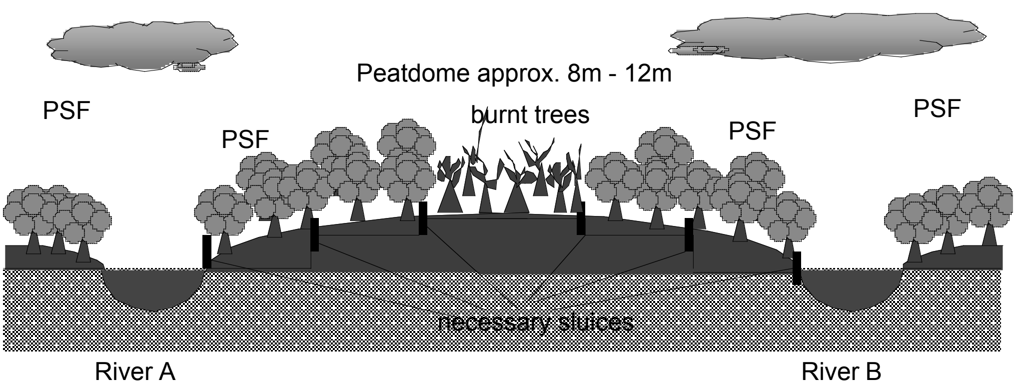

Figure 4. Cross-section between two rivers showing the hydrological conditions of the PSF and the peat dome in the MRP. Irrigation is impossible without proper sluices. Sluices are only built at the end of the main channels and secondary channels but not every 5 km.

4 explains the hydrological conditions of two large rivers with a watershed between them, seen here as a high peat dome. Only sluices allow a proper irrigation system in the tropical rainforest. Big sluices are only built at the end of the main and secondary channels, but not in every 5 km. Distance. Fig. 3 shows the MRP and the peat drillings along the channels in block A, B and C done by the staff of University of Palangkaraya. Table 1 give some peat depth measurements along the main channel between Kahayan and Kapuas rivers (46km). More than 9m peat thickness was measured at the peat dome. The photos in figure. 5E highlights the problem of the channels in the MRP and show the many collected timber trunks in the Sebangau river from illegal logging.

Further analysis of the MRP channel system has revealed that rather than irrigating the peat areas, the channels have served to systematically drain moisture into the sea. The topography of the land was not taken fully into account during the project planning. As a result, the water table is falling, the remaining vegetation is dying off, and the peat is shrinking by 1cm to 2cm annually - releasing large volumes of carbon and increasing the risk of fire as the land dries out (Page et al. 2000 and 2002). In the rainy season, the water table now stays below the peat surface, and is much lower in the dry season. Water levels in the main rivers are either

Table 1: Peat depth (m) of Block B along the Main Parent Channel (46km) from Kahayan River to the middle of MPC at Kapuas River, see Figures 3, 4 and 5E.

BB10	BB9A	BB8A	BB7A	BB6A	BB5A	BB4A	BB3A	BB2A	BB1A	BB0	BB1
3.93	2.92	5.05	2.53	1.29	3.92	3.10	3.14	3.17	6.40	9.34	5.67
BB2	BB3	BB4	BB5	BB6	BB7	BB8	BB9	BB10	BB11	BB12	BB13
5.40	5.53	6.13	4.02	2.10	0.82	2.67	4.75	3.34	1.14	0.81	0.41

Table 2: 44% increase of the logged over area between 1997 and 2000 in different types of peat swamp forest (PSF).

	1997	**2000**	**Total area**	**% increase**
	ha	***ha***	***ha***	
Low Pole Peat Forest	3,056	3,649	189,257	**20%**
Medium Peat Forest	2,6371	43,293	698,559	**64%**
Tall Peat Forest	7,575	9,799	292,059	**29%**
Total Area	**39,566**	**56,891**	**1,607,775**	**44%**

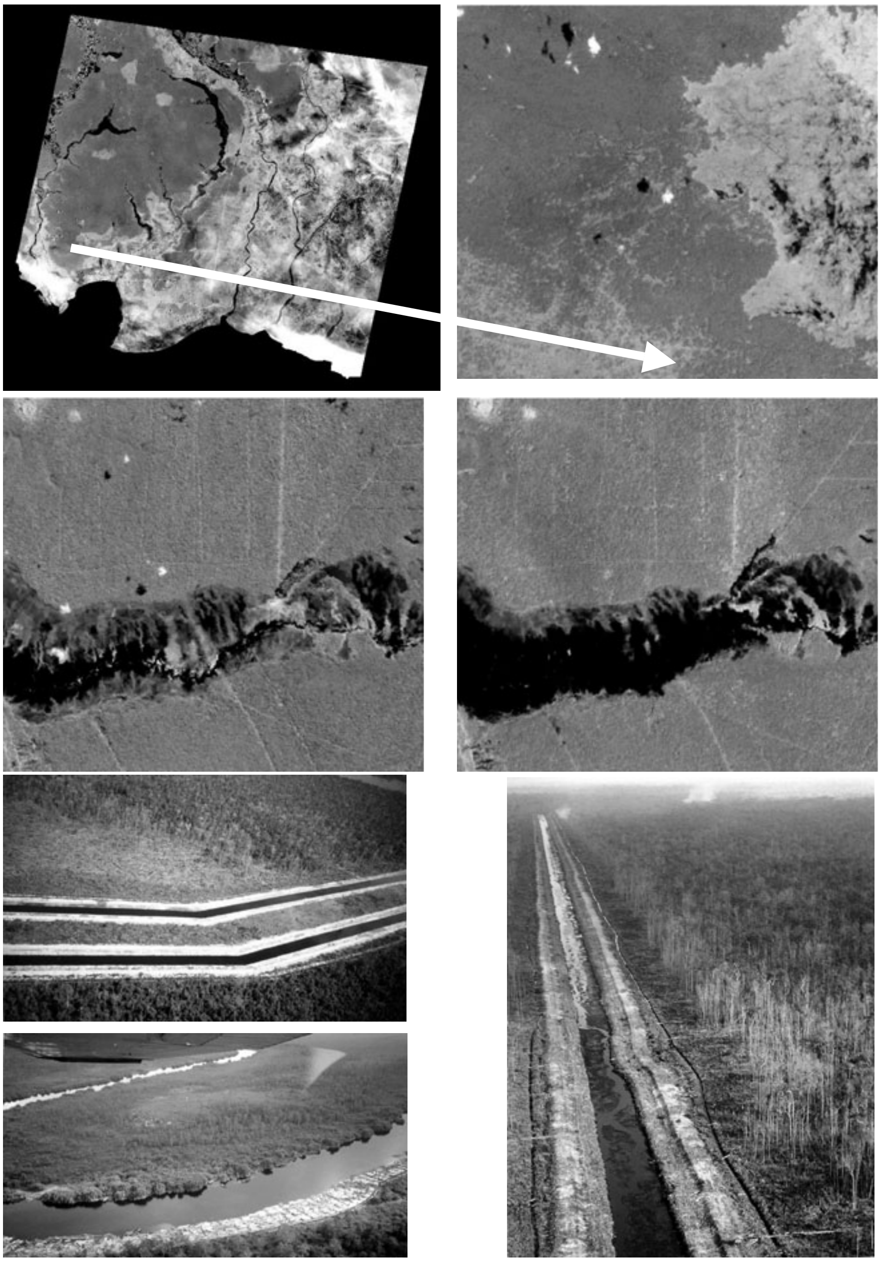

Figure 5. A: Landsat ETM7 acquired 7. Feb. 2000 (rainy season with high water table). B: Magnified image shows strong increase in (illegal) logging in 2000. C: Landsat from TM 29.5.1997 shows already logged over PSF, regular pattern of aisle are railways and meaning legal logging and D: nearly opened PSF in 2000, irregular pattern meaning illegal logging. E: Aerial photos from channels in the MRP partly without water and many timber trunks from illegal logging at Sebangau river.

abnormally high or low. Clear-cut peatland never floods. Poor design, construction and maintenance have also resulted in the rapid silting of the channels, and many will be filled in with peat mud within the next few years. The deep peat close to the channels will subside rapidly and decompose. During the dry season, water levels are very low and the channels are partly without water (Fig 5E).

Illegal logging could be often discriminated from legal logging operation in Landsat ETM images by itís spatial pattern. Figure 5A shows the Landsat TM image from 7.2.2000 and 5B a detail from this image in the southern area between Katingan and Sebangau rivers. Figure 5C indicates the logging situation near the Bulan catchment in May 1997 while Fig. 5D does this for Feb. 2000. Legal logging operation by concessionaires involves investment in infrastructure such as logging roads and railways along which the logs are transported after tree felling (Fig.5C). Roads and railways are clearly visible in the Landsat TM images even after 10 years; railway routes visible in 1991 were still visible in 2000 and 2001 (Fig. 9A-1991, 10B-2000 and 10C-2001). The removal of trees by logging appears as a change in signature in the Landsat TM image because some of the reflectance comes from soil. Illegal loggers do not have the money and equipment to establish roads and railways and their access tracks the forest appear as irregular patterns and follow natural features like small streams or abandoned logging railways, see Fig. 5A-D.

Another difference between legal and illegal logging becomes evident from the pattern of harvesting. While in concessions all merchantable trees are harvested along approx. 500 m wide strips to both sides of the roads and railways, illegal loggers take only the most accessible trees. This results in an irregular pattern in the Landsat ETM image (Fig. 5B and 5D). Table 2 shows a comparison of the logged over area in 1997 and in 2000. This area increased by 44% in this 3 years. Most prominent was the increase in medium pole swamp forest (64%), while there was less activity in low pole peat forest, which contains only small numbers of merchantable trees. We estimate that this extreme increase can be attributed mostly to illegal logging. This was confirmed for 23 sites by field checks and aerial reconnaissance (Boehm et al. 2003). Another alarming information is that 2000 most logging activity occurred between Sebangau and Kahayan river, while there was hardly any activity in the MRP area. This can be attributed to the fact, that almost all valuable forests in the MRP Block A and B area have been destroyed by the 1997 fires. The area between the Sebangau and Katingan river is the last remaining large, continuous of PSF in block C of Central Kalimantan. As logging opens the

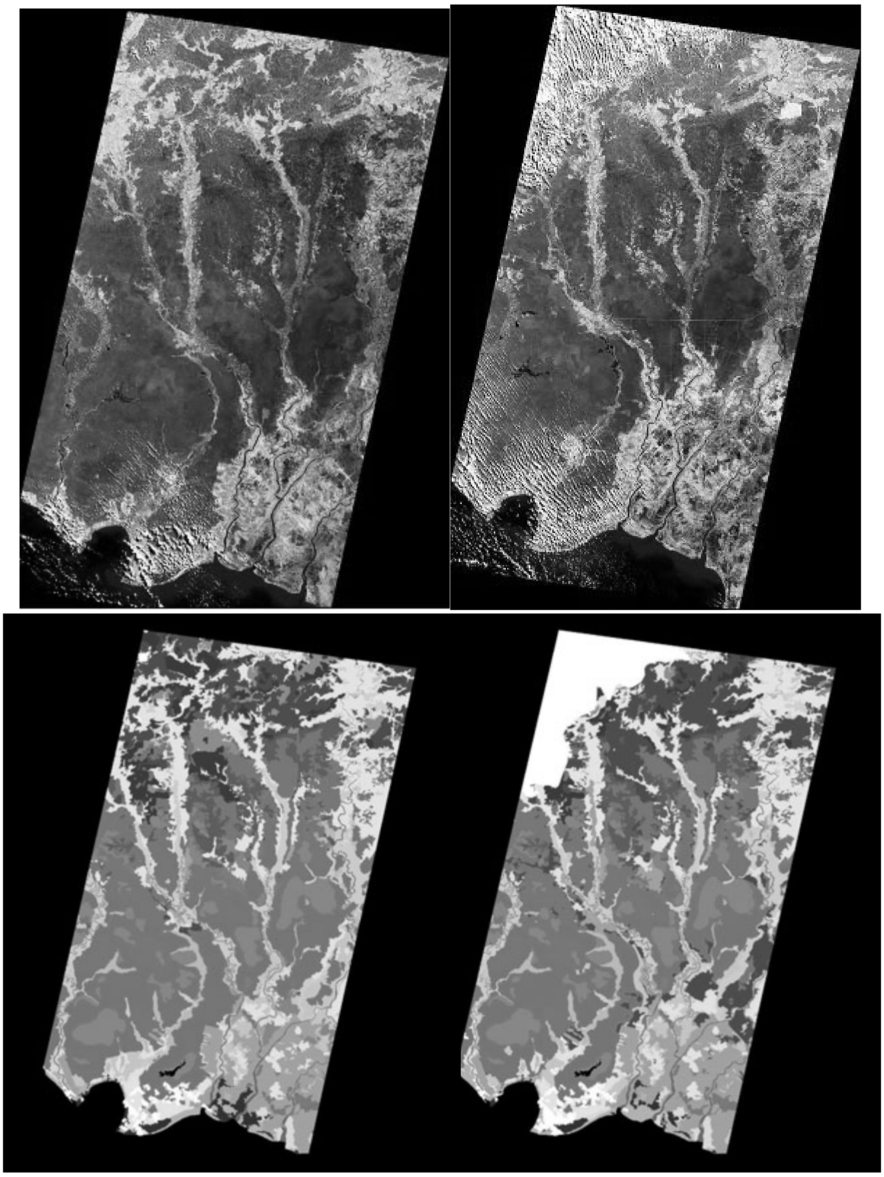

Figure 6. Geocoded Landsat image 118-61 und 118-62 (RGB=543) acquired on 30.6.1991 and 29.5.1997. approx. 180km x 360km from Central Kalimantan, compare Fig.1. Different types of green indicates forest classes in the two upper false coloured TM satellite images, while yellow shows the shifting cultivation along the big rivers. Types of red is opened area, where the soil is visible from the sky. The lower two images are the classified TM images 1991 and 1997. The deforestation per year was 1.9% from 1991 - 1997 for the hole area.

canopy and leaves huge amounts of logging waste (illegal logging even more than legal operation) there is an extreme danger for another fire disaster in the future.

An overview of the vegetation changes and classes of land use, which occurred within a 9 years period between 1991, 1997 and 2000, is presented in Boehm and Siegert, 2001, with the TREES (Tropical Ecosystem Environment

Table 3: Trees Classification of Land use classes (Stibig et al. 2000)

TREES Classification			
111a	Closed, high density, evergreen lowland forest..	170a	Closed, high density mangrove forest
111b	Closed, medium density, evergreen. lowland forest	170c	Open mangrove forest
111c	Open evergreen lowland forest	170d	Fragmented mangrove forest
111d	Fragmented evergreen lowland forest	210	Shifting Cultivation Mosaic
114a	Closed, high density, heath forest	23	Forest Mosaics, Other Vegetation & Forest
114b	Closed, medium density, heath forest	321	Dry grassland
114d	Open heath forest	322	Swamp grassland
131a	Closed, high density, periodically inundated forest	412	Rain-fed arable land
131d	Fragmented, periodically inundated forest	420	Plantations
134a	Closed, high density peat swamp forest	51	Urban
134b	Closed, medium density peat swamp forest	59	Bushland (Non-vegetated)
134c	Open peat swamp forest	62	Rivers
134d	Fragmented peat swamp forest	81	Clouds
160	Forest Regrowth		

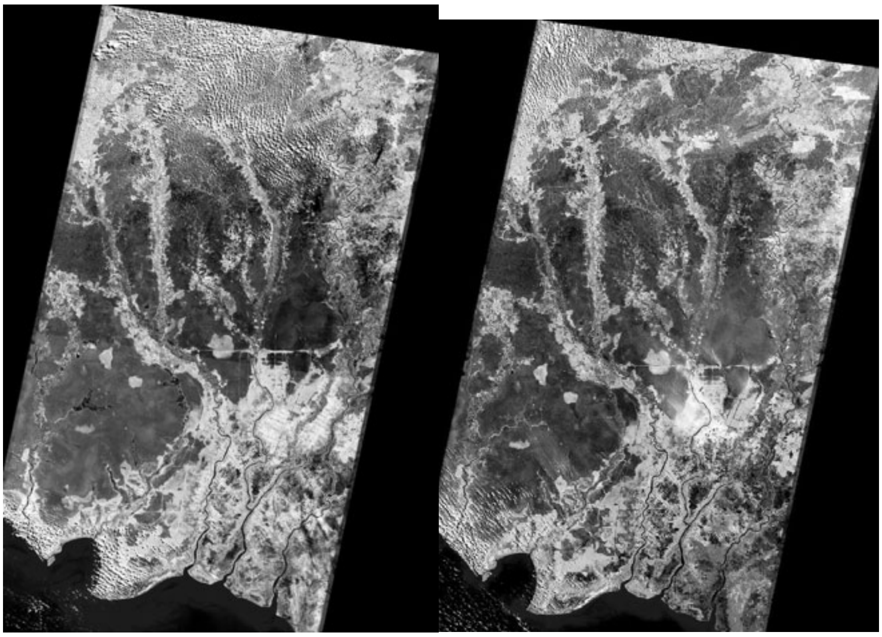

Figure 7. Geocoded Landsat image 118-61 und 118-62 (RGB=543) acquired on 16.7.2000 and 20.8.2001 with approx. 180km x 360km from Central Kalimantan, compare Fig.1. Different types of green indicates forest classes in the two upper false coloured TM satellite images. In both images the influence of the MRP is strongly visible. Cleared PSF, huge burnt scars in the PSF and smoke from fires is in the 2001 image (right) detected. Deforestation/year: 6.5% (1997-2000) and Deforestation/year: average3.2% (1991-2000)

Observation by Satellite, an EC funded initiative) classification legend, Table 3 (Stibig et al. 2000) and Table 4. The total analysed area was 5.2 Mha. Taken together, 8.6% of the area was covered in accumulated cloud over the three LANDSAT TM images from 30.6.1991, 29.5.1997 (Fig. 6), 16.7.2000 and 20.8.2001 (Fig.7). The clouds are subtracted from the GIS calculations. Classification of the TMs from 1991, 1997, and 2000 are manually delineated in the ArcView-GIS. In the Fig. 6 the results of classification is shown for 1991 and 1997, while Figure 11 shows this for the TM image of 2000. To be able to assess peat swamp forest conversion processes in detail, one has to have knowledge of the type of conversion. The highest rate observed for closed, medium density peat swamp forest was a 7.5% (23.8%- 16.3%, 134b) decrease over a period of 9 years, 1991 - 2000. The second largest figure is a 4.3% (10.4%-6.1%, 134a) decrease of closed, high-density peat swamp forest followed by 3.8% (5.5%-1.7%, 111a) decrease of closed, high density, evergreen lowland forest. Increase of non-vegetated bush land areas for land clearing is 7.3% (1.7%-9.0%, 59) and increase of forest mosaics or other vegetation and forest is 5.0% (6.7%-11.7%, 23) over the time period 9 years.

For this publication we have selected a specific area of 43.65km x 96km including Palangkaraya and the southern region during six time periods: 30.6.1991, 10.5.1996, 29.5.1997 (Fig. 9), 7.2.2000, 16.7.2000 and 20.8.2001 (Fig. 10) with high resolution.

The TM image from 1991 (Fig. 9) shows a closed big area of PSF (green colour). Only along the rivers Kahayan and Kapuas we see the beginning of deforestation. In the TM image from 10.5.1996 we can see the beginning of the 10km long channel construction at Kapuas river, (Fig. 9) while the 1997 TM image presents in reddish colour much more open PSF for the channels. The opening of PSF from 1991 up to 1997 before the fires was done in moderate form. The TM images from 7.2.2000, 16.7.2000 and 20.8.2001 (Fig.10) shows the strong influence of the MRP, illegal logging and fires in 1997. Burnt scars are visible and the opened forest in Blocks A, B and C. The burnt scars area are partly regrowing by ferns visible in the 2001 TM image. In the 2001 TM image the plumes of fires are superimposed. Fig. 8 contains the classification for the area of 43.65km x 96km from the 20.8.2001 TM image. Table 5 contains the change detection of several TREES-classes in an area 43.65km x 96km south of Palangkaraya with Rivers Sebangau, Kahayan and Kapuas, see Fig. 8, 9 and 10, between 1991, 1997, 2000 and 2001.

Table 4: TREES classification of LANDSAT TM 118-61 and 118-62 for 1991, 1997 and 2000, see Fig. 6 and 7, (Boehm and Siegert, 2001)

TM5 6/1991			TM5 5/1997			TM7 7/2000		
TREES 1991	**ha**	**%**	**TREES 1997**	**Ha**	**%**	**TREES 2000**	**ha**	**%**
111a	286.773	5.5%	111a	96.679	1.9%	111a	90.032	1.7%
111b	373.007	7.2%	111b	351.591	6.8%	111b	334.077	6.4%
111c	73.425	1.4%	111c	21.027	0.4%	111c	30.258	0.6%
111d	0	0.0%	111d	9.482	0.2%	111d	15.743	0.3%
114a	528.332	10.2%	114a	477.873	9.2%	114a	443.117	8.6%
114b	41.651	0.8%	114b	39.042	0.8%	114b	43.975	0.8%
114d	10.051	0.2%	114d	14.770	0.3%	114d	15.082	0.3%
131a	81.405	1.6%	131a	27.215	0.5%	131a	22.631	0.4%
131d	199.188	3.8%	131d	230.134	4.4%	131d	228.245	4.4%
134a	540.669	10.4%	134a	362.073	7.0%	134a	317.705	6.1%
134b	1.231.738	23.8%	134b	1.217.075	23.5%	134b	845.405	16.3%
134c	29.680	0.6%	134c	44.906	0.9%	134c	35.827	0.7%
134d	87.789	1.7%	134d	89.015	1.7%	134d	85.606	1.7%
160	55.324	1.1%	160	38.307	0.7%	160	34.059	0.7%
170a	47.747	0.9%	170a	30.504	0.6%	170a	30.504	0.6%
170c	28.600	0.6%	170c	15.519	0.3%	170c	15.518	0.3%
170d	16.572	0.3%	170d	42.369	0.8%	170d	43.431	0.8%
210	572.988	11.1%	210	493.043	9.5%	210	503.030	9.7%
23	348.582	6.7%	23	362.939	7.0%	23	608.406	11.7%
321	6.465	0.1%	321	7.330	0.1%	321	7.330	0.1%
322	84.486	1.6%	322	87.617	1.7%	322	85.466	1.6%
412	293.266	5.7%	412	306.358	5.9%	412	314.781	6.1%
420	28.815	0.6%	420	47.684	0.9%	420	47.135	0.9%
51	11.666	0.2%	51	12.038	0.2%	51	12.038	0.2%
59	87.043	1.7%	59	252.368	4.9%	59	467.722	9.0%
62	57.462	1.1%	62	57.135	1.1%	62	57.133	1.1%
81	59.888	1.2%	81	446.279	8.6%	81	446.124	8.6%
Total	**5.182.614**	**100%**	**Total**	**5.180.374**	**100%**	**Total**	**5.180.380**	**100%**

Table 5: Change detection of several TREES-classes in an area 43.65km x 96km south of Palangkaraya with Rivers Sebangau, Kahayan and Kapuas, see Fig. 8-10, between 1991, 1997, 2000 and 2001. Deforestation in this area shows a value of 33% in 10 years from 1991-2001 (from 338,041 ha in 1991 reduced to 226,759.6 ha in 2001). This is a **3.3% deforestation/year** in this selected area partly inside in the former MRP with Blocks A+B+C. The closed, high density PSF has gone nearly completely. The opened area No.59 Bushland-Clearcuts has increased from 54,914.4 ha in 1991 to 166130.6 ha in 2001.

Central Kalimantan Palangkaraya 43.65km x 96.0km	**TREES-Classes**	**TM 30-06-1991**	**TM 29-05-1997**	**TM 16-07-2000**	**TM 20-08-2001**
		ha	*ha*	*ha*	*ha*
Urban 5	**1**	3,191.4	3,501.9	3,511.5	3,493.1
Transmigration	**52**	1,037.6	1,774.1	1,767.6	1,758.8
Bushlands-Clearcut	**59**	54,914.4	84,108.4	163,384.9	166,130.6
PSF closed,high density	**134a**	109,099.8	17,826.0	2,334.5	2,088.2
PSF closed, medium density	**134b**	146,046.8	217,214.6	87,557.1	87,075.1
PSF open	**134c**	40,935.3	64,815.0	126,163.2	126,371.1
PSF fragmented	**134d**	41,959.1	7,707.9	13,335.7	11,225.2
PSF Sum	**134a-d**	(338,041.0) **100%**	(307,563.5) **90.98%**	(229,390.4) **67.86%**	(226,759.6) **67.08%**
Rivers 62 6	**2**	5,192.0	5,357.9	5,342.0	5,315.4
Catchments-rivers	**322**	16,663.6	16,734.3	15,643.7	15,582.5
Sum 419,040 ha		**419,040**	**419,040**	**419,040**	**419,040**

Deforestation in this area shows a value of 33% in 10 years from 1991 - 2001 (from 338,041 ha PSF in 1991 reduced to 226,759.6 ha PSF in 2001). This is a **3.3% deforestation/year** in this chosen area inside in the former MRP with Blocks A+B+C partly. The closed, high density PSF has gone almost completely. The opened area No.59 bushland-clearcuts has increased from 54,914.4 ha in 1991 to 166,130.6 ha in 2001.

The reduction of the forest between 1991 and 1997 is approx. 1.9%/year and between 1991 and 2000 in average approx. 3.2%/year, Table 6. Between 1997 and 2000 logging is increased for this three years of approx. 6.5%/year, this includes the fires in 1997, the illegal logging and the MRP activities. Block D had already in 1991 not much forest. Major causes for deforestation between 1991 and 1997 were logging operation, land clearing for small scale farming and land clearing for plantations. This changed in the period between 1997 and 2001 where large scale land clearing by fire for MRP (Blocks A, B, and C) and legal and illegal logging operation were the major causes for deforestation (Fig 9 and 10).

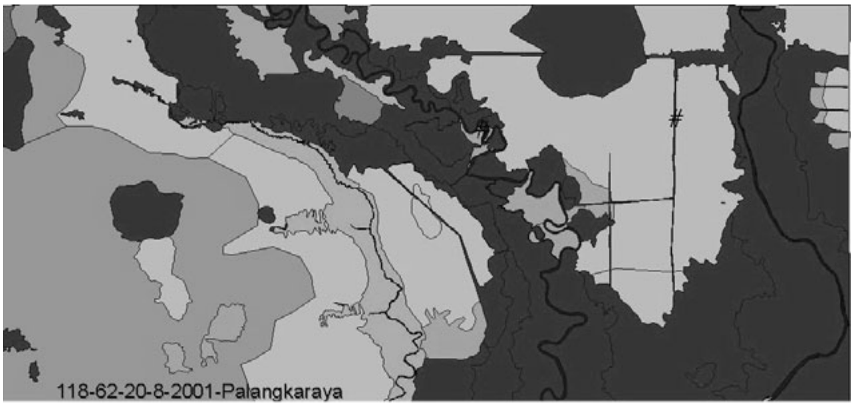

Figure 8. 2001-TREES-Classification of the area (43.65km x 96km) south of Palangkaraya on the based on the Landsat image 16.7.2000. Compare Table 5 and Fig. 9 and 10 (10C).

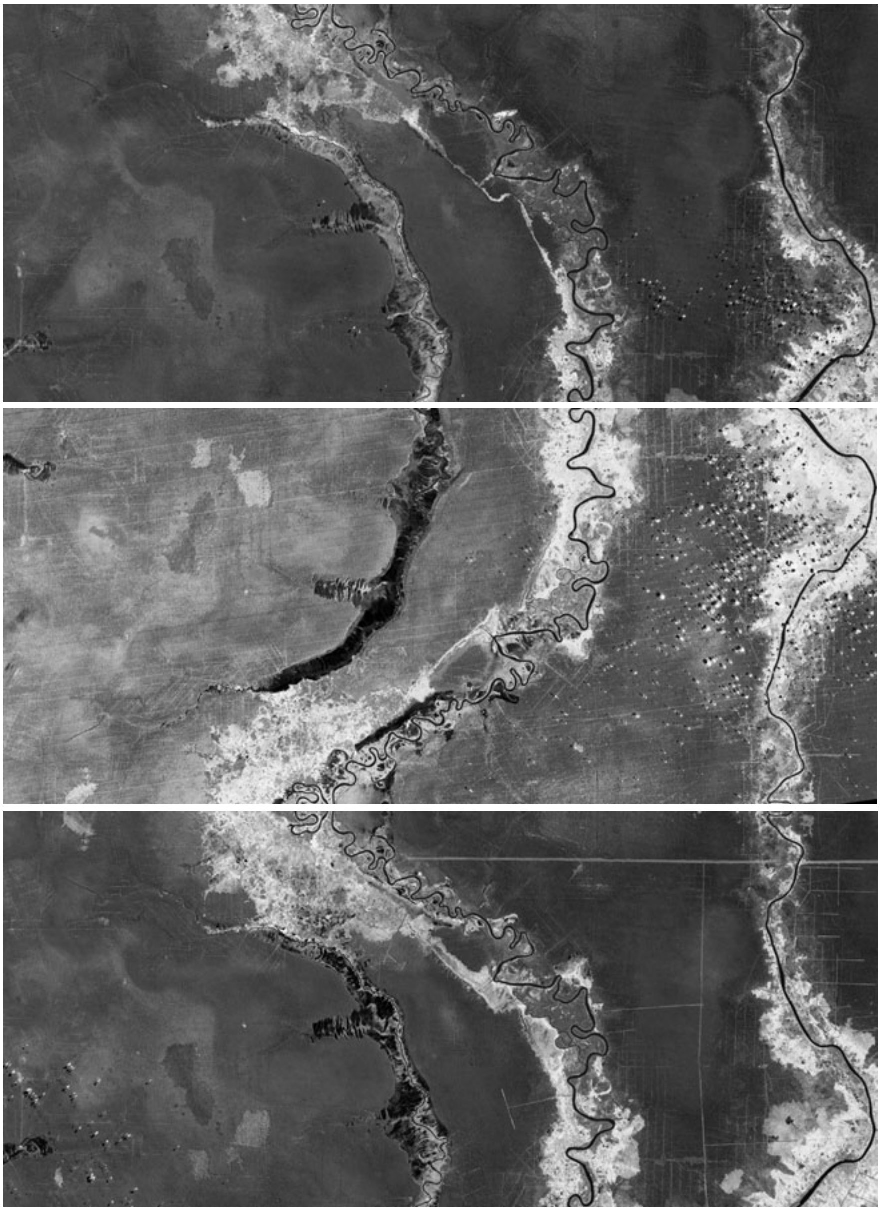

Figure 9. Details from Landsat images see Fig. 6 with an area of 43.65km x 96km. It shows in each images the region of Palangkaraya and southern area with Sebangau Catchment, Kahayan, Kapuas (right). A: Landsat image from 30.6.1991, B: Landsat image from 10.5.1996; in 1996 the big channel on river Kapuas started to be built, C: Landsat image from 29.5.1997 with more opened forest for the channels in Block A, B and C.

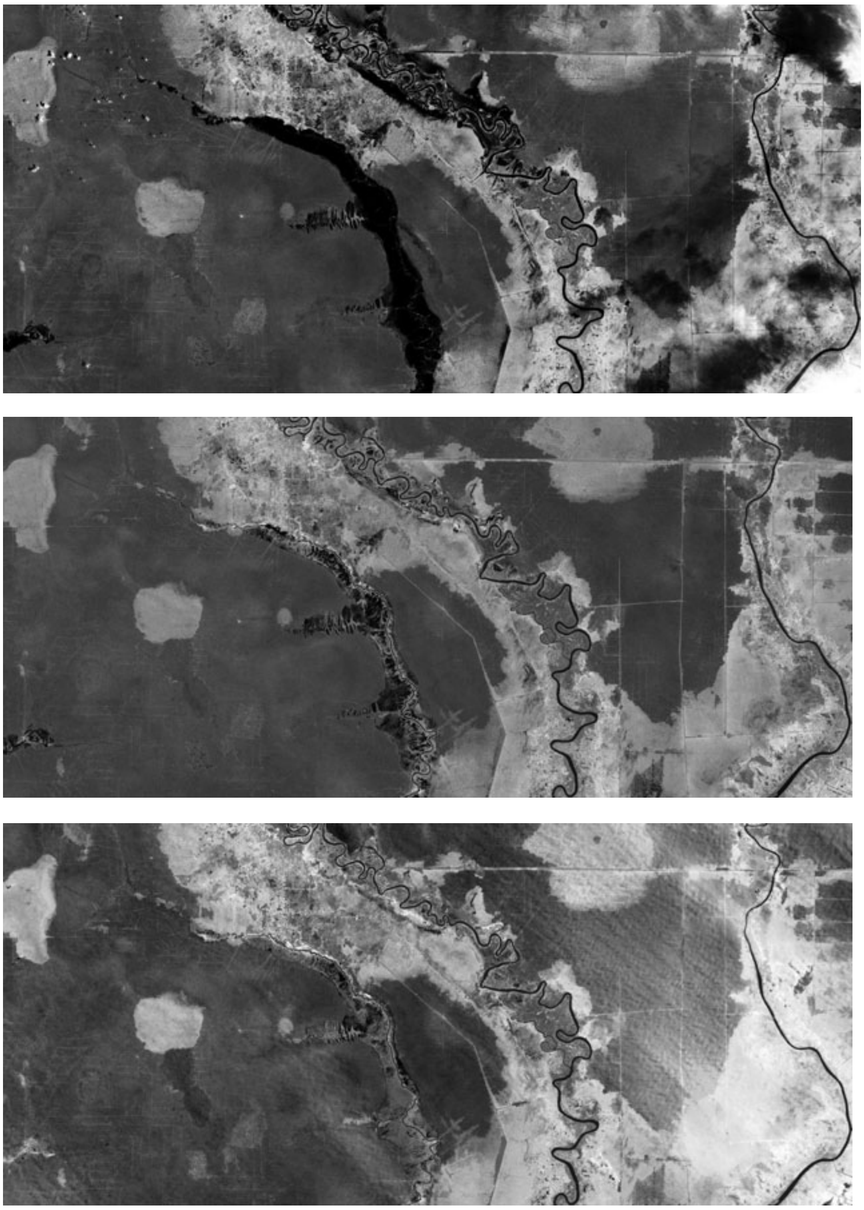

Figure 10. Details from Landsat images see Fig. 7 with an area of 43.6km x 96km. It shows in each images the region of Palangkaraya and southern area with Sebangau Catchment, Kahayan, Kapuas (right). The influence of this area by the MRP and the fires from 1997 (Burned cares) are documented. A: Landsat image from 7.2.2000 (rainy season with much water in the catchment Sebangau, black colour), B: Landsat image from 16.7.2000, C: Landsat image from 20.8.2001 with smoke from the fires in 2001.

CONCLUSION

If the situation continues as it has for the years 1991 to 2001 there is a very high risk that most of the peat swamp forest resource in Central Kalimantan will be destroyed within a few years with grave consequences for the hydrology, local climate, biodiversity and livelihood of the local people (Page et al. 1998 and 2002, Boehm et al. 2000 and 2003). Peat layer up to 12m thickness have been measured in the MRP, with an average of 2.5m to 4m in the study area. The 4000km of channels from the MRP disturbs the hydrology of the peatland.

Land clearing is continuing although the Indonesian Government abandoned the MRP in 1998. Satellite images show a rapid conversion of peat swamp forest mostly into un-used fallow land. Roads and the irrigation system of the MRP allow loggers and farmers unprecedented access into otherwise highly inaccessible forests. During dry seasons they lit fires which create a lot of smoke and haze over the island Borneo and releases huge amount of carbon (CO_2) into the atmosphere.

Illegal logging occurs all over the area with a strong increase of 44% since the beginning of the economic crisis. Even when commercially viable trees have already been cut, illegal loggers take smaller trees of only 10cm - 20cm diameters. Countless floats transport timber over black-water lakes and along channels and rivers. Huge areas of ecologically

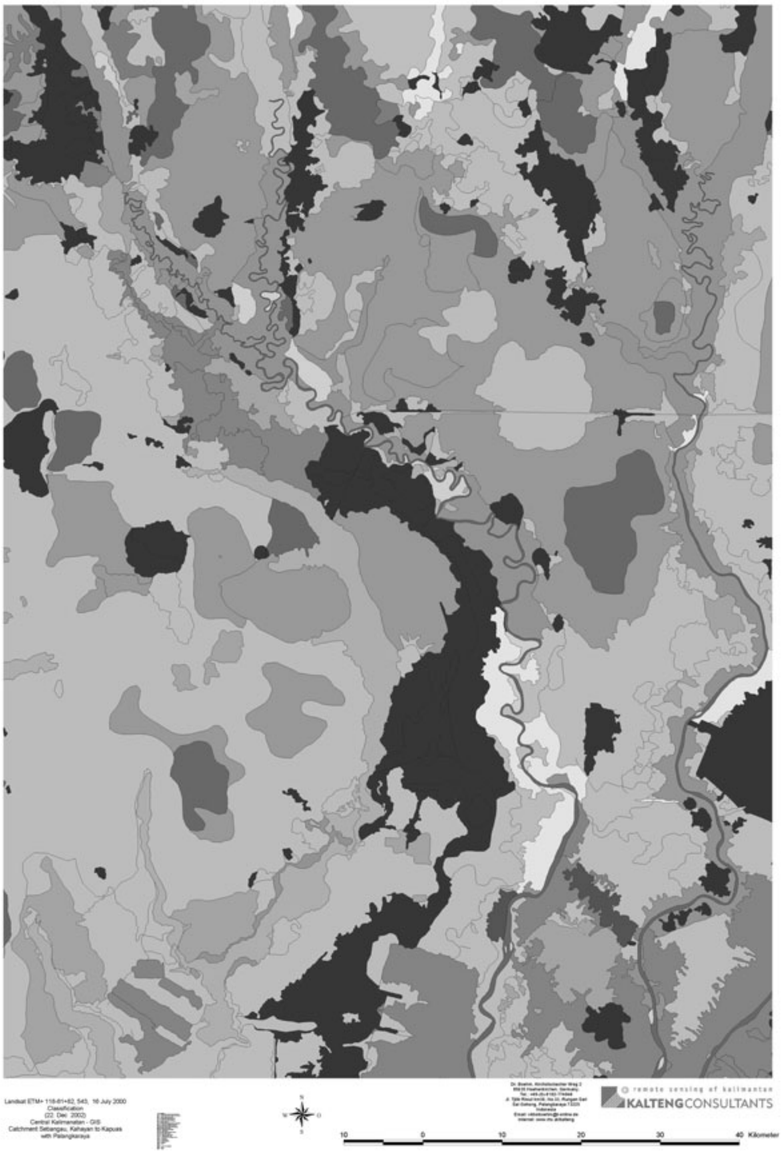

Figure 11. TREES-Classification of the area around Palangkaraya from the Landsat ETM image acquired on 16.7.2000. TREES-classes 23, 51, 59, 131d, 134a, 134b, 134c, 134d, 322, 412, see Tab. 3, 4, 5 and 6.

Table 6: Change detection of forest areas between 1991, 1997 and 2000 for 5 MRP regions and between rivers Katingan and Sebangau. The reduction of the forest between 1991 and 1997 is approx. 1.9%/year and between 1991 and 2001. Between 1997 and 2000 logging is increased for this three years of approx. 6.5%/year, this includes the fires in 1997, the illegal logging and the MRP activities. In average the deforestation is approx. 3.2%/year between 1991 and 2000.

Central Kalimantan		**Landsat TM5 30-06-1991**	**Landsat TM5 29-05-1997**	**Landsat TM7 16-07-2000**
MRP with 5 Blocks:	Regions ha	PSF-Forest ha	PSF-Forest ha	PSF-Forest ha
Block A	315.894 (100%)	135.585 42.9%	107.330 34.0%	39.838 12.6%
Block B	161.461 (100%)	109.134 67.6%	82.816 51.3%	51.008 31.6%
Block C	440.760 (100%)	233.275 52.9%	180.196 40.9%	73.387 16.6%
Block D	145.707 (100%)	3.159 2.2%	0 0%	0 0%
Block E	504.022 (100%)	399.475 79.2%	383.042 76.0%	359.988 71.4%
Rivers Katingan and Sebangau (PSF)	838.888 (100%)	682.056 81.3%	631.262 75.2%	573.921 68.4%
Sum for 6 regions	**2.406.732 100%**	1.560.377 64.8% (100%)	**1.377.442 57.5%** (88.3% in 6years) (100%)	**1.110.151 45.7%** (71.1% in 9years) (80.6% in 3years)

damaged peat landscape are visible from the air and satellite imagery. Logging and the drainage of the peat swamp by the channels greatly increase the risk of fire. Drought and/or low water tables in peat areas cause trees to die and make the forests even more susceptible to fire. Recurrent fires e.g. in 2002 do not allow forests to recover and ferns and grasses invade (Boehm et al. 2003).

Unless land use policies are changed to control logging and the drainage of the peatland stopped recurrent fires will lead to an irrecoverable loss of this unique rainforest ecosystem.

The reduction of the forest between 1991 and 1997 is approx. 1.9%/year. Between 1997 and 2000 logging is increased for this three years of approx. 6.5%/year, this includes the fires in 1997, the illegal logging and the MRP activities. In average the deforestation is approx. 3.3%/year between 1991 and 2001.

ACKNOWLEDGEMENTS

The project was funded partly by a European Union project with 8 international partners with the title: *Natural Resource Functions, Bio-diversity and Sustainable Management of Tropical Peatlands* (INCO-DC Contract Number ERB18CT980260) and a TREES-project (Tropical Ecosystem Environment Observation by Satellite).

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Remote Sensing and Aerial Survey of Vegetation Cover Change in Lowland Peat Swamp of Central Kalimantan during the 1997 and 2002 Fires

H.-D. V. Boehm[1] and F. Siegert[1] and S. C. Liew[2]
[1]Kalteng Consultants
Kirchstockacher Weg 2, 85635 Hoehenkirchen near Munich, Germany
Tel.: (49) 8102-774848, Fax: (49) 8102-774850, Mobile: (49) 170-316-1199
Email: viktorboehm@t-online.de
[2]Centre for Remote Imaging, Sensing and Processing,
National University of Singapore, Blk S17, Level 2, Lower Kent Ridge Road,
Singapore 119260
Tel: (65) 8745069, Fax: (65) 7757717, Email: liew_soo_chin@nus.edu.sg

ABSTRACT

Peat swamp forests play important roles in the regulation of hydrology, the maintenance of biodiversity and in global climate regulation. In tropical areas they are being depleted by logging and land conversion activities, especially by fires. In autumn 1997, fire raged out of control in the ìMega-Rice Project" area in Central Kalimantan, Indonesia, where over one million hectares of land was earmarked for conversion into agricultural land. The impact of this fire on the vegetation in this area was studied using satellite remote sensing imagery and by ground and aerial surveys. This study focuses on the use of interferometric synthetic aperture radar technique in mapping vegetation cover change. ERS SAR imagery over the area of interest was acquired during two tandem missions in April 1996 and October 1997. The change in vegetation cover was mapped by comparing the change in coherence and backscatter intensity. The results of the ERS SAR analysis were checked on the ground and during aerial surveys in part of the study area in June and November 1998 and August 1999. Comparison with SPOT images acquired during the fire period and Landsat TM images acquired before and after the fire period confirms the interpretation of the ERS interforemetric SAR images. NOAA images to count hot spot information were also used.

New huge fires were observed in autumn 2002 (End July to End of October) over the island of Borneo caused by draughts of the next El Nino Southern Oscillation (ENSO) five years later. Fires and smoke can be detected with the NOAA and with the MODIS sensor (e.g. on 18. Aug. 2002) covering the whole period. It seems that now every year for several months during the dry period smoke and haze conditions around Palangkaraya and the MRP area become the norm.

INTRODUCTION

Indonesia has the largest area of peatlands in the tropics. Indonesian Kalimantan possesses 6.4 to 9.2 million ha of lowland peatlands, which is approximately half of Indonesia's peatlands (Rieley et al. 1996). The southern part of the Central Kalimantan province around the capital Palangkaraya has one of the major peat swamp forest habitats (about 2.2 Mha) in Indonesia. Peat swamp forests are important ecosystems. They play important roles in the regulation of hydrology (flood prevention, sources of fresh water, prevention of saline water intrusion) and the maintenance of biodiversity and are sources of timber and non-timber natural products (Silvius and Giesen 1996). Peatlands also play an important role in global climate regulation. It has been estimated that the carbon stocks held by peatlands account for 35% of total terrestrial carbon (Maltby and Immirzi 1992). Release of the carbon stocks into the atmosphere due to peat fires and non-sustainable development would contribute to global warming (Pages et al. 2000 and 2002). Peat swamp forests act as carbon sinks and regulate climate via evapotranspiration and heat absorption.

Peatlands have traditionally been viewed as "wastelands" to be reclaimed for development. In recent years, tropical peat swamp forests are being threatened by anthropogenic activities, which include logging and conversion to agricultural land use (Riswan and Hartanti 1995, Rieley and Ahmad-Shah 1996, Phillips 1998). The reclamation process normally involves draining the swamps with ditches, which are usually laid out in a grid pattern (Notohadiprawiro 1996, 1998 and 1999). The lands are then usually cleared by the cheapest means, i.e. by the use of fires (Goldammer 1997). In 1997, during the dry season from July to November, fires raged out of control in the tropical forests of Sumatra and Kalimantan, aggravated by the severe drought brought by the El-Nino Southern Oscillation effect. The peat swamp of Central Kalimantan was among the three main peat swamp areas in Indonesia affected by the 1997 fires (Barber and Schweithelm 2000 and Boehm and Siegert 2000), the other two were in West Kalimantan and South Sumatra (Liew et al. 1998). Peatlands are prone to burning during droughts due to their high carbon reserve (Pages et al. 2000 and 2002). It has been reported that peat fires may spread underground, destroying the root systems of the standing trees, and resulting in complete destruction of the forests. Peat fires are usually smouldering fires with high particulate emissions. During the 1997 fire episode, the smoke haze spreading to the neighbouring countries has been estimated to have resulted in a loss of billions of US dollars (SEAEEP and WWF 1999). In addition to the transboundary pollution, the effects of forest fires on the environment include the loss of biodiversity, loss of forests as carbon sinks and emission of greenhouse gases with potential contribution to global warming (Levine 1991, Zepp 1994, Levine 1996, Pages et al. 2000 and 2002).

In this study, the specific area of interest is an area in Central Kalimantan where more than one million ha of peatlands, comprising virgin and logged-over forests as well as existing agricultural sites, have been earmarked for conversion into a vast area of irrigated rice fields and plantations. This ìPeat Land Project" (Proyek Lahan Gambut) was initiated in June 1995 by Presidential Decree No. 82/95 (Development of One Million Hectares of Peatland for Food Crop Production in the Province of Central Kalimantan, Peat Reclamation). It is popularly known as the ìMega-Rice Project" (MRP). Construction of irrigation/drainage channels began in April 1996. More than 4,500 km of channels have so far been constructed, draining and desiccating the peatlands. The environmental implications of the project have alerted the scientific community. In an International Symposium ìBiodiversity and Sustainability of Tropical Peatlands" held in Palangkaraya, Central Kalimantan, Indonesia, 4 - 8 September 1995, the delegates prepared a statement emphasising the importance of tropical peat ecosystems, urging governments, planners and developers to prepare policies for sustainable use of tropical peatlands (Rieley and Page 1996). After three years in operation, the MRP had failed to achieve its goal (Notohadiprawiro 1996, 1998 and 1999). The dried-up peatlands were ravaged by fires from July to November, 1997, contributing to the smoke-haze pollution in the entire Southeast Asian region during this period. The mega rice project was officially terminated in July 1999. However, a new project KaKaB (Kahayan, Kapuas, Barito) has been established by presidential decree No. 80/1999, issued in July 1999 (General planning guidelines and management of peatland development area in Central Kalimantan) in which a significantly larger area (2.8 Mha) will be developed and converted into mostly palm oil plantations.

It is important to monitor the extent of change in forest cover in the peat swamp area in order to assess the impacts of the anthropogenic activities to the environment. Satellite remote sensing is an effective and cost-efficient method of monitoring/surveying of landcover changes (Malingreau 1990). Several satellite sensor platforms are currently available. The AVHRR sensor on board the NOAA satellites can provide a 1-km resolution vegetation index map using the two visible and near infrared bands. The third band (3.8 µm) is used for detecting hot spots due to fires (Matson et al. 1987, Kaufman et al. 1990, Robinson 1991, Arino and Melinotte 1998, Siegert and Hoffman 1998, Nakayama et al. 1999). The optical and infrared bands of the Landsat-TM and SPOT-HRV sensors provide high resolution images (30 m for Landsat 5, (TM7 ETM PAN channel for 15m) and 20 m for SPOT (PAN channel 10m)) for land cover mapping, burnt scars delineation and monitoring of land cover change.

One major limitation of optical/infrared remote sensing imagery lies in the inability of optical/infrared radiation to penetrate clouds and thick haze. The cloud-penetrating ability of radar provides an alternative method of monitoring land cover changes. Synthetic aperture radar (SAR) imagers are carried on-board the ERS-1 and ERS-2 satellites. The orbits of the ERS satellites are identical except that ERS-2 lags ERS-1 by one day. This configuration of the two satellite orbits provides a unique opportunity for performing interferometric SAR in the tandem mode, i.e. a location on earth can be imaged by the two satellites with identical geometry with a one-day interval.

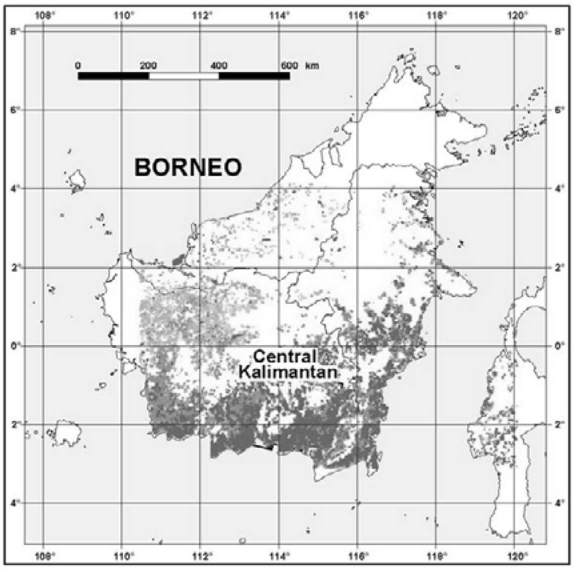
SAR backscatter intensity and interferometric coherence have been used in forest mapping and monitoring (Wegmuller and Werner 1995, LeToan et al. 1996, Askne et al. 1997, Stussi et al. 1997, Liew et al. 1999, Siegert and Hoffmann 1998, Siegert et al. 2001). In particular, tropical forests are known to have a constant backscattering coefficient between -7 and -6 dB in C-band. The interferometric coherence of the vegetated area is typically low compared with clear cut or sparsely vegetated area. If multi-temporal SAR data of an area of interest are acquired, clearings of forests/ vegetation can be detected by an observed change in backscatter intensity and/or an increase in coherence of the area.

In this paper, we describe the use of satellite remote sensing and aerial survey in mapping vegetation cover changes in the MRP area of Central Kalimantan, Indonesia, during the 1997 and 2002 forest fire episode. We focus on the use of the interferometric synthetic aperture radar (SAR) technique in mapping vegetation cover change. SAR imagery over the area of interest was acquired during two tandem missions of the ERS satellites in April 1996 and October 1997. The forest cover is characterised by a high radar backscatter intensity and low interferometric coherence. By comparing coherence and backscatter intensity data acquired during the two periods, the change in vegetation cover can be mapped and the extent of areas affected by the 1997 fires can be estimated. The results of the ERS SAR analysis were checked on the ground and during aerial surveys in part of the study area in June and November 1998 and August 1999. Comparison with SPOT images acquired during the fire period and Landsat TM images acquired before and after the fire period confirms the interpretation of the ERS interforemetric SAR images.

The hot spots detected by the NOAA Satellite are shown for the 1997 and 2002 fires as well as Modis sensor information taken on 18. Aug. 2002 from strong smoke plumes.

STUDY AREA

The location map of the study area that covers four ERS frames is shown in Fig. 1A and 1B. Each ERS frame has a nominal dimension of 100 km by 100 km. The study area is located in the southern part of Central Kalimantan, drained by the Sebangau, Kahayan, Kapuas and Barito rivers. A Landsat TM image of this area acquired on 29 May 1997 is shown in Fig. 2. This image was acquired after the construction of irrigation/drainage channels had begun, but before the large scale 1997 fire event. Thus, it gives a snapshot of the MRP area before the full scale implementation of the project. In this image (RGB = Bands 543), peat swamp forests (PSF) are indicated in dark green while the lighter green areas are



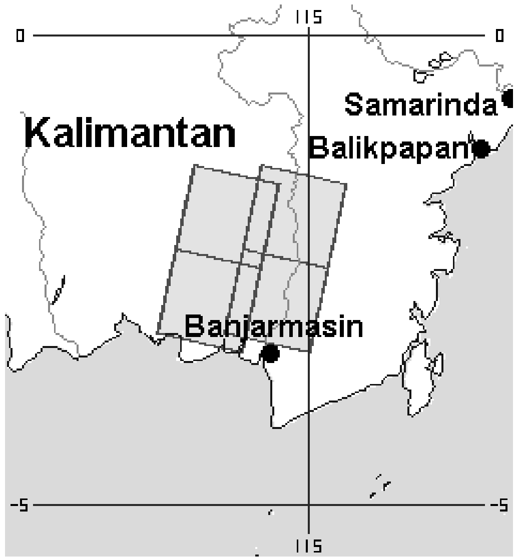


Figure 1. A: Island Borneo with Hot Spots (yellow and red colour) collected in 1997, data courtesy by IFFM/GTZ, Samarinda B: Location of the study area covered by four ERS frames

Figure 2. Landsat TM image (frame 118-62) of the study area acquired on 29 May 1997 (RGB = Bands 543) before the huge fires showing the Mega-Rice Project area in Central Kalimantan, with the channels visible especially in the Southeast quadrant of the image. GPS tracks from the Nov 1998 aerial survey (red trails) and ground survey (blue trails) are overlaid on the image. Aerial photos of two types of peat swamp forests taken near Palangkaraya at locations B: Low pole forest approx. 20m high near catchment of Sungai Sebangau and C: High peat swamp forest approx. 40m high near the centre of the peat dome are shown below the TM image.

forests that have been opened up. The relatively dense PSF exist mainly in the western and northern portions of the image. The peat swamp forest west of Sebangau river remains relatively untouched. Aerial photos of two types of PSF in this region are shown in Fig. 2, below the TM image. The pinkish areas in the TM image are cleared lands for agriculture or settlements. Networks of irrigation channels can clearly be seen in these regions, especially at the lower right quadrant of the image. Most of these channels were the old channels constructed by the early settlers for rice cultivation. Channels connecting big rivers such as the Barito, Kapuas and Kahayan rivers were built by the Netherlands Indians government in late 19th and early 20th century, during the colonial era. These channels also provide waterways, making the area between the cities of Banjarmasin, Kuala Kapuas and Palangkaraya accessible. GPS (Global Position Sensor) tracks from a Nov. 1998 aerial survey (red trails) and ground survey (blue trails) are superimposed on the GIS image (Geographical Information System).

Table 1. ERS-1/2 SLC Dataset Used in the Study, acquired by CRISP, Singapore

SLC Pair	Frame	ERS-1 Orbit (date)	ERS-2 Orbit (date)
1	3645	24998 (26 April 96)	5325 (27 April 96)
2	3663	24998 (26 April 96)	5325 (27 April 96)
3	3645	24769 (10 April 96)	5096 (11 April 96)
4	3663	24769 (10 April 96)	5096 (11 April 96)
5	3645	32513 (03 Oct 97)	12840 (04 Oct 97)
6	3663	32513 (03 Oct 97)	12840 (04 Oct 97)
7	3645	32765 (22 Oct 97)	13112 (23 Oct 97)
8	3663	32765 (22 Oct 97)	13112 (23 Oct 97)

MAPPING VEGETATION COVER CHANGE USING INTERFEROMETRIC SAR IMAGES

The ERS dataset used in the study is shown in Table 1. It was acquired during two tandem missions in March/April 1996 and October 1997, and processed to the level of Single-Look Complex (SLC). Altogether 8 pairs of tandem-SLC data were used. Each pair of the SLC images was first co-registered and the coherence and intensity images were generated. All SAR images were acquired and processed at the Ground Station of the Centre for Remote Imaging, Sensing and Processing (CRISP), Singapore. Details of the interferometric SAR processing have been described elsewhere (Stussi et al. 1996, Stussi et al. 1997, Liew et. al. 1999). Post-processing of the images consists of antenna pattern correction, slant range to

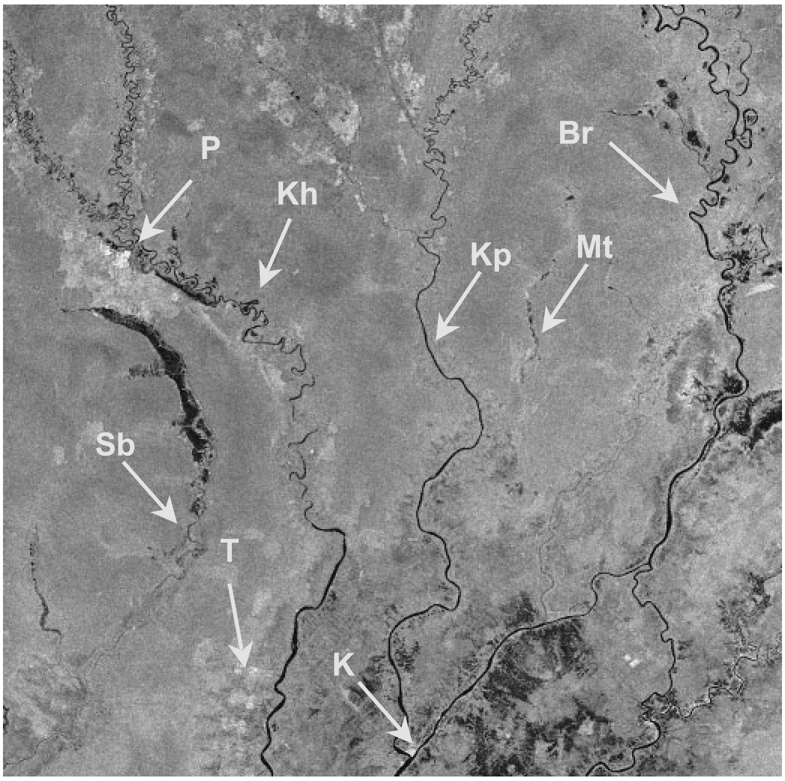


Figure 3. Interferometric SAR false colour composite image (April 1996) showing the area between Kahayan and Barito rivers (ERS image ”ESA 1996). Br: Barito river; Kp: Kapuas river; Kh: Kahayan river; MT: Mentangai river; Sb: Sebangau river; P: Palangkaraya; K: Kuala Kapuas; T: Transmigration Settlements established in the eighties. Courtesy by CRISP, Singapore.

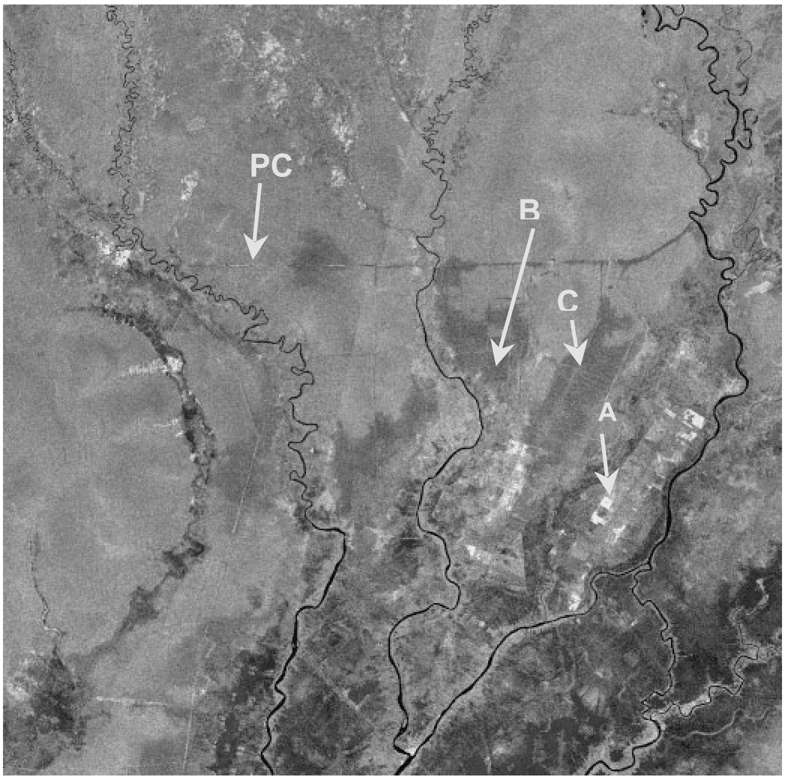
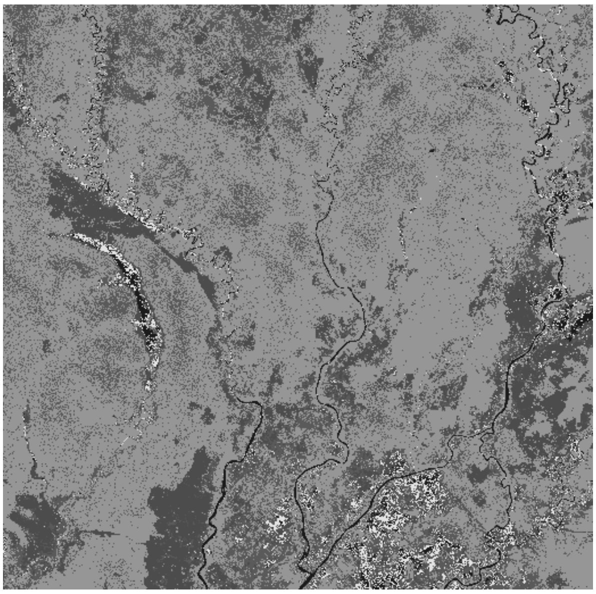


Figure 4. Interferometric SAR false colour composite image (Oct. 1997) of the same area shown in Fig. 5 (ERS image ”ESA 1997). Light cynic areas are the remaining vegetation while red areas are land clearings. The extensive network of newly constructed channels are visible. PC: Parent Primary channel connecting the Barito and Kahayan rivers. A: Land cleared by fires in Dadahup area. B: Channels between Kapuas and Mentangau rivers. The dark areas between the channels are dried and dead trees resulting from the fires. C: Part of a 66-km long primary channel connecting the parent primary channel in the north to the Kapuas river in the south. Courtesy by CRISP Singapore.

ground range correction for transforming the images to map coordinates and speckle removal using an adaptive noise smoothing filter.

Pseudo-colour mosaics of the SAR coherence-intensity images were generated. Extracts of the mosaics covering most parts of the MRP area are shown in Fig. 3 and Fig. 4 for the 1996 and 1997 datasets respectively. In each mosaic, the interferometric coherence is shown in the red display channel, the ERS-2 backscattered amplitude in the green and blue display channels. Vegetated areas appear in shades of cyan and non-vegetated areas in shades of red. The brighter cyan areas are more densely vegetated than the darker cyan areas. The dark red areas have low radar backscatter but high coherence. Rivers, catchments and inland water masses appear in black due to low coherence and low backscatter. Settlements and built-up areas appear as bright white. The Central Kalimantan province capital, Palangkaraya (labelled P in Fig. 3), can be seen in the two images.

Most areas in the April 1996 image (Fig. 3) are cyanic in colour, showing the presence of PSF. In the Oct. 1997 image (Fig. 4), the deforested regions can be detected visually. The Parent Primary Channel (PPC in Fig. 4) constructed for the MRP connecting the Barito river in the east and the Kahayan river near Palangkaraya in the west can be seen.



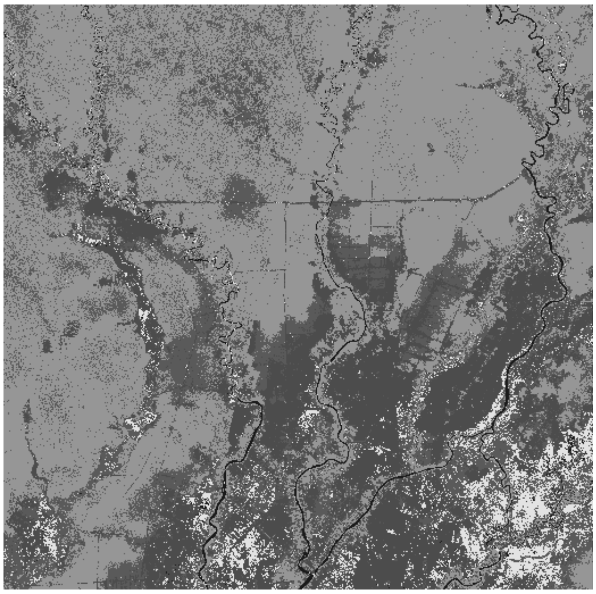


Figure 5. (left) Vegetation cover map of the study area (April 1996).
Figure 6. (right) Vegetation cover map of the study area (Oct. 1997)
Legends for both maps: Red: Clearings and settlements. Green: Dense forest. Dark green: Burnt/degraded peat swamp forest with low biomass. Yellow: Grass or sparse vegetation. Blue: open water (catchments and rivers). Courtesy by CRISP Singapore.

Extensive networks of channels are visible between the Barito and Kapuas rivers. Much of the land has been cleared (e.g. the Dadahup area, labelled A in Fig. 4), presumably by fires. Some areas in between the channels appear dark (B and C in Fig. 4), indicating a low interferometric coherence and low radar backscattered intensity. Aerial surveys (described in later sections) reveal that these areas are occupied by standing dead trees. The dead trees have low biomass, resulting in low radar backscatter. However, the remaining dead tree branches probably result in loss of coherence in the interferometric data.

Two vegetation cover maps (Fig. 5 for Apr. 1996 and Fig. 6 for Oct 1997) of the study area were generated from the two tandem ERS SAR datasets by thresholding the coherence and intensity. For each dataset, a threshold of 0.5 was applied to the coherence data to separate the land into two major classes: low coherence (<0.5) areas consisting of vegetation and open waters and high coherence (>0.5) areas consisting of clear cuts or settlements. The low coherence areas were further separated into four more classes by thresholding the intensity. The low-coherence class with the lowest intensity was the water body. The resulting five classes in the vegetation cover maps are: 1. non-vegetation with high coherence (clearings or settlements, coloured red in Figs. 5 and 6); 2. vegetation with high radar brightness (forest with high biomass, green in Figs. 5 and 6); 3. vegetation with medium radar brightness (burnt forest or degraded forest with low biomass, dark green in Figs. 5 and 6); 4. vegetation with low radar brightness (grass or sparse vegetation areas, yellow in Figs. 5 and 6); 5. Water body (blue in Figs. 5 and 6).

Changes in land cover between April 1996 and Oct. 1997 can be derived by comparing the two corresponding vegetation cover maps. The resulting land cover change map is shown in Fig. 7 and Table 2 shows the results of this change analysis. In Fig. 7, the areas affected by the 1997 fire are coloured in red and orange. They occupy about 25% of

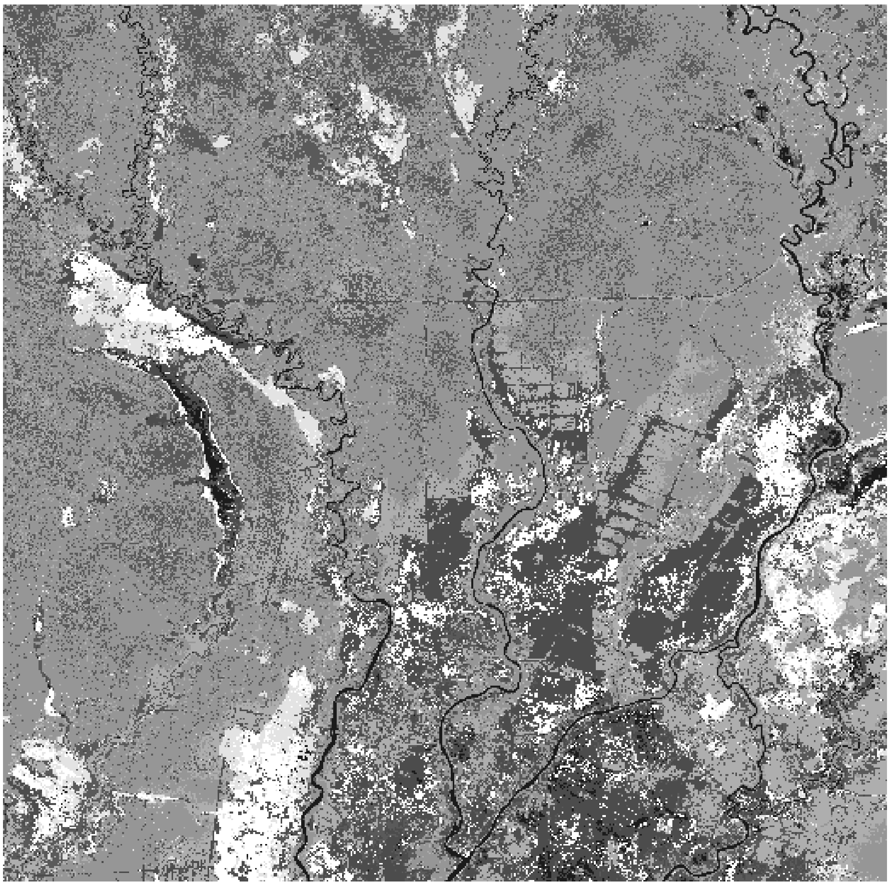


Figure 7. Land cover change map derived from the April 1996 and Oct. 1997 interferometric SAR datasets. The areas affected by the 1997 fire are coloured in red and orange. They occupy about 25% of the total area surveyed in the ERS images. Red: New clearings, fire burnt scars. Orange: Degraded forests, standing dead trees. White: Settlements, old clearings. Yellow: Old clearings with vegetation regrowth. Green: Remaining dense forests. Dark green: Remaining low biomass forests, shrubs. Blue: Rivers, catchments, water bodies. The channels are not resolved in the image. They are visible due to clearing of vegetation on both sides of the channels. Courtesy by CRISP Singapore.

the total land area in the ERS images. The red areas have low coherence in 1996 and an increase in coherence in 1997. These areas are new clearings and are possibly burnt areas. The orange areas are standing dead trees due to fires. The coherence remains low both in 1996 and 1997. However, the radar backscatter decreases in 1997 due to a decrease in biomass. The areas coloured green and dark green are vegetated in both 1996 and 1997. The white areas are the old clearings and settlements. They have high coherence in both the 1996 and 1997 imagery. Old clearings with vegetation regrowth (i.e. high coherence in 1996 but decreased coherence in 1997) are coloured yellow in Fig. 7. Approximately 25% (913 000 ha) of the vegetation (mostly PSF) in the study area has been burnt.

COMPARISON WITH OPTICAL REMOTE SENSING IMAGES

Multi-spectral SPOT images of parts of the study area were acquired on July and September 1997. SPOT quick-look images are shown in Fig. 8. The June and September 1997 images illustrate the situation during the active fire period in 1997. In the mosaic of SPOT images, several intense smoke plumes can be seen emanating from the sites of active fires, especially in the September 1997 scene. The reddish regions are vegetated while the dark areas have been burnt. The parent primary channel (labelled PPC) can be detected. The dark green areas near to the channels in Fig. 4 (labelled B and C) are indeed burnt vegetation. This SPOT mosaic confirms that most of the areas delineated as burnt vegetation in the land cover change map derived from interferometric SAR images (red and orange areas in Fig. 7) have been affected by the fires of 1997.

Two cloud-free Landsat-TM images of the study area were acquired on 10 May 1996 and 29 May 1997, before the 1997 fires. Another image (hazy) acquired on 29 March 1998 (after fire) was also available. Extracts from these images for an area vastly affected by the 1997 fires near Dadahup are shown in Fig. 9 (A and C). The spectral characteristics of fire scars in Landsat TM images of Amazonian forests have been studied by Pereira and Setzer (1993). They found a combination of channels 4 and 5 is the best for separating burn scars from tropical forests and pastures. The TM images in Fig. 9 are displayed with bands 5, 4 and 3 in the red, green and blue display channels respectively.

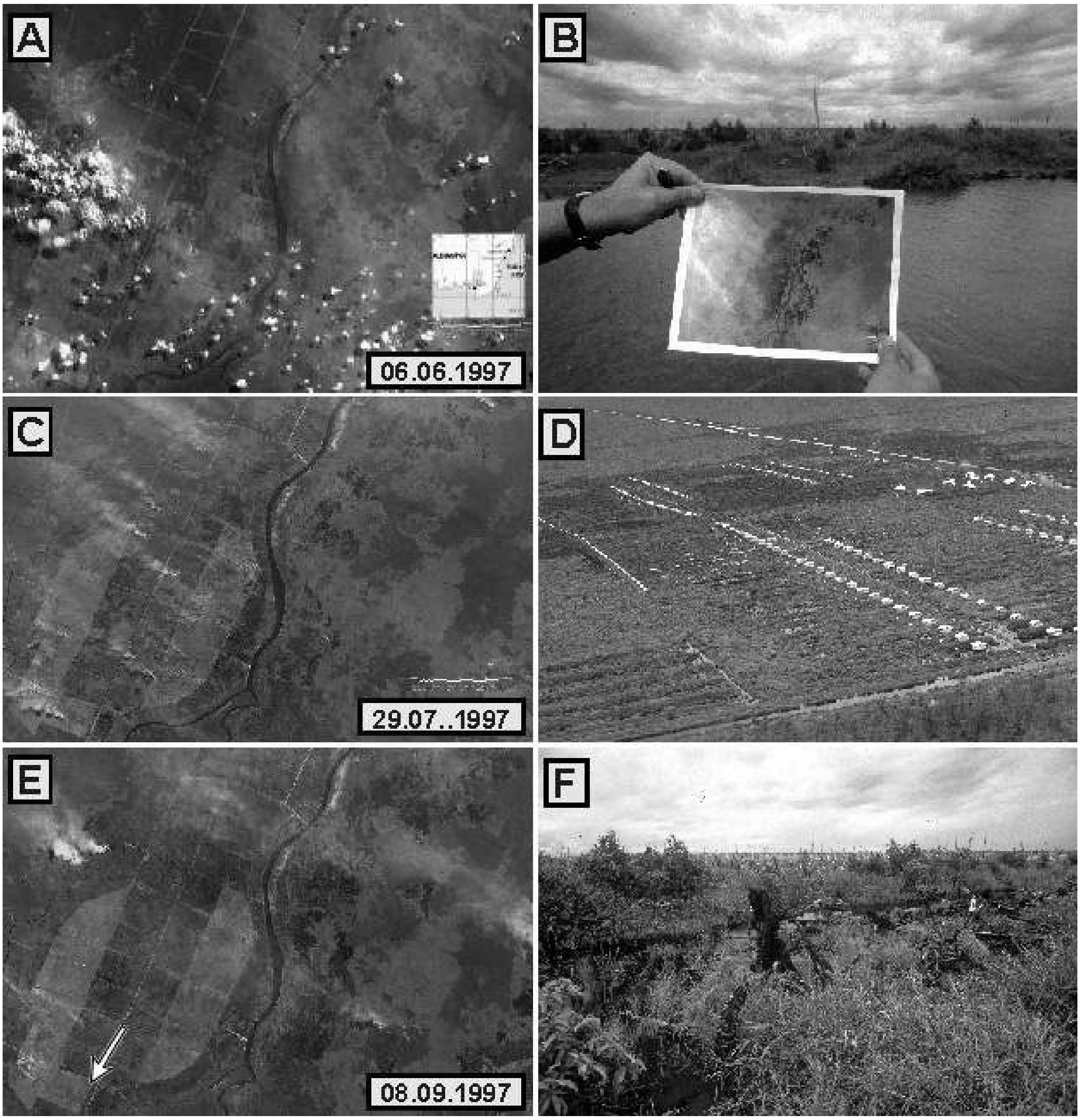


Figure 8. SPOT quick look images of the study area acquired on 6.June, 29.July and 8.September 1997. Several smoke plumes due to fire activities can be clearly seen. A: Spot image from 6. June 1997 before the fires with Barito river. B. Ground photo in the Dadahup area. C: Land cleared by fires in 29. July 1997. D: Aerial photo of transmigration houses E: Spot image from 8.9.1997, dark green areas in Fig. 4. F: Ground photo with cleared forest.

For comparison, extracts of the ERS interferometric SAR pseudo colour composite images of Apr. 1996 (from Fig. 3) and Oct. 1997 (from Fig. 4) covering the same area are shown in Fig. 9 (B and D). In the TM images, PSF is shown in green colour, clear-cut in red and magenta colours. The bright yellowish areas are open land with sparse vegetation and regrowth. Newly built channels are seen in the 1998 TM images as well as in the Oct. 1997 ERS interferometric SAR image. As can be seen in the time series, most of the remaining PSF in the area have been destroyed by the fires. The high coherence areas (reddish) in the ERS interferometric SAR images correspond to the reddish and yellowish areas in the TM images. The burn scars in the 1998 TM image appear reddish in colour due to a high reflectance in band 5 (short-wave infrared band) and low reflectance in bands 4 (near infrared) and 3 (visible red). Parts of areas delineated as burn scars in the ERS SAR images appear yellowish in the 1998 TM image (e.g. on the west bank of the Barito river, near the top half of the image), indicating the emergence of some sparse vegetation such as grass and shrubs in the burn areas which are identified as regrowth of vegetation. The reddish areas in the left half of the 1998 after-fire TM image appear to be larger than the corresponding area delineated as burn scars in the ERS image. This is probably due to the continued occurrence of fires in this area after the October 1997 acquisition of the ERS image. During the fires between End of July

Table 2. Percentage and total area of the classes derived from interferometric SAR datasets of April 1996 and Oct. 1997; red and orange area together is approx. 913,000 ha (25%).

Class	Colour in Fig. 7	Area (ha)	Percent of land
New clearings (Forests in 96, clearings and fires in 97)	Red	**379,120**	10.54
Degraded and burnt forests, standing dead trees (High radar brightness in 96, mid/low in 97)	Orange	**533,528**	14.84
Old clearings, settlements	White	211,662	5.89
Old clearings with vegetation regrowth (Bare in 96, vegetated in 97)	Yellow	206,332	5.74
Remaining forests, partly selective logged	Green	1,461,632	40.65
Remaining vegetation with low biomass (mid/low radar brightness in both 96 and 97)	Dark green	803,331	22.34
Catchments and Water bodies	Blue	(117,703)	--
Total Land Area (excluding water) of the four regarded ERS-images		**3,595,605**	**100**

and End of October 2002, NOAA and Modis images were acquired from the internet. A Landsat image from 20th August 2001 (Fig. 17) shows fires and smoke plumes of the MRP study area even one year before the next 2002 huge fires.

AERIAL AND GROUND SURVEYS IN 1998, 1999, 2000 AND 2001

To investigate fire impact and to survey several locations suspected as being burnt in the ERS and Landsat TM images, three aerial and three ground surveys were conducted in June and November 1998, and in August 1999 (Boehm and Siegert 1999, Boehm et al. 1999). Ground trials in June 2000 and July/August 2001 were added. During the November 1998 flight, total flight time of 2 hr 30 min and flight distance of 400 km were logged by GPS. The flight route was planned by storing ERS SAR map co-ordinates of interest (derived from a geo-referenced ERS image) within part of the fire affected area into the GPS of the aeroplane. The flight route was then recorded by GPS in continuous track mode storing geographic locations every 10 seconds. The flight survey was also documented by digital video. In order to facilitate later analysis of the video material and comparison with satellite images, video time code and GPS system time were synchronized. Similarly all travels on the ground were recorded by GPS in a 30 seconds interval and approx. 500 photographs were taken at know geographic locations. To check classification results, the GPS tracks were imported into a GIS (Geographical Information System) containing the geo-referenced ERS and Landsat TM satellite images (compare Fig.2). By overlaying the GPS tracks onto the satellite images and by comparing photographic and digital video information, specific signatures and features in the ERS images were checked.

Aerial surveys were mandatory since many areas in the test area could not be accessed on the ground. First of all, the infrastructure in Central Kalimantan is very poorly developed, many of the new channels cannot be travelled by boat due to a low water table in the channels. Fire affected forests and selective logged forest are almost hardly inaccessible on foot. These surveys revealed that, in general, fire in PSF almost completely destroyed the vegetation. Tree survival rate was estimated during the aerial survey to be less than 10%. Due to the extended drought period caused by the 1997/98 El Nino episode and aggravated by the newly made channel system which completely drained the peat domes, the water level in the peat swamps dropped several meters. This resulted in an extremely dry upper layer of peat which when set on fire produced huge amounts of smoke, haze and CO≤ emission. Since the fire affected the soil itself (the peat layer) it destroyed the root system of the trees which in consequence

Table 3. Hot Spot counts from NOAA images in Borneo during 15. July to 13 Oct. 2002

July	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
counts	50	15	0	0	67	60	0	0	15	30	0	0	100	125	0	0	5
Aug.	01.	02.	03.	04.	05.	06.	07.	08.	09.	10.	11.	12.	13.	14.	-	-	-
counts	83	0	5	100	450	70	0	15	115	225	0	190	420	785			
Aug.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
counts	125	285	1300	1185	350	335	500	135	365	50	465	965	450	50	335	735	350
Sept	01.	02.	03.	04.	05.	06.	07.	08.	09.	10.	11.	12.	13.	14.	-	-	-
counts	16	160	155	145	30	145	490	100	35	90	420	280	43	48	-	-	-
Sept.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	-
counts	363	750	760	320	660	425	250	16	170	255	250	40	60	350	170	10	-
Oct.	01.	02.	03.	04.	05.	06.	07.	08.	09.	10.	11.	12.	13.	-	-	-	-
counts	275	235	290	95	0	135	425	120	45	480	430	295	285	-	-	-	-

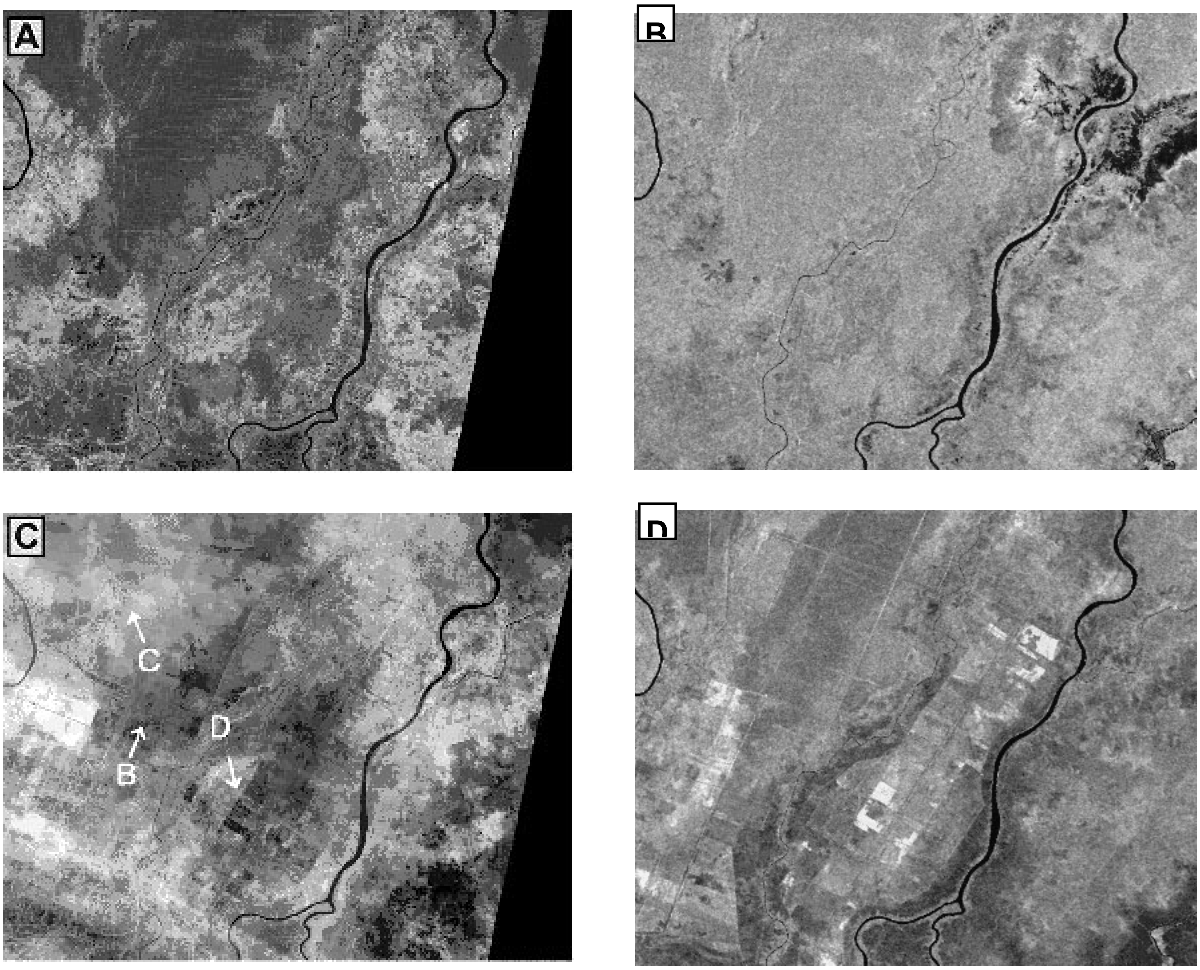


Figure 9. LANDSAT-TM images (RGB = Bands 543) of the Mega Rice Project area in Central Kalimantan near Dadahup acquired on 10 May 1996 before the 1997 fire (top left panel A) and on 29 March 1998 after the fire (Bottom panel C). Each image covers an area 44km by 58km. Peat swamp forests appear in shades of green, clear-cuts in shades of pink and purple. Burnt areas appear in red in panel C. The letters and arrows in panel C indicate the locations of the aerial and ground photos shown in Figure 10. For comparison, ERS interferometric SAR images of April 1996 (before fire, top right panel B) and Oct. 1997 (during fire, bottom right panel D) extracted from Fig. 3 and Fig. 4 are also shown.

toppled over. In most cases low pole PSF have been consumed completely by the fire, while in high PSF, trees have been killed but not combusted. The completely destroyed forests show up as areas of high coherence in the Oct. 1997 interferometric SAR image (reddish areas in Fig. 4). On the other hand, the burnt forests with standing dead trees have low interferometric coherence. These burnt forests can be discriminated from live vegetation by their generally low SAR backscatter in the interferometric SAR image (dark areas between channels in Fig. 4).

Figures 8A, 8C, 8E are SPOT quick look images of the study area acquired on 6. June, 29. July and 8. September 1997, before and during the fires. Several smoke plumes due to fire activities can be seen clearly in Fig. 8C and 8E. Figure 8B and 8F show ground photos in the Dadahup area and Figure 8D an aerial photo with new transmigration houses.

Figures 9A and 9C show LANDSAT-TM images (RGB = Bands 543) of the Mega Rice Project area in Central Kalimantan near Dadahup acquired on 10 May 1996 before the 1997 fire (top left panel 9A) and on 29 March 1998 after the fire (bottom panel 9C). Each image covers an area 44km by 58km. Peat swamp forests appear in shades of green, clear-cuts in shades of pink and purple. Burnt areas appear in red in panel 9C. The letters and arrows in panel 9C indicate the locations of the aerial and ground photos shown in Figures 10 and 11. For comparison, ERS interferometric SAR images of April 1996 (before fire, top right panel 9B) and Oct. 1997 (during fire, bottom right panel 9D) extracted from Fig. 3 and Fig. 4 are also shown. Fire impact was concentrated along the main and side channels. There were no examples of fire scars within closed forests (e.g. caused by self-ignition). This pattern confirms conjecture that most if not all fires can be attributed to arson. Fire was used for cheap land clearing in the framework of the Mega Rice Project.

Figure 10. Aerial photos acquired during a flight on 13 June 1998. A: PPC and burnt scars at Kapuas river with sluices, B: PPC interrupted by black water river Mentangai crossing the channels.

Figure 10A shows an aerial view of the main channel connecting the Kahayan, Kapuas and Barito rivers (see Fig. 2 and Fig. 4). The Photos in Fig. 10B and Fig. 11C were acquired in the middle between Kahayan and Kapuas river at blackwater river Mentangai, where the peat dome is several meters thick. On both sides of the channel the PSF has been destroyed to 100%, but many trees are still standing and represent an extremely high future fuel hazard during the next prolonged dry season.

Figure 11A shows a black and white ERS-image (18 Sept. 1997) with the rivers Kapuas and black water river Mentangai, the new channels and superimposed the flight route from 3 Nov. 1998 (dotted red lines), while Figures 11B presents a LANDSAT-TM image (10 May 1996, RGB = 543) of the same area without small channels. Fig.11C is an aerial photo of the Mentangai river crossing the main channel. Channel construction had to be interrupted because of the river. Figure 11D monitors illegal logging along the Mentangai river. Figure 11E shows dead trees along Mentangai river, remnants from the great fire in 1997. In this case the fire was not strong enough to combust the trunks of the trees probably because it was a smouldering fire propagated in the peat layer. Figure 11F presents a new transmigration settlement established on the land cleared by fire in 1997 (compare LANDSAT image in Fig. 2 and 11B) but not yet inhabited, location indicated by arrow in Fig. 11A.

FIRES IN 2002

The 2002 fires started at the End of July 2002 in Borneo island. Pak Suwido Limin from University of Palangkaraya and director of CIMTROP writes on the 29. July 2002:

ìCENTRAL KALIMANTAN IS ON FIRE AGAIN! A PLEA FOR URGENT ASSISTANCE! A fire fighting team, ëTim Serbu Apií (TSA) under my direction is working hard to suppress fires in Block C of the former Mega Rice Project area, near to the Kalampangan Channel in Central Kalimantan Province of Indonesia. We started on Friday 25th July 2002 and worked without rest or stopping, every day and night. So far we have successfully installed deep wells below this peat covered landscape in three locations and obtained water to wet the peat surface along a transect line 800-900 metres long to try to stop the fire from spreading to the nearby village and destroying crops, houses, forest and peat.Ö..The National, Provincial and Local Governments are powerless to do anything, only meeting and talking, while destruction takes place around them. All of the people in and around the Provincial capital of Palangka Raya are now suffering from the choking haze and smoke. The conditions are terrible and many children will become ill, some permanently. We desperately need help to extinguish these fires."

The satellite information from NOAA and Modis sensors documents this 2002 situation from the sky. Figure 12 shows accumulated NOAA hot spots in August 2002 from major parts of Indonesia. Especially Borneo and Sumatra produced many hot spot counts in this month. The NOAA hot spots for Borneo from 15. July to 13. October 2002 are shown in Figure 13. Around the 17. August 2002 the most hot spots with 1300 counts were visible and one month later around the 17. Sept. 2002 again high hot spot values with 760 counts were seen on the NOAA images. The fires, smoke and haze continued up to the end of October 2002.

Figure 14 presents the Island Borneo with a clear NOAA12 image from the 18. August 2002 showing smoke and haze (left). On the 10. Oct. 2002 image many clouds are visible covering the north part of Borneo (right). In the

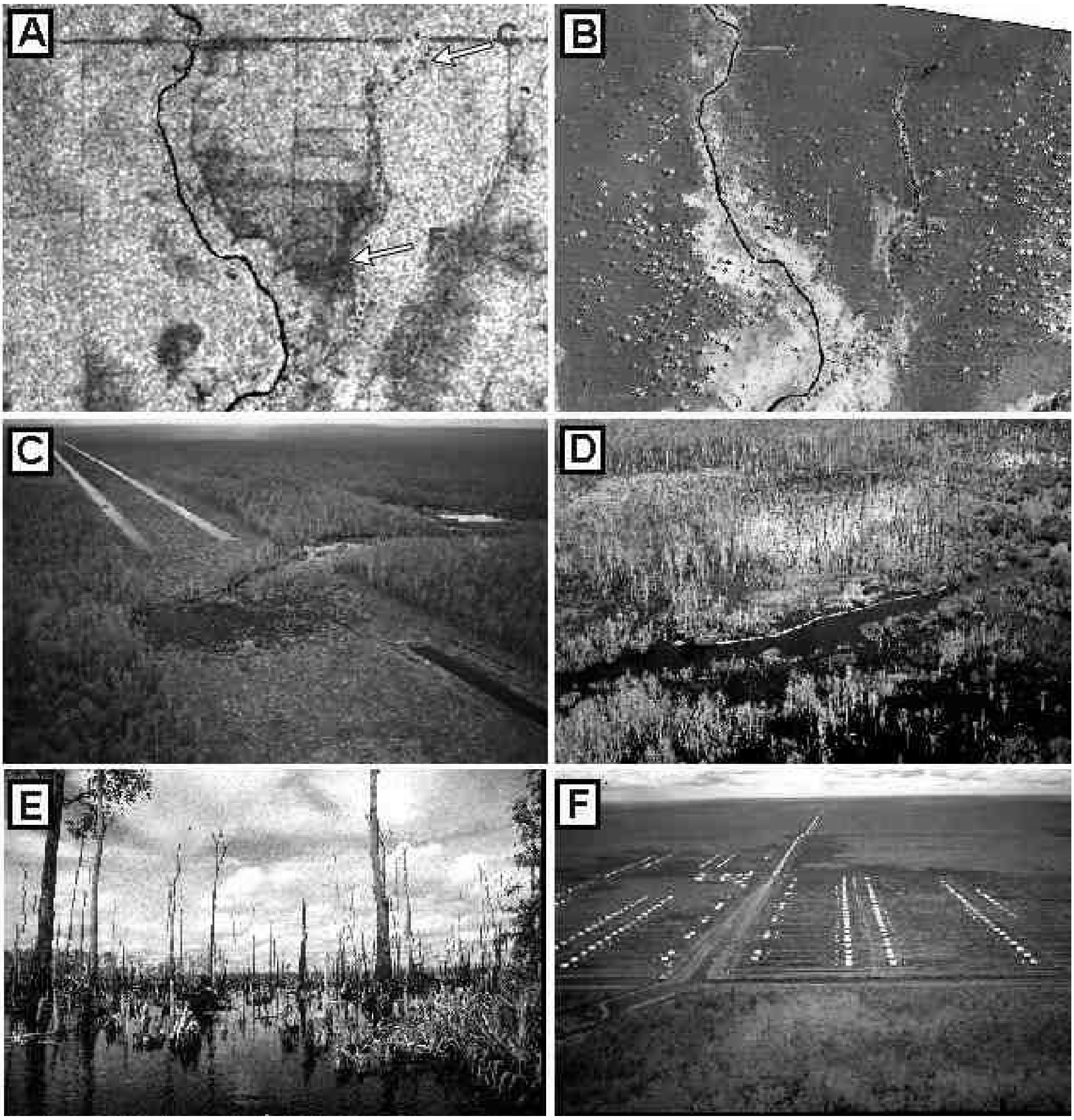


Figure 11. A: ERS-image (18 Sept. 1997) showing the rivers Kapuas and black water river Mentangai, the new channels and the flight route from 3 Nov. 1998 (dotted red lines). B: LANDSAT-TM image (10 May. 1996, RGB = 543) of the same area without small channels. C: Mentangai river crossing the main channel, channel construction had to be interrupted. D: Illegal logging along Mentangai river. E: Dead trees along Mentangai river, remnants from the great fire in 1997. F: New Transmigration settlement established after the land clearing by fire in 1997 (compare LANDSAT image in Fig. 2 A and B) not yet inhabited, location indicated by arrow in A.

southern area hot spots, smoke, plumes and haze were monitored (right). A Modis image acquired on 18. August 2002 shows many fires (Figure 15) with smoke and plumes over Central Kalimantan. Hot spot counts are compare in Fig. 13. Palangkaraya is totally covered by fires and smoke! The airport of Palangkaraya had to be closed for several weeks during this fire period. The people who had to fly to Jakarta had to use the airport of Banjarmasin.

The photos in Figure 16 are a documentation of the fire situation on the ground during September 2002 in the south of Palangkaraya. Figure 17 is a relative cloud-free Landsat image (118-62, 543) taken on 20. Aug. 2001, which represents one year before 2002 fires again strong plumes of smoke over the Block A and B of MRP in the dry season. It seems that now every year for several months during the dry period, smoke and haze conditions around Palangkaraya and the MRP area become the norm, which was predicted in 1999 (Boehm and Siegert, 1999 and Boehm et al. 1999).

CONCLUSIONS

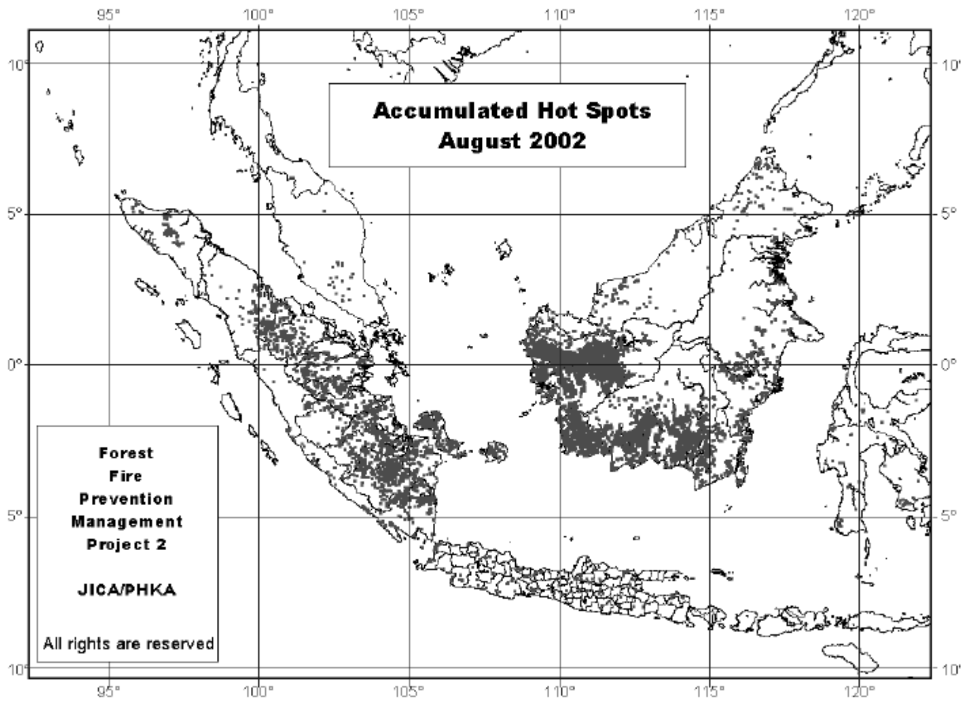


Figure 12. Accumulated NOAA Hot Spots in Aug. 2002 for Borneo, Sumatra, Java and Sulawesi. Courtesy by JICA.

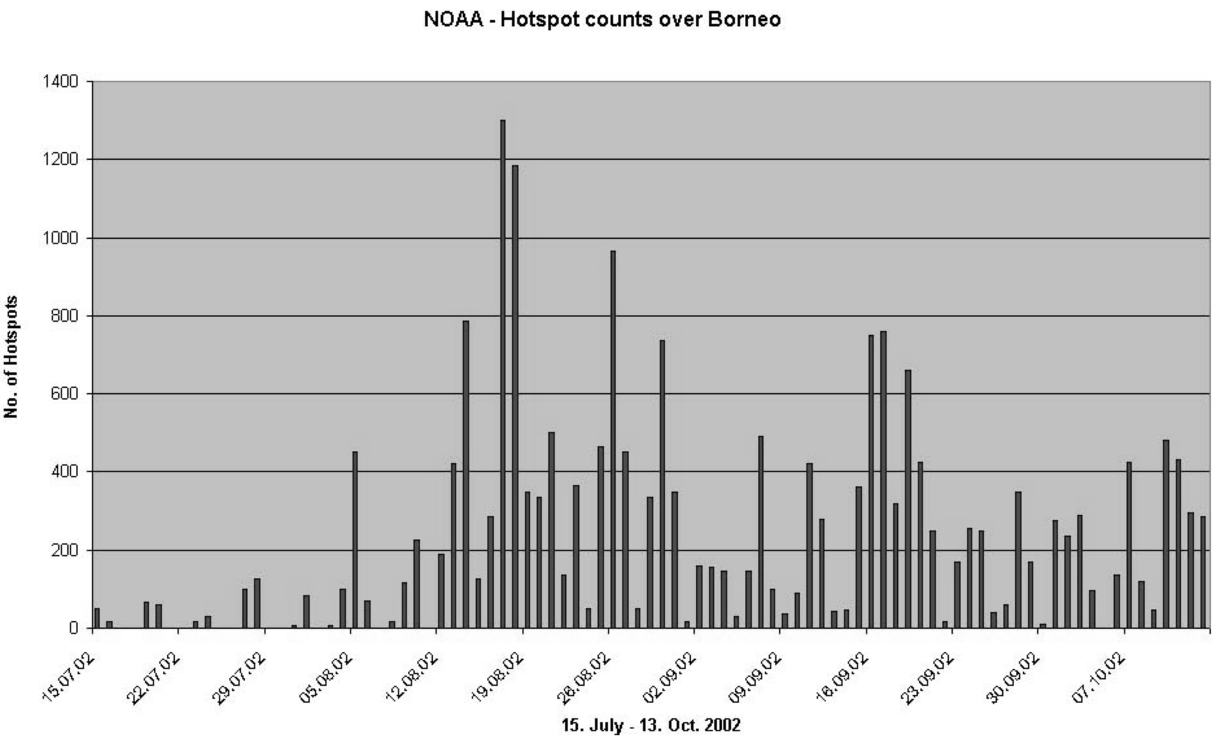


Figure 13. NOAA- Hot spots detected in Borneo over a period of three month. It started with the fires End of July 2002 and showed around the 17.August 2002 the most hot spot counts with 1300 and one month later around the 17. Sept. 2002 again high values with 760 hot spot counts. The fires, smoke and haze continued up to the end of Oct. 2002. Courtesy by National Environmental Agency, Singapore.

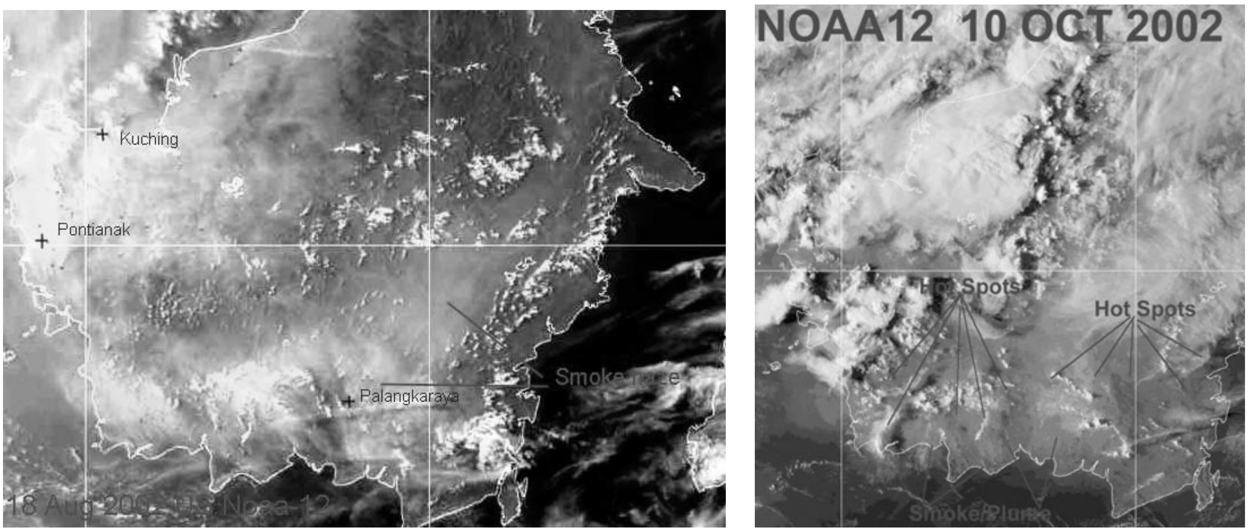


Figure 14. Island Borneo with a clear NOAA12 image from the 18. August 2002 showing smoke and haze (left). On the 10. Oct. 2002 many clouds are visible covering the north part of Borneo (right). In the southern area many hot spots, smoke, plumes and haze were monitored (right). Courtesy by National Environmental Agency, Singapore.

Figure 15. Modis image acquired on 18. August 2002 showing many fires, smoke and plumes over Central Kalimantan, compare hot spot counts in Fig. 13. Palangkaraya is totally covered by fires and smoke. Courtesy by NASA.

Figure 16. Fires in deep peatland south of Palangkaraya, Central Kalimantan from Sept. 2002, photos courtesy by Prof. J. Rieley, University of Nottingham and Dr. Takahashi, University of Hokkaido.

Figure 17. Landsat image (118-62, RGB=543) acquired on 20. Aug. 2001 from the MRP area located between Kapuas (left) and Barito rivers (right) with Lamunti and Dadahup villages. The time of acquiring the image is again during dry season visible with smoke plumes four years after the ENSO of 1997 and one year before ENSO 2002. The MRP channel system can be seen and it is mostly not working. The clear cuts of the peatland is shown in light green colour with regrowth of bush land. Red colours around the channels are burnt cars and fresh clear cuts, compare Fig. 2, 9A,C+F, and 11. The remaining PSF (dark green colour) in the upper part of the image is strongly reduced see Figure 2.

This work illustrates a case of monitoring vegetation cover change using multi-temporal remote sensing imagery, complemented by ground and aerial surveys. In particular, interferometric SAR imagery acquired by the ERS satellites during two tandem missions have been used to delineate burn scars in a tropical forest region. The change in vegetation cover due to the autumn 1997 fire in the iMega Rice Project" peat swamp forest area of Central Kalimantan has been mapped using the interferometric SAR imagery acquired during the two ERS tandem missions in April 1996 and Oct. 1997. Fire burn scars were characterized by a low interferometric coherence in the 1996 imagery and an increased coherence in the 1997 imagery, in areas where the fires had completely destroyed the forests. However, in areas where trees were killed but not completely combusted, the coherence remained low. This type of burn scar can be discriminated from the remaining living forest by a decrease in the backscattered SAR intensity. A combination of both coherence and SAR intensity is required to delineate burn scars. These observations were confirmed by ground and aerial surveys of the study area. About 25% (913 000 ha) of PSF was found to have been burnt in the study area in 1997.

Now there are more than 4000 km of channels in the MRP, which has many problems in hydrology of draining instead of irrigating the land and in big peat layers which are not suitable for rice cultivation. The big PPC between Kahayan, Kapuas and Barito (KaKaB) provides no irrigation and has a draining effect only. The eco-sociological aspects caused by large-scale transmigration are unsolved. Most transmigrants lack skills and experience with peatland.

The optical satellite images (Landsat, Spot, NOAA and Modis) and aerial photos showed that draught and/or low water-table cause trees to die. Frequent fires give forests no time to recover and the tropical climate causes quick regrowth by ferns and alang-alang, etc. Central Kalimantan PSF are highly endangered. No sustainable forest management is applied, rather illegal logging behaviour has strongly increased in 2000/2001/2002. Extreme fire risk now and in the future causes haze, smoke and illness in people. Most of the Central Kalimantan fires in 1997/1998 and 2002 were man-made. Fire was used for cheap land clearing in the framework of the MRP. Huge amounts of stored carbon were released into the atmosphere. Peatland destruction is an irreversible process which can be monitored in the time sequence (1996, 1997, 1998, 2001 and 2002) of Figs. 2, 7, 8, 9, 11 and 17. This reduces the biodiversity with loss of habitats and disturbs the hydrology, combined with losses of forest products.

It seems that now every year for several months during the dry period, smoke and haze conditions around Palangkaraya and the MRP area become the norm.

ACKNOWLEDGEMENTS

Two authors gratefully acknowledge financial support from the European Union (INCO-DC contract no. ERBIC18CT980260). The authors gratefully acknowledge the processing of the ERS-interferometric images by Centre for Remote Imaging, Sensing and Processing (CRISP), Singapore. The NOAA hot spot data courtesy by the Integrated Forest Fire Management-Project IFFM/GTZ, Samarinda East Kalimantan and by the National Environmental Agency, Singapore and by JICA. The Modis image courtesy by NASA. The photos in Fig. 16 from the Kalimantan fires in Sept. 2002 are taken by Prof. Jack Rieley, University of Nottingham and by Dr. Takahashi, University of Hokkaido. Thanks is also given to Pak Suwido Limin from University of Palangkaraya and CIMTROP for his 2002 fire report.

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Environmental Change in Danau Sentarum National Park - West Kalimantan

Dr. Ir. Gusti Zulkifli Mulki
Nurhayati, S.T., M.T.
Stefanus Barlian Soeryamassoeka, S.T., M.T.
FX Widadi Padmarsari S.,M.Si.
Center for Water Resources Studies (CeWARS)
Universitas Tanjungpura, Pontianak West Kalimantan, Indonesia
Jalan Achmad Yani Pontianak 78124, Fax. +62 561 740186
E-mail : cewars@voila.fr

ABSTRACT

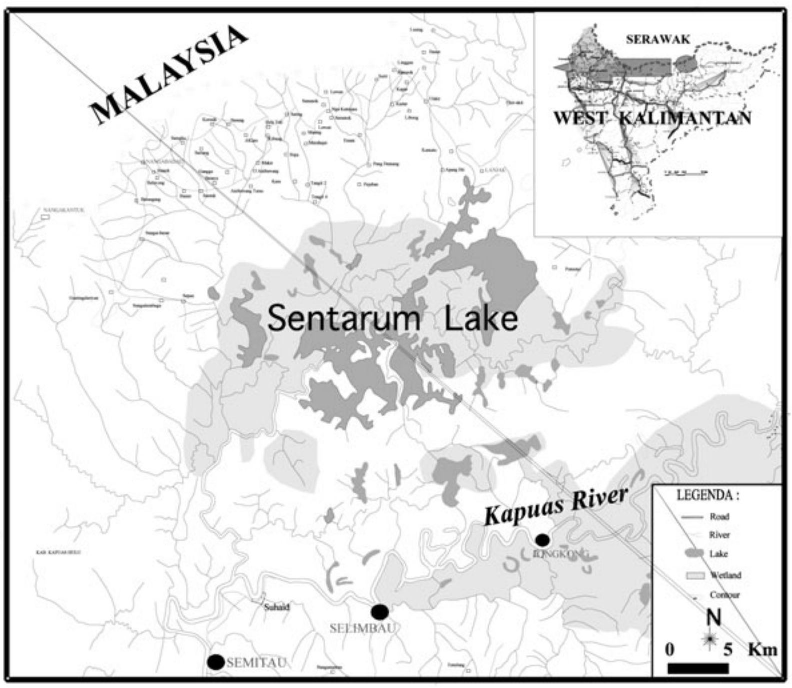
The Danau Sentarum National Park (DSNP) contains 132.000 Ha of lowland, seasonally flooded forest. The park contains a rich fauna including, crocodiles, pythons, gibbons, monkeys and orang utan. The located of Danau Sentarum is in the flood plain of the upper Kapuas River in West Kalimantan, Indonesia (between 0^{o}40í - 0^{o}55í N and 112^{o}00í - 112^{o}25í). This area support about 250 fish species, about 250 birds species and a large traditional fishing industry of 39 villages. In reality, the Danau Sentarum National Park consists of series interconnected seasonal lakes, and swamp forest on isolated hills. Since April 1994, the DSNP was declared as Ramsar Wetland of International Importance.

In the early XXI century, there are many problems in the park, like hydrology, water balance, fish industry, sanitation & fresh water for the population, etc. During the last 10 years, the DSNP indicate the significant change of the environment. The fishermen find some species of the fish decrease. Now, if there are no rainfalls during 2 weeks, the water level decrease quickly. It is difficult for the inhabitants because the water in DSNP is the only freshwater source. Rona et al. (2000) found an increase in the maximum size of burn scars between 1973 and 1997, from 581 ha to 1339 ha. This condition is urgent serious. because there are illegal logging in buffer zone too. We conclude that the future of DSNP is still in uncertainty

Key words : Wetland, Kalimantan, Borneo, Ramsar, Sentarum, fish, ENSO

INTRODUCTION

Wetland is normally the most productive ecosystem in the world. Danau Sentarum is located in flood plain of the upper Kapuas river in West Kalimantan (700 Km to the upper reaches of river) contain 132.000 Ha Which is one of the most important wetland in Indonesia. It is proven that this area was declared as Ramsar in April 1994. This region possesses the unique fresh water ecosystem, exist lot of biodivesity resources.



As it is know that the fresh water ecosystem is important for human being particularly the source of portable water (drinking water), cooking, washing, agriculture, fishery, transportation, electricity and recreation. Since the fresh water ecosystem is so important that is creates inhabitants who dwell in the wetland depend on the water supply. In Danau Sentarum for instance, the water transportation is the only alternative for inhabitants to migrate from one place to another. Such environmental alteration triggers the disturbance of natural balance in ecosystem.

Danau Sentarum of National Park (DSNP) is an important ecosystem having various functions in system of fisheries resources. The DSNP are remarkable for their fish diversity and 240-266 fish species have been identified at the park and smeller around the area, including 12-26 species endemics (Kottelat, 1995; Dudley & Widjanarti, 1996 In : Giesen & Aglionby, 2000). DSNP is not only support 70 % of Borneoís 340 species freshwater fish (and 76 % of the Kapuas), it also support a high proportion of West Borneoís endemics with the 19 potentially new species to be endemic Borneo (Kottelat, 1993 In : Jeanies & Erik, 2000). This diversity is remarkable when compared to the lakes in Europe, where a total only 195 primary freshwster fish are known.

Fisheries potential of Danau Sentarum not only for diversity, but also level production of fish. The potential of fish found are mainly consuption and ornamental fish, including two highly popular aquarium fish: *The Asian Arowana, Scleropages formosus (Siluk)* and *The Clow Loach, Botia macracanthus*. The latter is only known from Danau Sentarum and several locations in Jambi, Sumatra . The park is also harbors many interesting species from families that are primarily marine, such as soles, stingrays and pufferfish. The lakes can support a large traditional fishing industry, utilized over 6,500 fisher inhabiting 39 villages and add adjacent the park.

HYDROLOGY AND WATER BALANCE

Located in the flood plain, Danau Sentarum is the wetland which comprises series interconnected seasonal lakes and swamp forest on isolated hills, such as Danau luar, Danau Seriyang, Danau Sumbai, Danau Sumbu and Danau Sentarum. They are seasonal lakes. It means that they are filled water fully in rainy season whereas in drought, the rain water from the lakes goes to Kapuas river. The color of the water is brown or blackish (like the color of Coca cola) with low pH (pH 4 - 5.5) with the average depth of water ranges from 8 - 12 meters.

As the uniqueness and the breadth of the wetlands, this region is alleged to represent the species of alive fishes from the river old age system which connects Borneo and Sumatra (the river system of Sundaland). Today it is admitted that Kapuas lakes system have important roles in the ecosystem of Kapuas river, and they cannot be separated at all one another. Generally they are formed result from meander or the expansion of flood plain.

The Kapuas lakes are the flood plain which keep the overwhelming water of the Kapuas river in flood season, and refill the plot of the Kapuas River in drought. According to the research of Klepper et.al (1996), in drought around 50% of the water in Danau Sentarum (Kapuas Hulu) can fill the Kapuas river. On the contrary, in wet season around 1000-2000 m^3/seconds the water of the Kapuas River flows into the lakes.

PROBLEMS

Before discussing the problem, it is important for us to understand the problem, which occurs in Kapuas River. As the longest river in Indonesia, the natural resources are exploited massively. So, the river undergoes hydrological alteration and apprehensive water balance.

Nowadays the Kapuas river tends to be dry and seriously silting up. In last drought (even if short drought) the people of Sintang turned out that they could play a football (soccer) in the flood plain. According to one of the Sintang people, the flood plain annually wider and wider. It means that the rate of water flow becomes smaller and smaller, it can be seen that previously, the breadth of river 250 meters. The depth of river declines from 12 meters now left 30 up to 100 centimeters.

The condition is so concerned, in short dry season (about 2 -3 weeks with no rainfall) creates the rivers in this island to be dry. On the other hand, in wet seasons the rivers in Kalimantan generally filled fully with rain water (over flowed). Even in some zones this condition causes big flood like in Sintang and Puttusibau.

According to river science, there is a big disparity between the debit in wet season and dry season which is so drastic. This indicates that the condition of hydrology and hydraulics are not healthy. On the other hand, the rivers in West Kalimantan are getting sick.

In seminar ìThe Strategy of Freshwater Development in West Kalimantan, in effort to face water crisis in the future” presented by Center for Water Resources Studies (CeWARS) Technique Faculty of Tanjungpura University 8 November 2001

It is convinced that one of causes is that they are the destruction and the alteration of the river stream flow area. The problem is that flow big is the destruction of the river stream flow as well as flow big is the alteration happens in water balance ?

Tentatively, there are no answers for those questions due to the nil of the research in this field. Yet, one thing for sure, there have been big alterations with the rivers, result from the river stream flow area cannot hold the water when it rains hard.

The hazard of aridity due to ENSO phenomena

ENSO (El Nino-Southern Oscillation) is the anomalous weather which globally occurs in the world. The phenomena keeps going when the heating of water temperature on the surface of Pacific Ocean. If this happens, thus the condition of the weather all over the world is going to be irregular.

In Chili, for instance, there were dangerous flood and storm (hurricane) in 1997 rained heavily and the numbers can be 10 times from normal, on the other hand, in Indonesia the disaster of aridity will be continuous due to the rain water in normal condition falls in Indonesia, because anomaly will fall in Pacific ocean.

Due to the long drought creates farmers do not cultivate theirs farms. Besides, the worst thing is that there are forest fires everywhere. In Indonesia, for instance, forest fires happen in Irian Jaya, Sumatra and Kalimantan, and they befall the low peatland zones, thus, it is difficult to put it out. Like they say only the rain hard can extinguish the such fire. Based on my observation, it is closely related to ENSO and aridity which happens in West Kalimantan (Gusti Zulkifli Mulki, 1998). During the year 1957-1998 ENSO occurred 12 times in West Kalimantan.

The biggest ENSO took place in 1972/73, 1975/76, 1982/83, 1991/92, 1994/95 and 1997/98. And the worst thing is that the events frequently occur.

Since 1972 ENSO events took place 12 times. It means that the event befalls those zones more or less once in three years. Because of that, in Danau Sentarum zone happened tremendous forest fire and aridity in 1997.

Illegal logging in buffer zone

The existence of illegal loggings in buffer zones have triggered the ecosystem alteration in Danau Sentarum. People were with their ignorance cutting down the trees in buffer zone. It is proven that the timbers (logs) are sold to neighbor country (Malaysia).

The illicit timber industries bring the hazardous impact to Danau Sentarum, due to the zones own low elevations, in the meantime the felling of trees are done on the hills which encircle Danau Sentarum zone.

Nowadays after interviewing one of in habitants dwells in the area, happens a big alteration of water balance. Many of them state that when the wet season comes, the Danau Sentarum zone in rapidly to be overflowed whereas in drought the water rate is rapidly on the decline as well. It means that the natural balances which have protected Danau Sentarum zone during the centuries now commence to change. It is worried that when the speed of felling the trees keep going the water level in Danau Sentarum zone decreases totally.

The serious problems of Danau Sentarum fisheries

Nowadays DSNP management get challenges that bigger than situation before. However many activities tend to damage the fisheries resources, some fish species are caught at sub-optimal. The capture of large numbers of small fishes, including juvenils, also seem problematic as this may add to early mortality. At present, the amount of fish available for harvest in the DSNP is severely limited by past and current failures to protect natural habitat. Interview to fishers of 30 village indicated that 90-93 percent find that fish resourches have decreased over that past decade (Aglionby, 1997 In: Giesen & Aglionby, 2000). Local fisheries are already beginning to sense the species in avaibility are declining and that the situation is worsening rapidly. For example, fishers report that since 1997, it has become increasingly difficult to find young *toman* for rearing in cages. The Lais fish for smoking is becoming rare and it is increasing difficult to find large belida (*Chitala lopis*). Giesen (2000) also reported that, the estimated annual catch in DNSP for four fish types (Caged fish/ toman; smoked fish/lais; salted/dried fish and *Betutuk*) showed a decline in species availability between 1997 and 2000. The indication of decreasing of the DSNP resources related with complex problems at first economic point. Three serious problems are faced the DSNP fishery: a) involving an influx immigrations b) human population increased c) increased non-adherence to local customary law. With decreasing natural resources and an increasing human population the amount of resource available per person in DSNP becomes less every year and also the increased human population accelerate habitat destruction. However, govermentís ability to manage the DSNP fishery and enforce fishery regulation is very limited.

What are indication decreasing of fisheries Danau Sentarum? These question is difficult to answer because data abaut the fisheries are not collected on reguler basis. Ideally fisheries agencies at the national and provincial level should have a full time research presence in DNSP and at a minimum would ensure that accurate statistics from the fishery is collected regularly. Such data are necessary for the succesful long term management of DSNP fisheries. For example, fish production, no clear records of fluctuations in the catch of specific fish species exists. Consequently, no correlation with environmental factors can be examined.

By previous report and also interview to the fishermen and then could be prediction on the caused of resource problems: 1) Firstly, had been over fished in the park. As indicated by average size of specimens caught compared to maximum size attainable for each species. For example, Belantau is listed as having maximum length 100 cm, but the largest specimens recorded catch survey was 35 cm, and most individuals examined were less than 30 cm (Dudley, 2000). The reallity over fishing because the fishermen use many types of small gear, therefore result some fish are caught at sub-optimal size. It can be to damage the fisheries resources because the fishes had no time for recovery, and 2) Secondly, these are environmental factors including fire danger. Since the incidence and extend of fires in the swamp forest of DNSP has been increasing rapidly. Dennis et al. (2000) estimated that between 1973 and 1997, the burn area within the swamps increased from 5,483 hectares in 1973 and 18,905 hectares in 1997. However, increased logging activities, both legal and illegal are now damaging the forest in such a way as to make them more prone to fire. Fires lead to significant changes vegetation. On the whole, the trend is towards impoverishment-significant lower diversity, lower biomass and reduced conservation value. This would also affect fisheries, as DNSP fish and fisheries are dependent on forest biomass.

Utomo and Asyari (1999) reported that the freshwater forest is an important for fisheries. The freshwater forest provide as a media for feeding ground, nursery ground and spawning ground of fish. The cacth survey in DNSP showed that fish production in the freshwater swamp forest (Tekenang Hill) is higher than fishes production in freshwater forest trees (Seganal, Kenepai).

CONCLUSION

The existence of illicit timber industries and ENSO phenomenon creates the disturbance of natural balance in Danau Sentarum Zone. The Cope with this case and anticipate the impacts (effects), we recommend some suggestion as follows:

1. Recommended to do the research of migration system and the dynamics of fish population
2. To face the difficulty of clean water. Each house needs to be facilitated with big water containers (till 10 m^3) in order to keep the rain water in wet season and applied in drought. In this case, it is suggested to use ferrocement, due to the simple and cheep technology.
3. It is the over goal of fishery management to provide sustainable fish cathces within DNSP. For reasing the over goal are two components: 1) establish a better system for collecting and reporting statistics related to the fishery, and 2) carry out regular surveys and other scientific studies to support management decisions.

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The Impact of Traditional Benzoin Garden on Floristic Doversotu: Case Study at Pusuk District, North Tapanuli, North Sumatra, Indonesia

Eko B. Walujo and Y. Purwanto
Research Center for Biology-LIPI, Bogor

ABSTRACT
Study of the impact traditional benzoin garden of floristic diversity was conducted at Pusuk village, North Tapanuli in 1998 and 1999. The research was focused on the dynamic floristic composition in the different stages of the active benzoin garden (15 years old, 25-30 years, and 45-50 years) and in pasive garden (10 years after being abandoned, 15 years, 20 years and 22-25 years after being abandoned). Using the quadrate method, all species present in the sampling area block was inventoried, included the measurement of diameter of trees, height and number of individuals of species.

The result of this study, consist of 148 species of plants belonging to 101 genus and 45 families was recorded. In order to obtain detailed the evolution and dynamic of floristic structure and composition of each stage will be presented in this paper.

Key words: traditional benzoin garden, floristic diversity, Pusuk, North Tapanuli, North Sumatra, Indonesia.

INTRODUCTION

The research area was conducted at Pusuk village, of North Tapanuli regency, in the province of North Sumatra (Fig.1). At the village, traditional benzoin plantation is the major system of crop production as well as being the disturbance regime in the forest ecosystems. Although traditional benzoin plantation has caused deforestation and may contribute to the disappearance of countless plants and animal species.

Traditional benzoin plantation is also recognized as being a well adapted system of ì†*farming the forest*†" and can play an important role in the development of environmentally sound agroforestry practices and multiple use management of natural forests. Furthermore, traditional benzoin plantation may actually increase the habitat diversity and the number of species in some landscapes and these succession stages are required to preserve such species. Thus the traditional benzoin plantation may be similar to shifting cultivation or to natural patch dynamics in that it is an important component in maintaining the mosaic pattern of vegetation in tropical forests.

Traditional benzoin plantation is basically an agricultural system characterized by long periods of cropping and then removed and encourages the return of forest to those sites after the benzoin trees are not productive. The difference from shifting cultivation is characterized by short periods of cropping alternating with longer periods of fallow. Rappaport (1971) described the general strategy of shifting cultivation : it is to establish temporary associations of plants directly useful to man on sites from which forest is removed and to encourage the return of forest to those sites after the useful plants have been harvested.

The return of the forest makes it possible, or at least much easier, to establish again an association of cultivated plants sometime in the future. In the traditional benzoin plantation, fields are usually maintained in production for 50-60 years then abandoned to fallow.

Most Pusuk communities prefer using secondary forests rather than primary forests. The reason is that a secondary forest is easier to clear. Than the most communities maintain species diversity in their fields, especially useful plants like medicinal plants, timbers, fruit trees and vegetables.

RESEARCH LOCATION

The data were gathered during several periods of research, between the month of March and August, 1998 and July 1999. The most detailed data were gathered during an extended stay with Batak Toba speaking tribe of North Sumatra.

The population of Pusuk mainly live on grow dry rice (as well as some wet rice), maize, cassava, and a wide variety of non-rice crops in swiddens derived from both primary and secondary forests. In addition to cultivating annual food crops in swiddens, the inhabitant cultivates several types of perennial cash crops in the fallowed swidden land. These include a variety of trees yielding edible fruits, coffee (*Coffea* spp.), cinnamon (*Cinnamomum burmanni*), and especially benzoin (*Styrax* spp.).

Benzoin it has been a primary source of cash or tradable commodity used to obtain their subsistent needs as clothing, tobacco, kerosene, etc. It is also a major source of household income for most households in this area. Some of this benzoin is produced in gardens of a hectare or so, using traditional technology. The ordinary farmers produce benzoin with their families, their workers consists of the male family members.

Among Pusuk swidden cultivators of North Sumatra, customary law, or *hukum adat*, has long governed the patterns of forest management by determining peopleís rights of access to forest products, forest lands cleared for agriculture, and trees planted or growing wild outside the forest.

METHODOLOGY

Vegetation analysis was conducted in active benzoin plantations of 15 years old, 20 years, 25-30 years, 35-40 years and 45-50 years and in a non-active field of 10 years after being abandoned, 15 years, 20 years and 22-25 years old. Vegetation was sampled with the quadrate method (Muller-Dombois and Ellenberg, 1974).

The field was sampled with a block designed field condition (1.000 - 2.000 m≤), within which 20 x 20 m plots for recording trees (DBH > 2 cm) and subplots (1 x 1 m) for seedling (diameter of less than 2 cm) and herbs were systematically established.

Vegetation assessment in each plot included the measurement of diameters of trees (at breast height, 1.4 m), height and number of individuals of each species, and for seedlings or herbs species the estimation of coverage and height as well as the count of individuals. Voucher specimens were collected for identification at the Herbarium Bogoriense, Bogor, Indonesia. Scientific name of plant is based on Flora of Java, Flora Malesiana for Fagaceae, and Ashton (1982) for Dipterocarpaceae.

The data was calculated using basal area, relative frequency, relative density, relative domination, Important Value Index and Index of Diversity.

An index of diversity (H) is calculated using Shanonís formula : H = pi Log2 pi.

RESULTS AND DISCUSSION

The Ecological Aspects of Benzoin Plantation System

Traditionally, the opening of Benzoin gardens in the Pusuk village is carried out in forests after the timbers are exploited or in old secondary forest. The seedlings are planted among the remaining forest or under the big trees, in order to become the shade. The system results in irregular planting distance and sometimes the seedlings/saplings are inhibited in their growth, due to the density of the canopies of the forest trees. Therefore when the seedlings/saplings start to grow bigger, peeling the barks must reduce the surrounding trees, and when the trees are dead and dry, they are felled. In the next development all the other trees are disappeared. When the Benzoin trees have produced Benzoin or at least when the trees have been tapped, the gardens look monoculture. And then, because the gardens are close to the forest, saplings of other forest trees start to grow in between the Benzoin trees. The trees that are of useful kinds, for instance quality wood producing trees, will be maintained. The older the garden is, the more varieties of forest non-Benzoin trees will be seen. When the garden is over 50 years old, the garden is then dominated by forest trees species.

Species composition and vegetation dynamics

Results of transect sampling in several gardens of different ages show that the number of forest trees at the opening of the garden is high, it will decrease with the growth of Benzoin trees. At a certain stage the forest tree species will disappear, and then gradually the forest trees will grow and increase along with the age of the garden. After the garden is over 50 years old, it regains its forest look, being dominated by forest tree species.

Floristic inventory resulted in the identification of 148 species of 101 genus and 45 families. Due to the difficulties in identifying undergrowth plants and saplings, some species were not identified completely.

Results of floristic analysis in active or productive Benzoin gardens are as follows: In a 10-15 year old Benzoin garden, the dominating species are those of primary forests which were not felled during land clearing, because they served as shade for young Benzoin trees. They are among others *Eugenia sp, Eriglosum rubiginosum, Adinandra dumosa, Palaquium* sp., and *Calophyllum sp.* Meanwhile pioneer trees start to grow between the young benzoin trees. The opening of the canopies will result in the growth of pioneer species both herbal species like *Imperata cylindrica, Scleria laevis, Eupatorium inulifolium*, and tree species like *Melastoma polyanthum, Macaranga rubiginosa, Macaranga triloba, Ficus grassulariodes*.

In a 20 year old benzoin garden the plant species that grow between benzoin plants are *Adinandra dumosa, Arthrophyllum* sp., *Calophyllum* sp., *Eugenia* sp., *Palaquium* sp., *Wormia pulchella, Eridlosum rubiginosum* and *Litsea cubeba*. These species are either the result of regeneration or saplings left behind during land clearing, so the diameter of these species is between 5-15 Cm. These species are left growing in the Benzoin gardens because they are useful either for construction or for firewood. All the tree species of the primary forest have been felled, thus the Benzoin plantation looks monoculture. The pioneer species are rarely found. The reason is that before tapping the area around the benzoin trees are cleared. Care of the gardens are done once or twice a year, depending on the condition of the gardens. However several forest species that are beneficial or that have high economic value for instance commercial wood producing trees like *Dacrydium junghuhnii, Shorea multiflora, Palaquium hexandrum, P. obovatum, Quercus maingayi, Eugenia* sp., and *Callophyllum* sp., can be found in benzoin gardens and allowed to grow. However there are only one or two species of the trees in the benzoin gardens. Some fruit tree species are allowed to grow in the garden, for instance ***handis*** (*Garcinia parvifolia*), ***tere-tere*** (Flacourtiaceae), ***uncim, dalom*** (*Litsea noronhae*), and ***simar uban-uban*** (*Decaspermum fruticosum*) . Several kinds of plants the parts of which can be cooked are allowed to grow in the Benzoin garden, for instance ***rintua*** (*Mussaenda frondosa*), ***sitofu*** (?), ***pogi*** (*Ficus grassularioides*), ***dongdong*** (*Ficus septica*), ***tipang-tipang*** (*Medinella laurifolia*), ***singgaung*** (*Cyrtandra sandei*), and ***handis*** (*Garcinia parvifolia*). These useful plant species are mostly found in old Benzoin gardens.

In a 25-30 year old garden, the diversity of the plants are dominated by species like *Eurya acuminata, Macaranga triloba, Saurauia nudiflora, S. pendula, Evodia latifolia, Eugenia sp., Mischocarpus sp., Vernonia arborea, Cinnamomum burmani, Nyssa javanica* etc. At the age of 20-30 years the Benzoin gardens have their optimum production, therefore they are well cared and plants other than Benzoin which grow there, have small diameters sapling or belta level). There are a very low number of trees. (Table 1). In Benzoin gardens of an optimum production age, some pioneer plants like *Macaranga triloba, Melastoma polyanthum, Melastoma sp.*, and ferns like *Cyathea sp.* can be found. The opening of the canopies highly stimulates the growth of pioneer tree species.

Table 1. Floristic composition in an active Benzoin garden and in a Benzoin former garden in an area of Pusuk

Legend: Sd = seedling (diametre < 2 cm) and liane ; Spl = sapling/belta (diametre 2- < 10 cm) ; and Tr = tree (diametre > 10 cm).

No	Transect	Species Number			Genus Number			Family Number		
		Sd	Spl	Tr	Sd	Spl	Tr	Sd	Spl	Sd
1	Kemenyan garden 10-15 yrs	17	12	10	15	12	10	15	12	10
2	Kemenyan garden 20 yrs	23	16	3	20	16	3	13	13	3
3	Kemenyan garden 25 yrs	31	24	10	26	20	9	22	15	9
4	Kemenyan garden 30 yrs	22	15	4	20	16	4	17	14	4
5	Kemenyan garden 35-40 yrs	36	25	14	25	24	14	20	20	13
6	Kemenyan garden 45-50 yrs	37	17	21	34	16	18	24	13	15
7	Abandon Kemenyan garden 10 years	34	18	20	32	16	19	21	14	13
8	Abandon Kemenyan garden 14-15 years	36	54	12	33	47	12	28	36	11
9	Abandon Kemenyan garden 20-22 years	43	34	20	38	30	19	34	26	15
10	Abandon Kemenyan garden 25-27 years	47	33	20	44	29	19	34	22	17
11	Primary Forest	23	22	50	20	21	42	15	15	29

Forest tree species that can grow in a 35-40 year old benzoin garden are *Flacourtia rukam, Vernonia arborea, Eurya acuminata, Timonius wallichianus, Saurauia pendula, Ilex trifolia, Ilex cymosa, Lithocarpus hystrix, Gironniera subaequalis, Evodia latifolia, Erioglossum rubiginosum, Magnolia blumei, Symplocos odoratissima, Glochidion rubrum, Wendlandia glabrata, Engelhardia walichiana, Arthrophyllum sp., Palaquium hexandrum, Cratoxylum sumatranum, Alstonia spectabilis, Aquilaria microcarpa* and *Pittosporum ferugineum*. The plant species seedlings which grow in the garden are among others: *Macaranga triloba, Saurauia pendula, Alstonia spectabilis, Flacourtia rukam, Litsea cubeba, Vernonia arborea, Melastoma spp., Timonius wallichianus, Eurya acuminata, Ilex trifolia, Ilex cymosa, Evodia latifolia, Nephelium eriopetalum, Ficus sinuata, Ficus septica, Ficus ribes, Arthrophyllum sp., Prunus arborea, Ficus grassularioides, Symplocos odoratissima, Psychotria viridiflora, Schima noronhae, Schima wallichii,* dan *Artocarpus kemando*.

Benzoin gardens that have been abandoned or have reached the age between 45 and 50 years old, are dominated by forest plant species like *Eurya acuminata, Schima wallichii, Alstonia sepctabilis, Prunus arborea, Symplocos odoratissima, Quercus maingayii, Mischocarpus sp., Wendlandia glabrata* dan *Schefflera sp*. The number of Benzoin trees is decreasing, because some trees are getting old and dead, however when statistically analyzed, Benzoin plants still dominated the observed transect (Table 2).

Floristic analysis in a non-active or abandoned benzoin garden

In a Benzoin garden, which has been abandoned for about 10 years, the remaining Benzoin trees are decreasing. The Benzoin garden that has been abandoned for about 10 years has very few Benzoin trees left. Generally the remaining Benzoin trees are not those planted the first time the land was cleared. They are the saplings that grow by them after the garden is opened. Therefore the trees still exist even after the garden has been abandoned for about ten years. The dominating plant species are ***tulasom*** (*Altingia excelsa*), ***suhul-suhul*** (*Macaranga triloba*), ***suri-suri*** (*Gynotroches axillaris*), ***habitabing*** (*Alstonia spectabilis*), and ***monis-monis*** (*Ilex cymosa*). The seedlings that are dominant belong to the following species: ***simartolu*** (*Schima wallichii*), ***hauhodung*** (*Symplocos odoratissima*), ***hoting sangkar*** (*Lithocarpus sp.*), ***baja*** (*Rhodamnia cinerea*), ***suri-suri*** (*Gynotroches axillaris*), ***suhul-suhul*** (*Macaranga triloba*) and ***sida budaga*** (?).

In a Benzoin garden which has been abandoned for 15 years there are still a few Benzoin trees, but not as many as in the garden that has been abandoned for 10 years. The dominating plant species are primary forest species like *Altingia excelsa, Gynotroches axillaris, Alstonia spectabilis, Ilex cymosa, Schima wallichii* and *Symplocos odoratissima*. Here we see that the two last species, *Schima wallichii* and *Symplocos odoratissima* have become dominant among the trees, while in the garden that has been abandoned for 10 years they are dominant in the form of seedlings. The pioneer plants that are still dominant are: *Macaranga triloba*. This species can also be found in the swidden land, which is over 22 years old. The seedlings are dominated by the following species: *Schima wallichii, Artocarpus kemando, Symplocos odoratissima, Rhodamnia cinerea, Macaranga triloba, Psychotria viridifolia, Schefflera sp., Timonius wallichianus* and *Eugenia sp*.

The floristic diversity of a former Benzoin garden which has been abandoned for 20 years consist of 54 species from 49 genus dan 41 families. The dominating species at this stage are *Alstonia spectabilis, Arthrophyllum sp., Eugenia sp., Ilex cymosa, Macaranga triloba, Schima wallichii, Symplocos odoratissima, Timonius wallichianus, Wendlandia glabrata*. The saplings are dominated by *Macaranga triloba, Eugenia sp., Symplocos odoratissima, Timonius wallichianus, Rhodamnia cinerea, Nyssa javanica and Calamus sp*.

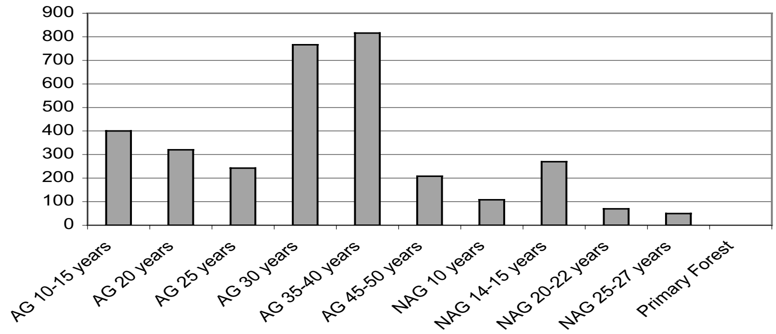

Figure 1a. Evolution of Kemenyan Trees Number

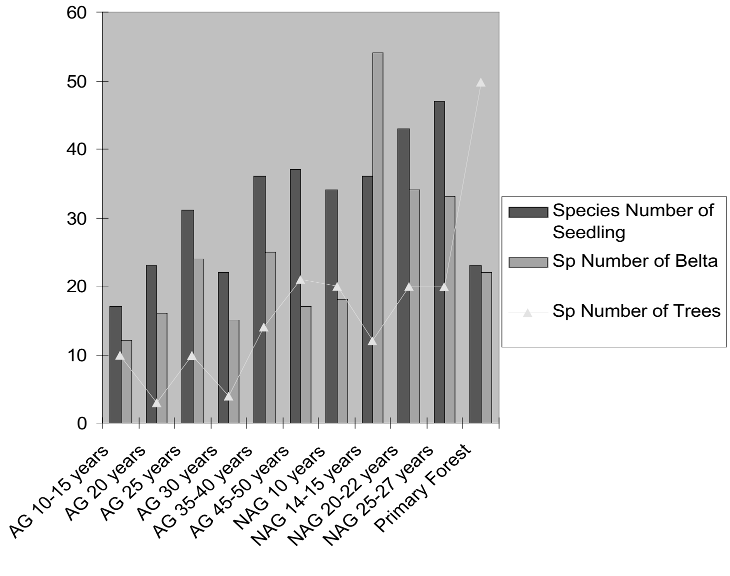

Figure 1b. Evolution of Species Number

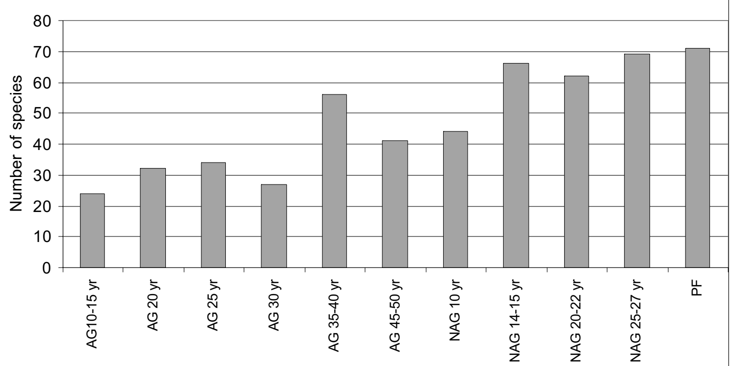

Figure 1c. Species richness in the active and abandon kemenyan garden

The former Benzoin garden that has been abandoned for 25-27 years has the floristic diversity as follows: 53 species consisting of 47 genus and 39 families. The species that dominate this former garden are primary forest plant species like *Altingia excelsa, Arthrophyllum sp*., *Ediandra sp., Eugenia sp., Magnolia blumei, Prunus arborea, Schima wallichii,* and *Timonius wallichianus.* While the species that dominate saplings are *Timonius wallichianus, Eugenia sp., Schima wallichii, Rhodamnia cinerea, Macaranga triloba, Lithocarpus sp.,* and *Psychotria viridifolia*.

Based on an inventory of the transect plots in an active Benzoin garden and in the abandon kemenyan garden in the Pusuk area, there are 148 flora species belonging to 101 genus and 45 families. In order to obtain the detailed number of species, genus and families in each age stages of a Benzoin garden and a former garden, please refer to the following table 1 and figure 1a, 1b and 1c.

From Table 1 and Figure 1c., we see the number of species at the seedling stage, sapling and tree stages increases along with the age of the active garden and the age of the abandon garden, and then it decreases after the former garden is over 25 years old. If we compare the number with the primary forest plant species, we will find that at the seedling stage the diversity of this abandon Benzoin garden is higher compared to primary forests, but the diversity of tree species is higher in a primary forest than an abandon kemenyan garden or an active garden.

Table 2 presents a list of ten main species based on the Important Value Index in each transect.

Forest Structure

The percentage of tree distribution based on their diameter class generally shows decrease with the increase of the diameter class (Table 3 and Figure 2-12). The percentage of trees with a diameter of < 30 cm tends to decrease along with the age of the abandon benzoin garden. The longer the garden is abandoned, trees with large diameters will dominate the

Table 2. Important Value Index in each observation plot.

No	Name of species	Family	Density (ha)	Basal Area (cm_/ha)	Important Value Index
I.	**Transect of Kemenyan garden 10-15 years**				
	1. Styrax benzoin	Styracaceae	400	2.209,813	50,220
	2. Eriglossum rubiginosum	Sapindaceae	12	19.014,287	13,978
	3. Calophyllum sp.	Araliaceae	12	8.839,287	8,123
	4. Palaquium sp.	Sapotaceae	12	8.259,825	6,072
	5. Adiandra dumosa	Theaceae	24	7.700,000	5,661
	6. Eugenia sp.	Myrtaceae	24	7.159,825	5,379
II.	**Transect of Kemenyan garden 20 years**				
	1. Styrax benzoin	Styracaceae	320	54.650,357	112,800
	2. Eridlosum rubiginosum	Sapindaceae	10	15.211,429	19,406
	3. Calophyllum sp.	Guttiferae	20	8.839,286	18,978
	4. Eugenia sp.	Myrtaceae	20	5.853,571	16,234
	5. Wormia pulchella	Dilleniaceae	20	2.655,714	13,296
	6. Arthrophyllum sp.	Araliaceae	20	1.147,142	11,909
	7. Palaquium sp.	Sapotaceae	10	6.607,857	11,500
	8. Adinandra dumosa	Theaceae	10	6.160,000	11,088
	9. Santiria tomentosa	Burseraceae	20	1.076,426	8,141
	10. Litsea cubeba	Lauraceae	10	1.887,678	7,162
III.	**Transect of Kemenyan garden 25 years**				
	1. Styrax benzoin	Styracaceae	243	69.713,725	114,259
	2. Nothaphoebe sp.	Lauraceae	25	5.038,837	16,018
	3. Litsea cubeba	Lauraceae	19	5.475,443	13.708
	4. Macaranga triloba	Euphorbiaceae	31	1.389.731	11,632
	5. Eurya acuminata	Theaceae	25	1.694,194	10,953
	6. Saurauia nudiflora	Actinidaceae	19	854,463	9,142
	7. Cinnamomum burmanni	Lauraceae	19	1.248,544	7,746
	8. Evodia latifolia	Rutaceae	19	422,319	6,929
	9. Nyssa javanica	Cornaceae	13	1.198,213	6,716
	10. Eugenia sp.	Myrtaceae	12	1.111,044	6,630
IV.	**Transect of Kemenyan garden 30 years**				
	1. Styrax benzoin	Styracaceae	766	312.490,299	168,802
	2. Evodia latifolia	Rutaceae	133	3.197,229	23,039
	3. Parkia speciosa	Fabaceae	75	4.173,933	14,836
	4. Macaranga triloba	Euphorbiaceae	42	4.498,037	12,195
	5. Vernonia arborea	Compositae	17	340,461	8,880
	6. Saurauia pendula	Actinidiaceae	17	268,439	8,858
	7. Eurya acuminata	Theaceae	25	392,884	5,879
	8. Mischocarpus sp.	Sapindaceae	17	654,732	5,398
	9. Saurauia nudiflora	Actinidiaceae	17	739,845	5,297
	10. Gendub	Gendub	17	1.735,047	5,599
V.	**Transect of Kemenyan garden 35-40 years**				

	1. Styrax benzoin	Styracaceae	816	370.907,458	171,530
	2. Eurya acuminata	Theaceae	67	3.486,050	12,770
	3. Evodia latifolia	Rutaceae	25	1.135,831	8,713
	4. Flacourtia rukam	Flacourtiaceae	33	1.551,535	7,924
	5. Symplocos odoratissima	Symplocaceae	17	729,942	6,331
	6. Vernonia arborea	Asteraceae	12	1.207,840	6,107
	7. Glochidion rubrum	Euphorbiaceae	21	1.594,091	5,309
	8. Parkia speciosa	Fabaceae	25	1.891,959	5,371
VI.	**Transect of Kemenyan Actif garden of 45-50 years old**				
	1. Styrax benzoin	Styracaceae	208	79.633,865	52,234
	2. Prunus arborea	Rosaceae	117	35.498,130	27,963
	3. Eurya acuminata	Theaceae	108	5.890,981	16,238
	4. Mischocarpus sp.	Sapindaceae	50	15.458,306	14,786
	5. Quercus maingayi	Fagaceae	58	10.308,812	13,595
	6. Leucaena sp.	Fabaceae	8	3.527,071	13,231
	7. Symplocos odoratissima	Symplocaceae	58	10.225,332	11,977
	8. Schefflera sp.	Araliaceae	42	7.277,383	11,039
	9. Wendlandia glabrata	Rubiaceae	50	7.670,226	10,323
	10. Schima wallichii	Theaceae	25	7.228,277	9,593
VII.	**Transect of Abandon Kemenyan garden 10 years**				
	1. Eurya acuminata	Theaceae	120	354.981,30	27,963
	2. Styrax benzoin	Styracaceae	108	58.909,80	16,238
	3. Archidendron clypcaria	Fabaceae	58	35.270,71	13,231
	4. Wendlandia glabrata	Rubiaceae	58	102.253,33	11,976
	5. Schima wallichii	Theaceae	50	93.088,12	11,593
	6. Symplocos odoratissima	Symplocaceae	50	72.773,82	11,038
	7. Prunus arborea	Rosaceae	25	72.282,76	9,593
	8. Eugenia sp.	Myrtaceae	25	4.187,86	8,916
	9. Alstonia spectabilis	Apocynaceae	41	3.977,67	7,978
	10. Quercus sp.	Fagaceae	25	7.464,28	7,712
VIII	**Transect of Abandon Kemenyan garden 14-15 yrs**				
	1. Styrax benzoin	Styracaceae	270	73.197,14	41,636
	2. Ilex cymosa	Aquifoliaceae	330	15.242,857	19,129
	3. Alstonia spectabilis	Apocynaceae	250	17.609,82	17,585
	4. Macaranga triloba	Euphorbiaceae	350	3.109.460	15,097
	5. Arthrophyllum sp.	Araliaceae	150	15.525,714	14,667
	6. Eurya acuminata	Thecaeae	240	8.619,285	14,583
	7. Lithocarpus elegans	Fagaceae	30	23.304,285	11,408
	8. Decaspermum fruticosum	Myrtaceae	180	2.443,571	9,025
	9. Endiandra sp.	Lauraceae	60	12.728,571	8,276
	10. Schima wallichii	Theaceae	120	6.152,143	8,056
IX	**Transect of Abandon Kemenyan garden 20-22 yrs**				
	1. Schima wallichii	Theaceae	120	50.340,714	23,701
	2. Eugenia sp.	Myrtaceae	270	18.458,393	22,833
	3. Wendlandia glabrata	Rubiaceae	230	22.744,642	19,085
	4. Arthrophyllum sp.	Araliaceae	70	32.088,571	16,368
	5. Alstonia spectabilis	Apocynaceae	140	22.935.000	15,666
	6. Ilex cymosa	Aquifoliaceae	140	17.034,285	15,308
	7. Styrax benzoin	Styracaceae	70	32.552,142	15,116
	8. Macaranga triloba	Euphorbiaceae	180	6.717,857	13,105
	9. Timonius wallichiana	Rubiaceae	180	3.492,500	12,845
	10. Symplocos odoratissima	Symplocaceae	70	12.139,285	9,073
X	**Transect of Abandon Kemenyan garden 25-27 yrs**				
	1. Prunus arborea	Rosaceae	160	37.297,857	24,367
	2. Timonius wallichianus	Rubiaceae	290	5.162,145	18,959
	3. Schima wallichii	Theaceae	110	27.830,000	18,519
	4. Arthrophyllum sp.	Araliaceae	90	23.799,285	14,294
	5. Eugenia sp.	Myrtaceae	190	2.757,857	14,131
	6. Magnolia blumei	Magnoliaceae	160	8.540,714	13,448
	7. Styrax benzoin	Styracaceae	50	23.084,285	13,138
	8. Endiandra sp.	Lauraceae	20	26.478,571	10,969
	9. Altingia excelsa	Hammamelidac.	80	15.022,857	10,287
	10. Symplocos odoratissima	Symplocaceae	70	11.212,143	10,010
XI	**Transect of Primary Forest**				
	1. Schima wallichii	Theaceae	110	429.620,714	33,754
	2. Eugenia sp.	Myrtaceae	270	140.627,143	31,152
	3. Wormia pulchella	Dilleniaceae	140	268.447,143	26,372
	4. Ilex cymosa	Aquifoliaceae	140	34.689,285	17,277
	5. Cratoxylum sumatranum	Clusiaceae	30	181.046,250	13,075
	6. Garcinia parviflora	Clusiaceae	80	36.598,571	11,251
	7. Lithocarpus elegans	Fagaceae	80	61.914,285	11,101
	8. Carallia lucida	Rhizoporaceae	100	38.932,143	10,997
	9. Adiandra dumosa	Theaceae	60	90.121,429	10,748
	10. Antidesma tetrndum	Euphorbiaceae	50	55.141,429	8,416

stands. In an active benzoin garden, the case is the other way around.

The distribution of tree species based on crown height looks different in each sample plot. Figure 13 shows the change of crown height, where in a young garden tree crown is dominated by primary forest species stands, then it is dominated by benzoin plant stands, and with the increase of the age of the garden, the canopies of primary forest tree species will dominate the sampled plots.

The crown in an active garden plot generally forms a simple layer and with the age of the garden it gets more

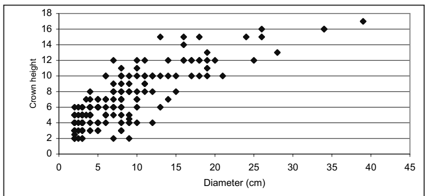

Figure 2. Relation between crown height and diameter of trees in the transect of active kemenyan garden 10-15 years

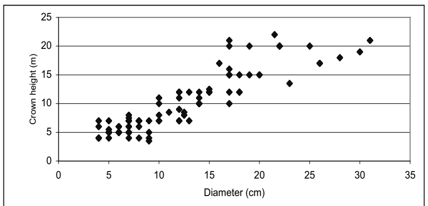

Figure 3. Relation between crown height and diameter of trees in the transect of active kemenyan garden 20 years

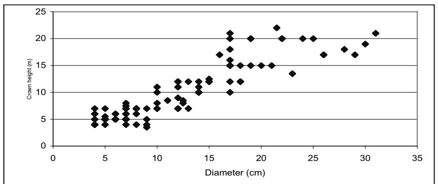

Figure 4. Relation between crown height and diametre of trees in the active kemenyan garden 25 years

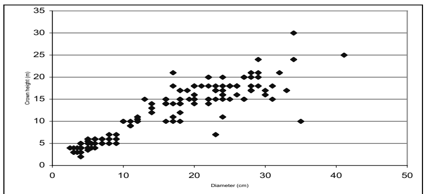
Figure 5. Relation between Crown height and diametre of trees in the transect of the active kemenyan garden 30 years

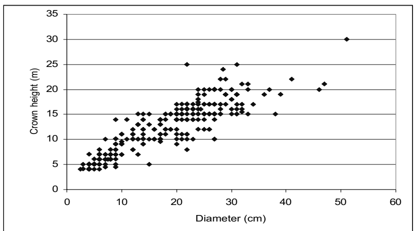

Figure 6. Relation between diameter of trees and crown height in the transect of active kemenyan garden 35-40 years

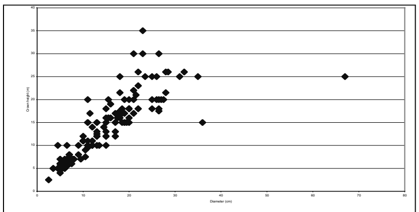
Figure 7. Relation between crown height and diameter of trees in the active kemenyan garden 45-50 years

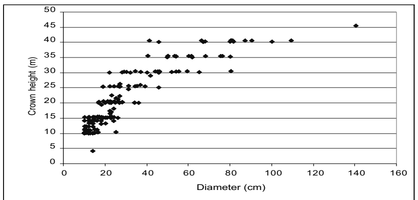

Figure 8. Relation between crown height and diameter in the transect of primary forest

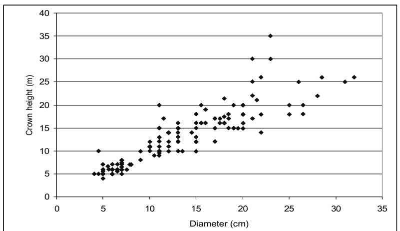

Figure 9. Relation between crown height and diametre of trees in the transect of abandon kemenyan garden 10 years

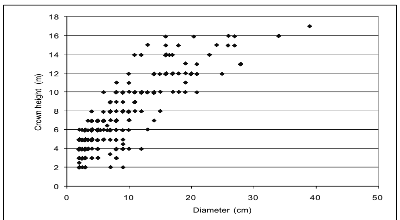

Figure 10. Relation between crown height and dbh of trees in the transect of abandon kemenyan garden (14-15 years)

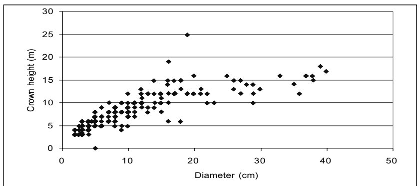

Figure 11. Relation between diameter of trees and crown h trees in the transect of abandon kemenyan garde years

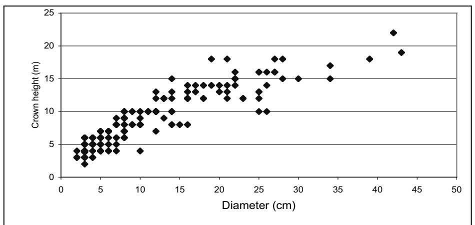

Figure 12. Relation between crown height and dbh of trees in the transect of abandon kemenyan garden 25-27 years

Table 3. The percentage of trees in each dbh class in a Benzoin garden, abandon kemenyan garden and a primary forest

Transect	**Diamatre class (cm)**									**Bigest diametre trees**
	2 -10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	>80	
KG10-15	28,2	54,3	13,04	4,6	4,6	-	-	-	-	44
KG 20 yrs	38,6	48,3	9,2	6,6	2,6	-	-	-	-	42
KG 25 yrs	29,2	26,9	32,9	10,1	1,42	-	-	-	-	42
KG 30 yrs	35,9	48,4	15,6	1,5	-	-	-	-	-	32
KG 35-40	22,1	25,9	36,1	13,3	1,9	0,63	-	-	-	53
KG 45-50	21,1	47,7	25,5	4,44	-	-	1,11	-	-	68
AKG 10 yr	44,7	36,8	15,79	2,6	-	-	2,6	-	-	67
AKG14-15	59,8	27,3	11,11	1,7	-	-	-	-	-	39
AKG20-22	61,8	25,4	5,45	7,27	-	-	-	-	-	38
AKG25-27	37,4	39,4	15,2	7,1	1,01	-	-	-	-	41

Note : KG = Kemenyan garden ; AKG = Abandon Kemenyan Garden

Table 4. Percentage of trees in each crown height class in the observed plot

Transect	Trees Height Class (m)									The highest of Crown height
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	>45	
KG 10-15	21,7	21,7	36,9	17,39	-	2,71	-	-	-	-	30
KG 20 yr	16,8	26,6	40,4	13,9	1,2	1,2	-	-	-	-	29
KG 25 yr	21,34	16,85	25,84	28,09	6,74	1,12	-	-	-	-	30
KG 30 yr	16,92	35,38	24,61	18,46	4,61	-	-	-	-	-	24
KG 35-40	8,22	24,05	34,17	27,21	5,69	0,63	-	-	-	-	30
KG 45-50	5,5	20,0	22,2	30,0	13,3	7,7	1,1	-	-	-	35
AKG 10 yr	10,5	10,2	32,0	30,0	7,6	13,2	-	1,1	-	-	34
AKG14-15	28,21	41,88	24,78	5,13	-	-	-	-	-	-	17
AKG20-22	19,1	40,1	28,3	10,11	1,1	1,1	-	-	-	-	26
AKG25-27	19,2	41,1	30,3	8,08	1,01	-	-	-	-	-	25

Note : KG = *Kemenyan garden* ; AKG = *Abandon Kemenyan Garden*

Table 5. Pioneer species diversity and primary forest tree species in the fallow

Transect	**% tree species**	**% herbal species**	**% pioner species**	**% forest species**
Fallow 1-2 years	27,125	72,875	76,777	23,222
Fallow 5-6 years	34,333	65,666	54,555	45,444
Fallow 8-9 years	56,064	43,935	58,111	40,888
Fallow 12 years	55,142	44,857	68,750	31,250
Fallow 15 years	54,555	45,444	52,333	47,666
Fallow 20 years	79,000	21,000	56,142	43,857

Table 6. Species diversity in a former dry ricefield with different length of fallows

Observation	Age of fallow					
	1-2 yrs	5-6 yrs	8-9 yrs	12 yrs	15 yrs	20 yrs
Number of species	32	34	23	43	28	35
Number of genus	30	30	20	39	17	28
Number of family	22	22	15	30	13	20
Number of individus	52	299	175	310	187	163
Basal Area (m_/ha)	-	2,483	5,8531	5,534	6,833	18,611
H (Diversity Index)	-	0,1249	0,0245	0,0172	0,0431	0,0214
Richness Index d = S√N	-				1,099	2,193
Domination Index (c=Σ(ni/N)_	-				0,1421	0,0713

complex by forming two layers; this also occurs in the abandon benzoin garden. In the abandon kemenyan garden plot of 20 years old the crown tends to make three layers, the first layer is > 20 m, the second layer between 12-20 m and the third layer.

A clearer picture of the changes of tree size in the observed plots is shown through the correlation between crown height and the dbh (Figure 2-12). The figure shows the changes in crown height and diameter of the trunk along with the age of the Benzoin garden and the length of abandonment of the garden. Here the influence of human intervention is significant on the diversity and the dynamics of the vegetation in the garden and in the abandon garden.

Observation on the density of trees shows that human intervention lowers the density of the trees. This is seen in Figure 14. The number of individual non-benzoin plants in an active benzoin garden is smaller compared to the number of individual non-benzoin plants in the abandon benzoin garden.

FLORISTIC DYNAMICS IN SWIDDEN LANDS

Generally Pajugaratan village communities in Pusuk fulfill their subsistence needs by developing farming system of food crops using shifting cultivation system and irrigated ricefield. The plants that are grown in their fields are dry rice, several kinds of grains, vegetables, and fruit.

Their consideration on selecting their dry ricefield locations are based on several factors like suitability and potentials, in this case they mean the fertility, the site, the size of the land and the property rights.

In the research report the writer is not going to discuss the shifting cultivation method, the focus of the discussion is the floristic dynamics after the ricefield is abandoned.

The traditional agricultural system is the result of an evolutionary process, where migration, plant transformation, agricultural techniques, and selection play an important role in its development. The traditional agricultural system with the use of the fallowing system to regain soil fertility and environmental stability which have endured constant pressures from human activities. The fallow system in a farming business is a system that has been undertaken by the Indonesian communities, by abandoning their former farming land for several years. During the fallow, a potential, physical, and biological reconstruction occurs on the ecosystem, and the fallow is determined by the farmers themselves. They have a parameter to decide when the garden can be reopened. A fallow period is varied, generally between 10-30 years or more, depending on the weather condition, the kind of soil, and the farming system technigue.

The population of vegetation existing on the fallowed land is a structured system. Studying the evolution and the dynamics of the vegetation of a fallowed land is an important step to know the biological reconstruction process, particularly the vegetation on a former ricefield land. We can detect the species which indicate each reconstruction stage related to soil fertility.

In this case I assume that a fallow is a stretch between an ecological system and a farming system, and is an interesting topic to study the diversity of species and plant community stability in the evolution process and its dynamics.

Species Diversity and Floristic Composition

Generally a secondary forest which used to be a ricefield is situated in the vicinity of settlements. This secondary foresst is the result of a primary forest for a farming system. The plant diversity for each transect is shown in the following table:

A fallow of shifting cultivation at the age of 1-2 is dominated by herbal plants like *alang-alang* (*Imperata cylindrica*), *arsam* (*Histiopteris reniformis*), *bunga japang* (*Clibadium surinamensis*), and several shrubs like *sanduluk* (*Melastoma aspermum*), *bunga-bunga* (*Eupatorium inulifolium*) and several pioneer tree saplings like *Macaranga triloba, Macaranga rubiginosa, Ficus grossularioides, Ficus padana,* and *Schefflera* sp. In the fallow at the age of 5 there grow saplings of forest tree species like *Cratoxylum sumatranum, Schima wallichii, Eugenia sp., Symplocos odoratissima* etc. The table also presents an indication that with the increasing age of the fallow, the number of tree species also increases. On the contrary the number of herbal species decreases with the age of fallowing. This is caused by the growth of primary forest tree species which have canopies that shade the land, and therefore the herbal species are decreasing and unable to grow in the shade. Figure 15. shows the relationship between the number of tree species and the number of herbal species in gardens of different ages. Figure 16 shows the relationship between the number of pioneer species with the number of primary forest species.

The density of trees in the fallow at a young age is very high, due to the inclusion of all saplings in the transect. The total number of tree species saplings in a 10 year old fallow decreases. Then the density of tree species with a diameter of 2 cm or more will be higher and higher until the fallow is 15th years old. The number of pioneer tree species decreases and are very few in the fallow at the age of 20. Actually the pioneer species have been replaced by primary forest plant species.

The dominant species in each transect are presented in the following table 7:

The table only presents the dominant species existing in the observed transect plots. A former ricefield at the age of less than five is dominated by herbal species consisting of *Imperata cylindrica, Eupatorium inulifolium, Clibadium surinamensis,* and *Histiopteris reniformis* and a kind of pioneer tree species *Melastoma aspermum*. In the fallow at the age of less than 2 years I found several saplings of pioneer tree species like *Ficus grossularioides, Macaranga rubiginosa, Macaranga triloba, Melastoma polyantum, Medinella laurifolia* and several saplings of primary forest tree species like *Schima wallichii* and *Artocarpus kemando* , starting to grow among the saplings of pioneer tree species. Several ubiquist species like *Ficus padana* dan *Schefflera sp*.

In a 5-6 year old fallow, the herbal layer decreases and the fallow is dominated by pioneer tree species like *Melastoma polyantum, Melastoma aspermum, Macaranga rubiginosa* and *Macaranga triloba*. Saplings of primary forest

Table 7. Species richness of the secondary forest with different ages

Name of species	Family	Density (ha)	Basal Area (cm_/1000 m_)	Important Value Index
I. Transect 2 years				
1. *Imperata cylindrica*	Cyperaceae	-	-	49,210
2. *Eupatorium inulifolium*	Asteraceae	-	-	31,716
3. *Clibadium surinamensis*	Asteraceae	-	-	29,644
4. *Melastoma aspermum*	Melastomataceae	-	-	25,964
5. *Histiopteris reniformis*	Petridaceae	-	-	14,845
II. Transect 5-6 years				
1. *Melastoma polyantum*	Melastomataceae	150	83,993	47,077
2. *Cratoxylum sumatranum*	Clusiaceae	50	33,715	21,517
3. *Ficus padana*	Moraceae	70	26,251	21,091
4. *Macaranga rubiginosa*	Euphorbiaceae	40	73,071	23,272
5. *Casuarina sumatrana*	Casuarinaceae	30	54,214	16,898
6. *Wendlandia glabrata*	Rubiaceae	30	17,097	16,860
7. *Schima wallichii*	Theaceae	10	78,571	16,575
8. *Melastoma aspermum*	Melastomataceae	50	22,361	15,941
9. *Macaranga triloba*	Euphorbiaceae	50	17,034	15,031
10. *Deplanchea bancana*	Bignoniaceae	20	57,836	16,184
III. Transect 8-9 years				
1. *Melastoma polyantum*	Melastomataceae	1910	1341,081	125,994
2. *Schima wallichii*	Theaceae	130	122,178	17,376
3. *Symplocos odoratissima*	Symplocaceae	90	130,821	13,684
4. *Eurya acuminata*	Theaceae	120	149,286	14,079
5. *Litsea sp.*	Lauraceae	50	63,839	11,000
6. *Ficus grossularioides*	Moraceae	60	28,482	7,207
7. *Glochidion rubrum*	Euphorbiaceae	40	27,696	7,858
8. *Vernonia arborea*	Asteraceae	30	85,839	7,163
9. *Wendlandia glaabrata*	Rubiaceae	50	34,767	7,126
IV. Transect 12 years				
1. *Eurya acuminata*	Theaceae	490	665,303	34,493
2. *Symplocos odoratissima*	Symplocaceae	140	329,410	15,801
3. *Melastoma polyantum*	Melastomataceae	230	184,839	14,092
4. *Wendlandia glabrata*	Rubiaceae	150	245,928	14,615
5. *Macaranga rubiginosa*	Euphorbiaceae	200	185,625	13,805
6. *Arthrophyllum sp.*	Araliaceae	80	493,428	13,495
7. *Cratoxylum sumatranum*	Clusiaceae	130	278,339	13,889
8. *Ficus grassularioides*	Moraceae	180	95,071	12,191
9. *Litsea mappacea*	Lauraceae	80	254,571	11,181
10. *Pittosporum ferrugineum*	Pittosporaceae	100	221,571	11,895
IV. Transect 15 years				
1. *Eurya acuminata*	Theaceae	360	2893,874	45,484
2. *Wendlandia glabrata*	Rubiaceae	260	1928,783	28,751
3. *Ficus grossularioides*	Moraceae	240	1187,801	25,177
4. *Symplocos odoratissima*	Symplocaceae	180	808,075	19,812
5. *Deplanchea bancana*	Bignoniaceae	120	776,084	17,386
6. *Cratoxylum sumatranum*	Clusiaceae	80	813,201	16,503
7. *Arthrophyllum sp.*	Araliaceae	80	640,554	15,145
8. *Melastoma polyantum*	Melastomataceae	70	407,586	12,571
9. *Viburnum sambucinum*	Caprifoliaceae	80	776,886	11,768
10. *Carallia lucida*	Rhizophoraceae	60	224,511	11,524
V. Transect 20 years				
1. *Eurya acuminata*	Theaceae	340	3208,480	63,696
2. *Ficus grossularioides*	Moraceae	260	2893,780	51,177
3. *Cratoxylum sumatranum*	Clusiaceae	180	1187,334	19,812
4. *Arthrophyllum sp.*	Araliaceae	160	1090,543	26,302
5. *Wendlandia paniculata*	Rubiaceae	90	888,321	16,964
6. *Schima wallichii*	Theaceae	90	776,080	15,145
7. *Symplocos odoratissima*	Symplocaceae	110	1331,782	19,385
8. *Pittosporum ferrugenium*	Pittosporaceae	80	640,554	15,965
9. *Viburnum sambicunum*	Caprifoliaceae	70	213,512	12,526
10. *Deplanchea bancana*	Bignoniaceae	70	206,511	10,354

tree species have started to grow among the pioneer tree species and start to show their domination. The primary forest tree species are *Cratoxylum sumatranum, Schima wallichii*, and *Deplanchea bancana*. The forest tree species that have grown are among others *Eurya acuminata, Litsea ferruginea, Wendlandia glabrata, Rhodamnia cinerea, Pittosporum ferrugeneum* and *Saurauia leprosa*. Ubiquist plant species that have started to grow are *Casuarina sumatrana, Ficus padana,* and *Ficus grossularioides*. The tree species of both the pioneer and the primary forest in the fallow of 5-6 year old have reached a diameter of 2 cm. This growth is faster than in the fallow of sweet potato garden in the Baliem Valley which is 5-6 years old. There neither the pioneer nor the primary forest tree species have not reached the diameter of 2 cm. This slower growth is caused by the uprooting land clearing by the Baliem community during the opening of the garden (PURWANTO, 1997). The Pusuk community left the stumps of the trees when they cleared their land, so a few species are able to sprout again quite easily.

In fallow of 8-9 years old, the herbal species have decreased significantly. Several species are still able to grow under trees among others *Imperata cylindrica, Scleria laevis* and *Breynia racemosa.* Herbal species like *Eupatorium inulifolium, Clibadium surinamensis,* and *Histiopteris reniformis* are very rarely found, except in niches of on an open area. In the fallow there is only one pioneer tree species namely *Melastoma polyantum* which is still dominant. The other dominant plants are primary forest tree species like *Schima wallichii, Symplocos odoratissima, Eurya acuminata, Litsea sp., Glochidion rubrum,* and *Wendlandia glabra* (Table 7.).

In a 12 year old fallow, only one species of pioneer plant is dominant, namely *Macaranga rubiginosa*. Similarly in a 15 year old fallow, there is only one pioneer tree species, *Melastoma polyantum* which is dominant. The rest is dominated by primary forest tree species (Table 7.). In a 20 year old or older fallow the dominating species are all primary forest tree species.

Vegetation Dynamics
In order to reconstruct the vegetation dynamics, first I group faloow based on age, then floristic analysis is carried out for each fallow at different ages. Observation includes frequency, density, dominance, importance value, and diversity index. With this analysis I have 5 successive stadiums in a vegetation reconstruction in the fallow in the Pusuk area. Each reconstruction stadium is characterized by the specific species that are dominant.

1. First stadium (herbal stadium):
The herbal stadium exists in the fallow of 0-3 years. The fallow is characterized by the domination of herbal strata like the following species: *Imperata cylindrica, Eupatorium inulifolium, Clibadium surinamensis, Histiopteris reniformis,* and *Leersia hexandra*. The saplings of pioneer species which start to appear in the herbal stadium are *Melastoma polyantum, Melastoma aspermum, Macaranga rubiginosa,* and *Macaranga triloba*.

2. Second stadium (herbal-pioneer tree stadium):
This stadium is seen in the fallow of 5-8 years old. In this stadium the composing plants are pioneer tree species with a diameter of 1 cm until 5 cm, with tree height varies between 2-6 meters. The pioneer tree species that are dominant are : *Melastoma polyantum, Melastoma aspermum, Macaranga rubiginosa, Macaranga triloba*. The dominant herbal species of the previous stadium still exist, but the number has decreases. The herbal species that are still growing are *Imperata cylindrica* and *Scleria laevis*. In this stadium primary forest tree species have grown, for instance *Cratoxylum sumatranum, Schima wallichii, Wendlandia glabrata, Eurya acuminata, Deplanchea bancana, Litsea ferruginea,* and *Artocarpus kemando*. The decrease of herbal species is caused by the canopy cover of pioneer tree species and primary forest tree species.

This stadium is where pioneer tree species dominate, and primary forest tree species start to grow, and herbal species start to decrease. The other species that appear in this stadium are ubiquist species, like *Ficus grossularioides, Ficus padana, Casuarina sumatrana* and *Schefflera* sp.

3. The third stadium (pioneer tree-primary forest tree stadium):
In this stadium a 12-15 year old fallow is dominated by pioneer tree species and primary forest tree species. Only two of the pioneer tree species are dominant, namely *Melastoma polyantum* and *Macaranga rubiginosa*. The pioneer tree species which were dominant in the previous stadium has decreased and domination has been taken over by primary forest tree species like *Eurya acuminata, Symplocos odoratissima, Litsea mappacea, Arthrophyllum* sp., *Cratoxylum sumatranum, Wendlandia glabrata* and *Pittosporum ferrugineum*. In this stadium the primary forest tree species are more compared to the previous stadium.

4. The Fourth Stadium (The primary forest tree species cover stadium):
This stadium exists in a 18-20 year old fallow, which is characterized by the dominance of forest tree species. The pioneer tree species have become very rare and the pioneer species in the first stadium do not exist anymore. Primary forest tree species which dominate this stadium are *Eurya acuminata, Cratoxylum sumatranum, Arthrophyllum* sp., *Ficus grossularioides, Deplanchea bancana, Schima wallichii, Wendlandia glabrata, Pittosporum ferrugineum, Saurauia leprosa* and others. Pioneer tree species that still exist in this stadium are *Macaranga rubiginosa* and *Melastoma polyantum*.

5. Fifth Stadium (Primary Forest Stadium):
This is a stadium which is 100 % dominated by primary forest tree species. Generally this stadium is found in the fallow which is over 2O years old. In the Pusuk region, a fallow this old is rarely found. Generally the Pusuk community only fallow their land for about 10 years , there are even cases where they only fallow their abandon garden less than 10 years. The dominating species are *Eurya acuminata, Eugenia* sp., *Schima wallichii, Cratoxylum sumatranum, Ilex cymosa, Symplocos ododratissima, Saurauia pendula*, etc.

In order to understand the successive reconstruction dynamics of the vegetation in the fallow, refer to Figure 18 below :

DISCUSSION
There is a gradual increase in the proportion of species diversity and a corresponding increase in the vertical development of fallow vegetation with time (Figure 19). This figure shows that an active field has lower species diversity compared to a primary forest, an old secondary forest and a young secondary forest. The reason for this is the influence of human activities, like garden management (cutting the herbs and useless trees species).

According to my observation during the first years of fallow, the growing plants are the species of adventis,

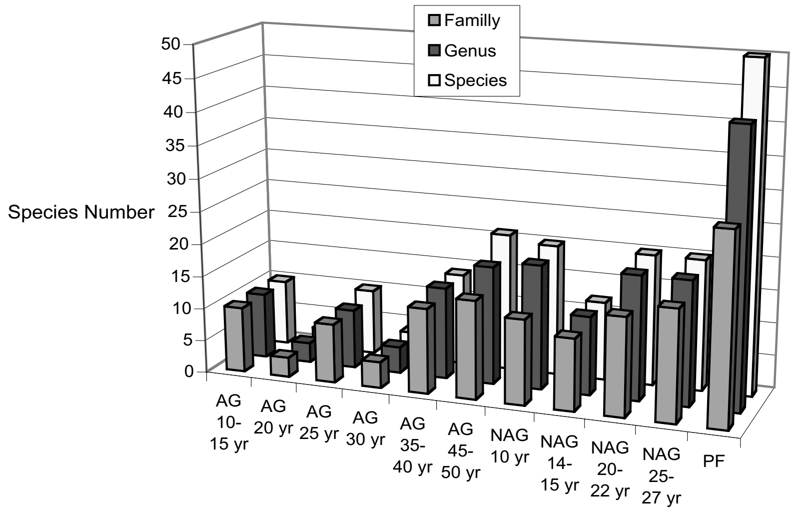

Figure 19. Species richness in the observation transects

ruderal, and heliophile, which principally becomes the early stadium of evolutionary process. The growth of these species continue until the fallow is 3 years old, it then decreases and the species are eliminated by wood tree species of the pioneer trees in the second stadium. In the next development, primary forest plant species appear in the third stadium. This second and third stadium began in a young fallow about 4-6 year old until the age of 12-15. This stadium is characterized by the existence of a mixed community of heliophile and sciaphile. In the second stadium, the species that grow belong to heliophile, which only grow in open places. In the next stadium sciaphile species will develop and grow well in a favorable condition. The succession process of the development stadium of plant species in the fallow and in an abandon benzoin garden is a direct competition phenomenon of various plant species and the limiting factors are sunlight and space. In a plant species evolution process in the fallow, it is observed that in the early stadium the land is the fallow is rich with pioneer species, which is characterized by fast growth, short life, abundance, and very fast and easy dissemination by wind, birds and small mammals.

The species that grow in the fallow have different characteristics with the original species. It clearly shows that the soil in the forests contains pioneer species seeds, which are stagnant or dormant, and if condition permits, the seeds of the pioneer species will grow quite fast. For example, in the gap created by a fallen tree (chablis), the pioneer species will grow real fast. The dissemination of the seeds of the pioneer species can also be done through a disseminator agent after a forest clearing. Therefore I noted that the soil in a fallow in the Pusuk area contained the seeds of pioneer plant species, which start the vegetation evolution process. The species composition of the early success ional community is heterogeneous as indicated by pioneer secondary plants and primary forest plants in the benzoin cultivation and by pioneer herbs and secondary species. This occurs because several plant species which grow in the Benzoin garden have been allowed to continue growing, particularly those which are useful and economically valuable like *Dacrydium junghuhnii, Shorea multiflora, Palaquium hexandrum, Eugenia* sp., *Podocarpus* sp. ,*Schima noronhae, Callophyllum* sp., etc. Prevalent species in the early success ional community of shifting cultivation included *Imperata cylindrica, Scleria sp., Eupatorium inulifolium, Macaranga rubiginosa, Melastoma polyantum*.

The floristic composition of secondary forest after benzoin cultivation is more heterogeneous than that of secondary forest after shifting cultivation. This is indicated by a very high species diversity of the secondary forest after benzoin cultivation. The prevalent species are *Wendlandia glabrata, Macaranga triloba, Schima wallichii, Eugenia* sp., *Timonius wallichianus, Symplocos odoratissima, Alstonia spectabilis,* and *Arthrophyllum* sp., etc.

The floristic composition of the 22 years old secondary forest after benzoin cultivation has large trees, such as : *Ilex cymosa, Wendlandia glabrata, Glochidion rubrum, Simar sihala (?), Litsea mappacea, Schima wallichii* and *Symplocos odoratissima* with the tree diameter ranging from 20 cm to 40 cm. Benzoin cultivators for the purpose of facilitating tree regeneration have retained these large trees.

The seedlings and herbs in the old secondary forest of benzoin cultivation are less heterogeneous than the old secondary forest of shifting cultivation. This is due to the intensive management in the benzoin cultivation, particularly the activities of clearing herbs, seedlings and shrubs before harvesting (manigi). The composition of tree species in the old secondary forest is quite heterogeneous and dominated by forest species, for example: *Wendlandia glabrata, Eugenia* sp., *Schima wallichii* and *Timonius wallichianus*.

In hilltop forest, which belongs to the primary forest category, although the communities have occasionally exploited them for their timber, the composition is also heterogeneous. In this forest the prevalent species include *Palaquium* sp., *Litsea* sp., *Eugenia* sp., *Garcinia parvifolia, Dacrydium junghuhnii*, etc. They have an average tree density of 930 /ha and a basal area of 57,5 m≤/ha. The tree diameter ranges from 10 to 80 cm and the height ranges from 5 to 45 m.

The development of vegetation in the secondary forest is related to the distribution of trees. Tree distribution based on diameter and height is bunched in a young secondary forest and much more widely distributed in an old secondary forest and a primary forest. The forests there have been somewhat disturbed, which have created gaps. The gaps are caused by tree felling for timber and collecting other forest products to supply local needs.

If we compare the plant diversity between a fallow and a former Benzoin garden, it is evident that there is less diversity in the fallow of shifting cultivation than in the abandon benzoin garden. This happens because just before the Benzoin garden is abandoned, several tree species, lianas and herbs have grown in the garden. It is important to remember that in the Benzoin garden several kinds of plant species which are useful for the households, like fruit trees, vegetables, and timber tree species are allowed to grow and sometimes even well cared.

Then if we compare the growth speed or vegetation dynamics based on average diameters and average crown height, the abandon benzoin garden has a faster dynamics. This is due to the faster dynamics of the benzoin garden, for land clearing for shifting cultivation all the trees are felled and then followed by burning, so several species that can not resist fire will die. In a benzoin garden, planting of benzoin is done in an old secondary forest or in a primary forest and felling is done gradually along with the growth of benzoin trees. Apart from that, saplings of tree species with good quality timber, and several useful plants will be allowed to grow in mixture with the benzoin plants. The growth speed and vegetation dynamics in a former ricefield is highly affected by historical, physical and biological factors. Land clearing which does not fell all the trees will highly influence the regeneration growth of the trees on the land. Moreover the plant species existing on the land also affects the regeneration speed, especially of the fire resistant plants. In the fallow I observed, most of the existing plant species are not fire resistant, so after burning , almost all the plant species will be damaged by the fire.

CONCLUSION

The benzoin garden

1) Traditional benzoin plantation is basically an agricultural system characterized by long periods of cropping, using traditional technology.
2) The opening of benzoin gardens in the Pusuk village is carried out in forests after the timbers are exploited or old secondary forest. Then the benzoin seedlings are planted among the remaining forest trees. Planting under the big trees is done in order that the big trees become the shade of the young seedlings. The system results in irregular planting distance and sometimes the seedling are inhibited in their growth, due to the density of the canopies of the forest trees. Therefore when the seedling start to grow bigger, the surrounding benzoin trees must be reduced by peeling the barks, and when the trees are dead and dry, there are felled. In the next development all the forest trees are cleared (disappeared).

Floristic diversity

1) There is a gradual increase in the proportion of species diversity and a corresponding increase in the vertical development of fallow vegetation with time.
2) The floristic richness from the different landscape (of the gardens, abandoned gardens and primary forest) is 148 species of 101 genus and 45 families.
3) During the first years of fallow, the growing plants are the species of adventist, ruderal, and heliophile. The species continue growth until the fallow is 3 years old.
4) The second and third stadium began in a young fallow about 4-6 year old until the age of 12-15. This stadium is characterized by the existence of a mixed community of heliophil and sciaphil. In the second stadium, the species that grow belong to heliophil which only grow in open places
5) The species composition of the early success ional community is heterogeneous as indicated by pioneer secondary plants and primary forest plants in the benzoin cultivation and by pioneer herbs and secondary species.
6) The floristic composition of secondary forest after benzoin cultivation is more heterogeneous than that of secondary forest after shifting cultivation. The prevalent species are *Wendlandia glabrata, Macaranga triloba, Schima wallichii, Eugenia* sp., *Timonius wallichianus, Symplocos odoratissima, Alstonia spectabilis, and Arthrophyllum sp*., etc.
7) Due to the intensive management in the benzoin cultivation, particularly the activities of clearing herbs, seedlings and shrubs before harvesting (manigi), the old secondary forest of benzoin cultivation are less heterogeneous than the old secondary forest. The composition of tree species in the old secondary forest is dominated by forest species, for example : *Wendlandia glabrata, Eugenia* sp., *Schima wallichii* and *Timonius wallichianus*.
8) The comparison of the plant diversity between a fallow and an abandon benzoin garden, it is evident that there is less diversity in a fallow than in an abandon benzoin garden. It is important to remember that in the benzoin garden several kinds of plant species which are useful for the households, like fruit trees, vegetables, and timber tree species are allowed to grow and sometimes even well cared.
9) The comparison of the vegetation dynamics based on average diameters and average crown height, showed that the

abandoned benzoin garden has a faster dynamics.

Vegetation Dynamics

Using the floristic analysis, 5 successive stadiums was resulted. Each stadium is characterized by a specific species dominant. The first stadium (0-3 years abandoned) is dominated by herbal species. The second is herbal-pioneer tree stadium (5-8 years abandoned). The third is the pioneer tree-primary forest tree stadium (12-15 year abandoned). The fourth is where the primary forest tree species cover in this stadium (18-20 years abandoned). The fifth is to be come primary forest (over than 20 years abandoned).

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Food Consumption and Nutritional Status of The Communities Live at Surrounding Peatland Areas at Central Kalimantan

Hartoyo
The Department of Community Nutrition and Family Resources
Bogor Agricultural University (IPB)
Jl. Lingkar Akademik, Kampus Darmaga, Bogor 16680, Indonesia
TEL. +62-(0)251-621258
E-mail: dini88@telkom.net

Emmy U. Antang
Faculty of Agriculture, University of Palangkaraya
Kampus Unpar Tunjung Nyaho, Palangkaraya 73111, Central Kalimantan, Indonesia
TEL. +62-(0)536-25645
E-mail: emmyantang@yahoo.com

Clara M. Kusharto
The Department of Community Nutrition and Family Resources
Bogor Agricultural University (IPB)
Jl. Lingkar Akademik, Kampus Darmaga, Bogor 16680, Indonesia
TEL. +62-(0)251-621258
FAX. +62-(0)251-622276
E-mail: kcl@indo.net.id

ABSTRACT

The nutritional status of the communities depends on to great extent on environmental conditions. There are two factors considered to have immediate impact on nutrition, i.e., dietary intake and health status. These factors are influenced by food security, health security, and caring capacity (UNICEF, 1998). The objectives of study was to identify household food consumption level and pattern of the communities live surrounding peatland areas; and to assess nutritional status of the under five year child and analyze the factors affecting the nutritional status.

The study was cross-sectional survey and covered of three villages, i.e., Bukit Rawi, Basarang Jaya (Kapuas) and Kalampangan (Palangkaraya) with a total of 103 samples (31 Dayak, 37 Balinese, and 35 Javanese). Samples were farm households who have an under-five year child and were selected randomly. Samples represent three different ethnic groups, i.e., Dayak (Bukit Rawi), Balinese (Basarang Jaya) and Javanese (Kalampangan). Interviews were conducted at each sampleís home. To assess food intake, the study conducted food recall. Meanwhile, nutritional status is measured by Z-score of weight by age. Multiple regression analysis was employed to determine factors affecting nutritional status.

The characteristics of the samples were young couples with two children, less educated (more than 50 percent of household head graduated from junior high school), and lower income families (the average of monthly income is about Rp 660.000,00). The study found that Dayak and Javanese families rely mainly on rice as a source of energy intake, while Balinese families combine rice and cassava as sources of energy intake. Balinese families seem to have greater food security level as compared to Dayak and Javanese families, even though their income is lower. In term of protein intake, Dayak families consume fish more frequent than Javanese and Balinese families. In the meantime, Javanese families consume egg, tofu, tempeh, and vegetable leaves more often than Dayak and Balinese families. In general, Javanese families tend to consume less calorie but higher protein, vitamin A, and minerals (Ca & Fe) than Dayak and Balinese families.

The proportion of under-five year children of the Javanese families who suffers from protein energy malnutrition (PEM) is 31.4 percent, higher than those of Dayak families (9.7%) and Balinese (27.0%). In fact, four children of the Javanese families (11.4%) suffer from severe PEM. The result of regression analysis indicates that nutritional status is positively and significantly affected by the level of food security, the level of energy intake, and child-feeding practices ($p < 0.05$) and negatively by the age of children. Children who live in food secured families and eat enough energy have a greater chance of being well-nourished. The finding shows us the importance of household food security as well as child-feeding practice to improve childís nutritional status.

Keyword: food consumption, nutritional status, food security, feeding practices, childcare

INTRODUCTION

Background

Nutritional status of under-five year children is often being utilized as an indicator of community or family well-being. The higher prevalence of malnourished children in a community indicates lower well-being. In addition, malnutrition is attributable to several and complicated problems dealt by the community. UNICEF (1998) stated that nutritional status could immediately be influenced by dietary intake and health status of the children. Furthermore, the level of food security, health security, and child caring capacity are often considered to have impact on nutritional status of the communities.

One of the determinant factors of dietary intake is food availability at household level in which could be fulfilled from subsistence crop products and purchased foods (Braun, 1992). Based on the Food Balance Sheet of Central Kalimantan Province (National Bureau of Statistics, 1998), the supply of food in this area mostly comes from neighbor provinces or even comes from the Java (Hartoyo, et. al., 2001). Poor micronutrients of the soil in this area may limit the crop growth (Tadano, 1985), and in turn, it could limit the food production.

The utilization of and choice of available foods are also influenced by ecological, social, cultural, and economic factors of the family and community. Therefore, the variation and the quantity of food available at household level are also different (Hartog, et. al., 1995; Fieldhouse, 1995; Rose, 1999).

The paper is based on Antangís research for her thesis. The specific objectives of the paper were: (1) to identify the level of food intake at the household level and at individual (of under-five children); (2) to assess the nutritional status of under-five year children; and (3) to analyze the determinant factors affecting the nutritional status of under-five children of the family live at surrounding peat land areas.

RESEARCH METHODS

Design, Location, and Period of the Study

The study was a cross-sectional survey. Data collection was done during the period of September-December 2001. The research was conducted in three purposively selected villages, those were: (a) Bukit Rawi Village (Sub-district of Kahayan Tengah, the District of Kapuas), represented the area where Dayak people live; (b) Kalampangan Village (Sub-district of Pahandut, the City of Palangkaraya) represented the area where the Javanese people live; and (c) Basarang Jaya Village (Sub-district of Basarang, the District of Kapuas), represented the area where the Balinese people live.

Sampling Method

The samples of the study were households which at least one under-five year child and live permanently in selected villages. The study covered a total of 103 households, which consisted of 31 Dayak, 35 Javanese, and 37 Balinese. The samples were all households who live in the selected villages in which they met requirement to be the samples of the study.

Data Collection Method

The household data consists of: (a) socio-economic and demographic characteristics, (b) income and expenditure, (c) food intake of the household, (d) food intake of under-five year children, (e) nutritional status of under-five year children (weight by age), (f) child rearing practice, and (g) sanitation. The researchers conducted interview with household head and/or homemaker. The interview was took place at the sampleís house, therefore, the researcher had an opportunity to observe their habit and home environment. Questionnaire was developed to direct the interview. Seven-day list recall method was employed to gather data of food consumption at household level. The study utilized two-day recall method to assess food intake at individual (under-five year child) level. In addition, direct weighing was conducted to measure the childís weight.

Data Processing and Analyzing

1. To assess the level of food consumption, the study used the ratio of actual dietary intake and recommended dietary allowance (RDA). The Department of Health (1996) divided the level of food consumption adequacy into five categories (Table 1).

Table 1. The Categorization of the Level of Food Consumption

Level of Consumption (%)	% RDA
Severe	< 70
Moderate	70 – 79
Mild	80 – 89
Normal	90 – 119
Over	≥ 120

Source: The Department of Health (1996)

2. Nutritional status of the children was assessed based on the Z-score of weight by age (w/a) and will be grouped in to four categories (Table 2).

Table 2. The Categorization of Nutritional Status of the Children

Nutritional Status	Z-Score
Obese	> 2 SD
Normal	-2 SD ≤ Z-score < 2 SD
Mild	-3 SD ≤ Z-score < -2 SD
Severe	> -3 SD

Note: SD = standard deviation

3. Multiple linear regression analyzes was employed to analyze the determinant factors of under-five children nutritional status. The regression model was:

$$\mathbf{Y=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6+b_7X_7+b_8X_8+b_9X_9+d_1D_1+d_2D_2+u}$$

Y = The nutritional status of the Children (the Z-score value of weight by age)

A = Intercept

bi = Estimated regression coefficient of the ith variable

d_i = Estimated regression coefficient of the ith dummy variable

X_1 = The level of energy consumption (%)

X_2 = The level of protein consumption (%)

X_3 = Sanitation (score)

X_4 = Child rearing practice (score)

X_5 = Level of food security (score)

X_6 = Monthly household income (Rp)

X_7 = Monthly household expenditure (Rp)

X_8 = The level of fatherís education (year of schooling)

X_9 = The level of motherís education (year of schooling)

D_1 = Dummy variable for ethnicity

D_1 = 1, for Javanese

D_1 = 0, for others

D_2 = Dummy variable for ethnicity

D_2 = 1, for Balinese

D_2 = 0, for others

u = error

RESULTS

Household characteristics

The household size indicates insignificantly difference among the ethnics. In general, most of the households have four members. The average age of fathers in Balinese community, as seen in Table 3, is relatively lower (31.65 years) compared to Dayak (35.32 years) and Javanese (35.31 years). On the other hand, the average age of the mothers seems to relatively similar. The difference in age between the father and the mother in Balinese community seems to be smaller as compared to Dayak and Javanese communities.

Dayak people are relatively more educated than other ethnics in the study. The averages year of schooling of mothers and fathers in Dayak are higher than those of Javanese and Balinese. These phenomena might relate to the economic status of the household. As seen in Table 3, the average monthly income of Dayak is also the greatest, while that of Balinese is the lowest among the ethnic groups in the study.

Table 3. Households Characteristics

The Average of	Dayak	Javanese	Balinese
Household size (person)	4.4	4.5	4.5
Age of father (years)	35.32	35.31	31.65
Age of mother (years)	29.00	29.11	28.95
Father's educational (years)	10.23	7.89	8.65
Mother's educational (years)	10.00	8.20	5.92
Household income (Rp)	794,824.19	758,763.80	464,042.78
Household expenditure (Rp)	627,109.84	662,797.80	396,548.35

Most of households in Dayak (95,33%) earn their living from such agricultural activities as: rattan, rubber, fishing, and logging. In the meantime, 60 percents of Javanese and 83,14 percents of Balinese depend mostly from cultivated crop production, particularly vegetables and fruits. More Javanese households rely their lives on off-farm activities, such as: construction labor, trade, and other unskilled jobs.

Level of Food Consumption

The level of energy consumption of the Balinese at household level, as seen in Table 4, is considered in normal category. The intake of energy in average is about 93.83 percents of the total energy required to live normally healthy. The average level of energy intake of the Dayak is considered in mild deficit and that of the Javanese is in moderate deficit in energy.

The average intake of protein is greater than the total recommended protein intake (RDA) for all ethnic groups. Even though it indicates insignificantly difference among the ethnic groups, in the average, the Javanese tends to consume more protein, particularly protein from soybean, than the other ethnic groups. Food habit seems to be different among the ethnic groups. The Javanese tends to consume tofu and tempeh more often than other ethnic groups.

The Level of vitamin A intake is considered to be normal for the Javanese. While the Dayak and Balinese tends to suffer from vitamin A deficiency at severe level. All ethnic groups live at mild risk of being vitamin B1 deficiency. In the meantime, the intake of vitamin C is considered sufficient for all ethnic groups (> 100 % of RDA). Three ethnic groups

Table 4. The Level of Food Consumption at Household Level (the Average % RDA)

Nutrients	Dayak	Javanese	Bali	Total
	%	%	%	%
Energy	88.23	76.09	93.83	86.12
Protein	123.59	140.21	126.44	130.27
Vitamin A	44.97^{a}	96.48^{ab}	54.91^{b}	66.04
Vitamin B_1	86.15	86.50	84.68	85.74
Vitamin C	194.05^{a}	192.34^{b}	315.00^{ab}	237.05
Ca	36.44^{ab}	84.52^{a}	69.06^{b}	64.49
P	202.40	219.32	212.40	212.04
Fe	47.30^{a}	91.43^{ab}	61.47^{b}	67.39

Note: ^{ab} the same notation at the same row indicates significantly difference at $\propto < 0.05$

might also at risk of calcium and iron deficiencies. It is indicated by the lower intake of these two minerals as compared to the recommended allowances.

In general, the under-five year children have greater risk of being nutrition deficiency. On the average, nutrition intake at individual (under five year children) level is lower than the recommended allowances, with exception forby all household members. Therefore, the level of food consumption at individual level is lower than at household level.

Under-five year children of the Dayak have less risk of being protein-energy malnutrition as compared to other ethnic groups. The Dayak children experience mild deficiency, while the Javanese and Balinese children suffer from severe energy deficiency. The levels of consumption of Vitamin A, B1, and C are considered to be severely deficient for all ethnic groups. These phenomena indicate that most of children have greater likelihood of being malnourished, and in turn, may threaten their lives.

Nutritional Status of Under-five Children

The result of assessment of the nutritional status of the children is presented in Table 6. As seen in Table 6, the prevalence of malnutrition (severe and mild) for three ethnic groups is about 24.2 percents. The prevalence of malnutrition in three villages might be better as compared to the prevalence of malnutrition at district or provincial levels. In 1998/99, the prevalence of malnutrition at Central Kalimantan was higher than 30 percents (Hartoyo, et. at., 2001).

Under-five year children of the Dayak have a better nutritional status. The prevalence of malnutrition in the Dayak is less than 10 percent. Meanwhile, in the other ethnic groups, the prevalence is more than 25 percents (31.4% for the Javanese and 29.7% for the Balinese). In fact, in the Javanese communities, there are about 14.3 percent of the children suffers from severe malnutrition.

Table 5. The Level of Nutrient Intake at Individual (Under-five Children) Level
(The Average % RDA)

Nutrient	Dayak	Javanese	Balinese	Total
	%	%	%	%
Energy	85.55[a]	51.41[a]	67.58[a]	67.49
Protein	93.00	85.34	81.16	85.87
Vitamin A	34.40	49.13	46.86	43.88
Vitamin B_1	38.95	33.06	40.48	37.50
Vitamin C	39.08	42.61	56.11	46.40
Calcium	37.67	44.85	44.16	42.44
Phosphor	112.53	104.00	102.24	105.93
Iron (Fe)	61.18	74.72	64.05	66.81

Note: [a] the same notation at the same row indicates significantly difference at _ < 0.05

Table 6. The Proportion of Under-five Year Children Suffered from Malnutrition

The Level of Nutritional Status	Dayak		Javanese		Balinese		Total	
	n	%	n	%	n	%	n	%
Severe	-		5	14.3	-		5	4.8
Mild	3	9.7	6	17.1	11	29.7	20	19.4
Normal	28	90.3	24	68.6	25	67.6	77	74.7
Obese	-		-		1	2.7	1	1.0
Total	31	100.0	35	100.0	37	100.0	103	100.0

Factors Affecting the Nutritional Status of the Children

The estimation of regression model of the nutritional status is presented in Table 7. As seen in Table 7, the level of food security, the level of individual energy intake, age of the children, and child rearing practice have impact on nutritional status of the children ($\alpha<0.05$). The higher food security of the household may lead to a better nutritional status of the children. The nutritional status could also be improved by providing the children with sufficient energy intake, better childcare, and good sanitation ($\alpha<0.10$). In the meantime, the older children may have worse nutritional status.

The ethnic groups, the level of protein intake, the mother education, and food expenditure have no significant effect to the nutrition status of the children. The impact of these variables seems to be smaller and have already being represented by other variables in the equation. For example, the level of protein intake is being expected to have greater correlation with the level of energy intake. The level of food security might have greater correlation with food expenditure.

DISCUSSION

Household food availability is one of important factors that determine fulfilling the need of household food consumption. The food availability can be fulfilled by growing the crops, collecting the food from the nature, purchasing the food from the market, and accepting assistance from relatives or other people (Smith, 2000). Households in this study supply their needed food, including rice mostly by purchasing from the market. It is because the soil has poor micronutrients so that it has lower productivity of rice. In general, the supply of rice in Central Kalimantan is mainly imported from neighbor areas and from Java Island.

Table 7. Predicted Factors Affecting the Nutritional Status of the Children

Independent Variables	b	t	Significance
Intercept	-4.963		
The level of energy intake (%)	0.222	2.134	0.036
The level of protein intake (%)	0.045	0.557	0.579
The level of food security (%)	0.406	4.923	0.000
The age of children (months)	-0.229	-2.530	0.013
Sanitation (score)	0.197	1.818	0.072
Childcare (score)	0.183	2.141	0.035
Mother's Education	0.021	0.242	0.809
Food expenditure	0.050	0.593	0.554
D1 (1=Javanese; 0=others)	0.000	0.002	0.998
D2 (1=Balinese; 0=others)	0.173	1.443	0.152

Most of the samples, particularly the Dayak and Javanese rely mainly on rice as their staple food. The intake of energy for Dayak and Javanese is depended on rice consumption. On the contrary, Balinese households have habit to mixed rice and cassava as their staple food. Cassava can be produced in their backyard or farmland as inter cropping. The intake of energy can be self-sufficiently provided without buying it. As a result, Balinese have less dependence on rice, an in turn, they have greater level of food security (Antang, et. al., 2002).

In term of vitamin and mineral intakes, more Dayak and Balinese households suffer from deficiencies as compared to Javanese households. This attributable to a different eating habit of green leave vegetables, beans, and eggs. The Javanese households consume more green leave vegetables (raw and cooked), tofu and tempeh, and eggs. Suhardjo (1986) and Kodyat (1995) stated that these foods are rich in vitamin and mineral. By consuming more these foods, the intake of vitamin and mineral is elevated.

The level of energy and other nutrients intake at individual (children) level is lower as compared to that at household level. The level of nutrients intake at individual level will be substantially influenced by the child-feeding practices. Birch (1998) stated: ìparentsí child-feeding practices are central in the early feeding environment and affect childrenís food preferences and their regulation of energy intake." Therefore, it is important to understand children food preferences to increase the dietary intake of the children. In most cases, the ability of mothers to serve better child-feeding practices needs to be improved.

Regression analysis resulted that the nutritional status of the children is significantly influenced by the level of food security and the level of energy intake. The level of food security may represent the ability of the household to provide sufficient foods for all members. While the level of energy intake indicates total energy consumed at individual level as compared to the total energy required for normal healthy life. Both variables have a positive impact on nutritional status. When a child lives in the household in which they are able to provide enough food and s/he consumes enough energy and other nutrients, s/he has a greater chance of being well-nourished.

Child-feeding practices has also a positive and significant impact on the nutrition status. The better child-feeding practices applied by the caregivers may improved the childís nutrition status. According to Engle (1999), childcare or feeding practices may increase food intake of the children. The ability to apply better feeding practices is believed to be depended on mothers (caregivers) education. Garret and Ruel (1999) stated that caregiversí education could be used as a proxy determinant of the ability of caregivers to apply feeding practices. Moreover, according to Alderaman and Garcia (1994), mothersí education may influence the nutritional status through the provision of input for better health and nutrition. More educated mothers are expected to have greater attention and economic ability to vaccination, breastfeed practices, nutritious food, etc.

The negative and significant impact of the childís age to nutrition status, according to Garret and Ruel (1999), could be explained in several ways. First, the mobility of older child is higher, therefore the older child needs more intake of energy. Second, during weaning process and the beginning of eating grow-up food/meal, the older child might experience adjustments that lead the child at risk of being malnutrition. Third, the older child might easily being exposed with contaminated environment so that s/he might easily being sick.

CONCLUSION

1. The level of energy intake of Balinese households is considered to be normal, while Dayak and Javanese households consecutively are in mild and moderate deficient of energy.
2. The ability of Balinese households to provide adequate intake of energy may be attributable the habit of eating mixed rice and cassava as their staple food.
3. Dayak and Bali households suffered in mild deficiency of vitamin B1 and in severe deficiency of vitamin A, Ca, and Fe; meanwhile Javanese suffered in mild deficiency of vitamin B1 and Ca.
4. The eating habit of green leaf vegetables, tofu, tempeh, and eggs might cause less Javanese households, as compared to other ethnic groups, suffer from vitamin and mineral deficiencies.
5. Child nutritional status of Dayak is better than Javanese and Balinese
6. There are three determinant factors in which they have a positive and significant impact on child nutritional status, these are: the level of energy intake, the household food security, and child rearing. On the other hand childís age had negative impact on it.

SUGGESTION

1. To improve the household food security of the communities live at surrounding peat land areas, it is suggested to develop activities to generate the family income through such activities as: utilization and intensification of back yard with easy grow food crops, small animal husbandry. These activities, in turn, are expected to contribute to the improvement of nutrition status.
2. It is suggested to educate mothers and other caregivers about better practical childcare and feeding practices. The process of education activities should be integrated with other income generating activities. Therefore, it is important to develop a community center with integrated activity programs to empower the community.

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Ethnobotanical Study and Nutrient Potency of Some Local Traditional Vegetable in Central Kalimantan (1)

Daisy Irawan[1], C. Hanny Wijaya[1], Suwido H. Limin[2],
Yasuyuki Hashidoko[3], Mitsuru Osaki[3] and Ici P Kulu[2]
[1]Department of Food Science, Postgraduate Program,
Bogor Agricultural University, Kampus IPB Darmaga, Bogor, Indonesia.
[2]Faculty of Agriculture, Palangka Raya University, Palangka Raya, Indonesia
[3]Laboratory of Ecological Chemistry, Division of Applied Bioscience, Graduate School of Agriculture, Hokkaido University, Sapporo, Japan.

Corresponding Author:Prof. C. Hanny Wijaya,
Jurusan Teknologi Pangan dan Gizi, Fakultas Teknologi Pertanian,
Kampus IPB Darmaga, Bogor, Indonesia 16002
Fax 62-251-622093
Phone: 62-251-627446, 630544
e-mail: hazemi@indo.net.id

ABSTRACT

Dayak people in Central Kalimantan, traditionally consumed local vegetable, either collected from the wild or traditionally cultivated. Unfortunately, many of the traditional vegetables are approaching extinction, even in their local market. This research is intended to conserve the traditional vegetable by collecting nutritional data and cultural information about the vegetable.

Nineteen traditional Dayak vegetables have been observed in local markets and in wild area. Taxonomy identification revealed that the vegetables are *Passiflora foetida* L. (kemot), *Diplazium esculentum* (Retz). SW. (bajey fern), *Spondias* pinnata (L.f.) Kurtz (kedondong leaves), *Neptunia oleracea* Lour (malu-malu leaves), *Manihot esculenta* Crantz (cassava leaves). *Vigna unguiculata* (L.) Walp. (talak leaves), *Etlingera elatiar* (Jack) R.M. Smith (potok shoot, red and green cultivar), *Calamus* sp. (rotan shoot), *Nauclea* sp. (Taya leaves), *Momordica charantia* L. (paria leaves), *Gymnopetalum cochinense* Kurz (kanjat), *Solanum torvum Swartz*. (segau fruit), *Colocasia esculenta* (L.) Schott (sulur keladi shoot), *Stenochlaena palutris* (Burm.)Bedd. (kalakai leaves; red and white cultivar), lotus shoot (pucuk teratai), and *Cnesmone javanica* Blume (lampinak leaves).

Nutrient analysis revealed that red kalakai (wild fern) is potential to overcome nutrient deficiency problem in Indonesia. It had high amount of Fe (41.53 ppm), Cu (4.52 ppm), vitamin C (15.41 mg/100g), protein (2.36%), b-carotene (66.99 ppm), and folic acid (11.30 ppm). Other iron rich vegetables were sulur keladi (49.25 ppm) and bajey (44.6 ppm). While other vitamin C rich vegetables were paria leaves (18.34 mg/100 g wb), and bajaj fern (22.05 mg/100g w.b). Sulur keladi, and bajey were also rich in folic acid. They had 11.3, 16 and 6.3 ppm of folic acid respectively. The b-carotene content in bajey were 74.04 ppm while taya (77.41 ppm).

From the initial nutrient analysis and cultural information, we may conclude that local traditional vegetable in Central Kalimantan is promising to supply nutrient requirement of the local people and others with similar environmental condition. Unfortunately, their availability is diminishing both physically and culturally. Such as it is they need to be conserved.

Key words: Central Kalimantan, Dayak, traditional vegetable, nutritional value.

INTRODUCTION

Conserving worldís biodiversity is very important to support sustainable living. Each plant has already developed their own environmental preferences and resistance to pest and disease. Each of them also plays important roles to support other organism living. If one of them become extinct, the environmental balance will be disturbed, included human live.

Unfortunately, due to improper modernization and globalization the extinction of the world biodiversity is proceeding, both physically and culturally in many areas of the world. The Nature Conservancy Council (1984) in Dalzell (1994) reported that between 1945 to 1984, 95% of the UKís wildflower-rich-meadows destroyed due to intensive agriculture practice. A survey on 42 agricultural students in an Indonesian university revealed that among 33 native auxiliary plants being asked, 35 students knew less than 50% of the auxiliary plants.

The research was intended to conserve traditional vegetables in Central Kalimantan by conducting an initial survey about them and collecting basic nutrient information. Nutrient information is also important to help local health practitioners to make food consumption guideline for local community.

Saifullah (2002) mentioned that according to the BKKBN (The Coordination Agency for National Family Planning) survey in 2001, there are 14.7 million of Indonesian families living in poverty. In year 2000, the number of malnourished Indonesian children (0-5 year old) is 25% of the total 0-5 year old Indonesian children population (Jahari and Sumarno, 2002). In this case, traditional vegetables that have been adapted to its environment for decades might plays important roles to combat nutrient deficiency in local areas.

METHODOLOGY

Ethnobotanical study was conducted by direct observation, and interview. In this activity, the availability of the plant was also noted. Identification of the traditional vegetables was conducted by botanist at the Herbarium Bogoriense in Bogor, West Java. The nutritional value were studied on fresh vegetables collected at the local market in Central Kalimantan. The vegetables were wrapped by banana leaves, packed in carton box cooled by ice, and then flight to West Java for analysis at the next day. Prior to analysis the vegetables were stored in refrigerator (approx 10^{o}C). The nutritional values being analyzed are moisture content (by thermogravimetri; AOAC 1984), fat content (soxhlet method), protein content (micro kjeldahl method), total ash (dry ashing method), crude fiber (by H_2SO_4 destruction method), vitamin C (iodine method)

Folic acid analysis (Balitbio method) was conducted by macerating 10 g sample in 25 ml acetonitrile for 5 minutes. Followed by filtration with Whatman paper No. 45 and vacuum evaporation. The filtrate was diluted with 5 ml of methanol prior to HPLC analysis. The HPLC condition was as followed: column C18, mobile phase methanol: water (60:40). Column temperature 27-28^{0}C, flow rate 1 ml/min. Detector UV (l = 254 nm).

Beta carotene analysis (Balitbio method) was conducted by macerating 5 g of sample in 50 ml of KOH-methanol (60 g KOH in 50 ml of water diluted by methanol into 1 l). The suspension was stirred and heated at 60^{0}C for 1 hour. After that, the suspension was dissolved into 20 ml hexane and 50 ml aquadest. The hexane phase was separated while the aqueous phase was extracted once more with hexane. Furthermore, all of the hexane phase were combined and concentrated with vacuum evaporator to get the b-carotene extract. The extract was analyzed by HPLC with the following condition: column C-18, mobile phase acetonitrile : methanol : dichloromethane (60:35:5), flow rate 1 ml/min, column temperature 27-28^{0}C, detector UV (l = 462 nm).

The vitamin analysis was conducted as soon as the vegetables arrived. Only vegetables which in good condition were being analyzed. The conversion factor from total N to protein is 4.39 instead of 6.25, the consideration is based on Fujihara et al. (2001) survey on the protein content in vegetables.

RESULT AND DISCUSSION

Plants & Availability

On the observation of vegetables in local market and in wild area, we found 19 traditional Dayak vegetables (Table 1). Except kalakai and bajey, most of the vegetables were rarely found in the market. Pucuk teratai, a traditional vegetable, was only sold by one vegetable seller in small amount (2 pieces). Meanwhile, kalakai and bajey was found in large amount by the street, on agricultural areas, and on open peat areas around Palangkaraya. Another wild plant, kemot, was found in small amount in an open peat area near Palangkaraya. Figure 1 presents some of the Dayak traditional vegetables.

Most of the traditional vegetables are wild plants. Only paria leaves, senggau (Devilís fig), lampinak (seasonal bush plant), sulur keladi, and malu-malu been cultivated in small amount. Paria is mostly cultivated for its fruit (bitter gourd), while sulur keladi is mostly cultivated for its tuber (keladi or taro). The wild plant of senggau is frequently misunderstood as weed.

Some of the vegetables might function as auxiliary plants as well. Malu-malu is an aquatic plant with sponge tissue to make it float on the water. Its cultivation might be good to support other beneficial wildlife such as fish and frogs that might reduce the population of agricultural pest. Kalakai, bajey and kanjat are wild plants that frequently grow after fire accident in a forest. Figure 1 presents red kalakai plant that grows in burned soil. The aforementioned plants might be good for soil rehabilitation before other plant germination. Senggau might prevent bacterial wilt on tomatoes and eggplant

Table 1. Identification result of the Traditional Vegetables

Latin Name	Family	Vernacular Name	Part being used
Calamus sp.	Arecaceae	Pucuk Rotan	Shoot
Cnesmone javanica Blume	Euphorbiaceae	Lampinak	Leaves
Colocasia esculenta (L.) Schott	Arecaceae	Sulur keladi	Young shoot
Diplazium esculentum (Retz). SW.	Athyrium	Bajey	Leaves
Etlingera elatiar (Jack) R.M. Smith	Zingiberaceae	Potok (Red and Green Kultivar)	Young shoot
Gymnopetalum cochinense Kurz	Cucurbitaceae	Kanjat	Fruit
Lotus[1]		Pucuk teratai	Young shoot
Manihot esculenta Crantz	Euphorbiaceae	Daun singkong	Leaves
Momordica charantia L.	Cucurbitaceae	Daun paria	Leaves
Nauclea sp.	Rubiaceae	Daun taya	Leaves
Neptunia oleracea Lour	Mimosaceae	Malu-malu (uru mahamen)	Leaves
Passiflora foetida L.	Passifloraceae	Kemot	The whole plants
Solanum torvum Swartz.	Solanaceae	Segau	Fruit
Spondias pinnata (L.f.) Kurtz	Anacardiaceae	Daun kedondong	Leaves
Stenochlaena palutris (Burm.) Bedd.	Pteridaceae	Kalakai (red and white cultivar)	Leaves
Vigna unguiculata (L.) Walp.	Papilionaceae	Daun talak	Leaves

[1]Not identified

(Boonkerd et al., (1994) in Siemonsma and Piluek (ed.)).

Pucuk rotan or rattan shoot is an epiphyte, its livelihood is depends on other trees, especially big trees in the forest. Although it is economically attractive (for furniture and art works), it is rarely being cultivated by local communities. Rattan does play important role for wildlife protection such as orang utan. Due to its nutritional value and other uses, rattan should be integrated in forest rehabilitation program.

According to the interview, Dayak people also consumed bakung shoot, coconut shoot, palm shoot and arenga shoot. However, the vegetables were not found during the survey.

There are two different kind of edible rattan shoot; irit and bajungan. Bajungan (Figure 1) is bigger than irit. Potok is also consist of two different types, i.e. red and green potok. Edible kalakai do consist of two different types, traditionally called kalakai merah (Figure 1) and kalakai putih. Kalakai merah is green kalakai fern with redish color,

Figure 1. Some of the Dayak Traditional Vegetables

while kalakai putih is green kalakai fern with pale green color. Kanjat also consist of two different types: the bitter one and the unbitter one. Both are consumed but the unbitter one is more common.

Ethnobotanical

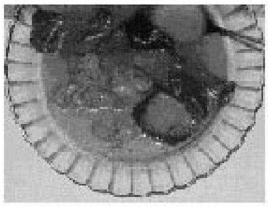
Dayak people usually stir and fry the vegetables, or make them into clear soup or light coconut-milk soup (juhu). They add a lot of herbs and spices into the soup such as terung asam (*Solanum ferox*), shallot, and garlic. Sometime, they also add tempuyak (fermented durian fruit) as spices for the soup. The soup may be cooked with fish, pork or bat meat. Many of the traditional vegetables are believed that it may reduce the fattiness of pork or the fishy odor of fish. They are lampinak, pucuk rotan, (cooked with pork or fatty fish head such as baung fish, patin fish and jelawat fish), taya, potok, kanjat, and bajey. Figure 2 presents juhu singkah babi, i.e. traditional soup made of peeled pucuk rotan and pork meat, and juhu taya tempuyak (made of taya leaves, fermented durian and pork meat).

Lampinak and pucuk rotan has slightly bitter taste. Meanwhile, malu-malu and potok have mild acidic flavor. After being peeled to get the inner side, the potok is chopped and cook with grilled fish. The fragrance aroma of potok is could reduce the fishy flavor of fish. The unbitter kanjat is also commonly cooked with grilled fish. Kanjat do has ability to absorb bitterness and frequently used as sweeteners. Some vegetables commonly consumed as lalab (Indonesian salad, usually eaten with hot chilly sauce to accompany the main dishes) are paria leaves (steamed or boiled), senggau (boiled and raw state).

Dayak people usually prepare vegetable dishes to be finished in one day so that the nutritional losses could be minimized. Among the aforementioned Dayak vegetables, only cassava leaves are commonly consumed in Java and Sumatera (Indonesia). Paria leaves consumed in small amount in Bogor. In East and Central Java, it is the fruit that commonly consumed either as vegetable or traditional medicine for diabetes.

Uru Mahamen or malu-malu is also popular in Thailand, but not in Java. According to Barminas et al. (1999), mostly, it is the taro tuber and the leaves that being consumed, but in Central Kalimantan, the shoot is commonly consumed as vegetable. This vegetable may cause itching on the consumerís mouth, thus pretreatment with salt is necessary prior to consumption.

Juhu singkah babi



Juhu taya tempuyak

Figure 2. Some of Dayak Traditional Cooking

Table 2 revealed that compared to other vegetables being surveyed, **paria leaves** has significant amount of protein (3.26%) (conv. Factor 4.25) and vitamin C (18.34 mg/100g) (Figure 3). According to Reyes et al. (1994) in Siemonsma and Piluek (ed), it is also a good source of iron and calcium. Besides, the leaves has guanylate cylase inhibitor that has the activity to lessen chemical carcinogen induced increases in guanylate cyclase activity. However, its bitterness could be a hindrance of it utilization as nutrient source.

Many of the Dayak traditional vegetables are good source of iron (Table 3). They are sulur keladi (49.25 ppm), bajey (44.6 ppm), and kalakai (41.53 ppm). Sulur keladi has high amount of Fe, Cu (4 ppm), protein (1.44%) and vitamin C (15.34 ppm). The vegetable might be suitable to overcome iron deficiency anaemia in Indonesia. Other potential vegetable is red kalakai. It has high

Table 2. Proximate analysis of Dayak traditional vegetables

Vegetables	Moisture	Ash	Fat	Protein	Crude fiber
Bajey	90.84	1.38	0.04	2.23	4.82
Green Potok	91.85	1.21	0.19	0.80	4.51
Kanjat	91.39	0.90	0.15	0.77	3.81
Lampinak	81.47	1.65	1.28	2.72	4.30
Malu-malu	78.22	1.81	0.39	2.69	3.50
Malu-malu Paisooksantivatana (1994) in Siemonsma and Piluek (ed.)	*89.40*	*1.20*	*0.40*	*6.40*	
Paria Leaves	84.38	2.38	0.29	3.26	3.21
Paria leaves Reyes et al. (1994) in Siemonsma and Piluek (ed)	*82-86*	*2.30*	*0.10*	*2.30*	*0.80*
Pucuk rotan	89.96	1.52	0.50	2.29	7.93
Pucuk teratai	94.37	0.72	0.05	0.92	1.54
Red Kalakai	89.08	1.19	0.11	2.36	4.44
Red Potok	93.67	1.29	0.13	0.56	4.52
Senggau	83.83	1.03	0.25	2.83	4.79
Senggau Boonkerd et al., (1994) in Siemonsma and Piluek (ed.)	89		0.1	2	
Sulur Keladi	93.54	0.90	0.05	1.44	3.52
Taya leaves	66.98	1.31	0.17	2.71	4.32

Note: unit in g/100 g wb

amount of Fe, Cu (4.52 ppm), vitamin C (15.41 mg/100g) (Figure 3) and protein (2.36%).

The nutrient combination is necessary, since in blood plasma, copper would linked to ceruplasmin that catalyzes the oxidation of Fe^{2+} into Fe^{3+} thus it could be transported by the transferrin protein to the liver (Belitz and Grosch, 1999). Meanwhile, vitamin C (ascorbic acid) would enhance the bioavailability of Fe, i.e by increasing enteric absorption of it. This vitamin do has many other function such as electron transport, collagen synthesis, drug and steroid metabolism, tyrosine metabolism, metal ion metabolism, antihistamine, immune functions, anticarcinogenecity and antioxidant and prooxidant function (Combs, 1992).

Table 3. Mineral content of some of the Dayak traditional vegetables

Minerals (ppm dry weght)	Rattan	Sulur keladi	Bajey	Taya	Kalakai
P	0.09	0.06	0.09	0.1	0.24
K	0.46	0.21	0.24	0.45	1.02
Ca	0.41	0.35	0.39	0.39	0.49
Mg	0.12	0.16	0.14	0.29	0.24
Fe	35.41	49.25	44.6	22.02	41.53
Cu	4.10	4.00	4.24	5.6	4.52

Kalakai is also traditionally recognized that it may stimulate the production of breast milk on postdelivery mothers. The fact is supported by the nutritional data. However, in order to acquire more reliable recommendation, it would be beneficial to conduct deeper research.

Figure 3 revealed that **senggau** has moderately high amount of vitamin C. According to Boonkerd et al., (1994) in Siemonsma and Piluek (ed.), it is also rich in phosphorus (3 ppm), and calcium (5 ppm). In addition to its nutritional value, senggau has a number of bioactivity as traditional medicine such as antidote to snake and insect bites, stomach pain poultice for crack in feet, etc. It also has steroida; alkaloid solasodine which is an ingredient for oral contraceptive. Some vegetables are rich in b-carotene. They are bajey (74.04 ppm), taya (77.41 ppm), and kalakai (66.99 ppm). Bajey is also a good source of protein (2.23%). According to Handique (1993), the young leaf of bajey or *Diplazium esculentum* contains four free amino acids, in which the three of them is essential. It has very low fat, and moderate amount of fiber. The folic acid of fresh bajey is moderately high (6.3 ppm), while the vitamin C of it is high (21.72 mg/100 g). The value is comparable to tomatoes, which has 21 mg/100g of vitamin C (Opena and van der Vossen in Siemonsma and piluek (ed.), 1994). Unfortunately, as vegetable, bajey is quite perishable, therefore it should be handled well during transportation.

According to Paisooksantivatana in Siemonsma and Piluek (ed.) (1994), malu-malu has low amount of iron (5.3 ppm), but a good source of calcium (38.7 ppm) and phosphorus (0.7 ppm). It also contains 0.12 mg/100 g of vitamin B1, 0.14 mg/100 g of vitamin B2 and 3.2 mg/100 g of niacin. In Malaysia it is reported that the stem could be used to treat earache, and the root for siphilis (Paisooksantivatana in Siemonsma and Piluek (ed.), 1994). Meanwhile, Nakamura et al. (1996) reported that 6 chlorophyll-related compounds, isolated from leaves of N. oleracea, could inhibit the activation of tumour promoter induced Epstein-Barr virus (EBV).

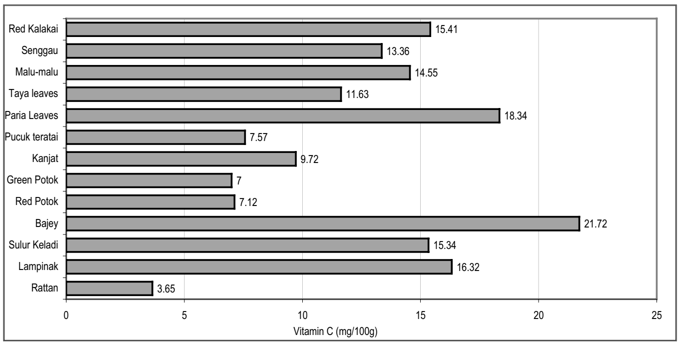
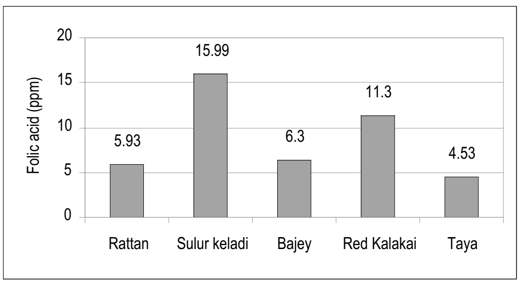


Figure 1. Vitamin C content in some Dayak traditional vegetables



Barr virus (EBV).

Figure 4. Folic acid in some of the Dayak traditional vegetable

Compared to other vegetables, **sulur keladi** has high amount of folic acid (15.99 ppm) (Figure 4). The level is even higher than spinach that has 0.8 ppm of folic acid (Belitz and Grosch, 1999). Folic acid may prevent congenital malformation such as neural tube defect (Shane, 2002), cleft lips and/or palate (Hernandez-Diaz et al., 2000), heart defects and limb malformations (Shane, 2002). In Indonesia, inborn malformation is quite prevalent especially among the low income society. In this case, sulur keladi may help to overcome the problem.

Cultivating taro or sulur keladi or *Colocasia esculenta* as a staple food would bring several benefits. Not only the tuber, but also other parts of it, i.e the leaves and the flowers could be consumed as vegetable with good nutritional quality. Ejoh et al. (1996) mentioned that *Colocasia esculenta* leaves and flowers had high crude protein value, i.e. 30,7 % dw and 14.9 % dw respectively. The amino acid profile of its leaves and flowers were balanced and comparable to the reference FAO pattern. It is also a good source of Fe and Zn.

Based on the preliminary analysis, kanjat, pucuk teratai, and potok do not have any outstanding nutrient. However, they may have beneficial activities. Kanjat, as well as other cucurbitaceae, may have some bioactivities. As a water clearing plant, teratai may have significant amount of minerals. Unfortunately, because of limited sample, the mineral was not being analyzed. In addition, as *zingiberaceae* it is possible that potok does have some bioactivities which needed to be further investigated.

CONCLUSION

From the aforementioned information of the initial survey of traditional vegetables in Central Kalimantan we may conclude that there are some vegetables which is very potential to overcome nutritional anaemia among the Indonesian people, especially on women. They are kalakai, rattan shoot, paria leaves, and taya. Meanwhile, kalakai, sulur keladi and bajey could be a good source of folic acid. The vegetables might be suggested for woman at bearing period and post delivery. Some vegetables are not only nutritionally outstanding but might also support sustainable agriculture as well. They are kalakai, bajey, senggau, malu-malu and teratai.

ACKOWLEDGEMENT

Upon completing this paper, we would like to acknowledge Mr. Lumban Rangin, a native Dayak people from Central Kalimantan for the generous ethnobotanical information about the vegetables.

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A New Approach of Tropical Peat Characterization Based on Field Experiences in Riau, Sumatra

Darmawan, Basuki Sumawinata, Budi Mulyanto, and Suwardi
Member of Center for Wetland Studies, Dept. of Soil Science, Bogor Agricultural University, Email: soilipb@indo.net.id

Corresponding author:
Dr. Darmawan
Center for Wetland Studies
Dept. of Soil Science, Bogor Agricultural University
Jl Meranti, Kampus IPB, Darmaga, Bogor 16680, Indonesia
Email: soilipb@indo.net.id
Phone 0251-627792
Fax: 0251-629358

ABSTRACT

Coastal peat land is a potential land resource in tropical region including the land in Indonesian coastal plains. The success of reclamation of the land for any use depends among others on the appropriateness of methods use in characterization of the peat. Despite significance differences between tropical and temperate peat, characterization methods used in tropical region during the past have never been set based on the nature of the tropical peat. As the result, some data of physical and chemical characteristics of tropical peat seem to be unrealistic, which did not reflect the actual characteristics of the land at all. This suggests that the methods of characterization need to be reviewed. Some inappropriate analytical methods and its alternative are discussed in this paper. Furthermore, this paper suggests that it is important to consider that each area within a certain unit of coastal peat land ecosystem can affect others and be affected as well. Thus considering the characteristics of the whole ecosystem of the coastal peat land including the type of depositional environment of the land sediment is as crucial as the characterization of peat material it self.

Keywords: Tropical wetland, peat characteristic, reclamation

INTRODUCTION

Soil is one of the most importance environment components of the living system, besides water and air. Soil characteristics determine the capability of the soil to support living organism including human being. Therefore characterization of soil is an important step before the land use and management technologies are determined.

Based on its widespread area, coastal peat land is regarded as a potential land resource in Indonesia for agriculture use. The use of these areas for agriculture has been initiated by traditional farmers living in the circumstances since the early 1960's. Inspired by the success of the traditional farmers in managing the coastal peat land, Indonesian government has created projects of reclamation of the coastal peat land in Sumatra and Kalimantan through a national transmigration program.

Soil survey and land evaluation had always been made prior to the reclamation of every selected area. Despite the intensive survey, most of the reclamation projects of the coastal peat land, such in Pulau Petak in Kalimantan, Sugihan, Saleh and Pulau Rimau in South Sumatra and Rantau Rasau in Jambi, were ended up at a failure and a destruction of the ecosystem. The most distinct destruction is the disappearance of the peat layers from the land regardless the original thickness, which in turn has led toxicogenic materials, i.e. acid sulphate soil and acid affected-soil occupied the land surface.

Failure of the reclamation project of the coastal peat land in Indonesia is caused by inappropriateness of characterization methods. The existing methods used in peat characterization as well as in modeling, such as model of peat land subsidence of Sageberg (Sageberg, 1960), were set based on temperate peat. In fact, characteristics of tropical peat are strongly different with that of temperate peat. Peat of tropical region are all woody, the products of tropical rain forests and quite different in composition from the sphagnous peat of colder region. Consequently values of peat characteristics obtained by the method were not reflect the real potential of the Indonesian peat land and led to misinterpretation in determining the land use and management technologies.

The objective of this study is, therefore, to review some methods that have been used in characterization of peat in Indonesia and to develop a new approach that more appropriate to the tropical peat land characteristics.

GENESIS, COMPOSITION AND CHANGES OF TROPICAL PEAT

According to Polak (1933) peat developed in wet tropical region was derived from woods of tropical rain forest. The peat is not only composed of fine organic debris but consist of coarse woody materials of trunks and branches of trees which are not completely decayed as they always existed in anaerobic or water saturated condition. Due to the coarse size of the woody materials, materials of tropical peat do not form a continuous and compact mass, but leaving unfilled voids or holes of different sizes (Figure 1). Interlayer blank parts which are common in boring column taken in the tropical peat reflect the presence of such voids or holes (Figure 2). Under the natural condition, the peat land is continuously waterlogged where the water resulting in a floating effect to the peat materials. It is clear that the nature of tropical peat is completely differs from that of temperate peat which generally was developed from sphagnum, where the peat composed almost entirely of finely fragmented organic materials which form a continuous and homogeneous distribution of peat mass.

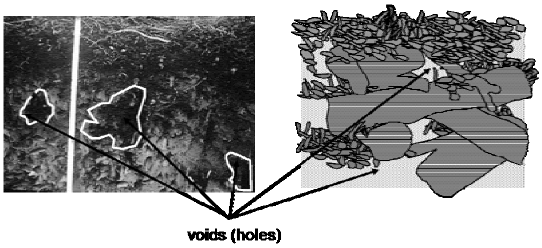

Figure 1. Profile of tropical peat showing woody materials and voids.

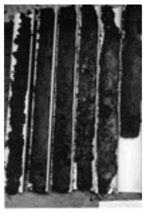
Figure 2. Boring column of tropical peat with blank part.

In general, the utilizations of peat land for any use including agriculture will change the areas from anaerobic to aerobic condition. Under the aerobic condition, the rate of decomposition increases sharply. Field experiences show that after some years of cultivation, the thickness of peat layers decreased significantly as the result of decomposition taken place under an aerobic condition. In the reclamation practices of peat land, canals of different size have always been made to drain the land. In many cases, this drainage system has led to a drastic and rapid change of the land condition. By draining the land, the water level of the peat land would decrease significantly leaving the upper parts of peat layers lack of water. As the consequence, the floating effect of water to the peat materials disappeared. This situation would cause the peat to collapse resulting in a great subsidence of the land. The situation becomes worst in dry season because dry peat materials are very easy to burn and once fire started to burn the peat it is extremely difficult to halt. Decomposition, subsidence, and fire altogether accelerate the lost of peat layers from the land surfaces.

When peat layers completely disappear, then the land surface will be occupied by mineral sediment formerly existed under the peat layers. Thereafter characteristics of the land, therefore, depend on the type of the emerged sediment. The type of mineral sediment beneath the peat layers in coastal peat land depend on their depositional environment. Sumawinata (1998). Peat land that developed in a riverine swamp environment, for example, would has underlying mineral sediment that differ with that of peat land that developed in brackish swamp environment. The mineral sediment of the riverine swamp would not contain sulfidic materials. In the contrary, the mineral sediment of the brackish swamp environment generally contains significant amount of sulfidic materials.

INAPPROPRIATE CHARACTERIZATION METHODS AND ITS ALTERNATIVE

The failure of most coastal peat land reclamation projects in Indonesia more or less was attributed to inappropriate characterization of the land taken during preparation prior to the implementation of the projects. Some methods in characterizing the peat have resulted in data, including physical and chemical characteristics of the peat materials, which did not reflect the actual characteristics of the land at all. Some inappropriate methods and its alternative are discussed below.

In predicting of what extent the subsidence would happen, a model of subsidence of peat land developed based on experience in European countries, such as model of Sageberg (Sageberg, 1960) was commonly used in Indonesian coastal peatland reclamation. The suitability of using such model for tropical peat land is questionable. In addition, since this model includes value of bulk density of peat as one of the parameters, then the technique used in determining value of


Figure 3. Small ring sampler being used for tropical peat soil.


Figure 4. Larger measurement unit for bulk density.

bulk density of tropical peat has to be evaluated. The technique that has been used in the past was adapted from the technique set for mineral soils in that undisturbed samples were usually taken using a ring sampler of 10 cm in diameter and 6-7 cm in height or smaller (Figure 3). Regarding the field variation of tropical peat materials as described earlier, this approach is clearly untenable since the ring is too small to represent all field variation, including the presence of voids. Since *in situ* variation of peat materials in tropical peat land occurs in much larger three dimensional directions, the more reliable value of bulk density of the tropical peat must be based on a larger measurement unit as illustrated in Figure 4. Taking large sized samples for further *ex situ* determination may be impractical, thus *in situ* measurement can be a good alternative.

Regarding methods of laboratory analysis for peat samples that have been carried out in Indonesia during the past, there is an incorrect approach in samples preparation. The peat samples for chemical analysis used to be crushed and sieved with 2 mm sieve prior to analysis. This sieving step follows the technique that is a standard for analyzing samples of mineral soils. Definition of mineral soils says that the soil components are the entire fraction sized 2 mm or less. In fact, original size of peat materials is the nature of peat that relates to the degree of decomposition and naturally determines chemical characteristics of the materials. Fibric, hemic, and sapric material have naturally chemical characteristics that are unique for each. By sieving the sample, will exclude coarse materials (fibric or woody materials) from analysis. When part of the sample that passed the sieve, that mostly consists of hemic and sapric materials, is analyzed for the CEC, for example, the value would be much higher than the actual value. The high CEC values of fibric materials (Table 1) are an example of unrealistic peat chemical data obtained by an incorrect method of analysis. To get more realistic data, therefore, the samples do not need to be sieved but the hole samples have to be crushed to the size of less than 2 mm or smaller.

Table 1. Some chemical characteristics of fibric materials obtained from sieve-passed samples.

Depth (cm)	Type of material	pH	Ca	Mg	Na	K	CEC
			(me/100 g)				
0-50	fibric	3.80	1.52	3.96	0.20	0.15	210.00
50-100	fibric	3.80	3.55	3.41	0.19	0.42	171.64
100-150	fibric	3.90	1.80	4.08	1.45	0.22	199.36
150-200	fibric	4.40	0.92	3.26	0.19	0.38	194.79

In addition to some inappropriate technical methods in characterizing tropical peat, there is also a misconception in considering the tropical coastal peat land as an ecosystem that more or less has led to the destruction of the ecosystem upon reclamation. The land was much more regarded as a compartment of peat or peaty mineral bodies that have a series of physical and chemical characteristics regarded as the most crucial in determining the land potential for agriculture. However, the drastic change of the ecosystem upon the reclamation, such as the loss of peat layer after some years of cultivation and the subsequent development of acid sulphate soils and its potential to acidified the water and soil of the whole area, suggests that considering the characteristics of the whole ecosystem of the land including the type of depositional environment of the land sediment is as crucial as the characterization of peat material it self. Each area should be considered as a part a certain unit of coastal peat land ecosystem that can affect other parts and be affected as well, rather than regarded as an individual area that can be characterized partially regardless the overall characteristic of the whole ecosystem unit.

CONCLUSION

Characteristics of tropical peat are strongly different with that of temperate peat, in that material of tropical peat much more heterogeneous with respect to its size and degree of decomposition. Some methods of characterization that originally was adapted from the methods set for mineral soils might be workable for temperate peat but using them for tropical peat are untenable. Measurement of bulk density of tropical peat should not be taken by using a small ring sampler but it should be done using a larger measurement unit. Sample of peat for chemical analysis should not be sieved but the whole sample should be crushed to smaller size. In characterizing tropical peat land, consideration of the whole ecosystem is as crucial as the intensive characterization of the peat materials.

ACKNOWLEDGMENTS

The authors wish to thank the consent of Center for Wetland Studies (CWS), Bogor Agricultural University and Japan Society for the Promotion of Science (JSPS) for their financial support to present this paper in the International Symposium on Land Management and Biodiversity in Bali, 17-20 September 2002.

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Recycle and Regeneration of Polysaccharide Resource by Biological Process

Hiroshi Tamura, Hideaki Nagahama, Hiroyuki Takano and Seiichi Tokura*
Faculty of Engineering, Kansai University and HRC, Suita, Osaka 564-8680, Japan

*Corresponding author; Seiichi Tokura
Tel : +81-6-6368-0868 Fax : +81-6-6330-3770
E-mail : stokura@ipcku.kansai-u.ac.jp

ABSTRACT

We have investigated to modify *Acetobacter xylinum*, one of bacteria to produce cellulose with high purity, by repeated subcultures in the medium containing several strange carbon sources. Several novel polysaccharides have been induced containing residual saccharides such as N-acetylglucosamine, carboxymethyl side chain and so on through repeated subcultures. A newly designed shallow pan cultivator with wind up roller to produce cellulose filament or membrane directly from the surface of culture medium enhanced the cellulose yield remarkably comparing with static or rotatory cultivation.

Key words : bacterial cellulose, polysaccharide, recycle, cultivation

INTRODUCTION

Cellulose, the most natural abundant polysaccharide, is known to be the most useful polymeric resource to human life. Though there are variety of forms of cellulose products depending on the demand from us, paper is the highest application among polysaccharide products. According to progress of human civilization and population, woods has become more important tool to keep various environments clean including conversion of carbon dioxide to oxygen. Recycle of cellulose is one of valuable participation to reduce the consumption of woods, especially the recycle of paper.

A bacterial reconstruction of cellulose would be one of ways among biological processes of cellulose recycle. Though bacterial cellulose (Brown, 1886) produced by *Acetobacter xylinum* is pure and has high mechanical properties, it is relatively strange to market due to high production cost. It would be possible to overcome the high production cost through the introduction of several functions during fermentation by repeated subcultures in the medium containing several strange carbon sources. The method, biological modification of bacteria, is based on the adaptability of bacteria and is much simpler and safer than the conventional gene manipulation methods (Kawano, 2001). Another way is reduction of procedures to obtain fibrous or membrane forms of cellulose. A newly designed shallow pan cultivator with wind up roller produces cellulose filament or membrane directly from the surface of culture medium. The present paper describes about production of several novel polysaccharides by the biological modification of bacteria, and of cellulose filament or membrane directly from the surface of culture medium using a newly designed shallow pan cultivator.

EXPERIMENTAL

Static Incubation

A wild type of *Acetobacter xylinum* ATCC 23769 strain was repeatedly subcultured at 28 ˚C in SH medium containing glucose as a carbon source (Hestrin, 1954), and repeatedly transferred to the new culture medium every 3 days. The pellicle formed after 7 days incubation was collected by filtration and 2% sodium dodecyl sulfate (SDS) aqueous solution was applied at boiling temperature for 3h. The pellicle was washed with water and boiled again in 4% NaOH solution for 1.5h. The whole procedure is schematically shown in Figure 1.

Shallow Pan Incubation

The pan was equipped with a winding roller and a bath of 2% aqueous SDS, as shown in Figure 2. The whole apparatus was set in a sealed chamber in which the temperature was maintained at 28 ˚C and filtered air was passed through the incubator. SH medium was added to the culture pans with a depth of the culture medium of 3-4 mm. The subcultured Acetobactor xylinum was inoculated in the medium under static condition at 28 ˚C. After 2 days of incubation, the edge of the pellicle produced on the surface was picked up to wind at a rate of 35-40 mm/h under 28 ˚C for a couple of weeks. The inside shape of the pan was specially designed to facilitate harvesting the thin gel smoothly to obtain filament. A membrane of the BC is capable of production by winding from the reverse side of the pan.

RESULTS AND DISCUSSION

We have investigated to modify *Acetobacter xylinum*, one of bacteria to produce cellulose with high purity, by repeated subcultures in the medium containing several strange carbon sources. Incorporation of amino-sugar residues has been successfully attained by incubation of the bacteria that had been subcultured repeatedly in a medium containing N-acetylglucosamine (GlcNAc) and glucose (Glc) or only GlcNAc as carbon source (Ogawa, 1992). The subculture of

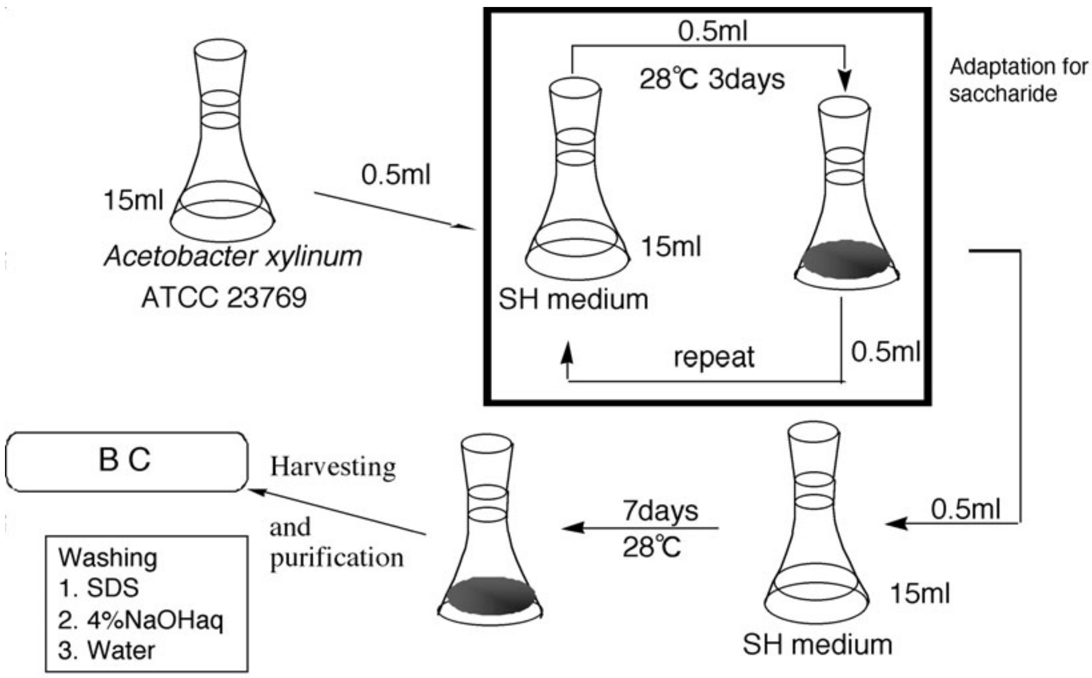

Figure 1. Subculture of *Acetobacter xylinum* in the medium containing several saccharides.

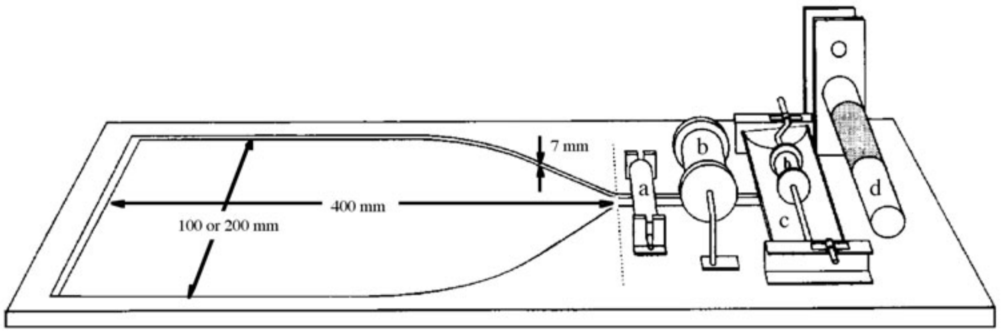

Figure 2. Outline of the culture pan for the direct filamentation of BC.
a, sinker; b, roller; c, washing pan; d, wind up roller.

bacteria was required in GlcNAc medium to form the pellicle containing GlcNAc. Since a similar degree of GlcNAc incorporation was found by employing media containing Glc and either galactosamine or glucosamine but not by mannosamine, the activation of transaminase was assumed to be route of metabolic cycle of the bacteria (Shirai, 1994). Several novel polysaccharides have been induced containing residual saccharides such as N-acetylglucosamine, carboxymethyl side chain and so on through repeated subcultures (Figure 3). The extent of the GlcNAc incorporation was best improved by the cultivation with partially hydrolyzed phosphoryl chitin (PHPC) probably by the fact that the intermediate substance for the biosynthesis of cellulose is believed to be a 6-phospho-glucose which is a similar substance for monomer of PHPC. The modified BC is expected to become a multifunctional polymer with both chitinous and cellulosic properties when N-acetylglucosamine residues are introduced into the BC main chain. The success of incorporation of carboxymethyl group cultivated with carboxymethyl cellulose (CMC) was striking since CMC, one of the waste polysaccharide from the agriculture and food industry, can be recycled and regenerated into different type of polysaccharide.

A shallow pan was devised to make thinner BC gel suitable for direct and continuous filamentation during the incubation of *Acetobacter xylinum* together with increase of yield. In a preliminary incubation under static conditions using a pan with 10 mm depth, thin BC gel was obtained on the surface of the culture medium, and gels were strong and elastic enough to pick up and manipulate. Taking the growth of the BC gel into account, the optimum rate of wind up was found to be around 40mm/hr for continuous filamentation. The thin BC gel was directly passed through a bath containing aqueous SDS solution to reduce the bacterial activity and then the filament was wound slowly on an attached roller to

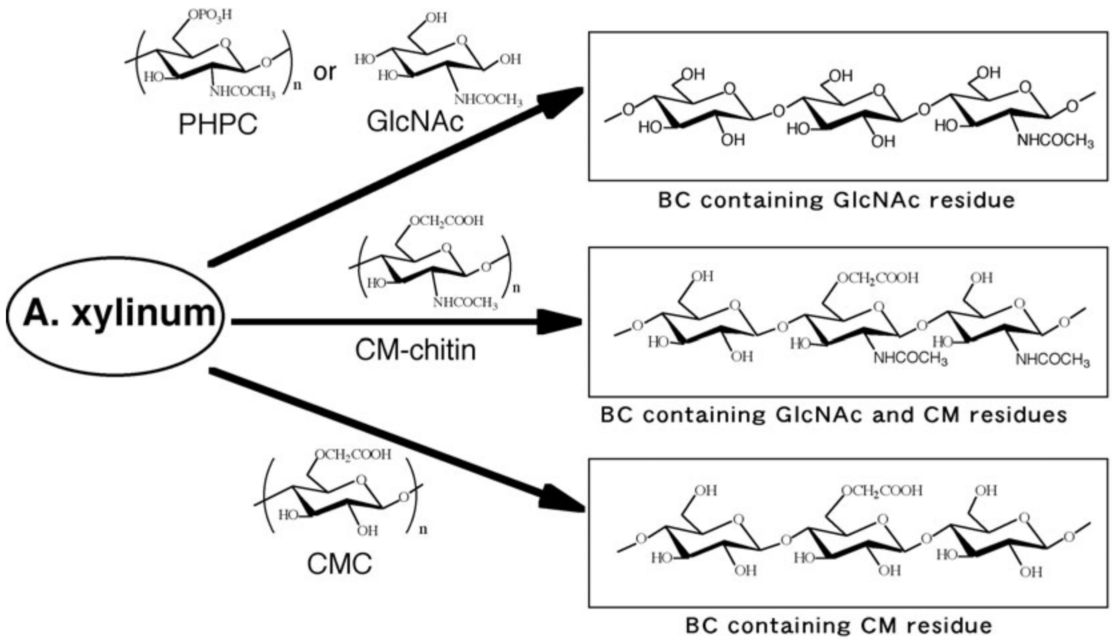

Figure 3. Several novel polysaccharides produced by the repeated subculture containing several sugar sources.

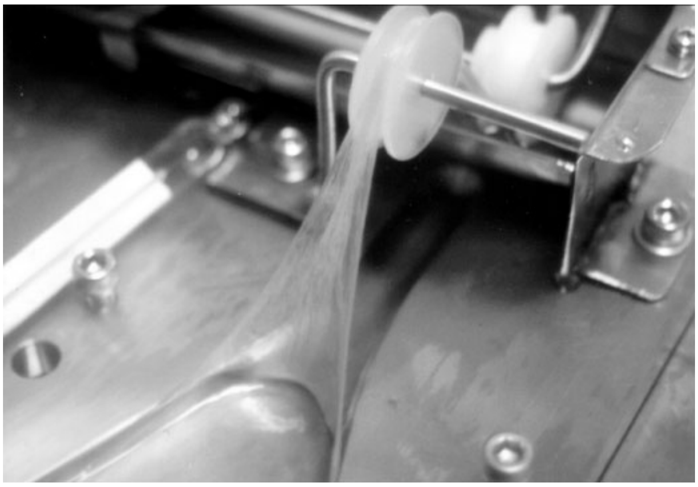

Figure 4. Direct filament preparation of BC by shallow pan

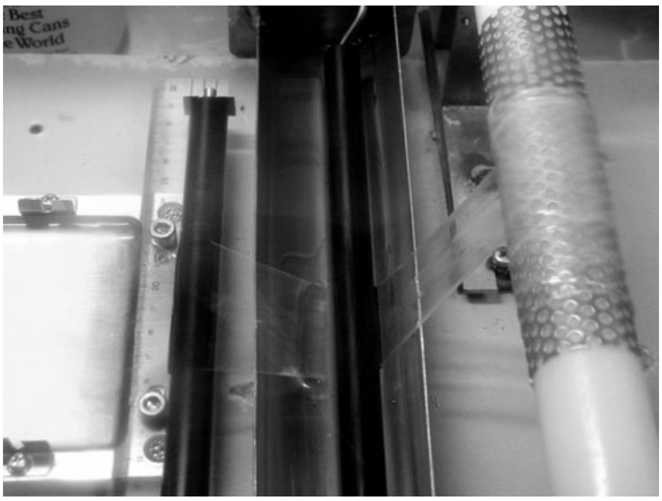

Figure 5. Direct membrane preparation of BC by shallow pan cultivator.

give filament (Figure 4). To maintain the depth of the culture medium, SH medium was supplied in increments during the incubation, without further addition of bacteria. From the width of 100 mm pan, a filament of more than 5 m length was obtained by winding-up at a rate of 16 mm/h for 14 days. When the pellicle was wind up from the reverse side of the pan, bacterial cellulose was wind up as a membrane applying the same way to the filament (Figure 5). The Figures show that the filament and membrane was stretched enough during the wind up process. This stretching process might bring strengthen the product by the orientation of cellulose molecule.

Figure 6 shows the yield of bacterial cellulose produced by shallow pan method comparing the conventional methods. The yield of bacterial cellulose produced by shallow pan method was superior to that by conventional static and rotatory methods. The increase of yield on shallow pan cultivation seems to be due to the freshness of medium by stepwise addition of medium. Sufficient air supply is also one of major factors in regulating yield, because a fresh surface is served every time on the shallow pan cultivation due to wind up the product.

CONCLUSION

The biomodification of bacterial cellulose would be favorable way both to give new function and to simplify the modification process in addition to environmentally clean process. On the way to reconstruct of cellulose applying *Acetobacter xylunum* and aminosugars instead of glucose, *Acetobacter xylunum* was found to incorporate the N-acetyl-glucosamine (GlcNAc) residues into cellulosic main chain following to repeated subculture

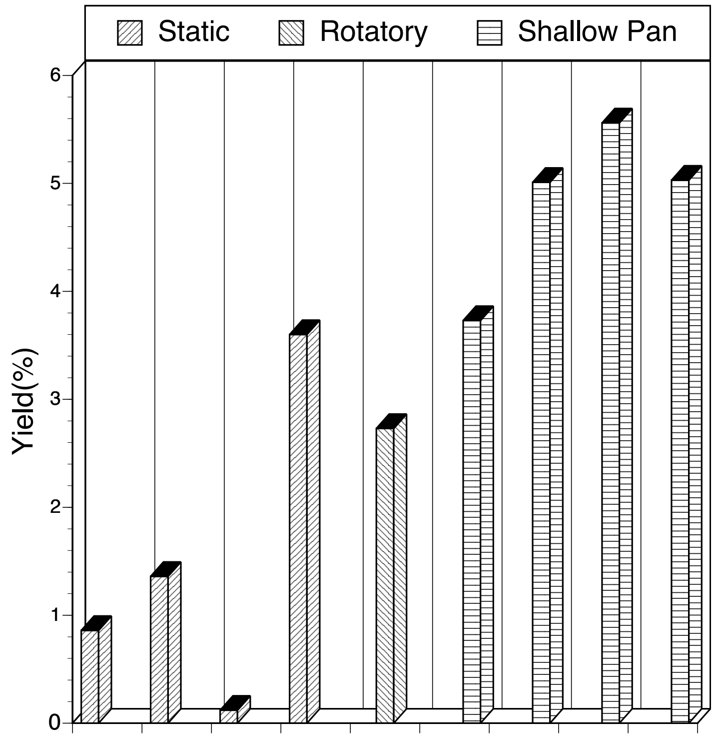

Figure 6. Yield of bacterial cellulose produced by shallow pan method comparing the conventional methods.

in the medium containing GlcNAc, glucosamine (GlcN) or galactosamine (GalN). Since similar level of GlcNAc incorporation was observed as that by GlcNAc, GlcN or GalN, above assumption might be confirmed to find a new enzyme system such as transamidase. Our design of a simple and direct fabrication system for the production of bacterial cellulose is the first such procedure to be reported in the literature. These simplified methods for producing and harvesting bacterial cellulose are expecting to lower the production cost of bacterial cellulose together with the basic research for the orientation of cellulose molecule.

ACKNOWLEDGEMENTS
A part of this research was financially supported by the Grant-in-Aid for Scientific Research (14593007).

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ADDITIONAL PAPER

Impact of the El Niño 1997-1998 on the Growth of Abundant Tree Species Grown in Peat Swamp and Heath Forests of Central Kalimantan

Herwint SIMBOLON
Research Center for Biology, Indonesian Institute of Sciences
Jalan Raya Juanda 22, Bogor-INDONESIA
E-mail address: herbolon@indo.net.id

ABSTRACT

A 1-ha plot was established at each of peat swamp and heath forests in Lahei, Central Kalimantan in early dry season July 1997. Both plots were then re-measured in the early rainy season of February 1998, then in August 1998 and May 1999. The periods between July 1997 and February 1998 were known as the long dry season in Kalimantan area caused by ENSO (El Niño Southern Oscillation). The impact of El Nino 1997-1998 on the growth rate and mortality of abundant tree species grown in both forest types of studied plots were then examined by comparing the results of measurements during July 1997-February 1998 (El Niño periods), February-August 1998 (recovery period) and August 1998-May 1999 (regular growth period). The growth rate of trees during the El Nino 1997-1998 period is lower than of during the recovery period and the regular growth period of both plots in the heath and peat swamp forest types. The growth rate during the similar period of measurements at the heath forest is lower than of at the peat swamp forest. Many species grown in the heath forest (such as: *Cotylelobium burckii*, *Dipterocarpus* sp., *Shorea platicarpa* and *S. retusa;* those are Dipterocarpaceae) and some species (such as: *Semecarpus* sp., *Buchanania sessifolia*, *Tetractomia obovata*) in the peat swamp forest performed minus growth rates during the El Nino 1997-1998 periods, but no minus growth rate during the recovery and regular annual growth periods. Minus growth rate indicates that diameter of trees at the end of dry season in February 1998 were lower than the tree diameter of the previous measurement in the early dry season in July 1997, because of tree barks are shrinkage during the dry periods due to El Niño. Although some trees performed minus growth rates, no significant impact of El Nino 1997-1998 have been detected on the mortality rate of trees in both forest types.

INTRODUCTION

Winarso (1999) had summarized the history of ENSO (El Niño Southern Oscillation) and wildfire in Indonesia since 1888. Goldammer and Seibert (1989, 1990) also have studied the evidence of ancient wildfires in East Kalimantan that occurred between ca. 17,510 and ca. 350 BP. Although no enough data have been reported on the occurrence of long dry season caused by ENSO during the periods between 350 BP and 1888 as in both reports, there was an indication that the cycle period of ENSO is getting closer and closer. The cycle periods of ENSO in Indonesia became more important since those of recently noted long dry seasons due to the ENSO complex have been known as the main causes of wildfires in Indonesia, and wildfires have been accounted as the main threat to the biodiversity in the last two decades (Lennertz & Panzer, 1984; Wirawan 1993; Simbolon, 2000).

A few studies have been done on measuring the impact of wildfires on the biodiversity (such as Riswan & Yusuf, 1986; Riswan *et al.*, 1984; Ngakan, 1999; Simbolon *et al.*, 2000), but not much data have been reported on the impact of long dry season on the growth of tree plants in the forest. Simbolon *et al.*, (2001) reported that forest fires 1997-1998 gave great impact on the destruction of structure and composition of a mixed dipterocarp forests by burnt out about 36 to 70% individuals of forest trees and reduced about 45 to 85% of total basal areas and in turn, reduced tree canopy coverage about 23 to 79%. The dry season and wildfires were also reduced the number of species, genus and families about 23 to 79%, 53 to 66% and 18 to 21%, respectively. They also noted an indication that long dry season of 1997-1998 episodes caused 12.02% mortality of individual of trees in MDF due to desiccation, or about 21.67% loss of total basal areas. The present paper intends to report the impact of long dry season of 1997-1998 on the growth and mortality of the most abundant tree species grown in heath and peat swamp forests in Central Kalimantan.

METHODS

STUDY SITES

In August 1997, two of 1-ha permanent plots were established in about 3-4 km east of the recent settlement Kampung Babugus, Desa Lahei, Kecamatan Mentangai, Kabupaten Kapuas, about 2 hours by car from Palangkaraya, the capital of Central Kalimantan Province (Fig 1). One plot was established in a heath (*kerangas*) forest and another in a peat swamp forest type, in the river bank of Mangkutup River, a branch of Kapuas River. The common species in heath forest were consisted of *Cotylelobium lanceolatum, Dryobalanops rappa* (Dipterocarpaceae) and *Palaquium leiocarpum* (Sapotaceae, also distributed in peat swamp forests). While *Semecarpus longifolius*, *Buchanania sessifolia* (Anacardiaceae) and *Shorea balangeran* (Dipterocarpaceae) mainly dominated the canopy layer of peat swamp forests along the riverbank. *Vatica oblongifolia* (Dipterocarpaceae) was also a common species, though it rarely became canopy trees. Number of species, density and basal areas of trees with diameter at breast height more than 5 cm in a 1-ha plot of the peat swamp forest were 70, 1590, and 45.6m^2, and in the heath forest were 150, 2130 and 31.2m^2, respectively (Suzuki *et al.*, 1999).

During the August 1997 field study, the disturbed heath forests along the road were almost entirely burnt out, while the peat-swamp forests were remaining unburned until December 1999.

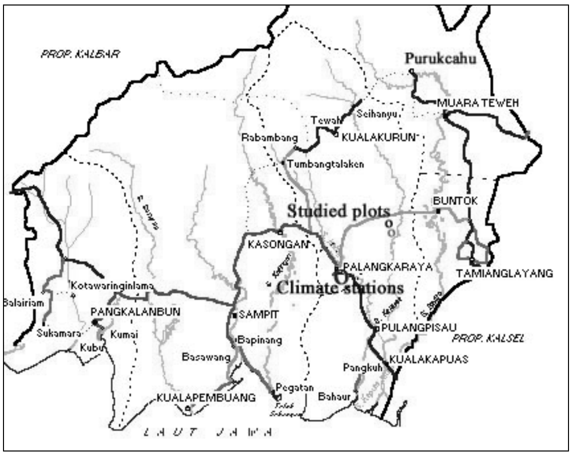

Figure 1. Location of study sites within the map of Central Kalimantan province (**o**: peat swamp forest and **o**: heath forest) and climate stations (**o**: at Palangkaraya).

CLIMATE STATION

The data on the rainfall and temperature presented in this paper are based on the collected data from the micro climate station at the Palangkaraya Airport area and also micro climate stations that had been set up by Dr. H. Takahashi at the campus of Palangkaraya University, both stations were located in Palangkaraya city (capital of Central Kalimantan province) about 80km away from the study site (Fig 1). Palangkaraya and both micro climate stations are the nearest city and micro climate stations from the study site.

METHODOLOGY

In August 1997 a 1-ha permanent plot (100 m by 100 m) was established in each of heath and peat swamp forest types in Desa Babugus, Lahei, Central Kalimantan. The 1-ha plot was divided into 100 sub-plots of 10 x 10 m^2. All trees with stem girth more than 15 cm at 130 cm above the ground (*gbh*) were individually numbered with aluminum tag, mapped the position in the plot, identified to species, measured *gbh* and tree height. Initial census was completed just before the dry season started in August 1997. Most of Kalimantan areas have no dry month; however, in 1997 the dry season in Central Kalimantan was started in June and extended until December 1997 due to El Niño cycle, while some areas remain dry until March 1998 and during these long dry periods many forest areas especially in Kalimantan were burnt. These plots were then re-measured in the early rainy season of February 1998, August 1998 and May 1999.

In this study, tree growth between two periods of measurements in August 1997 and February 1998 were accounted to represent the growth of trees that affected by long dry season due to El Niño 1997-1998 and named then as El Niño period (codes as dry in the figures). The period between the measurements in February and August 1998 was accounted to present the tree recovery growth after long dry season, named then as recovery period (wet in the Figures) and the growth between August 1998 and May 1999 was accounted to present the regular annual growth of trees, named then as regular growth period (after in the Figures) of both forest types.

The impact of El Niño on the abundant tree species within both forest types will be measured by comparing the relative growth rate (*rGR*) and mortality rate (m) of those trees within both plots during the El Niño period, the tree recovery period and the regular tree growth period. The growth rate of species was analyzed based on the trunk diameter change per year and mean relative growth rate (*rGR*) and was calculated based on equation as explained in Kohyama & Hotta (1986) and Simbolon *et al.* (2000). The mortality rate during the similar time periods of the *rGR* will be analyzed by formula as in Sheil *et al.* (1995) and Simbolon *et al.* (2000). Both rGR and mortality growth will also be discussed in relation to the rainfall and mean temperature recorded during these three time periods of growth.

RESULTS

MICROCLIMATE (temperature, rainfall and rain days)

As for the other areas in Kalimantan, starting from June 1997, the climate of Central of Kalimantan also was affected by El Niño Southern Oscillation (ENSO) that caused dry months in the area. Rainfall of Palangkaraya areas were about 256mm in May, but then dropped to almost zero in June, and continue low until November 1997 but then rainfalls were increase to about 400 and 140mm in December 1997 and January 1998, respectively and dropped again in February to March 1998 (Fig 2). The mean monthly temperatures in the area also show a great increase in August 1997, while other months showed no drastically changes.

DIVERSITY AND ABUNDANT TREE SPECIES WITHIN THE PLOTS

There were 152 species (12 species were Dipterocarpaceae) and 72 species (4 species Dipterocarpaceae) within the plots of heath and peat swamp forest types, respectively. Fisherherrs" α of diversity index in the heath forest is 38 and in the peat swamp forest is 16. Three main species based on the total basal areas in heath forest types were: *Cotylelobium burckii*, *Shorea teysmannii* (Dipterocarapaceae) and *Callophyllum* sp. (Guttifeare); and three main species in peat swamp forest were: *Semecarpus* sp. (Anacardiaceae), *Shorea balangeran* (Dipterocarapaceae) and *Buchanania sessifolia*

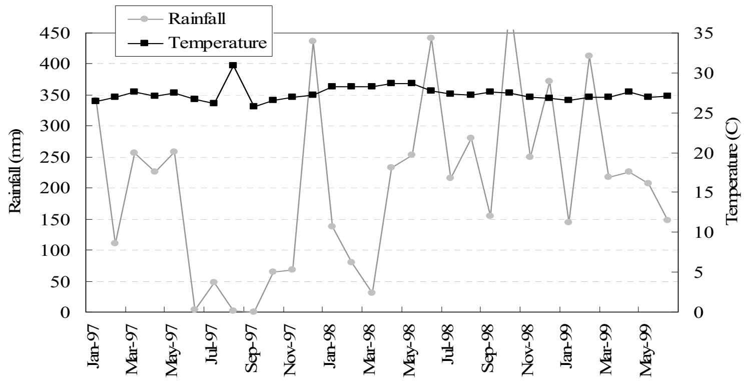

Figure 2. Mean monthly rainfalls and temperature distributions during January 1997 and June 1999 at Palangkaraya city, Central Kalimantan.

Table 1. Number of individuals (NI) and basal areas (BA, m2/ha) of each species in the heath forest during study periods.

Fam	Species	Jul-97		Feb-98		Aug-98		May-99		Aug-99	
		NI	BA	NI	BA	NI	BA	NI	BA	NI	BA
Dipt	Cotylelobium burckii	108	4.45	107	4.40	105	4.16	89	3.38	88	3.26
Dipt	Shorea teysmanniana	58	1.91	54	1.89	52	1.85	48	1.77	48	1.79
Dipt	Shorea platycarpa	43	1.26	41	1.24	41	1.25	40	1.25	40	1.27
Dipt	Hopea dryobalanoides	163	0.87	162	0.87	161	0.88	144	0.81	141	0.81
Dipt	Vatica umbonata	14	0.78	12	0.78	12	0.77	12	0.78	12	0.79
Dipt	Shorea (K11426)	5	0.47	4	0.45	3	0.21	2	0.21	2	0.21
Dipt	Dipterocarpus (K11384)	12	0.35	12	0.35	12	0.35	12	0.36	12	0.36
Dipt	Dipterocarpus borneensis	27	0.34	27	0.34	27	0.35	26	0.35	26	0.36
Dipt	Shorea retusa	34	0.34	33	0.34	31	0.24	29	0.24	29	0.24
Dipt	Vatica (K11445)	10	0.11	9	0.11	9	0.11	8	0.11	8	0.11
Dipt	Cotylelobium melanoxylon	1	0.06	1	0.06	1	0.06	1	0.07	1	0.07
Dipt	Vatica sarawakensis	3	0.02	3	0.02	3	0.02	3	0.02	3	0.02
Gutt	Calophyllum [bintangor]	180	1.89	177	1.86	166	1.72	138	1.19	128	1.02
Arau	Agathis borneensis	26	1.35	18	0.40	18	0.40	15	0.37	15	0.37
Jugl	Engelhardia serrata	12	1.09	11	0.69	11	0.69	8	0.45	8	0.46
Myrt	Syzygium klosii cf.	79	0.94	77	0.93	76	0.93	75	0.94	73	0.94
Myrt	Tristania obovata	55	0.87	53	0.85	51	0.81	46	0.72	43	0.69
Legu	Sindora coriacea	77	0.84	77	0.84	76	0.83	73	0.83	70	0.71
Gutt	Garcinia rostrata	87	0.74	84	0.72	81	0.70	70	0.64	68	0.64
Gutt	Calophyllum pulcherrimum	91	0.72	88	0.71	82	0.63	74	0.62	68	0.55
Gutt	Calophyllum [kapur naga]	6	0.62	6	0.59	5	0.52	5	0.54	5	0.54
Anno	Anno (K11443)	13	0.58	13	0.58	10	0.50	7	0.31	5	0.24
Sapo	Palaquium leiocarpum	22	0.42	22	0.42	22	0.42	22	0.44	22	0.46
Thea	Ternstroemia aneura	35	0.38	35	0.37	33	0.37	26	0.31	24	0.29
Sapo	Palaquium sp.	22	0.37	20	0.35	20	0.35	19	0.32	17	0.29
Myrt	Eugenia [kayu raras]	54	0.34	53	0.33	53	0.33	51	0.32	51	0.32
Anac	Campnosperma (K11347)	12	0.32	9	0.32	9	0.32	8	0.31	7	0.23
Rubi	Rubi (K11459)	24	0.31	23	0.29	20	0.24	15	0.20	13	0.15
Eben	Diospyros pilosanthera cf.	13	0.31	13	0.30	13	0.30	13	0.30	12	0.30
	Other species	844	8.19	786	7.75	768	7.56	693	7.17	662	6.99
	Total	2130	31.22	2030	29.15	1971	27.88	1772	25.34	1701	24.49

(Anacardiaceae). However, the most abundant tree species in the heath forest were *Callophyllum* sp. (**bintangor**, Guttiferae), followed by *Hopea dryobalanoides* and *Cotylelobium burckii* (Dipterocarpaceae). In the peat swamp forest type the most abundant tree species were *Vatica* sp. (Dipterocarapaceae), followed by *Semecarpus* sp. (**umpa**, Anacardiaceae), *Tetractomia obovata* (Rutaceae) and *Buchanania sessifolia* (Anacardiaceae), see Table 1 and 2. Both Tables also indicate the number of individual and total basal areas changes of each species during the monitoring periods.
study periods.

Table 2. Number of individuals (NI) and basal areas (BA, m2/ha) of each species in the peat swamp forest during the study periods.

Fam	Species	Jul-97		Feb-98		Aug-98		May-99		Aug-99	
		NI	BA	NI	BA	NI	BA	NI	BA	NI	BA
Dipt	Shorea balangeran	24	8.33	23	8.25	23	8.26	23	8.28	23	8.29
Dipt	Vatica (K11508)	237	2.13	235	2.13	232	2.12	225	2.10	226	2.15
Dipt	Shorea platycarpa	1	0.06	1	0.06	1	0.06	1	0.06	1	0.07
Dipt	Cotylelobium melanoxylon	3	0.01	3	0.01	3	0.01	3	0.01	3	0.01
Anac	Semecarpus [umpa]	161	8.91	159	8.90	156	8.83	148	8.63	146	8.78
Anac	Buchanania sessifolia	147	6.30	145	6.29	139	6.27	131	5.89	128	5.42
Sapo	Madhuca sericea cf.	127	4.58	127	4.61	127	4.64	127	4.67	126	4.63
Ixon	Ixonanthes reticulata	12	1.66	12	1.89	12	2.13	11	2.08	11	2.08
Chry	Parastemon urophyllus	6	1.53	6	1.53	6	1.54	6	1.54	5	1.44
Ruta	Tetractomia obovata cf.	150	1.32	145	1.28	136	1.22	116	1.03	112	1.04
Myrt	Syzygium (K11600)	21	1.26	21	1.24	21	1.25	20	1.24	19	1.22
Anac	Anac [Rengas manuk]	32	1.23	30	1.20	29	1.20	26	1.08	26	1.09
Eben	Diospyros evena	25	0.97	25	0.96	25	0.97	24	0.99	24	1.00
Euph	Cleistanthus (K11560)	52	0.90	52	0.90	45	0.74	38	0.68	32	0.49
Anac	Semecarpus [katiau jangkar]	7	0.69	7	0.69	7	0.70	6	0.67	6	0.68
Eben	Diospyros bantamensis	26	0.58	26	0.58	26	0.59	24	0.58	25	0.59
Cela	Lophopetalum beccarianum	6	0.39	6	0.37	6	0.38	6	0.37	6	0.38
Meli	Sandoricum beccarianum	10	0.38	9	0.38	9	0.38	9	0.39	9	0.32
Gutt	Calophyllum [marutan] long	47	0.33	46	0.32	45	0.33	44	0.33	44	0.34
Anno	Goniothalamus malayanus	35	0.30	32	0.29	29	0.22	26	0.21	24	0.21
Legu	Dialium (K11539)	16	0.28	16	0.28	16	0.28	16	0.29	15	0.29
Gutt	Calophyllum pulcherrimum	24	0.26	23	0.22	23	0.22	22	0.22	21	0.22
Tili	Pentace borneensis	19	0.25	19	0.26	18	0.25	18	0.25	16	0.24
Legu	Legu (K11385)	43	0.24	43	0.24	42	0.24	41	0.24	38	0.19
Myri	Knema (K11331)	13	0.21	13	0.21	13	0.21	12	0.20	12	0.20
Eben	Diospyros hermaphroditica	3	0.19	3	0.19	3	0.19	2	0.12	2	0.12
Myrt	Syzygium chlorantha cf.	32	0.18	32	0.18	29	0.13	29	0.13	29	0.13
Anno	Anno [kambalitan]	40	0.17	40	0.17	38	0.17	37	0.17	35	0.16
Burs	Canarium <Kerowin>	12	0.17	12	0.17	12	0.17	12	0.17	12	0.17
Mela	Pternandra coerulescens	4	0.15	4	0.15	4	0.15	3	0.06	3	0.06
Olea	Chionanthus (K11571)	21	0.15	18	0.13	19	0.13	15	0.08	14	0.08
Sapi	Nephelium maingayi cf.	18	0.15	17	0.13	17	0.13	16	0.14	15	0.14
Eben	Diospyros confertiflora cf.	22	0.14	22	0.14	22	0.14	21	0.13	19	0.11
Icac	Stemonurus secundiflorus	12	0.11	12	0.11	10	0.11	10	0.11	10	0.11
Gutt	Garcinia (K11554)	12	0.11	12	0.11	11	0.10	11	0.11	10	0.09
	Other species	170	0.98	167	0.95	162	0.93	149	0.89	138	0.82
	Total	1590	45.61	1563	45.52	1516	45.41	1428	44.15	1385	43.34

Impact of El Niño on the growth rate and mortality

Impact of the El Niño 1997-1998 on the growth of some selected species in the heath forest and peat swamp forest types are summarized in Figures 3 and 4, respectively. In heath forest types, mean growth rate (rGR) of tree species within the plot during July 1997-February 1998 (dry, El Niño period) was negative, the rGR during February-August 1998 (wet, recovery period) and August 1998-May 1999 (after, regular growth period) were positives, but the rGR of the regular growth periods (after) is much higher than of in recovery periods (wet). When the rGRs of each species were verified in more detail, various impacts were performed among species. Species *Horsfieldia crassifolia* (Hcra) for example has positive rGR during the El Niño periods and even higher than of during the recovery period. In the other hand, *Lithocarpus* sp. has negative rGR during the El Niño periods but the rGR during the recovery period and the regular growth period were similar, see Figure 3 for other species.

Unlike in heath forest type, in peat swamp forest type, mean growth rates (rGR) of tree species within the plot during the three periods of measurement were positive, but the rGR during the El ño period is lower than of during the other two periods of measurements. As in the heath forest types, some species were also performed negative relative growth rates during the periods of El Niño (dry), especially on *Syzygium* sp., *Diospyros bantamensis*, *Diospyros evena*, *Dialium* sp., etc. In both forest types, the growth rate (rGR) of tree plants during August 1998-May 1999 (after) that presented the regular annual growth rate were always higher than of during the El Niño period and the recovery periods that occurred soon after the El Nino periods (Figure 4). The specific impact of the El Nino 1997-1998 on the growth and mean annual growth of trunk diameter of some Dipterocarpaceae species within both forest types are also presented in Table 3.

The mortality rates of plants within both plots were analyzed by applying formula of Sheil *et al.* (1995) onto the number of individuals in Tables 1 and 2. In heath forest, the mortality rate of plants during the El Niño period (July 1997-February 1998) was higher than of during the recovery period (February-August 1998), however the rate was lower than of in the next two other period measurements (August 1998-August 1999). In the peat swamp forest however, the mortality

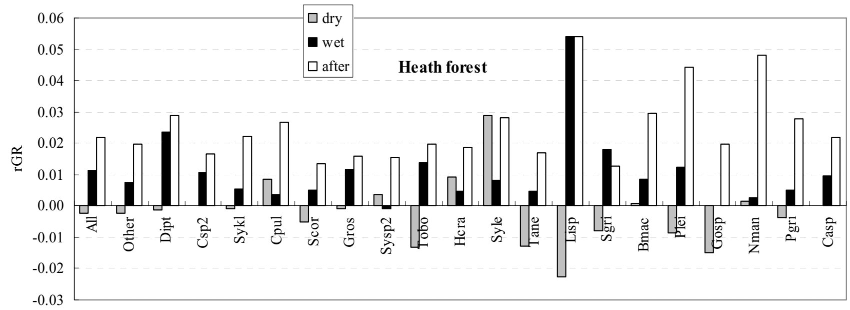

Figure 3. Growth rates of some tree species in the heath forest type during long dry season July 1997-Februari 1998 (dry); February- August 1998 (wet) and regular growth rate August 1998-Mei 199 (after). All: all species; Other: all species except species of Dipterocarpaceae (Dipt); Csp2: Calophyllum sp.; Sykl: *Syzygium klosii*; Cpul: *Callophyllum pulcherrimum*; Scor: *Sindora coriacea*; Gros: *Garcinia rostrata*; Sysp2: *Syzygium* sp.; Tobo: *Tristania obovata*; Hcra: *Horsfieldia crassifolia*; Syle: *Syzygium lepidocarpa*; Tane: *Tristania aneura*; Lisp: *Lithocarpus* sp.; Sgri: *Santiria graffithii*; Bmac: *Baccaurea macrocarpa*; Plei: *Palaquium leiocarpum*; Gosp: *Goniothalamus* sp.; Nman: *Nephelium maingayi*; Pgri: *Pimelodendron griffithianum*; Casp: *Canarium* sp.

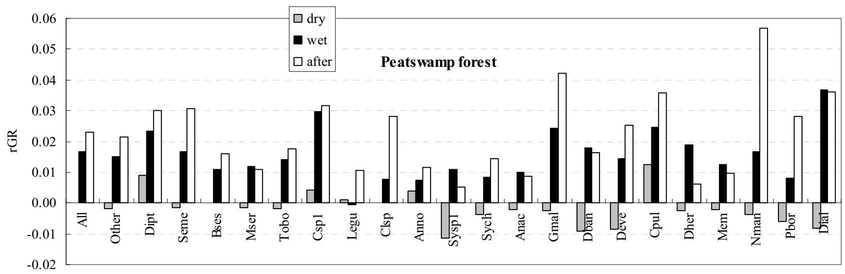

Figure 4. Growth rates of some tree species in the peat swamp forest type during long dry season July 1997-Februari 1998 (dry); February- August 1998 (wet) and regular growth rate August 1998-Mei 199 (after). All: all species; Other: all species except species of Dipterocarpaceae (Dipt), Seme: *Semecarpus* sp.; Bses: *Buchanania sessifolia*; Mser: *Madhuca sericea*; Tobo: *Tetractomia obovata*; Csp1: *Calophyllum* sp.; Clsp: *Cleistanthus* sp.; Sysp1: *Syzygium* sp.; Sych: *Syzygium chlorantha*; Gmal: *Goniothalamus malayanus*; Dban: *Diospyros bantamensis*; *Diospyros evenia*; Cpul: *Calophyllum pulcherrimum*; Dher: *Diospyros hermaphroditica*; Mem: *Memecylon* sp.; Nman: *Nephelium maingayi*; Pbor: *Pentace borneensis*; Dial: *Dialium* sp..

rate of plants during the El ño periods was lower than of in the recovery periods and in the next two other period of measurements.

DISCUSSION

Fisher indices of diversity in both forest types (38 in the heath and 16 in the peat swamp forests) were relatively low compare to the indices of mixed dipterocarp forest in West Kalimantan (105-131). These diversity indices were just equal with sub-mountain and mountain forests (35 and 10, respectively) in West Java (see Suzuki *et al*., 1997). Number of Dipterocarp species in the heath forest type (12 species in 1ha plot) is slightly lower, but the Dipterocarp species of the peat swamp forest was much lower than in a mixed dipterocarp forest in Bukit Bangkirai, East Kalimantan (16 species, Simbolon, unpublished data). Low indices of species diversity, even for species of Dipterocarpaceae that commonly distributed in the lowland forest of Kalimantan, and the lower value of total basal areas especially in the heath and peat swamp forests indicated a severe condition of the both forest types for tree species to grow. The forest environment will much more severe when drought also takes place in both areas.

The long dry season due to the El Niñcycle in 1997-1998 in Central Kalimantan decrease the mean monthly precipitation even into 0 mm in June 1997 and increased the mean daily temperature up to 32^{o}C. The dry month condition was prolonged until March 1998 although normally, almost no dry month (precipitation of less than 60 mm) in Central Kalimantan. During the dry months due to El Niño, the water table in soil was drastically dropped while litter falls and other organic materials on the forest floor were dried and make it fragile to the forest fire. The dried condition was much

Table 3: Growth rate (rGR) and mean annual growth of tree diameter (delta D, cm/year) of Dipterocarp species in the heath and peat swamp forest types of study sites.

Sp code	Species	N	DBH-Jul 97 (cm)			N of trees with rGR			Mean rGR			delta D (cm/year)		
			mean	min	max	zero	plus	minus	dry	wet	after	dry	wet	after
	L-1(heath forest)													
Cbur	Cotylelobium burckii	86	18.93	4.97	46.12	8	30	48	-0.0048	0.0095	0.0140	-0.110	0.150	0.210
Cmel	Cotylelobium melanoxylon	1	28.43	28.43	28.43	0	1	0	0.0179	0.0351	0	0.100	0.500	1.030
Dsp.	Dipterocarpus sp. (K11384)	12	12.09	4.77	60.29	1	6	5	-0.0111	0.0392	0.0241	0.018	0.309	0.246
Dbor	Dipterocarpus borneensis	25	10.04	4.90	29.41	7	9	9	0.0070	0.0251	0.0356	0.024	0.180	0.288
Hdry	Hopea dryobalanoides	142	7.58	4.77	20.18	28	68	46	0.0021	0.0400	0.0573	0.013	0.257	0.423
Ssp.	Shorea sp. (K11426)	2	28.85	5.03	52.68	0	0	2	-0.0272	0.0184	0.0062	-1.163	0.353	0.127
Spla	Shorea platycarpa	40	18.21	5.09	38.71	3	11	26	-0.0071	0.0147	0.0279	-0.161	0.175	0.347
Sret	Shorea retusa	29	8.26	4.93	32.88	4	16	9	-0.0018	0.0175	0.0535	-0.022	0.083	0.375
Stey	Shorea teysmanniana	48	17.82	4.93	63.88	5	25	18	0.0018	0.0111	0.0239	0.019	0.119	0.278
Vsp1	Vatica sp. (K11445)	8	11.22	4.97	24.80	1	3	4	0.0029	0.0258	0.0244	0.055	0.136	0.192
Vsar	Vatica sarawakensis	3	7.53	5.12	11.78	1	2	0	0.0125	0.0227	0.0390	0.085	0.202	0.339
Vumb	Vatica umbonata	12	23.37	5.44	62.13	1	8	3	0.0128	0.0027	0.0081	0.154	-0.114	0.168
	L-2 (peat swamp forest)													
Cmel	Cotylelobium melanoxylon	3	5.95	4.74	6.75	1	1	1	-0.0032	0.0655	0.0240	-0.023	0.383	0.116
Sbal	Shorea balangeran	23	55.14	13.50	100.20	3	9	11	0.0007	0.0026	0.0022	0.128	0.110	0.099
Spla	Shorea platycarpa	1	27.69	27.69	27.69	0	1	0	0.0058	0.0115	0.0136	0.170	0.320	0.370
Vsp2	Vatica sp. (K11508)	226	9.32	4.42	48.96	27	133	66	0.0098	0.0250	0.0329	0.063	0.214	0.287

more severe in the heath forest than in the peat swamp forest since the soils of the heath forest were consisted of porous sand while peat swamp forests were consisted of inundated un-decomposed organic matters. During the long dry season 1997-1998 about 9.5 million ha of Indonesian forest were burnt out, including 0.8 million ha peat swamp forests and 1.7 million ha other forest types, but mostly lowland forests (ADB, 1999). These long dry season and forest fires were noted to decrease the quality of environment, forest structure and biodiversity loss (Riswan *et al.*, 1984; Riswan & Yusuf, 1986, Tagawa *et al.*, 1988, Ngakan, 1995, Simbolon *et al.*, 2001, Siregar *et al.*, 2002).

El Niño 1997-1998 periods caused the forests became fragile to fires and also affect the physiological process of tree forest, characterized by negative relative growth rates of almost all trees within the plots in the heath and peat swamp forests. The mean diameter of trees in both forest types were decreased during the El Niño period because of tree barks are shrinkage. Most of the trees in tropical rain forests were not adapted to water shortage such as deciduous trees in monsoon areas which are adapted to drought by dropping out all the leaves simultaneously during dry season. In that condition, trees reduced the evaporation and hence its physiological activities which in turn the tree diameter growth may stagnant. However, trees of the heath and peat swamp forests were not adapted to such pattern but remain bare it leaves even in long dry season makes the tree evaporation is higher than water absorption, consequently water loss or biomass shrinkages may occurred. The severe water loss of a tree might also caused the mortality of the tree due to desiccation as has been observed in some trees in the lowland forests of Bukit Bangkirai, East Kalimantan areas in the end of El Niño 1997-1998 period (Simbolon *et al.*, 2001)

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International Symposium on Land Management and Biodiversity in Southeast Asia
Bali, Indonesia, September 17-20, 2002

List of Participants

No.	Name	Affiliation	Country
1	Adi Jaya	Nottingham University	United Kingdom
2	Adi Susmianto	Director, Department of Forestry	Indonesia
3	Afrida	R&D for Biology, LIPI	Indonesia
4	Ahmad Diran	Deputy Governor of Central Kalimantan Province	Indonesia
5	Ahmad Kurnain	Gadjah Mada University	Indonesia
6	Akifumi Ohtaka	Hirosaki University	Japan
7	Akio Mori	Hokkaido University	Japan
8	Akira Haraguchi	Kita Kyusyu University	Japan
9	Alejhandro A. Chinen	Hokkaido University	Japan
10	Andrew Alek Tuen	Universiti Malaysia	Malaysia
11	Ardianor	Palangka Raya University	Indonesia
12	Arie Budiman	Head, Reseach Center for Biology, LIPI	Indonesia
13	Ariyanti Oetari	University of Indonesia, Culture Collection	Indonesia
14	Aswin Usup	Hokkaido University	Japan
15	Asyraf Bin Mansor	Universiti Sains Malaysia	Malaysia
16	Atit Kanti	R&D for Biology, LIPI	Indonesia
17	Awalina Satya	Limnology, LIPI	Indonesia
18	Bambang Setiadi	Director, BPPT	Indonesia
19	Basuki Sumawinata	Bogor Agricultural University	Indonesia
20	Bismart Ferry Ibie	Hokkaido University	Japan
21	Bostang Radjagukguk	Gadjah Mada University	Indonesia
22	Clara M. Kusharto	Bogor Agricultural University	Indonesia
23	Daisy Irawan	Bogor Agricultural University	Indonesia
24	Darmawan	Bogor Agricultural University	Indonesia
25	Dede Irving Hartoto	Limnology, LIPI	Indonesia
26	Dewi M. Prawiradilaga	Biology, LIPI	Indonesia
27	Djamhuriyah Said	Limnology, LIPI	Indonesia
28	Dwi Astuti	Hokkaido University	Japan
29	Edi Mirmanto	R&D for Biology, LIPI	Indonesia
30	Eko Baroto Waluyo	R&D for Biology, LIPI	Indonesia
31	Eko Yulianto	Hokkaido University	Japan
32	Emmy U. Antang	Bogor Agricultural University	Indonesia
33	Endang Sukara	Deputy Chairman for Life Sciences, LIPI	Indonesia
34	Erry Purnomo	Center for Tropical Acid Soils Studies, South Kalimantan	Indonesia
35	Evi Veronica	University Palangka Raya	Indonesia
36	Fifi Widjaja	Bogor Agricultural University	Indonesia
37	Gadis Sri Hariyani	Limnology, LIPI	Indonesia

38	Gunawan Dajajakirana	Bogor Agricultural University	Indonesia
39	Gusti Zulkifli Mulki	Universitas Tanjungpura	Indonesia
40	Hajime Yamaguchi	Foundation River Environment Management	Japan
41	Hanny Wijaya	Bogor Agricultural University	Indonesia
42	Hany Handajani	Muhammadiyah Univ	Indonesia
43	Hari Sutrisno	Hokkaido University	Japan
44	Hartoyo	Bogor Agricultural University	Indonesia
45	Harukuni Tachibana	Hokkaido University	Japan
46	H-D.V. Boehm	Kalteng Consultants	Germany
47	Hendrik Segah	University Palangka Raya	Indonesia
48	Herwint Simbolon	R&D for Biology, LIPI	Indonesia
49	Hidenobu Kunii	Shimane University	Japan
50	Hidenori Takahashi	Hokkaido University	Japan
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57	Hitoshi Suzuki	Hokkaido University	Japan
58	I Made Sudiana	R&D for Biology, LIPI	Indonesia
59	I Wayan Sumantera	Bali Botanical Garden, LIPI	Indonesia
60	Ibnu Maryanto	R&D for Biology, LIPI	Indonesia
61	Ici Piter Kulu	University Palangka Raya	Indonesia
62	Ike Rachmatika	Biodiversity C. P. JICA	Indonesia
63	Irawati	R&D for Biology, LIPI	Indonesia
64	Isamu Yamada	Kyoto University	Japan
65	Iskandar	Bogor Agricultural University	Indonesia
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82	Koyo Yonebayashi	Kyoto Prefectural University	Japan
83	Laura J D'rquote Arcy	Nottingham University	United Kingdom
84	Linda Wulandari	University Palangka Raya	Indonesia
85	M.H.Sinaga	Research Center for Biology-LIPI	Indonesia
86	Maharadatunkamsi	R&D for Biology, LIPI	Indonesia
87	Maman Turjaman	Ministry of Forestry, Indonesia	Indonesia
88	Martin Stahlhut	Nottingham University	United Kingdom
89	Masaaki Kurasaki	Hokkaido University	Japan
90	Masahito Kimura	Hokkaido University	Japan
91	Masashi Iwai	Hokkaido University	Japan
92	Masato Shibuya	Hokkaido University	Japan
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98	Motoki Terashima	Hokkaido University	Japan
99	Muhamad Rahman Djuwansa	Geotechnology, LIPI	Indonesia
100	Muhamad Suhaemi Syawal	Limnology, LIPI	Indonesia
101	Mumpuni	R&D for Biology, LIPI	Indonesia
102	Mustaid Siregar	R&D for Biology, LIPI	Indonesia
103	Nabiha Zain Muhamad	Wahana Lingkungan Hidup Indonesia	Indonesia
104	Nick Baker	Nottingham University	United Kingdom
105	Nicola J.L. Waldes	Leicester University	United Kingdom
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107	Noriaki Sakaguchi	Biodiversity C. P. JICA	Japan
108	Noriko Azuma	Hokkaido University	Japan
109	Nyahu Rumbang	Palangka Raya University	Indonesia
110	Nyoman N. Suryadiputra	Wetlands International-Indonesia Program	Indonesia
111	Nyoman Sumawijaya	Geotechnology, LIPI	Indonesia
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125	Sih Kahono	R&D for Biology, LIPI	Indonesia

126	Siti Susiarti	R&D for Biology, LIPI	Indonesia
127	Sri Purwaningsih	R&D for Biology, LIPI	Indonesia
128	Sri Sulandari	R&D for Biology, LIPI	Indonesia
129	Suciatmih	R&D for Biology, LIPI	Indonesia
130	Sudarsono Jayadi	Bogor Agricultural University	Indonesia
131	Sulastri	Limnology, LIPI	Indonesia
132	Suparka	Vice Chairman of LIPI	Indonesia
133	Susan E. Page	Leicester University	United Kingdom
134	Suwardi	Bogor Agricultural University	Indonesia
135	Suwarno	Bogor Agricultural University	Indonesia
136	Suwido H. Limin	Palangka Raya University	Indonesia
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138	Syamsul Arifin Zein	R&D for Biology, LIPI	Indonesia
139	Tadahiro Murai	Hokkaido University	Japan
140	Takashi Hirano	Hokkaido University	Japan
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149	Typuk Artiningsih	R&D for Biology, LIPI	Indonesia
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160	Yoko Tatsumi	Hokkaido University	Japan
161	Yoyok Sudarso	Limnology, LIPI	Indonesia
162	Yulita Kusamadewi	R&D for Biology, LIPI	Indonesia
163	Yuni S. Rahayu	Hokkaido University	Japan
164	Yustiawati	Hokkaido University	Japan
165	Yustinus Sulistiyanto	Nottingham University	United Kingdom
166	Yutaka Tamai	Hokkaido University	Japan

ISBN4-9901827-0-7

9784990182700

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