Acid Deposition Monitoring Network
in East Asia (EANET)

Periodic Report on the State of Acid Deposition in East Asia

Part II: National Assessments

Cambodia China Indonesia Japan Lao P.D.R Malaysia Mongolia
Myanmar Philippines Republic of Korea Russia Thailand Viet Nam

Periodic Report
on the State of Acid Deposition in East Asia

Part II : National Assessments

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Preface

The Acid Deposition Monitoring Network in East Asia (EANET) was established as an important initiative for regional cooperation among counties in East Asia to create a common understanding of the state of acid deposition problems in East Asia, as well as to provide useful inputs for decision-making at local, national, and regional levels, aimed at preventing or reducing adverse impacts on the environment caused by acid deposition. Significant achievements have been made by EANET during the last five years, particularly in advancing the scientific and technical capabilities of its members through support provided by EANET's Network Center (NC).

The economic development and financial situation in each country in East Asia, of course, differs, and each has its own national priorities for planning environmental monitoring and management activities. In addition, there may be limitations of manpower and other resources in some countries. Most of the developing countries in East Asia have limited capacity in starting acid monitoring and research activities. A regional approach that promotes close cooperation among countries is considered an effective way to address regional problems, such as acid deposition and other regional air pollution issues.

Since the start of its regular phase of operation in 2001, EANET's activities have included the establishment of a monitoring network, capacity building, training, and promoting public awareness on acid deposition. A large amount of high-quality monitoring data has been accumulated from the vast East Asian region using common methodologies for selection of sites, comparable equipment, and standardized procedures for sampling, chemical analysis, and data management. The datasets are verified by designated experts from the network before they are submitted to the NC, where they are then compiled and stored for various uses such as in regional studies and decision-making.

The Periodic Report on State of Acid Deposition in East Asia is an initiative of the Scientific Advisory Committee (SAC) for EANET as a joint task to prepare an assessment on the state of acid deposition in East Asia from data accumulated in the first five years, to document the progress and achievements of EANET during its regular phase, and to plan the future development of the network. The SAC decided on the scope of monitoring data evaluation, the procedures of report preparation, as well as on the regional approaches to assessment. The Regional Assessment (Part I) was prepared by a Drafting Committee composed of SAC members and selected experts from the countries participating in EANET.

The National Assessments (Part II) were contributed by the National Focal Points (NFPs) of the participating countries. Although a general format was provided to them, they were free to decide on the contents to be included. Countries were encouraged to report trends of measured parameters in air, precipitation, inland aquatic environments, and soil and vegetation, including elaboration of any data abnormalities by analyzing any local influences and peculiarities. Information on assessments of the severity of acid deposition carried out by the countries, the impacts of acid deposition at the local level, and mitigation measures could be included, if available. Participating countries could also report other measurements from their national monitoring networks.

The Network Center has compiled 12 national assessments with minimal changes to their contents. Each contains interesting and valuable information related to the country of focus. The information in the National Assessments will provide researchers and other users with a better insight into the challenges faced by countries in addressing acid deposition issues, and they will serve as useful guidance for planning the future development of EANET.

NATIONAL ASSESSMENT ON ACID DEPOSITION IN CAMBODIA

1.1 Basic Information on National Monitoring Activities

1.1.1 Outline of activities on acid deposition and national monitoring plan

Cambodia is the one of participating countries of EANET started its activities in November 2001 with the aim to increase knowledge and effectively contribute to EANET as a member country. The National Center of EANET is the Department of Environmental Pollution Control (DEPC) of Ministry of Environment (MoE), the agency responsible for recording, controlling, inspecting on the polluted sources of the environment, and completing the tasks relevant to Conventional Agreements and International Protocols on the Environmental Quality Protection and other works which provided by MoE. Being the national center DEPC set up national monitoring plan for acid deposition in Cambodia.

Increased levels of acid deposition are fairly new phenomena for Cambodia and the national capacity in the prevention of this problem is limited. There is a shortage of knowledge on various aspects of sulfur and nitrogen pollution including emissions, atmospheric transport and deposition, direct impacts of gases on human health, vegetation and corrosion of monuments and indirect impacts via changes in the soil. For this reason there is a need for a better understanding in these problems in Cambodia. To protect the country from the acid deposition problem, Cambodia joined with EANET in November 2001. The following are some relevant activities and programs that are currently implemented:

- Developed National Monitoring Plan for EANET;
- Developed Standard Operating Procedures (SOPs);
- Upgrading of the Laboratory is on-progress;
- Capacity building of staffs in Cambodia on acid deposition;
- Participation in the inter-comparison projects on wet deposition;
- Plan for public awareness activities in Cambodia in coordination with the Secretariat and the Network Center (NC) for EANET;
- To tutor officers of provincial-city environmental department on basic knowledge of acid deposition;
- To publish on brochures of acid deposition to relevant institutions and public sector.

1.1.2 Monitoring Program in 2000-2004

The National Monitoring Plan for the year 2004 has been developed by the Cambodia National Center for EANET. Regarding to the capacity of the Cambodia, wet deposition monitoring was conducted with measuring pH, EC, NO_3^- ,NH_4^+, K^+, Ca^{2+}, Mg^{2+}, and amount of precipitation. In order to carry out the analysis of all mandatory parameters for wet deposition, DEPC will be started an analysis of SO_4^{2-}, Cl^- and Na^+ in near future.

1.1.3 Monitoring Stations

One monitoring site with wet deposition sampler had been installed on the roof of Ministry of Environment in 2003. From then, we started to collect rain water samples on weekly basis. These samples are analyzed in laboratory of Ministry of Environment. The information on sampling site is shown below:

Site category	Site classification	Location
Wet deposition	Urban	Phnom Penh

Figure 1.1 Location and view of wet deposition monitoring site in Cambodia

1.1.4 Sampling and Measurements

Rainwater samples for wet deposition monitoring were collected weekly by the wet-only sampler installed on site. For sampling and analysis the national center is following the technical manual for wet deposition monitoring analysis adopted by EANET. So far, we do the measurements on pH (Glass electrode), EC(Glass electrode), NO_3^- (Spectrophotometer), NH_4^+ (Spectrophotometer), K^+ (AAS), Ca^{2+}(AAS), Mg^{2+}(AAS) and amount of precipitation. The data collected for the mentioned parameters are presented below (Table 1.1).

Table 1.1 Measurement data on wet deposition in Phnom Penh in 2004

Start of sampling	NO_3^- µmol·L^{-1}	NH_4^+ µmol·L^{-1}	K^+ µmol·L^{-1}	Ca^{2+} µmol·L^{-1}	Mg^{2+} µmol·L^{-1}	pH	EC mS·m^{-1}	Pre mm
05-Apr	6.393	8.174	N.D*< 1	N.D< 5	N.D<0.8	7.54	3.29	9.063
02-May	5.938	10.390	N.D< 1	N.D< 5	N.D<0.8	4.57	1.458	67.098
08-May	6.741	9.488	N.D< 1	N.D< 5	N.D<0.8	6.13	1.753	8.904
20-May	7.024	8.158	N.D< 1	N.D< 5	N.D<0.8	6.69	1.039	35.689
02-Jun	6.310	7.273	2.201	N.D< 5	N.D<0.8	7.62	0.908	51.010
09-Jun	6.076	9.659	1.985	N.D< 5	N.D<0.8	7.58	0.585	27.197
15-Jun	7.020	10.338	2.010	N.D< 5	N.D<0.8	6.72	0.892	14.846
24-Jun	9.378	8.351	1.565	N.D< 5	N.D<0.8	6.92	1.148	28.617
09-Jul	9.378	28.628	1.728	N.D< 5	N.D<0.8	6.73	1.129	30.408
16-Jul	10.259	11.00	2.442	N.D< 5	N.D<0.8	6.81	1.086	30.408
28-Jul	12.921	13.975	1.146	N.D< 5	N.D<0.8	5.9	0.809	17.400
03-Aug	4.553	6.288	2.424	N.D< 5	N.D<0.8	5.92	1.312	50.524
12-Aug	6.974	6.812	3.267	N.D< 5	N.D<0.8	5.78	1.289	28.808
17-Aug	17.821	19.919	4.111	N.D< 5	N.D<0.8	5.72	0.832	18.967

* - N.D – Not detected (Below detection limits)

1.2 State of acid deposition in Cambodia.

1.2.1 Atmospheric Deposition

1.2.1.1 State of wet deposition

In the year 2004, data recorded minimum of pH = 4.57 (lowest acidic value) , EC = 0.585 mS·m^{-1}, NO_3^{--}= 4.553 µmol·L^{-1}, NH_4^+= 6.288 µmol·L^{-1}; values under the detection limits for K^+, Ca^{2+} and Mg^{2+} and smallest weekly amount precipitation is 8.904 mm. The maximum were recorded among the data on pH as 7.62 , 3.29 mS·m^{-1} for EC, 17.821 µmol·L^{-1} for NO_3^-, 28.628 µmol·L^{-1} for NH_4^+ , 4.111 µmol·L^{-1} for K^+ and 67.098 mm for weekly amount precipitation .

1.2.1.2 State of dry deposition

Cambodia will start the monitoring of dry deposition in the future in order to follow the requirements for EANET activities.

1.2.2 State of inland aquatic environment

Cambodia will start the monitoring of inland aquatic environment in the future in order to follow the requirements for EANET activities.

1.2.3 State of soil and vegetation

The activities for soil and vegetation monitoring have not yet been decided now in Cambodia due to constraints for instrument supply and capacity building. However, the national center will also plan to conduct soil and vegetation monitoring in the future.

1.2.4 Overall analysis

Wet deposition has only been the monitoring activities in Cambodia as mentioned above. Analysis of parameters related to acid deposition is very difficult because ion concentrations are very low in rain water samples. Acid deposition monitoring results much depends on sampling, instruments and experience of staffs to be responsible for sampling and analytical performance. From the data obtained in 2004, the overall analysis described that the average concentrations and annual mean precipitation are evaluated as the followings:

Table 1.2 Evaluated average data on wet deposition in Phnom Penh in 2004

pH	EC ($mS \cdot m^{-1}$)	Ca^{2+} ($\mu mol \cdot L^{-1}$)	Mg^{2+} $\mu mol \cdot L^{-1}$)	K^{+} $\mu mol \cdot L^{-1}$)	NO_3^{-} ($\mu mol \cdot L^{-1}$)	NH_4^{+} ($\mu mol \cdot L^{-1}$)	Precipitation (mm)
6.015	28,244	N.D	N.D	1.634	7.219	11.446	1 597.36

1.3 Review of National Measure against Acid Deposition.

Acid deposition status and its negative impacts has not identified yet in Cambodia. Nevertheless, the DEPC as the agency responsible for environmental quality protection will continue relevant activities. Furthermore, the government has established and implemented some programs below related atmospheric pollution and acid deposition issues:

- National Climate Change Project have been implemented;
- Cleaner Production Project have been set up and operated by Ministry of Industry, Mine and Energy;
- Sub-degree (regulation) on Air Pollution and Noise Disturbance Control has been implementing.
- The National environment policy and Strategy was developed.
- The public awareness activities on environment and acid deposition has been conducting.

Regarding acid deposition monitoring, only wet deposition have been monitored due to lack of funds, equipments, reagents, skilled staff, and relevant organizations /agency to deal with this matter.

Monitoring Report in China of Acid Deposition Monitoring Network in East Asia

2.1 Basic Information on National Monitoring Activities

2.1.1 Outline of the activities on acid deposition

Since the commencement of Regular Phase Activities of EANET from 2001, monitoring on wet deposition, dry deposition, inland water, soil and vegetation have being carried out in the 4 participating cities of EANET in China. As the national center for EANET, China National Environmental Monitoring Center (CNEMC) organized the monitoring activities in China according to the technical manuals for EANET.

2.1.2 Monitoring Sites

Chongqing: 2 sites, Guanyinqiao(urban site) and Jinyunshan(rural site).

Guanyinqiao: located in Jiangbei District, Chongqing, on the top of laboratory building of Chongqing Environmental Monitoring Center, 106°31'45" E, 29°34'32" N, the altitude is 262m. This site is surrounded by residential area and shopping centers, there is a high building located in the northeast of the site, and the distance is about 150~200 meters. There is a main street about 150 meters away from the site.

Jinyunshan: located in Beibei district, northwest of ChongQing, about 40 km from the urban area of ChongQing, 106°22´E and 29°49´N. Jinyunshan is one of the natural protection region of Chongqing. The Jinyunshan Mountain is the west border of the parallel mountains and valleys in east part of SiChuan Province, with NW-SE tending towards and about 16 km length. The altitude of the Mountain is about 700~900 meters, and the summit is 952m. The physiognomy is typical low mountains. The climate in Jinyunshan is suitable for the growth of diversified plants, due to plenty of precipitation amounts and high humidity of air and soil. The dominant plants are the evergreen vegetations with stable structure and good conservation. As a natural protection region, there're no industrial factories, only a few farming houses, vacationer's village and microwave transmission station scatter in different places. In recent years, on the north side of the mountain, some cement factories appeared; on the south side of the mountain, some residential areas have been developed, which may affect the air quality around the mountain area.

Xi'an: 3 sites: named Shizhan (Monitoring Center, urban site), Weishuiyuan (rural site) and Jiwozi (remote sites).

Monitoring Center: located in south suburb of Xi'an, 108°57'E and 34°14'N, the elevation is 400 meters high, with the environment of residential area, shopping center and transportation trunk.

Weishuiyuan: located in Weishuiyuan Vacation fazenda, with strait north and 18 km distance from Xi'an, 108°52'E and 34°22'N, the elevation is 360 meters high, circle by open farming land.

Jiwozi: located in south mountains of Chang'an county of Xi'an, 108°48´E and 33°50´N, with 60 km distance from the center of Xi'an. The elevation of the mountains is around 800~2000 meters high with the crest of 2886 meters. The climate there belongs to warm temperate zone, with 13.2 ^{o}C annual average air temperature, 687mm annual average rainfall and 150 day's non-frost season. The temperature in mountains is lower than other place. It's a rocky place with a vegetation mainly made up with shrubbery and scattered high arbor. A lot of artificially planted forest with Huashan Pine, larch and Chinese Pine.

Xiamen: 2 sites, named Hongwen (urban site) and Xiaoping (remote site).

Hongwen: located in the middle of Xiamen Island, a newly built urban district, 118°8'E and 24°28'N. The peak of Xiamen Island, Yundingyan, locate southward of this site. Yundingyan is well known for the forest with vegetation cover rate of 90%. Hubian reservoir is the largest spare water source of Xiamen Island, locate northward of this site. A new main trunk named Lianqian Road pass in front of the site. The elevation of Hongmen is 50 meters high.

Xiaoping: located in the center of the remote forest of Xiamen, 118°2'E and 24°51'N, far from highway, railway, town and other place with many human beings activity. The elevation is 686 meters high.

Zhuhai: 2 sites, named Xiangzhou (urban site) and Zhuxiandong (urban site).

Xiangzhou: loceated in the center of Zhuhai, the top of office building in Zhuhai Environmental Monitoring Center, 113°34'E, 22°16'N. It's government office area and there's no industrial infrastructure. The pollution source mainly come from service industry, motor vehicle and daily life of the resident. The building is adjacent with the main trunk named Binhaibeilu and BanZhang Hill locates westwards. The elevation is 40 meters high.

Zhuxiandong: It's a soil and vegetation monitoring site, located in Zhuxiandong Park, 113°31'E, 22°12'N, Nanping town, with 15 km distance from the city zone. Zhuxiandong Park is a scenic area while have the functionality of water supply. The southward is Lizhi Hill with elevation around 300 meters high and northward is Nanwan Road. The elevation is 45 meters high.

Table 2.1 The information of monitoring sites of EANET China

City Name	Site class	Site Name	Longitude	Latitude	elevation(m)
Chongqing	Urban site	Guanyinqiao	106°31′	29°34′	262
	Rural site	Jinyunshan	106°22′	29°49′	800
Xi'an	Urban site	Shizhan	108°57′	34°14′	400
	Rural site	Weishuiyuan	108°51′	34°22′	366
	Remote site	Jiwozi	108°48′	33°50′	1800
Xiamen	Urban site	Hongwen	118°8′	24°28′	50
	Remote site	Xiaoping	118°2′	24°51′	686
Zhuhai	Urban site	Xiang Zhou	113°34′	22°16′	40
		Zhuxian Cavern	113°31′	22°12′	45

Table 2.2 The monitoring types of the monitoring sites

City Name	Site class	Site Name	Wet deposition	Dry deposition	Soil and vegetation	Inland water
Chongqing	Urban site	Guanyinqiao	√			
	Rural site	Jinyunshan	√	√	√	√
Xi'an	Urban site	Monitoring center	√			
	Rural site	Weishuiyuan	√	√		
	Remote site	Jiwozi	√		√	√
Xiamen	Urban site	hongwen	√	√		
	Remote site	xiaoping	√		√	√
Zhuhai	Urban site	Xiangzhou	√	√		
		Zhuxiandong	√		√	√

2.1.3 Monitoring program from 2001 to 2004

As the national center for EANET, CNEMC establishes the national monitoring plan annually, the cities' monitoring center carry out the monitoring work and send the data to CNEMC according to the national plan.

2.1.3.1 Wet deposition monitoring

From 2001 to 2004, 9 sites in 4 cities carried out wet deposition monitoring. The monitoring parameters are rainfall, pH, EC, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, and Mg^{2+}. Frequency of monitoring is 24 hours, start from 9:00 a.m. to 9:00 a.m. the next day.

2.1.3.2 Dry deposition monitoring

From 2001 to 2004, 4 sites in 4 cities carried out dry deposition monitoring. The monitoring parameters are SO_2, NO_2, and PM_{10} in the air. Frequency of monitoring is 1 hour.

2.1.3.3 Monitoring on Inland Aquatic Environment

From 2001 to 2004, 4 sites in 4 cities carried out monitoring on inland aquatic environment. There're 2 kinds of monitoring parameters: pH, EC, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+} ,monitoring 4 times once a year; chroma, transparency, COD, NO_2^- and PO_4^{3-}, monitoring annually.

2.1.3.4 Monitoring on soil and vegetation

In 2001, ZhuHai monitoring center and Xi'an Monitoring Center carried out soil monitoring. All of the 4 cities' monitoring center carried out soil monitoring and vegetation survey according the emendatory national monitoring work plan. The soil monitoring and vegetation survey will be carried out once 3 years since 2003 according the national monitoring work plan.

Soil monitoring parameters: pH(H_2O), pH(KCl), exchangeable Na^+、K^+、Ca^{2+}、Mg^{2+}，ECEC(valid cation exchanging ability), exchangeable acidity, P,T-N, and T-C.

Vegetation survey parameters: trees growth status, survey on low-living vegetation and vegetation degeneration.

Table 2.3 Monitoring Parameters and Frequency of EANET China

Content	Monitoring Parameters	Frequency
Wet deposition	pH, EC, rainfall，SO_4^{2-}, NO_3^-,Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, $Mg^{2+,}$	24h, 09:00-09:00
Dry deposition	SO_2, NO_2, PM_{10}	1h
Inland water	pH, EC, SO_4^{2-}, NO_3^- ,Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}， alkalinity	Four times per year
	Chroma、transparancy、COD、NO_2^-、PO_4^{3-}	Once per year
Soil	pH(H_2O), pH(KCl), exchangeable Na^+、K^+、Ca^{2+}、Mg^{2+}, ECEC(valid cation exchanging ability), exchangeable acidity, P, T-N, T-C	Once three years
Vegetation	trees growth status, survey on low-living vegetation and vegetation degeneration	Once three years

2.1.4 Outline of Sampling and Measurements

2.1.4.1 Collection and handling of samples

All of the sites use automatic precipitation collector for sampling. Frequency of monitoring is 24 hours, start from 9:00 a.m. to 9:00 a.m. the next day.

Table 2.4 Sampling method, instruments name and style of the monitoring sites

City name	Monitoring site	Sampling method	Instruments name and style
Chongqing	Guanyinqiao	auto	YSC-1 automatic precipitation collector
	Jinyunshan	auto	YSC-1 automatic precipitation collector
Xi'an	Monitoring center	auto	XHARS30A automatic precipitation collector
	Weishuiyuan	auto	XHARS30B automatic precipitation collector
	Jiwozi	auto	XHARS30A automatic precipitation collector
Xiamen	hongwen	auto	Anderson automatic precipitation collector
	xiaoping	auto	Anderson automatic precipitation collector
Zhuhai	Xiangzhou	auto	OGASAWARA KEIKI US-320H automatic precipitation collector
	Zhuxiandong	auto	XHARS30A automatic precipitation collector

Precipitation amount should be measured and recorded at the sampling site. After the EC and pH have been measured, the rest samples should be collected in a special sampling bottle for acid rain and refrigerated at 4ºC before shipment to the analytical laboratory.

2.1.4.2 Samples analysis

Sample solutions received at a laboratory must be well documented at the sampling sites. And the stuff in laboratory should filter the samples with 0.45 um filterable membrane for ion measurements. The samples that couldn't be analyzed will be refrigerated at 4ºC and must be analyzed in 15 days.

Table 2.5 measurement method, instruments name and style of the cities

City name	Monitoring parameters	Measurement method	Instrument name and style
Chongqing	pH	Glass electrode method	METTLER TOLEDO 320
	EC	electrode method	CM-60G orLeici
	F^- Cl^- NO_3^- SO_4^{2-}	IC	DX-120
	Na^+ NH_4^+ K^+ Mg^{2+} Ca^{2+}	IC	DX-500
Xi'an	pH	Glass electrode method	Leici PHS-3C
	EC	electrode method	DDS-11A
	NH_4^+、Na^+、K^+ Mg^{2+}、Ca^{2+}、Cl^- NO_3^-、SO_4^{2-}	IC	DIONEX 120
Xiamen	pH	Glass electrode method	PHS-301
	EC	electrode method	DDS-307
	Cl^- NO_3^- SO_4^{2-}	IC	Dionex-300
	Na^+ NH_4^+ K^+ Mg^{2+} Ca^{2+}	IC	Dionex DX-80
Zhuhai	pH	Glass electrode method	ORION 420A
	EC	electrode method	DDS-307
	NH_4^+、Na^+、K^+ Mg^{2+}、Ca^{2+}、Cl^- NO_3^-、SO_4^{2-}	IC	SHIMADZU LC-10ADVP or DIONEX 120

2.1.4.3 QA/QC of Wet Deposition Monitoring

All of the measurements must be carried out according the Technical Manual for Wet Deposition Monitoring in East Asia and QA/QC Program for Wet Deposition Monitoring in East Asia. The pH meter should be calibrated before each set of precipitation samples, pH 4.0 and 7.0 buffer solutions are therefore used. The buffer solutions should be refrigerated at 4ºC and replaced periodically (2-3 monthly).

Calibration for conductivity measurement is multipoint. With each set of precipitation samples, a set of 0.0001Mol/L, 0.0005 Mol/L, and 0.001 Mol/L KC1 solutions should be prepared from 0.01 Mol/L KC1 stock solution by dilution with deionized water. The stock solution should be replaced periodically (each season).

During the measurements of the ion constitution by IC method, 5 concentration points' calibration curves, 5 percents parallel measurement and adding calibration recovery measurement have been carried out. Full procedure empty measurements have been carried out monthly.

2.2 State of Acid Deposition in China

2.2.1 Atmospheric deposition

2.2.1.1 State of wet deposition

From 2001 to 2004, the monitoring results of pH, EC and ion concentrations from the 9 wet deposition

monitoring sites were shown in figure 2.1~ figure 2.10.

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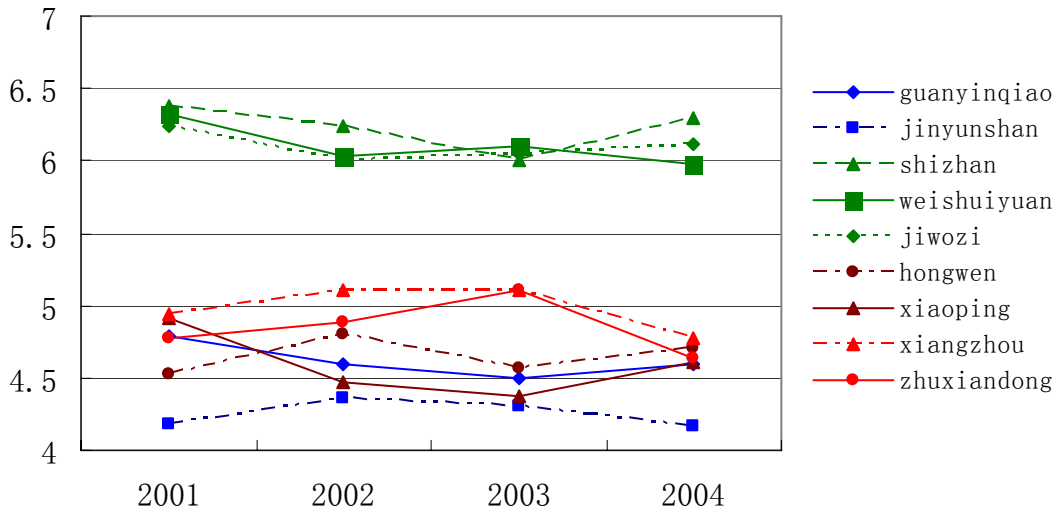


Figure 2.1 pH annual average changing tendency of the monitoring sites, EANET China

From 2001 to 2004, the pH annual average of the 9 wet deposition monitoring sites is between 4.16~6.38. The pH of the sites in Xi'an is highest, and Jinyunshan in Chongqing is the lowest. There was no obvious changing tendency of the pH value in the monitoring sites.

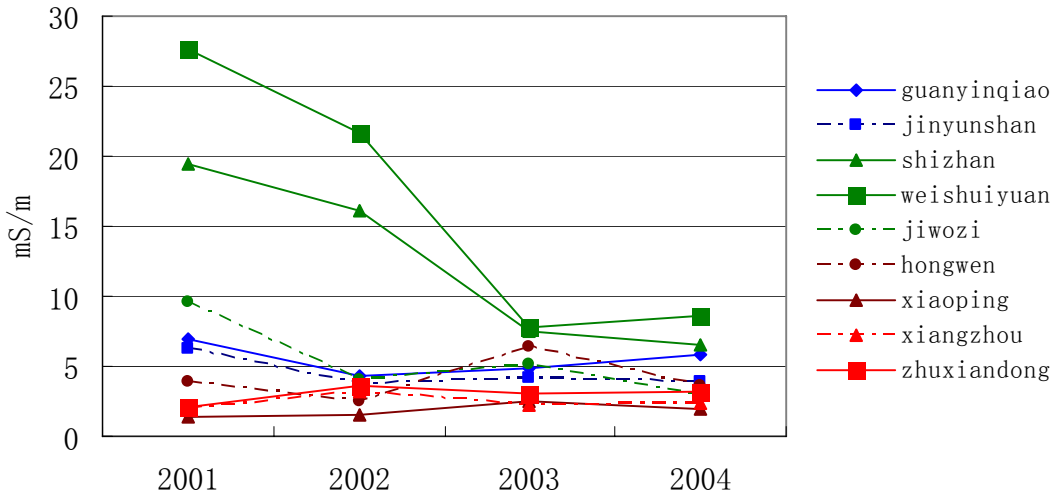


Figure 2.2 EC annual average changing tendency of the monitoring sites, EANET China

From 2001 to 2004, the EC annual average of the 9 wet deposition monitoring sites is between 1.42~27.68 mS/m. The EC annual average of Weishuiyuan and Monitoring Center in Xi'an decreased sharply in 2001 and 2002, that's mainly for that the sampling method changing from manually to automatic.

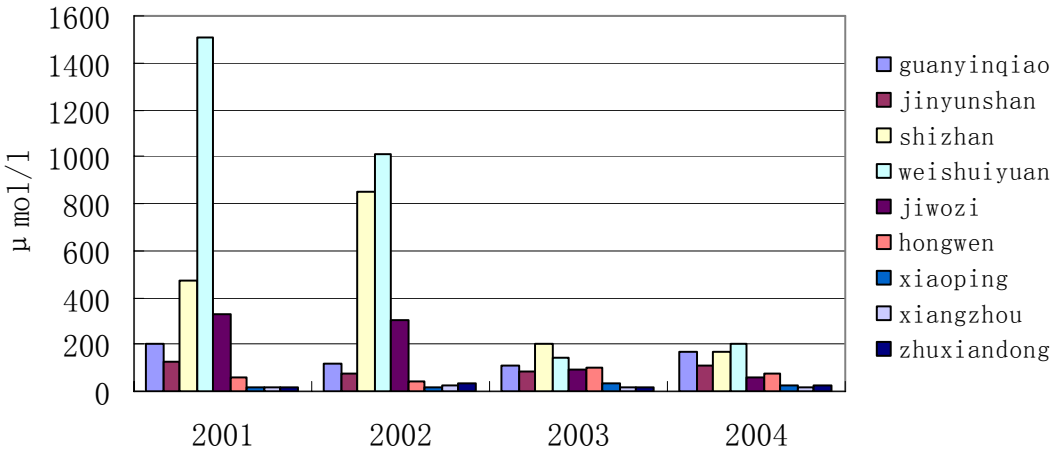


Figure 2.3 SO_4^{2-} concentration annual average tend in each monitoring sites, EANET China

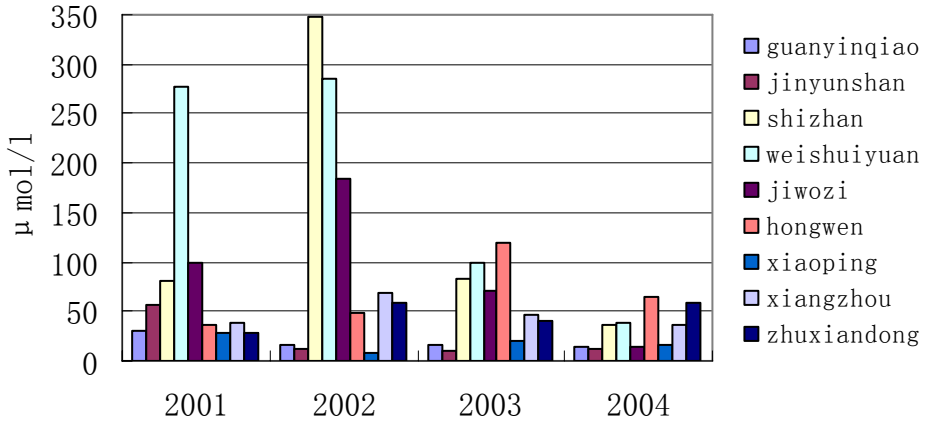


Figure 2.4 NO_3^- annual average changing tendency of the monitoring sites, EANET China

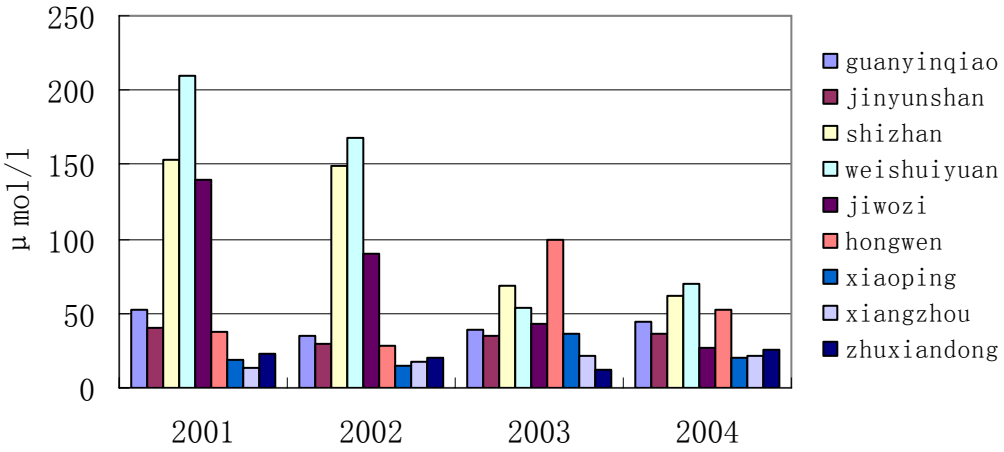


Figure 2.5 Cl^- annual average changing tendency of the monitoring sites, EANET China

From 2001 to 2004, There was no obvious changing tendency of the ion concentration in the monitoring sites except those in Xian. The ion concentration of the sites in Xi'an decreased obviously, that's mainly for that the sampling method changing from manually to automatic.

The SO_4^{2-} concentration of inland cities Xi'an and Chongqing is higher than coastal cities Xiamen and Zhuhai. The SO_4^{2-} concentration of urban sites Monitoring Center and Weishuiyuan in Xi'an is obvious higher than the remote site Jiwozi. There's the same situation in Chongqing and Xia Men.
The concentration of NO_3^-、NH_4^+、Ca^{2+}、Mg^{2+} in urban parts is higher than rural parts and remote sites in all of the 9 monitoring sites.

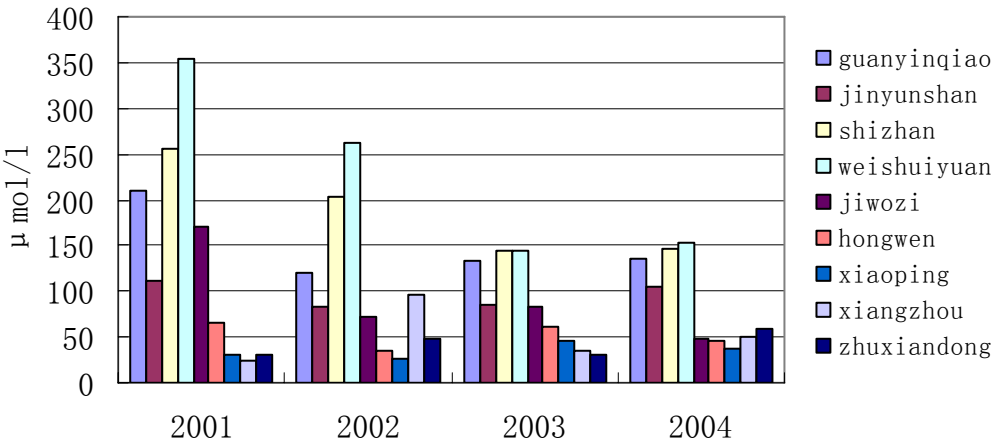


Figure 2.6 NH_4^+ annual average changing tendency of the monitoring sites, EANET China

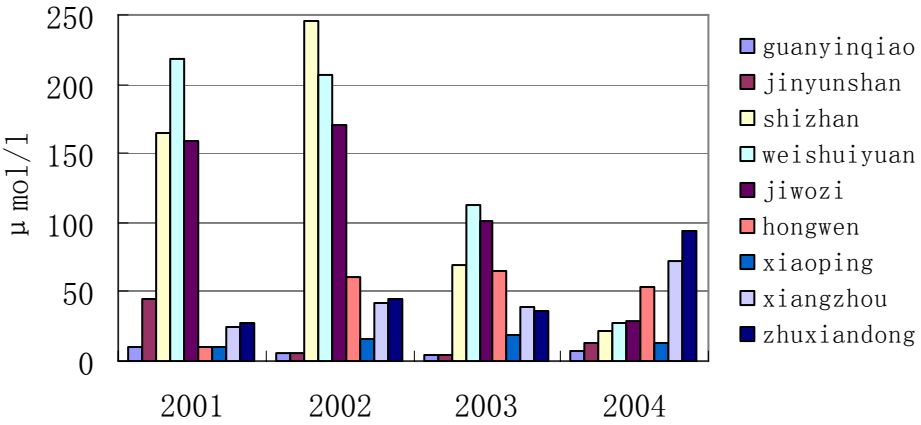


Figure 2.7 Na^+ annual average changing tendency of the monitoring sites, EANET China

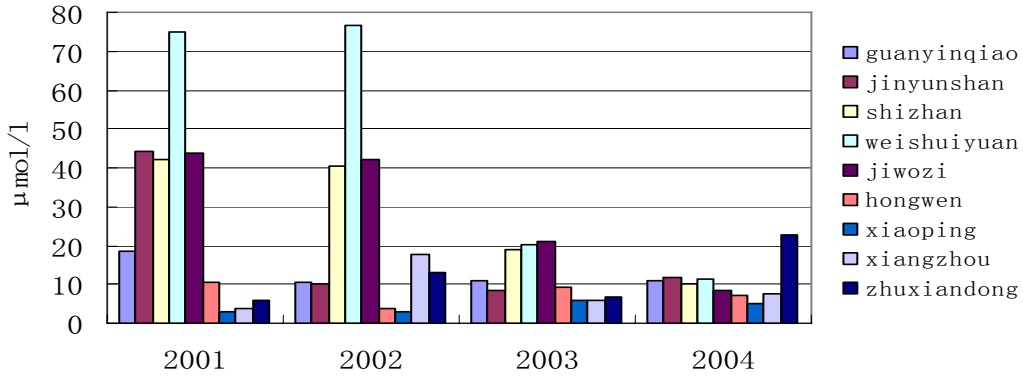


Figure 2.8 K^+ annual average changing tendency of the monitoring sites, EANET China

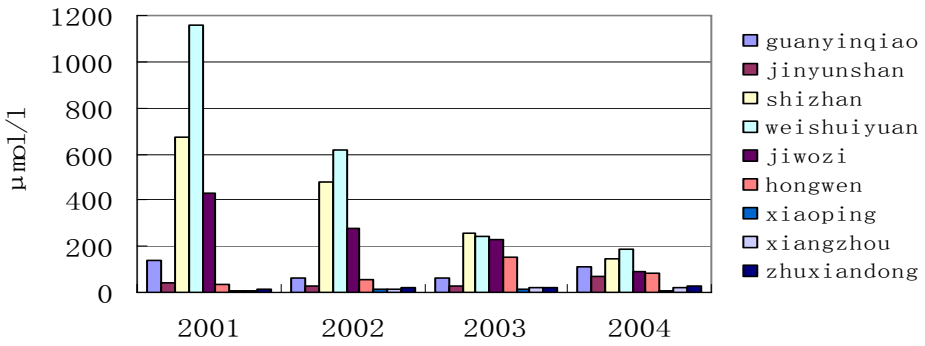


Figure 2.9 Ca^{2+} annual average changing tendency of the monitoring sites, EANET China

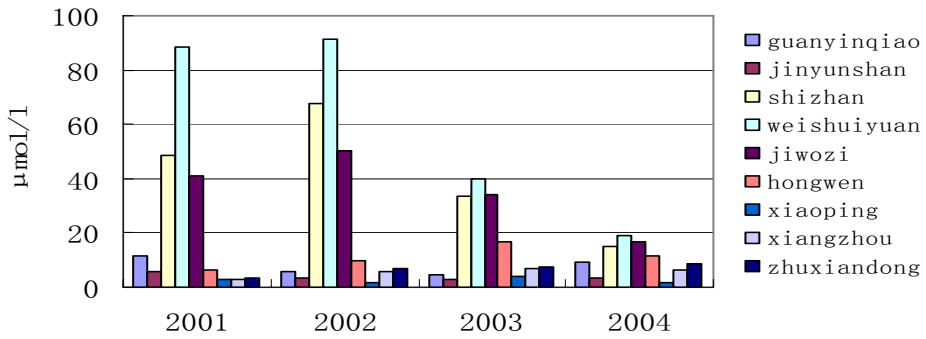


Figure 2.10 Mg^{2+} annual average changing tendency of the monitoring sites, EANET China

2.2.1.2 State of dry deposition

From 2001~2004, Jinyunshan Site in Chongqing, Weishuiyuan Site in Xi'an, Xiaoping site in Xiamen, Xiangzhou Site in Zhuhai carried out dry deposition monitoring. The monitoring parameters are SO_2, NO_2 and PM_{10}. All of the parameters were measured by automatic systems. The annual average changing tendency of the monitoring sites are presented in figure 2.11 ~ figure 2.13.

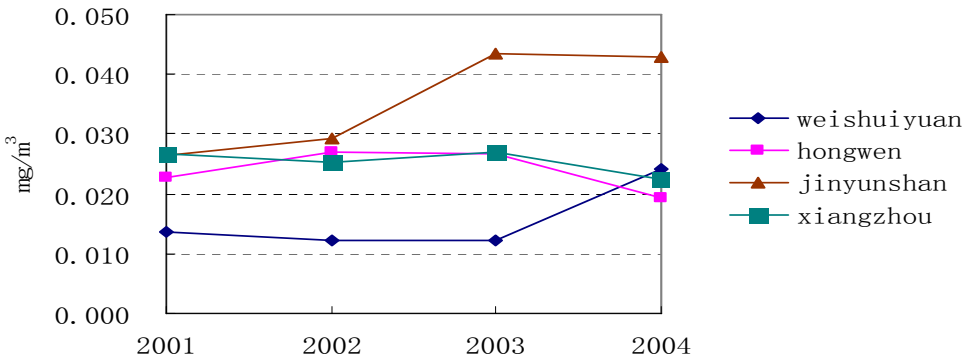


Figure 2.11 SO_2 annual average changing tendency of the monitoring sites

From 2001~2004, the concentration of SO_2 in Jinyunshan Site had the increasing tendency, and there were no obvious changing tendency in other 3 monitoring sites. The SO_2 concentration of Jinyunshan is the highest among the 4 monitoring sites while Weishuiyuan in Xi'an is the lowest.

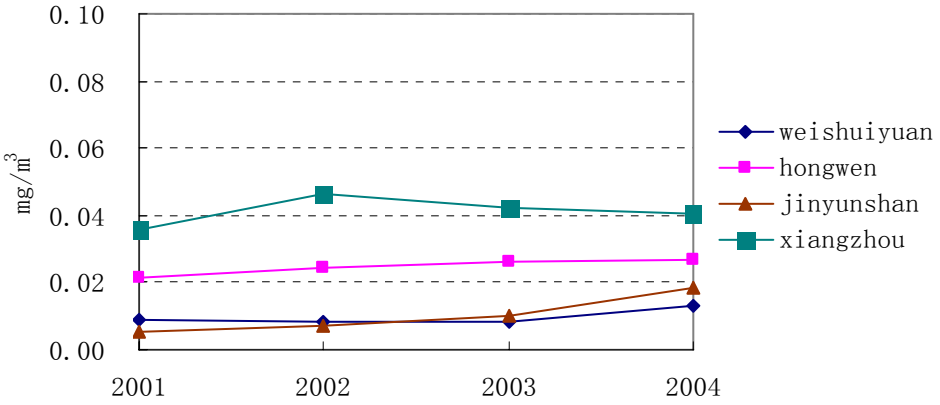


Figure 2.12 NO_2 annual average changing tendency of the monitoring sites

From 2001~2004, the NO_2 annual concentration in urban sites Xiangzhou and Hongwen is higher than the rural sites Jinyunshan and Weishuiyuan. The NO_2 concentration had increasing tendency in Hongwen and Jinyunshan.

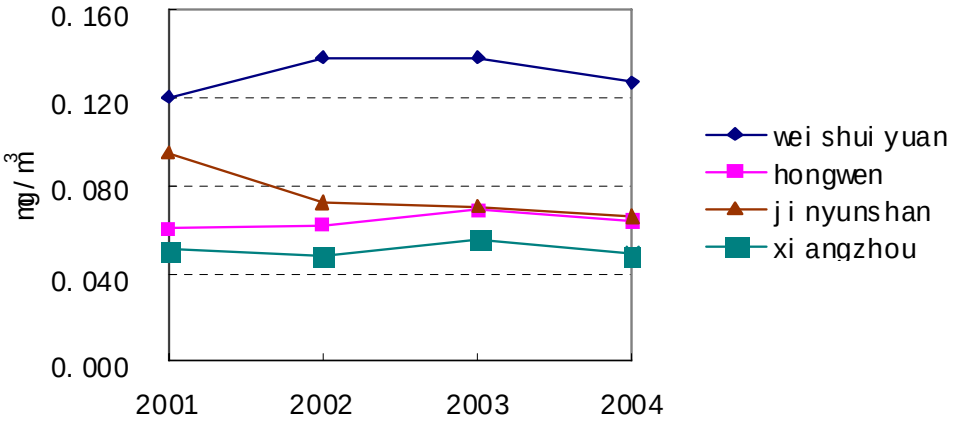


Figure 2.13 PM_{10} annual average changing tendency of the monitoring sites

From 2001~2004, the PM_{10} annual concentration in inland sites Weishuiyuan and Jinyunshan is higher than the rural sites Xiangzhou and Hongwen. The PM_{10} concentration had decreasing tendency in Jinyunshan, and there were no obvious changing tendency in other 3 monitoring sites.

2.2.1.3 State of inland aquatic environment

From 2001~2004, the 4 network cities carried out monitoring on inland aquatic environment in Jiwozi, Jinyunshan, Zhuxiandong and Xiaoping respectively. Site in Chongqing, Weishuiyuan Site in Xi'an, Xiaoping. Two kinds of parameters had been measured in the 4 sites: pH, EC, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, altogether 11 paremeters, monitoring once a season; chroma, transparency, COD, NO_2^- and PO_4^{3-}, monitoring annually.

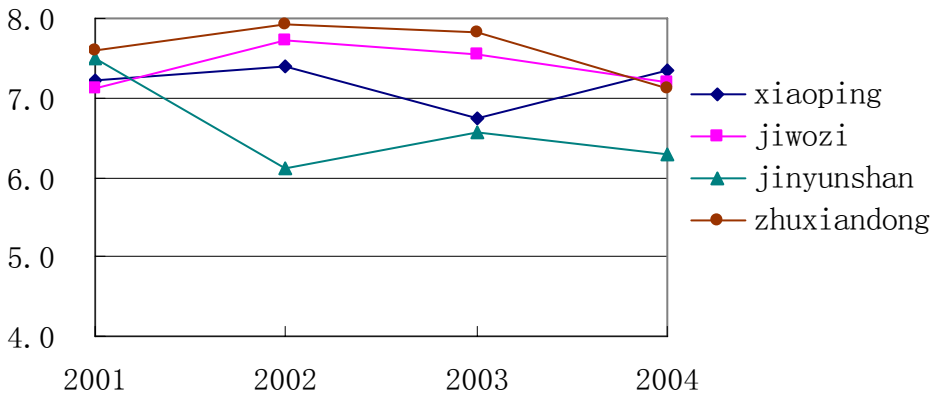


Figure 2.14 pH annual trend of the inland aquatic environment monitoring sites

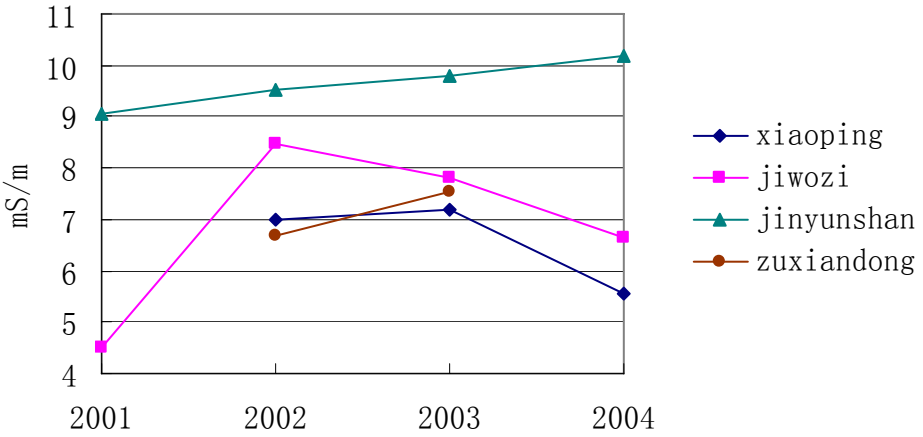


Figure 2.15 EC annual trend of the inland aquatic environment monitoring sites

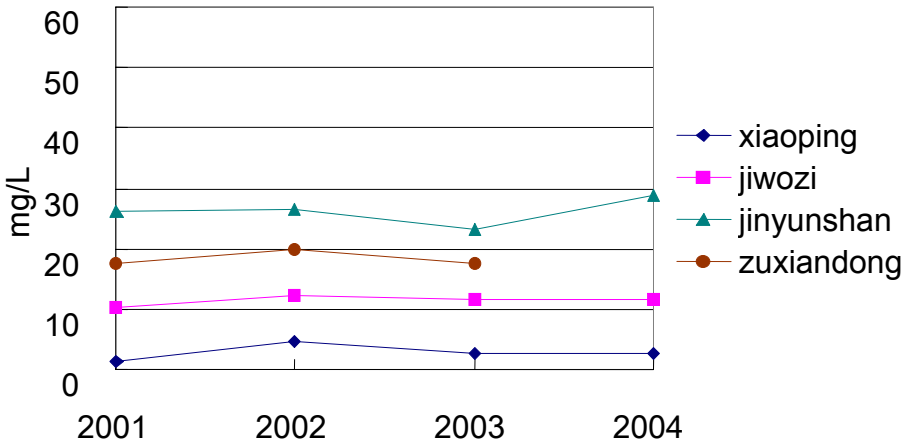


Figure 2.16 SO_4^{2-} annual trend of the inland aquatic environment monitoring sites

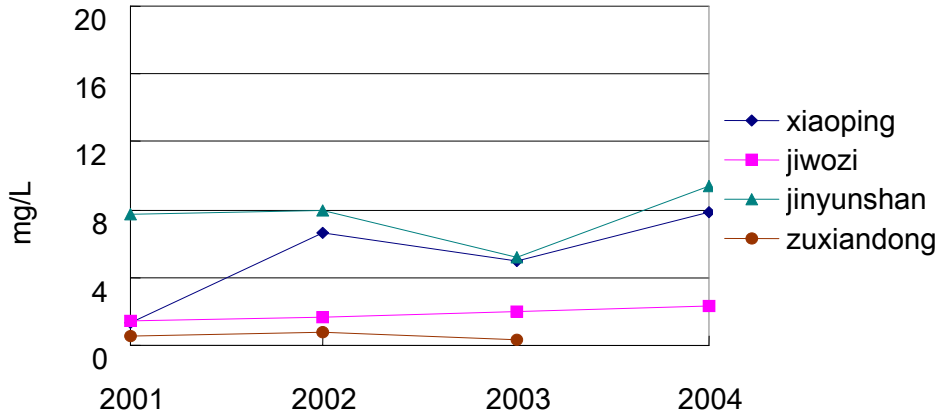


Figure 2.17 NO_3^- annual trend of the inland aquatic environment monitoring sites

From 2001~2004, the pH annual average of the inland aquatic environment monitoring sites is between 6.12 ~ 7.92. There were no obvious changing tendency in all of the 4 sites. Annual average of SO_4^{2-}, NO_3^- in 4 sites remained stable in 3 sites except for xiaoping site, where a increasing trend of NO_3^- was observed.

2.2.2 Overall analysis

2.2.2.1 Analysis of Wet Deposition

From 2001 to 2004, there was no obvious changing tendency of the pH and ion concentration in the 9 acid deposition monitoring sites. The geographical difference of pH and ion concentration is apparent from south cities and north cities, coastal cities and inland cities. That's mainly for the difference of geography environments and climate.

2.2.2.2 Analysis of Dry Deposition

From 2001~2004, in the 4 dry deposition monitoring sites, there were no obvious changing tendency of SO_2 concentration in monitoring sites expect that Jinyunshan Site had increasing tendency. It's probably because there were some newly built cement plant and residential area in north and south part of Jinyunshan.

The reason of NO_2 concentration increasing tendency in Hongwen probably is the increasing of motor vehicles amount in Xiamen, and the increasing in Jinyunshan should be done more research.

2.2.2.3 Analysis of Inland Aquatic Environment

From 2001~2004, there were no obvious changing tendency of the pH annual average and EC, SO_4^{2-}, NO_3^- concentration in all of the 4 inland aquatic environment monitoring sites.

2.2.2.4 Conclusion

According to the acid deposition monitoring results, there was no obvious changing tendency of the ion constitution in the rainfall. pH and ion concentration in the 9 acid deposition monitoring sites. There were no obvious changing tendency of SO_2 concentration in 3 monitoring sites expect for Jinyunshan site. The increasing tendency may be caused by the recent emergence of local factories;

NO_2 concentration had increasing tendency in 1 urban site, and probably due to the increasing of motor vehicles amounts. There was no obvious changing tendency of the constitution of in land water.

The observation of acid deposition should be based on long period monitoring. There were no obvious conclusion of the acid deposition impacts on rainfall and inland water because only 4 years' monitoring data are available. Because the monitoring parameters have being updated since 2001, and the monitoring site had been adjusted individually, the research on changing tendency of inland aquatic environment need more monitoring activities and more data in the following years.

2.3 Review of National Measures against Acid Deposition

2.3.1 National plans

The State Council approved "the National Plan for Environmental Protection" for every five-year. It is in the Ninth Five-year Plan and the Tenth Five-year Plan, to reduce the emission of SO_2.

China invested 58 billion Yuan into the environmental protection and ecological environmental conservation from 1998 to 2002, which account for 1.29% of GDP at the same period and as 1.8 times as the total investment in the past 47 years from 1950 to 1997 in this area.

During the tenth five-year plan period, the total investment for the environmental protection in China will reach more than 700 billions Yuan, and by 2005, it will account for 1.3% of GDP .In Beijing, this kind of investment has accounted for 4.7% of GDP of the entire city. By 2008, Beijing will invest more than 100 billion Yuan into environmental protection while by the end of the tenth five-year plan period, Shanghai's investment has accounted for 3% of GDP of the single city and will keep this rate in the tenth five-year plan period.

The perspective measures to reduce the discharge including the reduction of the sulfur content in coal; in 2005, power stations within the "Two-controlled Zones" will reduce the amount of SO_2 emission at the rate of 20% based on the amount in 2000; to control the amount of SO_2 discharge in boiler, industrial furnace, technical procedure and living source respectively; besides simultaneously raising the investment in Two-controlled Zones to reinforce the charge of SO_2 emission and tentatively adopt the transaction system of SO_2 discharge right.

During the tenth five-year plan period, china will set up 550 SO_2 comprehensive treatment projects to achieve 387 ten thousand ton discharge reducing ability per year. By 2005, the acid rain pollution will be reduced in the entire country. For over 80% cities within Two-controlled Zones, the average concentration of SO_2 will reach Grade Two of the national air quality standard; and in the cities of Non-Two-controlled Zones, SO_2 concentration will be reduced distinctly.

During the tenth five-year plan period, China plan to plunge into 96.7 billion Yuan for prevention of SO_2 and acid rain pollution so as to guarantee that compared with 2000, within the Two-controlled Zones SO_2 emission will be reduced 20% by 2005.

2.3.2 The Two-controlled Zones

The "Two-controlled Zones" is confirmed for the control of SO_2 emission and acid deposition in the Ninth Five-year Plan. It means acid rain control zone and $S0_2$ control zone. There are more than 170 cities in the "Two-controlled Zones". The total area of Two-controlled Zones is about 109 sq km, accounting for 11.4% of the entire country where the amount of SO_2 emission reach 1316.4 ten thousand ton which account for 66% of the total SO_2 emission. The urban SO_2 has decreased in "Two Controlling Zones" in the past 5 years, refer to table 2.6.

Table 2.6 Compliance of Urban SO_2 in "Two Controlling Zones"

SO_2 concentration degree	SO_2 pollution control areas			acid rain control areas		
	1998	2000	2002	1998	2000	2002
percentage of Grade II cities % ($SO_2 \leq 0.06$ mg/m^3)	32.8	47.7	40.6	70.6	81.2	79.5
percentage of Grade III cities % (0.06 mg/m$^3 \leq SO_2 <$ 0.1 mg/m^3)	29.7	24.6	28.1	13.7	6.3	13.7
percentage of Grade III Plus cities % ($SO_2 >$ 0.1 mg/m^3)	37.5	27.7	31.3	15.7	12.5	6.8

2.3.3 The latest plan by SEPA

About one third of the Chinese territory suffers pollution from acid rain, according to the report by State Environmental Protection Administration (SEPA) in Oct. 2003. The administration has pledged to reduce the emission of sulfur dioxide in China, which is the main cause of acid rain, by 10 percent from its 2000 level by 2005. The country has officially recognized four municipalities, 21 provincial capitals and 175 cities as zones heavily polluted by acid rain or sulfur dioxide. It is urgent for the country to control the sulfur dioxide emission by coal-fueled power plants. No coal-fueled power plants will be built or expanded in big and medium-sized cities and in the remaining areas, power plants are required to be equipped with devices to reduce sulfur dioxide emission. According to SEPA's five-year plan from 2000 to 2005 to cope with acid rain and sulfur dioxide, 137 large coal-fueled power plants must equip devices to reduce the emission of sulfur dioxide.

National Assessment on Acid Deposition
Indonesia

3.1 Basic Information on Acid deposition Activities

3.1.1 Background

The rapid industrial growth in some countries of East Asia causes increasing use of fossil fuel that emits acid gases such CO_2, SO_2, NO, HNO_3 and particle H_2SO_4 to the atmosphere. This and other human activities such as increasing use of fertilizers in agriculture eventually will acidify the earth with acid deposition. However, information on the present status of acid deposition in the region is very sketchy. Therefore, it will be very difficult to formulate a sound and concrete strategy to mitigate the problem of acid deposition in the region. Since the deposition is also known to be trans-boundary, cooperation among the countries in the region is imperative. This particularly true for the implementation of Agenda 21 that was adopted by UNCED in 1992 aiming to minimize acid deposition and certainly the affects.

In this context the Government of Japan has taken the initiative in establishing monitoring network in the region, the Acid Deposition Monitoring Network of East Asian (EANET). The network and ADORC at Niigata have actively organized workshops and trainings for capacity building for professionals in the region. Indonesia has been actively participating since 1998 both in intergovernmental and scientific advisory committees in setting up the policy and methodology of monitoring acid deposition.

3.1.2 Outline of the Activities on Acid deposition and National Monitoring Plan

The monitoring of acid deposition in Indonesia is carried out by observing wet deposition, dry deposition, and attempts in assessing the impacts by observing soil, vegetation and inland aquatic water. These tasks are conducted by various related national institutions where Pusarpedal of the Ministry of Environment is the national coordination center. The participating institutions are National Geophysics and Meteorology Agency (BMG) and National Aeronautic and Space Agency (LAPAN) for wet and dry deposition; The Center for Limnology Research of the Indonesian Institute of Sciences and Center for Water Research for inland aquatic and Center for Soil and Agro-climatology Research of the Department of Agriculture for soil and vegetation monitoring.

a. Wet deposition

Monitoring of wet Deposition is conducted:

- On daily basis or at every rainy event at urban, rural and remote sites.
- Once a week until once a month at the locations for monitoring soil and vegetation and inland aquatic.
- Monitored of deposition properties are: pH, electrical conductivity(DHL), sulfate ion concentration (SO_4^{2-}), nitrate (NO_3^-), chloride (Cl^-), ammonia (NH_4^+), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^+)
- Measurement of meteorology variables includes: wind direction (WD), wind speed (WS), temperature, relative humidity, rainfall and global radiation.

b. Dry deposition

Monitoring of dry Deposition is conducted:

- Every 2 weeks until once a month or at every rainy event at urban, rural and remote sites
- Once a week until once a month at locations for monitoring soil and vegetation and inland aquatic.
- Monitored deposition properties are: pH, electrical conductivity(DHL), sulfate ion concentration (SO_4^{2-}), nitrate (NO_3^-), chloride (Cl^-), ammonia (NH_4^+), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^+)
- Measurement of meteorology variable includes: wind direction (WD), wind speed (WS), temperature, relative humidity, rainfall and global radiation

c. Soil and Vegetation

Monitoring of soil and vegetation is conducted:

- Samplings of soil are carried out periodically every 3 until 5 year, and frequency sampling for vegetation depend on the type of monitoring to be done. Survey for inclination of trees are carried out every 3 to 5 year and analysis for fresh leaf done every year, at least one or more location in point like urban, rural and remote area. Because the location for monitoring of wet and dry deposition is not suitable for monitoring soil and vegetation, other location was selected within 50 km radius from wet and dry deposition monitoring location.
- Properties of soil that are monitored are:
  - → Soil: pH (H_2O and KCl), cation exchange capacity, and concentration of extractable bases (Na^+, K^+, Ca^{2+} and Mg^+). Exchangeable ions such as aluminum, sulfate and availability of phosphate are optional.
  - → Vegetation: backward of crop, leaf abnormality and ramification, chemical component (S, K, Ca, and Mg) in fresh leaf (optional).
  - → Measurement of meteorology conditions is similar to the wet deposition monitoring.

d. Inland Aquatic

Monitoring of inland aquatic is conducted:

- Over 4 times every year at rural, urban and remote location, or similar location with soil and vegetation monitoring.
- Once/year for transparancy, water colour, nitrit, phosphate, COD monitor
- Properties of water that are monitored are: pH, electrical conductivity (DHL), and alkalinity (if necessary), ion sulfate (SO_4^{2-}), nitrate (NO_3^-), chloride (Cl^-), ammonia (NH_4^+), sodium (Na^+), potassium(K^+), calcium (Ca^{2+}) and magnesium (Mg^+) concentration

3.1.3 Monitoring stations

Monitoring stations of acid deposition in Indonesia are:

1. Monitoring of wet deposition

a. Serpong Station (Pusarpedal)

- Location : rural
- Interval : daily
- Variables : pH, electrical conductivity (DHL), concentration of SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^+
- Methods : glass electrode cell, ion chromatography, atomic absorption spectrophotometry and spectrophotometry.
- Laboratory: Pusarpedal – KLH.

b. Jakarta (BMG office)

- Location : urban
- Interval : weekly

- Variables : pH, electrical conductivity (DHL), concentration of SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^+
- Methods : glass electrode cell, ion chromatography, atomic absorption Spectrophotometry and spectrophotometry.
- Laboratory: BMG - Jakarta.

c. Kototabang, West Sumatra (BMG office).

- Location : remote area
- Interval : weekly
- Variables : pH, electrical conductivity (DHL), concentration of SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^+
- Methods : glass electrode cell, ion chromatography, atomic absorption Spectrophotometry and spectrophotometry.
- Laboratory: BMG - Jakarta.

d. Bandung (LAPAN Office)

- Location : urban
- Interval : daily (every 24 hour)
- Variables : pH, electrical conductivity (DHL), concentration of SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+,
- Methods : glass electrode cell, ion chromatography,
- Laboratory: LAPAN - Bandung.

2. Dry deposition monitoring

a. Serpong Station (Pusarpedal)

- Location : rural
- Interval : Biweekly
- Variables : SO_2, HNO_3, SO_4^{2-}, HCl, NH_3, Cl^-, NO_3^-, Na^+, K^+, Ca^{2+}, Mg^{2+}, NH_4^+
- Wind direction, Wind speed, Air temperature, Humidity, and Rainfall.
- Methods : filter pack (aerosol), automatic for meteorology
- Laboratory: Pusarpedal – KLH.

b. Jakarta (Kantor BMG)

- Location : urban
- Interval : 24 hours every five days
- Variables : SO_2, NO_2, Wind direction, Wind speed, Air temperature, Humidity, Solar radiation and Rainfall.
- Methods : Passive sampler (SO_2,NO_2), Automatic for meteorology
- Laboratory: BMG - Jakarta.

c. Kototabang, West Sumatra (BMG Office)

- Location : remote area
- Interval : weekly
- Variables : SO_2, NO_2, Wind direction, Wind speed, Air temperature, Humidity, Solar radiation and Rainfall.
- Methods : passive sampler and automatic air monitoring equipment.
- Laboratory: BMG, Kototabang, West Sumatra.

3. Monitoring of soil and vegetation

Soil:

Bogor Forestry Research Station

- Location : rural
- Interval : every three until five years

- Variables : moisture content, pH (H_2O and KCl), concentration of exchangeable cation, exchangeable acidity, effective cation exchange capacity.
- Methods : Drying oven, balance, glass electrode, AAS, ICP-AES or ICP-MS (CH_3COONH_4-Extraction), titration (KCl- Extraction), calculation (as sum of exchangeable cations)
- Laboratory: Center for Soil and Agro-climatology Research, Bogor

4. Monitoring of inland aquatic

The monitoring site of acid deposition impact to aquatic environment is Patengan lake. Patengan Lake located in the area of South Bandung at Ciwidey district of West Java province and detail of lake explain as a below

- Location : remote
- Interval : four times /years
- Variables : water temperature, pH, EC and Alkalinity (at pH 4.8 baseline) and concentration of SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^+
- Methods : pH meter, EC meter, Titration and Spectrofotometer and AAS
- Laboratory: Research Institute for Water Resources (RIWR), Ministry of Public Works
- Interval : once /years
- Variables : transparency, water colour, COD, NO_2^-, PO_4^{3-}
- Methods : Sechi disk, spectrofotometer, titration and spectrofotometer
- Interval : once in three until five years
- Variables : sediment (SO_4^{2-}, NO_3^- and NH_4^+)
- Methods : spectrofotometer

3.1.4 Monitoring program of acid deposition from 2001-2005

Monitoring program for acid deposition is followed the EANET guideline for selected sampling point for wet, dry and inland aquatic, analysis and data reporting. In year 2001 to 2005 the monitoring point and properties not changed. The monitoring program for 2001-2005 is.

- Monitoring of wet deposition at several cities such as Jakarta, Serpong, Bandung, Bukit Kototabang
- Survey area of monitoring for wet deposition such as Medan, Palangkaraya, Manado, Batam and Kupang was done in 2003
- Monitoring of inland aquatic is carried out in Patengan lake West Java and 2006 will be surveyed Sicikeh-cikeh lake in Dairi North Sumatera.
- Inter laboratory exchange information about laboratories condition, methods and equipment used in analyses
- To make cooperation with local government for coordination of monitoring activities
- Every year participate on Inter Laboratory Comparison like round robin test program that is carried out by Government of Japan
- Every year participate on training programs carried out by Government of Japan

3.1.5 Outline of sampling and measurement

i. Wet deposition

a. Classification of sampling point and Monitoring

The sampling locations of wet deposition can be classified in 3 types: remote, rural and urban area according to the target is achieved.

b. Remote area: is a purlieu location was selected in order to determine the status of acid deposition at background region. Result of monitoring data of this area can be used to evaluate influence of long distance transportation of pollutant, which has the character of acid in East Asian region. In this case selected locations have to be in the form of the area with minimum influence of local emission contamination and emission sources (the sources like residential, power plant, factory, toll road, and harbor and train road). The selection of sampling point for wet deposition monitoring it was not in the location influence by natural sources.

c. Rural area: is selected location that is rural area or hinterland. The monitoring result data can be used for evaluation of impact of wet deposition for forest and plantation. Selected location have to be in the form of region with minimum influence of local emission and source contamination and have to lay in distance which far from main stationary and mobile sources. At some rural locations which fulfill above criterion, get data result is also can be used to evaluate long distance transport and result of transmission model of compound have the character of acid.

d. Urban area: is urban location determined for examination of status of acid deposition which is selected for examination of level of acid deposition at an area. That is industrial, urban and other area where closely. The monitoring result can be used for evaluation presipitation and trend of acid deposition in urban area.

e. Measurement and Analysis

Measurement of parameter for monitoring of wet deposition covering: pH, Conductivity(DHL), Ion Concentration of (SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^+).Equipment, chemical substances have to free contamination in order measurement and analysis of sample, and blank sample low value for parameter pollutant to be analysis.

ii. Dry deposition

a. Classification of sampling point and monitoring

The sampling sites of dry deposition have to represent three locations *i.e.* a remote area, rural and urban areas where human activities exist. The methods used in collecting the samples is four level filter pack and applied at the sampling site at Sarpedal Serpong. Measurement of the dry deposition properties are: ion concentration of (SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+} and Mg^+), and SO_2, NO_2, NH_3 gases. Sampling period for all samples starts from January each year (sampling period 1 stands for starting month i.e. January).

3.2 State of acid deposition in Indonesia

3.2.1 Atmospheric Deposition

3.2.1.1 State of Wet Deposition

Observation of wet deposition in urban areas is conducted in Jakarta city as a coastal area, and Bandung at elevation about 743 m above sea level surrounded by mountains. The observation for the rural site is at Serpong, about 40 km to south of Jakarta city. The remote site was selected at Kototabang, West Sumatra. The concentrations of pollutants in the rain samples calculate by considering the volume of the rain are

weighted mean. The annual mean results of ions, pH and electrical conductivity in three years observation from 2001 to 2003 are presented in Table 3.1. The pH of the rain water ranged from 4.6 to 5.2 well below the criterion of acid rain with pH 5.6. This means that all the sites have experienced acid rain in increasing order from Serpong, Bandung, Jakarta and Kototabang.

Jakarta a metropolitan city with high transportation activities and surrounded by industrial plants, close to the sea that seen in the high concentration of chloride ion (Cl^-) with annual mean value of 39.8 µmol/l higher than Serpong, Bandung and Kototabang those are farther inland, respectively with 27.4 µmol/l; 19.4 µmol /l; dan 16.5 µmol /l. The influence of the sea also seen in the concentration of Na^+, Mg^{2+}, SO_4^{2-} and Ca^{2+} are higher compared to those from Serpong, Bandung and Kototabang. Jakarta also has higher non sea salt SO_4^{2-} and NO_3 because of the emission from transportation activities. High concentration of non sea salt Ca^{2+} is also emitted from transportation activities.

At Serpong, the rural site with many tree vegetations as land cover has very high concentration of NH_4^+ compared to the other sites. This is high concentration is probably because of the present of NH_3 and ammonium gases from agriculture and animal husbandry activities. The gases further reacted with H_2SO_4 and HNO_3 to form sulfate and nitrate aerosol and increase the concentration of SO_4^{2-} , NO_3^- in the rain water. The high concentration of non sea salt SO_4^{2-}, NO_3^- indicating the influence of high transportation and industrial activities from Tangerang and Jakarta nearby Serpong. The concentration of Cl^-, Na^+, Mg^{2+}, SO_4^{2-} and Ca^{2+} are also high compared to Bandung and Kototabang although lower than Jakarta. Hence other than agriculture and animal husbandry the influence of the sea has been observed at Serpong site.

Differ with Jakarta that a coastal city, Bandung is high on a plateau far from the sea. The highest concentrations are of nss ion SO_4^{2-} , NO_3^- , NH_4^+ and nss Ca^{2+}. This because of the high transportation activity along with high sulfate and nitrate aerosol, therefore affecting ammonium concentration. Significantly high nss Ca^{2+} concentration in the rain water is probably because of the high Ca concentration of the soil. The Cl^- concentration as the fourth highest is probably is because of the effect of HCl used in pharmaceutical industry in the city, because Bandung is far from the sea. While the concentration of ion that come from the sea as Na, Mg^{2+}, and K^+ are relatively low.

Kototabang as Global Atmosphere Watch, site is far from the sea and industrial and transportation activity, the concentration of Cl^-, Na, Mg^{2+}, Ca^{2+} and K^+ ions are very low. As also concentration of nss SO_4^{2-}, NO_3^- , NH_4^+ and nss Ca^{2+} that from human activities are very low.

Hence, in the four sites the precipitation chemistry is influenced by its local geographical location. At Serpong other than local factors are also affected by it vicinity to Jakarta with relatively high concentration of nss SO_4^{2-} , NO_3^- and NH_4^+ ions.

Table 3.1 Annual average of ions concentration of Rain water

No	location	No. of samples	SO_4^{2-} umol/l	nss SO_4^{2-} umol/l	NO_3^- umol/l	Cl^- umol/l	NH_4^+ umol/l	Na^+ umol/l	K^+ umol/l	Ca^{2+} umol/l	nss Ca^{2+} umol/l	Mg^{2+} umol/l
1	Serpong	198	29.0	27.8	38.0	27.4	52.8	20.1	6.3	10.0	9.6	3.6
2	Jakarta	71	55.3	53.3	46.8	39.8	32.8	33.9	7.7	69.5	68.8	31.6
3	Bandung	257	27.3	26.6	24.5	19.4	33.5	12.0	6.2	17.4	17.1	2.5
4	Kototabang	124	6.9	6.5	18.2	16.5	1.6	6.6	8.3	3.8	3.7	3.2

No	location	H^+ umol/l	pH umol/l	EC mS/m
1	Serpong	23.4	4.6	2.4
2	Jakarta	9.2	5.1	11.4
3	Bandung	18.4	4.8	1.8
4	Kototabang	6.0	5.2	2.4

3.2.1.2 State of Dry Deposition

a. Introduction

Dry deposition in Indonesia is being sampled using Filter Packs method since 2001until now. The other method such as Air Quality Monitoring has many problems in the continuity of data producing, due to calibration and maintenance problems. Filter Packs method is developed by Japan for sampling dry deposition by means of chemical reaction in each stage of filter absorber. Parameter to be analyzed are SO_2, HNO_3, HCl and NH_3 in a gas phase; and SO_4^{2-} , NO^{3-}, Cl^-, NH_4^+, Na^+, K^+, Mg^{2+}, Ca^{2+} in a particulate phase.

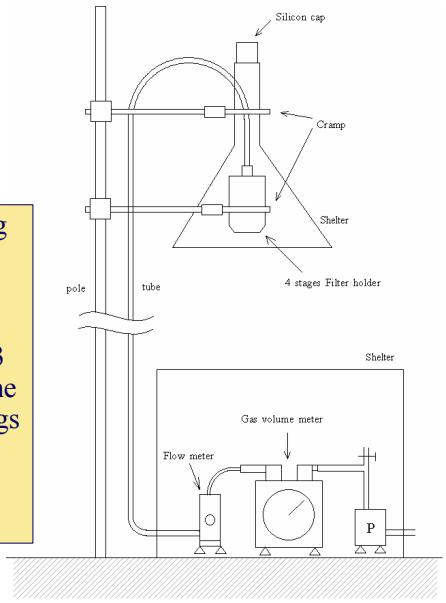
b. Methods of air concentration monitoring

- Automatic monitor - *expensive*, parameter to be measured is SO_2, NO, NO_2, O_3, PM
- Filter pack - *inexpensive, simple*, parameter to be measured is SO_2, HNO_3, HCl, NH_3, and Particle components
- Denuder - *expensive, complicated*, parameter to be measured is SO_2, HNO_3, HCl, NH_3, and Particle components
- Passive sampler - *inexpensive, simple*, parameter to be measured is SO_2, NO, NO_2, HNO_3, HCl, NH_3, O_3, etc

c. Sampling Train

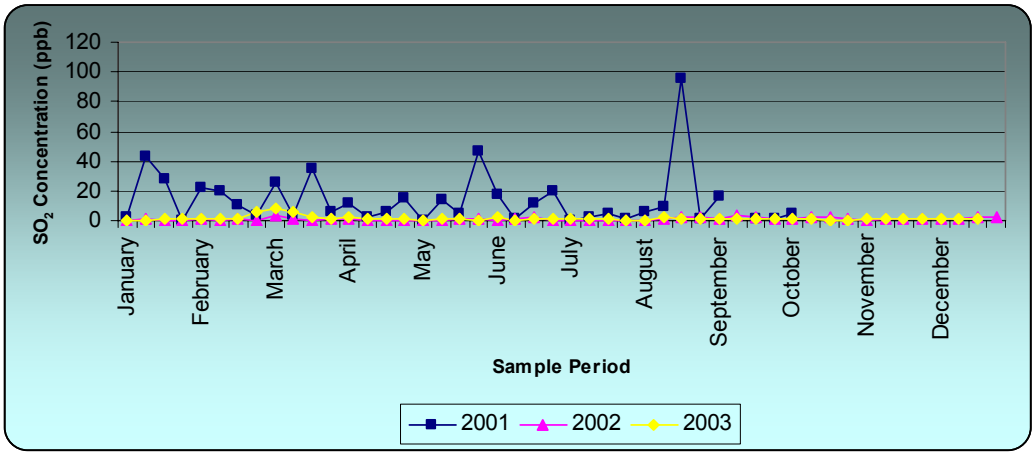
Sampling system

- The inlet of sampling air should be set up from 5 to 10 meters above the ground.
- It should be around 3 meters higher than the height of the buildings if the inlet is on the buildings. (QA/QC program)



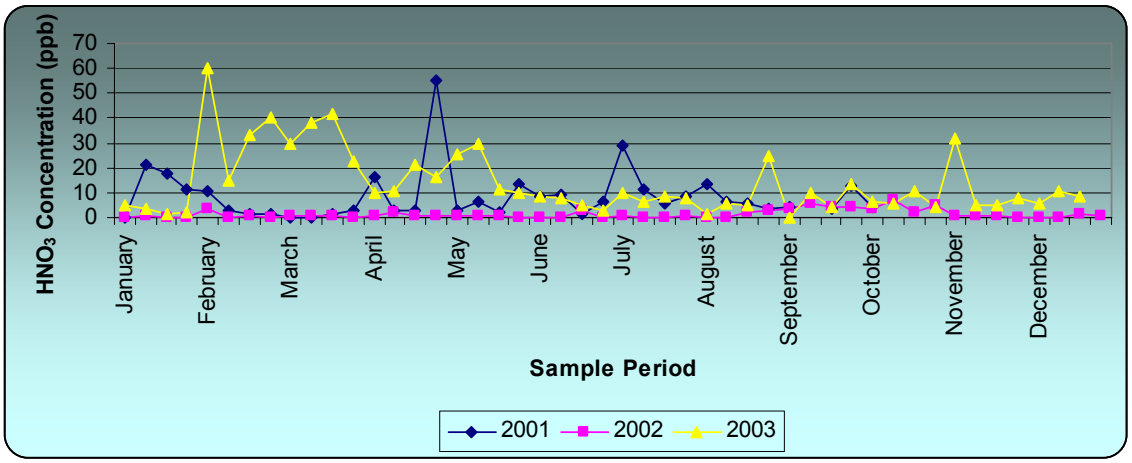
The following graphic elaborated and clustered for each month where x axis are weekly sampling times.

Diurnal of SO_2 Variation (with data 2001)



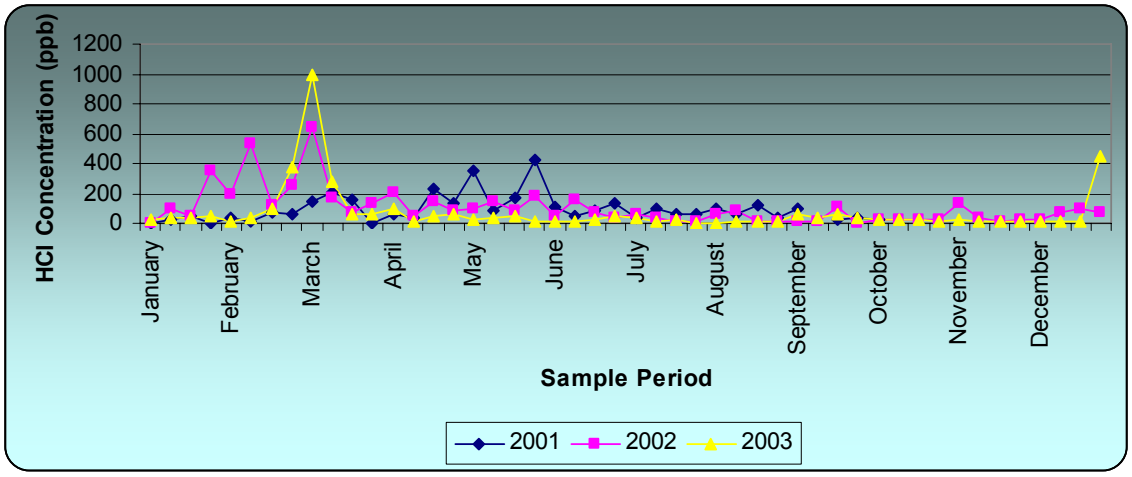
NOTE: Significant difference between data 2001 and 2002-2003.
Hit the highest point for period of 31 (3/6~10/6) in 2001

Diurnal of HNO_3 variation



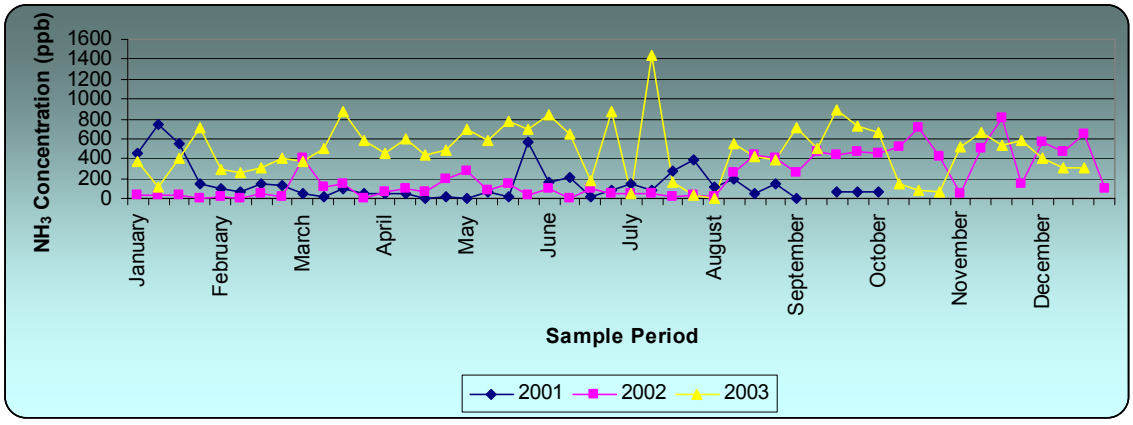
NOTE: Fluctuate both year 2001 and 2003. Level off during year 2002.
Relatively higher variation for period 2003

Diurnal of HCl variation



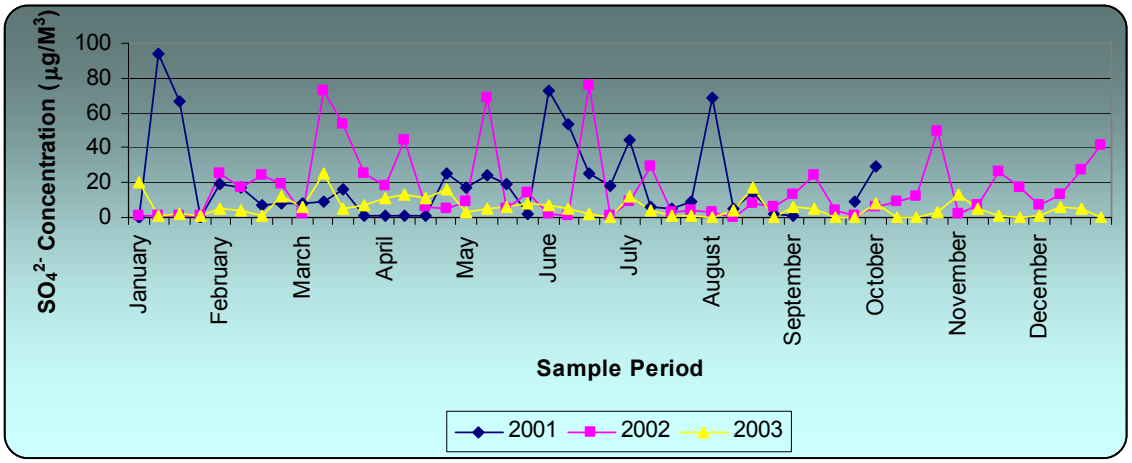
NOTE: Hit the highest point for period of 9 (11/3~18/3) in 2002 and (25/2~4/3) in 2003

Diurnal of NH_3 Variation



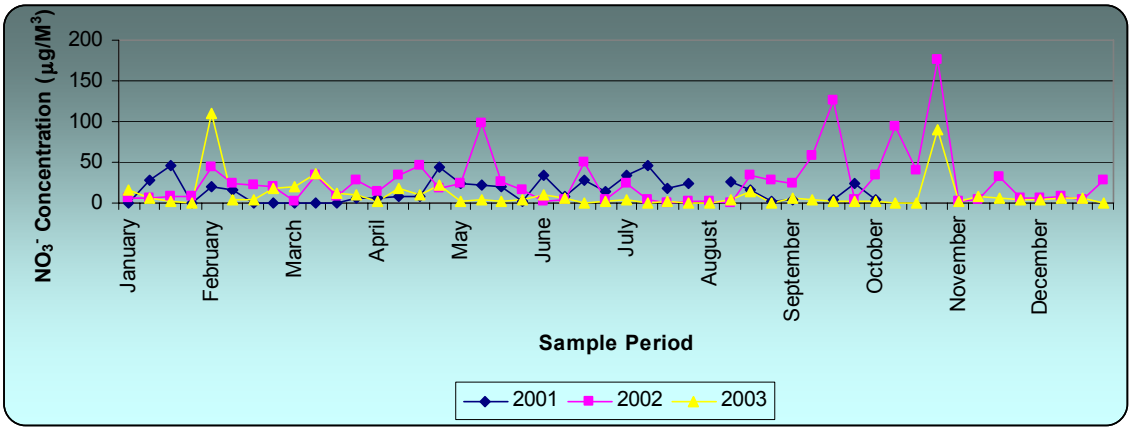
NOTE: Fluctuate through the year.
Relatively higher variation for period 2003

Diurnal of SO_4^{2-} Variation



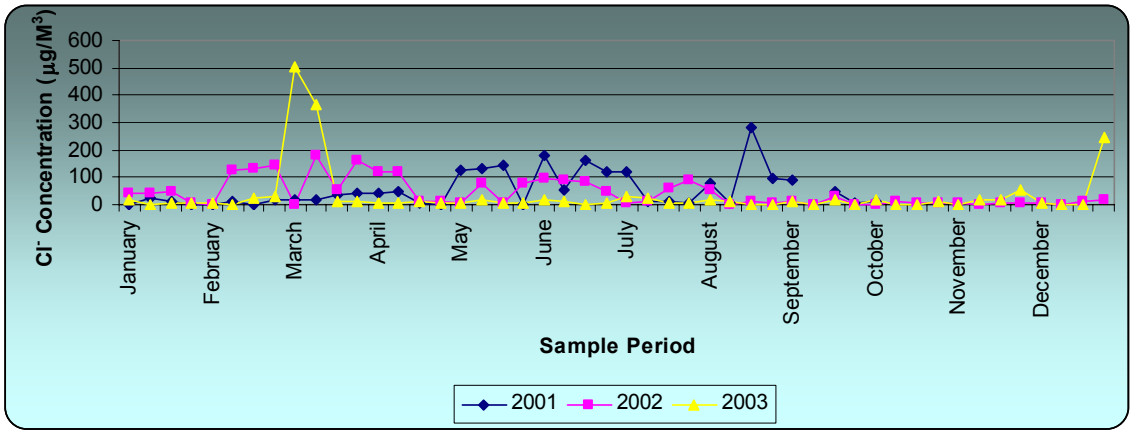
NOTE: Fluctuate through the year.
Relatively lower variation for period 2003

Diurnal of NO_3^- Variation



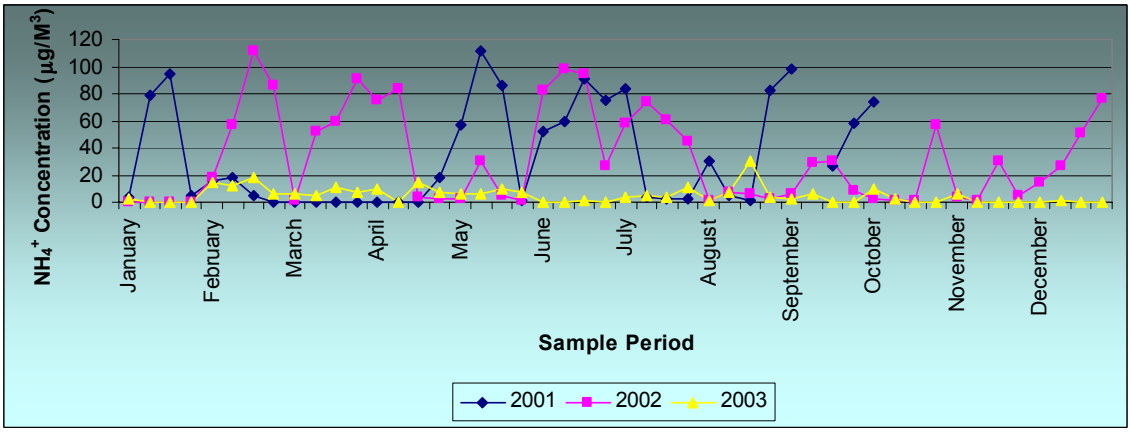
NOTE: Fluctuate through the year.
Relatively lower variation for period 2003

Diurnal of Cl^- Variation

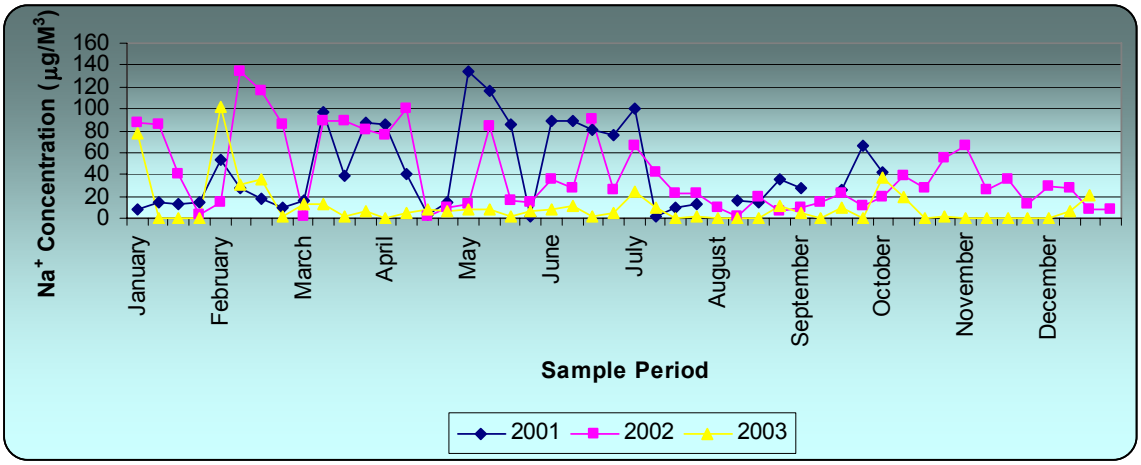


NOTE: Hit the highest point for period of 9 (25/2~4/3) in 2003
Relatively lower variation for period 2003

Diurnal of NH_4^+ Variation

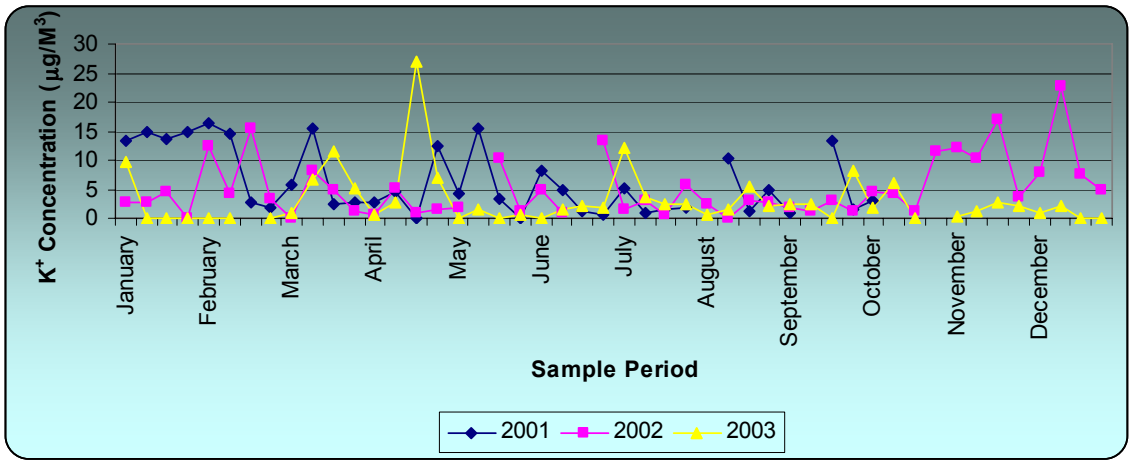


Diurnal of Na^+ Variation



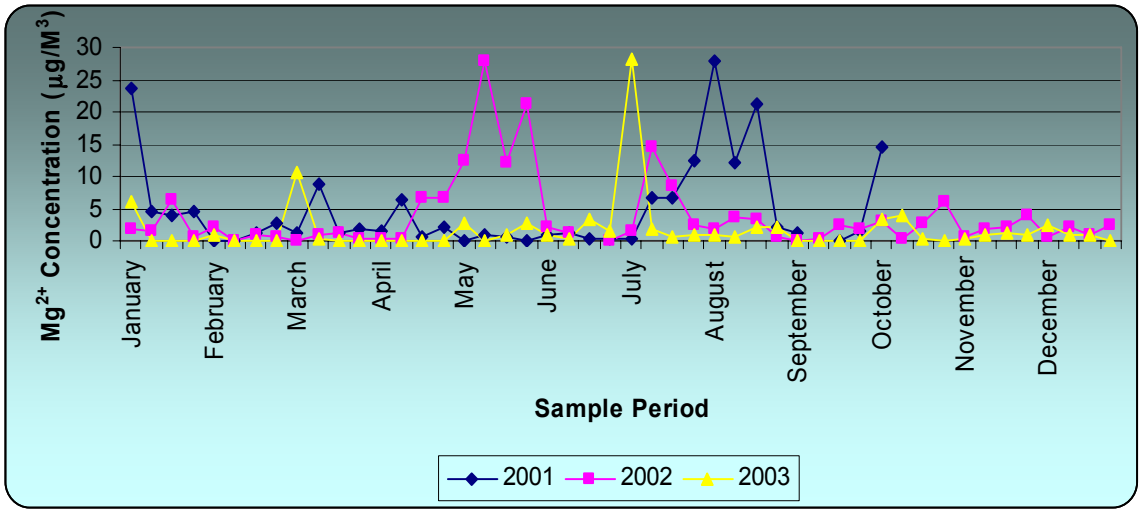
NOTE: Relatively lower variation for period 2003

Diurnal of K^+ Variation



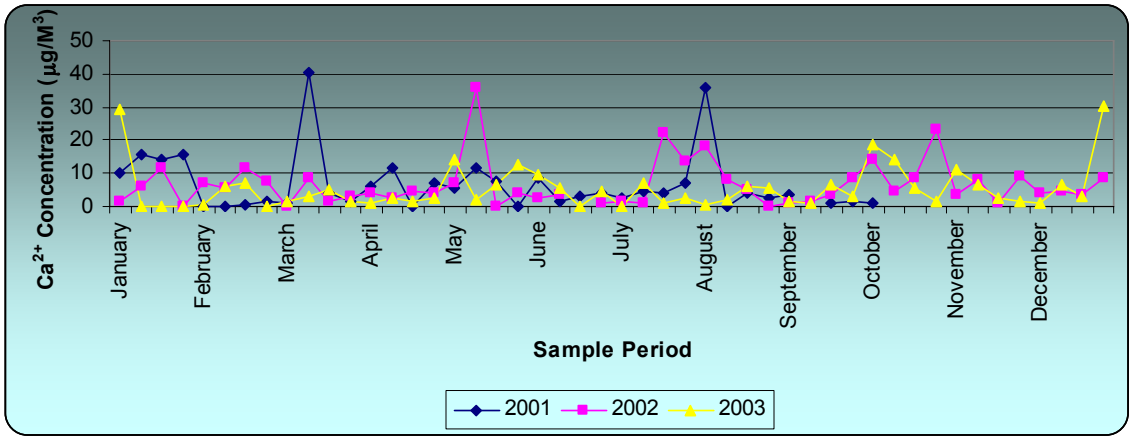
NOTE: Relatively lower variation for period 2003

Diurnal of Mg^{2+} Variation



NOTE: Relatively lower concentration for year 2003

Diurnal of Ca^{2+} Variation



Source of higher concentration during certain period

- Biomass burning during period of sampling could contribute to the higher concentration of NH_3 and NH_4^+. NH_3 has relatively highest concentration among other pollutant
- Sample contamination during preparation due to the reactivity of the adsorbent with the indoor pollution (No special room for preparation)
- Deviation of sample concentration during analysis due to the lower stability of the column

Discussion (1)

- There is a pattern that the data for gas parameters in year 2003 has relatively higher concentration than other years. On the other side, the data for particulate parameters in year 2003 has relatively lower concentration than other years. The adoption of technical guideline in year 2003 may be contributed to the technical aspects during sampling and analysis.
- Data for SO_2 in year 2001 has significantly differed from other (2002 and 2003). The whole data in year 2001 should be deleted.

Discussion (2)

- There is no exact range for the period of dry season and wet season. The tendency is more on the characteristic of the pollutant catched by rained out or washed out.
- There is no National Standard for all parameters except SO_2. There is no warning level so it should be evaluated which source we should pay attention for, that gave the highest contribution to the lower pH in Indonesia.
- There is no exact range for the period of dry season and wet season. The tendency is more on the characteristic of the pollutant catched by rained out or washed out.
- There is no National Standard for all parameters except SO_2. There is no warning level so it should be evaluated which source we should pay attention for, that gave the highest contribution to the lower pH in Indonesia.

Recommendation

- Alternative method to be considered is using Passive Sampler for some gases (SO_2, NO_2, Oxidant, etc) for monitoring dry deposition.
- QA/QC guideline for data analysis should be established.
- Recovery test method should be applied for Filter Pack samples to check matrix interferences.
- The action plan for National Strategy is to give recommendation about specific sources which contribute highest to the lower pH.

3.2.2 Ecological Impacts

3.2.2.1 State of Soil & vegetation

The world is an acidic place naturally. Most of the atmosphere has more acidic gases and particles than basic ones. Thus it is not surprising that wet deposition in terrestrial and marine regions remote from human influence is acidic (Galloway *et al*., 1982). Most of natural soils are acidic due to both organic matter production and decomposition, as are drain from acid soils. Indeed the only large region of the world that is not acidic is the ocean.

There are three processes are that have made the world more acidic: increasing population that results in increasing food and energy productions. Energy production from fossil fuel combustion causes the formation of NO and SO_2 which form nitric and sulfuric acids. Currently the emission rate of these two

gases in the atmosphere exceed natural rate by about 8 and 4 times, respectively (Galloway, 1996). Food production in turn causes acidification because of inefficiency of fertilizers uptake. About 90% of NH_3 produced is lost, prior to human consumption, much of it to the atmosphere (Galloway, 1998)

Acidification of soil results in less optimal growth of particular crops in the long run, but acidification can also directly have adverse effects on the vegetation. To monitoring the impacts of acid deposition on soil and vegetation in Indonesia permanent sites that are expected not to be disturbed in the future have to be decided. Initially three monitoring sites were selected and characterized namely, Serpong, Bogor and Gunung Mas in the vicinity of the capital Jakarta with longest distance of more than 50 km. However, the exceeding 50 km distance and the unnatural vegetation of the two sites (Serpong and Gunung Mas) made them unqualified for the samples sites.

Efforts have been made to find suitable sites for substitutes, but in the overcrowded place near the capital such places are very limited. The site at Bogor is a forest research station with vegetation dominated by *Dipterocarpus sp.* The soil is classified as *Typic Dystrudept* based on USDA soil classification indicating a moderately developed soil on a humid climate with acidic surface soil. The initial chemical characteristics considered as baseline are presented in the following Table.

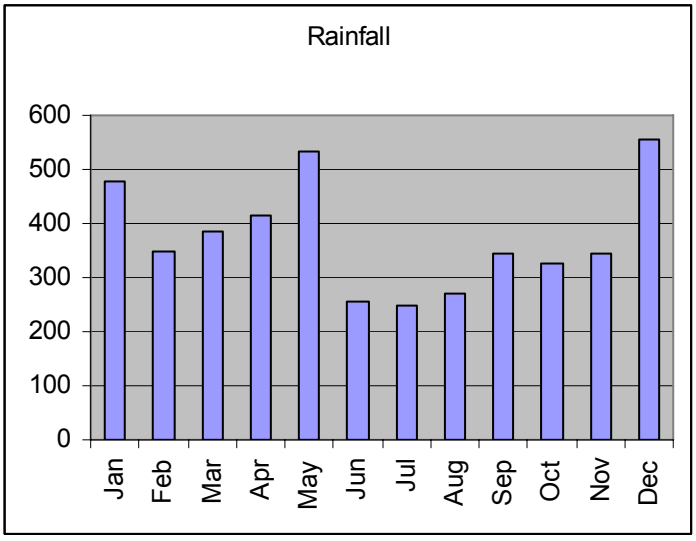


Figure 3.1 Monthly Rainfall Distribution in the Site (mm)

Table 3.2 Soil Particle Distribution and Chemical Characteristics a Four Top Layers

	Depth (cm)			
Property	**0-16**	**16-33**	**33-62**	**62-87**
Sand (%)	8	7	5	4
Silt (%)	12	20	16	23
Clay (%)	80	73	73	70
pH (H_2O)	4.1	4.4	4.7	4.8
pH (KCl)	3.7	3.9	4.0	4.0
Organic C (%)	1.48	0.98	0.65	0.52
Organic N (%)	0.18	0.14	0.12	0.09
Bray-1 P (ppm)	6.7	4.3	3.7	3.6
P retention (%)	64.3	62.8	63.1	63.9
Exchangeable Ca ($Cmol^{(+2}g^{-1}$)	0.64	2.03	3.56	4.00
Exchangeable Mg ($Cmol^{(+2}g^{-1}$)	0.31	0.85	2.12	2.01
Exchangeable K ($Cmol^{(+)}\ kg^{-1}$)	0.08	0.08	0.05	0.02
Exchangeable Na ($Cmol^{(+}kg^{-1}$)	0.06	0.06	0.08	0.18
Exchangeable Al ($Cmol^{(+3}kg^{-1}$)	4.46	2.23	0.61	0.48
Exchangeable H ($Cmol^{(+)}\ kg^{-1}$)	0.25	0.11	0.08	0.12

3.2.2.2 State of Inland Aquatic

a. GENERAL INFORMATION

The Research Institute for Water Resources (RIWR), as Agency for Water Resources, Development has the task to implement research and development in the field of water resources based on technical policy of the Directorate General of the Agency for Research and Development of the Ministry of Public Works.

In implementing its task as mentioned above, the Research Institute for Water Resources has the function as follow:

- Formulation of research and development program in water resources
- Implementation of research and development in water resources technology
- Evaluation and analysis of the result and research and development in water resources
- Coordination of dissemination and socialization of the result research and development in water resources
- Development of corporation in management R & D in water resources
- Implementation of testing and preparation of technical advice in water environment, hydrology, hydraulic and water geo-technique, river, sabo, swamp-coasts and irrigation

b. PROGRAM IMPLEMENTATION

Since 1999 the Experimental Station for Water Environment (ESWE) as the technical services unit of RIWR, has been participated the preparation of national acid deposition monitoring network in Indonesia, and since September 1999 the implementation of monitoring has been carried out at 9 location in Java and

Sumatra island for further selection. From those locations, the Patenggang Lake has been selected as one of national station for acid deposition monitoring in Indonesia.

Related to program implementation on acid deposition monitoring in Indonesia, the ESWE has function similarly to the program such as:

- Compile work programs, implement R & D as well as prepare technical advice and become a scientific back bone in the field or water environment.
- Monitoring of water quality.
- Assessment of environment quality data of water resources.
- Research and development of field and laboratory test.
- Preparation of draft national technical standard, procedures and manuals/guideline in field of water environment.
- Supervision of national and regional water quality monitoring program.

c. PARTICIPATION ON ACID DEPOSITION MONITORING

1. Participation of RIWR

In the national acid deposition monitoring program in Indonesia, RIWR participates in the monitoring of acid deposition impact to inland aquatic. Beside others institute, which are participated on the acid deposition monitoring program in dry deposition, wet deposition, and impact to soil and vegetation.

2. Method of Monitoring

– Sampling Method
Lake water sample is taken with Grab at determined area in outlying place; example conservation is for analyzing unstable parameter during containing process to Experimental Station for Water Quality and Environment, Research Institute for Water Resources in Bandung.

Table 3.3 List of Analyzed Parameters

No.	Parameter	Method	Instrumental
1	pH	Electrometrically	pH meter
2	Electrical conductivity	Electrometrically	Conductivity meter
3	Alkalinity	Titration	Titrator, Digital Buret with pH meter
4	Chloride (Cl)	Titration	Titrator
5	Sulphate (SO_4)	Spectrophotometry	Spectrophotometer
6	Nitrate (NO_3)	Spectrophotometry	Spectrophotometer
7	NH_4	Spectrophotometry	Spectrophotometer
8	PO_4^{3+}	Spectrophotometry	Spectrophotometer
9	Sodium (Na)	Spectrophotometry	Atomic Absorption Spectrophotometer
10	Pottasium (K)	Spectrophotometry	Atomic Absorption Spectrophotometer
11	Calsium (Ca)	Titration	Titration
12	Magnesium (Mg)	Titration	Titration

– Method of Analysis and Measurement

Analysis method contains temperature; pH, Electrical Conductivity, Alkalinity, SO_4, NO_2, Cl, PO_4, NH_4, K, Ca^{2+}, and Mg^{2+} are referred to Indonesian National Standard in general. For determination and evaluation of data validity comparing with member of acid deposition monitoring network in South East Asia (EANET), it calculated and processed data suit to quality guarantee program and quality monitoring as well as QA/QC method of ADORC.

d. RESULT OF INLAND AQUATIC ENVIRONMENT MONITORING

The result of water quality monitoring of **Patengan Lake** as well as acid deposition monitoring program can be investigated in the result of inland aquatic environment monitoring duration of year 2001-2003.

Table 3.4 The Result of Inland Aquatic Environment Monitoring (Year 2001)

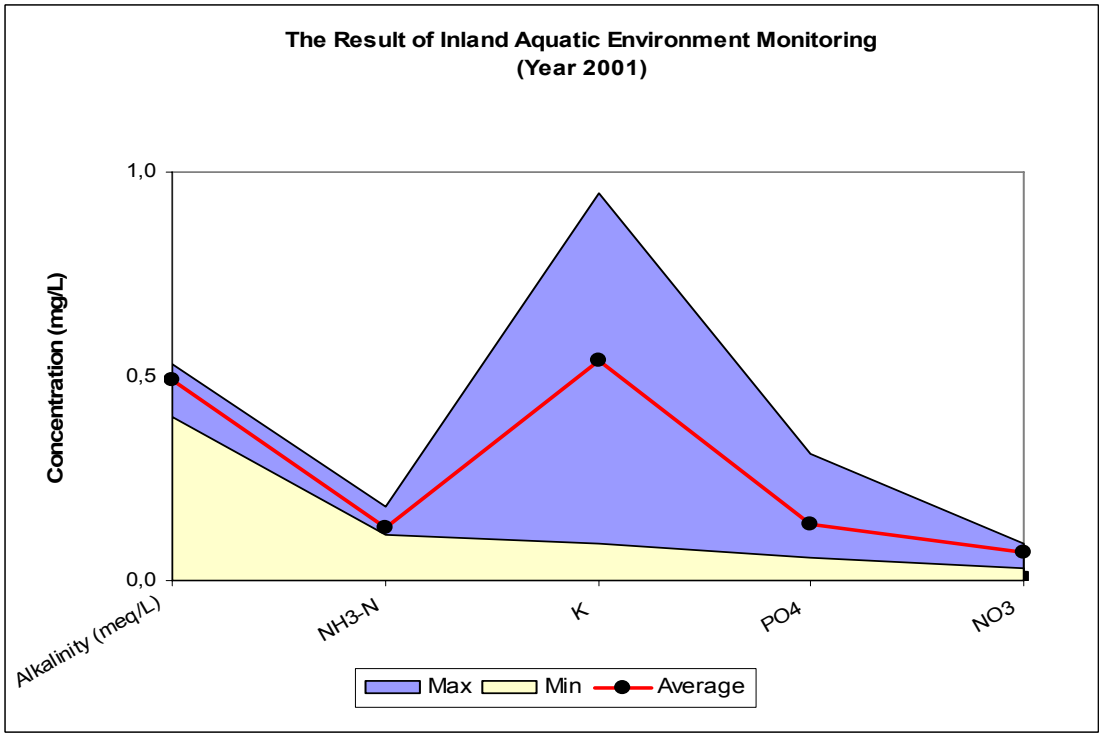
Parameter	Unit	Result of Water Quality Analysis					
		May, 26	July, 30	Sept, 29	Oct,30	Nov, 08	Average
Electrical Conductivity	mS/cm	7.95	8.35	5.80	6.15	8.15	7.28
Temperature	^oC	-	-	-	-	-	-
pH	-	7.60	7.80	8.30	8.30	7.95	7.90
Alkalinity	meq/L	0.53	0.53	0.40	0.49	0.50	0.49
Total Ammonia (NH_3-N)	mg/L	0.16	0.11	0.12	0.11	0.18	0.13
Chloride (Cl)	mg/L	11	11	5.80	5.05	8.10	8.19
Sodium (Na)	mg/L	6.75	6.75	2.20	2.65	6.15	4.90
Potassium (K)	mg/L	0.90	0.09	0.35	0.40	0.95	0.54
Sulfate (SO_4)	mg/L	2.75	4.10	4.00	3.15	7.65	4.33
Calcium (Ca)	mg/L	5.20	7.20	5.95	6.30	6.95	6.32
Magnesium (Mg)	mg/L	2.35	1.90	2.55	2.00	2.10	2.18
Phosphate (PO_4)	mg/L	0.085	0.105	0.310	0.130	0.055	0.137
Nitrate (NO_3)	mg/L	0.09	0.03	0.07	0.07	0.09	0.07

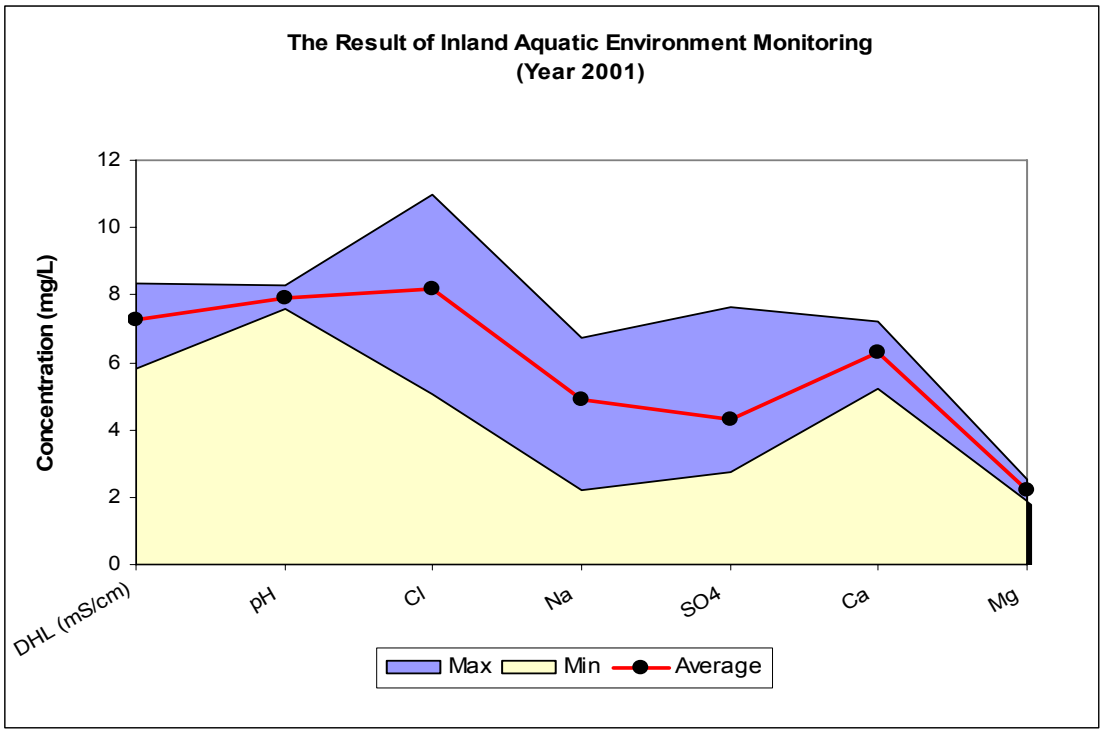
Table 3.5 The Result of Inland Aquatic Environment Monitoring (Year 2002)

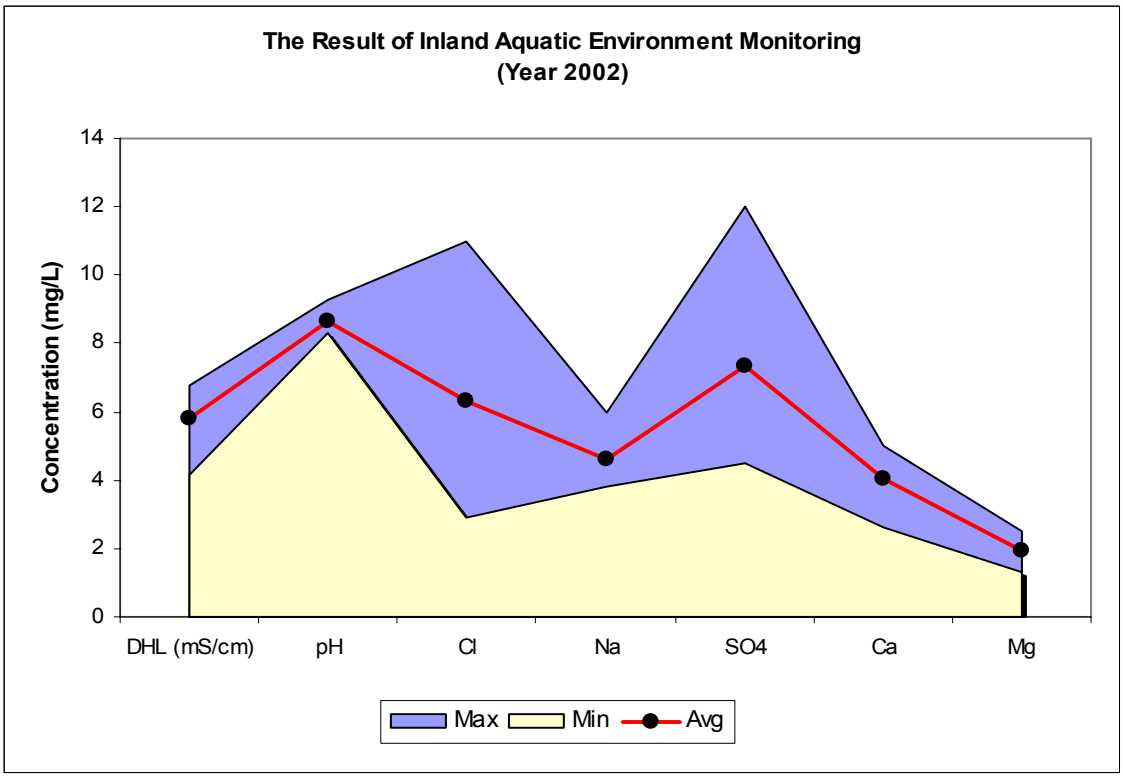
Parameter	Unit	Result of Water Quality Analysis			
		Aug, 30	Nov, 02	Dec, 16	Average
Electrical Conductivity	mS/cm	6.58	6.78	4.13	5.83
Temperature	^{o}C	-	-	-	-
pH	-	9.27	8.31	8.30	8.46
Alkalinity	meq/L	0.280	0.250	0.236	0.255
Total Ammonia (NH_3-N)	mg/L	0.460	0.018	0.018	0.165
Chloride (Cl)	mg/L	5.00	11.0	2.90	6.30
Sodium (Na)	mg/L	4.00	6.00	3.80	4.60
Potassium (K)	mg/L	1.00	0.74	0.40	0.71
Sulfate (SO_4)	mg/L	12	5.50	4.50	7.33
Calcium (Ca)	mg/L	5.00	4.50	2.60	4.03
Magnesium (Mg)	mg/L	2.50	2.00	1.30	1.93
Phosphate (PO_4)	mg/L	-	-	-	-
Nitrate (NO_3)	mg/L	0.00	0.10	0.08	0.06

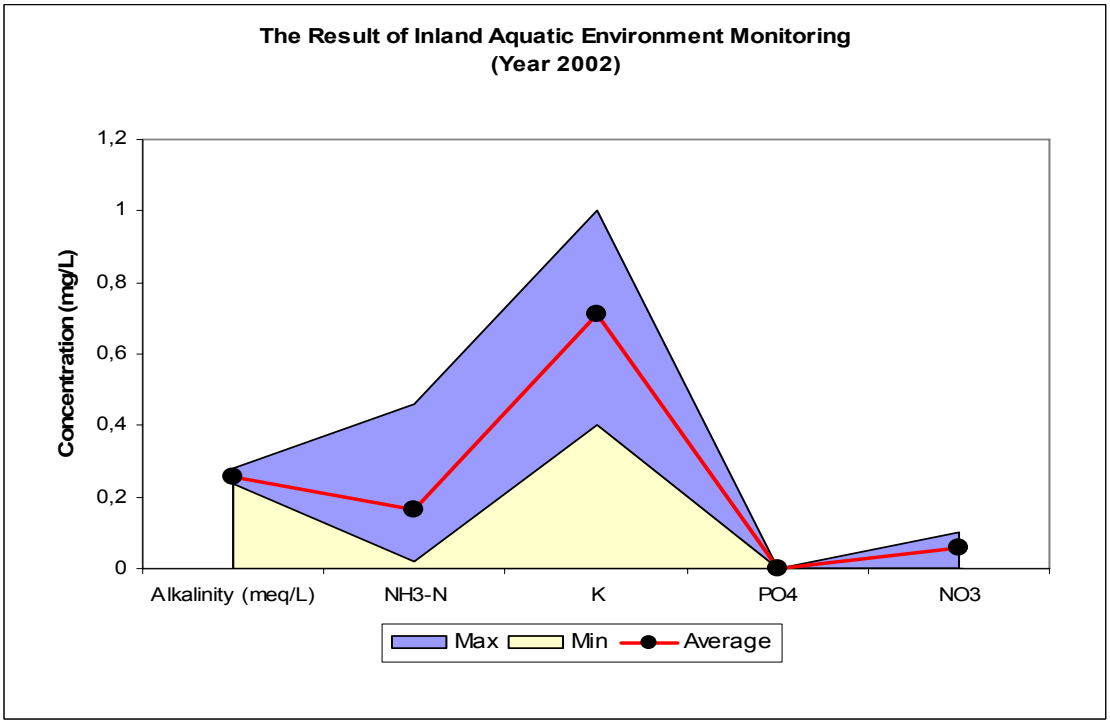
Table 3.6 The Result of Inland Aquatic Environment Monitoring (Year 2003)

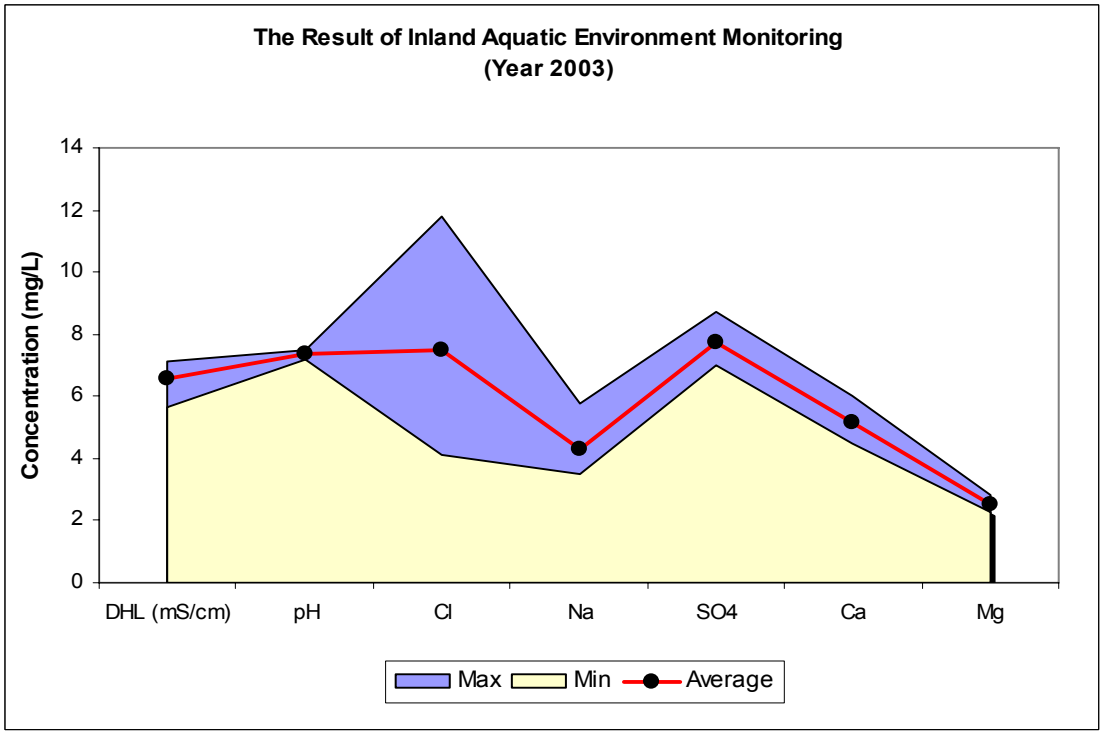
Parameter	Unit	Result of Water Quality			
		Apr, 17	Oct, 20	Dec, 31	Average
Electrical Conductivity	mS/cm	7.00	5.64	7.10	6.58
Temperature	^{o}C	23.5	20.3	24.1	22.6
pH	-	7.40	7.18	7.50	7.34
Alkalinity	meq/L	0.44	0.60	0.34	0.46
Total Ammonia (NH_3-N)	mg/L	0.46	0.59	0.54	0.53
Chloride (Cl)	mg/L	11.80	4.10	6.60	7.50
Sodium (Na)	mg/L	3.60	3.50	5.80	4.30
Potassium (K)	mg/L	0.68	0.40	0.40	0.49
Sulfate (SO_4)	mg/L	7.00	7.50	8.78	7.76
Calcium (Ca)	mg/L	6.00	4.50	5.00	5.17
Magnesium (Mg)	mg/L	2.80	2.30	2.50	2.53
Phosphate (PO_4)	mg/L	0.62	-	-	0.21
Nitrate (NO_3)	mg/L	0.18	0.00	0.38	0.19

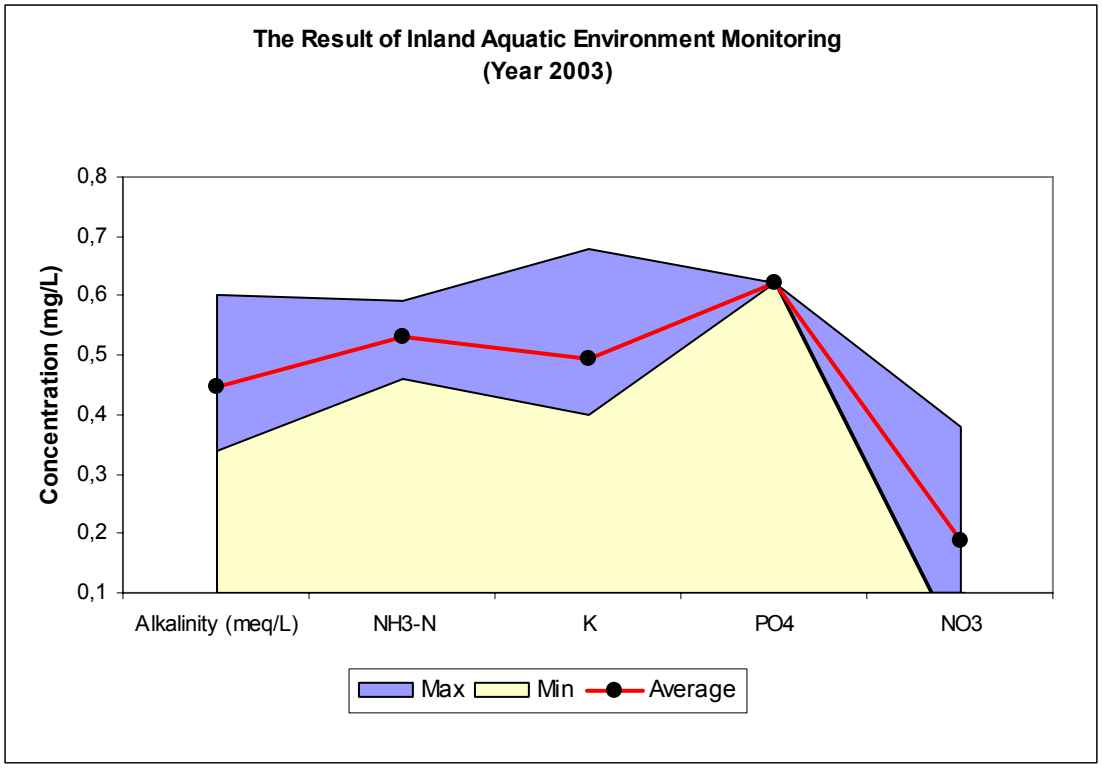

The Result of Inland Aquatic Environment Monitoring
(Year 2001)
Concentration (mg/L)
1,0
0,5
0,0
Alkalinity (meq/L)
NH3-N
K
PO4
NO3
Max
Min
Average


The Result of Inland Aquatic Environment Monitoring
(Year 2001)
Concentration (mg/L)
12
10
8
6
4
2
0
DHL (mS/cm)
pH
Cl
Na
SO4
Ca
Mg
Max
Min
Average


The Result of Inland Aquatic Environment Monitoring
(Year 2002)
Concentration (mg/L)
14
12
10
8
6
4
2
0
DHL (mS/cm)
pH
Cl
Na
SO4
Ca
Mg
Max
Min
Avg


The Result of Inland Aquatic Environment Monitoring
(Year 2002)
Concentration (mg/L)
1,2
1
0,8
0,6
0,4
0,2
0
Alkalinity (meq/L)
NH3-N
K
PO4
NO3
Max
Min
Average


The Result of Inland Aquatic Environment Monitoring
(Year 2003)
Concentration (mg/L)
14
12
10
8
6
4
2
0
DHL (mS/cm)
pH
Cl
Na
SO4
Ca
Mg
Max
Min
Average


The Result of Inland Aquatic Environment Monitoring
(Year 2003)
Concentration (mg/L)
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
Alkalinity (meq/L)
NH3-N
K
PO4
NO3
Max
Min
Average

e. CONCLUSION

The acid deposition was monitored annually from 2000 to 2004 for wet, dry and impact to inland aquatic water. Data used for evaluation of impact of acid deposition in Indonesia is from 2001 to 2003. The conclusion gets from the activities and evaluated data of acid deposition monitoring and study is:

- Acid deposition monitoring program should be implemented with good and correct methodologies in order to obtain valid data.
- Regular technical training courses on acid deposition monitoring are required to support good performance of monitoring.
- Long Term monitoring data are required to evaluate the impacts of acid deposition on inland aquatic.

3.2.3 Overall Analysis

The annual mean results of ions, pH and electrical conductivity in three years observation from 2001 to 2003 are presented in Table 1. The pH of the rain water ranged from 4.6 to 5.2 well below the criterion of acid rain with pH 5.6. This means supposed that all the sites have experienced of increasing of acid rain order from Serpong, Bandung, Jakarta and Kototabang.

Jakarta as a metropolitan city with high transportation activities and surrounded by industrial plants, close to the sea and seen in the high concentration of chloride ion (Cl^-) that is annual mean value is 39.8 µmol/l higher than in Serpong, Bandung and Kototabang, which those are farther inland, respectively with 27.4 µmol/l; 19.4 µmol /l; dan 16.5 µmol /l. The influence of the sea also seen in the concentration of Na, Mg^{2+}, SO_4^{2-} and Ca^{2+} are higher compared to those from Serpong, Bandung and Kototabang. The other properties also higher non sea salt SO_4^{2-} and concentration of NO_3^- because of the emission from transportation activities. High concentration of non sea salt Ca^{2+} is also detect from transportation activities in Jakarta.

The rural site Serpong area with many trees, vegetations has very high concentration of NH_4^+ compared to the other sites. This high concentration is probably because of the present of NH_3 and ammonium gases from agriculture and animal husbandry activities. These gases further reacted with H_2SO_4 dan HNO_3 to form sulfate and nitrate aerosol and increase the concentration of SO_4^{2-} , NO_3^- in the rain water. The high concentration of non sea salt SO_4^{2-}, NO_3^- indicating the influence of high transportation and industrial activities from Tangerang and Jakarta nearby Serpong. Concentration of Cl^-, Na, Mg^{2+}, SO_4^{2-} and Ca^{2+} from the sea are also high compared to Bandung and Kototabang although lower than Jakarta. Hence other than agriculture and animal husbandry the influence of the sea has been observed at Serpong site.

Differ with Jakarta as a coastal city; Bandung is high on a plateau far from the sea. The highest concentrations are of nss ion SO_4^{2-} , NO_3^- , NH_4^+ and nss Ca^{2+}. These because of the high transportation activity along with high sulfate and nitrate aerosol, therefore affecting ammonium concentration. Significantly high nss Ca^{2+} concentration in the rain water is probably because of the high Ca concentration of the soil. The Cl^- concentration as the fourth highest is probably is because of the effect of HCl used in pharmaceutical industry in the city. While the concentration of ion that come from the sea as Na, Mg^{2+}, and K^+ are relatively low.

Kototabang as Global Atmosphere Watch site and in acid deposition activities was determined as a remote site, is far from the sea, industrial and transportation activity, the concentration of Cl^-, Na, Mg^{2+}, Ca^{2+} and K^+ ions are very low. And also concentration of nss SO_4^{2-}, NO_3^- , NH_4^+ and nss Ca^{2+} that from human activities are very low.

Hence, in the four sites the precipitation chemistry is influenced by its local geographical location. At Serpong other than local factors are also affected by it vicinity to Jakarta with relatively high concentration of nss SO_4^{2-} , NO_3^- and NH_4^+ ions.

In case of dry deposition monitoring result, the sources of higher of concentration during certain period supposed come from

- Biomass burning during period of sampling could contribute to the higher concentration of NH_3 and NH_4^+. NH_3 has relatively highest concentration among other pollutant
- Sample contamination during preparation due to the reactivity of the adsorbent with the indoor pollution (No special room for preparation)
- Deviation of sample concentration during analysis due to the lower stability of the column
- There is a pattern that the data for gas parameters in year 2003 has relatively higher concentration than other years. On the other side, the data for particulate parameters in year 2003 has relatively lower concentration than other years. The adoption of technical guideline in year 2003 may be contributed to the technical aspects during sampling and analysis.
- Data for SO_2 in year 2001 has significantly differed from other (2002 and 2003). The whole data in year 2001 should be deleted.
- There is no exact range for the period of dry season and wet season. The tendency is more on the characteristic of the pollutant cached by rained out or washed out.
- There is no National Standard for all parameters except SO_2. There is no warning level so it should be evaluated which source we should pay attention for, that gave the highest contribution to the lower pH in Indonesia.
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Recommendation

To performance and evaluated the state of acid deposition in whole Indonesia area, it is recommended to develop and expand the monitoring site with simple and low cost of sample like:

- Alternative method to be considered is using Passive Sampler for some gases (SO_2, NO_2, Oxidant, etc).
- QA/QC guideline for data analysis should be established.
- Recovery test method should be applied for Filter Pack samples to check matrix interferences.
- The action plan for National Strategy is to give recommendation about specific sources which contribute highest to the lower pH.
- Monitoring program should be implemented with good and correct sampling and analysis.
- The technical training courses to local staffs are required to support the activities in order to obtain and increase validity of data

3.3 Review of National Measure against Acid Deposition

Based on monitoring result of Acid deposition from 2001 to 2003, status and its negative impacts has not identified yet in Indonesia. Nevertheless the Ministry of Environment as the agency responsible for environmental quality protection was developed and set up ambient and emission air quality standard and

water body and effluent standard. For ambient air quality control we have National Ambient Air Regulation (PP. 41/1999). For emission control sources from mobile and factories we have: Decrees of Ministry No-35/1993, No-141/2003 for emission control from mobile source, and No-13/1995 for emission control from factories source.

3.4 References

1. Acid Deposition Monitoring Network in East Asia: 2000, Guideline for Acid Deposition Monitoring in East Asia

2. Network Center for EANET: 2000, 2001, 2002, 2003, 2004, Data Report on the Acid Deposition in the East Asian Region, pp, 150-169

3. Network Center for EANET: 2005, Proceedings the Second Scientific Workshop on Evaluation of the State of Acid Deposition in East Asia, pp, 59-69

4. Indonesia National Ambient Air Regulation (PP41/1999), Ambient Air Quality Control

5. Decree of Ministry of Environment, No-35/1993, No-141/2003 for emission control from mobile sources, and No-13/1995 for emission control from stationary sources

National Assessments (Japan)

MOE: Ministry of the Environment (Japan)
ADORC: Acid Deposition and Oxidant Research Center

4.1 Basic Information on National Monitoring Activities

4.1.1 Outline of the activities on acid deposition and National Monitoring Plan

Acid deposition was drawing considerable concern in Europe and North America during the 1970s and 1980s. In 1983, aware that it was also important to determine the state of acid deposition and its adverse effects in Japan, the Environment Agency (which became the Ministry of the Environment [MOE] in January 2001) set up the Committee for Acid Deposition Measures, consisting of experts on air pollution, soil, vegetation, and inland aquatic environments, and launched the Acid Deposition Monitoring Survey.

4.1.2 Comprehensive report on acid deposition monitoring survey

The Acid Deposition Monitoring Survey, now conducted for over 20 years, has proven valuable in the effort to understand the state and effects of acid deposition in Japan, although the monitoring methods and sites have not always been the same since the First Survey.

In 2004, MOE published a comprehensive report on the Acid Deposition Monitoring Survey. The report reviews 20 years of monitoring, comparing the findings of the first to fourth surveys and with 2001 and 2002, It describes the findings obtained from analyzing all the monitoring data on wet and dry deposition, soil, vegetation, and inland aquatic environments, as well as integrated monitoring.

The main findings are described below (further detail is provided later in this document).

4.1.2.1 Situation of acid deposition (results of monitoring survey of acid deposition and others)

- Rain and snow with a pH of less than 3, which may cause acute damage to plants, was not observed. However, studies at 23 sites from FY 2000 to FY 2002 indicated that about 5% of samples had a pH of less than 4. This suggests that rain and snow were still as acidic in Japan as in Europe and the United States.
- Sulfate and nitrate deposition varied with season. The maximum value was observed in winter along the Sea of Japan side of the main island of Japan, where the supply of sulfur and nitrogen oxides in the atmosphere in winter is thought to increase, suggesting that pollutants may originate from the Asian continent.
- An increase in tropospheric ozone concentrations was observed nationwide in spring. Transboundary air pollution is strongly suspected as the source.

4.1.2.2 Effects on ecosystems (results of monitoring of vegetation, soil, and inland waters)

- At present, there is little reason to believe that acid deposition has caused any widespread damage to vegetation. It is therefore difficult to conclude that acid deposition has caused significant damage to ecosystems.
- Tree damage was observed at some sites where vegetation monitoring was carried out. In most cases, the cause of tree damage can be specified, for example, as damage by diseases and pests (such as pine wilt disease). Acid deposition and soil acidification were not confirmed as the primary causes of tree damage, although for certain tree species, such as

Japanese red pine, the causes of damage to some trees were unknown.

- By and large, the report found no evidence of serious acidification of the soil.
- Nevertheless, acid deposition was suspected as the cause of physical and chemical changes observed in rivers flowing into Ijira Lake in Gifu Prefecture, and in soil in the vicinity. It is considered unlikely that the phenomena will have any immediate adverse effects on human health or on the ecosystems of plants and aquatic organisms in the basin. Continuous and intensive monitoring will be necessary to investigate possible changes, in this water catchment area.

4.1.3 Plan on the long-term monitoring of acid deposition

Recognizing through the experiences and results of those surveys that it was necessary to establish a framework to understand the influence of acid deposition from a long-term perspective, MOE drew up a "Plan on the long-term monitoring of acid deposition," based on discussions at a meeting of the Committee on Acid Deposition held in 2001. Monitoring in accordance with the plan started in April 2003.

In March 2002, MOE formulated the "Plan on the long-term monitoring of acid deposition." The objectives of the plan are to detect at an early stage any impacts of acid deposition, to learn about long-range transport and long-term trends of pollutants related to acid deposition, and to learn about both temporal and spatial variations and impacts of acid deposition, in order to predict the future impacts of acid deposition. Work is to be done in close combination with EANET. An outline of the plan is provided below.

4.1.3.1 Institutional arrangement of long-term monitoring

Table 4.1 Implementation bodies for each task

Tasks	Implementation bodies
1. Planning and coordination	MOE, ADORC
2. Sampling	Local governments and other bodies commissioned by MOE
3. Analysis	Local governments and other bodies commissioned by MOE ADORC
4. QA/QC	ADORC
5. Compilation, analysis and assessment of monitoring data	MOE, ADORC

4.1.3.2. Monitoring sites

Table 4.2 Number of monitoring sites

Monitoring items		Number
Acid deposition monitoring	Wet deposition	31*
	Dry deposition	31*
Ecological impact monitoring	Soil and vegetation	19
	Inland aquatic environment	12

* The number includes one site (still to be determined) in Tokyo.

Under the plan, acid deposition monitoring is being conducted at 30 sites, including 15 "remote," 11 "rural," and 4 "urban" sites.

Three types of sites have been set up for soil and vegetation monitoring: sites to monitor impacts on natural forests (13), sites to monitor impacts on soil impacts (4) and EANET sites (2). All sites set up for natural forest impacts are located in national parks. Tree deterioration is surveyed every year. Soil

monitoring and a general survey on forests, including descriptions of each tree species and understory vegetation, are implemented every five years.

Sites for inland aquatic monitoring were established for 12 lakes/reservoirs, including two EANET sites (Lake Ijira and Lake Banryu).

Wet and dry deposition is being monitored at all sites. In addition, soil, vegetation and inland aquatic environments are being monitored in the vicinity of those sites to enable the study of cause-effect relationships.

4.1.3.3. Measurement parameters and equipment/instruments

(1) Wet/dry deposition

1) Wet deposition
   Sampler: Automatic wet deposition collector (daily wet-only precipitation collector)
   Measurement parameters: pH, EC, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-,and Cl^-
   Equipment: Standard rain gauge
   Sampling interval: Daily or weekly composite (Lake Ijira and Lake Banryu)
2) Dry deposition
   - Automatic monitoring method
     Measurement parameters: SO_2, NO, NOx, O_3, PM_{10} and $PM_{2.5}$
     Equipment: Automatic air concentration measurement system
     Sampling interval: Hourly
   - Filter pack method (EANET sites only)
     Measurement parameters: Gases (SO_2, HCl, HNO_3 and NH_3) and particulate matter (NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^- and Cl^-)
     Sampling interval: Weekly (or bi-weekly)
3) Meteorology
   Measurement parameters: Temperature, wind direction, wind velocity, humidity, and solar radiation
   Sampling interval: Hourly

(2) Soil and vegetation

Measurement parameters
   Soil: pH (H_2O), pH (KCl), exchangeable Na^+, K^+, Ca^{2+}, Mg^{2+}, Al^{3+}, H^+, exchangeable acidity, ECEC and SO_4^{2-}
   Vegetation: Observation of tree decline, description of trees, understory vegetation survey and photographic record
Sampling interval: Every 5 years (except observation of tree deterioration, which is conducted every year)

(3) Inland aquatic environment

Measurement parameter: Water temperature, pH, EC, alkalinity, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, Cl^-, total Al, transparency, water color, DOC, NO_3^-, PO_4^{3-}, COD, Chl-a
Sampling interval: Every 3 months

4.1.3.4 Reporting, compilation, verification and evaluation

All the monitoring data obtained by participating laboratories are periodically reported to ADORC, the National Center of Japan. After compilation and verification, data are evaluated by the Committee on Acid Deposition in Japan, and reported to MOE.

4.1.3.5. QA/QC activities

QA/QC programs are carried out at all stages of the monitoring activities. Laboratory staff all receive training on the procedures required in the QA/QC programs. In addition, ADORC inspects all monitoring sites and laboratories at least once every two to three years to maintain the quality of monitoring data.

All laboratories involved in the Network Center's inter-laboratory comparison projects (on wet deposition, soil and inland aquatic environment monitoring) are participating in performance reviews.

4.2 State of Acid Deposition in Japan

4.2.1 Atmospheric deposition

4.2.1.1 Wet deposition

(1) Ion concentrations and composition of precipitation

The average pH level in precipitation at each monitoring site throughout the entire survey period (20 years) ranged from pH 4.49 (Ijira Lake) to pH 5.85 (Ube), while the overall average was pH 4.77 (Figure 4.1). The median of annual average levels at each site showed no clear trend during the period from 1988 to 1999, but have decreased since 2000. Variation related to the eruption of the volcano on Miyake Island mainly. However, sulfur dioxide emissions of the Asian continent, which are currently increasing, and their contribution to acidification of precipitation in Japan should be considered.

Useful information regarding acids and bases, which acidify and neutralize precipitation, respectively, can be obtained by analyzing the composition of precipitation (Figure 4.2). Concentrations of non-sea salt sulfate (nss-SO_4^{2-}), which corresponds to sulfuric acid, acidified precipitation, were ranged from 3.0 (1992JFY, Ogasawara) to 59.1 μmol L^{-1} (1986JFY, Aomori) with an overall average of 16.4 μmol L^{-1}. The annul average has decreased since 1988 at many sites. Concentrations of nitrate (NO_3^-), which corresponds to nitric acid, acidified precipitation, were ranged from 2.0 (1992JFY, Ogasawara) to 50.3 μmol L^{-1} (1986JFY, Koto) with the overall average of 14.6 μmol L^{-1}. The annual average NO_3^- concentration varied at each site, with no clear trends evident.

The ratio of nss-SO_4^{2-} to (nss-SO_4^{2-} +NO_3^-) is useful for understanding the relationship between sulfuric and nitric acid. The overall average of the ratio in equivalent basis was 0.69, indicating a greater contribution of sulfuric acid to the acidification of precipitation, compared with nitric acid. Since the ratio tended to decrease over time, however, the contribution of nitric acid has had an increasing impact on the acidification of precipitation.

On the other hand, the overall average concentrations of NH_4^+ and nss-Ca^{2+}, which correspond to ammonia gas and basic calcium aerosol, neutralized precipitation, were 18.5 μmol L^{-1} and 6.6 μmol L^{-1}, respectively. One can conclude that ammonia gas had a greater impact than basic calcium aerosol in the neutralization of precipitation.

A large contribution of sea salt is evident, since sea salt components such as sodium and chloride accounted for 60-70% of the total anion and cation concentrations in precipitation. As the sum of non sea salt cations (H^+, NH_4^+, and nss-Ca^{2+}) was in balance with the sum of non sea salt anions (NO_3^-, nss-SO_4^{2-}), it is thought that the observed acidity (pH) of precipitation corresponds to the concentrations of H^+ remaining in precipitation after reactions in which sulfuric and nitric acids are neutralized by ammonia gas and basic calcium aerosol.

Phase1 (1983-1987) mean / Phase 2 (1988-1992) mean / Phase3 (1993-1997) mean / Phase4 (1998-2000) mean / Over-all periodic mean (1983-2002)

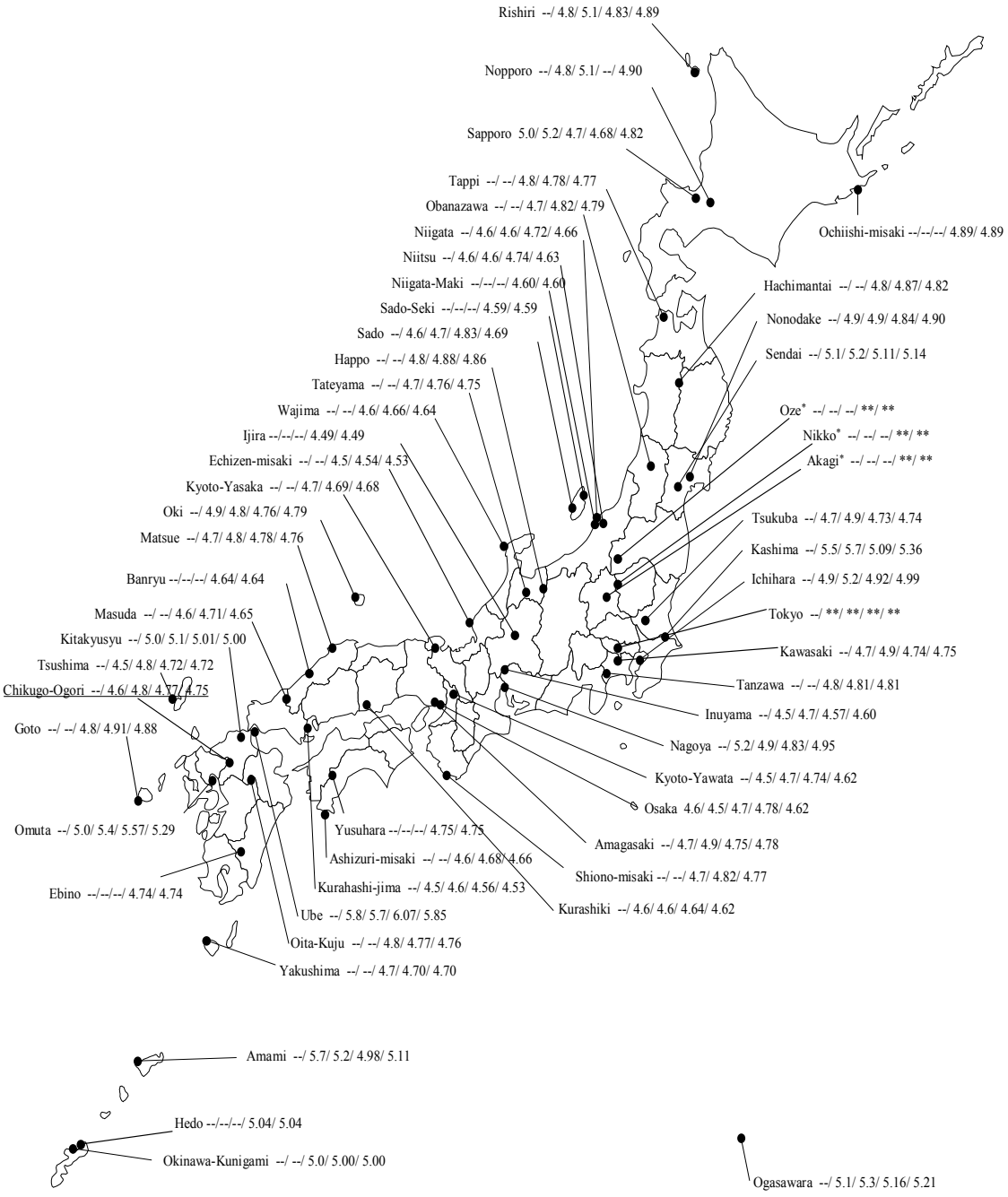

Figure 4.1 Geographical distribution of precipitation pH over Japan

－: Not measured

**: Data do not satisfy criteria for completeness.

Notes: 1. Weighted means for precipitation amounts are calculated.

2. Data that do not satisfy criteria for completeness are not used for the calculation.

3.Data at Oze, Nikko, and Akagi, which are closed in winter, are not shown on the map.

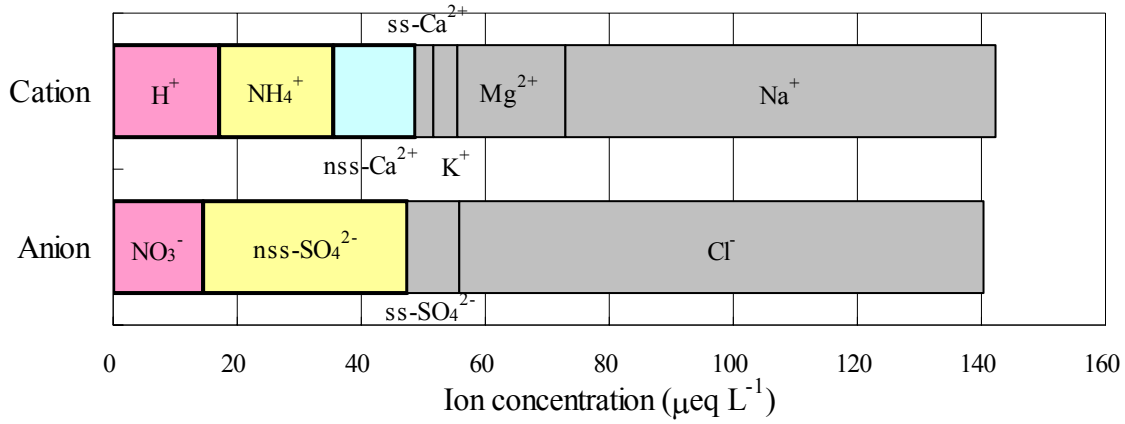

Figure 4.2 Overall mean composition of precipitation

The histogram shows the distribution of precipitation pH monitored daily at 23 sites in Japan from 2000 through 2003 (Figure 4.3, n=8976). Precipitation pH ranged from pH 3.35 to pH 7.77, with the arithmetic average of pH 4.82. The number of data records less than pH 4 was 458 (5.1%). Precipitation with a pH of less than 3, which may cause acute damage to plants, was not observed. The lowest average pH was observed at Kurahashijima (pH 4.53), followed by Inuyama and Echizenmisaki (pH 4.63). The frequency of data below pH 4 was highest at Tanzawa (15%), followed by Kurahashijima (13%) and Inuyama (12%).

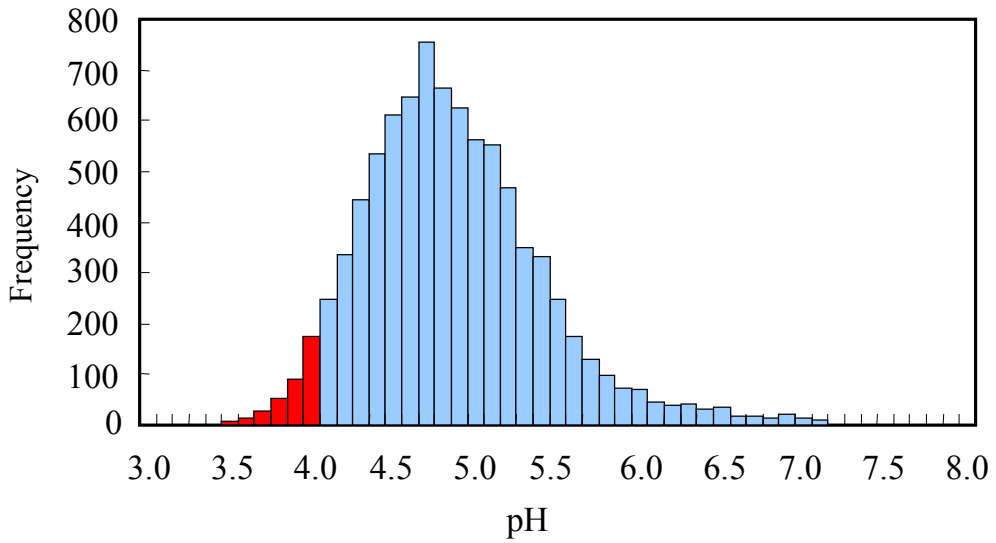

Figure 4.3 pH distribution of daily precipitation (2000-2002, n=8976)

(2) Wet deposition

The wet deposition in the rural areas in Japan was compared with urban areas to elucidate relationships between the distance from sources to receptors and deposition. Thirteen urban sites (Sapporo, Niigata, Matsue, Sendai, Kashima, Ichihara, Kawasaki, Nagoya, Amagasaki, Osaka, Kurashiki, Ube, and Omuta) and six rural sites in the fourth phase of the survey (Nonodake, Tsukuba,

Inuyama, Kyoto-Yawata, Kurahashijima, and Chikugo-Ogori) were selected as representative sites of urban and rural areas in Japan, respectively. The monitoring results of wet deposition at these sites during the period 1988-2002 were divided into five-year intervals (1988-1992, 1993-1997, and 1998-2002). The medians of monthly deposition for each month of each period were then calculated. The medians of monthly deposition throughout the year were also calculated for each period. The results of nss-SO_4^{2-}, NO_3^-, and H^+ are shown in Figure 4.4. The wet deposition of nss-SO_4^{2-} was decreasing and broadly flattening in urban areas, and shifted from decreasing to increasing in rural areas. The deposition of nss-SO_4^{2-} in rural areas was on par with urban areas. The wet deposition of NO_3^- was equable in urban areas, and increasing in rural areas. The deposition of NO_3^- in rural areas was larger than in urban areas. The wet deposition of H^+ was equable in urban areas, and shifted from decreasing to increasing in rural areas. The deposition of H^+ in rural areas was approximately twice that of urban areas.

The wet deposition of nss-SO_4^{2-} in rural areas was similar to the urban areas, while the wet deposition of NO_3^- in rural areas was large than in urban areas (Figure 4.4). The reaction rates of precursors of nss-SO_4^{2-} and NO_3^- (i.e., SO_2 and NO_2, respectively) are largely different in their oxidation. It is known that the oxidation rate of NO_2 into nitric acid is ten times larger than the rate for SO_2 into sulfuric acid. As for the locations of sources, which can be broadly divided into the Asian continent and urban areas in Japan, the distance between rural and urban areas within Japan is quite short compared with the distance between the Asian continent and rural areas in Japan. The difference in wet deposition of nss-SO_4^{2-} and NO_3^- between rural and urban areas can therefore be ascribed to the difference in oxidation rates of SO_2 and NO_2 emitted in urban areas of Japan. Namely, very little oxidation of SO_2 into sulfuric acid occurred on the short path from urban to rural areas within Japan, compared to the oxidation of NO_2 into nitric acid. This is a likely explanation for the finding that the wet deposition of NO_3^- in rural areas was larger than in urban areas.

The same method for wet deposition of nss-SO_4^{2-} and NO_3^- was applied to the wet deposition of inorganic nitrogen ($\Sigma N = NO_3^- + NH_4^+$), effective hydrogen ions ($H_{eff} = H^+ + 2\ NH_4^+$), and initial acidity ($A_i = 2$ nss-$SO_4^{2-} + NO_3^-$) to determine the monthly and annual medians of wet deposition for each five-year period (Figure 4.5.). Increases in ΣN and H_{eff} indicate an increase of potential nitrogen saturation and soil acidification, respectively. The changes in wet deposition of ΣN were relatively flat in urban areas, but on an increasing trend in rural areas. The magnitude of ΣN deposition was similar between urban and rural areas, although strong seasonal variation was found in rural areas. Changes in deposition of H_{eff} were also flat in urban areas, but increasing from summer to autumn in rural areas. The deposition of H_{eff} in rural areas was larger than in urban areas. The deposition of A_i was decreasing or flat in urban areas, while it shifted from decreasing to increasing in rural areas. The deposition of A_i during the period 1988–2002 in rural areas was larger than in urban areas, and significant seasonal changes were found in rural areas.

In urban areas, changes in annual wet deposition of ΣN and H_{eff} were generally flat, while A_i was slightly decreasing or flat. On the other hand, in rural areas, annual wet deposition of ΣN, H_{eff}, and A_i were increasing slightly after the mid-1990s. The slight decrease in wet deposition of H_{eff} and A_i is thought to correspond to increases in emissions of ammonia and nitrogen oxides. The fact that the 1960s and 1970s, when air pollution was a serious problem in Japan, were not included in the analysis may also partially explain the non-decreasing trend.

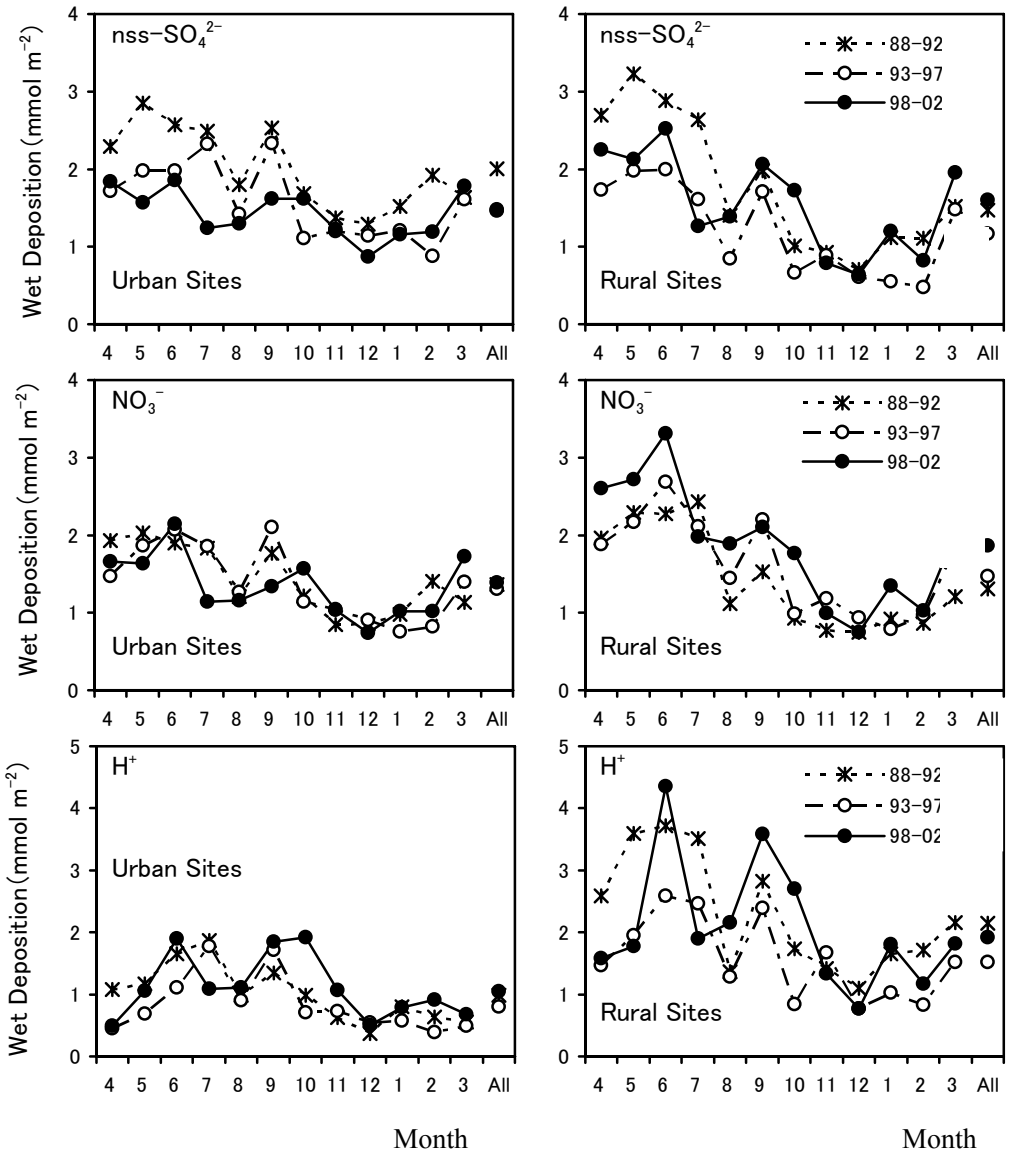

Figure 4.4 Monthly and annual medians of wet deposition for each five-year period

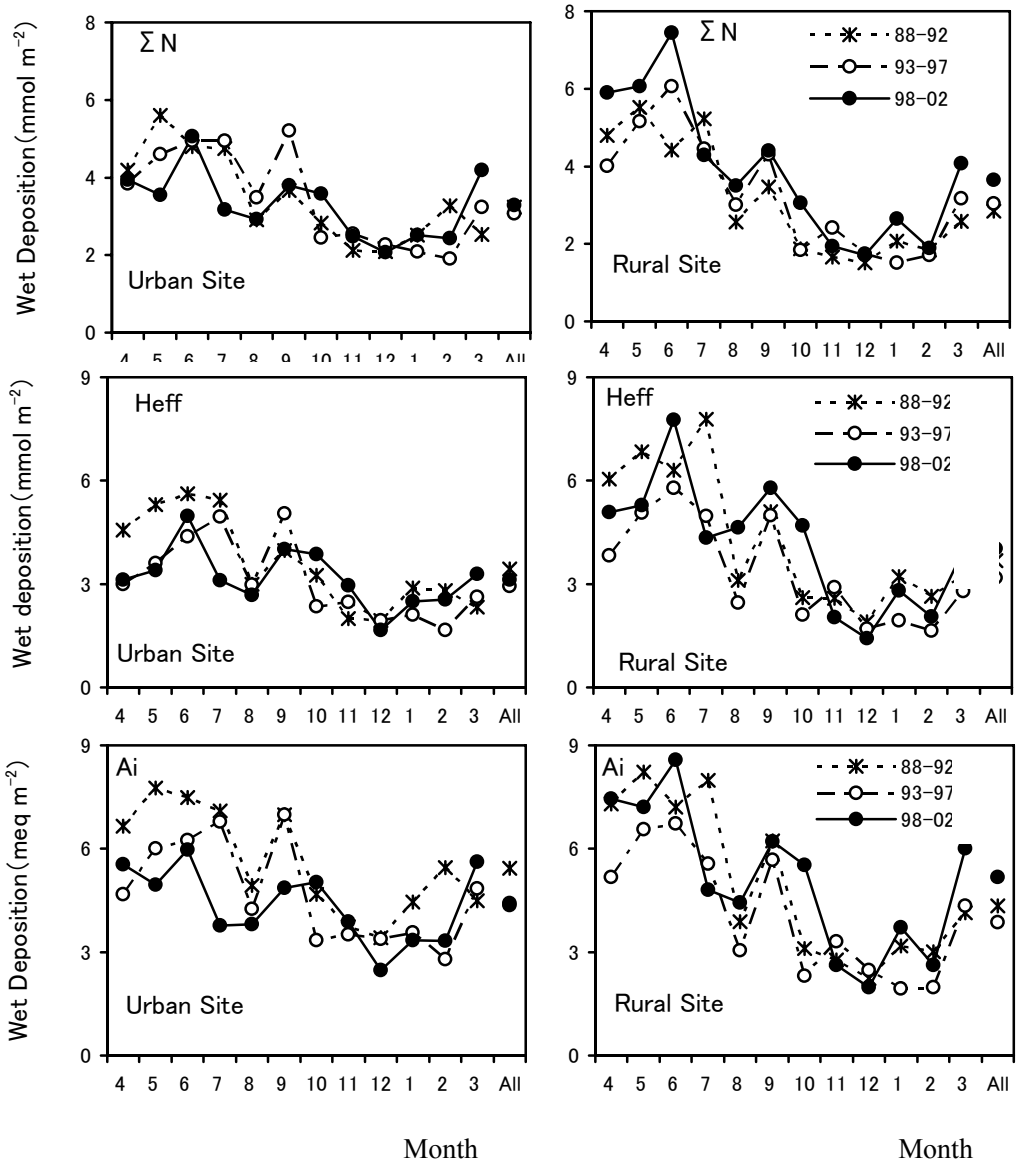

Figure 4.5 Monthly and annual medians of indicators on wet deposition for each five-year period

(3) Long-term trends of concentrations and wet deposition of major components

Because sampling methods for wet deposition have been improved and changed at sites over the 20 years of this survey, it is difficult to evaluate the long-term trends of concentrations and deposition for each site and period. However, data (wet only) from 1988 to 2002, which were comparatively independent of changes in sampling methods, were used to consider trends in precipitation amounts, concentrations and depositions of components. Seasonal and annual median values were used in this study at all sites. The following conclusions can be drawn:

1) There were no clear trends evident in precipitation amounts.
2) Concentrations and deposition of nss-SO_4^{2-} showed a downward trend. This trend was observed clearly in the summer season, although an increase is evident at certain times after 2000.
3) Concentrations and deposition of NO_3^- were nearly stable or showed a slight upward trend.
4) Concentrations and deposition of NH_4^+ were nearly stable or showed a slight downward trend.

5) Concentrations and deposition of nss-Ca^{2+} showed a downward trend except in 2000, when significant levels of "kosa" were observed.
6) Concentrations and deposition of H^+ showed an upward trend (pH values showed downward trend). After 2000, there was a significant upward trend of H^+ (and downward trend of pH).
7) Emissions of SO_2 from Mt. Oyama, Miyake Island, which erupted suddenly in 2000, affected the concentrations and deposition of nss-SO_4^{2-} and H^+ (pH) after that year.

4.2.1.2 Dry deposition

(1) *Dry deposition of sulfur oxide and nitrogen compounds*

The amounts of dry deposition of SO_2 were estimated by inferential methods[1)] at ten EANET sites in Japan (Rishiri, Tappi, Sado-seki, Happo, Oki, Banryu, Ijira, Yusuhara, Ogasawara, Hedo). The dry deposition of SO_2 was about half the amount of the wet deposition of nss-SO_4^{2-} at remote sites in Honshu (main island of Japan) (Tappi, Sado-seki, Happo, Oki, Yusuhara), Ijira and Banryu. On the other hand, the dry deposition of SO_2 was less than half the amount of the wet deposition of nss-SO_4^{2-} at Rishiri, Ogasawara and Hedo, where SO_2 concentration was lower than at other sites (Figure 4.6). Higher concentrations of SO_2 appeared most frequently at Ijira in 2001. As a result, it is suggested that the dry deposition amount of SO_2 was largest at Ijira.

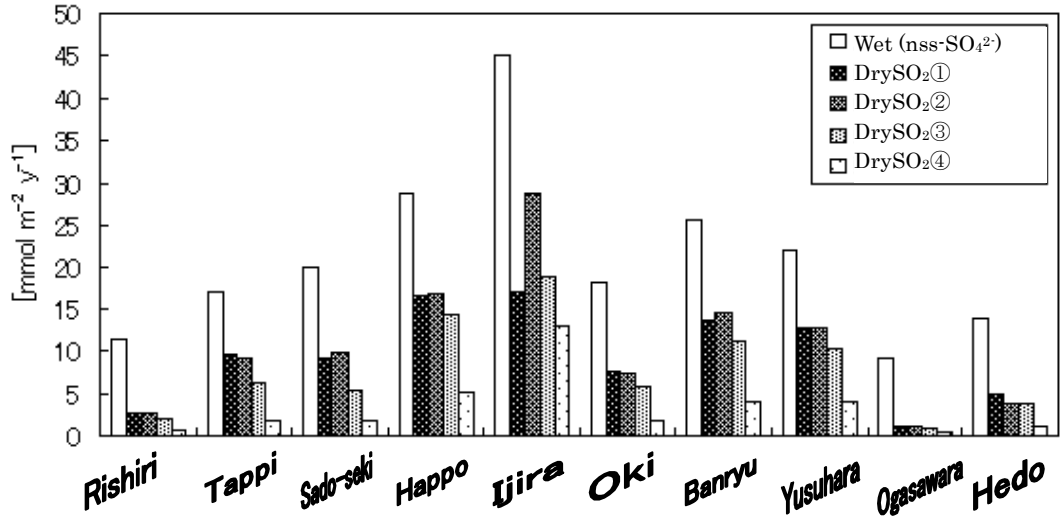

Figure 4.6 Annual dry deposition amount of SO_2 estimated by four inferential methods (2001)

① Erisman et al. (1994), ② Hicks et al. (1987), ③ Wesely (1989) that includes cuticle resistance of Erisman et al. (1994), ④ Wesely (1989)
(Note: ①, ② and ③ were considered as appropriate methods for Japan in this study.)

The dry deposition amounts of sulfur oxide and nitrogen compounds, including particulate matter, were estimated from filter-pack monitoring results at two remote sites (Rishiri and Oki) in JFY 2002. Observed annual average concentrations of SO_2, NO and NOx were less than 1 ppb. However, it was found from the result that the dry deposition amounts of sulfate, nitrate and ammonia could not be ignored at both sites, in terms of environmental impacts. Dry deposition amounts of the gases and particles measured at the Oki site were more than at Rishiri (Figure 4.7).

[1)] Indirect methods to estimate the amount of dry deposition by the product of concentration in the air and the deposition velocity. This is called "inferential method," because the amount of dry deposition is inferred from the deposition velocity calculated by meteorological factors.

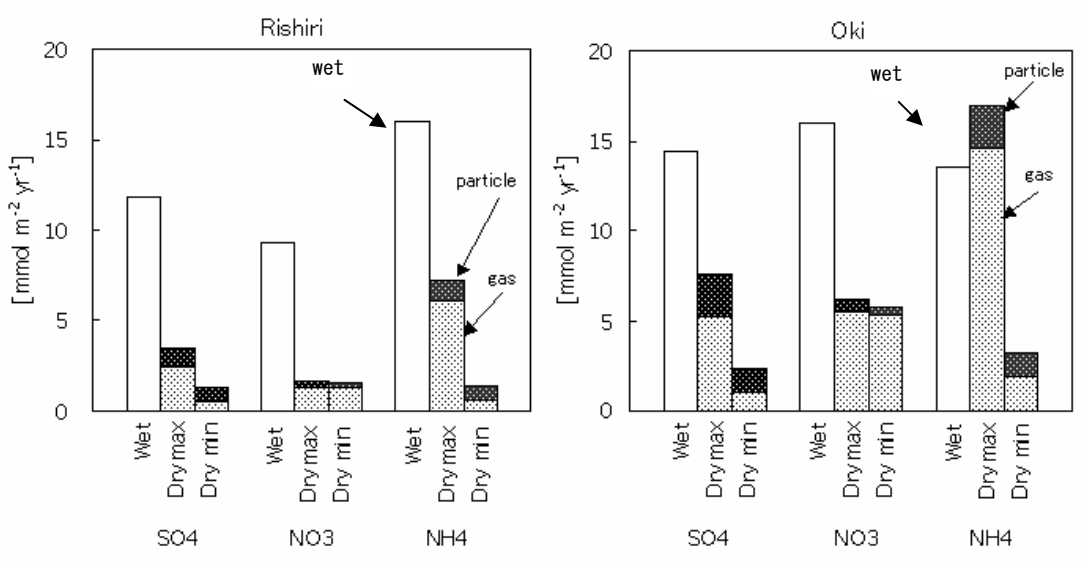

Figure 4.7 Amounts of wet and dry deposition at Rishiri and Oki (Apr.2002 - Mar.2003)

In addition, as a part of research on ecosystem impacts, the dry deposition amounts of sulfur oxide and nitrogen compounds were estimated by throughfall and stemflow methods at Ijira and Banryu in JFY 2000. It was found that the amounts of dry deposition at Banryu and Ijira were more than at Rishiri and Oki (Figure 4.8).

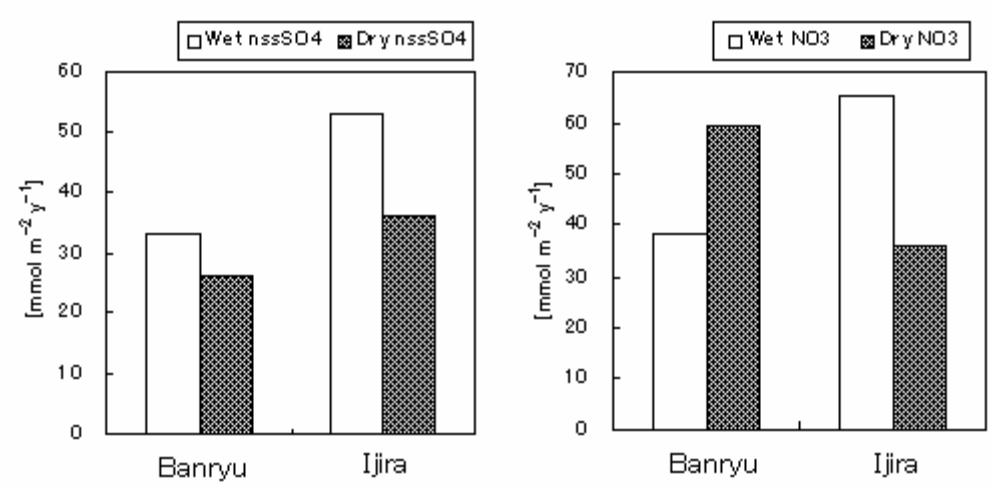

Figure 4.8 Wet and dry deposition amounts estimated by throughfall and stemflow method in Ijira and Banryu. (Apr.2000 - Mar.2001)

(2) Ozone

High concentrations of O_3, an oxidizer, were observed during the spring at every EANET site in Japan (Figure 4.9). The concentration level of O_3 was almost the same for remote sites in and around the island of Honshu, and no significant difference for diurnal variation was confirmed (Figure 4.10) at those sites. Notably, the short-term variation patterns of O_3 concentrations were relatively similar to each other at Rishiri, Tappi, Sado-seki and Oki, remote sites located along the Sea of Japan (Figure 4. 11). Trajectory analysis suggests that O_3 concentrations observed along the Sea of Japan were generally due to long-range transport from the Asian continent. On the other hand, a link was also confirmed between high O_3 concentrations from Hedo to Ogasawara, located on the Pacific Ocean side of the country (Figure 4.11). It is suggested from the results that O_3 concentrations observed on the

Pacific Ocean side were also influenced by long-range transport from the Asian continent.

Annual cumulative hours with O_3 concentrations over 60 ppbv which is the Atomospheric Environmental Quality Standard value in Japan regarded as the critical threshold level, ranged from 480 to 960 hours at EANET sites in and around Honshu. More than 70% of the annual cumulative hours over 60 ppbv occurred during spring. This suggests that high concentrations of O_3 in spring originate from an increase in the background concentration, and this results in levels that exceed the Atmospheric Environmental Quality Standards.

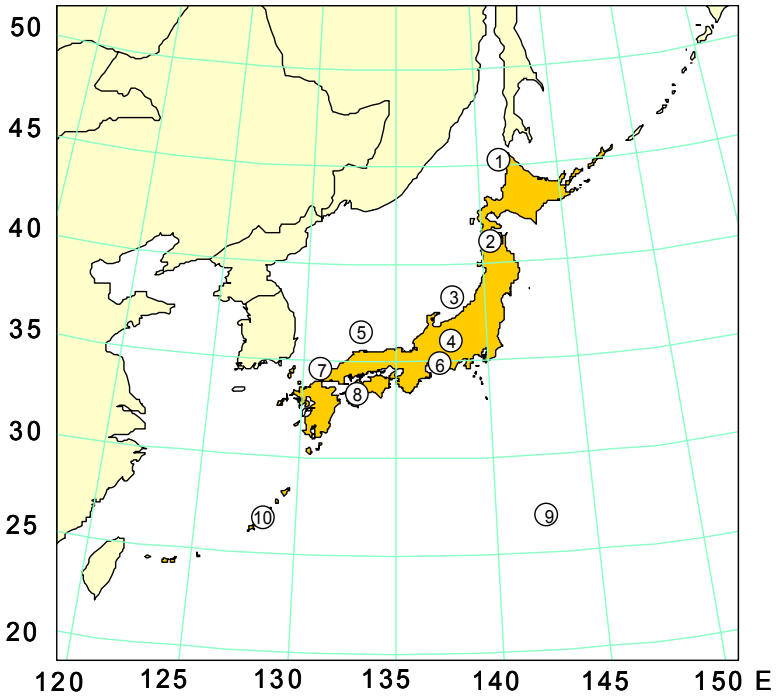

Figure 4.9 Location of EANET sites in Japan

1 Rishiri, 2 Tappi, 3 Sado-seki, 4 Happo, 5 Oki, 6 Ijira, 7 Banryu, 8 Yusuhara, 9 Ogasawara, 10 Hedo

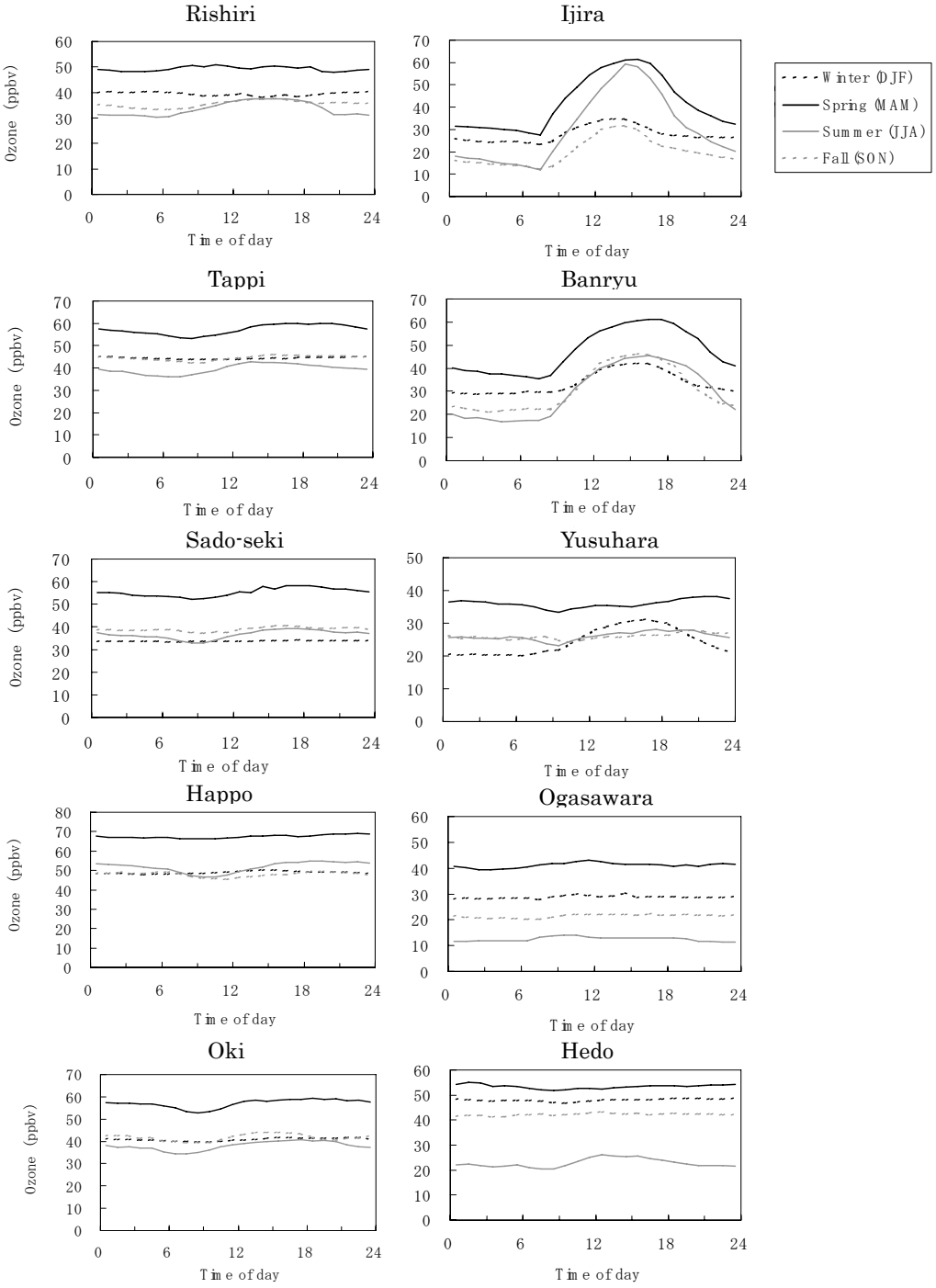

Figure 4.10 Averaged diurnal variation in each season (1998-2002)
DJF: December, January, February MAM: March, April, May
JJA: June, July, August SON: September, October, November

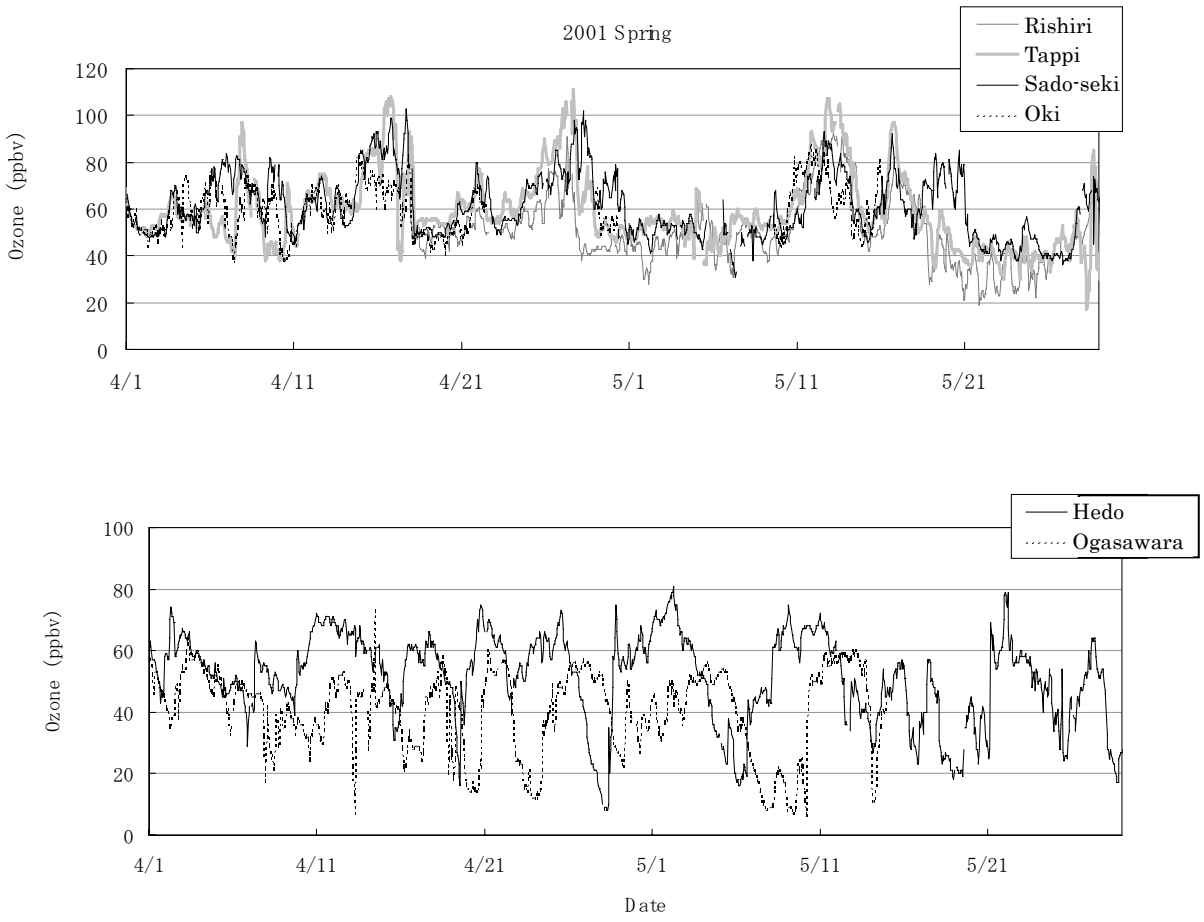

Figure 4.11 Episodes of high O_3 concentration in spring 2001

4.2.2 Ecological impacts

4.2.2.1 Soil monitoring

Soil chemical properties were analyzed in approximately 500 plots in Japan. Mean values of representative properties were as follows: pH (H_2O) of surface soils was 4.9; concentration of exchangeable base cations was 7.5 cmol(+)/kg; base saturation was 33%; and concentration of exchangeable Al was 5.5 cmol(+)/kg.

In general, forest soils in Japan are acidic, have small amounts of base cations and contain exchangeable Al. Therefore, these soils are not best for tree growth. However, (Ca+Mg+K)/Al molar ratio of exchangeable cations in soils, which can be considered as an index of tree growth, was larger than 10 on average, and most soils have not reached the acidic level in which tree growth would be inhibited. For podzols and red and yellow soils, pH values were low and (Ca+Mg+K)/Al molar ratios of exchangeable cations were lower than 1.0. Plants may be under stress in such soil conditions. Vegetation grown on these soil types might be sensitive to other environmental stresses and synergistic effects.

As shown in Table 4.3, soil chemical properties did not change significantly over the period of

three-year surveys in the 1990s, suggesting that no acidification of the soil had occurred. Since the value of pH (H_2O) decreased slightly in dry brown forest soils only, further investigation is necessary for this soil type.

Table 4.3 Chemical changes in surface soil condition over 3 years of monitoring in 1990s

Soil type	Parameter	First year	After 3 years
Black soils	pH (H_2O)	5.4	5.7***
	Exchangeable base cations	11.1	11.9
	Exchangeable Al	1.34	1.11
Brown forest soils	pH (H_2O)	5.0	5.1***
	Exchangeable base cations	9.91	10.5
	Exchangeable Al	3.75	3.63
Dry brown forest soils	pH (H_2O)	4.8	4.7**
	Exchangeable base cations	5.89	5.42
	Exchangeable Al	6.84	6.79

Note: The first survey year for a given survey site was between 1989 and 1995. In each case, the second survey was conducted three years later.

Statistically significant level: **:$p<0.01$, ***: $p<0.001$

4.2.2.2 Study on soil acidification (laboratory experiment)

Soil samples were collected from 20 different locations in Japan. Three levels (pH 3.0, 3.5 and 4.0) of simulated acid rain were prepared and applied to the soil samples. Applied amounts of the rain were equivalent to almost 2000 mm precipitation. All the samples were acidified by the simulated acid rain of pH 3.0. Some soil types showed a slight decrease in the seepage water by the simulated acid rain of pH 4.0.

After application of the simulated acid rain of pH 3.0 for five years, (Ca+Mg+K)/Al equivalent ratios (BC/Al eq ratio) in the seepage water showed significant correlation to BC/Al eq ratios of exchangeable cations in the original soils. The result suggested that BC/Al eq ratio of exchangeable cations in soil might be useful as an index for sensitivity to acid deposition or prediction of the effects. In addition, in cases where the BC/Al eq ratio in the original soil was lower than 0.1, the BC/Al eq ratio in the seepage water also decreased significantly when exposed to simulated acid rain of pH 4.0. This suggests that a value of 0.1 for the BC/Al eq ratio of soil might be useful as an index value for sensitivity to soil acidification.

Figure 4.12 shows changes of the BC/Al eq ratio in the seepage water of the soil sample “Gunma 4”, whose BC/Al eq ratio was lower than 0.1. When the simulated acid rain of pH 4.0 was applied, the ratio in the seepage water decreased significantly. Similar results could be seen only in soil samples with a BC/Al eq ratio lower than 0.1.

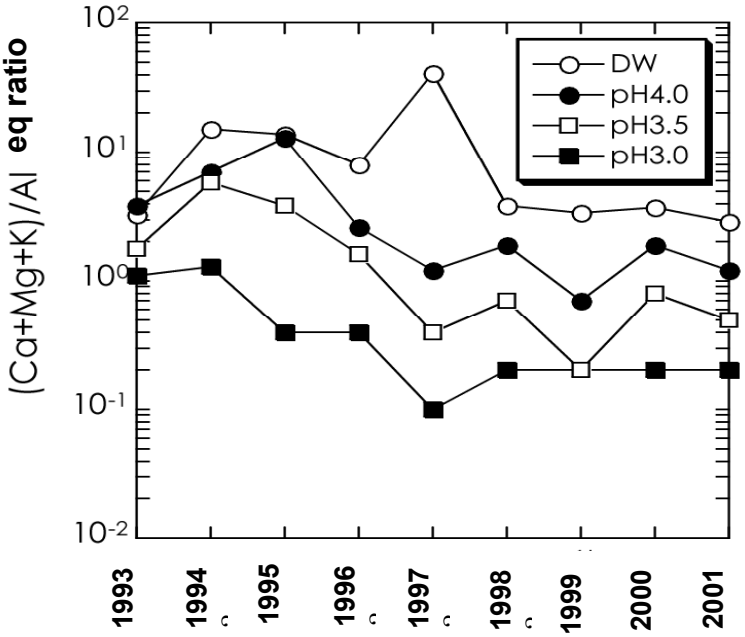

Figure 4.12 Temporal changes in (K+Mg+Ca)/Al of the seepage water from the soil sample (Gunma 4) by adding artificial acid rain.
DW: Distilled water
pH values: Simulated acid rain of pH 4.0, pH 3.5, and pH 3.0. The soil sample was collected in Gunma Prefecture, in the Kanto district of Japan.

4.2.2.3. Survey on QA/QC in soil monitoring

(1) Hierarchical sampling design

Soil chemical/physical properties depend mainly on location, rather than on changes over time. Soil monitoring should evaluate spatial variation of soil quantitatively and efforts should be made to improve inter- and intra–laboratory precision on chemical/physical analysis.

A hierarchical sampling design was adopted for soil monitoring that would allow the calculation of variances for each sampling level, country, local government, soil type, sampling plot, subplot, and repeat analysis, etc. Intra- and inter-laboratory comparison tests were carried out with participation of analytical laboratories. Based on this survey, future directions were clarified for statistical evaluation on variability of soil chemical properties and improvement of analytical accuracy.

Table 4.4 shows the average values and confidence intervals of pH (H_2O) at each level, and is an example of results obtained by hierarchical sampling based on a statistical random model. In this way, the average values and standard errors at each sampling level could be reported at the nationwide level based on soil monitoring experience and accumulated data.

(2) Inter-laboratory comparison projects

According to the inter-laboratory comparison projects on soil, coefficients of variation (CVs) of the intra-laboratory-precision were lower than 10% in almost all parameters and most were lower than 5%. In terms of pH values, all values except a few were below 1%. These results suggest that many laboratories had conducted analysis according to the standard method, and that they used instruments/apparatus that were in stable condition.

Inter-laboratory-precision was relatively low in pH (H_2O), below 3.8%, but in contrast, it exceeded 20% in other parameters, even achieving 100% in some. It was speculated that the data were affected by environmental factors in the laboratories, such as location of the laboratory, instruments/apparatus, and person, and/or random errors in the processes, from soil extraction to instrumental or titration analysis.

Precision in the instrumental/titration analytical process was estimated by using soil extract samples. The intra-laboratory precision was the same as the precision in the case of using soil samples, but the inter-laboratory-precision for most parameters was improved in the soil extract sample. CVs decreased to less than half of those in case of soil sample.

This study clarified that the soil extraction process had larger effects on total accuracy than did instrumental or titration analytical processes. This suggests that attention should be given to the standardization and the consistency of the methods involved in the pretreatment process, including soil extraction, in order to improve inter-laboratory-precision.

Table 4.4 Average and confidence interval of pH (H_2O) at the respective sampling level of the hierarchical design

Country	Area		Soil type		Plots	
4.7 (±0.4)	Aichi	4.7 (±7.3)	Brown forest soils (dry)	4.1 (±0.1)	1	4.1 (±0.1)
					2	4.1 (±0.3)
			Brown forest soils	5.2 (±0.0)	3	5.2 (±0.2)
					4	5.2 (±0.1)
	Ishikawa	4.5 (±0.9)	Brown forest soils	4.4 (±1.0)	I	4.4 (±0.1)
					II	4.5 (±0.2)
			Red soils	4.6 (±0.1)	I	4.6 (±0.2)
					II	4.6 (±0.2)
	Osaka	4.0 (±0.4)	Reddish brown forest soils	4.0 (±2.9)	1	4.2 (±0.3)
					2	3.8 (±0.3)
			Yellow soils	3.9 (±0.3)	1	3.9 (±0.2)
					2	4.0 (±0.2)
	Shimane	4.5 (±3.1)	Brown forest soils	4.7 (±0.2)	1	4.8 (±0.3)
					2	4.7 (±0.4)
			Red soils	4.3 (±0.5)	3	4.3 (±0.1)
					4	4.2 (±0.1)
	Niigata	4.4 (±1.9)	Red soils	4.3 (±2.3)	S-1	4.1 (±0.3)
					S-2	4.4 (±0.1)
			Brown forest soils	4.6 (±1.7)	K-1	4.4 (±0.3)
					K-2	4.7 (±0.2)
	Fukuoka	5.0 (±8.1)	Reddish brwon forest soils	4.4 (±2.0)	1	4.2 (±0.3)
					2	4.5 (±0.2)
			Brwon forest soils (wet)	5.6 (±10.6)	1	4.8 (±0.5)
					2	6.5 (±1.4)
	Fukushima	5.5 (±3.0)	Reddish brown forest soils	5.7 (±2.1)	1	5.6 (±0.2)
					2	5.9 (±0.1)
			Brown forest soils	5.2 (±0.8)	1	5.2 (±0.1)
					2	5.3 (±0.2)
	Yamaguchi	4.7 (±1.7)	Black soils	4.6 (±0.1)	T1	4.6 (±0.2)
					T2	4.6 (±0.2)
			Yellow soils	4.9 (±0.8)	S1	4.9 (±0.2)
					S2	4.8 (±0.3)

4.2.2.4 Vegetation monitoring

(1) Results of survey

A survey of tree deterioration was conducted on 120 plots in Japan from 1988 to 2002. According to the survey, more than one tree had deteriorated (i.e., had a "deterioration value" larger than 2 in 55 plots, or approximately 50% of all the plots. Species in which such trees were observed included *Abies firma*, *Pinus densiflora*, *Cryptomeria japonica* and *Chamaecyparis obtusa* among coniferous trees, and *Fagus crenata*, *Quercus crispula* and *Quercus serrata* among broadleaf trees. The deterioration was mainly caused by biotic damage (e.g., damage by woodborers, and infection by the pine wood nematode), suppression by surrounding trees, drought stress, and damage by strong typhoon winds. There were no reports of direct effects of acid deposition and soil acidification, although the cause of deterioration was unknown for *Pinus densiflora*, *Cryptomeria japonica*, *Chamaecyparis obtusa* and *Fagus crenata*.

The mean deterioration value of the respective plots was larger than 1.0 in 24 plots (20% of all plots), and larger than 2.0 in 14 plots, where significant deteriorate symptoms could be observed. Although the main cause of the deterioration was not clear in several plots, the effects of acid deposition and soil acidification were not reported as the main causes.

As for annual changes in the symptoms of deterioration, an increase of mean deterioration values was observed due to infections of the pine wood nematode in several plots, while a decrease of the value was also observed due to recovery from typhoon damage. This suggests that the number of plots and/or frequency of surveys need further discussion in order to ensure accurate detection of deterioration trends.

(2) Discussion

Long-term and nationwide monitoring should be further promoted for the following reasons: (1) some trees were deteriorating due to unknown causes, which have yet to be identified; (2) symptoms of deterioration were observed in both coniferous and broadleaf trees, and in various geographical locations and soil conditions; and (3) experimental case studies have suggested that acid deposition and soil acidification can cause tree deterioration. In the future, monitoring and measurement of atmospheric factors such as acid deposition are required, as well as soil investigation at the study plots. The impacts of ozone on plants have been given attention recently in domestic and overseas surveys. Studies on chronic impacts are still limited, although some case studies on visible symptoms from acute impacts such as necrosis were conducted from the 1960s to 1970s in Japan.

Visual assessment of tree deterioration by observation is an important technique to detect visible symptoms. In addition, quantitative studies are also necessary in order to evaluate other symptoms, such as physiological change or a decrease in growth rate. Remote-sensing techniques may be one option for large-scale measurements. Non-destructive measurement methods would also be useful. Leaf analysis could also be a useful method to detect physiological changes.

For the promotion of long-term and nation-wide monitoring, the following points should be borne in mind: (1) study plots should be in mountainous areas, where amounts of deposition of acid substances are likely to be higher than in lowlands and where there are soils with low acid neutralizing capacity, (2) consistent guidelines are needed for the selection of tree species for observation, because reactions to environmental factors might vary among species; and (3) comparative studies should be conducted

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7) The "degree of deterioration" in the condition of trees was expressed as a "deterioration value," from 0 (healthy) to 4 (dead or almost dead). Obvious abnormalities can be observed where the deterioration value is larger than 2.

between plots with and without deteriorating trees. Moreover, in order to quantitatively evaluate the effects of acid deposition on vegetation, it is important to conduct comprehensive and systematic surveys in the future, focusing on elemental cycles of forest ecosystems.

4.2.2.5 State of inland aquatic environments

(1) Screening of sensitive lakes

One hundred and thirty three lakes in Japan were surveyed in order to detect lakes that are highly sensitive to acidification. The pH values of most lakes were higher than 6.5. About 45% of the lakes surveyed had pH values from 6 to 7, and about 13% had pH values lower than 6. Lakes and rivers whose alkalinity was lower than 0.2meq/L and electrical conductivity was lower than 5 mS/m may be sensitive to acidification. Such lakes and rivers should therefore be selected as monitoring sites for the inland aquatic environment in Japan.

(2) Periodical survey of lakes

A periodical survey of lake water was conducted over several years in 42 lakes in Japan. Acidification of the water was not observed in most lakes, although clear tends were evident in the lakes that were surveyed for longer than 10 years: a downward trend in the pH value was observed in the rivers flowing into Lake Ijira-ko and in the springs near Lake Kuttara-ko, and a downward trend in alkalinity was observed in Lake Unagi-ike. Upward trends in alkalinity and electrical conductivity were observed in Lake Kamakita-ko and Lake Banryu-ko.

Acidification of the water may have already occurred in the lakes with low alkalinity, electrical conductivity and pH values, such as Lake Oke-numa, Lake Futago-ike Meike, Lake Yasha-ga-ike and Lake Imagami-o-ike. It is unlikely that acidification of these lakes and ponds was caused by artificial contaminants other than acid deposition, such as wastewater. Most of these lakes are located in mountainous areas, are surrounded by immature soils and granite, and receive much precipitation.

(3) Classification of lake sensitivities to acid deposition

Principal component analysis was applied for lakes that had an alkalinity of less than 0.2meq/L, and also for lakes near Mt. Norikura-dake in central Japan, for which a high sensitivity to acid deposition (due to poor soil conditions) has been already reported. Chemical properties of these lakes were loaded for the analysis, and the properties could be expressed by two components, the first component related to ion concentrations and the second component related to acid neutralizing capacity as shown in Figure 4.13 Based on the scores for these components, the lakes could be classified into the following four types (Figure 4.14):

1) Lakes showing high sensitivity to acidification, and low concentrations of dissolved constituents
   Lake Futago-ike Meike, Lake Oke-numa, Lake Goshiki-numa, and four mountain lakes near Mt. Norikura-dake
2) Lakes showing no influence of acidification
   Lake Futago-ike Oike, Lake Hoko-no-ko
3) Acidified lakes with high concentrations of dissolved constituents
   Lake Imagami-o-ike, Lake-Numayama-o-numa
4) Acidified lakes with low concentrations of dissolved constituents
   Lake Yasha-ga-ike, Lake Oda-no-ike, Lake Sawa-no-ike

The above features should be taken into account when designing a monitoring plan and when evaluating the monitoring data.

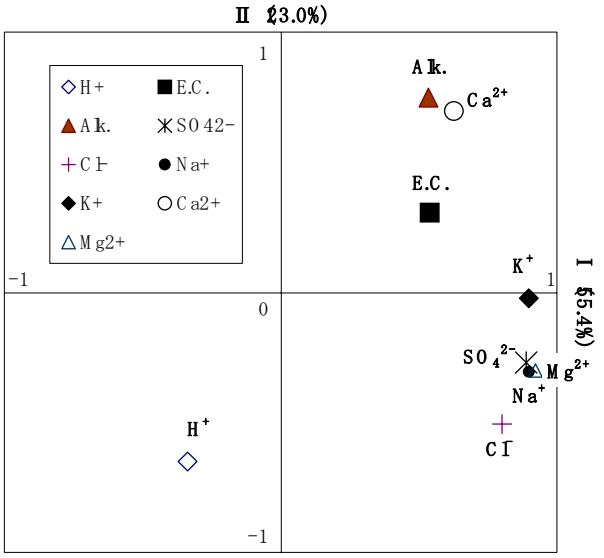


Figure 4.13 Component loading of analysis

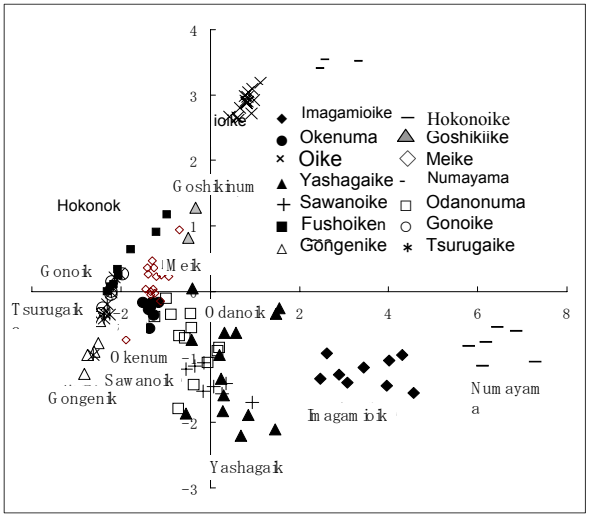


Figure 4.14 Principal component score of analysis

(4) Groundwater and rivers

No clear acidification trend (e.g., as downward trend in pH levels) was observed in groundwater and rivers in the survey until 2002, although downward trend in alkalinity was observed in the rivers flowing into Lake Ijira-ko and the springs in the vicinity of Lake Kuttara-ko, as mentioned above. Research in mountainous areas of Japan such as Yakushima Island, however, have shown temporary acidification of stream water after rainfall in areas with granite rock. In addition, the “acid shock” phenomenon during snow melt has been observed in several lakes and streams in Hokkaido and other parts of northern Japan. Acid deposition might affect inland waters in regions that have specific conditions creating high sensitivity to acid deposition.

(5) Discussion

Periodical surveys should be further promoted for lakes and rivers that are sensitive to acid deposition, while integrated survey had been carried out in several lake catchments for longer than ten years.

In terms of basic research on acid deposition problems, it is necessary to promote studies on bio-indicators such as diatoms; monitoring of aquatic biota; studies on ecological impacts of acid shock; and the accumulation of basic data for simulation models on ecological impacts, including on inland aquatic environments.

In Japan, SO_2 emissions have decreased in recent years, but NO_X emissions have not shown any downward trend. Future studies should therefore include impacts on inland aquatic environments caused by nitrogen saturation, and eutrophication caused by nitrogen loads.

4.2.3 Special Topics

4.2.3.1 Influence of Miyakejima volcano

Japan is famous for frequent volcanic eruptions, and atmospheric deposition sometimes includes volcanic emissions such as sulfates and chlorides. One noteworthy event during the period of the survey is the explosion of a volcano on Miyake Island, located 100 km south of Japan's main island, Honshu, which began in August of 2000 with maximum daily SO_2 emissions of 82,200 tons.

In order to detect continuous influence of the activity, monthly wet deposition of non-sea-salt sulfate (nss-SO_4^{2-}) from September 2000 through August 2001 was statistically compared with September 1996 through August 2000. The ratio of monthly nss-SO_4^{2-} deposition to the sum of nss-SO_4^{2-} and nitrate (NO_3^-) deposition (S/(S+N) ratio, hereafter) was similarly evaluated.The comparison did not reveal a significant difference in the S/(S+N) ratio between the two periods in Hokkaido, although one was obvious at almost all the sites in Honshu (Figure 4.15, 4.16). With respect to nss-SO_4^{2-} deposition, any significant difference was limited to rural sites on Honshu.In conclusion, nss-SO_4^{2-} deposition clearly increased due to the eruptions, but was not always significant compared to background values to date. In addition, the influence of the eruption was not significant continuously throughout the year, but was noticeable for several months.

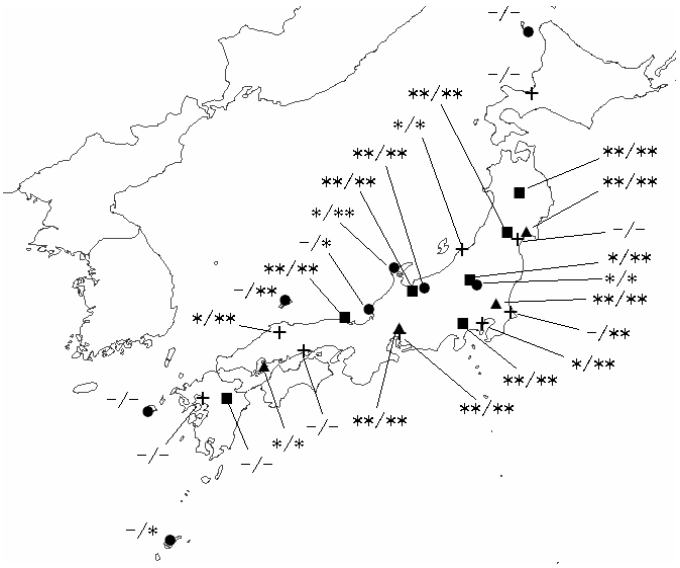


Figure 4.15 Result of statistical evaluation of the ratio of monthly nss-SO_4^{2-} deposition to the sum of nss-SO_4^{2-} and NO_3^- deposition. Remarks on the left of each site indicate the result of a t-test, and on the right an NP-test.

Site category

● : Remote; ■ : Ecological; ▲ : Rural; ＋ : Urban

Result of test

-- : Not significant ($p<0.05$)

* : Significant ($p<0.05$)

** : Strongly significant ($p<0.01$)

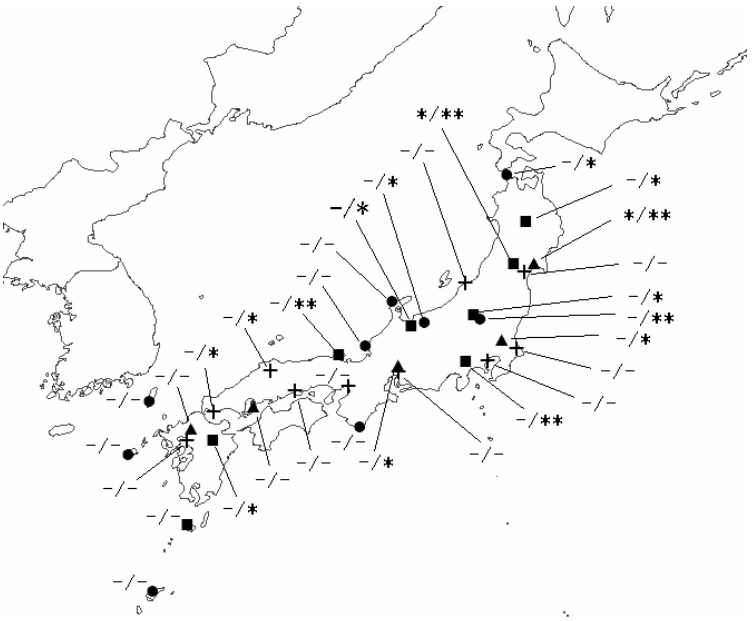


Figure 4. 16 Result of statistical evaluation of monthly nss-SO_4^{2-} deposition
See Fig.2-.15. .for remarks.

4.2.3.2 Effect of dust and sandstorm aerosols

A kind of atmospheric long-range transport in East Asia, dust and sandstorm aerosols originating from continental deserts are often observed in Japan in spring. Such a phenomenon can be expected play an important role in the precipitation chemistry. This study evaluated the influence on pH of rainwater and wet deposition of non-sea-salt calcium (nss-Ca^{2+}), as well as on the deposition of non-sea-salt sulfate (nss-SO_4^{2-}), using the monitoring results in March each year.

Six sites were selected for the analysis, all of which were located in the coastal area of the Sea of Japan and which were categorized into remote observational sites to obtain daily wet deposition. Quantitative evaluation of the influence on wet deposition was performed as follows: (1) The day of sampling was divided into two categories—days with dust and sandstorms, and days with no dust and sandstorms (the former category was determined based on reported visibility of less than 10 km, caused by the mineral aerosols, as reported at meteorological observatories of the Japan Meteorological Agency neighboring each site). (2) The average amount of deposition for days with no dust and sandstorms was calculated and defined as the background value for the month. (3) The difference between the total amount of daily wet deposition and the background value was regarded to be additional deposition by dust and sandstorms, and was summed as a monthly value.

Nss-Ca^{2+} deposition and pH value have increased at several stations since 2000, together with more frequency reports of dust and sandstorm phenomena. Goto is the most noticeable site in this context, where nss-Ca^{2+} concentrations increased by a factor of several times and rainwater samples with pH levels above 6.0 were observed more frequently. Relationship between the background value and the additional value of monthly nss-Ca^{2+} deposition did not show a clear tendency, primarily because of variation of the latter. Generally, the background value seemed to exceed the additional value, while the inverse was found for 2000 through 2002. Additional nss-SO_4^{2-} deposition also showed a large fluctuation at several sites, although no correlation with was found with the value for nss-Ca^{2+}.

4.2.3.3 Results of integrated monitoring

Monitoring was implemented for rainwater, aquatic environment, soil and vegetation at five lakes

(Lakes Kuttara-ko, Kamakita-ko, Ijira, Banryu-ko and Unagi-ike) and their catchments, with a view to conducting an integrated assessment on ecological impacts of acid deposition. The quality of the river water flowing into Lake Ijira-ko, the catchment of which was the most acidified among the five catchments, was disturbed during the monitoring period.

Figure 4.17 shows the trend of water quality in the Ijira River, which flows into Lake Ijira-ko. Whites dots in Fig. (c) and (d) indicate the water quality of the river, and gray dots are for rainwater. Dotted lines are drawn at the concentration of sulfuric ion that balances the input of sulfuric ion by rainwater with the output by average outflow from 1988 to 2003. That concentration was calculated using the ratio of the outflow to inflow concentrations of chloride ions, which are practically not consumed in the ecosystem. Ion concentrations in the river above the line, means that the output (outflow) exceeds the input (deposition), while concentrations below the line, indicate that output is below input.

The output of SO_4^{2-} has been slightly exceeding input since 1988, when monitoring began. This indicates that the catchment of Lake Ijira-ko was always at the state of saturation in terms of SO_4^{2-}, and for four years from 1994 to 1997, a sudden outflow of these ions took place.

Along with that, concentrations of calcium and aluminum rose and the basin was acidified. Moreover, since 1997 when the outflow of SO_4^{2-} started to decline, pH and alkalinity of the river started to decline. That kind of acidification of the river can be attributed to the supply of protons generated by the release of SO_4^{2-} in the soil upstream.

Although there is no immediate evidence showing that the change of water quality was caused by acid deposition, it is certain that acid deposition could explain that phenomenon. Specifically, without both conditions of a continuous supply of SO_4^{2-} and saturation with SO_4^{2-} at the catchment, the sudden outflow of SO_4^{2-} observed from 1994 could not have happened. The most reasonable assumption is that such continuous supplies of SO_4^{2-} came from acid rain, given no natural source (e.g., volcanoes) or agricultural source (e.g., fertilizer) was present. Further investigation based on that hypothesis should continue.

In that connection, the SO_4^{2-} and H^+ depositions onto this catchment were more than in any other monitoring area and the precipitation pH was the lowest among them. The pH level of the surface water at the center of the lake has been trending downward since 1996. The concentration of nitrates was increasing year by year in lake water as well as in the river flowing into the lake.

In Lakes Kuttara-ko, Banryu-ko and Unagi-ike, while a long-term tendency of an increase in electrical conductivity was observed in the water, changes of alkalinity and pH were small, so the direct influence of acid deposition on lake water could not be confirmed during the ten years of monitoring. However, in the catchment areas of Lake Kuttara-ko and Unagi-ike, which have no major rivers flowing in, spring water near the lakes showed symptoms of acidification. In the area of Lake Kamakita-ko as well, the river flowing into the lake showed a trend similar to that of Lake Ijira, so monitoring should be continued here as well.

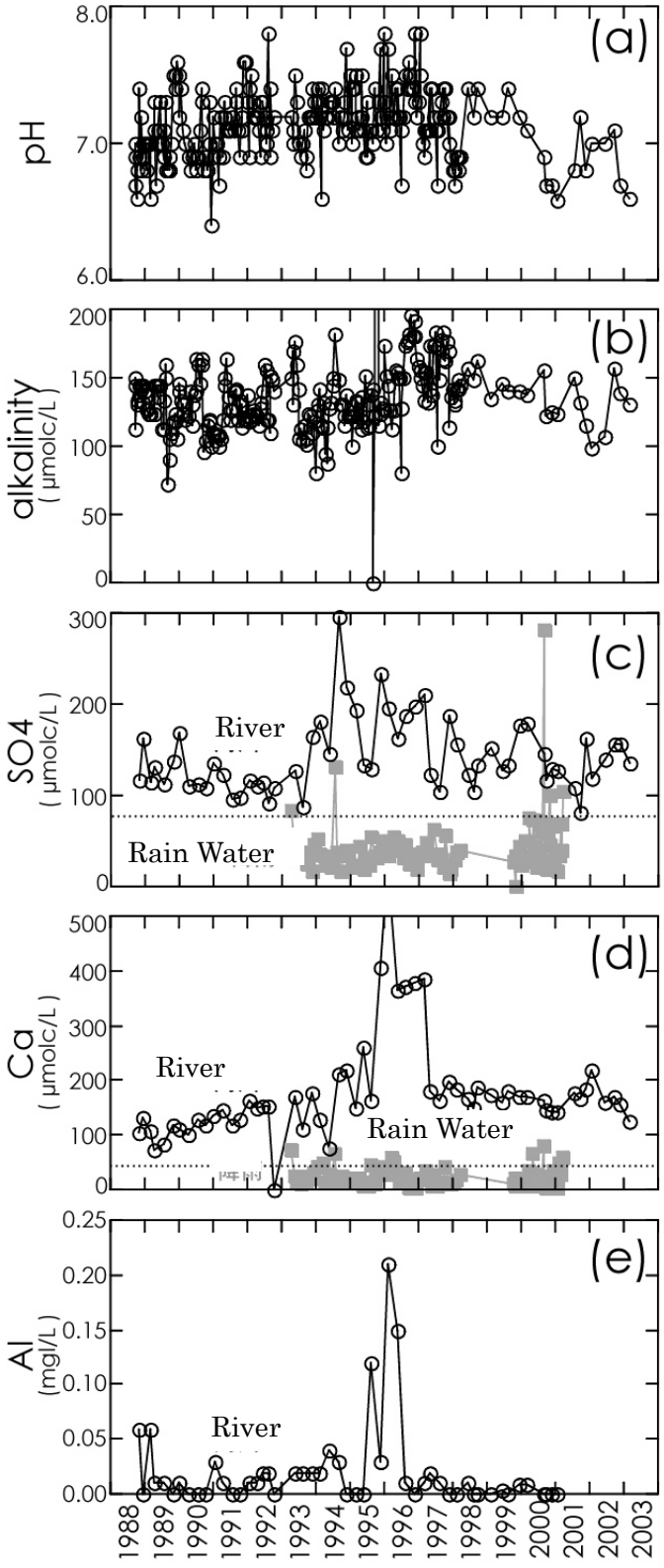


Figure 4.17 Change of water quality in the Ijira River flowing into the lake

4.3 Status of Atmospheric Pollution Control Measures

4.3.1 Air Pollution Control Law regulations

Japan's Air Pollution Control Law was enacted in 1968. This law made what was previously voluntary monitoring and control of soot and smoke emissions from plants and factories compulsory, in order to protect the health of citizens and maintain an acceptable living environment.

- Soot and smoke are harmful substances generated primarily through combustion. Substances such as sulfur oxides, dust, and nitrogen oxides fall under this category.
- Boilers larger than a certain size, waste incineration facilities, gas turbines, and diesel engines are designated under the ordinance as facilities with a high probability of emitting soot and smoke.
- Operators of such facilities are required to register in advance with the relevant local government authorities, and to comply with emission standards set by the Ministry of the Environment based on controlled substances and the type of facility emitting the soot and smoke. They are also required to monitor emissions of controlled substances.

Table 4.5 Outline of Soot and Smoke Controls

Substance		Outline of control
Sulfur dioxide		□ Determination of emission limit (volume) according to the height of the flue outlet (H_e) and a constant K that is decided by region. □ Fuel consumption standard according to season (as sulfur compounds in fuel for each region) □ Total volume control (determined for each region and site)
Soot		Emission standard at each site and scale of operations (concentration; by standard oxygen concentration correction method) General emission standard: 0.04–0.7 g/Nm^3 Special emission standard: 0.03–0.2 g/Nm^3
Harmful substances	Other than nitrogen oxides	Emission control at each site (concentration)
	Nitrogen oxides	□ Emission standard for each site and scale of operations (concentration; new or existing site) □ Total volume control (in each region and site)

Emission standards for SO_x

Emission standards for sulfur oxides vary depending on the effective flue height and the region. Accordingly, control values cannot be stated unconditionally. Rather, they are calculated based on a fixed equation that takes into account the region in which the soot and smoke emitting facility is based and the height of the flue. This regulation is called the K Value Control Equation, shown below:

$$q = K \times 10^{-3} H_e^{\ 2}$$

K: Constant set on a regional basis
H_e: Effective height of flue outlet. (Actual height of flue outlet plus rise height of flue gas column; units in meters)
q: Maximum permissible sulfur oxides emission limit (Nm^3/h)

Table 4.6 Example of Emission Standards Set by Ministry of Environment for Different Types of Soot and Smoke Sources (Emission Standards for New Facilities)

Facility type		Scale	*On (%)	Dust		NO*x* (ppm)
				General	Designated	
Boiler	Heavy oil-fired boiler	Above 200,000 m^3	4	0.05	0.04	130–150
		40,000–200,000 m^3	4	0.15	0.05	150
		10,000–40,000 m^3	4	0.25	0.15	150
		< 10,000 m^3	4	0.3	0.15	180
	Coal-fired boiler	Above 200,000 m^3	6	0.1	0.05	200–250
		40,000–200,000 m^3	6	0.2	0.1	250–320
		< 40,000 m^3	6	0.3	0.15	250–350

* On: Concentration of oxygen (percentage) for the estimation of dilution level

Table 4.7 Monitoring Frequency, Monitoring Methodology, and Recording of Controlled Substance Emissions

Substance	Classification of facilities emitting pollutants	Interval of measurement	Storage of records
Sulfur oxides	Facilities discharging over 10 Nm^3/h of sulfur dioxide	• At least once every two months • Continuous monitoring of fixed sources at sites (specially designated sites)	Three years
Soot	Facilities discharging 40,000 Nm^3/h or more of flue gas	At least once every two months	
	Facilities discharging less than 40,000 Nm^3/h of flue gas	At least twice a year	
Nitrogen oxides	Facilities discharging 40,000 Nm^3/h or more of flue gas	• At least once every two months • Continuous monitoring of fixed emission sources at specially designated sites under total volume control	
	Facilities discharging less than 40,000 Nm^3/h of flue gas	At least twice a year	

- Administrative officers can enter sites and factories for inspections in order to verify data such as soot and smoke emissions.
- If sites and factories fail to register with the relevant authorities in advance, fail to maintain records and make reports, or fail to comply with emission standards, the relevant authorities will issue an emission standards compliance order. Failure to comply with such an order will result in penalties such as fines or imprisonment.

Table 4.8 Examples of Penalties

Failure to pre-register facility	Up to 3 months' imprisonment or a fine of not more than 300,000 yen
Non-compliance with soot and smoke emission standards	Up to 6 months' imprisonment or a fine of not more than 500,000 yen
Failure to comply with improvement orders issued by relevant authorities	Up to 1 year's imprisonment or a fine of not more than 1 million yen

4.3.2 Local government measures

Local governments can mandate environmental pollution prevention ordinances for substances and facilities not addressed by the Air Pollution Control Law, set standards that are stricter than the APCL

in accordance with local conditions, and formulate pollution prevention agreements between sites and factories.
Sites and factories carry out regular monitoring of soot and smoke concentrations based on such pollution prevention agreements, and the results are reported to local governments.

4.3.3 Trend of annual average of SO_2 concentrations in Japan

The annual average of SO_2 concentrations decreased drastically in the 1970s, but remains stable these years (see Figure 4.18).

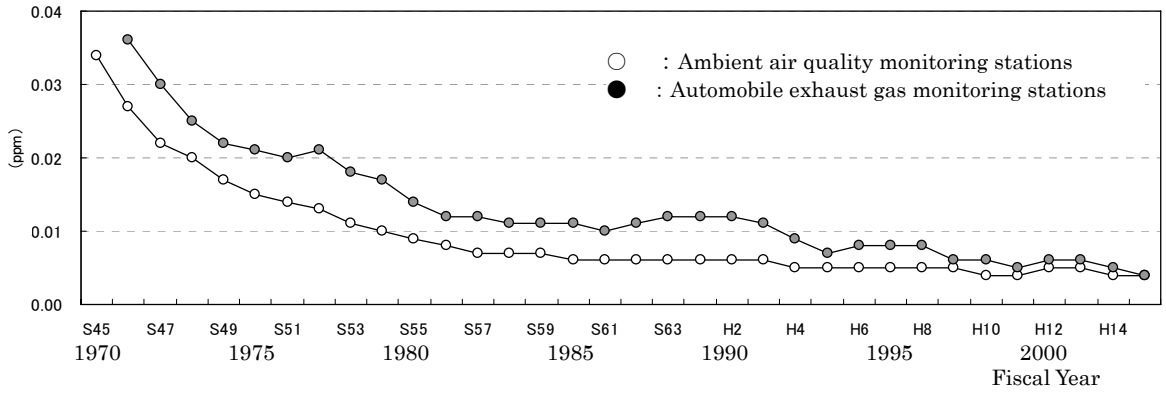


Figure 4. 18 Trends of annual average of SO_2 concentrations in Japan

4.3.4. Trend of emissions of SOx, NOx and soot in Japan

The emission of SOx decreased drastically in the 1970s, but remains stable these years. NOx emission has slightly increased these days, which would be considered as related to the increase of the automobiles.

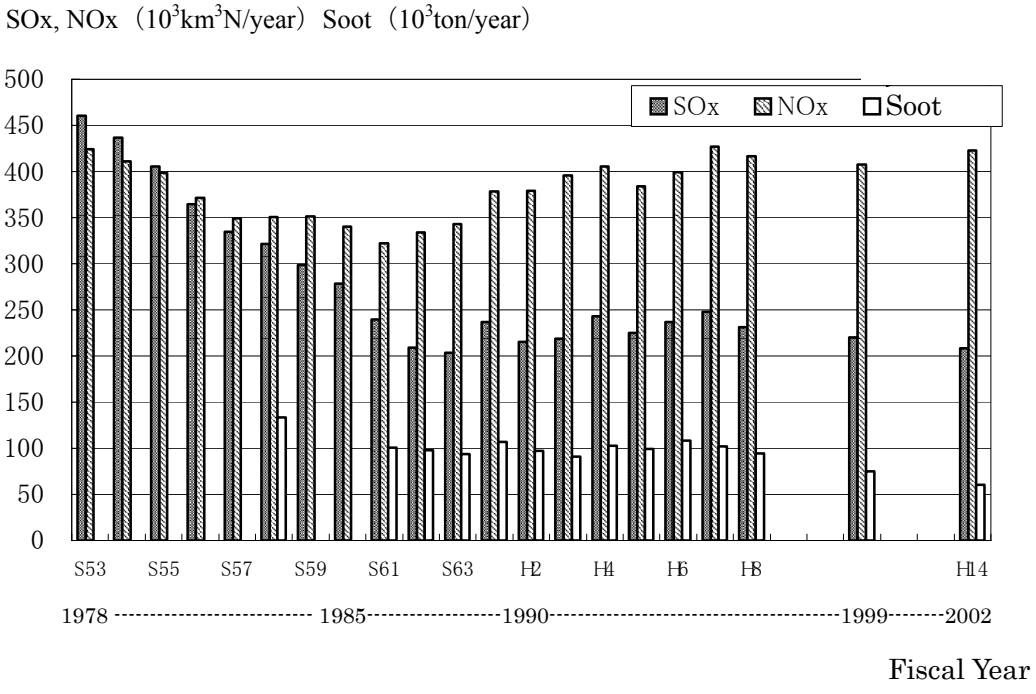


Figure 4. 19 Trend of emissions of SOx, NOx and soot in Japan

National Assessment on Acid Deposition in Lao PDR

5.1 Basic Information on National Monitoring Activities

5.1.1 Background information

Acid deposition issues are a fairly new phenomenon for Lao PDR and the interest in the prevention of this problem is still gaining momentum. There is a lack of knowledge on various aspects of sulfur and nitrogen pollution including emissions, atmospheric transport and deposition, direct impacts of gases on human health, vegetation and corrosion of monuments and indirect impacts via changes in the soil. For this reason there is a need for a better understanding in these problems in Lao PDR.

Nevertheless, it is possible that the high rate of urbanization and industrialization and population growth will lead to air pollution problems as well as acid deposition in the urban areas of Lao PDR. The population growth rates in urban areas are higher than the national average, signifying rural to urban migration. The capital, Vientiane has a population growth rate of 3.9% per year and the population of Savannakhet, the second largest urban center, has more than tripled from 30,000 to 100,000 inhabitants between 1975 and 1995, an annual growth rate of about 3.5% (ADB 2000). On the other hand, in the rural areas the expansion of intensive slash-and-burn shifting cultivation also contributes carbon dioxide (CO_2) to the atmosphere which is responsible for making natural rainwater slightly acidic.

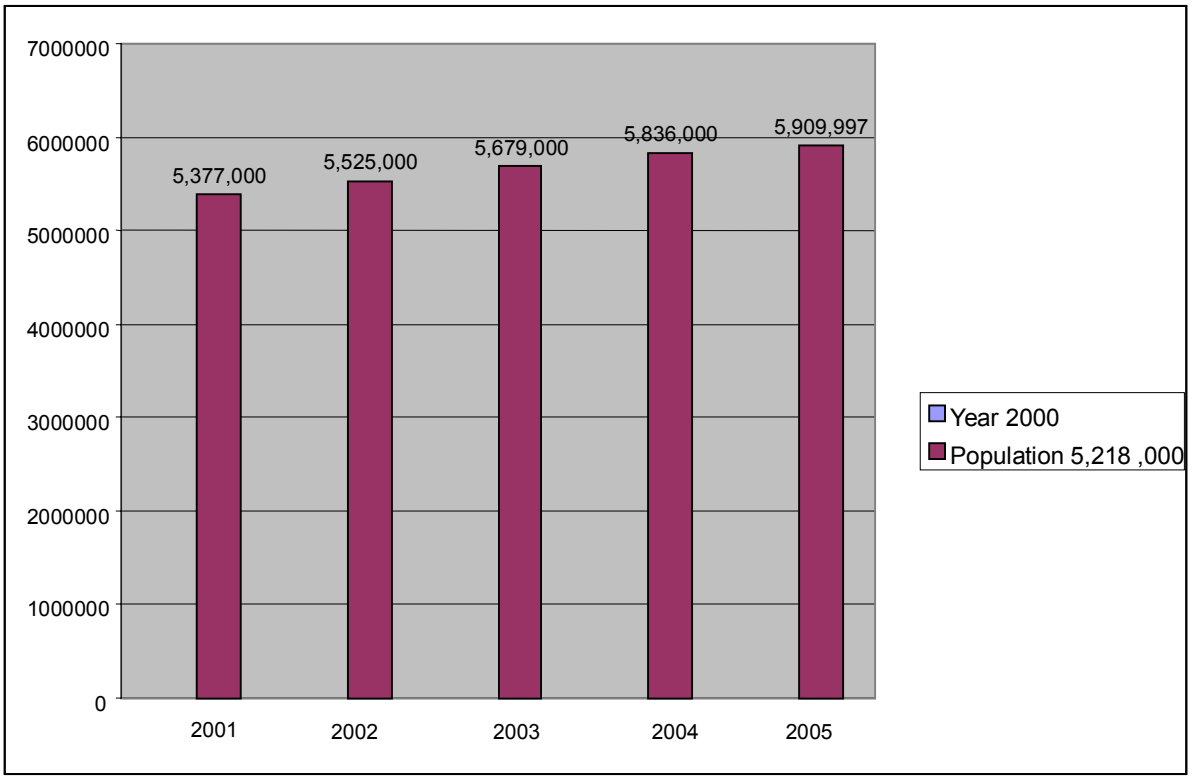


Figure 5.1 **T**rend of the population

Realizing the need to protect the country from the acid deposition problem, Lao PDR decided to join and became one of the participating countries of EANET in November 2002. Since then, Lao PDR has started to monitor and collect data on acid deposition. In order to ensure the monitoring activities of acid deposition in Lao PDR, the country established the National Center for acid deposition within The Environment Quality Monitoring Center (EQMC) of Environment Research Institute (ERI) of STEA. The center is responsible for implementing of nation plan on monitoring of acid deposition in Lao PDR as well as collecting the national monitoring data, promoting national QA/QC activities and dealing with technical matters on the network activities in the country.

5.1.2 Outline of the activities on acid deposition and national monitoring plan

The following are some of the programs that are currently implemented and others still being established:

- Developed National Monitoring Plan for EANET;
- Developed Standard Operating Procedure （SOP）
- Upgrading of the Laboratory is in progress;
- Capacity building of key staff in Lao on acid deposition;
- The joint project for complying the brochure on public awareness activities in Lao PDR in coordination with the Secretariat and the Network Center (NC) for EANET;
- Participation in the Inter-Laboratory comparison project on acid deposition (Artificial rain water);
- Surveyed to set-up an inland aquatic monitoring site is in progress;

5.1.3 Monitoring Program from 2003-2004

The National Monitoring Plan for the year 2003-2004 has been developed by the Lao National Center for EANET. Due to the lack of necessary facilities and equipments, wet deposition monitoring was only conducted and measuring merely pH and EC. The monitoring activities have been done for daily sampling based on rain condition.

However, in order to accomplish the analysis of mandatory parameters for wet deposition, the STEA (implementing agency) requested Chinaimo Water Supply Laboratory to do the analysis of SO_4^{-2}, NO^-_3, CI^-, Na^+, Ca^{2+}, Mg^{2+} and NH_4^+ starting 2005.

5.1.4 Monitoring Stations.

At present, there are no remote and rural sites for monitoring of acid deposition in Lao PDR yet. With reference to recommendations of technical mission in 2003, an interim site for wet sampler can be installed at STEA, Vientiane Capital City, for the assessment of the state of acid deposition in urban areas. However, the later mission found out that the interim site is considered as not satisfactory for site selection criteria of EANET because it might be disrupted by surrounding trees and be influenced by nearby emission sources. The inappropriate site may impact on monitoring results. Hence, it is necessary to decide on the wet deposition monitoring sites for future monitoring activities.

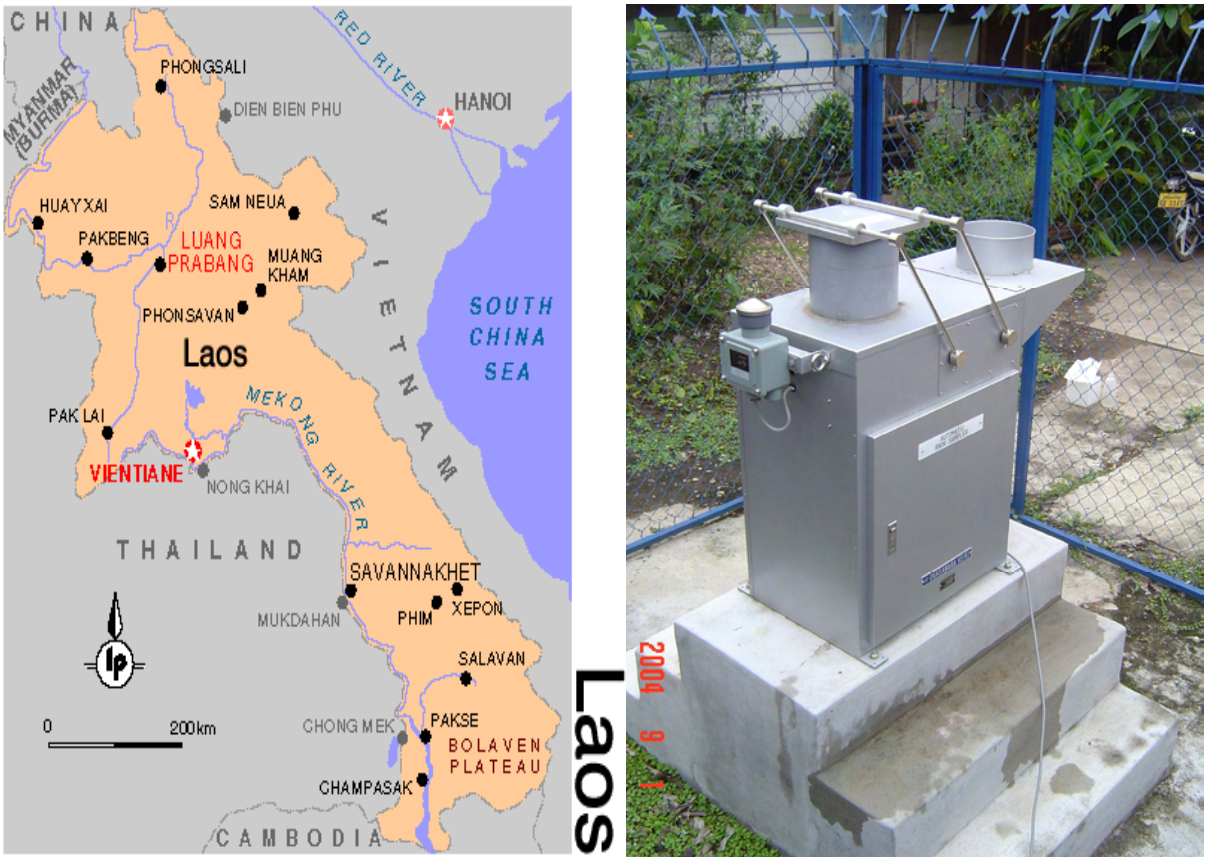


Figure 5.2 Sampling site

5.1.5 Sampling and Measurements.

Wet deposition sampling is being conducted by using the wet sampler only. The national center is following the technical manual for wet deposition monitoring analysis adopted by EANET. So far, we have the measurements for pH and EC. The data collected for the mentioned parameters are described below.

5.2 State of Acid Deposition in Lao PDR.

5.2.1 Atmospheric Deposition

5.2.1.1 State of Wet Deposition

For the year 2003, data recorded minimum values of pH were 6.15 and EC were 1.72 respectively. The maximum values recorded were 6.74 for pH and 2.38 mS/m for EC.

For the year 2004, the minimum values were 4.98 for pH and 1.09 ms/m for EC. The maximum values were 6.58 for pH and 5.68 mS/m for EC.

5.2.1.2 State of Dry Deposition

Lao PDR will start the monitoring of dry-deposition in the future in order to follow the requirements for EANET activities.

5.2.2 State of Inland Aquatic Environment

The survey for the monitoring station was already undertaken in 2005. The sampling site will soon be established from the candidate sites.

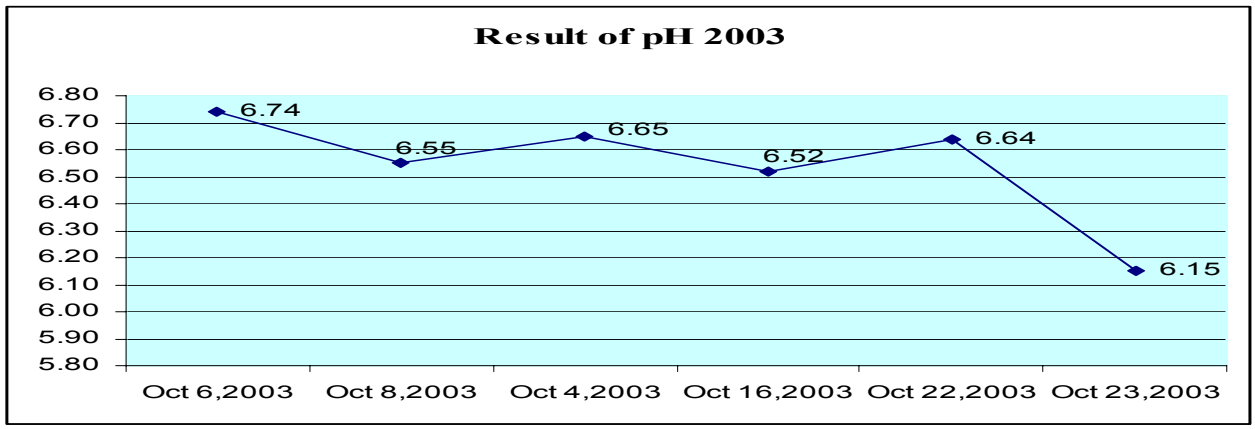
5.2.3 State of Soil and Vegetation

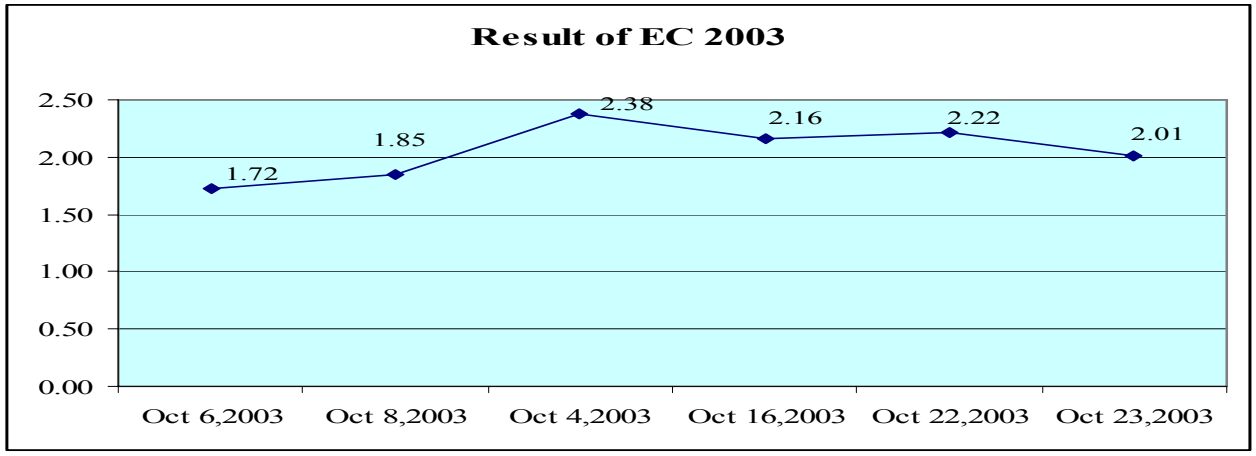
The monitoring activities for soil and vegetation have not yet been decided at this time in Lao PDR due to capacity consideration. However, the national center will also plan to conduct soil and vegetation monitoring.

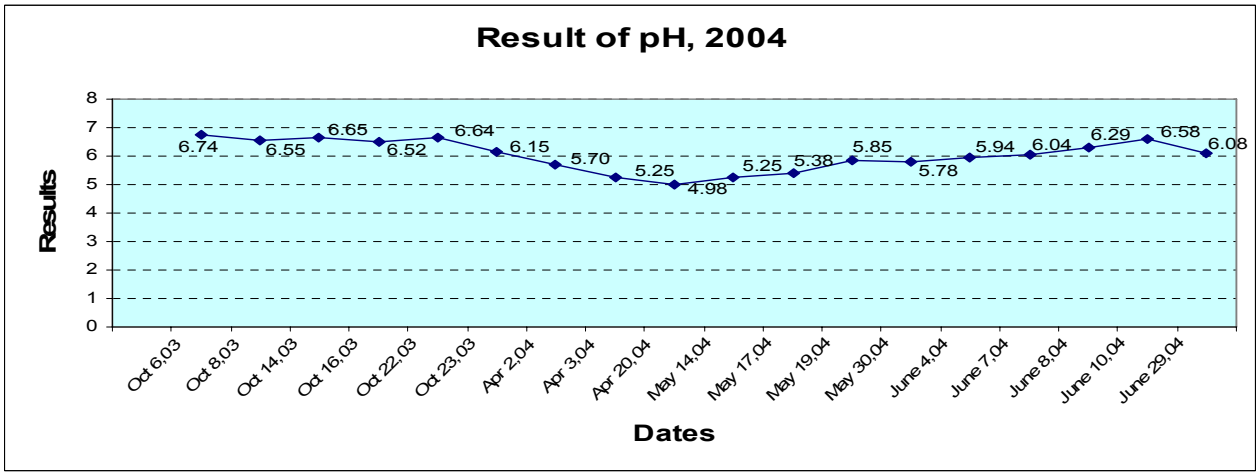
5.2.4 Overall Analysis

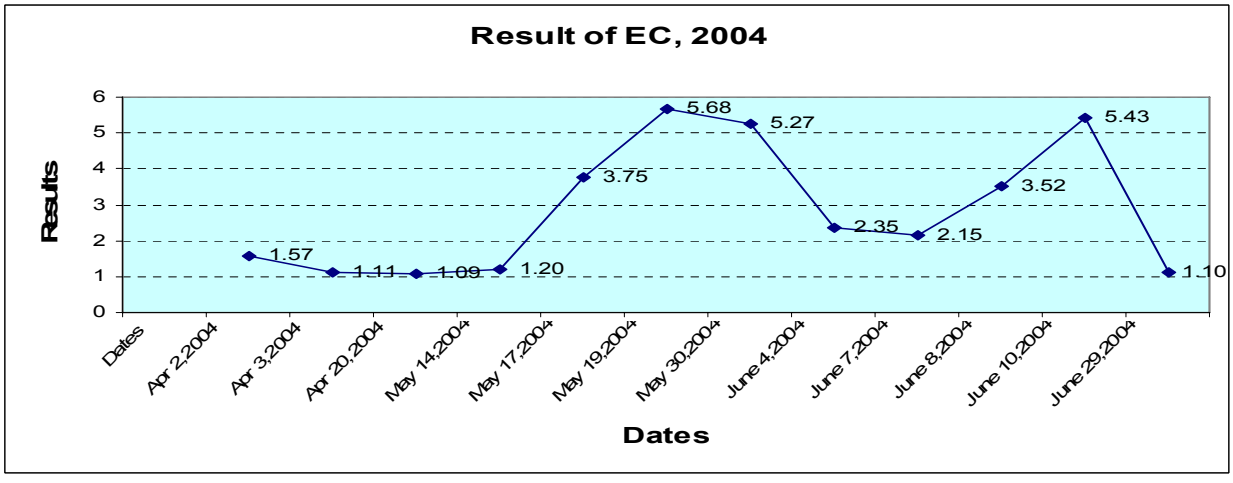
Wet deposition as mentioned has been the only monitoring activity in Lao PDR. From the data recorded in 2003 and 2004, the overall analysis describes the average concentrations of pH and EC respectively, which are still within the acceptable level.

Year	Parameter	Min	Max	Average Value
2003	pH	6.15	6.74	6.54
	EC mS/m	1.72	2.38	2.05
2004	pH	4.98	6.58	5.46
	EC mS/m	1.09	5.68	2.58




Result of EC 2003
2.50
2.00
1.50
1.00
0.50
0.00
1.72
1.85
2.38
2.16
2.22
2.01
Oct 6,2003
Oct 8,2003
Oct 4,2003
Oct 16,2003
Oct 22,2003
Oct 23,2003


Result of pH, 2004
Results
Dates
6.74
6.55
6.65
6.52
6.64
6.15
5.70
5.25
4.98
5.25
5.38
5.85
5.78
5.94
6.04
6.29
6.58
6.08
Oct 6,03
Oct 8,03
Oct 14,03
Oct 16,03
Oct 22,03
Oct 23,03
Apr 2,04
Apr 3,04
Apr 20,04
May 14,04
May 17,04
May 19,04
May 30,04
June 4,04
June 7,04
June 8,04
June 10,04
June 29,04


Result of EC, 2004
Results
Dates
1.57
1.11
1.09
1.20
3.75
5.68
5.27
2.35
2.15
3.52
5.43
1.10
Dates
Apr 2,2004
Apr 3,2004
Apr 20,2004
May 14,2004
May 17,2004
May 19,2004
May 30,2004
June 4,2004
June 7,2004
June 8,2004
June 10,2004
June 29,2004

5.3 Review of National Measures Against Acid Deposition

Acid deposition is not evident in the Lao PDR at the present time. Nevertheless, the STEA as the agency responsible for environmental protection is in the process of formulating environment quality standard at the national level including air pollution standards. Further, the government has established and implemented some programs below:

- National Greenhouse Gas Inventory Project have been implemented;
- Cleaner Production Project have been set up and operated by Ministry of industry and Handicraft;
- Develop the National Ambient and Emission Standards;
- Develop the Ambient Air Quality and Emission Monitoring Programme for Vientiane Capital City the year 2006-2010;
- The Ministry of Communication, Transportation, Post and Construction together with STEA is formulating the Sustainable Transport Strategy up to the year 2020.
- The National environment Strategy up to the year 2020 and National Environment policy was developed.

Regarding to acid deposition monitoring, only afew parameters have been monitored due to lack of funds, equipment, instruments and skilled staff to deal with this matter.

To strengthen the national capacity building at national level, including government and the private sector, there is a need for capacity building and an appropriate legal framework needs to be established, particularly to control industrial processes. In addition, the environment policy must be developed by considering the economic issues and life style of the population. It is also necessary to establish the environment quality standard at the national level. Promotion of public awareness is also necessary.

5.4 Organization structure

The Science Technology and Environment Agency – STEA, established within the Prime Ministry's Office, is the regulatory agency for the Science, Technology and Environmental management and administration in LAO PDR. Its mandate and activities are stipulated in the Prime Minister Decree No. 68, 1999, related to the Science, Technology and Environment Agency Creation, as well as in the Environment Protection Law, promulgated in April 1999.

Among seven departments and institutes of STEA, the Environment Research Institute (ERI) has four centers and one division, and is in charge of the following main tasks:

(i) To conduct research on the sustainable use and protection of natural resources (specifically water and biological diversity resources), on the implementation of environment policy and regulations and on the technology of pollution prevention and control.
(ii) To undertake environment quality at the national level, as well as being the third-party or independent party monitoring body.
(iii) To compile environment data, formulating and publishing the State of Environment Indicators.
(iv) To provide services in these above mentioned functions.

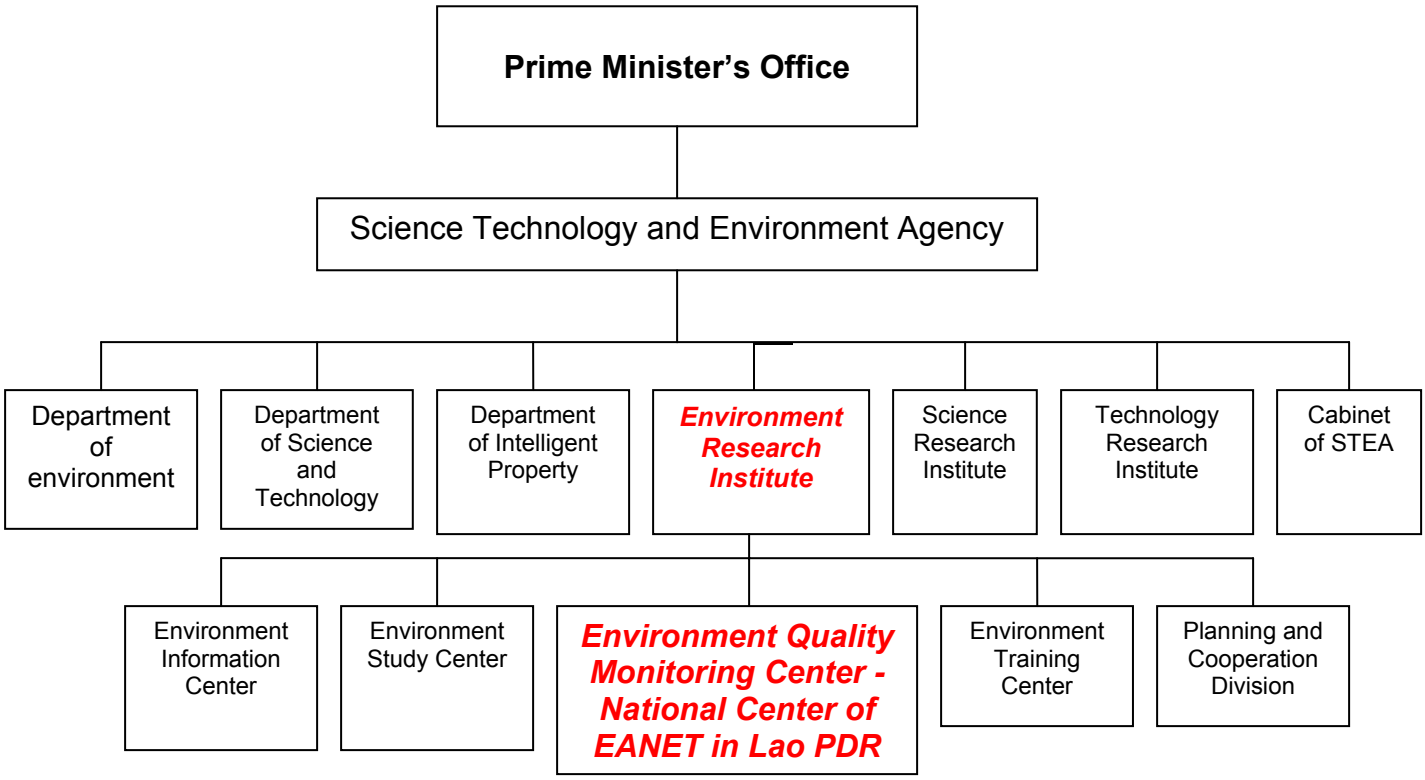
The Environment Quality Monitoring Center (EQMC), set up in ERI, is mandated to perform the following tasks:

(i) To monitor and control the environmental quality, such as water, noise, hazardous chemical

products, air, and acid deposition at the national level;
(ii) To conduct research on the pollution control and prevention technology;
(iii) To disseminate environment toxicology and to make the Lao society aware of the negative impacts from the use of hazardous chemical products, and
(iv) To provide services on the above mentioned tasks.

This center also acts as National Center for Acid Deposition and Implementation of nation plan on monitoring of acid deposition in Lao PDR.

Organization Chart:



National Monitoring Activities

6.1 Basic Information on National Monitoring Activities

6.1.1 Outline of Activities on Acid Deposition and National Monitoring Plan

Malaysia participated in the preparatory phase of the East Asia Acid Deposition Network (EANET) from the beginning in 1989 to 2000 and agreed to implement regular monitoring activities together with nine other countries. The national monitoring plan for the regular-phase activities was implemented in 2001 at two sites, Petaling Jaya and Tanah Rata, monitoring wet and dry acid deposition. Following this, soil and vegetation started in late 2001 also at two sites, Pasoh Forest Reserve and Sungai Lalang Forest Reserve. Inland aquatic environment monitoring was initiated only in 2004 after a suitable site, the Seminyih Dam was surveyed and found suitable. In late 2004, wet and dry deposition monitoring was established at the Danum Valley Global Atmosphere Watch Station on a trial basis.

6.1.2 Monitoring Program

Malaysia started regular phase of with wet and dry deposition monitoring at two sites, the Petaling Jaya and Tanah Rata site which subsequently expanded to three sites when wet and dry monitoring started at Danum Valley in 2004. Soil and vegetation monitoring was conducted at two sites, namely Pasoh Forest Reserve and Sungai Lalang Forest Reserve in 2001 and 2002 respectively. Inland aquatic environment monitoring began in 2005 after a suitable site, Seminyih Dam was surveyed. The measurement parameters and monitoring intervals are tabulated below;

Table 6.1 Measurement parameters and monitoring interval

Items	**Measurement parameters**	**Monitoring interval**
Wet deposition	pH, EC, NH_4^+, K^+, Na^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, CL^-, $CH_3SO_3^-$, CH_3COO^-, $HCOO^-$, $C_2O_4^{2-}$, Br^-, PO_4^{3-}, NO_2^-	weekly
Dry deposition	SO_2, NO_2, NO, O_3, HNO_3, NH_3, HCl, PM10, Components in PM10 (pH, EC, NH_4^+, K^+, Na^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, CL^-, $CH_3SO_3^-$, CH_3COO^-, $HCOO^-$, Br^-, PO_4^{3-}, NO_2^-)	weekly
Soil	1.pH(H_2O), 2.pH(KCl), exchangeable (3. Na^+, 4.K^+, 5.Ca^{2+}, 6.Mg^{2+}, 7.Al^{3+}, 8.H^+), 9.exchangeable acidity, 10.ECEC, 11.Carbonate, 12.T-C, 13.T-N, 14.SO_4^{2-}, 15.available phosphate	Sampling time: 11 a.m month: Dec year: 2004
Vegetation	1.observation of tree decline, 2.description of trees	Sampling time: 9 a.m month: Dec year: 2004
Inland aquatic environment	Temperature, pH, EC, alkalinity, ammonium, sodium, potassium, calcium, magnesium, sulphate, nitrate, and chloride ions.	4 times a year.

Sampling is conducted by the Malaysian Meteorological Department and the Department of Chemistry (DOC), Malaysia analyses the wet and dry deposition samples and the filter pack for the chemical species tabulated above. The DOC participates actively in the inter-laboratory comparison activities of EANET and the World Meteorological Organization (WMO) Global Atmosphere Watch (GAW) program.

Table 6.2 Measurement and analytical method

Parameter	Measurement/ analytical method	Manufacturer/ type of equipment	Detection limit
pH	Glass electrode	ACCUMET Research/ACCUMET AR20	0.06
EC	Conductivity cell	HANNA Instrument/ HANNA HI9032	0.1uS/cm
SO_4^{2-}	Determination of Anions by Electrochemically Suppressed Ion Chromatography	DIONEX USA/ DX600-Anion	0.03 umol/L
NO_3^-			0.14 umol/L
Cl^-			0.20 umol/L
CH_3COO^-			0.05 umol/L
$HCOO^-$			0.10 umol/L
$C_2O_4^{2-}$			0.07 umol/L
NH_4^+	Determination of Cations by Electrochemically Suppressed Ion Chromatography	DIONEX USA/ DX600-Cation	0.20 umol/L
Na^+			0.40 umol/L
K^+			0.08 umol/L
Ca^{2+}			0.50 umol/L
Mg^{2+}			0.40 umol/L

Soil and vegetation sampling is conducted by University Putra Malaysia (UPM). The laboratory in UPM analyses the collected samples and participates in the annual EANET inter-comparison activities.

Inland aquatic environment monitoring which began in 2004 is carried out by Universiti Teknologi Mara Malaysia (UiTM). Sample analysis is done by the laboratory in UiTM.

6.1.3 Monitoring Stations

6.1.3.1 Wet and Dry Monitoring Sites

Presently there are three monitoring sites for wet and dry deposition and the stations are;

i). GAW Station, Danum Valley;
ii). Petaling Jaya Air Pollution Station, Selangor and
iii). Tanah Rata Regional GAW Station.

The full complement of meteorological parameters are monitored at these three sites. Outline of the stations are as follows;

i). Station name : Danum Valley GAW Station
ii). Address: c/o Tawau Airport Meteorological Station
Lapangan Terbang Wakuba,
P.O. Box 60109,

		91011 Tawau, Sabah, Malaysia.
iii).	Site classification:	remote
iv).	Latitude:	04 deg. 58' 53" North
v).	Longitude:	117 deg. 50' 37" East
vi).	Altitude:	427 m above MSL
vii).	Topography:	hilly terrain
viii).	Landuse:	forest reserve and conservation area
ix).	Vegetation:	tropical rain forest
x).	Sources of pollution: none	

The Danum Valley GAW Station is located in the Danum Valley Forest Conservation area, a well known tropical rain forest research site. The station was established in 2004 to make reliable, comprehensive observations of the chemical composition and selected physical characteristics of the atmosphere on a regional and global scale for the purpose of monitoring and predicting changes in atmospheric composition and its impacts. Access to the site is by four-wheel drive vehicles and the nearest town is approximately 100 kilometres away.

View of Danum Valley GAW Station:

i).	Station name	:	Petaling Jaya Air Pollution Station
ii).	Address:		Malaysian Meteorological Department Jalan Sultan, 46667 Petaling Jaya, Selangor

		Malaysia
iii).	Site classification:	urban
iv).	Latitude:	03 deg. 06' North
v).	Longitude:	101 deg. 39' East
vi).	Altitude:	45.7 m above MSL
vii).	Topography:	flat terrain in a basin
viii).	Landuse:	urban, commercial and light industry
ix).	Vegetation:	planted trees
x).	Sources of pollution: motor vehicles and light industries	

The Petaling Jaya monitoring site is located in the Klang Valley, the most developed area in Malaysia. It is also the commercial centre of the country. The site is surrounded mainly by buildings and infrastructure with recreational areas such as parks and lakes. Ten kilometres to the northeast of Petaling Jaya is the largest city Kuala Lumpur and to the west is the light industrial city of Shah Alam and the port of Klang, 40 kilometres away.

View of the Petaling Jaya Air Pollution Station site.

i).	Station name :	Tanah Rata Regional GAW Station.
ii).	Address:	Meteorological Station, Langgak Mercu, 39000 Tanah Rata, Pahang, Malaysia.
iii).	Site classification:	rural
iv).	Latitude:	04 deg. 28' North
v).	Longitude:	101 deg. 22' East
vi).	Altitude:	1545 m above MSL

vii). Topography: hilly terrain
viii). Landuse: farming and tourism
ix). Vegetation: highland forest
x). Sources of pollution: domestic

The Tanah Rata Regional GAW Station is situated in the tourist resort of Cameron Highlands where the surface temperature range is between 15 and 28 degrees Celcius. The station is surrounded by highland forest, vegetable and flower farms and residential buildings. The site is easily accessible by motor vehicles and this site is fully manned.

View of Tanah Rata Regional GAW Station.

6.1.3.2 Soil and Vegetation Monitoring Sites

As regards soil and vegetation monitoring, there are two sites for monitoring;

a) Pasoh Forest Reserve
b) Sungei Lalang Forest Reserve

Outline of the sites are:

i). Site name : Pasoh Forest Reserve
ii). Latitude: 02 deg. 28 ' North
iii). Longitude: 102 deg. 19' East
iv). Site classification: rural
v). Topography: flat terrain
vi). Landuse: forest reserve and conservation
vii). Vegetation: tropical rain forest

viii). Sources of pollution: motor vehicles > 20 km away.

Pasoh is a lowland dipterocarp forest. The emergent layer at Pasoh averages 46m and the main canopy is 20 –30m. Tree density is 545 per hectare.

i). Site name : Sungai Lalang Forest Reserve
ii). Latitude: 03 deg. 55' North
iii). Longitude: 103 deg. 08' East
iv). Site classification: rural
iv). Topography: hilly with elevation of between 50 and 600 m above MSL
v). Landuse: forest reserve and conservation
vi). Vegetation: tropical rain forest
vii). Sources of pollution: motor vehicles > 10 km away.

The Sungai Lalang Forest Reserve area is considered rich in flora and fauna.

6.1.3.3 Inland Aquatic Monitoring Site

Inland aquatic monitoring started only in 2005. An experimental site, the Seminyih Dam was selected and sampling was conducted once in three months.

6.1.4 Sampling and Measurements

6.1.4.1 Wet Deposition

As mentioned earlier, wet deposition is monitored at three monitoring sites, namely;

i). GAW Station, Danum Valley;
ii). Petaling Jaya Air Pollution Station, Selangor and
iii). Tanah Rata Regional GAW Station.

The sampling details are as follows;

i). Height of sampling collector:Height from ground: 5 mHeight from floor: 1.5 m
ii). Period of sample collection: weekly
iii). System of sample collection: wet-only
iv). Collector: Ecotech Model 200, funnel diameter: 117 mm
v). Sampling bottle: polyethelene
vi). Sample temperature: uncontrolled
vii). Shipping sample temperature: uncontrolled
viii). Packing procedure: in boxes
ix). Mean time from sampling to analysis: 4 weeks
x). Use of biocide: thymol and 400mg/l

Ecotech Wet-only Sampler

Meteorological observation are monitored at the three wed deposition monitoring sites. The details are as follows;

i). Precipitation:
Instrument: Rain gauge
Manufacturer: Rimco
Model: 8000 series
Height from ground: 4m
Method: tipping bucket

ii). Other parameters:
1. wind direction,
2. wind speed,
3. temperature
4. humidity and
5. solar radiation

Automatic weather system

6.1.4.2 Dry Deposition

Dry deposition is monitored at the same three sites as wet deposition and the details of dry deposition sampling for gases are as follows;

i). Height of sampling: Height from ground: 5 m
Height from floor: 1.5 m
ii). Measured parameters: SO_2, NO_2, HNO_3, NH_3 and HCl
iii). Sampling period: 1 and 2 weeks
iv). Measurement interval: continuous
v). Monitoring method: passive sampling and filter pack

For measuring particulate matter load, an automatic PM10 monitor manufactured by Rupprecht and Patashnick model TEOM 1400a is used at Petaling Jaya and Tanah Rata sites.

Meteorological parameters such as wind direction, wind speed, temperature, humidity, solar radiation and precipitation amount are measured as well.

Filter pack sampling

Rupprecht and Patashnick TEOM 1400a

Passive sampler

6.1.4.3 Quality Assurance and Quality Control Activities

Quality assurance and quality control (QA/QC) activities are conducted at all stages of monitoring and analysis. QA/QC activities are not confined to analytical laboratories alone but to monitoring sites as well. Monitoring sites and methodology are inspected and reviewed regularly.

The analytical laboratories participant in inter-laboratory comparison projects undertaken by the network centre and other well known laboratories as well to review their performance.

Overall, due to QA/QC activities, data quality has improved during the regular-phase of EANET.

6.1.5 Data Submission

Acid deposition data from all the monitoring sites are checked and submitted to Network Centre in Japan periodically through the National Centre.

6.2 State of Acid Deposition in Malaysia

6.2.1 Introduction

In terms of the amount of acid deposition data, only two sites, the Petaling Jaya site and the Tanah Rata Regional GAW Station is available to assess the state of acid deposition. These two sites started EANET acid deposition monitoring in the year 2001. As mentioned in Chapter 1, the Ecotech wet-only sampler is the instrument used to collect wet samples and for acidic gaseous, the passive sampler and the filter pack are employed to sample the gases. The sampling frequency of wet deposition and gas samples is weekly.

Although a number of acid deposition parameters are monitored and analyzed, this assessment examines the wet deposition of sulphates and nitrates and the ambient air concentration of sulphur dioxide (SO_2), nitrogen dioxide (NO_3) and gas phase nitric acid (HNO_3).

6.2.2 State of Wet Deposition

Weekly wet deposition fluxes are calculated as the product of each weekly sample ion concentration with the weekly rainfall total at each of the site and the annual wet deposition flux is the sum of the weekly deposition fluxes.

Figure 6.1 and Figure 6.2 show the time series of weekly wet deposition of sulphate and nitrates at Tanah Rata and Petaling Jaya respectively.

Figure 6.3 and Figure 6.4 show the annual wet deposition flux of sulphate and nitrates at Tanah Rata and Petaling Jaya respectively.

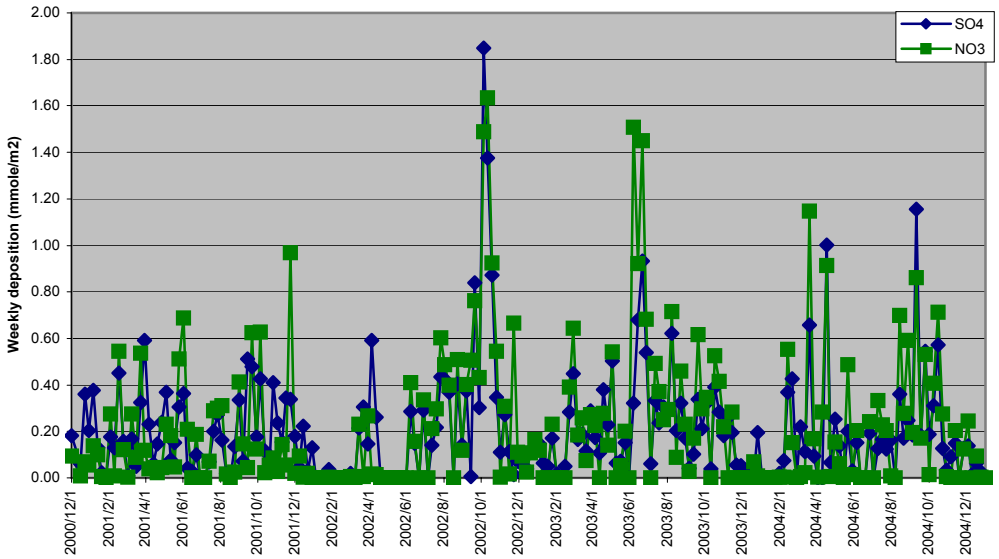


Figure 6.1 Time Series of Weekly Wet Deposition of Sulphate and Nitrate
Tanah Rata Regional GAW Station (rural site)

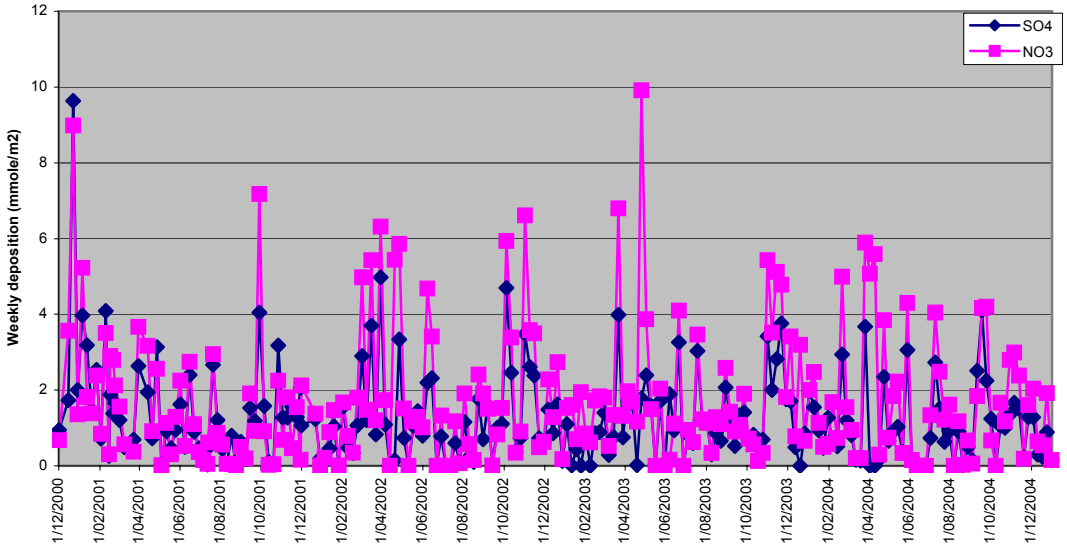


Figure 6.2 Time Series of Weekly Wet Deposition of Sulphate and Nitrate
Petaling Jaya Station (urban site)

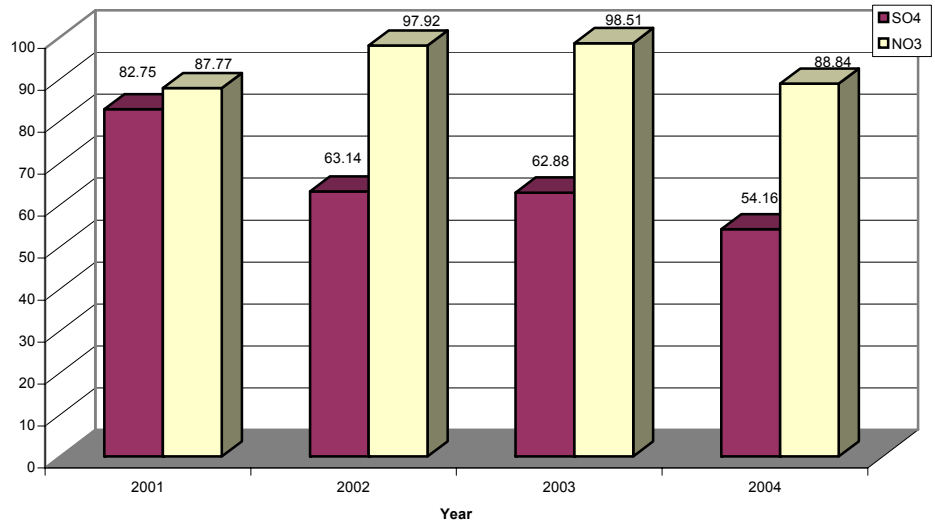


Figure 6.3 Annual Wet Deposition (mmole/m^2)
Tanah Rata Regional GAW Station (rural site)

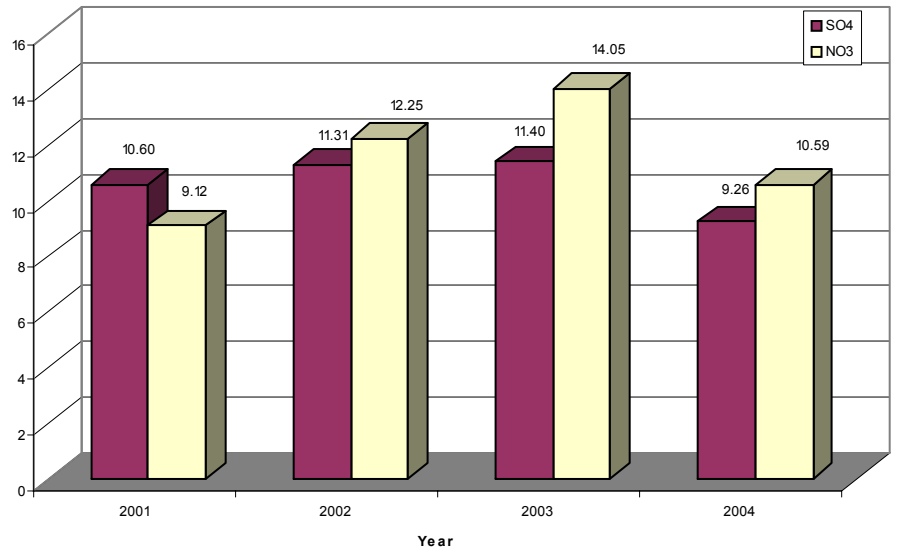


Figure 6.4 Annual Wet Deposition (mmole/m^2)
Petaling Jaya Station (urban site)

From the figures, the following conclusions were arrived at:-

a). High variability of wet deposition at both the sites and this is due to the inherent high rainfall variability in the tropics.
b). Wet deposition of nitrate is more than sulphate at both sites. The difference is more pronounced at the Petaling Jaya site.
c). From the four years of available data, annual sulphate deposition shows a rapidly decreasing trend in Petaling Jaya during the past 4 years from 2001 to 2004 and in Tanah Rata, the decreasing trend is gradual and it is during the past 3 years from 2002 to 2004.
d). The annual amount of nitrate in wet deposition at both sites did not show any significant changes.
e). The annual wet deposition of sulphate in Petaling Jaya, an urban site is approximately 6 to 8 times that of Tanah Rata, a rural site. As for nitrates, the wet deposition of nitrates in Petaling Jaya is between 7 and 10 times that of Tanah Rata.

6.2.3 State of Dry Deposition

As dry deposition flux is dependant on ambient air concentration of the acidic gases and dry deposition velocity which in turn is dependant a number of factors like the physical and chemical properties of the gases, surface properties and other environmental factors, the dry deposition flux is not examined and reported. However, to estimate the magnitude of dry deposition flux, the ambient air concentration of these gases, SO_2, NO_2 and HNO_3 are presented and discussed.

In Tanah Rata, the rural site, as shown in Figure 6.5, the weekly concentrations of all three gases SO_2, NO_2 and HNO_3 are mainly below 2 ppb during the first two years of passive sampling and concentrations of these gases were found to be mainly below 1 ppb during the last two years, 2003 and 2004.
In Petaling Jaya, the weekly concentrations of HNO_3 and SO_2 are below 5 ppb and 10 ppb respectively as shown in Figure 6.6. Unlike in Tanah Rata and in relation to SO_2 and HNO_3, the weekly concentrations of NO_2 is much higher and it ranged between 15 and 45 ppb during the 4-year monitoring period.

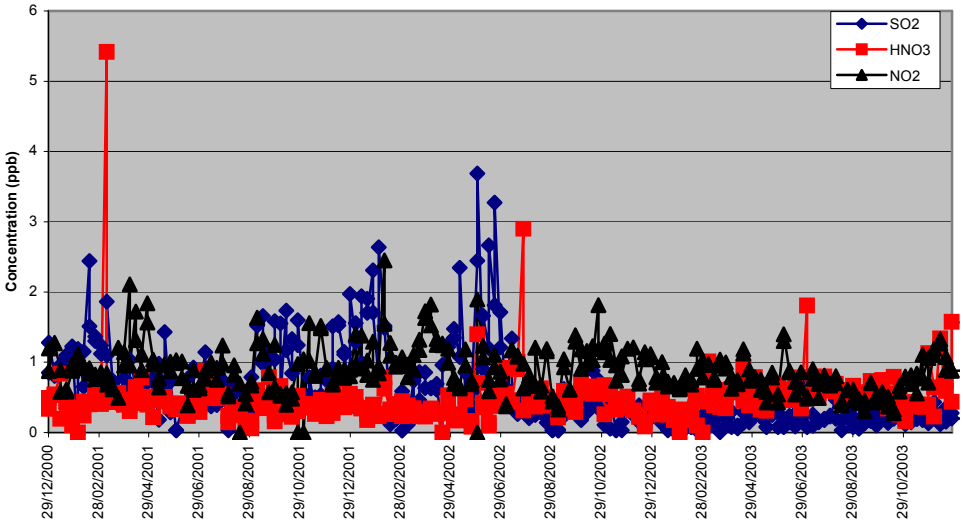


Figure 6.5 Weekly Gaseous Concentration (ppb)
Tanah Rata Regional GAW Station (rural site)
Passive Sampler

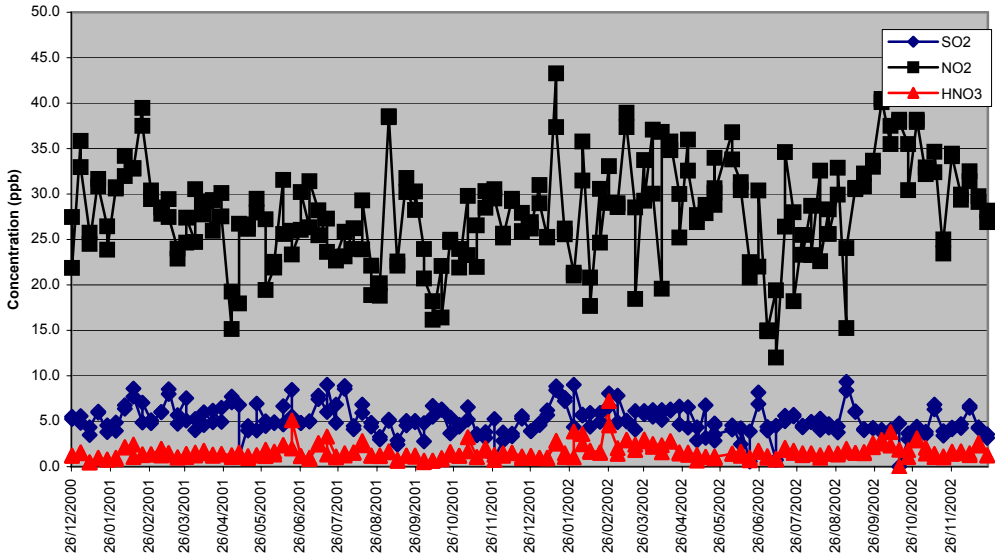


Figure 6.6 Weekly Gaseous Concentration (ppb)
Petaling Jaya Station (urban site)
Passive Sampler

6.2.4 State of Inland Aquatic Environment

Inland aquatic monitoring began only in the year 2005 and as such there is insufficient data for any assessment.

6.2.5 State of Soil and Vegetation

Soil and vegetation sampling was conducted in the year 2001 and 2004 and the next sampling will be in 2007. Changes if can only be studied and assessed after the third sampling in 2007.

6.2.6 Overall Analysis

In certain areas especially the urban Petaling Jaya and Kuala Lumpur area, the rainwater is considered to a certain extent acidified.

Organic acids contributes to rain water acidity but the dominant acids are the mineral acids, sulphuric and nitric acid. Nitric acid is the dominant mineral acid especially in Petaling Jaya whereas in Tanah Rata, the amount of sulphuric and nitric acid in precipitation are quite the same.

Because of the high rainfall variability in both sites, wet deposition is highly variable as well.

6.3 Review of National Measures against Acid Deposition

In Malaysia, the Ministry of Natural Resources and Environment through the Department of Environment is the lead agency entrusted with the management and conservation of the environment.

The mission of the Department of Environment is to promote, ensure and sustain sound environmental management in the process of nation building. A number of strategies have been identified towards this goal, namely:

- Sustainable development through conservation of resources
- Integration of environmental factors in development planning
- Pollution prevention and control
- Promotion of environmental education and awareness
- Inter-agency and federal-state cooperation
- Public participation in environmental management
- Bilateral, regional and international cooperation

Although Malaysia does not have specific national measures against acid deposition, there are sufficient rules and regulations in the country to control pollution emissions in the country. In particular the Environmental Quality Act (EQA) 1974, the first enactment in the country to protect and conserve the environment. This act was amended in 2001 to further strengthen the existing regulations to protect the environment. From time to time a number of legal instruments such as the Environmental Quality (clean air) Regulations 1978 were gazetted and enforced to maintain environmental quality. The Malaysian government has also developed the Malaysian Ambient Air Quality Guidelines for the major air pollutants.

Environmental impact assessment (EIA) has been used as a tool to incorporate environmental considerations into project planning. It has enabled us to avoid costly mistakes in project implementation as well as minimize project cost. In 2003 alone, a total of 98 reports were received of which 83 were preliminary EIA reports and 15 detailed reports whereas in 2004, 87 EIA reports were approved. Enforcement visits are conducted to check on progress of projects and compliance of EIA approval conditions. Environmental inputs are also provided to agencies in connection with large development projects. Where development projects are not subjected to the Environmental Quality Order 1987, pre-siting evaluation of proposed site suitability were carried out to identify issues that could potentially arise in the future, besides complementing project monitoring. The Environmental Quality Regulations 1979 and the Environmental Quality (Clean Air) Regulations 1978 require written permissions and approvals to be obtained from the Director General of Environment before any new potentially plants are installed. The Department of Environment also operates an Advisory Services Desk at the Malaysian Industrial Development Authority which serves to provide environmental information and advice to prospective local and foreign investors pertaining to project site suitability, buffer zones, environmental consultancy expertise and government policy on waste management.

6.3.1 Air Quality

The Department of Environment monitors air quality at 51 automatic and 25 manual sites throughout the country. Sulphur dioxide, carbon monoxide, nitrogen dioxide, ozone and particulate matter are continuously monitored while several heavy metals are measured once in six days. The data collected is used to compute the Air Pollutant Index (API). The air quality status for Malaysia is reported based on the API which is made readily available to the public.

Several studies have been conducted relating to air pollution sources as measures to control air pollution which also includes acid deposition.

6.3.1.1 Study on formulation of emission factors for industrial pollutants

This study was completed in October 2003 and recommended values of emission factors for selected pollution sources to provide better estimates of emission load calculations such as for crude palm oil mills, rubber factories, cement plants, quarries, power generation stations, incinerators, metal industries, petrochemical plants and mobile sources. This is to enable the country to better manage its resources.

6.3.1.2 Study on odour measurements and standards

The Department of Environment (DOE) with cooperation from other agencies conducted a study on odour measurements and standards with the objective of determining odour thresholds and odorant concentrations of the gas samples collected for air pollution control. The study which stared in 2002 took two years to complete. The findings and recommendations from this study will be used by the DOE as a basis to formulate regulations on odour emission standards.

6.3.1.3 Enforcement and Surveillance

Besides studies, the government carries out enforcement against activities that contravene the regulations such as enforcement against open burning. In 2003 alone, a total of more than 1,000 open burning cases were detected and investigated.

Then there is also the National Airborne Surveillance Programme to monitor and detect environmental pollution such as open burning activities, emission from industries, coastal and marine pollution, land clearing activities for development on highlands and islands.

Regular checks on compliance with the Environment Quality (Clean Air) Regulations are conducted throughout the year on activities that releases air pollutants. Action is taken against parties that are non-compliant.

To further reduce and mitigate the impact of air pollution, the Government of Malaysia has targeted the sources and emission of pollution. Among the actions taken are the introduction of the Environmental Quality (Control of Emission from Diesel Engines) Regulations 1996 and Environmental Quality (Control of Emission from Petrol Engines) Regulations 1996. Units and divisions are being established in government agencies to look into cleaner, better control and emission reduction technologies.

6.3.2 Water Quality

6.3.2.1 River Water Quality Monitoring

In addition to air quality, a National River Water Monitoring Programmes was started in 1978 with monitoring conducted at 926 stations located within 120 river basins in Malaysia. Water samples were analysed to compute the Water Quality Index based on the following parameters: biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen (NH_3N), pH, dissolved oxygen (DO) and suspended solids (SS). Depending on site requirement, other parameters such as heavy metals and bacterial contamination are also measured. In addition, 10 automatic water quality monitoring stations monitor river quality changes on a continuous basis. An Action Plan is being prepared for enhancement and maintenance of the water quality of selected rivers in each state taking into account pollution load and the integrated river basin management concept. This programme is aimed at seeking the cooperation of other stakeholders for river quality enhancement.

In 2003, the Department of Environment established a River Division to manage the River Pollution Prevention and Water Quality Improvement Programme. Cameron Highlands was chosen as one of three river basins to be studied in 2004 with the objectives of:

- Identifying all pollution sources in the selected river basins and to determine the pollution loading from each source;
- Determine the impact of pollution on the water quality; and
- Formulate action plans for water quality improvement

In order to enhance the effectiveness of the River Pollution Prevention and Water Quality Improvement Programme in the selected river basins, enforcement visits are conducted to ensure compliance of discharge standards.

6.3.2.2 Marine Water Quality

As marine water quality is important for the conservation of marine resources such as corals reefs, fisheries and mangroves which contribute to the stability of the marine ecosystem, the National Marine Water Quality Monitoring Programme was started in 1978 for Peninsular Malaysia and the whole country in 1985. This programme's aim is to provide early warning of marine water quality changes and to identify the origin, pathway and fate of pollutants. More than 200 monitoring stations were set up all over the country for this purpose.

6.3.3 Public Awareness Programmes

Public awareness programmes on pollution prevention such as seminars, dialogues, workshops, exhibitions and community campaigns are conducted for targeted groups such as industries, development project proponents, local communities, school children and teachers within the selected areas. Among the public awareness programmes are Promotion of Environmental Awareness (Schools), "Wira Alam Project", "Riadah Alam Sekitar (PRIAS) Project, Inter-Varsity Environmental Debate Among Institutions of Higher Learning, Bandar Lestari-Environment Award, Malaysia Environment Week, Langkawi Award, environmental conferences, exhibitions, environmental awareness quiz, camps, competitions, websites, dissemination of information, responses to public questions and enviro-library services.

6.3.3.1 Promotion of Environmental Awareness (Schools)

This programme is to assist schools in strengthening the implementation of environmental education programmes and activities. Knowledge, skill development and positive environmental values are infused into the components of the programme.

6.3.3.2 Wira Alam Project

This annual project was launched in 1998 with the cooperation of three agencies, the DOE, Malaysian Nature Society and Ministry of Education. The programme is aim at students completing environmental task assigned to them to promote environmental awareness and conservation.

6.3.3.3 Riadah Alam Sekitar (PRIAS) Project

This is another annual project which started in 1992 aimed at students where participating students are to undertake a "research" on an environmental subject. The theme changes from year to year.

6.3.3.4 Inter-Varsity Environmental Debate Among Institutions of Higher Learning

This programme is organized by the Malaysian Universities Debating Council in collaboration with other lead agencies where universities debate issues related to the environment. Awards and cash prizes are given to the winning teams.

6.3.3.5 Lestari-Environment Award

This most recent award was initiated by the DOE in 2003 in collaboration with relevant government agencies and community based organizations to give recognition to local authorities in urban centres that have incorporated the environmental dimension in the planning, administration and implementation of their programmes, projects and activities.

6.3.3.6 Malaysia Environment Week

This is an annual event organized by the DOE primarily to inculcate and enhance environmental awareness among Malaysians. The main venue of the event changes every year to be closer to the people. Various activities are organized throughout the country.

6.3.3.7 Langkawi Award

The Langkawi Award is given to individuals who has contributed significantly to the protection of the environment.

6.3.3.8 Others

Environmental conferences, exhibitions, quiz, camps and competitions are conducted regularly throughout the country to instil environmental awareness among the people of Malaysia. Information and services on environmental matters are made readily available to the people through the mass media and other channels.

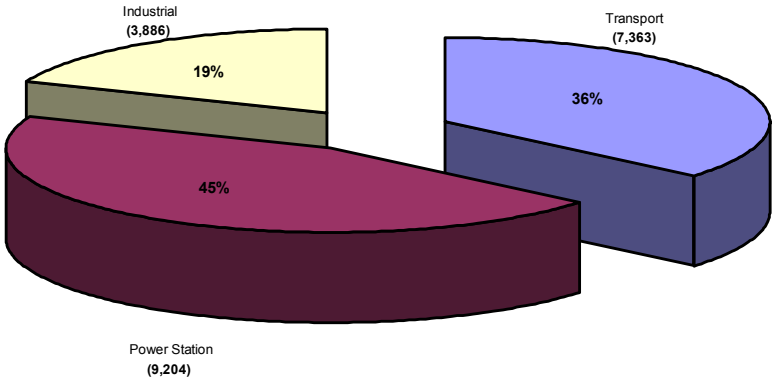
6.3.4 International Environment Affairs

Measures against acid deposition is not only confined to national borders as it is well documented that air pollution is a transboundary issue. Malaysia has taken measures to address this problem through a number of initiatives namely, ASEAN Working Groups on Sub-Regional Fire Fighting Arrangement for Sumatra and Borneo, ASEAN Haze Agreement, Sustainable Development Strategy for Seas of East Asia, EANET activities, multilateral and bilateral agreements.

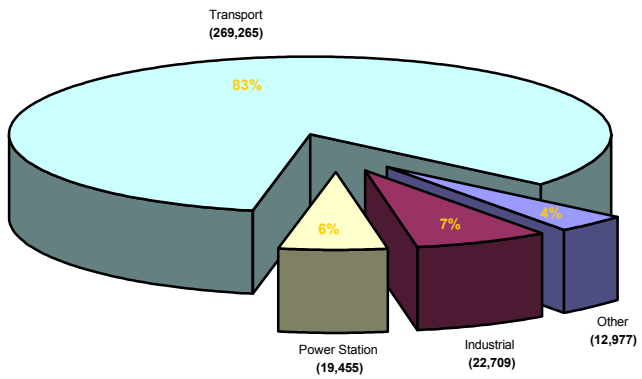
6.3.5 Data Collection and Archive

Part and parcel of any efforts and measures to control air pollution in general and acid deposition in general is the collection and archive of data related to air pollution. The Department of Environment (DOE) is the central agency in Malaysia entrusted with this task. Annual emission inventory of the major air pollutants are published and distributed to all users for the management of air pollution. Figures below show the amount of the major air pollutants emitted in 2003 and the contribution of the different sources.

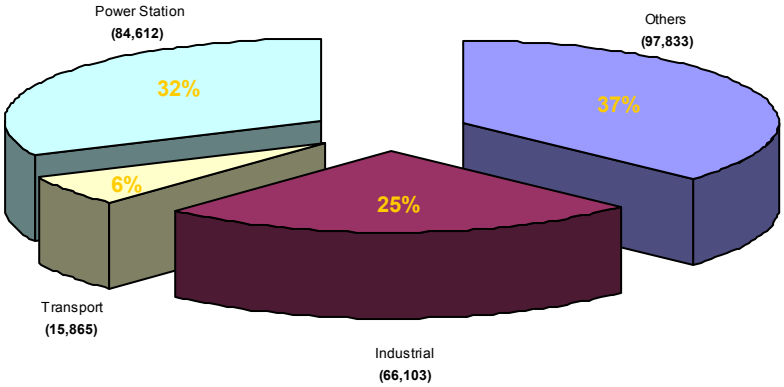
Malaysia Combined Particulate Matter Emission by Sources (tonnes), 2003



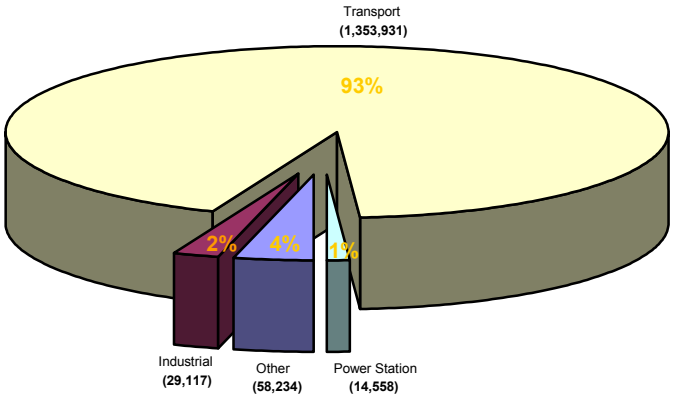
Malaysia Combined Nitrogen Oxides (NOx) Emission by Sources (tonnes), 2003



Malaysia Combined SO_2 Emission by Sources (tonnes), 2003



Malaysia Combined Carbon Monoxide (CO) Emission by Sources (tonnes), 2003



National Assessment Report for Mongolia

T.Bulgan
Central Laboratory of Environmental Monitoring, Ulaanbaatar-36, Mongolia.

7.1 Basic Information on National EANET Monitoring Activities

Mongolia is a country in Northeast Asia of extending between the latitudes of 41°35'N and 52°09'N and the longitudes of 87°44'E and 119°56'E with coverage of an area of 1.564 million square kilometers. The climate of Mongolia is harsh continental with sharply defined seasons, considerable annual and diurnal temperature fluctuations and low rainfall. Because of high altitudes, the country's climate is generally colder than of other countries of the same latitudes. An average annual temperature is around 8.5°C in the Gobi desert and –8°C in the high mountainous areas. The extreme minimum temperature is –31.1°C to –52.9°C in January and the extreme maximum temperature is in the range of +28.5°C to +43.1°C in July. The annual precipitation amount is low with average of 200-220 mm per year. Around 80 percent of annual precipitation occurs in summer from June to August in central part of Mongolia due to terrestrial precipitation regime (Batima and Davgadorj, 2000).

7.1.1 Outline of the activities on acid deposition and National Monitoring Plan

The acid deposition monitoring in Mongolia was initiated in August 1998 at two sites of wet and dry deposition that were supplied with equipment within the EANET activities. Now there are 2 sites of wet and dry deposition monitoring and one site of inland aquatic environment monitoring being operated (Figure 7.1) for the EANET.

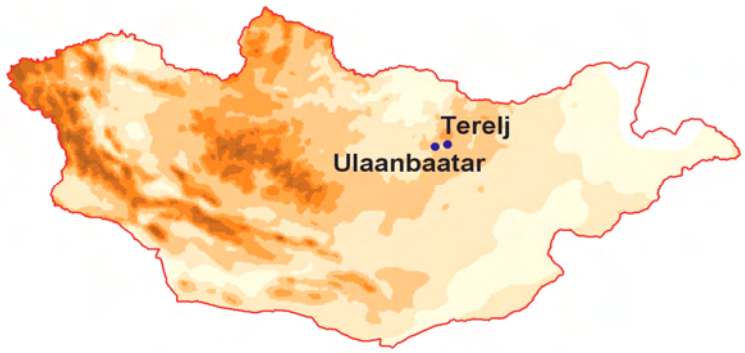


Figure 7.1 Location of the EANET monitoring sites in Mongolia

Central Laboratory of Environmental Monitoring (CLEM) was designated and has been operating as the National Center of Mongolia for the EANET.

7.1.2 Monitoring stations

a. Wet and dry deposition monitoring sites:

Terelj – remote site, 47°59'N, 107°27'E, 1550 m *asl* (above sea level).
The site is located in central part of Mongolia, in the western part of the Khentei mountain ranges and away from major industrial pollution sources. The nearest major city is Ulaanbaatar of 50 km far to the southwest. The immediate surrounding surface is grassland. There is a meteorological station approximately 1 km to the northwest where snow sampling is carried out during winter period.

Ulaanbaatar – urban site, 47°55'N, 106°54'E, 1275 m *asl*.
The site is situated in the center of Ulaanbaatar city (on the building roof of the National Agency of Meteorology, Hydrology and Environmental Monitoring) and well isolated from intensive stationary sources of air pollution. The biggest coal-fired thermal power plant No.4 is located of 10 km southwest; another power plant No.3 is located also to southwest of 8 km far from the site.

b. Inland aquatic environment monitoring site:

Terelj river, 47°59'N, 107°27'E, 1590 m *asl*.

The site is co-located with the Terelj hydrological station in the vicinity within 3 km of the Terelj wet/dry deposition monitoring site. Watershed area of the river is 1220 km^2, mean annual flow is 7.96 m^3sec^{-1}. An ice phenomena starts in the river in October and it freezes to bottom from December to the end of March.

7.1.3 Monitoring program from 2001 to 2005

Wet and dry deposition monitoring at the urban monitoring site in Ulaanbaatar has been carried out only from May to October and it has been suspended during cold season due to technical problem caused by climatic factors. Snow samples were collected on an event basis only at Terelj site using a bulk sampler. The monitoring program is presented in Table 7.1.

Table 7.1 The monitoring program for 2001-2005

Items	Monitoring site	Monitoring period	Monitoring interval	Monitoring parameters
Wet deposition *Rain*	Terelj Ulaanbaatar	2001-2005	Daily (May-October)	pH, EC, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}
Snow	Terelj	2003-2005	Event (November-April)	pH, EC, SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}
Dry deposition	Terelj Ulaanbaatar	2001-2005	Weekly Weekly (May-October)	Gases: SO_2, HNO_3, HCl, NH_3 Aerosol: SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}
Inland aquatic environment	Terelj river	2003-2005	4 times/year	pH, EC, alkalinity, SO_4^{2-}, NO_2^-, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, PO_4^{3-}

7.1.4 Sampling and Measurements

In general, all procedures of site selection, sampling, chemical analysis, and implementation of QA/QC activities are carried out in accordance with the Guidelines and Technical Manuals for the EANET. Ion balance checking (R_1) and comparison of measured and calculated conductivities (R_2) were carried out every time, however, the R_1 value of wet deposition samples did not met the required criteria in the most cases, especially when pH>5.5 because of undetermined hydrogen carbonate and other ions.

a. Sampling method and sample handling:

The wet-only sampler with refrigerator (collection diameter is 357 mm) manufactured by Ogasawara Co.Ltd. was installed for rain sampling. The equipment is uninstalled once a year before frost time and kept in the store during winter season because it does not meet the operation conditions under cold weather. After the winter season, the equipment is installed again and samples are collected on a daily basis. During winter a plastic basket with 395 mm diameter was used for snow sample (bulk)

collection at the Terelj site.

A sampler with four-stage filter pack MB-01T manufactured by Tokyo Dylec Co.Ltd. was used for the dry deposition monitoring. The first membrane filter collects particles, the second cellulose filter is designed for absorption of SO_2, HCl, HNO_3, the third alkaline impregnated filter is for residual SO_2, HCl and the fourth acid impregnated filter - for NH_3 absorption.

Wet and dry deposition samples at Terelj remote site are collected and transported to the analytical laboratory twice per month by local staffs and then analyzed by the Central Laboratory of Environmental Monitoring (CLEM). Samples at Ulaanbaatar urban site are handled by CLEM.

b. Measurements:

The information on measuring methods and devices being used for the monitoring activities is presented in Table 7.2 below.

Table 7.2 Analytical methods and equipment

Items	Monitoring parameters	Measuring method	Equipment
Wet deposition	pH	pH-meter	HM-30V, TOA
	EC	EC-meter	DS-12, Horiba
	SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}	Ion chromatography	120DX, Dionex
Dry deposition	Gases: SO_2, HNO_3, HCl, NH_3 Aerosol: SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}	Ion chromatography	120DX, Dionex
Inland aquatic environment	SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}	Ion chromatography	120DX, Dionex
	Alkalinity	Titration	Titration with 0.02n H_2SO_4
	PO_4^{3-}	Colorimetric	Using ammonium molibdate
	NO_2^-	Colorimetric	Using Griss reagent

7.2 State of Acid Deposition in Mongolia

7.2.1 Atmospheric deposition

7.2.1.1 State of wet deposition

The state of acid rain and chemical composition of rainwater is presented in this report for central part of Mongolia during the period 1999-2005, since the acid deposition monitoring sites are located in central area of the country and the monitoring period was extended only from May to October.

a. Concentrations:

The pH of rainwater was in the range from 4.3 to 7.8 in remote site Terelj, however, considerable part of measurements, about 7% of all samples had a pH of less than 5.0 and 17% had less than 5.6. At urban site Ulaanbaatar, the pH varied from 4.8 to 8.3 and the rain with pH below 5.0 was observed several times in 2003, 2005. The range of pH variations and calculated statistical parameters for the data of monitored years is presented in Figure 7.2.

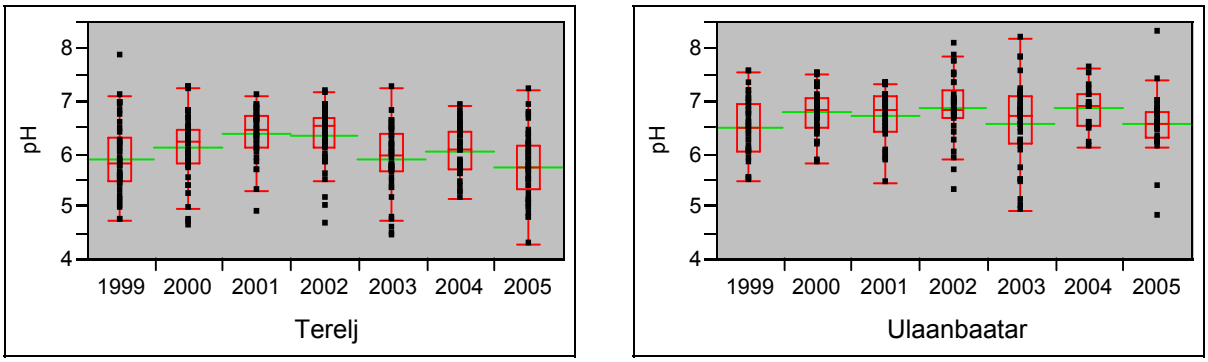


Figure 7.2 Box plot of rainwater pH variations by years. For each box, whiskers and box outline represent the 5th, 25th, 75th, and 95th percentiles with median shown as a solid red line. The mean is shown as a green line.

There was observed a slight decrease in rainwater pH for the whole assessment period in Terelj at a statistically significant level (*significance probability* $p<0.05$), while there was no clear trend to be found for data of Ulaanbaatar. The volume-weighted annual average of rainwater pH was 5.6 for Terelj and 6.1 for Ulaanbaatar. The frequency distribution of the rainwater pH is presented in Figure 7.3.

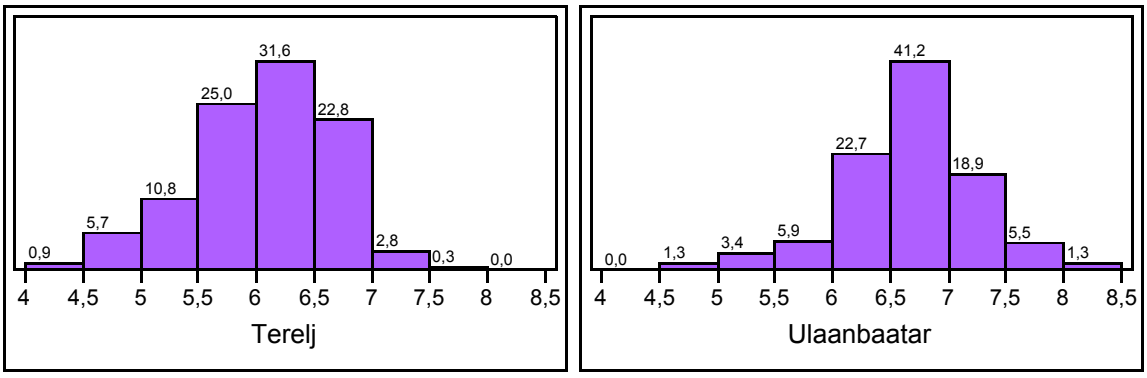


Figure 7.3 Frequency distribution (in %) of the rainwater pH

More acidic precipitation has occurred at Terelj remote site compared with the urban site and the main fraction of pH values was between 5.5 and 7.0, while in the urban area it was shifted to range between 6.0 and 7.5. Rainwater collected at Ulaanbaatar was more neutral and had relatively higher conductivity than at Terelj. There are many factors to neutralize pH and increase concentrations of the major ions in rainwater at the urban area as recognized from results of measurements, among them there is a presence of not only acidic species but also alkaline species such as calcium carbonates in urban air. These species mainly derive from soil erosion or emitted aerosols from power generation and construction related activities (Bulgan, 2004).

The volume-weighted average annual electric conductivity (EC) of rainwater was 11 $\mu S \cdot cm^{-1}$ in Terelj site, however it increased to 18 $\mu S \cdot cm^{-1}$ in Ulaanbaatar due to higher concentrations of water soluble ions such as SO_4^{2-}, CO_3^{2-}, Ca^{2+} in the atmosphere. Electric conductivity was relatively high in May-June and decreased from July to September to reach its minimum due to relatively abundant rainfall, and then it rose again in October. The relationship between pH values and electric conductivity is shown in Figure 7.4.

In both sites, at the range of lower pH, the pH values tend to increase as the conductivity decreases, on the contrary an opposite tendency is appeared at the range of higher pH being inverse one as clearly reflected especially in data for Ulaanbaatar.

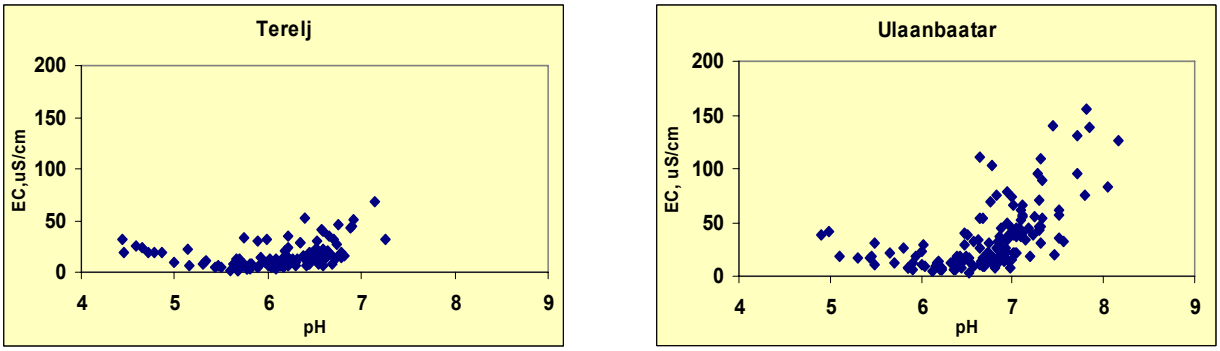


Figure 7.4 Relationship between pH and EC

Volume-weighted annual averages, standard deviations, and absolute extreme values of pH and concentrations of major ions in rainwater are summarized in the Table 7.3.

Table 7.3 Volume weighted averages of pH and concentrations of the major ions, $\mu eq \cdot L^{-1}$

Components	Terelj				Ulaanbaatar			
	Average	S.D.	Max	Min	Average	S.D.	Max	Min
pH	5,6	0,6	7,8	4,3	6,1	0,6	8,3	4,8
EC, $\mu S \cdot cm^{-1}$	11,4	15,2	99,3	2,1	18,2	30,3	155,4	3,6
Cl^-	8,3	14,9	90,8	0,6	8,6	23,9	185,6	1,7
NO_3^-	14,3	22,6	155,0	0,5	19,7	40,8	275,9	2,6
SO_4^{2-}	24,2	40,4	296,7	<0,2	46,8	89,7	487,0	6,9
H^+	2,5	5,8	36,3	0,05	0,9	1,6	12,6	0,01
Na^+	8,0	21,5	145,2	<0,4	6,8	33,1	251,4	<0,4
NH_4^+	43,7	65,4	442,9	<0,5	55,3	51,9	288,8	4,4
K^+	5,1	15,3	107,9	<0,2	3,9	7,9	45,5	<0,2
Mg^{2+}	6,3	8,8	67,4	<0,8	8,3	18,8	107,7	0,8
Ca^{2+}	33,3	85,2	664,7	1,0	80,5	215	1119,3	10,5

Ammonium and calcium ions mostly have predominated among the cations in the precipitation water. The cation ratio of rainwater at both sites is shown in Figure 7.5. In the remote area, NH_4^+ was the most predominant cation with contribution of 44% in average to total cation amounts, while Ca^{2+} was the predominant one in Ulaanbaatar with its 51% accounts due to alkaline dust effects. These major cations neutralize the original acidity and provide relatively high pH of rainwater at both sites, especially in Ulaanbaatar in spite of a high concentration of acidic constituents. The NH_4^+/Ca^{2+} ratio was 1.3 in Terelj and 0.7 in Ulaanbaatar.

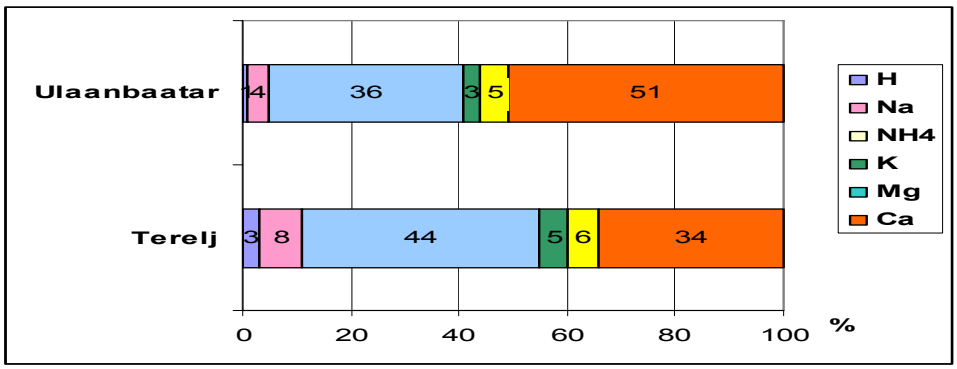


Figure 7.5 Comparison of cation ratio at the urban (upper) and remote (lower) sites

Concentration comparison of three measured anions in rainwater (except carbonates) and comparison of anion ratio are presented in Figure 7.6. The contribution of SO_4^{2-} to precipitation acidity was much higher than NO_3^- and the ratio of $[NO_3^-]/[nss\text{-}SO_4^{2-}]$ was 0.4 in the urban site. The ratio in remote area was 0.6 that indicates the NO_3^- contributes more to precipitation acidity in remote site than in Ulaanbaatar even though input of SO_4^{2-} predominates in most cases. Both SO_4^{2-} and NO_3^- are considered to be strong acids which provide lower pH value of rain water.

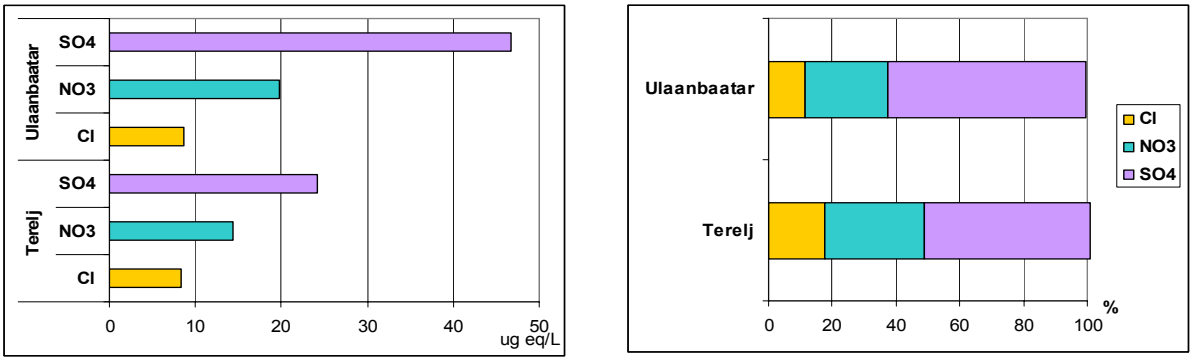


Figure 7.6 Comparison of anion concentration (left) and ratio (right) in rain water

The ratio of $[NH_4^+ + Ca^{2+}]/[NO_3^- + SO_4^{2-}]$ was 2.0 for both sites. It implies that alkaline species are dominated over acidic species and sufficient neutralization takes place. Scatter plots of pH and pA_i, defined as $-log([nss\text{-}SO_4^{2-}]+[NO_3^-])$ are presented in Figure 7.7.

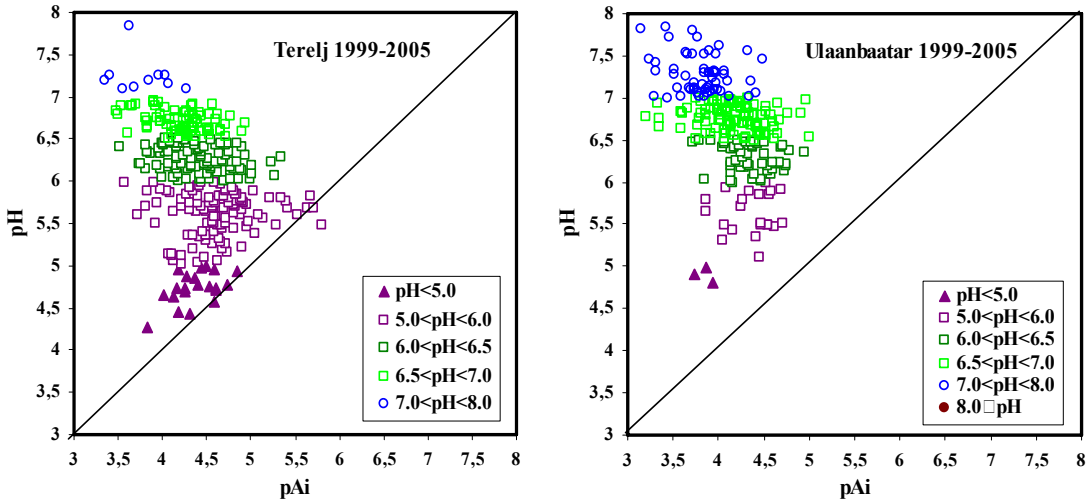


Figure 7.7 pH against pA_i in rainwater samples

The pH was more increased in samples at Ulaanbaatar than in Terelj at the similar pA_i levels. This strongly implies that the original acidity of Ulaanbaatar precipitation has been more neutralized to such an extent as yield higher pH than of Terelj (Yamada et al., 2004).

b. Depositions:

The mean annual wet depositions of $nss\text{-}SO_4^{2-}$, NO_3^-, NH_4^+, $nss\text{-}Ca^{2+}$ at both sites are shown in Figure 7.8. Although annual precipitation amount is relatively lower in the urban site comparing with Terelj remote site, the wet depositions of $nss\text{-}SO_4^{2-}$ and $nss\text{-}Ca^{2+}$ were larger there than those in the remote site due to their higher concentrations in urban area. The depositions of nitrogen compounds were almost of same magnitudes at both sites.

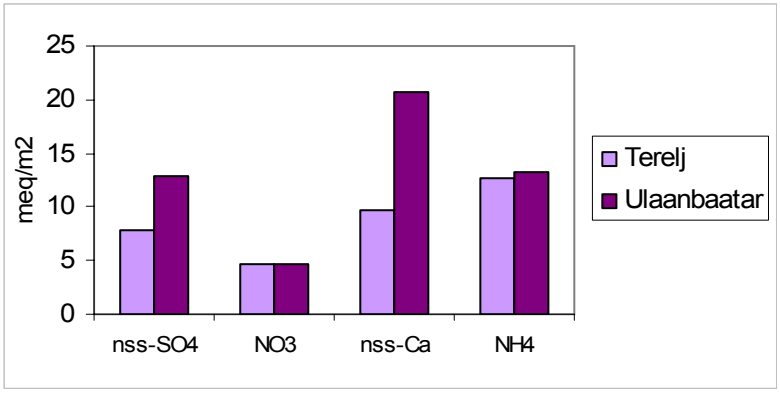


Figure 7.8 Mean annual wet depositions (2000-2005)

7.2.1.2 State of dry deposition

Sulfur. The mean annual concentrations of sulfur dioxide and particulate sulfate in air at remote site Terelj have ranged 0.8-1.4 $\mu g \cdot m^{-3}$ and 0.7-1.3 $\mu g \cdot m^{-3}$, respectively. Dry deposition monitoring at urban site Ulaanbaatar was carried out only from April to November during 1999-2004. Therefore, the mean annual concentrations of sulfur and nitrogen compounds at Ulaanbaatar were calculated for the warm period of years. The trends of sulfur compounds in air at Terelj and Ulaanbaatar are presented in Figure 7.9.

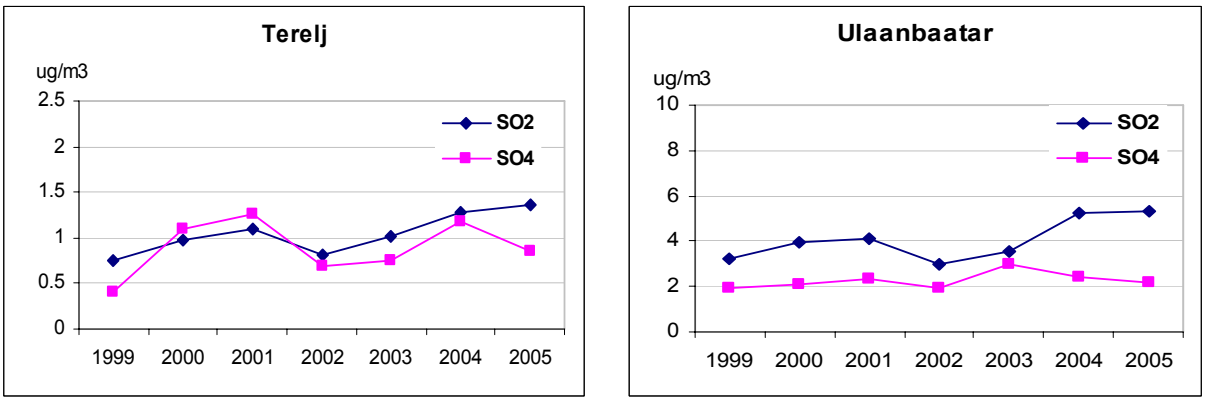


Figure 7.9 The mean annual concentrations of sulfur dioxide and particulate sulfate in air

The slight increasing trend in sulfur dioxide concentrations from 1999 to 2005 was observed at a statistically significant level ($p<0.05$ at Terelj, $p<0.01$ at Ulaanbaatar). The trend in particulate sulfate concentrations was also somewhat raising but it was statistically insignificant ($p>0.1$). The Figure 7.10 shows monthly change of sulfuric species at Terelj and Ulaanbaatar. The monthly values in the figures are based on the averaged data of the whole period of assessment, however, the monthly average values from December to March in Ulaanbaatar correspond to the data for 2005 only.

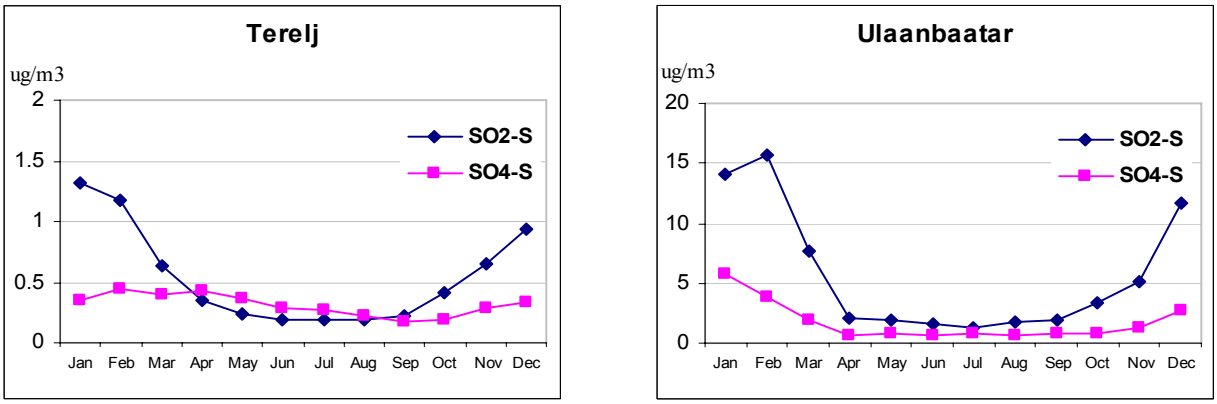


Figure 7.10 Monthly changes of sulfur dioxide and particulate sulfate

Sulfur dioxide concentrations were characterized by a strong pronounced seasonal variation with winter maximum at both sites indicating both effect of contributing climatic factors such as stable temperature inversions and influence of increased local emissions due to heating requirements, especially in urban area. The monthly change of particulate sulfate had weak seasonal variation at the remote site with spring maximum and its concentration exceeded the gaseous sulfur compound during spring and summer months. In Ulaanbaatar, the change of particulate sulfate has followed by the monthly change of sulfur dioxide and its concentrations were 2-3 times lower than SO_2 concentrations throughout years.

Nitrogen. The yearly changes of mean annual concentrations of nitrogen compounds at Terelj and Ulaanbaatar are presented in Figure 7.11. The mean annual concentrations of nitrogen species in air were fairly low and almost at same level in Terelj with no particular trends during the monitoring period except gaseous ammonia. In Ulaanbaatar, the mean concentrations of particulate nitrate were higher than gaseous HNO_3 and there were no clear trends. The mean annual concentrations of gaseous ammonia in both sites were higher than particulate one and they have been increasing slightly (p<0.05) probably due to effect of population pressure. The monthly changes of nitrogen compounds are shown in Figure 7.12.

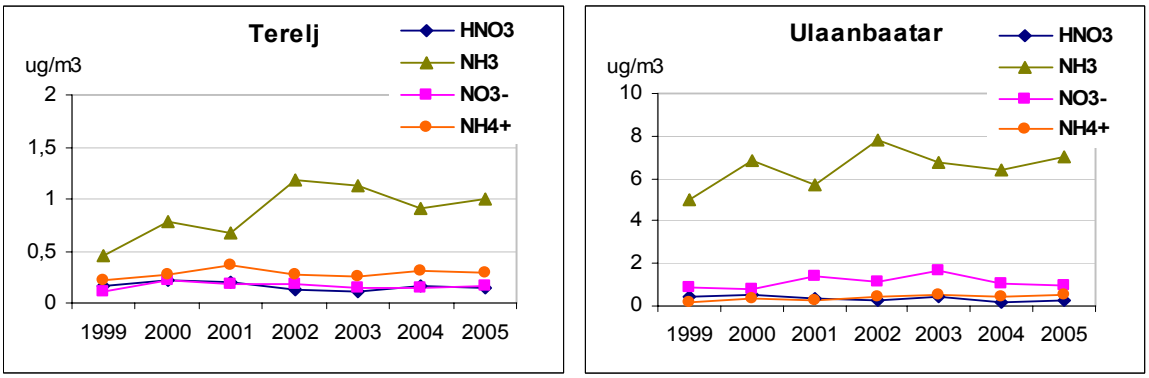


Figure 7.11 The mean annual concentrations of nitrogen compounds

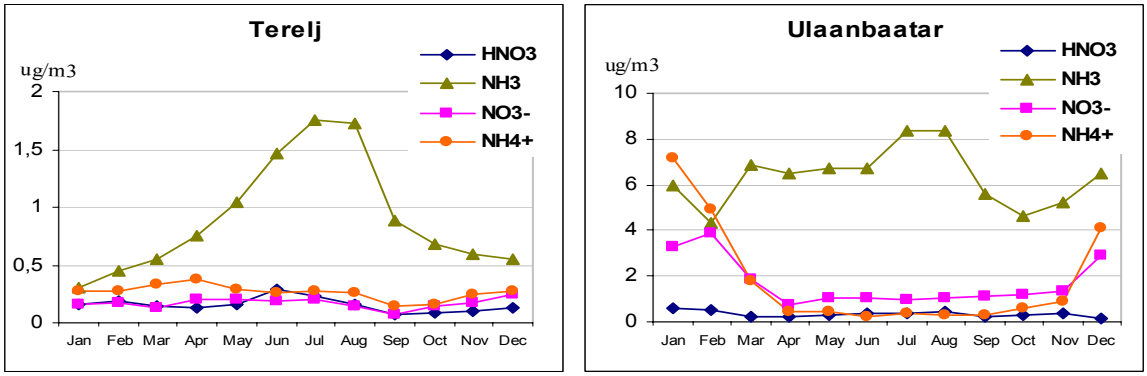


Figure 7.12 The monthly changes of nitrogen compounds

There was visible seasonal change of gaseous ammonia with summer maximum and winter minimum at the both sites describing an increase of ammonia emission in warm season caused by natural and anthropogenic factors. There were no clear variations for the other nitrogen compounds in Terelj, while seasonal variations for the nitrogen particles were evident in Ulaanbaatar suggesting large presence of ammonium associated salts in winter air of the city.

7.2.2 State of inland aquatic environment

Terelj river has been selected for the inland aquatic environment monitoring purpose because its water has quite low electric conductivity. The river is started at the western slope of Khentei mountain range and flows into the Tuul river. It is estimated that annual runoff of Terelj river consists of about 69% of rainfall water, 6% of snow melting water, and 25% of groundwater. A mean annual discharge at Terelj site is estimated to be 7.96 $m^3 \cdot sec^{-1}$. The main type of bed rocks is granite and drainage area is forest steppe. There are no permanent settlements upstream to sampling point. River water has very low mineralization with electric conductivity in the range of 33–53 $\mu S \cdot cm^{-1}$ and pH variations within 6.4-7.6. Composition ratio of the major ions in the river water is presented in Figure7.13.

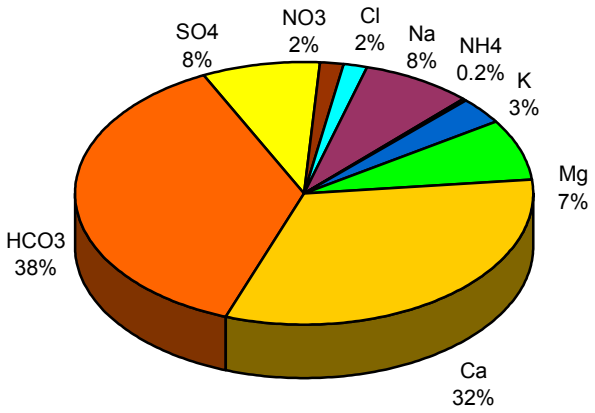


Figure 7.13 Composition ratio of the major ions in river water

The main dominated ions are bicarbonate and calcium. Composition ratio of the major ions is quite stable. Monthly changes of some parameters of Terelj river water chemistry are presented in Figure7.14.

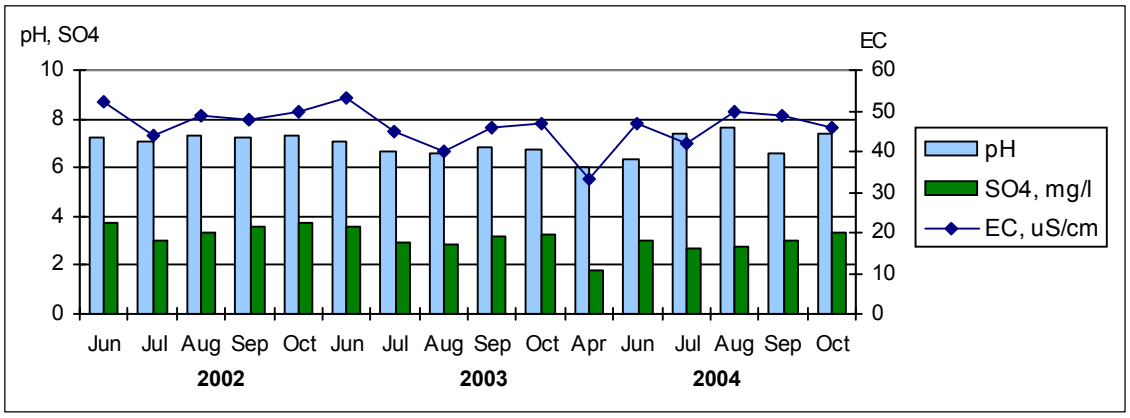


Figure 7.14 Monthly change of some measured parameters of the river water chemistry

According to the monitoring results, there were no clear seasonal and yearly trends of pH, EC and sulfate concentration of the river water.

7.2.3 State of soil and vegetation

Regular monitoring on soil and vegetation hasn't been conducted yet and it will be started in coming year.

The Joint Research Project on plant sensitivity to acid deposition in Mongolia was implemented by Acid Deposition and Oxidant Research Center (ADORC) and Central Laboratory of Environmental Monitoring (CLEM) with support of the Global Environment Research Fund, Ministry of the Environment, Japan and the Sumitomo Foundation. A decline of larch trees (*Larix sibirica*) has been reported around the Bogdkhan Mountain near the city of Ulaanbaatar, and it was suggested that air pollution derived from the thermal power plants was one of the possible causes. Within the joint project, surveys on air pollutant concentrations by passive samplers, field observation of tree decline and chemical properties of needles/soils were carried out in 2001 and 2003 at Bogdkhan Mountain. The result of the survey is briefly presented below (Sase et al, 2005).

There were 7 monitoring sites established in the city area of Ulaanbaatar and the Bogdkhan Mountain (Figure 7.15). Sites A1 and A2 were at the places of Ulaanbaatar wet/dry deposition monitoring site and CLEM, respectively. Sites B, C and D were in a boundary area between grassland, an open forest and a closed forest, respectively. Sites RF1 and RF2 were selected at certain distance from the power plant as reference forest areas.

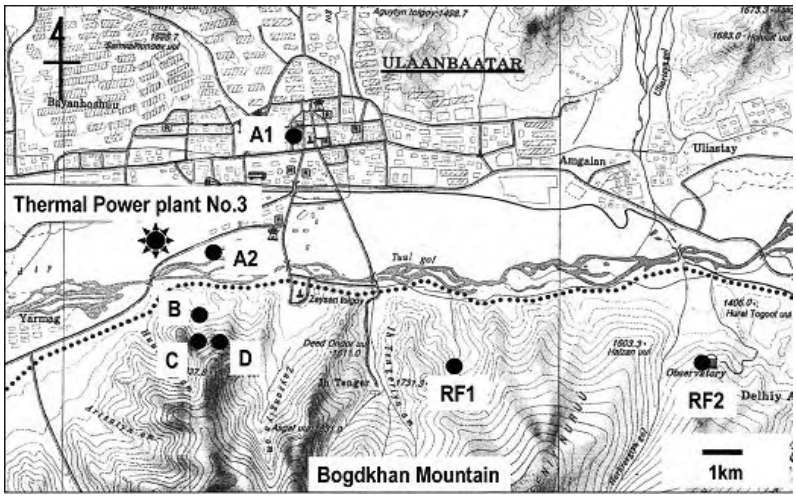


Figure 7.15 Location of the monitoring sites

Tree sizes of *Larix sibirica* are presented in Figure 7.16(left). Only young trees were observed in the bottom of the slope facing the power plant (at site B) and so their sizes were three times smaller than trees in the other sites. Trees at site C were significantly smaller than trees at sites RF1 and RF2 in diameter at breast height (DBH), while they were not different from trees at RF2 in height.

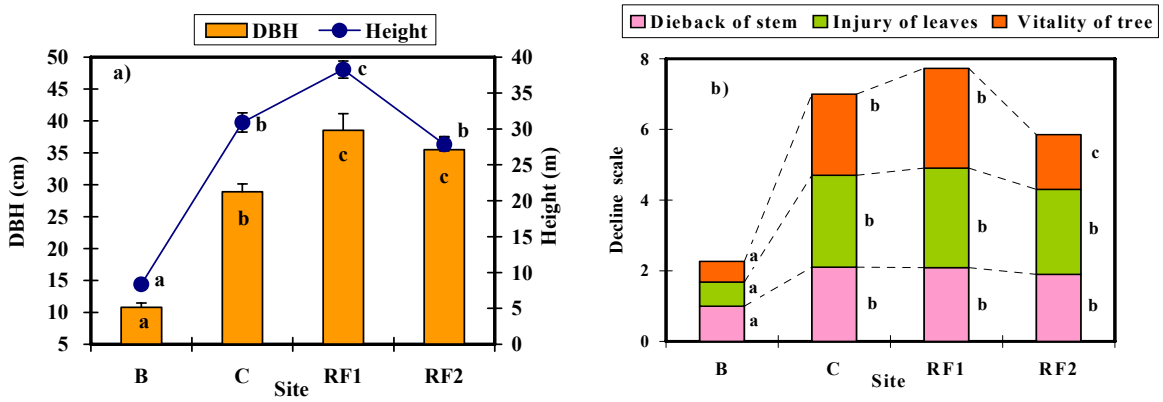


Figure 7.16 Tree size (left) and decline condition (right) of *Larix sibirica* in Mt. Bogdkhan.

Decline classes by the representative observation parameters are shown in Figure 7.16(right). The forest population at sites B and RF1 consisted of not only *Larix* sp. but also other species such as *Picea* sp. and *Betula* sp. Numbers of *Larix* trees were 19, 20, 11 and 20, in site B, C, RF1 and RF2, respectively. For recording observation of decline symptoms "dieback of stem" and "vitality of tree" were classified into five classes (0 to 4), and "injury of leaves" was classified into four classes (0 to 3). Plots of (b) show averages of the decline classes. "Vitality of tree" was recorded as total evaluation of the decline based on other observation parameters. Different letters (a, b or c) beside the bars refer to significant (P<0.05) differences by Tukey's HSD test for the respective parameters (Sase et al., 2005).

Trees at site B were evaluated as healthier than trees at the other sites. Trees at sites C and RF1 were worse than those at RF2 in vitality of trees. Even in the reference area far from the thermal power plant, older trees were declined probably due to other natural factors such as forest fire, strong wind and insect attack. However, trees at sites B and C on the slope facing the thermal power plant showed typical dieback symptoms mainly on the crown, which were different symptoms observed in site RF1 and RF2. Other effects than of natural environmental factors should be considered as possible causes for the decline of larch tree on the slope.

In summer, concentrations of all the monitored air pollutants in the sites were not high except ozone:

less than 5 ppb (average concentration of two weeks). O_3 concentrations were relatively high (ca. 40 ppbv) in mid summer and gradually decreased from autumn to winter, especially in the city area. In the mountainous area, relatively high concentration (more than 30 ppbv) was recorded even late autumn of 2003. Concentrations of O_3 were usually higher on the slope facing the thermal power plant than over the city area through the survey periods. Mean concentrations of SO_2 and O_3 during the sampling period of the year 2003 are presented in Table 7.4 Concentrations of both SO_2 and O_3 were higher at sites B and C on the slope facing the thermal power plant than those at the other sites, while SO_2 concentration was relatively low. Sulfur contents of larch needles were higher on the slope (at B and C) than in the reference forests (at RF1 and RF2) as also shown in Table 7.4.

Table 7.4 Mean and maximum concentration (ppbv) of SO_2 and O_3 during the sampling period of 2003, and sulfur concentrations (mg*S*·g^{-1} of dry needles) of *Larix sibirica* (Sase et al., 2005)

Site	Passive sampling*[1]				Sulfur in needles*[3]
	SO_2		O_3		
	Mean	Max.**[2]	Mean	Max.*[2]	
A1	1.0 (0.4) ac	4.0	16.0 (1.8) a	27.4	1.5
A2	0.5 (0.2) a	1.6	21.7 (1.6) b	32.1	-
B	1.7 (0.4) bc	3.8	27.2 (1.5) c	35.1	1.8
C	1.6 (0.5) bc	3.9	30.8 (2.0) d	40.5	2.2
RF1	0.4 (0.1) a	1.1	22.1 (2.1) b	32.3	1.2
RF2	0.8 (0.2) ac	2.0	27.4 (1.8) c	34.5	1.1

Note: *[1] Sampling period, July 31 to November 21; Values show mean and standard error in parenthesis; Different letters beside the data indicate significant difference (P<0.05) by Tukey's HSD test.
*[2] Average values of triplicate sampling.
*[3] Average values of triplicate analysis.

It was suggested that air pollutants such as SO_2 and O_3 were transported to the Bogdkhan Mountain, and the slope (Chandman) facing the thermal power plant suffered more negative effects of the pollution than the reference forests. Direct effects of air pollution, especially effect of O_3, should be considered as one of the possible causes for tree decline on the slope, while effect of insect attack might be another important factor.

Soil pH and contents of exchangeable base cations were relatively high; e.g. values of pH (H_2O) were 6.7, 5.9 and 5.8 in sites B, C, and D, respectively; values of exchangeable Ca were 46.31, 22.6 and 34.4 cmol(+)·kg^{-1}. Soil acidification due to acid deposition might hardly occur because of the high concentration of base cations. Accumulation of heavy metals, such as Pb, Cu and Zn, cannot be detected in soil samples on the slope.

7.3 Review of National Measures against Acid Deposition

In present years, Mongolia is undergoing rapid urbanization with a dramatic shift in the rural and urban proportions. According to estimations by governmental statistics about one third of total population lives in Ulaanbaatar while over 60 percent of population live in the central areas of the country. This rapid increase in urban residents has placed stress not only on social requirements (housing, transportation, waste disposal) but also on urban environment. Inadequate services are resulted in significant air pollution from traffic congestion, coal burning in residential areas and old technology in energy sector. On the fact that air quality is worsening in the major cities, the Mongolian government has attached a particular attention to the air pollution problem and it has been identified as one of the highest priority problems. During last few years, the actions taken by the government mainly have directed to improvement of household stoves, strengthening of legislation enforcement, investigating of clean alternative fuels and energy saving.

There is an absence of official emission data except green house gases; therefore it would be essential to carry out emission inventory and emission estimation for Mongolia in the coming years as

appropriate.

National emission inventory on green house gases for 1990-1998 was conducted in 2001 using the IPCC guidebook (UNFCCC/CP/1996, 10/CP.2) (Batjargal et al., 2000). The results of inventory are presented in the Figure 7.3.1. A decrease in total green house gases emission was observed from 1990 to the mid-nineties likely because of a loss of industry during the socio-economic transition of the country. The similar feature would be proposed for emission sources causing acid deposition due to significant correlation of them.

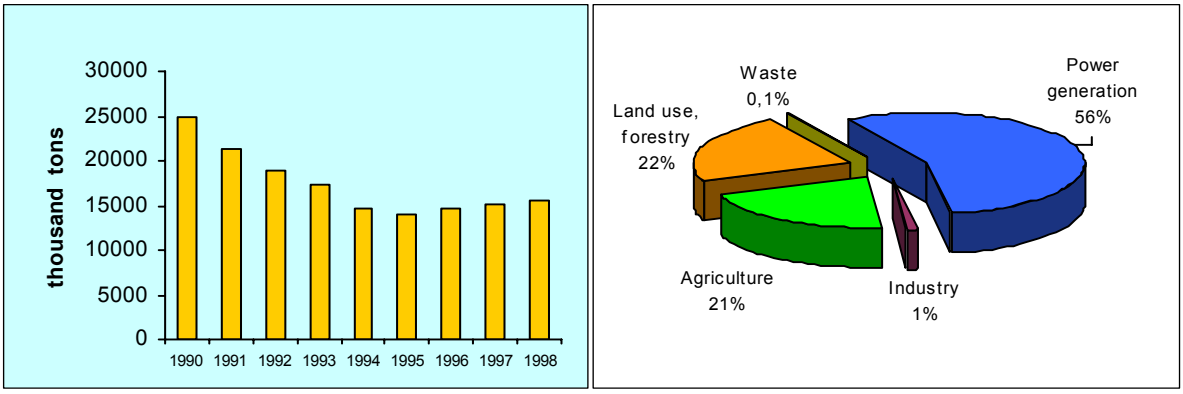


Figure 7.17 Total emission of green house gases converted to CO_2 (left) and contribution by sectors (right)

References

Batima, P., Davgadorj, D., 2000. Climate change and its impact in Mongolia. Ulaanbaatar.

Batjargal, Z., Davgadorj, D., Batima, P., 2000. Mongolian National Action Program on Climate Change. Ulaanbaatar.

Bulgan, T., 2004. Evaluation of acid rain for the central Mongolia, Proceedings of 6th International Workshop on Climate Change in Arid and Semi-Arid Regions of Asia, Ulaanbaatar, 152-156.

EANET, 2000. Technical Documents for Acid Deposition Monitoring in East Asia. Adopted at the Second Interim Scientific Advisory Group Meeting of EANET. March 2000.

Sase, H., Bulgan, T., Batchuluun, T., Shimizu, H., Totsuka, T., 2005. Tree decline and its possible causes around Mt. Bogdkhan in Mongolia. Phyton 45 (special issue: "APGC 2004"), 583-590.

Yamada,Y., Bulgan, T., Alimaa, S., Noguchi, I., Hara, H., 2004. Precipitation Chemistry in Mongolia. Nucleation and Atmospheric Aerosols 2004: Proceedings of 16th International Conference, 793-796.

The Philippines Periodic Report on the State of Acid Deposition in East Asia

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8.1 Basic Information on National Monitoring Activities

8.1.1 Activities in Acid Deposition and National Monitoring Plan

The Philippines is one of the ten (10) countries that first established the Acid Deposition Monitoring in East Asia (EANET) in 1998. The Philippines participated in the preparatory phase of EANET during the period 1998-2000 and has affirmed its continued participation in the Network. The country's national monitoring plan is based on the guidelines for acid deposition monitoring developed by the Environment Agency, Government of Japan, and adopted by the Experts Meetings on Acid Deposition Monitoring Network in East Asia (EANET) in March 1997. The National Monitoring Plan was developed in 1999 after the basic monitoring infrastructure was set up with the assistance of the Government of Japan.

Acid deposition activities in the Philippines during the regular phase of EANET could be categorized into the following: (1) implementation of the National Monitoring Plan through the conduct of acid deposition monitoring in the following media: wet deposition, dry deposition, soil, vegetation, and inland aquatic; (2) participation in inter-laboratory comparison exercises for wet deposition, soil, and inland aquatic environment; and (3) conduct of public awareness activities through the preparation of the acid deposition brochures, conduct of seminar-workshops for stakeholders, and initiation of a "Rain Watch" project involving elementary schools in Metro Manila. At the regional level, the Philippines also participates in sessions of the (1) Senior Technical Managers that discuss the results of monitoring and quality assurance/quality control (QA/QC) activities; (b) Scientific Advisory Committee that provides advice from the scientific and technical viewpoints; and (3) Intergovernmental Meeting that sets the policy and makes decisions relative to EANET budget and operations.

8.1.2 Monitoring program from 2001 to 2004

The National Monitoring Plan covers the generation of the relevant data, operation and maintenance of field and laboratory facilities and equipment, and conduct of QA/QC activities. The list of monitoring stations is presented on Table 8.1 while the map showing the monitoring stations is presented in Figure 8.1.

For wet deposition monitoring, weekly monitoring was conducted in the Metro Manila and Los Baños stations. Measurements were done on ten (10) parameters as follows: pH, electrical conductivity, sulfate (SO_4^{2-}), nitrate (NO_3^-), chloride (Cl^-), ammonium (NH_4^+), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}).

For dry deposition monitoring, weekly monitoring was conducted in the Metro Manila and Los Baños stations. Measurements were done for four (4) gases, i.e., sulfur dioxide (SO_2), nitric acid (HNO_3), hydrogen chloride (HCl), and ammonia (NH_3), and for eight (8) parameters in aerosol, i.e., sulfate (SO_4^{2-}), nitrate (NO_3^-), chloride (Cl^-), ammonium (NH_4^+), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}).

For soil monitoring, soil samples were collected and analyzed for pH (H_2O), pH (KCl), exchangeable base cations (Ca, Mg, K, Na), and exchangeable acid cations (Al, H). Exchangeable acidity and ECEC were calculated. Study sites for soil vegetation are the Mt. Makiling Forest Reserve at the University of the Philippines at Los Baños in Laguna and the U.P. Quezon Land Grant in Quezon (Figure 8.2). The prescribed monitoring frequency for soil monitoring is 3-5 years. For the period 2001-2004, there was only one (1) sampling event.

For vegetation monitoring, investigations were made on the trees in the sampling plots (species, diameter at breast height/DBH, height) and understorey vegetation in terms of species. Indicators of tree damage were also noted. Study sites for vegetation monitoring are the Mt. Makiling Forest Reserve at the University of the Philippines in Laguna and the U.P. Quezon Land Grant located in Quezon. The prescribed monitoring frequency for vegetation monitoring is 3-5 years. The results of two (2) sampling events are presented in this report.

For inland aquatic monitoring, quarterly monitoring was conducted in Mojicap Lake for the period 2001-2003. Measurements were done on twelve (12) parameters as follows: temperature, pH, electrical conductivity, alkalinity, sulfate (SO_4^{2-}), chloride (Cl^-), phosphate (PO_4^{3-}), ammonium (NH_4^+), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}).

8.1.3 Monitoring stations

Table 8.1 List of monitoring stations

Site Category	Site Classification	Location
Acid deposition monitoring site: Wet deposition	Urban Rural	Metro Manila (Ateneo de Manila University Campus, Quezon City) Los Baños (University of the Philippines Los Baños Campus)
Acid deposition monitoring site: Dry deposition	The same as the wet deposition sites	The same as the wet deposition sites
Ecological survey site: Soil monitoring	Basic survey site: Rural	Makiling Forest Reserve Los Baños, Laguna University of the Philippines Quezon Land Grant Real, Quezon
Ecological survey site: Vegetation monitoring	The same as the soil monitoring site	The same as the soil monitoring site
Ecological survey site: Inland aquatic monitoring	Basic survey site: Rural	Mojicap Lake, San Pablo City (2001-2003) Pandin Lake, San Pablo City (2004- present)

In all, there are five (5) acid deposition monitoring locations in the Philippines.

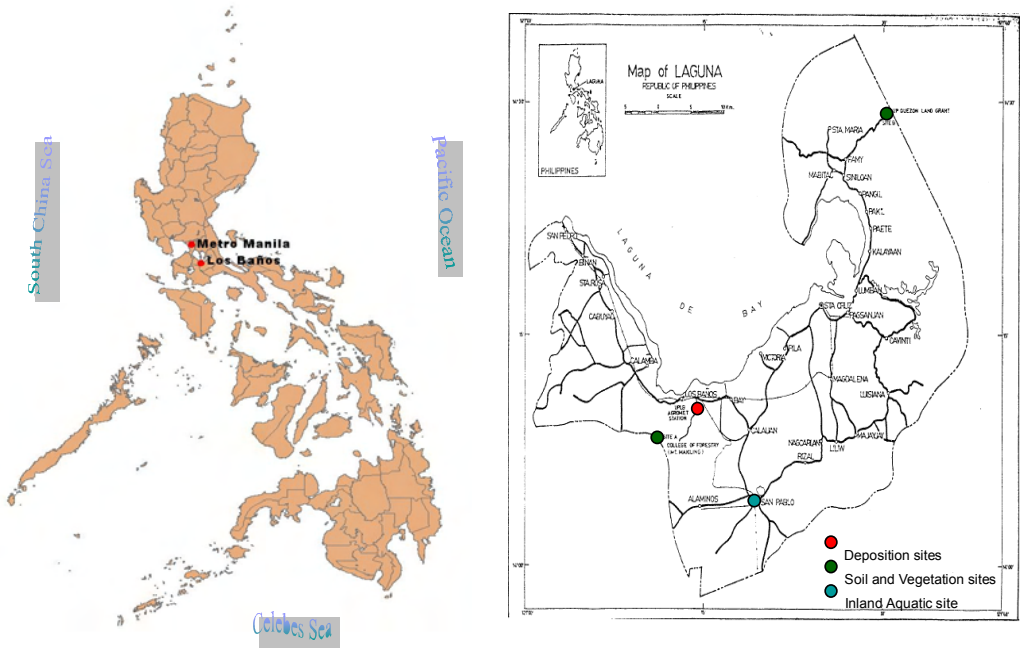

Figure 8.1 Acid Deposition Monitoring Stations in the Philippines

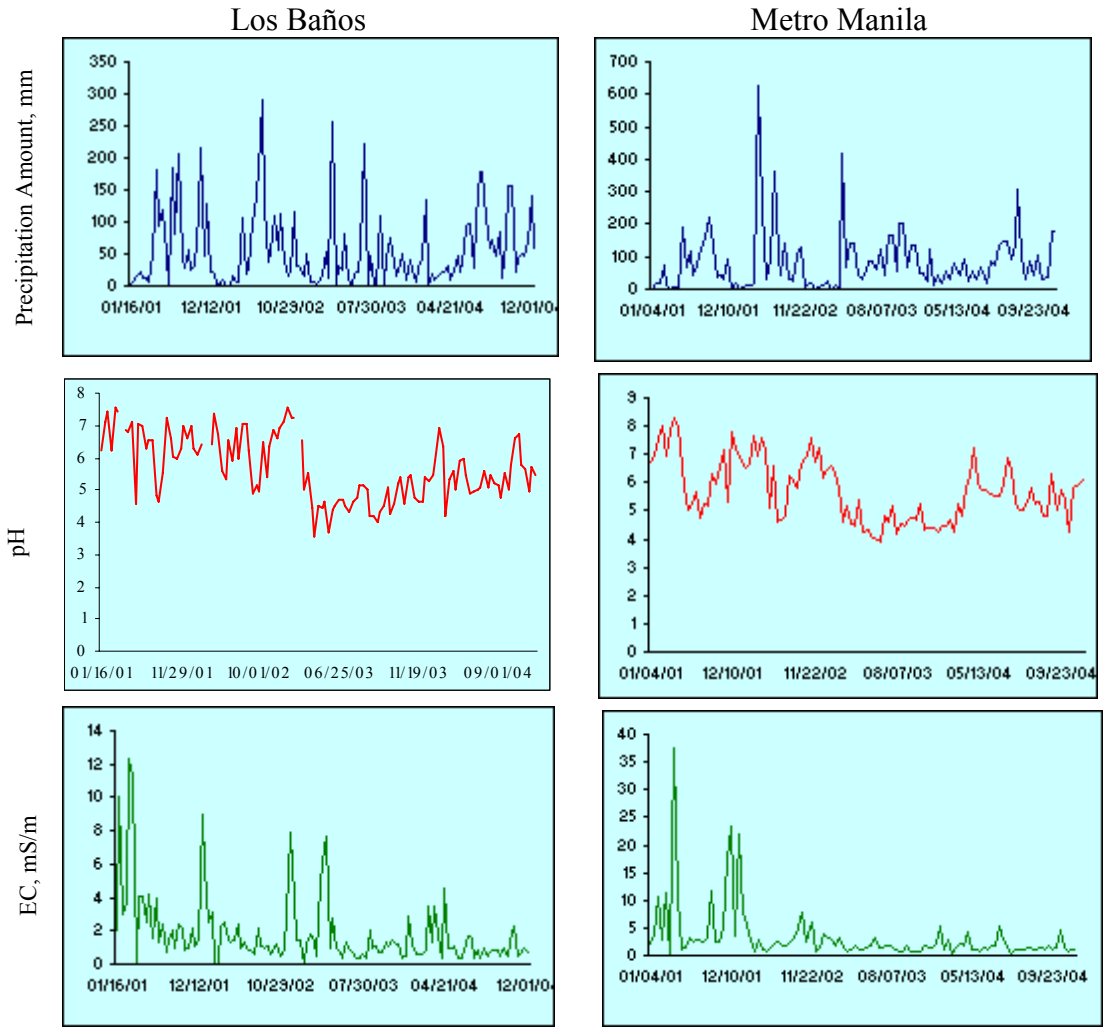

Figure 8.2 Precipitation, pH and EC in Los Baños and Metro Manila

8.1.4 Sampling and measurements

Rainwater samples for wet deposition monitoring were collected by the "wet-only" samplers installed on site. Gas and aerosol samples for dry deposition monitoring were collected by the filter pack. Soil samples were collected by soil augers. Lake water samples were scooped directly into the sample containers.

Analytical methods for the measurement of specific parameters are the methods recommended in EANET manuals.

8.2 State of acid deposition in the Philippines

8.2.1 Atmospheric deposition

The lowest precipitation amount recorded in Los Baños and Metro Manila is 0.0 mm while the highest precipitation amount is 627.3 mm in July 2002. The seasonal minimum, average, and maximum precipitation amount (in mm) recorded in the two stations are tabulated below:

Table 8.2 Seasonal amounts of rainfall recorded at Los Baños and Metro Manila

Season		Precipitation amount, mm	
		Los Baños	Metro Manila
Dry season 2001 (January - April)	Minimum	1.9	0.0
	Mean	15.7	16.7
	Maximum	48.6	73.7
Wet season 2001 (May - October)	Minimum	4.3	38.1
	Mean	89.7	116.3
	Maximum	205.7	219.5
Dry season 2001-2002 (November 2001- April 2002)	Minimum	1.1	0.3
	Mean	38.9	24.0
	Maximum	214.2	93.5
Wet season 2002 (May - October)	Minimum	7.8	16.4
	Mean	83.0	102.7
	Maximum	289.9	627.3
Dry season 2002-2003 (November 2002 - April 2003)	Minimum	3.9	0.2
	Mean	29.0	23.2
	Maximum	114.4	128.4
Wet season 2003 (May - October)	Minimum	4.3	0.0
	Mean	53.8	65.3
	Maximum	257.8	417.0
Dry season 2003-2004 (November 2003 - April 2004)	Minimum	8.0	18.2
	Mean	33.2	77.4
	Maximum	134.7	88.8
Wet season 2004 (May - October)	Minimum	12.7	17.8
	Mean	70.9	103.8
	Maximum	177.1	309.4

In general, the amount of precipitation recorded is higher in Metro Manila compared to Los Baños for the period 2001-2004 except for the dry seasons of 2001-2002 and 2003-2004.

8.2.2 State of wet deposition

pH. For the period 2001-2004, a total of 122 and 107 samples from Los Baños and Metro Manila, respectively, were collected and analyzed for pH. pH values were of the range 3.55 - 7.57 and 3.90 - 8.30 in Los Baños and Metro Manila, respectively. The annual means of pH for 2001-2004 are presented in Table 8.3.

In Los Baños, it is observed that in general, the dry season mean pH values were higher than the wet season mean pH values except for the dry season 2003/2004 and wet season 2004 values where the mean pH values were equal at 5.40.

In Metro Manila, it is likewise observed that the dry season mean pH values were higher than the wet season mean pH values.

The general trend in the time series concentrations show a decrease in pH values from 2002 to 2003 and toward early 2004, there has been a slight increase in pH for both stations (Figure. 8.2).

Electrical conductivity. For the period 2001-2004, a total of 122 and 106 samples from Los Baños and Metro Manila, respectively, were collected and analyzed for electrical conductivity (EC). EC values were of the range 0.31-12.29 mS/m and 0.30-23.50 mS/m in Los Baños and Metro Manila, respectively. The overall mean EC values were 2.47$\pm$1.83 and 4.5$\pm$3.76 in Los Baños and Metro Manila, respectively.

In Los Baños, it is observed that the dry season mean EC values were higher than the wet season mean EC values.

In Metro Manila, it is likewise observed that the dry season mean EC values were higher than the wet season mean EC values.

The time series EC concentrations show an even horizontal trend with fluctuations that occur on a seasonal basis. The extremely high EC values observed in Metro Manila for the period 2001 to early 2002 must have been responsible for the higher EC value in the station compared to that of Los Baños (Table 8.3)

Table 8.3 Annual means of pH and EC

Station	Year	pH			EC, mS/m		
		Annual weighted mean	Min	Max	Annual weighted mean	Min	Max
Los Baños	2001	5.53			2.08		
	2002	5.74	4.92	7.57	1.22	0.44	7.92
	2003	4.49	3.55	6.55	1.99	0.35	7.65
	2004	5.26	4.16	6.90	0.80	0.31	4.58
Metro Manila	2001	5.41			6.49		
	2002	5.09	4.63	7.68	1.85	0.71	21.9
	2003	4.44	3.90	6.60	1.36	0.29	5.41
	2004	5.18	4.22	7.20			

Anions. For the period 2001-2004, a total of 123 and 99 samples from Los Baños and Metro Manila, respectively, were collected and analyzed for sulfate, nitrate, and chloride using ion chromatography (Table 8.4).

Table 8.4 Annual mean anion flux

Station	Year	Sulfate (SO_4^{2-}), mmol m^{-2}	Nitrate (NO_3^-), mmol m^{-2}	Chloride (Cl^-), mmol m^{-2}
Los Baños	2001	28.4	25.3	62.7
	2002	27.3	14.0	41.9
	2003	11.4	10.0	7.84
	2004	14.7	10.6	24.9
Metro Manila	2001	85.5	42.5	264
	2002	78.2	52.3	55.9
	2003	37.6	35.2	28.8
	2004	44.0	33.4	52.0

For both stations, chloride had the highest concentration followed by sulfate. Nitrate had the lowest concentration. Higher sulfate and chloride levels were observed in Los Baños compared to that in Metro Manila. For nitrate, the two locations had comparable concentration levels. The time series plots of anion concentrations in Los Baños show extremely high values for sulfate (2102.9 µmol/L) and chloride (4090.3 µmol/L) for the period 26 December 2002-09 January 2003). These extremely high anion values must have greatly affected the findings on anion concentrations in Los Baños.

In Los Baños, it is observed that dry season sulfate and chloride levels were higher than wet season levels. This observation was not apparent for nitrate.

In Metro Manila, it is observed that dry season anion concentrations were higher than wet season levels. The exception is the wet season 2003 nitrate concentration mean that was higher than the dry season 2002/2003 mean.

The time series concentration trends show a fairly even horizontal trend for all anions in both stations. Extremely high concentrations have been observed for sulfate, nitrate, and chloride in Los Baños.

Cations. For the period 2001-2004, a total of 121 and 107 samples from Los Baños and Metro Manila, respectively, were collected and analyzed for ammonia using the colorimetric method and sodium, potassium, calcium, and magnesium using atomic absorption spectrometry (Table 8.5)

Table 8.5 Annual mean cation flux

Station	Year	NH_4^+ mmol m^{-2}	Na^+ mmol m^{-2}	K^+ mmol m^{-2}	Ca^{2+} mmol m^{-2}	Mg^{2+} mmol m^{-2}	H^+ mmol m^{-2}
Los Baños	2001	40.7	67.6	17.3	119	20.1	5.41
	2002	58.8	35.9	10.9	12.3	5.00	3.07
	2003	23.3	24.6	2.94	12.5	4.18	52.2
	2004	24.3	20.9	3.74	9.41	6.25	9.5
Metro Manila	2001	177	470	53.1	164	34.4	8.86
	2002	137	43.3	29.4	25.9	9.72	24.1
	2003	52.2	40.5	5.55	19.3	6.60	79.8
	2004	76.6	35.3	8.50	24.1	9.47	14.4

For both stations, ammonium had the highest concentration followed by sodium. In Los Baños, sodium was followed by calcium, potassium and magnesium in terms of concentration levels. In Metro Manila, However, sodium was followed by potassium, calcium and magnesium in terms of concentration levels.

Los Baños had higher sodium concentration compared to Metro Manila while Metro Manila had higher concentrations of ammonium, potassium, calcium, and magnesium.
In terms of seasonal variations, in Los Baños had relatively higher concentration levels of all cations during the dry season compared to the wet season. The only exception was observed during the wet season 2001 when its ammonium concentration was found to be higher than the dry season 2001/2002 level.

In Metro Manila, all the cations exhibited higher concentrations during the dry season compared to the wet season. The only exception noted was in the case of the wet season 2003 concentration of Mg that was higher than the dry season 2002/203 concentration.

Ionic balance. Figure 8.3 shows the ionic composition of rainfall in Metro Manila in 2003. It is noted that cations is greater than anions in terms of µeq/L. In this particular case, anions are 86% of cations. This condition holds true in 6 out of 8 of the annual ionic balance in Los Baños and Metro Manila.

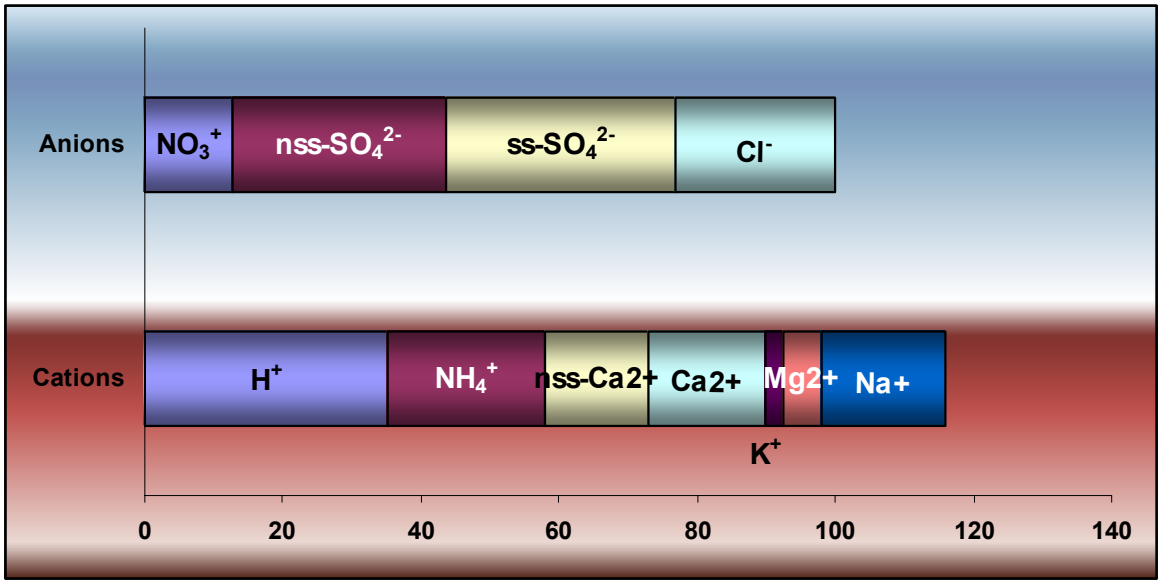

Figure 8.3 Ionic Concentration (µeq/L)

8.2.2 State of dry deposition

Gases. For the period 2001-2004, a total of 162 samples were collected by the filter pack and analyzed for gaseous components by the colorimetric method (for ammonia) and ion chromatography for other gases. The annual mean values obtained for the two stations are given below:

Station	Year	Concentration in µg/m^3, Annual mean			
		SO_2	HNO_3	HCl	NH_3
Los Baños	2001	1.88	0.505	8.51	2.65
	2002	2.03	0.306	0.884	4.44
	2003	2.50	0.498	1.73	3.99
	2004	1.09	0.411	0.771	2.73
Metro Manila	2001	22.0	2.22	4.50	4.42
	2002	11.4	0.577	1.34	7.04
	2003	11.7	1.17	1.75	7.29
	2004	9.00	1.44	1.49	6.32

Concentration levels of SO_2, HNO_3, and NH_3 were higher in Metro Manila than in Los Baños. Except in 2001, HCl concentration was higher in Metro Manila than in Los Baños.

No general trend could yet be determined for the concentration of gases in both stations (Figure 8.4).

Figure 8.4 Time Series Concentration of dry deposition (Gases) in Los Baños and Metro Manila

Anions in Aerosol. Higher concentrations of chloride were observed in Los Baños while in Metro Manila, higher concentrations of sulfate and nitrate were noted. In Los Baños, the anion with the highest concentration was chloride, followed by sulfate, and nitrate

In Metro Manila, the anion with the highest concentration was sulfur dioxide followed by nitrate and chloride.

No general trend could be determined for the concentration of anions in aerosol in both stations.

Cations in Aerosol. Higher concentrations of ammonium, potassium, and calcium were observed in Los Baños while Los Baños and Metro Manila had comparable concentrations levels for sodium and magnesium.

In Los Baños, sodium was observed to have the highest concentration followed by calcium, ammonium, potassium, and magnesium.

In Metro Manila, calcium, sodium, and ammonium had comparable concentration levels and magnesium had the lowest concentration.

No general trend could be determined for the concentration of cations in aerosol in both stations.

8.2.4 State of soil

At present, the East Asian countries are experiencing rapid economic growth and industrialization which could cause various impacts on the environment of this region. The continuation of this trend might result to significant adverse effects caused by air pollution and acid deposition on the ecological systems of this region. This similar situation is also occurring in our country.

Acidification of the soil, nutrient imbalance and direct damage to the plant caused by acid deposition could lead to forest decline. However, due to the fact that this process is relatively slow, it becomes increasingly important to obtain accurate, precise and comparable data on a long term basis on acid deposition through soil and vegetation monitoring.

Soil acidity and the problems associated with it are the major constraints for higher crop production and crop growth not only in the Philippines but also in several parts of the world. Approximately 30% or 3950 million hectares of the world's ice-free land area are acid soils. About 58% or 17 million hectares of the 30.8 million hectares of total land area in the Philippines are estimated to be acid soils. In other Southeast Asian countries the extent of acid soils (not necessarily due to acid rain and with pH <5.5) are the following: Burma – 28.5 M ha; Indonesia – 67.6 M ha; Kampuchea – 6.1 M ha; Laos – 15.6 M ha; Malaysia – 22.5 M ha; Thailand – 21.5 M ha and Vietnam – 16.2 M hectares (IRRI, 1986).

Acid soils are infertile primarily because of toxicity, nutrient deficiency and slower microbial activity. The common causes or sources of soil acidity are: humus or organic matter, crop removal of base cations (Ca, Mg, K, Na), soluble salts and acids, leaching, aluminum and iron oxides, use or addition of ammoniacal fertilizers in the field, carbon dioxide, oxidation of pyrite and acid rain or acidic gases (by-products from power plants, manufacturing plants, transport and domestic heating). The effects of acidification are lowering of soil pH, nutrient imbalance, direct damage to plant body (forest decline) and yield reduction (agricultural crops).

Although some scientists have discovered and confirmed that sulfur dioxides and nitrogen oxides are the primary causes of acid rain; and that in the US, about 2/3 of all sulfur dioxides and ¼ of all nitrogen dioxides comes from electric power generation that relies on burning fossil fuels like coal (Almanac of Policy Issues, 2002); only few studies were being done or conducted in the Philippines to determine the effect or contribution of acid rain in soil acidification.

Description of Baseline Data on Soil

Soil reaction (soil pH). **A**nalyses of soil samples collected at different monitoring sites at Mt. Makiling, Los Banos, Laguna and UP Quezon Land Grant are presented in Tables 8.6 and 8.7, respectively. In general, the pH_w of the surface soil at UP Quezon Land Grant which is described as extremely acidic (3.99 – 4.10), based on corresponding terms in table 5, is very much lower when compared to the soil pH_w values at Mt. Makiling which is described as strongly acidic to moderately acidic (5.02 – 5.82). It was also observed that the lower layer of the soil (10 –20 cm depth) showed lower pH values than the upper layer (0 – 10 cm). The pH_{KCl} was also noted to give lower pH values than the pH_w.

Exchangeable Aluminum. In connection with exchangeable aluminum, it was observed to be present when the pH_w falls below 5.20 as shown by the data from Mt. Makiling, however, site 1 showed high exchangeable Al than site 2 which has no Al. UP Quezon Land Grant exhibited highly toxic level of Al in both sites sampled. Aluminum was also observed to have higher values in the lower layer where pH is also lower. In areas planted to corn, the critical level for Al was shown to be 0.03 cmol(+)/kg soil. Table 8.9 shows that at pH 5.5, exchangeable Al is not present and pH 6 is the most suitable for the growth of a wide variety of plants while Table 8.10 presents the pH reference of most agricultural crops. This Table also shows that most trees like rambutan, mango, lanzones, avocado, coffee and rubber grow well at pH range of 5.5 to 6.5.

Exchangeable Base cations. The soil test values for Ca, Mg and K for Mt. Makiling were all above the critical levels as cited by Haby et al. (1990) wherein they mentioned critical values of 1.25 – 2.5, 0.13 – 0.25 and 0.28 – 0.51 cmol (+)/kg soil for Ca, Mg and K, respectively. However, this does not hold true for the exchangeable Ca and K for UP Quezon Land Grant where the soil test values obtained were below the critical levels having mean values of 0.38 – 0.60 cmol(+) Ca/kg soil while the exchangeable K ranges from 0.16 – 0.25 cmol(+)/kg soil. Exchangeable Mg is above the critical level.

Table 8.6 Soil chemical analysis: Philippines-1

Sampling period: 19-Feb-05

Name of analytical laboratory: Department of Soil Science, UPLB

Sample No.	Location	Soil type	Plot No.	Subplot No.	Layer analyzed (cm)	Repeat* analysis	Moisture content	pH		Exchangeable base cations (B)				Ex-acidity (A)	Ex-acid cations		ECEC	Base saturation	T-C	T-N	
										Ca	Mg	K	Na		Al	H	(A)+(B)				
							(wt%)	H_2O	KCl	(cmol(+)kg^{-1})								%	(g kg^{-1})		acidity/ (Al+H)
1	Mt. Makiling, Los Banos, Laguna	Eutric Cambisol	1	1	0-10	1st	1.1	5.22	4.73	18.00	16.86	2.56	2.86	0.21	0.00	0.21	34.40	117.09	29.70		1.00
				2			1.1	5.10	4.49	13.01	18.04	2.51	2.51	0.36	0.11	0.25	28.81	125.20	23.80		1.00
				3			1.2	5.18	4.59	14.98	15.84	2.58	2.79	0.29	0.06	0.23	29.34	123.35	23.60		1.00
				4			1.1	5.15	4.51	12.96	16.69	2.53	2.53	0.33	0.10	0.23	29.18	118.95	22.00		1.00
				5			1.1	4.44	3.95	7.46	15.85	2.20	2.36	2.62	1.99	0.63	25.68	108.53	19.30		1.00
2				1	10-20		1.1	5.02	4.39	14.21	14.02	1.92	2.44	0.43	0.20	0.23	28.28	115.24	18.00		1.00
				2			1.1	4.57	4.05	7.79	15.23	2.00	2.28	2.20	1.62	0.58	25.63	106.52	14.70		1.00
				3			1.1	4.62	4.02	10.17	13.01	2.02	2.24	1.91	1.34	0.57	25.73	106.65	15.50		1.00
				4			1.1	4.64	3.99	8.46	14.88	2.28	2.26	2.52	1.78	0.74	18.09	154.12	15.60		0.63
				5			1.1	4.32	3.78	4.22	15.20	1.82	2.08	6.15	4.90	1.25	24.65	94.60	13.50		1.00
3			2	1	0-10		1.1	5.97	5.24	23.96	15.21	3.19	3.15	0.13	0	0.13	37.37	121.78	24.80		1.00
				2			1.1	5.95	5.26	23.08	15.31	3.10	3.20	0.12	0	0.12	37.52	119.11	24.70		1.00
				3			1.1	5.88	5.17	23.57	16.13	3.53	3.28	0.13	0	0.13	39.95	116.42	26.50		1.00
				4			1.1	5.42	4.73	20.66	13.89	2.73	2.84	0.17	0	0.17	32.99	121.61	23.10		1.00
				5			1.1	5.86	5.04	19.28	15.56	3.04	2.80	0.13	0	0.13	35.21	115.54	20.90		1.00
4				1	10-20		1.1	5.91	5.03	18.34	14.54	2.96	2.91	0.14	0	0.14	31.61	122.59	14.70		1.00
				2			1.1	5.85	4.86	16.03	15.30	2.69	2.60	0.17	0	0.17	30.64	119.52	13.30		1.00
				3			1.1	5.67	4.72	17.11	14.39	2.67	2.62	0.20	0	0.20	32.14	114.47	15.20		1.00
				4			1.1	5.54	4.41	17.84	13.22	2.14	2.61	0.19	0	0.19	30.10	118.97	16.20		1.00
				5			1.1	5.58	4.63	15.02	15.45	2.56	2.53	0.20	0	0.20	30.66	115.98	14.60		1.00

Note: Repeat analysis was not reported.

Table 8.7 Soil chemical analysis: Philippines-2

Sampling period: 30-Oct-01

Name of analysis laboratory: Department of Soil Science, UPLB

Sample No.	Location	Soil type	Plot No.	Subplot No.	Layer analyzed (cm)	Repeat analysis	Moisture content	pH		Exchangeable basecations (B)				Ex-acidity (A)	Ex-acid cations		ECEC	Base saturation	T-C	T-N	
										Ca	Mg	K	Na		Al	H	(A)+(B)				
							(wt%)	H_2O	KCl	(cmol(+)kg^{-1})								%	(g kg^{-1})		
1	Up Quezon - Laguna Land Grant	Dystric Nitosol	1	1	0-10	1st	1.1	4.02	4.00	0.37	0.35	0.21	0.29	4.40	3.85	0.55	5.62	21.71	37.00		1.00
				2			1.1	4.04	4.02	0.69	0.61	0.30	0.45	4.42	3.79	0.63	6.47	31.68	37.90		1.00
				3			1.1	4.09	4.05	0.53	0.37	0.23	0.41	4.45	3.90	0.55	5.99	25.71	39.90		0.98
				4			1.1	4.09	4.05	0.48	0.39	0.24	0.31	4.13	3.53	0.60	5.55	25.59	39.00		1.00
				5			1.1	4.24	4.06	0.53	0.42	0.25	0.44	3.76	3.27	0.49	5.40	30.37	34.70		1.00
2				1	10-20	1st	1.1	4.02	3.87	0.37	0.35	0.18	0.27	5.28	4.66	0.62	6.45	18.14	23.30		1.00
				2			1.1	4.01	3.81	0.64	0.35	0.22	0.36	4.59	4.03	0.56	6.16	25.49	26.50		1.00
				3			1.1	4.04	3.83	0.27	0.26	0.20	0.31	4.60	3.93	0.67	5.64	18.44	28.20		1.00
				4			1.1	4.04	3.96	0.37	0.35	0.23	0.28	4.45	3.79	0.66	5.68	21.65	33.40		1.00
				5			1.1	4.15	4.06	0.26	0.35	0.23	0.39	4.27	3.63	0.64	5.50	22.36	24.00		1.00
3			2	1	0-10	1st	1.1	4.01	3.88	0.75	0.62	0.21	0.51	6.72	4.86	1.86	8.81	23.72	31.60		1.00
				2			1.1	3.93	3.92	0.37	0.25	0.16	0.28	6.39	4.69	1.70	7.45	14.23	32.20		1.00
				3			1.1	3.95	3.99	0.59	0.39	0.18	0.42	6.06	4.48	1.58	7.64	20.68	24.60		1.00
				4			1.1	3.92	3.91	0.74	0.33	0.16	0.33	6.58	4.68	1.90	8.14	19.16	26.00		1.00
				5			1.1	4.14	3.99	0.53	0.30	0.17	0.29	5.78	4.30	1.48	7.07	18.25	29.80		1.00
4				1	10-20	1st	1.1	3.90	3.88	0.48	0.52	0.18	0.33	6.91	5.09	1.82	8.42	17.93	23.40		1.00
				2			1.1	3.91	3.72	0.37	0.25	0.16	0.26	6.67	4.86	1.81	7.71	13.49	24.80		1.00
				3			1.1	3.94	3.74	0.43	0.26	0.16	0.27	6.35	4.66	1.69	7.47	14.99	21.80		1.00
				4			1.1	3.90	3.91	0.64	0.31	0.15	0.30	6.70	4.91	1.79	8.10	17.28	21.30		1.00
				5			1.1	3.98	3.84	0.48	0.25	0.16	0.28	5.80	4.16	1.64	6.97	16.79	19.60		1.00

Note: Repeat analysis was not reported.

Table 8.8 Corresponding terms to use for ranges in pH

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5-5.0
Strongly acid	5.1-5.5
Moderately acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral[1]	6.6-7.3
Mildly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	9.1 and higher

[1]Strict neutrality is pH 7.0 but in field work those soils between pH 6.6 and 7.3 are called neutral. In rare cases, the terms very slightly acid and very mildly alkaline may be used for soils of pH 6.6 to 6.9 and 7.1 to 7.3 respectively.

Source: Soil Science 1 Laboratory Manual (2005).

Table 8.9 pH values of special significance in soils

pH*	**Soil Conditions Inferred from pH**
<4.0	Free mineral acids present, most often H_2SO_4 from the oxidation of pyrites
4.0	pH of soil largely saturated with exchangeable aluminum and moderately low to very low in exchangeable divalent cations
5.5	pH above which there is essentially no exchangeable aluminum
6.0	Soil pH suitable for a wide variety of plants
7.0	Neutral pH
8.3	Soil in equilibrium with an excess of $CaCO_3$ at the partial pressure of CO_2 in the atmosphere (0.003 atm)
>8.3	Na_2CO_3 present in the soil

*pH on a 1:1 soil: water suspension

Source: Soil Science 1 Laboratory Manual (2005).

Table 8.10 Soil pH references of some agricultural crops

Common name	**pH preferences**
1. Abaca	6.0-7.0
2. Alfalfa	6.5-7.2
3. Ampalaya	6.0-6.7
4. Avocado	6.0-8.0
5. Banana	6.0-7.5
6. Beans (snap, lima, string)	5.5-6.5
7. Cabbage	6.0-7.5
8. Cacao	6.0-7.0
9. Camote (sweet potato)	5.0-7.0
10. Coffee	4.5-7.0
11. Corn	6.0-8.0
12. Cotton	5.5-6.5
13. Cowpea	5.0-6.5
14. Cucumber	6.0-8.0
15. Eggplant	5.5-6.7
16. Garlic	5.4-6.8
17. Ginger	5.5-6.5
18. Grapes	6.0-7.0
19. Lanzones	5.5-6.5

20. Lettuce	5.5-7.0
21. Mango	5.5-7.5
22. Mungo	5.5-6.5
23. Muskmelon	6.0-6.7
24. Okra	5.8-8.0
25. Onion	5.8-6.5
26. Papaya	5.8-7.0
27. Peanuts	6.0-6.5
28. Pepper (Sweet)	5.8-6.8
29. Pineapple	5.0-6.5
30. Potato (Irish)	4.8-6.5
31. Rambutan	5.5-6.5
32. Ramie	5.5-6.5
33. Rice (paddy)	6.0-6.5
34. Rice (upland)	5.0-6.5
35. Rubber	5.8-8.0
36. Sorghum	6.0-7.5
37. Soybean	6.0-7.0
38. Sugarcane	6.0-8.0
39. Tobacco	5.5-7.0
40. Tomato	4.5-6.5
41. Wheat	6.0-7.0

Source: Soil Science 1 Laboratory Manual (2005).

8.2.5 State of vegetation

Impact Assessment of Acid Deposition in the Country

Soil and vegetation monitoring as regards impacts of acid rain was only initiated in the Philippines with the country's participation in the EANET activities. As such, the observations made during the last two monitoring activities provide baseline information on the status of the same relative to the effects of rainfall acidification in the country. Tree height and DBH are essential parameters in the estimation of growth and yield of the stand. Impacts of acid rainfall can be manifested in reduced growth and yield of the stand through time. It may take long before a noticeable decrease in incremental growth will be manifested by the affected trees. Thus, long term observations on growth parameters are expected.

Tables 8.11 and 8.12 provide the measurements on height and diameter of the sampled trees within the monitoring plots in the Mt. Makiling Forest Reserve and UPLB Land Grant, respectively. In general, there was an increase in both parameters for all the trees enumerated in both sites. While the ages of the trees have not been determined, the stand appearance in both sites indicate that the majority of the enumerated trees have not yet reached their maturity and are still expected to grow significantly in the coming years. It is worthwhile to note too, that almost all of the species sampled do not have any existing growth and yield estimates. Thus, the data to be generated through the coming monitoring years will also be essential whenever said species will be brought into management for production purposes, if they qualify.

Table 8.11 Change in tree measurements at the Makiling Forest Reserve

NO.	SPECIES NAME	DBH (cm)		HT (m)	
		2000	**2005**	**2000**	**2005**
Plot No. 1 (7.98 m)					
001	*Celtis luzonica*	7.3	7.45	5.6	7.20

002	*Palaquium foxworthyi*	4.5	4.58	2.44	4.54
003	*Chisocheton pentandrus*	12.2	12.3	10.93	11.19
004	*Diplodiscus paniculatus*	4.5	4.52	9.52	13.47
005	*Celtis luzonica*	3.3	3.38	3.70	3.78
006	*Myristica philippinensis*	4.0	4.40	2.37	4.44
007	*Celtis luzonica*	8.7	8.80	6.5	9.83
008	*Parashorea malaanonan*	3.5	4.75	3.35	4.75
009	*Diplodiscus paniculatus*	2.0	Dead	2.37	Dead
010	*Parashorea malaanonan*	1.5	3.70	2.19	3.70
011	*Celtis luzonica.*	3.3	3.40	2.90	4.33
012	*Dysoxylum arborescens*	1.5	2.20	3.34	3.95
013	*Diospyrus philippinensis*	0.5	2.00	1.53	2.45
014	*Casearia fuliginosa*	15.0	15.50	9.74	14.35
015	*Celtis luzonica*	3.0	3.20	3.23	4.13
016	*Drypetes maquilengensis*	1.0	1.60	0.80	2.80
017	*Dracontomelon dao*	11.2	11.50	12.30	12.75
018	*Drypetes maquilengensis*	0.5	1.30	2.02	2.60
019	*Celtis luzonica*	3.7	3.8	2.72	2.82
020	*Celtis luzonica*	7.7	7.8	6.49	6.55
021	*Coffea arabica*	2.0	2.2	3.35	4.85
022	*Diplodiscus paniculatus*	37.2	37.4	13.80	15.88
023	*Celtis luzonica*	1.5	7.7	2.00	8.24
024	*Celtis luzonica*	1.5	1.8	2.50	4.20
025	*Celtis luzonica*	1.5	1.7	2.50	8.00
026	*Knema glomerata*	11.20	11.20	6.61	7.28
027	*Drypetes maquilengensis*	1.0	Dead	2.50	Dead
028	*Neotrewia cumingii*	18.0	Dead	6.26	Dead
029	*Strombosia philippinensis*	1.0	2.4	2.7	3.10
030	*Diplodiscus paniculatus*	0.5	2.5	1.8	2.10
031	*Dimorphocalyx luzoniensis*	0.5	1.30	2.10	2.15
032	*Celtis luzonica*	0.5	0.80	2.20	3.30
033	*Radermachera pinnata*	1.0	2.00	2.30	2.50
034	*Micromelum compressum*	0.5	1.20	2.00	2.20
035	*Drypetes maquilengensis*	1.0	1.20	2.10	2.48
036	*Syzygium calubcob*	1.0	1.50	2.40	3.25
037	*Strombosia philippinensis*	0.5	1.00	2.40	2.95
038	*Celtis luzonica*	9.0	9.20	6.74	7.83
039	*Parashorea malaanonan*	3.0	3.40	2.10	1.65 (cut)
040	*Ficus congesta*	20.0	Dead	5.22	Dead
041	*Aglaia edulis*	2.50	2.54	3.00	3.40
042	*Alangium meyeri*	5.7	7.10	2.78	6.40
043	*Parashorea malaanonan*	0.5	1.20	2.50	2.90
044	*Dysoxylum arborescens*	3.5	3.58	3.00	3.20
045	*Celtis luzonica*	1.5	2.00	3.20	3.35
046	*Celtis luzonica*	2.5	2.57	3.42	3.60
047	*Dillenia philippinensis*	6.0	6.35	4.28	5.33
048	*Celtis luzonica.*	2.0	2.20	3.30	4.15
049	*Parashorea malaanonan*	5.0	5.50	3.61	4.62
050	*Alangium meyeri.*	3.5	5.0	2.91	4.03
051	*Aglaia edulis.*	3.0	3.10	2.89	3.10
052	*Drypetes maquilengensis*	2.2	2.50	2.89	2.94
053	*Syzygium curranii*	45.0	47.00	14.21	16.90
054	*Nephelium ramboutan-ake*	12.5	18.0	9.75	10.62
055	*Pisonia umbillifera*	30.5	30.7	9.46	10.38

056	Coffea arabica.	2.0	2.10	3.50	4.00
057	Coffea arabica.	2.5	2.60	4.00	4.30
058	*Drypetes maquilengensis*	1.5	2.00	3.00	3.80
059	*Neotrewia cumingii*	5.5	5.80	1.76	4.98
060	Coffea arabica	2.0	2.10	3.50	3.52
061	*Coffea* arabica	0.5	1.30	3.00	3.47
062	*Drypetes maquilengensis*	2.0	2.20	3.00	3.45
063	*Syzygium nitidum*	19.2	19.5	12.62	12.75
064	*Knema glomerata*	2.0	Cut	2.50	Cut
065	*Dysoxylum arborescens*	4.0	4.10	3.26	4.35
066	*Celtis luzonica*	1.0	1.80	2.50	2.80
067	*Diplodiscus paniculatus*.	0.5	1.20	2.00	2.45
068	*Camelia lanceolata*	6.5	6.60	3.55	5.27
069	*Camelia lanceolata*	4.0	4.20	5.50	5.53
070	*Neolitsea vidalii*	8.2	8.30	5.81	8.19
071	*Celtis luzonica*	2.0	2.70	3.20	3.79
072	*Pisonia umbillifera*	30.5	30.70	8.84	12.31
073	*Celtis luzonica*	3.0	3.10	3.9	3.83
074	Pseudo pinanga	9.0	9.00	4.17	4.60
075	*Dysoxylum arborescens*	1.5	2.00	2.80	2.90
076	*Parashorea malaanonan*	3.5	3.80	4.00	4.20
077	*Diplodiscus paniculatus*	2.5	2.80	3.70	3.85
078	Pseudo pinanga	8.5	8.70	2.2	3.55
079	*Nephelium ramboutan-ake*	9.0	9.10	7.42	11.27
080	*Dysoxylum arborescens*	2.5	2.50	3.5	3.55
Plot No. 2 (11.28 m)					
081*	*Nephelium ramboutan-ake*	45.0	Cut	9.40	Cut
082	*Diplodiscus paniculatus*	7.20	7.20	6.28	6.80
083	*Knema glomerata*	8.0	8.00	6.29	7.84
084	*Diplodiscus paniculatus*	6.3	9.30	6.95	8.86
085	Psychotria luzoniensis	17.0	17.20	10.55	10.57
086	*Chisocheton pentandrus*	24.0	24.20	12.75	12.85
087	*Duguan Myristica philippinensis*	16.5	18.50	7.41	14.46
088	*Nephelium ramboutan-ake*	12.0	12.30	10.08	10.56
089	*Parashorea malaanonan*	5.8	7.10	4.37	6.14
090	*Nephelium ramboutan-ake*	29.0	Topped	7.84	Topped
091	*Lagerstroemia speciosa*	11.3	11.38	0.63	7.17
092	*Palaquium foxworthyi*	5.0	5.10	4.13	4.73
093	*Diplodiscus paniculatus*	10.5	10.54	8.26	9.00
094	*Celtis luzonica*	5.0	5.30	3.69	4.77
095	*Alangium meyeri*	7.7	9.00	5.52	5.88
096	*Pseudo pinanga*	12.0	14.30	2.87	15.61
097	*Parashorea malaanonan*	5.0	5.10	4.99	5.18
098	*Pterocymbium tinctorium*	7.0	7.10	4.69	4.79
099	*Nephelium ramboutan-ake*	11.9	Topped	9.44	Topped
100	*Litsea garciae*	46.5	50.30	16.92	17.06
101	*Dendrocnide meyeniana*	7.7	7.90	6.50	7.20
102	*Celtis luzonica*	4.9	4.98	4.63	6.14
103	*Cynometra ramiflora*.	4.2	4.45	4.28	5.10
104	*Diplodiscus paniculatus*.	22.0	22.20	10.73	14.27
105	*Leea philippinensis*.	4.1	Dead	4.41	Dead
106	*Celtis luzonica*	32.0	34.10	15.86	19.19
107	*Celtis luzonica*.	5.5	5.57	4.39	5.97
108	*Voacanga globosa*.	5.0	Dead	3.45	Dead
Plot No. 3 (17.85 m)					

109	*Turpinia ovalifolia*	45.0	45.30	8.07	20.00
110	*Pterocymbium tinctorium*	27.0	31.00	20.29	20.84
111	*Gompandra spp.*	27.0	28.00	13.63	17.51
112	*Celtis luzonica*.	28.0	30.20	12.38	15.15
113	*Pterocymbium tinctorium*	50.0	50.8	13.92	18.98
114	*Dysoxylum arborescens*	24.5	24.75	10.90	15.01
115	*Parashorea malaanonan*	37.0	42.00	15.78	39.27
116	*Diplodiscus paniculatus*	50.0	53.20	14.65	21.94
117	*Litsea garciae*	81.0	81.00	26.58	26.58
118	*Parashorea malaanonan*	22.5	22.60	13.57	13.69
119	*Turpinia ovalifolia*	32.0	32.20	14.11	14.86
120	*Parashorea malaanonan*	47.5	51.00	18.48	25.70
121	Solenospermum toxicum	110.0	110.00	20.87	21.44
122	*Knema glomerata*	18.3	18.37	10.97	11.44
123	*Parashorea malaanonan*	35.0	40.00	16.41	20.69
124	*Kingiodendron alternifolium*	100.0	100.00	14.43	15.50
125	*Diplodiscus paniculatus*	21.0	21.35	12.51	13.01
126	*Planchonia spectabilis*	24.5	24.58	11.34	17.62
127	*Celtis luzonica*	46.0	46.60	21.14	21.89
128	*Celtis luzonica*	52.0	53.00	19.22	21.59
129	*Diplodiscus paniculatus*	32.0	32.20	12.49	21.67
130	*Sterculia montana*	47.0	49.00	15.40	23.80

Note: Dead/cut/overtopped trees were damaged by strong winds when a typhoon passed through the area last December 2004

Table 8.12 Change in measurement of trees from 2001-2005 of trees at the UPLB Quezon Land Grant.

TREE NO.	**NAME OF SPECIES**	**DBH (cm)**		**HEIGHT (m)**	
		2001	**2005**	**2001**	**2005**
Plot No. 1 (7.98 m)					
001	*Pterocarpus indicus*	**14.0**	**17.20**	**8.13**	**9.37**
002	*Pterocarpus indicus*	**11.0**	**11.30**	**4.16**	**6.16**
003	*Syzygium nitidum*	**5.0**	**Cut**	**4.5**	**Cut**
004	*Buchanania arborescens*	**2.0**	**Cut**	**2.0**	**Cut**
005	*Hopea foxworthyi*	**4.2**	**7.30**	**4.2**	**5.00**
006	*Sandoricum dubium*	**5.0**	**6.80**	**2.3**	**6.05**
007	*Vitex parviflora*	**4.5**	**8.20**	**5.0**	**6.21**
008	*Syzygium decipiens*	**8.5**	**8.50**	**3.0**	**5.90**
009	*Syzygium striatulum*	**11.5**	**11.50**	**8.96**	**9.00**
010	*Buchanania arborescens*	**12.0**	**12.30**	**7.61**	**9.05**
011	*Dimocarpus longan*	**5.4**	**7.80**	**4.2**	**4.24**
012	*Hopea foxworthyi*	**4.0**	**4.20**	**3.9**	**5.70**
013	*Baccaurea philippinensis*	**9.0**	**9.10**	**6.5**	**7.95**
014	*Ficus cumingii* Miq. var. *terminalifolia*	**3.2**	**6.30**	**2.6**	**5.20**
015	*Microcos stylocarpa*	**5.4**	**6.40**	**4.0**	**6.20**
016	*Pandanus spp.*	**5.7**	**Cut**	**3.5**	**Cut**
017	*Xanthophyllum flavescens*.	**3.5**	**4.60**	**3.5**	**4.10**
018	*Cryptocaria glauca*	**6.2**	**7.50**	**5.2**	**5.30**
019	*Neonauclea puberula*	**3.5**	**3.60**	**4.15**	**4.20**
020	*Syzygium brevistylum*	**3.0**	**5.30**	**2.9**	**4.30**
021	*Macaranga bicolor*	**7.0**	**9.10**	**6.0**	**6.82**
022	*Baccaurea philippinensis*	**4.0**	**5.20**	**4.0**	**4.03**
023	*Pterocarpus indicus*	**0.5**	**Uprooted**	**3.8**	**Uprooted**
024	*Cinnamomum mercadoi*	**4.0**	**6.80**	**5.3**	**5.37**

025	*Canarium vrieseanum*	**4.5**	**8.70**	**5.0**	**5.02**
026	*Ficus callosa*	**7.0**	**7.20**	**6.0**	**6.10**
027	*Ficus callosa*	**7.5**	**8.00**	**5.9**	**6.00**
028	*Baccaurea philippinensis*	**6.0**	**Uprooted**	**6.2**	**Uprooted**
029	*Cratoxylum sumatranum*	**4.0**	**5.00**	**3.8**	**5.35**
030	*Cinnamomum mercadoi*	**3.0**	**Uprooted**	**2.6**	**Uprooted**
031	*Baccaurea philippinensis*	**4.5**	**4.80**	**3.9**	**4.25**
032	*Mallotus korthalsii*	**13.0**	**13.10**	**5.4**	**5.74**
033	*Syzygium striatulum*	**6.0**	**7.50**	**4.2**	**5.45**
034	*Nauclea orientalis*	**5.5**	**5.55**	**4.2**	**4.80**
035	*Nauclea orientalis*	**5.0**	**5.20**	**4.5**	**4.70**
036	*Diospyros pilosanthera*	**3.0**	**3.05**	**4.3**	**4.40**
037	*Ficus nota*	**2.5**	**Uprooted**	**2.0**	**Uprooted**
038	*Baccaurea philippinensis*	**5.0**	**6.80**	**5.0**	**5.27**
039	*Guioa myriadenia*	**5.0**	**6.20**	**5.4**	**5.45**
040	*Aglaia spp*	**7.5**	**Uprooted**	**6.0**	**Uprooted**
041	*Broussonetia papyrifera*	**7.0**	**8.30**	**6.5**	**7.30**
042	*Hopea foxworthyi*	**6.5**	**Cut**	**8.0**	**Cut**
043	*Hopea foxworthyi*	**3.5**	**Cut**	**4.0**	**Cut**
044	Mangkunai	**2.5**	**Uprooted**	**2.9**	**Uprooted**
045	*Solanum erianthum*	**3.0**	**Uprooted**	**2.5**	**Uprooted**
046	*Dipterocarpus philippinensis*	**9.0**	**9.10**	**6.5**	**6.70**
047	*Elaeocarpus candollei*	**2.9**	**3.30**	**2.7**	**4.20**
048	*Cratoxylum formosum*	**3.0**	**3.60**	**3.0**	**4.50**
049	*Ficus callosa*	**5.0**	**5.10**	**6.0**	**6.70**
050	*Ficus callosa*	**8.5**	**8.60**	**5.5**	**5.71**
051	*Cratoxylum formosum*	**6.5**	**Uprooted**	**5.5**	**Uprooted**
052	mangkunai	**3.0**	**5.89**	**3.0**	**4.85**
053	*Dipterocarpus philippinensis*	**9.5**	**13.00**	**5.8**	**6.71**
054	*Macaranga bicolor*	**5.0**	**5.02**	**5.6**	**5.65**
055	*Mangifera altissima*	**7.5**	**10.40**	**6.2**	**6.22**
Plot No. 2 (11.28 m)					
056	*Macaranga bicolor*	**9.2**	**11.30**	**5.0**	**5.03**
057	*Trichadenia philippinensis /Broussonetia papyrifera*	**5.9**	**Uprooted**	**5.0**	**Uprooted**
058	*Dimocarpus longan*	**6.0**	**6.20**	**4.5**	**5.90**
059	*Pterocarpus indicus*	**5.3**	**6.80**	**5.0**	**5.56**
060	*Beilschmiedia glomerata*	**4.5**	**4.53**	**4.0**	**4.10**
061	*Unidentified*	**15.0**	**Uprooted**	**7.0**	**Uprooted**
062	*Baccaurea philippinensis*	**4.0**	**4.10**	**3.5**	**3.55**
063	*Polyscias nodosa*	**5.2**	**Cut**	**3.2**	**Cut**
064	*Polyscias nodosa*	**5.4**	**Cut**	**4.3**	**Cut**
065	*Artocarpus rubrovenius* War	**6.4**	**8.00**	**4.7**	**5.15**
066	*Delonix regia*	**19.8**	**22.10**	**11.42**	**11.52**
067	*Pay-at*	**9.0**	**10.10**	**7.15**	**7.80**
068	*Ficus callosa*	**4.5**	**Uprooted**	**4.5**	**Uprooted**
069	*Pterocarpus indicus*	**9.5**	**14.00**	**9.0**	**9.08**
070	*Artocarpus rubrovenius*	**5.0**	**9.40**	**5.9**	**6.15**
071	*Dipterocarpus philippinensis*	**5.0**	**6.40**	**5.4**	**6.33**
072	*Pandanacea spp.*	**9.0**	**9.20**	**4.0**	**4.60**
073	*Ficus callosa*	**7.0**	**Cut**	**6.7**	**Cut**
074	*Pterocarpus indicus*	**4.5**	**6.40**	**6.0**	**9.91**
075	*Ficus congesta* var. *congesta*	**8.0**	**8.50**	**7.0**	**7.09**
076	*Pterocarpus indicus*	**7.5**	**7.70**	**7.8**	**8.05**
077	*Acacia mangium*	**20.0**	**Cut**	**11.92**	**Cut**

078	*Pterocarpus indicus*	**4.5**	**12.70**	**4.0**	**7.18**
079	*Artocarpus blancoi*	**5.4**	**6.00**	**7.0**	**7.69**
080	*Pterocarpus indicus*.	**12.5**	**17.50**	**8.0**	**8.53**
081	*Calophyllum inophyllum*	**4.2**	**Cut**	**4.0**	**Cut**
082	*Macaranga bicolor*	**5.0**	**13.00**	**3.7**	**4.59**
083	*Antidesma catanduanense*	**7.0**	**9.90**	**7.2**	**7.35**
084	*Palaqium merrillii*	**10.8**	**Uprooted**	**6.3**	**Uprooted**
085	*Microcos stylocarpa*	**5.5**	**Uprooted**	**3.2**	**Uprooted**
086	*Ficus callosa*	**5.2**	**7.60**	**4.0**	**5.46**
087	*Mallotus korthalsii*.	**8.5**	**11.00**	**6.5**	**8.08**
088	*Ficus ampelas* Burm	**8.3**	**Cut**	**5.3**	**Cut**
089	*Ficus ampelas* Bur	**8.0**	**Cut**	**5.5**	**Cut**
Plot No. 3 (17.98 m)					
090	*Baccaurea philippinensis*	**28.0**	**28.40**	**12.45**	**13.49**
091	*Litchi chinensis spp. philippinensis*	**21.0**	**22.80**	**11.37**	**11.74**
092	*Paraserianthes falcataria*	**20.0**	**24.20**	**9.79**	**11.66**

Tables 8.13 and 8.14 provide information on the changes on the other stand parameters that are indicative of growth and yield of trees in both monitoring sites. Relative increases are noted in all the parameters. There were also trees that were lost in the second enumeration. There were strong indications that those trees were heavily damaged by the strong typhoon that passed through both areas during the previous year and consequently died.

Table 8.13 Changes in stand parameters at the monitoring site in Mt. Makiling Forest Reserve (2000-2005)

PARAMETERS	**MEASUREMENTS**	
	2000	**2005**
Maximum height	26.58 m	39.27 m
Maximum diameter	110 cm	110 cm
Mean height of dominant species (*Celtis luzonica* Warb.)	5.53 m	7.46 m
Mean DBH of dominant species (*Celtis luzonica* Warb.)	8.48 cm	10.13 cm
Basal area	5.61 m^2 in a hectare	5.73 m^2 for all trees sampled; 35 m^2 in a hectare
Total volume	90.44 m^3 for all trees	111.55 m^3 for all trees sampled; 697 m^3 in a hectare

Table 8.14 Changes in stand parameters at the monitoring site in Mt. Makiling Forest Reserve (2000-2005).

PARAMETERS	MEASUREMENTS	
	2001	2005
Maximum height	12.45 m	13.49 m
Maximum diameter	28.0 cm	28.40 cm
Mean height of dominant trees		
Pterocarpus indicus	6.35 m	7.09 m
Ficus callosa	5.02 m	5.99 m
Dipterocarps		
Hopea foxworthyii and *Dipterocarpus philippinensis*	5.40 m	5.70 m
Macaranga bicolor	5.49 m	5.52 m
Baccaurea philippinensis.	4.1 m	6.42 m
Mean DBH of dominant trees		
Pterocarpus indicus	8.13 cm	10.4 cm
Ficus callosa	5.92 cm	7.3 cm
Dipterocarps (*Hopea foxworthyii* and *Dipterocarpus philippinensis*	5.96 cm	6.66 cm
Macaranga bicolor	7.04 cm	9.60 cm
Baccaurea philippinensis.	4.38	9.73 cm
Basal area	0.50 m^2	0.55 m^2 for the trees sampled; 3.44 m^2 in a hectare
Total volume	4.01 m^3	4.77 m^3 for the trees sampled; 29.81 m^3 in a hectare
Density	575 trees/hectare	456 trees/hectare

In the regeneration sampling done, some species were lost, but there were new ones recorded. Observations on soil conditions during the two monitoring occasions did not indicate soil acidification. At this stage, the loss of some species and the accretion of new ones can be said to be part of the regeneration dynamics on the forest floor where survival of the fittest is the rule. Tree decline as noted in the sampled trees was basically not evident in both monitoring sites.

Overall, the various manifestations of the two stands between the two monitoring periods did not indicate any adverse conditions. When coupled with the absence of significant rainfall and soil acidification as resulting from the accompanying wet and dry deposition, as well as soil monitoring, it can be said that there is, at the moment no problem on acid rain in the Philippines.

Other Research Activities on Impacts of Acid Rain on Forest Vegetation in the Philippines

Research on the impacts of rainfall acidification on the forests of the country is very nil. To date, there were only two studies reported, both dealing with the sensitivities of certain tree species to various pH levels of the soil under nursery conditions. The first study (Costales, 2004) determined the effects of varying levels of concentrations of sulfuric acid and hydrochloric acid on the growth and development of selected reforestation species in the Cordillera Region of the Philippines. Concentrations for both acids were at 10, 20 and 30 ppm with a control. Species tested *were Pinus kesiya, Eucalyptus camaldulensis, Swietenia macrophylla, Pterocarpus indicus, Acacia auriculiformis*, and *Gmelina arborea*.

Survival, height and diameter growth of seedlings in the nursery were measured every three months. The morphological appearances of the experimental plants were also characterized throughout the

experiment. There were no significant effects observed on all the species when performances as affected by the two types of acids were compared. *P. indicus* exhibited poor growth and survival at lower pH. Reduced height and diameter increments were also observed at lower pH for *G. arborea* while it was only height that was affected in *S. semacrophylla. A. auriculiformis, E. camaldulensis* and *P. kesiya* were not significantly affected by the acid treatments in terms of surivival and growth. Interveinal chlorosis from the mid-portion of the leaves progressing towards the margin and slight curling of young leaves were noted in *P. indicus*. Leaf blight and skeletonizing were also noted.

In another study, Picundo (2005) tested the effects of different pH levels on seed germination, seedling survival, growth and biomass of *Swietenia macrophylla, Samanea saman, Cassia fistula, Gliricidia sepium* and *Wikstroemia lanceolata*. Zero survival occurred in the seedlings of all the species studied at ph 3.0. However, survival of all species did not significantly differ at pH levels of 4.0, 5.0 and 7.0. There were also no significant differences on height and diameter growth of seedlings of all the species at the same remaining pH levels mentioned. *G. sepium* showed the least survival at pH 4.0, while the highest were observed with *W. lanceolata* and *S. macrophylla*.

As of the writing of this report, a dissertation research is being undertaken by a graduate student at the University of the Philippines Los Banos which seeks to determine the sensitivities of three tree species in the Mt. Makiling Forest Reserve to several levels of rainfall acidity in two soil types (Carandang, 2004). Species included in the study are *Madhuca betis, Toona calantas* and *Dysoxylum arborescens*.

8.2.6 State of inland aquatic environment

pH, Electrical conductivity, and Alkalinity. The time plot of pH in Mojicap Lake, for the period 2001-2003, shows a slightly decreasing trend. From a pH of over 8 in 2001, the pH as of 2003 was recorded at 7.7 (Figure 8.5)

The time plot of EC shows an increasing trend for the period 2001-2003 in Mojicap Lake.

The time plot of alkalinity shows an increasing trend for the period 2001-2003 in Mojicap Lake.

Anions. Concentration levels for sulfate, nitrate, and chloride show a slightly increasing trend as shown in the time plot.

Cations. **C**oncentration levels for sodium, potassium, and magnesium showed an increasing trend. Increase in cation levels indicate a gradual input of domestic waste into the Lake.

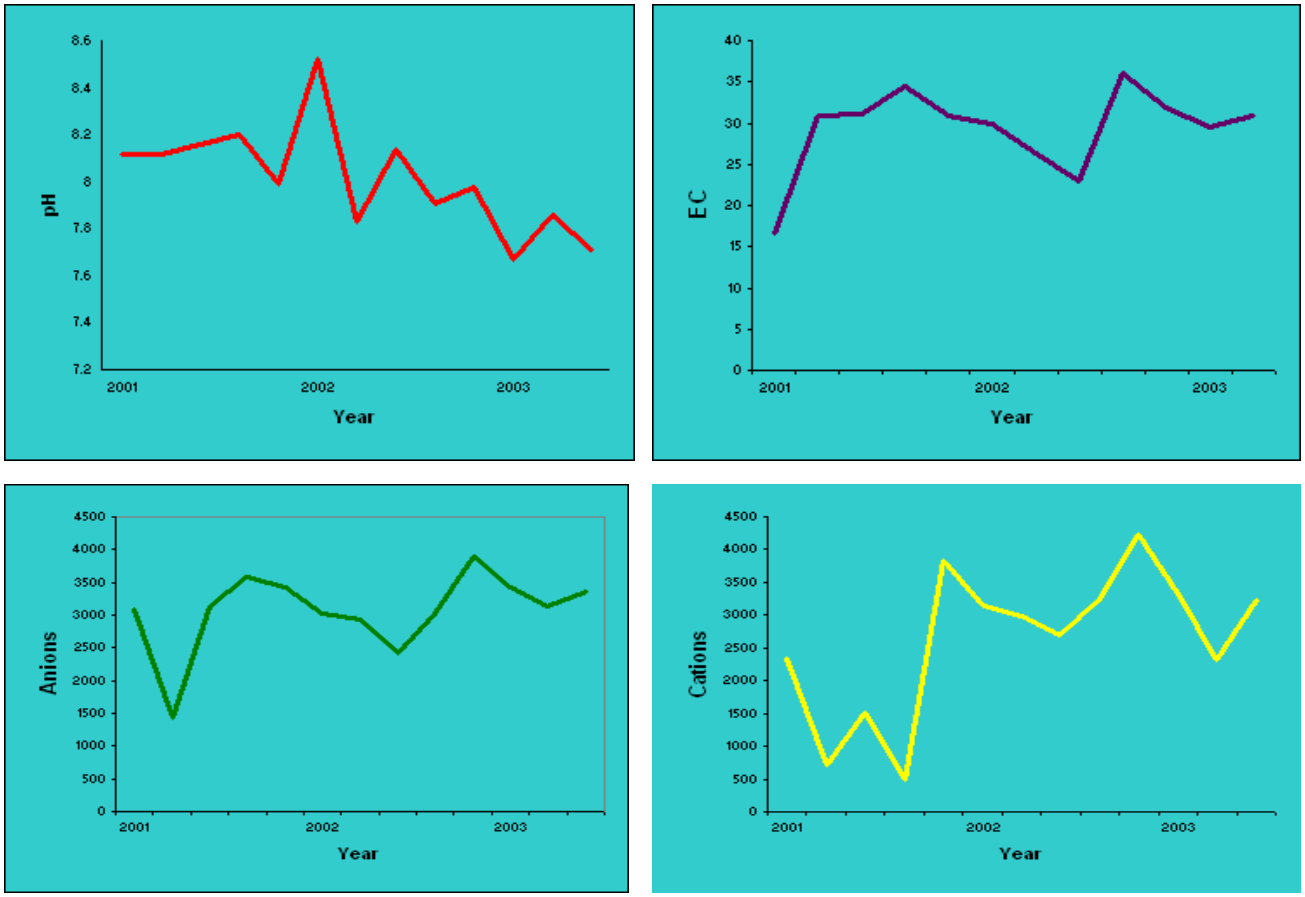

Figure 8.5 Levels of pH, EC, Anions and Cations in Lake Mojicap

Conclusion and Recommendations

The annual weighted mean pH of rainfall in both Los Baños and Metro Manila for the 4-year period is in the range 4.44-5.74. These indicate that in general, rainfall pH in both stations is in the acidic range. However, ecological measurements indicate that soil conditions in the monitoring sites have not become acidified and forest vegetation has not shown any morphological and physiological abnormality or damage related to acid deposition as observed in the two previous monitoring done over a span of four years. There are also no evidences of forest decline in the two monitoring sites, as well as documented occurrences of the same in the past anywhere in the Philippines. In addition, the pH of Mojicap Lake, although exhibiting a slow decline (from the alkaline to the nearly neutral level), has not yet reached the acidic range. Nonetheless, the monitoring should be continued as the impacts are expected to occur in the long term.

In the Philippines, further investigations have to be carried out in line with the thrusts of the proposed five-year medium term plan for the EANET (2006-2010) and other national priorities. The following major activities are suggested:

1. Continuation of the generation of acid deposition monitoring data. These data would include measurements of ambient conditions and the possible effects of acid deposition on ecosystems, materials, and organisms. More efforts should be exerted to generate data and information that are accurate, representative, and complete.

2. Determination of the sources and/or causes of acid deposition including transboundary transport and mechanisms. This implies more priority to be given to emission inventories, modeling, and simulation studies.

3. Conduct of re search studies, examples of which are the following:

a. Qualitative and quantitative studies on the sensitivities to acid rain of more tree species;
b. Effects of increased chemical deposition on seed germination and natural regeneration dynamics in natural forests;
c. Evaluation of the change in element concentration of pollutants on the morphology and physiology of vegetation surrounding power plants in the Philippines;
d. Evaluation of forest tree growth/decline using hemispherical photography;
e. Use of remote sensing techniques for assessing acid deposition effects on tree vegetation;
f. Development of bioindicators of acid deposition effects on forest and agricultural systems;
g. Acid deposition effects on the watershed/landscape;
h. Establishment of threshold limits for different air pollutants relative to forest ecosystem effects.

8.3 Review of national measures against acid deposition

The national measures against acid deposition are categorized into the following:
-Policy and standards;
-Government initiatives;
-Private sector initiatives; and
-Civil society initiatives.

Policy and standards. In June 1999, the Philippine Clean Air Act, also known as Republic Act No. 8749, was signed. This legislation provides the policy and policy direction to improve air quality in the country. Among the major provisions of this law are the following: establishment of airsheds for better and focused air quality management; ambient air quality guidelines, emission standards for stationary pollution sources, emission charges, air quality management fund, clearances and permits for stationary pollution sources, emission standards for motor vehicles, standards for fuels/petroleum products and fuel additives, use of alternative fuels (e.g., liquefied petroleum gas, compressed natural gas, ethanol, biodiesel, etc.), air quality management fund, permitting and licensing system, and fines and penalties.

Of particular relevance to acid deposition are guideline values for various air quality parameters such as sulfur dioxide, nitrogen dioxide, and particulate matter, and emission standards for motor vehicles that include nitrogen oxides.

Government initiatives. In accordance with the Phil. Clean Air Act, the national government has established the mechanisms for implementing the mandated responsibilities provided for in the law. Of particular relevance to acid deposition are air quality monitoring, air quality reporting, public awareness campaigns, anti-smoke belching campaigns, and enforcement of environmental laws at all levels of government, i.e., national, regional, and local levels.

Greening campaigns (for urban areas and the countryside) are also supported by the government to absorb air pollutants and control, among others, the generation/re-suspension of dust and soil particles.

Participation in bilateral and/or multilateral projects/programs (i.e., EANET, ASEAN Haze Agreement, etc.) is also an example of activities that aim to contain acid deposition not only in the country but also the region.

Private sector initiatives. The private sector complies with environmental laws through the adoption of pollution control measures that minimize the emission of acid deposition precursor pollutants. The private sector also sets up and operates emission testing centers to monitor emissions from mobile sources of pollution. The private sector and the general public also promote and patronize mass transit systems to minimize air pollution from motor vehicles. A number of greening initiatives for urban areas and the countryside is being sponsored by the private sector. The private sector also co-sponsors public awareness campaigns on air pollution control/air quality management.

Civil society initiatives. Some NGOs are actively involved in the roadside monitoring of smoke belchers, emission testing, and advocacy for clean air. Some NGOs are also involved in greening activities for urban areas and the countryside.

Reference:

Almanac of Policy Issues, 2002. What is acid rain and what causes it? In: Acid Rain. Environmental Protection Agency.

Carandang, V.Q., 2004. The effects of simulated acid rainfall on the regeneration dynamics of three tree species in the Mt. Makiling Forest Reserve. A dissertation outline submitted to the Graduate School of the University of the Philippines Los Baños, College, Laguna.

Costales, E.F. Jr., Martinez, E.B, 2004. Survey of acid rain occurrence and determination of the effects of simulated acid rainfall on the growth and survival of selected forest tree seedlings. Terminal Report. NRCP Project Np. F-122. Ecosystems Research and Development Service, DENR – Cordillera Administrative Region, Baguio City, Philippines.

EANET. 2000. Technical Documents for Soil and Vegetation Monitoring in East Asia. Adopted at the Second Interim Scientific Advisory Group Meeting of the Acid Deposition Monitoring Network in East Asia (EANET).

Environmental Management Bureau. National Air Quality Status Report (2003-2004).

Haby, V.A., Russell, M.P. Russelle and Skogley, E.O., 1990. Testing soils for potassium, calcium and magnesium. p. 181-227. In: R.L. Westerman (ed.). Soil testing and plant analysis. 3rd Ed. Soil Science Society of America, Madison,WI.

International Rice Research Institute (IRRI). 1986. Area and distribution of acid upland soils in Southeast Asia. In: Annual Report for 1985. IRRI, Los Baños, Laguna, Philippines.

Laboratory Manual in Soil Science 1. 2005. Revised by R.B. Badayos, R.L. Castillo, W.C. Cosico and P.B. Sanchez. Agricultural Systems Cluster, College of Agriculture, UPLB, College, Laguna, Philippines.

First Periodic Report on the State of Acid Deposition in Korea

National Institute of Environmental Research

9.1 Introduction

Recognizing the importance of air pollution resulting from industrialization taken place since 1960s, Korean government has taken comprehensive measures to control the air pollutant emission for the last thirty years or so. Also, a nation air monitoring program was initiated in the middle of 1970s and evolved to the present comprehensive monitoring network comprising 213 urban sites, 11 rural sites, 5 remote sites, 22 traffic sites for the criteria air pollutants as of the year 2004. The importance of acid deposition has been well accounted into the monitoring program by having 31 monitoring stations. Photochemical assessment stations and hazardous air monitoring stations were added to complete the present comprehensive air monitoring network in the early 2000s.

Adverse effects by long range transport of air pollutants have a long history in Korea. Since Asian dusts were first recorded over six hundred years ago in Yi-dynasty, numerous records were found to show its past occurrence and its harmful effects. More importantly, North East Asia, one of the most populated regions in the world, has been experiencing extensive industrialization in the last 50 years or so and therefore a long range transport of man-made air pollutants rapidly has become a great public concern in addition to natural air pollutants, Asian dusts. Therefore, rural sites and remote sites were established to evaluate the effect of long range transport on the air quality along with implementation of the acid deposition monitoring network.

Recognizing that international collaboration is required to effectively resolve trans-boundary air pollutant, Korea has actively promoted to and, if allowed, participated in regional endeavors such as LTP(Long range Transport Project), NEASPEC(North East Asian Sub-regional Program of Environmental Cooperation), EANET(Acid Monitoring Network in East Asia), NOWAP(Northwest Pacific Action Plan), and ACE-ASIA(Asian Pacific Regional Aerosol Characterization Experiment). Each of these regional collaborative efforts has its own objectives and methods in addressing regional air quality problems including long range transport of air pollutants.

EANET has become a leading acid deposition monitoring network in East Asia region since its formal inauguration in the year 2001. Being a founding member of EANET, Korea has been actively involved in various efforts of EANET such as preparation of technical manuals, participation of QA/QC program, and regular monitoring of wet deposition, dry deposition, soil and vegetation. These monitoring data have been regularly submitted to Network Center of EANET to provide information for evaluation of the state of acid deposition as well as impacts on ecosystem in East Asia. In the present National report, characteristics of monitoring stations for EANET were noted in detail and preliminary analysis of monitoring data were described.

9.2 Network Description

Korea nominated three stations, namely, Gwanghwa, Imsil, and Jeju as the acid deposition monitoring sites for EANET. Ganghwa and Jeju were classified into “rural site”, and Imsil were to “remote site” following the Technical Manual of EANET as summarized in Table 9.1. The geographical locations and pictures of the stations were shown in Figure 9.1 and Figure 9.2, respectively. Ganghwa and Jeju sites are located near ocean to minimize anthropogenic emissions. On the other hand, Imsil site is located near the mountain, which was chosen for soil and vegetation monitoring.

Automatic air monitoring devices were used for NO_x, SO_2, O_3 and PM10 mass and the filter pack for PM2.5 compositions and the gaseous species other than those measured by automatic instruments as noted in Table 9.2. Together with monitoring of chemical species, meteorological parameters such as wind speed, wind direction, air temperature, relative humidity, and solar radiation were observed by automatic weather stations installed at the sites or nearby the meteorological observatories.

Table 9.1 The Characteristics and Location of Monitoring Sites in Korea

Name of sites	Site Classification	Latitude	Longitude	Height above the sea level
Ganghwa	Rural	37° 42'N	126° 17'N	102m
Imsil	Remote	33° 18'N	126° 10'N	50m
Jeju	Rural	35° 36'N	126° 11'N	-

Table 9.2 The Selected Monitoring Parameters and Methods in Korea

Name of sites	Wet Dep.	Dry Dep.			
		Automatic			Filter Pack
		SO_2, NO_x	O_3	PM	
Ganghwa	O	O	O	O	O
Imsil	O	O	O	O	O
Jeju	O	O	O	O	O

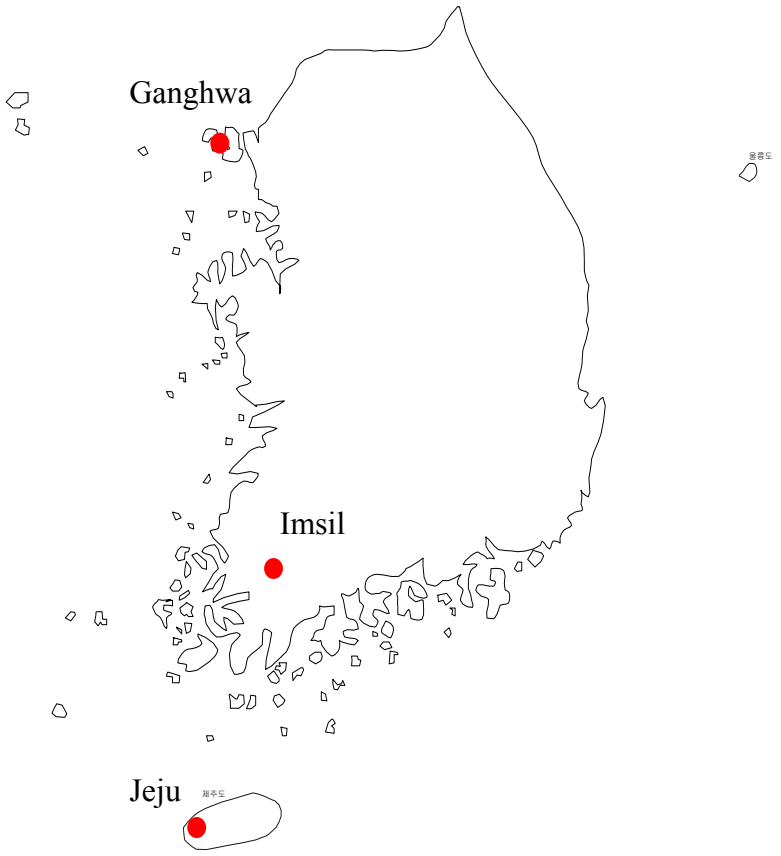

Figure 9.1 The Geographical Locations of EANET Sites in Korea

(a)

(b)

(c)

Figure 9.2 Pictures of Monitoring Sites in Korea ((a) Ganghwa, (b) Imsil, (c) Jeju)

9.3 Meteorological Condition of Monitoring Sites

Korea has a distinctive four seasons, characterized by temperatures, precipitation amounts and wind directions. As shown in Figures 9.3, 9.4, 9.5, August is the hottest month and January is the coldest month. The differences between the highest and lowest monthly averaged temperatures range from 25 to 30 degree Celsius. Precipitation concentrated in the summer raining season which starts from a middle or end of June and lasts approximately a month. Also, an appreciable precipitation may occur in August due to localized fast floods or typhoon. Although the wind direction varies from one site to another, it generally appears from northwest to north except summer during which southward winds are frequently observed. Therefore, all three sites chosen for EANET are susceptible to continental outflows of air pollutants.

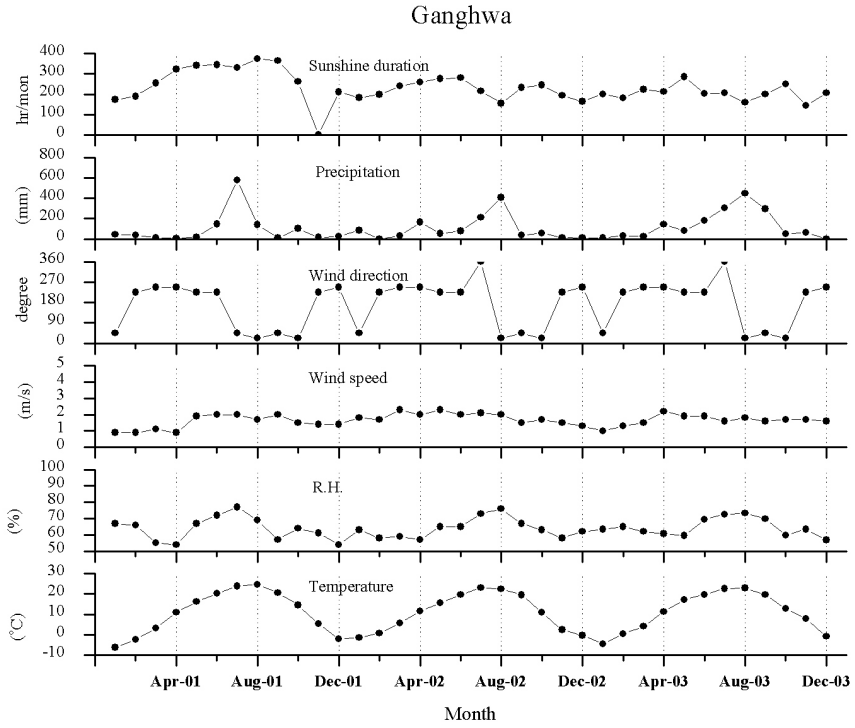

Figure 9.3 Monthly variation of meteorological data at Ganghwa

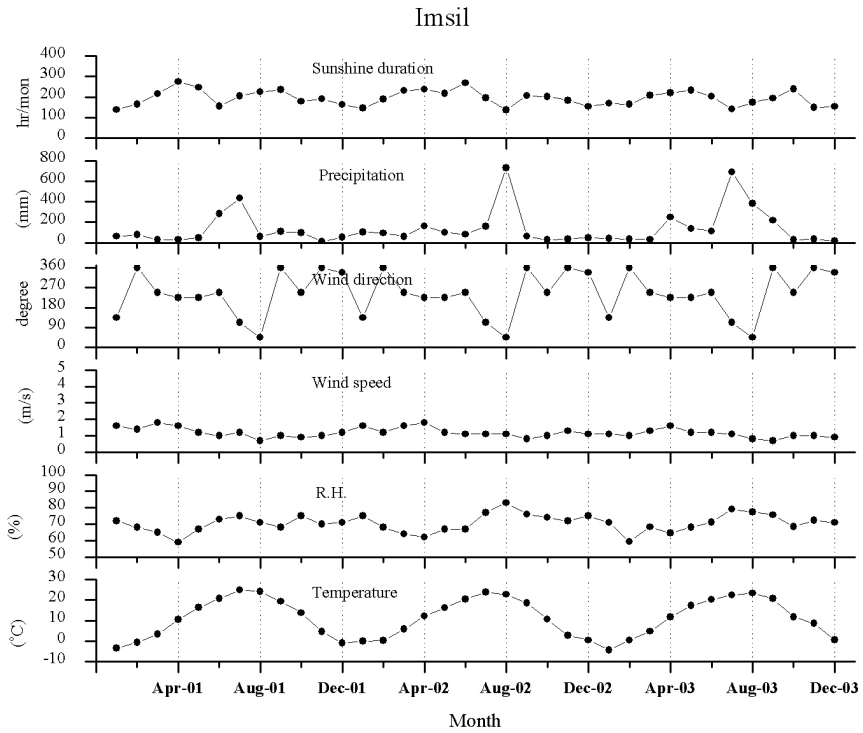

Figure 9.4 Monthly variation of meteorological data at Imsil

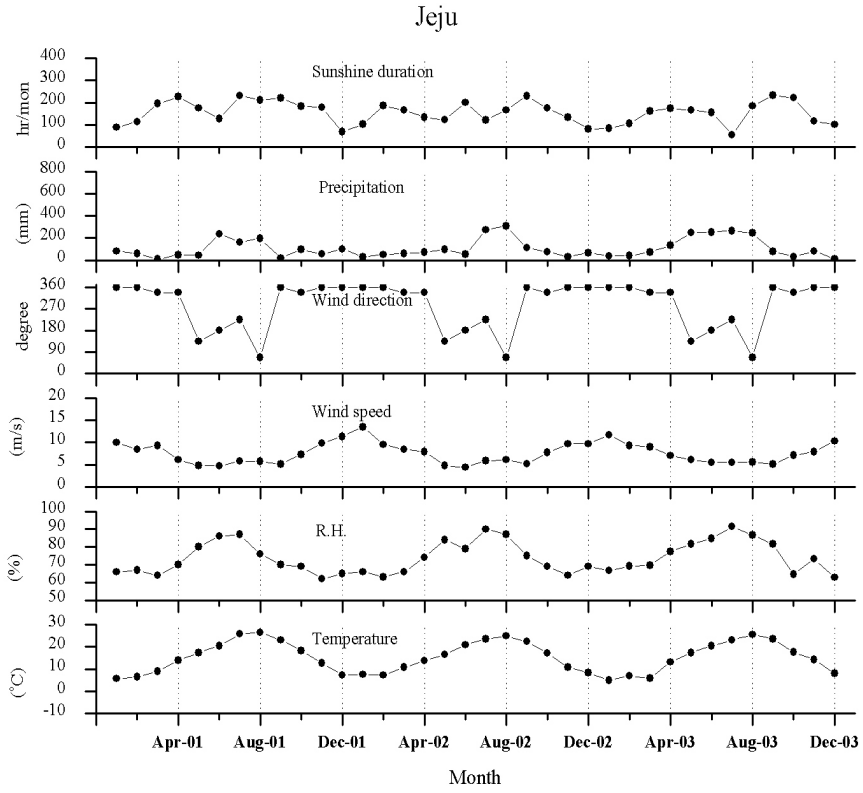

Figure 9.5 Monthly variation of meteorological data at Jeju

9.4 Wet Deposition Monitoring

9.4.1 Method

Acid deposition monitoring in Korea has been carried out according to the common methodologies specified in the "Technical Documents for Wet deposition Monitoring in East Asia"(hereafter denoted as Manual) in order to obtain the equivalent quality of monitoring data. Wet-only samplers shown in Figure 9.6 were used and Precipitation samples were collected on a daily basis at 3 sites as listed in Table 9.3. Collected samples without biocides were shipped to laboratories and stored in a cooling box to preserve the sample composition.

Rainwater major constituent were analyzed according to analysis by Manual as shown in Table 9.4. Ion Chromatography is a major analytical method for chemical analysis of anions and Atomic Absorption Spectrometry for Na^+, K^+, Ca^{2+}, and Mg^{2+}, and Spectro-photometric method for NH_4^+. All the data were checked using ion balance and conductivity agreement by calculating ion balance (R_1) and conductivity agreement (R_2). If a sample or individual datum has problems including "insufficient sample volme" or "low precision", the flags corresponding to the problems were attached to the data, following "Quality Assurance/Quality Control (QA/QC) Problem for Wet Deposition Monitoring in East Asia" (2000).

AQUA(RM8300,
Japan) (Ganghwa,

APMKOREA
(ARS101,Korea)

Figure 9.6 Pictures of Wet deposition monitoring Samplers

Table 9.3 Sampling Method for Wet Deposition Monitoring in Korea

Name of sites	Site Classification	Sampling Frequency	Starting Month
Ganghwa	Rural	Daily	March '99
Imsil	Remote	Daily	April '99
Jeju	Rural	Daily	January '99

Table 9.4 Analytical Method for Wet Deposition Monitoring in Korea

Name of sites	Site Classification	Anion Analysis	Cation Analysis	
			NH_4^+	Other Cations
Gwanghwa	Rural	IC	SP	AAS
Imsil	Remote	IC	SP	AAS
Jeju	Rural	IC	SP	AAS

(Note) AAS: Atomic Absorption Spectrometry, IC: Ion Chromatography, SP: Spectrophotometry

Figure 9.7 displays the sum of major anion and cation ratio and SO_4^{2-} and NO_3^- ratio at each daily sample. NH_3^+ and Ca^{2+} were selected as major cations and SO_4^{2-} and NO_3^- were selected as major anions. The sum of SO_4^{2-} and NO_3^- concentrations appeared to be slightly larger than the sum of NH_3^+ and Ca^{2+} because of other anions, mainly Na^+ and Mg^{2+} derived from sea salts. The ratios of major anions and cations were constantly checked as a key parameter for the ion balance and for rain water characteristics. In addition, SO_4^{2-} and NO_3^- ratios were deemed as measures of emission characteristics of sulfur and nitrogen containing species and checked together with major anion and cation ratios.

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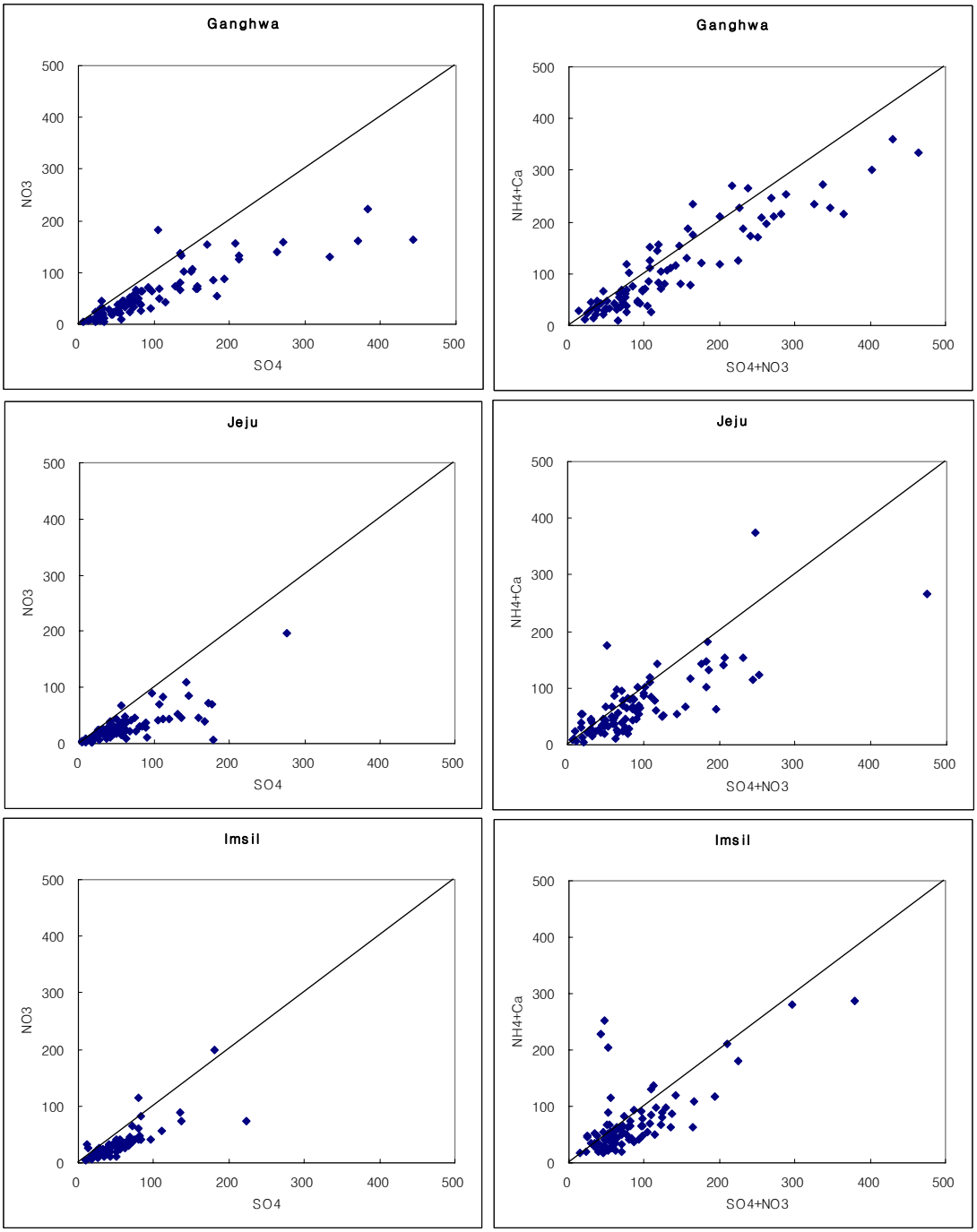


Figure 9.7 Ion balance check in Gwanghwa, Imsil and Jeju (Unit: ueq/L)

9.4.2 Results of Wet Deposition Monitoring

pH determines the acidity of rain waters and therefore is regarded as a major parameter characterizing the acid rain. Figure 9.8 shows the precipitation frequencies and amounts in the three EANET sites in Korea from 2001 to 2003. Both the most frequent and the largest precipitation occurred for the pH of 4.6~5.0 in Ganghwa and Jeju, both of which sites are located in the seaside region. The rain waters collected in Imsil site, located inland, appeared less acidic when the precipitation frequencies and amounts were compared with the other two sites.

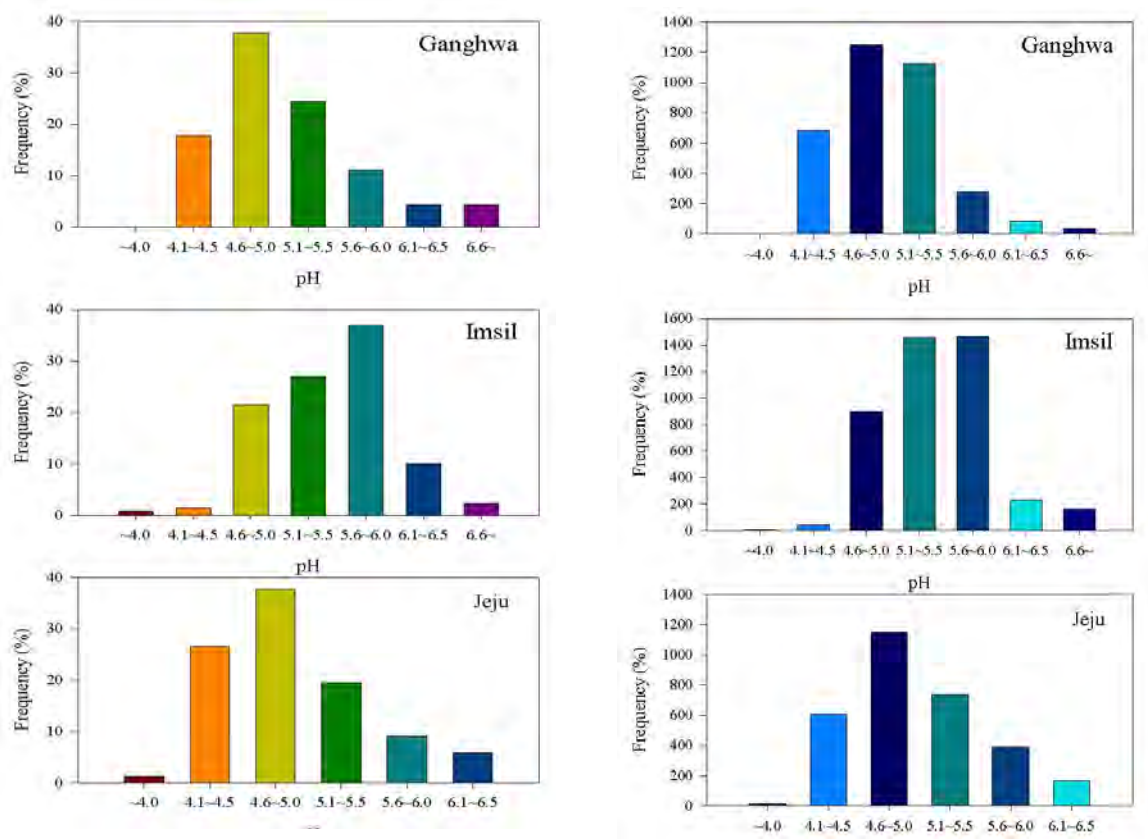


Figure 9.8 Precipitation Frequency and amount classified by pH

Seasonal variations of precipitation, EC, and pH were shown in Figure 9.9. Precipitation concentrates on summer, rainy season in Korea. A large amount of precipitation lowered EC along with less air pollutant emissions from heating, in summer. Despite of having the lowest EC, summer is not always the season for the highest pH. The pHs in Ganghwa and Imsil had the maximum value in spring instead of summer probably due to calcium carbonate contained in Asia dusts, which mainly occur during spring in North East Asia.

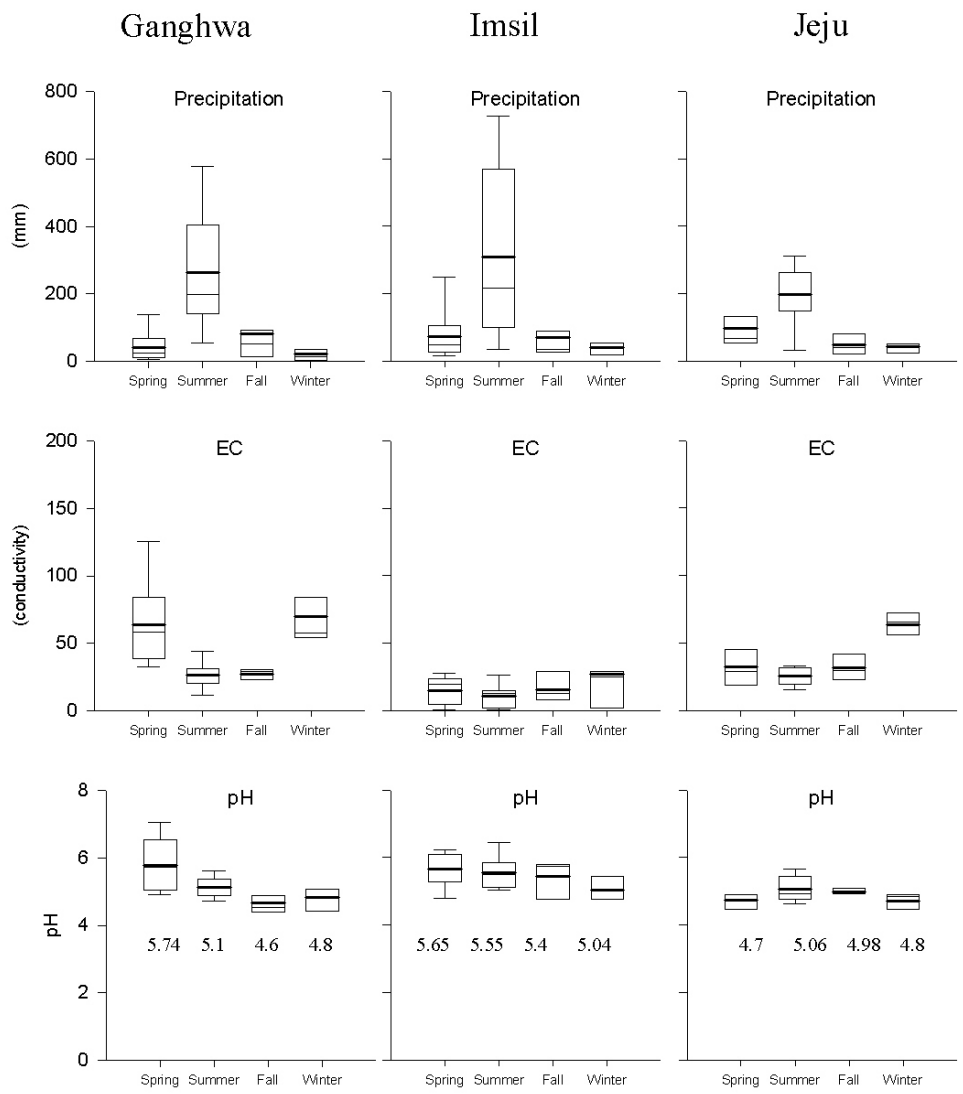


Figure 9.9 Seasonal variation of precipitation, electronic conductivity and pH

Figures 9.10, 9.11 and 9.12 show seasonal variations of major ionic species concentrations and wet deposition amounts. The heavy precipitation during summer as discussed above diluted ionic species concentrations for rain waters to have the lowest concentration in summer. Despite of the lowest ionic concentrations, the wet deposition amounts were still the largest in summer again due to the large amount of precipitation. The SO_4^{2-} and NO_3^- concentrations were high in winter due to high fuel demand for heating in Imsil and Jeju. This influence of heating appeared less distinctive in Ganhwa, indicating existing of industrial influence. Ca^{2+} concentration in spring in Gangwha and Imsil exhibited considerable variability in spring due to Asian dust as noted earlier.

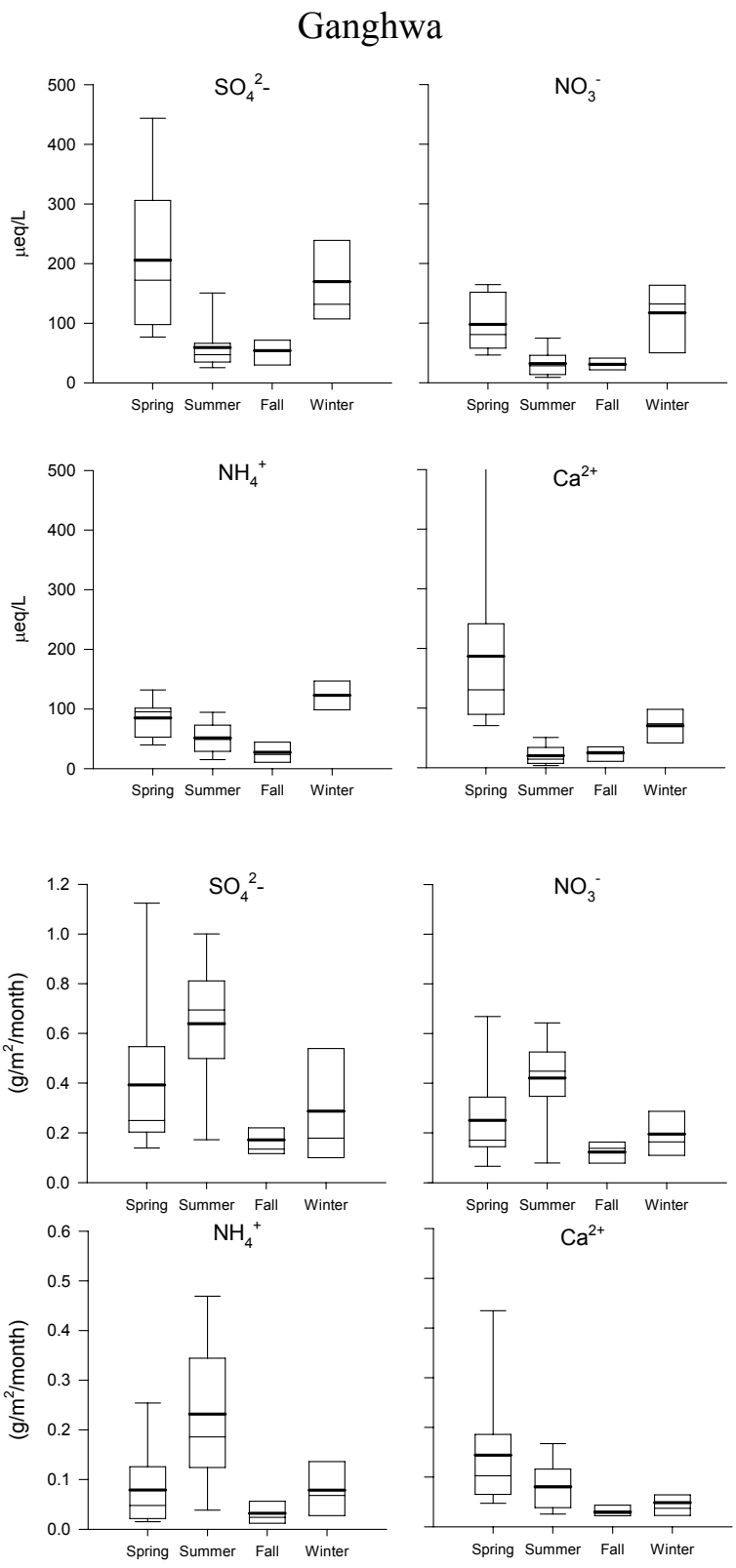


Figure 9.10 Seasonal variation of wet deposition (equivalent concentration) at Ganghwa

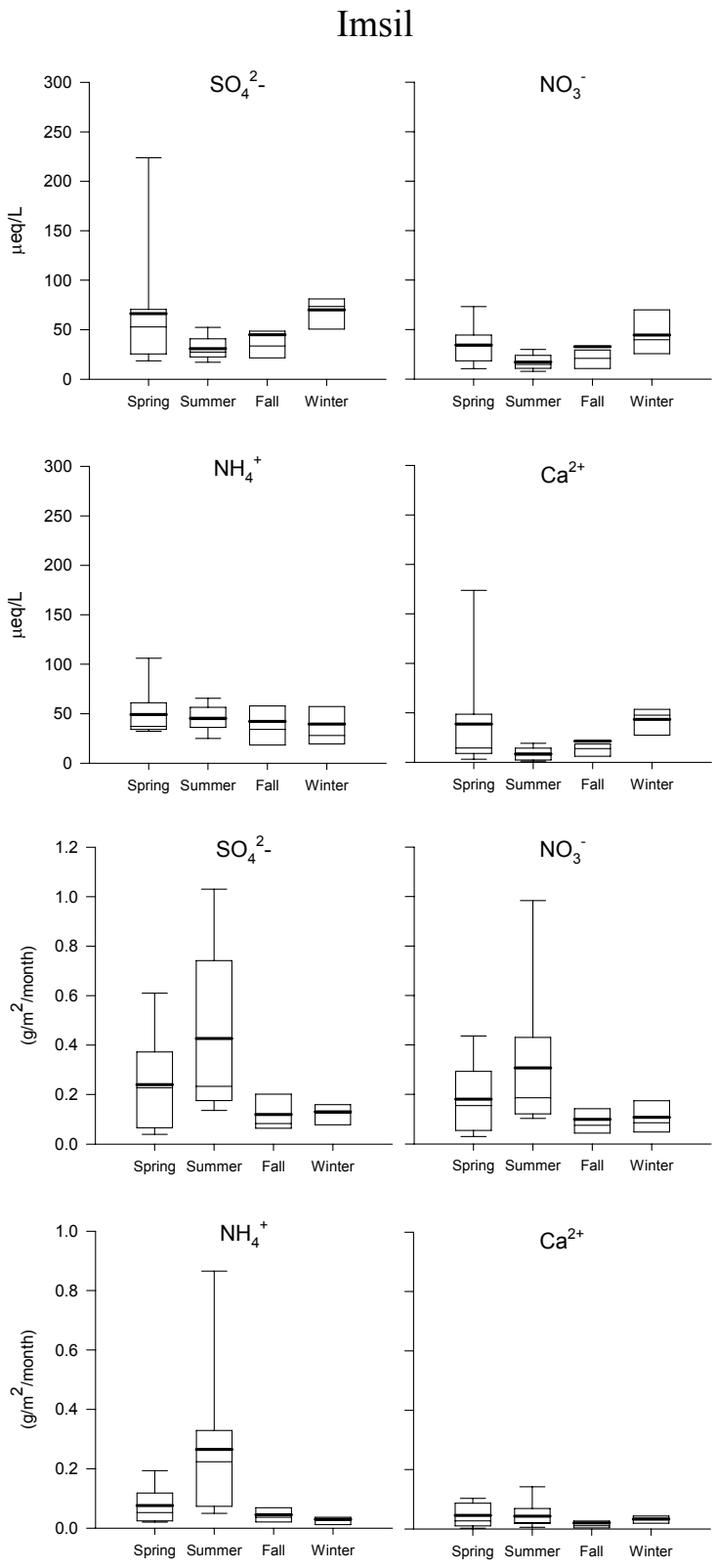


Figure 9.11 Seasonal variation of wet deposition (equivalent concentration) at Imsil

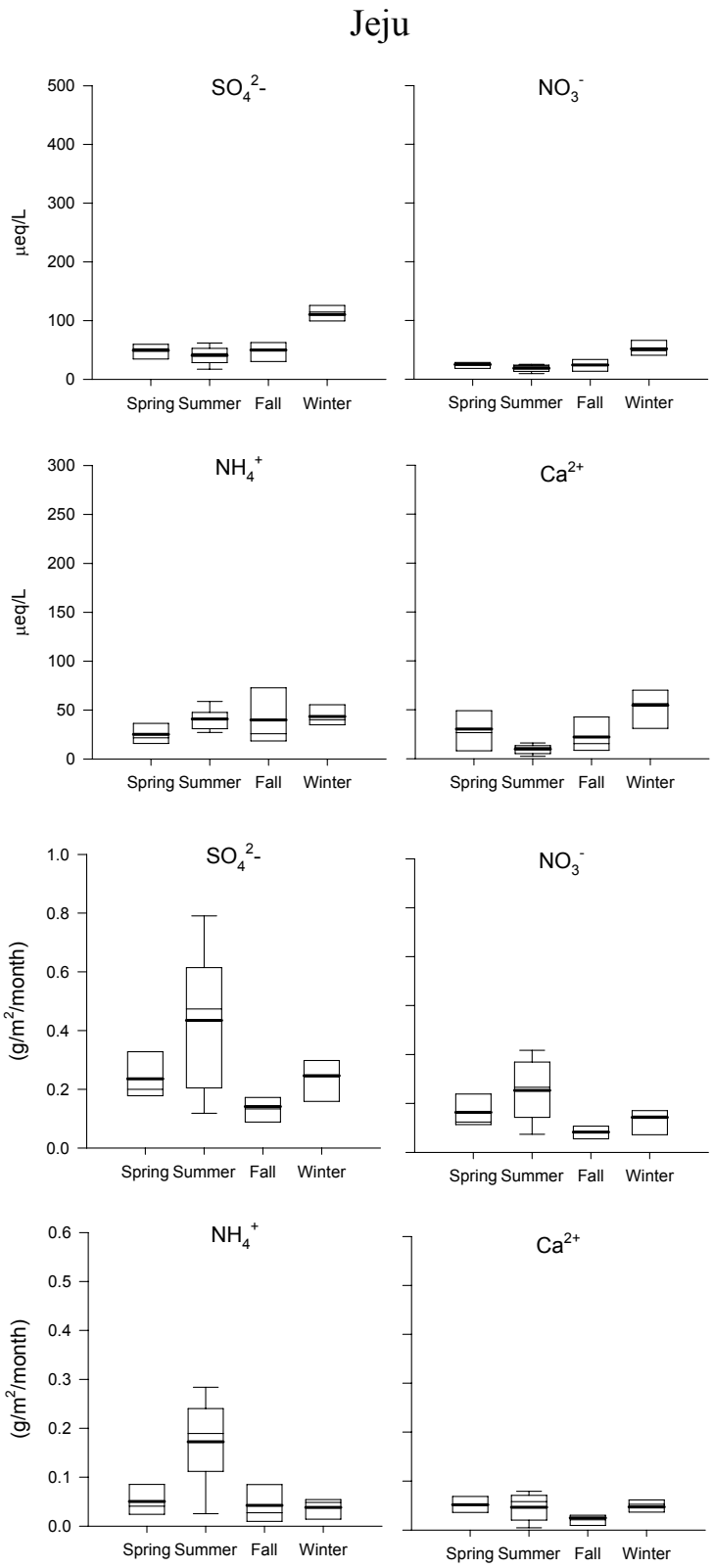
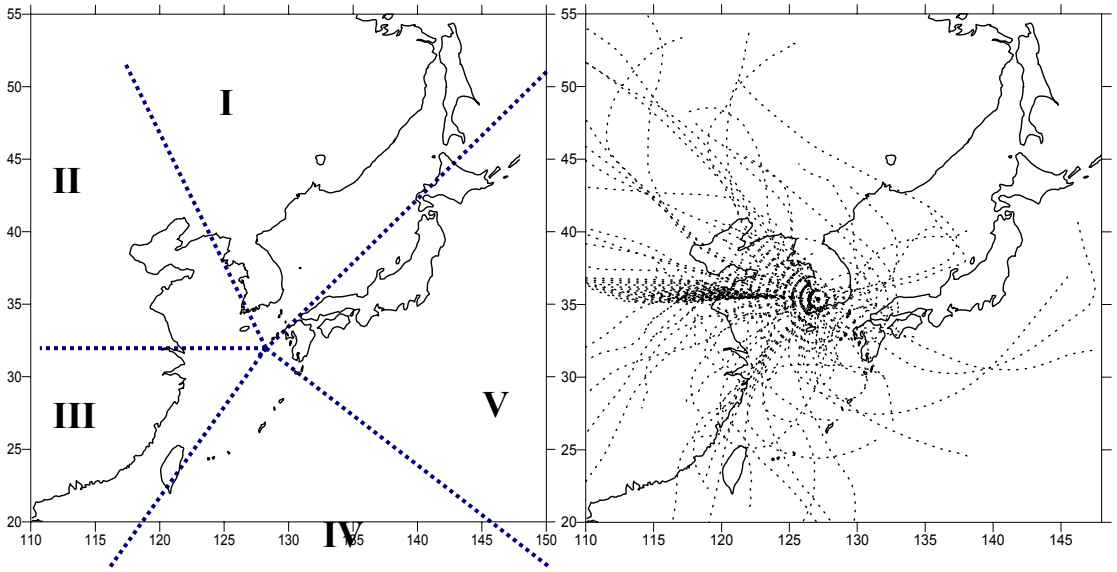


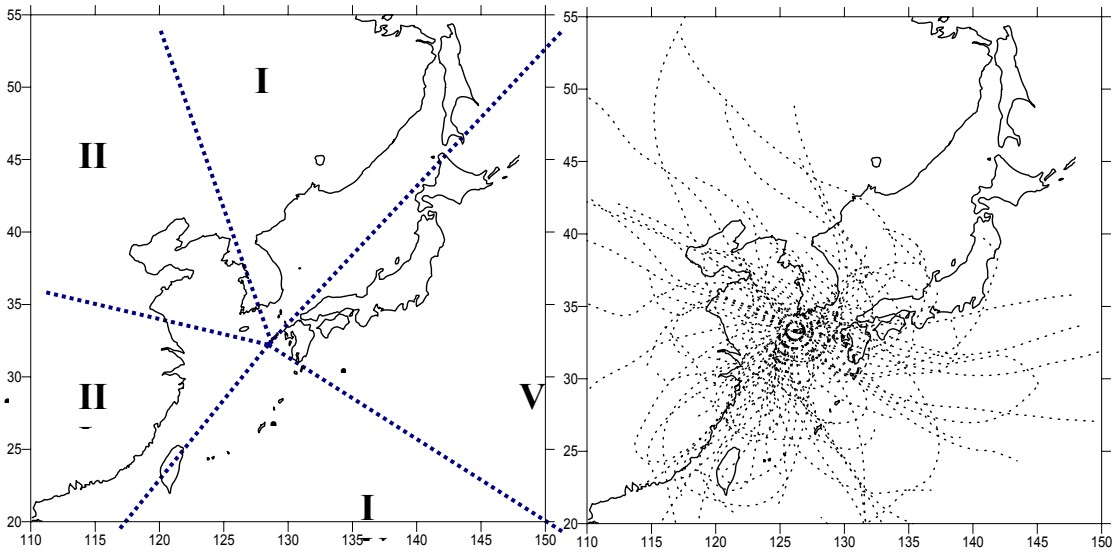
Figure 9.12 Seasonal variation of wet deposition (equivalent concentration) at Jeju

Long range transport plays important role in determining the chemical composition of rain water. A 3 day backward trajectory was calculated for each precipitation event with high ionic concentrations to find out where the air mass came from. The source region was divided into 5 region as shown in Figur e 9.13. Gangwha was excluded in this analysis because of its close proximity to Seoul metropolitan area, which is one of the largest mega-city areas in Asia.

The air masses of Imsil were trace back to section I, representing Northern China, for the half of episodic cases. Contrarily, section II, III, IV all contributed rather equally to the air masses in Jeju site. However, it may be noted that acid deposition greatly differs from phenomena associated by purely gaseous and particulate species in atmospheric processes and therefore the trajectory analysis should be interpreted very carefully.



a)



(b)

Figure 9.13 Classification of domain and 3-day backward trajectory (1000m)((a) Imsil, (b) jeju)

Table 9.5 Frequency of backward trajectory (1000m) in total and episodic cases by regional groups

(Unit: %)

Name of sites	Region	Total	Episodic cases		
			SO_4^{2-} (>100ueq/L)	NO_3^- (>50ueq/L)	NH_4^+ (>100ueq/L)
Imsil	I	8.9	16.7	10.0	0.0
	II	25.6	66.7	50.0	45.5
	III	27.8	0.0	10.0	9.1
	IV	23.3	16.7	10.0	27.3
	V	14.4	37.5	20.0	18.2
Jeju	I	8.2	8.7	10.0	0.0
	II	13.4	26.1	20.0	12.5
	III	17.5	21.7	30.0	50.0
	IV	41.2	34.8	30.0	25.0
	V	19.6	8.7	10.0	12.5

9.5 Dry Deposition Monitoring

9.5.1 Method

The priority of the chemical species, SO_2, NO_2, O_3, and PM_{10} mass were monitored by automatic instruments as directed by "QA/QC Program for the Air Concentration Monitoring in East Asia (2001)" as noted in Table 9.6. Three stage $PM_{2.5}$ filter pack sampler, shown in Figure 9.14, were used to monitor gaseous acids and bases, HNO_3, HCl, NH_3, and particulate components(SO_4^{2-}, NO_3^-, Cl^-, Na^+, K^+, NH_4^+, Ca^{2+}, Mg^{2+}).

Table 9.6 Sampling Method and Parameter for Dry Deposition Monitoring

Name of sites	Characteristics of sites	Method	Parameter
Ganghwa	Rural	AT	SO_2, NO_2, O_3, PM_{10}
		FP	PMC in $PM_{2.5}$
Imsil	Remote	AT	SO_2, NO_2, O_3, PM_{10}
		FP	PMC in $PM_{2.5}$
Jeju	Rural	AT	SO_2, NO_2, O_3, PM_{10}
		FP	PMC in $PM_{2.5}$

(Note) AT: Automatic monitor, FP: Filter pack, PMC: particulate matter components

URG (3 stage $PM_{2.5}$ Sequential Sampler, USA)

Figure 9.14 Instruments used for Dry deposition monitoring

9.5.2 Results of Dry Deposition Monitoring

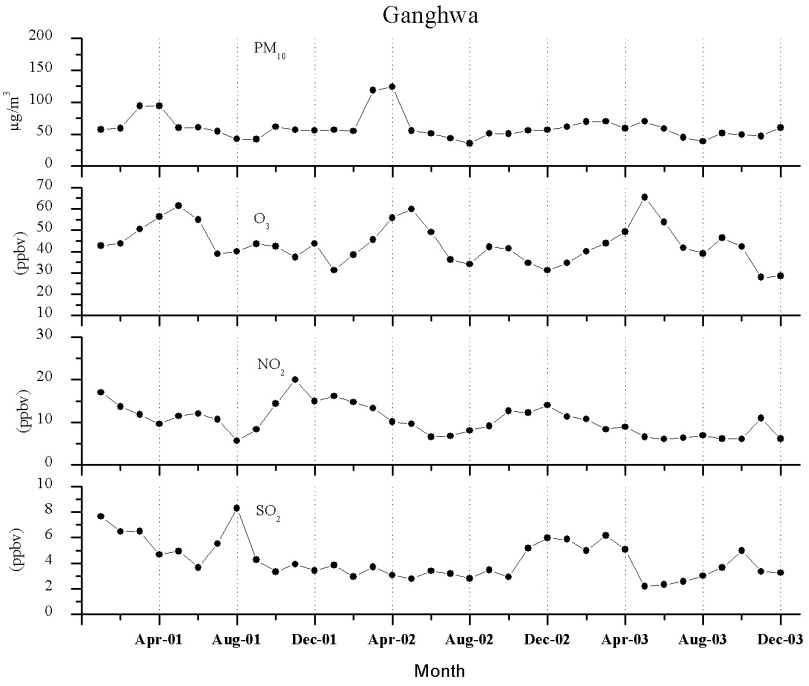


Figure 9.15 Monthly Averaged Concentrations of SO_2, NO_2, O_3 and PM_{10} at Ganghwa

Monthly averaged concentrations for SO_2, NO_2, O_3, and PM_{10} mass were depicted in Figures 9.15, 9.16, and 9.17. The monthly averaged concentrations of PM_{10} ranged from 21 ㎍/㎥ to 186 ㎍/㎥ with the period average of all three sites equal to 53 ㎍/㎥. The high PM_{10} concentrations were observed mainly in March or May, which constitutes a season of Asian dust. The monthly averaged O_3 concentration in Gangwha behaved similarly to that in Seoul, that is, it reached maximum in May due to its close proximity to Seoul. Contrarily, seasonal variation of O_3 concentrations were not observed in Imsil and Jeju sites. SO_2 and NO_2 concentrations were the lowest in Jeju site and the highest in Ganhwa site, indicating that Jeju site is the remotest site among three sites considered here.

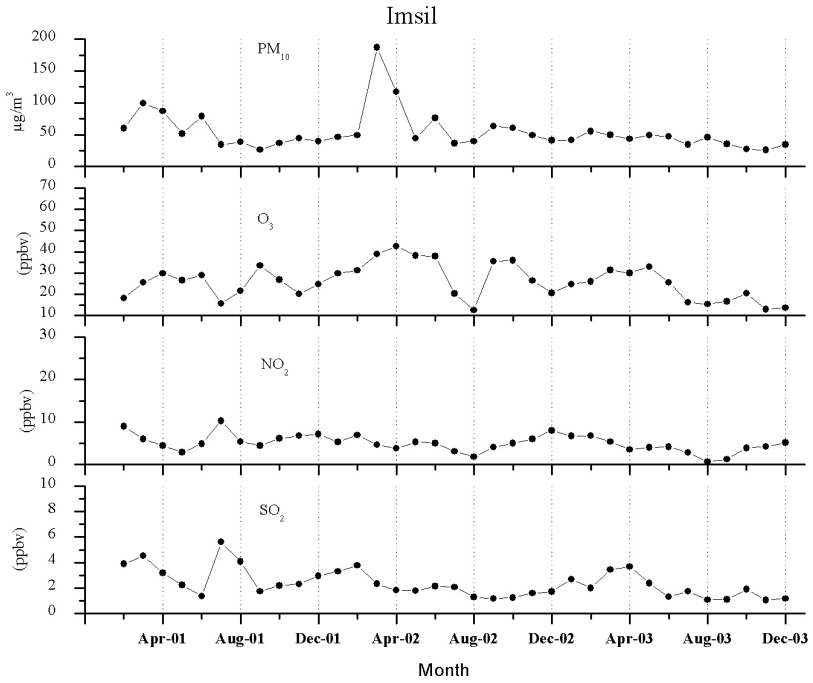


Figure 9.16 Monthly Averaged Concentrations of SO_2, NO_2, O_3 and PM_{10} at Imsil

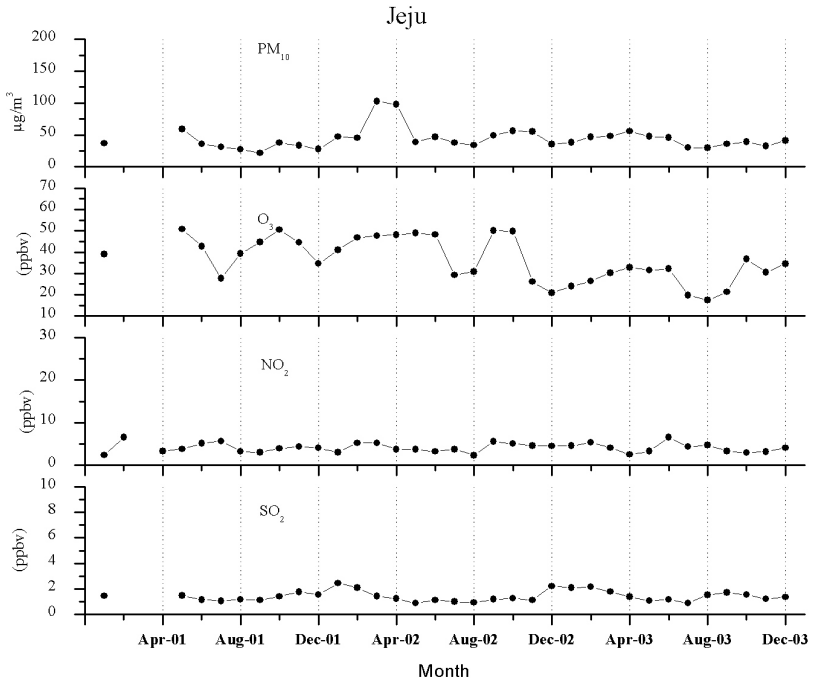


Figure 9.17 Monthly Averaged Concentrations of SO_2, NO_2, O_3 and PM_{10} at Jeju

Chemical composition analysis on $PM_{2.5}$ collected by filter packs stated that SO_4^{2-} and NH_3^+ were major chemical constituents for Imsil and Jeju sites. And NO_3^- was observed to have a concentration comparable to SO_4^{2-} and NH_3^+ only in Ganghwa site. As shown in Figure 9.18, the seasonally averaged SO_4^{2-}, NH_3^+ and NO_3^- concentrations did not vary much except Imsil site. The SO_4^{2-} and NH_3^+ concentrations exhibited a high variability in summer and fall. Characteristics of seasonal variations were observed differently from one site to another, requiring further studies to identify the cause of them.

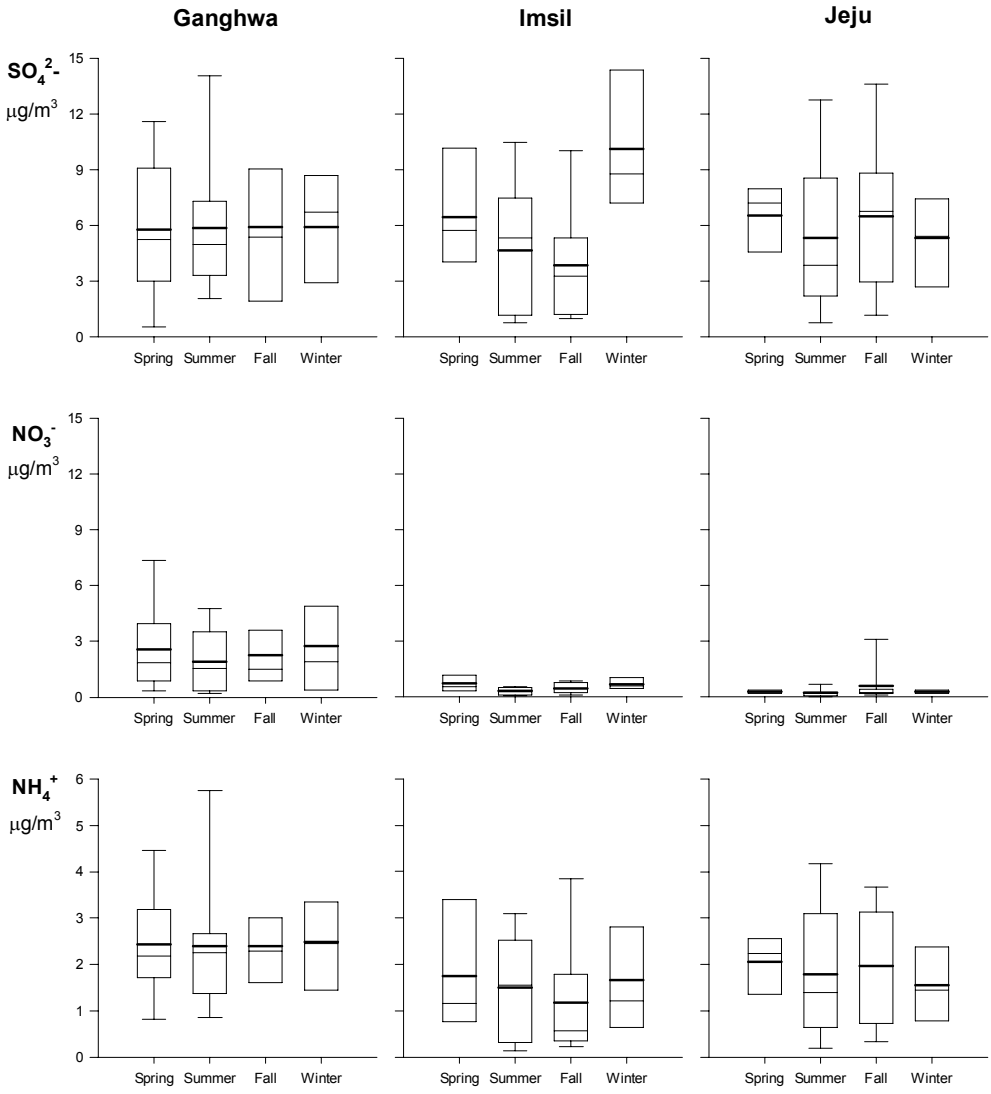


Figure 9.18 Seasonal variation of major chemical species concentrations in $PM_{2.5}$ at sites.

National Assessment of the State of Acid Deposition monitoring

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10.1 Introduction

Russian Federation has been participating in EANET since the 1998 with start of activities during the preparatory phase. The experts from several governmental authorities and institutes related to environmental monitoring took part in expert meetings and workshops with contributing to the preparation of technical documents and guidelines for monitoring operation and chemical analysis.

Russian Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET) was designated as the National Focal Point at the regular phase of EANET and took responsibility on coordination relevant activities. Institute of Global Climate and Ecology (IGCE) of Roshydromet and Russian Academy of Sciences (RAS), Moscow was designated as Russian National EANET Center and Limnological Institute of RAS (LIN), Irkutsk was designated as National EANET Data Center.

Russian EANET monitoring stations were established in the South-Eastern parts of Asian Russia including Far East region. Together with LIN they produced the measurement data in accordance with unified EANET programs using the manuals and technical documents adopted by the Network. Besides them there is the number of the monitoring stations of national networks operated under the management of Roshydromet. Their programs also include the sampling and measurement of atmospheric deposition of airborne pollutants. The review of the state of national monitoring activities related to acid deposition over the whole Asian part of Russia is also presented below.

10.2 Basic Information on National EANET Monitoring Activities

10.2.1 Monitoring stations

Two regions of Asian territory of Russia were chosen to be suitable for national EANET monitoring activities: South-East Siberia and Far East. Three stations in East Siberia (Irkutsk region) were established during the preparatory phase and had been working since the 1998. There is one station been established in Far East (Primorskiy region, near Vladivostok) during the regular phase (Fig. 10.1).

According to the EANET approaches two soil and vegetation monitoring sites (the sensitive and the control) were established in line with adopted methodology in the surround (within the radius of 50 km) of each deposition sampling point. Two surface water objects were also selected for inland aquatic environment monitoring (one is in East Siberia and one in Far East) (Table 10.1).

The geographical conditions of the regions over Asian Russia covered by EANET monitoring are different. East Siberia is represented by three sites: Irkutsk, Listvyanka, and Mondy. Their physical-geographical conditions are differed as well as the levels of anthropogenic emission to the atmosphere.

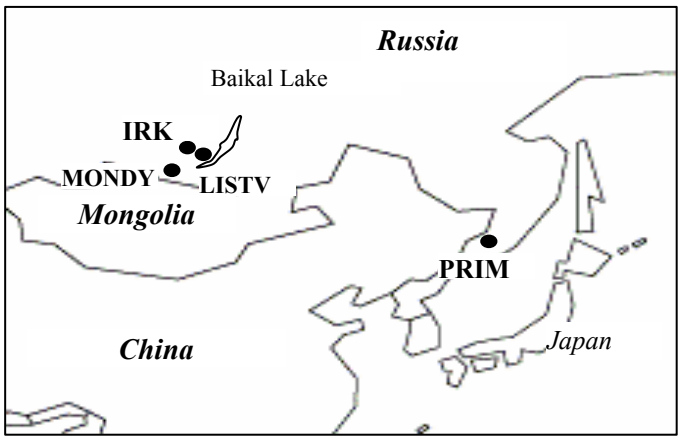


Fig10.1 The location of Russian EANET monitoring sites.

Irkutsk (urban site) is located within a large industrial city of Eastern Siberia and affected by many types of anthropogenic atmospheric emission and loading. The city is situated inside the broad valley of Angara river which flow from Lake Baikal and partly exposed by the emission transport from other industrial towns downstream.

Listvyanka (rural) is located on the south-west shore of Lake Baikal, 70 km far to southeast of Irkutsk, near the inlet of Angara river. The winds of NW and SE directions (along Angara river) are prevailed for both Irkutsk and Listvyanka sites due to influence of valley relief.

Mondy (remote) is situated in the background region (mountain area near Russian-Mongolian border), at least 200 km away from any large anthropogenic sources.

The rural monitoring station "Primorskaya" was established in Far East region in 2002 to monitor a long-range transport of pollutants through Asian part of Russia towards the Pacific. Primorskaya station is situated on branch of the Southern Sikhote-Aline Ridge, 25 km southeast of Ussuriisk city, nearby the Ussuriisky biosphere reserve.

Table 10.1 Some geographical characteristics of Russian EANET monitoring stations.

Region, site name, classification and geographical position.	**Topography; landscape**	**Dry/wet deposition**	**Soil and vegetation**	**Inland Aquatic**
East Siberia (Irkutsk region):				
1. Mondy (remote) (51^0 40'; 101^0 00'; 2005 m)	Upper slope (N) of mountain; forest	+	+	-
2. Listvyanka (rural) (51^0 51', 104^0 54', 700 m)	Hilly terrain, peak of the hill; forest.	+	+	+
3. Irkutsk (urban) (52^0 14'; $104^0$15'; 400 m)	Slope (NE) of broad valley, city.	+	+	-
Far East (Primoskiy region)				
4. Primorskaya (rural) (43 ^{0}42'; 132 ^{0}07'; 84 m)	Plane, forest	+	+	+

10.2.2 Sampling and measurement

10.2.2.1 Sampling

Wet deposition. Automatic wet-only samplers are used to collect precipitation during the period of rainfall. However during winter season an automatic wet-only sampler has low sampling efficiency

(for solid snow precipitation) and therefore manual sampling is the only way to collect precipitation. Snow is sampled every precipitation event as well as rain. Measurement parameters for rain and snow water are the same: pH, EC, NH_4, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, HCO_3^- and Cl^-.

Dry deposition. Four stage filter pack method is used for sampling. At urban and rural stations samples are taken weekly, at background station (Mondy) – bi-weekly. Air flow rate is about 1 liter/minute. Measured substances are gases (SO_2, HC1, HNO_3 and NH_3) and water-soluble fraction of particulate matter (NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, HCO_3^- and Cl^-). Besides the above-mentioned parameters ozone is also measured at Mondy station using 1006-AHJ in the frame of cooperative research with JAMSTEC, Japan. Sampling interval for ozone is 10 minutes. Meteorological parameters such as air temperature and humidity, wind direction and velocity are observed directly at sampling sites or obtained from nearest meteorological station.

Soil and vegetation. Soil and vegetation are sampled once every 3-5 years. Measured parameters are:

- for soil: pH (H_2O), pH (KC1), exchangeable Na^+, K^+, Ca^{2+}, Mg^{2+}, Al^{3+}, H^+, exchangeable acidity, ECEC , carbonate, T-C, T-N . Sampling interval: Every 3-5 years;
- for vegetation: Observation of tree decline, description of trees, under-story vegetation survey and photographic record. Interval: every 3-5 years.

Inland aquatic environment. Monitoring objects are represented by two rivers: Pereemnaya river (East Siberia) and Komarovka river (Far East). Measurement parameters are water temperature, pH, EC, alkalinity, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, NO_3^-, transparency, water color, DOC, NO_3^-, PO_4^{3-}. Sampling interval: four times per year.

10.2.2.2 Measurement

Two chemical laboratories analyze collected samples: 1. Laboratory of Hydrochemistry and Atmospheric Chemistry, Limnological Institute of SB/RAS, Irkutsk (all mandatory items) and 2. Primorsky Monitoring Center of Russian Hydrometeorological Service, Vladivostok (wet deposition and surface water samples).

In Limnological Institute the following analytical methods are used to measure ion/element concentrations in atmospheric precipitation, inland water, extracts from aerosols and soils: atomic absorption (AAS) and flame spectrophotometry for Ca^{2+}, Mg^{2+}, Na^+, K^+; spectrophotometry for NH_4^+, and high-performance liquid chromatography (HPLC) - for anions HCO_3^-, SO_4^{2-}, Cl^-, and NO_3, using procedures developed in the Limnological Institute SB RAS.

Primorsky Monitoring Center uses methods of spectra-photometry, titration and atomic absorption.

10.2.3 QA/QC activities

QA/QC programs are carried out at all stages of the monitoring activities. A quality of the analytical data was regularly controlled by means of ion balance calculations and by means of comparing the measured and the calculated electrical conductivities.

The laboratories are involved in the Network Center's inter-laboratory comparison projects (on wet deposition, soil and inland aquatic environment monitoring; Report..,1999; 2000; 2001; 2002; 2003; 2004, 2005). Another inter-laboratory comparison project (on wet deposition) was realized in the frame of Global Atmospheric Watch (GAW) under the aegis of World-wide Meteorological Organization (WMO).

10.3 State of acid deposition in Asian part in Russia

10.3.1. Dry deposition

At all the monitoring sites SO_2 predominates among the other small gaseous admixtures in the atmosphere. Its highest content observed in Irkutsk and Listvyanka during cold season when the amount of burning fuel (mostly coal) increases and the atmosphere mixing is low due to anticyclone (Figure 10.2). Maximal average SO_2 concentrations were observed in the atmosphere of Irkutsk, however SO_2 content in the atmosphere of Listvyanka site is close to that in Irkutsk especially in winter.

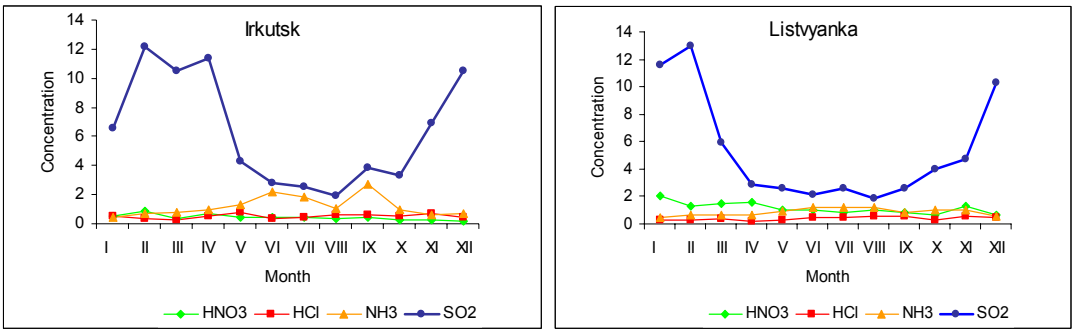


Figure 10.2 Seasonal variations (2000-2005) of gaseous admixtures in the atmosphere of Irkutsk and Listvyanka (at leeward side of Irkutsk) , $\mu g \cdot m^{-3}$.

At remote station Mondy and rural station Primorskaya seasonal variations of SO_2 concentrations are not so clear (Fig. 10.3). Minimal SO_2 concentrations are observed at Mondy site.

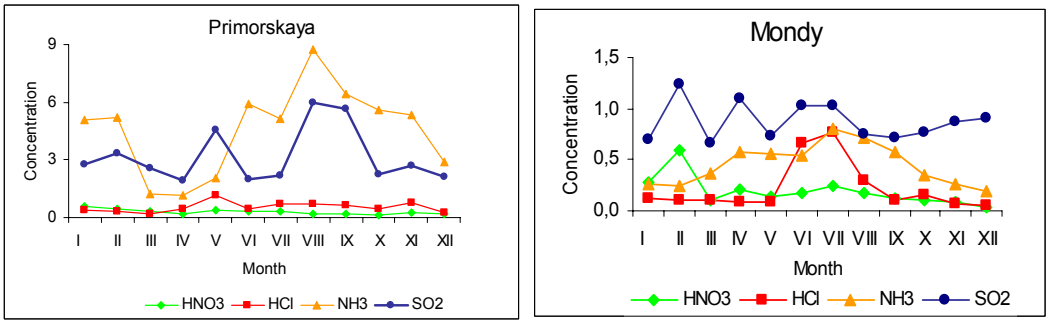


Figure 10.3 Seasonal variations (2000-2005 average) of gaseous admixtures at rural site Primorskaya (up wind side of Vladivostok) and at remote site Mondy, $\mu g \cdot m^{-3}$.

In 2005, the SO_2 concentration at sites located in Eastern Siberia has substantially increased compared to that during 2000-2004 (Figure 10.4). Higher annual and winter SO_2 concentrations in 2001 and 2005 coincide with extremely cold winters. This possibly means that large power plants of Irkutsk region strongly influence on SO_2 concentration at Irkutsk and Listvyanka stations. However in 2005 at remote site Mondy SO_2 concentration is also higher than in previous years. This can be explained by long range transport of SO_2. At Primorskaya site, the SO_2 concentration in 2005 was close to that in 2004.

The level of air pollution by gaseous nitrogen compounds (HNO_3) is highest at Listvyanka monitoring station. The HNO_3 concentration in the atmosphere at Listvyanka was about 2-3 times higher than in Irkutsk (Table 10.2). It looks unexpected because Listvyanka settlement itself has no any large emission sources. Motor transport (both boats and vehicles), local boilers, and private house stoves (which mostly use timber as a fuel) are major sources of the nitrogen oxides in the atmosphere of the village. In spring and summer local forest fires also may also be sources of nitrogen oxides.

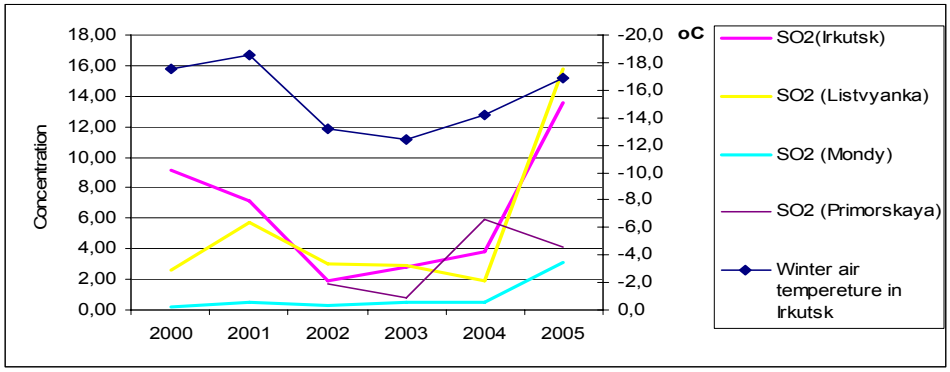


Figure 10.4 Inter-annual variations of the SO_2 concentration at monitoring sites, $\mu g \cdot m^{-3}$

Table 10.2 Average monthly concentrations ($\mu g \cdot m^{-3}$) of gaseous components at the monitoring sites in Russia, 2000-2005

Month	Irkutsk (2000-2005)				Listvyanka (2000-2005)			
	HNO_3	HCl	NH_3	SO_2	HNO_3	HCl	NH_3	SO_2
I	0.51	0.49	0.43	6.58	2.07	0.29	0.46	11.56
II	0.86	0.31	0.68	12.20	1.28	0.25	0.61	12.93
III	0.37	0.29	0.78	10.52	1.46	0.39	0.62	5.93
IV	0.68	0.56	0.97	11.37	1.59	0.19	0.69	2.87
V	2.16	0.82	1.34	4.31	1.06	0.25	0.94	2.62
VI	0.44	0.31	2.18	2.77	0.97	0.47	1.17	2.09
VII	0.40	0.40	1.80	2.55	0.83	0.42	1.22	2.55
VIII	0.34	0.60	1.05	1.88	1.03	0.54	1.21	1.83
IX	0.44	0.63	2.67	3.84	0.85	0.58	0.83	3.09
X	0.24	0.49	0.92	3.34	0.62	0.29	0.99	3.94
XI	0.24	0.71	0.63	6.92	1.28	0.52	1.00	4.75
XII	0.18	0.44	0.67	10.52	0.66	0.50	0.52	10.28
Year	**0.57**	**0.50**	**1.18**	**6.40**	**1.14**	**0.39**	**0.85**	**5.37**

Month	Mondy(2000-2005)				Primorskaya (2002-2005)			
	HNO_3	HCl	NH_3	SO_2	HNO_3	HCl	NH_3	SO_2
I	0.28	0.12	0.26	0.69	0.57	0.37	5.07	2.78
II	0.59	0.11	0.25	1.23	0.46	0.30	5.22	3.34
III	0.10	0.10	0.37	0.66	0.30	0.19	1.21	2.55
IV	0.20	0.09	0.58	1.10	0.22	0.47	1.18	1.94
V	0.14	0.09	0.56	0.74	0.41	1.16	2.07	4.58
VI	0.17	0.67	0.54	1.04	0.34	0.46	5.93	1.98
VII	0.24	0.76	0.80	1.04	0.31	0.72	5.17	2.19
VIII	0.17	0.30	0.72	0.75	0.21	0.69	8.76	5.96
IX	0.12	0.10	0.58	0.71	0.19	0.66	6.45	5.65
X	0.10	0.15	0.34	0.77	0.16	0.45	5.57	2.23
XI	0.09	0.07	0.25	0.87	0.23	0.80	5.31	2.70
XII	0.03	0.05	0.20	0.91	0.20	0.23	2.90	2.11
Year	**0.19**	**0.22**	**0.46**	**0.88**	**0.30**	**0.54**	**4.57**	**3.17**

Among the other gases only NH_3 has clear seasonal variation at all stations: higher concentrations in summer and lower in winter. This means that natural sources of NH_3 are prevailed in South-East Siberia and especially in Far East.

A comparison of the long-term data on aerosols chemistry obtained at all monitoring stations does not show a principal difference in their composition during 2000-2005 periods. This indicates their common source (Figure 10.5). It is interesting that in 2005 when the highest SO_2 concentrations were observed, the sulfates concentrations in aerosols significantly decreased (Table 10.3).

Table 10.3 The chemical composition of aerosols at the EANET monitoring sites, $ng \cdot m^{-3}$

Year	HCO_3^-	SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Na^+	K^+	Mg^{2+}	Ca^{2+}
Irkutsk									
2000	3015	2352	777	118	1019	144	471	147	641
2001	1276	3901	1190	486	1610	79	250	76	480
2002	309	3941	1643	414	1481	157	136	87	489
2003	355	2417	920	230	735	175	206	79	432
2004	800	1713	531	159	584	130	87	58	294
2005	576	2671	679	117	694	213	179	68	454
Listvyanka									
2000	761	2922	691	184	1101	187	227	43	238
2001	1029	2474	439	801	1156	167	235	55	305
2002	260	1906	308	323	765	92	56	39	154
2003	628	2706	680	139	928	177	226	45	262
2004	1019	1733	185	207	617	169	121	40	186
2005	669	787	172	24	368	47	88	19	69
Mondy									
2000	379	523	39	31	148	48	78	15	109
2001	175	697	107	105	252	28	32	12	74
2002	78	554	145	22	201	15	45	9	54
2003	204	972	116	120	355	43	83	9	80
2004	212	661	21	22	169	36	51	14	79
2005	146	339	16	10	120	25	17	3	30
Primorskaya									
2002	933	2701	803	222	1125	184	239	28	217
2003	708	2469	353	207	738	198	365	34	226
2004	533	3418	564	185	741	275	353	189	275
2005	100	3767	1237	207	1099	224	276	78	362

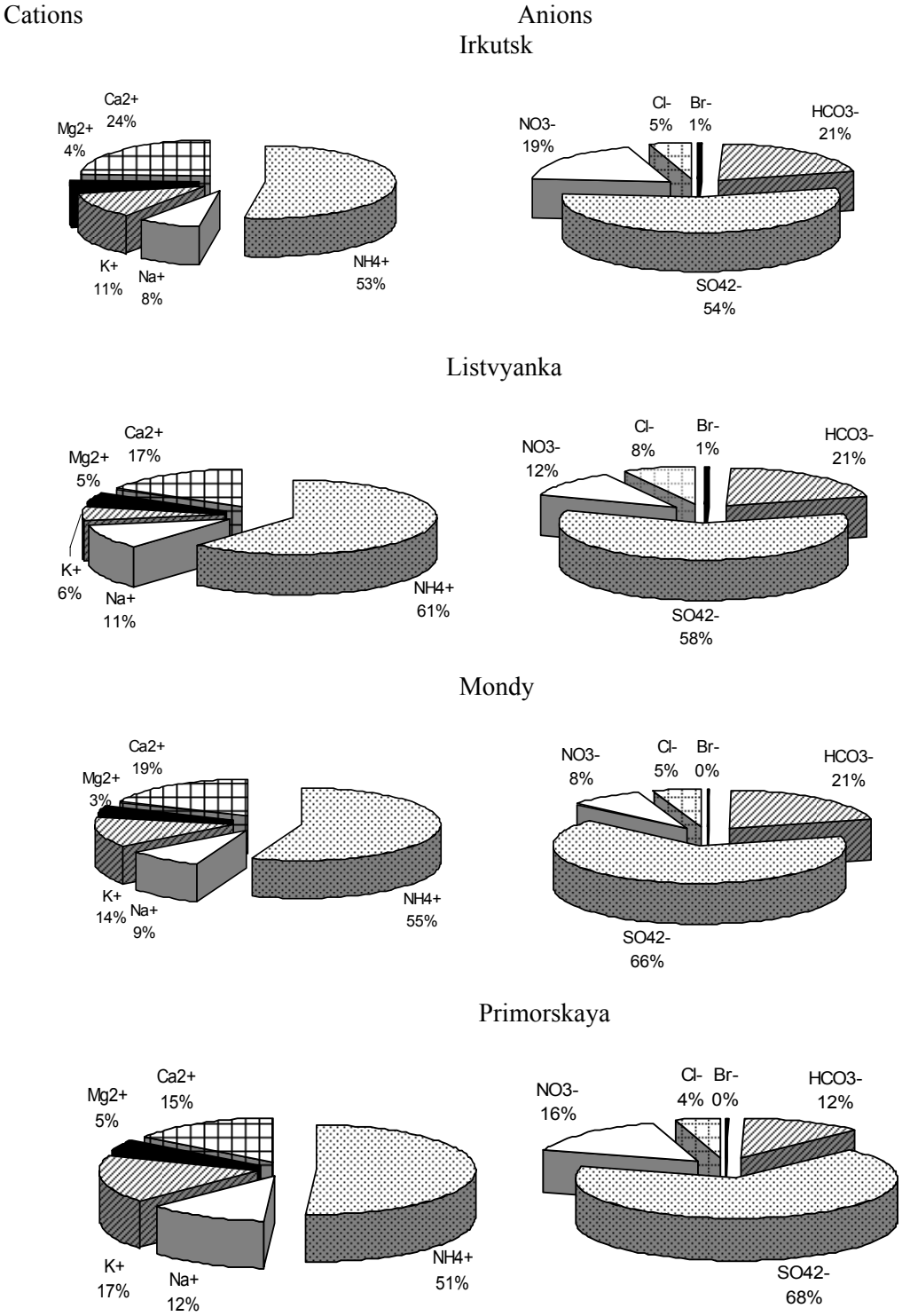


Figure 10.5 Percentage share (% eq.) of different ions in soluble fraction of aerosols in the atmosphere of monitoring sites.

During 2003-2005, the sum of ions in aerosol extracts at Irkutsk and Listvyanka stations decreased by 30-40% compared to that in 1991-1999 (figure 10.6). This decrease was mainly due to lower concentrations of the NH_4^+, SO_4^{2-} , and HCO_3^- ions.

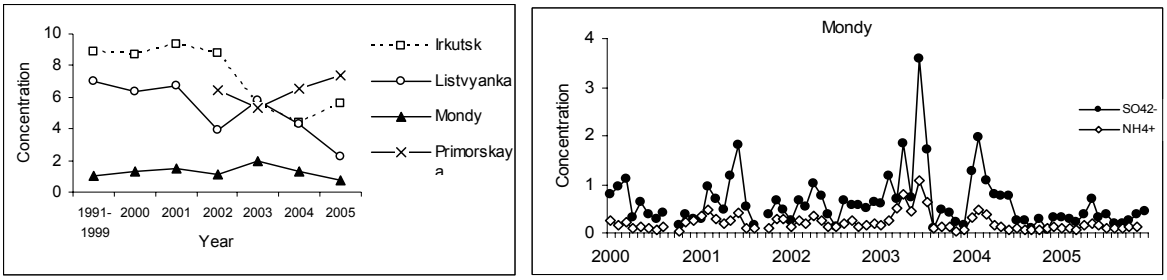


Figure 10.6 Inter-annual dynamics of the sum of ions (at all monitoring sites), sulfate, and ammonium concentrations (at Mondy site), $\mu g \cdot m^{-3}$

At the Mondy station, the highest concentrations of NH_4^+ and SO_4^{2-} ions in aerosols observed during intensive forest fires in spring and summer of 2003 (Fig.10.6). At the same time, a tendency of the sum of ions decrease was also revealed.

In contrast to the monitoring stations in Eastern Siberia, at Primorskaya station, the sum of ions increase was observed during the cold 2004-2005 season (Table 10.3). That was mostly due to increase of NH_4^+, Ca^{2+}, Na^+, and SO_4^{2-} concentrations.

The statistical analysis of the data on aerosol chemistry showed that $(NH_4)_2SO_4$ was major compound at all monitoring sites (r = 0,90-0,93). In Eastern Siberia, strong correlation was found between the cations concentration and the SO_4^{2-} ion (r = 0,6-0,9). Besides, at Listvyanka station, there were high positive correlation between the concentrations of cations and NO_3^- ion (r >0,70), at Mondy station – between the cations and the HCO_3^- ion (r >0,60). In contrast to Eastern Siberia, at Primorskaya station, a relationship between the concentrations of cations and the NO_3^- ion was stronger (r =0,63-0,82) than between cations and the SO_4^{2-} anion.

10.3.2 Wet deposition

Inter-annual dynamics of wet deposition in Eastern Siberia is shown on Figure 10.7. In Irkutsk and in Listvyanka, sulfate concentration, unlike SO_2 in 2005 was at the same level that in previous years. In Mondy sulfate concentration even decreased. Comparing to the data from eighties (Obolkin and Khodzher, 1990; Obolkin et al., 1991) sulfates and especially nitrates have tendency to grow at Listvyanka station.

Calcium, sulfate, and ammonium are major ions in the atmospheric precipitation of Eastern Siberia (Fig. 10.8). Due to the low pH, HCO_3^- is completely absent in rain water at Listvyanka station.

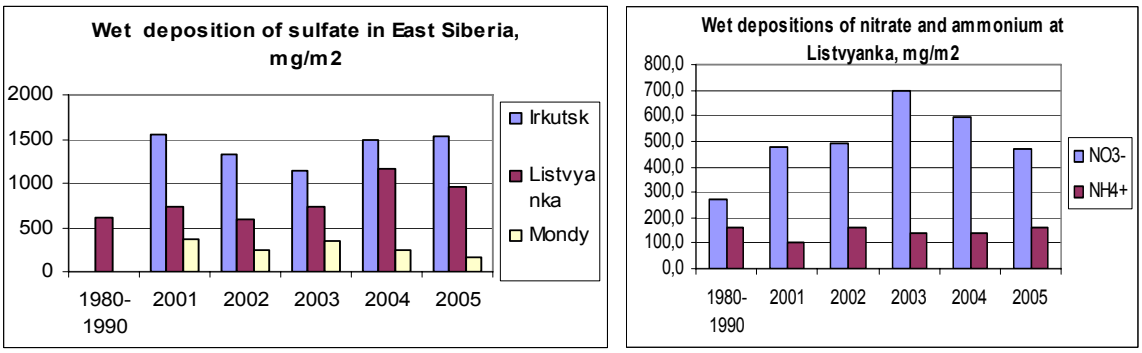


Figure 10.7 Inter-annual variation of SO_4^{2-} deposition at the monitoring stations of Eastern Siberia (on the left) and of NO_3^- and NH_4^+ deposition at Listvyanka station (on the right), $mg \cdot m^{-2}$

As in previous years, there is a significant share of NO_3^- in ionic composition of snow waters at Listvyanka site (35 %-eq.). The NO_3^-/SO_4^{2-} ratio in snow water from Listvyanka is 0.85, whereas in Mondy and Irkutsk sites it is equal to0.63 and 0.47, respectively. In contrast to the other stations at Listvyanka station, nitrate is the most acidifying agent. During warm season, NO_3^-/SO_4^{2-} ratio is highest at Mondy station (0.66) and the lowest at Irkutsk site (0.29). At Listvyanka site it is equal to 0.35. As in previous years, sulfates are predominant ions of wet deposition in East Siberia.

In rain water, ions NH_4^+ dominate at Mondy station, the shares of Ca^{2+} and NH_4^+ at Irkutsk and Listvyanka stations are approximately the same. In snow waters ion Ca^{2+} prevails over the other ions.

There is an apparent tendency of deposition acidification at Listvyanka station. This tendency appeared in recent years (2004-2005). The share of hydrogen ion has increased up to 32% (Figure 10.8). Partly this is due to the low buffering capacity (low concentrations of dissolved matter) of precipitation at Listvyanka station.

The ratio between the sums of cations and anions ($NH_4^+ + Ca^{2+} + Mg^{2+} + K^+ + Na^+ / SO_4^{2-} + NO_3^- + Cl^-$) at Listvyanka station is about 0.7 in rain water and about 0.9 in snow water. In some rains it decreased down to 0.4. As regards to inter-annual dynamics, the ratio decreased from 1.06 in 2000 to 0.87 in 2005. At Irkutsk and Mondy sites, this ratio is betwen 1.2 and 1 in rain water and between 1.4 and 1.6 in snow water.

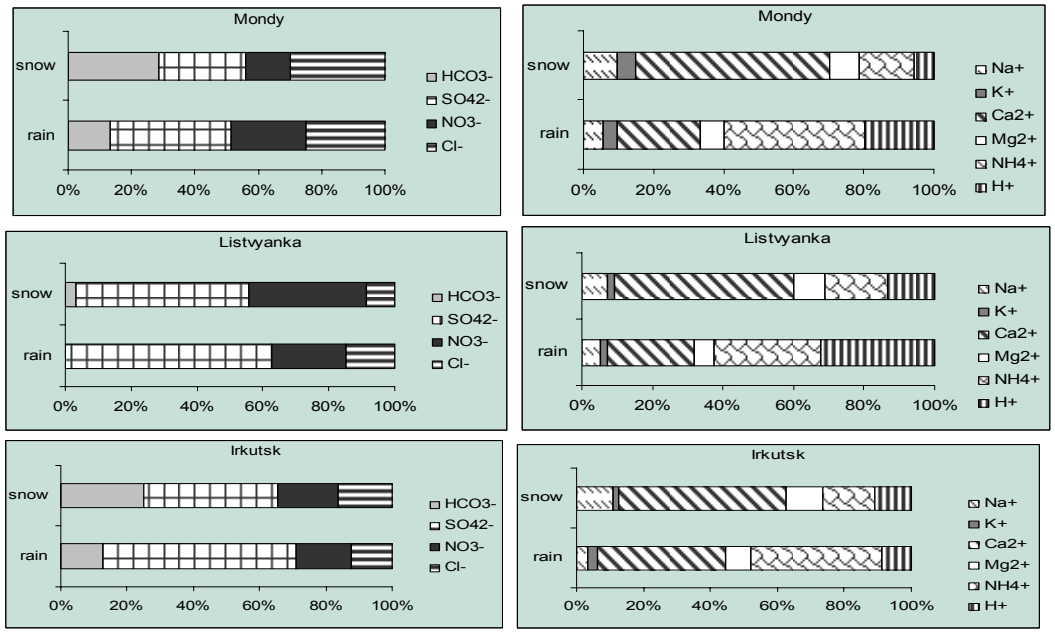


Figure 10.8 Anions and cations ratios in the atmospheric precipitation at the monitoring stations in East Siberia (2000- 2005), %-eq

Inter-annual dynamics of acid rain (pH < 5.0) contributions to the total amount of wet deposition is presented on Figure 10.9. The highest frequency of acid rain events observed at Listvyanka station: 67% of all the rain samples collected at this station had pH < 5.0. The average weighted pH value is 4.95.

At Irkutsk site the share of samples with pH < 5.0 was 19%. The annual average pH was 5.78. At all the stations, the higher pH values observed in cold season (Figure 10.9).

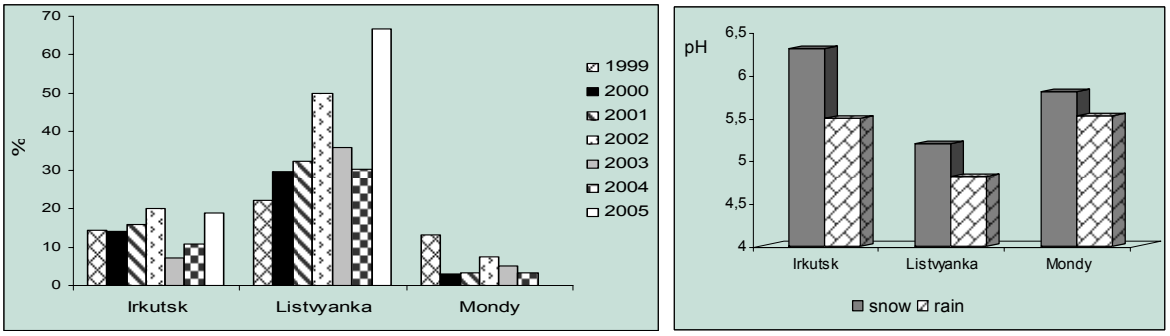


Figure 10.9 Inter-annual dynamics of the percentage of precipitations with pH < 5.0 (left figure) and the seasonal dynamics of pH at monitoring sites of Eastern Siberia, 1999-2005

In contrast to Eastern Siberia, at Primorskaya station the sum of ions in precipitation of warm season is higher than that in precipitation of cold season. Predominant ions are sulfate and ammonium. Calcium and nitrate are predominant ions in snow water (Figure10.10). In winter, the NO_3^-/SO_4^{2-} ratio increases up to 1.3, whereas the average annual ratio was 0.4. An increase of the nitrates concentration was accompanied by sharp pH decrease to 4.2-4.3. At Primorskaya site pH of precipitation vary in a wide range from 4.16 to 6.95. The average annual pH value is equal to 5.56 (Figure 10.10). The most acidic precipitation occur in November and January and the less acidic in March and April.

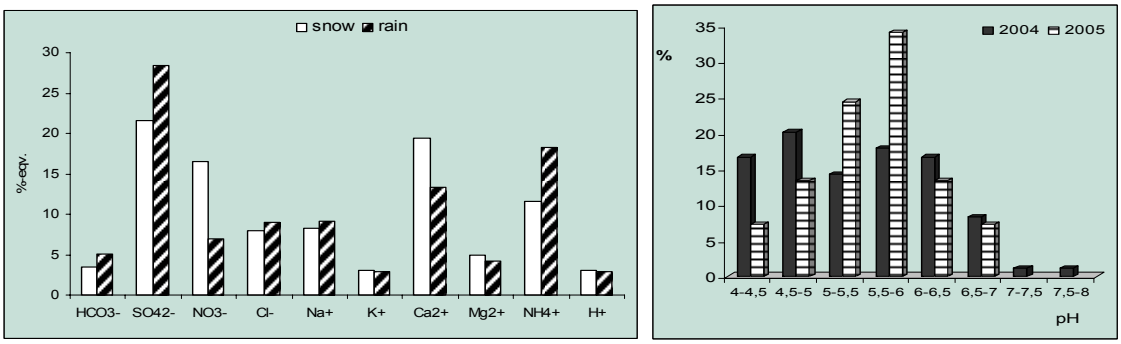


Figure 10.10 The ionic composition of the atmospheric precipitations, %-eq. and repeatability of different pH values in the precipitations at Primorskaya site.

In contrast to Siberia, there is no clear relationship between the concentrations of sulfates and nitrates in the precipitation at Primorskaya station. Low correlation coefficient (r = 0,13) indicates that these ions have different sources.

The averaged chemical composition of wet depositions at the monitoring stations is shown in Table 10.4. During the warm period, the concentrations of all ions except H^+ at Primorskaya site are higher compared to those at the urban station Irkutsk. This is related to the specific geographical position of Primorskaya station. As regards to the cold period there is much higher concentration of the ash-originated ions (HCO_3^-, Ca^{2+},Mg^{2+}) in Irkutsk in comparison to Primorskaya.

The maximal annual fluxes were calculated for Primorskaya site (Table 10.5). This is due to the both higher amount of atmospheric precipitation (two times higher than in Siberia) and higher concentrations of ions in the precipitation (Table.10.4). The annual flux of H^+ ions at Primorskaya is almost equal to that at Listvyanka, however in the case of Primorskaya this is due to higher amount of precipitation. The lowest H^+ flux observed at Mondy station.

Table 10.4 The average weighted concentrations of major ions (μmol·l^{-1}), pH and EC at the EANET monitoring sites in Russia in 2005

	Irkutsk		Listvyanka		Mondy		Primorskaya	
	snow	**rain**	**snow**	**rain**	**snow**	**rain**	**snow**	**rain**
HCO_3^-	42.5	10.9	4.0	0.0	8.6	6.0	12.0	20.0
SO_4^{2-}	40.1	28.5	23.3	21.5	3.1	5.0	41.9	46.8
NO_3^-	32.0	14.3	24.9	12.2	4.9	5.3	58.9	17.6
Cl^-	33.1	9.9	5.5	6.2	7.4	6.0	31.4	31.4
Na^+	31.6	4.0	5.6	3.2	3.5	1.2	29.9	35.8
K^+	5.7	3.3	1.4	1.4	2.0	1.7	11.4	10.0
Ca^{2+}	51.3	20.2	23.3	9.0	8.1	4.0	39.2	23.6
Mg^{2+}	13.7	4.0	3.9	2.1	1.5	1.3	8.9	7.9
NH_4^+	30.9	38.9	14.6	20.7	4.9	11.2	42.4	50.6
H^+	1.4	7.9	6.7	17.3	1.6	3.6	16.2	7.2
pH	6.14	5.40	5.43	4.84	5.91	5.54	5.28	5.47
EC,mS/m	2.88	1.58	1.33	1.33	0.46	0.49	3.07	2.42

Table 10.5 The atmospheric ions fluxes (mg·m^{-2}) in winter and summer seasons at the EANET monitoring sites in Russia.2005

Prec.	**mm**	**Sites**	HCO_3^-	SO_4^{2-}	NO_3^-	Cl^-	Na^+	K^+	Ca^{2+}	Mg^{2+}	NH_4^+	H^+
Snow	116	Irkutsk	240	359	171	88	45	23	173	28	62	0.2
Rain	326		146	817	277	105	24	35	206	27	218	3.2
snow	115	Listvyan-	12	209	139	25	15	7	70	7	31	1.1
Rain	333	ka	0	530	192	60	16	13	78	10	102	5.2
Snow	45	Mondy	26	22	10	17	3	3	17	2	4	0.1
rain	241		46	130	83	48	7	9	31	5	42	1.2
Snow	109	Primor-	41	541	379	95	74	43	147	20	95	2.4
Rain	607	skaya	451	2055	585	454	286	155	455	79	439	3.9

10.3.3 Ecological impacts

10.3.3.1 Soil and vegetation

Soil. Two type of soils, the sensitive and the control were chosen within the radius of 50 km from each deposition sampling point (Table 10.6). The results are presented at Table 10.7. The profile distribution of exchangeable base cations is of an accumulative character in all the soils investigated except the soil of 6th plot (the data on plots 3 and 5 are missing in the tables, since they are very close to data on pots 4 and 1 correspondently but have less developed profiles). For all the horizons, the total amount of base cations decreases in row: $Ca^{2+} > Mg^{2+} > K^+ \geq Na^+$; the share of calcium comprises 40-95% of total amount.

Table 10.6 Types of soils investigated.

	Sensitive		Control	
Stations	**Plot No.**	**Soil type**	**Plot No**	**Soil type**
Mondy	1	Gelic podzol	2	Calcic gleysol
	4	Gelic gleysol		
Listvyanka	7	Dystric leprosols*	6	Mollic leprosol
Irkutsk	8	Eutric regosol	9	Calcaric luvisol

* the seventh plot was established in the basin of Pereemnaya river - inland aquatic monitoring site.

As expected, the highest amount of base cations, as well as the highest pH values, were observed in control soils. The largest amount of exchangeable acidity are coupled with the lowest pH_{KCl} values. The

only exception is plot 7 established in the Pereemnaya River basin (on the East shore of Lake Baikal, opposite Listvyanka monitoring site). In this soil, both the content of exchangeable bases and the acidity content are quite low because of the absence of clay minerals, which was proved by X-ray diffraction analysis of the <1 μm fraction. Apart from the dynamic parameters, we also measured the total element composition of soil. In this connection, it noteworthy that the soil plot 2 was characterized by a considerable CaO content in A horizons – 10,84% (Ca measured in filtrate after SiO_2 precipitation), which amounted to 19.35% of $CaCO_3$ per total soil, or 34.54% of $CaCO_3$ per mineral substance. This was also confirmed by the results of acidimetric measurements of carbonates.

The special study was conducted to assess the integral ecosystem stability to acidification. Critical load of acidity (CL(Ac)) was chosen as the measure of stability. According to the definition elaborated at an UN ECE expert workshop in Skokloster, Sweden in 1988, critical load is the deposition of acidifying compounds that will not cause chemical changes leading to long term harmful effects on the ecosystem structure and function. Critical loads of acidity were calculated for both terrestrial and aquatic ecosystems. For terrestrial ecosystems calculations were made using the Steady State Mass Balance (SSMB):

$$CL(Ac) = BC_w – ANC_{le(crit)},$$

where CL(Ac) – critical load of acidity ($keq \cdot ha^{-1} \cdot yr^{-1}$), BC_w – Ca, Mg, and K (base cations) release due to weathering ($keq\ ha^{-1}\ yr^{-1}$), $ANC_{le(crit)}$ – critical value of acid neutralizing capacity ($keq \cdot ha^{-1} \cdot yr^{-1}$), $ANC_{le(crit)} = -Q \cdot ([Al^{n+}]_{crit} + [H^+]_{crit})$, Q – runoff, i.e. water leaving the root zone ($m^3\ ha^{-1}\ yr^{-1}$), $[Al^{n+}]_{crit}$ and $[H^+]_{crit}$ are critical concentrations of positively charged aluminium ions (Al^{3+}, $AlOH^{2+}$, $Al(OH)_2^+$), and hydrogen set to 0.2 $eq \cdot m^{-3}$ and 0.1 $eq \cdot m^{-3}$ respectively.

For aquatic ecosystems Steady State Water Chemistry (SSWC) method was applied:

$$CL(Ac) = ([BC]_0 – [ANC]_{limit}) \cdot Q – BC_{dep} + BC_u,$$

whereCL(Ac) – critical load of acidity ($keq \cdot ha^{-1} \cdot yr^{-1}$), $[BC]_0$ – base cations concentration in water ($eq \cdot m^{-3}$), $[ANC]_{limit}$ – desired ANC threshold (set to 0.02 $eq \cdot m^{-3}$), $[ANC]_{limit} = [HCO_3^-] + [A^-] – [H^+] – [Al^{n+}]$, $[A^-]$ and $[Al^{n+}]$ – concentrations of organic anions and positively charged aluminium ions respectively ($eq\ m^{-3}$), Q – runoff ($m^3 \cdot ha^{-1} \cdot yr^{-1}$), BC_{dep} – atmospheric deposition of base cations ($keq\ ha^{-1}\ yr^{-1}$) and BC_u – net long term uptake in biomass ($keq \cdot ha^{-1} \cdot yr^{-1}$). BC_u should be set to zero if there is no management.

The most important characteristic for assessment of terrestrial ecosystem susceptibility to acidification using SSMB is soil weathering rate. It was calculated from the comparison of $^{87}Sr/^{86}Sr$ ratios in soils, precipitation and surface waters. In the case of terrestrial ecosystems, CL(Ac) was calculated for the root-inhabited layer. Calculations were made as follows:

$$\text{Weathering} = BC/Ca \cdot Ca_{dep} \cdot [(({}^{87}Sr/{}^{86}Sr_R - {}^{87}Sr/{}^{86}Sr_D)/({}^{87}Sr/{}^{86}Sr_S - {}^{87}Sr/{}^{86}Sr_D))/ (({}^{87}Sr/{}^{86}Sr_R - {}^{87}Sr/{}^{86}Sr_S)/({}^{87}Sr/{}^{86}Sr_D - {}^{87}Sr/{}^{86}Sr_S))],$$

whereBC/Ca – $([Ca^{2+}]+[Mg^{2+}]+[K^+]+[Na^+])/[Ca^{2+}]$ ratio in runoff, $Ca_{dep.}$ - atmospheric deposition of calcium, $keq \cdot ha^{-1} \cdot yr^{-1}$, $^{87}Sr/^{86}Sr$ – strontium isotopes ratio in: $_R$ - runoff, $_D$ – deposition, $_S$ – soils, ($^{87}Sr/^{86}Sr_R - {}^{87}Sr/{}^{86}Sr_D)/({}^{87}Sr/{}^{86}Sr_S - {}^{87}Sr/{}^{86}Sr_D)$ – soil contribution to runoff and ($^{87}Sr/^{86}Sr_R - {}^{87}Sr/{}^{86}Sr_S)/({}^{87}Sr/{}^{86}Sr_D - {}^{87}Sr/{}^{86}Sr_S)$ – contribution of atmospheric deposition to runoff.

Obtained weathering rates were extrapolated to nearby areas on the base of Arrhenius' equation:

$$BC_{we}(T) = BC_{we}(T_0) \cdot e^{(A/T0 - A/T)},$$

where $BC_{we}(T)$ – weathering rate for sought location at local temperature T (ºK), $BC_{we}(T_0)$ - weathering rate measured for certain monitoring plot at reference temperature T_0 (ºK), e – base of natural logarithm and A – pre-exponential factor (set to 3600 K).

The results obtained show, that the weathering rates obtained for monitoring sites vary within the range between 0.3 and 6.8 keq·ha^{-1}·yr^{-1}. These values were extrapolated to nearby areas on the base of Arrhenius' equation. The critical load values obtained on the base of weathering rates vary in the range of 0.4 – 20.0 keq·ha^{-1}·yr^{-1}. Minimum values (0.3 – 1.3 keq·ha^{-1}·yr^{-1}) were observed for highland ecosystems (mountain tundra and mountain forest-tundra) and surface waters. Maximum values (7.5 – 20.0 keq·ha^{-1}·yr^{-1}) – for the coniferous forests on various soils, especially on carbonate-rich soils.

In general, surface waters of the Baikal watershed are more sensitive than soils to acid deposition. Comparing the triply enlarged (to obtain the total - wet plus dry deposition) values of present acidity load calculated on the base of wet deposition data and critical loads, exceedance is not observed for all the monitoring sites. However, in mountain tundra and mountain forest-tundra zones, especially under excessive precipitation, the modelled critical load and acidity deposition values are close to each other.

Table 10.7 Chemical properties of soils at East Siberia monitoring sites.

Plot		Depth	pH		Exchangeable cations (meq. kg^{-1})					Total	Total
No.	Layer	(cm)	H2O	KCl	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	$Al^{3+} + H^{+}$	C(%)	N(%)
1	AO	3 - 6	5.05	3.80	152.61	40.91	9.54	0.91	17.42	13.81	3.12
	AB	6 – 9	5.05	3.50	46.43	8.92	1.73	0.94	87.44	3.63	0.71
	B	9 – 25	4.92	3.96	10.84	4.43	2.64	1.12	62.13	3.22	0.80
	BC	>25	5.66	4.00	31.91	11.92	1.02	0.92	12.55	1.22	0.52
2	Ok	0 – 2	7.62	-*	898.8	84.24	45.91	-	-*	22.85	3.04
	Ak	2-20	7.84	-	1398.4	188.6	0.01	-	-	15.93	3.15
	Bkg	20-45	7.34	-	350.2	35.82	4.62	-	-	2.44	0.21
4	AO	8 - 18	4.90	3.95	135.23	48.51	5.32	0.72	20.81	7.42	1.22
	B	18 -25	6.42	5.07	93.71	18.73	1.83	0.41	<d.l.**	0.83	0.61
	BCg	25 -45	6.92	5.91	127.62	15.92	2.01	0.52	<d.l.	1.41	0.63
6	A	0 - 18	6.76	5.85	196.94	31.01	2.54	0.83	0.91	3.16	0.68
	B1	18 -28	6.90	5.59	167.63	34.53	2.33	0.84	0.43	1.02	0.36
	B2	28 -60	7.03	5.41	186.54	46.03	1.72	0.92	0.54	0.45	0.29
	BC	>60	6.90	5.43	168.91	46.72	1.21	0.73	0.42	0.31	0.20
7	AB	0 – 5	4.21	3.83	8.35	6.12	4.31	1.82	<d.l.	11.52	-
	BC	5 – 10	4.12	4.02	2.12	1.74	1.32	1.33	<d.l.	0.56	-
8	A	1 – 3	7.00	6.06	228.81	41.71	4.94	2.34	1.01	6.72	-
	B	3 - 15	6.56	4.47	113.32	23.03	2.12	1.25	1.92	1.32	-
	BC	15 -60	6.18	4.00	115.44	23.02	1.31	1.44	3.81	0.95	-
9	A	0 – 6	6.65	5.79	266.23	64.22	2.33	1.84	-	9.12	0.50
	B	6 - 16	6.89	5.72	218.85	54.22	2.24	1.95	-	2.53	0.27
	BC	16 -35	7.94	6.16	170.44	44.41	1.91	1.52	-	0.32	0.60
	Ck	35 -55	7.99	6.66	237.01	44.15	2.12	1.63	-	0.26	0.04

* - this parameter was not measured
** - value lower then detection limit (< 0.10 meq. kg^{-1})

Vegetation. The monitoring of forests at Mondy, Listvyanka, and Irkutsk stations started in 1999. The state of vegetation at Primorskaya site was firstly examined in June 2006.

The both, field observations and results of chemical analyses of samples allow to conclude that there are no any evidences of the atmospheric pollutants influence on vegetation at Mondy station. The accumulation of heavy metals, as well as of sulfur and fluorine, which are acid forming components of industrial air emissions, was not observed in the trees needles.

In contrast to Mondy station forests around Listvyanka are affected by the atmospheric pollutants. Defoliation of crowns reaches the value of 25-50% for pine, 20-30% for larch, 30-40% for birch. Needles age of fir is decreased down to 3 years, whereas normally it is about 5-6 years. Increased contents of sulfur, fluorine, lead, cadmium, iron, and aluminum are observed in the needles of larch and pine.

The most evident vegetation decline observed in Irkutsk city. Defoliation of crowns comprises 30 60% for pine, 40-50% for larch, 20-40% for birch. The pine needles age is decreased to 2-3 years. The coniferous trees have low mass and length of the shoots. In the needles of pine and larch as well as in birch leaves, the concentrations of sulfur, fluorine, lead, cadmium, iron, and cooper are few times higher compared to those at Mondy station.

Summarizing the information on the both morphological and chemical parameters of vegetation we can characterize the vegetation around the Mondy station as relatively healthy. In surroundings of Listvyanka vegetation is evidently oppressed. Vegetation in Irkutsk city is oppressed to a greater extent than in Listvyanka.

Apart from the data given above, we have an information on forests condition under air pollution impacts in the Baikal region on the whole. The information is based on our long studies of the region's forests (Mikhailova, 2000; Mikhailova et al., 2005). Air pollution effects on treestands we assess using a set of morphostructural and physiological parameters as well as needle elements content. According to the results, within the polluted areas the following parameters such as trees crown defoliation, length of shoots, needles mass, intensity of photosynthesis and respiration, content of elements in the needles are found to have changed to a great extent. A high level of a reverse correlation has been found between accumulation of elements-pollutants in the needles and most of the morphostructural parameters of pine trees polluted by industrial emissions. The data obtained witness reduction of the quantity of assimilating phytomass in the weakened treestands. Changes in the pigments content, in the intensity of photosynthesis and respiration of the weakened trees are more pronounced with the calculation for the whole shoot needles mass. Structural and functional violations of the assimilating organs bring about reduction of carbon assimilation by the forest ecosystems.

10.3.3.2 Inland Aquatic environment

In East Siberia several lakes and small rivers were investigated as potential objects for Inland aquatic monitoring. However there were appropriate (sensitive enough) objects near Mondy and Irkutsk, all nearest lakes or rivers had too high alkalinity concentration. Only Pereemnaya river located on the opposite shore of Lake Baikal on the leeward slope of Khamar-Daban Ridge (40 km southeast from Listvyanka) matched all the selection criteria. As it was mentioned in previous paragraph, soils in this area are also most sensitive to acid deposition. In Primorskii region Komarovka River near Primorskaya monitoring station was chosen as the object for inland aquatic monitoring.

Pereemaya river. The lowest pH and alkalinity of Pereemnaya river water is observed in spring (Table 10.8), when the snow in river catchment starts to melt. The less mineralized and more acidic snow water dilute the riverine water.

Table 10.8 The average (2004-2005) chemical composition of the Pereemnaya river, mg·l^{-1}.

	pH	EC	Alk.	SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Na^+	Ca^{2+}	K^+	Mg^{2+}
March	6.65	4.46	0.15	8.87	0.96	0.26	0.024	1.38	0.85	3.71	0.94
May	6.50	3.34	0.12	5.78	0.82	0.18	0.022	0.80	0.59	2.95	0.76
July	6.94	-	0.13	7.68	0.48	0.17	0.040	0.94	0.82	3.14	1.06
October	6.86	4.18	0.14	7.70	0.58	0.26	0.015	1.00	0.71	3.26	1.20

The comparison of present data on ion composition of Pereemnaya River with data from fifties (Sorokovikova et al., 2004) shows the grow of sulfate share and decrease of HCO_3^- and Ca^{2+} shares. Several years ago the special study was conducted on mountain Lake Kholodnoe - the source of Pereemnaya river. It was shown that this lake has even lower pH and alkalinity than Pereemnaya river. In algae community of this lake there are species which are typical for acidic water.

One year observation on Komarovka river (Far East) demonstrate much higher resistance of its water to acidification (Table 10.9) than that of Preemnaya river.

Table 10.9 The chemical composition of the Komarovka river in 2005, mg·l^{-1}.

	pH	EC	Alk.	SO_4^{2-}	NO_3^-	Cl^-	NH_4^+	Na^+	Ca^{2+}	K^+	Mg^{2+}
August	7.10	8.81	0.47	12.48	0.33	2.80	0.447	0.96	8.65	0.60	2.32
September	7.21	8.70	0.56	8.25	0.41	2.80	0.093	3.40	9.13	0.47	2.53
October	7.51	8.78	0.57	9.87	0.33	3.45	0.082	2.63	9.58	0.80	2.42
November	7.11	8.71	0.45	12.48	0.31	3.18	0.085	3.85	9.03	0.62	1.77
December	7.41	8.73	0.43	12.82	0.27	3.22	0.042	3.02	8.97	0.50	2.22
mean	7.24	8.75	0.50	11.18	0.33	3.09	0.150	3.34	9.07	0.60	2.25

Summarizing all the mentioned above one can say that the highest risk of acidification is most probable in the area leeward to Irkutsk industrial zone.

10.3.4 Some conclusions from EANET monitoring data

At all sites studied, sulfur dioxide dominates in the composition of gaseous admixtures, sulfates and ammonium – in the ionic composition of aerosols. At the same time, bicarbonates comprise a substantial share of aerosols at the sites of Eastern Siberia, whereas at Primorskaya site, their percentage in aerosol composition is rather low. At the remote Mondy site, higher concentrations of admixtures were observed in the atmosphere during warm season. At the other sites (urban and rural), on contrary, the increased concentrations of ammonium and calcium ions, sulfates and sulfur dioxide were recorded in cold season, when the amount of burning fuel was high and anticyclone type of weather predominated. Forest fires play important role in the formation of the composition of gaseous and aerosol admixtures in the atmosphere of Siberia.

In wet deposition at all the stations, calcium, sulfate, and ammonium ions prevail over the other ions. Concentrations of major ions (sulfates, nitrates, and calcium) at all stations located in East Siberia are higher during cold season, whereas at Primorskaya station concentrations of these constituents are higher during the warm season.

A tendency of acid deposition increase is observed in Listvyanka. This tendency became appeared recently (in 2004-2005). At Mondy and Irkutsk stations acid deposition events are rare. In the case of Mondy the absence of acidification is due to remoteness from pollution sources and elevation. As for Irkutsk, land use plays the most important role in reducing the atmospheric acidity.

The atmospheric fluxes of ions on the underlying surface are substantially higher in warm season and this is related to significant amount of the precipitation in this season. All the data obtained show the

highest probability of acidification in Asian part of Russia is expected is small areas characterized by low buffering capacity of both, soil and surface waters and located leeward to industrial centers at the distance of hundreds kilometers from them.

10.4 Basic Information on State of National Monitoring Activities related to Acid Deposition

10.4.1 Outline of the national activities on acid deposition and monitoring system

The Russian Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET) is responsible for monitoring of environmental pollution in Russia including measuring and evaluating acid depositions and their effects, contamination of the atmosphere and other related environmental media as well as climate changes.

There are several monitoring networks in Russia developed by Roshydromet as mostly independent systems of environmental quality control:

- Urban air quality control;
- Precipitation chemistry monitoring network over urban and rural territories;
- Russian EMEP monitoring network;
- Russian EANET monitoring sites,
- Monitoring of chemical pollution of snow cover;
- Surface water quality network near the cities and far from towns;
- Control of soil pollution by heavy metals and pesticides;
- Integrated background monitoring network.

Most of this networks are covered the whole territory of Russia, wile EMEP sites are situated along the western border of Russia and EANET sites are situated only at Asian part of the country. All of the mentioned networks conduct monitoring programs which are related or immediately caused by acid deposition problems. However there are five monitoring subsystems, besides EANET, performed the most correspondent activities in this field which experience and capacities could be useful for EANET.

They are:
Urban air quality monitoring network was developed at the beginning of 1960s for measuring air pollutant's concentrations in living settlements. After 2000, about 600 sites in 230-260 towns in Russia were operating where the short-time (20 minutes) concentration of SO_2, NO_2, CO, SPM and other specific pollutants are measured three or two times per day.

Precipitation chemistry monitoring network was established in urban and rural sites at the end of 1960s. Nowadays, the Russian national monitoring system of acidity and chemical composition of atmospheric precipitations consists of about 130 sites. All major ions, conductivity and pH are determined in fall-out atmospheric water after the collecting in bulk samplers during a week or month.

EMEP monitoring network are operated along the north-western boundary of Russia from 1980s according to the same principles and analytical procedures as for most of EMEP countries. The sulfur and nitrogen atmospheric compounds are measured in air and precipitation on the daily basis as well as ozone (continuously). The ion chromatography and AAS are used for analysis by special operational laboratory in Institute of Global Climate and Ecology.

Chemical composition of snow cover are evaluated in snow sampling gathering every year before melting over the whole Russian territory. Up to 1000-1200 sampling sites provide spatial information on integrated dry and wet deposition during snow season. All major ions and pH are determined by wet chemistry analytical methods in regional laboratories.

Integrated Background Monitoring Network (IBMoN) was established in the former Soviet Union as a specific observation system for the realization of integrated approach to control a re-distribution and cycling of environmental pollutants and was considered as a part of UNEP Global Environmental Monitoring System (UNEP/GEMS). This monitoring system conducted measurements of pollutant concentrations in different environmental media including air, precipitation, surface water, bottom sediments, soil, snow cover, and biota out of the areas with direct anthropogenic influence (far from main urban, industrial centers or highways). The initial plan suggested opening at least 16 stations over the territory of Russia to provide comprehensive information on the state of each type of large-scale bio-geographical ecosystem existing in Russia. However, as a maximum during the all period of the network activity, 9 stations were really operated in Russia and now they are only 5 for Russia.

10.4.2 National environmental monitoring program for the Asian territory of Russia in 2001-2005

About 70 precipitation chemistry monitoring sites are situated at the Asian territory of Russia (ATR). Location of the sites situated to the East from 80-th longitude is listed at the table and shown at the map in Annex 1. Background sites are highlighted.

Unfortunately, after the closure of IBMoN sites in Barguzin biosphere reserve in Baikal region and in Sikhote Alin BR there is no any more integrated monitoring sites which are working at the Asian territory of Russia (ATR).

Asian territory of Russia is also covered by the sites of snow monitoring network.

10.4.3 Principles of data interpretation and publications

Analysis and generalization of data, their interpretation, local forecasts and evaluation of the state of the environment according to these data are annually published in a number of issues. Annual publications are “Review of the state of the environmental pollution in Russian Federation” and “Reviews of the state of background environmental over the territory of CIS”. Reviews of the state of the environment are also annually prepared and published separately for each region of Russia.

The system of the data availability and their usage by different environment stakeholders is not developed very well. Currently, copies of each annual review are sending to a list of libraries and to all regional centers of the Russian Service on Hydrometeorology and Environmental Monitoring. Free copies of the Review are also available at the request. The interest to such publication is quite high and obviously much higher then very limited number of copies which are usually published. Last years Reviews are also available in the Internet. The only Russian sites for which initial data could be obtained are EMEP sites. This information can be fined at EMEP/CCC (NILU) website after 1 year storage.

10.4.4 Air quality control and standardization

The basic criteria according to which the degree of air pollution is defined in Russia are maximum permissible concentration (MPC known as «PDK» in Russian) and provisional standards (known as «OBUV» in Russian). Both these criteria are defined during the medical studies and then approved by the Russian Sanitary - Epidemiology Service. OBUV is a temporary criterion that can be used not more than 3 years, after it a MPC of certain pollutant should be defined. Maximum permitted concentration is defined as a concentration of a pollutant in the atmosphere which acting periodically or permanent is not dangerous for people's health (based on the most sensitive functions of an organism) and does not cause an addiction (MEP 1994b). There was an attempt to evaluate a MPC for plants and animals which are more sensitive than people, but this idea did not get a practical implementation (Goscomecologiya 1995).

There are two types of MPC: average and episodic maximum permitted concentration (episodic MPC). Maximum episodic concentration is established in order to prevent reflection reactions caused by unpleasant smelt, light or feeling. An average MPC (daily) is a concentration that does not cause any direct or indirect dangerous effect on human health by birthing during a certain period of time. According to the State Committee of Russian Federation on Environmental Protection (Goskomecologiya 1995), it is required that a real concentration over the borders of a sanitary-protected area (buffer zone) around an emission source should not be higher than MPC. There are also separated system of MPC established for air quality inside of a working zone. Maximum permissible concentrations in the atmosphere are established now for more than 5000 elements. Maximum permissible concentrations for those elements connected with acid deposition issues are presented in Table 10.10.

Table 10.10 Maximum permissible concentrations which are set in Russia for those elements connected with acid deposition issues (mg/m^3). (Modified from MEP 1994)

Pollutant	Episodic MPC	Daily MPC
Nitrogen dioxide	0.2*	0.04
Nitrogen oxide	0.4	0.06
Sulphur dioxide	0.5	0.05
Carbon Monoxide	5.0	3.0
Black carbon	0.15	0.05
Total suspended particles	0.5	0.15
Lead	0.001	0.0003
Ozone	0.16	0.03

* New MPC for nitrogen dioxide equal to 0.2 mg/m^3 was set by the Ministry of Health and Social Development at February 2006. The previous MPC level for NO_2 was 0,085 mg/m^3

10.5 Review of the state of acid deposition over the Asian part of Russia according to national monitoring data

10.5.1 The state of the environment before 2000 and long term concentration tendency.

This analysis is almost based on the data from the background monitoring sites operated over the territory of Russia at the period from the end of 1980-s to 2000. Evaluation of a spatial distribution of sulfur and nitrogen compounds both in the air and precipitations shows their maximums over the western part of Russia with a general decreasing toward to the east direction (Figure 10.11). Comparison of the sulfur and nitrogen concentrations for Asian and European part of the country shows that average concentration of sulfur dioxide was less then 0.1 $\mu g/m^3$ in background territories of Baikal region, while at the European territory of Russia it was 5-6 times higher. Sulfates concentration in air was generally higher than SO_2 . At the Asian region of Russia it average value were about 2 $\mu g/m^3$ during cold seasons and about 0.7 $\mu g/m^3$ during warm seasons.

Concentrations nitrogen compounds in precipitation are also generally decreasing along the West-East direction with higher values in the central regions of Russia. Year average concentration of sulfur over the Asian part of Russia was varying during the period of 1990-2000 from 1.5 mg/l in Huzhir to 4.0 mg/l in Sikhote-Alinskiy BR, average value for European territory of Russia for the same period is 3.1 mg/l.

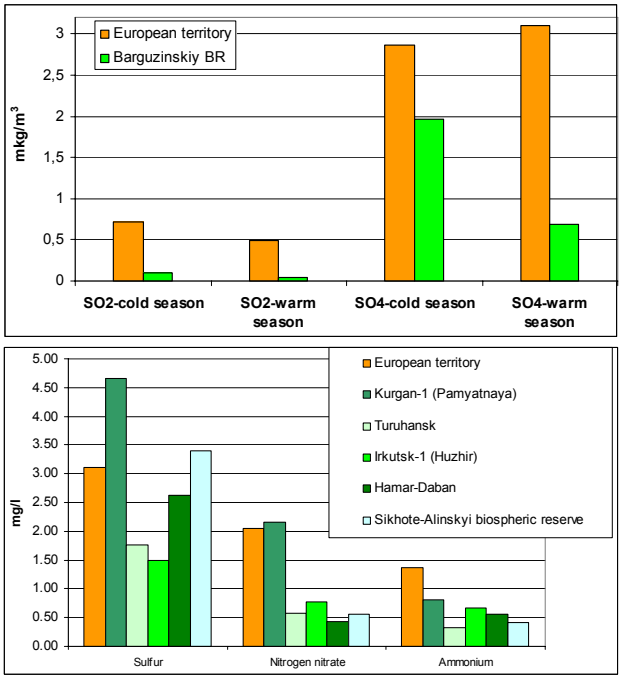


Figure 10.11 Comparison of European and Asian levels of acid compounds concentrations in air (a) and precipitation (b) in Russia in 1990-2000.

Long term monitoring data obtained from the background monitoring stations over Russia (Figure 10.12) shows that generally for Russia territory there is a tendency for decreasing of sulfur and increasing of nitrogen concentrations. Sulfur concentration in precipitations of Siberian and Far East background regions was the lowest among other regions of Russia at the begging of measurement period. However, it stays practically stable and even a bit increases during more then 30 year's period, while sulfur concentration has decreased significantly at other regions.

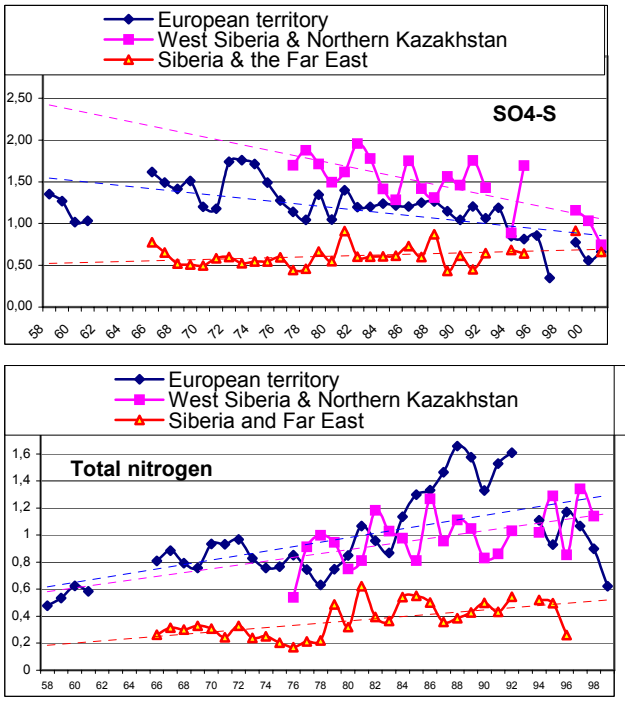


Figure 10.12 Long-term trends of sulfur (a) and nitrogen (b) concentrations (mg/l) in precipitations over Russian territory.

10.5.2 Wet deposition at 2000-2004

Initial monitoring data gathering from the network of precipitation chemistry and acidity monitoring are averaged over the following regions: Central and North Siberia, South Siberia, Baikal region, Far East region. In order to compare the level of precipitation pollution at Asian and European territories of Russia average data for both these regions are also presented. These data are annually prepared by the Main Geophysical Observatory, St. Petersburg, Russia and published in the "Review of the state of the environmental pollution in Russian Federation" (Chistyakova, 2002; Shalamanskiy et al., 2002; Chistyakova et al., 2003; Svistov et al., 2004; Svistov et al., 2005).

Average weighted data on ions concentrations in the precipitations of the regions are presented in the Table 10.11. Predominated ions in the precipitation of Russian Asia are sulfate and bicarbonates. Bicarbonates are predominated in Baikal region (more then 60% of ion balance), Central and North Siberia, while sulfate is a main ion in precipitation of South Siberia and Far East region (33-40% of ions sum) –Figure 10.13. Baikal region is characterized by the highest mineralization (30.5 mg/l) of precipitations among other regions.

Table 10.11 Average weighted ions concentrations in the precipitations of the regions in 2004, mg/l.

Region	SO_4^{-2}	Cl^-	NO_3^-	HCO_3^-	NH_4^+	Na^+	K^+	Ca^{+2}	Mg^{+2}	M	pH
Central and North Siberia	2.9	1.2	0.8	4.1	0.6	1.0	0.4	0.6	0.6	12.2	6.3
South Siberia	6.1	0.9	2.0	3.9	0.8	0.5	0.4	0.6	0.4	15.6	6.4
Baikal region	5.1	0.9	2.2	16.2	0.4	1.2	0.7	1.4	2.4	30.5	6.4
Far East	4.1	2.4	1.1	1.0	0.4	1.5	0.5	1.0	0.3	12.3	5.3
ATR average	**4.6**	**1.4**	**1.5**	**6.3**	**0.6**	**1.1**	**0.5**	**0.9**	**0.9**	**17.7**	**6.1**
ETR average	**3.3**	**1.3**	**1.2**	**6.8**	**0.6**	**0.6**	**0.5**	**2.0**	**0.7**	**17.0**	**6.1**

Minimum and maximum concentrations for sulfur and nitrogen compounds in precipitations measured in 2004 are shown in Table 10.12. Generally for Asian territory maximum values of sulfur, nitrate and ammonium concentrations are 4 - 6 times higher then average ones. However in Central and North Siberia region maximum concentration of ammonium is 11 times higher then average, while in Far East maximum nitrate concentration 9 times prevail average one.

Far East region is characterized by the lowest pH value (5.3) which can be compared only with precipitation acidity at north-west territory of Russia. It should be noted that both these regions are characterized by sulfate type of precipitations. All over the last territory of Russia precipitations are almost neutral (pH = 6.1- 6.4). Minimum pH value of precipitations (3.5) was observed in Central and North Siberia region. All over the Asian territory of Russia there was registered acid precipitation with pH about 4.5, however the frequency of such events is less then 5%.

Table 10.12 Minimum and maximum values of sulfur and nitrogen compounds and pH value in 2004

	SO_4		NO_3		NH_4			
	mg/l						pH	
Region	**min**	**max**	**min**	**max**	**min**	**max**	**min**	**max**
Central and North Siberia	0.07	16.4	0.04	3.8	0.02	6.80	3.5	7.1
South Siberia	0.10	22.9	0.10	5.1	0.05	2.80	5.0	7.5
Baikal region	0.40	28.4	0.05	5.5	0.02	2.20	4.8	8.4
Far East	0.30	16.8	0.10	10.3	0.10	2.30	4.1	7.4
ATR average	**0.22**	**21.1**	**0.07**	**6.2**	**0.05**	**3.53**	**4.4**	**7.6**
Standard deviation	*0.16*	*5.7*	*0.03*	*2.8*	*0.04*	*2.20*	*0.7*	*0.6*
ETR average	**0.18**	**16.5**	**0.03**	**6.1**	**0.10**	**3.45**	**4.5**	**7.1**
Standard deviation	*0.10*	*8.7*	*0.01*	*4.0*	*0.13*	*1.30*	*0.6*	*0.4*

Evaluation of precipitation mineralization and acidity in urban regions of Asian Russia shows that distribution of ions is almost the same as for rural regions (Figure 10.13). In urban sites of Central, North Siberia and Baikal region predominated anion is bicarbonate, while sulfate is a main ion in precipitation of South Siberia. In Far East region main anions in urban precipitations are SO_4^{2-} and marine origin Cl^-. Average concentrations of main ions in urban sites are about 2-2.5 times higher then in rural ones. There is no big difference in urban and rural levels of sulfate concentrations during summer months. It does not exceed 2 mg/l all over Baikal region. Otherwise, the influence of urban and industrial centers can clear be seen during winter time when sulfate concentration in Irkutsk increasing up to 15-23 mg/l, while at regional level in Baikal region this parameter is almost 3 times lower. The influence of urban and industrial centers at the territory of Siberia and the Far East region is resulting in increasing of sulfate ion concentration in precipitation and sulfur dioxide concentration in air at urban and regional sites comparing with background level.

Concentration of nitrogen compounds in urban sites almost the same or 1,5 times higher then in rural ones.

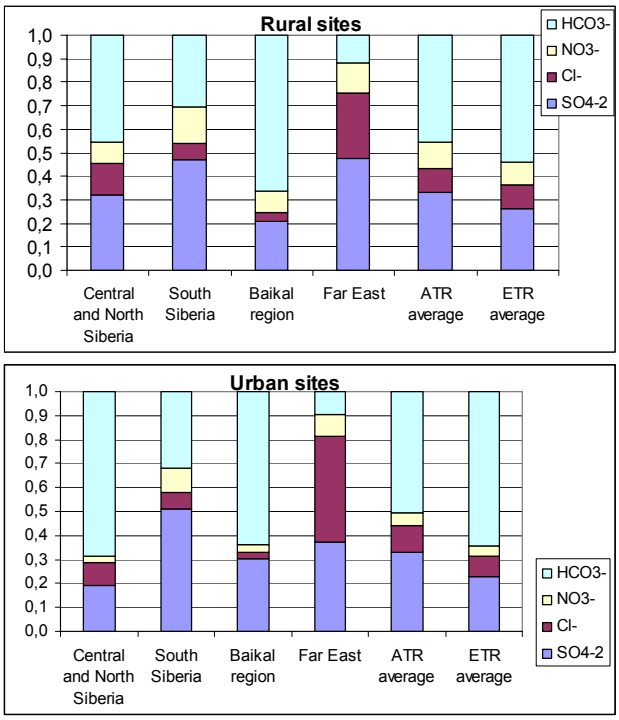


Figure 10.13 Anions ratio in precipitation of urban and rural sites of the Asian territory of Russia

According to the information prepared for AMAP assessment report (Hole et al., 2006), concentrations of sulfatic sulfur in the North Siberian region ranged from zero to 143.06 mg/l in industrial area of Norilsk (which was the highest concentration observed throughout Russia). The average level for the region, excluding Norilsk, did not exceed 0.89 mg/l and there was a maximum concentration of 16.85 mg/l. Background concentrations, characterized by data for Urengoy, Turukhansk, Polyarniy, and Zhigansk, ranged from 0.2 to 1.2 mg/l with the minimum values in warm or spring months. In contrast, average monthly sulfur concentrations at Norilsk were 50 to 60 times higher than at Turukhansk. Precipitation at Norilsk was most polluted in May and September (Figure 10.14). Seasonal variation at the background station in Turukhansk follows the same pattern as at Norilsk.

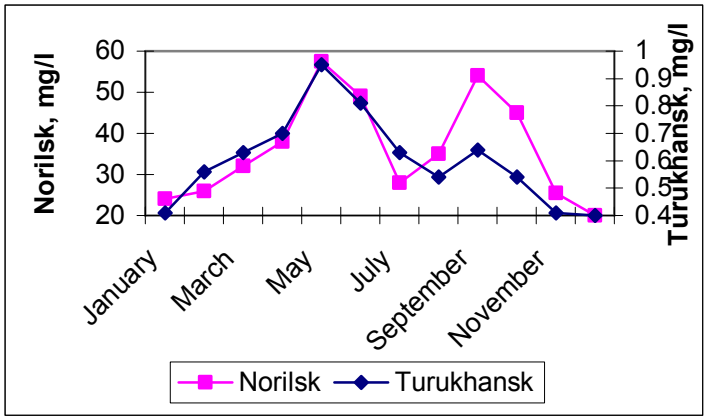


Figure 10.14 Seasonal distribution of sulfur concentration in precipitations in Norilsk industrial area and Turukhansk background site

Based on the data of ion concentration and precipitation amount, average wet deposition of sulfur, nitrogen and ion sum is presented in the Table 10.13. Annual sulfur deposition fluxes are varying over Asian part of Russia from 0,3 to 1,1 t/km^2, average total nitrogen deposition is about 0,4 t/km^2 with highest values in South Siberia and Far East. Average total elements deposition in the Asian territory is about 1.5 times less the average value for European territory of Russia.

Table 10.13 Average annual wet deposition of sulfur, nitrogen and ion sum (t/km^2 per year)

Regions	S (SO_4^{2-})	N (NO_3^-)	N (NH_4^+)	∑ N	M	S/∑N	N (NH_4)/ N (NO_3^-)
Central and North Siberia	0.36	0.07	0.18	0.24	4.6	1.5	2.6
South Siberia	1.11	0.25	0.34	0.58	8.5	1.9	1.4
Baikal region	0.49	0.14	0.09	0.23	8.8	2.1	0.6
Far East	1.00	0.18	0.23	0.41	9.0	2.4	1.3
ATR average	0.70	0.16	0.20	0.36	7.1	2.0	1.2
ETR average	0.70	0.16	0.30	0.46	10.8	1.5	1.8

During the last 5 years period (2000-2005), there was no any clear tendency observed in total mineralization of precipitation at Asian territory of Russia. At the same period mineralization of precipitations in European territory had significantly decreased. The same situation was observed for sulfur concentrations. Its values varied about 3 to 8 mg/l with maximum for all regions over Asian territory during this period in 2000. Chlorine concentration shows clear tendency to decrease almost in all regions except of North and Central Siberia. Nitrogen concentration had increased in Far East region.

10.5.3 Comparison of the Russian EANET and national monitoring data on precipitation chemistry

Different sampling and analytical methodology used at national monitoring network and at EANET sites do not allow to make a representative comparison of results. This should be a subject of separate detail investigation. Some preliminary attempts to compare these data were made in (Ginzburg et al., 2006). Generally, it could be noted that according to the both networks predominated ions in precipitations over Asian part of Russia is sulfate and bicarbonates. However, according to the measurements at background sites of national precipitation monitoring network, average for ATR ration of bicarbonates is 30% (>50% Baikal region) and sulfate is 25%. At the same time according to data from Listvyanka (EANET) sulfate ion takes more then 50% of anions.

Comparison of average levels of main ions concentrations in precipitation of Russia regions and at Russian EANEN sited is presented at figure 10.15a for rural and 10.15b for urban areas. According to Russian EANET data Far East region is characterized by the higher level of sulfur in precipitation, while higher levels of nitrogen compounds are measured in Baikal region. Otherwise, according to long-years measures at the national precipitation monitoring network, sulfate concentrations in precipitation of Far East region is lower then in South Siberia and Baikal region. It also can be noted that concentrations of all main ions at Listvyanka site is lower then average for Baikal region (sulfate concentration is 3 times lower, nitrogen – 1.5 times lower, ammonium – 2.5 times lower). At the same time, data for Primorskaya EANET site is quite good correlated with average data for Far East region.

Differences in concentration levels at different monitoring networks can be explained by different sites location and sampling methodology. Reasons of such differences and detail comparison of methodology and monitoring results should be made in the future.

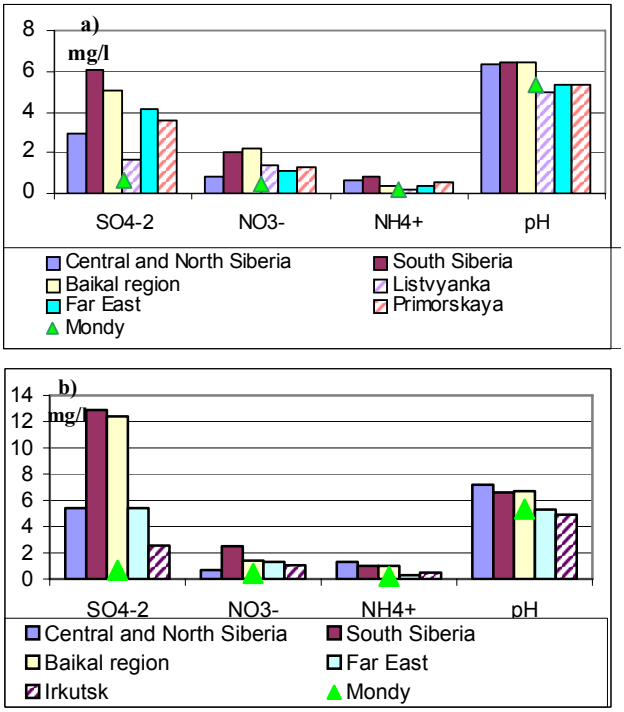


Figure 10.15 Comparison of average region concentrations of sulfate, nitrate and ammonium ions in precipitations (according to national monitoring network) with background levels (Mondy) and EANET data (Listvyanka, Primorskiy) in 2004 for **a)** rural and **b)** urban sites.

10.5.4 Snow monitoring data

This chapter is prepared based on the data from the snow monitoring network (Nazarov et al., 2002; Artemov et al., 2005). Some Results are also compared with the data obtained from the sites of precipitation chemistry and acidity monitoring.

Snow monitoring network is operated in Russia since 1980 on the bases of hydro meteorological snow monitoring network. Its main goal is evaluation of atmospheric pollution loads. Planned density of snow monitoring network for Asian part of Russia should be 1 site per 36,1 thousand km^2 (that is about 360 sites per territory). Results from measured parameters allow evaluating annual sulfate sulfur, nitrate and total nitrogen loads and snow pH values.

Average annual values of atmospheric loads for Asian territory of Russia for sulfate sulfur is 210 kg/km, for nitrate nitrogen – 60 kg/km, for total nitrogen – 175 kg/km. Average annual data for administrative regions of Russian Asian territory are presented in table 10.14.

Table 10.14 Deposition of sulfur and nitrogen at Asian territory of Russia in 2000-2004 (kg/km^2 per year).

Region		Square, km^2	Sulfur	Nitrogen nitrate	Total nitrate
West Siberia	Tumen region	1435	212	83	294
	Omsk, Tomsk and Novosibirsk regions	635	344	168	346
	Khemerovo and Altay regions	265	547	207	372
	Republic of Altay	93	220	63	293
East Siberia region		4123	269	55	174
Far East region	Yakutiya	3103	60	21	95
	Khabarovsk, Amur, Kamchatka, Magadan, Chukotka regions	2860	143	34	104
	Primorskiy kray, Sakhalin region	237	397	83	318

The most intensive deposition of sulfur is registered at the South and Central part of West Siberia region (547 and 344 kg/km^2 year) and Sakhalin and Primorskiy region (397 kg/km^2 year). The highest values of nitrogen and total nitrate deposition are also observed at the South and Central part of West Siberia region.

Comparing with the data obtained from the precipitation chemistry network (table 5) intensities of sulfur and nitrogen deposition measured at snow monitoring network are much lower. The first values exceed the second in 3 times for sulfur, and in 2 times for total nitrogen.

10.5.5 Conclusions based on the results of national monitoring

Russian national acid deposition monitoring network at the Asian territory of the country consists of regional and background precipitation chemistry and acidity monitoring sites; urban sites, where pollutants concentration in both air and precipitation are measured; and snow monitoring network. Analysis and generalization of monitoring results, their interpretation, and evaluation of the state of the environment according to these data are annually published in a number of issues. The most complete of them is “Review of the state of the environmental pollution in Russian Federation” which is published by a very limited number of copies, but the last years issues are available in the Internet.

A basic criterion according to which the degree of air pollution is defined in Russia is maximum permissible concentration. It is determined during the medical studies and then approved by the Russian Sanitary - Epidemiology Service. There are two types of MPC: average and episodic maximum permitted concentration. These maximum permissible concentrations are set for more than 5000 pollutants.

Long term monitoring data obtained from the background monitoring stations over Russia shows that generally for Russia territory there is a tendency for decreasing of sulfur and increasing of nitrogen concentrations. At the same time, sulfur concentration in precipitations of Siberian and Far East background regions stays practically stable and even a bit increases during more then 30 year’s measurement period.

Predominated ions in the precipitation of Russian Asia are sulfate and bicarbonates. Bicarbonates are predominated in Baikal region, Central and North Siberia, while sulfate is a main ion in precipitation

of South Siberia and Far East region. Baikal region is characterized by the highest mineralization of precipitations among other regions.

Far East region is characterized by the lowest pH value (5.3) which can be compared only with precipitation acidity at north-west territory of Russia. All over the last territory of Russia precipitations are almost neutral (pH = 6.1- 6.4).

Average concentrations of main ions in urban sites are about 2-2.5 times higher then in rural ones. The influence of urban and industrial centers can mostly be seen during winter time when sulfate concentration in urban regions increasing significantly. Concentration of nitrogen compounds in urban sites almost the same or 1.5 times higher then in rural ones.

Average annual values of atmospheric loads for Asian territory of Russia measured at the snow monitoring network for sulfate sulfur is 210 kg/km, for nitrate nitrogen – 60 kg/km, for total nitrogen – 175 kg/km. Comparing with the data obtained from the precipitation chemistry network (table 5) intensities of sulfur and nitrogen deposition measured at snow monitoring network are much lower. The first values exceed the second in 3 times for sulfur, and in 2 times for total nitrogen.

Different sampling and analytical methodology used at national monitoring network and at EANET sites do not allow to make a representative comparison of results. However, some preliminary attempts show that there are some variances in the measurements results from different networks. Reasons of such differences and detail comparison of methodology and monitoring results should be a subject for a separate investigation.

References

Artemov, Y.M., Belikova, T.V., Vasilenko, V.N., Nazarov, I.M., 2005. Atmospheric deposition of sulfur and nitrogen over the territory of Russia (according to snow monitoring data). In Review of the state of the environmental pollution in Russian Federation in 2004, Moscow.

Chistyakova, M.V., 2002. Acidity and chemical composition of precipitations. In Review of the state of the environmental pollution in Russian Federation in 2001, Moscow.

Chistyakova, M.V., Pavlova, M.T., Sokolova, O.I., 2003. Acidity and chemical composition of precipitations. In Review of the state of the environmental pollution in Russian Federation in 2002, Moscow.

Ginzburg, V.A., Paramonov, S.G., Alekseeva, L.I., Sokolova, O.A., 2006. Complex assessment of sulfur and nitrogen pollution over Asian territory of Russia (according to the monitoring data). In Proceedings of the Second Russian Conference “Scientific aspects of environmental problems in Russia”. May 29-30, Moscow, Russia (in press)

Hole, L.R, Christensen, J., Ginzburg, V.A., Makarov, V., Polishok, A.I., Ruoho-Airola, T., Vasilenko, V.N., 2006. Concentration and deposition of acidifying pollutants. In AMAP assessment 2006: Acidifying pollutants, arctic haze, and acidification in the Arctic, AMAP, Oslo, (in press).

Nazarov, I.M., Vasilenko, V.N., Belikova, T.V., 2002. Atmospheric loads of sulfur and nitrogen over the territory of Russia. In Review of the state of the environmental pollution in Russian Federation in 2001, Moscow.

Shalamyanskiy, A.M., Romashkina, K.I., Chistyakova, M.V., 2002. Acidity and chemical composition of precipitation. In Review of the state of the environmental pollution in Russian Federation in 2001, Moscow.

Svistov, P.Ph., Pershina, N.A., Pavlova, M.T., Polishok, A.I., 2004. Acidity and chemical composition of precipitation. In Review of the state of the environmental pollution in Russian Federation in 2003, Moscow.

Svistov, P.Ph., Pershina, N.A., Pavlova, M.T., Polishok, A.I., 2005. Acidity and chemical composition of precipitation. In Review of the state of the environmental pollution in Russian Federation in 2004, Moscow.

Mikhailova T (2000) The physiological condition of pine trees in the Prebaikalia (East Siberia). Forest Pathology 30:345-359

T.A. Mikhailova, N.S. Berezhnaya, O.V. Ignatieva, L.V. Afanasieva. Complex assessment of forest condition under air pollution impacts. In: Plant Responses to Air Pollution and Global Change. K. Omasa, I. Nouchi, L.J. De Kok (Eds), Springer-Verlag Tokyo, 2005 – 45-51.

Obolkin, V.A., Khodzer, T.V., 1990. Annual fluxes of sulfate and mineral nitrogen in the Lake Baikal region. Meteorology and Hydrology; 7, 71-76 (In Russian).

Obolkin, V.A., Khodzer, T.V., Anokhin, Yu.A., Prokhorova, T.A., 1991. The acidity of atmospheric deposition in Baikal region. Meteorology and Hydrology; 1, 55-60 (In Russian).

Semenov, M.Yu., Khodzer, T.V., Obolkin, V.F., Domysheva, V.M., Golobokova, L.P., Kobeleva, N.A., Netsvetaeva, O.G., Potemkin, V.L., Van Greeken, R., Fukuzaki, N., 2006. Assessing the acidification risk in the Lake Baikal region. Chemistry and Ecology, 22 (1), 1-11.

Semenov, M., Bashkin, V., Sverdrup, H., 2001. Critical loads of acidity for forest ecosystems of North Asia. Water, Air, and Soil Pollution, 130, 1193-1198.

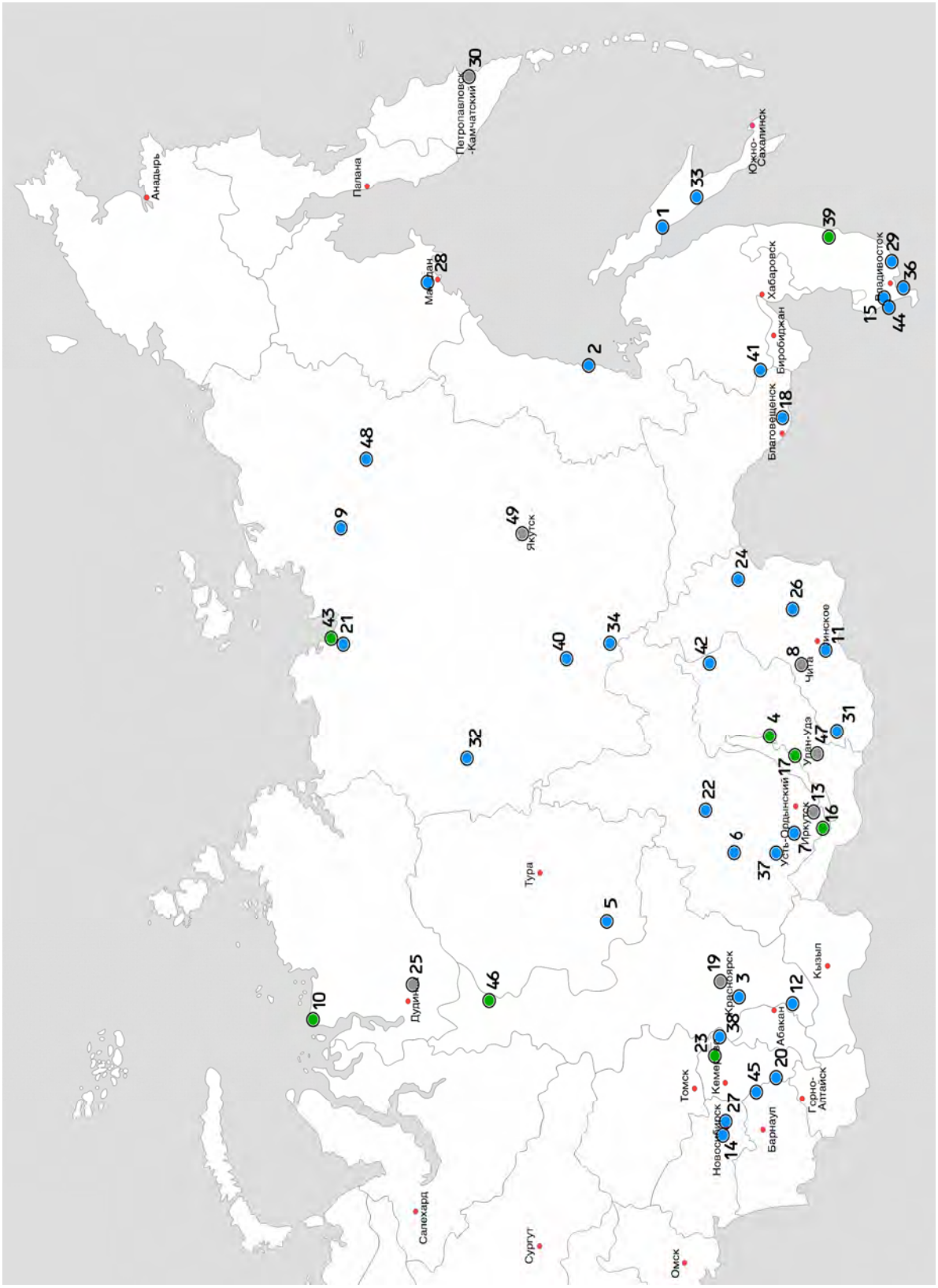
Sorokovikova, L.M., Netsvetaeva, O.G., Tomberg, I.V., Khodzher, T.V., Pogodaeva, N.V., 2004. Effect of atmospheric precipitation on the chemical composition of river waters in South Baikal region. Atmospheric and Ocean Optics, 17 (5,6), 423-427 (In Russian).

Annex 1.

Regional and background monitoring sites on precipitation chemistry situated at the Asian territory of Russia in 2001-2004.

Nane of Station	Latutude, deg	Long, deg
Akexandrov	50.9	142,2
Ayan	56.5	138,2
Balakhat	55.4	91,7
Barguzinskiy BR	54.3	109,5
Baykit	61.7	96,4
Bratsk	56.3	101,7
Cheremkhovo	53.2	103
Chita	52.1	113,5
Deputatskiy	69.3	139,7
Dikson	73.5	80,4
Duldurga	50.7	113,6
Ermakovskoe	53.3	92,4
Irkutsk	52.3	104,3
Iskitim	54.7	83,3
Khalkidon	44.3	132,4
Khamar-Daban	51.9	103,6
Khuzhir	53.2	107,3
Konstantinovka	49.6	128
Krasnoyarsk	56.0	92,9
Kuzedeevo	53.3	87,2
Kyusyur	70.7	127,4
Maksimovo	57.1	104,9
Marinsk	56.1	87,8
Mogocha	53.7	119,8
Norilsk	69.3	88,3
Nrechinsk	52.0	116,5
Ogurtcovo	55.1	83
Palatka	60.1	150,9
Partizansk	43.2	133
Petropavlovsk-Kamchatskiy	52.9	158,6
Petrovskiy Zavod	51.3	108,9
Polyarniy	66.7	112,4
Poronaysk	49.2	143,1
Preobrazhenka	60.1	108,1
Romanovka	53.2	112,8
Sad-gorod	43.3	132,1
Sayansk	54.0	102
Sharipovo	56.0	89
Sikhote-Alinskiy BR	45.0	136,6
Suntar	62.2	117,7
Sutur	50.1	132,1
Taksimo	56.4	114,8
Tiksi	71,6	128,9
Timiryarevskiy	43.9	131,9
Togul	53.5	85,9
Turukhansk	65.8	87,9
Ulan-Ude	51.8	107,6
Ust-moma	66.5	143,2
Yakutsk	62.0	129,7
Yaylu	51.8	87,6
Zhigansk	66.8	123,4

* Background sites are shown by **Bold** font, urban sites are shown by *Italic* font


Анадырь
Палана
Петропавловск-Камчатский
Южно-Сахалинск
Магадан
Хабаровск
Биробиджан
Владивосток
Благовещенск
Якутск
Чита
Улан-Удэ
Иркутск
Усть-Ордынский
Тура
Дудинка
Красноярск
Кызыл
Абакан
Томск
Кемерово
Новосибирск
Барнаул
Горно-Алтайск
Салехард
Сургут
Омск

Status of Acid Deposition in Thailand

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11.1 Information on Acid Deposition Activities in Thailand

11.1.1 Outline of the activities on acid deposition

The Air Quality and Noise Management Bureau, Pollution Control Department, Ministry of Natural Resources and Environment is appointed by the Royal Thai Government as the National Focal Point and National Center in Thailand for the Acid Deposition Monitoring Network in East Asia (EANET). Thailand participated in the preparatory phase of (EANET) during 1998-2000 and jointly announced to implement EANET activities on a regular basis together with other nine East Asian countries, namely China, Indonesia, Japan, Republic of Korea, Malaysia, Mongolia, the Philippines, Russian Federation, and Vietnam at the Second Intergovernmental Meeting held in Japan during October 25-26, 2000.

There are 5 EANET monitoring sites: two urban (Bangkok and Samutprakan), two rural (Prathumthani and Chiangmai) and one remote sites (Kanchanaburi). The monitoring activities have started since 2000.

In addition to the EANET activities, Thailand under the Pollution Control Department established 5 other acid deposition monitoring stations cover all regions of Thailand. They include: 1. Nakorn Prathom (West), 2. Nakorn Ratchasima (Northeast), 3. Cholburi (East), 4. Ayuthaya (Central), and 5. Songkhla (South). The regional stations monitor both wet and dry depositions. The wet deposition uses the automatic wet only sampler collected daily and the dry deposition employs the four-stage filter packs collected every 10 days in monthly basis. The work has started since in the year 2000.

The status of acid deposition in Thailand presented in this report will be based on the EANET data only.

11.1.2 Monitoring stations

There are 5 designated EANET monitoring sites as shown in Figure 11.1.

(1) Vachiralongkorn Dam (VLK), Kanchanaburi province (Remote Site): monitoring for wet deposition, dry deposition, Inland aquatic environment and soil and vegetation.
(2) Pollution Control Department/The Public Relation Department (PCD/PRD), Bangkok (Urban Site): PRD site monitoring for dry deposition by automatic analyzer and PCD site is monitoring for wet deposition and dry deposition by filter pack. Both sites located in the same area.

(3) Environmental Research and Training Center (ERTC), Pathumthani Province (Rural Site) : monitoring for wet deposition and dry deposition.
(4) Thailand Meteorological Department (TMD), Samutprakarn province (Urban Site): monitoring for wet deposition and dry deposition.
(5) Chiang Mai University (CMU)(Mae-Hia Campus), Chiang Mai Province (Rural Site): monitoring for wet deposition and dry deposition.

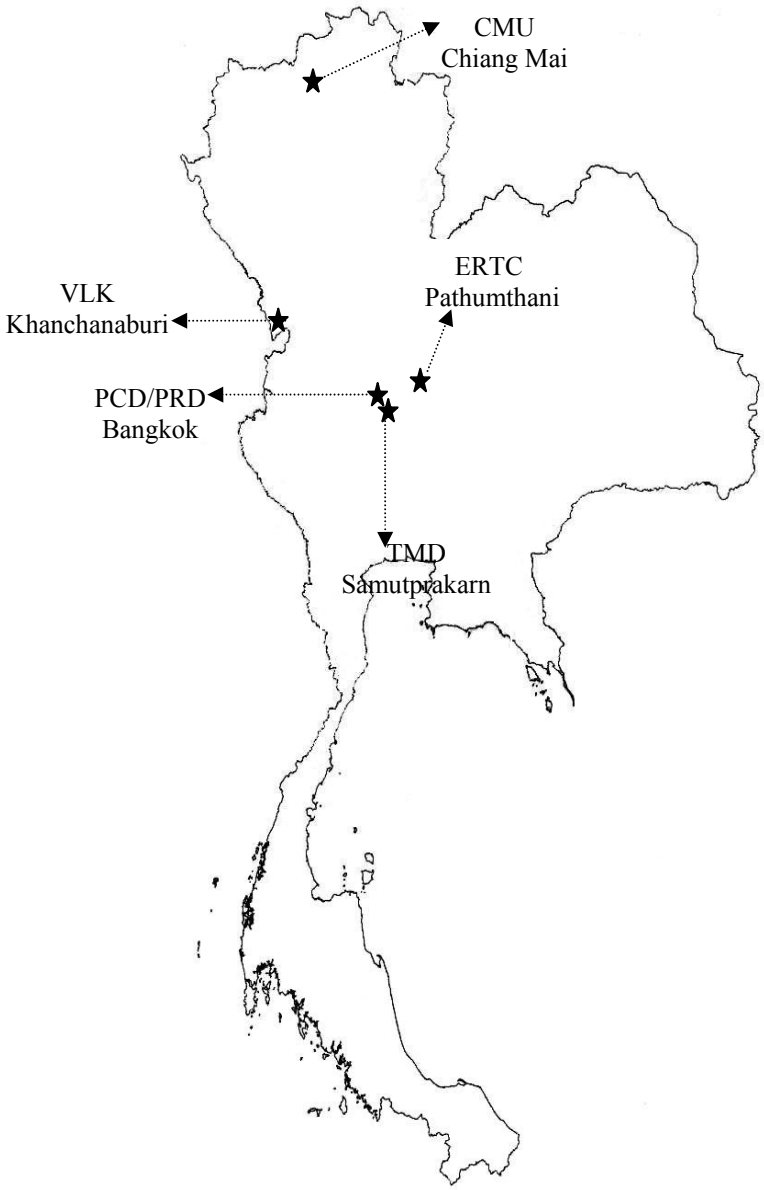

Figure 11.1 EANET Monitoring Sites in Thailand

11.1.3 Outline of sampling and measurement

11.1.3.1. Wet Deposition Monitoring

Wet deposition is monitored by "Wet-Only-Sampler" for concentration and rain gauge for precipitation measurement. Twenty-four hours composite samples are collected in polyethylene collecting bottles. Rain samples are weighted and then analyzed for chemical composition (EC, pH and ionic species). If the samples cannot be analyzed in one day or need to transport from the

sampling site to laboratory, the samples are refrigerated at 4 ^{o}C or kept with freezer packs in a box and transported to the laboratory daily.

11.1.3.2.Dry Deposition Monitoring

Atmospheric gases concentrations, i.e. SO_2, NO_X and O_3, are measured by automatic analyzers at the Vachiralongkorn (VLK) Dam, ERTC, PRD and TMD. For VLK site, SO_2, NO_x and O_3 are monitored for 2 weeks, three times a year around March, July and November. For TMD and PRD site, SO_2, NO_x and O_3 are monitored continuously all year round.

Atmospheric gases and aerosols concentrations are measured by filter pack method at CMU, PCD and ERTC. Duration of sampling of every sites except VLK is 10 days/sample continuously. For VLK the frequency is three times a year (14 days/sample) in the same period of monitoring by an automatic analyzer. The samples are analyzed for SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Mg^{2+} and Ca^{2+} in particulate (aerosol) and SO_2 , HNO_3 NH_3 and HCl in gas phase.

11.1.3.3 Soil and Vegetation Monitoring

Soil and vegetation are monitored at Vachiralongkorn Dam in every 3 years.

11.1.3.4 Inland Aquatic Environments Monitoring

Inland aquatic environments are monitored at Vachiralongkorn Dam, Khanchanaburi. Samples are collected from two locations in Vachiralongkorn Reservoir, namely Ban Pong Chang (BPC) and Ban Pang Pueng (BPP) station.

The frequency of sampling for Inland Aquatic Environment is every 3 months , 4 times a year in March , June , September and December.

Table 11.1 Summary of Acid Deposition Monitoring Parameter and Method in Thailand

Site	Wet Deposition		Dry Deposition		Inland Aquatic Environment		Soil and Vegetation		Meteorological Data
	Parameter	Method	Parameter	Method	Parameter	Method	Parameter	Method	
Khanchanaburi	EC, pH, Anion, Cation, %CE	EC-meter, pH meter, IC, Balance	SO_4^{2-} NO_3^- Cl^- NH_4^+ K^+ Na^+ Mg^{2+} Ca^{2+} SO_2 HNO_3 NH_3 HCl NOx CO PM O_3	Filter Pack, Automatic analyzer	EC, pH, DO, COD, Alkalinity, Anion, Cation, Water Color	EC-meter, pH meter, IC, Titration	Soil and Vegetation	EANET's Guildline	Temp, WS WD (Mobile unit and Thongpaphum)
Bangkok	EC, pH, Anion, Cation, %CE	EC-meter, pH meter, IC, Balance	SO_4^{2-} NO_3^- Cl^- NH_4^+ K^+ Na^+ Mg^{2+} Ca^{2+} SO_2 HNO_3 NH_3 HCl NOx PM O_3	Filter Pack, Automatic analyzer	-	-	-	-	Temp WS WD Rain RH GRD (Chatuchak)
Pathumtani	EC, pH, Anion, Cation, %CE	EC-meter, pH meter, IC, Balance	SO_4^{2-} NO_3^- Cl^- NH_4^+ K^+ Na^+ Mg^{2+} Ca^{2+} SO_2 HNO_3 NH_3 HCl	Filter Pack	-	-	-	-	Temp RH WS WD (Pathumtani Agro Met)
Samutprakarn	EC, pH, Anion, Cation	EC-meter, pH meter, IC	SO_2 NOx O_3	Automatic analyzer	-	-	-	-	Temp WS WD Rain RH (Bangna
Chiangmai	EC, pH, Anion, Cation, %CE	EC-meter, pH meter, IC, Balance	SO_4^{2-} NO_3^- Cl^- NH_4^+ K^+ Na^+ Mg^{2+} Ca^{2+} SO_2 HNO_3 NH_3 HCl	Filter Pack Automatic analyzer	-	-	-	-	Temp GRD RH WS WD (Chiang Mai)

Temp= Ambient temperature, WS= Wind Speed, WD= Wind Direction, GRD= Global Radiation, RH= Relative Humidity

11.2 State of acid deposition in Thailand

As part of the Acid Deposition Monitoring Network in East Asia (EANET), Thailand had establish an acid deposition monitoring program in order to collaborate with the acid deposition measurement networks across member countries in the East Asia region. This section summarizes the results from the measurement of wet deposition and its chemical composition in Bangkok and suburbs (Pathumthani). Data from a rural (Chiangmai) and remote (Kanchanaburi) monitoring sites were also compared to help elucidate and better appreciate the pattern and level of wet deposition in Thailand. The sampling and analysis of wet deposition were carried out following EANET technical guidelines (EANET, 2000).

This report analyzed the data measured during 2000-2004. Since the monitoring at Chiangmai has started in 2001, the analysis for this site was taken from the available data during 2001-2004.

11.2.1 State of wet deposition

11.2.1.1. Chemical Composition of Rainwater

The collected rainwater samples were analyzed for their chemical compositions (both cation and anion) by Ion Chromatography. The results from the measurement are summarized in Table 11.2.

Table 11.2 Average concentration of chemical constituents in rainwater (μeq/L)

Ionic Species	Bangkok	Pathumthani	Chiangmai	Kanchanaburi
pH	5.00 (5.21)	5.00 (5.32)	5.56 (6.13)	5.76 (5.90)
H^+	9.89 (13.24)	9.91 (10.03)	2.75 (1.97)	1.74 (1.67)
Na^+	7.38 (10.97)	6.89 (13.06)	3.44 (6.93)	8.34 (10.99)
NH_4^+	40.05 (50.28)	30.53 (43.52)	17.91 (20.00)	7.34 (6.95)
K^+	1.88 (2.89)	1.15 (1.89)	2.05 (4.65)	3.31 (4.27)
Mg^{2+}	3.86 (5.77)	2.68 (5.19)	3.91 (6.58)	3.01 (4.03)
Ca^{2+}	20.77 (33.70)	16.48 (34.91)	11.81 (23.92)	8.32 (9.78)
Cl^-	9.72 (13.57)	7.24 (14.19)	4.68 (7.88)	11.66 (14.19)
NO_3^-	22.22 (32.11)	18.89 (29.22)	6.79 (10.97)	4.75 (5.39)
SO_4^{2-}	39.09 (50.03)	30.94 (43.95)	14.95 (15.39)	7.83 (8.03)

Note: ( ) = arithmetic mean concentration

Precipitation measurements are reported as volume-weighted means (VWM). Comparisons of volume-weighted mean (VWM) and the arithmetic mean values as shown in Table 1 confirm the effect of rainfall amount to the amount of chemical composition in the rainwater. Most of the VWM concentrations were lower than the arithmetic mean values, indicating that higher concentrations were usually associated with lower precipitation amounts.

Generally, the volume weight mean concentration of the ionic species in the rainwater of Bangkok were the highest across this range of places. In Bangkok, NH_4^+ was the most abundant with a volume weight mean concentration of 40.05 μeq/L. It was also the most abundant ion found in most other areas (except Kanchanaburi), with the VWM of 33.53, 17.91 and 7.34 μeq/L at Pathumthani, Chiangmai and Kanchanaburi, respectively. The concentrations of anthropogenic ion species (SO_4^{2-}, NO_3^- and NH_4^+) were high in Bangkok and its sub-urban area (Pathumthani). The levels were found relatively higher than the concentrations measured in the rural area (Chiangmai) and the remote area (Kanchanaburi) as shown in Figure 11.2.

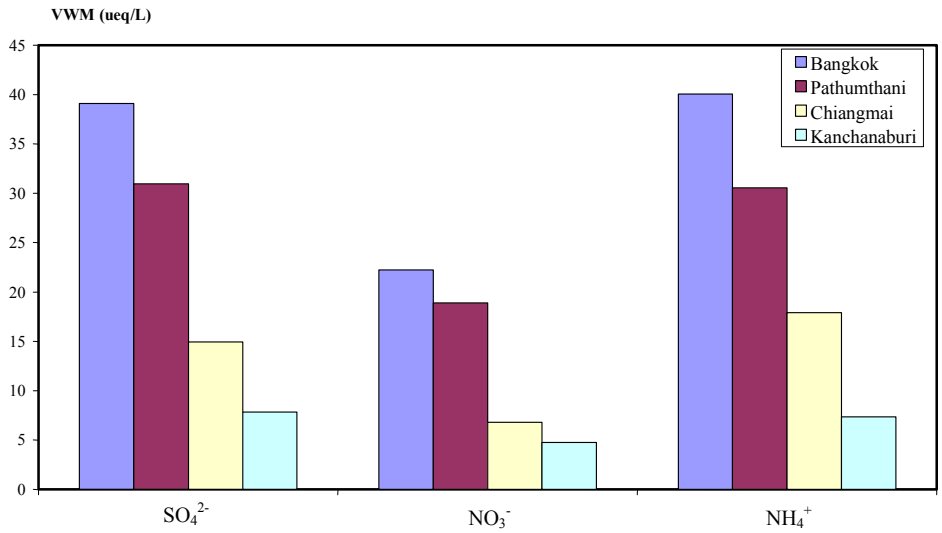

Figure 11.2 Comparison of VWM of SO_4^{2-}, NO_3^- and NH_4^+

11.2.1.2 pH of rainwater

The average pH of the rainwater, calculated from volume weight mean concentration of H^+, were 5.00, 5.00, 5.56 and 5.76 for Bangkok, Pathumthani, Chiangmai and Kanchanaburi, respectively. The spatial and temporal distribution of pH values is as illustrated in Figure 11.3. It was found that the percentage of the precipitation samples measured at all sites exhibited pH values lower than 5.6, the reference pH, obtained by dissolving atmospheric CO_2 (360 ppmv) in pure water had an increase tendency in Bangkok and Pathumthani. More than 50% of rainwater samples were found having pH < 5.6 in those areas in 2003. However, it was found that these percentages at both sites were decreased in 2004 as compare with the measured values in 2005. There were slightly increase tendency of low pH at Chiangmai (rural area).

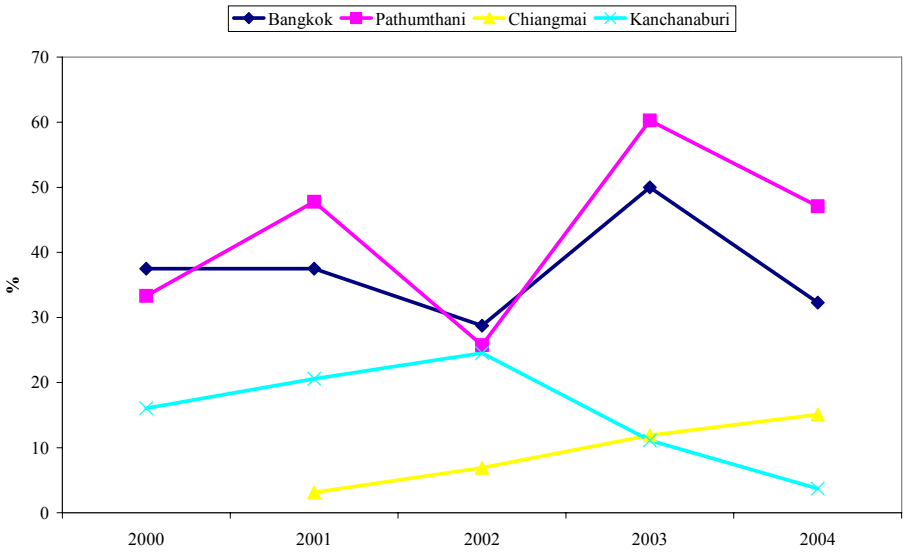

Figure 11.3 Spatial and temporal distributions of percentage of pH value < 5.6

However, considering the water pH below 5.6 as an indicator of acidic rain might be misleading. The concentration of H^+ is a more appropriate indicator. It was found that H^+ concentration in Bangkok was the highest when compare to other places. The data indicated that the levels of H^+

were increased according to the higher degree of urbanization. The VWM of H^+ was 9.89, 9.91, 2.75 and 1.74 µeq/L at Bangkok, Pathumthani, Chiangmai and Kanchanaburi, respectively.

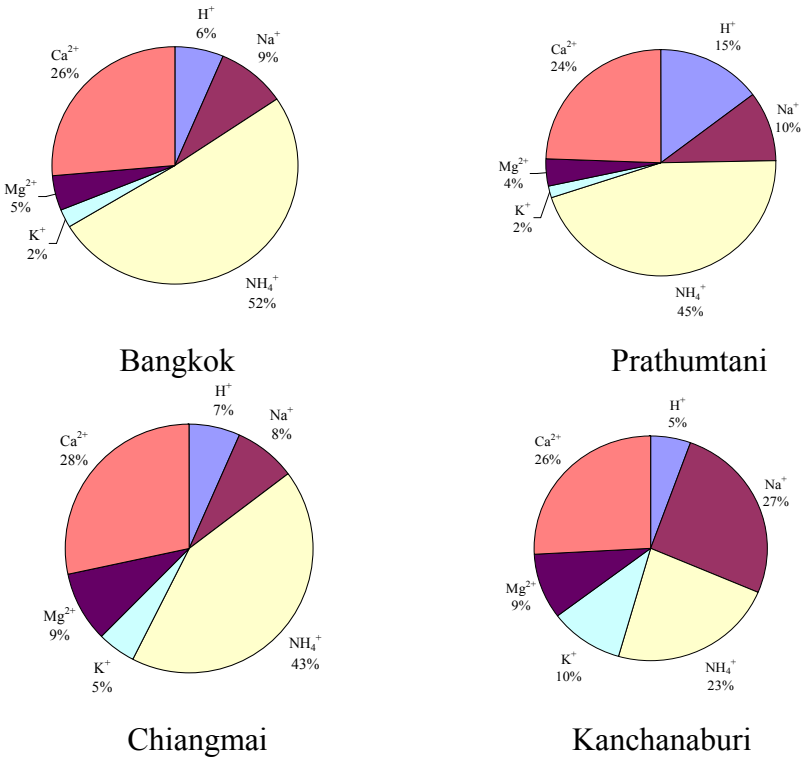

Figure 11.4 Fractional contribution of cation species

The fractional contribution of each cation to the total cation concentration indicated that the major cation found in the rain waters was NH_4^+ (52%) at all sites except Kanchanaburi as illustrated in Figure 11.4. The contribution of NH_4^+ to the total cation concentration at other places were 43% and 23% for Chiangmai and Kanchanaburi, respectively. The intensive fertilizer and relatively poor treatment of wastes from agriculture and residential activities might be the cause of the higher level of gaseous ammonia (Dianwu and Anpu, 1994; Fujita *et al*., 2000; Lee *et al*., 2000 and Zhao and Wang, 1994). The high level of NH_4^+ in precipitation coincides with the fact that the emission of ammonia in the Asian region is several times higher than in North America and Europe (Galloway, 1995).

Among anion, SO_4^{2-} was the most abundant at Bangkok, Pathumthani and Chiangmai with a volume weight mean concentration of 39.09, 30.94 and 14.95 µeq/L, respectively. The second most abundant anion at these sites was NO_3^- with a volume weight mean concentration of 22.22, 18.89 and 6.79 µeq/L for Bangkok, Pathumthani and Chiangmai, respectively. The concentrations of SO_4^{2-} and NO_3^- in the rainwater at Chiangmai and Kanchanaburi (rural and remote areas) were about 2-4 times lower than the level of these ionic species found at Bangkok and Pathumthani as shown in Figure 11.5.

The fractional contribution of Cl^- to the total anion was higher in the rural and remote areas as compared to Bangkok and its sub urban areas, due to lower ionic concentration in the rainwater. Concentrations of Cl^- found at all sites could be considered as contribution from marine origin which affected the chemical composition of the rainwater. The levels of Cl^- were found close to Na^+ concentrations as shown in Figure 11.6.

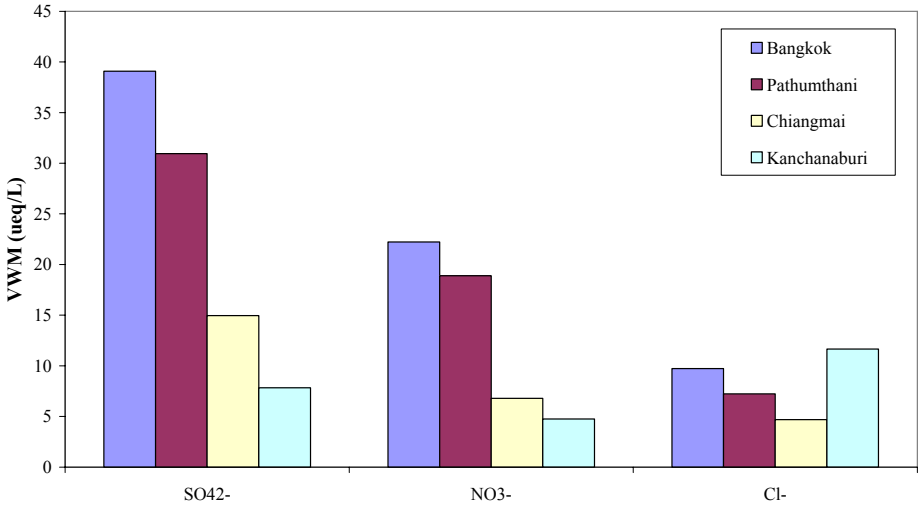

Figure 11.5 Spatial comparison of major anion concentration in rainwater

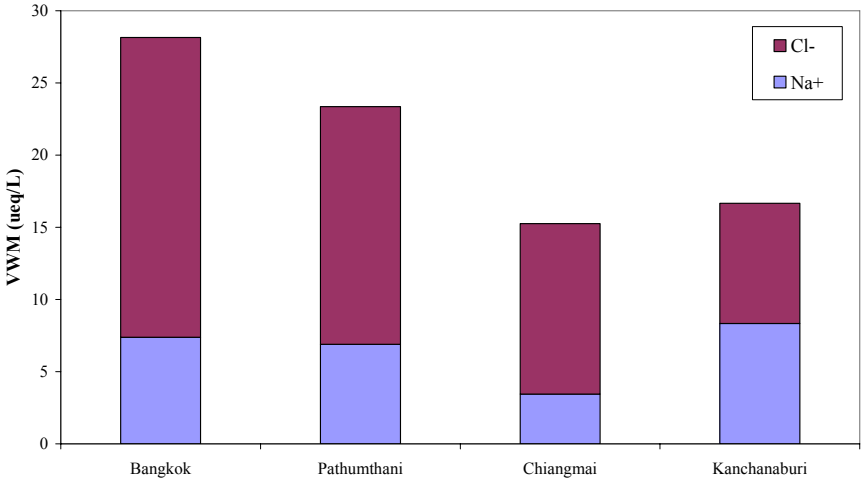

Figure 11.6 Volume weighted mean concentration of Na^+ and Cl^- in the rainwater

It could be concluded that Na^+ and the majority of Cl^- ions in the rainwater originated from sea. However, Cl^- also had a significantly high correlation with K^+. The correlation coefficients between these 2 species were 0.48, 0.48, 0.84 and 0.63 ($p < 0.01$) at Bangkok, Pathumthani, Chiangmai and Kanchanaburi, respectively (Thepanondh, 2003). It was found that the rural area (Chiangmai) and the remote area (Kanchanaburi) had higher correlation between these ions than the correlations found in the urban and sub urban areas. These finding indicated that K^+ and Cl^- found in the rainwater were associated with a specific source in the sampling area. Since K^+ is a good indicator of airborne particles generated by biomass burning, it is mostly associated with the fine discharge of smoke aerosols (Andreae, 1983, Andreae *et al*., 1998). It is also released by and accumulated by wind action (de Mello, 2001). Therefore, it is proposed that concentrations of these two species were originated from sea and were also partly released into the atmosphere as a result of the biomass burning that exists in the region.

A significant correlation of Ca^{2+} with Mg^{2+} ($p < 0.01$) at every monitoring sites strongly suggests that the soil could be a substantial source of them. The relatively significant ($p < 0.01$) SO_4^{2-} correlation values with NH_4^+, Mg^{2+}, Ca^{2+} and K^+ as well as high NO_3^- correlation values with these ionic species imply a neutralization process affecting the rainwater chemistry.

The sea salt fractions and non-sea salt fractions were calculated, which indicated the magnitude of the contribution of marine constituents to the rainwater chemistry, illustrated in Figure 11.7. Most of the Ca^{2+} concentrations at every monitoring sites (> 98 %) were considered to have been derived from a non-marine origin. Results from the calculation of enrichment factor using Na^+ as for a reference material were also supported this finding. Approximately 98% of SO_4^{2-} presented in rainwater samples in Bangkok, Pathumthani and Chiangmai were of non-sea salt origin (NSS-SO_4^{2-}), while the contributions of these species at Chiangmai and Kanchanaburi was about 92%, respectively.

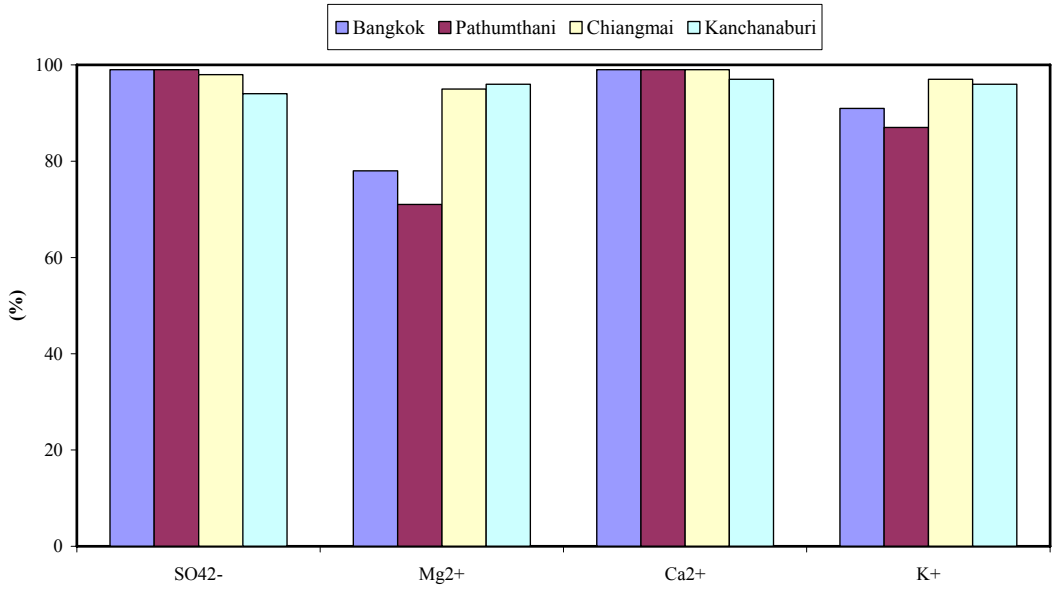

Figure 11.7 Fractional contribution of non-sea salt concentration in rainwater (%)

11.2.2. State of dry deposition

Dry acid monitoring sites were set along side with the wet only samplers covering six regions of the country namely the north (Chiangmai), central (Ayuthaya), northeast (Nakonrachasima), east (Chonburi), west (Nakonprathom), and south (Songkla). These six regional monitoring stations are outside the EANET, except Chiangmai in the north. Other EANET sites include Bangkok (Urban), Samutprakan (Industrial), Prathumthani (Rural) and Kanchanaburi (Remote). The non-EANET monitoring sites employ the four-stage filter pack method to collect the air samples. The EANET sites use the automatic samplers to measure the gaseous data. In this section, Chiangmai (urban site), Bangkok (urban site) and Kanchanaburi (remote site) are selected for the state of acid deposition study.

Chiangmai, the northern site

Chiangmai site is classified as a populated area. Since dry deposition monitoring started in 2001, data presented here will cover a period of 2001-2004. Figure 11.8 illustrated monthly four-year averages of NO, NO_2, SO_2 and O_3. The value of NO_x is a combined NO and NO_2. The monitoring results show the urbanized behavioral of Chaingmai city in which NO, NO_2 and PM10 concentrations were significantly high during the dry season (October - March) and low during the wet season (May – August). During the rainy months, those gaseous species were evidently washed down by the tropical rainfalls. The ten year average of rainfall (1991-2000) in Chiangmai in January was 5 mm and in August was 221 mm. The amount of dry deposition is obviously related to seasonal variation.

The SO_2 concentration was seen very low throughout the year in Chiangmai and hence less impact caused by this gaseous chemical. The ambient air quality standard of SO_2 in 1-hour is 300 ppb. For O_3, its concentration was in trend with NO and NO_2 which indicated the effect of photo chemical reaction of these precursors in the urban area.

For a long term study of dry deposition in Chiangmai, Figure 11.9 presented four years monitoring result (2001-2004). For the gaseous concentration, O_3 was significantly increased in 2004, similary with the particulate concentration of PM10. The increasing trend of the two chemicals indicated a rapidly urbanized growth of the Chiangmai city. However, the measured O_3 and PM10 concentrations are still far below the ambient air quality standard of 100 ppb in 1-hour and 330 $\mu g/m^3$ in 24-hour, respectively.

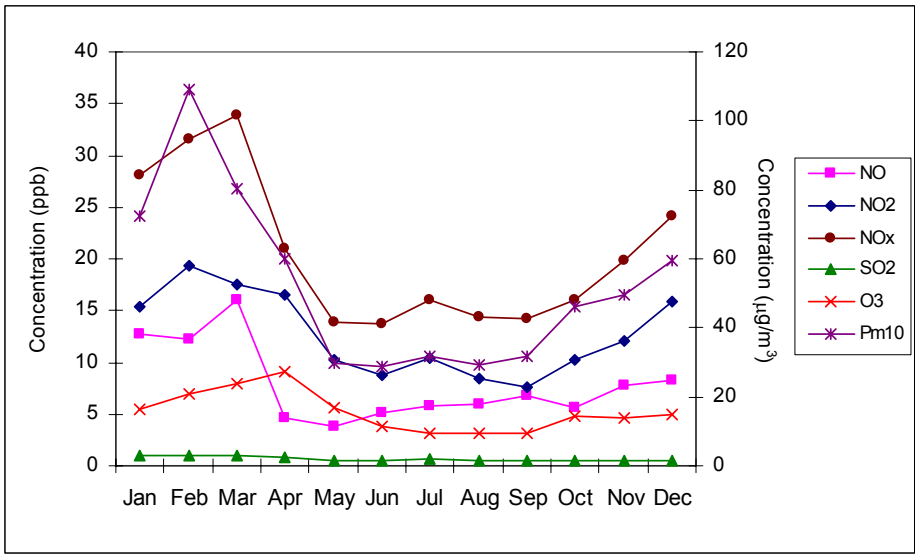

Figure 11.8 Monthly four-year averages of the gaseous and particulate concentrations in Chiangmai City during 2001-2004. The right side unit is for PM10. NO_x is a summing of NO and NO_2.

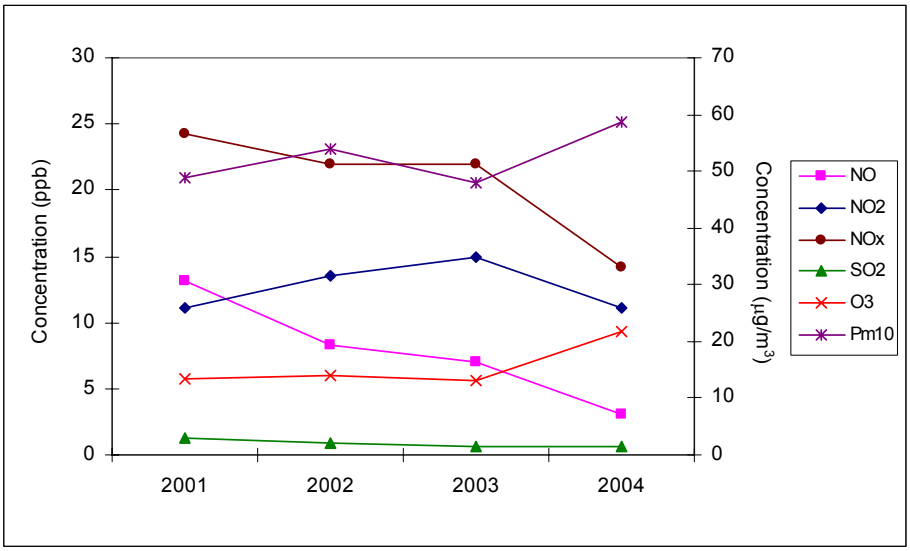

Figure 11.9 Annual averages of the gaseous and particulate concentrations in Chiangmai City in 2001-2004. The right side unit is for PM10. NO_x is a summing of NO and NO_2. Bangkok Metropolitan, the central site

The four-year averages of NO, NO_2 and SO_2 concentrations in Bangkok Metropolitan, the heavy populated area were presented in Figure 11.10. The value of NO_x resulted from a summing of NO and NO_2. Due to some technical problems during these monitoring period, O_3 and PM10 are not included in the figure. The monitoring results show monthly variation of the compound of nitrogen related to the seasons. During the dry season (October – March), the concentration of NO_x reached a high value of 65 ppb and a low value of 40 ppb during the rainy season (May – August). For SO_2, the ambient concentration is very low with a four-year average value of 5 ppb throughout the year, regardless of which season.

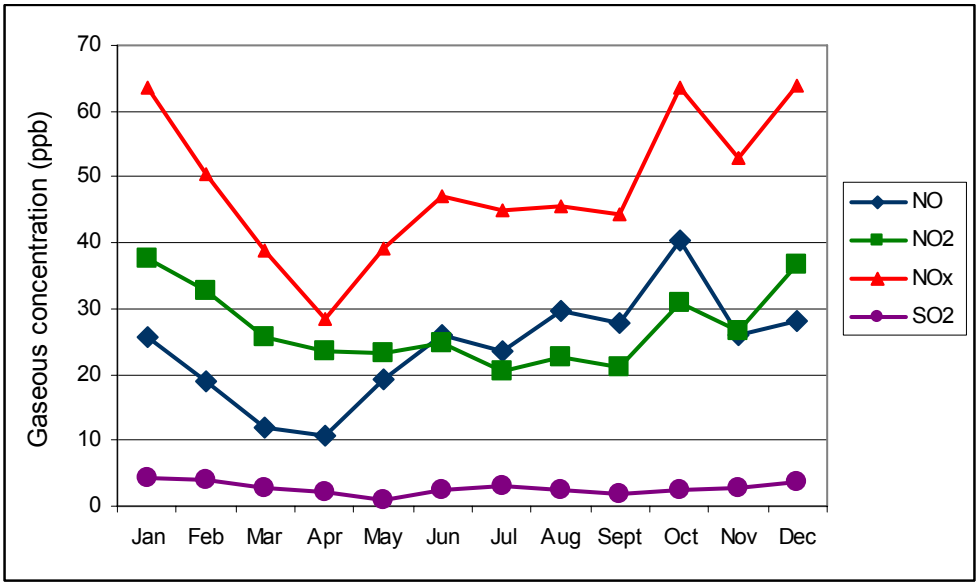

Figure 11.10 Monthly four-year averages of the gaseous concentrations in Bangkok Metropolitan during 2001-2004. NO_x is a summing of NO and NO_2.

The average concentrations of SO_2 in the past four year (see Figure 11.11) was noticeably unchanged although there was increasing number of vehicles each year. It is seen that implementation of a low sulfur-content in diesel (less than 0.05%) turns out to be every effective control of sulfur in the city. Similarly, the concentration of NO_x appeared in a declining trend, due to a mandatory requirement of NO_x control using catalytic converters for all the gasoline vehicles.

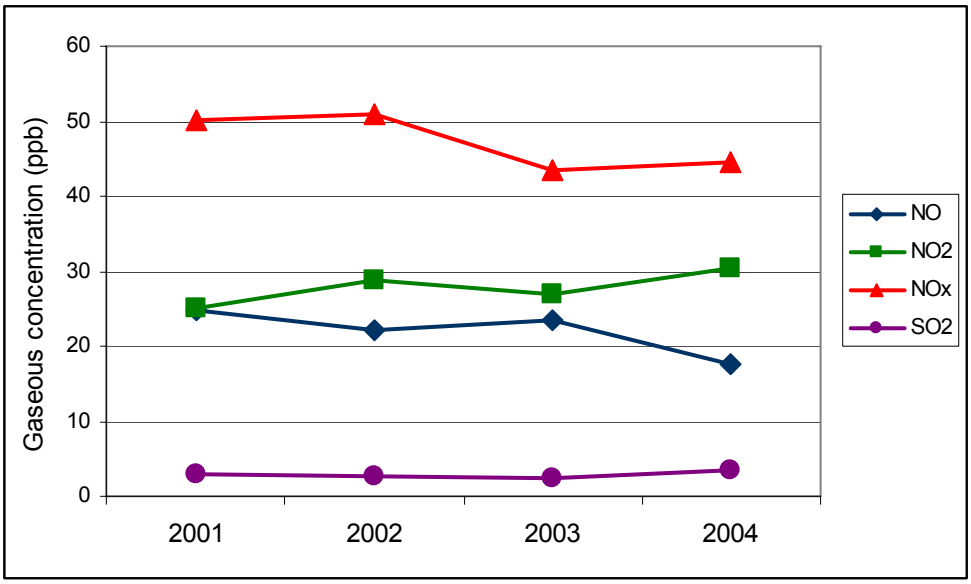

Figure 11.11 Annual averages of the gaseous concentrations in Bangkok Metropolitan in 2001-2004. NO_x is a summing of NO and NO_2.

Kanchanaburi, the remote site

The remote site was located in Kanchanaburi, the western region. The site was in a deciduous forest near Vachiralongkorn Dam. Because of the distance and mountainous environment, the ambient air was monitored by the automatic equipment in a mobile unit only two times a year, i.e. in August and November.

Since the remote site is purposely used as a background study, the gaseous pollutants, i.e. NO, NO_2, SO_2 and O_3 were being compared for the year 2001 and 2004 (Figure 11.12).

It was found that concentrations of NO, NO_2, and O_3 measured during the dry season (November) were significantly higher than those measured during the wet season (August). Since there were no industrial emission sources existed in this area, concentrations of these gases were quite low compared with the levels found in other areas. The only potential emission sources may come from the forest fire and burning of agricultural waste which might be the cause of increasing concentrations of NO, NO_2, and O_3 during the dry season.

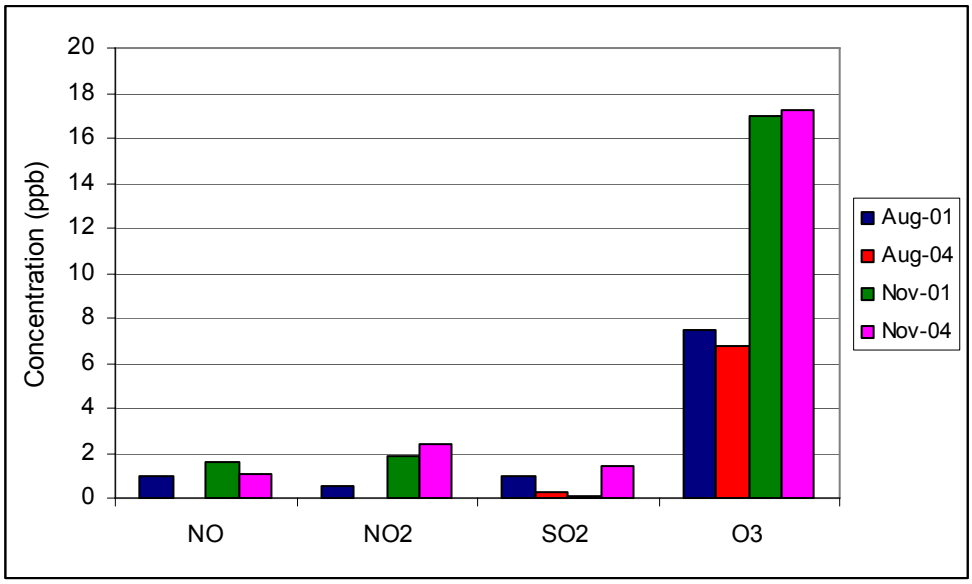

Figure 11.12 Concentrations of NO, NO_2, SO_2 and O_3 monitored at Kanchanaburi, remote site in August and September of 2001 and 2004.

11.3 Ecological Impact

Ecological impact caused by acid deposition is a subject to be tended for a long term assessment. Khaolam forest in Kanchanburi province is a remote site appointed for monitoring inland aquatic and soil environment for this long term ecological study. The site is located on latitude 14° 46' North and longitude 98° 35' East with altitude of 170 M MSL. A water reservoir of Vichiralongkorn Dam, part of the Khaolam forest is used for inland aquatic environmental study.

11.3.1 State of inland aquatic environment

Vachiralongkorn Dam is a rock filled dam covering the area of 388 km^2. The watershed area was 3,720 km^2 with an average inflow of 5,500 million m^3. The maximum water storage volume was 8,860 million m^3. The average water depth was 11499.08 m with the maximum depth of 153.21 m. The annual water level fluctuated between 0-18 meters (average 9 m.). The residence time of water was 165 days. One river flows into the dam via Quae Noi River. The dam is highly utilized for electric power generation, irrigation, fish culture and recreation.

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Figure 11.13 Monitoring site for inland aquatic at Vachiralongkorn Dam

The water chemistry during 2000-2005 was examined four times a year at the two selected monitoring sites (Figure 11.13). The measured parameters related to acidification of the inland aquatic water are reported as follow: the pH ranges of 6.7 to 8.8, alkalinity of 0.20 to 1.35 meq/L and electrical conductivity of 9.4 to 19 ms/m. It was found that the water is high in pH and alkalinity which are associated with the lime stone rock type of the reservoir basin. These data indicated that the Vichiralongkorn reservoir is not likely to be acidified in the near future. The major cation of the inland water is reported to be Ca^{2+} (16.44 $\pm$ 2.88 meq/L) or 72.8% of the total cations. Other cationic components are presented in Table 11.3.1. For the anion components, sulfate (SO_4^{-2}) is the highest ionic concentration found in the inland water (57.9 %). This reflects the high alkalinity of the water caused by the limestone mineral.

Table 11.3 The major cation and anion content (C, meq/l), deviation (δ, meq/l), percentage (%), and number of observation (N)

Item	Cation					Anion					
	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	H^{+}	SO_4^{2-}	Cl^{-}	HCO_3^{-}	NO_3^{-}	PO_4^{3-}	OH^{-}
C	16.44	3.36	1.41	1.28	$1.58*10^{-8}$	3.99	1.97	0.81	0.07	0.020	$6.3*10^{-07}$
δ	2.88	1.02	0.65	0.86	$3.19*10^{-08}$	5.90	1.92	0.61	0.08	0.030	$7.9*10^{-07}$
%	72.82	14.90	6.27	5.69	$3.66*10^{-08}$	57.99	28.65	11.83	1.12	0.38	$9.1*10^{-06}$
N	36	34	34	34	36	36	36	34	33	28	36

11.3.2 State of soil and vegetation

The Khoa Laem forest type is mixed deciduous trees. The sampling area is 4,026.5 m^2 in rectangular. The dominant tree species were *xylia xylocarpa*, *lagerstroemia tomentosa* and *dalbergia cana*. The diameter at breast height (DBH) of *xylia xylocarpa* varied from 23 – 74 cm and 20 – 40 m in height. For *lagerstroemia tomentosa* species, the DBH varied from 30 – 136 cm and 18 – 50 m in height. The DBH of *dalbergia cana* species was in a range of 29 – 55 cm with height in a range of 18 – 20 cm.

The survey of tree symptoms at Vachiralongkorn Dam during 2000 - 2004 were carried out two times per year. Results of the survey can be summarized as follow: There were no sign of the crown defoliation of *Xylia xylocarpa*. No visible symptom appeared.

The soil type of Kho Laem forest is ferric acrisols**.** The pH measured during 2000 – 20004 was in a range of 5.70-8.4 at the soil depth level of 0-20^{+}. There was no noticeable change in the soil pH for the last five years.

In 2002, a new monitoring plot of dry evergreen forest has been established at Puye on the 40 km distance from the first site (less than 50 km) in order to comply with EANET two types of forest requirement. The forest health state was assessed. The dominant tree species was *Dipterocarpus turbinatus*. The survey results have confirmed no effects caused by the acid deposition on vegetation. However, the soil at Puye was lower in pH compared with Khoa Laem forest site. The Puye soil type was luvisols and pH of 4.3 – 7.2 at 0-20 cm of the soil profile level.

11.4 National Measures on Acid Deposition

The Pollution Control Department (PCD) in cooperated with the Japanese International Cooperation Agency (JICA) has conducted a control strategy study on acid deposition in Thailand in 2001. According to the concept of countermeasure and management (Figure 1), following integrated control strategy is proposed.

The countermeasure for mitigating air pollution in Bangkok Metropolitan Region (BMR)
Strategy A: Shift to natural gas by vehicles and stationary sources
Strategy B: Introduction of substantial compliance with the emission standard (Real-Euro), low emission vehicle promotion (LEV), and over age vehicle retirement (OVR).
Acid deposition and air pollution management,
Strategy C: Enhancement of Environmental Management

The Strategy C is the prioritized approach in the series of management and the reinforcement of institution and capacity to tackle problems of acid deposition and air pollution.

11.4.1 Strategy A: Shift to Natural Gas for SO_2 Mitigation in the BMR

The shift to natural gas is a countermeasure of the first priority for mitigation of SO_2 concentration in the BMR. It can be introduced by economic mechanisms, and do not need preparing new or more stringent regulations. It is consistent with the national policy to enhance natural gas in the new vehicles and manufacturing sector.

Natural gas is an almost domestic energy in Thailand. And in many cases, the shift to natural gas brings energy saving effects. It also helps the country saving foreign money exchange due to the skyrocketing oil prices. Moreover it is an environmentally friendly measure in many aspects, such as lower dusts and SOx emissions and lower chances of black smoke.

Currently in the BMR, the trunk pipeline is laid in the eastern area. Another trunk line in the western area will be laid by the end of the year 2005. After the completion of the western part, Bangkok Gas Ring will be finished and available. Bangkok Gas Ring will enable many areas in the BMR to shift to natural gas, mainly in industrial estate.
In order to mitigate possible deterioration beforehand, it is appropriate and realistic to enhance step by step introduction. The first priority is the introduction of shift in and around

11.4.2 Strategy B: Enhancement of Real-EURO and LEV/OVR for NO_2 Mitigation in the BMR

The countermeasures are recommended as follows,
(1) Substantial compliance with the latest emission standard (Real-EURO)
- All high speed diesel vehicles and trucks (HDDV/Ts) should comply more strictly with the latest emission standard when they come onto the market (Real-EURO)

(2) Low Emission Vehicle Promotion (LEV)
- New NG Urban Buses should be purchased instead of conventional diesel ones (NG2),
- Over aged Urban Bus (over 10 years) should be replaced with New NG ones (NG3)

(3) Overage Vehicle Retirement (OVR)
- Over aged Urban Bus (over 10 years) should be replaced with New Diesel ones (VR1)

Substantial Compliance with the Latest emission standard (Real-EURO) was considered essential for NOx emission reduction in the BMR, since it could reduce nearly a third of the total NOx emission from current vehicles. The Real-EURO should be assigned as the highest priority countermeasure among them.

The other countermeasures, namely Low Emission Vehicle Promotion (LEV) and Overage Vehicle Retirement (OVR), should be launched with Real-EURO at the further steps for additional NOx reduction although their additional effects were estimated relatively small. Because the traditional countermeasures for NOx reduction, namely enforcement or compliance of stricter emission standard for new vehicles, would have their definite limits in the near future. Therefore LEV and OVR should be provided for future full implementation immediately.

The natural Gas Vehicle (NGV) was selected to be promoted as LEV. Currently, the government policy is to replace the gasoline by natural gas. The Bangkok Mass Transport Agency (BMTA) has purchased 3000 NGV buses from China and expected to be in operation by the end of 2006. The NGV infrastructure would be developed along by the Petroleum Authority of Thailand (PTT) to serve an increasing demand in the near future.

Although more stringent emission standard limits the emission from new vehicles, the effect would be limited usually and the ambient NO_2 level could not be improved drastically, since the worn-out vehicles from overwork and overage engines, especially overage HDDV/Ts emit considerable amount in total. There would be considerable number of worn-out HDDV/Ts still in-use at the target year in Thailand, therefore the retirement program of them was considered effective.

It is expected that the Real-EURO implementation would reduce around 34% of vehicle NOx emission in 2011. The implementation of Real-EURO with LEV (NG2+NG3) and Real-EURO with OVR (VR1) would reduce around 38%.

11.4.3 Strategy C: Enhancement of Environmental Management

The management strategy should be integrated with countermeasure strategy as shown in Table 11.4. The environmental management is divided into two groups. They are intensification of focused and prioritized approach and reinforcement of institution and capacity. Concerning the focused and prioritized approach, various activities of management are divided into three fields, i.e. realization, study and policy.

Table 11.4 Strategy for Environmental Management

C Enhancement of Environmental Management
- C-1 Intensification of Focused Activity
  - *Realization*
    - Regular Monitoring
    - Specific Monitoring for Investigation
    - Establishment of Emission Inventory
  - *Study*
    - Evaluation of Acid Deposition & Atmospheric Condition Data
    - Application of International Simulation Model
    - Research of Acid Deposition
    - Prioritization of Acid Deposition Issues
  - *Policy*
    - Investigation of Policy
    - Formulation and Implementation of Policy
- C-2 Reinforcement of Institution & Capacity
  - *Institution*
    - Inventory Group
    - Analyzing and Simulation Group
    - Scientific Advisory Function
    - Policy Investigation Function
  - *Capacity*
    - Systematization of Environmental Knowledge
    - Investigation of Policy

11.4.3.1. Intensification of Focused Activity

Realization

Realization is the starting point of environmental administration. The monitoring of environmental conditions and knowledge of pollutant emission by human activities is a major part of realization.

Steady monitoring of atmospheric conditions and acid deposition has been conducted by PCD. This activity is a vital issue for environmental management. It is very important to continue the current activity. Acid deposition is monitored in 5 locations. However, it is necessary to expand monitoring to cover developing areas such as the industrial area in eastern part of the country.

For the mobile source inventory, plans and data of relevant agencies are vital. Without information of such plans and data, the mobile source inventory cannot be established. For the stationary source inventory, information by the EIA report is vital. Besides, the national energy balance is substantial information.

Study

Because acid deposition is a global issue, it should be analyzed by an internationally approved model. International models are developed by international discussion. The outcome of the Study can be regarded as the basis of participation to the international modeling activity.
In order to bridge the study activities and policy activities, prioritization is important. Through evaluation of the monitored data compared with Thai standard and the WHO guideline, simulation analysis by the international model, and the outcomes of research, the most urgent issues for mitigation in Thailand will be prioritized. After prioritization, the investigation of policy starts.

Policy

A series of tasks are necessary to consolidate the investigation of policy. In the first place, the possible countermeasures are investigated. Many aspects of the countermeasures, effect, cost, environmental impact, and social acceptance should be deliberated. Simulation is important for investigation. The environmental effect of the policy can be evaluated quantitatively by simulation analysis. International framework, such as Clean Development Mechanism (CDM), ISO and Cleaner Production are indispensable factor for the introduction of the countermeasure from now.

The adequate application of the command and control method and the economic incentive method is important. CDM has an international framework and is an economic incentive method. One of the economic incentive methods is emission trading. However, application cases of emission trading are scarce now.

The acid deposition issue has a complex nature. It is an environmental issue and also an energy issue. And sometimes it is a transportation issue. The sulfur content of oil products is related to the national energy policy and the national environmental policy for stationary sources and mobile sources. Moreover it is a matter of commercial activity. Sometimes the economic incentive of the Government is the key factor. Therefore, in order to formulate and implement the policy, the allocation of tasks for relating agencies by the responsible agency is quite important.

11.4.3.2. Reinforcement of Institution and Capacity

Institution

The preparation of the inventory needs experience and a huge volume of study. Information of the energy balance of Thailand, the traffic volume of major roads and the focus of economic growth are examples of vital materials. It needs specialty. A specific implementing group for the inventory is a starting point for preparing inventory. And the commissioning of adequate parts of the study to the private sector is important.

Analysis and simulation is important for scientific administration. Every administration group has an analyzing function. Concerning acid deposition, the evaluation of ambient air quality and critical load and simulation analysis are typical subjects of the group. Simulation by the international model is one function of this group. The role of the group is not collecting monitoring data but rationalizing the causes and results of environmental issues. Besides, it is necessary to analyze the effect of the policy options by simulation.

Capacity

Capacity building for systematized knowledge is an important point of capacity building. Environmental administration can not be undertaken without systematic knowledge.

In order to get systematized knowledge, it is necessary to experience the preparation of annual reports or similar reports that integrate various fields. The investigations of policy is another important chance for this capacity building. Policy is a result of synthesis. It cannot be established by the consideration of only narrow fields. Studies for social issues, economic situation, and scientific facts should be integrated. Many administration fields, i.e. energy, transportation, commerce, revenue and environment should be investigated simultaneously.

References

Andreae, M.O. (1983) Soot carbon and excess fine potassium: long range transport of combustion-derived aerosols, *Science* **220**, 1148-1150.

Andreae, M.O., Andreae, T.W., Annegarn, H., Beer, J., Cachier, H., Le Canut, P., Elbert, W., Maenhaut, W., Salma, I., Wienhold, F.G., and Zenker, T., (1998) Airborne studies of aerosol emissions from savanna fires in southern Africa: 2. Aerosol chemical composition. *Journal of Geophysical Research* **103**, 32119-32128.

Dianwu, Z., and Anpu, W., (1994) Estimation of anthropogenic ammonia emissions in Asia, *Atmospheric Environment* **28**, 689-694.

Galloway, J.N. (1995) Acid deposition: perspectives in time and space, *Water, Air and Soil Pollution* **85**, 15-23.

Fujita S., Takahashi, A., Weng, J., Huang, L., Kim, H., Li, C., Huang, F.T.C., and Jeng, F. (2000) Precipitation chemistry in East Asian, *Atmospheric Environment* **34**, 525-537.

Lee, B.K., Hong, S.H., and Lee, D.S. (2000) Chemical composition of precipitation and wet deposition of major ions on the Korean peninsula, *Atmospheric Environm*ent **34**, 563-575.

Acid Deposition Assessment in Viet Nam: National Report

Institute of Meteorology and Hydrology (IMH)

12.1 Basic information on National Monitoring Activities

12.1.1 Outline of the activities on acid deposition and National Monitoring Plan

12.1.1.1 Outline of the activities on acid deposition

In Viet Nam, several networks of environmental monitoring stations are simultaneously in operation. Those networks are, usually, designed for different purposes and authorized by a ministry level. The largest monitoring network on air quality, water quality and rain-water chemistry under of Ministry of Natural Resources and Environment (formerly, under Hydro meteorological Service) includes 23 rain-water chemistry monitoring stations, 1 background air pollution monitoring station, 51 river quality stations, 10 reservoir monitoring stations, 1 experimental station for reservoir environment, and 6 sea water monitoring stations. Beside on-site observation, samples taken in these stations are delivered to 3 laboratories in the north, center and south of Viet Nam to analyze.

In this network, 23 rain-water chemistry monitoring stations have been operated since 1987 and located in Thai Nguyen, Viet Tri, Bac Giang, Bai Chay, Phu Lien, Hai Duong, Ha Noi, Ninh Binh, Cuc Phuong in the North of Viet Nam; Thanh Hoa, Vinh, Hue, Da Nang, Quy Nhon, Nha Trang, Phan Thiet in the Middle of Viet Nam; Pleiku, Buon Me Thuot, Da Lat in the Central High Land of Viet Nam; Nha Be, Tan Son Hoa, Tay Ninh, Can Tho, Ca Mau in the South of Viet Nam. In these stations, rain water samples are collected semi-automatically, and pH and EC are measured on site.

Monitoring parameters and interval are as following:

- Air quality stations: In order to observe wet deposition, samples are taken in every precipitation event. Beside these samples, ten day-mixed samples are also analyzed with parameter of pH, EC, SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, Ca^{2+}, Na^+, Mg^{2+}, and K^+.
- River and reservoir quality monitoring stations: Every month, water samples are taken. The monitoring parameters compose of pH, EC, alkalinity, SO_4^{2-}, COD, Cl^-, Ca^{2+}, Na^+, NH_4^+, NO_3^-, Mg^{2+}, and K^+.

Since 2002, 6 Micro Computer Systems for Air Monitoring stations (MCSAM) with high-volume sampler and acid rain monitor have been set up and operated in Ha Noi (Lang), Phu Lien, Cuc Phuong, Da Nang, Pleiku, Nha Be stations. In these stations, some chemical are automatically analyzed such as: ozones, nitrogen oxides, hydrocarbon, sulfur dioxide, ammonia, PM_{10}. Detailed measured and analyzed parameters are: wind direction, wind velocity, air temperature, air humidity, air pressure, solar radiation, rainfall, ultra-violet, pH, EC, SO_2, NO, NO_2, NH_3, CO, O_3 in surface, CH_4, OBC, TSP, PM_{10}. Among them, every millimeter of rain water, pH and EC are measured. All real-time data of 6 MCSAM stations are online transferred to a data-server in Ha Noi to process.

12.1.1.2 National Monitoring Plan

Vietnam has taken a part in EANET since August 1999 and Institute of Hydrology and Meteorology is representative as the National Center for Viet Nam. With the support of equipments and machines (two wet only samplers and two filter packs) from Japan Government, 2 monitoring stations based in Lang (Hanoi) and Hoa Binh province have been set up and operated since then.

Additionally, to have the broad-spectrum view of the acid deposition state, Vietnam, which is a long S-shape country, requires several monitoring stations uniquely distributed along the country rather than two stations in northern part. In this context, the revised National Plan, in which three additional monitoring stations were allocated, has been submitted to the Ministry of Natural Resources and Environment.

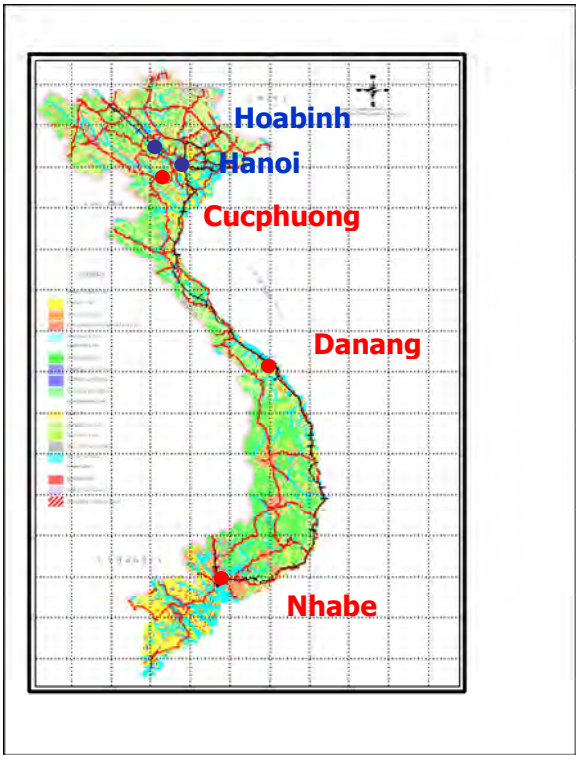


Figure 12.1 Tentative design of the National EANET network

12.1.2 Monitoring program

12.1.2.1 Monitoring Stations

Ha Noi site is an urban acid deposition station where both wet and dry deposition samples are collected and analyzed. In Ha Noi, sampling wet deposition using wet only sampler and dry deposition using Filter Pack are carried out and follows technical guidelines of EANET. During 2000-2001, filter pack motor was broken sometimes and some data were lost.

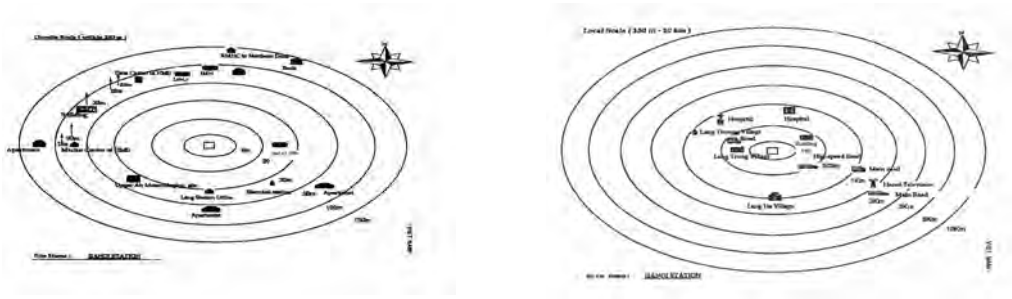


Figure 12.2 Outline of Hanoi monitoring site

Hoa Binh site is an rural and ecological acid deposition station. However, around Hoa Binh region, it is difficult to find sites suitable to monitor inland aquatic environment and soil and vegetation due to high alkalinity.

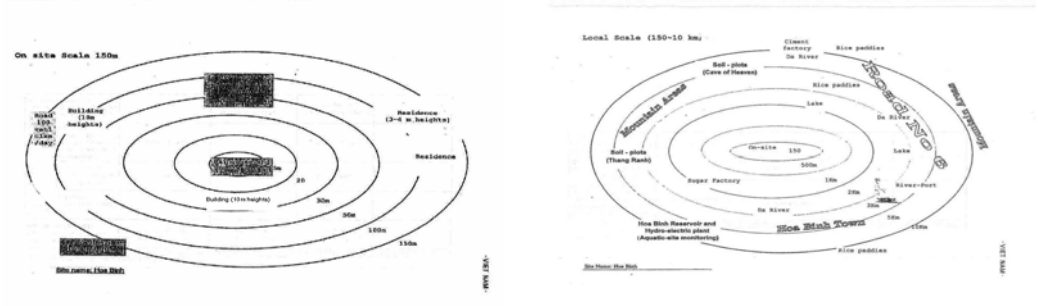


Figure 12.3 Outline of Hoa Binh monitoring site

12.1.2.2 Sampling and measurements

a. Wet deposition

Sampler: Wet only sampler
Measured parameters: pH, EC, SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, Ca^{2+}, Na^+, Mg^{2+}, K^+
Sampling interval: Daily, seven days composite samples can be analyzed

b. Dry deposition

Sampler: Filter pack
Measured parameters:
- Gases: SO_2, HNO_3, HCl, NH_3,
- Aerosol: SO_4^{2-}, NO_3^-, Cl^-, NH_4^+, Na^+, K^+, Ca^{2+}, Mg^{2+}

Sampling interval: Weekly

c. Meteorology

Measured parameters: Wind direction/speed, temperature, humidity, precipitation amount and solar radiation
Sampling interval: 0h, 6h, 12h, 18h GMT

d. Soil and vegetation

Measured parameters:
- Soil: $pH_{(H2O)}$, $pH_{(KCl)}$, ECEC, exchangeable ions (Na^+, K^+, Ca^{2+}, Mg^{2+}), moisture, exchangeable acidity
- Vegetation: Degree of decline of trees, abnormalities of leaves and branches

Sampling interval:
- Soil: 3 years/time
- Vegetation: Every year

e. Inland aquatic environment

Measured parameters: pH, EC, alalinity, SO_4^{2-}, NO_3^-, NH_4^+, Cl^-, Ca^{2+}, Na^+, Mg^{2+}, K^+
Sampling interval: 4 times/year

12.1.2.3 QA/QC activities

QA/QC programs are conducted at all stages of monitoring activities. A quality of the analytical results was regularly controlled by the balance of cations and anions in each sample examined and by comparison of the measured and the calculated electrical conductivity as well.

The laboratory, where analysis was made, involved in the Network Center's inter-laboratory comparison projects (on wet deposition, soil and inland aquatic environment monitoring; Report on acid deposition monitoring data in 1999, 2000, 2001, 2002, 2003, 2004, 2005). Another inter-laboratory comparison project realized in the frame of EMEP.

12.2 State of the Acid Deposition in Vietnam

12.2.1 Atmospheric deposition

12.2.1.1 State of wet deposition

a. Ion concentrations in precipitation

The average pH at Hanoi and Hoa Binh sites in survey period (2000-2004) is shown on Figure 12.4.

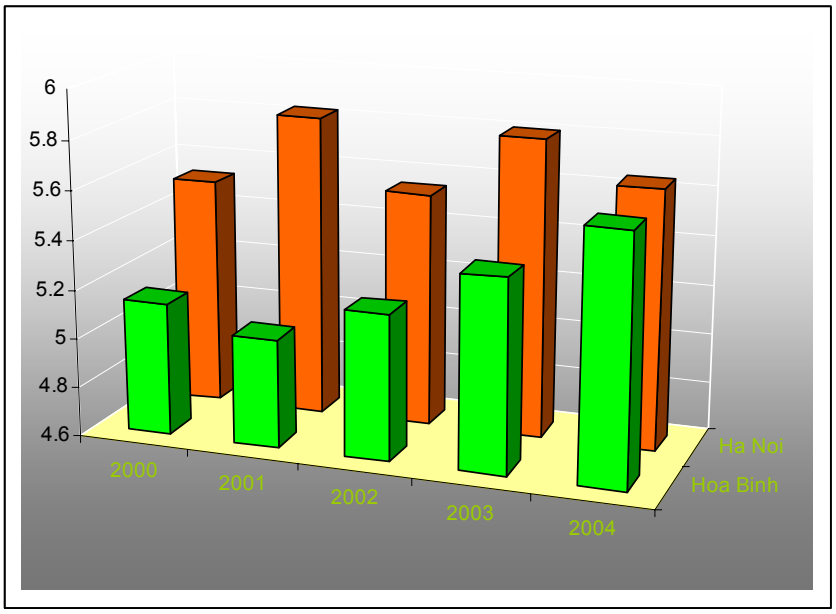


Figure 12.4 Average pH in atmospheric precipitations at the Hanoi and Hoa Binh sites (2000-2004)

Average pH value in precipitation in survey period (5 years) vary from pH 5.04 (Hoa Binh) to pH 5.83 (Hanoi). The annual average pH levels at Hanoi site showed no clear trend during the period from 2000 to 2004, but at Hoa Binh site have lightly increased from 2001 to 2004. At all observation years, the lowest pH values were found in the precipitation collected at Hoa Binh site, 25% of all samples at this site had pH < 5.5 in 2000 (Figure 12.5). Ratio of annual average concentrations of major ions $(NH_4^+ + K^+ + Na^+ + Mg^{2+} + Ca^{2+})/(SO_4^{2-} + NO_3^- + Cl^-)$ ranged from 0.88 in 2000 to 1.13 in 2004.

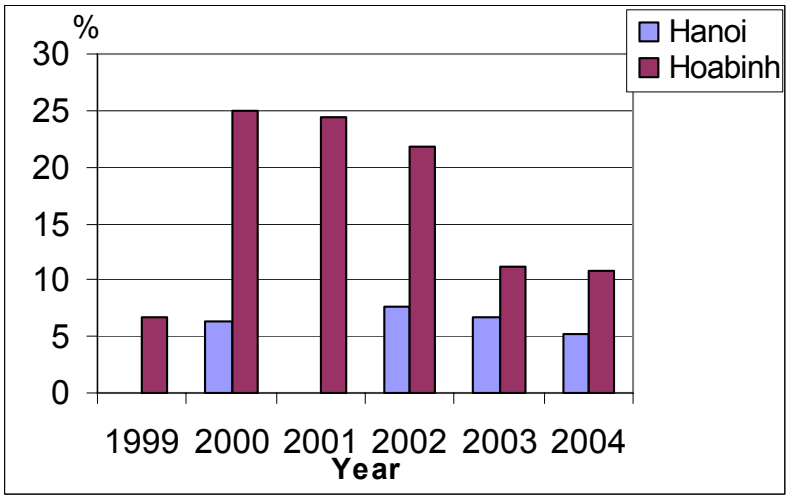


Figure 12.5 Percentage of precipitation with pH < 5.5 at Hanoi and Hoa Binh sites

At Hanoi site, the number of samples with pH < 5.5 was in ranges 5%-7% of total samples and ratio of annual average concentrations of major ions changed from 0.8 in 2000 to 1.2 in 2004.

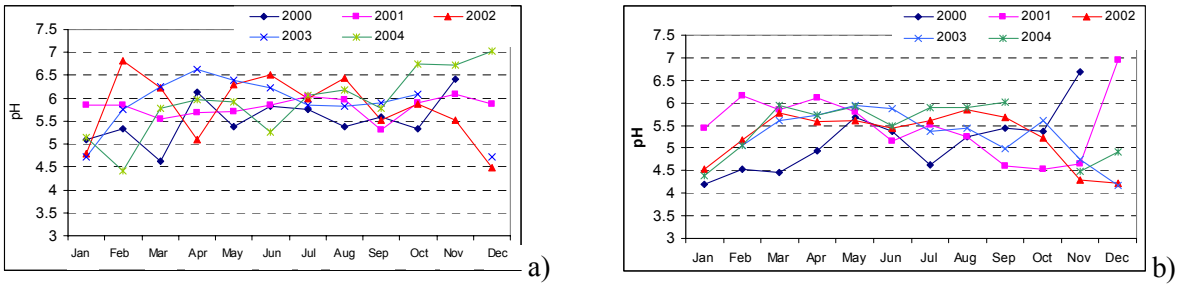


Figure 12.6 Seasonal variation of pH value in precipitation at Hanoi (a) and Hoa Binh (b) sites

In Vietnam, dry season is from November to April and rain season is the period from May to October. At all monitoring sites, the higher pH values were found in the precipitation of dry season (Figure 12.6).

To calculate pAi values, monthly average concentrations of sulfates and nitrates in precipitation from 2000 to 2004. Figure 12.7 presents pH and pAi values at Hanoi and Hoa Binh sites.

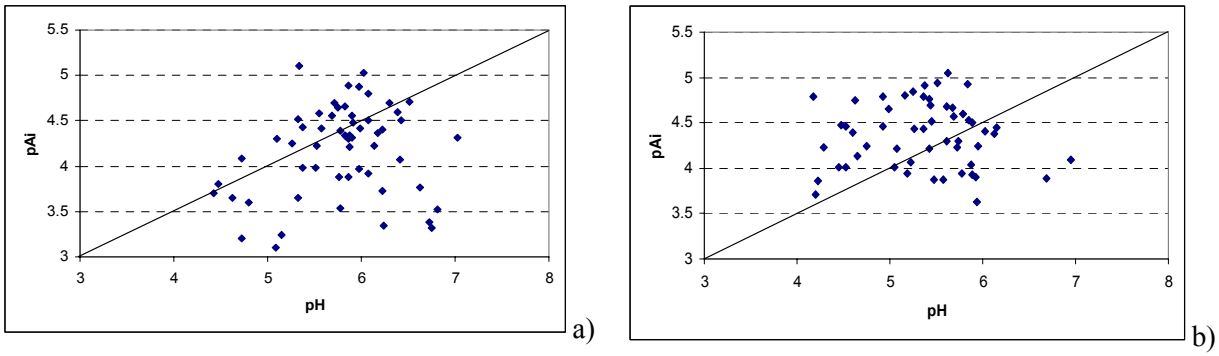


Figure 12.7 pH and pAi in precipitation at Hanoi (a) and Hoa Binh (b) sites

At Hanoi site, in dry season, pAi and pH values vary in rather wide ranges, 3.01-4.58 and 4.42-7.02 respectively, indicating insufficient contribution of alkaline components into acidity neutralization. Long-term average weighted pH value was 5.82 at pAi = 4.21. It testifies the high probability of nss-SO_4^{2-} and NO_3^- play important role into acidification of precipitation.

At Hoa Binh site, amplitude of monthly average pH and pAi values (pH 4.17-6.97 and pAi 3.62-4.79) was higher compared to that in Hanoi site. Long-term average weighted pH value was 5.36 at pAi = 4.38. Assessments on the probability of acidified or neutralized precipitation are based on analyzing the components of precipitation.

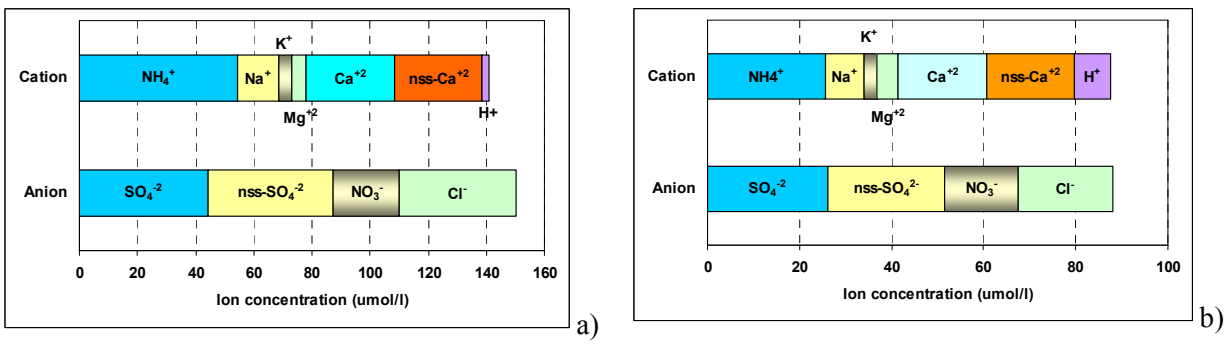


Figure 12.8 Average concentration of major ion in precipitation in Hanoi (a) and Hoa Binh sites (b) (2000-2004)

Figure 12.8 shows average concentration of major ion in precipitation in Hanoi and Hoa Binh sites in period 2000-2004. Monthly average concentrations of nss-SO_4^{2-}, which corresponds to sulfuric acid, were in range from 3.8 (2001, Hoa Binh) to 574 µmol/l (2000, Hanoi). The annual average concentration varied with no clear trend in Hanoi but increased significantly in Hoa Binh (form 14.1 in 2001 to 29.2 µmol/l in 2004).

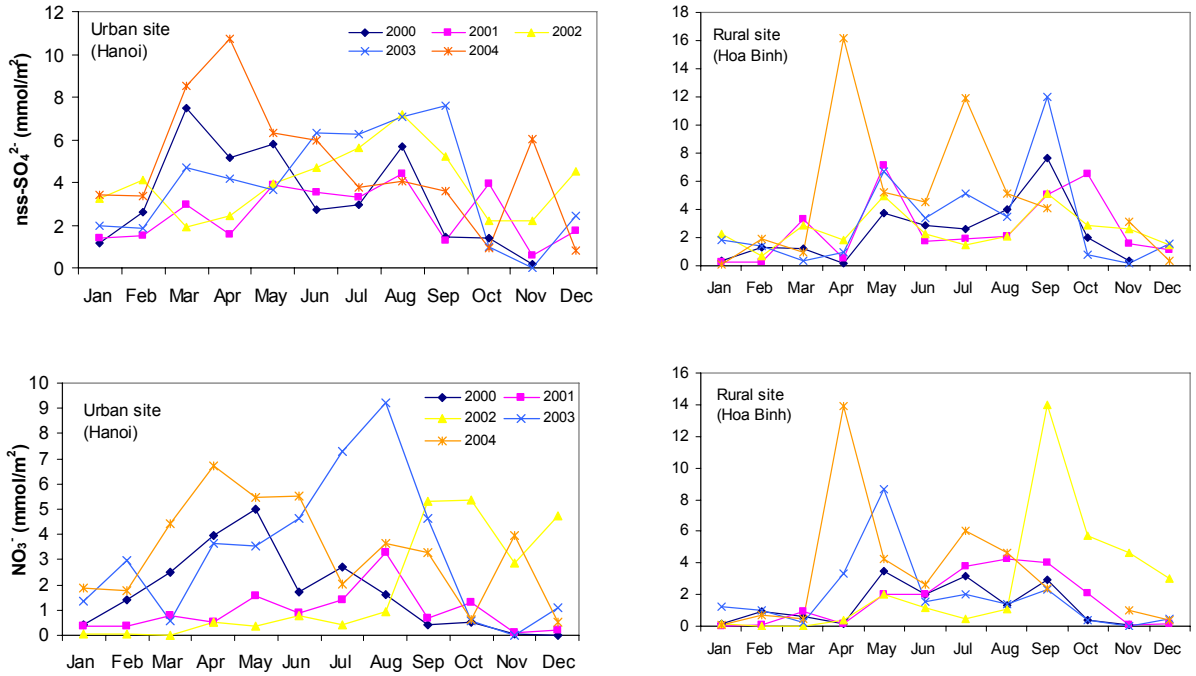
Monthly average concentrations of NO_3^-, which corresponds to sulfuric acid, were range from 2.6 (2001, Hanoi) to 2.17 µmol/l (2000, Hanoi). Trend of NO_3^- variation was not clearly in Hoa Binh but increased in Hanoi.

The ratio of nss-SO_4^{2-} to (nss-SO_4^{2-}+NO_3^-) is useful for understanding the relationship between sulfuric and nitric acid. The ratio indicates which sulfuric or nitric acid has greater contribution to the acidification of precipitation. The overall average of the ratio was 0.66 in Hanoi and 0.61 in Hoa Binh. It shows the important role of sulfuric in the acidification of precipitation. However, the ratio was in trend of the decrease in Hanoi, the contribution of nitric acid has been increasing in acidified precipitation.

In contrast, overall average concentration of NH_4^+ and nss-Ca^{2+}, which show the neutralization probability of precipitation, were 25.6-54.4 µmol/l and 19.1-30 µmol/l, respectively. It results in the greater impact of ammonia gas in comparison with basic calcium aerosol in the neutralization of precipitation.

b. Wet deposition

The wet deposition in Hanoi and Hoa Binh is difference that is depended on relationship between the distance from sources to receptors and deposition. The monitoring result of wet deposition at these sites during from 2000 to 2004 is presented at Figure 12.9. The wet deposition of nss-SO_4^{2-} was increasing in Hanoi (urban site), and varied from increasing to slightly decreasing in Hoa Binh (rural site). But the deposition of nss-SO_4^{2-} in rural area was higher than it in urban area. The wet deposition of NO_3^- varied in large range 0.02-5.76 in urban area but decreasing in rural area. However, deposition of NO_3^- in rural was also larger than it in urban. The wet deposition of H^+ in rural area was approximately twice that of urban area and fall down in both of urban and rural areas.



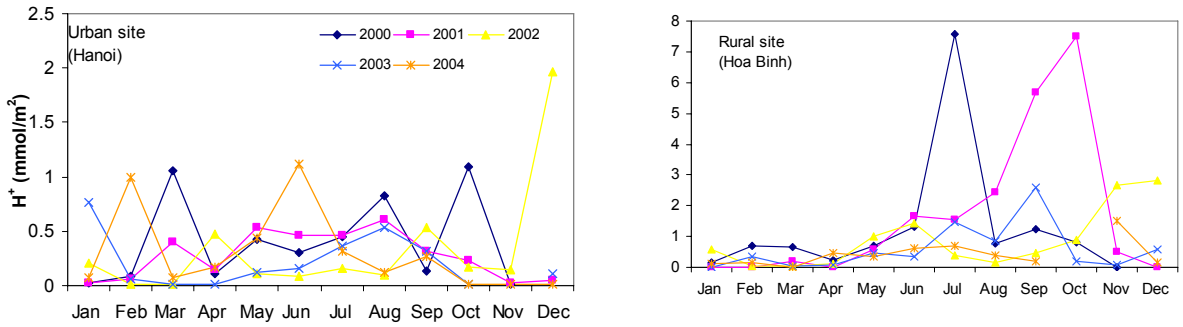


Figure 12.9 Monthly average value of nss-SO_4^{2-} , NO_3^-, H^+ for each year.

The same method for wet deposition of nss-SO_4^{2-} and NO_3^- was applied to the wet deposition of inorganic nitrogen ($\Sigma N=NO_3^-+NH_4^+$), effective hydrogen ($H_{eff}=H^++2NH_4^+$) and initial acidity ($A_i=2$nss-SO_4^{2-} + NO_3^-) to determine the monthly and annual average value of wet deposition for each year (Figure 12.10). Increases in ΣN and H_{eff} indicate an rise of potential nitrogen saturation and soil acidification.

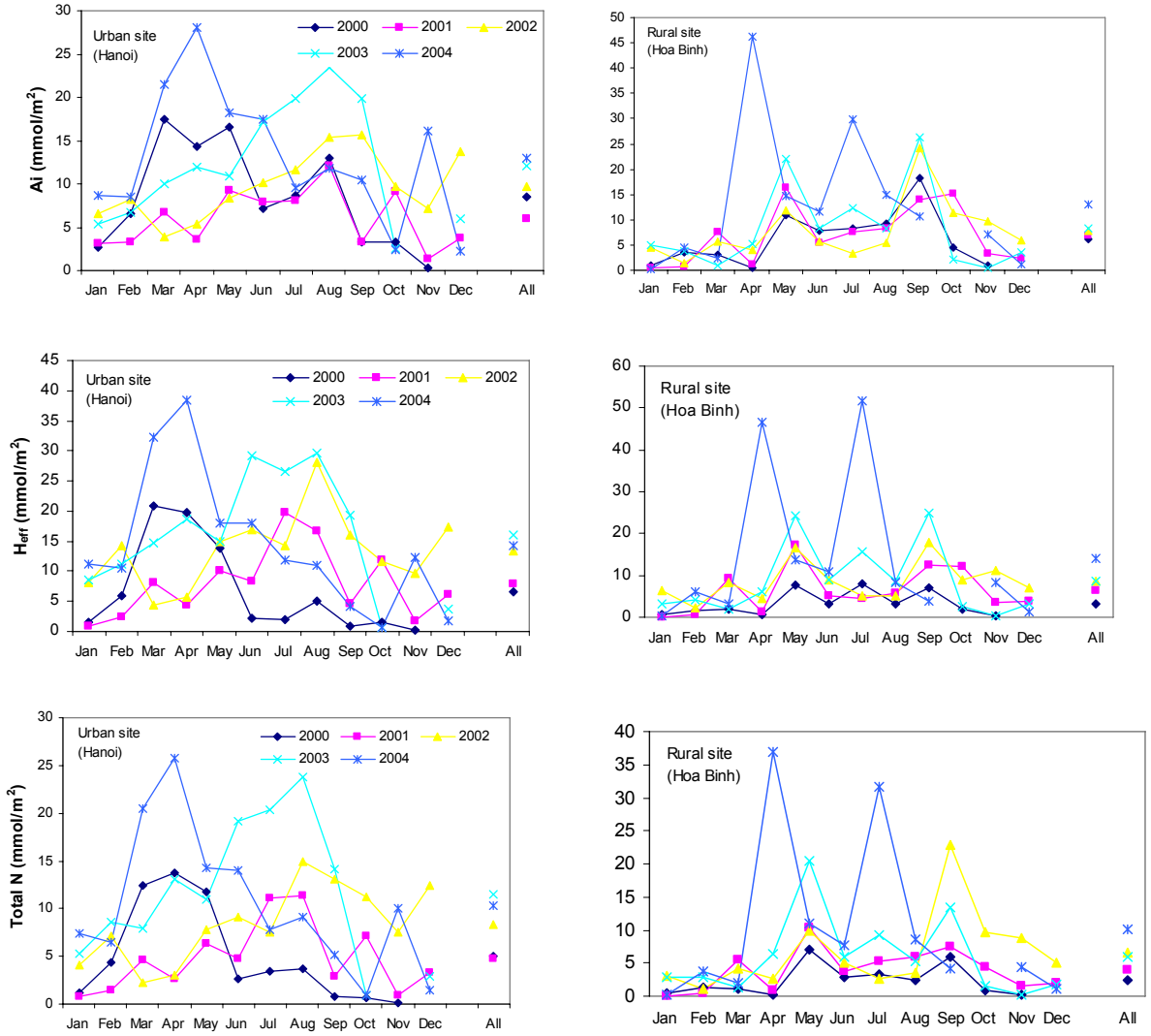


Figure 12.10 Monthly and annual average value of indicator on wet deposition for each year (2000-2004)

The change in wet depositions of ΣN was in large range. The magnitude of ΣN deposition was found in Hoa Binh. The deposition of H_{eff} in Hoa Binh was higher than Hanoi. The deposition in Hanoi was in increasing trend but decreasing in Hoa Binh. However, this value in rural was still higher than it in urban. The increase of wet deposition of H_{eff} and A_i in urban is thought to correspond to increases in emissions of ammonia and nitrogen oxides.

12.2.1.2 State of dry deposition

In all monitoring sites, SO_2 concentration predominated among small gases admixtures in the atmosphere. Figure 12.11 shows the monthly SO_2 concentration of monitoring period from 2001 to 2004 in Hanoi and Hoa Binh. Its highest concentration was observed in dry season when amount of rainfall decreases.

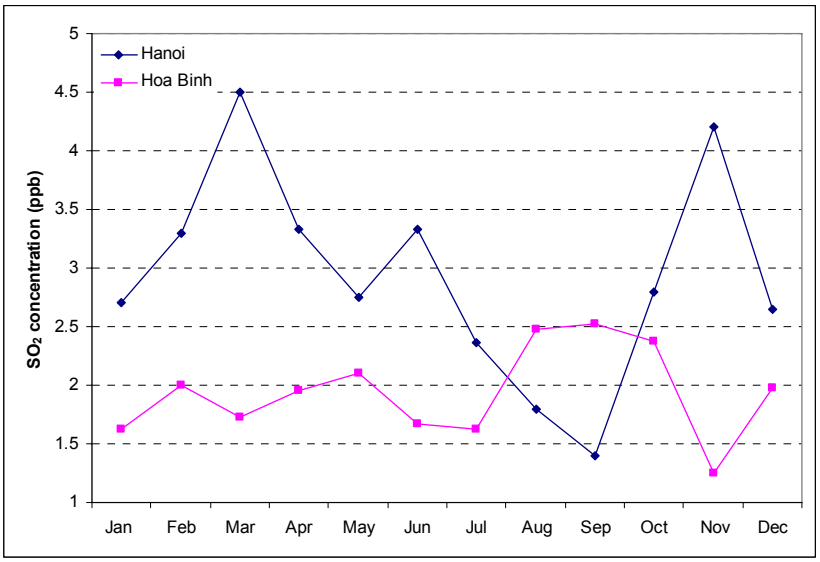


Figure 12.11 Monthly SO_2 concentration of monitoring period (2001-2004) in Hanoi and Hoabinh

SO_2 concentration in Hanoi, urban area, was higher than it in Hoa Binh, rural area (Figure 12.12). Both of SO_2 concentration in Hanoi and Hoa Binh was in trend of increase.

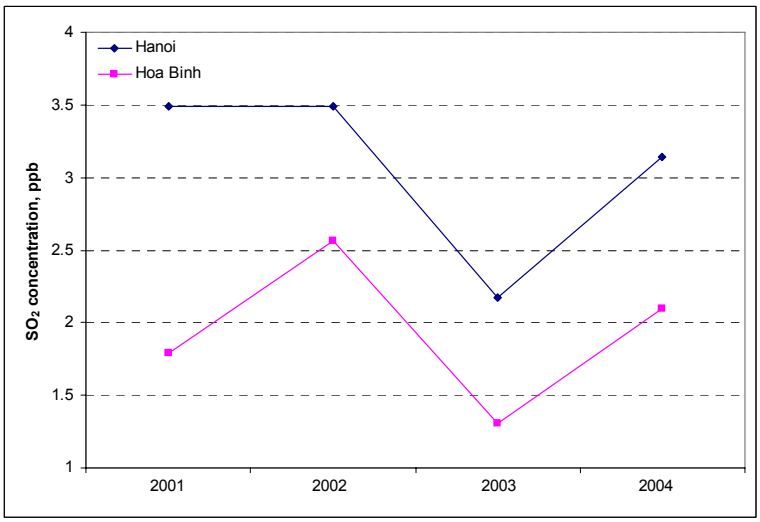


Figure 12.12 Annual SO_2 concentrations in Hanoi and Hoa Binh (2000-2004)

The level of air pollution by gaseous nitrogen compounds in Hanoi was higher than that in Hoa Binh (Figure 12.13). Variation of HNO_3 concentrations in Hanoi and Hoa Binh was similar while maximum HNO_3 concentration in Hanoi equaled that in Hoa Binh.

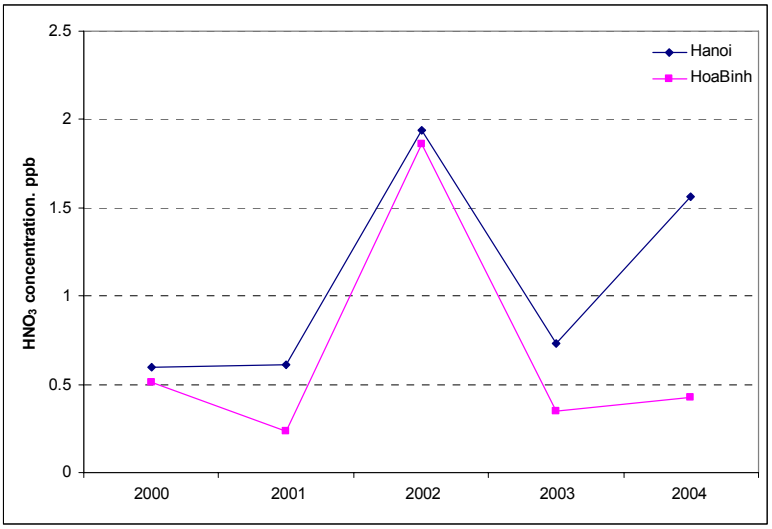
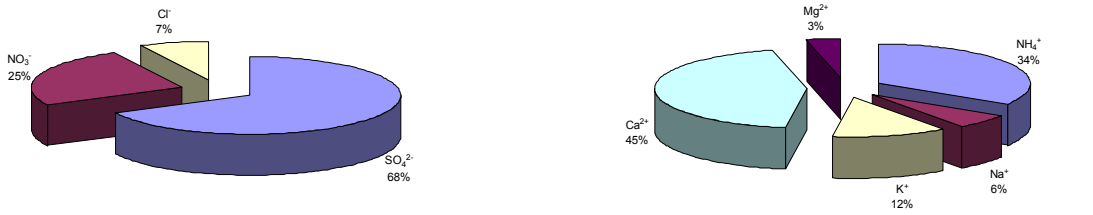


Figure 12.13 Annual HNO_3 concentrations in Hanoi and Hoa Binh (2000-2004)

A comparison of long-term data on aerosols chemistry obtained at Hanoi and Hoa Binh site during monitoring period 2000-2004 is shown in Figure 12.14. SO_4^{2-}, NO_3^-, NH_4^+ and Ca^{2+} were predominant ions in aerosol.

Anion **Cation**

Hanoi



Hoa Binh

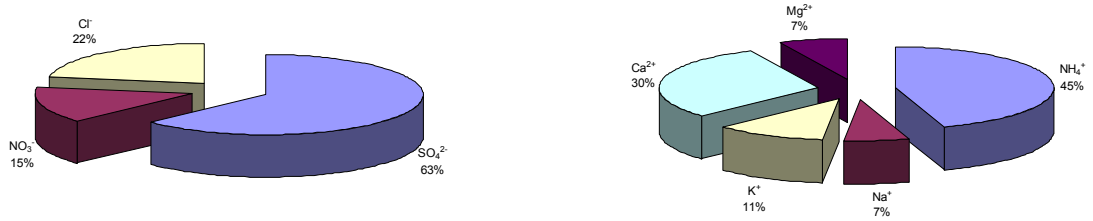


Figure 12.14 Percentage of major ions in aerosol (2000-2004)

Most of maximum concentration of ions in aerosol was found in 2004 dry season in Hanoi and Hoa Binh while concentration of SO_4^{2-} in Hanoi and NH_4^+ in Hoa Binh was highest in 2003.

At the same time in Hanoi, a tendency of ions concentration in aerosol to increase was also revealed. Opposite to the monitoring site in Hoa Binh, the decrease of SO_4^{2-}, NH_4^+, Cl^- concentrations were observed. The other ions concentrations, however, were in slight increase from 2003 to 2004.

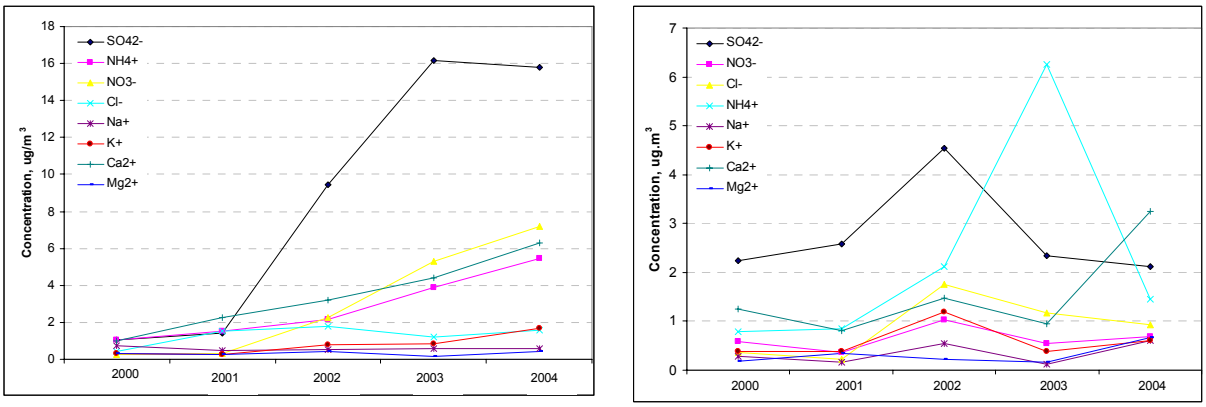


Figure 12.15 Variation of concentration of major ions in Hanoi and Hoa Binh from 2000 to 2004

Analysis of the within – year variation of the concentrations of all components of ionic composition in aerosols has revealed a relationship between meteorological factor and accumulation of admixtures in the atmosphere. Increased ionic concentrations during the dry season in Hanoi and Hoa Binh were related to reduction of rainfall and increased pressure in the near-ground atmospheric layer.

12.2.2 State of inland aquatic environment

At present, Hoa Binh reservoir did not meet criteria of EANET for site selection to monitor inland aquatic environment because its alkalinity is high and the lake is too long and big. However, samples were conducted and analysed as presented in Table 12.1.

The results show that surface water has not acidified yet. Minimum pH value of all samples is higher 6.0. The concentration of all analysed ions in surface water samples meets the surface water standard.

Table 12.1 Analytical result of inland aquatic samples in Hoa Binh reservoir

Time	Parameter											
	Temp (^oC)	pH	EC (mS/m) at 25^oC	Alkalinity (meq/l)	SO_4^{2-} (mg/l)	NO_3^- (mg/l)	Cl^- (mg/l)	NH_4^+ (mg/l)	Na^+ (mg/l)	K^+ (mg/l)	Ca^{2+} (mg/l)	Mg^{2+} (mg/l)
9/18/1999	30	7.94	119.4	1.6	29.79	14.35	37.46	15.56	106.09	45.52	541	106.08
3/15/2000	21.4	8.33	16.72	1.7	4.1	0.42	1.88	0.28	2	0.94	21.86	6.18
6/15/2000	25.4	7.89	19.6	1.9	3.33	0.38	1.71	0.32	2.5	1.09	22.99	8.92
9/15/2000	27.4	6.62	15.49	1.4	9.23	0.33	1.54	0.22	1.27	0.68	19.6	5.49
12/15/2000	23.8	7.32	16.83	1.5	8.21	0.18	1.2	0.11	1.7	1	21.86	5.95
3/15/2001	21.4	7.23	178.2	1.5	8.97	0.24	1.2	0.13	2.72	1.07	24.37	5.73
6/15/2001	25.6	8.49	178	1.7	2.6	1.19	0.68	0.13	2.37	1.47	22.43	6.1
9/15/2001	28.9	7.57	165.4	1.55	3.8	0.43	1.54	0.06	1.5	1.05	20.42	6.2
12/15/2001	22.5	7.83	174.4	1.55	6.4	0.5	1.2	0.28	1.3	1.29	20.17	6.45
3/15/2002	21.4	8.24	17.92	1.7	3	0.41	1.28	0.2	1.41	0.78	23.47	6.07
6/15/2002	27.6	8.02	17.64	1.6	6.2	0.9	1.28	0.56	1.88	1.53	22.7	5.84
9/15/2002	29	7.68	15.69	1.55	1	0.18	1.28	0.07	2.38	1.33	20.39	4.44
12/15/2002	23.6	7.78	17.29	1.6	5.4	0.34	1.54	0.01	1.13	1	23.57	5.62
3/15/2003	22.6	7.82	17.32	1.68	3.2	0.28	1.28	0.06	1.8	1.16	24.41	5.11
6/15/2003	29.3	6.85	19	1.65	7.04	1.36	2.73	0.1	1.6	1.5	25.25	5.87
9/15/2003	27.2	7.52	18.8	1.55	9.3	0.37	0.85	0.06	2.31	1.31	24.12	4.47
12/15/2003	21.4	7.71	18.5	1.5	4.96	0.51	0.47	0.09	2.84	1.47	24.21	3.68
3/15/2004	21.2	6.69	19.27	1.75	4.15	0.32	0.45	0.1	3.34	1.07	24.89	5.1
6/15/2004	26.8	7.81	19.92	1.7	4.36	2.46	1.68	0.36	1.92	0.91	29.17	3.85
9/15/2004	28.8	6.31	18.67	1.7	3.71	0.2	0.49	0.14	2.15	0.8	527.7	3.45
12/15/2004	16	6.38	19.21	1.55	5.83	1.67	2.89	0.09	2.4	1.65	27.1	4.05

12.2.3 State of soil and vegetation

According to the regulation of EANET, soil, forest and inland aquatic environment must be observed, but Vietnam has only carried out the soil and inland aquatic surveys. Moreover, surveys on soil were carried out in Hoa Binh in 1999 and 2001 only. The lack of data causes difficulty to carry out the specific researches. Table 12.2 provides analytical result of soil samples in Hoa Binh site.

The data given in Table 12.2 shows that pH_{H2O} and pH_{KCl} of soil is very low with range of 3.30-4.44 and 2.75-3.51 respectively so cations such as Ca^{++}, Na^+, K^+ are easily washed away from soil.

Table 12.2 Analytical result of soil samples in Hoa Binh site in 2001

No	Sample	Depth, cm	Humidity %	pH KCl	pH H2O	Exchangeable cations, Cmol/kg				ECEC
						Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cmol/kg
1	North PD	0-5	3.79	3.10	3.37	19.93	11.96	2.83	1.94	46.79
2	West PDP3	0-10	3.05	2.94	3.3	13.85	9.89	3.06	1.82	38.93
3	East PDP4	0-10	3.27	2.96	3.39	17.84	9.91	3.06	1.58	42.73
4	P1, humic cover	0-10	2.86	2.99	3.33	15.80	5.92	3.05	1.68	36.75
5	South PP2	5-20	1.80	3.29	4.1	16.42	10.95	2.21	0.92	40.18
6	South PDP2	0-5	3.24	2.75	3.23	17.84	7.93	2.85	1.91	40.99
7	P1B profile m	20-60	1.78	3.44	4.44	22.67	12.51	2.01	0.69	47.55
8	North PDP 1	10-20	1.92	3.51	4.2	29.74	11.35	2.22	0.80	53.83
9	North PDP	0-10	3.07	3.18	3.5	27.70	9.89	3.46	1.69	53.31
10	East PDP4	10-20	2.13	3.42	4.02	18.83	9.41	2.42	0.85	41.48
11	P1A	10-20	1.96	3.49	3.99	21.53	14.49	2.42	0.91	49.30
12	PDP1	5-20	1.89	3.32	4.04	19.56	7.82	2.01	0.88	40.09
13	West PDP3		1.58	3.49	4.17	12.48	8.97	1.81	0.81	33.36

12.2.4 Overall analysis

Analysis of parameters related to acid deposition is very difficult because concentration of these parameters is very low in wet season. Acid deposition monitoring results much depends on sampling, equipment and experience of sampling and analytical staff. Therefore, a help and support from Network Centre for training in sampling, analysis, correct sampling and analytical equipment are very necessary.

12.3 Emission inventory

12.3.1 Biogenic Source Data

Vietnam is basically an agricultural country but has extensive forests, particularly in the mountain areas. Paddy rice and annual crops are the predominant land use in the deltas and flat coastal areas. In the south central area, industrial crops, such as coffee and rubber are grown in the upland areas.

Emissions of biogenic organic compounds from vegetation play an important role in photochemical smog formation, and the trace chemistry of the atmosphere. Background concentrations of ozone are directly determined by these emissions, so that an accurate estimate of biogenic fluxes into urban airsheds is an important requirement for an air quality forecasting system. All methods for estimating vegetative emissions follow a basic process. A landcover database is developed for the area of interest either through aerial (satellite or aerial photography) or ground-based methods (e.g. vegetation surveys) or both. Typically, various land uses identified on the map are classified according to standard land-use practices. Using species composition information for each vegetative cover type and emission rates known for individual species, aggregate species-weighted VOC emission rates are computed for each land use type. Foliar biomass density is then determined for each land cover type. Methods for these computations are well described in the scientific literature. Combining foliar biomass results with the weighted emission factors for each land-use type yields emission factors per land-use type on an area basis.

MODIS is one of the sensors onboard Terra and Aqua satellite. This instrument belongs to moderate

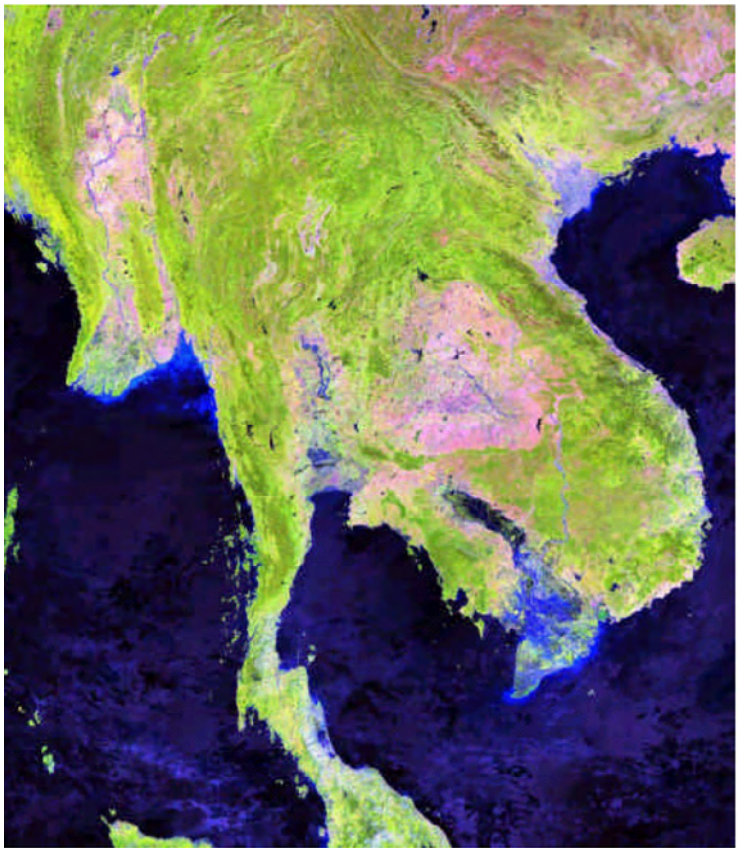


Figure 12.16 Cloud free MODIS 16-day composite

spatial resolution sensor group that consists of sensors such as ADEOS-II GLI, ENVISAT MERIS. This is a class of sensors which are capable of observation of Earth surface and atmosphere in

moderate spatial resolution, high spectral resolution with short revisit time. Data provided by these sensors are extremely useful for environmental monitoring and natural resource management in global, regional and country-wide scale.

MODIS data have been in high demand for ocean colour, fire hot spots, burnt area mapping and drought assessment and for an innovative product that creates a virtual Landsat Normalised Difference Vegetation Index when Landsat is obscured by cloud.

In near real-time, IMAPP software from the Wisconsin University is used to process routinely the level 0 data producing calibrated and geolocated radiances (level 1b) for archiving (Tran and Yasuoka, 2005). In addition to providing raw and level 1b data to research community, we also operationally produce selective high-level products such as cloud mask, fire/burned area, 500m-resolution NDVI, 1km-resolution LST, reflectance products and its 16-days and monthly composites for specified regions. MODIS level 0 and level 1b data in the IIS archive are available freely for registered users/ researchers.

In this study, 64 selected images of MODIS data to level 1b (geometric and radiometric correction) in 2002 were processed to receive cloud-free 16-day composite (Figure 12.16). The IMAPP L1B processor does the geometric and radiometric calibration of MODIS data.

Vegetation mapping at the regional and global level is very important for understanding the regional and global environment. The availability of high temporal resolution MODIS NDVI data is very useful for mapping the vegetation cover based on dynamic analysis of the temporal patterns of NDVI data. From the IIS MODIS archive, monthly cloud -free composite MODIS NDVI data in the domain are generated and then, a time series is constructed where the seasonal agricultural lands are clearly distinguished from other land cover types. The index for temporal signature similarity (TSS) is calculated from patterns of temporal variability of MODIS NDVI values over different months and then, is used in a classification scheme to produce the vegetation map for the area with reasonable accuracy.

Table 12.3 Land cover classes analysis from MODIS data

Land cover class	USGS code
Urban	3
Cropland	5
Grassland	8
Shrubland	9
Deciduous (forest)	12
Overgreen (forest)	13
Mixed forest	15
Waterbodies	16
Wetland	17
Bareland	18

Comparison of 20 independent samples of 30m x 30m resolution satellite data with the ground observations revealed that the land classification was about 90% in accuracy.
Emissions for the total area of each land use type can then be aggregated to compile a total emissions inventory for the area of study.

Among the ozone precursors of concern, emissions of (VOC) from vegetation commonly referred to as emissions of BHC. Although the emission of BHC such as isoprene and monoterpenes by vegetation has been known for several decades, concern about the potential impact of these emissions on urban air quality has been reinforced by studies indicating many BHC are on average as reactive, or more reactive, in the atmosphere than emissions from mobile or stationary anthropogenic sources; and a growing body of research from throughout the world suggesting BHC can constitute a significant and even dominant contribution to the overall VOC inventory in both regional airsheds and the global atmosphere. Recent modeling studies using the UAM have shown that, depending upon the airshed, biogenic hydrocarbons can make the difference between ROG emission controls or NOx emission controls being the most effective in reducing ozone concentrations.

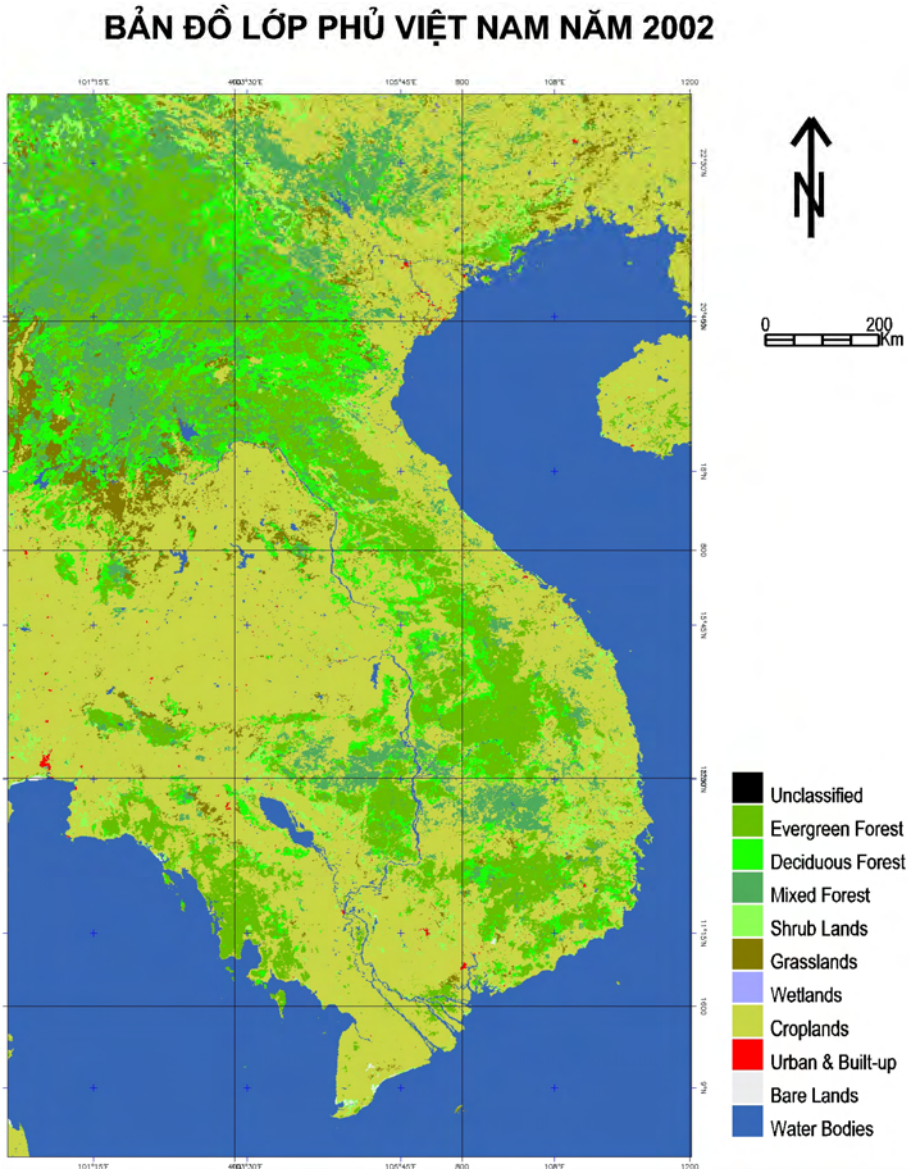


Figure 12.17 Land coverage of Vietnam 2002 from MODIS data

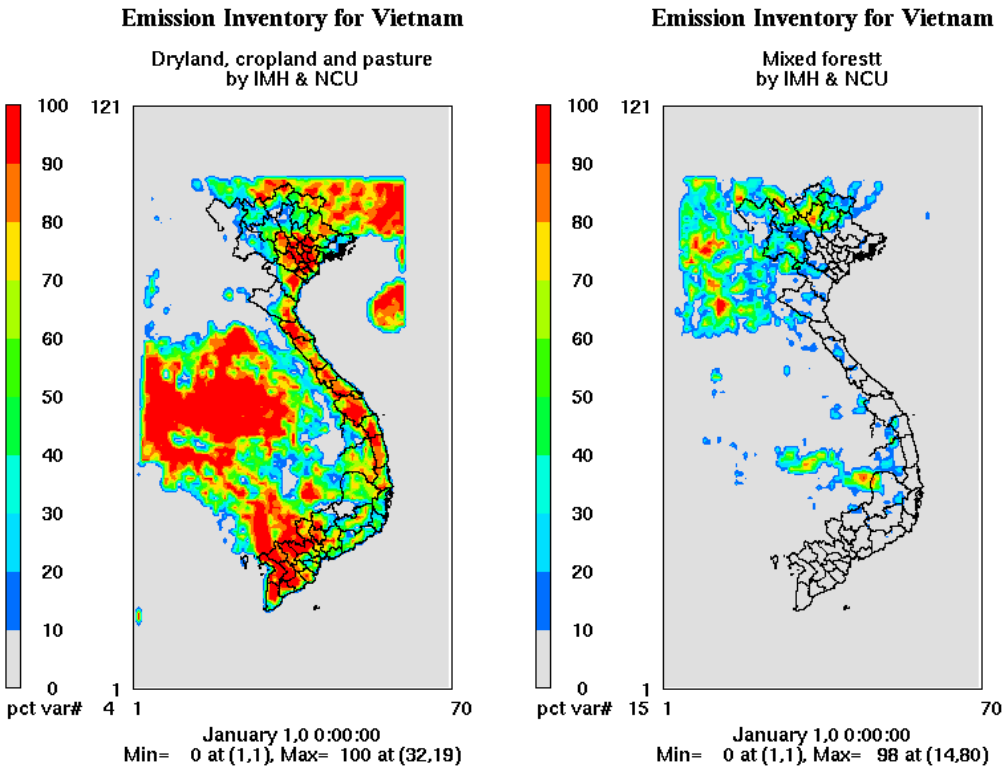


Figure 12.18 Distribution of dryland and grassland

Currently isoprene and other biogenic hydrocarbons are incorporated into atmospheric models using a variety of methods that are all quite similar to the BEIS (Vukovich and Pierce, 2001). The BEIS models generate hourly emission estimates of biogenic VOCs. Plant species composition and foliar density distributions are characterized using satellite derived databases and vegetation inventories. Above canopy meteorological conditions (e.g., photosynthetic photon flux density (PPFD), wind speed, temperature, and humidity) are scaled for each layer within the canopy according to a simple canopy model. Leaf temperature is calculated using an iterative method to solve a leaf energy budget for each canopy layer. The vertical profiles of leaf temperature and PPFD are then used to drive empirical equations to estimate genus specific biogenic emission rates. Additional factors are also included in the above-canopy flux equation to account for the different processes that affect emission activity behavior (e.g., leaf age, phenology, and past leaf temperature) and the landscape escape efficiency (canopy ventilation).

The types of input data used in BEISv3.09, an updated version, are similar to the types used in BEIS2 models. The seven primary inputs to BEIS3 models are:

- Spatially and temporally resolved meteorological data including temperatures, solar radiation and surface pressures
- Spatially resolved, species-specific vegetation
- Species-specific biogenic emissions factors (including a winter adjustment)
- Species-specific leaf area indices (LAI)
- Chemical speciation profiles

BEISv3.09 typically uses meteorological data from MM5. However, BEISv3.09 can take any meteorological data as long as its in NetCDF). BEISv3.09 uses the incoming shortwave radiation to estimate the amount of PAR available in the plant canopy.

One of the most important changes included in the BEIS3 modeling system is the use of the (BELD3. The BELD3 consists of 1km horizontal resolution for 230 different land use types. The previous

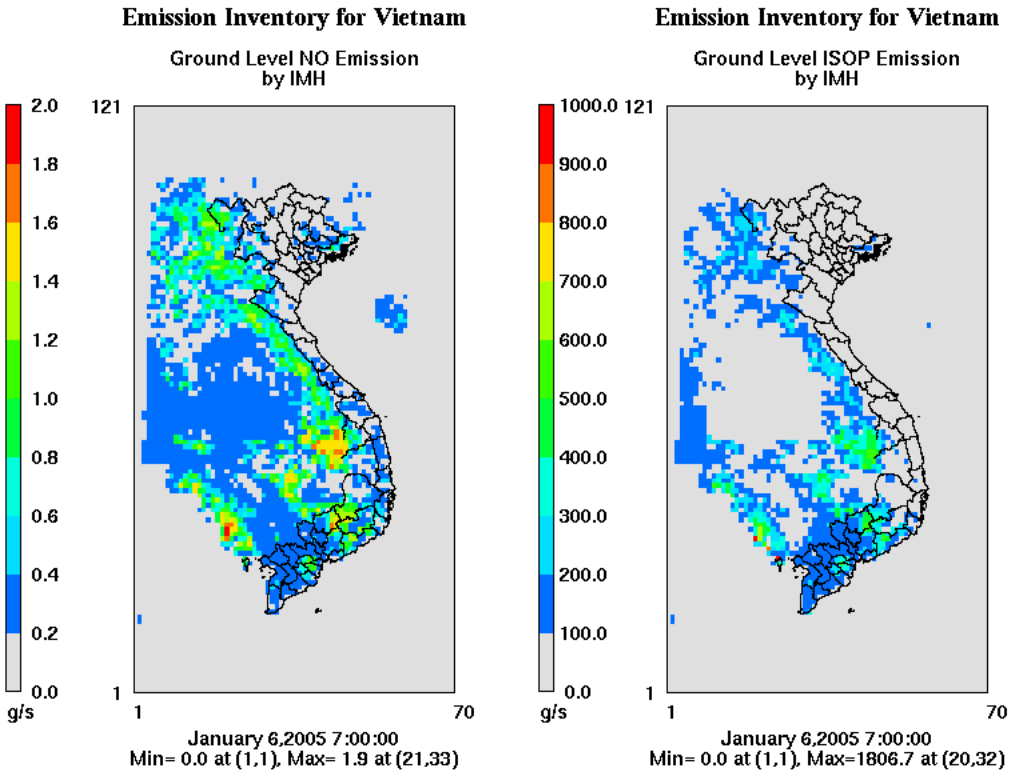


Figure 12.19 Emission of NO and ISOP from biogenic source

version, BELD2, was used in most BEIS2 applications and consisted of mainly county level land use of up to 156 different land use types. BELD3 combines the spatial resolution available from the USGS 1-km data with the detailed tree and crop species information available in county-level forest and agricultural datasets. The BELD3 data is aggregated and/or interpolated to the desired modeling domain and resolution and the land use data input into BEISv3.09 must be in netCDF.

Emission factors in BEISv3.09 consist of isoprene, monoterpene, nitrogen oxide and other VOC factors for all BELD3 land use types. The emissions factors are the flux-rate that each species emits under standard environmental conditions (i.e. 30ºC and 1000 □mol/m^2/s PAR for isoprene and 30ºC for monoterpenes, other VOCs, and NO). The emissions factors are stored in an ASCII file. This emission factors file also includes a winter adjustment factor and LAI for each land use type. LAI is defined as the total one-sided, or one half of the total all-sided, green leaf area per unit ground surface area11. In BEIS3, LAI is used to adjust the isoprene emissions for the effects of PAR penetrating through the leaf canopy.

The SMOKE-BEISv3.09 modeling system is a two-step process. In step one, the land use data and emissions factors file are input into a program called normbeis3. The normbeis3 program estimates normalized emissions (at 30ºC and 1000 □mol/m^2/s PAR environmental conditions) by multiplying the emissions factor by the appropriate land use for each grid cell. These biogenic emissions data are reported in grams of Carbon or grams of Nitrogen per hour. An average LAI for each grid cell is also calculated in normbeis3. The next program is called beis3. The input data for this program consist of the meteorological data, speciation profiles, and the normalize emissions generated after the execution of normbeis3. The speciation profiles are used to allocate other VOC and monoterpene emissions to species recognized by the chemistry mechanism in the desired air quality model. The BEISv3.09 currently supports speciation of emissions for the CB IV and RADM2 chemical mechanisms.

The output from beis3 is gridded, speciated and temporally allocated emissions. The user can assign the units for the output emissions as gram-moles per hour or grammoles per second. The output is in netCDF and can be input into MAQSIP and CMAQ modeling systems. SMOKE also has a conversion program that will convert the netCDF BEIS3 output files into a binary format recognized by CAMx, UAM and REMSAD models.

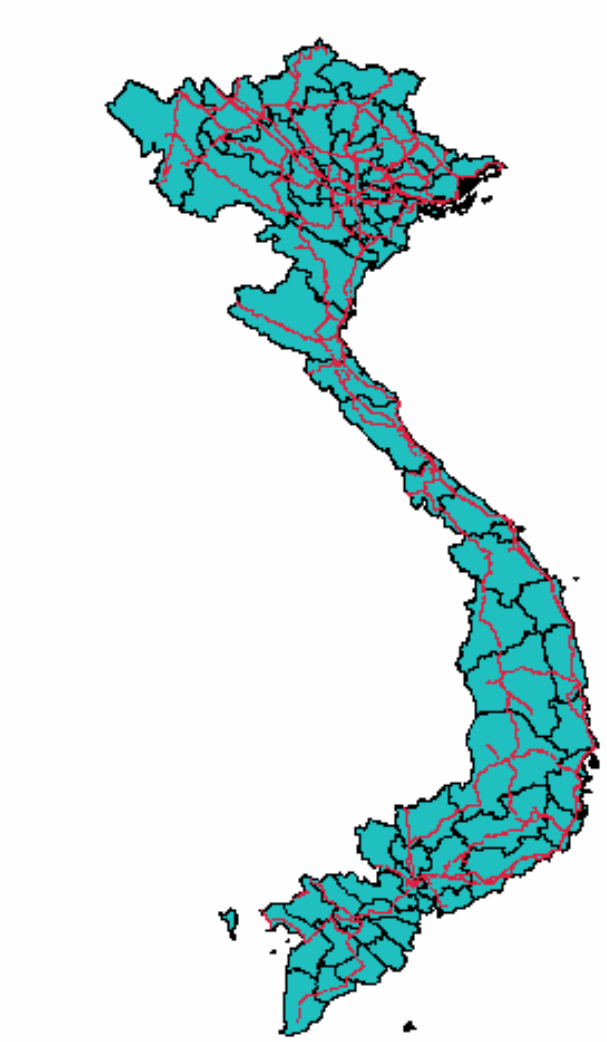


Figure 12.20 National roadway network

Biogenic emissions can vary greatly from day to day and from area to area depending on ambient conditions. To account for these expected variations for the Vietnam application, surface temperature and solar radiation estimates were extracted from the output of the MM5 meteorological model. In particular, hourly-specific, gridded temperatures from layer 1 of the MM5 model were used in the model to adjust the emissions to account for spatial and temporal differences in ambient conditions. Before preparing the biogenic emissions using the MM5-derived temperature fields, the MM5 outputs were thoroughly examined and evaluated. MCIP converter allowed us to merge and interpolate necessary meteorological data of 31 layers to 15 layers.

In rural areas, isoprene is almost always the dominant reactive hydrocarbon. In order to understand the chemistry of rural atmospheres, it is essential that the emissions of isoprene be well characterized. However, the details of how much isoprene, from what ecosystems, and under what conditions, remain troublesome aspects of accurately portraying isoprene in chemical cycles. In many cases, our ability to

model isoprene and other biogenic hydrocarbons is limited to an accuracy of approximately a factor of two.

Table 12.4 An increase of motobikes

Year	Number of motorbikes in Hanoi	Number of motorbikes in Hochiminh
1996, 1997	600,000	1,300,000
2001	1,000,000	2,000,000
2002	1,300,000	2,500,000

12.3.2 Mobile Source Data

In recent years, Vietnam transportation systems including roads, railways, waterway (including sea routes and river routes) and airways have developed very rapidly (Figure 12.1). Over 106,000 kilometers of classified roads make up the present network and the proportion of paved roads has now grown from 13,000 to over 20,000 kilometers. These roads are better maintained than in the past, but significant improvements are still needed. Road transport is the dominant mode and the road freight industry has benefited from the relaxation of the previously strictly controlled allocation of freight permits and tariffs. Water transport is also significant because of the extent of navigable waterways (11,000 kilometers) especially in the Mekong and Red River deltas. However, these same rivers pose a challenge to road engineers as they are formidable constraints to the continuity of the road network in certain areas, necessitating costly bridges and ferries.

Table 12.5 An increase of cars in Hanoi

Year	Number of cars
1990	34,222
1995	60,231
2000	130,764

The total number of transportation vehicles has also increased very rapidly, in particular motorcycles and automobiles. Table 12.5 showed a numbers of cars has been, in Hanoi, doubled every five years since 1995 (VEPA, 2004). The total volume of fuel for transportation increased from only half a million ton in 1990, to about 1.2-1.4 million tons at present. Automobiles and motorbikes still use leaded petrol of two kinds: Mogas 92 with lead (Pb) content of 0.15 g/l and Mogas 83 with lead content of 0.40 g/l.

According to environmental monitoring data from 1997-1998, dust concentration in air next to large roads is 2 to 6 times higher than the acceptable limit (0.2 mg/m^3). The lead (Pb) content in major cross-roads of large cities has nearly touched the permissible limit (0.005 mg/m^3), whereas the contents of SO_2, NO_2, CO are lower than the acceptable limits. Traffic bottlenecks are on the increase in large cities. The waterways transportation causes water pollution, particularly in harbours, estuaries and coastal areas. Oil content in harbours is close to the acceptable limit. Noise level exceeds 70 dBA next to large roads, and reaches to 83-85 dBA in some major traffic routes in Ha Noi, Hai Phong, Da Nang, Ho Chi Minh cities.

EPA's MOBILE model is used to estimate mobile source emissions based on vehicle miles traveled. This model is complex and requires data from a number of sources, including vehicle mix data, speeds on various types of roadways, fuel Reed Vapor Pressure (RVP) and ambient temperatures, local vehicle inspection and maintenance programs, etc.

12.3.2.1Methodology

In order to quantify the attainment year mobile-source emission reductions, two essential data sets are required to produce the estimate. The two required data sets are projected VMT, expressed in miles per day, and vehicle emission factors (for the mobile-control programs under consideration), and expressed in grams per mile. When multiplied together, one can estimate the area-wide daily ozone precursor emissions derived from motor vehicles (grams or tons/day of VOC and NOx) for any given analytical scenario. Mobile-control program credits derived through this process are simply the difference between an uncontrolled base case scenario and the control scenario.

Compared to the United States, the availability of motor vehicle activity data in Vietnam is somewhat limited. In major U.S. metropolitan areas, travel demand models (TDMs) are typically used to estimate VMT. In Vietnam, however, TDMs are not widely used; and the development of TDMs for the entire country is not technically or economically feasible at this time. In the five Air Quality Plan emissions inventories identified above, vehicle kilometers traveled (VKT) were estimated using vehicle registration statistics combined with assumed daily VKT based upon some limited traffic count statistics, informal surveys, and anecdotal information. Examination of vehicle registration data in various areas in Vietnam has indicated that there are some deficiencies in the available records. Also, there is inherent uncertainty with the assumed daily VKT estimates.

Accurate VKT estimates cannot be readily developed for the entire country using TDMs, limited traffic count statistics, or fuel sales statistics. Therefore, a unique methodology was developed that utilizes modeled traffic volumes and congestion levels at representative urban areas for different city size categories to generate daily per capita emission rates. This methodology is described below.

12.3.2.2 Roadway Networks

In order to facilitate trip distribution, a roadway network was developed for each of the representative urban areas. The networks are simplified versions of the current roadway infrastructure layout and only include freeways, main arterials, and collector roads. Local streets are modeled using artificial links called .connectors. which channel local traffic flows between the zones (represented at zone centroids) and the network system. The networks were developed from the maps of the representative urban areas and organized in a roadway GIS. Figure 12.20 shows the primary roadway network developed for Vietnam.

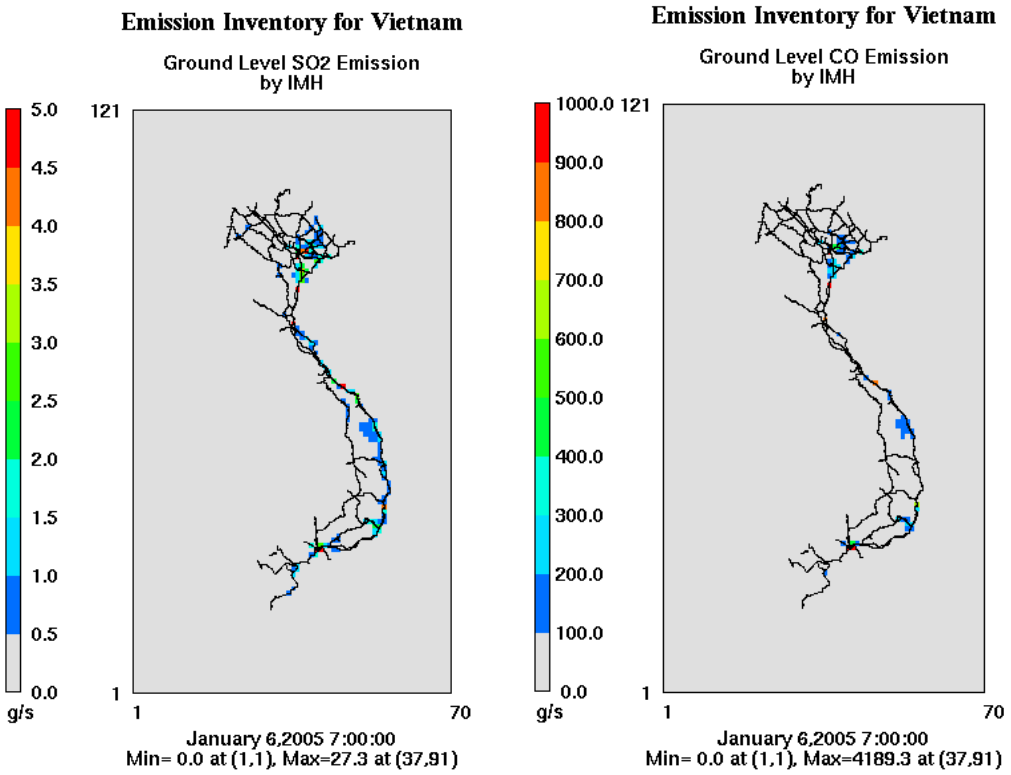


Figure 12.21: SO_2, CO emission from mobile source

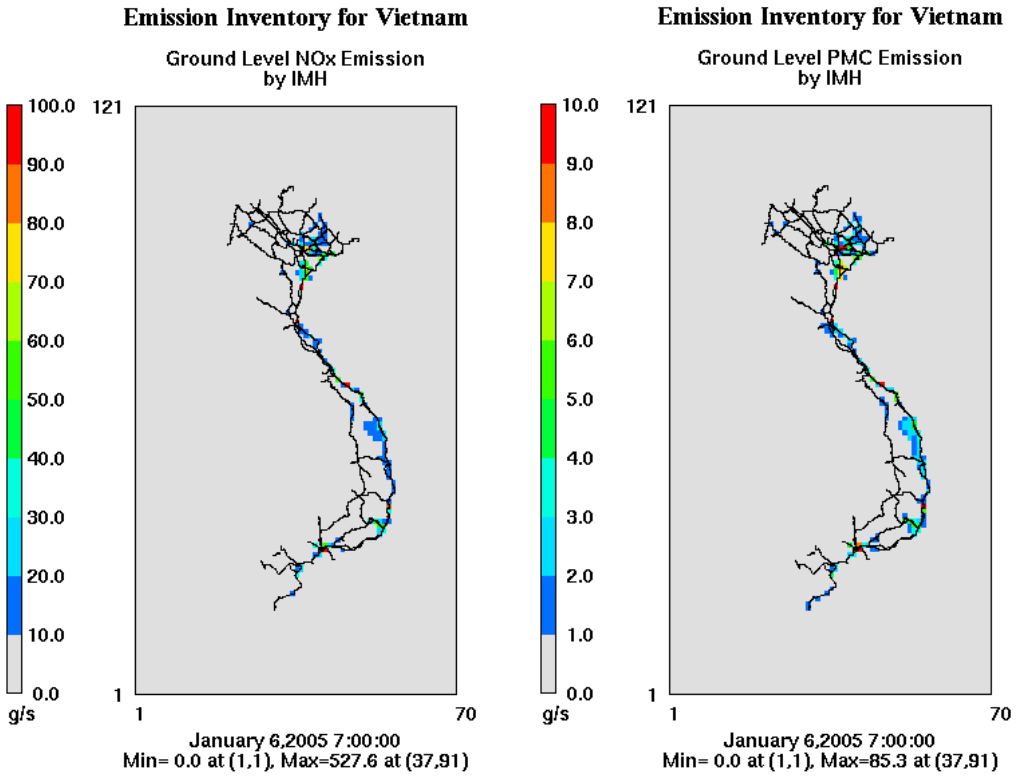


Figure 12.22 NOx and PMC emission from mobile

Each link in the network was initially assigned a function class and flow direction. This information was gathered during site visits to the representative urban areas through visual observation and characterization (for the smaller urban areas) and through interviews with local transportation officials. From this collected information, a second set of network link attributes was developed based on average conditions identified in the National Road No. 1. These attributes were link capacity and average daily speed corresponding to the functional class and area type where individual links were located. Individual link travel time was then computed using the assigned link speed.

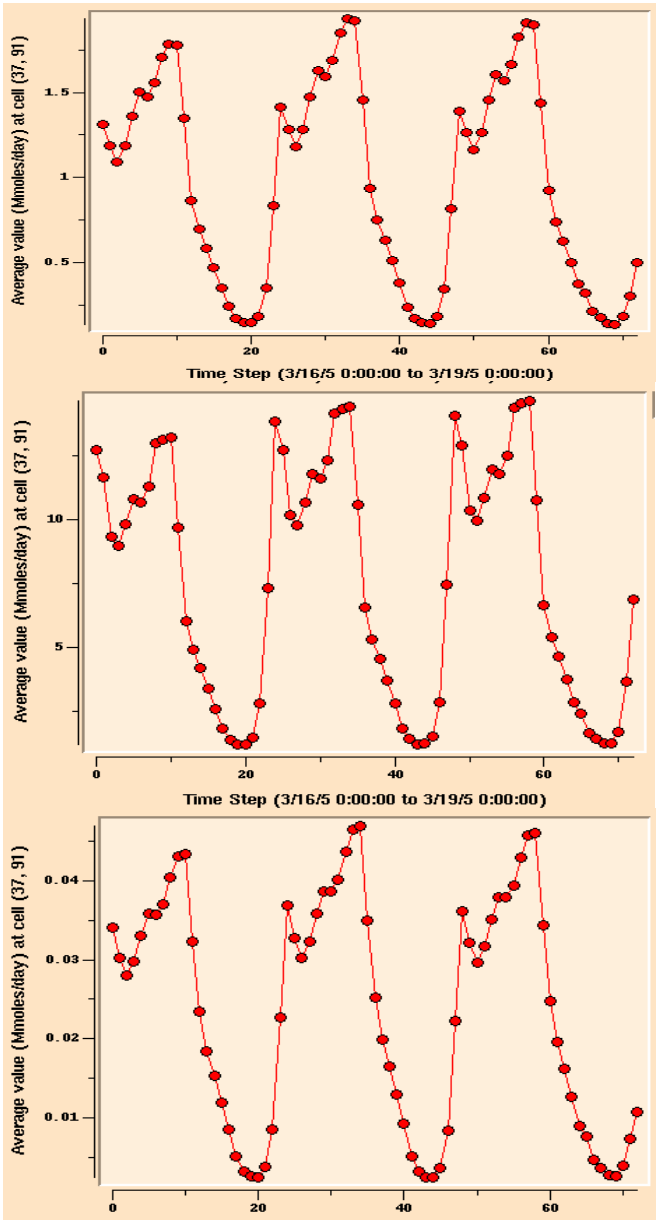


Figure 12.23 Emission (as Mmoles/day) of NO_2, CO, SO_2 from mobile source in Hanoi from Mar. 16-19, 2005

12.3.2.3 Emission Factors

Emission factors in all cases were obtained from the US EPA's MOBILE6 model. MOBILE6 produces emission factors for eight vehicle types that include gasoline- and diesel- fueled light-duty

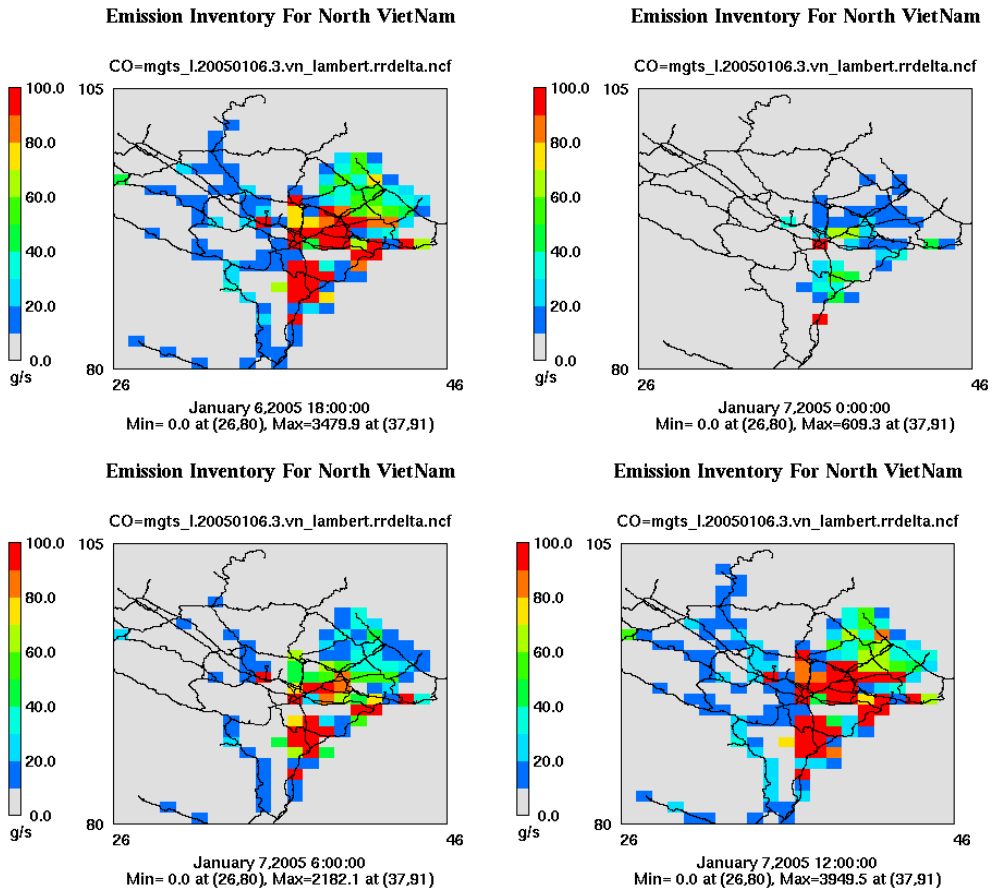


Figure 12.24 CO emission from mobile source in North Vietnam

cars and trucks, heavy-duty vehicles, and motorcycles. Temperature and humidity inputs were taken from MM5 modeling performed by IMH for the air quality modeling portion of this work.
VMT Projections

Link-based activity (VMT) data for 2000 for the 4 types of road were estimated. Corresponding MOBILE6 emission factors were prepared by running the model over a range of temperatures, speeds, and humidity conditions. These emission factors were estimated by running MOBILE6 with daily minimum and maximum temperatures (rather than for a range of specific temperatures).

12.3.3 Point Source data

Vietnam had a population of 81,022,000 in 1999, which made it the 13th most populous country in the world. There are 61 provinces in Vietnam and 570 urban centers. In total, Vietnam has 19 cities, of which 3 (Ho Chi Minh City, Hanoi and Hai Phong) have populations greater than one million.

A major event in the economic development of Vietnam was the introduction in 1986 of doi moi. The goal of doi moi was to reform the centrally planned economy and to decentralize the government. The contents of these reforms included:

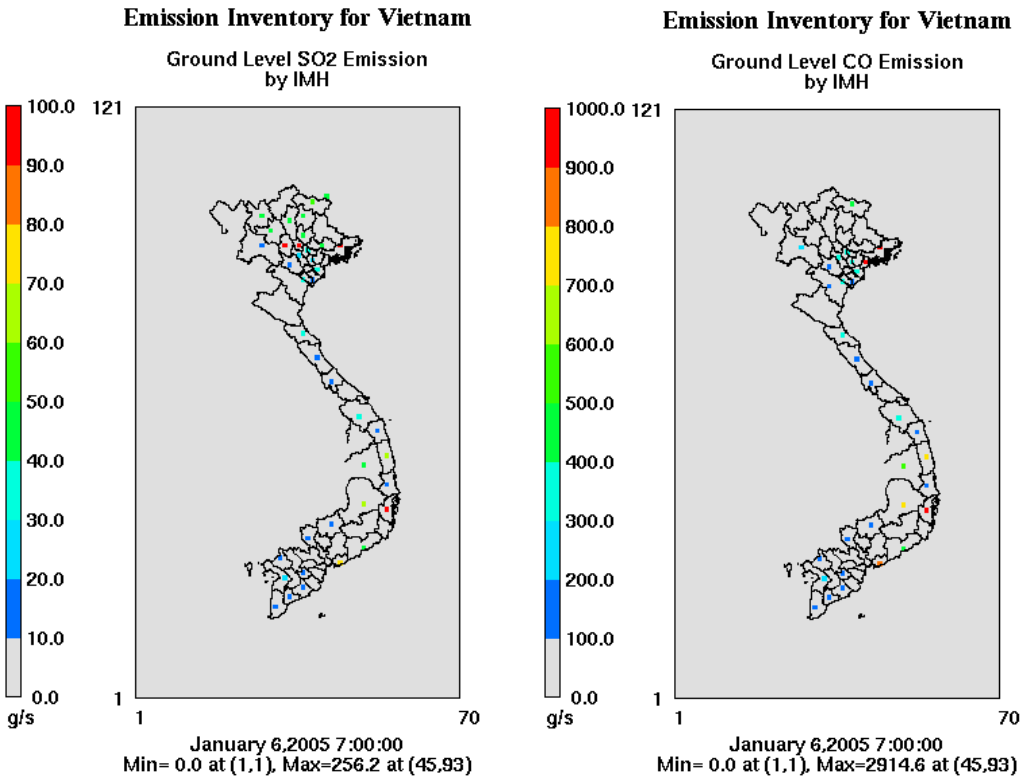


Figure 12.25 SO_2 and CO emission from point sources

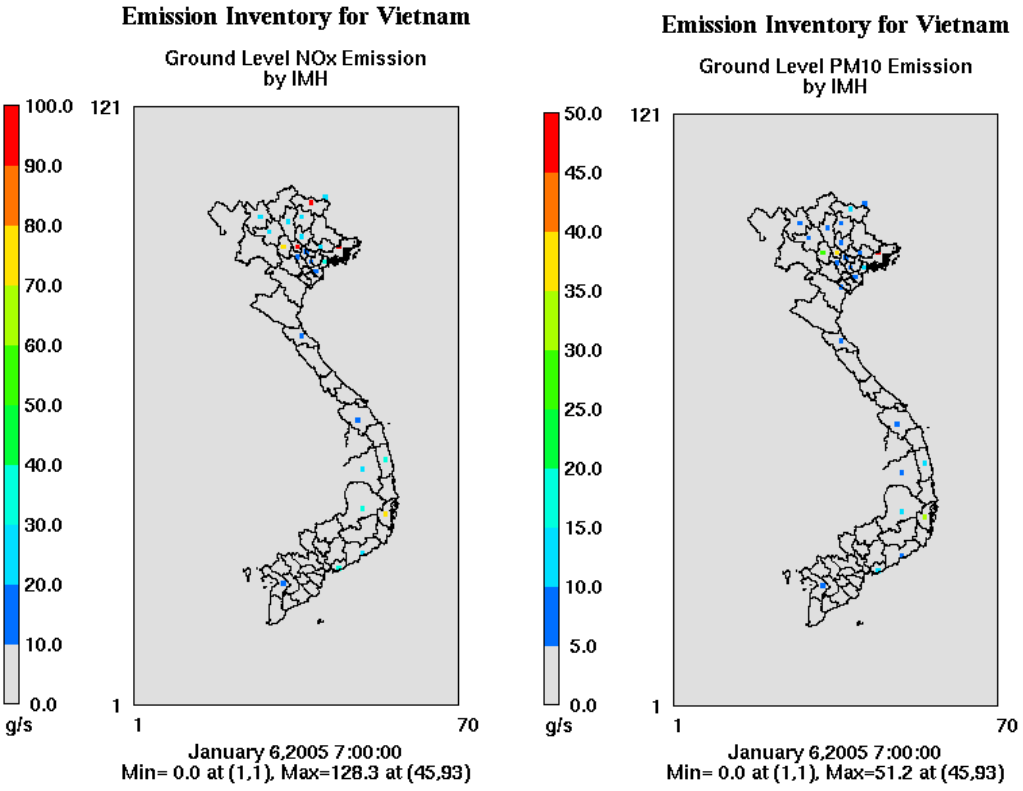


Figure 12.26 NOx and PMC emission

– Shift of the centrally planned economy to a market economy under state management,
– Development and diversification of international economic relations, and
– Reform of state administration.

More than a decade after the advent of doi moi, the stimulation of the economy catalyzed by the country's market-oriented reforms helped transform a serious economic crisis in the 1980s into rapid economic growth in the 1990s. For Vietnam's population, the modernization and resultant growth and industrialization of the economy has resulted in an overall improvement in welfare. This progress has not occurred without serious environmental degradation: pollution caused by a rapidly expanding industrial sector has become one of the most pressing environmental issues in Vietnam today. Considering that Hanoi is the capital of Vietnam and a major industrial centre, it is not surprising that much of the industrial pollution is occurring in and around its borders.

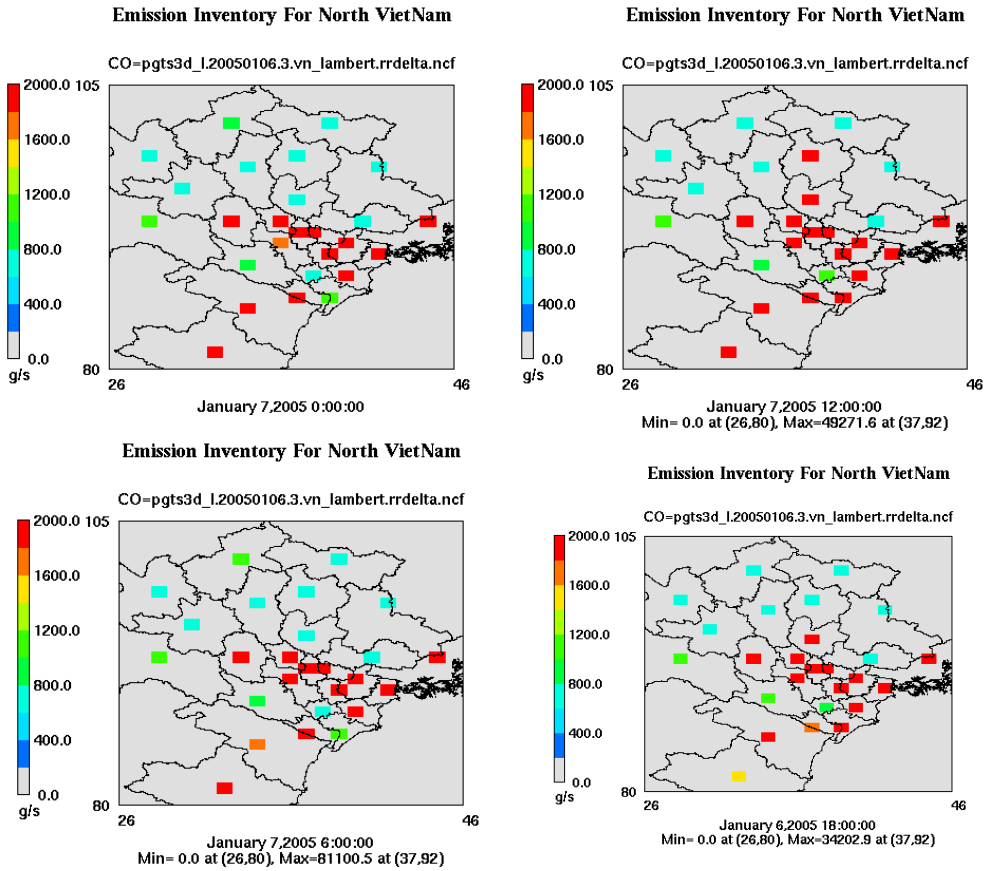


Figure 12.27 CO emission from point sources in North Vietnam

Industrial zones have been established in many Asian countries as a means of promoting industrial growth, foreign investment and trade. Industrial zones are comprised of groups of industries clustered together in a given geographical area because of collective benefits, such as industrial linkages, labors, infrastructure, and land. Industrial zones appear from their structure alone to offer numerous environmental benefits.

But literature on the environmental advantages of these zones is scarce and is, for the most part, limited to discussions of the benefits of eco-industrial parks. The few literature sources that do address this issue find that, besides providing adequate infrastructure (as mentioned above), the environmental

advantage of this approach is that it brings together waste producers and waste users. By this method, it is expected that the user will minimize quantities of raw materials required for processing, and the producer, through prevention of waste, will reduce their impact on the environment. However, the key to the success of this approach is the ability to select an appropriate combination of plants. In other words, because the user must have an operation that is compatible with the producer's, the proper selection of compatible industrial factories is necessary to ensure an environmentally responsible and efficient industrial complex. In developing nations, where planning is generally inadequate, this approach is appears unlikely to succeed.

Recently, a number of industrial zones considerably increase (80 zones in 2002 to 120 zones in 2005) and mostly located in north and south deltas. However because of not being well planned, many of the industrial zones constructed in vicinity of resident areas and national roadways and, consequently, resulted in environmental and public health problems.

The major sources of electric energy in Vietnam are thermal and hydraulic power. In 1998, the total electricity output of Vietnam was estimated at about of 30.266 billion kWh, comprising 12.2 billions kWh (40%) and 18.066 billions kWh (60%) of hydroelectricity and thermoelectricity respectively. The thermal power plants in the north use mainly coal, those in the south use furnace oil and/or natural gas. The thermal power plants often use Quang Ninh coal with average ash content (A) of 10-15% and sulphur content (S) of 0.5%. The power plants based on furnace oil often use oil with ash content of 0.01- 0.50% and sulphur content of 2.7- 3.0%. Therefore, the power plants emit much SO_2 and dust into the atmosphere, causing air pollution. However, the pollution only occurs in local areas. So far, the thermal power plants in Vietnam only use dust filters but no SO_2 treatment equipment.

For the purposes of this study, we initially consider all industrial and commercial facilities that might impact pollutant concentrations in Vietnam. We include in this category main point emissions sources that can be identified to occur at these facilities. To compile this inventory, we first develop a list of facilities. We then collect inventory data from as many different sources as possible, and identify data gaps. We conduct surveys to augment inventories to fill data gaps, and to enhance our ability to assess data quality. The inventory is compiled to a single database by assigning inventory from the most complete data source or sources representing each facility.

The point source section of the inventory addresses those facilities or industrial plants for which individual source records are maintained. Actual process or throughput information was used to calculate the point source portion of the inventory. Though, the surveys mostly were conducted in the Red River delta area (North Vietnam), the list of point sources here with satisfactory details was still in an embryonic stage.

12.4 Review of national measures against acid deposition

In Vietnam, acid deposition is mostly composed of nss-S origin. The deposition of nitrogen compounds is less than that of sulfur, therefore, the major measures against acid deposition is to reduce SO_2 emission. However, the reduction in deposition of other acidifying compounds will also reduce exceedance of critical loads.

Vietnam joined some international conventions on emission reduction of SO_2 and other air pollutants such as: United Nation Frame Convention of Climate Change (UNFCCC); Kyoto Protocol on Emission reduction of greenhouse gases; etc. Vietnam has also strived for reducing air pollutant emission in industries as applying ISO 14000 Environmental System Management Standards; cleaner production technology.

Some researches on pollution and impact level of air pollution issue have carried out such as building project of Red river delta air environment in 2001-2010; air quality forecast in Northern Vietnam. However, it is difficult to collect data so these researches have not been widened in whole country yet. The preliminary national emissions inventory for Vietnam is currently under development. Because the availability of data used in traditional estimation methodologies is extremely limited in Vietnam, most of the data were collected and built from the unsystematic sources. At the current time, this methodology has not been completely implemented.

These difficulties have been originated from the uncompleted and un-synchronic monitoring system. There are only Hanoi and Hoa Binh stations operate according to the regulation of EANET, but Hoa Binh does not meet the criteria of EANET for site selection to monitor inland aquatic environment.

Vietnam need be supported to supplement some stations in Middle and Southern Vietnam or equipments for main stations in national network. Vietnam also need be assisted in finance to carry out the researches on acid deposition.

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