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RÜSIE

Translation*: 'A movement for a cause' is the literal translation of the Tenyidie word* ***'Rϋsie'****. It is a movement of united action and efforts by a group or a community for a specific purpose.*

The name 'Rϋsie' befits the journal which is also a movement for a cause- of Science and Social issues. A forum to disseminate ideas and knowledge through united and collective efforts.

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SURFACE CHARACTERIZATION AND ADSORPTION STUDIES OF *BAMBUSA VULGARIS*-A LOW COST ADSORBENT

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Abstract: The raw materials for the synthesis of Activated carbon were taken from the stem and leaves of the plant *Bambusa vulgaris.* The raw materials were given thermal treatment which was subsequently followed by chemical activation using 0.1N HNO_3 and 0.1N H_3PO_4. The parameters included in the surface characterization of activated carbons consist of FTIR, EDX, SEM and surface area by BET (method). Activated carbon provides a large surface area with well developed pores. Adsorption studies of Methylene blue on the activated carbon were studied for removal of dye from water.

Keywords: Activated carbon, surface area, adsorption studies, methylene blue

Introduction

Activated carbons are known for their large surface area, microporous structure, high adsorption capacity, and high degree of surface reactivity. Depending on the functional group and ions present on the surface of the activated carbon, its adsorption quality varies (Bansal & Goyal, 2005). Some of their important applications are the adsorptive removal of color, and other undesirable organic and inorganic pollutants from drinking water, in the treatment of industrial waste water. (Bansal & Goyal, 2005; Berl, 1938). Activated carbon is obtained from a carefully controlled process of dehydration, carbonization and oxidation of organic substances (Bandosz, 2006). It can be prepared for research in the laboratory from a large number of materials. However, the most commonly used ones in commercial practice primarily industrial and agricultural byproducts and forest wastes, such as coconut shell (Radhika & Palanivelu (2006), sugar beet bagasse (Onal *et. al.*, 2007), rice straw (Wang *et. al.*, 2007), bamboo (Hameed *et. al.* 2007a), rattan sawdust (Hameed *et. al.* 2007b), molasses (Legrouri *et. al.*,2005), rubber wood sawdust (Kumar *et. al.*, 2006), oil palm fiber (Tan *et. al.*, 2007), waste apricot (Basar, 2006), and coconut husk (Tan *et. al.*, 2008).

Carbonization is a heat treatment at 400-800°C which converts raw materials to carbon by minimizing the content of volatile matter and increasing the carbon content of the material. This increases the materials strength and creates an initial porous structure which is necessary if the carbon is to be activated. Adjusting the conditions of carbonization can affect the final product significantly. An increased carbonization temperature increases reactivity, but at the same time decreases the volume of pores present. This decreased volume of pores is due to an increase in the condensation of the material at higher temperatures of carbonization which yields an increase in mechanical strength. Therefore, it becomes important to choose the correct process temperature based on the desired product of carbonization (Bansal & Goyal, 2005). After the initial porous structure has been created by carbonization, this pore structure in carbonized char is further developed and enhanced during the activated carbon process, which converts the carbonized raw material into a form that contains the greatest possible number of randomly distributed pores of various sizes and shapes, producing an extended and extremely high surface area of the product (Bandosz, 2006). Activation can be carried out by chemical activation. The objective of this study is to produce activated carbon from locally available biowaste with two different acids, characterization of the produced activated carbons and finally examine the changes in the adsorption capacity towards transition metal ions by the formation of various oxygen and nitrogen surface functionalities by oxidation of activated carbons of similar porosity with nitric acid and phosphoric acid.

Materials and methods

Preparation of activated carbon

Activated carbon in powder form is prepared by the pyrolysis of *Bambusa vulgaris (BVC).* Stem and leaves of BVC were collected, washed, dried, and crushed before carbonizing in a uniform nitrogen flow in a horizontal tube furnace electrically heated at 600 ^{o}C for 4 hours. Then the activated carbon was cooled to room and ground to 45 mesh. These powdered carbons were subjected to liquid phase oxidation with 0.1N HNO_3 and 0.1 N H_3PO_4. After that the carbons were washed with double-distilled water to remove the excess acid and dried at 150^{o}C for 12hours. All the activated carbons (BVC) are chemically activated with 0.1N solution HNO_3 and H_3PO_4. The powdered activated carbon obtained after HNO_3 and H_3PO_4 treatment has a particle size in the range of 40-50 μm mesh.

Surface characterization of prepared carbons

Fourier transform infra-red spectroscopy

The spectra were recorded using Perkin–Elmer SPECTRUM-2000 spectrometer. Carbon samples were dried in a drier, then 2 mg of each sample was powdered and mixed with 300 mg of anhydrous KBr (Merck; for spectroscopy). The mixture was pressed under vacuum to obtain the pellets. The spectra were performed between 4000 and 400 cm^{-1} (100 scans). The background spectrum of air was subtracted from the spectra of the samples. The carbon samples were investigated using this technique.

Energy Dispersive X-ray Analysis (EDX)

Energy Dispersive X-ray Analysis (EDX) technique is used for performing elemental analysis or chemical characterization of a sample in conjunction with Scanning Electron Microscopy (SEM).For determining elemental content, the electron-beam strikes the surface of conducting sample (SEM) .The energy of the beam is typically in the range of 10-20 keV. This causes X-rays to be emitted from the irradiated material. The energy of the X-rays emitted depends on the material under examination. The X-rays are generated in a region about 2 microns in depth. By moving the electron beam across the material a 2-D (two dimensional) image of each element in the sample can be acquired. Due to the low X-ray intensity, images usually take a number of hours to be acquired. Elements of low atomic number are difficult to detect by EDX.

Determination of surface area (BET method)

BET-N_2 adsorption experiments were carried out manometrically using an Autosorb (Quanta Chrome Crop). Prior to gas adsorption measurements, the carbon samples were degassed at 200 ◦C in a vacuum condition for a period of at least 24 h. Nitrogen adsorption isotherms were measured at a series of different pressures at -196° C. And the BET surface area was determined by means of the standard BET equation.

$$\frac{P}{V(P-P_0)} = \frac{1}{V_m - C} + \frac{C-1}{V_m C}\frac{P}{P_0} \quad (1)$$

The surface area is determined by the following equation

$$S_{BET} = \frac{N_A A_M V_m 10^{-20}}{m_s V_M} \quad (2)$$

Where;

S_{BET} is the BET surface area (m^2 /g)

N_A is Avogadro's number (6.023 x 10^{23} molecules/mole)

A_M is the area occupied by an adsorbate molecule (16.2 $Å^2$ for nitrogen)

V_m The quantity of gas adsorbed for monolayer coverage of surface (cm^3)

m_s is the mass of the solid analyzed (g)

V_M is the molar volume of gas (22,414 cm^3/mol)

For nitrogen as adsorptive gas, equation (2) becomes

$$S_{BET} = \frac{4.35 V_m}{m_s}$$

Results and discussion

The results for FT-IR of the two different carbons activated with HNO_3 and H_3PO_4 are shown in fig. 3 and 4. The band at 3215-3125 cm^{-1} is due to the absorption of water molecules as result of an O-H stretching mode of hydroxyl groups and adsorbed water. The band of asymmetric at lower wave numbers indicates the presence of strong hydrogen bonds (Bulut and Aydin 2005; Langmuir and Irving, 1918). Bands at 2714 cm^{-1} are connected with $(C\text{-}H)_s$ and *v*s $(C\text{-}H)_{as}$ vibrations (s=symmetric, as=asymmetric).The C=O vibration near 1821-1642 cm^{-1} is the specific peak for the carboxylic acid, aldehydes, ketones, esters and lactones groups. The *v* (C=C) vibration mode at about 1510 cm^{-1} are probably due to stretching vibration of C=O moieties of conjugated systems or aromatic ring stretching coupled to highly conjugated carbonyl groups (Aziz *et. al.*,2011). While the bands at 1245, and1125 cm^{-1} are clearly observed and correspond to C-O stretching bonds in phenols, ethers, lactones. Bands at 1062,and 1068 cm^{-1} correspond to alcoholics C-O stretching vibration (Chinniagounder *et. al.*, 2011). The formation of C-O stretching of oxygenated groups may be attributed to redox reactions of incorporated HNO_3 and H_3PO_4 with carbon during the chemical treatment. The band at wave number below 874 cm^{-1} may be related to out of the plane bending modes. The BET specific surface area of BVC (HNO_3) sample shows high surface area of 570 m^2/g , as compared to other activated carbons under study. It can be concluded that the surface area of the resulting activated carbons can be designed by varying the amount of the activation agents (Sivakumar and Palanisamy, 2009; El-Sayed, 2011).The micrographs from SEM analysis of the activated carbons show a highly developed pore structure for both the adsorbents. It is evident that there are larger numbers of pores present in the activated carbon produced using Nitric acid (HNO_3) activation than the activated carbon obtained from phosphoric acid (H_3PO_4). EDX show that the carbon samples primarily consist of carbon and oxygen at varied proportions. The carbon and oxygen content is higher in BVC (HNO_3) and less in BVC (H_3PO_4). EDX analysis of the samples practically does not show the presence of Nitrogen; neither does it show Phosphorus which could explain the rather good adsorbent properties observed particularly for this activated carbon.

Properties	B.V.C(HNO_3)	.V.C(H_3PO_4)
Surface area m^2/g (BET method)	570	530

Table 1: surface area of *Bambusa vulgaris*

Element	Weight %	Atomic %	K-Ratio	Z	A	F
C K	87.12	90.14	0.7	1.0	0.80	1.000
O K	12.56	9.75	0.0	0.9	0.13	1.00
S K	0.12	0.05	0.0	0.9	1.01	1.00
Ca K	0.19	0.06	0.0	0.9	1.05	1.00
Total	100	100				

Table 2: Elemental composition from EDX of BVC (HNO_3)

Element	Weight %	Atomic %	K-Ratio	Z	A	F
C K	83.75	87.95	0.54	1.0	0.6	1.0
O K	14.00	11.04	0.01	0.9	0.1	1.00
Si K	2.24	1.01	0.18	0.9	0.88	1.00
S K	0.01	0.00	0.00	0.9	0.98	1.00
Ca K	0.00	0.00	0.00	0.9	1.05	1.00
Total	100	100				

Table 3: Elemental composition from EDX of BVC (H_3PO_4)

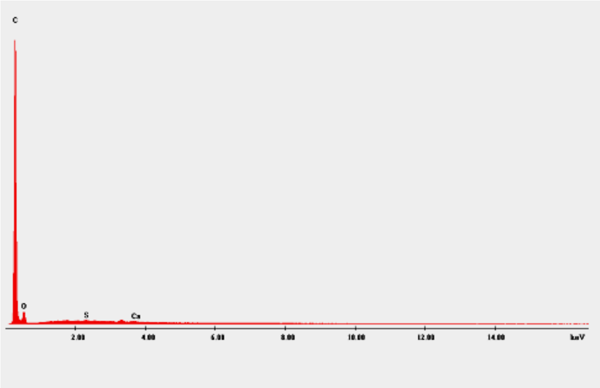

Fig 1: EDX spectra of BVC (HNO_3)

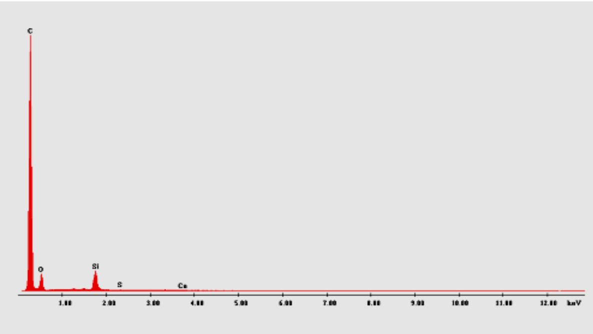

Fig 2: EDX spectra of BVC (H_3PO_4)

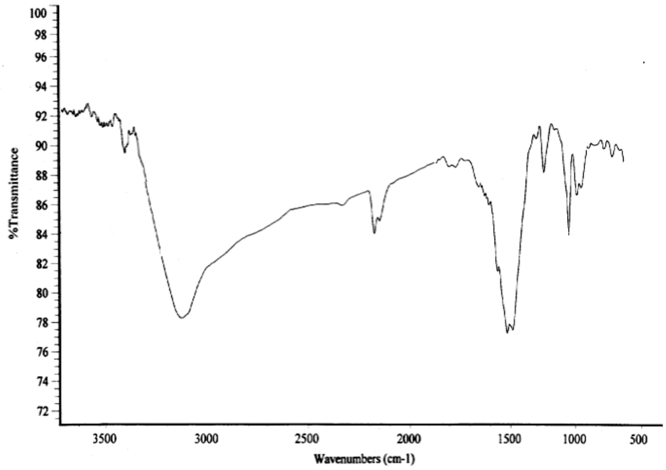

Fig 3: FTIR spectra for BVC (HNO_3)

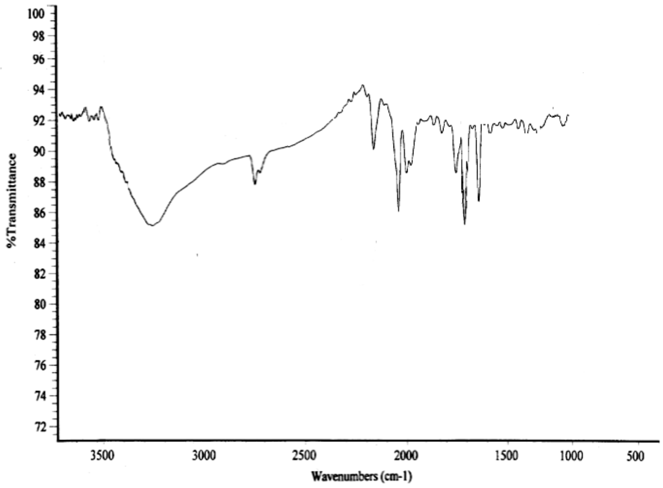

Fig 4: FTIR spectra for BVC (H_3PO_4)

Conclusions

Activated carbon was prepared from stem and leaves of *Bambusa vulgaris (BVC)*, for which thermal treatment subsequently followed by chemical activation using different acids were done. The principle behind the chemical activation of activated carbon was to introduce certain functional groups on the surface of the carbon in order to enhance the adsorption capacity. Surface characterization of the adsorbents from FTIR, EDAX and BET method have been done to compare the effectiveness and adsorption capacity between the two activated carbons understudy. The adsorbents BVC (HNO_3) has the better adsorption characters due to high surface area of 570 m^2/g as compared to 530 m^2/g for BVC (H_3PO_4) , This is well supported by the EDAX data's. EDAX studies further strengthen the fact that BVC (HNO_3) is the better activated carbon produced with the higher carbon content and the less oxygen content. Thus it may be concluded that the chemical structure of the activated carbon were found to be influenced markedly with its activation scheme and thus chemical activation by nitric acid is far more better than phosphoric acid.

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A STUDY ON THE PREVALENCE OF DISEASES IN RURAL AREAS OF NAGALAND DURING 2011

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Abstract: Health status of a population is a major concern for every welfare state. Nagaland is always at risk for occurrence of outbreak of vector borne diseases along with asthma, jaundice, TB and diseases of liver. The objective of this study is to find the disease specific prevalence rates of morbidity in rural areas of Nagaland. This study is based on cross-sectional primary household data. The sample consists of 5404 persons selected from 23 villages of Kohima and Dimapur districts of Nagaland by using multistage sampling technique. Sample data revealed that total of 886 (164 per 1000) were suffering due to diseases. Of this 497 (92 per 1000), 388 (72 per 1000) and 504 (93 per 1000) were suffering due to acute, chronic and infectious diseases respectively. The leading causes of ailments were lower respiratory infections (LRI) (25 per 1000) followed by cardiovascular diseases (22 per 1000), diabetes (15 per 1000), malaria (13 per 1000) and gastro intestinal diseases (11 per 1000). Children were mostly affected by the infectious diseases.

Keywords: Ailment, morbidity, prevalence, disease, Nagaland.

Introduction

Health is a leading characteristic of the members of a population, akin to other demographic and socioeconomic characteristics. The World Health Organization (WHO, 1946) has defined health as ‘a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity’. Health is generally thought of as a basic right of citizens (Humphreys and Rolley, 1991) yet there exists many inequalities in the levels of health experienced by a population. This is particularly so of people living in rural areas (AIHW, 1998). Health is a major concern of every population. It is the general desire of every population to be in good health which means free of diseases. But, it is not pragmatic to think of a population which is not suffering from any kind of disease. Therefore, health status of population and their studies have received considerable importance since the past many decades.

The diseases that are responsible for the cause of illness and death can be classified mainly in two categories- communicable and non-communicable or degenerative diseases (Murray and Lopez 1996). The deaths due to communicable diseases have drastically gone down during the last few decades, whereas deaths from non-communicable or degenerative diseases like cardiovascular diseases are alarmingly increasing (Gaminiratne, 1984). This phenomenon has occurred in all developed countries, and the developing countries are in transition towards this state (Crimmins *et al.*, 1994). The epidemiologic transition characterized by a decline in infectious or communicable diseases, which disproportionately strikes young children, and a corresponding rise in the proportion of deaths and of morbid episodes that occur among adults (Omran, 1971). It is estimated that by the year 2025, majority of the developing countries are likely to face an enormous burden of chronic non-communicable diseases (WHO, 2001).

Prevalence of a disease indicates how common the disease is in a population and can be explained by measuring the morbidity rates. The prevalence of most diseases has increased in the older population as people survive longer with disease and the reduction in incidence does not counter the effect of increased survival (Crimmins, 2004).

The prevalence of some diseases such as tuberculosis, asthma, jaundice and malaria are much more in Nagaland compared to all India level (NFHS-II; 1998-99). Nagaland is always at risk for occurrence of outbreak of mosquito borne diseases (Datta *et al*, 2010). The morbidity rate, a measurement of incidence or prevalence of diseases, is not only increasing in Nagaland over the period 1995 to 2004, but it is increasing faster than all India level (NSSO, 1998, 2004).

Objective

In this backdrop, our objective is to study the prevalence of different types of diseases in the rural areas of Nagaland in 2011.

Materials and Methodology

Data

This study is based on cross-sectional primary data collected through household survey during May-June, 2011 from 23 villages of Kohima and Dimapur districts for the purpose of a Minor Research Project (MRP) sponsored by UGC-NERO Office, Guwahati. The multi-stage sampling design was adopted to collect data. Altogether, we interviewed 5404 respondents from 1150 households. The enquiry on morbidity or the prevalence of diseases was conducted with a reference period of 30 days. All spells of ailment suffered by each member of the sample household during the 30 days preceding the date of enquiry, whether or not the patient was hospitalised for treatment, were covered in the survey. A respondent was classified as afflicted by any disease if he/she is reported to be ailing due to any kind of disease within the reference period. The morbidity data collected in the survey are based on the respondents' own assessment of their medical status, rather than on medical examination. The diseases are classified as infectious and non-communicable diseases according to the International Classification of Diseases 10th Revision (ICD-10) (Canadian Institute for Health information, 2012). Moreover, the identification of particular disease was done in consultation with a government doctor of Nagaland on the basis of the collected information regarding the diseases' symptoms.

Methodology

This paper basically describes the disease specific morbidity prevalence in the rural areas of Kohima and Dimapur districts of Nagaland. The *prevalence rate of any* *ailment or its morbidity* is defined by

$$\text{Morbidity Prevalence Rate} = \frac{M}{P} \times 1000$$

Where, M=Number of ailing persons in the sample households and P= Total number of persons alive in the sample households.

Results

From the sample data, we found that total of 886 (16.4%) were suffering due to diseases of which 497(9.2%), 388(7.2%) and 504(9.3%) were suffering due to acute, chronic and infectious diseases respectively. The disease and age specific morbidity prevalence rates in the rural areas of Nagaland is presented in Table-1. It is evident from this table that the leading causes of morbidity in the rural areas of Nagaland were lower respiratory infections (LRI) (2.5%) such as influenza, pneumonia, etc, followed by cardiovascular (2.2%), diabetes (1.5%), malaria (1.3%) and gastro intestinal diseases (1.1%). The leading causes of morbidity among the children of age groups 0-5 & 6-17 years are LRI (7.1% & 2.6%) followed by diarrhoea (2.1% & 1.1%), measles and chicken pox (1.4% & 1.1%). The adults of age group 18-45 were suffering mainly due to LRI (5.4%) followed by gastro intestinal diseases (1.5%), malaria (1.4%) and renal problems (1.3%). On the other hand people of age group 45-59 were mostly suffering from diabetes (7.1%) and cardiovascular (6.5%) while the main causes of suffering for persons of age 60 years and above were non-communicable diseases such as cardiovascular (16.7%) followed by cancer (9.7%), diabetes (4.8%), bronchitis (3.6%) and arthritis (3.0%).

Within the morbid episodes, 56.88%, 43.79%, 38.60% & 24.94% were suffering due to infectious, chronic, non-communicable and respiratory diseases respectively (Table-2). It is also observed that the children in the age group 0-5 years were suffering only due to infectious diseases (Table-1) while 72.9% (113 of 155 morbid persons) and 87.1% (135 of 155 morbid persons) of the older persons (60 years & above) were suffering due to non-communicable and chronic diseases respectively.

As expected, the disaggregated morbidity prevalence rates due any of disease by age provide ‘J’ shaped curves (Figure-1) indicating that the prevalence rates are higher among children and are much higher among the aged persons.

Discussion

The observed high rate of morbidity prevalence (164 per thousand populations) in the rural areas of Nagaland is consistent with the increasing trend found in the earlier surveys (NSSO, 1998, 2004). The morbidity rates in the rural areas of Nagaland were 31 and 61 per thousand populations respectively in 1995-96 (NSSO, 1998) (52^{nd} round) and (NSSO, 2004) (60^{th} round) (15 days reference period were taken in both rounds). These figures could be nearly 50 in 1995-96 and 102 (almost double) in 2004 per thousand populations provided 30 days reference period would be considered in the survey. On the other hand, the morbidity rates in regard to India (Rural) were 64 per thousand population in 1986-87 (NSSO 42^{nd} Round with 30 days reference period) and 55 per thousand in 1995-96 (NSSO, 1998) (52^{nd} round) with 15 days reference period). This figure stood at 86 per thousand (an increase of about 60%) derived by recalling the 30 days reference period in 1995-96. The morbidity further increased to 88 per thousand (NSSO, 2004) (60th round) with 15 days reference period (which certainly would be nearly 140 if 30 days reference period is considered) in 2004. This suggests that the morbidity in respect to rural areas of Nagaland is increasing in a pace more than the all India level.

We also observed that out of the total morbid persons nearly 57% (503 out of 886) were suffering due to infectious diseases and 30% (265 out of 886) were due to non-communicable chronic diseases (such as cardiovascular, diabetes, arthritis and renal diseases) which can be considered to be very high. This finding is consistent with some previous study (Sundar and Sharma, 2002; World Bank Report, 1993). In their study, Sundar and Sharma (2002) found that the infectious diseases account for 51.7% and 58.5% of the total number of reported morbidity episodes respectively in Delhi and Chennai slum areas. Also, according to World Bank report (1993), the morbidity prevalence due to infectious diseases is more dominant in the underdeveloped and developing countries. The finding also establishes the fact that the prevalence of non-communicable diseases has been disproportionately increasing compared to communicable diseases. In some earlier studies, it has been observed that the burden of diseases has been shifting from communicable towards non-communicable chronic diseases (Gaminirate 1984; Crimmins *et al*. 1994). The prevalence of high morbidity rate indicates that though the people are living a longer life with increase in expectation of life at birth, they are living in ill health.

Within the morbid episodes, we observed that children below 6 years of age were suffering only due to infectious diseases while the older persons of age 60 years and above were mostly suffering from chronic diseases. Similar results were observed in another study (Sundar and Sharma, 2002). They observed that in the case of children, more than 80% and nearly 90% of the reported illness in Delhi and Chennai slums respectively were due to infectious diseases. In the case of the old (60+ age), more than 80% of the reported illness episodes were chronic in nature. Moreover, we observed that about 25% of the total morbid persons were due to respiratory diseases such as T.B., Asthma, Bronchitis and LRI alone. In a study Bronchitis and Asthma, Pneumonia and Tuberculosis of lungs was suggested as one of the five major cause of deaths in rural India (Agnihotram and Chattopadya, 2005). We observed high morbidity rate due to chronic diseases in the rural areas of Nagaland. In one of the study in Andhra Pradesh, it is found that chronic diseases are the leading cause of death in rural India (Joshi *et al*., 2006).

The observed 'J' shaped pattern of the relationship between age and morbidity prevalence due to any diseases indicating that the children and aged are more susceptible to diseases are similar to some earlier studies (Kannan *et al*, 1991; Gumber and Berman, 1997; Shariff, 1995; NSSO, 1998; NSSO, 2004). Moreover, there exists significant relationship between age differentials and morbidity prevalence due to any disease. These findings are consistent with earlier findings (Dilip, 2007; NSSO, 2004; Ghosh and Arokiasamy, 2009).

Conclusion

Government needs to pay special attention to eradicate the infectious diseases that affects mostly the children in the rural areas of Nagaland. Also, the observed high morbidity rate due to non-communicable chronic diseases is a matter of great concern as it is the major cause of ill health leading ultimately to death.

Acknowledgement

The author sincerely acknowledges the financial support granted by UGC-NERO, Guwahati in the form of Minor Research Project which immensely helped to carry out the household survey for data collection.

Table-1: Age and Disease Specific Morbidity Prevalence Rate in the rural areas of Nagaland during 2011:

Sl. No.	Name of Disease	Age (in years)					Total
		0-5	6-17	18-45	46-59	60 & above	
1	Tuberculosis	-	4(3)	17(6)	10(17)	7(21)	38(7)
2	Hepatitis	3(7)	1(1)	6(2)	3(5)	-	13(2)
3	Asthma	1(2)	5(4)	21(8)	5(8)	-	32(6)
4	Bronchitis	1(2)	-	2 (1)	1(2)	12(36)	16(3)
5	Malaria	5(12)	13(10)	38(14)	11(18)	3(9)	70(13)
6	LRI	30(71)	35(26)	54(20)	12(20)	4(12)	135(25)
7	Cardiovascular	-	3(2)	23(9)	39(65)	55(167)	120(22)
8	Diabetes	-	-	24(9)	43(71)	16(48)	83(15)
9	Liver Cirrhosis	-	-	15(6)	11(18)	1(3)	27(5)
10	Cancer	-	1(1)	6(2)	6(10)	32(97)	45(8)
11	Arthritis	-	1(1)	13(5)	3(5)	10(30)	27(5)
12	Diarrhoea	9(21)	15(11)	20(7)	1(2)	2(6)	47(9)
13	Renal disease	-	-	34(13)	1(2)	-	35(7)
14	Chronic dysentery	1(2)	-	17(6)	3(5)	2(6)	23(6)
15	Emphysema	-	1(1)	3(1)	4(7)	4(12)	12(2)
16	Measles and chicken pox	6(14)	15(11)	3(1)	-	-	24(4)
17	Diphtheria	4(10)	1(1)	1(0.4)	1(2)	-	7(1)
18	Gastro int. diseases	1(2)	7(5)	40(15)	8(13)	5(15)	61(11)
19	Typhoid	-	-	7(3)	3(5)	2(6)	12(2)
20	Eye Infection	2(5)	3(2)	5(2)	4(7)	-	14(3)
21	Others	-	6(5)	32(12)	7(12)	-	45(8)
22	Overall Morbidity (in %)	14.96 %	8.31%	14.03%	29.24%	46.97%	16.40%

N.B. Figures in bracket represents morbidity prevalence per 1000 population within that age group.

Table-2: Percentage distribution of prevalence of different types of diseases of the total 886 morbid persons observed in the sample.

Disease Type	Number of Morbid Persons	Percentage
Infectious Diseases	504	56.88
Chronic Diseases	388	43.79
Non Communicable Diseases (NCD)	342	38.60
Respiratory Diseases	221	24.94

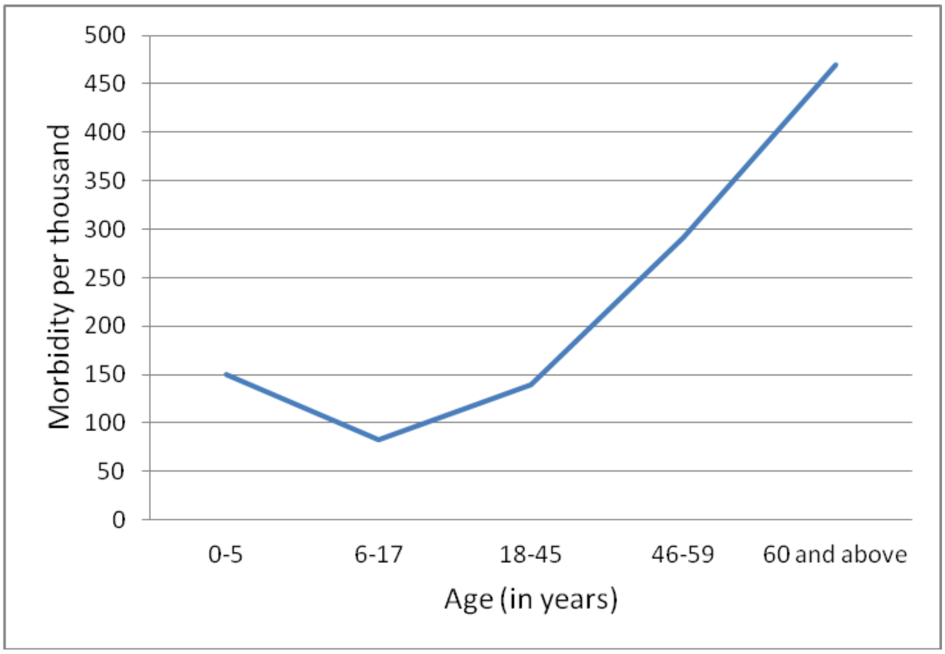

Figure-1: Curve showing the morbidity prevalence due to any disease in different age groups.

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DE-MIXING OF BINARY FLUID MIXTURE IN PRESENCE OF SORET AND DUFOUR EFFECTS IN MHD NATURAL CONVECTION FLOW IN POROUS MEDIA

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Abstract: De-mixing of a binary fluid mixture of incompressible viscous fluids in MHD natural convection flow in an infinite porous media bounded by a vertical impervious wall is studied numerically by taking into account the Soret and Dufour effects. The concentration profiles are drawn and the effects of Hartmann, Dufour and Soret numbers are exhibited graphically. It is observed that separation near the plate increases with the increase in the Hartmann, Soret and Dufour numbers.

Keywords: Soret effect, Dufour effect, Binary fluid, porous media.

Introduction

Natural convection in a fluid saturated porous medium has attracted considerable attention in the last several decades due to its many important engineering and geophysical applications. Comprehensive reviews in this field have been made by Nield and Bejan (2006), and Ingham and Pop (1998, 2002) in their books. Several researchers such as Bejan and Khair (1985), Makinde (2005), Makinde and Ogulu (2008), Ibrahim and Makinde (2011) have studied free convection heat and mass transfer problems neglecting Soret and Dufour effects on the basis that they are of a smaller order of magnitudes. However, exceptions are observed therein. The Soret effect has been found to be utilized for isotope separation, and in mixture between gases with very light molecular weight (H_2, He) and of medium molecular weight (N_2, air). Similarly, the Dufour effect is also found to be of the order of considerable magnitude such that it cannot be ignored (Eckert and Drake (1972)). In view of the importance of above mentioned effects, Kafoussias and Williams (1995), Anghel et al. (2000). Postelnicu (2004), Alam and Rahman (2006) discussed free/forced convective heat and mass transfer boundary layer flow by taking into consideration the Soret and Dufour effects. In all of the above mentioned investigations the concentration of one component of the binary mixture has been taken to be constant at the plate.

The objective of the present paper is to investigate Soret and Dufour effects on de-mixing of an electrically, thermally conducting and chemically reacting incompressible viscous binary fluid mixture about a vertical stationary flat plate embedded in a saturated porous medium, using Darcy Boussinesq model considering the plate to be insoluble in the fluid in presence of a uniform magnetic field applied in a direction perpendicular to the plate.

Mathematical Formulation

We consider the steady two-dimensional natural convection flow of Newtonian binary fluid mixture in a porous medium bounded by an impervious vertical stationary flat plate with constant wall temperature T_w in presence of a uniform magnetic field intensity B_0 applied in a direction perpendicular to the plate. The temperature of the ambient medium is T_∞ where $T_w > T_\infty$ and C_∞ is the concentration of the binary fluid mixture far away from the plate. The x-coordinate is measured along the plate from its leading edge, and the y-coordinate normal to it.

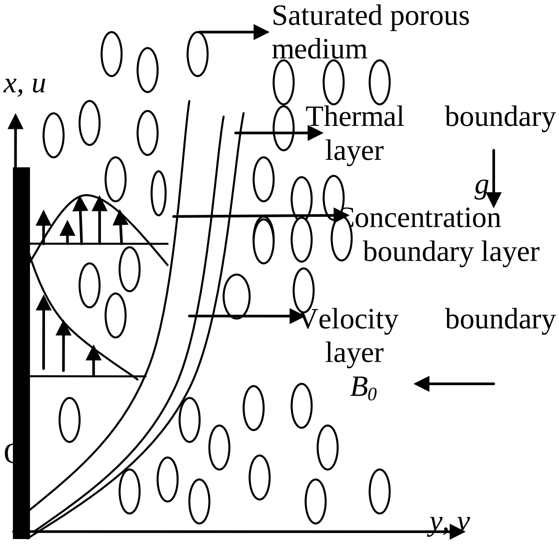

Figure 1: Physical model and coordinate system

Under the boundary layer and Boussinesq approximations, the basic boundary layer equations describing the conservation of mass, momentum, energy and concentration can be written as follows:

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}=0\,, \qquad (1)$$

$$u\left(1+\frac{k\sigma\mu_e^2 H_0^2}{\mu}\right)=\frac{gk}{\vartheta}\left[\beta_T(T-T_\infty)+\beta_c(C-C_\infty)\right], \qquad (2)$$

$$u\frac{\partial T}{\partial x}+v\frac{\partial T}{\partial y}=\alpha_m\frac{\partial^2 T}{\partial y^2}+\frac{D_m k_T}{C_s C_p}\frac{\partial^2 C}{\partial y^2}\,, \qquad (3)$$

$$u\frac{\partial C}{\partial x}+v\frac{\partial C}{\partial y}=D_m\frac{\partial^2 C}{\partial y^2}+\frac{D_m k_T}{T_m}\frac{\partial^2 T}{\partial y^2}-K(C-C_\infty) \qquad (4)$$

where u and v are fluid velocity components along the x and y–axes, ϑ is the kinematic viscosity, g is acceleration due to gravity, ρ is the density, β_T and β_c are the coefficients of thermal expansion and concentration expansion, k is the Darcy permeability, α_m is the thermal diffusivity, D_m is the mass diffusivity, T_m is the mean fluid temperature, k_T is the thermal diffusion ratio and C_s is the concentration susceptibility, K is the dimensional chemical reaction rate parameter, C is the concentration of the rarer and lighter component of the binary fluid mixture and T denotes the temperature of the binary fluid mixture.

The boundary conditions are

$$\left.\begin{array}{l} u=0,\ T=T_w,\ \dfrac{\partial C}{\partial y}+\dfrac{k_T}{T_m}\dfrac{\partial T}{\partial y}=0 \ \text{ at } y=0 \\ T\to T_\infty,\ C\to C_\infty \quad \text{as } y\to\infty \end{array}\right\} \qquad (5)$$

We now introduce the following dimensionless variables:

$$\left.\begin{array}{l} \eta=\left(\dfrac{y}{x}\right)Ra_x^{\frac{1}{2}},\ \psi=\alpha_m Ra_x^{\frac{1}{2}}f(\eta), \\ \theta=\dfrac{T-T_\infty}{T_w-T_\infty}\,,\ \ \phi=(C-C_\infty)/C_\infty, \end{array}\right\} \qquad (6)$$

where ψ is the stream function that satisfies the continuity equation (1) and is defined as $u=\frac{\partial\psi}{\partial y}$,$v=-\frac{\partial\psi}{\partial x}$ and $Ra_x=gk\beta_T(T_w-T_\infty)x/(\nu\alpha_m)$ is the local Rayleigh number.

Introducing the relation (6) into the Equations (2) to (4) we obtain the following governing equations:

$$(1+M^2)\,f'=\theta+N\phi, \qquad (7)$$

$$\theta''+\frac{1}{2}f\theta'+D_f\phi''=0, \qquad (8)$$

$$\phi''+\left(\frac{Le}{2}\right)f\phi'+LeSr\theta''-Le\gamma\phi=0 \qquad (9)$$

where M, Le, D_f, Sr, N and γ are Hartmann, Lewis, Dufour, Soret numbers, buoyancy parameter and dimensionless chemical reaction rate parameter respectively and are defined as

$$M = \sqrt{\left\{\frac{k\sigma\mu_{\varepsilon}^{2}\, H_0^2}{\mu}\right\}},\ Le = \frac{\alpha_m}{D_m},\ D_f = \frac{D_m k_T C_\infty}{C_s c_p \alpha_m (T_w - T_\infty)},\ Sr = \frac{D_m k_T (T_w - T_\infty)}{T_m \alpha_m C_\infty},\ N = \frac{\beta_c\, C_\infty}{\beta_{T(T_w - T_\infty)}} \text{ and } \gamma = \frac{Kx^2}{\alpha_m Ra_x}$$

The boundary conditions are now transformed into

$$f' = 0,\ \theta = 1,\ \phi' + Le\, Sr\theta' = 0, \text{ at } \eta = 0 \qquad (10)$$

and

$$\theta \to 0, \phi \to 0 \ \text{ at } \eta \to \infty. \qquad (11)$$

Equations (7) to (9) are non-linear coupled ordinary differential equations and so their solution in closed form is not possible. Hence the set of equations (7) to (9) under the boundary conditions (10) and (11) have been solved numerically by using bvp4c.

Result and Discussion

Numerical calculations have been carried out for various values of the parameters D_f and Sr. Two cases are considered

Case I: N=1, M =1, D_f =0.2, Sr = (0.2, 0.6, 0.9), γ = 0.5 and Le =1.

Case II: N = 1, M =1, D_f = (0.1, 1, 3), Sr = 0.2, γ = 0.5 and Le = 1.

The numerical results for concentration profiles are displayed in figures 2 to 3.

It has been noticed from the figures 2 to 3 that concentration of the rarer and lighter component of the binary fluid mixture is less near the plate than its value at the edge of the boundary layer. Concentration of the rarer and lighter component increases sharply, attains its maximum value at about $\eta = 2$ and then decreases slowly to reach a fix value at the end of the boundary layer. Figures 2 to 3 reveal that concentration of the rarer and lighter component of the binary fluid mixture decreases near the plate due to increase in the values of the parameters Sr and D_f but reverse effect is observed away from the plate.

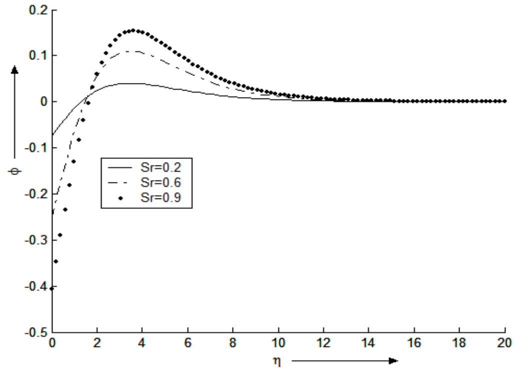

Figure 2: Concentration profiles for various values of Sr

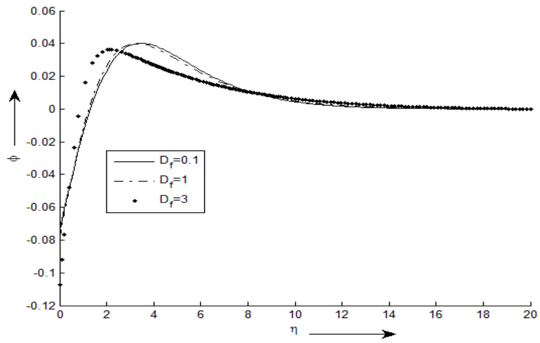

Figure 3: Concentration profiles for various values of D_f

Conclusion

From the above discussions we conclude that the effects of Soret and Dufour are to enhance the process of separation by throwing away the rarer and lighter component of the binary fluid mixture away from the plate and collecting the heavier and more abundant component near it.

Thus, conclusion derived in this paper suggests that gas separating instruments can be installed in big cities where harmful gases are present in very small quantities that can be sucked after separating them and as such pollution can be controlled.

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GEOCHEMICAL ANALYSIS OF THE PALAEOGENE DISANG – BARAIL TRANSITIONAL SEDIMENTS IN PARTS OF KOHIMA SYNCLINORIUM, KOHIMA DISTRICT, NAGALAND

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Abstract: To ascertain the provenance and depositional environment and also the rock nomenclature of the Palaeogene Disang – Barail Transitional Sediments (DBTS) the study was undertaken along the tip of the Kohima Synclinorium, south of Kohima town. Twenty samples from the area have been analyzed quantitatively and semi quantitatively for major and trace elements. Based on the observations it may be inferred that the sediments in the study area are Quartzose sandstones to litharenites and greywackes. Ratios of significant major oxides suggest acidic and basic materials of granite and granodioritic source. Sediments exhibit chemical maturity and were deposited in semi humid to humid climatic condition and were deposited in a eugeosynclinal and marine environment of deposition.

Keywords: Disang-Barail Transitional Sediments (DBTS), Kohima Synclinorium, Tectonic provenance, Palaeoenvironment, Major and Trace elements.

Study area

The study area (Fig.1) forms a part of the Kohima Synclinorium (Fig.2) lying at a distance of 4kms south of Kohima (Lat.25^0 40 N; Long.94^o 08E), a district headquarter and the capital town of Nagaland state bordering Manipur . It is bounded by Latitudes 25^0 32 N – 25^0 36 N, and Longitudes 94^0 05 E – 94^0 10 E of the topographic sheet no. 83 K/2 of Survey of India and covers nearly 100 sq.kms including Phesama, Kigwema, Jakhama, Viswema and Khuzama villages. The National Highway No.39 passes almost through middle of the study area connecting Dimapur (Lat. 25^0 51 N; Long 93^0 48' E), the nearest railhead and airport located to the north west of Kohima at a distance of 74 kms.

Geological framework

Geologically, the Northeast India represents northern part of an orogenic province, termed Assam-Arakan. Two orogenic belts warp around its northeastern corner marking the zone of plate convergence. The Himalayan belt on the north marks the India-Asia plate collision zone and the Assam-Arakan belt (IBR) on the southeast marks the collision front of the Indian plate with the amalgamated Indo-Sinian and Malayasian plates (Acharyya, 1991; Biswas et al. 1993). A north-south convergence of India and Asia has resulted in a straight collision while northwest-southeast convergence of the Indo-Sinian plate culminated into an oblique collision (Deweye et al., 1989; Burchfiel, 1993; Uddin and Lundburg, 1998 a &b, Naik, 1998). In the Assam-Arakan region, suturing extended progressively southwestward like a zipper as the two continental plates converged obliquely with a pole in the Naga Hills region (Biswas and Agarwal, 1990. Three distinct facies - deep-sea flysch, shallow marine shelf and continental sediments (molasse) have been recognised by earlier workers. Marine shelf facies and continental facies together characterise the Assam region where as deep-sea facies dominate the Naga Hills.

Methodology

The geochemical composition of the terrigenous sedimentary rocks is a function of the interaction of variables such as provenance, weathering, transportation and diagenesis. The relationship among the framework grains of sandstones, provenance type and tectonic settings of sedimentary basins is shown by Crook (1974), Schwab (1975) and Dickinson and Suczek (1979). The chemical composition of sedimentary rocks, therefore provides an insight into their evolution and the geochemical processes involved (Pettijohn,1975; Mclennan and Taylor,1991). Excellent chemical indicators for petrographic composition of sandstones are TiO_2, Al_2O_3, Fe_2O_3, Na_2O and K_2O (Kukal, 1968). Geochemical studies are particularly important in dealing with altered clastic sedimentaries and are found useful in discriminating sediment composition into broadly defined tectonic or sedimentary environments (Argast and Donnelly, 1987). The bulk chemical composition also throws light on palaeoclimate and gives an idea of the chemical maturity of the rocks (Potter, 1978 b; Suttner and Dutta, 1986). Several factors including pressure and temperature, the physical and chemical properties control the presence of trace elements in sandstones (Taylor, 1965), The presence of certain trace elements in sedimentary rocks is indicative of the mode of formation and environment of deposition of the sediment (Majumder et al., 1980).

To ascertain the provenance and depositional conditions, and also the rock nomenclature, twenty samples of the Disang - Barail transitional sandstones were quantitatively analysed for the major oxides and fifteen samples were semi-quantitatively analysed for trace elements.

Results and discussion

Analysis of the twenty samples for major oxide include SiO_2, Al_2O_3, Fe_2O_3, TiO_2, MnO, CaO, MgO, Na_2O and K_2O (Table.1). They range from 86.10 to 73.46 %, 10.28 to 5.71 %, 6.78 to 1.77 % , 1.20 to 0.20 % , traces to 0.09 % , 0 to 3.36 % , 1.96 to 0.03 % , 1.34 to 0.50 % and 1.80 to 0.25 % respectively. The average percentages are 80.13, 8.25, 3.98, 0.70, 0.03, 1.07, 0.89, 0.86 and 2.97 % respectively. Values of Si, Al and FeT (Total Iron) calculated from their oxides are shown in table .2.

The ratios of some significant major oxides are shown in table.3. The TiO_2 / Al_2O_3 ratios range from 0.02 to 0.20 and average 0.08. The ratios suggest acidic and basic materials besides humid climatic conditions at the time of deposition of the sediments (Spears and Stiriov, 1976). K_2O / Na_2O ratios range between 0.47 to 9.62 with more than 60 % of the samples showing a ratio less than 1 which points to an eugeosynclinal environment of deposition (Middleton, 1960).

The values of (SiO_2 + TiO_2), Al_2O_3 and remaining oxides, excluding MnO are recalculated to 100 percent (Table. 4) and used as end members in a ternary diagram (Fig .3) following Kukal (1968) for rock nomenclature. Plots suggest that sandstones be catagorised as quartzose sandstone. Na_2O percentages are plotted against those of K_2O in a binary diagram (Fig.4) following Pettijohn (1984) and plots indicate that the sandstones are of greywacke catagory. Following Herron (1988), log values of Fe_2O_3 / K_2O ratios are plotted against those of SiO_2 / Al_2O_3 (Table.3, Fig. 5) in a binary diagram. According to this scheme, the sandstones may be termed as litharenites and greywackes.

The percentages of CaO, Na_2O and K_2O and Fe_2O_3, MgO and TiO_2 (Table. 4) are recalculated to 100 percent and plotted in ternary diagrams (Fig.6 and 7) following Condie (1967). The diagrams suggest a granite-granodioritic source for the sediments. SiO_2 percentages are plotted against those of Al_2O_3 , K_2O and Na_2O combined (Fig. 8) in a binary diagram following Suttner and Dutta (1986) which indicate prevalence of semi-humid climate at the time of deposition of the Disang - Barail transitional sediments.

The values of (Fe_2O_3 + MgO) Na_2O and K_2O (Table.4) recalculated to 100 percent and plotted in a ternary diagram (Fig. 9) following Blatt et al., (1980), indicate an eugeosynclinal environment of deposition . The higher Al_2O_3 / Na_2O values (> 6) indicate chemical maturity. The positive co-relation between Na / Al and K / Al (Fig.10) ratios implies that there is no separation of the sediments into mica rich or feldspar rich fractions. Such absence of feldspars in the sediments is reflected , in general, by higher Na / Al ratio than K / Al ratio and no co-relation between Na_2O and SiO_2 (Fig. 11). Lower values of Na / Al and Na / K ratios (Pettijohn, 1957; Crook, 1974 and Sayeed, 1993) indicate mineralogical maturity . The lack of co-relation between Fe_2O_3 and Al_2O_3 (Fig 12) and between MgO and Al_2O_3 (Fig.13) indicate that the sediments do not contain clays in significant amounts. The plot of Al_2O_3 versus SiO_2 (Fig. 14) do not show any definite trend indicating that the quartz to feldspar ratios are highly variable and also the fine grain matrix may have contained somewhat more illite content . Poor co-relation between K_2O and Al_2O_3 (Fig. 15) indicates that the K_2O / Al_2O_3 ratio has been disturbed by the alteration of the feldspars and thus a linear trend is not seen.

The trace elements analysed are Pb, Sn, Cr, W, Ge, Ir, Bi, Ti, Mo, V, Nb, Ta, Zr, La, Y, Yb, Mn, Se, Be, Ba, Sr, Ga, B and Rb (Table. 5) in parts per million averaging < 10, < 10, 52.06, < 100, < 10, <10, < 20, <1000, < 10, 13.66, < 30, < 500, < 30, < 50, < 30, < 5, < 10, >30, < 5, 182.00, <50, < 10 and <10 respectively.
Following Degens et al., (1957), ppm B, Rb and Ga recalculated to 100 percent are plotted in a ternary diagram (Table.5. Fig.16) which indicates a marine environment of deposition for the Disang - Barail transitional sediments. Simillar results are also obtained when ppm B is plotted against ppm Rb and ppm Ga (Fig.17 and 18) in a binary diagrams after Degens et al., op.cit.

Conclusion

Based on the above results and observations it may be inferred that the sediments in the study area derived their detritus largely from a recycled orogen comprising all the three kinds of source terranes viz. subduction complex provenance, collision orogenic provenance and arc orogenic provenance which are made up of acidic and basic materials formed in humid climatic condition

The Palaeogene Disang-Barail transitional sequences of the study area vary from quartzose sandstone to lithic arenite and greywackes. The study reveals chemical and mineralogical maturity of the sediments. The sediments were deposited in an eugeosynclinal depositional environment under marine condition.

Table 1(a): Major Oxide Composition (percentage) of the Palaeogene Disang-Barail Transitional sediments.

S.No	SiO_2	AL_2O_3	Fe_2O_3	TiO_2	MnO	CaO	MgO	Na_2O	K_2O	L.O.I
L1	75.66	8.40	4.97	0.99	0.08	0.97	1.38	0.63	0.52	6.39
L2	74.12	9.58	6.78	0.30	0.09	2.80	0.09	1.34	1.50	3.18
L5	80.80	7.14	4.51	0.30	0.05	3.36	0.06	1.00	1.20	1.54
L6	83.96	8.30	2.27	1.15	Traces	0.61	1.11	0.70	0.42	1.49
L7	81.44	10.08	2.95	0.62	Traces	Nil	0.86	1.09	0.98	1.97
L18	86.10	5.71	2.97	0.20	0.04	2.24	0.05	0.67	0.90	1.11
L23	78.85	10.28	3.90	0.91	0.03	Nil	1.49	1.10	0.80	2.63
L24	80.41	6.41	4.79	1.20	0.03	Nil	1.69	0.80	0.74	3.92
L29	77.89	8.47	5.50	1.05	0.02	0.47	1.87	0.90	0.76	3.06
L30	82.58	8.50	1.77	1.24	0.04	0.61	1.22	0.98	1.32	1.74
L31	73.46	7.95	8.40	0.20	0.02	1.68	0.08	1.00	1.80	5.40
L33	78.12	6.47	5.30	1.33	0.02	0.48	1.96	0.50	0.25	5.56
L34	84.43	7.94	2.64	0.78	0.03	0.48	1.30	075	0.47	1.17
L37	81.65	9.33	3.37	0.89	0.04	0.58	1.03	0.60	0.29	2.21
L38	78.14	9.58	5.08	0.20	0.06	1.68	0.09	1.00	1.50	2.30
L39	79.55	8.71	3.51	0.98	0.09	1.80	1.59	1.00	0.56	2.00
L40	82.82	7.65	2.85	0.30	0.05	0.54	1.10	0.91	1.00	2.50
L41	76.41	9.25	3.15	1.13	0.03	1.90	0.90	0.72	0.47	5.56
L42	82.11	6.95	2.65	0.20	0.02	0.72	1.20	0.94	0.87	4.25
L43	84.26	8.42	2.28	0.20	0.02	0.60	0.38	1.21	1.01	1.60
Average	80.13	8.25	3.98	0.70	0.03	1.07	0.97	0.89	0.86	2.97

Table : 1(b): Major Oxide (in percentage) Volatile – free in the Palaeogene Disang – Barail Transitional sediments.

S.No	SiO_2	AL_2O_3	Fe_2O_3	TiO_2	MnO	CaO	MgO	Na_2O	K_2O
L1	80.83	8.97	5.30	1.05	0.08	1.03	1.47	0.67	0.55
L2	76.55	9.89	7.00	0.30	0.09	2.89	0.09	1.38	1.54
L5	82.06	7.25	4.57	0.30	0.05	3.41	0.06	1.01	1.21
L6	85.22	8.42	2.30	1.16	Traces	0.61	1.12	0.71	0.42
L7	83.07	10.28	3.00	0.63	traces	Nil	0.87	1.11	1.02
L18	87.06	5.77	3.00	0.20	0.04	2.26	0.05	0.67	0.91
L23	80.97	10.55	4.00	0.93	0.03	Nil	1.53	1.12	0.82
L24	83.69	6.67	4.98	1.24	0.03	Nil	1.75	0.83	0.77
L29	80.34	8.73	5.67	1.08	0.02	0.48	1.92	0.92	0.78
L30	84.04	8.65	1.80	1.26	0.04	0.62	1.24	0.99	1.34
L31	77.65	8.40	8.87	0.20	0.02	1.77	0.08	1.01	1.90
L33	82.71	6.85	5.61	1.40	0.02	0.50	2.07	0.52	0.26
L34	85.42	8.03	2.67	0.78	0.03	0.48	1.31	0.75	0.47
L37	83.49	9.54	3.44	0.91	0.04	0.59	1.05	0.61	0.29
L38	79.97	9.80	5.19	0.20	0.06	1.71	0.09	1.01	1.53
L39	81.17	8.88	3.58	1.00	0.09	1.83	1.62	1.02	0.57
L40	84.94	7.84	2.92	0.30	0.05	0.55	1.12	0.93	1.02
L41	80.90	9.79	3.33	1.19	0.03	2.00	1.01	0.76	0.49
L42	85.75	7.25	2.76	0.20	0.02	0.75	1.25	0.98	0.90
L43	85.63	8.55	2.31	0.20	0.02	0.60	0.38	1.22	1.02
Average	82.57	8.50	4.11	0.72	0.03	1.10	1.00	0.90	0.89

Table 2: Weight percentages of Si,AI and FeT (Total Iron) in the Palaeogene Disang – Barail Transitional Sediments.

Sample No.	Si	AI	FeT
L1	83.000	13.000	4.000
L2	81.889	12.475	5.636
L5	87.255	9.085	3.659
L6	88.536	10.191	1.273
L7	85.988	12.102	1.910
L18	90.575	7.080	2.345
L23	84.517	12.903	2.580
L24	88.366	8.311	3.323
L29	85.430	10.597	3.973
L30	88.387	10.323	1.290
L31	82.405	10.509	7.086
L33	87.837	8.108	4.055
L34	88.608	9.494	1.898
L37	85.988	11.464	2.548
L38	83.793	12.109	4.098
L39	86.045	11.101	2.854
L40	88.131	9.592	2.277
L41	85.204	12.156	2.640
L42	88.970	10.346	2.156
L43	87.869	10.346	1.785
Average	86.439	10.491	3.069

Table 3: Ratios and Log values of some ratios of the oxides in the Palaeogene Disang – Barail Transitional sediments.

S. No.	SiO_2 / Al_2O_3	TiO_2 / Al_2O_3	Fe_2O_3 / K_2O	K_2O / Na_2O	Log (Fe_2O_3 / K_2O)	Log (SiO_2 / Al_2O_3)
L1	9.01	0.11	9.63	0.82	0.98	0.95
L2	7.74	0.03	4.54	1.11	0.65	0.88
L5	11.31	0.04	3.77	1.19	0.57	1.05
L6	10.12	0.13	5.47	0.59	0.74	1.00
L7	8.08	0.06	2.94	0.91	0.47	1.00
L18	15.08	0.03	3.29	1.35	0.51	1.17
L23	7.67	0.08	4.87	0.73	0.68	0.88
L24	12.54	0.18	6.46	0.92	0.81	1.09
L29	9.20	0.12	7.26	0.86	0.85	0.96
L30	9.71	0.14	1.34	1.35	0.12	0.94
L31	9.24	0.02	4.66	1.88	0.66	0.96
L33	12.07	0.20	21.57	0.50	1.32	1.08
L34	10.63	0.09	5.68	0.62	0.75	1.02
L37	8.75	0.09	11.86	0.47	1.06	0.94
L38	8.16	0.02	3.39	1.51	0.52	0.91
L39	9.14	0.11	6.28	0.55	0.79	0.96
L40	10.83	0.03	2.86	1.09	0.39	1.03
L41	8.26	0.12	6.79	0.64	0.82	0.91
L42	11.82	0.02	3.06	0.91	0.48	1.07
L43	10.01	0.02	2.26	0.83	0.35	1.00
Average	9.96	0.08	5.89	0.93	0.67	0.98

Table : 4

Recalculated values of i) CaO, Na2O and K2O ii) Fe2O3 MgO and TiO2 iii) Fe2O3 + MgO, Na2O and K2O and iv) Al2O3 , SiO2 + TiO2 and Remain of the Palaeogene Disang – Barail Transitional sediments.

S.No.	CaO	Na_2O	K_2O	Total	Fe_2O_3	MgO	TiO_2	Total	Fe_2O_3+MgO	Na_2O	K_2O	Total	Al_2O^3	SiO_2+TiO_2	Remain	Total
L1	45.75	29.71	24.52	99.98	67.71	18.80	13.48	99.99	84.66	8.40	6.93	99.99	8.96	81.96	9.05	99.97
L2	49.64	23.75	26.59	99.98	94.14	1.25	4.18	99.57	70.75	13.80	15.44	99.99	10.26	79.76	9.96	99.98
L5	60.43	17.98	21.58	99.99	92.60	1.23	6.16	99.99	67.50	14.77	17.72	99.99	7.25	79.76	9.96	99.98
L6	35.46	40.69	23.83	99.98	50.11	24.50	25.38	99.99	75.27	8.40	9.13	99.80	8.42	86.39	5.17	99.98
L7	0.00	52.65	47.34	99.99	66.59	19.41	13.99	99.99	64.79	18.53	16.66	99.98	10.28	83.71	5.99	99.98
L18	58.79	17.58	23.62	99.99	92.23	1.55	6.21	99.99	65.79	14.59	19.60	99.98	5.71	86.43	7.84	99.98
L23	0.00	57.89	42.10	99.99	61.90	23.65	14.44	99.99	73.93	15.08	10.97	99.98	10.56	81.94	7.48	99.98
L24	0.00	51.94	48.05	99.99	62.36	22.00	15.62	99.98	80.79	9.97	9.22	99.98	6.67	84.97	8.35	99.99
L29	22.06	42.25	35.68	99.99	65.32	22.20	12.47	99.99	81.61	9.96	8.41	99.98	8.74	81.45	9.80	99.99
L30	20.96	33.67	45.36	99.99	41.84	28.84	29.31	99.99	56.52	18.52	24.95	99.99	8.87	86.87	4.31	100.05
L33	39.02	40.65	20.32	99.99	61.09	22.81	15.48	99.38	90.63	6.24	3.12	99.98	6.85	84.15	8.71	99.71
L34	28.23	44.11	27.64	99.98	55.93	27.54	16.52	99.99	76.35	14.53	9.10	99.99	8.02	86.09	5.88	99.99
L37	39.45	40.81	19.72	99.98	63.70	19.47	16.82	99.99	83.17	11.34	5.48	99.98	9.54	84.44	6.00	99.98
L38	40.19	23.92	35.88	99.99	94.59	1.67	3.72	99.98	67.40	13.03	19.55	99.99	9.84	80.53	9.61	99.98
L39	53.57	29.76	16.66	99.99	57.73	26.15	16.11	99.99	76.57	15.01	8.40	99.98	8.91	82.42	8.65	99.98
L40	22.04	37.11	40.81	9.96	67.05	25.88	7.05	99.98	67.40	15.52	17.06	99.98	7.87	85.54	6.58	99.99
L41	61.48	23.30	15.21	99.99	60.11	18.32	21.56	99.99	77.57	13.58	8.86	100.01	9.84	82.49	7.66	99.99
L42	28.45	37.15	34.38	99.98	65.43	29.62	4.93	99.98	68.04	16.60	15.37	100.01	7.26	86.06	6.67	99.99
L43	21.27	42.90	35.81	99.98	79.72	13.28	6.99	99.99	54.50	24.79	20.69	99.98	8.56	85.86	5.57	99.99
Average	33.21	35.51	31.26	99.99	69.84	17.45	12.63	99.99	72.91	13.93	13.13	99.99	8.53	83.56	7.86	99.99

Table : 5

Trace Element in ppm in the Palaeogence Disang – Barial Transitional sediments.

Sample No.	Pb	Sn	Cr	W	Ge	Ir	Bi	Ti	Mo	V	Nb	Ta	Zr	La	Y	Yb	Mn	Sc	Be	Ba	Sr	Ga	B	Rb
L1	<10	<10	<10	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	<50	<50	<10	9	<20
L2	<10	<10	<10	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	<25	<50	<10	34	<20
L6	<10	<10	<10	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	80	<50	<10	23	<20
L8	<10	<10	<10	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	250	<50	<10	57	<20
L18	<10	<10	<10	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	25	<50	<10	16	<20
L19	<10	<10	<10	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	150	<50	<10	9	<20
L24	<10	<10	80	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	500	<50	<10	62	<20
L25	<10	<10	80	<100	<10	<10	<20	<1000	<10	20	<30	<500	<30	<50	<30	<5	<10	<30	<5	500	<50	<10	25	<20
L26	<10	<10	50	<100	<10	<10	<20	<1000	<10	25	<30	<500	<30	<50	<30	<5	<10	<30	<5	350	<50	<10	72	<20
L27	<10	<10	25	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	25	<50	<10	80	<20
L29	<10	<10	10	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	25	<50	<10	324	<20
L30	<10	<10	100	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	50	<50	<10	102	<20
L31	<10	<10	100	<100	<10	<10	<20	<1000	<10	20	<30	<500	<30	<50	<30	<5	<10	<30	<5	250	<50	<10	52	<20
L36	<10	<10	150	<100	<10	<10	<20	<1000	<10	30	<30	<500	<30	<50	<30	<5	<10	<30	<5	250	<50	<10	9	<20
L38	<10	<10	120	<100	<10	<10	<20	<1000	<10	<10	<30	<500	<30	<50	<30	<5	<10	<30	<5	200	<50	<10	24	<20
Average:	<10	<10	52.06	<100	<10	<10	<20	<1000	<10	13.66	<30	<500	<30	<50	<30	<5	<10	<30	<5	182	<50	<10	9	<20

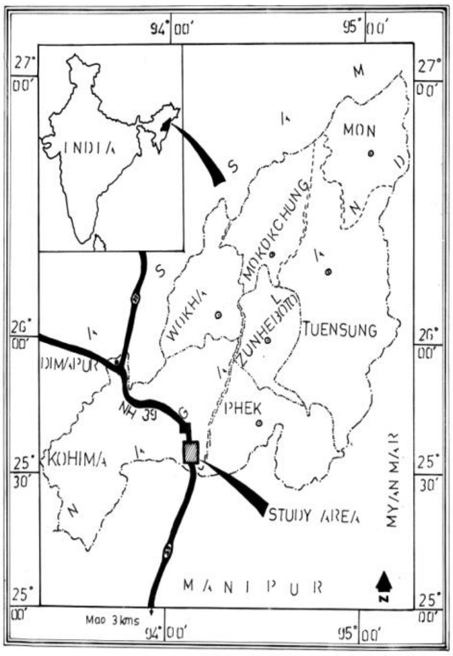

FIG: 1 LOCATION OF THE STUDY AREA.

GEOLOGICAL MAP OF PART OF NAGA-LUSHAI-PATKAI HILL RANGES AND ADJOINING AREAS.

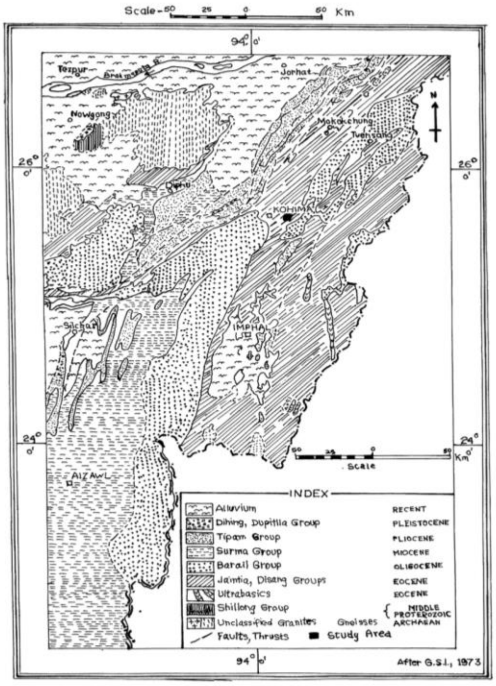

FIG: 2

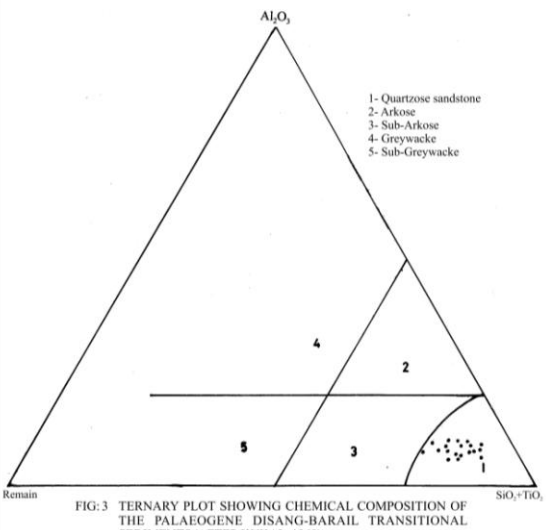

FIG: 3 TERNARY PLOT SHOWING CHEMICAL COMPOSITION OF THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS (AFTER KUKAL, 1968).

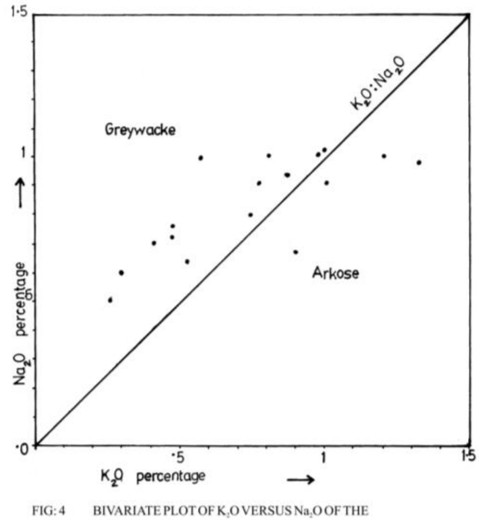

FIG: 4 BIVARIATE PLOT OF K_2O VERSUS Na_2O OF THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS (AFTER PETTIJOHN, 1984).

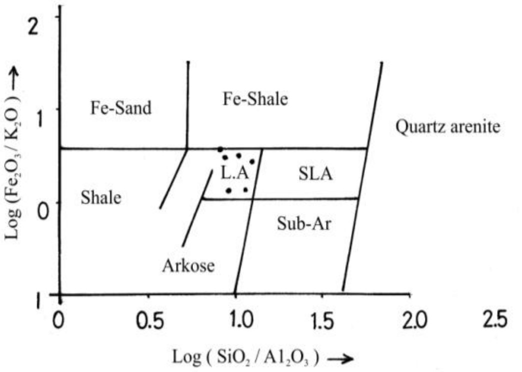

FIG: 5 GEOCHEMICAL CLASSIFICATION OF THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS (AFTER HERRON, 1988).

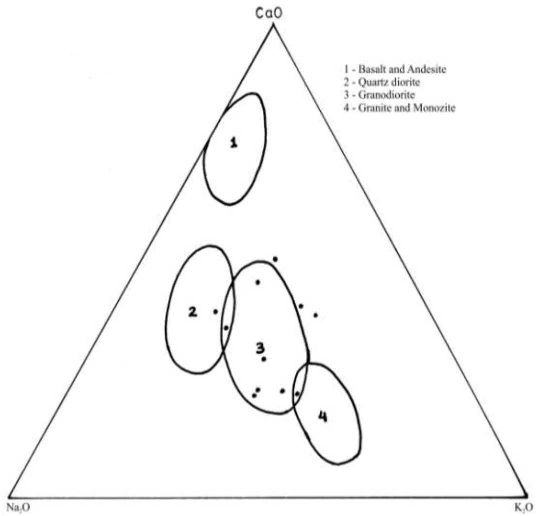

FIG: 6 CHEMICAL COMPOSITION OF THE PALAEOGNE DISANG-BARAIL TRANSITIONAL SEDIMENTS IN RELATION TO PROVENANCE (AFTER CONDIE, 1967).

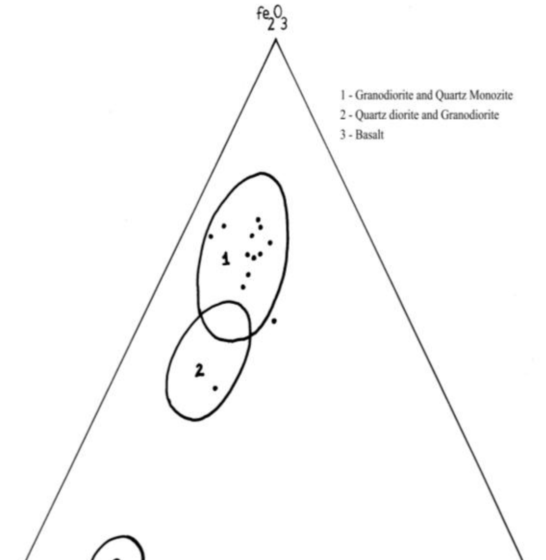

FIG: 7 CHEMICAL COMPOSITION OF THE PALAEIOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS IN RELATION TO PROVENANCE (AFTER CONDIE, 1967).

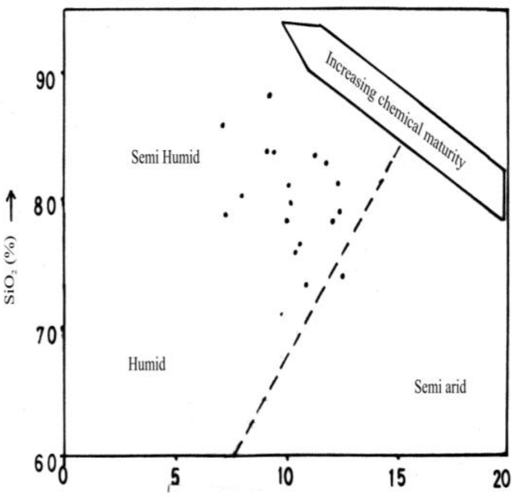

FIG: 8 BIVARIATE PLOT BETWEEN SiO_2 AND TOTAL Al_2O_3 , Na_2O AND K_2O PERCENTAGES OF THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS (AFTER SUTTNER AND DUTTA, 1986).

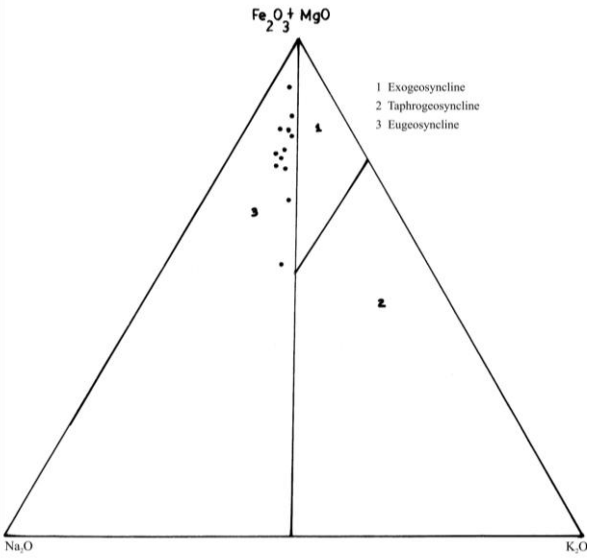

FIG: 9 CHEMICAL COMPOSITION OF THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS IN RELATION TO TECTONIC SETTING (AFTER BLATT ET AL., 1980).

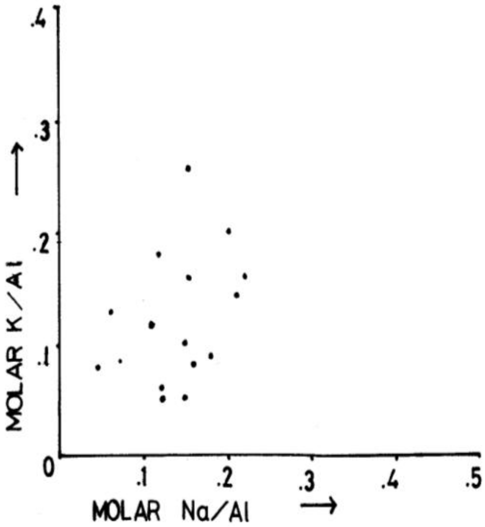

FIG: 10 MOLAR Na/AL VERSUS MOLAR K/ AL IN THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS.

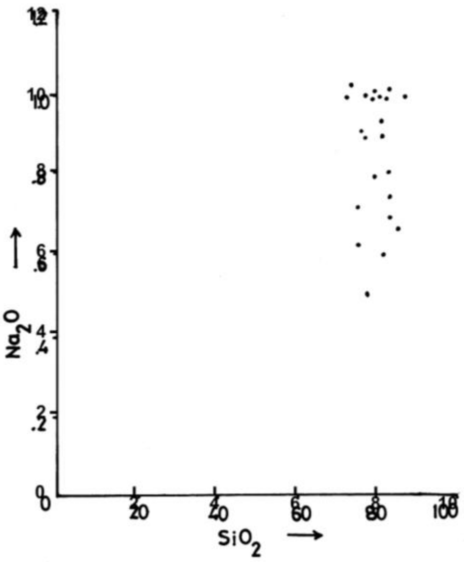

FIG: 11 SiO_2 VERSUS Na_2O IN THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS.

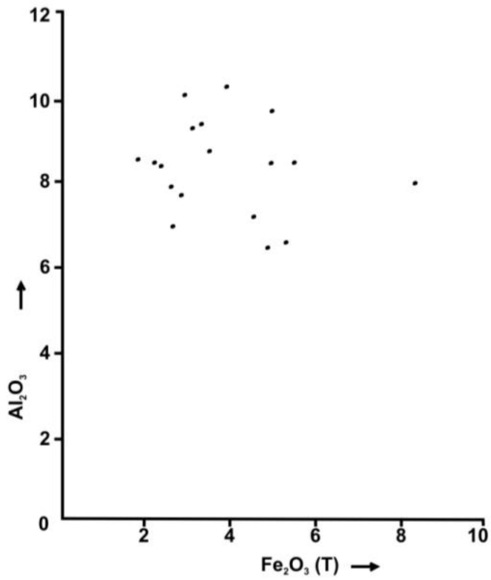

FIG: 12 Fe_2O_3 VERSUS Al_2O_3 IN THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS.

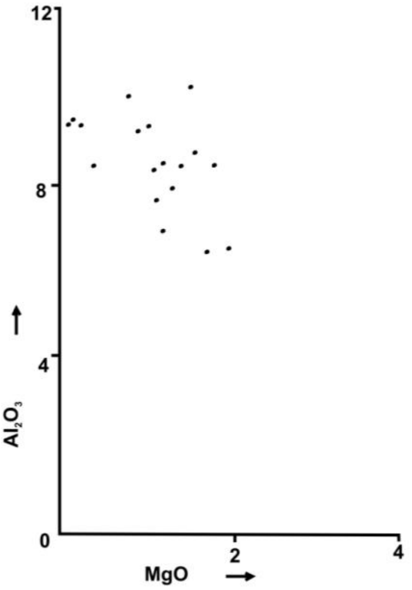

FIG: 13 MgO VERSUS AI_2O_3 IN THE PALAEOGENE DISANG- BARAIL TRANSITIONAL SEDIMENTS.

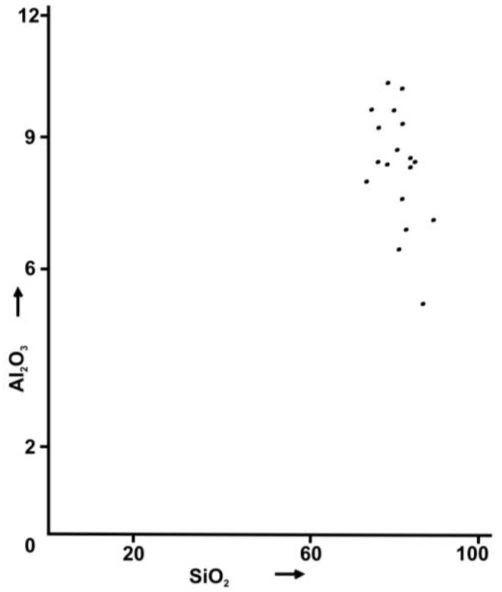

FIG: 14 SiO_2 VERSUS AI_2O_3 IN THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS

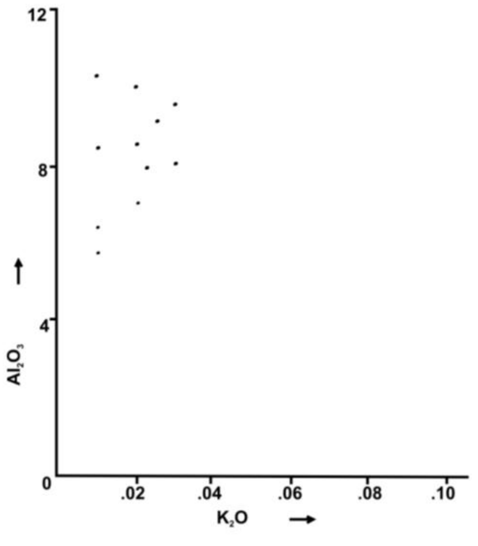

FIG: 15 K_2O VERSUS AI_2O_3 FOR THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS.

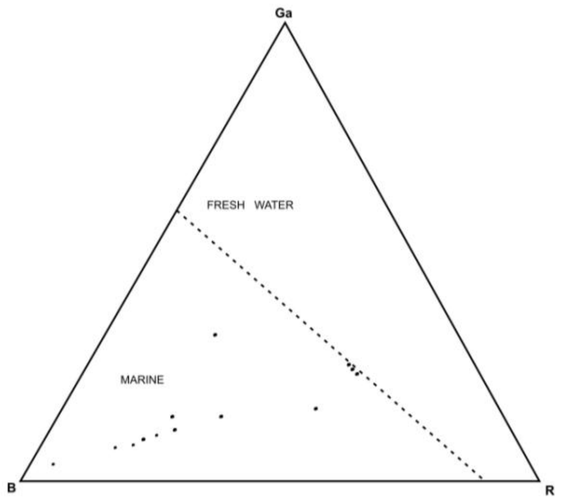

FIG: 16 RELATIONSHIP AMONG Ga , Rb AND B IN THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS (AFTER DEGENS et al., 1957).

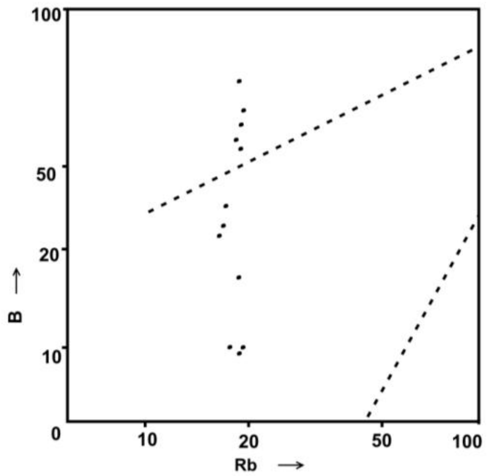

FIG: 17 RELATIONSHIP BETWEEN B AND Rb (ppm) IN THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS (AFTER DEGEN et al., 1957).

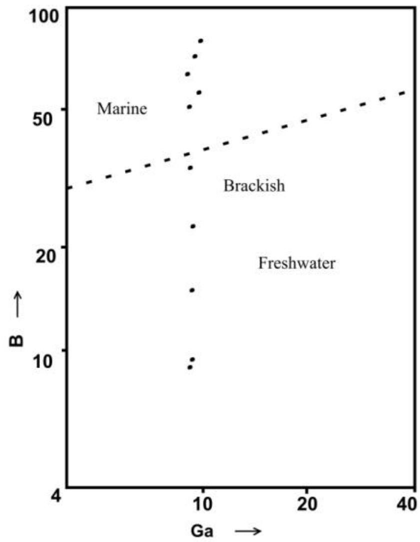

FIG: 18 RELATIONSHIP BETWEEN B AND Ga (ppm) IN THE PALAEOGENE DISANG-BARAIL TRANSITIONAL SEDIMENTS (AFTER DEGEN et al., 1057).

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A NOTE ON BOTANICAL TRIP TO FAKIM WILD LIFE SANCTUARY, NAGALAND, INDIA

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Abstract: This paper gives a brief account on plants from Fakim Wildlife Sanctuary in Nagaland, India collected during a botanical trip. The plant specimens collected gives an account of 103 taxa belonging to 48 angiosperm families, which includes a few taxa of rare occurrence and four new records from Nagaland state.

Key words: Fakim Wildlife Sanctuary, angiosperm families, rare occurrence, new records, Nagaland

Introduction

Fakim Wildlife Sanctuary, which is famous for the habitat of a rare and endangered Blyth's Tragopan (*Tragopan blythii*)- the state bird of Nagaland, falls into one of the world biodiversity hotspots "Indo-Burma", and is located in the foothills of Mt. Saramati of the Patkai Mountain Range in the eastern part of Kiphire district of Nagaland bordering Myanmar.

Geographically, it lies between 25° 48' to 25° 49' North latitudes and 94° 00' to 95° 58' East longitudes. The altitude ranges from 1715 to 2737 metres. The forest was declared as 'Fakim Wildlife Sanctuary' in the year 1986 and it covers an area of 641 hectares. It is bounded by Mt. Saramati in the east, Fakim village on the west, Wongtsuvong village on the north and Thanamir village on the South.

The wildlife sanctuary is situated in Fakim village of a Yimchunger- Naga tribe. This tribal people speak 'Gher' local dialect. The population of the village is about 550-600 comprising 65 families. Fakim literally means 'place surrounded by salt ponds' as the village is surrounded by about 50 salt ponds.

The region receives moderately high rainfall with humid and cold climate conditions. The annual rainfall varies from 200 to 300 cm. The average temperature of the area is 5°C during winter and 29°C during summer. (Rongsensashi et al., 2013)

Botanical exploration in this part of the state is poorly carried out in the past except by Hynniewta (1994) and recently by Rongsensashi (2013) for his PhD work. Due to the remoteness, poor connectivity and hilly terrain, makes the region least accessible and inhospitable for botanical exploration.

The vegetation type of Fakim Wildlife Sanctuary is subtropical pine forest with species composition like *Pinus* spp., in association with *Alnus nepalensis*, *Rhus chinensis*, *Lithocarpus* sp., *Quercus* sp. *Schima wallichii*, and temperate forest with species composition like *Alnus nepalensis*, *Engelhardtia* sp., *Magnolia* sp., *Rhododendrom macabeanum*, R. *arboreum*, *Actinodaphne obovata*, *Betula alnoides*, *Litsea* spp., *Docynia indica*, etc. Some commonly represented shrubby species are *Viburnum* sp., *Rubus* sp., *Indigofera* sp., *Desmodium* sp., *Strobilanthes* spp. *Crotalaria* spp. and some common herbaceous species covering the ground vegetation like *Anaphalis* sp., *Carex* sp., *Polygonum* sp., *Potentilla* sp., *Impatiens* sp. Etc.

Material and methods

The Botanical field trip was carried out in the first week of October, 2016 to document the floristic diversity in the Fakim Wildlife Sanctuary. The Camp guides from the Forest Department and the village local guides accompanied and assisted in providing valuable information during the exploration inside the sanctuary. The plant specimens were collected, preserved and herbarium were prepared following standard procedure (Jain & Rao, 1977) and identification of the specimens were done following the scientific method with the help of regional and national flora and available literatures.

The wildlife sanctuary is still intact with rich flora and fauna harbouring several rare, endangered and endemic species. One interesting observation is, the villagers are conscious of the importance of conservation of biodiversity which has to be encouraged. It is also learnt that several wildlife related research studies have been carried out in and around the Fakim wildlife Sanctuary. The following table presents a list of 103 taxa belonging to 48 angiosperm families including new records and rare occurrence from Nagaland state viz., *Hoya edenii* Hook. f., *Phyllanthus grifithii* Mull. Arg., *Bulbophyllum retusiusculum* Rchb.f., *Dactylicapnos torulosa* (Hook.f. & Thomson) Hutch and a few rare occurrences viz., *Holcoglossum nagaladensis* (Phukan & Odyuo) X.H. Jin, and *Pendulorchis himalaica* (Deb, Sengupta & Malick) Z.J. Liu, Ke Wei Liu & X.J. Xiao, as floristic composition of the vegetation in alphabetical order of family:

Observation

SL. NO	NAME	FAMILY
1.	*Asystasia* sp.	Acanthaceae
2.	*Justicia mollisima* (Nees) Y.F.Deng & T.F.Daniel	Acanthaceae
3.	*Strobilanthes rhombifolia* C.B. Clarke	Acanthaceae
4.	*Thunbergia coccinea* D. Don.	Acanthaceae
5.	*Actinidia callosa* Lindl.	Actinidiaceae
6.	*Sambucus javanica* Blume	Adoxaceae
7.	*Viburnum* sp.	Adoxaceae
8.	*Deeringia amaranthoides* (Lam.) Merr.	Amaranthaceae
9.	*Rhus chinensis* Mill.	Anacardiaceae
10.	*Ichnocarpus frutescens* (L.) W.T.Aiton	Apocynaceae
11.	*Panax* sp.	Araliaceae
12.	*Phoenix* sp.	Arecaceae
13.	*Hoya edenii* Hook. f.	Asclepiadaceac
14.	*Maianthemum fuscum* (Wall.) LaFrankie	Asparagaceae
15.	*Polygonatum* sp.	Asparagaceae
16.	*Prenanthes* sp.	Asteraceae
17.	*Sigesbeckia orientalis* Linnaeus	Asteraceae
18.	*Gynura cusimbua* (D.Don)S.Moore	Asteraceae
19.	*Impatiens mengtszeana* Hook.f.	Balsaminaceae

20.	*Impatiens* sp.	Balsaminaceae
21.	*Cynoglossum zeylanicum* Wall.ex Roxb.	Boraginaceae
22.	*Maharanga emodi* (Wall.) A. DC.	Boraginaceae
23.	*Campanula pallida* Wall.	Campanulaceae
24.	*Lobelia nicotianifolia* Roth ex Schult.	Campanulaceae
25.	*Lobelia montana* Reinw. ex Blume	Campanulaceae
26.	*Silene* sp.	Caryophyllaceae
27.	*Rhopalephora scaberrima* (Blume) Faden	Commelinaceae
28.	*Argyreia capitiformis* (Poir.) Ooststr.	Convolvulaceae
29.	*Porana paniculata* Roxb.	Convolvulaceae
30.	*Herpetospermum pedunculosum* (Ser.) C.B. Clarke	Cucurbitaceae
31.	*Elaeagnus pyriformis* Hook.f.	Elaeagnaceae
32.	*Aeschynomone americana* Linnaeus	Fabaceae
33.	*Apios carnea* (wall.) Benth.	Fabaceae
34.	*Astragalus chlorostachys* Lindl.	Fabaceae
35.	*Crotalaria tetragona* Andrews	Fabaceae
36.	*Cortalaria calycina* Schrank	Fabaceae
37.	*Dendrolobium triangulare* (Retz.) Schindl.	Fabaceae
38.	*Erythrina* sp.	Fabaceae
39.	*Flemingia* sp.	Fabaceae
40.	*Indigofera* sp.	Fabaceae
41.	*Bauhinia scandens* Linnaeus	Fabaceae
42.	*Parochetus communis* D. Don	Fabaceae
43.	*Pueraria peduncularis* (Benth.) Benth.	Fabaceae
44.	*Uraria* sp.	Fabaceae
45.	*Uraria* sp	Fabaceae
46.	*Lithocarpus xylocarpus* (Kurz) Markgr.	Fagaceae
47.	*Exacum tetragonum* Roxb.	Gentianaceae
48.	*Swertia nervosa* (Wall. ex G. Don) C.B. Clarke	Gentianaceae
49.	*Tripterospermum volubile* (D. Don) H. Hara	Gentianaceae
50.	*Illigera villosa* C. B. Clarke	Hernandiaceae
51.	*Illicium griffithii* Hook. f. & Thomson	Illiciaceae
52.	*Holmskioldia sanguine* Retz.	Lamiaceae
53.	*Leucas decemdentata* (Willd.) Sm.	Lamiaceae
54.	*Vitex quinata* (Lour.) F.N.Williams	Lamiaceae
55.	*Dumasia cordifolia* Baker	Leguminosae
56.	*Abelmoschus moschatus* Medik.	Malvaceae
57.	*Oxyspora vagans* (Roxb.) Wall.	Melastomataceae
58.	*Musa sikkimensis* Kurz	Musaceae
59.	*Jasminum multiflorum* (Burm.f.) Andrews	Oleaceae
60.	*Arundina graminifolia* (D.Don) Hochr.	Orchidaceae
61.	*Bulbophyllum retusiusculum* Rchb.f.	Orchidaceae
62.	*Coelogyne fimbriata* Lindl.	Orchidaceae
63.	*Cymbidium elagans* Lindl.	Orchidaceae

64.	*Cymbidium erythraeum* Lindl.	Orchidaceae
65.	*Dendrobium denudans* D.Don	Orchidaceae
66.	*Dendrobium longicornu* Lindl.	Orchidaceae
67.	*Dendrobium fuscescens* Griff.	Orchidaceae
68.	*Habenaria dentata* (Sw.) Schltr.	Orchidaceae
69.	*Holcoglossum nagalandensis* (Phukan & Odyuo) X.H. Jin	Orchidaceae
70.	*Liparis distans* C.B.Clarke	Orchidaceae
71.	*Pendulorchis himalaica* (Deb, Sengupta & Malick) Z.J. Liu, Ke Wei Liu & X.J. Xiao	Orchidaceae
72.	*Spathoglottis pubescens* Lindl.	Orchidaceae
73.	*Zeuxine affinis* (Lindl.) Benth. ex Hook. f.	Orchidaceae
74.	*Corydalis borii* C.E.C.Fisch.	Papaveraceae
75.	*Dactylicapnos scandens* (D.Don) Hutch.	Papaveraceae
76.	*Dactylicapnos torulosa* (Hook.f. & Thomson) Hutch.	Papaveraceae
77.	*Wightia speciosissima* (D.Don) Merr.	Paulowniaceae
78.	*Pittosporum* sp.	Pittosporaceae
79.	*Coix* sp.	Poaceae
80.	*Polygala arillata* Buch.-Ham. ex D. Don	Polygalaceae
81.	*Polygala longifolia* Poir.	Polygalaceae
82.	*Polygonum molle* D. Don	Polygalaceae
83.	*Polygonum* sp.	Polygonaceae
84.	*Clematis acuminata* DC.	Ranunculaceae
85.	*Clematis buchananiana* DC.	Ranunculaceae
86.	*Gouania tiliifolia* Lam.	Rhamnaceae
87.	*Rhamnus nepalensis* (Wall.) M. A. Lawson	Rhamnaceae
88.	*Docynia indica* (Wall.) Decne.	Rosaceae
89.	*Potentilla* sp.	Rosaceae
90.	*Luculia pinceana* Hook.	Rubiaceae
91.	*Neohymenopogon parasiticus* (Wall.) Bennet	Rubiaceae
92.	*Wendlandia pendula* (Wall.) DC.	Rubiaceae
93.	*Boenninghausenia albiflora* (Hook.) Rchb. ex Meisn.	Rutaceae
94.	*Toddalia asiatica* (L.) Lam	Rutaceae
95.	*Zanthoxylum* sp.	Rutaceae
96.	*Zanthoxylum scandens* Blume	Rutaceae
97.	*Alectra avensis* (Bentham) Merrill	Scrophulariaceae
98.	*Buddleja macrostachya* Benth.	Scrophulariaceae
99.	*Symplocos* sp.	Symplocaceae
100.	*Laportea bulbifera* (Siebold & Zucc.) Wedd.	Urticaceae
101.	*Hedychium greenii* W.W. Sm.	Zingiberaceae
102.	*Phyllanthus grifithii* Mull. Arg.	Phyllanthaceae
103.	*Dendrophthoe* sp.	Loranthaceae

Result and conclusion

During the present botanical trip, 103 taxa belonging to 48 angiosperm families were recorded in Fakim Wildlife Sanctuary including the taxa new record for Nagaland state and rare occurrence as well viz., *Hoya edenii* Hook. f., *Phyllanthus grifithii* Mull. Arg., *Bulbophyllum retusiusculum* Rchb.f., *Dactylicapnos torulosa* (Hook.f. & Thomson) Hutch; and taxa of rare occurrence viz., *Holcoglossum nagaladensis* (Phukan & Odyuo) X.H. Jin, and *Pendulorchis himalaica* (Deb, Sengupta & Malick) Z.J. Liu, Ke Wei Liu & X.J. Xiao.

Since the wildlife Sanctuary harbours rich plant diversity; more research studies are required to make detail observation to obtain information related to understanding the composition of forest which is very important for conservation and management of wildlife sanctuary forest. It will further provide information to encourage the need and importance of creating more similar type of wildlife sanctuary in and around the region for conservation and preservation of the rich biodiversity in the region. It will also be helpful in taking decision and formulating action plan towards the conservation and preservation of Biodiversity within the local context.

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Actinidia callosa Lindl.


Apios carnea (Wall.) Benth.


Bulbophyllum retusiusculum Rchb.f.


Boenninghausenia albiflora (Hook.) Rchb. ex Meisn.


Buddleja macrostachya Benth.


Clematis acuminata DC.


Coelogyne fimbriata Lindl.


Corydalis borii C.E.C.Fisch.


Cymbidium elagans Lindl.


Cymbidium erythraeum Lindl.


Dactylicapnos scandens (D.Don) Hutch.


Dactylicapnos torulosa (Hook.f. & Thomson) Hutch.


Dendrobium denudans D.Don


Dendrobium fuscescens Griff.


Dendrobium longicornu Lindl.


Dumasia cordifolia Baker


Elaeagnus pyriformis Hook.f.


Exacum tetragonum Roxb.


Flemingia sp.


Gynura cusimbua (D.Don) S. Moore


Habenaria dentata (Sw.) Schltr.


Hedychium greenii W.W. Sm.


Alectra avensis (Bentham) Merrill


Herpetospermum pedunculosum (Ser.) C.B. Clarke

Holcoglossum nagalandensis (Phukan & Odyuo) X.H. Jin

Ichnocarpus frutescens (L.) W.T.Aiton

Illicium griffithii Hook. f. & Thomson

Pendulorchis himalaica (Deb, Sengupta & Malick) Z.J. Liu, Ke Wei Liu & X.J. Xiao

Impatiens mengtszeana Hook.f.

Indigofera sp.

Jasminum multiflorum (Burm.f.) Andrews

Justicia mollisima (Nees) Y.F.Deng & T.F.Daniel

Laportea bulbifera (Siebold & Zucc.) Wedd.

Leucas decemdentata (Willd.) Sm.

Liparis distans C.B.Clarke

Lobelia nicotianifolia Roth ex Schult.

Zeuxine affinis (Lindl.) Benth. ex Hook. f.

Luculia pinceana Hook.

Maharanga emodi (Wall.) A. DC.

Wightia speciosissima (D.Don) Merr.

Neohymenopogon parasiticus (Wall.) Bennet

Panax sp.

Illigera villosa C. B. Clarke

Bauhinia scandens Linnaeus

Parochetus communis D. Don

Polygala longifolia Poir.

Prenanthes sp.

Rhopalephora scaberrima (Blume) Faden

Sigesbeckia orientalis Linnaeus

Silene sp.

Spathoglottis pubescens Lindl.

Strobilanthes rhombifolia C.B. Clarke

Swertia nervosa (Wall. ex G. Don) C.B. Clarke

Symplocos sp.

Thunbergia coccinea D. Don.

Toddalia asiatica (L.) Lam

Tripterospermum volubile (D. Don) H. Hara

Uraria sp.

Uraria sp.

Wendlandia pendula (Wall.) DC.

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CATCHMENT MORPHOMETRY OF CHÜRÜ (JOTSOMA)

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Abstract: The present study on Catchment Morphometry of Chürü (Jotsoma) has been conducted during the early part of 2016. Morphometry involves quantitative analysis of the earth's surface, shape and forms and is an essential component of geomorphological study. It involves the analysis of terrain characteristics of the catchment and assists the geographers to understand better the geomorphic personality of the catchment for its management. The objective of this study is to obtain geomorphic information of Chürü catchment so that the catchment is better understood for effective management to ensure perpetuation of ecological services to its inhabitants.

Keywords: Catchment, morphometry , basin, relief and profile**.**

Introduction

The main task before geomorphology is to use an ideal unit of the earth's surface for the study of its landforms. Catchment has been considered as an ideal areal unit to serve the purpose. Chürü catchment, being near to the college, has been selected for the study. Catchment also known as the drainage basin or the river basin, is defined as the area drained by stream or a system of connecting streams such that all the surface runoff originating in this area leaves the area in a concentrated flow through a single outlet.

Measurement of the shape or geometry of any natural form is termed morphometry (Strahler, 1969). In geomorphology, morphometry may be defined as the measurement and mathematical analysis of the configuration of the earth's surface and of the shape and dimension of its landforms (Clarke, 1970). Catchment Morphometry, therefore, may be considered as the measurement and analysis of the configuration of the Catchment basin.

Study Area

Chürü, a mini-catchment, lies between latitudes 25^0 30' N and 25^0 45' N and longitudes 94^0 E & 94^0 5' E in Kohima District, Nagaland. It covers an area of 3.75 sq km and the elevation ranges from less than 1300 m to 2364 m above mean sea level (msl). Chürü Catchment encompasses Kohima Science (PG) College campus on the north while on the south-east lies Pulie Badze. Chürü is a tributary of Dzüna river. The river Chürü originates near Pulie Badze peak and flows north westerly direction and later confluence with Dzüna river (Fig.1).

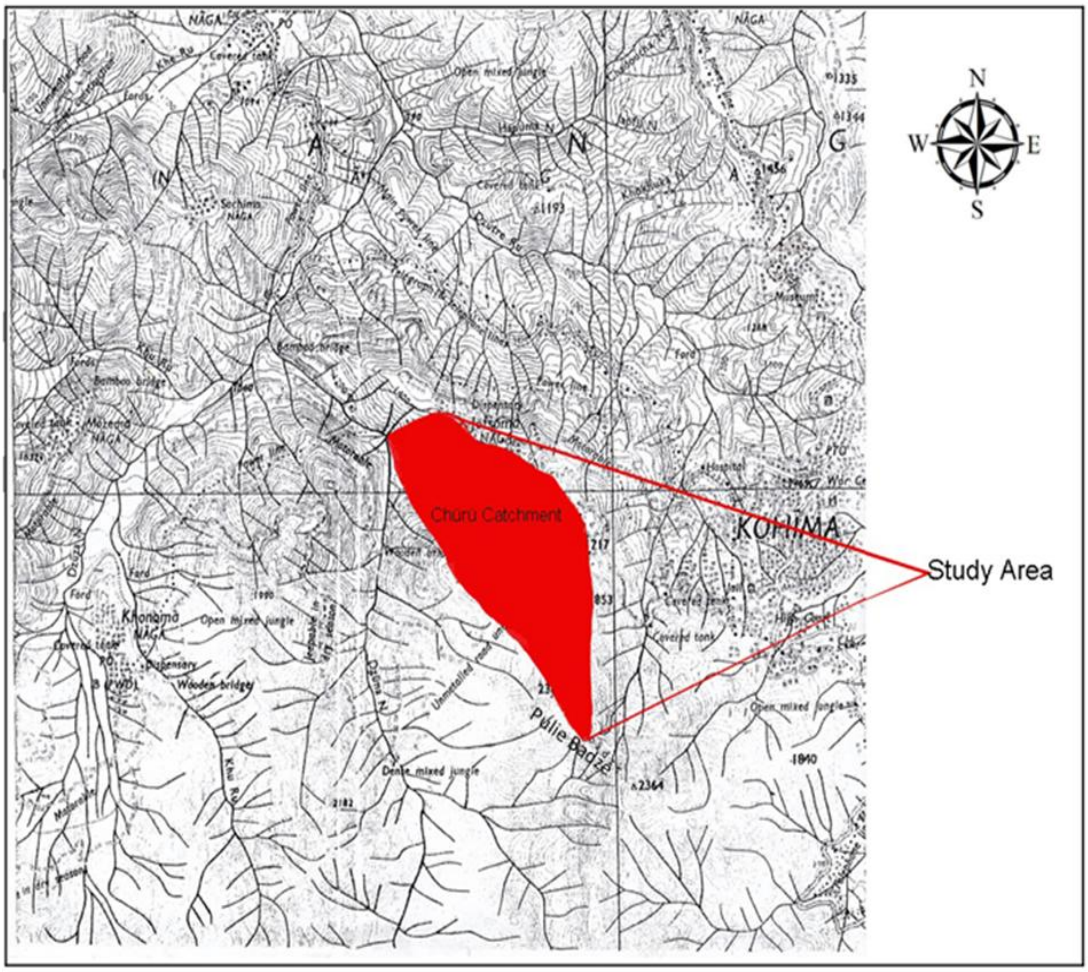

Fig. 1: Location map of Chürü catchment

Objectives

The objective of this study is to obtain geomorphic information on catchment (drainage) morphometry and relief morphometry of the Chürü catchment so that the catchment is understood and better managed by the catchment inhabitants without endangering ecological services of the catchment.

Materials and methods

Of late, drainage basin (catchment) is used widely as a geomorphic unit because of its topographic, hydraulic and hydrological unity, which laid the keystone of Horton’s morphometric system (1945) wherein he, emphasized quantitative analysis of drainage basin characteristics and erosional landforms (Singh and Srivastava, 1974). Catchment (drainage basin) is being frequently selected as an ideal areal unit for the analysis of forms and processes of a region delineated by the basin perimeter. Catchment (drainage basin), being widely used as a natural unit, is also been used here as a geomorphic unit for the study of Chürü catchment.

The entire study area has been divided into 7 grids of one sq. km each and important catchment geomorphic parameters were derived. Data collected were analysed using Quantitative (Statistical) techniques to obtain the nature of different morphometric characteristics. Channel and relief Morphometry data presented in this study were derived from topographic sheet 83k/2 by using map measurer and planimeter.

Morphometric characteristics of Chürü Catchment

Linear aspects

Linear aspects of the catchment are related to the channel patterns of the drainage network where in the topological characteristics of the stream segments in terms of open links of the network system (stream) are analyzed (Singh, 1998).

Stream ordering

It is the determination of the hierarchical position of a stream within a catchment. Strahler's scheme, popularly known as 'Stream segment method' is employed here for stream ordering. Chürü catchment is a 3rd order stream consisted of 25 first, 2 second, and 1 third order streams.

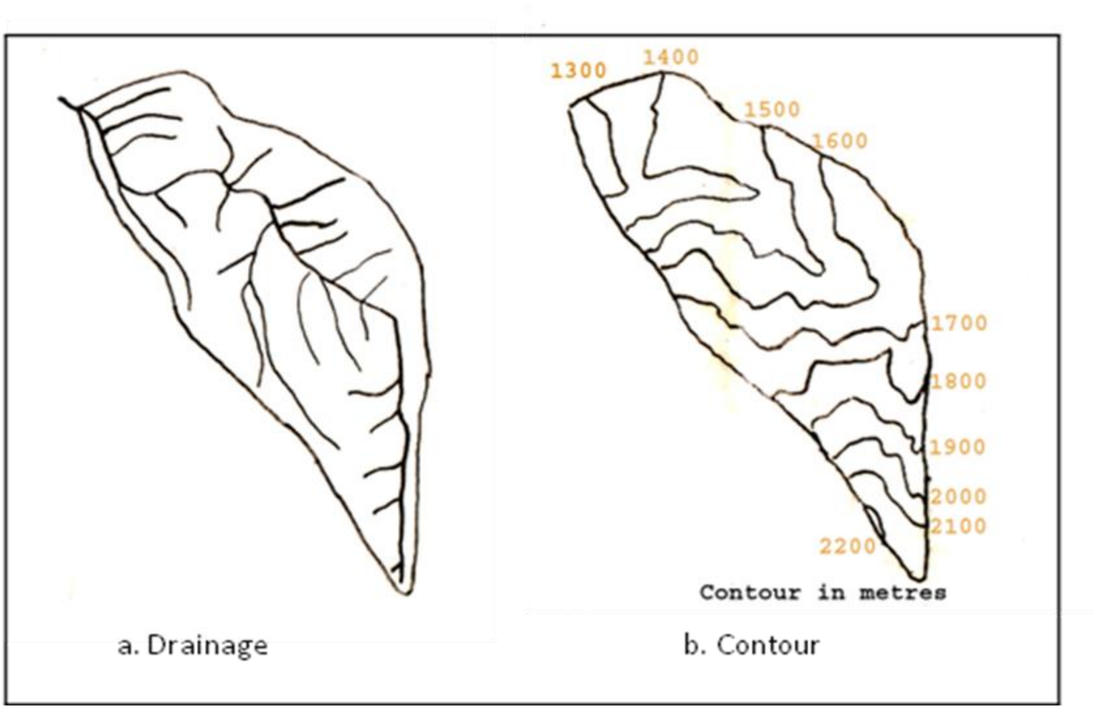

Fig 2: Drainage & Contour maps of Chürü catchment

Stream length

Stream length is measured with the help of rotatory instrument. The total stream length of Chürü catchment is 28 km.

Areal aspects

Areal aspect is related to the spatial distribution of a number of significant attributes such as drainage density, stream frequency, drainage texture, etc**.**

Basin area

The drainage basin area drained by a particular order of streams is the area of that particular order which is bounded by water divides on all sides with only one opening. These water divides separate the drainage basin area from the next higher or lower order drainage basins. The total drainage basin area of Chürü catchment is 3.75 Km^2.

Basin perimeter

Basin perimeter (catchment perimeter) is obtained by measuring the outside edge of the Catchment or drainage basin. Basin perimeter of Chürü catchment is found to be 9 km.

Basin length

Maximum length between drainage basin mouth and reach has been considered as basin length. Basin length of Chürü catchment is found to be 4 km.

Drainage density

Drainage (Catchment) density may be defined as the length of streams per unit of the catchment area which can be computed as follows; $Dd = \sum L/Ab$ (where Dd = Drainage density, $\sum L$ = the total stream length & Ab = area of the same basin).

The drainage (Catchment) density of Chürü catchment is found to be 3.8 km/sq.km (ie. in every one sq.km, about 3.8 km stream length is found).

Stream frequency

Stream Frequency is the measure of number of streams per unit area and can be computed as follows: $Sf = \sum N/Ab$ (where, Sf =Stream frequency, $\sum N$ =Total no. of basin streams & Ab=Total basin area).

Stream Frequency of Chürü Catchment is 6.05 no./sq.km (ie. in every one sq.km, there are about 6.05 number of streams)

Table 1**:** Summary of linear & areal aspects of Morphometry of Chürü catchment.

Morphometric parameters	**Symbol used**	**Chürü Catchment**
Total no. of streams	(N)	28
Total stream length (Km)	(L)	28
Catchment Area (Km^2)	Ca	3.75
Drainage Density (km/Km^2)	Dd	3.8
Stream Frequency (no/Km^2)	Sf	6.05
Basin Length (Km)	BL	4
Catchment Perimeter (Km)	Bp	9

Relief aspects

The relief aspects of the catchment relates to the study of three dimensional features. The relief aspects in this study include the description of absolute relief, relative relief, average slope and profiles of river & terrain.

Absolute Relief (AR)

It is the maximum height of a unit from the mean sea level. Chürü Catchment has been divided into 7 grids of one sq.km each with contour interval of 100 m. Absolute Relief of Chürü Catchment ranges from 1400 m to more than 2200 m above msl. It is found that the elevation of the catchment increases from north to south.

Relative Relief (RR)

Relative Relief also termed as 'amplitude of available relief 'or 'local relief 'is the difference in height between the highest and the lowest points (height) in a unit area (grid square). The Relative Relief of Chürü Catchment ranges between 100 m and 300 m. The Catchment is characterized by higher Relative Relief in the north-west and south east.

Average slope (AS)

Slopes, defined as angular inclination of terrain between hill-tops and valley bottoms, are significant morphometric attributes in the study of land forms of a drainage basin (Singh and Srivastava, 1975). The technique of Wentworth (1930), being widely used by several geomorphologists, is also been used here.

Slope angle =N x 1/636.6 for MKS (metric system)

Where N = number of contour crossing per mile or Kilometer length

I = contour interval

636.6 = constant (for metric system i.e. when the contour interval is in meter).

The values of slope angles are classified into categories and isopleths (Fig.3) is prepared for the study of spatial variation within the catchment. The catchment is having maximum area under Steep slopes of 11° to 20°. Small patch of moderate slope is found in the northern part of the catchment.

Table 2: Calculation of Average slope of Chürü catchment.

No. of contours per sq. km grid	**Average no. contours covering per sq. km**	**Tan ϴ = NxI/636.6**	**ϴ = Average angle of the slope**
4/4	1	1x100/636.6 = 0.15	8º
4/6	1.5	1.5x100/636.6 = 0.23	13º
11/4	2.75	= 0.43	23º
8/4	2	= 0.31	17º
10/4	2.5	= 0.39	21º
8/4	2	= 0.31	17º
10/4	2.5	= 0.39	21º
8/4	2	= 0.31	17º

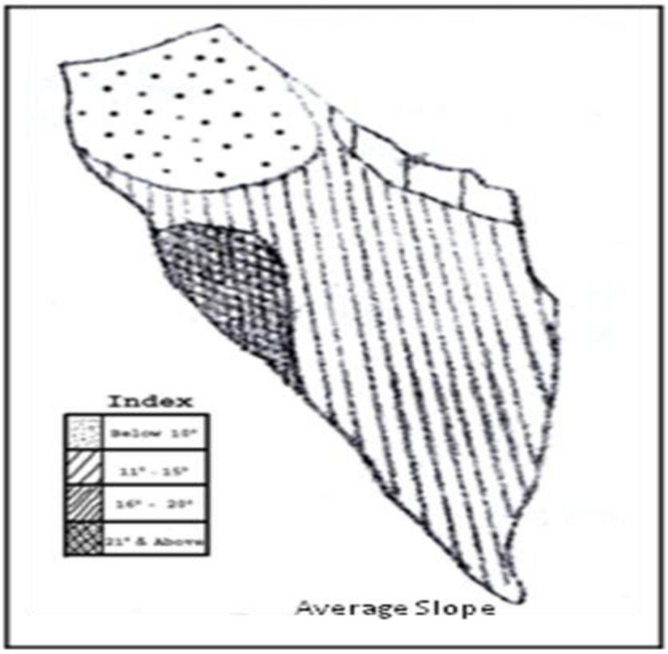

Fig.3: Average slope of Chürü catchment

Profile Analysis

Profiles provide a visual perception of the actual nature of terrain and are of great assistance to the geomorphologists. In this study, longitudinal river profile and terrain profiles (superimposed & projected) are dealt with in the analysis. Superimposed and Projected profiles were drawn out of many serial profiles combine and it may be preferred to be called MODEL PROFILE (Lohe, 2014).

Longitudinal River profile

Longitudinal River Profile gives a vivid picture of longitudinal course of the river (Fig.4**)**. The river course of Chürü catchment (ie., towards Pulie Badze peak) exhibit steep gradient which indicate active vertical cutting of river bed-a characteristic feature of juvenile stage of cycle of erosion. As we move downward along the river course, the gradient gradually decreases.

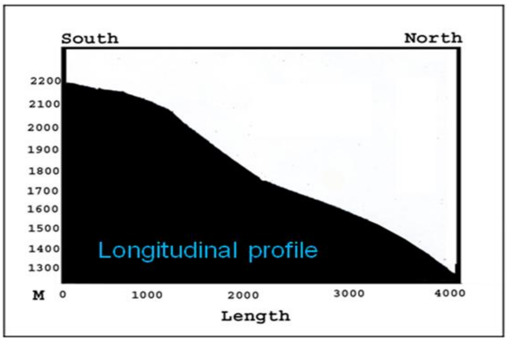

Fig.4: Longitudinal River Profile of Chürü catchment

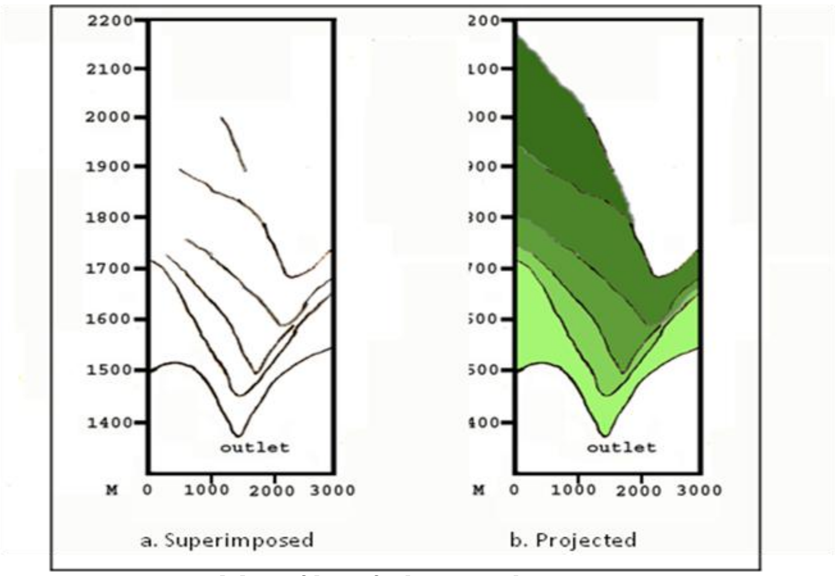

Fig.5: Model Profiles of Chürü catchment

Terrain profile

Model profiles (Superimposed & projected) have been presented in Fig.5. Profiles provide a panoramic view of the whole landscape of the catchment as if seen from above and they also present a vivid picture of the magnitude of relief and the general nature of dissection of the catchment.

The slope of the eastern limb of the catchment, as seen from the profile, is much higher and steeper than the western limb which indicates higher vulnerability of erosion compared to its counterpart western limb of the catchment.

Summary & Conclusions

Chürü catchment is a 3rd order stream consisted of 25 first, 2 second, and 1 third order streams. The total stream length of Chürü catchment is 28 km. The catchment density of Chürü is 3.8 km/sq.km while it's Stream Frequency is found to be 6.05 no./sq.km. The Absolute Relief (AR) of Chürü catchment ranges from 1400 m to more than 2200 m above msl and the elevation of the catchment increases from north to south. The Relative Relief (RR) of Chürü Catchment ranges between 100 m and 300 m. The Catchment is characterized by higher Relative Relief in the north-west and south east. The catchment is having maximum area under Steep slopes of 11° to 20° while small patch of moderate slope is found in the northern part of the catchment. The slope of the eastern limb of the catchment is found to be higher and steeper than the western limb. The river course of Chürü catchment exhibits steep gradient.

It may be concluded that Chürü catchment is characterized by a dense network of streams with high reliefs, steep slopes; active in vertical cutting and the catchment is going through juvenile stage of cycle of erosion.

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ECONOMIC ANALYSIS OF SYSTEM OF RICE INTENSIFICATION (SRI) AND TRADITIONAL PADDY FARMING METHOD IN CUDDALORE DISTRICT OF TAMIL NADU

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Abstract: The economics analysis of system of rice intensification and traditional Paddy farming have been examined and the under system of rice intensification farming has been assessed with respect to important sustainability indicators such as conservation of soil, water, power and farmers economic well-being and livelihood security. The study is based on primary data for 2014-15 collected from 60 systems of rice intensification farming and 60 traditional sample households from the Cuddalore district of Tamil Nadu. The system of rice intensification farming sample households have been found younger and more educated having larger landholdings and better resources. The system of rice intensification farming is labour intensive, but its cost of cultivation is lower due to saving on chemical fertilizers, irrigation, seeds and agrochemicals. The yield on system of rice intensification farmer has been reported lower but it is more than compensated by the price premium received and yield and profit stability observed on the system of rice intensification farming. In addition, the system of rice intensification farming has been found superior in terms of economic well-being and livelihood security of the farmer.

Keywords: Economic, Sustainability, System of Rice Intensification (SRI), Traditional, Soil, Livelihood, Paddy.

Intorduction

Rice feeds more than half of the world's population. It has been cultivated in Asia for several thousand years; recently discovered archeological rice in South Korea is reported to be 14,000 years old. Rice is now grown on about 250 million farms in 112 countries (Hossain and Fischer, 1995). About 95% of the crop is grown and consumed in Asia. Of all the cereals, rice produces the most calories per unit of land. This combined with its capacity to with stand inundation and its ability to tolerate a range of climatic and agricultural conditions, accounts for its importance.

Between 2001 and 2007 global rice prices nearly doubled, primarily because of a drawing down of stocks to fill the gap caused by stagnating yields. Fifty nine million tones of additional milled rice will be needed by 2020 about the 2007 consumption of 422 million tons (Mohanty 2009). Since there is not much scope to increase the area of rice cultivation (due to urbanization and severe water constraints) the additional production has to come from less land, less water and less human labour.

Irrigated rice is grown on about 79 million hectares, contributing 75% of the world's rice production (Maelean et al., 2002). Historically, wetland rice cultivation in Asia has been focused on lands that are flooded or are prone to flooding during the wet/monsoon season.

Rice cultivation is a very water intensive activity. To produce one kilo of rice requires 3000-5000 liters of water. It is estimated that irrigated rice receives 34-43% of the world's irrigation water (Boruman et al., 2007). It is also estimated that by 2025, 15-20 million ha of irrigated rice will suffer some degree of water scarcity (Tuong and Bouman, 2003).

Rice plays a major role in India's diet. With 44 million hectors, India has the biggest area under rice worldwide; with a production of 96.43 million tons (2007-2008) it comes second only to china in total rice production. The area under rice accounts for 34% of India food crop and 42% of its cereal crop areas. But India's current productivity is still much lower than many other rice producing countries; it needs to be increased despite the limited options for expanding the area or irrigation coverage.

In fact, rice cultivation is in crisis the world over and India is no exception, with a shrinking area, fluctuating annual production, Stagnating yields and escalating input costs. There is clearly an urgent need to find ways to grow more rice, but with less water and few inputs. An exciting approach has recently been developed the system of rice Intensification (SRI) – which not only reduces the use of irrigation water, but also increases yields significantly and enhances the livelihood of rice farmers.

The SRI methodology was developed in the early 1980's by Fr. Henri de Laulanie. He wanted to find ways to enhance the rice productivity of Madagascar farmers. He noticed that two innovative farmer practices-transplanting single seedlings and keeping the soil moist rather than continuously saturated-were more productive. He added two practices, planting single seedlings in a square pattern and using a rotary – hoe perpendicularly in two directions. With these practices, Fr.Laulinie recorded a remarkable difference in plant growth. He named this the system of Rice Intensification (Uphoff, 2005), but it took another two decades for SRI to become known to the rest of the rice world.

Timothy J. Krupnik, Carol Shennan (2012), William H. Settle and Matty Deurout tested different crop management systems for irrigated rice in three seasons of adaptive research trials in three locations in the middle sewage river valley. Their objective were to assess the agronomic and socio-economic viability of recommended Management practices (RMPs) compared to the system of rice Intensification (SRI) and Farmer's practices (FPs).

Anchal Dass, Ramanijit Kaur (2015), Anil K. Choudhary and Pooniya say that this an environment and ecology benign method efficiency of irrigated rice by changing the way of managing soil, plants , water and nutrients. A record yield of 19 tons per ha has been reported by china, while in India 50-100% increases in yield have been reported over conventional rice culture. As per general notion, SRI is not cultivar - specific. However, differential yield responses of cultivars have been observed under SRI at different locations in the country. SRI has been found to enhance the yield of hybrids, and long and medium duration cultivation under SRI. Yield enhancement with SRI was greater under constrained soil conditions like acidic soils, red lateritic soil conditions etc. Although under SRI yields were best when irrigations were scheduled at 3 days after disappearance of pounded water (DADPW), but larger water savings with same yield penalty suggests the delaying irrigation till 5 or 7 DADPW. Regarding nutrient management, it could be concluded that yield, profitability and resource - use efficiency from SRI under integrated nutrient management capsule consisting 50% RDF + 50% nutrients from organic sources were either higher or equal to those obtained from the use of 100% RDF. Weeds infestation is more in SRI, which could be managed most economically by employing integrated weed management, using cono-weeder as one of the component.

Bhattacharjee, Suchiradipta and Saravanan Raj's (2014) paper identifies the stakeholders of system of Rice Intensification (SRI) their roles and action's and the supporting and enabling environment of innovation in the state as the elements of the Agricultural Innovation systems (A/s) in SRI in Tripura state of India and shares the relationship matrix among the stakeholders. They have followed a descriptive research design was followed to study the agricultural innovation system in SRI.

Their finds were that the major stakeholders of the innovation systems were the public extension system and the farmers. A unique hole of popularization and dissemination of the agricultural technology among the farmers was played by the Panchayat Raj Institutions, the democratize decentralized administrative units at the gross-root level for the dissemination. The relationship between the farmers and the Department of Agriculture, Government of Tripura was found to be strong. The farmers, even though they were not much integrated in the system in decision-making, media, an important stakeholder for creating awareness, was found to be working independently in the state to create awareness on SRI. The enabling environment for innovation was supported to a great extent by the policies and political and administrative support structures in the state by assisting the farmers in growing rice through SRI. This paper concentrates on how the integration of state holders in the SRI innovation systems has promoted knowledge generation, management sharing and learning in SRI which can be effectively applied in other crops and sectors in India and the developing world. This paper one of the very few studies conducted to understand the state holders of SRI in the contact of Agricultural Innovation Systems in North East India.

Jharna Pathak (2010) says that it is conventional wisdom in agricultural production that to achieve productivity growth either technical innovation or more efficient use of production technologies or balances of both are required. The scenario, where new technological frontier both in genetically modified technology and production of integrated nutrition and pest management have not been adopted on wider scale, this paper is located in the larger contest of the debate above ways to approach limit of economically optimum yield of paddy with available technologies . The objective of this paper is to examine form level performance of System of Rice Intensification (SRI) method of paddy cultivation as against the traditional method. However small it is in scale of adoption in the state of Gujarat. The paper has examined the role of NGOS in raising awareness among farmers about the SRI technique as also of agricultural extension service in general. The lesions from the analyzed are expected to contribute to the ability of the government to support strategies which would go a long way in increasing returns to farmers.

Objective

1. To study the cost effectiveness of the SRI technique in relation to traditional cultural practices
2. To assess the increase in the per acre yield in the SRI method

Methodology

The study was conducted in Cuddalore district of Tamil Nadu. Two blocks namely Kammapuram and Annagramam were randomly selected, further, two villages from each block were selected. From each village 60 system of rice intensification (SRI) and 60 traditional farmers were randomly selected. The data on cost-returns aspects of paddy cultivation were collected through pre-structured questionnaires. The data collected on one agriculture year 2014-15 was subjected to statistical analysis. Input cost relates to owner farm situation in which the farmers cultivate own land and also contributes other resources. Since all the sample growers are owner cultivators, this cost concept is appropriate to calculate cost of cultivation. The two sample t-test (Snedecor and Cochrav 1989) is used to determine if two population means are equal. A common application is to test if a new process or treatment is superior to a current process or treatment.

Result and discussion

The characteristics of paddy growing farmers have been recorded in Table 1. The average size of landholding observed on sample farms. The major livestock owned by sample farmers included bullocks, cows, buffaloes, sheep and goats. The livestock position, depicted in table 1 reveals that the number as well as the value of livestock owned by sugarcane farmers.

Table 1: Socio-economic Background of Sample Respondents

Social Background	**SRI Paddy Cultivation Method Farmers**	**Traditional Paddy Cultivation Method Farmers**
Average Family Size (Number)	2.33	2.45
Average age of Family head (Year)	38.58	53.54
Average Education of Family head	9.78	7.56
Famers with agriculture as a main Occupation	56.24	53.25
Landholding	**SRI Paddy Cultivation Method Farmers**	**Traditional Paddy Cultivation Method Farmers**
Size of owned landholding (ha)	8.96	6.36
Major livestock owned (Number per household)	10.00	8.25
Value of major livestock owned (Per household)	56807	49560
Major machinery owned (Number per household)	6.45	4.89
Value of major machinery owned (Per household)	100896	90418
Paddy	53.5	42.3

Sources: Primary Data

The better livestock position of SRI farmers may be attributed to their higher demand for manures and other livestock products. The major machinery consisted of bullock carts, electric pumps, drip irrigation sets, tractors, threshers, sprayers and dusters. The major machinery position was also better, both in terms of number and value, on paddy sample farms.

Average cost per acre in the production of paddy under the system of rice intensification and traditional farming system, yield per acre, return from main product, net returns per acre are presented in table – 2.

Table –2 Costs and Returns in Paddy Cultivation of SRI and Traditional Method (in per acre)

Sl. No	Particulars	Expenditure (Rs/per acre) of SRI method Paddy	Expenditure (Rs/per acre) of Traditional method Paddy
1	**Nursery** I. Seed Rate II. Nursery Management	 60 (2 kg) 168	 600 (30 kg) 1350
2	Land Preparation	1860	1860
3	Transplantation	1250	2550
4	Fertilizer application	1280	3250
5	Weed Management	150 (cono-weeder rent per day)	2500
6	Pesticide Management	120	3100
7	Harvesting	2600	2600
8	Irrigation	500	500
9	Land Tax	100	100
10	Charges on Implements and Machineries	6767	3265
11	Repair of Machineries	2845	351
12	**Total Cost of Cultivations (1+2+3+4+5+6+7+8+9+10+11)**	**17700**	**22026**
13	Yield (Quintal / acre)	35	33
14	Value (Per Quintal)	1200	1150
15	Gross Returns (13*14)	42000	37950
16	**Net Returns (15-12)**	**24300**	**15924**

Sources: Primary Data

Gross return from Cuddalore district under system of rice intensification agriculture found to be marginally higher comported to the paddy produced under traditional farming system. While gross returns from system of rice intensification agriculture were 42000 per acre, the traditional agriculture was 37950 per acre with a difference of 4050 per acre. But net return was relatively high from system of rice intensification agriculture 24300 per acre compared to traditional agriculture 15924 per acre. Because cost of cultivation was lower for system of rice intensification farms 17700 per acre compared to traditional farms 22026 per acre. The yield from system of rice intensification agriculture was higher than traditional agriculture, while system of rice intensification farm produced 35 quintal/acre, 33 quintal/acre were produced from traditional farms and system of rice intensification agriculture economically well-being.

Conclusion

The conclusion that gross return from Cuddalore district under system of rice intensification agriculture was found to be marginally higher compared to the paddy produced under traditional farming system. While gross returns from system of rice intensification agriculture were 42000 per acre, the traditional agriculture was 22026 per acre with a difference of 4050 per acre. But net return was relatively high from system of rice intensification agriculture 24300 per acre compared to traditional agriculture 15924per acre. Because cost of cultivation was lower for system of rice intensification farms 17700 per acre compared to traditional farms 22026 per acre. The system of rice intensification farming has been found to conserve the soil and water resources, increases farmers' income, thereby enhancing their economic well-being and livelihood security. Thus, system of rice intensification paddy is important in achieving the goal of sustainable agriculture. It has been suggested that system of rice intensification farming should receive prime attention from all the stakeholders to realize its full potential in increasing profitability and providing the much sought after sustainability of agriculture.

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