GEOBOTANY AND BIOGEOCHEMISTRY

AN ORIENTATION STUDY IN SINGHBHUM COPPER BELT, BIHAR

P. VENU & GYAN CHAND

BOTANICAL SURVEY OF INDIA
CALCUTTA

1997

GEOBOTANY AND BIOGEOCHEMISTRY

AN ORIENTATION STUDY IN SINGHBHUM COPPER BELT, BIHAR

P. VENU
Central Botanical Laboratory
Botanical Survey of India
Howrah - 711 103

GYAN CHAND
Palaeontology and Stratigraphy Div -2
Geological Survey of India
Calcutta 700 016

BOTANICAL SURVEY OF INDIA
CALCUTTA

1997

Date of Publication : August, 1997

Price :

Published by the Director, Botanical Survey of India, P-8, Brabourne Road, Calcutta 700 001.
Composed at Computer Unit, Botanical Survey of India, Southern Circle, Coimbatore and printed at M/s Image Graphics, 62/1 Bidhan Sarani, Calcutta - 700 006. Phone : 241-5827

CONTENTS

FOREWORD

The scale of mineral exploration is now of unprecedented proportions owing to increasing demands placed upon earth's resources by the urgent needs of expanding industries and burgeoning populations. The exploration techniques were revolutionized with the advances taken place both in geophysical and geochemical methods of prospecting. Recognition of ore deposits based on plant affinities to minerals was realized and this added new dimension to plant utilities to mankind. This field of research is essentially multidisciplinary in scope and involves such diverse subjects as botany, chemistry,geology, soil science and statistics.

Botanical approach involves two different subjects: Geobotany and Biogeochemistry. These two branches are closely linked since the nature of the vegetation and its elemental contents are influenced both by the chemical composition of the soil and by the physical features of the environment. In recent years, satellite imaging and their analyses with sophisticated computer assisted techniques stimulated this branch permitting a thorough statistical treatment of raw data generated in these explorations.

In this publication, an attempt is made to present the information obtained on geobotanical and biogeochemical investigations of Singhbhum copper belt. The study was jointly undertaken by Botanical Survey of India and Geological Survey of India. I deeply appreciate the authors for producing a comprehensive information base on this copper belt. Such information is necessary for other mineralised zones of the country to use this technique effectively as a supplementary to conventional geophysical methods in the mineral exploration.

P. K. Hajra
Director

Botanical Survey of India
P-8, Brabourne Road
Calcutta - 700001

PREFACE

Present publication pertains to the outcome of the collaborative programme between Geological Survey of India and Botanical Survey of India titled "Geobotanical and Biogeochemical investigations in Singhbhum copper Belt, District Singhbhum, Bihar." for the period between 1987-88 to 1992-1993. Field investigations, laboratory analysis, computerization of data and compilation of the work are the major works undertaken during the above period. As a part of field investigations, three sampling belts were established in Singhbhum Copper belt between Dhobani and Jaduguda to have a thorough study on the aspects namely phytosociology,morphological aberrations and biogeochemistry. The study areas include Dhobani(2 line km), Sidhesar (4 line km) and Tamapahar (1 line km) and these belts run across the general strike of the rocks. Basing on observations on the general vegetational pattern along copper mineralization, three test transects (C1,C2,C3) were studied to have an assessment on the role of botanical expressions obtained in the orientation survey in the reflection of copper mineralization. These belts located around village Durgahata and fall in an area where copper mineralization is not reported. These test transects constitute a cumulative length of 0.5 km. In addition, the detailed vegetational studies were also taken up in the oldworkings and minepit head areas commencing from Ramachandrapahar in the northwest to Chapri area in the southeast of the copper belt. The details of sampling units studied and also the samples collected for chemical analysis were given in the table 1. Results on chemical analysis were computerized and the conclusions were drawn basing on the orientation studies carried out in above three belts. Data have been presented integrating the results obtained from lithology, geochemistry, phytosociology, biogeochemistry and mineralization to have a comprehensive understanding on the relationships in these subject areas. Information presented in this publication also serves as a useful reference on elemental levels in plants, both in the background and mineralized situations, and the limits of distribution of a species in relation to soil geochemistry.

Authors

ACKNOWLEDGEMENTS

The present work on geobotany and biogeochemistry in Singhbhum copper belt is the result of a collaboration programme between the Geological Survey of India and the Botanical Survey of India. The authors are thankful to the Director General, Geological Survey of India and Dr.P.K.Hajra, Director, Botanical Survey of India for their interest in the programme and facilities provided. They are also grateful to previous Directors of BSI, Dr.M.P. Nayar for formulation of the programme with the then Director General, GSI, Shri D.P.Dhoundiyal; and Dr. B.D.Sharma for his keen interest and constant encouragement in the course of this investigation.

The book presents a great deal of information on the chemical analyses of plants and soils which were undertaken by the chemical laboratory of Geological Survey of India. With vast amount of information in hand, it had become imperative to computerize the data for drawing meaningful conclusions. In this connection, the help rendered by Dr.K.Ayyasami, Geologist (Sr.),Stratigraphy division, GSI. and Shri A.K.Pathak, System Analyst BSI is gratefully acknowledged. Finally the authors express their sincere thanks to senior officers, S/Shri S.C.Shah (Retd.), P.R.Chandra(Retd.), A.N.Trivedy (Retd.), Dr. G. Ahmed and Sibdas Ghosh of GSI and Shri A.R.K.Shastry, Dr. G.V.S. Murthy of BSI for their help and encouragement.

LIST OF TABLES

LIST OF FIGURES

TABLE 1: SUMMARY OF THE WORK CARRIED OUT IN THIS PROGRAME (Excluding Pathargora Section)

Transect	Length	Direction	Sampling units	Study interval	Samples collected		Samples analyzed	
					Plants	Soils	Plants	Soils
Sidhesar	4 line km.	N60°E-S60°W	36 Quadrats**	50 meter	841	451	528	451
			310 Units *	10 meter				
Tamapahar	1 line km	N45°E-S45°W	85 Units	10 meter	351	175	50	164
Dhobani	2 li e km	N45°E-S45°W	30 Units	10 meter	31	135	10	105
			66 Quadrats	50 meter				
Test transects								
C1.		N45°E-S45°W				32		32
C2.	0.5 line km	-do-				37		31
C3.		-do-				45		45

* Unit is 20 meter line across the sampling zone where vegetation analysis was carried out

** Quadrats used are 1 sq. meter size

INTRODUCTION

GENERAL GEOLOGY OF THE AREA

Singhbhum copper belt lies in the northeastern part of the Indian Peninsular Shield. The copper belt is marked by a major shear zone named Singhbhum Shear Zone or Copper Belt Shear Zone. This arcuate shaped Shear zone runs almost East-West in the western part and takes a turn towards southeast in the eastern part. This zone extends from Porahat in western Singhbhum through Chakradharpur, Rakha and Musaboni mines of Bihar into Mayurbhanj of Orissa over a distance of 160 km. The area encompasses the Dhanjori and Chaibasha group of rocks of Pre-Cambrian age. Mineralization generally confined along the Singhbhum Shear zone. The maximum width of the Shear zone is recorded around Musabani. Results obtained in three sectors namely, Sidhesar, Tamapahar and Dhobani are given in the present report.

LOCATION AND ACCESSIBILITY

The area under study falls in Toposheet No. 73 J/6. Musabani is an important town approachable by all weather road and 11 km. away from Ghatsila. Ghatsila, on Howrah Tatanagar main line, is the rail head for the area.

PHYSIOGRAPHY AND DRAINAGE

The topography of the area is undulating. River Subarnarekha flowing southeast is located to the east of the area. The slope above the river gradually rises towards west. The highest peak of the studied area is known as Sidhesar peak (.1428 ft). The hills and ridges trend NNW-SSE following the trend of geological formations.

CLIMATE

The area experiences humid, subtropical climate with temperature ranging from 40°C and occasionally 42°C during summer to a low of 5°C during winter. The monsoon breaks here by the end of June and continues till September. The average annual precipitation is around 1960 mm.

FIELD AREAS AND METHOD OF STUDY

FIELD AREAS

The selected sampling belts include Pathargora (T_0 belt:N45°E S45°W, N80°W), Sidhesar (T_1 belt or CHP$_1$ belt:N60°E S60°W) ,Tamapahad (T_2 belt:N45°E-S45°W) and Dhobani (T_3 belt: N45°E-S45°W). The results obtained in the Pathargora were compiled and presented in the progress report of the year 1990. While the data obtained in the remaining three belts are projected in the present report. These sampling belts are diverse in nature in the sense some are away from biotic interferences and form virgin areas while the others are mixed, partly forming pure forests and partly fallow lands. Dhobani area is majorly interfered with human activities and plants established there are the results of secondary succession. Sampling belts are also diverse in terms of species composition, some are dominated by shrubs and trees like Sidhesar belt where as Dhobani is majorly constituted by herbs or smaller shrubs. It is worth recalling here that specifications given by Brooks (1972) for selecting sampling belts. He contends that sampling areas in the orientation survey should be drawn from areas that contain natural vegetation. However, it is felt, species that get established after human interference ,say in the form of mining activities are also equally important in developing a database on plant diversity and density for various basemetal mineralizations. In a similar vein, mine pitheads and old workings were also selected to study the vegetational composition and in the process mine pitheads namely Badia, Banalapa, Mosabani, Dhobani, Surda South and North, Kendadih, Rakha, and the oldworkings like Dhobani, Netra, Laukesra, Pathargora, Surda, Sidhesar, Tamapahad, Bhatin, Narwapahar and Ramachandrapahar were included in the studies.

In selecting a field area for orientation survey,the investigating team is guided by some important parameters. The first of these is that the area should contain an anomaly. Secondly, the success of the orientation survey depends largely on the contrast between background and mineralised locations in the test areas. In Sidhesar, the belt contains mineralised zone at stations 1,6 and 7 while the stations 2 and 1 to -3 are partially mineralised. The remaining areas are constituted by barren zones. In Dhobani sites between 4 and 8 are mineralised while the other are partially mineralised or barren zones. In Tamapahar, sites between 2 and 5 and site 8 are mineralised and the remaining portion (sites 1 and 6 to 10) is barren. In total, we have thoroughly examined 7.0 line km. covering mineralised, partially mineralised and barren zones in the aforesaid three traverses. The data obtained are evaluated for the geobotanical expressions with reference to copper mineralization.

VEGETATION ANALYSIS

Communities are characterized basing on phytosociological analysis. Several values are used in the community characterization. When community analyses was conducted , the main aim was centered around the dominant species in different groups such as herbs,shrubs and trees. Hence calculations connected to relative importance such as relative frequency, relative density etc. are based on these groups separately. This method of calculation was adopted to know dominance in various groups. In the present investigation, vegetation analysis was done using line transects of 20 meter length across the sampling zone and quadrats of 1 square meter size. A total of 425 line transects 102 qradrats were used to quantify different life forms available in each station/site in various sampling belts. Plant richness was measured in terms of total numbers of individuals in a particular site. This is a rough approximation of indicating the total plant strength in a particular site. In the present context, this expression served the purpose of projecting 'plant richness' in the required terms.

PLANTS FOR CHEMICAL ANALYSIS

Selection is made basing on the dominance and distribution of large plant species. Chemical analysis was majorly limited to shrubs and trees and the plant parts selected include leaves, stems or bark, and in some cases flowers and fruits.

SAMPLING PATTERN

The selection of the sampling pattern was done keeping in view the topography, size and shape of anomaly and the type of plants available. Smaller the size of the anomaly,the sampling was at closer intervals. A rectangular grid pattern was adopted in the sampling of plant species. At each sampling point, observations on the topography and geology of the site, plant composition, diversity and abundance are made.

METHODS OF SAMPLING

The amount of fresh plant material collected was sufficient enough to get 30 grams of dry weight material. Generally 100 grams of fresh plant material was collected for this purpose. The samples were plucked or cut through a stainless steel chopper. These were numbered and these numbers are indicative of sampling belt from where the sample was collected, the location / site /station in the sampling belt and the serial number of the sample collected. Besides,type of plant organ collected was also indicated in the number with letters like B (Bark), P (Entire plant), F (Flowers) and FR (Fruits). The location maps of plant and soils samples are presented to project the sample collection intensity in various belts (Figs 2,4 and 6). Soil samples were taken from various points in each traverse, particularly at the beginning of each site and also close to each plant sampled. The soil was collected from one feet depth close to 'A' zone and around 500 grams of soil was collected It is assumed that this forms the representative sample from where plants derive their nutrients including copper. Hence calculations connected to relationships between soil and plant elements are based on the figures obtained from these samples. Plant samples were initially collected in sealed plastic bags to keep them fresh before washing which is the next stage of processing. When plant samples were removed from plastic bags, they were washed vigorously under running water with a final rinse in distilled water. The samples were dried at 70 80°C in a oven. Majorly, leaves and twigs were crushed with hands. These samples were sent to laboratory for ashing.

In case of soil samples, they were laid out on paper and were air dried for about two days. After drying, the samples were lightly crushed with a mortar and pestle and sieved through a 15 mesh nylon sieve before storage.

SAMPLE PREPARATION FOR ANALYSIS

The final preparation of the material was undertaken by Chemical Laboratory, Geological Survey of India. It involved dry ashing of plant material in a muffle furnace at a temperature below 500°C. Due to limitations imposed by furnace space and to meet the targets, around three hundred plant samples were ashed in chemical laboratory, GSI, Patna. Sufficient plant material was taken for ashing to give a representative sample.

EXPRESSION OF ANALYTICAL DATA

For plant samples the data are expressed on ash weight basis and also on dry weight basis. While the soil values are expressed on a dry weight basis. Special care was taken while avoiding risk of contamination through various sources. Samples collected close to highways were given special care while cleansing with water as contamination through trucks carrying ore body was documented earlier (Cannon, 1952). Another form of contamination is by non-mineralised dust which has the effect of diluting the plant and hence lowering concentration of some elements. However, this factor is fairly negligible.

BACKGROUND DATA

It is very important to acquire data on normal background concentrations of different elements in various species. This information is quite useful for comparison with elemental levels obtained from anomalous zones. The expenditure involved in orientation surveys get effectively reduced once we acquire enough information on these lines. In the present investigation, analysis for various chemical elements was completed in plant samples collected both from barren and mineralised zones. Thus, the information presented in the report forms a good basis for comparison for the future studies.

ORIENTATION SURVEY AND STATISTICS

After collection of samples and their preparation for analysis, the next steps involved chemical and statistical analyses. On completion of chemical analysis, results were subjected to various statistical treatments for meaningful inferences. The first of these is the information on the degree of correlation of the element content of different species with the corresponding values in the soil. Correlation coefficients(r) are obtained by applying the below formula to evaluate this relationship.

$$r = \frac{\Sigma (x - \bar{x})(y - \bar{y})}{\sqrt{\Sigma (x - \bar{x})^2 (y - \bar{y})^2}}$$

where, 'x' and 'y' are variables

An indication of the reproducibility of element accumulation in a plant is provided by calculation of the coefficient of variation(τ). This was also defined as sum of the squares of the deviation from the mean divided by the total number of observations. This is obtained by the following formula:

$$C.V = d^2/n \quad \text{or} \quad \Sigma (x - \bar{x})^2/n$$

Significant differences between two sets of data:

One of the problems frequently encountered in the interpretation of biogeochemical data is whether there is a significant difference between the averages of two sets of values. We have a set of analysis for leaf samples of a particular species and wish to compare with another set, the data is of bark samples of the same species. It would be interesting to know if there is any difference between the means and if so with what degree of confidence we can say that difference exists. The well known Student's t-test is applied at 95% confidence limit. To know the significance of difference of elemental accumulation of a species in relation to various bioparts, the following formula for t-test is applied:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{Sp\,(1/n_1 + 1/n_2)^{1/2}}$$

where, x_1 and x_2 are the variables and n_1 and n_2 are number of samples taken into consideration; and Sp is the pooled standard deviation.

In the plant phytosociology, community characteristics were studied. These are species diversity, dominance and relative density (Michael, 1984). After obtaining community structure, dominant species were isolated in every traverse at site level. This was done to understand the community structure along copper gradient in various sites.

A REVIEW ON THE EARLIER LITERATURE

Geobotanical investigations evaluate the precise relationships between the composition, form and distribution of plant communities in relation to soil factors in undisturbed natural terrain. Normally, they are accompanied by geochemical and biogeochemical investigations which provide some essential data on relationships between elemental levels and plant communities. In mineral exploration, the objectives of this kind of investigations are the identification of anomalous plant communities related to mineralised bedrock, the recognition of communities associated with particular bedrock units and types and depths of overburden and the detection of distribution patterns indicative of structures and of lithological and stratigraphical sequence (Cole, 1980).

Many plants were reported as mineral indicators through various geobotanical investigations. However, some claims were disputed. For example, in England, persons conversant with copper turbaries consider the presence of copper in the soil to be indicated by the growth of the sea pink (*Armeria maritima*) which appear to flourish in remarkable luxuriance. *A.maritima* is extremely common plant in coastal areas of great Britain and in the absence of a more definitive study, there would be no reason to suppose that this taxon has any copper indicating ability whatsoever (Brooks, 1972). It does, however, form part of a heavy metal community including other species namely *Minuartia verna* and *Agrostis tenuis* (Ernst, 1967). *Minuartia verna* was also found over lead workings in Wales and Pennines (North England) and certainly has resistance to heavy metals although it is not clear whether this is only to zinc, copper or lead or any combination of these elements. Another best known copper indicator, *Polycarpaea spirostylis* was reported from Australia (Nicolls et al., 1965; Cole et al., 1968; Correl and Taylor, 1974 and 1975; Brooks and Radford, 1978). A large number of copper indicators were found in the copper belts of Zaire and Zambia(Central Africa). The best researched plant was *Becium homblei* (Howard-Williams, 1970). Besides, many other species were reported as copper indicators. These are *Acalypha dikuluwensis, Anisopappus hoffmanianus, Ascolepsis metallorum, Commelina zigzig, Cyanotis cupricola, Haumaniastrum katangense* and *H.robertii* from Zaire (Duvigneaud and Denaeyer de Smet, 1963); *Aeolanthus biformifolius* from Zaire (Malaisse et al, 1978); *Ecbolium lugardae* and *Helichrysum leptolepis* from S. W. Africa (Cole, 1971); *Eschscholzia mexicana* from USA (Chaffe and Gale, 1976); *Gypsophila patrinii* from the erst while USSR (Nesvetailova, 1961); and *Impatiens balsamina* (Aery, 1977) and *Vernonia cinerea* (Venkatesh, 1964, 1966) from India.

Zinc floras have been known well over a century and include *Viola calaminaria* and *Thlaspi calaminare*. Ernst (1967) compiled a bibliography of zinc flora.

Many plants were listed to grow in nickel rich areas. They include *Alyssum* species (Brooks, et al., 1979a); *Dicoma macrocephala* (Wild, 1970); *Dicoma niccolifera* (Wild, 1978); *Homalium kanaliense, Hybanthus austrocaledonicus* and *H.caledonicus* (Brooks, et al., 1974); *Hybanthus floribundus* (Severne and Brooks, 1972; Cole, 1973) and *Sebertia acuminata* (Jaffre et al., 1976). Except for the two species of *Dicoma* and *H.floribundus* from Rhodesia and Australia respectively, all other hyperaccumulators were from New Caledonia.

Indicator species connected to selenium rich areas were reported from Western United States (Beath et al., 1935, 1939a, 1939b) Colombia, Canada and Queensland (McCray and Hurwood, 1963). Cannon (1952, 1957, 1960a and 1964) was able to use the *Astragalus* species for indirect prospecting for uranium because the plant tends to grow in Selenium rich areas which is an associated element in Carnotite, the ore of uranium. Her classical work represents one of the most successful known applications of the geobotanical method for mineral prospecting. Although selenium indicating plants contain high concentration of this element, they are probably capable of growing without selenium. (Shrift, 1969).

Investigations on geobotany and biogeochemistry provided some valuable and applicable information for mineral exploration even in India and attained importance in recent years. Researches relating to copper mineralization and plant associations were carried out by Aery and Tiagi (1986) and Tiagi and Aery (1986) on Khetri copper deposits of Rajastan; Venkatesh (1964, 1966) and Shyam (1986, 1989) on Singhbhum copper belt; Tiagi and Singh (1973) on copper ore deposits in Madhya Pradesh, Bihar and Rajasthan; Karunakaran et al., (1969b) on some copper rich areas in North Eastern Himalayas; Roy Chowdhury et al., (1969) on some copper rich areas of Singhbhum, Bihar and Agnigundala, Andhra Pradesh. The investigations relating to other basemetals include the contributions of Aery (1977), Aery and Tiagi (1985), Tiagi (1968), Tiagi and Aery (1981, 1982, 1987), Poddar (1965) on Zawar belt of Rajastan (zinc mineralization) and Aery and Tiagi (1981) on lead mineralization in Zawar minesand and Roy(1974) and Ziauddin and Roy (1974) on Sukinda valley (nickel mineralization); Karunakaran et al. (1969a) in Purulia, Midanapur and Bankura districts of West Bengal; Gandhi and Aswathanarayana (1975) and Murthy (1964) in Mamandur, South Arcot district and Ravikiran and Bedi (1984) in Banaskantha district of Gujarat (Cu-Pb-Zn mineralization). These researches furnished information on different botanical aspects with reference to mineralization of various elements. Bhaumik (1978) and Tiagi and Aery (1985) reviewed the information on the subject.

Biogeochemical methods of exploration include the chemical analysis of elements in vegetation and its underlying soils. Credit for the development of the method is usually attributed to Brundin (1939). Following the pioneering work of Tkalich (1938, 1952, 1953), the erst while USSR remained the central zone for biogeochemical research. Malyuga contributed significantly to the literature on biogeochemistry (Malyuga, 1954, 1958, 1959, 1960, 1964). Cannon and her group worked mostly in the United States of America and Canada (Cannon, 1952, 1955, 1960a, 1971). Besides, some significant contributions were made by Antonovics et al., (1971), Anderson (1955), Brooks and Radford (1978), Brooks et al. (1979b), Lovering, et al. (1950), Lyon and Brooks (1969), Lyon et al. (1971), Nicolls et al. (1965), Reeves and Baker (1984), Reeves and Brooks (1983), Reily and Stone (1971), Roberts (1980), Warren (1962), Warren et al. (1949, 1951), Warren and Delavault (1950a, 1950b, 1954) and White (1954).

Analysis of herbarium specimens is another important area of biogeochemical investigations in the detection of mineral rich areas. Pioneering and some useful work was carried out by Chenery (1948), Brooks et al. (1977) and Goodman and Roberts (1971). Biogeochemical investigations also revealed that some plant species absorb some elements in anomalous amounts. These were designated as accumulators or hyperaccumulators depending on the concentrations of the elements recorded (Brooks et al., 1980; Brooks, et al., 1979a; Brooks et al., 1978; Jaffre et al., 1976; Lee et al., 1977a, 1977b; Malaisse et al., 1978). Investigations of this nature had very useful implications in the reclamation of mineral rich wastelands. The extensive literature on the subject has been reviewed by Malyuga (1964), Cannon (1960a) and Brooks (1972 and 1983) and in the Indian context by Tiagi and Aery (1985).

T1 BELT (CHP3 BELT) - SIDHESAR TRANSECT

In the vegetation analysis, a few sampling belts were selected for thorough orientation studies. CHP3 belt or T1 belt is one among the selected belts and runs for four line km. passing through Kumirmuri village and Sidhesar peak. The Sidhesar pahar is situated southwest of Kumirmuri village. The name of the belt (CHP3 belt) is derived from the designated name given for a drilling point in the area by Geological Survey of India in connection with copper investigations. For reference in the present context, it was termed as T1 belt. '0' point was fixed at the drilling point itself. From this point, the sampling belt runs two line km. on both the sides -N60^{0}E and S60^{0}W direction. The succession of rocks in the sampling belt is given below:

Mica schist
Quartz sericite schist
Kayanite quartz schist
Chlorite biotite schist
Chlorite schist
Micaceous quartzite
Conglomerate
Purple quartzite
Arkosic quartzite
Biotite chlorite schist
Meta-ultramafic
Basalt (massive)
Metabasalt

The ground nature of the belt varied from barren rock exposure to thick cultivated soil area. The hillocks falling in the belt bear residual soils thickened upto a maximum of one feet deep. Barren rock exposures in maximum cases are of quartzites. The sampling belt was divided into 40 stations each stretching 100 line meters with an area of 2000 sq m. The point 0 was assigned to the mid point of the sampling belt. To the northeast of the point, the stations begin with -1 and end with -20. Whereas towards the southwest of '0' point the stations begin with 1 and end with 20. Station 1 indicates the stretch between the points 0 and 1 while station -1 indicates the stretch between 0 and -1. Station 1 was located in the heart of mineralised part of the sampling belt where chlorite biotite schist and quartz-sericite schist are exposed.

Fig.:1 PROFILE SECTION OF SIDHESAR BELT

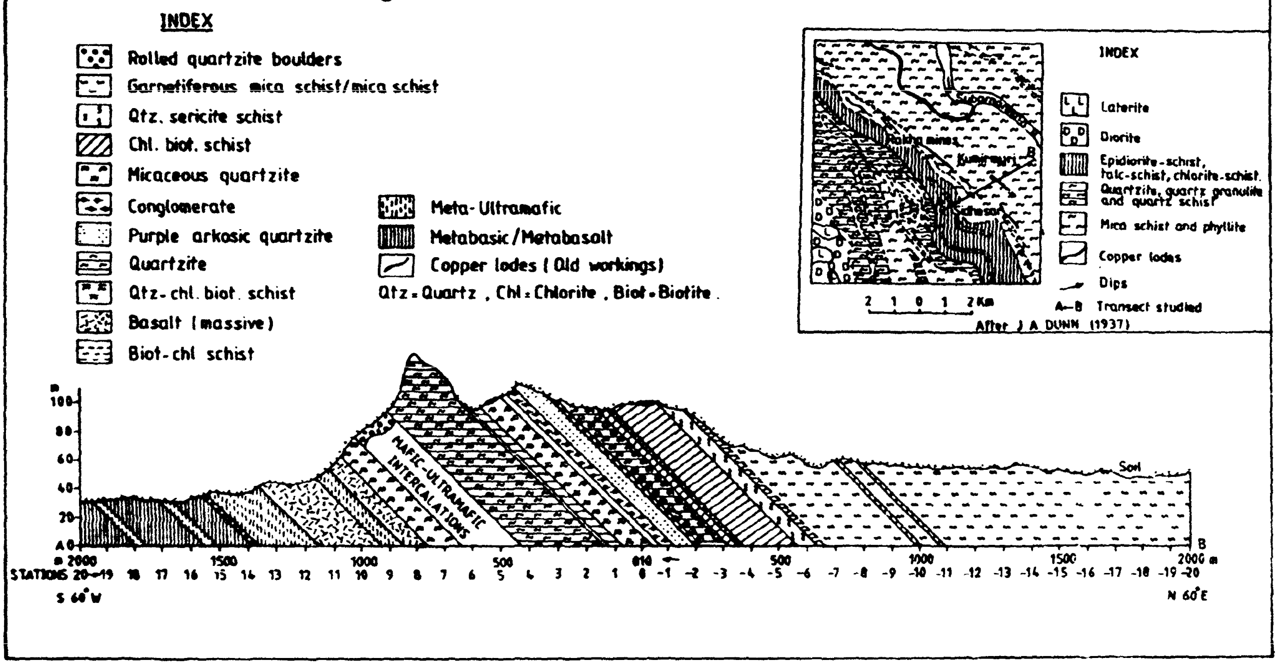


FIG : 2a SAMPLE LOCATION MAP ALONG SIDHESAR TRANSECT (A & B)

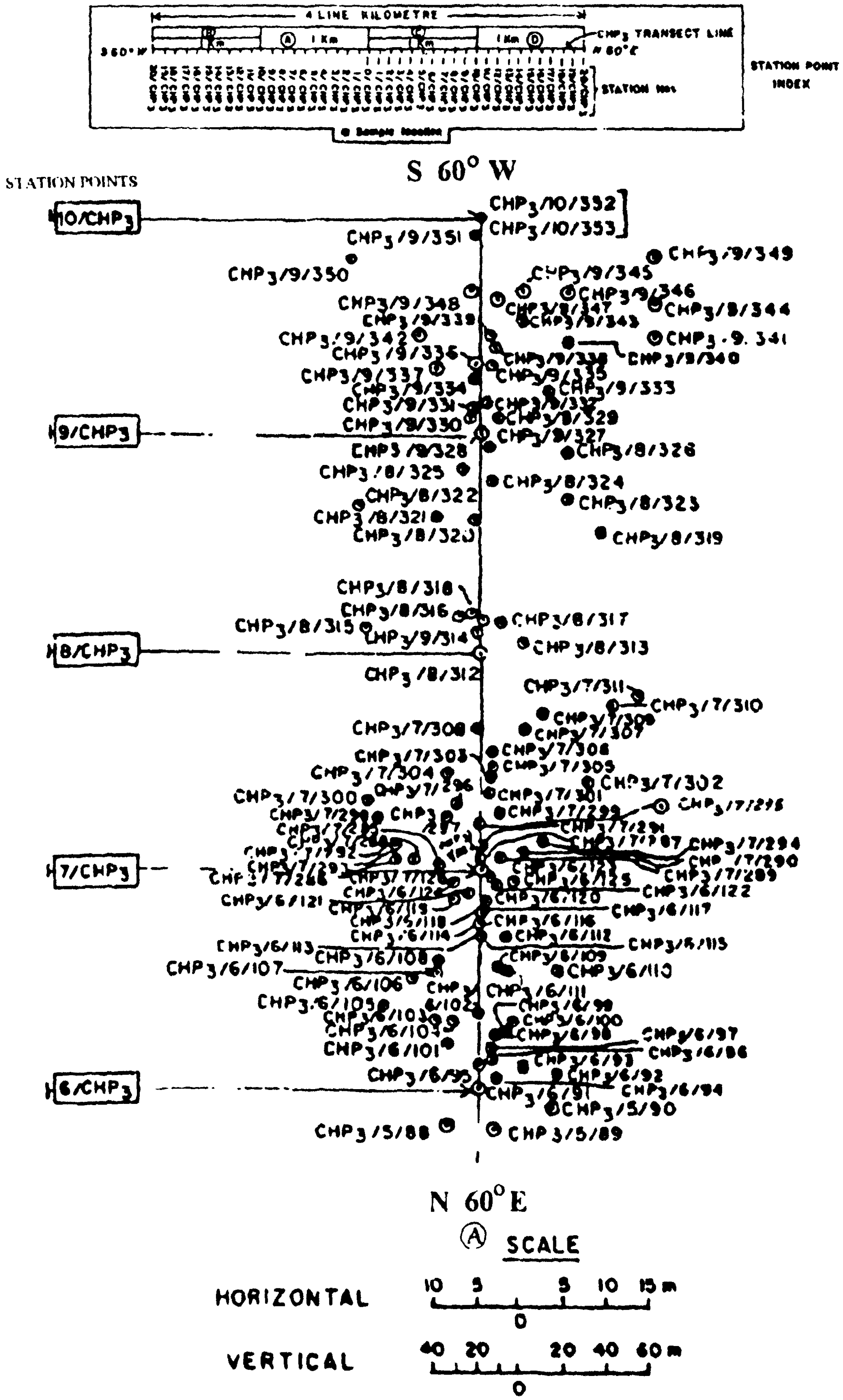


Fig 2a contd.

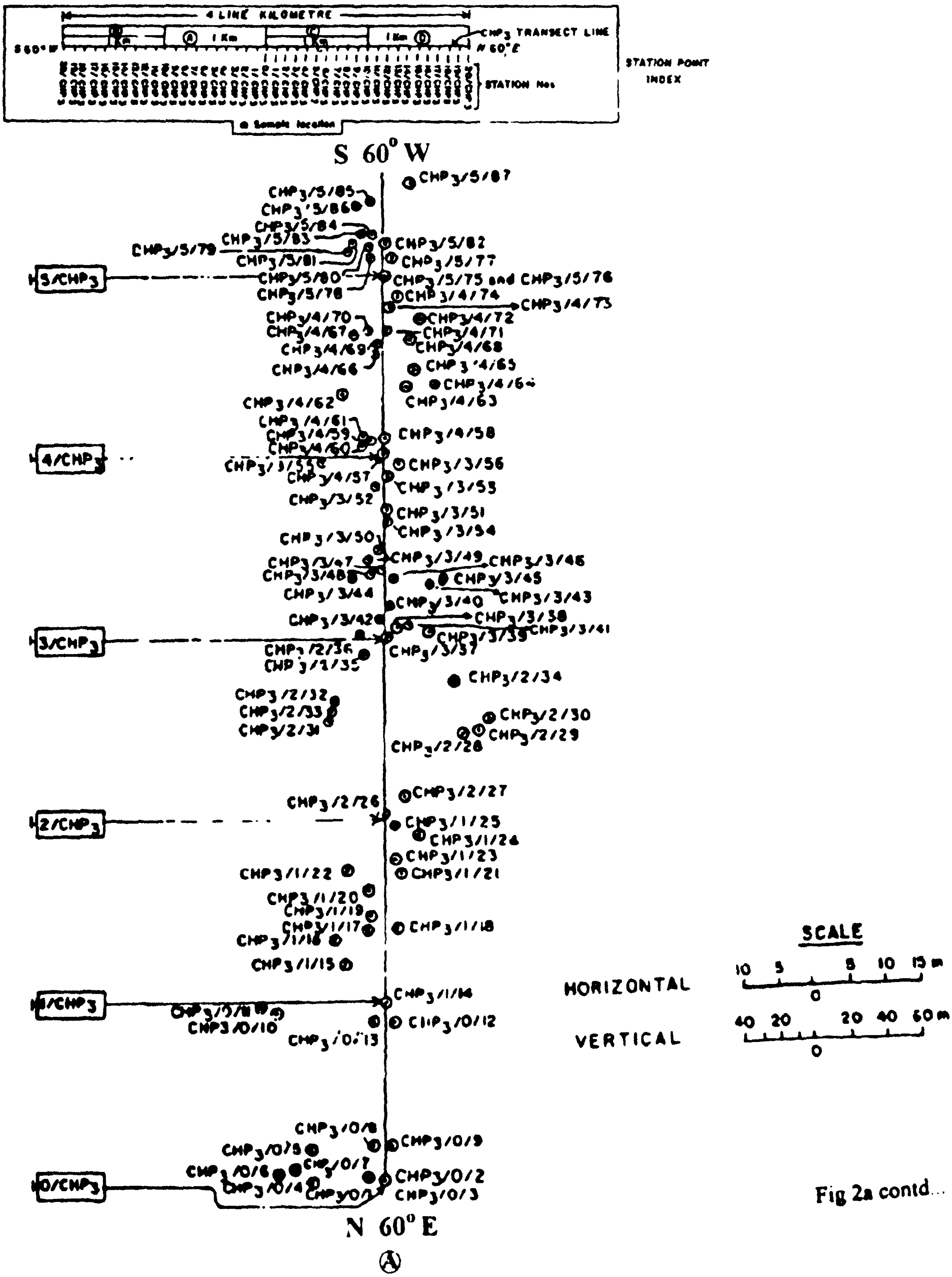

4 LINE KILOMETRE
CHP3 TRANSECT LINE
N 60° E
STATION POINT INDEX
STATION Nos
Sample location
S 60° W
CHP3/5/87
CHP3/5/85
CHP3/5/86
CHP3/5/84
CHP3/5/83
CHP3/5/79
CHP3/5/82
CHP3/5/77
CHP3/5/81
5/CHP3
CHP3/5/80
CHP3/5/75 and CHP3/5/76
CHP3/5/78
CHP3/4/74
CHP3/4/73
CHP3/4/72
CHP3/4/70
CHP3/4/71
CHP3/4/68
CHP3/4/66
CHP3/4/65
CHP3/4/62
CHP3/4/63
CHP3/4/61
CHP3/4/59
CHP3/4/58
CHP3/4/60
4/CHP3
CHP3/3/56
CHP3/4/57
CHP3/3/55
CHP3/3/52
CHP3/3/51
CHP3/3/54
CHP3/3/50
CHP3/3/49
CHP3/3/46
CHP3/3/47
CHP3/3/45
CHP3/3/44
CHP3/3/40
CHP3/3/43
CHP3/3/42
CHP3/3/38
CHP3/3/41
3/CHP3
CHP3/2/36
CHP3/3/37
CHP3/2/35
CHP3/2/34
CHP3/2/32
CHP3/2/33
CHP3/2/30
CHP3/2/31
CHP3/2/29
CHP3/2/28
CHP3/2/27
CHP3/2/26
2/CHP3
CHP3/1/25
CHP3/1/24
CHP3/1/23
CHP3/1/22
CHP3/1/21
CHP3/1/20
CHP3/1/19
CHP3/1/17
CHP3/1/18
CHP3/1/16
CHP3/1/15
CHP3/1/14
1/CHP3
CHP3/0/10
CHP3/0/12
CHP3/0/13
CHP3/0/8
CHP3/0/9
CHP3/0/5
CHP3/0/7
CHP3/0/6
CHP3/0/2
0/CHP3
CHP3/0/4
CHP3/0/3
N 60° E
(A)
SCALE
HORIZONTAL
10 5 0 5 10 15 m
VERTICAL
40 20 0 20 40 60 m

Fig 2a contd...

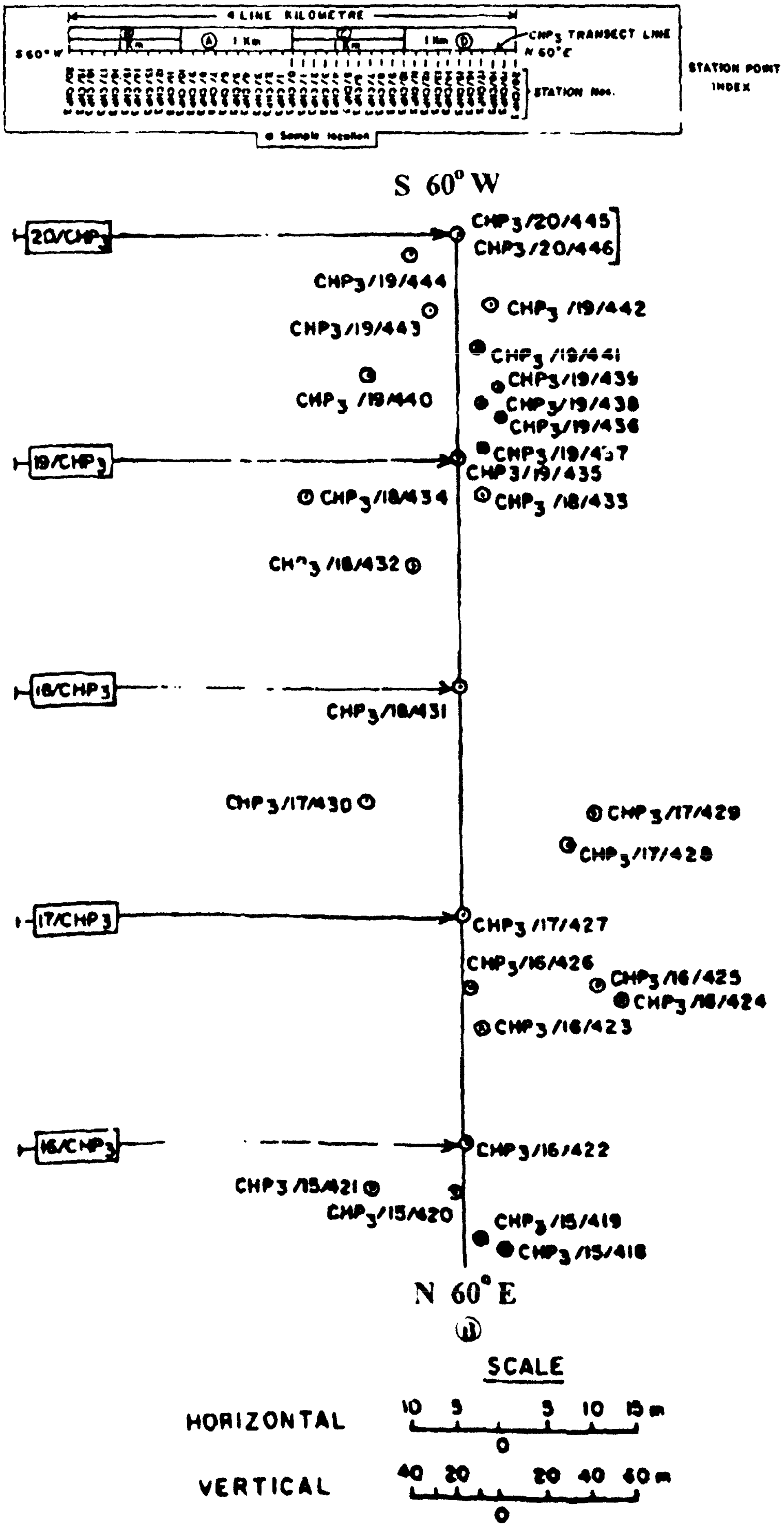
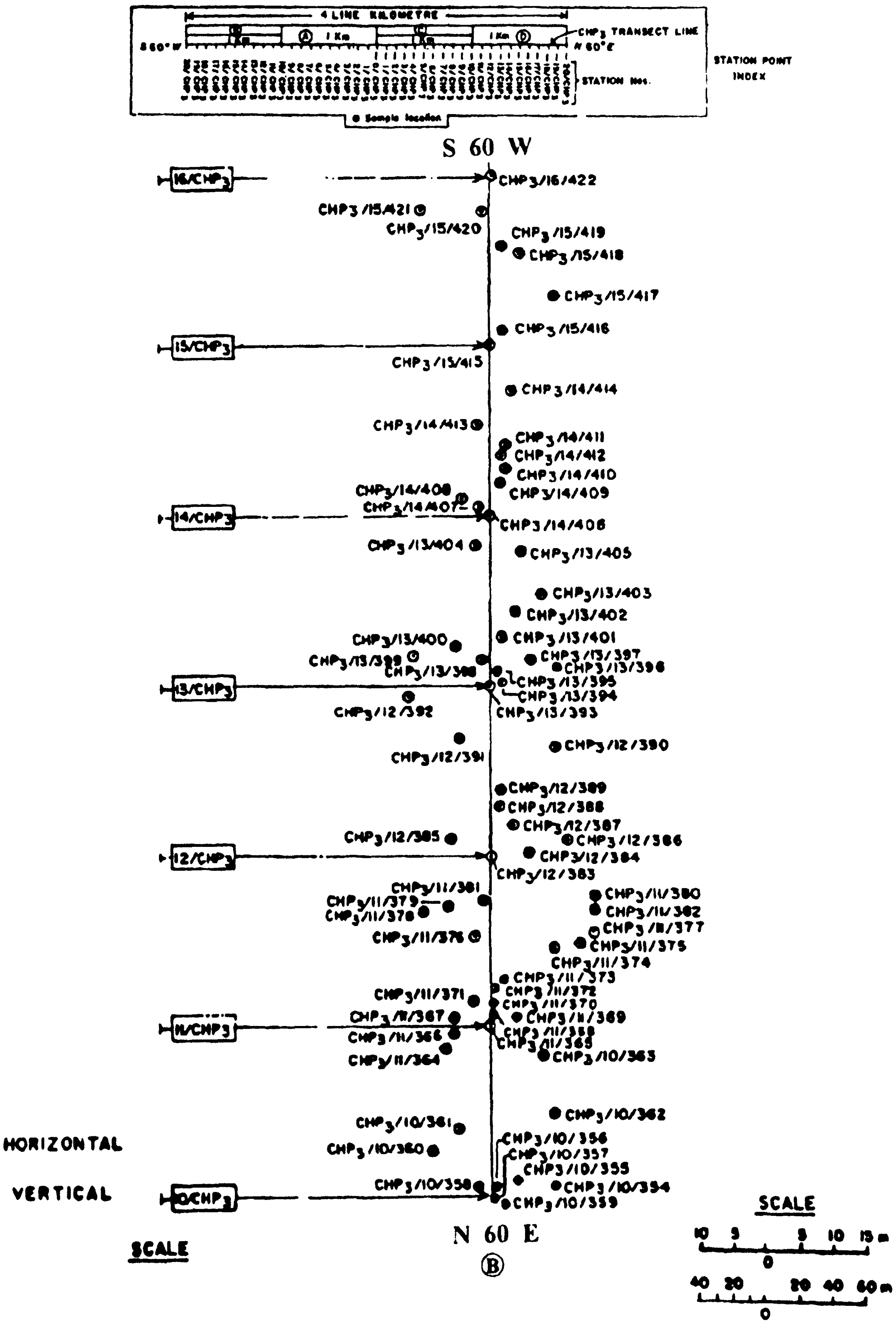

4 LINE KILOMETRE
CHP3 TRANSECT LINE N 60°E
STATION POINT INDEX
STATION Nos.
Sample location
S 60° W
20/CHP3
CHP3/20/445
CHP3/20/446
CHP3/19/444
CHP3/19/442
CHP3/19/443
CHP3/19/441
CHP3/19/439
CHP3/19/440
CHP3/19/438
CHP3/19/436
19/CHP3
CHP3/19/437
CHP3/19/435
CHP3/18/434
CHP3/18/433
CHP3/18/432
18/CHP3
CHP3/18/431
CHP3/17/430
CHP3/17/429
CHP3/17/428
17/CHP3
CHP3/17/427
CHP3/16/426
CHP3/16/425
CHP3/16/424
CHP3/16/423
16/CHP3
CHP3/16/422
CHP3/15/421
CHP3/15/420
CHP3/15/419
CHP3/15/418
N 60° E
(ii)
SCALE
HORIZONTAL
10 5 0 5 10 15 m
VERTICAL
40 20 0 20 40 60 m

Fig 2a contd


4 LINE KILOMETRE
1 Km
CHP3 TRANSECT LINE
N 60° E
STATION POINT INDEX
STATION Nos.
Sample location
S 60 W
16/CHP3
CHP3/16/422
CHP3/15/421
CHP3/15/420
CHP3/15/419
CHP3/15/418
CHP3/15/417
CHP3/15/416
15/CHP3
CHP3/15/415
CHP3/14/414
CHP3/14/413
CHP3/14/411
CHP3/14/412
CHP3/14/410
CHP3/14/409
CHP3/14/408
CHP3/14/407
14/CHP3
CHP3/14/406
CHP3/13/404
CHP3/13/405
CHP3/13/403
CHP3/13/402
CHP3/13/401
CHP3/13/400
CHP3/13/399
CHP3/13/397
CHP3/13/398
CHP3/13/396
CHP3/13/395
CHP3/13/394
13/CHP3
CHP3/12/392
CHP3/13/393
CHP3/12/390
CHP3/12/391
CHP3/12/389
CHP3/12/388
CHP3/12/387
CHP3/12/386
CHP3/12/385
CHP3/12/384
12/CHP3
CHP3/12/383
CHP3/11/381
CHP3/11/380
CHP3/11/379
CHP3/11/378
CHP3/11/382
CHP3/11/377
CHP3/11/376
CHP3/11/375
CHP3/11/374
CHP3/11/373
CHP3/11/372
CHP3/11/371
CHP3/11/370
CHP3/11/367
CHP3/11/369
11/CHP3
CHP3/11/368
CHP3/11/366
CHP3/11/365
CHP3/11/364
CHP3/10/363
CHP3/10/362
CHP3/10/361
HORIZONTAL
CHP3/10/356
CHP3/10/360
CHP3/10/357
CHP3/10/355
CHP3/10/358
VERTICAL
10/CHP3
CHP3/10/354
CHP3/10/359
SCALE
N 60 E
SCALE
10 5 0 5 10 15 m
40 20 0 20 40 60 m

Ⓑ

Fig:2b SAMPLE LOCATION MAP ALONG SIDHESAR TRANSECT (C & B)

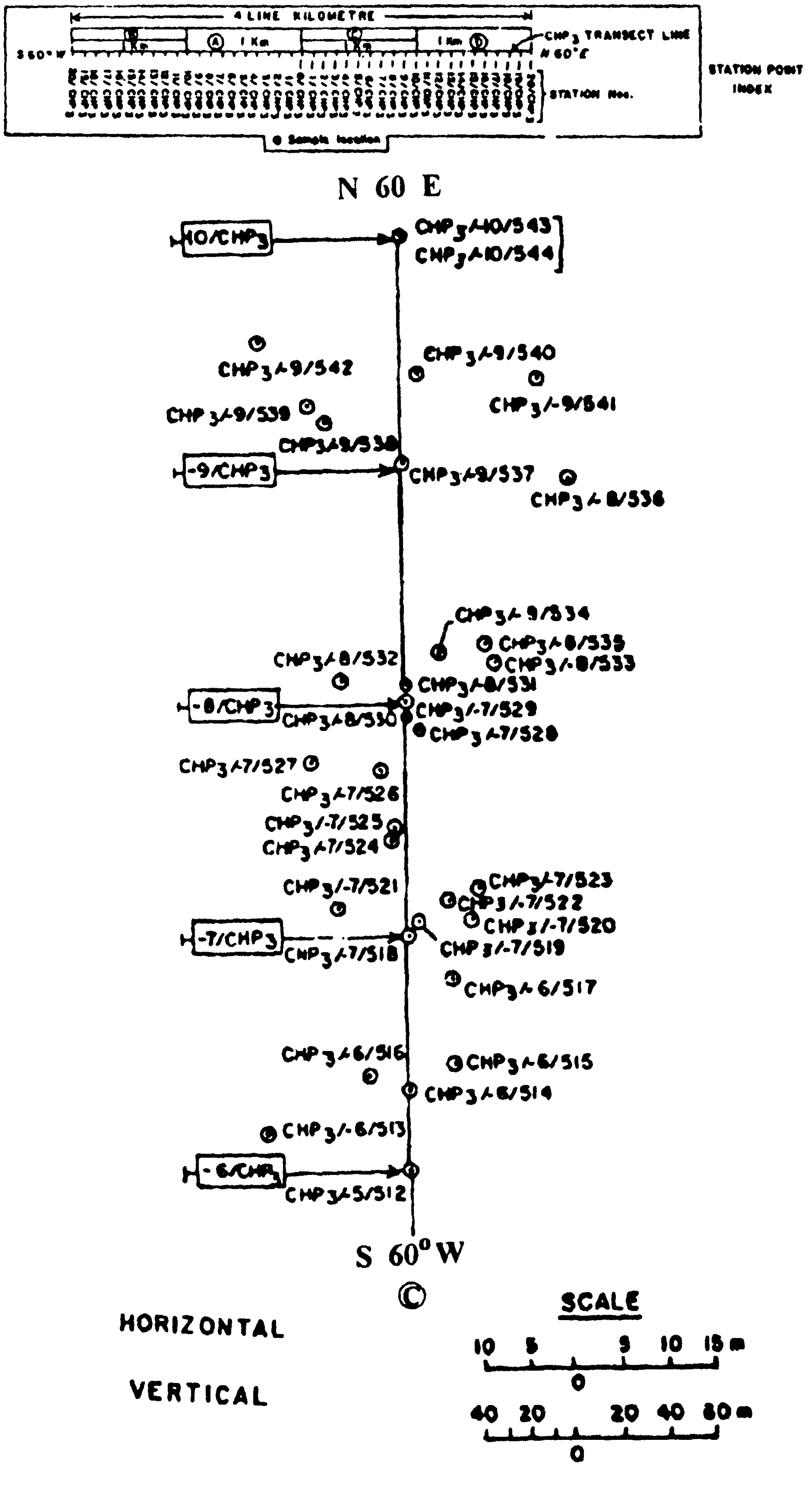


Fig 2b contd...

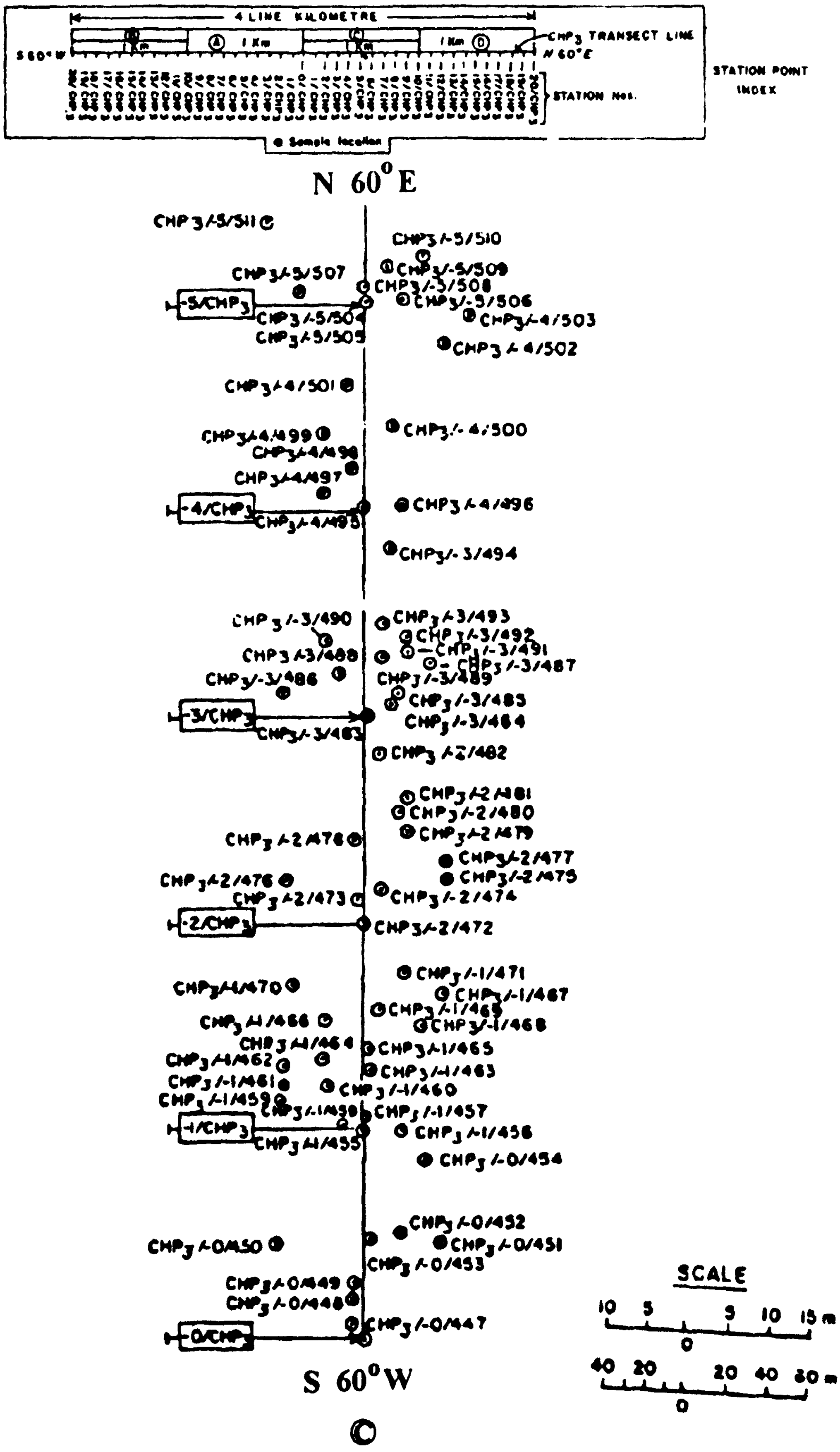


Fig 2b contd...

HORIZONTAL

VERTICAL

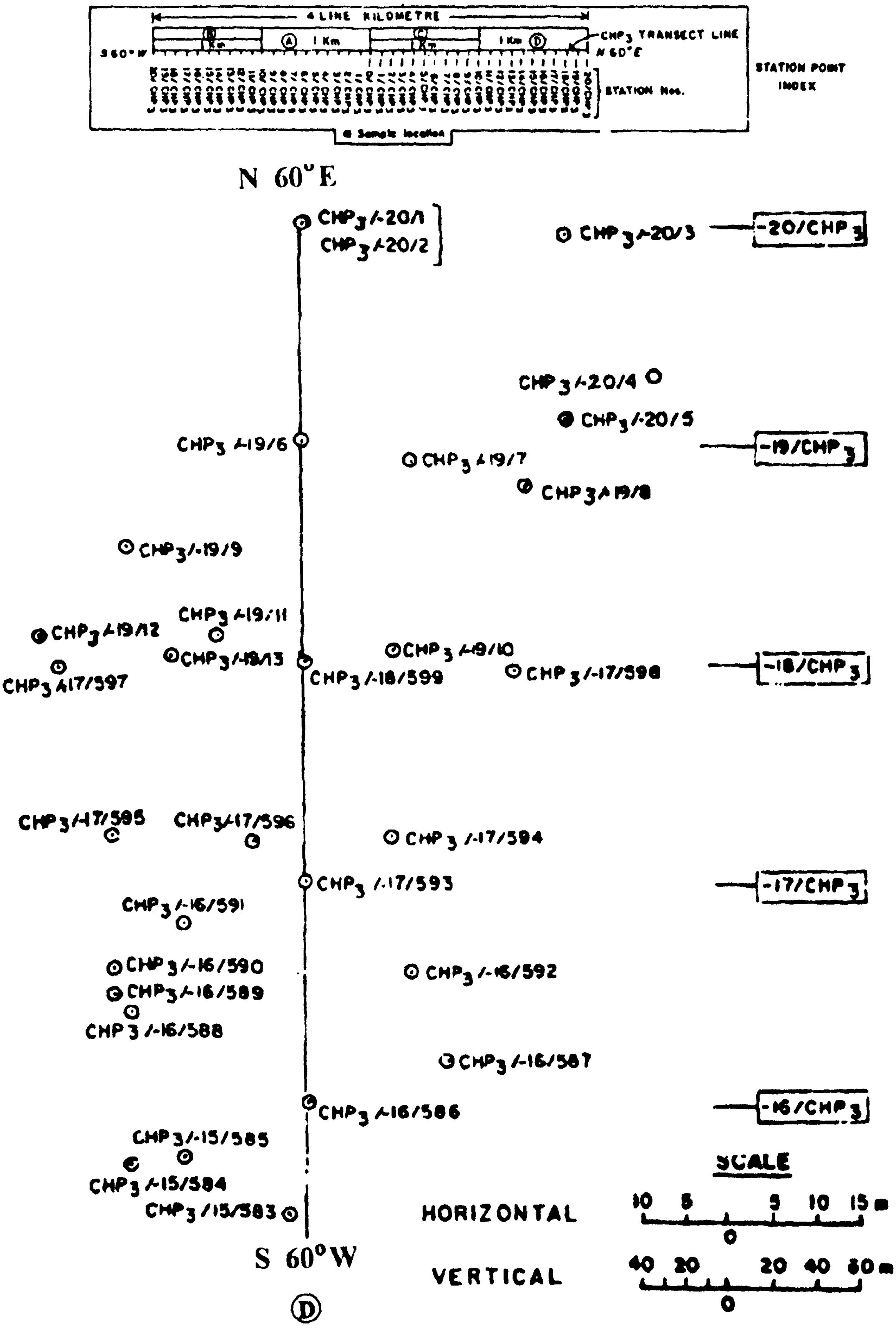
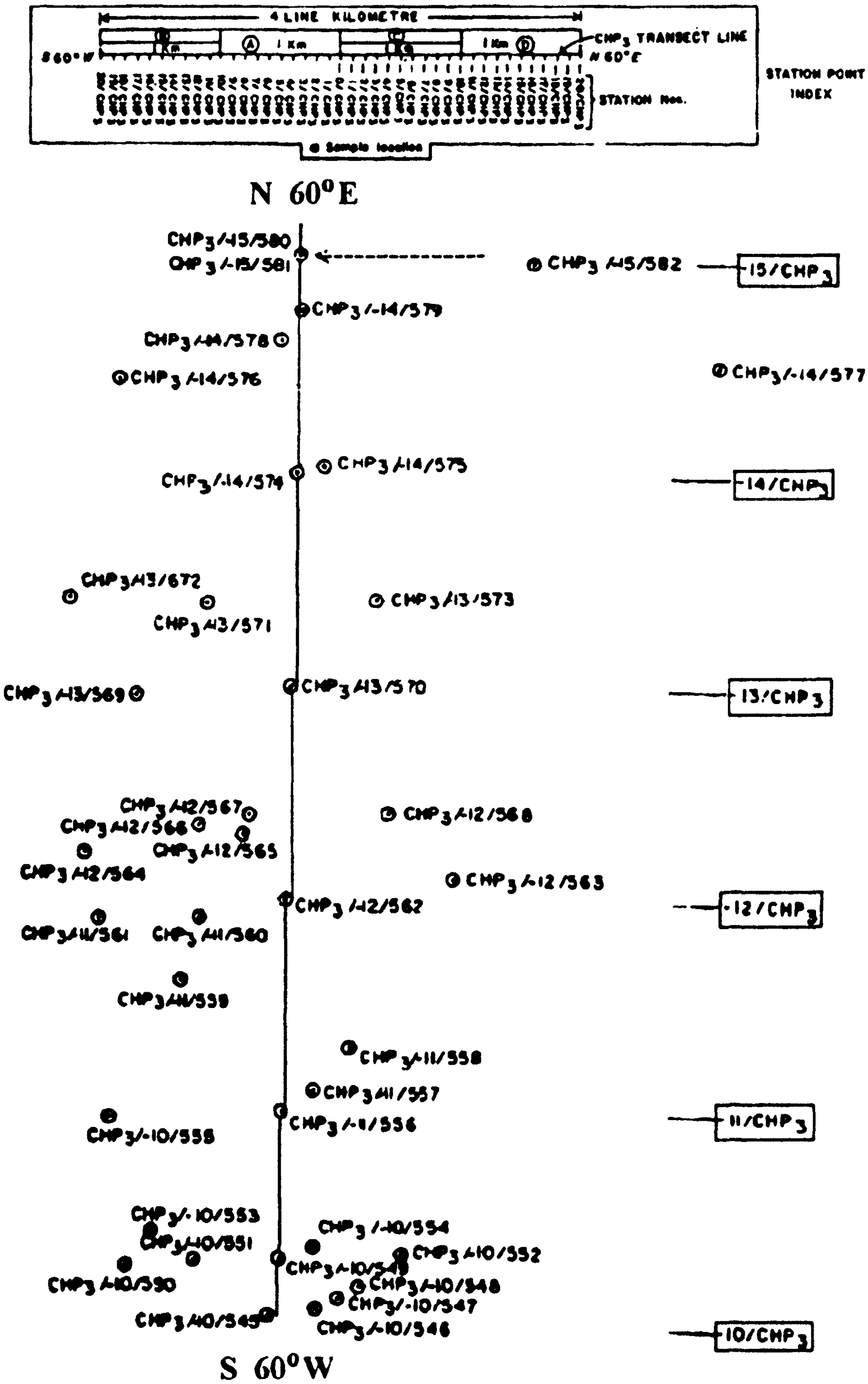

4 LINE KILOMETRE
CHP3 TRANSECT LINE
N 60°E
S 60°W
STATION POINT INDEX
STATION Nos.
Sample location
N 60°E
CHP3/-20/1
CHP3/-20/2
CHP3/-20/3
-20/CHP3
CHP3/-20/4
CHP3/-20/5
CHP3/-19/6
CHP3/-19/7
-19/CHP3
CHP3/-19/8
CHP3/-19/9
CHP3/-19/11
CHP3/-19/12
CHP3/-19/13
CHP3/-19/10
CHP3/-17/597
CHP3/-18/599
CHP3/-17/598
-18/CHP3
CHP3/-17/595
CHP3/-17/596
CHP3/-17/594
CHP3/-17/593
-17/CHP3
CHP3/-16/591
CHP3/-16/590
CHP3/-16/592
CHP3/-16/589
CHP3/-16/588
CHP3/-16/587
CHP3/-16/586
-16/CHP3
CHP3/-15/585
CHP3/-15/584
CHP3/15/583
S 60°W
D
SCALE
HORIZONTAL
10 5 0 5 10 15 m
VERTICAL
40 20 0 20 40 60 m

Fig 2b contd...



Ⓓ

SCALE

HORIZONTAL 10 5 0 5 10 15 m

VERTICAL 40 20 0 20 40 60 m

Vegetation analysis was carried out by adopting line transect and quadrat methods as per the suitability and the distribution of the vegetation in the area (Michael,1984). In total, about 310 line transects and 36 quadrats were studied for vegetation analyses. Each line transect is a 20 meter line across the sampling belt while a quadrat is of 1 square meter in size. Soil samples were collected in each station as well as from selected locations in each station and also from places where vegetative parts of the plants were sampled. Number of plants available at each station was recorded along with their density besides noting the geology of the area.

Plant Distribution along the Sampling Belt

Station 1: The rock types that occurs is of chlorite -biotite schist with soil copper values reaching upto 1800 ppm in the beginning of the station (CHP3/0/2 or 3). In the entire stretch at various locations close to the different dominant species copper level showed more or less high values and fluctuated between 510 ppm (CHP3/0/5) close to *Hyptis suaveolens* to 4400 ppm (CHP3/0/13) close to *Shorea robusta* , 3700 ppm close to *Woodfordia fruticosa* and 32700 ppm close to *Syzygium cumini*. Mean value for the copper for the entire station stand at 4493.07 With regard to the other base metals the ranges were relatively lower; 20 40 ppm (27.9 ± 6.1) for lead; 15 35 ppm (23.9 ± 5.5) for zinc; 120 365 ppm (243.7 ± 63.2)for nickel and 25 80 ppm (44.2 ± 16.8) for cobalt. In the vegetation analysis *Hyptis suaveolens* and *Holarrhena antidysenterica* are dominant species and are followed by *Cleistanthus collinus*. *Shorea robusta* and *Ichnocarpus frutiscence* restricted their presence in the first part of the sampling belt while the herb, *Blumea oxyodonta* dominated in the second part of the station.

Station 2: The rock types in this stretch include micaceous quartzite and chlorite biotite schist. Soil copper level in the beginning of the station showed a value of 3500 ppm (CHP3/1/14). However, the values obtained in different locations close to the dominant species were variable and showed a range from 175 ppm (CHP3/1/25) close to *Croton roxburghii* to 1500 ppm (CHP3/1/15) close to *Acacia torta* Mean copper value for the entire station is 731.51 ppm With regard to other basemetals, the value ranges were narrower with 40 60 ppm (47.9 ± 5.7) for lead; 10 30 ppm (20.5 ± 5.8) for zinc; 40 55 ppm (78.9 ± 34.3) for nickel and 10 30 ppm (15.2 ± 4.9) for cobalt. In vegetational analysis a total of 27 species were recorded and *Shorea robusta* and *Holarrhena antidysenterica* dominated the entire stretch followed by *Cleistanthus collinus*. *Hyptis suaveolens* occurs in quite lower numbers and less frequently. The presence of *Lantana camara* was restricted to first part of the stretch while that of *Croton* *roxburghii* to the latter part.

Station 3: Micaceous quartzite and conglomerate occur in this zone. Soil copper level in the beginning of the station showed a value of 155 ppm (CHP3/2/26). Geochemical samples collected at various locations close to different species also showed lower values and ranged from 150 ppm (CHP3/2/27) close to *Shorea robusta* to 425 ppm (CHP3/2/32) close to *Cleistanthus collinus*. Mean copper value for the entire station stands at 256. 9 ppm. With regard to other basemetals, the ranges were 40 75 ppm (60.7 ± 9.5) in case of lead; 10 35 ppm (21.0 ± 7.2) in case of zinc; 25 100 ppm (63.6 ± 20.1) for nickel and below 10 ppm for cadmium. In the vegetation analysis, as many as 40 species occurred in this station. However, only few, namely, *Shorea robusta, Holarrhena antidysenterica* and *Diospyros melanoxylon* made significant presence in terms of numbers. Some had restricted presence either in the first fifty meter stretch such as *Croton roxburghii, Madhuca indica* and *Pterocarpous marsupium*. While some were restricted to latter part, such as *Buchanania lanzan, Syzygium cumini* and *Ichnocarpous frutiscence. Acacia torta* and *Morinda pubescens* occupied all through the station evenly but in lower numbers.

Station 4: Purple arkosic quartzite is the main rock type of the area. The soil copper values in the beginning of the station showed a figure of 290 ppm (CHP3/3/37). The figures obtained for various soil samples in this zone varied greatly and showed a range from 135 ppm (CHP3/3/54) close to *Acacia torta* to 985 ppm (CHP3/3/45) close to *Syzygium cumini*. Mean copper value for the entire station stands at 462.5 ppm. With regard to other basemetals, the ranges were 20 80 ppm (30 ± 19.3) for lead; 5 30 ppm (11.6 ± 7.1)for zinc; 10 90 ppm (23.5 ± 20.5) for nickel and around 10 ppm (9.3 ± 3.1) for cobalt. In the vegetation analysis, a total of 38 species were recorded in the entire station and *Acacia torta* dominated the entire stretch followed by *Croton roxburghii* and *Shorea robusta*. Other species that form significant presence include *Cleistanthus collinus* and *Holarrhena antidysenterica*.

Station 5: Rock types occur in this station include purple arkosic quartzite, conglomerate and quartz-chlorite biotite schist. Soil copper level in the beginning of the station showed a value of 180 ppm (CHP3/4/57). But the samples collected from various locations in this zone showed a range from 165 ppm (CHP3/4/62) close to *Cassine glauca* to 1010 ppm (CHP3/4/74) close to *Smilax ovalifolia*. Soils samples close to *Combretum decandrum* (950 ppm), *Wendlandia tinctoria* (640 ppm) and *Areca lannata*(600 ppm) also showed high values. Mean copper value of the entire station stands at 415.6 ppm. With regard to other basemetals the figures were quite low and the values were around 20 ppm in case of lead and zinc while the values were slightly higher for nickel and cobalt which showed ranges 10 - 150 ppm (43.5 ± 40.1) for nickel and 10 60 ppm (28.8 ± 18.4) for cobalt respectively. In the vegetation analysis, a total of 41 species were recorded in this station. However, only few namely *Shorea robusta, Holarrhena antidysenterica* and *Diospyros melanoxylon* form significant presence in terms of numbers. Some have restricted their presence either in the first part of the station such as *Croton roxburghii, Madhuca indica* and *Pterocarpus marsupium* or in the latter part such as *Buchanania lanzan, Syzygium cumini* and *Ichnocarpus frutescens. Acacia torta* and *Morinda pubescens* occupy all through the stretch but in quite lower numbers.

Station 6: Quartz-chlorite biotite schist and quartzite occurred in this zone. Copper values in the beginning of the station were high (1000 - 1075 ppm; CHP3/5/75 & 76). The values obtained for the soils collected from different locations varied greatly. Thus, soil in the first part of the station (first 50 m) close to *Acacia torta* and *Terminalia crenulata* showed values of 915 ppm (CHP3/5/77) and 605 ppm (CHP3/5/78) respectively. These figures run into percentages as one proceeds towards station 7. Soil close to *Syzygium cumini*(CHP3/5/89), *Combretum decandrum* (CHP3/5/88) and *Anogeissus latifolia* , all showed more than 0.1% of copper in their soils. Mean copper value stands at 2894.2 ppm. Thus, very high level of standard deviation was recorded in this station. With regard to other basemetals, the values were quite low and the ranges were 20 55 ppm (30.0 ± 13.2) in case of lead; 5 45 ppm (24.3 ± 9.8) for zinc and 10 80 ppm (47.0 ± 20.9) in case of cobalt. The values for nickel were relatively higher and exhibited values showing a range from 175 530 ppm with a mean of 292.5 ± 111.2. The most dominant plants of this station include *Nyctanthes arbortristis, Hyptis suaveolens* and *Acacia torta*. *Shorea robusta* occupied in lower numbers through out the stretch. Some plants such as *Litsea polyantha, Lagerstroemia parviflora* and *Diospyros embriopteris* occupy only second part of the sampling belt.

Station 7: Quartzite is the main rock type of this station. Soil copper values showed very high figures in the beginning of the stretch with a value of 1.3% (CHP3/6/91). However, values obtained for different locations of this station were variable. Thus, figures for soil samples collected close to *Nyctanthes arbortristis* (CHP3/6/97), *Aegle marmelos* (CHP3/6/99) and *Acacia torta* (CHP3/6/100) and *Cleistanthus* *collinus* (CHP3/6/106) are below 1000 ppm. While, the values obtained close to *Shorea robusta* (CHP3/6/94), *Terminalia crenulata* (CHP3/6/95), *Croton roxburghii* (CHP3/6/96) and *Anogeissus latifolia* (CHP3/6/101) were above 1000 ppm. Mean copper value for the entire station stands at 1586.0 ppm. High variability among different locations were reflected in the high standard deviation values. With regard to other basemetals, the values were low and a range from 20 ppm to 70 ppm (32.7 ± 11.7) for lead; 10 40 ppm (28.4 ± 5.8) for zinc; 155 590 ppm (319.8 ± 128.2) for nickel and 10 80 ppm (44.0 ± 16.4) for cobalt. In the vegetation analysis, *Croton roxburghii*, *Grewia tiliaefolia* and *Flueggia obovata* dominated the entire stretch. *Anogeissus latifolia* occurs in the entire stretch in low numbers while *Nyctanthes arbortristis* occupies both in the beginning and end of the zone. *Acacia torta* was restricted to only first part of the stretch.

Station 8: The quartzite constitute this stretch with soil copper level fluctuating from 195 ppm to 360 ppm. At field point '7' soil copper value was recorded at 315 ppm. Highest soil copper level was recorded close to *Acacia torta* (360 ppm) followed by samples collected close to *Anogeissus latifolia* (325 ppm) and *Miliusa velutina* (310 ppm). Mean copper value for the entire station stands at 265.8 ppm. With regard to other basemetals, the ranges were below 20 ppm to 55 ppm (34.4 ± 10.7) for lead; 30 - 65 ppm (46.6 ± 10.1) for zinc; 65 300 ppm (111.6 ± 46.9) for nickel; 35 95 ppm (70.8 ± 23.5) for cobalt and below 20 ppm for chromium. In the vegetation analyses, *Grewia tiliaefolia* occurs uniformly throughout the station. While *Hyptis suaveolens* and *Cymbopogon martini* occur dominantly in the second part of the station.

Station 9: Quartzite is exposed in the initial 20 meters length of the station and the remaining part is covered with rolled quartzitic boulders. At field point '8' copper level was recorded at 290 ppm (CHP3/8/312). Copper level at various locations varied narrowly in this station and the highest recorded was close to *Acacia torta* with a value of 380 ppm followed by *Anogeissus latifolia* with a value of 370 ppm. Mean copper level for the entire station stands at 231.9 ppm. With regard to other elements, the values were less and fluctuated from 20 45 ppm (24.8 ± 8.9) for lead; 35 65 ppm (51.3 ± 10.6) for zinc ; 30 100 ppm (64.8 ± 20.4) for nickel; 25 65 ppm (43.9 ± 12.6) for cobalt and below 20 ppm in case of chromium. In the vegetation studies, like *Cymbopogon martini*, *Morinda pubescens* and *Acacia torta* dominated in the first part while in the later part, species namely, *Grewia tiliaefolia*, *Diospyros melanoxylon*, *Anogeissus latifolia* and *Nyctanthes arbortristis* dominated.

Station 10: In the beginning of this station, rolled quartzite boulders cover the ground while in the later part quartz-chlorite biotite schist is exposed. At field point '9', soil copper value was recorded at 110 ppm (CHP3/9/339). Values estimated at various locations were low with a maximum figure of 165 ppm (CHP3/9/350) recorded close to *Diospyros melanoxylon* followed by 160 ppm (CHP3/9/351) close to *Miliusa velutina*. Mean copper value stands at 117.0 ppm. With regard to other basemetals, the values showed a range from 20 70 ppm in case of lead (41.9 ± 14.4); 30 - 50 ppm (38.9 ± 5.9) in case of zinc ; 75 195 ppm (148.9 ± 32.4) in case of nickel; 25 70 ppm (50.3 ± 14.9) in case of cobalt and below 20 ppm in case of chromium. Species of *Grewia tiliaefolia* dominated the entire stretch followed by *Anogeissus latifolia* and *Cleistanthus collinus*. *Croton roxburghii* dominated close to the station point '10'.

Station 11: Between field points '10' and '11', rock exposures are of quartz-chlorite biotite schist, basalt and metaultramafic. At field point '10', copper level showed a value of 205 ppm (CHP3/10/352). The soil samples close to various species showed a variation from 158 ppm (CHP3/10/359) close to *Anogeissus latifolia* to 210 ppm (CHP3/10/355) close to *Terminalia crenulata*. Mean copper value stands at 182.4 ppm. The values for other basemetals showed a range from 30 55 ppm (44.5 ± 8.9) in case of lead ; 35 45 ppm (40.8 ± 3.3)in case of zinc ; 75 195 ppm (172.8 ± 31.0) in case of nickel and 20 45 ppm (29.0 ± 8.0) in case of cobalt. Chromium values were less than 20 ppm in most of the cases. The species namely, *Diospyros melanoxylon*, *Nyctanthes arbortristis* and *Cleistanthus collinus* dominated the entire station while *Croton roxburghii* dominated in the later part of the station.

Station 12: Meta ultramafic and massive basalt occupy this stretch. Copper level at field point '11' was 150 ppm (CHP3/11/365). However, soil samples of this station showed figures between 165 ppm (CHP3/11/371) close to *Buchanania lanzan* and 320 ppm (CHP3/11/374) close to *Shorea robusta*. Mean copper value recorded was 243.5 ppm. With regard to other basemetals, the figures fluctuated between 20 and 55 ppm (23.8 ± 10.9) in case of lead; 20 to 35 ppm (25.9 ± 4.9) in case of zinc; 120 to 310 ppm (186.5 ± 68.0) in case of nickel; 20 215 ppm (58.5 ± 32.9) in case of cobalt and 10 to 215 ppm (125.3 ± 54.1) in case of chromium. Vegetation analysis showed the dominance of *Cleistanthus collinus* followed by *Holarrhena antidysenterica* and *Croton roxburghii*. Among the trees, *Terminalia arjuna* was restricted to first 60 meters of the stretch while *Diospyros melanoxylon* appeared all over.

Station 13: This stretch is constituted by basalt (massive) entirely. At field point '12,' the copper level stands at 160 ppm. However, values of copper vary in the entire stretch from 85 ppm (close to *Diospyros melanoxylon* to 175 ppm close to *Terminalia crenulata*. Mean copper value stands at 125.3 ppm. With regard to other basemetals, the fluctuations range from 25 to 35 ppm (29.6 ± 2.9) in case of zinc; 90 125 ppm (113.9 ± 11.0) in case of nickel; 40 65 ppm (51.8 ± 8.9) in case of cobalt and 75 230 ppm (109.6 ± 37.9) in case of chromium. Plant distribution in this zone was dominated by *Anogeissus latifolia, Holarrhena antidysenterica, Diospyros melanoxylon* and *Cleistanthus collinus*. *Soymida febrifuga* occurs sporadically in the first 50 meters of the station. While *Terminalia crenulata* restricted to later part of the station.

Station 14: The rocks are basalt (massive) and meta ultramafic in this stretch. Soil copper level at field point'13' showed a value of 75 ppm. However, soils in this stretch exhibited a range from 85 ppm close to *Cleistanthus collinus* to 245 ppm close to *Cassia fistula*. Mean copper value for the entire station stands at 137.1 ppm. The fluctuations were narrow for other basemetals and showed a variation from 25 50 ppm (27.6 ± 7.3) for zinc; 115 165 ppm (136.6 ± 16.9) for nickel; 45 60 ppm (53.8 ± 4.6) for cobalt and 80 - 145 ppm (109.5 ± 16.2) for chromium. About 28 species were recorded in this station with *Holarrhena antidysenterica, Diospyros melanoxylon, Terminalia crenulata*, and *Cleistanthus collinus* dominating all through. The presence of *Shorea robusta* was restricted to later part of the station.

Station 15: Meta ultramafic rock covers the entire stretch. Soil copper level at field point '14' showed a value of 140 ppm (CHP3/14/406). Soil copper level estimated close to various dominant species showed a range from 85 ppm (CHP3/14/412) close to *Syzygium cumini* to 145 ppm (CHP3/14/413) close to *Shorea robusta*. Mean copper value stands at 112.9 ppm. The fluctuations were narrower for other basemetals showing a range from 25 35 ppm (29.6 ± 3.2) for zinc; 120 295 ppm (153.3 ± 63.8) for nickel; 55 - 90 ppm (66.6 ± 11.1) for cobalt and 60 210 ppm (97.9 ± 51.9)for chromium. Tree species namely, *Shorea robusta, Diospyros melanoxylon* and *Anogeissus latifolia* dominated the entire station. In the shrubs, *Cleistanthus collinus* and *Holarrhena antidysenterica* showed dominance over other species. *Croton roxburghii* occurred throughout the station but in lower numbers.

Station 16: Meta ultramafic, biotite-chlorite schist and metabasic/metabasalt occupied the zone. This zone is partly intercepted with disturbed soil. Soil copper at field point '15' was 70 ppm (CHP3/15/415).

While the estimated copper levels at various sites close to different species showed a range from 60 ppm (CHP3/15/416) close to *Lantana camara* to 110 ppm (CHP3/15/419) close to *Diospyros melanoxylon* and *Holoptelea integrifolia*. Mean copper value of the station stands at 90 ppm. With regard to other metals, the ranges were 20 30 ppm (24.2 ± 3.4) for zinc; 110 160 ppm (145.4 ± 14.5) for nickel; 35 60 ppm (47.1 ± 8.0) for cobalt and 125 260 ppm (200.8± 39.5) for chromium In the vegetation analysis, *Diospyros melanoxylon* dominated the entire station followed by *Shorea robusta*. Among the shrubs, *Cleistanthus collinus* and *Lantana camara* dominated this station.

Station 17: In this zone the rock types include meta basic/ metabasalt and metaultramafic. At field point '16' (CHP3/16/422) copper level was 115 ppm. Copper values close to some dominant species showed a range from 85 ppm (CHP3/16/426) close to *Holarrhena antidysenterica* to 100 ppm (CHP3/16/425) close to *Buchanania lanzan*. Mean copper value for the entire station stands at 95 ppm. The fluctuations for other metals were 25 30 ppm (29.0 ± 2.0) for zinc; 115 165 ppm (134.0 ± 14.9) for nickel; 50 75 ppm (66.0 ± 8.6) for cobalt and 165 300 ppm (211.0 ± 46.2) for chromium. Much area was disturbed in this zone and occupied by cultivated land. However, in the trees, *Diospyros melanoxylon* and *Schleichera oleosa* and in the herbs, *Andrographis paniculata* dominate in their presence.

Station 18: Metabasic/ metabasalt rocks occupy this zone. The soil copper level at station point '17' was recorded at 65 ppm. The figures in other locations of the station showed narrow variations and slightly exceeded 100 ppm. Thus, the range recorded 70 ppm close to *Madhuca indica* and 105 ppm close to *Diospyros melanoxylon* Mean copper value stands at 90 ppm for the entire station. The ranges for other metals were 25 40 ppm (35.0 ± 5.3) for zinc; 95 140 ppm (120.7 ± 18.0) for nickel; 60 90 ppm (70.0 ± 13.1) for cobalt and 125 230 ppm (177.1 ± 46.2) for chromium. Lead values were around 20 ppm. With regard to vegetational analysis, *Schleichera oleosa* and *Diospyros melanoxylon* were among the dominant trees and *Holarrhena antidysenterica* among the shruby species. In the ground flora, *Evolvulus alsinoides* dominated while *Andrographis paniculata* restricted its presence in the first fifty metres of the zone.

Station 19: Rock types that occur in this zone is similar to the previous station. At field point '18', soil copper level was recorded at 95 ppm (CHP3/18/431). There was not much variation in the copper level in different locations of this station and showed a range from 70 -90 ppm. Mean copper value stands at

82.5 ppm. With regard to other basemetals, the values were quite low in case of lead and zinc while significantly high values were recorded for nickel, cobalt and chromium. The value ranges were 20 ppm for lead; 35 40 ppm (39.2 ± 1.9) for zinc; 60 75 ppm (65.8 ± 5.3) for cobalt, 145 305 ppm (255.0 ± 53.8) for nickel and 265 375 ppm (347.5 ± 42.0) for chromium. This zone is partly intercepted with cultivated land. Similar to previous station, *Schleichera oleosa* is the dominant among trees followed by *Diospyros melanoxylon* and *Holarrhena antidysenterica*. In the ground flora high incidence of *Evolvulus alsinoides* was noted.

Station 20: In the beginning of this station, exposures of metaultramafic rocks appear while in the latter part of the zone metabasic/metabasalt occurred. At field point '19', soil copper level was recorded at 110 ppm (CHP3/19/435). However, the soil copper levels collected close to different species were still lower and showed a range from 60 ppm (CHP3/19/439) close to *Butea frondosa* to 100 ppm (CHP3/19/440) close to *Holoptelea integrefolia*. Mean copper value stands at 79.3 ppm. For other basemetals, 30 45 ppm (36.5 ± 5.5) for zinc; 65 310 ppm (160.3 ± 88.9) for nickel; 30 75 ppm (52.8 ± 13.6) for cobalt and 105 975 ppm (410.3 ± 331.5) for chromium. The dominant shrubs showed in this zone were *Cleistanthus collinus* and *Holarrhena antidysenterica*. In the tree species, *Schleichera oleosa* dominates others.

Station -1: Exposure of Chlorite-biotite schist constitutes this zone. Soil samples of this station showed variation for copper and showed a range from 277 - 1400 ppm. Highest value of 1400 ppm was recorded in a soil sample collected close to *Hyptis suaveolens*, *Anogeissus latifolia* and *Terminalia crenulata*. Mean copper value stands at 858.2 ppm. With regard to other metals, the ranges were 15 30 ppm (24.6 ± 4.3) for zinc; 56 - 625 ppm (354.1 ± 247.6) for nickel; 22 112 ppm (67.9 ± 37.0) for cobalt; 43 400 ppm (202.9 ± 181.6) for chromium and 200 466 ppm (375.1 ± 87.5) for manganese. *Hyptis suaveolens* is the dominant species in this stretch followed by *Cleistanthus collinus*, *Holarrhena antidysenterica* and *Andrographis paniculata*. Tree species like *Shorea robusta* and *Diospyros melanoxylon* also occurred in good numbers in this station.

Station -2: Rock types encountered in this station were quartz- sericite schist and soil copper level at field point '-1' stands at 246 ppm (CHP3/-1/455). Different locations of this station exhibited a range from 215 ppm (CHP3/-1/467) close to *Mitragyna parvifolia* to 584 ppm (CHP3/- 1/463) close to *Croton* *roxburghii*. Mean copper value for the station stands at 351.6 ppm. With regard to other metals, 13 19 ppm (15.9 ± 2.2) in case of zinc; 43 83 ppm (66.1 ± 12.9) for nickel; 19 40 ppm (26.1 ± 5.2) for cobalt and 113 340 ppm (239.4 ± 65.8) for manganese. The dominant species include *Grewia tiliaefolia, Holarrhena antidysenterica, Cleistanthus collinus* and *Hyptis suaveolens. Andrographis paniculata* and *Sida longifolia* occur in the latter part of the stretch. While *Morinda pubescens* and *Croton roxburghii* appear in the middle portion of the station.

Station -3: This stretch is mainly constituted by quartzite and the soil copper value at the field point '-2' is 492 ppm (CHP3/-2/472). Different locations in this station showed a range from 215 ppm (CHP3/-2/480) close to *Croton roxburghii* to 492 ppm (CHP3/-2/472) close to *Miliusa velutina*. Mean copper value for the entire station stands at 350.8 ppm. The values were quite low for other metals and showed a range from 23 48 ppm (31.2 ± 7.6) for zinc; 50 138 ppm (85.5 ± 23.5) for nickel and 26 54 ppm (43.7 ± 7.7) for cobalt. Values for manganese were quite higher even when compared with copper figures and showed a range from 400 866 ppm and with a mean value of 745.8 ± 128.0 ppm. In the phytosociological studies *Grewia tiliaefolia* dominated the entire stretch. While *Hyptis suaveolens* occurred in large numbers in the first fifty meters while *Holarrhena antidysenterica* and *Cleistanthus collinus* showed lower numbers throughout the station.

Station -4: This stretch was constituted by quartzite-sericite schist and garnetiferous mica schist/mica schist. Soil copper level at field point '-3' stands at 277 ppm (CHP3/-3/483). However, there was significant variation in copper level at various locations and the figures showed a range from 50 ppm (CHP3/-3/494) close to *Gardenia gummifera* to 400 ppm (CHP3/- 3/484) close to *Lannea coromandelica*. Mean copper value for the entire station stands at 213.2 ppm. With regard to other metals as in the previous station, the values were low except for manganese. The ranges exhibited were 21 - 52 ppm (29.1 ± 7.8) for zinc; 20 58 ppm (41.7 ± 10.6) for nickel; 20 35 ppm (24.9 ± 4.3) for cobalt and 15 45 ppm (19.2 ± 17.9) for chromium. In case of manganese, the value range stands between 270 ppm and 665 ppm with mean of 397.2 ± 131.3 ppm. As for the vegetation analysis was concerned, *Holarrhena antidysenterica* was recorded in maximum numbers followed by *Cleistanthus collinus. Woodfordia fruticosa, Lantana camara* occur only in the latter half.

Station -5 to -20: The stretch is entirely of garnetiferous mica schist/ mica schist except at two locations, one at station -8 and the other at station -9 metabasic/ metabasalt rocks appear. Soil copper levels were quite low in all the stations with mean copper levels in majority cases stand below 100 ppm. Mean copper values range from 58 ppm at station 11 to 202.8 ppm at station -7. The values were low for other elements and below 100 ppm in many instances. In case of zinc, the mean value range stands between 23.0 ± 2.4 ppm at station -7 and 72.8 ± 16.3 ppm at station -9. In case of nickel the values were slightly higher with 33.8 ± 3.6 ppm at station -10 to 79.2 ± 38.9 ppm at station -9. The values for cobalt ranged from 11.7 ± 2.4 ppm at station -10 to 28 ± 7.5 ppm at station -8. In case of chromium, the values were in between 33.1 ± 9.2 ppm at station -5 and 111.7 ± 79.4 ppm at station -9. In the vegetational studies, *Evolvulus alsinoides* dominated between stations -15 and -20, and also at station -13. *Woodfordia fruticosa* dominated in station -5 and -7. While in the remaining stations, *Polygonum plebejum*, and *Blumea oxyodonta* dominated.

TABLE 2 . SUMMARY OF DOMINANT SPECIES, GEOLOGY AND MEAN COPPER DISTRIBUTION IN SIDHESAR TRAVERSE

TABLE 2 - SUMMARY OF DOMINANT SPECIES, GEOLOGY AND MEAN COPPER DISTRIBUTION IN SIDHESAR TRAVERSE

SL. NO.	STATION NO.	MIN (CU)	MAX (CU)	MEAN (CU)	SD (CU)	LITHOLOGY	DOMINANT SPECIES	CO-DOMINANTS	NO.OF SPECIES	TOTAL PLANT STRENGTH
1.	-20	31	41	38.6	3.82		EVOLVULUS ALSINOIDES (0.79)	BLUMEA OXYODONTA (0.18)	4	158
2.	-19	24	200	76.55	55.70		-DO- (0.34)	BLUMEA OXYODONTA (0.33), LIPPIA NODIFLORA (0.28)	4	94
3.	-18	55	125	81.66	25.11		-DO- (0.58)	ANISOCHILUS CARNOSUS (0.22), BLUMEA OXYODONTA (0.12)	7	160
4.	-17	60	125	75	20.87	Mica schist (sometimes garnetiferous/quartzitic)	-DO- (0.55)	-DO- (0.22), -DO- (0.19)	9	161
5	-16	50	115	75	24.74		-DO- (0.64)	TRIDAX PROCUMBENS (0.21)	7	114
6	-15	40	190	86.66	49.21		-DO- (0.61)	LIPPIA NODIFLORA (0.20), TRIDAX PROCUMBENS (0.19)	4	157
7	-14	55	260	130	77.54		BLUMEA OXYODONTA (0.40)	-DO- (0.30), ZIZYPHUS JUJUBA (0.28)	5	87
8.	13	40	110	72.5	24.36		EVOLVULUS ALSINOIDES (0.40)	BLUMEA GLOMERATA (0.28), TRIDAX PROCUMBENS (0.24)	7	161
9	-12	45	100	70.83	18.57		POLYGONUM PLEBEJUM (0.41)	EVOLVULUS ALSINOIDES (0.39)	7	211
10.	-11	50	240	89.61	46.38		EVOLVULUS ALSINOIDES (0.26)	DIOSPYROS MELANOXYLON (0.09), LANTANA CAMARA (0.20)	21	528
11	10	35	80	58	16		-DO- (0.38)	LANTANA CAMARA (0.25)	21	515
12.	-9	55	170	107.14	36.23		LANTANA CAMARA (0.28)	EVOLVULUS ALSINOIDES (0.23)	27	268
13.	-8	50	120	79.16	28.05		HOLARRHENA ANTIDYSENTERICA (0.15)	WOODFORDIA FRUTICOSA (0.14), LANTANA CAMARA (0.14)	31	412
14.	-7	60	855	202.85	267.27	Basalt	WOODFORDIA FRUTICOSA (0.17)	LANTANA CAMARA (0.16), HOLARRHENA ANTIDYSENTERICA (0.15)	31	401
15.	-6	50	120	83.12	23.44	Mica schist	-DO- (0.19)	DIOSPYROS MELANOXYLON (0.13), -DO- (0.10)	27	352
16.	-5	35	115	82.5	24.23	-do-	-DO- (0.20)	-DO- (0.12), HYPTIS SUAVEOLENS (0.10),	28	416
17	-4	50	400	214.81	81.25	-do-	HOLARRHENA ANTIDYSENTERICA (0.16)	LANTANA CAMARA (0.12), WOODFORDIA FRUTICOSA (0.08)	36	395
18.	-3	215	492	368.7	87.01	-do-	HYPTIS SUAVEOLENS (0.27)	GREWIA TILIAEFOLIA (0.18), CROTON ROXBURGHII (0.07)	39	569
19	-2	215	584	325.88	113.53	Quartzite	-DO- (0.25)	GREWIA TILIAEFOLIA (0.17), HOLARRHENA ANTIDYSENTERICA (0.11)	38	477
20.	-1	277	1400	804.12	405.67	Quartz-Sericite schist	-DO- (0.28)	CLEISTANTHUS COLLINUS (0.14), HOLARRHENA ANTIDYSENTERICA (0.12)	37	582
21	1	510	32700	4493.07	8221.77	Chlorite-biotite schist	-DO- (0.22)	BLUMEA OXYODONTA (0.17), HOLARRHENA ANTIDYSENTERICA (0.11)	22	287
22.	2	175	3500	987.66	879.95	Micaceous quartzite	CROTON ROXBURGHII (0.72)	NYCTANTHES ARBORTRISTIS (0.02), SHOREA ROBUSTA (0.06)	27	1115
23.	3	150	425	252.27	94.42	Conglomerate	-DO- (0.14)	CLEISTANTHUS COLLINUS (0.11), SHOREA ROBUSTA (0.11)	26	369

24.	4	135	3255	482.5	670.65	Purple arkosic sandstone	SHOREA ROBUSTA (0.15)	CROTON ROXBURGHII (0.13), ACACIA TORTA (0.20)	39	459
25.	5	165	1010	436.11	248.30	Quartz-chlorite biotite	DIOSPYROS MELANOXYLON (0.19)	HYPTIS SUAVEOLENS (0.15), ACACIA TORTA (0.09)	31	585
26.	6	685	9700	2385.98	2949.48	Quartz-Chlorite mica schist	HYPTIS SUAVEOLENS (0.17)	NYCTANTHES ARBORTRISTIS (0.08), ACACIA TORTA (0.09)	31	323
27.	7	40	13700	2134.51	3385.59	Quartzite	CROTON ROXBURGHII (0.18)	GREWIA TILIAEFOLIA (0.16), COMBRETUM DECANDRUM (0.13)	40	384
28.	8	110	3455	480.8	424.95	-do-	HYPTIS SUAVEOLENS (0.23)	CYMBOPOGON MARTINI (0.21), GREWIA TILIAEFOLIA (0.15)	35	331
29.	9	110	2155	335.31	477.56	-do-	CYMBOPOGON MARTINI (0.28)	GREWIA TILIAEFOLIA (0.19), ANISOCHILUS CARNOSUS (0.10)	29	218
30.	10	95	1255	161.04	228.88	Rolled quartzite boulders	GREWIA TILIAEFOLIA (0.20)	CROTON ROXBURGHII (0.18), ANOGEISSUS LATIFOLIA (0.14)	22	224
31.	11	150	210	183.53	18.10	Basalt	CLEISTANTHUS COLLINUS (0.15)	DIOSPYROS MELANOXYLON (0.14), CROTON ROXBURGHII (0.10)	26	276
32.	12	150	3055	384.16	649.47	Basalt	ANOGEISSUS LATIFOLIA (0.12)	HOLARRHENA ANTIDYSENTERICA (0.11), CLEISTANTHUS COLLINUS (0.08)	44	453
33.	13	85	1355	258.8	366.96	Basalt	-DO- (0.21)	-DO- (0.20), DIOSPYROS MELANOXYLON (0.14)	23	257
34.	14	75	955	203.07	224.56	Meta-ultra-mafic	HOLARRHENA ANTI-DYSENTERICA (0.33)	ANOGEISSUS LATIFOLIA (0.12), -DO- (0.16)	28	432
35.	15	45	1155	223.88	330.11	-do-	SHOREA ROBUSTA (0.40)	TERMINALIA TOMENTOSA (0.09), -DO- (0.15)	33	454
36.	16	60	110	86.42	18.65	Meta-basalt	LANTANA CAMARA (0.25)	EVOLVULUS ALSINOIDES (0.22), TRIDAX PROCUMBENS (0.14)	18	177
37	17	85	1155	306	424.52	Meta-basic	-DO- (0.25)	-DO- (0.12), DIOSPYROS MELANOXYLON (0.22)	17	242
38.	18	65	105	83.75	16.72	-do-	-DO- (0.27)	-DO- (0.19), -DO- (0.13)	16	377
39.	19	70	95	83.75	9.60	Meta-basalt	-DO- (0.39)	HOLARRHENA ANTIDYSENTERICA (0.14), -DO- (0.14)	16	322
40.	20	60	110	78	16.76	Debris of quartzite and meta-basalt	-DO- (0.17)	-DO- (0.15), CROTON ROXBURGHII (0.16)	32	318

Note: Values in parentheses are relative densities of respective species.

T2 BELT TAMAPAHAR TRANSECT

A sampling belt of 1 line kilometer was selected close to Jublitola village as a part of orientation survey for the targeted 11 line km belt in Singhbhum belt. This belt has 20 meters width and the area is known for uranium enriched substrate. Atomic Minerals Division(AMD) established its office close to this village. The 0' point of this transect is fixed in N-E direction of the office. This point is surrounded by cultivated and alluvial land. This belt runs S45°W for 1 line kilometer and a variety of rock types appear in the following order.

Basalt

Talc-tremolite schist

Metabasalt

Chlorite biotite schist

Chlorite biotite quartz schist

-grading (upwards to quartzite)

Chlorite-biotite schist

Tremolite-talc schist

Quartz chlorite-biotite schist

Quartzite

Ferrugineous cherty quarzite

Quartz mica schist.

Sampling belt was divided into ten sites, each site having 100 meters length and 20 meters width, thus having an area of 2000 square meters. Each site is a rectangular grid and vegetation studies were taken up at 10 meter intervals on line transects of 20 meters length across this grid. Thus at each site, 10 sampling units were studied to know the community composition and dominant species. In total, 85 line transects were studied for this belt.

There is a variation in the profile of sampling zone, the highest point was recorded at site 6 with a value of 160 meters and the lowest point was recorded at site 10 with a value of 100 meters above mean sea level. Mineralization occurs between sites 2 and 5 and also at site 8 while the remaining sites are barren or partially barren.

Plant distribution along the sampling belt

In the phytosociological studies vegetation analysis was carried out in detail in each of these sites and each site as stated, has about 100 meter length and 20 meter width. Site 1 is the area covered between

FIG : 3 PROFILE SECTION OF TAMAPAHAR BELT

SCALE :- HORIZONTAL 1:5000
VERTICAL 1:1000

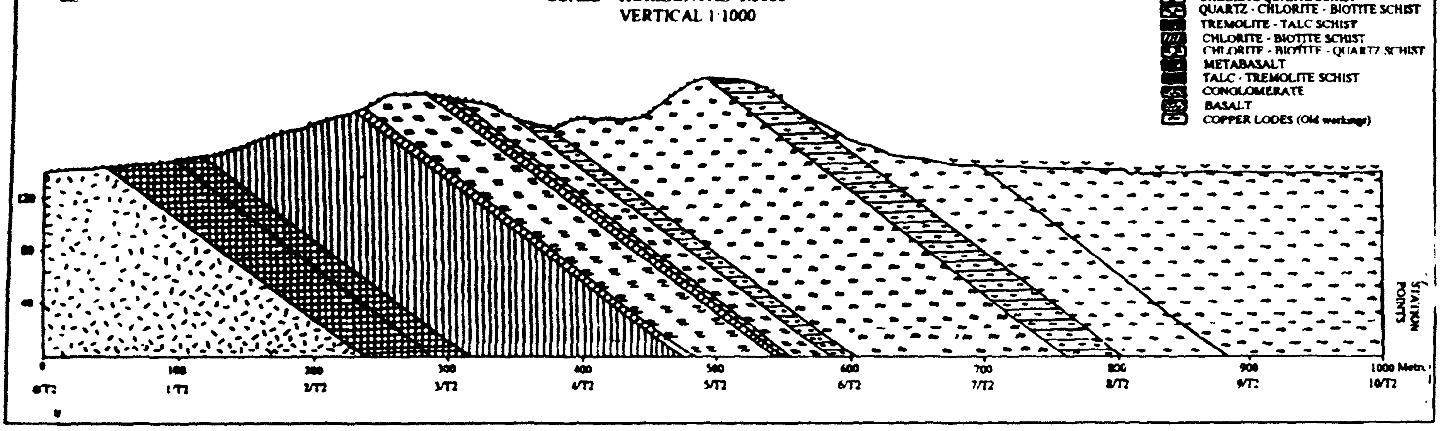
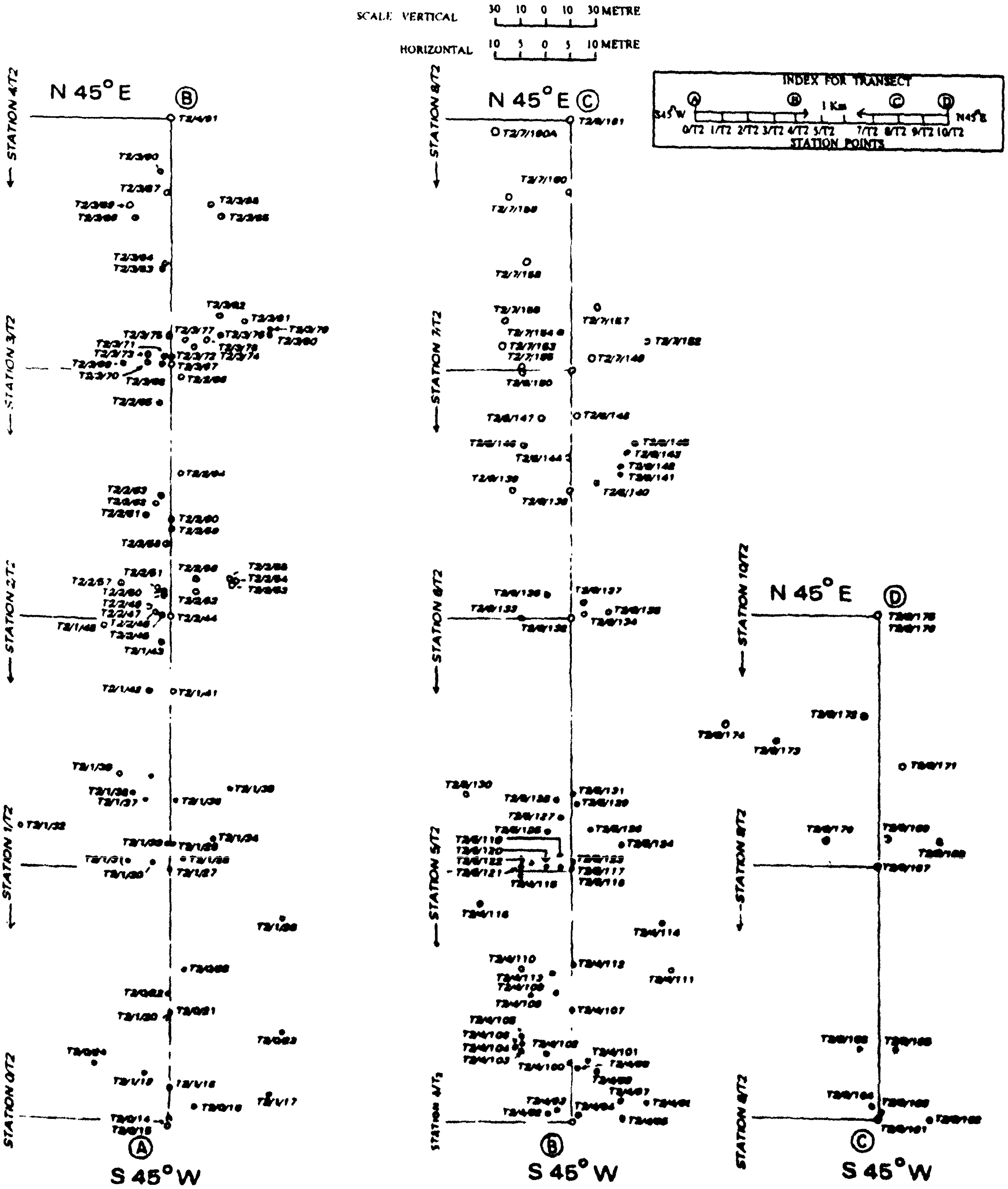


Fig:4 SAMPLE LOCATION MAP ALONG TAMAPAHAR TRANSECT



'0' and '1' sampling points, in a similar way site '2' is represented by the area between points '1' and '2' and so on.

Site 1: This zone is with basalt and conglomerates and the soil copper level in the initial point showed a value of 237 ppm (T2/0/14 or 15). However, values in different locations showed a range from 730 ppm collected close to *Adina cordifolia* to 193 ppm collected close to *Diospyros melanoxylon*, (T2/o/16). Mean value for the entire site stands at 325.8 ppm. With regard to other base metals, the values were relatively low and showed a range of 25-50 ppm (39.7 ± 8.6) for lead; 27-50 ppm (39.8 ± 7.2) for zinc; 97-177 ppm (133.5 ± 24.1) for nickel; 45-89 ppm (63.9 ± 14.1) for cobalt and less than 5 ppm in case of cadmium. Chromium and silver were recorded in trace levels As for the plant composition is concerned about 9 species were recorded and *Lantana camara* is found dominant followed by *Holarrhena antidysenterica*. Among other species *Croton bonplandianum*, *Euphorbia heyneana* and *Scoparia dulcis* occur in good numbers. In the tree species, *Diospyros melanoxylon* dominated the entire stretch.

Site 2 : Here the rock type that occur include conglomerate, talctremolite schist and metabasalt. This site falls under mineralised zone and the soil copper level in the beginning of the site stands at 840 ppm (T2/1/27). Still higher values were noticed for soil samples which were collected close to various dominant species. Thus, values as high as 2232 ppm (T2/1/40) close to *Adina cordifolia*; 4275 ppm (T2/1/5) close to *Terminalia belerica* and 2341 ppm (T2/1/36) close to *Terminalia crenulata* and *Hyptis suaveolens* were recorded. Lowest values of 215 ppm (T2/1/31) was recorded from soil sample collected from *Cassia fistula*. Mean copper value stands at 1283.6 ppm. With regard to other elements, the ranges were 33-66 ppm (44.4 ± 8.5) for lead; 23-50 ppm (41.3 ± 6.8) for zinc; 45-141 ppm (81.8 ± 22.6) for cobalt; 138-350 ppm (183.4 ± 63.7) for nickel and less than 5 ppm in case of cadmium. Only traces of chromium and silver were recorded. Twenty seven species were recorded in this stretch and the dominant of them being *Cleistanthus collinus*, *Hyptis suaveolens* and *Holarrhena antidysenterica*. *Alysicarpus vaginalis*, *Boerhavia repens* and *Indigofera linifolia* also occur in good numbers. The occurrence of *Mitragyna parvifolia* and *Nyctanthes arbortristis* was restricted to first 50 meters of the site. Among the tree species *Diospyros melanoxylon* and *Butea superba* occur.

Site 3 : Rock types in this stretch include metabasalt,Chlorite biotite schist and Chlorite biotite quartz schist. This site also falls under mineralised zone and the soil copper level in the beginning stands at 377 ppm (T2/2/44). However values of sol copper close to various dominant species are high and a maximum of 1000 ppm (T2/2/66) was recorded close to *Soymida febrifuga*. This was followed by a value of 763 ppm (T2/2/64 and T2/2/665) close to *Randia dumetorum* and *Mitrgyna parviflora* and 686 ppm (T2/2/55) close to *Anogeissus latifolia*. Mean copper value of the entire site stands at 550.4 ppm with a standard deviation of 164.6. With regard to other metals, except for nickel, the values for were quite low and varied from 25 to 75 ppm (46.1 ± 11.7) for lead; 23-668 ppm (30.9 ± 11.1) for zinc; 34- 100 ppm (70.2 ± 16.4) for cobalt and less than 5 ppm in case of cadmium.In case of nickel the values showed wider fluctuations with a range from 150-367 ppm and a mean value of 208.7 ± 47.9 ppm. In the vegetation analyses 26 species were recorded. *Hyptis suaveolens*, *Cleistanthus collinus* and *Holarrhena antidysenterica* dominated the entire stretch. Among other species, *Grangea maderaspatana*, *Phyla nodiflora* and *Tridax procumbens* occur in good numbers. In tree species, *Diospyros melanoxylon* and *Pterocarpus marsupium* are relatively dominant compared to *Nyctanthes arbortristis* and *Anogeissus latifolia*.

Site 4 : A variety of rocks appear in this site and they are chlorite biotite schist, tremolite talc schist, quartz, chlorite biotite schist, quartzite and chlorite quartz schist. This is also a mineralised zone and the soil copper level at point 3' is 779 ppm (T2/3/67). Values estimated for various locations in this site showed great variation and a maximum of 2775 ppm (T2/3/85) close to *Miliusa velutina* was recorded followed by 2675 ppm (T2/3/83) close to *Lantana camara* and 239 ppm (T2/3/90) close to *Lannea coromandelica*. Mean copper value for the entire site stands at 1527.7 ppm. With regard to other metals, the fluctuations are narrow and showed a range of 33 to 83 ppm (54.8 ± 13.8) in case of lead; 27-59 ppm (36.8 ± 7.8) in case of zinc; 48-132 ppm (87.3 ± 18.1) in case of cobalt and less than 5 ppm in case of cadmium. Though the values of nickel were lower compared to copper, the variations were wider and showed a range from 212-483 ppm (367.2 ± 107.9). Values for chromium which were represented as Cr_2O_3 % are much higher at some locations while in others it was recorded in traces. Vegetational studies indicated that about 40 species occur in this site in spite of very high concentration of copper and other elements. The most dominant shrubs in this stretch are *Hyptis suaveolens* followed by *Cleistanthus collinus*, *Holarrhena antidysenterica* and *Andrographis paniculata*. *Dentella repens*, *Evolvulus alsinoides* and *Euphorbia hirta* are some other species which occur in good numbers. Among the trees *Diospyros melanoxylon* dominated.

Site 5 : The entire zone is constituted by Chlorite quartz schist. Soil copper concentration at point '4' is of 1878 ppm (T2/4/91) which is very high compared to the mean value of previous site. However, the values in the soil copper level reduced considerably towards point '5'. Thus a value of 1546 ppm (T2/4/95) was recorded in a soil sample collected close to *Holarrhena antidysenterica*, 403 ppm (T2/4/99) in a sample close to *Sterculia urens* 299 ppm (T2/4/101) in a sample close to *Smilax ovalifolia*, and 124 ppm (T2/4/109) in a sample close to *Adina cordifolia* and 112 ppm close to *Terminalia crenulata*. Mean copper value stands at 498.2 ppm. With regard to other elements, the values are quite low, 25-67 ppm (44 ± 10.7)in case of lead; 13-50 ppm (29.1 ± 15.4) in case of zinc; 47-417 ppm (164.8 ± 106.3) in case of nickel; 25-86 ppm (41.9 ± 16.0) in case of cobalt and less than 5 ppm in case of cadmium. Chromium and silver were recorded in traces. About 37 species were recorded in this site. *Hyptis suaveolens, Cleistanthus collinus and Holarrhena antidysenterica* occur more or less uniformly in the entire site. But species like *Randia dumetorum, Breynia vitis-idaea, Mitragyna parvifolia* and *Erythrina stricta* appear only in the later part of the site where decreasing levels of the copper was noticed. *Sida cordata* and *Andrographis paniculata* exhibit stray occurrence in the entire site.

Site 6 : This area of the sampling zone is with quartzite and ferruginous cherty quartzite. The soil copper level at point '5' is relatively low with a value of 139 ppm. Even the estimated copper level in various samples in this stretch were low and showed a range from 310 ppm close to *Ficus semicordata* to 100 ppm close to *Nyctanthes arbortristis*. Mean copper value stands at 132.5 ppm. Lower levels were recorded for other elements and showed a range from 25 to 50 ppm (41.1 ± 8.0)in case of lead; 27 to 68 ppm (33.8 ± 11.1) in case of zinc; 43 to 70 ppm (58.5 ± 7.3)in case of nickel; 34 to 61 ppm (48.7 ± 7.3) in case of cobalt and less than 5 ppm in case of cadmium. Both chromium and silver recorded in traces. *Andrographis paniculata* dominated the entire belt followed by *Sida cordata. Lantana camara* and *Anisochilus carnosus* were restricted to second half of this station. Among other species, *Mimosa* sp., *Solanum sisymbrifolium, Euphorbia heyneana* and *Mullogo* sp. occur in good numbers.

Site 7 : The rock type that occurs in this zone is of ferruginous cherty quartzite. Site 7 starts with quarzited rocky terrain with thin accumulation of soil in patches. The soil copper level at point '6' (T2/6/132) is low with a value 135 ppm (T2/6/132). Slightly higher values were noticed at various locations of this zone and exhibited a range from 124 ppm (T2/6/50) close to *Calotropis gigantea* to 246 ppm (T2/6/137) close to *Holarrhena antidysenterica*. Mean copper level for the entire site stands at 183.5 ppm With regard to other elements the fluctuations were much narrower with a range from 42 to 75 ppm (56.4 ± 9.3) for lead; 13 to 86 ppm (44.1 ± 15.4) for zinc; 43 ppm to 77 ppm (63.0 ± 9.1) in case of nickel and 25 ppm to 93 ppm (59.2 ± 19.6) for cobalt. Soil cadmium levels were always lower than 5 ppm while chromium and silver occur in traces. With regard to plant distribution, 27 species occur in this site with *Lantana camara* and *Sida cordata* dominating the entire site. While *Cleistanthus collinus, Flueggia obovata,Croton roxburghii* and *Andrographis paniculata* appear prominently in the second part of the sampling belt. *Anisochilus carnosus* restricts its presence in the middle portion of the site.

Site 8 : This stretch of the sampling belt is covered by quartz-mica schist with soil copper at point '7' showed a value of 593 ppm (T2/7/149). Soil copper levels at various locations in this site showed much higher values and the highest being 1986 ppm recorded from soil sample collected close to *Diospyros melanoxylon* (T2/7/153). This was followed by values recorded for samples collected close to *Croton roxburghii* (1671 ppm, T2/7/157) and *Phoenix acaulis* (1395 ppm, T2/7/152). Mean copper value for the entire site stands at 1010.7 ppm. With regard to other basemetals, the ranges are 20 to 75 ppm (41.2 ± 18.8) for lead; 18 ppm to 64 ppm (30.7 ± 13.2) for zinc; 27 to 77 ppm (50.2 ± 16.0) for cobalt and less than 5 ppm in case of cadmium. Chromium and silver were recorded in traces in the entire stretch. However, values for nickel are quite high and showed a range from 20 ppm to 173 ppm(112.0 ± 54.3). 37 species were recorded in this site and dominated by *Hyptis suaveolens, Lantana camara, Holarrhena antidysenterica* and *Sida longifolia*. However, *Evolvulus alsinoides, Atylosia scarabaeoides* and *Andrographis paniculata* restrict their presence in the second part of this station.

Sites 9 and 10 : These two sites of the sampling belt were covered by quartz mica schist and the soil copper values were moderate at points '8' and '9', 81 ppm (T2/8/161) and 96 ppm (T2/9/167) respectively. Even the values for various locations close to different species were low. Thus, at site 9 copper level was recorded 100 ppm close to *Ipomoea carnea*, 80 ppm close to *Holoptelea integrifolia* and 57 ppm close to *Diospyros melanoxylon*. Mean copper value for the entire site stands at 78.5 ppm. With regard to other metals, they are much lower and their mean values were 48.3 ± 14.7 ppm for lead; 21.3 ± 9.9 ppm for zinc; 25.0 ± 6.3 ppm for nickel; 31.0 ± 4.7 ppm for cobalt and less than 5 ppm for cadmium. A total of 16 species were recorded from this site, *Lantana camara* dominate the entire site followed by *Croton bonplandianum, Scoparia dulcis* and *Hybanthus enneaspermus*. At site 10, similar to site 9 showed narrow fluctuations and a value of 51 ppm was recorded close to *Diospyros melanoxylon*, 67 ppm close to *Cassine glauca* and 84 ppm close to *Alstonia scholaris*. Mean value for copper was 75.6

ppm. With regard to other metals, the mean values were 51.0 ± 11.0 ppm for lead; 41.3 ± 19.9 ppm for zinc; 30.9 ± 13.3 ppm for nickel; 32.2 ± 5.6 ppm for cobalt and 5 ppm for cadmium. *Evolvulus alsinoides* dominated the entire stretch followed by *Sida cordata* and *Croton bonplandianum*.

TABLE 3. SITEWISE PRESENTATION OF DOMINANT SPECIES, GEOLOGY, COPPER RANGE AND MEAN COPPER LEVEL IN TAMAPAHAR TRAVERSE

Site	No.of Samples	Soil Copper level (in ppm) min	max	mean	SD	Lithology	Dominant species	No.of species	Total strength
1	14	193	730	336	152.2	Basalt, Conglomerate	*Lantana camara* (0.31) *Diospyros melanoxylon* (0.21) *Cassia fistula* (0.19)	9	188
2	20	215	4275	1283	986.6	Conglomerate Talc tremolite Schist and Metabasalt	*Cleistanthus collinus* (0.44) *Hyptis suaveolens* (0.11)	27	501
3	25	312	1000	575.8	159.8	Metabasalt Chlorite biotite schist	*Hyptis suaveolens* (0.41) *Cleistanthus collinus* (0.21)	26	483
4	29	425	11744	1866.8	1982.0	Chlorite biotite schist, Tremolite talc schist	*Hyptis suaveolens* (0.53) *Cleistanthus collinus* (0.09) *Holarrhena antidysenterica* (0.06)	40	786
5	34	81	1878	526.2	526.2	Chlorite quartz schist	*Hyptis suaveolens* (0.30) *Cleistanthus collinus* (0.21) *Holarrhena antidysenterica* (0.09)	37	642
6	16	100	167	132.1	15.4	Quartzite and ferruginous cherty quartzite	*Andrographis paniculata* (0.43) *Sida cordata* (0.11), *Anisochilus cornosus* (0.07)	31	565
7	23	124	246	183.5	39.7	Ferruginous cherty quatrzite	*Lantana camara* (0.37) *Sida cordata* (0.09) *Acacia torta* (0.08)	27	640
8	15	100	1671	1063.7	592.1	Quartz mica schist	*Hyptis suaveolens* (0.37) *Lantana camara* (0.11), *Sida cordata* (0.15) *Evolvulus alsinoides* (0.07)	37	743
9	6	57	100	78.5	12.7	Quartz mica schist	*Lantana camara* (0.63) *Evolvulus alsinoides* (0.15) *Hyptis suaveolens* (0.06)	16	693
10	12	38	108	75.6	20.4	Quartz mica schist	*Evolvulus alsinoides* (0.67)	12	210

T3 BELT -DHOBANI TRANSECT

In the orientation study, the fourth of the sampling belt was selected in the east of Pathargora and close to the villages Dhobani and Netra.The transect line runs N45°E S45°W between the above villages and has a length of 2 line kilometers. '0' point was established in quartzite terrain fully enveloped with soil cover. The quartzite rock is exposed in very small patches along the small drainage. About 150 meters southwest of the '0' point, a thick forest occurs comprising species namely, *Shorea robusta, Flueggia obovata, Cleistanthus collinus, Holarrhena antidysenterica, Breynia vitis-idaea* in combination with *Pterocarpus marsupium, Madhuca indica, Buchanania lanzan, Croton roxburghii* and *Adina cordifolia*. Plants like *Hyptis suaveolens, Terminalia belerica, Anacardium occidentale, Holoptelea integrifolia* also appear in lower frequencies. There is not much variation in the profile of the sampling belt. This belt was divided into 20 sites, each of 100 meters length and 20 meters width. Sites between 4 and 8 constitute highly mineralised zone while the rest are partially mineralised or barren.

The rock sequence of the sampling zone is as follows :

Intercalations of metabasalt and chlorite schist
and biotite chlorite schist;
Feldspathoid chlorite schist;
Sheared metabasalt;
Sheared quartzite;
Metabasalt.

Plant distribution along various sites

SITE 1 : This stretch is located in quartzite terrain with good amount of soil cover. Rock types are intercalations of metabasalt, chlorite schist and biotite chlorite schist. The soil copper values are low and showed a range from 37 ppm (T3/0/185) to 257 ppm (T3/0/184). Copper values estimated for various points close to dominant species showed a variation from 37 ppm (T3/0/185) close to *Annona squamosa* to 257 ppm (T3/0/184) close to *Madhuca indica*. Mean copper value stands at 111.8 ppm. Other basemetals, namely, lead, zinc, nickel, cobalt, cadmium, silver and chromium showed lower values relative to copper and they never exceeded 60 ppm. The value ranges were 48.0 ± 9.8 ppm for lead; 42.8 ± 9.2 ppm for zinc; 35.2 ± 12.5 ppm for nickel and 38.8 ± 6.8 ppm for cobalt. A total of 31 species were recorded in this site and *Evolvulus alsinoides* dominated followed by *Polygonum plebejum* and *Heliotropium stigosum*. In the tree species *Diospyros melanoxylon* occurs frequently in this stretch.

Fig:5 PROFILE SECTION OF DHOBANI BELT

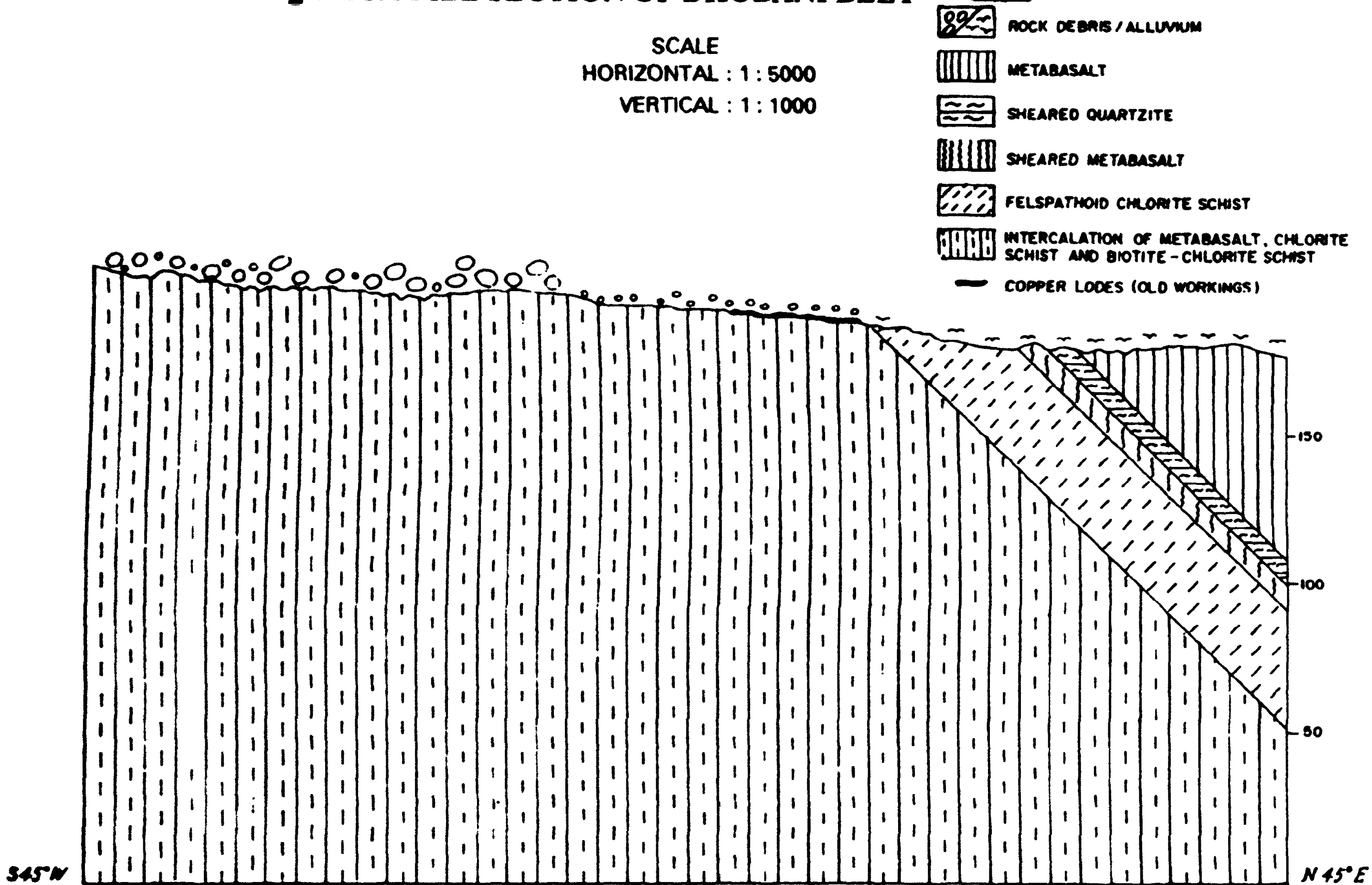
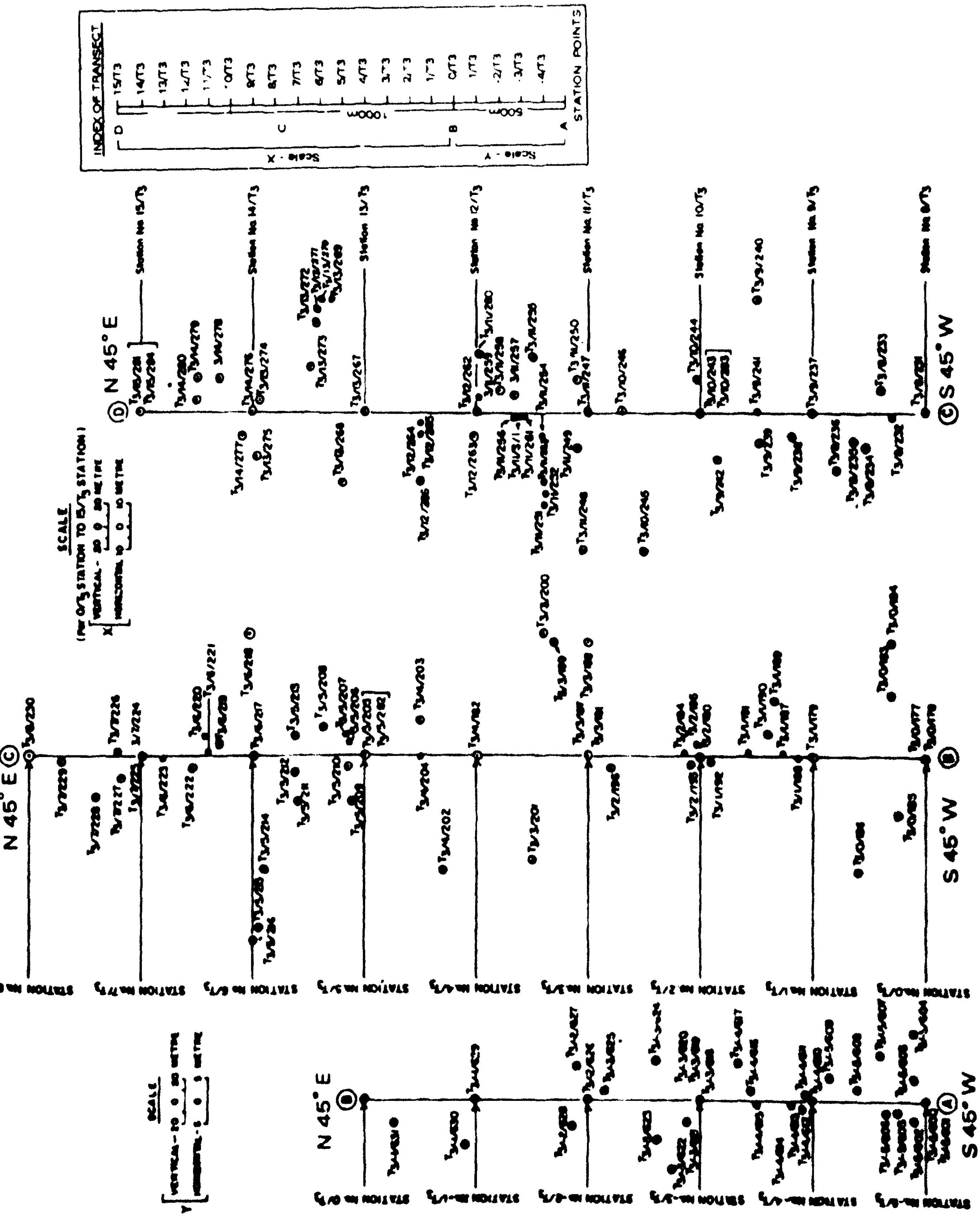


Fig:6 SAMPLE LOCATION MAP OF DHOBANI TRANSECT



SITE 2 : Rock type is similar to that of previous stretch with increasing slope. The soil copper values in the beginning of this site showed a value of 110 ppm (T3/1/179). Copper values estimated for various sampling points in the area close to different dominant trees showed a range from 73 ppm (T3/1/187) close to *Cassia occidentalis* to 137 ppm (T3/1/190) close to *Annona squamosa*. Mean copper value stands at 108.3 ppm. With regard to other basemetals like lead, zinc, nickel, cobalt and chromium, the figures were quite low and showed a maximum of 60 ppm as in the case of lead in two soil samples. Mean values stand at 54.3 ± 7.3 ppm for lead; 40.9 ± 6.4 ppm for zinc; 38.9 ± 7.2 ppm for nickel and 35.7 ± 3.5 ppm for cobalt. Low figures for standard deviation indicate that there is not much variation in various points of this site, 34 plant species were recorded in this site and the dominant species are *Evolvulus alsinoides, Polygonum plebejum* and *Tridax procumbens. Croton bonplandianum, Euphorbia heyneana* and *Scoparia dulcis* are some other important species.

SITE 3 : In this stretch rock and soil type were similar to that of Site 2. Soil copper level in the beginning of this site showed a value of 107 ppm (T3/2/193). Copper values estimated at various points close to dominant species varied from 107 ppm (T3/2/193) close to *Annona squamosa* to 194 ppm (T3/2/196) close to some unidentified grasses. Mean copper value of the entire site stands at 131.6 ppm with a standard deviation of 32.1. With regard to other metals, they are quite low and a maximum value of 78 ppm (T3/2/196) was recorded in case of nickel. Mean values for these elements stand at 38.0 ± 7.5 ppm (for lead); 51.4 ± 13.7 ppm (for nickel); 38.4 ± 12.4 ppm (for cobalt) and 5 ppm (for cadmium). A total of 28 species were recorded at this site and the dominant plants of this area include *Evolvulus alsinoides, Polygonum plebejum, Tridax procumbens* and *Hybanthus enneaspermus. Lantana camara* and *Solanum sisymbrifolium* make stray presence.

SITE 4 : This area falls under cultivated land and the soil copper values at the beginning of the site is 280 ppm (T3/3/197). However, variations are noticed at different points and values fluctuated from 371 ppm (T3/3/201) close to *Hyptis suaveolens* and *Holoptelea integrifolia* to 2986 ppm close to *Shorea robusta*. Mean copper value stands at 920.3 ppm With regard to other basemetals, nickel and cobalt showed relatively higher values (80-312 ppm) compared to lead and zinc which showed values always less than 60 ppm. Mean values for these elements showed at 56.6 ± 15.9 ppm (for lead); 40.5 ± 8.9 ppm (for zinc); 164.5 ± 69.6 ppm (for nickel) and 119.5 ± 37.9 ppm (for cobalt). Very low values were recorded for cadmium (below 6 ppm). A total of 27 species were recorded at this site and *Hyptis suaveolens* dominated in this stretch followed by *Croton roxburghii*, *Alternanthera aspera*, *Alysicarpus vaginalis* and *Boerhavia diffusa*.

Site 5 : This area is highly disturbed, partly cultivated land and partly occupied by mine dumps. The dump is mainly composed of hornblende schist. Copper level in this stretch varied from 514 ppm (T3/4/202) close to *Cassia occidentalis* to 1857 ppm close to *Lantana camara*. Mean copper value stands at 942.8 ppm. With regard to other metals, except nickel which showed variation between 100 and 200 ppm and cobalt in one occasion (147 ppm,T3/3/200) all the elements showed values below 100 ppm. Mean values stand at 60.0 ± 7.1 ppm for lead; 51.8 ± 3.0 ppm for zinc; 166.5 ± 15.5 ppm for nickel; 75.8 ± 20.7 ppm for cobalt and 5 ppm for cadmium. A total of 21 species were recorded at this site and *Evolvulus alsinoides* and *Vernonia cinerea* dominated throughout the stretch followed by *Polygonum plebejum*. Among the shrubs, *Hyptis suaveolens* dominated followed by *Croton roxburghii*. Other important species are *Alysicarpus vaginalis*, *Glinus lotoides* and *G. oppositifolius*.

Site 6 : Here rock type is similar to one exhibited by previous site. Soil copper level in the beginning of the site is very high with a value of 2186 ppm ((T3/5/205). Even the soil samples collected from various locations close to dominant species exhibited very high values, the highest being 5943 ppm (T3/5/210) close to *Cassia fistula* followed by 4014 ppm (T3/5/207) close to *Lantana camara* and 3843 ppm (T3/5/206) close to *Holoptelea integrifolia*. Mean copper value stands at 2297.6 ppm With regard to other metals, the values were quite low relative to copper. However, significantly higher fluctuations were recorded in case of nickel (84- 312 ppm) while lead and zinc showed variations below 100 ppm, cobalt stands in between with a maximum value of 133 ppm recorded in two points. Mean values for these metals are 52.5 ± 8.3 ppm for lead; 50.6 ± 10.9 ppm for zinc; 160.8 ± 63.4 ppm for nickel; 99.8 ± 23.1 ppm for cobalt and around 5 ppm for cadmium. A total of 24 species were recorded with dominance of *Evolvulus alsinoides*, *Polygonum plebejum* and *Heliotropium stigosum* throughout this site.

Site 7 : The rocks of this stretch are similar to previous site and the area passes across the old workings and cultivated lands. The soil copper level in the beginning was 386 ppm (T3/6/217). However, higher values were recorded at many locations in this stretch. The highest was 17600 ppm (T3/6/222) close to *Syzygium cumini* followed by 6885 ppm (T3/6/221) close to *Diospyros melanoxylon* and 5171 ppm (T3/6/220) close to *Holarrhena antidysenterica*. Mean copper value of the site stands at 4959 ppm. With regard to other metals, very low values were recorded for lead and zinc while fluctuations in the values of nickel and cobalt were relatively higher. Mean values were 55.7 ± 11.8 ppm for lead; 46.9 ± 14.1 ppm for zinc; 202.1 ± 115.4 ppm for nickel; 142.9 ± 31.9 ppm for cobalt and 5 ppm for cadmium. In total, 16 species were recorded in this zone. *Hyptis suaveolens, Heliotropium stigosum, Polygonum plebejum, Evolvulus alsinoides* and *Justicia diffusa* were prominent species available in this zone.

Site 8 : This stretch is also much disturbed and partly forms fallow land. The soil copper level at the point '7' is 571 ppm (T3/7/224). There is much variation in the copper concentration at various locations of the area and the values fluctuated from 307 ppm (T3/7/229) close to *Streblus asper* to 1386 ppm (T3/7/225) close to *Borassus flabellifer*. Mean copper level stands at 579.7 ppm. With regard to other metals, lead and zinc showed very low values and never exceeded 60 ppm. Nickel and cobalt levels were relatively higher and close to 100 ppm. Mean values were 35.0 ± 9.6 ppm for lead; 28.2 ± 13.1 ppm for zinc; 88.5 ± 20.5 ppm for nickel; 70.0 ± 15.8 for cobalt and 5 ppm for cadmium. Eighteen species were recorded at this site and the dominant species are *Hyptis suaveolens, Evolvulus alsinoides, Polygonum plebejum, Blumea oxyodonta* and *Scoparia dulcis*. Among the trees, *Streblus asper* and *Diospyros melanoxylon* appear less frequently.

Site 9 : Rock type that occurs is feld chlorite schist with much rock being covered by debris. In the beginning of the stretch, i.e. at point '8', soil copper level is 215 ppm (T3/8/230). Value for various samples collected close to different dominant species were low and ranged between 184 ppm (T3/8/232) close to *Holarrhena antidysenterica* and 241 ppm (T3/8/235) close to *Cassine glauca*. Mean copper value for the entire site stands at 206.1 ppm. With regard to other base metals, low values were recorded for both lead and zinc and never exceeded 60 ppm. While values for nickel and cobalt were slightly higher, and the range fluctuated from 59-89 ppm in case of nickel and 50-73 ppm in case of cobalt. Mean values were 31.4 ± 3.5 ppm for lead; 42.9 ± 9.4 ppm for zinc; 77.0 ± 9.0 ppm for nickel and 60.3 ± 12.7 ppm for cobalt. Cadmium levels were quite low and were always less than 5 ppm. 24 species occur at this site and the entire stretch is dominated by *Evolvulus alsinoides* followed by *Polygonum plebejum, Blumea oxyodonta, Hybanthus enneaspermus* and *Heliotropium stigosum*.

Site 10 : Rock type is similar to previous zone and the copper level in the beginning of the stretch is 514 ppm (T3/9/237). However, values estimated in this site varied greatly and show a range from 218 ppm (T3/9/242) close to *Cassine glauca* to 498 ppm (T3/9/238) close to *Nyctanthes arbortristis*. There is no specific trend noticed in this stretch and mean copper value of the site stands at 364.7 ppm. In spite of moderate copper levels the values for other elements were quite low particularly in case of lead and zinc which never exceeded 70 ppm. The values for nickel and cobalt were relatively higher and maximum figures reached upto 133 ppm. Mean values for other basemetals were 33.3 ± 4.7 ppm for lead; 41.6 ± 11.2 ppm for zinc; 86.8 ± 23.5 ppm for nickel; 58.8 ± 13.6 ppm for cobalt and less than 5 ppm for manganese. Twenty two species were recorded at this site with the dominance of *Evolvulus alsinoides, Blumea oxyodonta, Hybanthus enneaspermus* and *Coldenium procumbens*. Among the trees *Nyctanthes arbortristis* and *Cassine glauca* occur in good numbers.

Site 11 : In this site two types of rocks appear namely, feld spathoid chlorite schist and sheared meta basalt. Soil copper level in the beginning is 357 ppm (T3/10/243). Soil samples collected from other locations in this stretch varied from 270 ppm close to *Diospyros melanoxylon* to 493 ppm close to *Lantana camara*. Mean copper value stands at 348.5 ppm. With regard to other basemetals, the values were quite low particularly with respect to lead, zinc and cobalt, the maximum values recorded being 70 ppm in case of lead, 57 ppm in case of zinc, 58 ppm in case of cobalt. Nickel exhibited higher range and fluctuated from 81 ppm to 150 ppm. Mean values stand at 42.5 ppm for lead; 44.3 ± 14.3 for zinc; 108.7 ± 26.3 ppm for nickel; 43.3 ± 6.0 ppm for cobalt. Twenty two species were recorded in this site. *Evolvulus alsinoides, Hybanthes enneaspermus* dominated in the ground flora. Among the shrubs *Lantana camara* and in trees *Diospyros melanoxylon* appeared in good numbers.

Site 12 : This stretch is covered by sheared quartzite and meta basalt. Copper level in the beginning of the stretch showed a value of 287 ppm (T3/11/247). While other samples collected close to various trees showed great variation. The recorded range varied from 121 ppm (T3/11/260) close to *Terminalia crenulata* to 497 ppm (T3/11/253) close to *Trema orientalis*. Mean copper value is 229.6 ppm. With regard to other basemetals, lead, zinc and cobalt exhibited very low values and their mean figures were 44.0 ± 13.1 ppm, 40.9 ± 10.9 ppm, and 44.9 ± 11.6 ppm respectively. Nickel values are slightly higher with a maximum of 116 ppm (T3/11/250) recorded in the sample. Mean value for the entire site stands at 72.8 ±17.8 ppm. In the vegetation analysis a total of 27 species were recorded at this site and the entire stretch is dominated by *Evolvulus alsinoides, Coldenium procumbens* followed by *Hyptis suaveolens*. Among the trees, *Terminalia crenulata* and *Trema orientalis* appear in considerable numbers.

Site 13 : In this area of the sampling belt, the rock type that occurs is of metabasalt and the soil copper level in the beginning is 230 ppm (T3/12/262), slightly lower than previous site. There is further drop in the soil copper concentration in this site while proceeding from station point '12' to '13'. Thus, value showed a range from 120 ppm (T3/12/265) close to *Zizyphus mauritiana* to 170 ppm (T3/12/262), for the first geochemical sample of the site. Mean copper value stands at 155.8 ppm. Other basemetals showed relatively lower values and the mean values were 52.0 ± 7.5 ppm for lead; 38.2 ± 6.8 ppm for zinc; 57.0 ± 5.3 ppm for nickel and 32.8 ± 3.9 ppm for cobalt. There is not much variation in any of the mentioned elements in various locations of this site as indicated by low standard deviations. In the vegetation analysis a total of 28 species were recorded with *Evolvulus alsinoides* and *Blumea oxyodonta* dominating the entire stretch.

Sites 14 and 15 : This zone of sampling belt consists of meta basalt. Copper values are quite low and the figures recorded at station point '13' (T3/13/267) and station point '14' (T3/14/276) are 51 ppm and 124 ppm respectively. These two sites exhibited very low values of copper and site 14 showed a range from 51 ppm (T3/13/267 soil sample from station point '13') to 158 ppm (T3/13/275 soil sample close to *Pterocarpus marsupium*). Mean copper value stands at 83.7 ± 29 9 ppm. However, the values for copper are slightly higher for samples collected from site 15 with figures ranging from 111 ppm (T3/14/280) close to *Cassine glauca* to 144 ppm (T3/14/277) close to *Streblus asper* and *Holarrhena antidysenterica*. Mean copper value is 125.9 ± 25.6 ppm. With regard to other basemetals, at site 14 the values were low and never exceeded 100 ppm except for nickel in one sample which showed a value of 114 ppm. Mean values are 36.7 ± 12.5 ppm for lead; 36.9 ± 7.7 ppm for zinc; 49.9 ± 26.9 ppm for nickel and 38.1 ± 16.8 ppm for cobalt. At site 15 values for these metals are quite low in case of Pb, Zn and Co. However, the values for nickel are comparable with that of copper. Mean values are 47.1 ± 4.5 ppm for lead ; 48 ± 8.8 ppm for zinc; 147.6 ± 44.9 ppm for nickel and 82.3 ± 23.1 ppm for cobalt. Low figures for standard deviation indicate that there is not much variation in elemental content among different locations of this site. The number of species recorded were below twenty and *Polygonum plebejum, Hybanthus enneaspermus, Coldenium procumbens, Blumea oxyodonta* and *Mollugo hirta* occur more or less in equal relative densities. Among the trees, *Pterocarpus marsupium, Cassine glauca* and *Diospyros melanoxylon* and *Vitex negundo* appear in considerable numbers.

The sampling zone has been extended for 500 meters beyond '0' point in southwest direction. These sites were indicated with numbers between -5 and -1.

Sites -1 and -2 : The rocks appear in these sites include intercalations of meta basalt, chlorite schist and biotite chlorite schist. Copper levels in these two sites showed a little variation and the values are below 25 ppm in both the sites. Mean copper values were 22.5 and 21.6 ppm respectively for site -1 and site -2. Among the other basemetals, zinc, nickel and cobalt showed figures below 30 ppm while manganese showed relatively higher values and ranged between 60 ppm and 270 ppm. Mean values were 17.5 ± 2.5 ppm for zinc; 20.0 ppm for nickel and 12.5 ± 2.5 ppm for cobalt at site -1. These figures were 20.0 ppm for zinc; 25.0 ± 4.1 ppm for nickel and 13.3 ± 4.7 ppm for cobalt at site -2. There is not much variation in the plant composition in both the sites. In the tree species, *Madhuca indica* dominated both the sites. Among the herbs, *Polygonum plebejum* was dominant followed by *Heliotropium stigosum* or *Evolvulus alsinoides*. There is low diversity in both the sites with maximum occurrence of 15 species.

Site -3 : Rock type that occurs in this site is similar to one that occurs in the previous zone. Soil copper level at '-3' point (T3/-3/618) showed a value of 40 ppm. Values of copper at various points in this stretch showed a variation from 40 ppm (T3/-3/618 or 619) close to *Diospyros melanoxylon* to 20 ppm (T3/-3/626) close to *Cassia occidentalis*. Mean copper value was 34.4 ppm. The concentrations of other basemetals in this zone are low and never exceeded 30 ppm except for manganese which showed values varying from 235 ppm (T3/-3/619) to 270 ppm (T3/ -3/624). Mean figures were 3.3 ± 6.2 ppm for lead; 18.9 ± 2.1 ppm for zinc; 25.0 ± 3.3 ppm for nickel and 20 ± 4.1 ppm for cobalt. Mean value for manganese is quite high and stands at 259.4 ppm. In the vegetation analysis, a total of 16 species were recorded and the dominant tree species are *Diospyros melanoxylon, Shorea robusta, Grewia tiliaefolia, Zizyphus mauritiana, Holarrhena antidysenterica*. In the lower strata *Evolvulus alsinoides, Polygonum plebejum, Heliotropium stigosum, Atylosia scaerbaeoides, Ehretia laevis* and *Tridax procumbens* occur in good numbers.

Site -4 : Rock type that occurs in this zone are similar to previous site with soil copper concentration at -3 point (T3/-4/610) showed a value of 35 ppm. Copper values did not fluctuate much in the entire site and range from 35 75 ppm. Mean copper value stands at 50.6 ppm. With regard to other basemetals, the fluctuations are minimum and never showed more than 30 ppm with exception of manganese which showed relatively higher ranges with figures from 165 ppm (T3/-4/610) to 270 ppm (T3/-4/617). Mean value for manganese stands at 218.8 ppm. While it is 8.1 ± 8.3 ppm for lead; 21.3 ± 2.2 ppm for zinc; 25.6 ± 3.9 ppm for nickel and 16.4 ± 5.8 ppm for cobalt. Twelve species were recorded in this site and vegetation analysis revealed that *Diospyros melanoxylon* and *Shorea robusta* in the tree species and *Holarrhena antidysenterica, Hyptis suaveolens* and *Cleistanthus collinus* in the shrubs dominate the entire site. *Evolvulus alsinoides* restrict its presence in the first part of the sampling site. *Buchanania lanzan, Croton roxburghii* and *Miliusa velutina* project stray occurrence in this site.

Site -5 : The rocks that appear are similar to previous site. The soil copper at point '-4' is 25 ppm (T3/-5/603). Except one sample (T3/-5/608), all the samples at this site showed values below 100 ppm. Mean copper value stands at 40.7 ppm. With regard to other basemetals, the values were quite low and the mean values were 2.4 ± 5.2 ppm for lead; 17.1 ± 5.9 ppm for zinc; 15.7 ± 7.8 ppm for nickel; 16.4 ± 5.8 ppm for cobalt. However, manganese values were very high and fluctuated from 265 ppm (T3/-5/609) to 540 ppm (T3/-5/606 or 607). Mean manganese value for the entire site was 426.4 ppm. In the vegetation analysis, 14 species were recorded in this site. *Holarrhena antidysenterica, Flueggia obovata, Diospyros melanoxylon, Croton roxburghii, Shorea robusta* and *Cleistanthus collinus* dominated. *Buchanania lanzan* and *Miliusa velutina* restrict their distribution in the first part of the site.

TABLE 4. STATIONWISE PRESENTATION OF DOMINANT SPECIES, GEOLOGY AND MEAN COPPER LEVEL IN DHOBANI TRAVERSE

SITE	MIN	MAX	MEAN	SD.	LITHOLOGY	DOMINANT SPECIES	NO. OF SPECIES	TOTAL NUMBERS
1.	37	257	111.8	77.3	Intercalations of Metabasalt, Chlorite schist, Biotite chlorite schist	*Evolvulus alsinoides*(0.41) *Polygonum plebejum*(0.38)	31	486
2.	73	137	108.3	20.8	do	*Evolvulus alsinoides*(0.38) *Polygonum plebejum*(0.36)	34	525
3.	107	194	131.6	32.1	do	*Evolvulus alsinoides*(0.42) *Polygonum plebejum*(0.29)	28	470
4.	280	2986	920.3	938.6	do	*Hyptis suaveolens*(0.49) *Croton roxburghii*(0.41)	27	294
5.	514	1857	942.8	546.6	do	*Hyptis suaveolens*(0.61) *Croton roxburghii*(0.11) *Evolvulus alsinoides*(0.11) *Vernonia cinerea*(0.01)	21	324
6.	2186	5943	2297.6	1508.0	do	*Hyptis suaveolens*(0.64) *Croton roxburghii*(0.21) *Heliotropium stigosum*(0.08)	24	276
7.	38	17600	4959	5607.6	do	*Justicia diffusa*(0.51) *Vernonia cinerea*(0.11) *Hyptis suaveolens*(0.21)	16	264
8.	307	1386	579.7	370.9	do	*Hyptis suaveolens*(0.30) *Polygonum plebejum*(0.28) *Evolvulus suaveolens*(0.21)	18	238
9.	184	241	206.1	17.2	Feldspathic chlorite schist	*Evolvulus alsinoides*(0.39) *Polygonum plebejum*(0.32)	24	174
10.	218	490	364.7	115.9	do	*Blumea oxyodonta*(0.28) *Evolvulus alsinoides*(0.31) *Hybanthus enneaspermus*(0.21)	22	170
11.	270	493	348.5	90.4	Feldspathic chlorite schist, Sheared metabasalt	*Evolvulus alsinoides*(0.38) *Hybanthus enneaspermus*(0.21)	22	345
12.	121	497	229.6	90.8	Sheared quartzite Metabasalt	*Coldenium procumbens*(0.26) *Evolvulus alsinoides*(0.21)	27	374
13.	120	170	155.8	40.9	Metabasalt	*Evolvulus alsinoides*(0.24) *Blumea oxyodonta*(0.23)	28	318
14.	51	158	83.7	29.9	do	*Polygonum plebejum*(0.27) *Hybanthus enneaspermus*(0.21) *Coldenium procumbens*(0.08) *Blumea oxyodonta*(0.11)	18	218

cont.next page

15.	111	144	125.9	25.6	do	*Polygonum plebejum*(0.21) *Mollugo hirta*(0.20) *Coldenium procumbens*(0.07)	19	207
-1.	20	30.5	22.5	2.5	Intercalations of metabasalt, chlorite schist, Biotite chlorite schist	*Polygonum plebejum*(0.24) *Heliotropium stigosum*(0.21) *Tridax procumbens*(0.18) *Evolvulus alsinoides*(0.21)	14	176
-2.	20	28	21.6	2.3	do	*Polygonum plebejum*(0.18) *Evolvulus alsinoides*(0.17) *Hybanthus enneaspermus*(0.16)	15	136
-3.	20	40	34.4	8.6	do	*Diospyros melanoxylon*(0.21) *Holarrhena antidysenterica*(0.16) *Polygonum plebejum*(0.22)	16	94
-4.	35	75	50.6	9.8	do	*D. melanoxylon*(0.18) *Shorea robusta*(0.19) *H. antidysenterica*(0.18) *Hyptis suaveolens*(0.09)	12	68
-5.	30	89	40.7	29.2	do	*H. antidysenterica*(0.22) *Flueggia obovata*(0.19) *Shorea robusta*(0.18) *D. melanoxylon*(0.22) *Croton roxburghii*(0.09)	14	72

PLANT DISTRIBUTION VERSUS SOIL COPPER

An attempt is made to plot various parameters examined along the traverse on the same scale. This is done with a view to superimpose these plottings to have a clear assessment on the relationships among various parameters in this traverse.

As there is so much variation between minimum and maximum values of soil copper concentration, the original values were converted into log copper values and plotted against stations (Fig. 7). Results indicated two significant peaks, one close to stations 1 and 2 and the other around stations 6 and 7. Log copper values reached upto 4.5. Now on the same traverse, the total number of species occurring along the stations is plotted. Graph depicting total number of species available along different stations exhibited multiple peaks and the highest values could be seen close to the station 11 followed by stations 3 and 4 .The highest value is 45 species per 2000 sq. m. Thus,the number of species is not coinciding with stations that contain high copper values. At stations 3 and 4 which exhibited second sub-peak also project significant copper values (Fig. 8 and 9). Plant richness is measured in terms of total number of individuals of all the species in a particular station. Station 1 recorded the highest value of around 1100 nos. where log copper value stands at 3.4 (Fig. 10).

An attempt is made to know fluctuations of each species in terms of population strength with reference to log copper values. This would give a clue of the species that majorly constitute to the grand total of a station in a particular copper concentration. We have examined five dominant species in this regard. Here log copper values are plotted against the population strength of each species. Species like *Croton roxburghii* exhibited a single peak close to a value of 3.7 log copper. Below this value and beyond it, this species registered very low numbers. Similar to *Croton roxburghii, Cleistanthus collinus* exhibited a single peak but at log copper values between 3.5 and 4 (Fig. 12 and 14). In *Acacia torta,* similar to *Croton roxburghii,* a single peak was recorded at 2.5 log copper value (Fig. 13). In *Holarrhena antidysenterica* the maximum numbers were recorded around 2 and 2.5 log copper values(Fig. 16). While in *Diospyros melanoxylon* the peak values were recorded between 2.5 and 3. (Fig. 17). The population of *Hyptis suaveolens* exhibits two peaks one at 3 and another between 3.5 and 4 (Fig. 15).

Fig.:7 COPPER CONCENTRATION IN SIDHESAR TRAVERSE

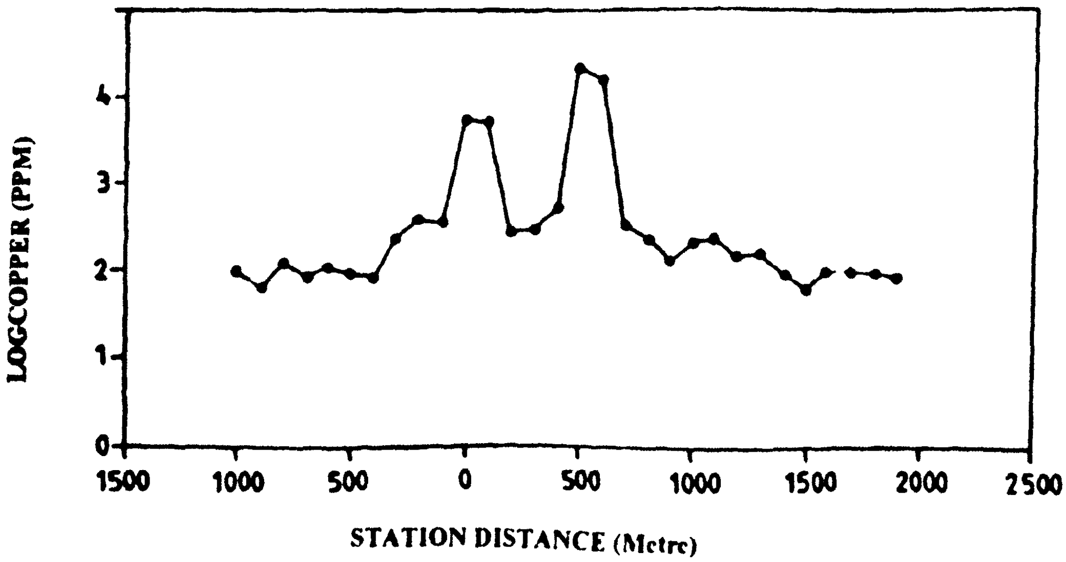


Fig.:8 SPECIES DIVERSITY IN SIDHESAR TRAVERSE

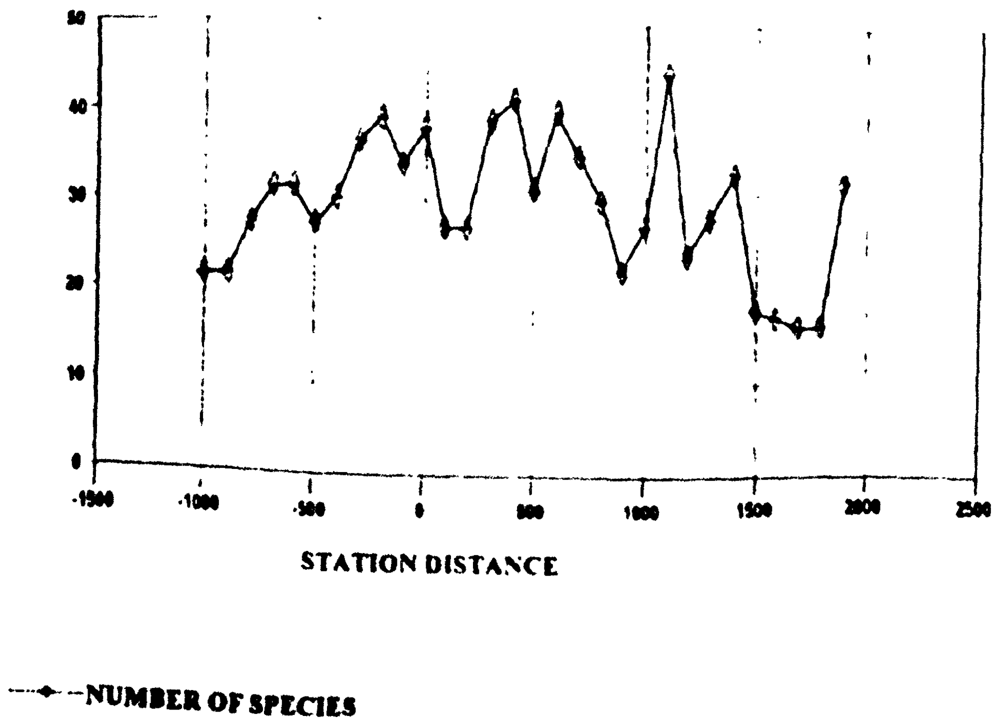


Fig.:9 SOIL COPPER VS. SPECIES DIVERSITY IN SIDHESAR

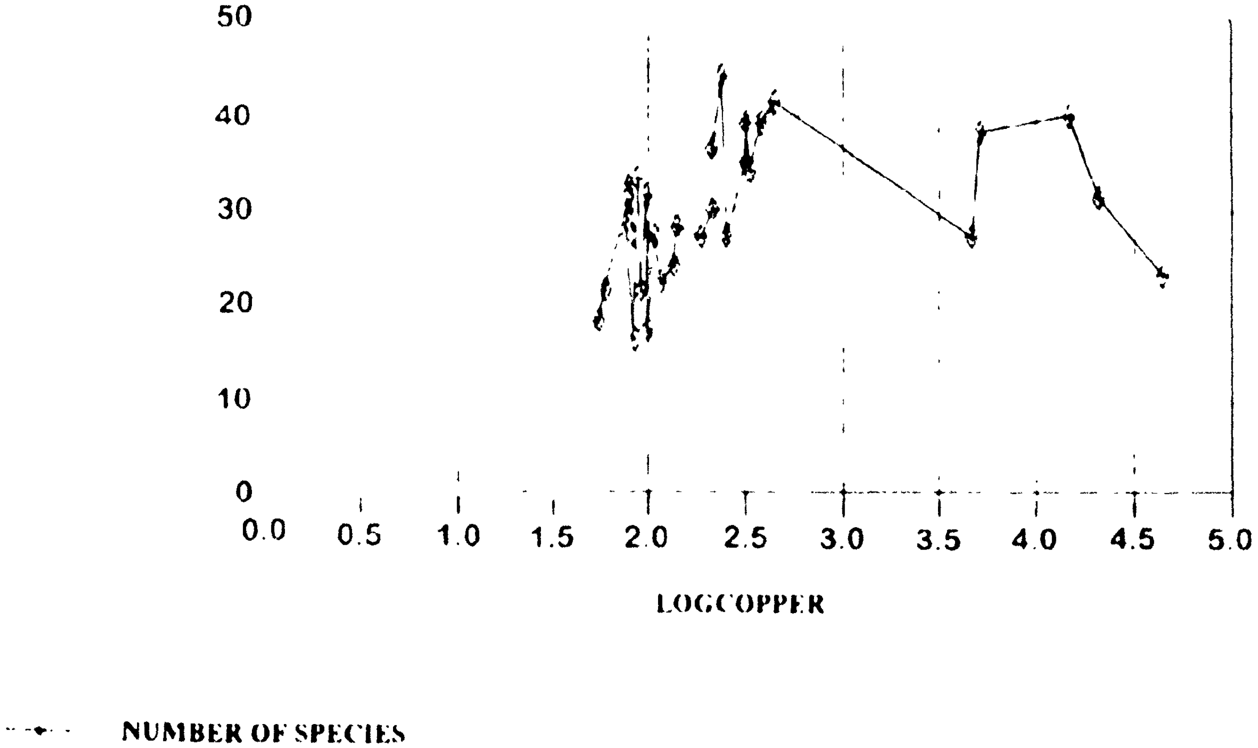
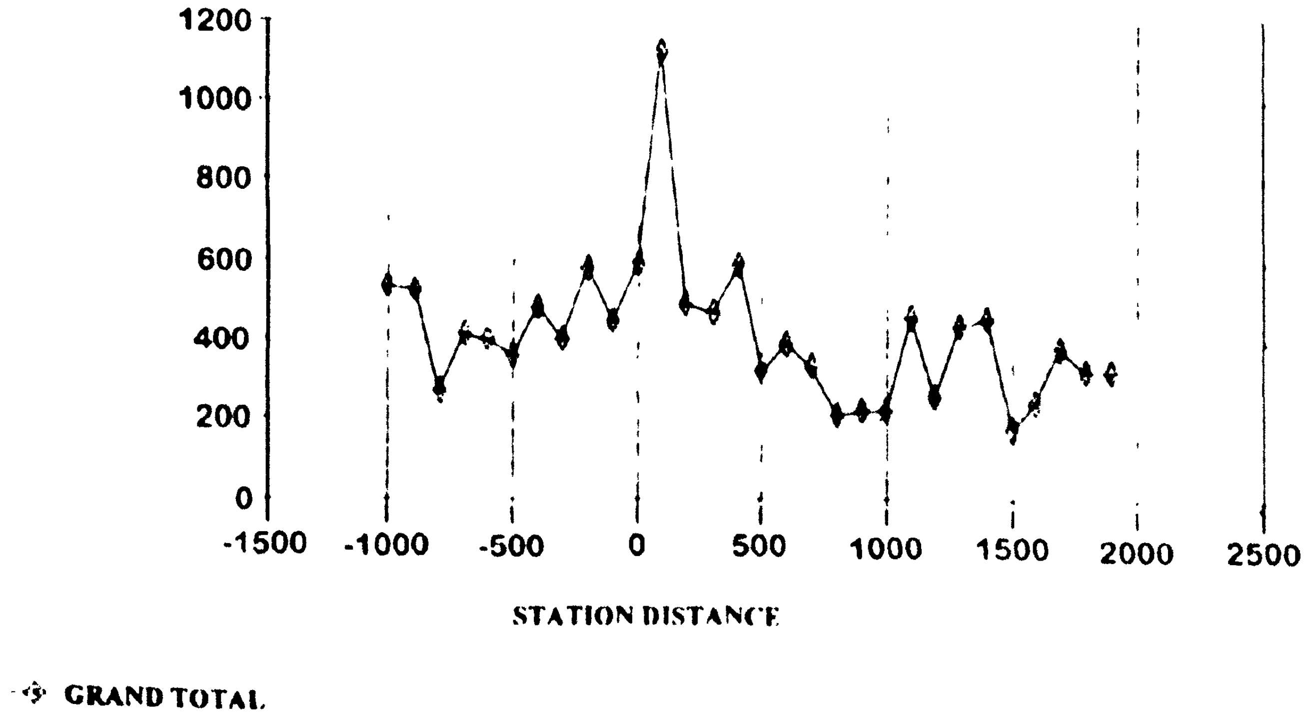
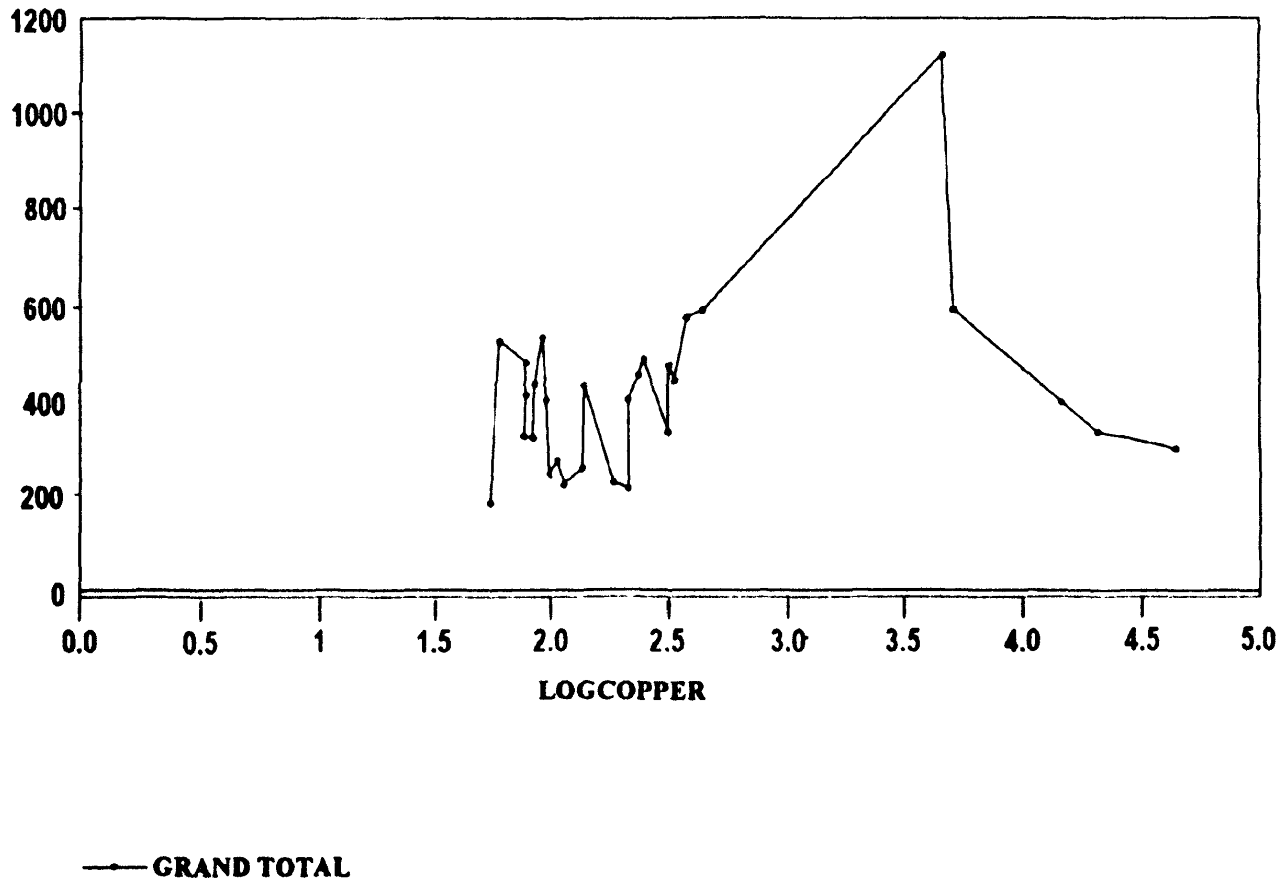


Fig.:10 PLANT RICHNESS ALONG SIDHESAR



PLANT TOTALS

Fig.:11 COPPER VS. PLANT RICHNESS IN SIDHESAR



PLANT TOTALS

Fig.:12 CR. ROXBURGHII : LOGCOPPER VS. TOTAL NUMBERS

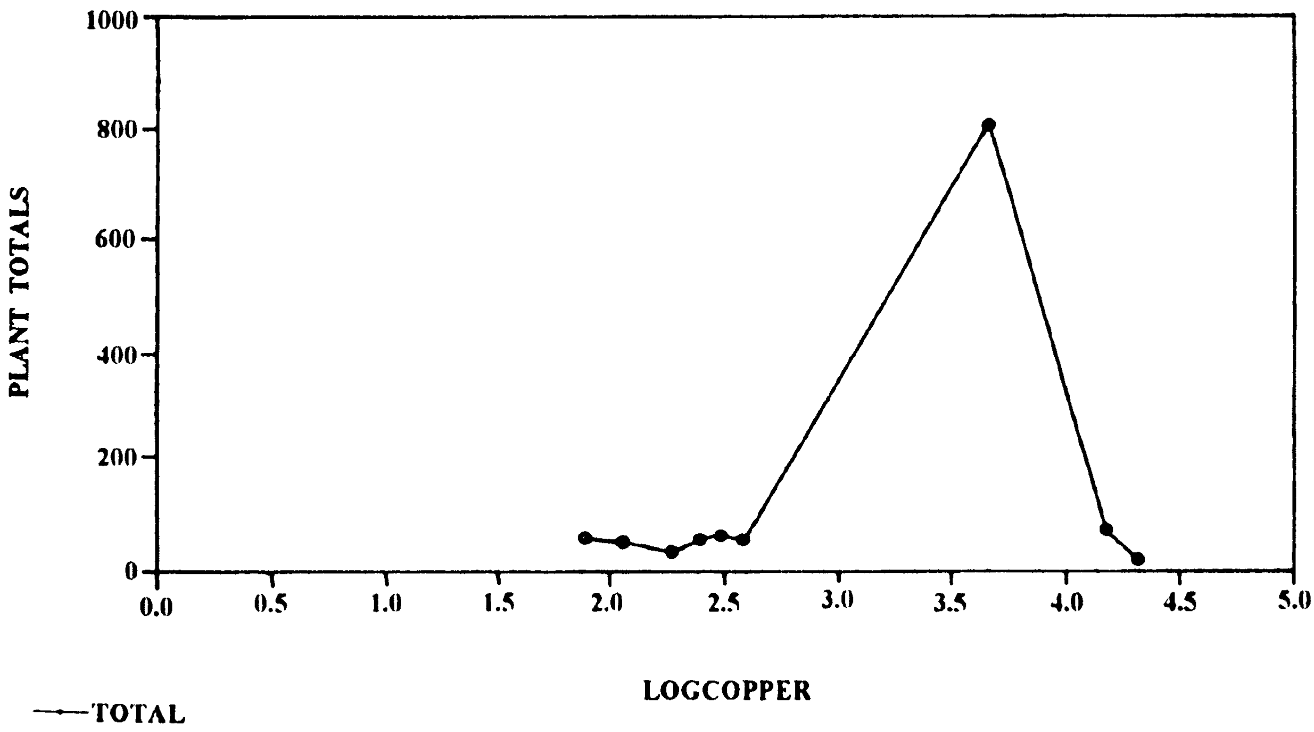
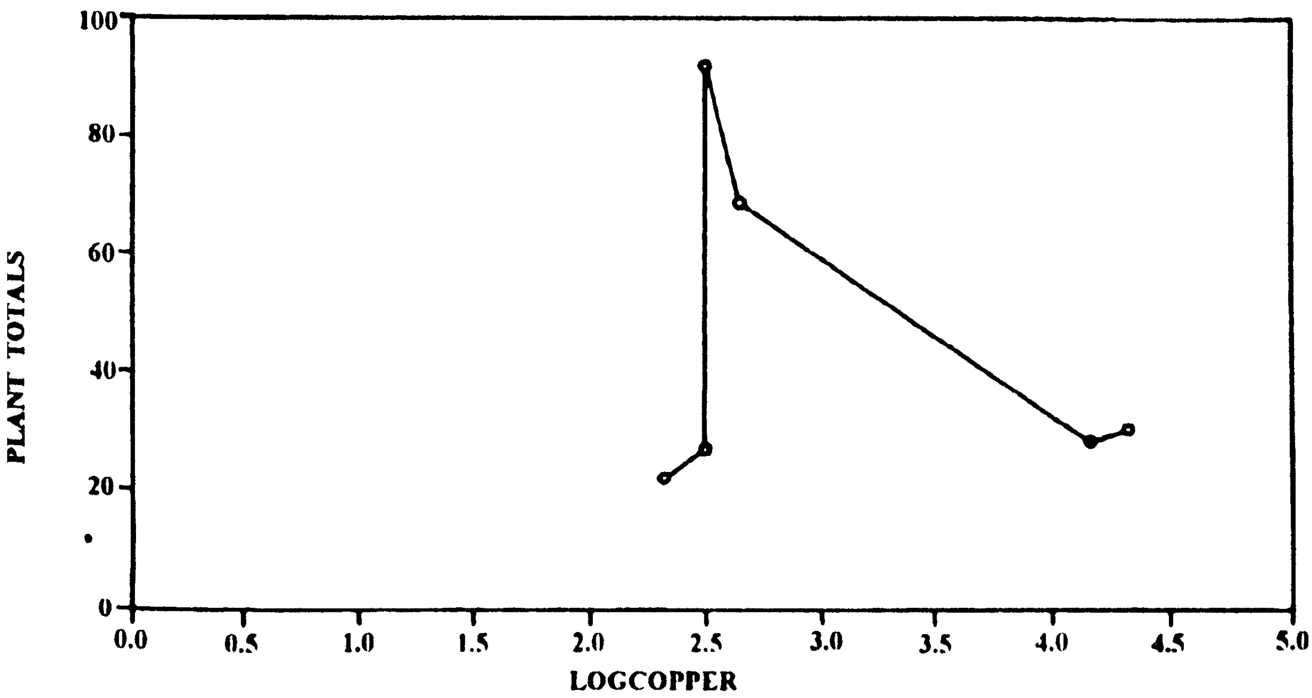


Fig.:13 ACACIA TORTA : LOGCOPPER VS. TOTAL NUMBERS



F

Fig.:14 CLEISTANTHUS COLLINUS : LOGCOPPER VS. TOTAL NUMBERS

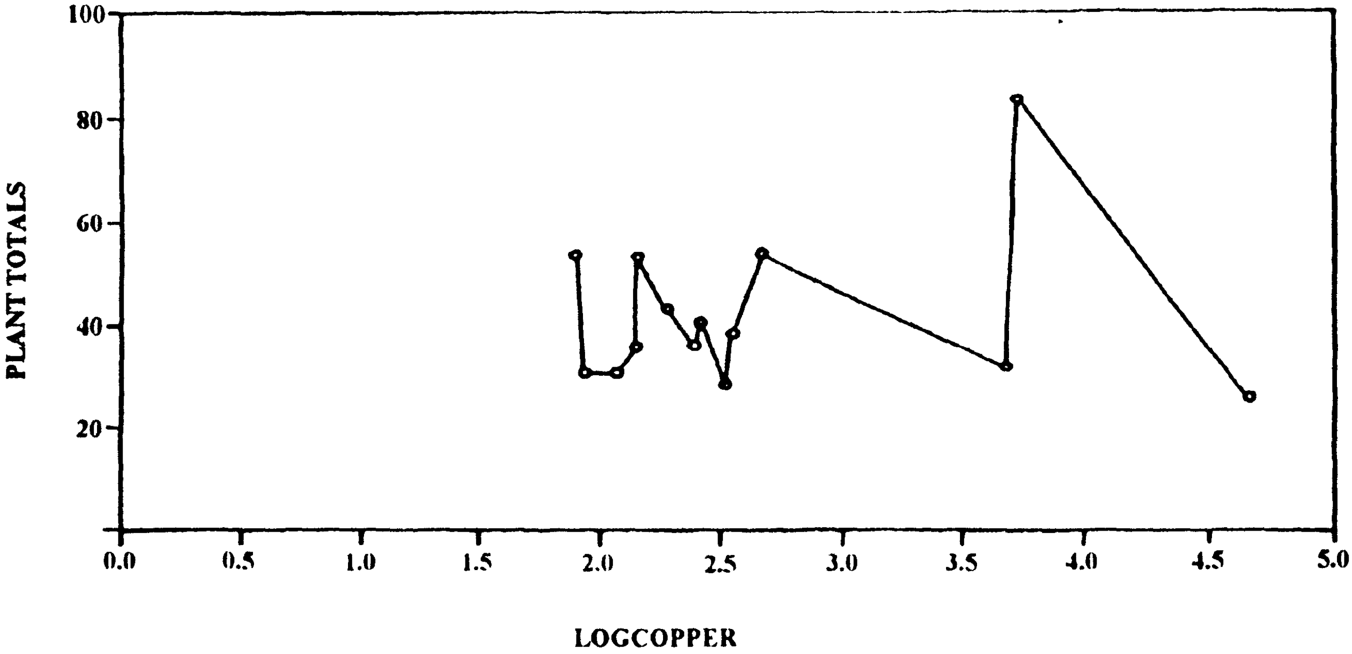


Fig.:15 HYPTIS SUAVEOLENS : LOGCOPPER VS. TOTAL NUMBERS

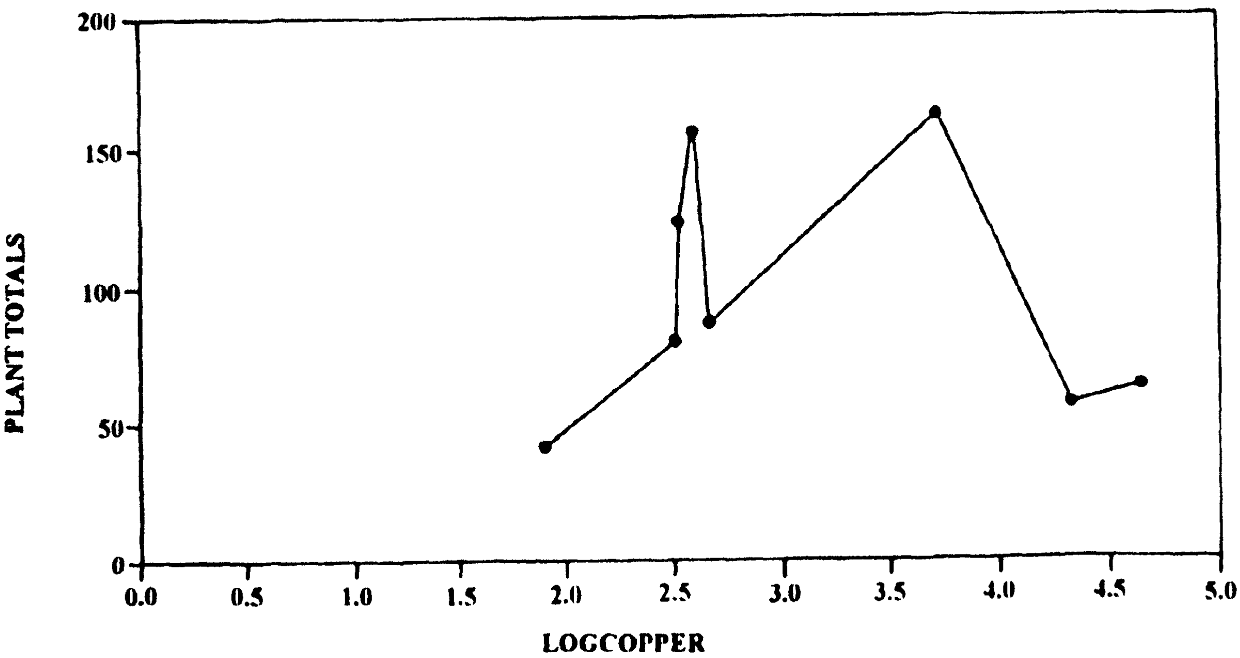


Fig.:16 HOLARRHENA ANTIDYSENTERICA : LOGCOPPER VS. TOTAL NUMBERS

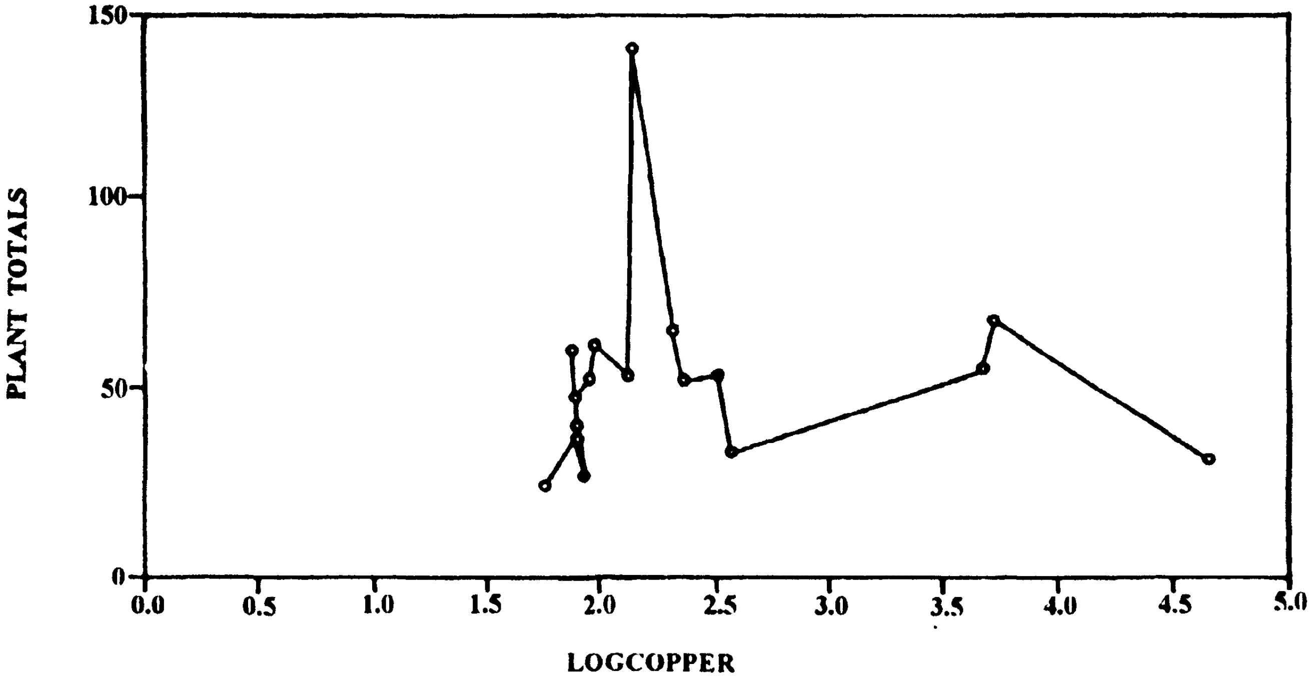
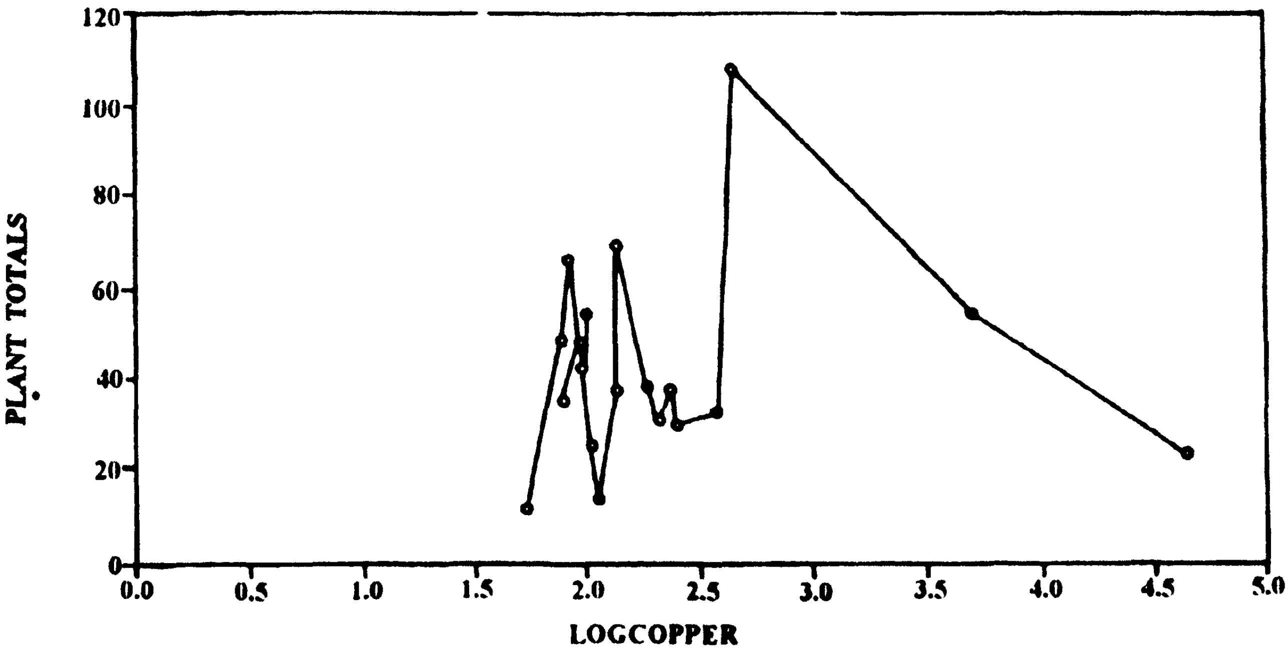


Fig.:17 DIOSPYROS MELANOXYLON : LOGCOPPER VS. TOTAL NUMBERS



BIOGEOCHEMISTRY

Prospecting based on the analyses of plant material for metal content and the delineation of favorable areas from the anomalous values obtained is called the biogeochemical method of prospecting. This method was used more extensively than any of the prospecting methods. It was first used during the period from 1938 to 1940 in prospecting for tungsten and tin in Cornwall, for nickel in England and for vanadium and tungsten in Sweden. In the middle of 1940, scientists of the erstwhile USSR, the USA, Cuba, Japan, West Africa and Canada began similar studies. These investigations helped to discover deposits of uranium, zinc, tungsten, tin, arsenic, copper and vanadium. Anomalous metal contents in plants were shown to correlate well with known deposits of lead, manganese, molybdenum, nickel, chromium and cobalt and poorly with silver. Geochemical parametres such as pH is important in determining the availability of some soil metals to plants (Lindsay, 1979; Lonergan, 1975; Hodgson, 1961). Plants can utilize only that fraction of soil nutrients which are available and availability increases with increase in pH. If a biogeochemical survey crosses a contact zone where there is a shift in the soil pH, the heavy metal concentrations of plant tissues are expected to be higher on the low pH side of the contact zone if the soil metal concentration remained the same. Any biogeochemical survey utilizing plant analysis must take these chemical fractions into account. Elements like iron, manganese, copper and zinc precipitate as hydroxides at high pH values. Deficiencies of these elements appear in some alkaline serpentine soils. At a low pH, manganese, copper and zinc become so soluble that they can be readily leached. Singhbhum soils show pH values below 7.2 and all the elements are assumed to be in available state. As solubility of molybdenum is increased at pH value above 6, this element is readily leached in these soils and showed good concentration in the analysis.

Biogeochemical studies involve evaluating copper levels in some important species against soil copper gradient. Forty eight plant species and a total of 528 plant samples were examined for their relationships with soil copper level in Sidhesar transect. A total of 24 plant species and 50 plant samples were studied in Tamapahar and some of these species are common both to Sidhesar and Tamapahar. In both the traverses, copper concentration ranges vary high. In Tamapahar mineralization occurs between site 2 and site 5 and also at site 8 while the remaining sites are barren or partially barren. Even within a site significant local concentration differences were recorded. For example, site 4 exhibited a copper concentration of 1174 ppm close to *Woodfordia fruticosa*; 1232 ppm close to *Cassine glauca*; 1360 ppm close to *Buchanania lanzan*; 1476 ppm close to *Albizia lebbeck*; 1951 ppm close to *Smilax ovalifolia* and finally 2439 ppm close to *Lannea coromandelica*. In a similar way, in Sidhesar mineralization occurred at stations 1, 6 and 7 which exhibit very high mean copper concentration. Copper levels within a station also varied greatly thus giving very high values of standard deviations. For example, at station 1, various locations close to dominant species fluctuated between 510 ppm close to *Hyptis suaveolens*, 3700 ppm close to *Woodfordia fruticosa* and 32,700 ppm close to *Syzygium cumini*.

Copper variability and its significance in plants:

A number of plant samples were analyzed for each species in both the sampling belts, namely, Sidhesar (CHP3 or T1 belt) and Tamapahar (T2 belt). Results concern to differences in the elemental concentration in different bioparts, tolerance level of a species and correlations, if any, between plant and soil elemental status. Data are summarized in tables 5 to 8.

Acacia torta: A total of 13 samples were analyzed for this species. In this species, soil copper concentrations range between 135 ppm and 1500 ppm while that of leaf samples showed a range from 44 ppm to 864 ppm and that of bark samples from 145 ppm to 560 ppm. Mean copper concentration in the leaf stands at 390.6 ppm while that of bark samples with a value of 293.6 ppm. There is difference in the copper concentrations between leaf and bark samples as evidenced by 't'test. Correlation coefficients indicate that there is no significant relationship between soil copper and that of leaf or bark samples.

Adina cordifolia: A total of 13(12+1) samples were analyzed in this species. Soil copper concentrations range between 100 ppm and 255 ppm. While that of leaf samples showed a range from 275 to ppm 567 ppm and bark samples varied from 25 ppm to 316 ppm. Mean copper value in the leaf samples stands at 354.4 ppm and that of bark samples showed a figure of 108.6 ppm. Results on 't'test indicates that there is significant difference in the concentration between leaf and bark samples. Correlation coefficients indicate that there are no significant relationships between soil copper and that of leaf or bark.

Anogeissus latifolia: 30 plant samples(26+4) were analyzed for this species. The soil copper values showed a range from 60 ppm to 1200 ppm while the variations were 20 ppm to 248 ppm in case of bark and 75 ppm to 500 ppm in case of leaf. Mean copper values in the bark and leaf samples stand at 80.1 ppm and 197.8 ppm respectively. 't'test indicates that there is significant difference in copper concentration between leaf and bark samples. Correlation coefficients reveal that a significant relation exists between bark copper levels and that of soil copper.

Buchanania lanzan: A total of 28 plant samples (24+4) were analyzed for this species. The soil copper values showed a range from 70 ppm to 1800 ppm while the variations in plant samples were 25 ppm to 214 ppm in case of bark and 20 ppm to 145 ppm in case of leaf samples. Mean copper values in the bark and leaf stand at 84.6 ppm and 93.6 ppm respectively. 't'test results indicate that there is no significant difference in the concentration of copper between leaf and bark samples. Correlation coefficients reveal that there is no significant relation between soil copper values and that of leaf. But significant relationship was recorded between soil copper and that of bark copper.

Butea frondosa: A total of 18 plant samples (14+4) were analyzed for this species. The soil copper values showed a range from 60 ppm to 546 ppm while the variations in leaf samples are of a range from 20 ppm to 510 ppm and in bark samples these are from 35 ppm to 370 ppm. Mean copper values in the bark stands at 223.4 ppm and 137.3 ppm in leaf samples. There is no significant difference in the copper concentration between leaf and bark samples as evidenced by 't' values. Correlation coefficients reveal that there is significant relationship between soil copper values and that of leaf.

Cassia fistula: A total of 11 plant samples (7+4) were analyzed and the soil copper showed a range from 70 ppm to 604 ppm. However, values recorded in the plant parts were lower with a range from 20 ppm to 84 ppm in the bark samples and 100 ppm to 347 ppm in the leaf samples. Mean copper value stands at 145.0 ppm in the leaf samples and 190.6 ppm in bark samples. 't'test indicates that there is no significant difference in copper concentration between leaf and bark samples. The values of correlation coefficients are low and no significant relations exist between soil copper values and that of plant parts.

Cleistanthus collinus: This is a quite common species in both the sampling belts and a total of 41 samples (34+7) were analyzed collected from different places. Collections of plant samples include from soils which showed a copper range from 55 ppm to 1671 ppm. However, the values were much lower in plant parts and on average, leaf samples showed higher values relative to twigs. Copper concentration in twigs showed a variation from 25 ppm to 268 ppm while in the leaf samples, it varied from 45 ppm to 520 ppm. Mean copper values in the leaf samples stand at 244.1 ppm while in the twigs 141.7 ppm. 't'test results indicate that there is a significant difference in the copper concentration between leaf and twigs. The study on correlation coefficients reveals that there is significant relationship between soil copper and that of twigs. However, this relationship was not so strong in case of soil copper and that of leaf.

Croton roxburghii: A total of 17 samples (13+4) were examined in this species and plant collections were made from soil samples that exhibit a copper range from 105 ppm to 1671 ppm. Values in the plant parts are much lower and showed fluctuations from 50 ppm to 539 ppm in case of bark samples and 30 ppm to 439 ppm in leaf samples. Mean copper values stand at 246.8 ppm in bark and 229.3 ppm in leaf samples. 't'test results indicate that there is no significant difference in copper concentration between leaf and bark samples. Results on correlation coefficients reveal that there is no significant relationship between copper concentration of plant bioparts and soil copper.

Diospyros melanoxylon: A total of 40 plant samples were analyzed from different locations and the soil copper values ranged from 51 ppm to 1100 ppm. However, values recorded for bark samples were much lower and ranged from 20 ppm to 373 ppm while the values of leaf samples are higher and showed a range from 20 ppm to 789 ppm. Mean copper value stands at 221.4 ppm in case of leaf samples and 96.9 ppm in case of bark samples. 't'test results indicate that there is significant difference in copper concentration between leaf and bark samples. Values with regard to correlation coefficients indicate no significant relation exists between soil copper and that of plant parts.

Cassine glauca: A total of 18 samples (13+5) were analyzed in this species and the soil copper concentration showed a range from 67 ppm to 1232 ppm. The bioparts showed lower values and the fluctuations were narrower with 64 ppm to 378 ppm in bark samples and 20 ppm to 303 ppm in leaf samples. Mean copper value stands at 191.1 ppm in leaf samples and 137.4 ppm in bark samples. Results on the 't' test indicate that there is no significant difference in the copper concentration between leaf and bark samples. Values on correlation coefficients indicate that leaf concentration showed significant positive relation with soil copper. However, this relationship was not so significant between bark samples versus soil samples.

Syzygium cumini: This plant was recorded to occur in highly mineralised zone and a total of 23 plant samples were analyzed in this species collected from different locations. This exhibited a copper range from 40 ppm to 32700 ppm. However, bioparts showed narrower fluctuations and ranged from 45 ppm to 1111 ppm in the bark and 115 ppm to 1234 ppm in case of leaf samples. Mean copper value stands at 391.6 ppm in case of bark and 560.5 ppm in case of leaf samples. Results on 't'test indicate that there is no significant difference in the copper concentrations between bark and leaf samples. The values on correlation coefficients indicate that there is significant positive correlation between soil copper and that of leaf or bark samples.

Holarrhena antidysenterica: A total of 17 plant samples (11+6) were analyzed in this species and the samples collections were made in the soils which exhibited a copper range from 55 ppm to 1546 ppm. However, bioparts showed narrower fluctuations and varied from 20 ppm to 160 ppm in twigs and 40 ppm to 165 ppm in case of leaf parts. Mean copper value stands at 91.4 ppm in case of twig samples and 111.3 ppm in case of leaf samples. Results of 't'test indicate that there is no significant difference in the copper concentration between leaf and twig samples. The values on correlation coefficients indicate that there is no significant relationship between soil copper and that of different bioparts of this species.

Lagerstroemia parviflora: A total of 12 samples (8+4) were analyzed for this species and the soil copper values exhibited wider fluctuations and showed a range from 90 ppm to 1189 ppm While the figures for leaf samples showed a range from 395 ppm to 1700 ppm. The values for bark samples were quite lower and exhibited a range from 105 ppm to 347 ppm. Mean copper values stand at 227.3 ppm in case of bark samples and 660.1 ppm in case of leaf samples. Results on 't'test indicate that there is significant difference in the copper concentration between leaf and bark samples. Values on correlation coefficients indicate that there is no significant relationship between soil copper and that of leaf and bark values.

Lantana camara: A total of 10 plant samples (9+1) were analyzed and there is no significant difference in copper concentration between samples of leaf and twigs. Copper values in soil samples exhibited a range from 57 ppm to 225 ppm while the values showed fluctuations from 135 ppm to 340 ppm in leaf samples and 175 ppm to 275 ppm in bark samples. Mean copper value stands at 256.7 ppm in leaf samples and 221.7 ppm in twigs. Results on 't'test indicate that there is no significant difference in copper concentration between leaf and twig samples. The value on correlation coefficient is low between soil copper and that of twigs. But a strong negative relationship observed between soil copper and that of leaf copper.

Mitragyna parvifolia: A total of 13 samples (9+4) were analyzed in this species collected from different locations, the soils showed a range from 110 ppm to 763 ppm. Plant bioparts showed lower values and the values in the leaf samples showed a variation from 20 ppm to 590 ppm. However, the values of bark are much narrower exhibiting a variation from 30 ppm to 330 ppm. Mean copper value stands at 253.8 ppm for leaf samples and 110.0 ppm for bark samples. Results on 't'test indicate that there is significant difference in the copper concentration between leaf and twig values. Low values of correlation coefficient was recorded between soil copper and that of leaf copper However, the value is significant between soil copper and that of bark

Gardenia gummifera: A total of 15 samples were analyzed in this species and soils exhibited a narrow range of variation in copper concentration and showed figures between 40 ppm and 277 ppm This species exhibits very low level of copper in the bark samples (60 ppm to 115 ppm) compared to leaf (125 ppm to 485 ppm) and floral parts (600 ppm). Mean copper level stands at 196.4 ppm in leaf samples and 79.3 ppm in bark samples. t' values indicate that there is significant concentration difference in copper between leaf and bark samples. With regard to correlation coefficients, the value was low and not significant between soil copper and that of bark copper. However, the relationship with leaf copper is significant and positive.

Nyctanthes arbortristis: A total of 20 plant samples were analyzed and this species was found to occur in high copper rich areas without showing significant increase of copper in its bioparts. Soil copper ranges showed a variation from 90 ppm to 1700 ppm while the values are 130 to 539 ppm in twig samples and 90 to 352 ppm in leaf samples. Mean copper value stands at 209.4 ppm for leaf and 281.7 ppm in twig samples. 't' test indicates that there is not much significant difference in the copper concentration between leaf and bark samples. Correlation coefficients estimated between soil copper and that of leaf copper or twig copper showed moderate values indicating significant relationships.

Shorea robusta: A total of 46 samples were analyzed for this species collected from different situations. Sample collections were taken from soils which exhibited copper values ranging from 55-440 ppm. Even plant bioparts also showed very high concentration of copper both in bark and leaf samples without showing any morphological aberrations. Thus values showed a range from 45-7099 ppm in bark samples and 195-1631 ppm in leaf samples. Mean copper value for the leaf stands at 580.2 ppm and 620.1 ppm for bark samples. 't' values showed that there is no significant difference in the copper concentration between leaf and bark samples. Values of correlation coefficients indicate that there is significant relationship between soil copper and that of leaf and bark copper levels.

Terminalia crenulata: A total of 39 samples (33+6) were analyzed in this species collected from various soils which exhibit a variation in copper level ranging from 45-11700 ppm. In spite of its growth in soils exhibiting high variation in copper level, plant copper levels are moderate. The variations recorded in the bark ranged from 20 ppm to 710 ppm while in the leaf copper levels it varied from 60 ppm to 844 ppm. Such low values in the bioparts reflect the species attitude towards high copper soils. Mean copper value stands at 137.5 ppm in bark and 271.2 ppm in leaf. 't'test results indicate that there is significant difference in the copper concentration between leaf and bark samples. Values of correlation coefficients showed that there is significant relationship between soil copper and copper level in the different bioparts.

Woodfordia fruticosa: A total of 25 samples (23+2) were analyzed in this species collected from different soils which showed a variation ranging from 50 ppm to 3700 ppm. However, as in case of *Terminalia crenulata*, values of copper in different bioparts are low and showed a fluctuation from 60 ppm to 380 ppm in twigs samples and 110 ppm to 450 ppm in case of leaf samples. Mean copper value stands at 173.9 ppm in case of twigs and 250.5 ppm in case of leaf samples. Results on 't'test indicate that there is no significant difference in copper concentration between leaf and bark samples. Values of correlation coefficients are low and indicate no significant relation between soil copper and that of leaf and bark samples.

In addition to the above most common dominant species in the studied sampling belt, chemical analysis was conducted in some other important shrubs and trees and their analysis report is presented below.

A number of plants have shown lower mean copper values in their bioparts compared to soil copper. In this list include species namely, *Aegle marmelos, Artocarpus chaplasha, Bombax ceiba, Bombax ceiba, Boswellia serrata, Breynia vitis-idaea, Casearia elliptica, Celastrus paniculatus, Chocolospermum religiosum, Combretum decandrum, Dillenia pentagyna, Diospyros montana, Emblica officinalis, Eriolaena hookeriana, Erythrina stricta, Ficus semicordata, Flacourtia ramontchi, Flacourtia indica, Gardenia latifolia, Hymenodyctyon excelsum, Hyptis suaveolens, Ichnocarpus frutescens, Leucaena glauca, Litsea polyantha, Mimosa himalayana, Morinda pubescens, Litchi chinensis, Polyalthia longifolia, Randia* *dumetorum, Semicarpus anacardium, Smilax ovalifolia, Soymida febrifuga, Sterculia urens, Terminalia chebula, Wendlandia tinctoria.* (Table-5)

Some species have shown lower copper values in the bark samples and higher values in leaf in relation to soil copper. The list includes *Albizia lebbeck, Bauhinia retusa, Butea superba, Careya arborea, Cordia macleodii, Dalbergia sissoo, Grewia tiliaefolia, Holoptelea integrifolia, Indigofera cassioides, Madhuca indica, Miliusa velutina, Ougeinia oojeinensis, Pterocarpus marsupium, Schleichera oleosa, Vangueria pubescens.* (Table-6)

Some species have shown high copper both in leaf and bark samples relative to soil copper. Those species include *Azadirachta indica, Alstonia scholaris, Canthium dicoccum, Cymbopogon martini, Ehretia aspera, Ficus benghalensis, Pavetta indica.* (Table-7)

TABLE 5: PLANTS SHOWING LOWER COPPER VALUES IN THEIR BIOPARTS COMPARED TO SOIL COPPER LEVEL

SPECIES	MEAN COPPER IN(in ppm)		
	SOIL	BARK/TWIGS	LEAF
Aegle marmelos	326-390(3)*	54.7 (3)	151.5 (2)
Areca lannata	600 (1)		52 (1)
Annona squamosa	95 (1)	80 (1)	
Artocarpus chaplasha	9700 (1)	322 (1)	500 (1)
Bombax ceiba	143 (2)	37 (2)	
Bombax malabaricum	245 (1)	20 (1)	
Boswellia serrata	535 (1)	411 (1)	
Breynia vitis-idaea	327 (4)	93.3 (4)	206.8 (4)
Casearia tomentosa	95 (1)	20 (1)	85 (1)
Celastrus paniculatus	560 (1)		316 (1)
Chocolospermum religiosum	225	50	
Combretum decandrum	1340 (2)	345 (2)	461.5 (2)
Dillenia pentagyna	605 (1)	122 (1)	
Diospyros montana	263.3 (3)	70 (3)	190 (3)
Emblica officinalis	95 (1)	30 (1)	65 (1)
Eriolaena hookeriana	395 (1)	241 (1)	310 (1)
Erythrina stricta	245 (2)	20 (2)	110 (1)
Ficus semicordata	1605/1670 (2)	343 (2)	243 (2)
Flacourtia ramontchi	209.5/213.6 (5)	49.6 (5)	187.8 (4)
Flacourtia indica	265 (1)	35 (1)	
Flueggia obovata	244 (1)	198 (1)	177 (1)
Gardenia latifolia	468.3 (3)	90 (3)	200 (3)
Hymenodyctyon excelsum	227.5 (2)	55 (2)	
Hyptis suaveolens	495.4 (5)	368.8 (5)	
Ichnocarpus frutescens	380 (1)	225 (1)	
Indigofera tinctoria	1476 (1)	153 (1)	429 (1)
Leucaena glauca	246 (1)	80 (1)	
Litsea polyantha	275 (1)	125 (1)	175 (1)
Mimosa himalayana	523 (1)	120 (1)	490 (1)
Morinda pubescens	423.7 (3)	233 (3)	301.3 (3)
Litchi chinensis	285 (2)	83.5 (2)	121 (2)
Pavetta crassiuscula	2282.5	280 (1)	269.5 (1)
Phoenix acaulis	1395 (1)	178 (1)	260 (1)
Polyalthia longifolia	255 (1)	178 (1)	90 (1)
Randia dumatorum	433.7 (6)	112.3 (6)	
Semicarpus anacardium	217.5/377.5(2)	120 (2)	158.5 (2)
Smilax ovalifolia	1072/1085.3(4)	482.7 (3)	645 (4)
Schrebera swetenoides	248 (2)	52 (1)	164.5 (2)
Soymida febrifuga	550 (1)	204 (1)	310 (1)
Sterculia urens	407.3 (3)	99 (3)	183.3 (3)
Terminalia chebula	304/235 (6)	88.6 (5)	168 (5)
Terminalia belerica	4275 (1)		74 (1)
Wendlandia tinctoria	640 (1)	280 (1)	450 (1)
Ziziphus mauritiana	1669.8 (6)	211.5 (6)	350.7 (3)

* Values in parenthesis indicate the number of samples analyzed.

TABLE 6: PLANTS SHOWING LOWER COPPER VALUES IN BARK AND HIGHER VALUES IN LEAVES IN COMPARISON TO SOIL COPPER

SPECIES	MEAN COPPER IN(in ppm)		
	SOIL	BARK/TWIGS	LEAF
Albizia lebbeck	410 (1)*	254 (1)	1111 (1)
Bauhinia retusa	312.5 (2)	197 (2)	455.5 (2)
Butea superba	70 (1)	30 (1)	120 (1)
Careya arborea	260 (4)	188 (2)	316.8 (4)
Cordia macleodii	120 (2)	42.5 (2)	167.5 (2)
Dalbergia sissoo	426 (1)	216.5 (2)	769.5 (2)
Grewia tiliaefolia	294.7 (6)	269.8 (6)	441.3 (3)
Holoptelea integrifolia	105 (2)	45 (2)	157.5 (2)
Indigofera cassioides	627.5 (2)	511 (1)	679 (2)
Madhuca indica	147.8 (5)	137.5 (5)	225.8 (5)
Miliusa velutina	334/243 (3)	224.7 (3)	309 (3)
Ougeinia oojeinensis	628 (1)	257 (1)	827 (1)
Pterocarpus marsupium	373.5 (6)	172.7 (6)	476.3 (4)
Schleichera oleosa	102.5 (2)	25 (2)	147.5 (2)
Vangueria pubescens	168.3 (3)	165.3 (3)	251.5 (2)

TABLE 7: SPECIES SHOWING HIGH COPPER BOTH IN LEAVES AS WELL AS BARK OR TWIGS RELATIVE TO SOIL COPPER

SPECIES	MEAN COPPER IN(in ppm)		
	SOIL	BARK	LEAF
Azadirachta indica	145.7(1)*	152(1)	
Canthium dicoccum	55(1)	255(1)	270(1)
Carissa paucinervia	30(1)	115(1)	210(1)
Cymbopogon martini	310(1)		195(1)
Ehretia aspera	70(1)	210(1)	
Ficus benghalensis	75(2)	145(2)	240(1)
Pavetta indica	125(3)	187.3(3)	163.3(3)
Alstonia scholaris	84(1)	246(1)	113(1)

* Values in parenthesis indicate number of samples analyzed

TABLE 8: PLANT AND SOIL COPPER RANGES WITH CORRELATION COEFFICIENTS AND STUDENT'S 't' VALUES IN SINGHBHUM COPPER BELT

Name of species	No.of Samples	Soil Cu range (in ppm)	Plant Cu range (in ppm on ash wt. basis) leaf	bark/twigs	Correlation Coeffit. Plant Cu vs Soil Cu Leaf	Bark/Twig	Calculated 't'value	Remarks table 't'value at 0.975
Acacia torta	13	135-1500	44-864	145-560	N.S.	N.S.	0.38	N.S.; ±2.20
Adina cordifolia	12	100-255	275-567	25-316	N.S.	N.S.	3.97	S.; ±2.23
Anogeissus latifolia	26	60-1200	75-500	20-248	N.S.	0.52 P<0.05	4.05	S.; ±2.06
Buchanania lanzan	24	70-1800	20-145	25-214	N.S.	0.49 P<0.05	0.13	N.S.; ±2.07
Butea frondosa	14	60-546	20-510	35-370	0.85 P<0.02	N.S.	1.24	N.S.; ±2.17
Cassia fistula	07	70-604	100-347	20 84	N.S.	N.S.	2.07	N.S.; ±2.57
Cassine glauca	13	67-1232	20-303	30-378	0.83 P<0.02	N.S.	1.20	N.S.; ±2.20
Cleistanthus collinus	34	55-1671	45-520	25-210	N.S.	0.59 P<0.01	3.84	S.; ±2.04
Croton roxburghii	13	105-1671	30-439	50-539	0.69 P<0.10	0.91 P<0.02	0.19	N.S.; ±2.00
Diospyros melanoxylon	40	51-1100	20-789	20-373	N.S.	N.S.	2.87	S.; ±2.02
Gardenia gummifera	15	40-277	125-485	60-115	0.86 P<0.01	N.S.	2.37	S.; ±2.18
Holarrhena antidysenterica	11	55-1546	40-165	20-160	N.S.	N.S.	0.57	N.S.; ±2.26
Lagerstroemia parviflora	08	90-1189	395-1700	105-347	N.S.	N.S.	2.52	S.; ±2.45
Lantana camara	09	57-225	135-340	175-275	-0.93 P<0.01	N.S.	0.78	N.S.; ±2.37
Mitragyna parvifolia	09	110-763	20-590	30-330	N.S.	0.92 P<0.05	2.45	S.; ±2.36
Nyctanthes arbortristis	20	90-1700	90-352	130-539	0.86 P<0.01	0.66 P<0.05	-1.20	N.S.; ±2.10
Shorea robusta	46	55-440	195-1631	45-7099	0.71 P<0.01	0.73 P<0.01	-0.13	N.S.; ±2.02
Syzygium cumini	23	40-32700	115-1234	45-1111	0.70 P<0.02	0.79 P<0.01	1.24	N.S.; ±2.08
Terminalia crenulata	33	45-11700	60-844	20-710	0.82 P<0.01	0.59 P<0.05	2.21	S.; ±2.04
Woodfordia fruticosa	23	50-3700	110-450	60-380	N.S.	N.S.	-1.68	N.S.; ±2.08

S = SIGNIFICANT N.S. = NOT SIGNIFICANT

Inferences can be drawn on variability of copper level including maximum, minimum, median and mean in all the 20 species. Figure 19a and b indicate numerical values for the said parameters. These parameters are further represented by the lines, boxes and positive signs. The line represents the range of copper values, the box, 25th to 75th percentile limit and the positive sign, the mean value.

Fig.:18a CU VARIATION IN AN. LATIFOLIA - SIDHESAR

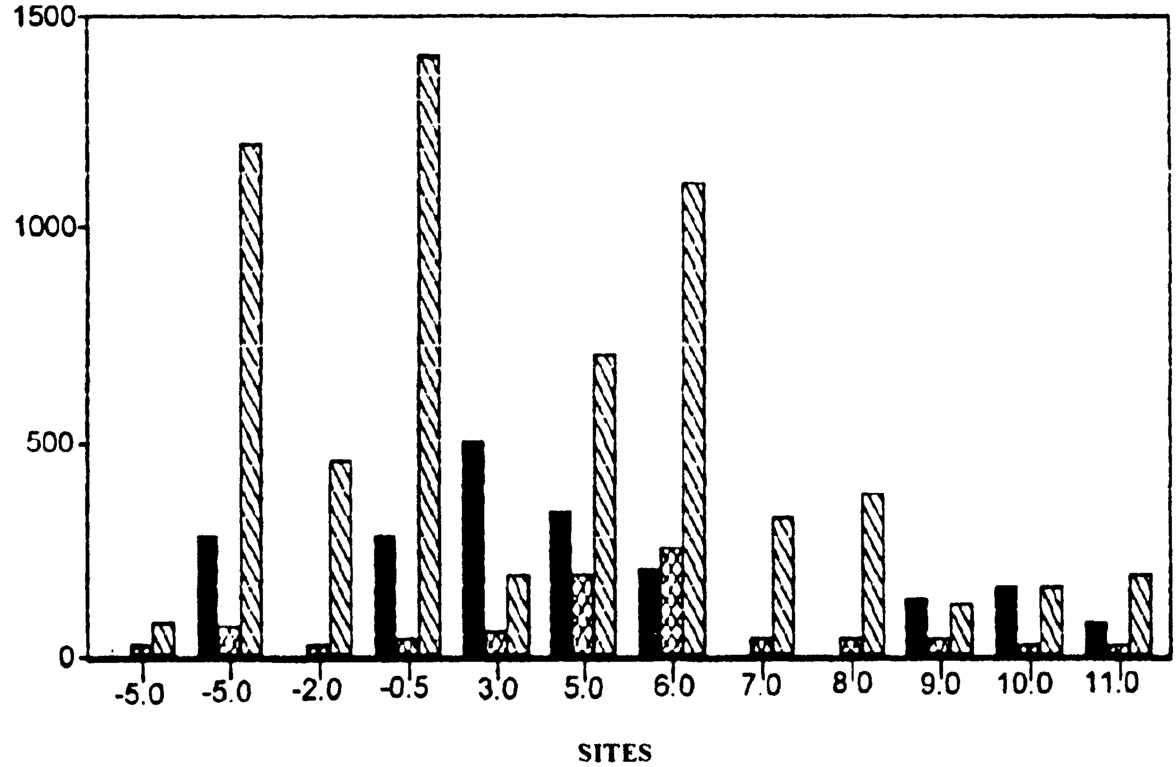


Fig.:18b CU VARIATIONS IN DIO. MELANOXYLON - SIDHESAR

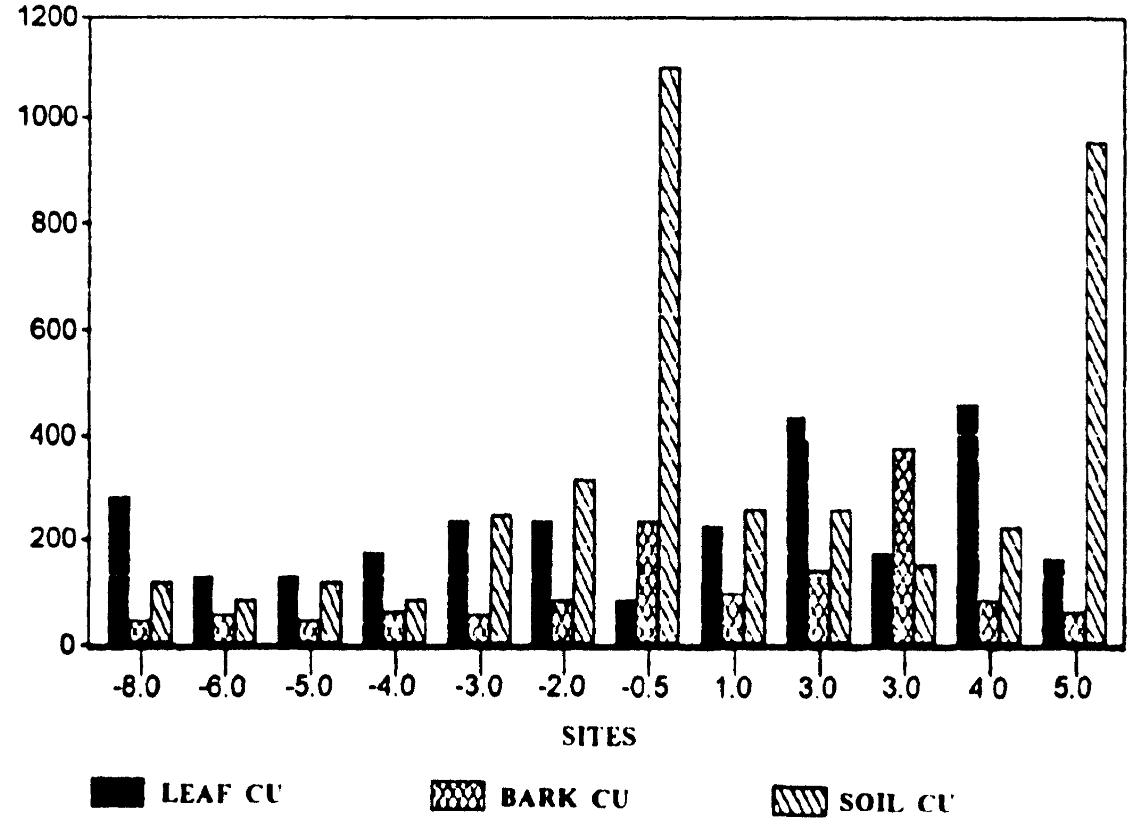


Fig.:18c CU VARIATIONS IN S. CUMINI SIDHESAR

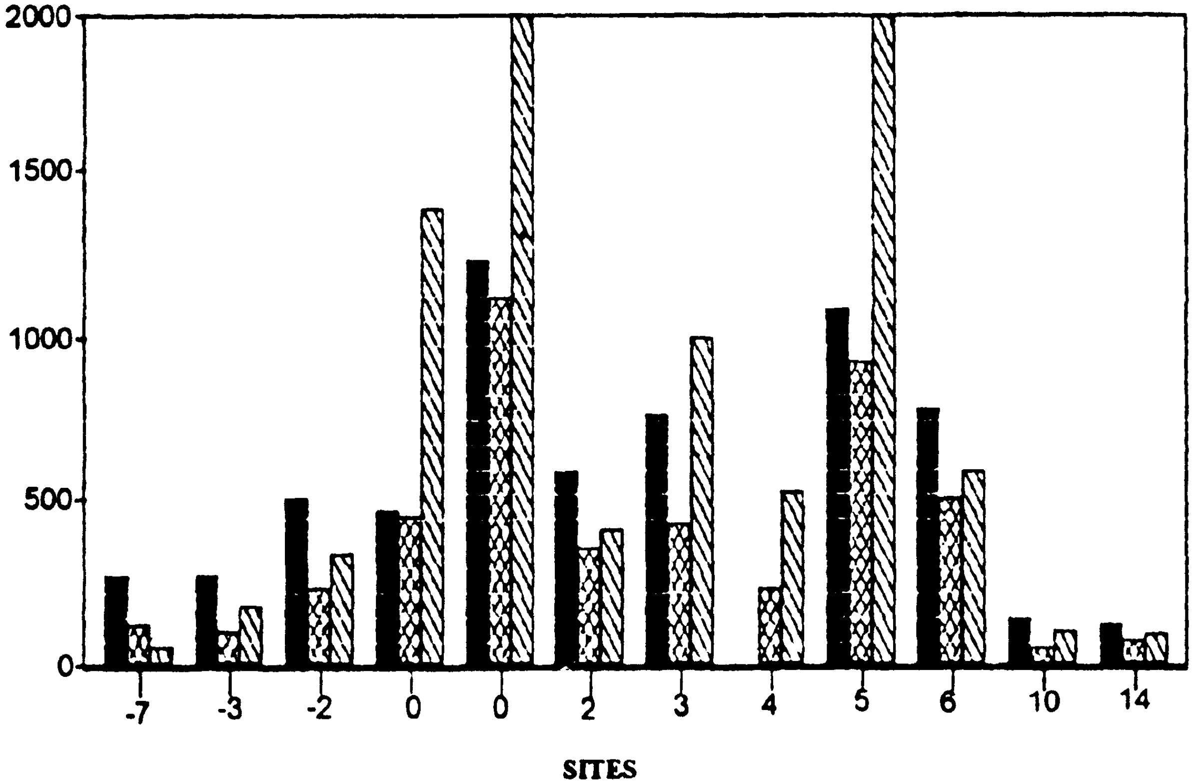


Fig.:18d CU VARIATIONS IN CASSINE GLAUCA - SIDHESAR

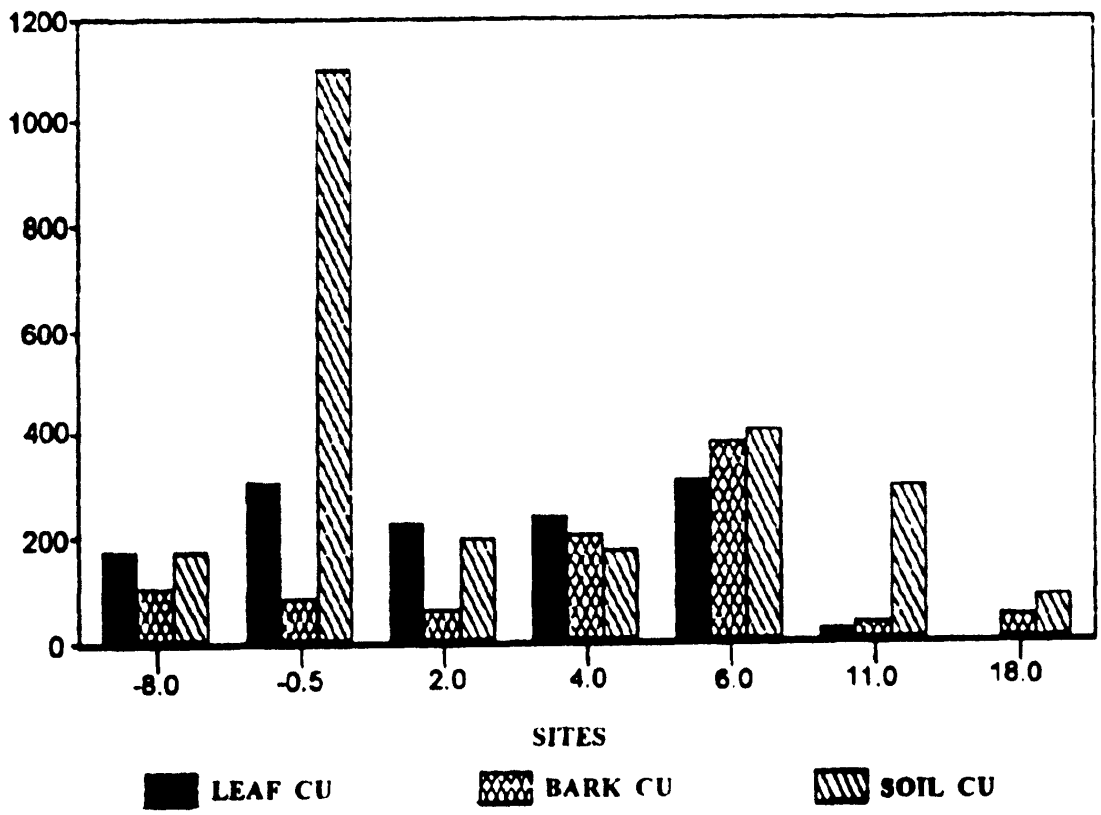


Fig.:18c CU VARIATIONS IN F. RAMONTCHI - SIDHESAR

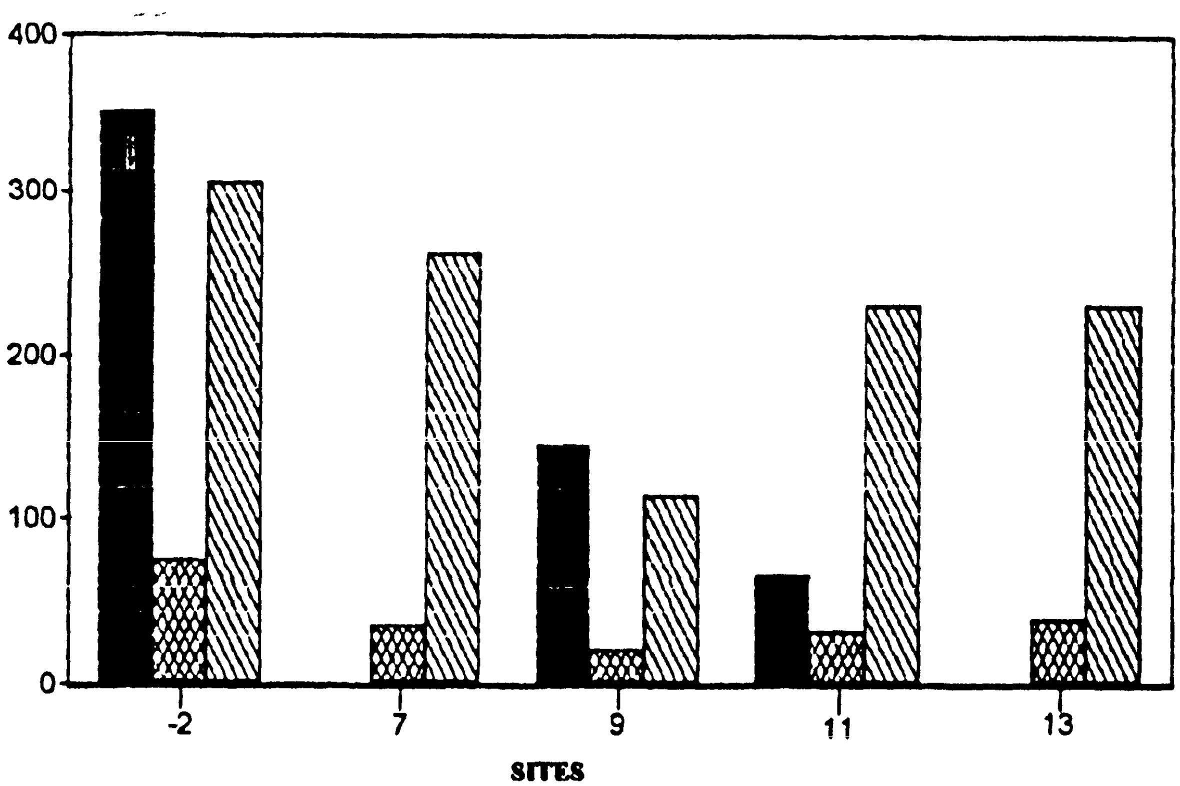


Fig.:18f CU VARIATIONS IN H. ANTIDYSENTERICA - SIDHESAR

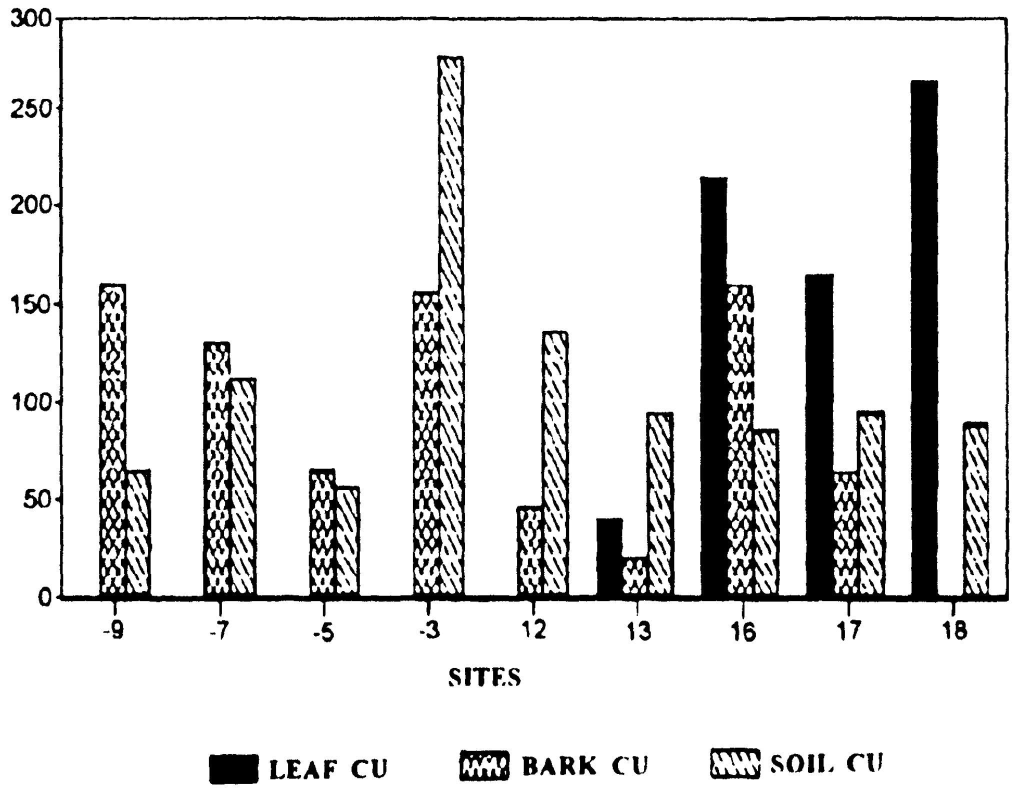


Fig.:18g CU VARIATIONS IN GAR. LATIFOLIA - SIDHESAR

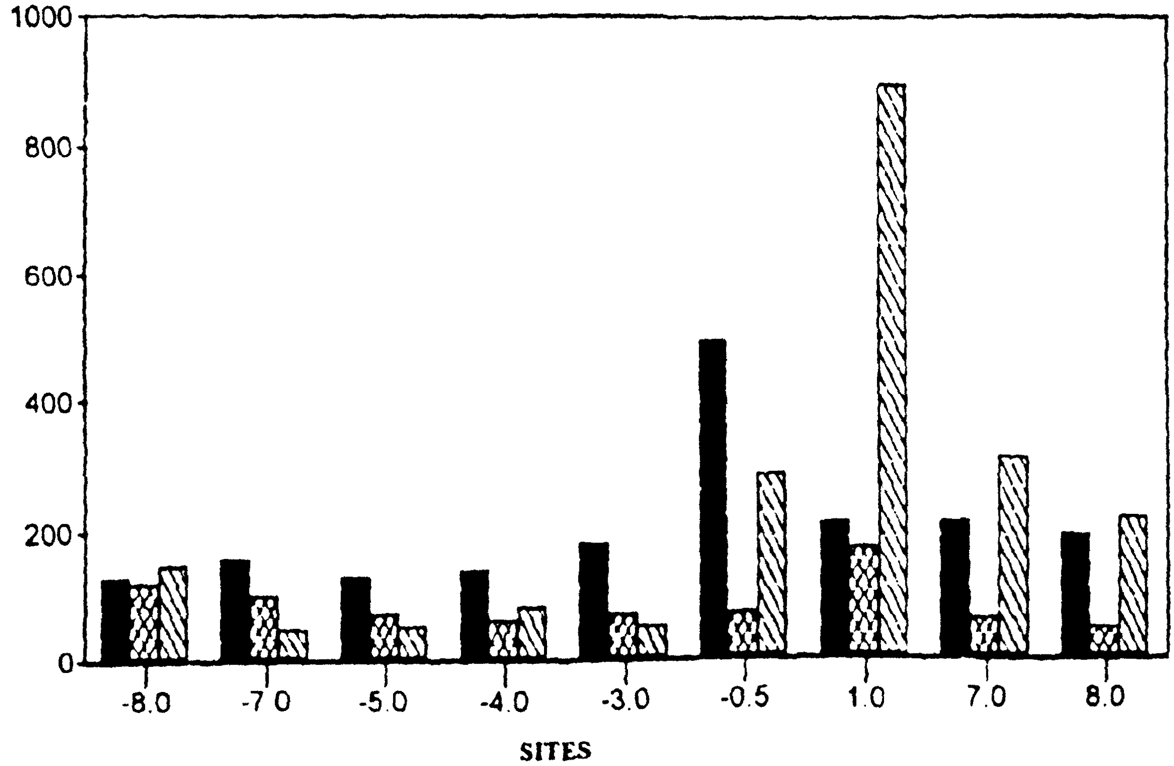


Fig.:18h CU VARIATIONS IN L. PARVIFLORA - SIDHESAR

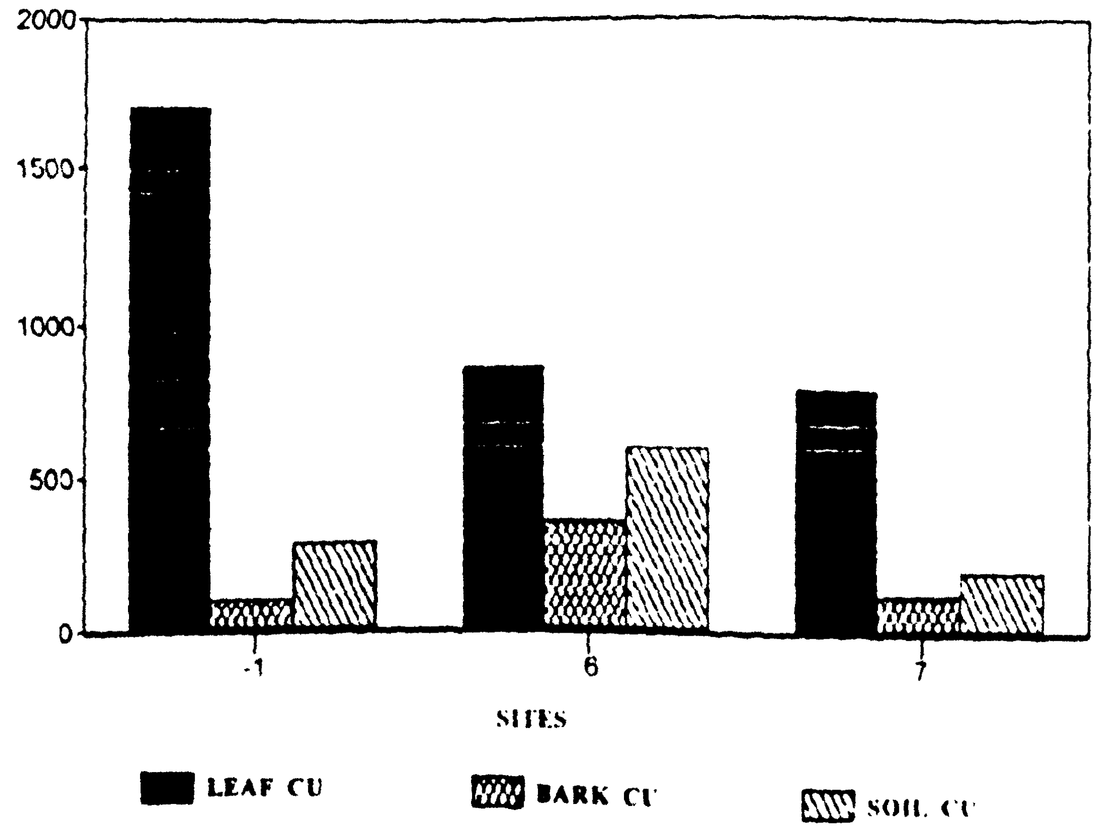


Fig.:18i CU VARIATIONS IN N. ARBORTRISTIS SIDHESAR

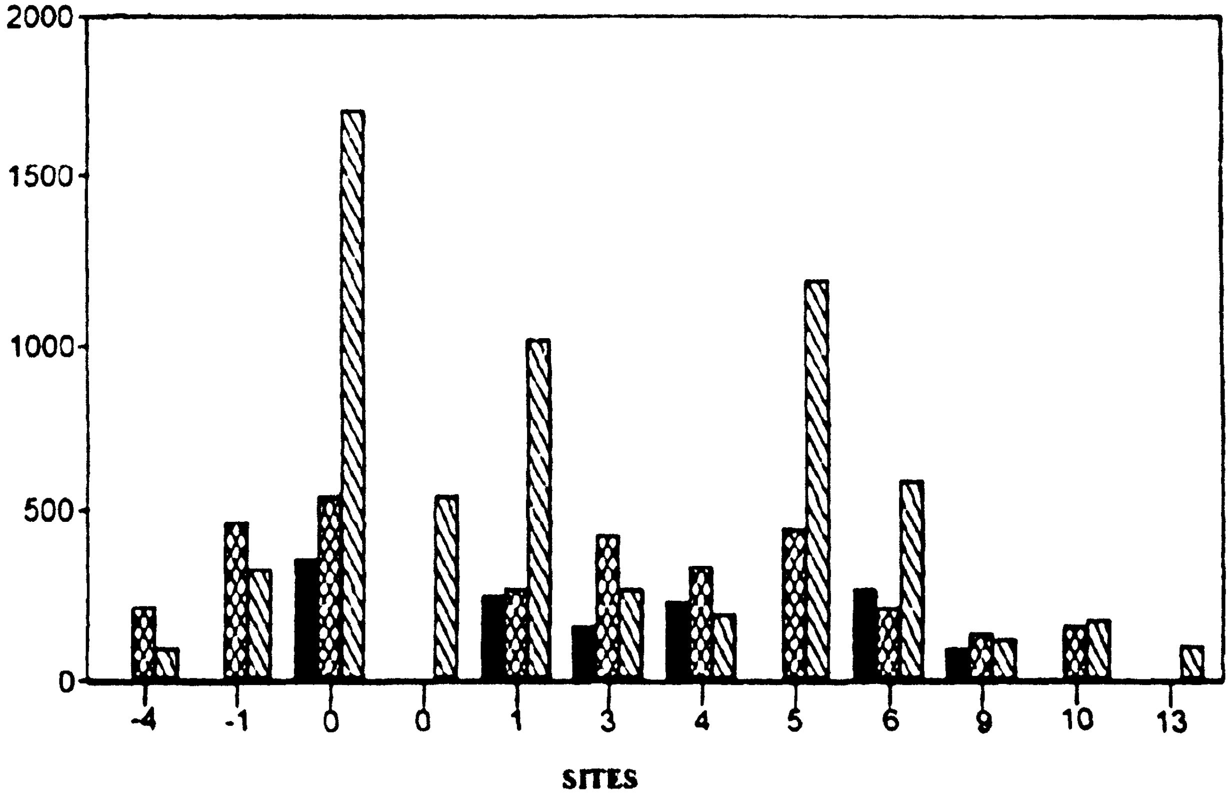


Fig.:18j CU VARIATIONS IN PT. MARSUPIUM - SIDHESAR

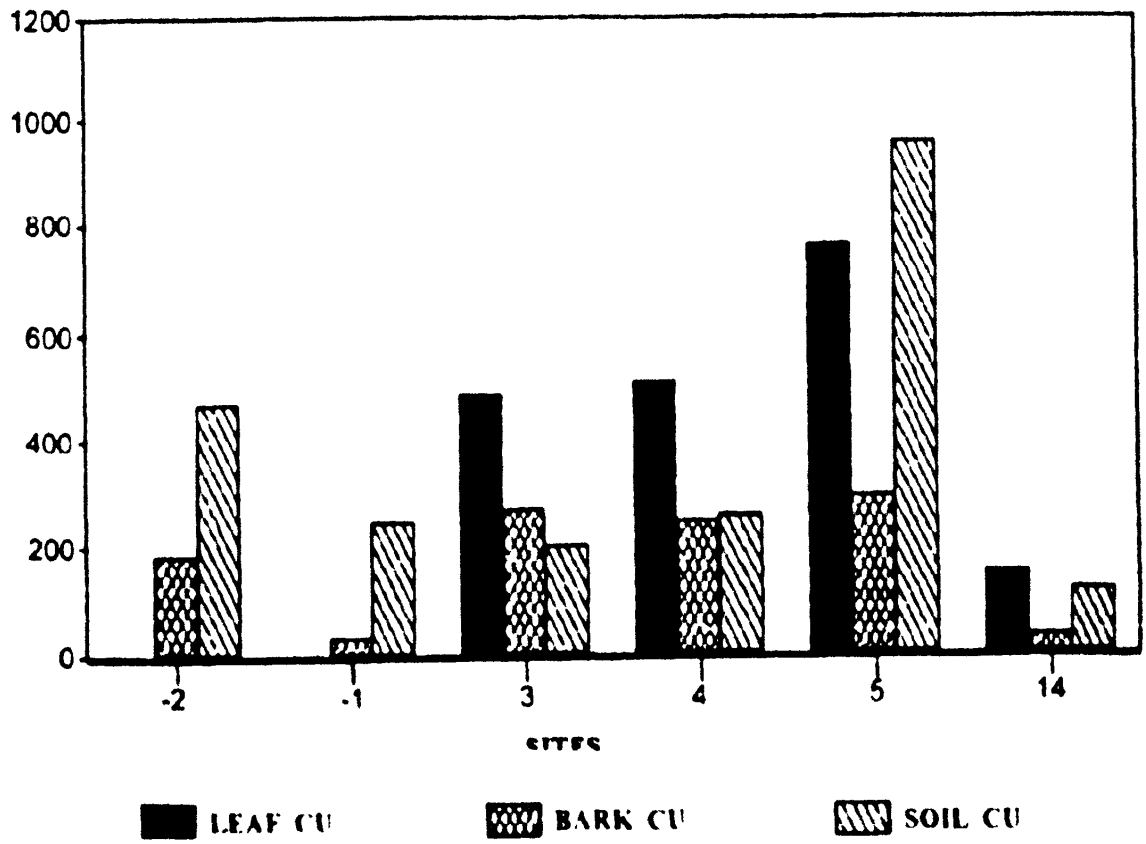


Fig.:18k CU VARIATIONS IN M. PARVIFOLIA - SIDHESAR

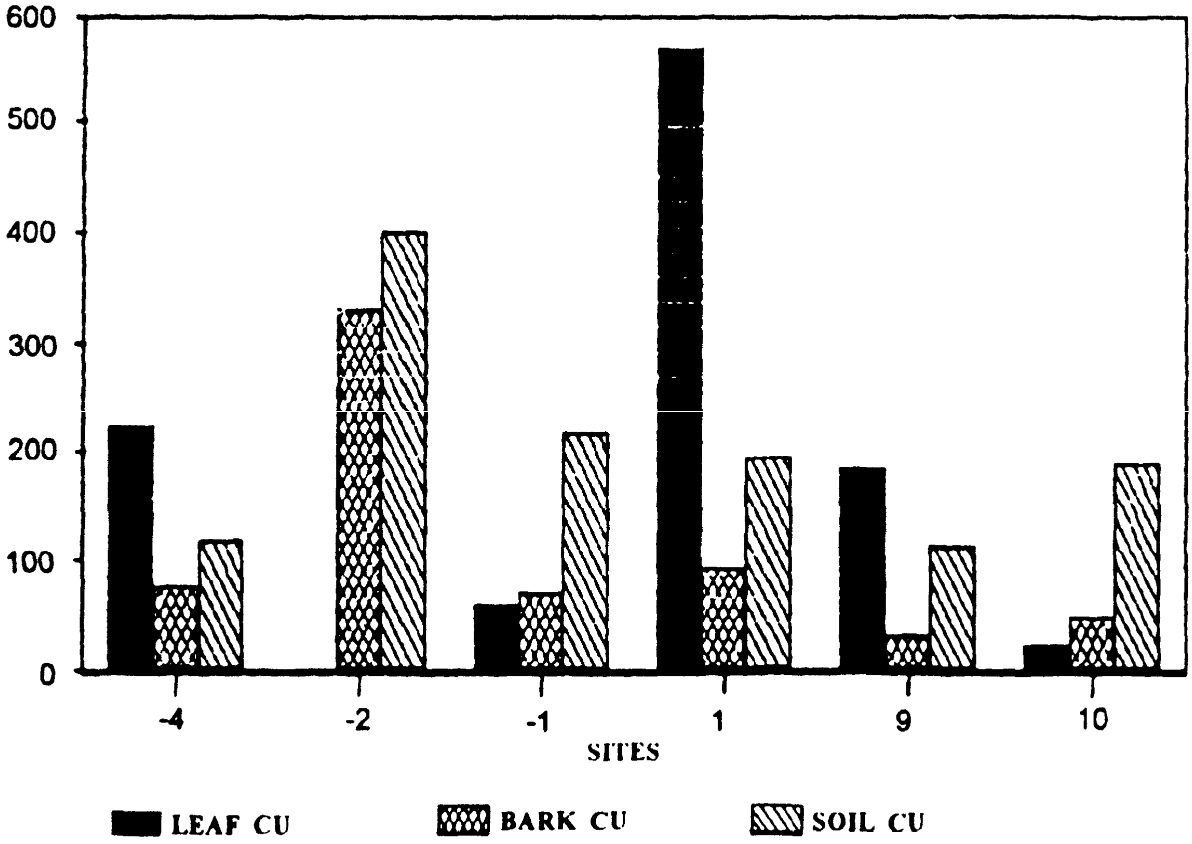


Fig.:18m CU VARIATIONS IN L. COROMANDELICA - SIDHESAR

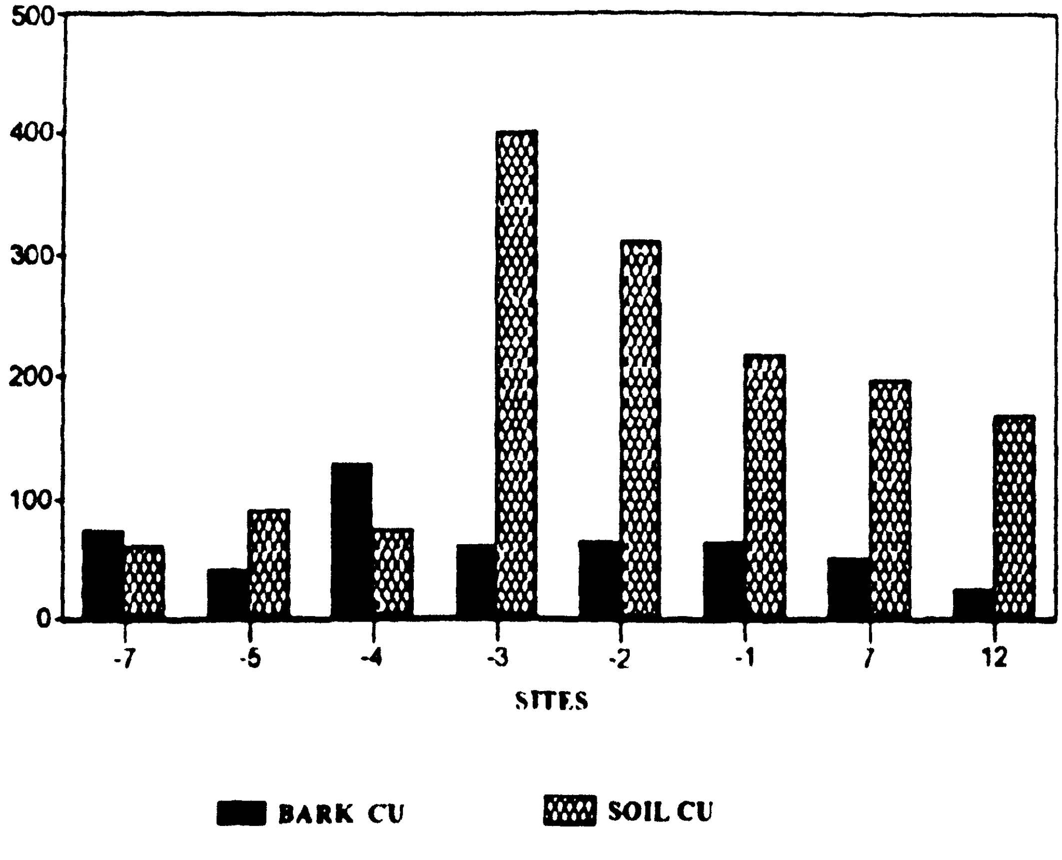
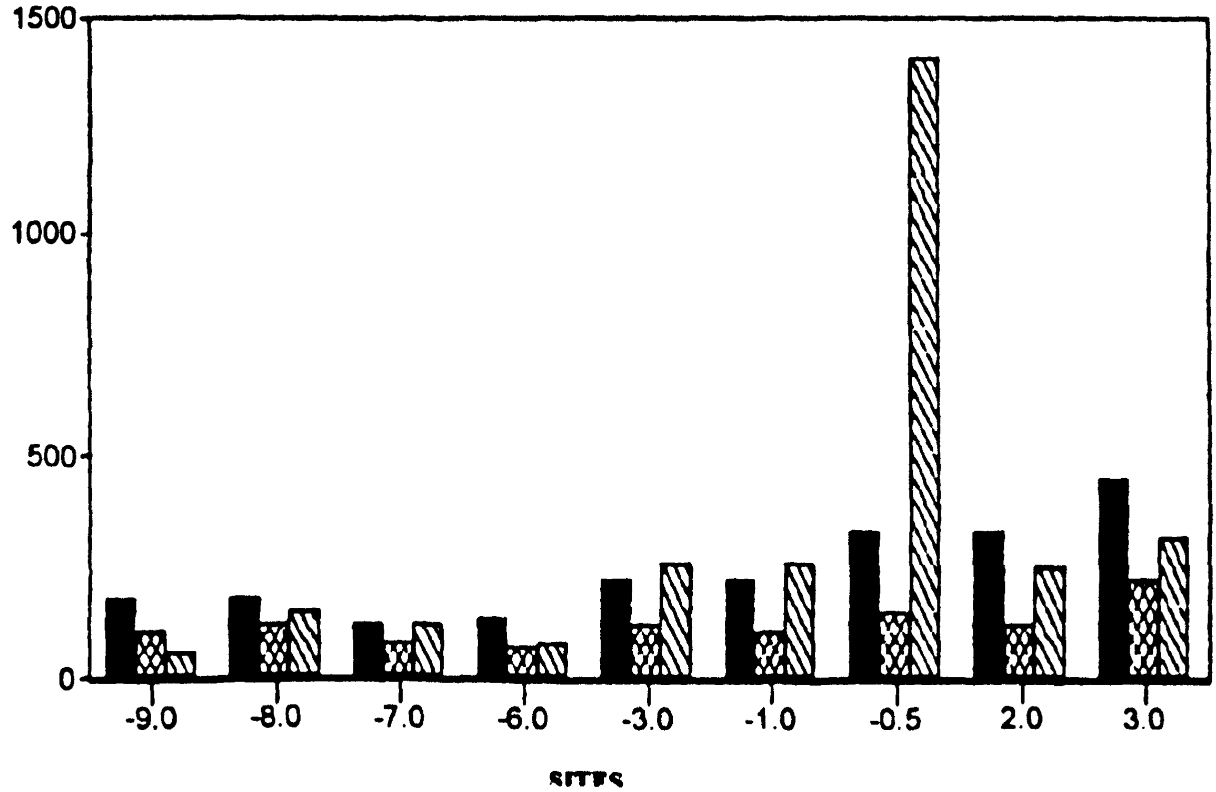


Fig.:181 CU VARIATIONS IN T. CRENULATA - SIDHESAR



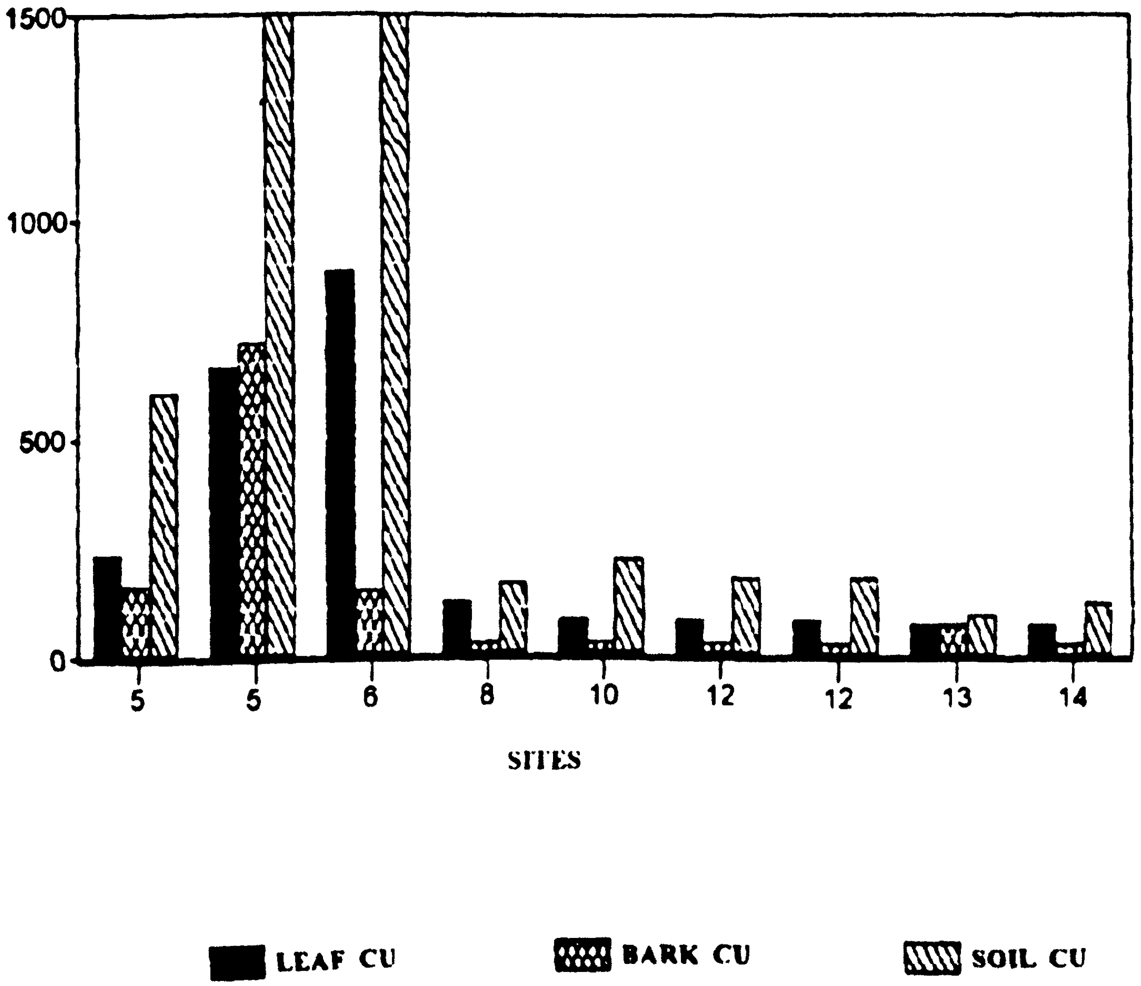


Fig.:18n CU VARIATIONS IN W. FRUTICOSA - SIDHESAR

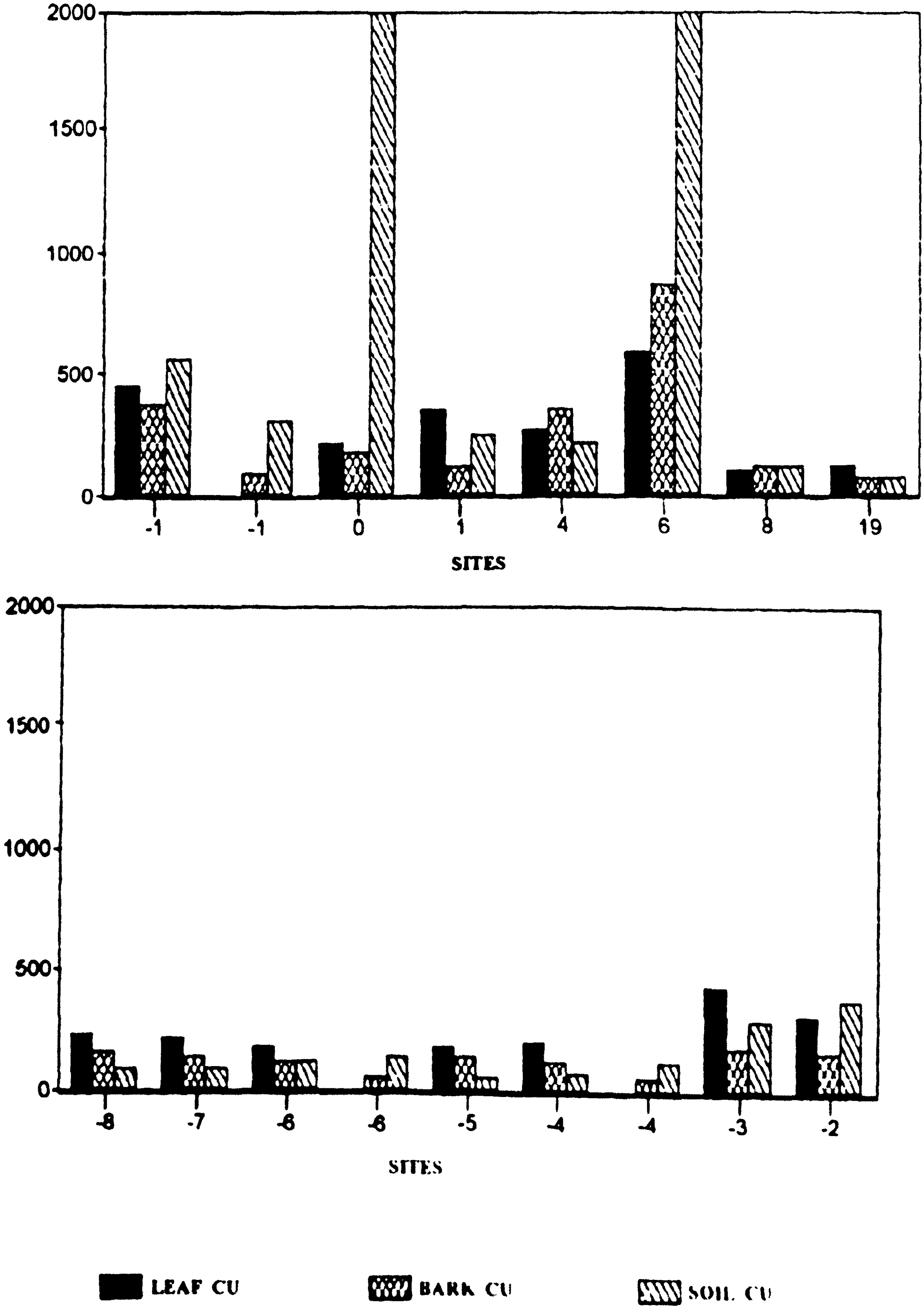


Fig.:18o CU VARIATIONS IN Z. MAURITIANA - SIDHESAR

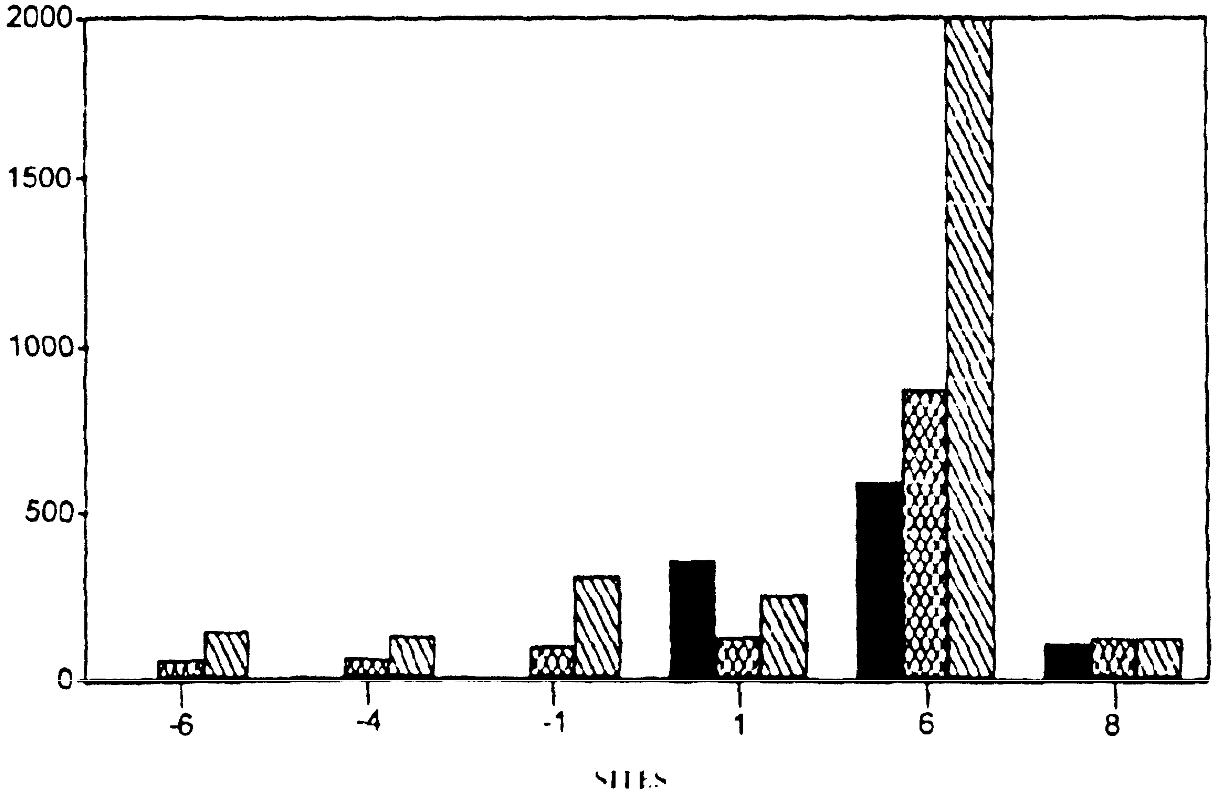


Fig.:18q CU VARIATIONS IN AD. CORDIFOLIA - SIDHESAR

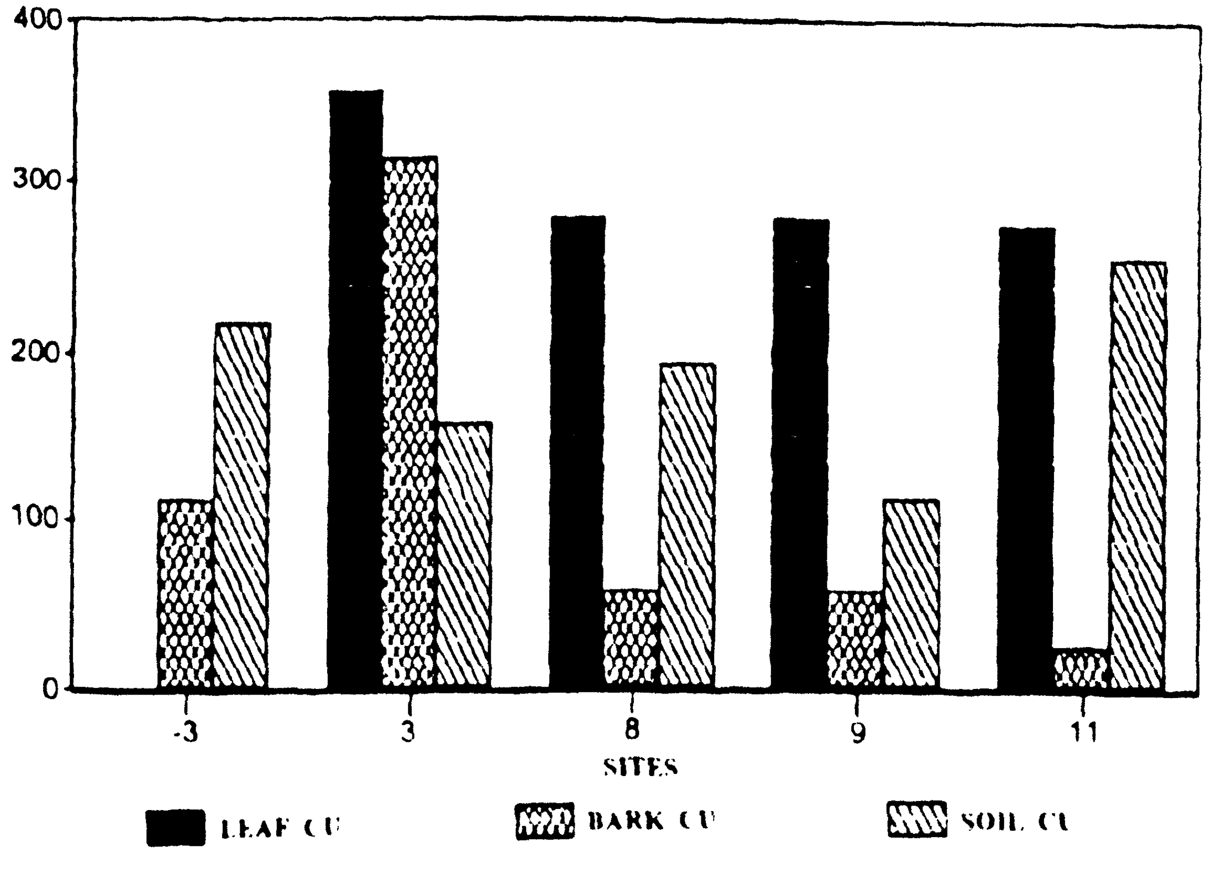


Fig.:18p CU VARIATIONS IN AC. TORTA - SIDHESAR

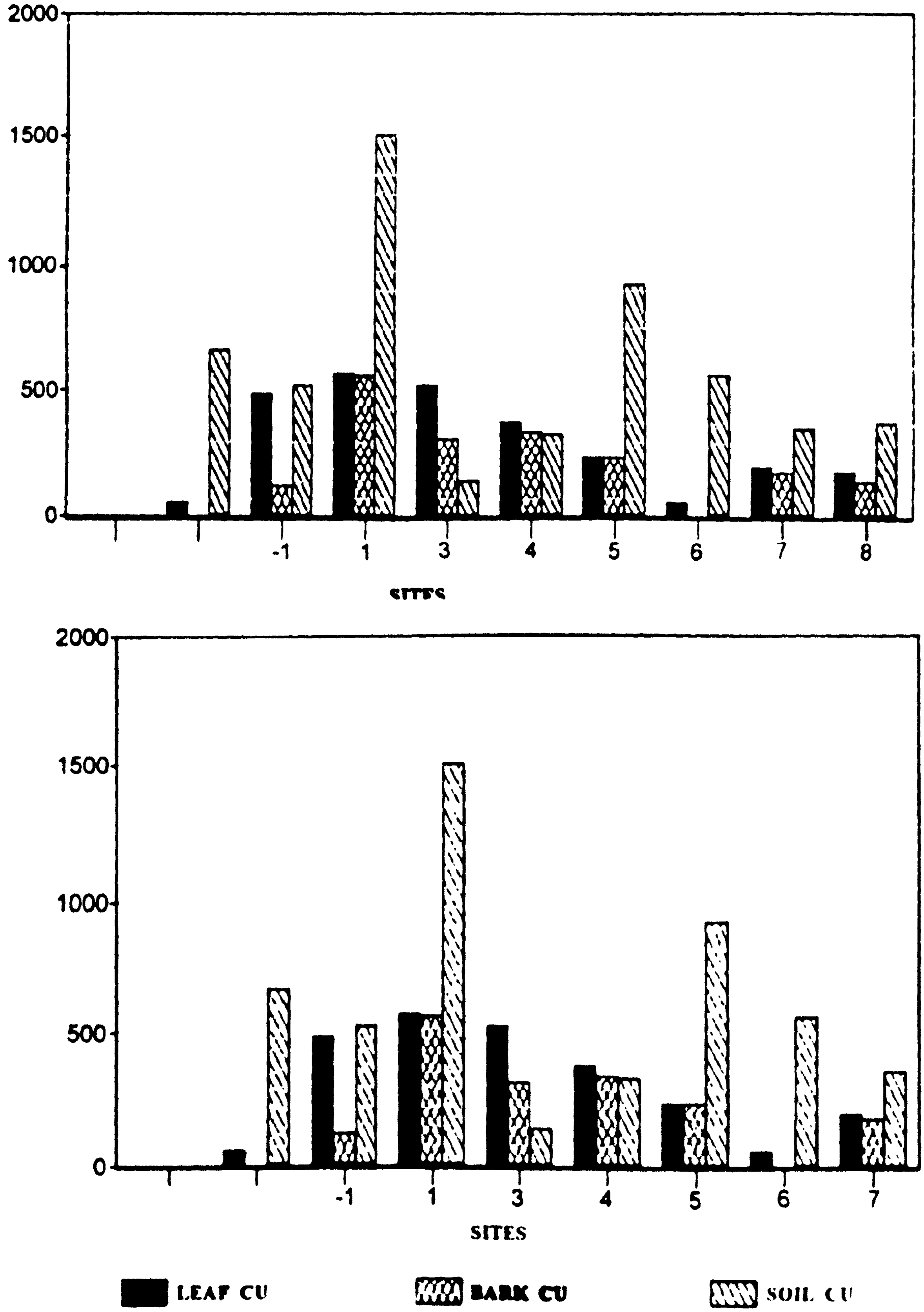


Fig.: 18r CU VARIATIONS IN B.LANZAN-SIDHESAR

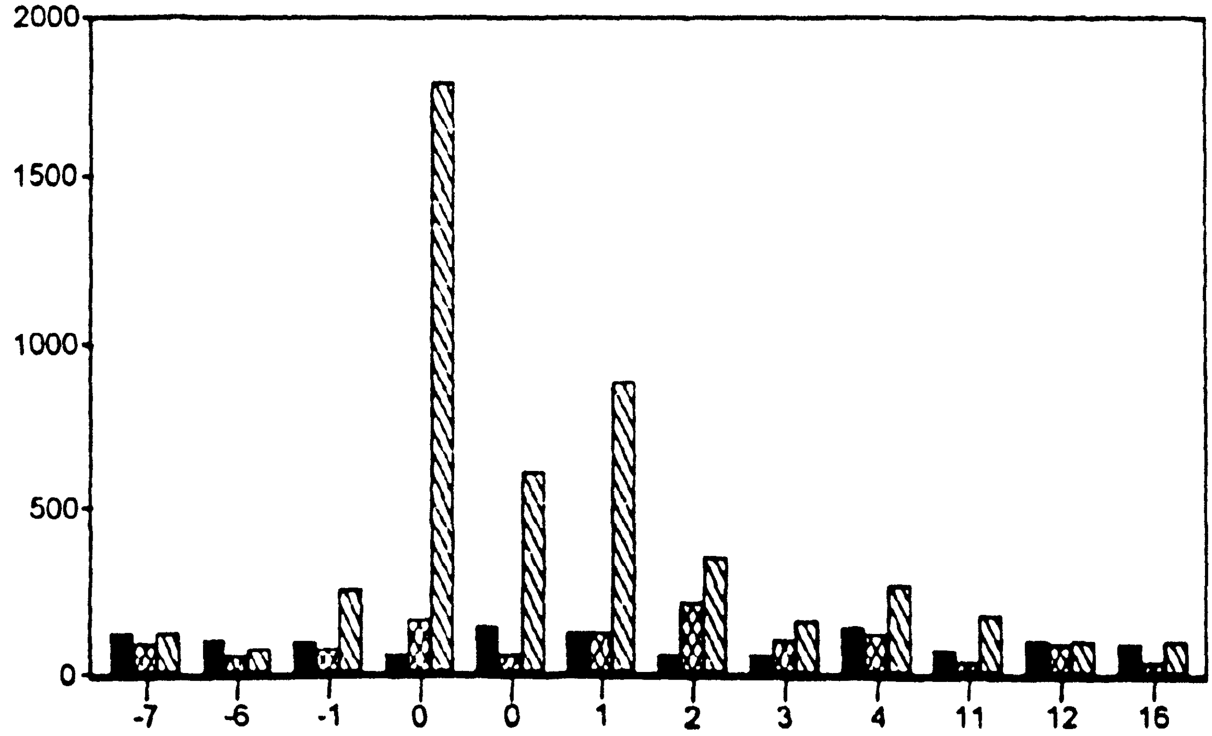


Fig.: 18s CU VARIATIONS IN B. FRONDOSA- SIDHESAR

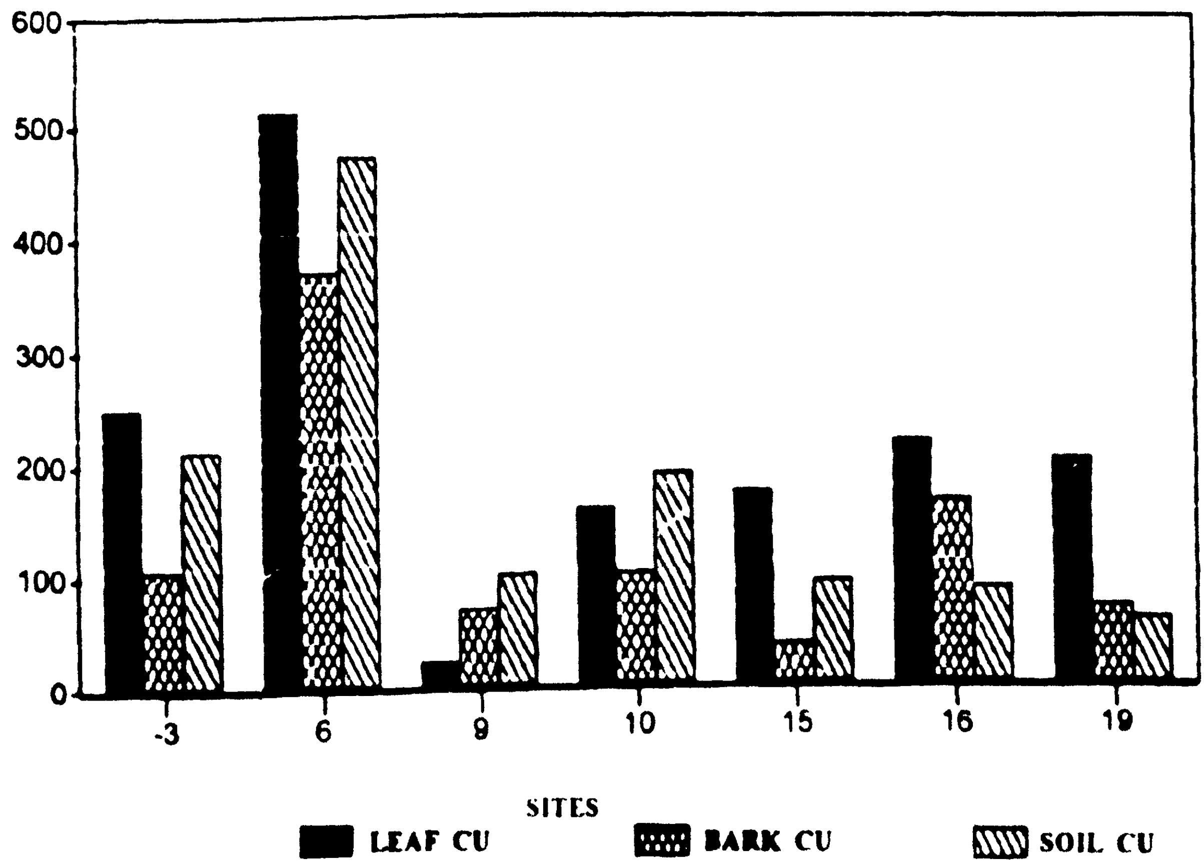


Fig.: 18t CU VARIATIONS IN CL.COLLINUS-SIDHESAR

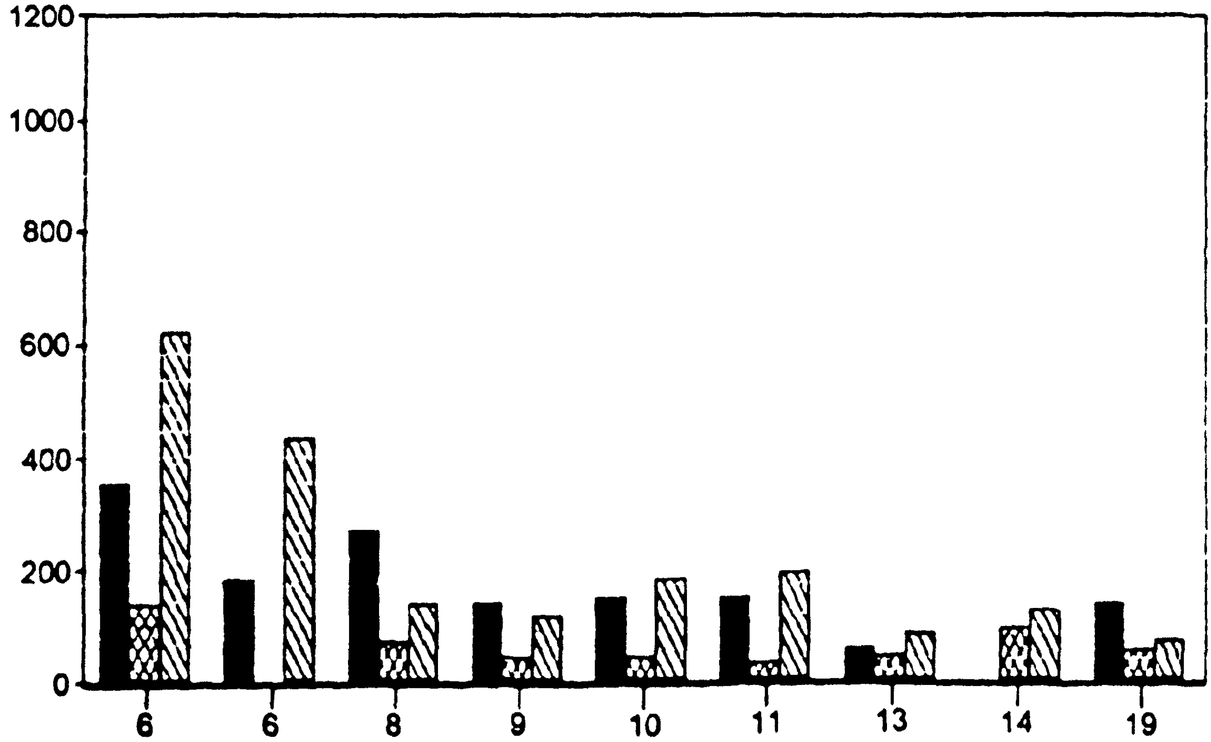


Fig.: 18u CU VARIATIONS IN C. ROXBURGHII- SIDHESAR

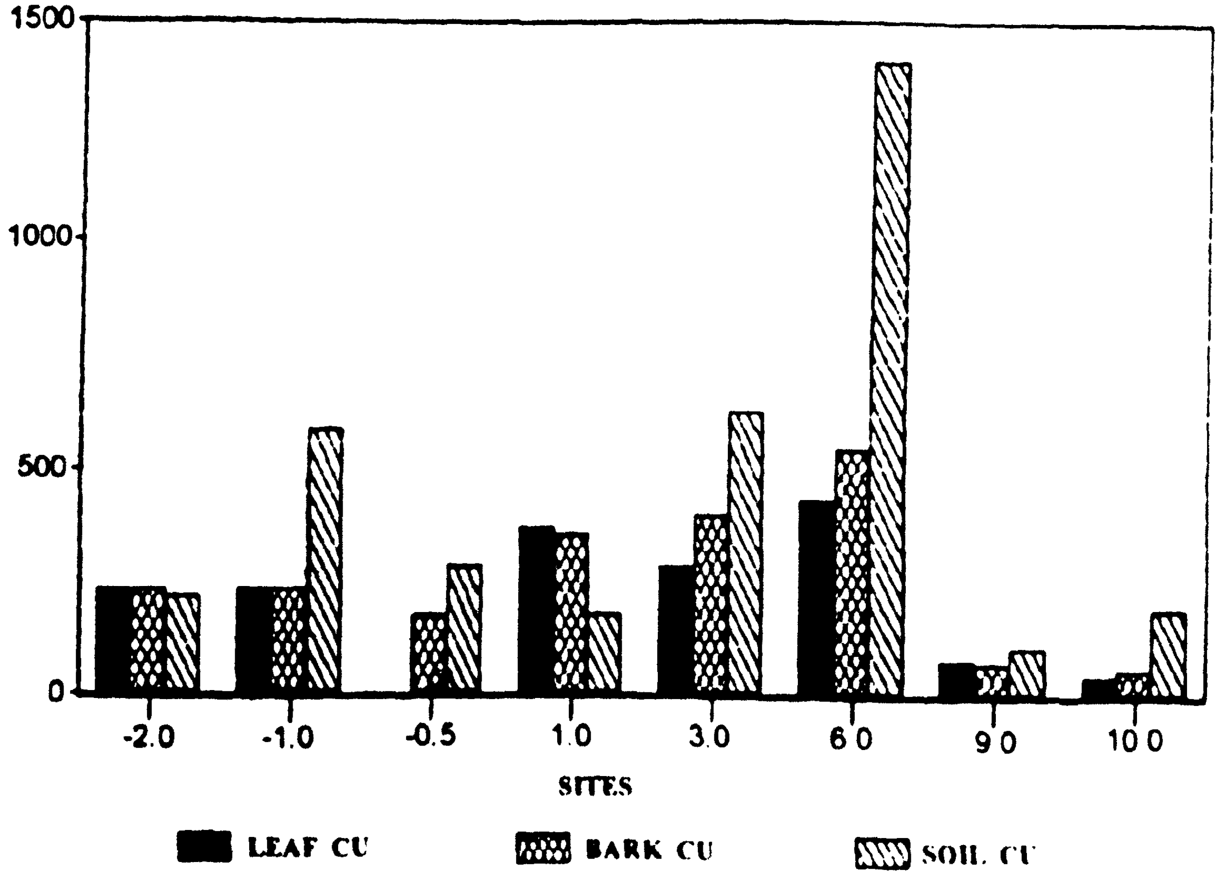


Fig.:19a COPPER VARIABILITY IN SOME DOMINANT SPECIES OF SINGHBHUM BELT

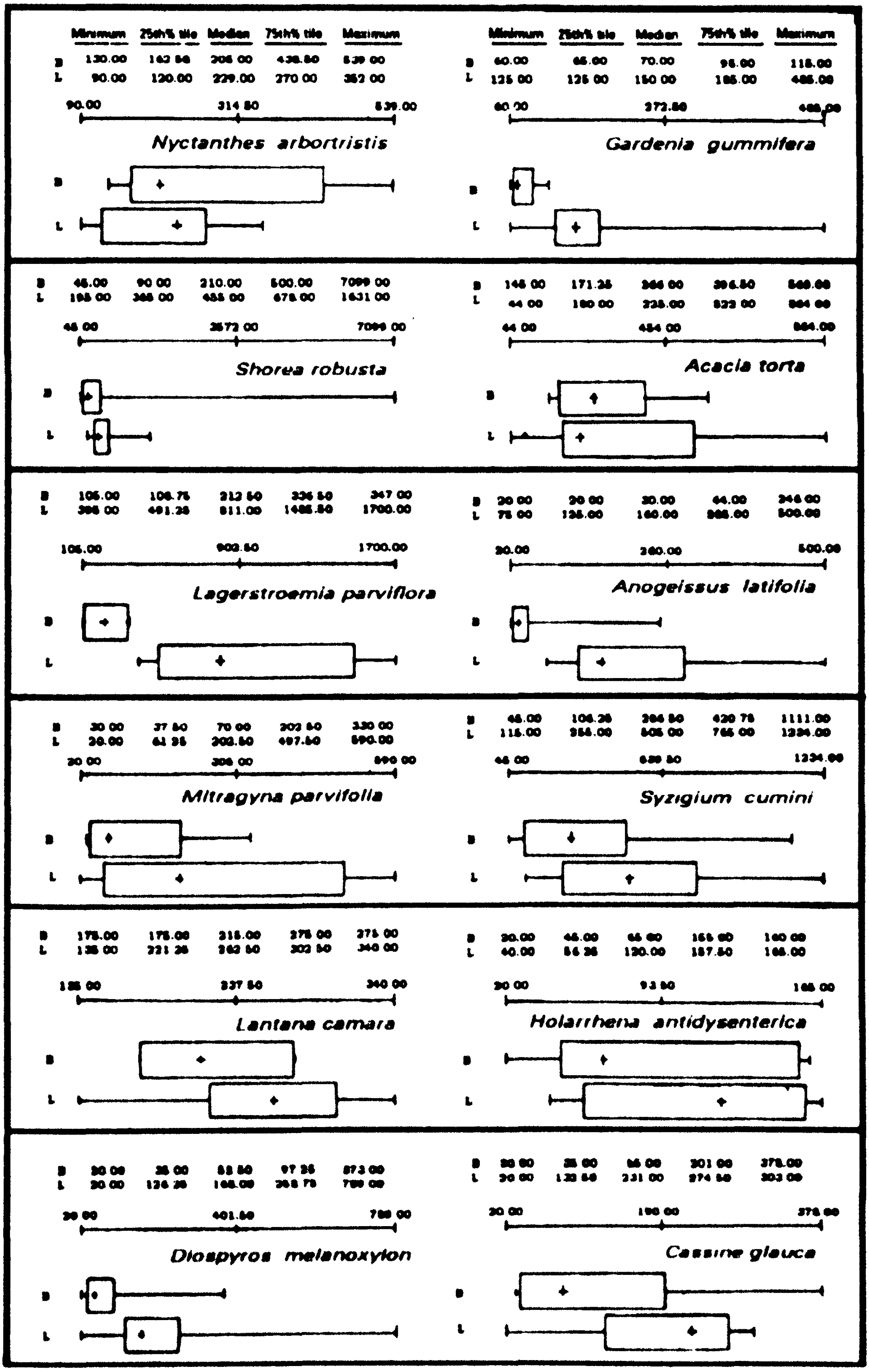
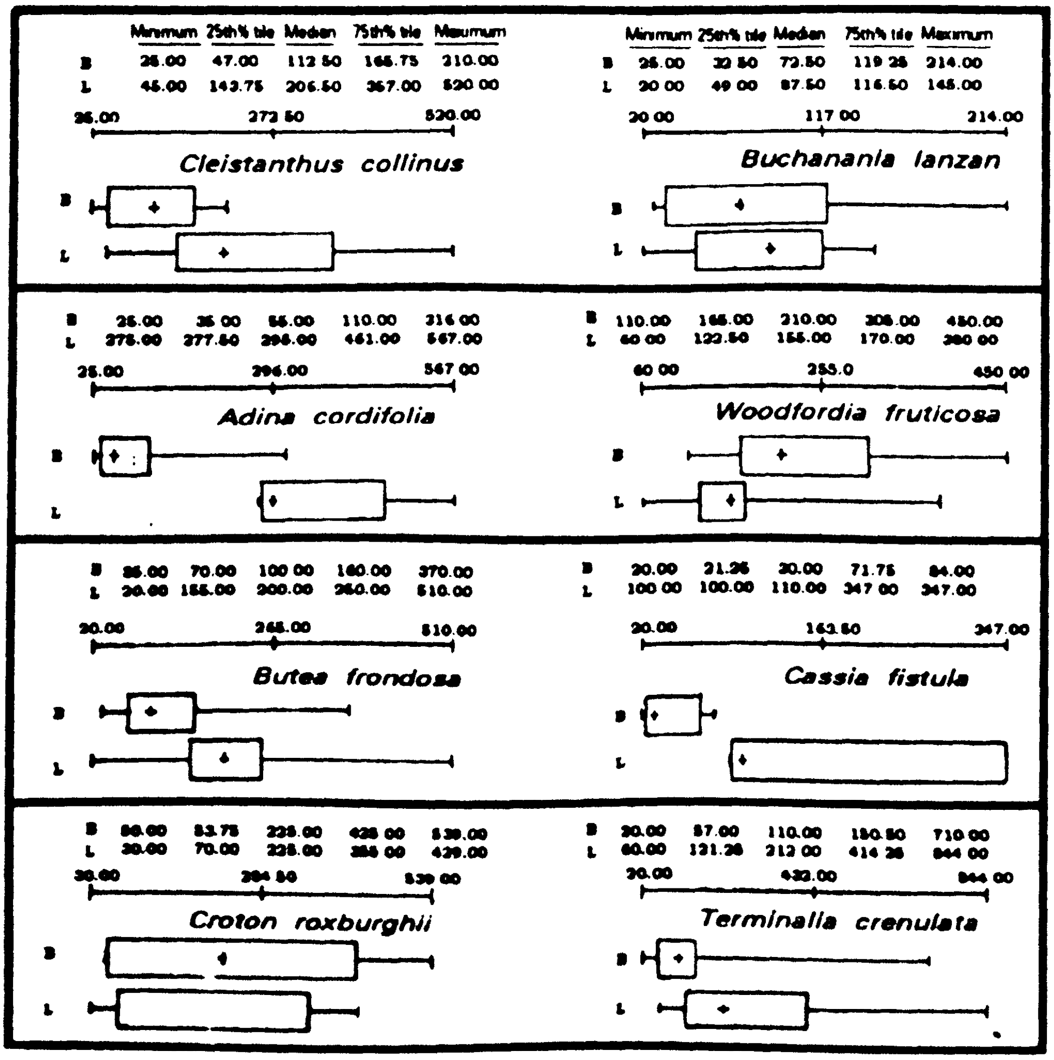


Fig.:19b COPPER VARIABILITY IN SOME DOMINANT SPECIES OF SINGHBHUM BELT



DISCUSSION

Ash contents: In the present report, chemical analysis was conducted in 72 species belonging to 35 families and in total 588 plant samples were analyzed. Results were presented in ppm on ash weight basis. However, these values were converted to dry weight basis for comparison as majority of the reports in the literature were presented on dry weight basis. Because of the interdisciplinary nature of biogeochemistry, plant tissue concentrations are not always presented in the same units. Plant physiologists and agronomists will generally use dry weight where as geochemists use ash weight as the basis for calculating tissue concentration. Because of cellulose and storage materials in plant tissues, ash weight ranges from around a low of 0.1 per cent in some woody tissues to a high of 10 per cent in some leaves. Thus, the use of these two bases of reference can cause an apparent difference in calculated tissue concentration of a factor of 10 or more. Percentage ash content of some dominant species of Singhbhum belt (dry weight basis) is presented in table 9.

Majority of the species showed percentage ash on dry weight around 10. In leaf parts, highest percentage of ash was recorded in *Terminalia crenulata* (14.96%) followed by *Morinda pubescens* (13.84%) In stem parts highest value was recorded in *Combretum decandrum* (14.22%) followed by *Miliusa velutina*(12.68%).

TABLE 9: PERCENTAGE ASH CONTENT ON DRY WEIGHT BASIS IN SOME DOMINANT SPECIES OF SINGHBHUM COPPER BELT.

NAME OF SPECIES	% ASH	
	LEAF	BARK/TWIGS
Acacia torta	7.31	7.58
Adina cordifolia	6.91	5.73
Areca lannata	7.75	
Albizia lebbeck	8.24	7.58
Anogeissus latifolia	6.30	8.17
Artocarpus chaplasha	7.03	7.48
Bauhinia retusa	9.78	9.63
Buchanania lanzan	11.04	9.13
Breynia vitis-idaea	8.64	7.65
Canthium dicoccum	9.80	9.82
Careya arborea	7.08	7.00
Carissa paucinervia	8.50	7.22
Cassia fistula	12.62	12.01
Cassine glauca	9.18	8.56
Cleistanthus collinus	6.98	7.45
Celastrus paniculatus	9.33	8.38
Combretum decandrum	9.80	9.82

Croton roxburghii	8.86	7.94
Dalbergia sissoo	9.84	6.21
Diospyros melanoxylon	9.82	9.00
Ehretia aspera	12.04	8.50
Flueggia obovata	11.04	8.03
Gardenia latifolia	10.24	6.73
Grewia tiliaefolia	12.24	9.74
Hyptis suaveolens	9.16	9.84
Indigofera cassioides	9.64	6.58
Lagerstroemia parviflora	10.24	8.16
Lantana camara	9.28	11.50
Madhuca indica	10.00	9.04
Miliusa velutina	12.24	12.68
Mitragyna parvifolia	10.16	6.89
Morinda pubescens	13.84	9.98
Litchi chinensis	11.77	6.27
Nyctanthes arbortristis	9.84	8.80
Ougeinia oojeinensis	7.44	10.82
Pavetta indica	11.55	12.08
Polyalthia longifolia	9.18	9.16
Pterocarpus marsupium	13.21	8.46
Smilax ovalifolia	9.86	9.80
Shorea robusta	10.34	7.82
Syzygium cumini	9.64	8.83
Terminalia crenulata	14.96	10.84
Terminalia chebula	9.21	8.49
Wendlandia tinctoria	12.40	10.61
Woodfordia fruticosa	8.91	10.64

A thorough scrutiny of the data with regard to elemental levels reveals that there is great variability among different species. And also even in same species, different bioparts showed variation in the level of specific element. Same biopart collected from different situations also exhibit a variation in its metal content.

With regard to copper, as stated earlier it is clear from the data that leaf or younger stem parts concentrate more of the element compared to older stems or bark samples. Difference in the copper level between leaf and bark samples are significant in majority of the cases as in the case of *Adina cordifolia, Aegle marmelos, Albizia lebbeck* and *Artocarpus chaplasha*. However, these differences are marginal in some cases. There are few exceptions to this observation and these include *Croton roxburghii, Ehretia aspera, Pavetta crassiuscula, P. indica, Polyalthia longifolia, Nyctanthes arbortristis, Shorea robusta* and *Zizyphus mauritiana*. In these cases, copper level was recorded higher in older twigs compared to leaf samples(Table 10).

TABLE 10: MEAN COPPER CONCENTRATION OF DIFFERENT SPECIES OF SINGHBHUM COPPER

NAME OF SPECIES	NO. OF SAMPLES	LEAF COPPER	STEM/BARK COPPER
Acacia torta	13	390.6	293.6
Adina cordifolia	5	354.4	108.6
Aegle marmelos	2	151.5	54.7
Albizia lebbeck	1	1111.0	254.0
Anogeissus latifolia	15	197.8	80.1
Artocarpus chaplasha	1	500.0	322.0
Bauhinia retusa	2	455.5	197.0
Breynia vitis-idaea	4	206.8	93.3
Buchanania lanzan	14	93.6	84.6
Butea frondosa	9	137.3	223.4
Butea superba	1	120	30.0
Canthium dicoccum	1	270.0	255.0
Careya arborea	1	381.0	276.0
Carissa paucinervia	1	210.0	115.0
Casearia elliptica	1	85.0	20.0
Cassia fistula	5	145.0	190.6
Cleistanthus collinus	16+4	244.1	141.7
Combretum decandrum	2	461.5	345.0
Cordia macleodii	2	167.5	42.5
Dalbergia sissoo	2	769.5	216.5
Diospyros melanoxylon	21	221.4	96.9
Diospyros montana	3	190.0	70.0
Cassine glauca	8+1	191.1	137.4
Emblica officinalis	1	65.0	30.0
Eriolaena hookeriana	1	310.0	241.0
Erythrina striata	1	110.O	20.0
Syzygium cumini	11	560.5	391.6
Flacourtia ramontchi	4	187.8	49.6
Gardenia gummifera	7	196.4	79.3
Gardenia latifolia	3	200.0	90.0
Holarrhena antidysenterica	5	212.8	143.2
Holoptelea integrifolia	2	157.5	45.0
Indigofera cassioides	1	950.0	511.0
Lagerstroemia parviflora	6	660.1	227.3
Litsea polyantha	1	175.O	125.0
Madhuca indica	4	225.8	137.5
Miliusa velutina	3	309.0	224.7
Mimosa himalayana	1	490.0	120.0
Mitragyna parvifolia	6	285.7	93.5
Morinda pubescens	3	301.3	233.0
Litchi chinensis	2	121.0	83.5

Pterocarpus marsupium	4	476.3	207.7
Schleichera oleosa	2	158.5	147.5
Semicarpus anacardium	2	645.0	482.7
Smilax ovalifolia	3	310.0	204.0
Soymida febrifuga	1	172.5	125.0
Sterculia urens	3	168.0	72.0
Terminalia chebula	4	168.0	72.0
Terminalia crenulata	18	271.2	137.5
Meyna pubescens	2	251.5	165.3
Wendlandia tinctoria	1	450.0	280.0
Woodfordia fruticosa	12	250.5	173.9

Nearly all chemical elements were determined in vegetation. Some species are designated as **accumulators**. The term accumulator as stated earlier is defined as a plant whose mean content of a particular element (expressed on ash weight basis) is greater than the content of the same element in the fine earth fractions of the substrate. As per this definition, many plants of the Singhbhum belt can be considered as accumulators. Brooks (1977) has developed a new system of classification based on the element content of the plant expressed on dry weight basis and neglecting the substrate elemental level. For elements such as copper, nickel and lead any value over 1000 ppm (on dry weight basis!) refers to higher accumulator, for zinc, the corresponding figure is 10,000 ppm. As per this definition, none of the plants in the present investigation can be graded hyper accumulators.

Estimations were made with regard to other metals also namely lead, zinc, nickel, cobalt, cadmium, chromium, manganese and silver. Basing on the average values, it could be generalized that most of the species showed higher values in the leaf samples compared to older stems or bark samples. However, these differences are not as significant as seen in the case of copper exceptions to this rule include *Aegle marmelos, Butea frondosa, Careya arborea, Croton roxburghii, Holarrhena antidysenterica, Litchi chinensis* for nickel; *Cleistanthus collinus, Diospyros melanoxylon, Lagerstroemia parvifolia, Miliusa velutina, Ougeinià oojeinensis, Pavetta crassiuscula, Semicarpus anacardium, Terminalia chebula* and *Vangueria pubescens* for cobalt and *Breynia vitis-idaea, Butea frondosa, Casearia tomentosa, Cassia fistula, Cordia macleoidii, Croton roxburghii, Dalbergia sissoo, Cassine glauca, Grewia tiliaefolia, Madhuca indica, Miliusa velutina, Mitragyna parvifolia, Nyctanthes arbortristis, Pavetta crassiuscula, Terminalia crenulata* and *Zizyphus mauritiana* for chromium. Here bark samples showed higher elemental levels compared to leaf samples(Table 11).

Each plant tissue has a characteristic mineral profile. For the purpose of biogeochemical prospecting, these tissues are grouped into following divisions: roots, stems, bark, leaves and fruit. For many of the common nonessential minerals and for zinc and copper under nondeficient conditions, the relative tissue concentration maintains the following order (Chapman, 1966; Tiffin, 1977).

Roots >>> Stems > Petioles > Leaves > Fruits.

The major concentration difference for metals is between roots and stems where the difference may be an order of 3105 times, while the difference between petioles and leaves is something closer to a factor of 2 (Berry,1971). The relative order of tissue concentration can be altered when a metal tolerant plant isolates stressful concentrations of a metal into a specific tissue such as bark. The tissue is in effect functioning as a sink for excess metal. Besides, the plants growing under favorable conditions, there are reciprocal relationships between certain elements such that if one is present at low concentrations, the other will be higher than expected for that environment. These elemental pairs are Fe-Mn, Cu-Zn, Zn-Cd, Mo-W, Ca-Mg, Na-K, and most heavy metals-Fe (Berry and Ulrich, 1979). These are geochemically associated elements.

TABLE 11: MEAN ELEMENTAL LEVELS IN DIFFERENT DOMINANT SPECIES OF SINGHBHUM COPPER BELT.

NAME OF SPECIES	Pb		Zn		Ni		Co		Cr	
	BARK	LEAF	BARK	LEAF	BARK	LEAF	BARK	LEAF	BARK	LEAF
	VALUES (IN PPM)									
Acacia torta	116.3	119.3	44.8	95.1	46.8	81.6	45.7	71.6	20.0	47.5
Adina cordifolia	76.4	64.0	73.3	188.8	29.5	60.0	35.6	39.8	44.3	35.0
Aegle marmelos	40.0	56.5	59.0	85.0	136.0	88.0	33.3	35.0	51.5	
Albizia lebbeck	114.0	80.0	87.0	50.0	20.0	135.0	48.0	52.0		
Anogeissus latifolia	59.2	90.0	46.0	112.9	32.8	66.5	28.8	30.3	30.2	30.2
Artocarpus chaplasha	60.0	100.0	44.0	29.0	36.0	150.0	36.0	46.0		
Breynia vitisidaea	43.0	44.0	136.8	514.8	32.0	55.3	40.5	55.5	66.0	45.6
Buchanania lanzan	75.4	45.1	40.4	82.0	34.1	93.3	57.9	138.0	20.3	20.0
Butea frondosa	53.6	92.9	122.3	55.7	74.9	56.6	32.7	36.6	45.8	28.3
Butea superba	20.0	20.0	35.0	50.0	20.0	20.0	20.0	20.0	20.0	20.0
Canthium dicoccum	65.0	110.0	395.0	380.0	65.0	110.0	20.0	25.0	100.0	120.0
Careya arborea	52.0		167.5		107.5	74.8	46.0	115.0	21.0	18.0
Carissa paucinervia	55.0	65.0	260.0	510.0	20.0	20.0	20.0	20.0	20.0	20.0
Casearia elliptica	20.0	390.0	25.0	125.0	20.0	20.0	20.0	20.0	50.0	30.0
Cassia fistula	35.2	74.0	200.7	214.2	25.8	41.0	26.2	42.0	24.8	31.8
Cleistanthus collinus	222.3	88.5	212.5	371.5	45.9	90.0	37.4	35.9	52.0	36.9
Combretum decandrum	184.0	98.3	57.5	155.7	83.0	130.7	110.5	482.6		
Cordia macleodii	20.0	22.5	40.0	35.5	20.0	45.0	20.0	20.0	37.5	30.0
Croton roxburghii	52.6	63.0	223.1	153.4	67.8	59.8	33.2	39.0	48.7	38.2
Dalbergia sissoo	59.0	61.0	160.0		61.5	142.0	55.5	78.0	150.0	100.0
Diospyros melanoxylon	82.4	86.6	337.5	134.2	69.5	99.8	41.7	33.5	62.3	60.0
Diospyros montana	28.3	28.3	70.0	215.0	41.7	85.0	20.0	20.0	23.3	71.6
Ehretia aspera	20.0	25.0	20.0	560.0	20.0	20.0	20.0	20.0	20.0	20.0
Cassine glauca	89.0	89.6	59.6	109.1	47.9	84.9	39.9	37.7	28.0	23.2
Eriolaena hookeriana					50.0	86.0	39.0	100.0		
Erythrina stricta	60.0	20.0	47.5	425.0	20.0	65.0	20.0	20.0	20.0	20.0
Syzygium cumini	110.7	92.1	90.7	114.8	63.6	133.1	43.9	72.3	54.0	58.0
Ficus benghalensis	35.0	45.0	132.5	360.0	20.0	50.0	20.0	20.0	20.0	20.0
Ficus semicordata	40.0	46.0	42.5	167.5						
Flacourtia ramontchi	30.2	24.8	170.2	397.5	36.3	58.0	36.4	47.8	52.5	75.0
Gardenia gummifera	64.3	57.9	77.9	116.4	34.3	50.0	21.4	20.7	55.7	64.3
Gardenia latifolia	93.3	75.0	67.0	126.0	30.3	43.0	43.7	43.7	20.0	82.5
Grewia tiliaefolia	226.7	66.0	,7.5	228.0	61.7	85.0	29.7	99.0	47.5	29.5
Holarrhena antidysenterica	43.8	33.1	151.8	208.1	54.5	48.9	21.1	20.2	47.9	47.0
Holoptelea integrifolia	20.0	20.0	55.0	122.5	20.0	25.0	20.0	20.0	20.0	20.0
Indigofera cassioides	60.0	128.0	190.0	54.5	56.0	111.5	39.0	66.0		
Lagerstroemia parviflora	69.4	71.4	116.6	302.0	96.8	186.3	39.4	26.8	25.8	90.2
Lantana camara	80.3	63.0	80.0	417.1	31.7	72.5	20.0	20.0	20.0	23.0
Madhuca indica	57.8	43.8	41.3	178.6	34.0	53.8	23.5	25.8	42.3	30.3
Miliusa velutina	55.0	58.7	168.3	275.3	48.0	90.3	51.7	29.5	90.0	37.5
Mimosa himalayana	30.0	75.0	100.0	210.0	20.0	125.0	20.0	20.0	20.0	75.0
Mitragyna parvifolia	46.0	48.8	122.2	249.4	49.5	107.5	52.0	31.3	67.7	42.5
Morinda pubescens	46.3	75.0	82.7	218.3	33.3	97.3	29.7	43.0	42.0	34.0
Litchi chinensis	78.5	83.5	44.5	69.0	54.0	49.5	10.5	58.5		
Nyctanthes arbortristis	71.2	103.1	162.3	125.9	39.4	54.0	33.2	30.9	40.0	27.5
Ougeinia oojeinensis	220.0	160.0	27.0	32.0	30.0	68.0	82.0	64.0		
Pavetta crassicaulis	80.0	63.0	55.0	50.0	36.0	79.5	35.0	26.5		
Pavetta indica	80.0	60.0	1200.0	381.7	288.3	910.0	68.3	206.6	63.3	50.0
Polyalthia longifolia	64.0	40.0	138.0	30.0	31.0	48.0	26.0	21.0		
Pterocarpus marsupium	69.6	95.3	56.1	133.3	40.5	118.0	45.0	49.5	21.7	
Schleichera oleosa	20.0	25.0	25.0	190.0	22.5	42.5	20.0	20.0	35.0	35.5
Semecarpus anacardium	30.0	30.0	95.0	197.5	28.5	28.0	36.0	20.5	20.0	20.0
Shorea robusta	132.8	85.6	117.6	341.6	102.2	136.3	47.7	47.0	35.4	67.5
Smilax ovalifolia	103.0	193.3	198.0	283.5	66.3	161.8	19.3	74.3	18.0	110.0
Soymida febrifuga	280.0	280.0	49.0	49.0	54.0	64.0	22.0	30.0		
Sterculia urens	45.3	28.3	172.0	456.0	22.7	34.3	23.0	40.3	28.3	44.3
Terminalia chebula	79.4	53.3	80.0	221.5	22.5	57.8	36.4	24.5	33.3	35.0
Terminalia crenulata	66.1	111.0	64.1	35.9	29.6	674.0	34.2	34.9	33.8	29.1
Vangueria pubescens	110.0	70.5	120.3	164.5	24.7	49.0	37.7	21.0	35.0	50.0
Wendlandia tinctoria	60.0	120.0	100.0	118.0	30.0	68.0	52.0	100.0		
Woodfordia fruticosa	75.7	110.7	136.4	165.9	59.8	103.2	38.6	45.6	71.3	80.9
Zizyphus mauritiana	70.1	67.3	50.3	73.5	40.0	122.5	33.0	50.0	48.8	20.0
Flueggea obovata					62.0	101.0	74.0	500.0	47.0	48.0

Further, it has been observed that the usefulness of vegetation in predicting the concentration of elements in the soil decreases in the order : **herbs> shrubs> trees**

Herbs were regarded to concentrate much more elements specifically zinc and cadmium in comparison to trees. Further, it is contended that herbs have a shallow and localized root systems and they would therefore obtain their nutrients from the soil. They accumulate very high concentration of the elements and the concentration of the element in the soil can be predicted from the concentration in their ash content. On the other hand, trees, however, have deep root systems which extend both laterally and vertically. Their roots, therefore sample a large volume of soil (and possibly bedrock) in which the concentration of the elements may vary greatly. A single soil sample therefore, may not always be a representative of the soil supplying various elements to the tree. This results in low concentration of the elements in the trees even if the upper soil horizon may be containing high concentration of metals. In the present investigation, copper analyses was conducted in 72 species out of which 50 species are trees. Proportional absorption was noticed both in trees and shrubs namely *Anogeissus latifolia, Buchanania lanzan, Croton roxburghii, Cliestanthus collinus, Lantana camara, Nyctanthes arbortristis, Shorea robusta, Syzygium cumini, Terminalia crenulata* and *Gardenia gummifera.*

Hence such a generalization appears to have little significance. It is recorded that the concentration of copper in bark or leaf samples of these species show positive relationship. Such a relationship does not exist in other species, some are trees and some are shrubs.

Elemental contents:

An examination of mean concentration of different elements in leaf samples indicates that in majority of the species copper was found to show very high values (Table-12). However, in few exceptional cases such as in *Terminalia chebula, Sterculia urens, Semicarpus anacardium, Casearia tomentosa, Flacourtia ramontchi, Erythrina stricta, Diospyros montana, Cleistanthus collinus, Cassia fistula* higher values were recorded for zinc in comparison to copper. It is worth mentioning a note of caution at this juncture that among the plants examined, the analysis was done for only one sample in *Casearia tomentosa* and *Erythrina stricta* and hence needs further verification on this conclusion. In *Cleistanthus collinus* fluctuations were wide, in spite of low soil zinc and should be examined closely and cautiously. In case of *Combretum decandrum*, surprisingly highest value was recorded for cobalt among all the elements examined though cobalt values are very low in soil samples. However, a generalization on elemental levels can be drawn basing on observations in majority of the plants as follows:

Cu > Zn > Ni > < Pb > Co > Cr

TABLE 12: COMPARISON OF MEAN ELEMENTAL LEVELS(IN LEAF SAMPLES) IN DIFFERENT SPECIES OF SINGHBHUM BELT (in PPM on ash weight basis).

NAME OF SPECIES	CU	PB	ZN	NI	CO	CR
Acacia torta	390.6	119.3	95.1	81.6	71.6	47.5
Adina cordifolia	354.4	64	188.8	60	39.8	35
Aegle marmelos	151.1	56.5	85	88	35	31.5
Albizia lebbeck	1111	80	50	135	52	
Anogeissus lanzan	197.8	50	112.9	66.5	30.3	30.2
Artocarpus chaplasha	455.5	100	29	150	46	
Breynia vitisidaea	206.8	44	514.8	55.3	55.5	45.6
Buchanania lanzan	93.6	45.1	82	93.3	138	20
Butea frondosa	137.3	92.9	55.7	56.6	36.6	28.3
Butea superba	120	20	50	20	20	20
Canthium dicoccum	270	110	380	110	25	120
Careya arborea	381		167.5	107.5	115	18
Carissa paucinervia	210	65	510	20	20	20
Casearia elliptica	85	390	125	20	20	30
Cassia fistula	145.2	74	214.2	41	42	31.8
Cleistanthus collinus	244.1	88.5	371.5	90	55.9	36.9
Combretum decandrum	461.5	130.7	155.7	130.7	482.6	
Cordia macleodii	167.5	225	40	45	20	
Dalbergia sissoo	769.5	61		142	78	100
Diospyros melanoxylon	221.4	86.6	134.2	99.8	33.5	60
Diospyros montana	190	28.3	215	85	20	71.6
Cassine glauca	191.1	89.6	109.1	84.9	37.7	23.2
Emblica officinalis	65					
Eriolaena hookeriana	310			86	100	
Erythrina striata	110	20	425	65	20	20
Flacourtia ramontchi	187.8	24.8	397.5	58	47.8	75
Gardenia gummifera	196.4	64.3	116.4	50	207	64.3
G. latifolia	200	75	126	43	43.7	32.5
Holarrhena antidysenterica	212.8	33.1	208.1	48.9	20.2	47
Holoptelea integrifolia	157.5	20	122.5	25	20	20
Indigofera cassioides	950	128	54.5	111.5	66	
Lagerstroemia parviflora	660.1	77.4	302	186.3	26.8	90.2
Litsea polyantha	175					
Madhuca indica	225.8	43.8	178.6	53.8	25.8	30.3
Miliusa velutina	309	58.7	275.3	90.3	29.5	37.5
Mimosa himalayana	490	75	210	125	20	75
Mitragyna parvifolia	285.7	48.8	294.4	107.5	31.3	42.5
Morinda pubescens	301.3	75	218.3	97.3	43	34
Litchi chinensis	121	83.5	69	49.5	58.5	
Nyctanthes arbortristis		103.1	125.9	54	50.9	27.5
Lannea coromandelica		160	32	68	64	
Pterocarpus marsupium	476.3	96.3	133.3	118	49.5	
Schleichera oleosa	147.5	25	190	42.5	20	35
Semicarpus anacardium	158.5	30	197.5	28	20.5	20
Shorea robusta		85.6	341.6	156.3	47	67.5
Smilax ovalifolia	645	193.3	283.5	161.8	74.3	110
Soymida febrifuga	310	280	49	64	30	
Sterculia urens	172.5	28.3	456	54.3	40.3	44.3
Syzygium cumini	560.5	92.1	114.8	133.1	72.3	58
Terminalia chebula	168	55.3	221.5	57.8	24.5	35
Terminalia crenulata	271.2	111	55.9	67.4	34.9	29.1
Vangueria pubescens	251.5	70.5	164.5	49	21	50
Wendlandia tinctoria	450	120	118	68	100	
Woodfordia fruticosa	250.5	110.7	165.9	103.2	45.6	83.9
Zizyphus mauritiana		67.3	73.5	122.5	50	20

Ravikiran and Bedi (1984) worked out chemical analyses in *Holarrhena antidysenterica* and *Nyctanthes arbortristis* growing in mineralised area (Cu-Pb-Zn) of Banaskantha district of Gujarat.

Incidently these species were analyzed from Singhbhum too which are quite dominant in the area. Values reported in the present investigation are comparable for copper and low for lead. However, in case of zinc, present values are higher in *Nyctanthes arbortristis* and low in *Holarrhena antidysenterica*.

SPECIES	CU	PB	ZN	REFERENCE
	(Values in ppm) on ash wt. basis			
Holarrhena antidysenterica	190	250	920	Ravikiran and
	±20	±40	±310	Bedi(1984)
(New mining area)				
Present report: Stem:	216	65	250	Present report
leaves:	220	55	349	
Nyctanthes arbortristis	550	420	110	Ravikiran and
	±240	±80	±190	Bedi(1984)
(New mining area)				
Present report: Stem:	539	185	325	Present report
Leaves:	352	200	318	

Tiagi and Aery (1986) while working in Khetri copper deposits of Rajasthan, identified several species which accumulate copper in significant quantities. The maximum copper content (on ash weight basis) are 5253 ug/g for *Talinum portulacifolium*; 3905 ug/g for *Tephrosia villosa*; 2593 ug/g for *Rhus mysorensis* and 2193 ug/g in *Bouchea morubifolia*. These values are very high compared to the mean values obtained for different species growing in Singhbhum copper belt. Venkatesh (1964) while working on geochemical prospecting in Singhbhum copper belt, Bihar noted that concentration of copper in *Shorea robusta* and *Syzygium cumini* is 500 ppm to 600 ppm in ash when grown in mineralised area. This is in contrast to 200 ppm to 400 ppm in the ash of same species growing in barren ground. Such chemovariability is recorded in many species in Singhbhum belt. Besides, the results of the present investigation reveal that copper concentration was recorded upto a value of 7099 ppm in bark samples and 1631 ppm in leaf samples of *Shorea robusta* while in *Syzygium cumini*, the values were 1111 ppm in bark samples and 1234 ppm in leaf samples. Thus, these values are much higher than the figures arrived at by Venkatesh. In addition, plants like *Dalbergia sissoo* (1150 ppm in leaf samples) *Grewia tiliaefolia* (900 ppm in bark samples), *Indigofera cassioides* (950 ppm in leaf samples), *Lagerstroemia parviflora* (1700 ppm in leaf) and *Smilax ovalifolia* (both in twigs and leaf samples 1000 ppm and 1600 ppm, respectively) exhibited occasional high values(Table 19). These values are much higher than the figures reported for some common species of Singhbhum belt by Shyam (1982).

Gandhi and Aswathanarayana (1975) report that *Waltheria indica* confines to mineralised zones in Mamandur district and also exhibits high concentration of many base metals. In the present investigation, surprisingly, a number of species showed very high values of zinc in spite of low soil zinc concentrations. Copper and zinc reports of some species from Mamandur are presented here for comparison

SPECIES	Cu (Values in ppm on ash weight basis)	Zn	REFERENCE
Chomelia asiatica (Rubiaceae)	199	572	Gandhi and
Waltheria indica (Sterculiaceae)	380	1740	Aswathana-
Atlantia monophylla (Rutaceae)	231	865	rayana
Clausena willdenovii (Rutaceae)	63	512	(1975)
Dalbergia sissoo (Fabaceae)		1000(L)	
Flacourtia ramontchi (Flacourtiaceae)		700 (L)	
Lantana camara (Asteraceae)		1600	Present
		1700(T)	investi-
Pavetta indica (Rubiaceae)		210-460(L)	gation
Shorea robusta (Dipterocarpaceae)		1300 (B)	
Smilax ovalifolia (Smilacaceae....)		650	
Sterculia urens (Tiliaceae)		704	

L = Leaves; T = Twigs; B = Bark

Excepting *Pavetta indica*, all other species showed occasional high values of zinc. These plants do not have any indicational significance as they do not reflect soil zinc levels. Much higher values of zinc were reported for some species growing in Zawar Mines by Tiagi and Aery (1981). In this area, *Impatiens balsamina* is reported to contain zinc as high as 12141 ppm. Its relative accumulation is 5.08 for leaf and 4.38 for stem. Certain other species also showed very high values of zinc which include *Acanthospermum hispidum*, *Celosia argentia*, *Crotalaria linifolia*, *Lindenbergia muraria*, *Melharia futteyperensis* and *Triumfetta pentandra*. Values obtained in the present investigation are much less compared to the values reported or the above species (Table 20).

Relative accumulation is also termed as 'enrichment coefficient' or 'biological absorption coefficient'(BAC) and it is a ratio of elemental content between that of plant and soil.

In Singhbhum belt, values for relative accumulation of copper indicated that majority of the species showed figures below 1(Table 13). This is partially due to reduction in copper concentration in plants after attaining a limiting value in soil. However, species namely, *Azadirachta indica, Bauhinia retusa, Butea superba, Canthium dicoccum, Casearia tomentosa, Cordia paucinervia, Cardia macleodii, Dalbergia sissoo, Ehretia aspera, Ficus benghalensis, Gardenia gummifera, Grewia tiliaefolia, Holoptelea integrifolia, Indigofera cassioides, Lagerstroemia parviflora, Lantana camara, Madhuca indica, Miliusa velutina, Mitragyna parvifolia, Pavetta indica, Pterocarpus marsupium, Schleichera oleosa*, exhibited relative accumulation values more than 1. Highest values were recorded for *Carissa paucinervia* (7.0) and *Canthium dicoccum* (4.9). It is worth noting at this point that more common species in mine dumps or mineralised zones namely, *Hyptis suaveolens* (RA = 0.74), *Croton roxburghii* (RA = 0.34), and *Holarrhena antidysenterica* (RA = 0.50) showed very low values of relative accumulation. It could be inferred that these indicators in copper mineralised area resist copper uptake in mineralised zone through special mechanism.

TABLE 13: RELATIVE ACCUMULATION OF COPPER IN SOME DOMINANT SPECIES OF SINGHBHUM COPPER BELT

SPECIES	RELATIVE ACCUMULATION LEAF	BARK/TWIGS
Acacia torta	0.658	0.488
Adina cordifolia	1.96	0.645
Aegle marmelos	0.388	0.168
Annona squamosa	--	0.842
Anogeissus latifolia	0.401	0.236
Artocarpus chaplasha	0.05	0.03
Areca lannata	0.09	
Azadirachta indica		1.04
Bauhinia retusa	1.45	0.63
Bombax ceiba		0.258
Boswellia serrata		0.768
Breynia vitis- idaea	0.632	0.285
Buchanania lanzan	0.197	0.178
Butea frondosa	0.928	0.570
B. superba	1.71	0.428
Canthium dicoccum	4.9	4.63
Careya arborea	1.21	0.93

Carissa paucinervia	7.0	3.83
Casearia elliptica	0.89	0.21
Cassia fistula	0.62	0.47
Celastrus paniculatus	0.56	
Chocolospermum religiosum		0.22
Cleistanthus collinus	0.68	0.39
Combretum decandrum	0.334	0.25
Cordia macleodii	1.39	0.35
Croton roxburghii	0.34	0.461
Dalbergia sissoo	1.80	0.50
Dillenia pentagyna		0.20
Diospyros melanoxylon	0.84	0.34
D. montana	0.72	0.26
Ehretia aspera	2.78	3.0
Cassine glauca	0.45	0.32
Ficus benghalensis	3.0	1.93
F. semicordata	0.15	0.21
Flacourtia ramontchi	0.89	0.23
F. indica		0.13
Gardenia gummifera	1.96	0.79
G. latifolia	0.43	0.19
Grewia tiliaefolia	1.37	0.92
Holarrhena antidysenterica	0.50	0.34
Holoptelea integrifolia	1.5	0.43
Hymenodictyon excelsum		0.24
Hyptis suaveolens	0.74	
Ichnocarpus frutescens	0.59	
Indigofera cassioides	1.08	0.54
Lagerstroemia parviflora	1.29	0.45
Lantana camara	2.5	2.56
Leucaena glauca	0.33	
Litsea polyantha	0.64	0.45
Madhuca indica	1.53	0.82
Miliusa velutina	1.27	0.67
Mimosa himalayana	0.94	0.23
Mitragyna parvifolia	1.11	0.36
Morinda pubescens	0.71	0.55
Litchi chinensis	0.42	0.29
Nyctanthes arbortristis	0.32	0.55
Lannea coromandelica		0.6
Ougeinia oojeinensis	1.31	0.41
Pavetta crassiuscula	0.12	0.06
Polyalthia longifolia	0.39	0.7
Pterocarpus marsupium	1.24	0.46
Randia dumetorum	0.26	
Schleichera oleosa	1.44	0.24
Semicarpus anacardium	0.42	0.55

Shorea robusta	0.84	0.89
Smilax ovalifolia	0.59	0.45
Soymida febrifuga	0.56	0.37
Sterculia urens	0.45	0.24
Terminalia chebula	0.71	0.24
T. crenulata	0.18	0.09
Vangueria pubescens	1.18	0.98
Woodfordia fruticosa	0.44	0.31
Ziziphus mauritiana	0.11	0.13

An interesting case of limiting copper uptake was reported by Tiagi and Aery (1986)at high soil copper concentration. *Rhus mysorensis* and *Talinum portulacifolium* exhibit a limit in the copper uptake on attainment of a limiting value. A gradual decrease in copper contents in the above two species was observed with further increase in the copper content of the soil. Similar observations were made in Singhbhum copper belt in *Buchanania lanzan, Gardenia gummifera, Terminalia chebula* for leaf copper; *Pterocarpus marsupium* and *Terminalia crenulata* for bark copper and *Anogeissus latifolia, Cassine glauca* for both leaf and bark copper (Fig. 19). Though some species show lower concentration of copper with increasing soil copper level, this tendency is not consistent as in the case of *Holarrhena antidysenterica, Woodfordia fruticosa, Diospyros melanoxylon* (for bark copper only) and *Nyctanthes arbortristis* where a decrease in the copper concentration was recorded when soil copper level reaches above a certain limiting value.

Another point for discussion is the copper zinc ratio. According to Warren and Dalavoult (1949), a copper / zinc ratio of 0.10 represents the average value and values higher than this represent copper mineralization and lower than this represent zinc mineralization. All the species without exception in Singhbhum belt showed Cu/Zn ratio higher than 0.10 indicating that the Singhbhum area is predominantly copper bearing. In *Zawar* area many species exhibit Cu/Zn ratio lower than 0.10 and indicates zinc mineralization.

TABLE 14: COPPER - ZINC RATIOS IN SOME DOMINANT SPECIES OF SINGHBHUM COPPER BELT.

NAME OF SPECIES	AVERAGE CONCENTRATION		RATIO
	CU IN LEAF	ZN IN LEAF	
	(Values in PPM on ash weight basis)		
Acacia torta	390.6	9.1	4.11
Adina cordifolia	354.4	188.8	1.88
Aegle marmelos	151.5	85.0	1.79
Albizia lebbeck	1111.0	50.0	22.2
Anogeissus latifolia	197.8	112.9	1.75
Artocarpus chaplasha	455.5	29.0	15.71
Breynia vitis-idaea	206.8	514.8	0.46
Buchanania lanzan	93.6	82.0	1.14
Butea frondosa	137.3	55.7	2.46
B. superba	120.0	50.0	2.4
Canthium dicoccum	270	380	0.710
Careya arborea	381	167.5	2.27
Carissa paucinervia	210	510	0.41
Casearia elliptica	85.0	125.0	0.68
Cassia fistula	145.2	214.2	0.68
Cleistanthus collinus	244.1	371.5	0.66
Combretum decandrum	461.5	155.7	2.96
Cordia macleodii	167.5	40.0	4.19
Diospyros melanoxylon	190.0	215.0	0.88
Cassine glauca	191.1	109.1	1.75
Erythrina stricta	110	425.0	0.26
Flacourtia ramontchi	187.8	397.5	0.47
Gardenia gummifera	196.4	116.4	1.69
G. latifolia	200	126.0	1.59
Holarrhena antidysenterica	212.8	208.1	1.02
Holoptelea integrifolia	157.5	122.5	1.29
Indigofera cassioides	950.0	54.5	17.4
Lagerstroemia parviflora	660.1	302.0	2.18
Madhuca indica	225.8	178.6	1.26
Miliusa velutina	309	275.3	1.12
Mimosa himalayana	490	210.0	2.33
Mitragyna parvifolia	285.7	249.4	1.15
Morinda pubescens	301.3	218.3	1.38
Litchi chinensis	121.0	69.0	1.75
Pterocarpus marsupium	476.3	133.3	3.57
Schleichera oleosa	147.5	190.0	0.78
Semicarpus anacardium	158.5	197.5	0.80
Shorea robusta		341.3	
Smilax ovalifolia	645.0	283.5	2.28
Soymida febrifuga	310.0	49.0	6.33
Sterculia urens	172.5	456.0	0.37
Syzygium cumini	560.5	114.8	4.88
Terminalia chebula	168.0	221.5	0.76
T. crenulata	271.2	55.9	4.85
Vangueria pubescens	251.5	164.5	1.53
Wendlandia tinctoria	450.0	118.0	3.81
Woodfordia fruticosa	250.5	165.9	1.51

Specific indicator value: There has already been some mention of a simple classification of indicator plants as 'local' or 'universal' This is a simplified approach that can be improved by the consideration of two other systems of classifications. The first of these is due to Duvigneaud (1959) and Duvigneaud and Denaeyer de Smet (1963) and refers significantly to the copper/cobalt flora of Shaba Province in Zaire. The second system is that of Jacobsen (1967, 1968, 1969) who used the term specific indicator value to describe indicator plants. The SIV is a function of the range of copper values found in the soils supporting the indicator plants and is inversely related to the mean content of the element in the soil.

$$SIV = \frac{\text{Highest copper level in soil - Lowest copper level in soil}}{\text{Mean copper level in soil}}$$

Jacobsen suggested that indicators should have SIV's of 4 or less.

TABLE 15: SPECIFIC INDICATOR VALUES OF SOME DOMINANT SPECIES OF SINGHBHUM COPPER BELT

SPECIES	NO. OF SAMPLES	SIV
Acacia torta	6	2.27
Adina cordifolia	8	0.92
Anogeissus latifolia	17	3.95
Breynia vitis-idaea	4	1.77
Buchanania lanzan	14	3.64
Butea frondosa	9	2.02
Careya arborea	4	1.46
Cassia fistula	6	1.75
Cleistanthus collinus	16	4.47
Croton roxburghii	8	2.72
Diospyros melanoxylon	21	3.55
D. montana	3	0.51
Cassine glauca	8	5.89
Flacourtia ramontchi	5	0.74
Gardenia gummifera	7	2.36
G. latifolia	3	1.45
Grewia tiliaefolia	6	1.42
Holarrhena antidysenterica	5	3.53
Hyptis suaveolens	5	2.71
Lagerstroemia parviflora	6	2.16
Lantana camara	7	1.36
Madhuca indica	4	1.00
Miliusa velutina	3	0.87
Mitragyna parvifolia	7	1.04
Morinda pubescens	3	0.95
Nyctanthes arbortristis	8	3.43

Lannea coromandelica	11	6.02
Pterocarpus marsupium	6	2.28
Randia dumetorum	6	1.62
Shorea robusta	23	6.30
Smilax ovalifolia	3	1.58
Syzygium cumini	11	8.96
Terminalia crenulata	19	7.61
Woodfordia fruticosa	12	6.47
Ziziphus mauritiana	6	5.38

In the present investigation, majority of the species exhibited SIV values less than 4. However, it is difficult to regard all these species as potentially good indicators due to low number of the samples analyzed for many species. Species like, *Anogeissus latifolia, Buchanania lanzan* and *Diospyros melanoxylon* were analyzed in good numbers and these species showed SIV values lower than 4. Species like *Hyptis suaveolens, Holarrhena antidysenterica* and *Croton roxburghii* which are proven indicators geobotanically also exhibit low values for SIV.

The nickel concentration in plant varies around a mean of 0.1 5 ug/gm of dry weight (Vanselow, 1956; Brooks, 1983). It is assumed that % ash is around 10, then the concentration would be 1 ppm to 50 ppm in ash weight. Plants growing in soils over ultrabasic rock terrain, however, may exceed 1000 ug/gm. Many serpentine endemic species have capacity to accumulate very large quantities of nickel. Nickel accumulators have been described from various countries such as, Italy, New Caledonia, Australia, Zimbabwe and more recently from Canada (Roberts, 1980) and the United States.

TABLE 16: NICKEL CONCENTRATIONS IN VARIOUS PLANT SPECIES FROM MINERALIZED AREAS

SPECIES	PLANT	SOIL	RATIO	REFERENCE
	PERCENT ASH WEIGHT			
Hybanthus floribundus	13	0.08	162.5	Severne & Brooks (1972)
H. austro-caledonicus	27	0.50	54.0	Brooks,et al.,(1974)
Pearsonia metallifera	15.3	0.55	27.8	Wild (1974)
Alyssum serpyllifolium	10.3	0.40	25.8	Menezes de Sequeira (1968)
Dicoma niccolifera	2.8	0.70	4.0	Wild (1970)
Pimelia sutsi	0.59	0.33	1.8	Lyon,et al. (1971)
Silene acaulis	0.18	0.33	0.5	Shewry and Peterson(1976)

In the present investigation, very low values of nickel were recorded in all the species. Among all the species analyzed, *Pavetta indica* exhibits the highest value of 288.3 ppm in twigs and 910 ppm in leaf samples. It is also noted that soils in the present investigation never exceeded 625 ppm of nickel, unlike the soils mentioned above which showed a range from 800 ppm to 7000 ppm. Sankarsan Roy (1974) reports that plants like *Combretum decandrum* and *Miliusa velutina* close to mineralization showed values upto 1000 ppm of nickel in leaf ash. The recorded values for nickel in both the species never exceeded 130 PPM in their bioparts in Singhbhum belt (Table 21). This is quite a high value when compared with figures obtained for dominant species of Singhbhum belt.

Chromium: *Sutera fodina, Pearsonia metallifera* and *Dicoma niccolifera*, are the chromium accumulators. These species are from Zimbabwe and reported to contain very high concentration of chromium in their ash (upto 5% by weight, Wild,1974). *Leptospermum scoparium* was reported to contain one per cent chromium by weight (Lyon *et al.*,1971).

TABLE 17: CHROMIUM CONCENTRATION IN VARIOUS PLANT SPECIES (ug/g ASH WEIGHT) FROM MINERALIZED AREAS

SPECIES	PLANT	SOIL	RATIO	REFERENCE
Sutera fodina	48000	1,25000	0.38	Wild,1974
Leptospermum scoparium	2470	8950	0.28	Lyon,et al.,1971
Dicoma niccolifera	30000	1,15000	0.24	Wild,1974
Cerastium nigrescens	147	1800	0.08	Shewry and Peterson, 1976
Silene martima	22	1800	0.01	-DO-
Aerobryopsis longissima	4740			Lee,et al.,1977a
Homalium guillainii	112	8550	0.01	-DO-

Similar to nickel, many plants in Singhbhum belt exhibit chromium values below 20 ppm except in few instances as in the case of *Dalbergia sissoo* (150 ppm in bark, 100 ppm in leaf), *Woodfordia fruticosa* (71.3 ppm in bark, 83.9 ppm in leaf) and *Canthium dicoccum* (100 ppm in bark, 120 ppm in leaf). Soil chromium values in majority of the cases showed below 100 ppm. However, in few cases the values attained are around 1000 ppm.

Cobalt: The cobalt content of non-serpentine soils is around 20 ug/gm while serpentine soils contain up to 500 ug/gm of this element. The mean cobalt content of non-serpentine vegetation is only about 1 ug/gm on a dry weight basis. Some plants such as *Nyssa sylvatica* and *N. sinesis* can contain over 500 ug/g even when growing over non-cobaltiferous substrates (Brooks, *et al.*,1977).

Brooks, *et al.*,(1980) have listed 15 taxa of cobalt tolerant plants from Shabah Copper Arc in Zaire which have this hyper-accumulation status. One of these plants *Haumaniastrum robertii* contained 10,000 ug/g cobalt. In the present investigation very few species exhibit cobalt concentration above 100 ug/g in ash. Notably high values were recorded in *Buchanania lanzan, Careya arborea* and *Combretum decandrum*. Soil cobalt concentration rarely exceeded 200 ppm.

Lead: The lead content of non-serpentine soils is around 10 ppm. The mean lead content from non-serpentine vegetation is 70 ppm. In the Indian context, a good number of species were analyzed for lead both from Rajasthan and Gujarat. *Cometes surattensis* appeared to have very high values of lead and reported to contain 7230 ± 310 ppm followed by *Lindenbergia muraria* which contains around 6070 ± 1200 ppm of lead in its ash. However, the values reported from Banaskantha district are low and never exceeded 500 ppm. In the present investigation, the highest mean values are reported in *Soymida febrifuga* (260 ppm) and *Grewia tiliaefolia* (226.7 ppm) in bark samples. In the leaf samples, highest lead value was recorded in *Casearia elliptica* with a value of 390 ppm.

TABLE 18: LEAD CONCENTRATION IN VARIOUS PLANT SPECIES FROM MINERALISED AREAS (IN PPM ON ASH WEIGHT BASIS)

SPECIES	IN SOIL	IN PLANT	REFERENCE
Acanthospermum hispidum(L)	190.14	162	
Aegle marmelos (Ll)	126.36	154	Tiagi and Aery
Crotalaria linifolia (L)	149.11	215	(1981)
Dycrophytum indicum (L)	335.59	318	
Grewia flavescens (L)	161.77	202	
Hemigraphis latebrosa (L)	106.95	249	
Impatiens balsamina (L)	262.20	436	
Cassia tora		1260±400	
Cometes surattensis		7230±310	
Evolvulus alsinoides		230±60	Ravikiran
Holarrhena antidysenterica		250±40	and
Impatiens balsamina		430±140	Bedi
Justicia diffusa		5300±550	(1984)
Lindenbergia muraria		6070±1200	
Nyctanthes arbortristis		420±80	
Vernonia cineria		430±50	
Wrightea tinctoria		660±380	

ACCUMULATOR PLANTS

A plant is described as an accumulator for a metal if the tissue concentrations of that element is greater than that available in the substrate on which it is grown. This concentration is achieved through an active biological mechanism. Such plants may exhibit very large changes in tissue concentration in relation to relatively small changes in soil concentration. However the uptake capacity of a plant for a given element is not always a simple linear or continuous function over an extended dose range. This makes it difficult to evaluate the changes that occur over a wide range of soil concentrations. A plant can be accumulator at low concentrations in soil but be an excluder at higher concentrations. Many dominant species in Singhbhum belt were studied to know their trend of absorption at different soil elemental levels. Soil copper values were plotted against plant copper figures in some dominant species.

Brooks (1977) has developed a new system of classification based on the element content in the plant expressed on the dry weight basis and neglecting the substrate elemental level. For elements such as copper, nickel and lead any value over 1000 ppm refers to hyperaccumulators, and for zinc the corresponding figure is 10,000 ppm. In the present investigation, the authors come across with a difficulty in arriving at this kind of groupings for the fact that analyses of various elements was conducted in every species collected from different situations. These soils exhibited a wide range of chemical levels and hence the concentration level of a particular element in a specific species varied greatly and may sometimes range from below 100 ppm to above 1000 ppm. An attempt is made to compare the highest values obtained for various elements with that of figures reported for some known accumulators.

Fig.:20a COPPER ACCUMULATION TREND IN SOME DOMINANT SPECIES OF SINGHBHUM BELT

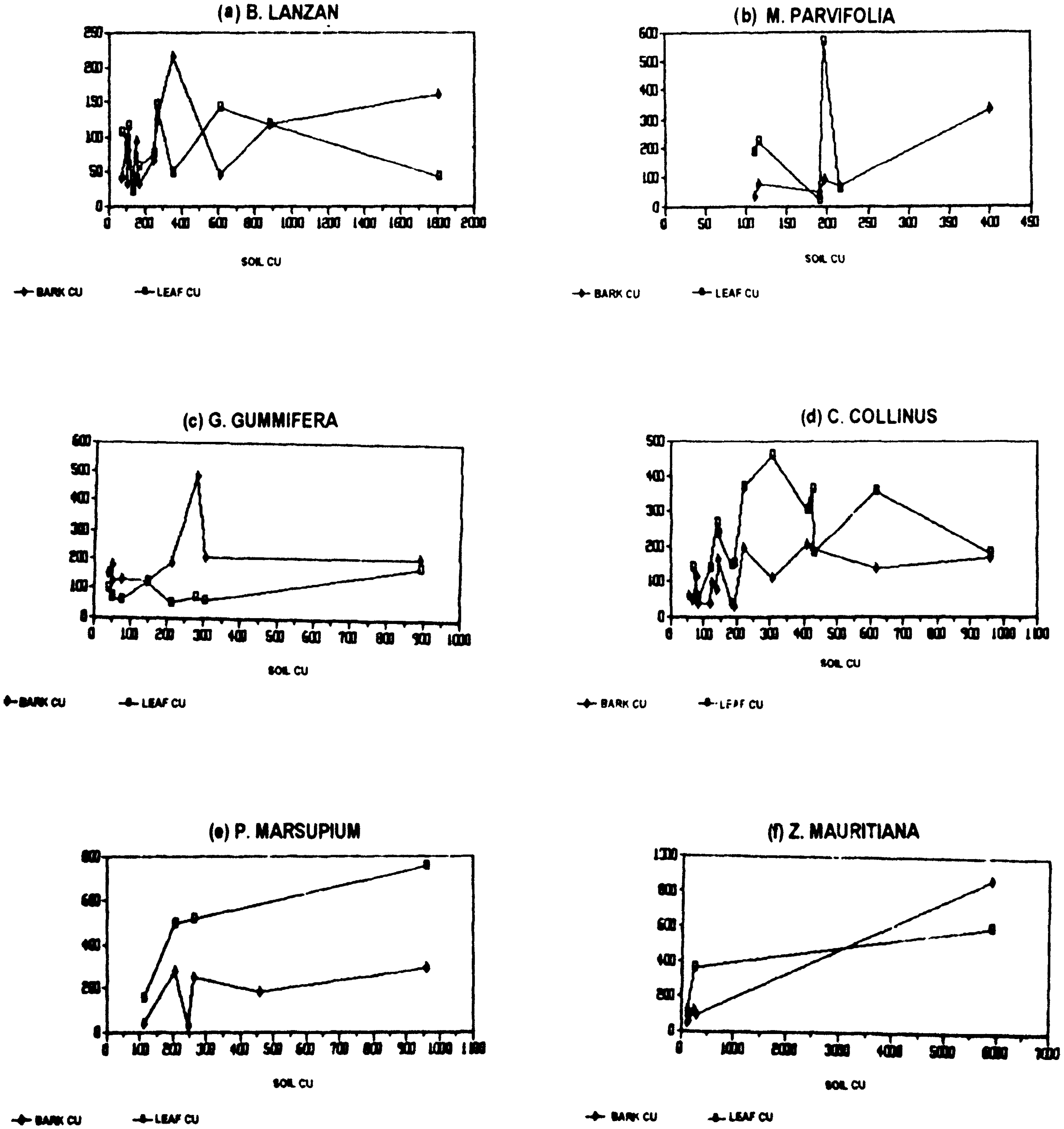


Fig.:20b COPPER ACCUMULATION TREND IN SOME DOMINANT SPECIES IN SINGHBHUM BELT

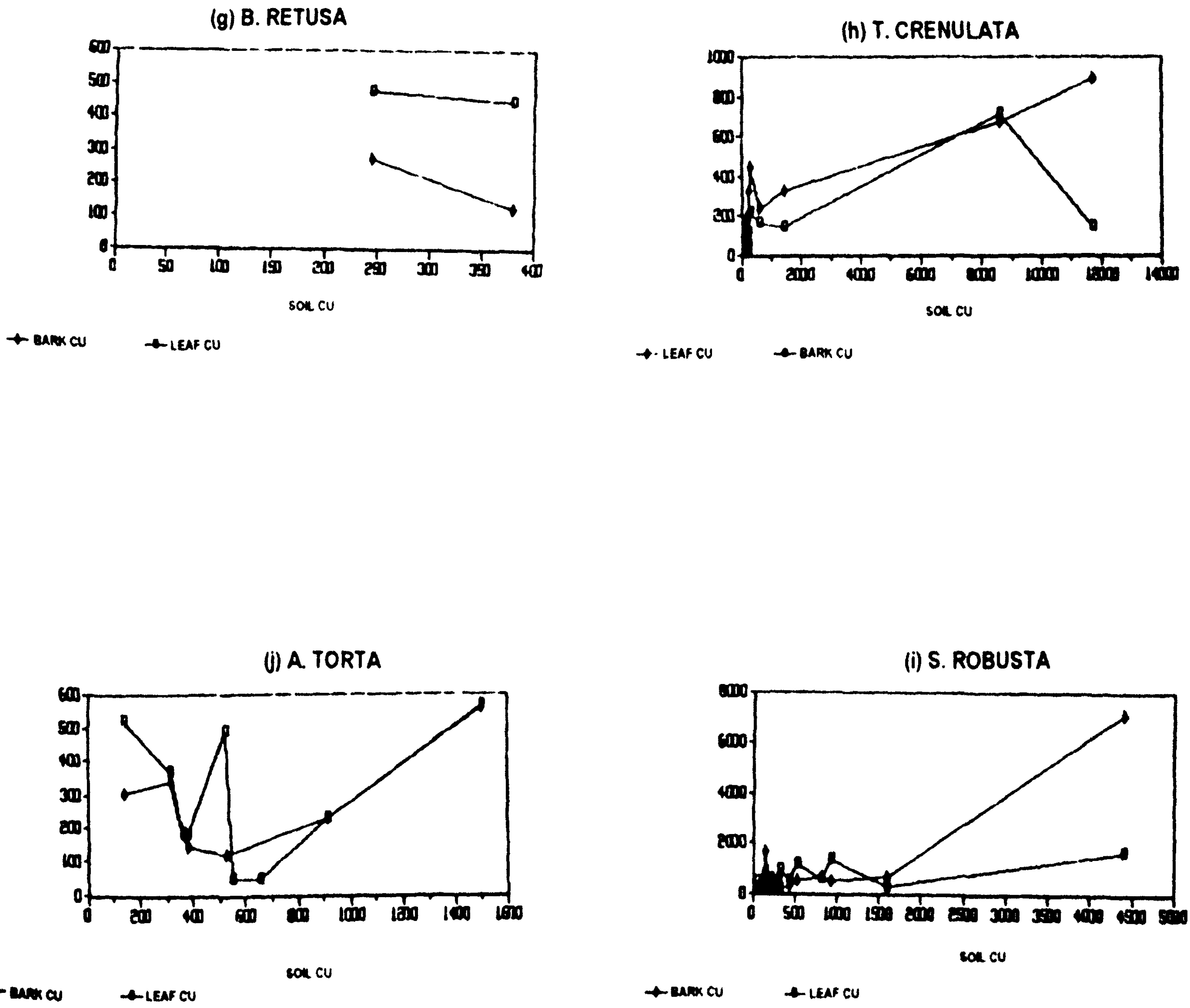


Fig.:20c COPPER ACCUMULATION TREND IN SOME DOMINANT SPECIES IN SINGHBHUM BELT

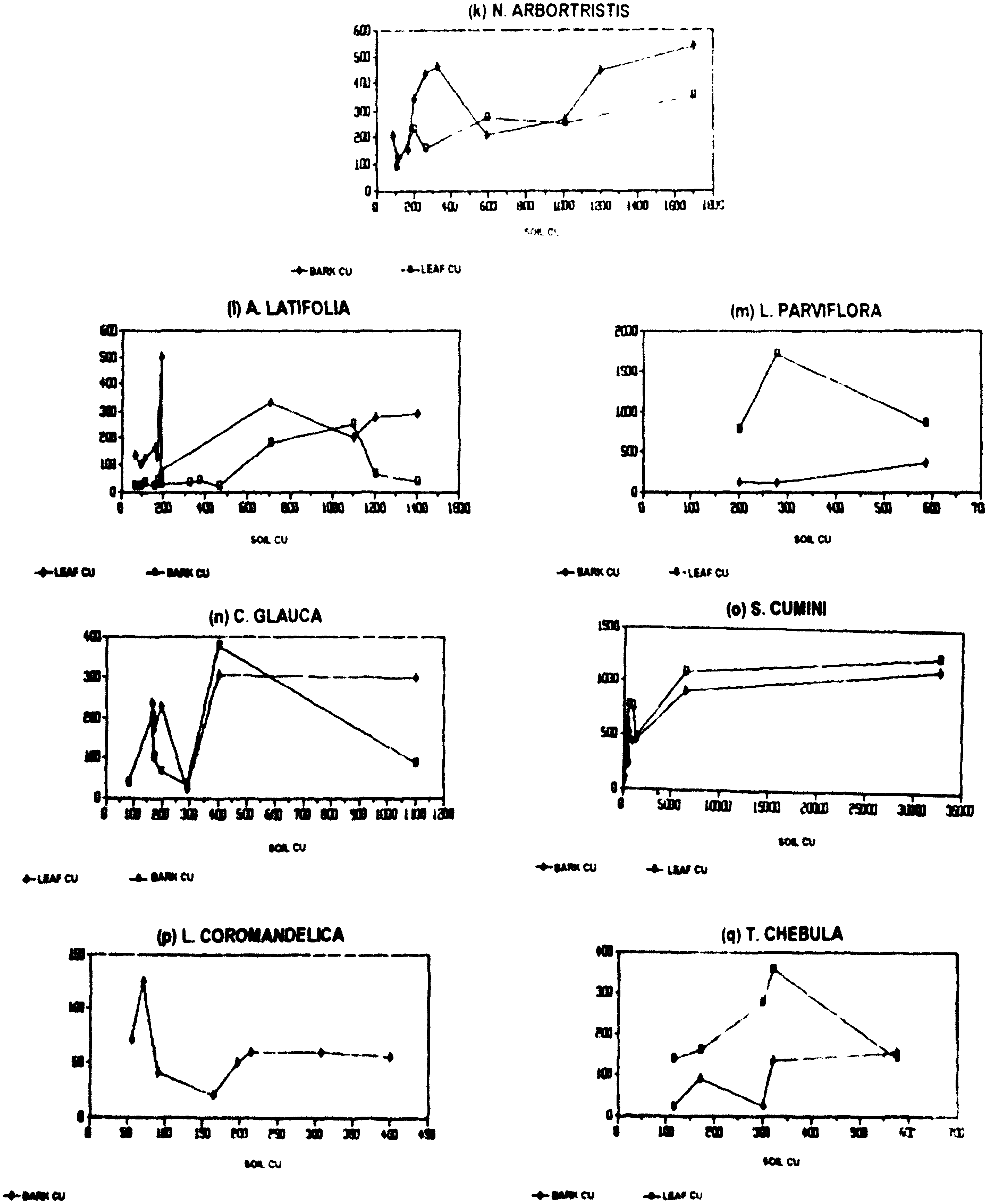


Fig.:20d COPPER ACCUMULATION TREND IN SOME DOMINANT SPECIES OF SINGHBHUM BELT

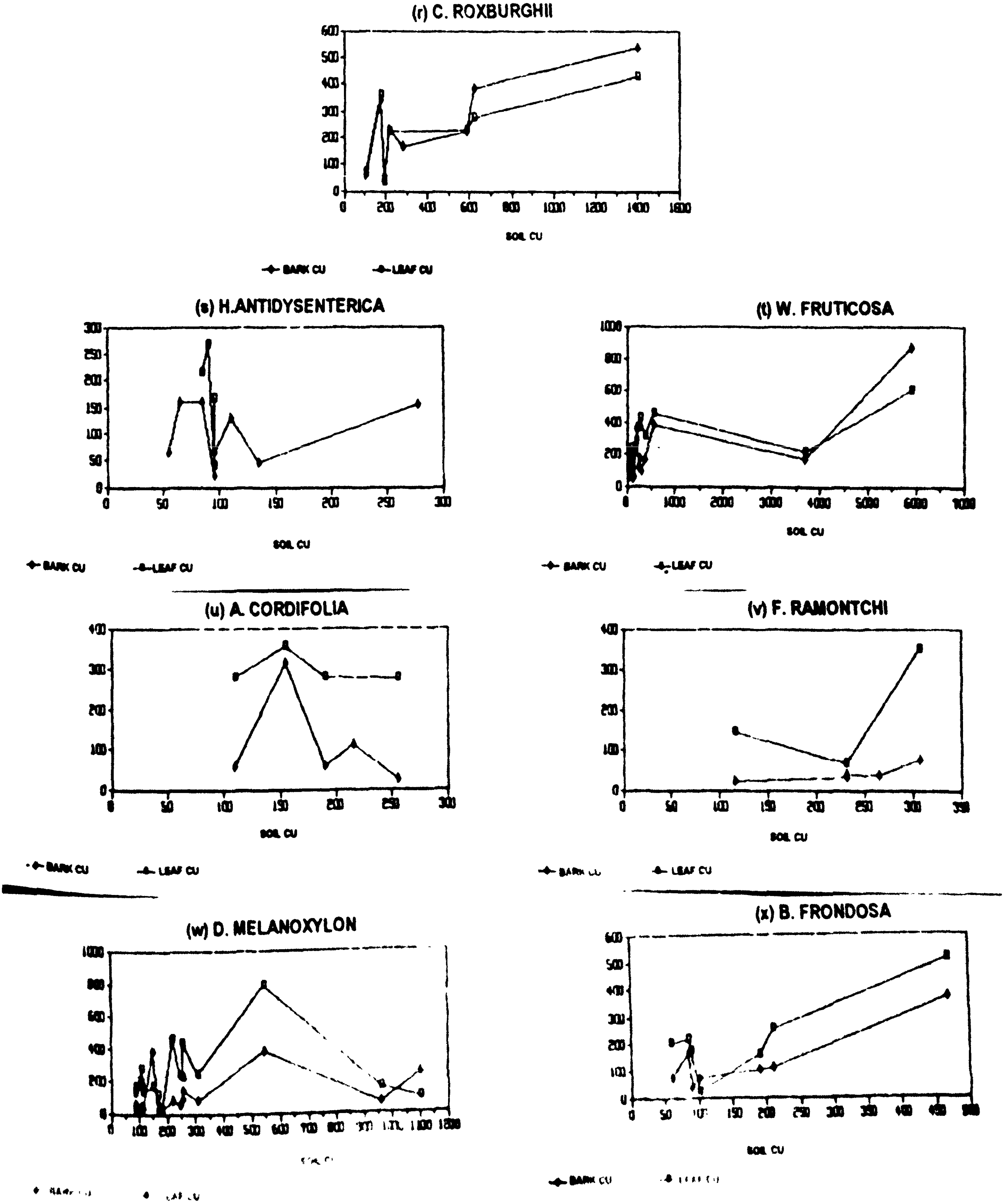


TABLE 19: A COMPARISON OF ELEMENTAL LEVELS FROM KNOWN ACCUMULATORS AND PLANT SPECIES FROM SINGHBHUM BELT

SPECIES	PLANT LEVEL ug/g dry wt.	SOIL LEVEL	REFERENCE
COPPER			
Aeolanthus biformifolius	3900		Brooks,*et al.*,
	1978		
Albizia lebbeck (L)	84.2	410	
Dalbergia sissoo	71.4	307	Present
Syzygium cumini (L)	118.9	32700	investigation
-DO- (B)	98.1	32700	
Shorea robusta (B)	1950.8	4400	
(L)	448.1	4400	
Smilax ovalifolia (L)	165.4	1951	
-DO- (STEMS)	103.4	1951	
LEAD			
Thlaspi rotundifolium	7900.0		Brooks (Unpublished)
Smilax ovalifolia (L)	27.2		Present report
Cleistanthus collinus (S)	28.2		
ZINC			
Thlaspi calaminare	40000.0		Reaves and Brooks (1983)
Cleistanthus collinus (B)	190.0		
(L)	318.0		
Pavetta indica (B/S)	138.6		Present report
Ehretia aspera (L)	47.6		
NICKEL			
Alyssum masmenaeum	24300		Brooks, *et al.* (1979a)
Pavetta indica (B)	63.3		
(L)	188.1		
Lagerstroemia parviflora (L)	36.1		Present report

COBALT		
Haumaniastrum robertii	10200	Brooks (1977)
Combretum decandrum (L)	70.8	Present report
Buchanania lanzan	39.8	
CHROMIUM		
Pearsonia metallifera	7700	Wild(1974)
Dalbergia sissoo (B/S)	14.8	
Canthium dicoccum	11.8	Present report

L: Leaves; B: Bark

In Singhbhum belt, none of the plants can be graded as accumulators or hyperaccumulators as the elemental levels are always less than 1000 ppm on dry weight basis.

TABLE 20: COPPER DISTRIBUTION IN PLANTS AND SOIL AROUND SINGHBHUM

SOIL SAMPLE NUM.	STATION	PLCU	SOILCU
ACACIA TORTA			
• BIOPART : B			
CHP/1/15	1	560	1500
CHP/3/54	3	303	135
CHP/4/61	4	342	315
CHP/5/77	5	229	915
CHP/7/300	7	180	360
CHP/8/317	8	145	380
• BIOPART : L			
CHP/1/15	1	864	1500
CHP/3/54	3	522	135
CHP/4/61	4	368	315
CHP/5/77	5	225	915
CHP/6/100	6	44	550
CHP/7/300	7	185	360
CHP/8/317	8	180	380
ADINA CORDIFOLIA			
• BIOPART : B			
CHP/1/24	1	92	195
CHP/3/56	3	316	155
CHP/8/323	8	55	190
CHP/9/333	9	55	110
CHP/11/376	11	25	255
CHP/19/440	19	35	100
CH/-3/488	-3	110	215
T2/5/126	5	111	126
• BIOPART : L			
CHP/1/24	1	567	195
CHP/3/56	3	355	155
CHP/8/323	8	280	190
CHP/9/333	9	295	110
CHP/11/376	11	275	255

AEGLE MARMELOS

* BIOPART : B

CHP/6/99	6	84	655
CHP/9/346	9	20	125
CHP/6/119	6	254	410
		60	198

* BIOPART : L

CHP/6/99	6	233	655
CHP/9/346	9	70	125
CHP/6/119	6	1111	410

ARECA LANNATA

* BIOPART : L

CHP/4/67	4	52	600

ANNONA SQUAMOSA

* BIOPART : B

CHP/15/418	15	80	95

ANOGEISSUS LATIFOLIA

* BIOPART : B

CHP/3/55	3	44	185
CHP/5/80	5	180	700
CHP/5/86	5	63	1200
CHP/6/101	6	248	1100
CHP/7/299	7	30	325
CHP/8/313	8	40	370
CHP/9/330	9	30	110
CHP/10/359	10	20	156
CHP/11/370	11	25	185
CHP/12/384	12	40	115
CHP/14/411	14	20	90
CHP/19/439	19	20	60
CH-1/448	-1	35	1400
CH-2/473	-2	20	460
[illegible]	5	20	75

* BIOPART : L			
CHP/3/55	3	500	185
CHP/5/80	5	329	700
CHP/5/86	5	276	1200
CHP/6/101	6	201	1100
CHP/9/330	9	125	110
CHP/10/359	10	160	156
CHP/11/370	11	75	185
CHP/12/384	12	130	115
CHP/14/411	14	100	90
CHP/19/439	19	135	60
CH/-1/448	-1	285	1400
ARTOCARPUS CHAPLASHA			
* BIOPART : B	5	322	9700
CHP/5/90			
* BIOPART : L			
CHP/5/90	5	500	9700
AZADIRACHTA INDICA			
* BIOPART : B			
TAMAPAHAR		128	171
CHP/15/418	15	130	95
* BIOPART : L			
TAMAPAHAR		198	171
BAUHINIA RETUSA			
* BIOPART : B			
CHP/3/47	3	125	380
CHP/6/125	6	269	245
* BIOPART : L			
CHP/3/47	3	433	380
CHP/6/125	6	478	245

BOMBAX CEIBA

* BIOPART : B

CHP/9/337	9	20	95
CHP/11/379	11	20	245
TAMAPAHAR		54	191

BOSWELLIA SERRATA

* BIOPART : B

CHP/6/109	6	411	535

BREYNIA VITIS-IDAEA

* BIOPART : B

TAMAPAHAR		92	221
CHP/6/103	6	161	680
CHP/9/239	9	45	100
CHP/-2/481	-2	75	307

* BIOPART : L

TAMAPAHAR		127	221
CHP/6/103	6	290	680
CHP/9/239	9	175	100
CHP/-2/481	-2	235	307

BUCHANANIA LANZAN

* BIOPART B

TAMAPAHAR		70	1360
TAMAPAHAR		109	469
CHP/1/1	1	160	1800
CHP/1/16	1	117	875
CHP/2/33	2	214	350
CHP/4/59	4	120	260
CHP/11/371	11	30	165
CHP/12/390	12	80	100
CHP/13/399	13	25	130
CHP/16/425	16	30	100
CHP/-1/451	-1	45	609
CHP/-1/465	-1	65	246

CH/-6/517	-6	40	70
CH/-7/527	-7	80	110

*** BIOPART : L**

CHP/1/1	1	43	1800
CHP/1/16	1	117	875
CHP/2/33	2	47	350
CHP/4/59	4	145	260
CHP/11/371	11	55	165
CHP/12/390	12	95	100
CHP/13/399	13	20	130
CHP/16/425	16	80	100
CHP/-1/451	-1	140	609
CHP/-1/465	-1	75	246
CH/-6/517	-6	105	70
CH/-7/527	-7	115	110

BUTEA FRONDOSA

*** BIOPART : B**

CHP/6/117	6	370	470
CHP/9/331	9	70	100
CHP/10/356	10	100	190
CHP/15/417	15	35	90
CHP/16/426	16	160	85
CHP/19/439	19	70	60
CH/-3/487	-3	105	210
TAMAPAHAR		144	415
TAMAPAHAR		182	546

*** BIOPART : L**

CHP/6/117	6	510	470
CHP/9/331	9	20	100
CHP/10/356	10	155	190
CHP/15/417	15	170	90
CHP/16/426	16	215	85
CHP/19/439	19	200	60
CH/-3/487	-3	250	210
TAMAPAHAR		298	415
TAMAPAHAR		193	546

BUTEA SUPERBA

* BIOPART : B

CHP/15/421	15	30	70

* BIOPART : L

CHP/15/421	15	120	70

CANTHIUM DICOCCUM

* BIOPART : B

CH/-5/511	-5	255	55

* BIOPART : L

CH/-5/511	-5	270	55

CAREYA ARBOREA

* BIOPART : B

CHP/2/30	2	276	170
TAMAPAHAR		100	231

* BIOPART : L

CHP/2/30	2	381	170
CHP/3/40	3	249	480
CHP/6/123	6	434	290
TAMAPAHAR		203	100

CARISSA PAUCINERVIA

* BIOPART : B

CHP/-7/522	-7	115	30

* BIOPART : L

CHP/-7/522	-7	210	30

CASEARIA ELLIPTICA

* BIOPART : B

CHP/9/342	9	20	95
* BIOPART : L			
CHP/9/342	9	85	95
CASSIA FISTULA			
* BIOPART : B			
TAMAPAHAR		520	215
TAMAPAHAR		62	604
CHP/6/118	6	84	395
CHP/11/368	11	120	1901
CHP/13/403	13	25	245
CHP/18/434	18	35	70
* BIOPART : L			
TAMAPAHAR		211	215
TAMAPAHAR		185	604
CHP/6/118	6	347	395
CHP/13/403	13	110	245
CHP/18/434	18	100	70
CELASTRUS PANICULATUS			
* BIOPART : L			
CHP/6/108	6	316	560
* BIOPART : B			
		70	120
CHP/7/310	7	45	235
CHP/8/315	8	55	215
CLEISTANTHUS COLLINUS			
* BIOPART : B			
TAMAPAHAR		185	171
CHP/1/7	1	1210	1600
CHP/1/20	1	166	960
CHP/2/32	2	191	425
CHP/3/49	3	191	220
CHP/4/66	4	204	410

CHP/6/114	6	136	615
CHP/8/324	8	75	140
CHP/9/334	9	35	120
CHP/10/357	10	35	185
CHP/11/367	11	25	190
CHP/13/394	13	35	85
CHP/14/407	14	195	1251
CHP/19/438	19	45	70
CH/-1/454	-1	1165	277
CH/-1/462	-1	145	430
CH/-2/481	-2	105	307
CH/-3/492	-3	160	145
CH/-5/511	-5	155	551
CH/-7/526	-7	115	80
CH/-9/538	-9	1110	801
TAMAPAHAR		268	1671
TAMAPAHAR		151	294

* BIOPART : L

CHP/1/20	1	178	960
CHP/2/32	2	363	425
CHP/3/49	3	368	220
CHP/4/66	4	304	410
CHP/6/106	6	1178	4301
CHP/6/114	6	355	615
CHP/8/324	8	265	140
CHP/9/334	9	135	120
CHP/10/357	10	145	185
CHP/11/367	11	150	190
CHP/13/394	13	45	85
CHP/19/438	19	140	70
CH/-3/492	-3	235	145
CH/-7/526	-7	520	80
TAMAPAHAR		1200	171
TAMAPAHAR		1217	732
TAMAPAHAR		196	294

COMBRETUM DECANDRUM

* BIOPART : B

CHP/5/84	5	128	1580
CHP/6/101	6	434	1100

* BIOPART : L

CHP/5/84	5	445	1580
CHP/6/101	6	478	1100

CORDIA MACLEODII

* BIOPART : B

CHP/9/349	9	30	145
CHP/13/398	13	55	95

* BIOPART : L

CHP/9/349	9	85	145
CHP/13/398	13	250	95

CROTON ROXBURGHII

* BIOPART : B

TAMAPAHAR		286	1671
TAMAPAHAR		355	221
CHP/3/43	3	387	620
CHP/6/96	6	539	1400
CHP/9/336	9	55	105
CHP/10/354	10	50	190
CH/-1/463	-1	220	584
CH/-2/480	-2	230	215

* BIOPART : L

TAMAPAHAR		166	1671
TAMAPAHAR		175	221
CH/1/25	1	1355	175
CHP/3/43	3	276	620
CHP/6/96	6	429	1400
CHP/9/336	9	70	105
CHP/10/354	10	30	190
CH/-1/463	-1	225	584
CH/-2/480	-2	220	215

CYMBOPOGON MARTINI

* BIOPART : P

CHP/7/302	7	335	310

DALBERGIA SISSOO

* BIOPART : B

CHP/6/113	6	278	545
CH/-2/478	-2	155	307

* BIOPART : L

CHP/6/113	6	389	545
CH/-2/478	-2	1150	307

DILLENIA PENTAGYNA

* BIOPART : B

CHP/6/115	6	122	605

DIOSPYROS MELANOXYLON

* BIOPART : B

CHP/1/21	1	89	255
CHP/3/42	3	141	255
CHP/3/52	3	373	150
CHP/4/58	4	80	220
CHP/5/79	5	59	960
CHP/6/113A	6	373	545
CHP/9/350	9	20	165
CHP/12/391	12	20	85
CHP/13/402	13	20	180
CHP/15/419	15	45	110
CHP/17/429	17	30	105
CH/-1/449	-1	240	1100
CH/-1/462	-1	100	430
CH/-2/479	-2	80	307
CH/-3/485	-3	50	246
CH/-4/499	-4	55	85
CH/-5/506	-5	35	115
CH/-6/513	-6	50	110
CH/-7/520	-7	50	90
CH/-8/531	-8	35	110
TAMAPAHAR		90	142
TAMAPAHAR	-	160	511

* BIOPART : L

CHP/1/21	1	227	255
CHP/3/42	3	433	255
CHP/3/52	3	171	150
CHP/4/58	4	458	220
CHP/5/79	5	154	960
CHP/6/113A	6	789	545
CHP/9/350	9	115	165
CHP/12/391	12	125	85
CHP/13/402	13	20	180
CHP/15/419	15	160	110
CHP/17/429	17	200	105
CH/-1/449	-1	85	1100
CH/-1/462	-1	265	430
CH/-2/479	-2	240	307
CH/-3/485	-3	235	246
CH/-4/499	-4	165	85
CH/-5/506	-5	130	115
CH/-6/513	-6	125	110
CH/-7/520	-7	145	90
CH/-8/531	-8	275	110

DIOSPYROS MONTANA

• BIOPART : B

CHP/7/302	7	105	310
CHP/8/320	8	70	175
CHP/11/373	11	35	305

• BIOPART : L

CHP/7/302	7	450	310
CHP/8/320	8	100	175
CHP/11/373	11	20	305

EHRETIA ASPERA

• BIOPART : B

CH/-7/529	-7	210	70

• BIOPART : L

CH/-7/529	-7	195	70

CASSINE GLAUCA

* BIOPART : B

TAMAPAHAR		74	67
CHP/2/28	2	64	195
CHP/4/62	4	201	165
CHP/6/124	6	378	400
CHP/11/380	11	30	290
CHP/18/433	18	35	801
CH/-1/449	-1	85	1100
CH/-8/533	-8	100	1232

* BIOPART : L

TAMAPAHAR	-	125	67
CHP/2/28	2	227	195
CHP/4/62	4	235	165
CHP/6/124	6	303	400
CHP/11/380	11	20	290
CH/-1/449	-1	265	1100
CH/-8/533	-8	170	170
TAMAPAHAR		184	1232
TAMAPAHAR		186	2561

EMBLICA OFFFICINALIS

* BIOPART : B

CHP/13/400	13	30	95

* BIOPART : F

CHP/13/400	13	65	95

ERIOLAENA HOOKERIANA

* BIOPART : B

CHP/6/107	6	241	395

* BIOPART : L

CHP/6/107	6	310	395

ERYTHRINA STRICTA

* BIOPART : B

CHP/8/314	8	20	365
CHP/9/341	9	20	125

* BIOPART : L

CHP/8/314	8	120	365

SYZYGIUM CUMINI

* BIOPART : B

CHP/1/8	1	464	1400
CHP/1/12	1	1234	32700
CHP/2/31	2	589	410
CHP/5/89	5	1090	6400
CHP/6/112	6	765	590
CHP/3/45	3	429	985
CHP/4/69	4	1226	5201
CHP/14/412	14	65	85
CHP/19/440	19	45	100
CH/-2/482	-2	220	338
CH/-3/493	-3	100	180
CH/-7/525	-7	125	40

* BIOPART : L

CHP/3/45	3	753	985
CHP/14/412	14	115	85
CHP/19/440	19	140	100
CH/-2/482	-2	505	338
CH/-3/493	-3	255	180
CH/-7/525	-7	255	40

FICUS BENGHALENSIS

* BIOPART : B

CH/-8/536	-8	130	80
CH/-10/552	-10	160	70

* BIOPART : L

CH/-8/536	-8	240	80

FICUS SEMICORDATA

* BIOPART : B

CHP/6/105	6	656	3000
CHP/8/316	8	30	210

* BIOPART : L

CHP/6/105	6	203	3000
CHP/7/316	7	285	235

FLACOURTIA RAMONTCHI

* BIOPART : B

		191	151
CHP/9/338	9	145	150
CHP/11/375	11	65	230
CH/-2/478	-2	350	307

FLACOURTIA SEPIARIA

* BIOPART : B

CHP/7/297	7	35	265

GARDENIA GUMMIFERA

* BIOPART : B

CH/-1/454	-1	70	277
CH/-3/494	-3	70	50
CH/-4/497	-4	60	75
CH/-5/510	-5	65	50
CH/-6/525	-6	95	40
CH/-8/534	-8	115	145
CH/-9/539	-9	80	65

* BIOPART : F

CH/-1/454	-1	600	277

* BIOPART : L

CH/-1/454	-1	485	277
CH/-3/494	-3	175	50
CH/-4/497	-4	130	75
CH/-5/510	-5	125	50
CH/-7/525	-7	150	40
CH/-8/534	-8	125	145
CH/-9/539	-9	185	65

GARDENIA LATIFOLIA

* BIOPART : B

CHP/1/19	1	170	890
CHP/7/305	7	55	305
CHP/8/316	8	45	210

* BIOPART : L

CHP/1/19	1	205	890
CHP/7/305	7	205	305
CHP/8/316	8	190	210

GREWIA TILIAEFOLIA

* BIOPART : B

CHP/6/98	6	900	600
CHP/8/323	8	110	190
CHP/10/360	10	125	180
CH/-1/455	-1	160	246
CH/-2/475	-2	100	369
		224	183

* BIOPART : L

CHP/6/98	6	539	600
CHP/10/3o0	10	225	180
		560	183

HOLARRHENA ANTIDYSENTERICA

* BIOPART : B

TAMAPAHAR		149	251
TAMAPAHAR		216	1546
TAMAPAHAR		266	116
ÇHP/12/388	12	145	1351
CHP/13/395	13	20	95
CHP/17/430	17	65	95
CH/-3/483	-3	155	277
CH/-5/511	-5	65	55
CH/-7/528	-7	130	110
CH/-9/539	-9	160	65

* BIOPART : F

TAMAPAHAR		336	256

TAMAPAHAR		229	1546
CHP/13/395	13	40	95
CHP/16/426	16	1105	851
CHP/17/430	17	165	95
CHP/18/432	18	294	1161

HOLOPTELEA INTEGRIFOLIA

* BIOPART : B

CHP/15/420	15	55	110
CHP/19/440	19	35	100

* BIOPART : L

CHP/15/420	15	165	110
CHP/19/440	19	150	100

HYMENODICTYON EXCELSUM

* BIOPART : B

CHP/7/295	7	60	280
CHP/8/321	8	50	175

HYPTIS SUAVEOLENS

* BIOPART : P

CHP/1/5	1	679	510
CHP/7/307	7	255	235
CH/-1/307	-1	325	1400
CH/-1/458	-1	430	277
CH/-5/511	-5	155	55

ICHNOCARPUS FRUTESCENS

* BIOPART : P

CHP/8/317	8	225	380

INDIGOFERA CASSIOIDES

* BIOPART : B

CHP/6/93	6	511	950

* BIOPART : L

CHP/3/44	3	408	305
CHP/6/93	6	950	950

LAGERSTROEMIA PARVIFLORA

* BIOPART : B

TAMAPAHAR		199	709
TAMAPAHAR		288	1189
CHP/6/104	6	347	585
CHP/12/392	12	305	90
CH/-1/457	-1	105	277
CHP/7/308	7	120	200

* BIOPART : L

CHP/6/104	6	842	585
CHP/12/392	12	395	90
CH/-1/457	-1	1700	277
CHP/7/308	7	780	200
		276	769
		628	1185

LANTANA CAMARA

* BIOPART : T

CHP/15/416	15	175	60
CH/-7/521	-7	215	120
CH/-9/538	-9	275	80
CH/-9/538	-9	340	80
CHP/17/430	17	290	95
CHP/18/432	18	265	90
CH/-3/491	-3	135	225
CH/-6/513	-6	250	110
CH/-8/532	-8	260	90

LEUCAENA GLAUCA

* BIOPART : B

CH/-1/456	-1	80	246

LITSEA POLYANTHA

* BIOPART : B

CHP/7/296	7	125	275

* BIOPART : L

CHP/7/296	7	175	275

MADHUCA INDICA

* BIOPART : B

TAMAPAHAR		86	219
CHP/3/55	3	394	185
CHP/10/358	10	35	170
CHP/19/436	19	35	95

* BIOPART : L

TAMAPAHAR	1	239	219
CHP/3/55	3	455	185
CHP/10/358	10	110	170
CHP/17/436	17	1165	701
CHP/19/436	19	160	95

MILIUSA VELUTINA

* BIOPART : B

CHP/2/29	2	444	200
CHP/7/301	7	125	310
CH/-2/476	-2	105	492

* BIOPART : L

CH1-2/416	-2	289	219
CHP/2/29	2	283	200
CHP/7/301	7	355	310

MIMOSA HIMALAYANA

* BIOPART : B

CH/-1/464	-1	120	523

* BIOPART : L

CH/-1/464	-1	490	523

MITRAGYNA PARVIFOLIA

* BIOPART : B

TAMAPAHAR		30	110
TAMAPAHAR		123	156
TAMAPAHAR		218	763
CHP/10/364	10	45	190
CH/-1/468	-1	70	215
CH/-2/477	-2	1330	4001
CH/-4/502A	-4	75	115

* BIOPART : L

TAMAPAHAR		185	110
TAMAPAHAR		266	156
TAMAPAHAR		433	763
CHP/10/364	10	20	190
CH/-1/468	-1	590	215
CH/-4/502A	-4	220	115

MORINDA PUBESCENS

* BIOPART : B

TAMAPAHAR		168	616
CHP/6/110	6	321	440
CHP/7/309	7	210	215

* BIOPART : L

TAMAPAHAR		147	616
CHP/6/110	6	432	440
CHP/7/309	7	325	215

LITCHI CHINENSIS

* BIOPART : B

CHP/2/34	2	77	260
CHP/4/72	4	90	310

* BIOPART : L

CHP/2/34	2	64	260

CHP/4/72	4	178	310

NYCTANTHES ARBORTRISTIS

* BIOPART : B

CHP/1/6	1	539	1700
CHP/1/18	1	264	1010
CHP/3/50	3	433	265
CHP/4/64	4	342	200
CHP/5/85	5	444	1200
CHP/6/97	6	205	590
CHP/8/326	8	175	120
CHP/9/345	9	130	110
CHP/10/361	10	150	170
CHP/11/378	11	175	225
CHP/13/397	13	140	95
CH/-1/471	-1	460	326
CH/-4/503	-4	205	90

* BIOPART : L

CHP/1/6	1	352	1700
CHP/1/18	1	247	1010
CHP/3/50	3	158	265
CHP/4/64	4	229	200
CHP/6/97	6	270	590
CHP/8/326	8	120	120
CHP/9/345	9	90	110

LANNEA COROMANDELICA

* BIOPART : B

TAMAPAHAR	1	117	2439
CHP/7/306	7	50	195
CHP/11/373	11	20	305
CHP/12/387	12	20	165
CH/-1/467	-1	60	215
CH/-2/479	-2	60	307
CH/-3/484	-3	55	400
CH/-4/496	-4	125	70
CH/-5/507	-5	40	90
CH/-6/513	-6	60	110
CH/-7/524	-7	70	55

OUGEINIA OOJEINENSIS

* BIOPART : B			
CHP/6/111	6	257	628
* BIOPART : L			
CHP/6/111	6	827	628
PAVETTA CRASSIUSCULA			
* BIOPART : B			
CHP/1/11	1	280	4200
* BIOPART : L			
CHP/1/11	1	150	4200
CHP/4/60	4	389	365
•			
PAVETTA INDICA			
* BIOPART : B			
CH/-3/490	-3	310	205
CH/-6/517	-6	120	70
CH/-7/519	-7	115	100
* BIOPART : L			
CH/-3/490	-3	265	205
CH/-6/517	-6	70	70
CH/-7/519	-7	155 •	100
POLYALTHIA LONGIFOLIA			
* BIOPART : B			
CHP/3/41	3	178	255
* BIOPART : L			
CHP/3/41	3	99	255
PTEROCARPUS MARSUPIUM			
* BIOPART : B			

CH/3/53	3	271	205
CHP/4/59	4	246	260
CHP/5/83	5	284	960
CHP/14/409	14	30	110
CH/-1/469	-1	25	246
CH/-2/473	-2	180	460

* BIOPART : L

CH/3/53	3	488	205
CHP/4/59	4	511	260
CHP/5/83	5	756	960
CHP/14/409	14	150	110

RANDIA DUMETORUM

* BIOPART :B

TAMAPAHAR		150	763
TAMAPAHAR		99	763
CH/-1/450	-1	115	615
CH/-1/470	-1	90	295
CH/-6/514	-6	165	60
CH/-7/519	-7	55	100

SCHLEICHERA OLEOSA

* BIOPART : B

CHP/9/339	9	30	110
CHP/16/423	16	20	95

* BIOPART : L

CHP/9/339	9	165	110
CHP/16/423	16	130	95

SEMICARPUS ANACARDIUM

* BIOPART : B

CHP/4/65	4	190	370
CH/-9/542	-9	50	65

* BIOPART : L

CHP/6/102	6	127	690
CH/-9/542	-9	190	65

SHOREA ROBUSTA

* BIOPART : B

CHP/1/4	1	261	1600
CHP/1/13	1	988	4400
CHP/1/17	1	500	925
CHP/2/27	2	1605	150
CHP/3/38	3	204	325
CHP/3/51	3	655	140
CHP/4/59	4	276	260
CHP/5/81	5	631	815
CHP/6/94	6	7099	4400
CHP/6/116	6	444	530
CHP/7/311	7	210	220
CHP/11/374	11	90	320
CHP/13/404	13	90	220
CHP/14/413	14	110	145
CHP/16/424	16	60	95
CHP/19/442	19	90	65
CH/-1/462	-1	270	430
CH/-2/481	-2	50	307
CH/-3/489	-3	205	210
CH/-4/496	-4	210	70
CH/-5/509	-5	45	75
CH/-7/523	-7	70	55
CH/-8/535	-8	100	100

* BIOPART : L

CHP/1/4	1	607	1600
CHP/1/17	1	1329	925
CHP/2/27	2	570	150
CHP/3/38	3	889	325
CHP/3/51	3	678	140
CHP/4/59	4	286	260
CHP/5/81	5	513	815
CHP/6/94	6	1631	4400
CHP/6/116	6	1111	530
CHP/7/311	7	375	220
CHP/11/374	11	195	320
CHP/13/404	13	240	220
CHP/14/413	14	255	145

CHP/16/424	16	370	95
CHP/19/442	19	300	65
CH/-1/452	-1	1000	492
CH/-1/462	-1	460	430
CH/-2/481	-2	455	307
CH/-3/489	-3	530	210
CH/-4/496	-4	365	70
CH/-5/509	-5	370	75
CH/-7/523	-7	380	55
CH/-8/535	-8	435	100

SMILAX OVALIFOLIA

* BIOPART : B

TAMAPAHAR	1	1000	1951
CHP/4/74	4	123	1010
CHP/11/382	11	325	255

* BIOPART : L

TAMAPAHAR		1600	1951
CHP/4/74	4	205	1010
CHP/6/121	6	130	295
CH/-3/493	-3	560	180

SOYMIDA FEBRIFUGA

* BIOPART : B

CHP/4/71	4	204	550

* BIOPART : L

CHP/4/71	4	310	550

STRECULIA URENS

* BIOPART : B

TAMAPAHAR		47	403
CHP/8/314	8	20	365
CH/-2/473	-2	230	460

* BIOPART : L

CHP/8/314	8	110	365

CH/-2/473	-2	235	460
		205	403
TERMINALIA CHEBULA			
* BIOPART : B			
TAMAPAHAR		133	320
CHP/6/122	6	133	320
CHP/4/68	4	1155	5751
CHP/9/338	9	20	150
CHP/11/377	11	45	300
CH/-8/533	-8	90	170
* BIOPART : F			
CHP/11/377	11	20	300
* BIOPART : L			
TAMAPAHAR		357	320
CHP/9/338	9	135	150
CHP/11/377	11	20	300
CH/-8/533	-8	160	170
CHP/6/122	6	357	320
TERMINALIA CRENULATA			
BIOPART : B			
TAMAPAHAR		20	175
TAMAPAHAR	12	85	2341
CHP/2/35	2	110	235
CHP/3/48	3	215	305
CHP/4/73	4	238	950
CHP/5/78	5	156	605
CHP/5/88	5	710	8600
CHP/6/95	6	137	11700
CHP/8/319	8	25	160
CHP/10/355	10	1201	2101
CHP/13/395	13	60	95
CHP/14/408	14	20	115
CH/-1/448	-1	145	1400
CH/-1/466	-1	100	246
CH/-3/485	-3	110	246
CH/-6/517	-6	55	70
CH/-7/521	-7	80	120
CH/-8/534	-8	110	145

CH/-9/541	-9	100	45
		80	175
* BIOPART : L	12	124	2341
CHP/2/35	2	322	235
CHP/3/48	3	444	305
CHP/4/73	4	592	950
CHP/5/78	5	229	605
CHP/5/88	5	666	8600
CHP/6/95	6	844	11700
CHP/8/319	8	120	160
CHP/13/395	13	60	95
CHP/14/408	14	65	115
CH/-1/448	-1	325	1400
CH/-1/466	-1	210	246
CH/-3/485	-3	215	246
CH/-6/517	-6	125	70
CH/-7/521	-7	120	120
CH/-8/534	-8	175	145
CH/-9/541	-9	165	45

VANGUERIA PUBESCENS

*** BIOPART : B**

CHP/6/120	6	136	330
CHP/9/340	9	65	95
CH/-7/526	-7	295	80

*** BIOPART : L**

CHP/6/120	6	381	330
CHP/9/340	9	120	95

WENDLANDIA TINCTORIA

*** BIOPART : B**

CHP/4/70	4	280	640

*** BIOPART : L**

CHP/4/70	4	450	640

WOODFORDIA FRUTICOSA

* BIOPART : B		142	1174
CHP/0/10	0	170	3700
CHP/4/63	4	355	210
CHP/19/444	19	60	70
CH/-1/461	-1	380	554
CH/-2/475	-2	160	369
CH/-3/483	-3	165	277
CH/-4/496	-4	120	70
CH/-5/510	-5	130	50
CH/-6/513	-6	120	110
CH/-7/520	-7	135	90
CH/-8/532	-8	150	90
* BIOPART : L		288	1174
CHP/1/10	1	210	3700
CHP/4/63	4	268	210
CHP/19/444	19	110	70
CH/-1/461	-1	450	554
CH/-2/475	-2	305	369
CH/-3/483	-3	425	277
CH/-4/496	-4	185	70
CH/-5/510	-5	165	50
CH/-6/513	-6	165	110
CH/-7/520	-7	205	90
CH/-8/532	-8	230	90
CH/-9/539	-9	170	65
ZIZIPHUS MAURITIANA			
* BIOPART : B			
CHP/1/23	1	110	252
CHP/6/92	6	864	9100
CHP/8/327	8	110	110
CH/-1/460	-1	90	307
CH/-4/501	-4	45	115
CH/-6/515	-6	50	135
* BIOPART : L			
CHP/1/23	1	357	252
CHP/6/92	6	600	9100
CHP/8/327	8	95	110

B:Bark or older twigs or stem outer peelings; P: Total plant; L:Leaves; F:Flowers

TABLE 21: LEAD AND ZINC VARIATIONS IN SINGHBHUM

	PLANT PB	SOIL PB	PLANT ZN	SOIL ZN
ACACIA TORTA				
* BIOPART : B				
	280	50	47	25
		60		35
	136	20	67	10
	93	20	29	10
	149	20	21	20
	20	45	50	50
	20	30	55	50
* BIOPART : L				
	250	50	22	25
		60		35
	73	20	45	10
	250	20	34	10
	79	20	125	20
	113	35	75	25
	40	45	145	50
	30	30	220	50
ADINA CORDIFOLIA				
* BIOPART : B				
	280	40	85	15
	121	20	37	10
	20	20	45	75
	20	50	70	50
	20	20	35	30
	20	20	90	45
	80		55	35
	50	50	169	32
* BIOPART : L				
	60	40	50	15
	190	20	94	10
	30	20	205	75
	20	50	320	50
	20	20	275	20

AEGLE MARMELOS

* BIOPART : B

93	30	55	30
20	50	20	30
7	58	102	23

* BIOPART : L

93	30	90	30
20	50	80	30

ALBIZIA LEBBECK

* BIOPART : B

114	35	87	25

* BIOPART : L

80	35	50	25

ANNONA SQUAMOSA

* BIOPART : B

20	20	50	25

ANOGEISSUS LATIFOLIA

* BIOPART : B

220	20	46	10
260	20	28	15
107	35	55	45
127	40	55	25
20	35	35	50
20	20	30	35
20	45	35	40
20	55	20	35
20	20	30	25
20	-	30	35
20	20	20	30
20	20	40	30
20	-	35	30
20	-	110	48

70		95	20
9	42	64	68
13	42	54	45

* BIOPART : L

67	20	50	10
107	20	21	15
114	35	21	45
80	40	35	25
20	45	150	40
20	55	160	35
20	20	105	25
35		175	35
30	20	20	30
65	20	210	30
40		180	30
29	42	187	68
23	42	154	45

ARTOCARPUS CHAPLASHA

* BIOPART : B

60	55	44	35

* BIOPART : L

100	55	29	35

AZADIRACHTA INDICA

* BIOPART : B

25	20	168	25

BAUHINIA RETUSA

* BIOPART : B

86	30	62	10
133	20	300	40

* BIOPART : L

180	30	114	10
93	20	250	40

BOMBAX CEIBA

* BIOPART : B

20	60	20	35
30	20	55	35

BOSWELLIA SERRATA

* BIOPART : B

107	30	80	25

BREYNIA VITIS-IDAEA

* BIOPART : B

93	20	75	20
20	55	110	50
50		150	25
9	58	212	41

* BIOPART : L

100	20	500	20
25	55	585	50
20		245	25
31	58	729	41

BUCHANANIA LANZAN

* BIOPART : B

280	20	34	25
107	60	37	20
93	75	25	30
93		21	
250	20	44	10
20	20	35	25
25		135	30
25	20	25	50
20	20	20	30
20		20	23
25		40	14
20		20	20
20	20	30	80
	50	51	41
58	50	69	45

* BIOPART : L

82	20	138	25
130	60	28	20
60	75	40	30
100		32	
29	20	37	10
25	20	65	25
40		90	30
35	20	90	50
20	20	70	30
20		75	23
20		45	14
30		90	20
20	20	80	80
21	50	219	41
	50	131	45

BUTEA FRONDOSA

* BIOPART : B

220	35	91	30
20	35	50	40
20	40	70	40
20	20	20	25
25	20	265	30
20	20	50	30
			18
50		318	30

* BIOPART : L

200	35	145	30
20	35	20	40
20	40	50	40
20	20	30	25
20	20	80	30
35	20	70	30
75		255	30

BUTEA SUPERBA

* BIOPART : B

20	20	35	20

* BIOPART : L

20	20	50	20

CANTHIUM DICOCCUM

* BIOPART : B

65		395	25

* BIOPART : L

110		380	25

CAREYA ARBOREA

* BIOPART : B

79	40	42	15
	60		20
25	30	293	20

* BIOPART : L

220	40	23	15
80	60	120	20
79	20	15	35
21	30	165	20

CARISSA PAUCINERVIA

* BIOPART : B

55		260	35

* BIOPART : L

65		510	35

CASEARIA ELLIPTICA

* BIOPART B

20	45	25	35

* BIOPART : L

390	45	125	35

CASSIA FISTULA

* BIOPART : B

8	33	176	32
71	30	33	25
30	20	120	20
35	20	165	25
30	20	130	40
37	42	580	45

* BIOPART : L

31	33	304	32
220	30	87	25
20	20	215	25
25	20	200	40
	42	265	45

CELASTRUS PANICULATUS

* BIOPART : L

136	20	125	25

CHOCOLOSPERMUM RELIGIOSUM

* BIOPART : B

20	30	35	50
80		205	30

* BIOPART : B

20	20	50	40

CLEISTANTHUS COLLINUS

* BIOPART : B

28	20	1750	64
24	75	342	41
240	25	94	25
114	40	42	20
200	70	62	20
260	30	96	10
73	20	45	10

220	35	93	30
20	20	65	40
20	60	30	50
20	55	35	40
20	20	30	25
20	20	60	25
20	20	20	35
25		330	23
20		90	14
65		65	25
300		145	25
75		185	25
30		260	60
20	15	530	60
31	50	489	45

* BIOPART : L

118	40	215	20
270	70	32	20
111	30	37	10
200	20	44	10
107	20	125	25
121	35	37	30
45	20	380	40
25	60	205	50
20	55	185	40
35	55	140	35
30	20	45	25
75	20	260	35
60		255	25
100		3300	60
32	75	313	41
67	20	371	64

COMBRETUM DECANDRUM

* BIOPART : B

248	20	94	20
128	40	21	26
			26

* BIOPART : L

300		58	
67	20	142	20

100	40	95	25
			26

CORDIA MACLEODII

* BIOPART : B

20	20	35	35
20	20	45	25

* BIOPART : L

20	20	120	35
50	20	335	25

CROTON ROXBURGHII

* BIOPART : B

92	20	108	10
86	20	46	30
20	70	90	35
20	40	100	45
45		215	18
80		265	30
25	58	620	41
	50	341	36

* BIOPART : L

79	50	229	20
100	20	14	10
180	20	49	30
20	70	160	35
20	40	80	45
30		140	18
55	-	255	30
	58	213	41
20	50	241	36

CYMBOPOGON MARTINI

* BIOPART : P

40	20	475	60

DALBERGIA SISSOO

* BIOPART : B

53	45	80	25
65		240	31

* BIOPART : L

47	45	75	25
75		1000	31

DILLENIA PENTAGYNA

* BIOPART : B

87	35	60	25

DIOSPYROS MELANOXYLON

* BIOPART : B

230	45	27	10
100	80	29	10
160	20	105	5
86	20	17	10
107	20	50	20
160	45	49	25
20	30	25	40
20		30	25
30	20	30	25
20	20	25	30
20	20	25	35
30		155	26
25		110	14
55		110	29
70		165	21
275		70	30
85		45	30
80		70	25
55		30	30
20	10	25	65
	67	156	50

* BIOPART : L

87	45	55	10
113	80	70	10

80	20	125	5
220	20	87	10
270	20	49	20
67	45	250	25
20	30	95	40
45		170	25
35	20	110	25
20	20	145	30
75	20	135	35
25		115	26
40		180	14
70		155	29
50		155	21
85		140	30
75		225	30
85		120	25
225		85	30
45	10	195	65
	67	157	50

DIOSPYROS MONTANA

* BIOPART : B

35	20	75	60
20	20	90	50
30	20	45	25

* BIOPART : L

30	20	345	60
20	20	175	50
35	20	125	25

EHRETIA ASPERA

* BIOPART : B

20	20	20	60

* BIOPART : L

25	20	560	60

CASSINE GLAUCA

* BIOPART : B

220	60	47	20
280	20	62	5
100	20	80	35
30	20	30	30
20	20	25	40
25		60	26
25		105	100
	50	56	36
12	40	72	28

* BIOPART : L

250	.60	122	20
280	20	53	5
73	20	45	35
20	20	25	30
35		180	26
30		135	100
18	40	14[illegible]	28
11	50	78	41
	50	198	36

EMBLICA OFFICINALIS

* **BIOPART** : **B**

25	20	115	25

* **BIOPART** : **F**

35	20	80	25

ERIOLAENA HOOKERIANA

* **BIOPART** : **B**

80	30	50	25

* **BIOPART** : **L**

140	30	284	25

ERYTHRINA STRICTA

* BIOPART : B

100	45	75	55
20	45	20	40

* BIOPART : L

20	45	425	55

FICUS BENGHALENSIS

* BIOPART : B

20	15	75	50
50	10	190	40

* BIOPART : L

45	15	360	50

FICUS SEMICORDATA

* BIOPART : B

	45		15
60	20	50	20
20	20	35	45

* BIOPART : L

	45		15
67	20	220	20
25	45	115	35

FLACOURTIA RAMONTCHI

* BIOPART :

	35		35

* BIOPART : B

20	45	20	40
30	20	115	25
20	20	250	25

55		270	31
26	33	196	18

* BIOPART : L

25	45	285	40
30	20	205	20
20		400	31
24	33	700	18

FLACOURTIA SEPIARIA

* BIOPART : B

20	25	130	45

GARDENIA GUMMIFERA

* BIOPART : B

20		45	23
110		165	40
75		70	40
90		90	25
30		60	80
20	10	75	75
60	20	40	70

* BIOPART : F

100		240	23

* BIOPART : L

50		155	23
105	-	150	40
85	-	105	40
105		135	25
30	-	70	80
20	10	110	75
55	20	90	70

GARDENIA LATIFOLIA

* BIOPART : B

240	45	136	25

20	25	30	60
20	20	35	45

* BIOPART : L

180	45	113	25
20	25	105	60
25	20	160	45

GREWIA TILIAEFOLIA

* BIOPART : B

73	30	40	30
20	20	245	75
20	55	160	45
20		245	19
50		270	30
42	50	400	45

* BIOPART : L

107	30	9	30
40	55	245	45
51	50	430	45

HOLARRHENA ANTIDYSENTERICA

* BIOPART : B

68	50	233	32
20		45	25
55	20	190	25
35	20	45	40
65		155	21
65	-	100	25
55	20	185	70
20	20	250	70
29	42	114	23
26	42	201	36

* BIOPART : F

35	20	30	25
35	20	170	30
55	20	260	40
40	20	210	40

19	42	207	23
34	50	349	32
14	42	231	36

HOLOPTELEA INTEGRIFOLIA

* BIOPART : B

20	20	75	25
20	20	35	45

* BIOPART : L

20	20	60	25
20	20	185	45

HYMENODICTYON EXCELSUM

* BIOPART : B

20	25	45	55
20	20	40	45

HYPTIS SUAVEOLENS

* BIOPART : P

150	30	149	25
	20		10
20	45	210	35
20		330	29
50		385	18
95		265	25

ICHNOCARPUS FRUTESCENS

* BIOPART : P

30	30	330	50

INDIGOFERA CASSIOIDES

* BIOPART : B

-	20		10
60	170	190	34

* BIOPART : L

86	20	75	10
170	170	34	34

LAGERSTROEMIA PARVIFLORA

* BIOPART : B

240	25	27	25
50		235	30
20		40	19
20	20	65	55
17	64	216	25

* BIOPART : L

40	20	300	55
100	25	25	25
60		255	25
150		530	19
37	64	400	25

LANNEA COROMANDELICA

* BIOPART : B

20	36	30	30
20	20	35	25
20		25	30
20		80	15
55		185	29
45		200	52
75		175	65
55		45	25
75		70	25
25		40	90

LANTANA CAMARA

* BIOPART : B

25	20	70	20
80	-	240	40
135	15	480	60

* BIOPART : L

185	15	410	60

* BIOPART : P

60	20	335	40
30	20	365	40
90	-	365	40
80		355	25
55	10	450	60
21	50	640	19

LEUCAENA GLAUCA

* BIOPART : B

20		310	18

LITCHI CHINENSIS

* BIOPART : B

67	70	45	25
90	20	44	5

* BIOPART : L

100	70	58	25
67	20	80	5

LITSEA POLYANTHA

* BIOPART : B

20	30	35	65

* BIOPART : L

20	30	175	65

MADHUCA INDICA

* BIOPART : B

180	20	47	10
20	35	20	40

20	20	20	35
11	33	78	41

* BIOPART : L

107	20	190	10
20	35	110	40
25	20	80	30
30	20	120	35
37	33	393	41

MILIUSA VELUTINA

* BIOPART : B

100	60	125	15
20	20	310	60
45		70	29

* BIOPART : L

87	60	35	15
45	20	490	60
44	42	301	13

MIMOSA HIMALAYANA

* BIOPART : B

30		100	15

* BIOPART : L

75		210	15

MITRAGYNA PARVIFOLIA

* BIOPART : B

20	55	50	40
20	45	65	40
40		60	13
55		375	29
95		65	45
	42	118	27
32	50	210	32

* BIOPART : L

20	55	205	40
40	45	240	40
50		255	13
110		255	45
24	42	292	27
27	50	331	32

MORINDA PUBESCENS

* BIOPART : B

46.3	40	82.7	35
20	20	80	45
24	42	148	23

* BIOPART : L

180	40	51	35
25	20	375	45
20	42	229	23

NYCTANTHES ARBORTRISTIS

* BIOPART : B

79	35	92	30
170	50	154	30
73	25	105	10
93	20	167	5
67	35	115	45
64	35	62	30
20	20	150	40
20	20	115	35
20	40	150	40
20	20	150	25
40	20	205	30
185	-	320	18
75		325	30

* BIOPART : L

100	35	87	30
200	50	318	30

150	25	49	10
87	20	30	5
148	35	32	30
25	20	235	40
20	20	130	35

OUGEINIA OOJEINENSIS

* **BIOPART : B**

220	45	27	30

* **BIOPART : L**

160	45	32	30

PAVETTA CRASSIUSCULA

* **BIOPART : B**

80	25	55	20

* **BIOPART : L**

79	25	25	20
47	20	75	10

PAVETTA INDICA

* **BIOPART : B**

150		1600	35
50		300	20
40		1700	30

* **BIOPART : L**

85		460	35
40		210	20
55		320	30

POLYALTHIA LONGIFOLIA

* **BIOPART : B**

64	65	138	25

* BIOPART : L

40	65	30	25

PTEROCARPUS MARSUPIUM

* BIOPART : B

73	20	80	10
136	20	58	10
140	20	47	20
20	20	20	30
20		20	18
30		115	48

* BIOPART : L

200	20	273	10
73	20	30	10
87	20	65	20
25	20	165	30

RANDIA DUMETORUM

* BIOPART : B

75		50	18
35		60	15
65		260	25
45		25	30
	50	52	32

SCHLEICHERA OLEOSA

* BIOPART : B

20	20	30	35
20	20	20	25

* BIOPART : L

20	20	290	35
30	20	90	25

SEMICARPUS ANACARDIUM

* BIOPART : B

	20		25
80	20	110	5
20	10	80	55

* BIOPART : L

40	20	180	25
20	10	215	55

SHOREA ROPUSTA

* BIOPART : B

277	30	68	20
150	25	34	20
182	50	154	25
168	50	32	15
107	50	65	30
150	20	284	10
150	20	25	10
71	20	46	15
120	45	109	30
73	40	160	30
20	40	125	40
25	20	130	20
20	20	75	25
25	20	25	35
20	20	150	30
20	20	70	35
50		190	14
65		235	25
155		265	30
100		250	65
75		90	20
20		40	95
20	15	90	70

* BIOPART : L

127	30	354	20
93	50	29	25
160	50	193	15
120	50	95	30

73	20	250	10
180	20	131	10
86	20	175	15
143	45	250	30
87	40	250	30
60	40	940	40
20	20	370	20
30	20	315	25
35	20	100	35
75	20	285	30
40	20	380	35
70		330	15
40		365	14
65		375	25
65		360	30
145		380	65
105		310	20
50		1300	95
100	15	320	70

SMILAX OVALIFOLIA

• **BIOPART : B**

260	20	53	15
30	20	195	30
25	58	346	32

• **BIOPART : L**

300	20	32	15
160	20	87	30
120		365	30
-	58	650	32

SOYMIDA FEBRIFUGA

• **BIOPART : B**

260	20	49	10

• **BIOPART : L**

280	20	49	10

STERCULIA URENS

* BIOPART : B

100	45	75	55
20		185	48
16	58	256	23

* BIOPART : L

20	45	425	55
20		245	48
45	58	704	23

SYZYGIUM CUMINI

* BIOPART : B

180	30	32	35
220	25	50	25
280	60	33	10
127	35	262	10
86	20	37	5
100	40	55	25
120	40	49	30
30	20	20	25
25	20	75	45
60		175	23
70		135	30
30		165	80

* BIOPART : L

45	20	40	25
118	30	108	35
120	25	50	25
60	60	80	10
120	35	58	10
130	40	60	25
170	40	107	30
30	20	100	45
75		145	23
115		280	30
30		235	80

TERMINALIA CHEBULA

* BIOPART : B

79.4	24	85	30
87	20	70	10
20	45	20	40
20	20	60	20
20		210	100

* BIOPART : F

20	20	215	20

* BIOPART : L

136	24	246	30
40	45	120	40
25	20	210	20
20		310	100

TERMINALIA CRENULATA

* BIOPART : B

20		25	35
107	65	25	25
155	25	246	10
200	20	87	15
100	20	70	15
220	50	46	25
93	50	55	35
20	20	20	50
20	50	20	45
20	20	25	25
20	20	70	30
20		50	30
20	-	25	13
55		170	21
			25
-			20
25		40	20
50		25	40
25	10	60	75
20	10	55	55
-	50	34	45

• **BIOPART : L**

25		85	30
180	65	127	25
67	25	35	10
79	20	21	15
107	20	325	15
73	50	110	25
80	50	35	35
20	20	155	50
20	20	70	25
20	20	70	30
40		140	30
25		70	13
70		180	21
			25
40		85	20
20		80	40
40	10	125	75
45	10	185	55
	50	100	45

VANGUERIA PUBESCENS

• **BIOPART : B**

200	25	23	10
20	30	80	35
110		285	60

• **BIOPART : L**

121	25	54	10
20	30	275	35

WENDLANDIA TINCTORIA

• **BIOPART : B**

60	20	100	10

• **BIOPART : L**

120	20	118	10

WOODFORDIA FRUTICOSA

* BIOPART : T

	30		45

* BIOPART : B

220	40	53	15
128	20	71	5
20	20	45	35
50		180	18
65		135	30
70		315	21
55		160	65
60		145	25
65		150	25
35		100	30
75	10	155	60
53	58	128	41

* BIOPART : L

250	40	49	15
87	20	55	5
20	20	145	35
80		235	18
70		215	30
50		65	21
135		215	65
105		190	25
70		190	25
405		140	30
35	10	165	60
21	58	327	41

* BIOPART : P

50	20	185	70

ZIZIPHUS MAURITIANA

* BIOPART : B

73	50	45	15
200	50	34	40
20	20	75	55

20		65	15
60		55	35
55		80	25
63	42	61	27

* BIOPART : L

180	50	27	15
40	50	110	40
20	20	100	55
29	42	57	27

B: Bark / Older twigs/Outer peelings; P:Total plant;

TABLE 22: NICKEL - COBALT CHROMIUM VARIATIONS IN SINGHBHUM

STATION	PLANT Ni	SOIL Ni	PLANT Co	SOIL Co	PLANT Cr	SOIL Cr
ACACIA TORTA						
* BIOPART : B						
1	61	155	100	25		
3	53	10	40	10		
4	20	15	44	10		
5	62	250	50	10		
7	60	130	20	85	20	20
8	25	35	20	30	20	20
* BIOPART : L						
1	141	155	182	25		
3	74	10	69	10		
4	84	15	100	10		
5	55	250	46	10		
6	67	330	39	40		
7	70	130	20	85	20	20
8	80	35	45	30	70	20
ADINA CORDIFOLIA						
* BIOPART : B						
-3	60	45	25	25	130	30
1	32	50	100	19		
11	20	130	20	50	20	110
19	20	310	20	70	20	975
3	53	15	44	10		
8	20	85	20	55	20	20
9	20	190	20	70	55	20
	11	60	-	50	21	
* BIOPART : L						
1	96	50	39	19		
11	40	145	20	55	20	120
3	64	15	100	10		
8	45	85	20	55	20	20
9	55	190	20	70	65	20

AEGLE MARMELOS

* BIOPART : B

6	250	245	43	45		
9	65	145	20	45	55	20
	93		37	-	48	

* BIOPART : L

6	80	245	35	45		

ARECA LANNATA

* BIOPART : B

4	26	65	32	50		

ANNONA SQUAMOSA

* BIOPART : B

15	20	145	20	50	20	195

ANOGEISSUS LATIFOLIA

* BIOPART : B

-1	20	600	20	104	20	400
-2	20	113	20	53	20	
-5	70	45	20	25	150	45
10	20	130	20	20	20	20
11	20	150	20	45	20	170
12	20	110	20	60	20	105
14	20	120	20	65	20	95
19	20	125	20	45	20	275
3	102	15	26	10		
5	36	270	118	40		-
5	30	244	13	40		
6	56	380	61	40		
7	20	115	20	90	20	20
8	20	85	20	55	20	20
9	20	120	20	55	20	20
T2	26		27		20	
T2	38		24		22	

• BIOPART : L

T2	98		24		25	
-1	175	600	20	104	20	400
10	40	130	20	20	20	20
11	30	150	20	45	20	170
12	25	110	20	60	20	105
14	30	120	20	65	20	95
19	130	125	20	45	30	275
3	63	15	43	10		
5	76	270	73	40		
5	79	244	50	40		
6	48	380	35	40		
9	45	120	20	55	70	20
T2	26		29		47	

ARTOCARPUS CHAPLASHA

• BIOPART : B

5	36	510	36	80

• BIOPART : L

5	150	510	46	80

BAUHINIA RETUSA

• BIOPART : B

3	50	15	33	10
6	62	260	52	30

• BIOPART : L

3	64	15	100	10		
6	69	260	52	30		-

BOMBAX CEIBA

• BIOPART : B

9	20	130	20	50	60	20
11	20	125	20	65	20	115

BOSWELLIA SERRATA

* BIOPART : B

6	87	370	39	45		

BREYNIA VITISIDAEA

* BIOPART : B

-2	60	62	60	41	150	
6	37	300	52	45		
9	25	75	20	40	20	20
T2	6		30		28	

* BIOPART : L

-2	30	62	20	41	60	
6	100	300	100	45		
9	60	75	20	40	45	20
T2	23		82		32	

BUCHANANIA LANZAN

* BIOPART : B

1	59	290	128	40		
-1	20	139	20	40	20	43
-1	20	50	40	19	20	
-6	20	45	20	25	20	45
-7	20	50	20	20	20	50
1	47	85	127	20		
11	20	155	20	45	20	195
12	65	115	20	45	20	80
13	20	130	20	50	20	105
2	50	65	60	10		
3	42		65			
4	36	15	155	15		
T2	14				25	
T2	44				18	

* BIOPART : L

1	42	290	224	40		
1	57	85	409	20		
-1	200	139	225	40	20	43
-1	150	50	250	19	20	

-6	55	45	40	25	20	45
-7	30	50	20	20	20	50
11	105	155	90	215	20	195
12	90	115	40	45	20	80
13	90	130	35	50	20	105
16	80	115	20	75	20	165
2	36	65	83	10		
3	68		128	-		
4	70	15	300	15		
T2	90		-			
T2	236		68			

BUTEA FRONDOSA

* BIOPART : B

-1		160		45		57
-3	55	45	20	25	100	35
10	35	195	20	40	45	20
15	20	160	20	40	20	160
16	110	125	20	70	20	170
19	60	125	20	45	30	275
6	109	320	109	40		
9	135	120	20	45	60	20

* BIOPART : L

-3	180	45	65	25	30	35
10	20	195	20	40	60	20
15	25	160	20	40	20	160
16	40	125	20	70	20	170
19	20	125	20	45	20	275
6	91	320	91	40		
9	20	120	20	45	20	20

BUTEA SUPERBA

* BIOPART : B

15	20	140	20	35	20	230

* BIOPART : L

15	20	140	20	35	20	230

CANTHIUM DICOCCUM

* BIOPART : B

-5	110	55	25	25	120	45

CAREYA ARBOREA

* BIOPART : B

2	76	35	46	10		-
3		50	-	10		-
T2	139				21	

* BIOPART : L

2	68	35	273	10		
3	70	50	26	10		-
6	85	180	46	40		
T2	76				18	

CARISSA PAUCINERVIA

* BIOPART : B

-7	20	65	20	35	20	45

* BIOPART : L

-7	20	65	20	35	20	45

CASEARIA ELLIPTICA

* BIOPART : B

9	20	145	20	55	50	20

* BIOPART : L

9	20	145	20	55	30	20

CASSIA FISTULA

* BIOPART : B

T2	24		29	-	33	
11	20	300	20	60	20	215

13	20	150	20	60	20	125
18	30	305	20	60	20	375
6	42	185	42	35		-
T2	19					

* BIOPART : L

T2	21		28		44	
13	35	150	20	60	25	125
18	25	305	20	60	25	375
6	84	185	100	35		
T2	40				33	

CASSINE GLAUCA

* BIOPART : B

T2	19		26		32	
T2	49		28		47	
-1	55	625	20	112	20	400
-8	80	145	20	25	20	250
11	20	130	20	70	20	115
18	20	245	20	70	20	320
2	36	70	100	10		
4	57	10	82	10		
6	87	190	43	45		

* BIOPART : L

T2	24		28		33	
-1	175	625	20	112	25	400
-8	135	145	20	25	20	250
11	20	130	20	70	20	115
2	57	70	43	10		
4	95	10	100	10		
6	100	190	26	45		
T2	73				18	

CELASTRUS PANICULATUS

* BIOPART : L

6	136	460	42	45		

CLEISTANTHUS COLLINUS

* BIOPART : B

-1	20	56	20	22	20	
-1	50	80	20	27	40	22
-2	85	62	75	41	190	
-3	100	25	35	20	140	30
-5	75	55	20	25	120	45
-7	35	50	20	30	20	35
-9	20	35	20	10	20	50
	163		24		47	
	23		27		32	
0	45	210	91	35		
1	36	55	23	10		-
10	25	155	20	25	45	20
11	20	235	20	30	20	20
13	25	165	20	55	20	145
14	20	135	20	55	20	75
19	20	120	20	50	50	285
2	32	50	100	10		
3	41	10	91	10		
4	24	50	35	45		
6	45	220	82	35		
8	50	80	20	45	20	20
9	20	185	20	70	60	20
	81				20	

* BIOPART : L

	45		33		36	
-3	115	25	35	20	100	30
-7	35	50	20	30	20	35
1	87	55	29	10		
10	20	155	20	25	45	20
11	30	235	20	30	20	20
13	20	165	20	55	20	145
19	35	120	20	50	20	285
2	68	50	64	10		
3	67	10	47	10		
4	390	50	100	45		
6	115	220	48	35		
6	62	385	43	50		
8	70	80	20	45	40	20
9	70	185	20	70	70	20
	191					

COCHLOSPERMUM RELIGIOSUM

*** BIOPART : B**

-5	80	45	25	25	120	45
7	20	70	20	40	20	20
8	20	55	20	45	20	20

COMRETUM DECANDRUM

*** BIOPART : B**

-3		46		22
5	68	285	48	45
6	98	380	173	40

*** BIOPART : L**

-3	-	46		32
3	134		35	
5	108	285	587	45
6	150	380	826	40

CORDIA MACLEODII

*** BIOPART : B**

13	20	120	20	50	20	100
9	20	155	20	30	55	20

*** BIOPART : L**

13	70	120	20	50	20	100
9	30	155	20	30	40	20

CROTON ROXBURGHII

*** BIOPART : B**

T2	62	-			22	
-1	50	75	20	27	20	22
-2	80	63	65	36	120	
10	20	160	20	25	40	20
3	100	25	32	10		
6	80	300	42	10		
9	25	180	20	65	50	20
	125	-			20	

* BIOPART : L

T2	34				11	
-1	40	75	20	27	20	22
-2	80	63	65	36	110	
1	38	40	31	10		-
10	20	160	20	25	30	20
3	109	25	44	10		-
6	114	300	73	10		
9	20	180	20	65	20	20
	83					

CYMBOPOGON MARTINII

* BIOPART : P

7	90	110	420	65	80	20

DALBERGIA SISSOO

* BIOPART : B

-2	90	80	85	40	150	-
6	33	155	26	30		

* BIOPART : L

-2	230	80	130	40	100	
6	54	155	26	30		

DILLENIA PENTAGYNA

* BIOPART : B

6	56	250	70	35		

DIOSPYROS MELANOXYLON

* BIOPART : B

-1	280	625	20	112	20	400
-1	65	80	20	27	20	22
-2	110	82	65	42	130	-
-3	60	46	65	22	150	
-4	140	30	55	25	150	35
-5	100	50	30	30	170	50
-6	70	60	35	30	130	70

-7	40	50	25	30	20	45
-8	20	45	20	10	20	50
1	50	50	109	10		
12	25	90	20	40	20	75
13	20	120	20	45	20	80
15	20	155	20	55	20	210
17	29	115	20	90	20	145
3	68	90	37	10		
3	79	10	109	10		
4	61	15	27	10		
5	40	175	26	40		
6	79	155	91	30		
9	20	160	20	25	45	20
	83					

• BIOPART : L

-1	80	625	20	112	20	400
-1	175	80	20	27	45	22
-2	155	82	105	42	120	
-3	240	65	55	22	140	
-4	70	30	20	25	120	35
-5	80	50	25	30	100	50
-6	55	60	20	30	120	70
-7	70	50	20	30	20	45
-8	35	45	20	10	20	50
1	104	50	39	10		
12	70	90	20	40	20	75
13	80	120	20	45	20	80
15	60	155	20	55	20	210
17	80	115	20	90	20	145
3	135	90	39	10		
3	46	10	26	10		
4	84	15	82	10		
5	225	175	39	40		
6	129	155	39	30		
9	20	160	20	25	55	20
	103					

DIOSPYROS MONTANA

• BIOPART : B

11	20	300	20	60	20	170
7	40	110	20	65	30	20
8	65	50	20	35	20	20

* BIOPART : L

11	60	300	20	60	20	10
7	135	110	20	65	175	20
8	60	50	20	35	20	20

EHRETIA ASPERA

* BIOPART B

-7	20	50	20	10	20	50

* BIOPART : L

-7	20	50	20	10	20	50

EMBLICA OFFICINALIS

* BIOPART : B

13	20	115	20	50	20	95

* BIOPART : F

13	50	115	20	50	20	95

ERIOLAENA HOOKERIANA

* BIOPART : B

6	50	370	39	55

* BIOPART : L

6	86	370	100	55

ERYTHRINA STRICTA

* BIOPART : B

8	20	90	20	65	20	20
9	20	160	20	70	20	20

* BIOPART : L

1	65	90	20	65	20	20

FICUS BENGHALENSIS

* BIOPART : B

-10	20	30	20	10	20	40
-8	20	45	20	10	20	20

* BIOPART : L

-8	50	45	20	10	20	20

FICUS SEMICORDATA

* BIOPART : B

3		30		10		
6	73	420	52	40		
8	20	35	20	25	20	20

* BIOPART : L

3		30		10		
6	112	420	26	40		
7	75	95	20	50	30	20

FLACOURTIA RAMONTCHI

* BIOPART : B

-2	85	80	110	40	150	
11	20	140	20	45	20	115
13	20	150	20	55	20	110
9	20	195	20	70	20	20
T2	-	-	12			

* BIOPART : L

T2	47		46			
-2	110	80	105	40	140	
11	25	140	20	45	20	115
9	50	195	20	70	65	20

FLACOURTIA SEPIARIA

* BIOPART : B

GARDENIA GUMMIFERA

* BIOPART : B

-1	20	56	20	22	20	
-3	50	20	20	20	90	15
-4	30	25	20	20	100	25
-5	80	50	30	25	120	50
-7	20	45	20	25	20	35
-8	20	85	20	15	20	100
-9	20	30	20	15	20	30

* BIOPART : F

-1	30	56	20	22	20	

* BIOPART : L

-1	30	56	20	22	20	
-3	65	20	20	20	130	15
-4	90	25	20	20	120	25
-5	105	50	25	25	120	25
-7	20	45	20	25	20	35
-8	20	85	20	15	20	100
-9	20	30	20	15	20	30

GARDENIA LATIFOLIA

* BIOPART : B

1	41	90	91	15		-
7	25	80	20	40	20	20
8	40	35	20	25	45	20

GREWIA TILIAEFOLIA

* BIOPART : B

-1	20	53	20	20	20	-
-2	165	105	60	50	130	-
10	35	150	20	25	20	20
6	70	290	39	55	20	20
8	50	85	20	55	20	20
	30		19			

* BIOPART : L

10	35	150	45	25	20	20
6	97	290	100	45		
	123		152		39	

HOLARRHENA ANTIDYSENTERICA

* BIOPART : B

T2	56		23		54	
T2	88		27		57	
-3	75	50	20	25	100	
-5	65	55	20	25	120	45
-7	20	50	20	15	20	50
-9	20	30	20	15	20	30
12	20	110	20	50	20	115
13	70	130	20	55	20	110
17	20	140	20	60	20	230

* BIOPART : F

T2	45		28		63	
T2	58		13		29	
13	20	130	20	55	20	110
16	40	125	20	70	20	170
17	40	140	20	60	20	230
18	35	265	20	65	130	375
T2	104					

HOLOPTELEA INTEGRIFOLIA

* BIOPART : B

15	20	155	20	45	20	260
19	20	310	20	70	20	975

* BIOPART : L

15	30	155	20	45	20	260
19	20	310	20	70	20	975

HYMENODICTYON EXCELSUM

* BIOPART : B

7	45	100	20	75	90	20
8	20	65	20	50	20	20

HYPTIS SUAVEOLENS

* BIOPART : P

-1	50	350	110	56	25	208
-1	20	56	70	25	20	
-5	95	55	20	25	100	45
0	75	120	136	30		
7	40	95	20	50	30	20

ICHNOCARPUS FRUTESCENS

* BIOPART : P

8	50	35	20	30	80	20

INDIGOFERA CASSIOIDES

* BIOPART : B

6	56	150	39	82		10

* BIOPART : L

3	73	10	50	10		
6	150	150	82	82		10

LAGERSTROEMIA PARVIFLORA

* BIOPART : B

	125				15	
-1	75	58	20	25	35	
12	65	125	20	45	20	90
6	57	300	100	45		
7	25	75	20	35	20	20
	234		37		39	

* BIOPART : L

	118				31	
-1	530	58	20	25	350	
12	45	125	20	45	20	90
6	115	300	42	45		
7	70	75	20	35	20	20
	240		32		30	

LANNEA COROMANDELICA

* BIOPART : B

-1	41	72	27	25	75	20-
-2	85	82	50	42	110	
-3	80	58	55	30	140	
-4	50	40	20	25	160	30
-5	60	45	20	30	120	45
-6	55	60	25	30	120	70
-7	20	65	20	30	20	40
11	20	300	20	60	20	170
12	20	120	20	60	20	120
7	20	70	20	35	20	20
T2	10					

LANTANA CAMARA

* BIOPART : B

-7	55	65	20	35	20	65
-9	20	35	20	10	20	50
15	20	125	20	55	20	175

* BIOPART : L

-9	40	35	20	10	20	50
	105				26	

* BIOPART : P

-3	70	55	20	35	80	45
-6	60	60	25	30	120	70
-8	20	40	20	15	20	60
17	60	148	20	60	25	230
18	35	265	20	65	60	375

LEUCAENA GLAUCA

* BIOPART : B

-1	65	57	20	20	25

LITCHI CHINENSIS

* BIOPART : B

2	40	70	4	10
4	68	40	17	50

* BIOPART : L

2	39	70	91	10		
4	60	40	26	50		

LITSEA POLYANTHA

* BIOPART : B

7	30	90	20	75	30	20

* BIOPART : L

7	65	90	20	75	95	20

MADHUCA INDICA

* BIOPART : B

10	35	145	20	25	60	20
19	20	140	20	60	20	245
3	32	15	26	10		
T2	49	102	28	48	47	Tr.

* BIOPART : L

T2	93	102	30	48	61	Tr.
10	70	145	20	25	20	20
17	30	100	20	70	20	135
19	40	140	20	60	20	245
3	36	15	39	10		

MILIUSA VELUTINA

* BIOPART : B

-2	48	110	51.7	54	90	
-2	70	110	100	54	160	
2	54	70	35	10		
7	20	110	20	65	20	20

* BIOPART : L

2	74	70	39	10		
7	130	110	20	65	20	20
T2	67				55	

MIMOSA HIMALAYANA

* BIOPART : B

-1	20	75	20	27	20	22
6	20	200	48	35		

* BIOPART : L

-1	125	75	20	27	75	22
6	135	200	52	35		

MITRAGYNA PARVIFOLIA

* BIOPART : B

-1	20	43	20	20	20	
-2	105	105	75	52	110	
-4	80	45	25	30	150	55
9	20	135	20	25	50	20
10	20	225	20	35	20	20
T2	51				56	

* BIOPART : L

T2	56				17	
-1	175	43	20	20	20	
-4	210	45	65	30	110	55
9	20	135	20	25	55	20
10	75	225	20	35	20	20
T2	109				33	

MORINDA PUBESCENS

* BIOPART : B

T2	16		21		40	
7	20	70	20	65	35	20
6	64	185	42	25		

* BIOPART : L

T2	78		27		48	
7	50	70	20	65	20	20
6	164	185	82	25		

NYCTANTHES ARBORTRISTIS

* BIOPART : B

-1	35	80	20	34	20	
-4	75	45	30	25	120	40
1	76	265	48	60		
1	43	60	91	15		
10	20	170	20	20	20	20
11	20	120	20	60	20	110
13	25	125	20	55	20	110
3	36	10	39	10		
4	53	10	37	10		
5	44	244	39	40		
6	35	284	27	45		
8	25	70	20	45	25	20
9	25	130	20	40	55	20

* BIOPART : L

1	66	265	100	60		
1	84	60	91	15		
3	39	10	26	10		
4	58	10	26	10		
6	66	284	73	45		
8	45	70	20	45	20	20
9	20	130	20	40	35	20

OUGEINIA OOJEINENSIS

* BIOPART : B

6	50	270	82	40

* BIOPART : L

6	68	270	64	40

PAVETTA CRASSIUSCULA

* BIOPART : B

1	36	270	35	30

* BIOPART : L

1	105	270	27	30
4	54	25	26	15

PAVETTA INDICA

* BIOPART : B

-3	670	50	85	35	150	30
-6	80	45	55	25	20	45
-7	115	50	65	30	20	40

* BIOPART : L

-3	2000	50	75	35	110	30
-6	360	45	355	25	20	45
-7	370	50	190	30	20	40

POLYALTHIA LONGIFOLIA

* BIOPART : B

3	31	45	26	15

* BIOPART : L

3	48	45	21	15

PTEROCARPUS MARSUPIUM

* BIOPART : B

-1	28	62	20	26	20	
-2	25	113	20	53	25	
14	20	125	20	65	20	65
3	28	20	48	10		
4	41	15	40	15		
5	109	175	127	50		

* BIOPART : L

14	70	125	20	65	40	65
3	86	20	91	10		
4	66	15	35	15		
5	250	175	52	50		

RANDIA DUMETORUM

* BIOPART : B

T2	36					
-1	25	160	20	45	20	57

-1	20	76	20	30	20	
-6	65	60	20	25	100	55
-7	20	50	20	30	20	40

SCHLEICHERA OLEOSA

* **BIOPART : B**

16	20	145	20	55	20	250
9	25	160	20	55	50	20

* **BIOPART : L**

16	20	145	20	55	20	250
9	65	160	20	55	50	20

SEMECARPUS ANACARDIUM

* **BIOPART : B**

-9	20	35	20	10	20	30
4	37	35	52	40		

* **BIOPART : L**

-9	20	35	20	10	20	30
6	36	390	21	55		

SHOREA ROBUSTA

* **BIOPART : B**

1	93	200	87	35		
7	40	65	20	35	45	20
-1	200	80	20	27	55	22
-2	215	62	55	41	140	
-3	165	40	35	25	130	35
-4	90	40	25	25	80	30
-5	75	45	40	25	150	45
-7	20	75	20	40	20	55
-8	55	75	20	15	20	120
1	114	190	100	35		
1	85	120	65	15		
11	55	310	20	60	20	155
13	75	160	20	60	20	110
14	95	295	20	90	20	[illegible]

16	60	140	20	70	30	235
19	160	105	20	40	90	240
2	50	45	91	10		
3	102	10	100	10		
3	71	30	43	10		
4	67	15	27	15		
5	138	320	60	45		
6	62	135	52	30		
6	264	420	136	60		

* BIOPART : L

7	70	65	20	35	40	20
-1	290	139	20	45	20	45
-1	175	80	20	27	25	22
-2	145	62	105	41	110	
-3	260	40	65	25	120	35
-4	115	40	55	25	160	30
-5	105	45	55	25	100	45
-7	100	75	20	40	20	55
-8	135	75	20	15	20	120
1	183	200	56	35		-
1	211	120	112	15		
11	115	310	20	60	10	155
13	140	160	20	60	20	110
14	110	295	20	90	20	210
16	195	140	20	70	220	235
19	220	105	20	40	60	240
2	89	45	100	10		
3	162	30	61	10		
3	62	10	30	10		
4	68	15	81	15		
5	165	320	63	45		
6	208	135	43	30		
6	272	420	56	60		

SMILAX OVALIFOLIA

* BIOPART : B

11	45	125	20	65	20	110
4	45	125	26	45		
T2	109		17		11	

* BIOPART : L

T2	340		22			
-3	205	30	75	25	110	45

4	66	125	100	45	-	-
6	36	270	100	30		

SOYMIDA FEBRIFUGA

* BIOPART : B

4	54	75	22	45		

* BIOPART : L

4	64	75	30	45		

STERCULIA URENS

* BIOPART : B

-2	25	113	20	53	20	
8	20	90	20	65	20	20
T2	23	137	29	36	45	Tr.

* BIOPART : L

-2	30	113	20	53	60	-
8	65	90	20	65	20	20
T2	68	137	81	36	53	Tr.

SYZYGIUM CUMINI

* BIOPART : B

1	59	365	43	60		
1	170	250	43	80		
2	57	90	100	10		
5	70	530	82	75		
6	80	215	54	30		
-2	60	50	35	26	110	
-3	75	30	25	25	100	45
-7	40	45	20	25	20	35
14	20	120	20	65	20	60
19	20	310	20	70	20	975
3	59	35	35	10		
4	53	50	50	45		

* BIOPART : L

1	224	365	132	60		
1	77	250	183	80		

2	87	90	56	10		
5	250	530	109	75		
6	170	215	73	30		
-2	55	50	65	26	110	
-3	150	30	45	25	120	45
-7	50	45	20	25	20	35
14	40	120	20	65	20	60
19	95	310	20	70	20	975
3	266	35	73	10		

TERMINALIA CHEBULA

*** BIOPART : B**

-8	20	145	20	25	20	250
11	20	145	20	55	20	120
4	30	55	22	40		
9	20	195	20	70	60	20
T2	36	290	100	40		

*** BIOPART : F**

11	50	145	20	55	20	120

*** BIOPART : L**

T2	111	250	38	40		
-8	20	145	20	25	20	250
11	35	145	20	55	20	120
9	65	195	20	70	65	20

TERMINALIA CRENULATA

*** BIOPART : B**

-1	20	600	20	104	20	400
-1	20	58	20	27	20	
-3	55	46	55	22	150	
-6	20	45	20	25	20	45
-7	20	65	20	35	20	65
-8	20	85	20	15	20	100
-9	20	40	20	10	20	30
10	20	225	20	45	55	20
13	20	130	20	55	20	110
14	20	120	20	60	20	70
2	44	60	44	10		
3	30	20	32	10		

4	43	150	82	50	-	-
5	46	320	43	50		
5	64	370	101	80		
6	30	590	39	80		-
8	20	50	20	40	20	20
12	20	120	20	65	20	125

* BIOPART : L

-1	165	600	20	104	20	400
-1	40	58	20	27	20	
-3	130	46	55	22	100	
-6	25	45	20	25	20	45
-7	20	65	20	35	20	65
-8	40	85	20	15	20	100
-9	20	40	20	10	20	30
12	20	120	20	65	20	125
13	20	130	20	55	20	110
14	20	120	20	60	20	70
2	52	60	73	10		
3	50	20	52	10		
4	167	150	44	50		
5	162	370	52	88		
5	40	320	78	50		
6	120	590	39	80		
8	55	50	20	40	40	20

VANGUERIA PUBESCENS

* BIOPART : B

-7	20	50	20	30	20	35
6	34	265	73	35		
9	20	155	20	50	50	20

* BIOPART : L

6	48	265	42	35		
9	50	155	20	50	50	20

WENDLANDIA TINCTORIA

* BIOPART : B

4	30	65	52	60

* BIOPART : L

4	68	65	100	60		

WOODFORDIA FRUTICOSA

* BIOPART : B

-1	30	83	20	40	20	38
-2	55	105	175	50	150	
-3	220	50	25	25	110	
-4	70	40	20	25	120	30
-5	60	50	20	25	130	50
-6	75	60	25	30	100	70
-7	30	50	20	30	20	45
-8	20	40	20	15	20	60
1	34	200	26	25		
T2	32	292	23	98	23	Tr.
19	20	75	20	40	20	105
4	71	15	69	10		

* BIOPART : L

-1	340	83	50	40	165	38
-2	160	105	165	50	160	
-3	60	50	25	25	130	
-4	55	40	20	25	120	30
-5	105	50	55	25	100	50
-6	35	60	35	30	20	70
-7	50	50	20	30	20	45
-8	30	40	20	15	20	60
1	93	200	52	25		
19	40	75	20	40	20	105
4	136	15	61	10		
T2	134	292	24	98		

* BIOPART : P

-9	20	30	20	15	20	30

ZIZIPHUS MAURITIANA

* BIOPART : B

-1	20	58	20	27	20	22
-4	75	35	30	20	120	25
-6	20	45	20	25	20	45

1	38	65	26	10		
6	89	570	82	80		
8	80	70	20	40	35	20

* BIOPART : L

1	136	65	91	10		
6	210	570	39	80		
8	105	70	20	40	20	20
	39	39				

B : Bark or Outer peelings
L: Leaves
P : Entire Plant
F: Flowers

SUMMARY

The present publication concerns to a research programme jointly undertaken by Botanical survey of India and Geological Survey of India, titled "Geobotanical and Biogeochemical investigations of Singhbhum copper belt, District Singhbhum, Bihar". The programme was mainly targeted to identify indicator species, fluctuations in community structure along mineralization and also morphological aberrations exhibited by some plants in response to stress conditions by the presence of excessive base metal concentrations in the substratum. The studies were conducted at three levels to achieve this objective. Firstly, the team recognized some sampling belts which consisted of both mineralized and barren zones between Dhobani and Jaduguda to have a complete understanding of geobotanical expressions/changes with varying metal gradient.

The traverses namely Sidhesar, Tamapahar and Dhobani (of 4, 2 and 1 line kilometers respectively) constituting 7 line kilometers were analyzed for the above aspects. Each of these sampling belts was divided into stations/sites and each site/station is of 100 meters length and 20 meters width encompassing an area of 2000 square meters. Plant collections in these areas were dominated by families of Acanthaceae, Labiatae and Fabaceae. The species namely *Hemigraphis latebrosa, Daedalocanthus purpurascens, Justicia diffusa, Rungia repens, Leucas cephalotes, Andrographis paniculata, Nelsonia campestris, Elsholtzia blanda, Ocimum canum, Anisomeles ovata, Leonotis nepetaefolia, Anisochilus cornosus, Hyptis suaveolens, Crotalaria acicularis, C. albida, C. striata, Alysicarpus vaginalis, Abrus precatorius, Erythrina stricta, Desmodium latifolium* and *Smithia sensitiva* are common in these belts and some represent in good densities. These studies revealed that different species responded in diverse ways in terms of distribution pattern along the mineralization. Among the trees, *Diospyros melanoxylon, Shorea robusta, Madhuca indica, Syzygium cumini, Terminalia crenulata, T. chebula, Lannea coromandelica, Anogeissus latifolia, Combretum decandrum,* and *Chocolospermum religiosum* appeared in considerable numbers.

In Sidhesar, studies on plant distribution in relation to copper mineralization indicated that in the heart of mineralized zone, *Hyptis suaveolens* or *Croton roxburghii* dominated. In areas under moderate levels of copper the dominant species were not uniform and some of the stretches were taken control by *Hyptis suaveolens* or *Croton roxburghii* while others had shown *Cymbopogon martini* and the tree species like *Anogeissus latifolia, Shorea robusta* or *Diospyros melanoxylon* in considerable numbers. In contrast, the sampling zone containing low levels of copper (200 ppm and less) was crowded by *Evolvulus*

alsinoides in the ground layer while shrubs namely *Lantana camara* and *Woodfordia fruticosa* occurred in greater numbers in the upper layers. Both species diversity and plant richness (Total number of all the species) were recorded highest in the zones containing moderate levels of copper. The sampling belt is of 1 line kilometer length in Tamapahar. In the mineralized zone (sites 2 to 5 and 8) *Hyptis suaveolens* or *Cleistanthus collinus* or it's combination dominated. Above 500 ppm, the influence of the former was more evident with relative density (RD) values reaching up to 0.53 at 1860 ppm of soil copper. However, this rise in the values of RD was not linear and sometimes there was a fall in this value which was made up by another species namely *Cleistanthus collinus*, thus the communities dominated by the above two species represented areas of high soil copper values. In areas of barren/partially mineralized zones, *Andrographis paniculata, Lantana camara* and *Evolvulus alsinoides* took control in the total community structure. With few exceptions, the general trend revealed that the species diversity and total plant richness were relatively more in mineralized sites compared to barren zones.

In Dhobani traverse, mineralized area was between sites 4 and 8 stretching 500 meters in total length. Mean soil copper value in these sites varied from 579.7 ppm at site 8 and 4959.0 ppm at site 7. *Hyptis suaveolens* dominated all these sites with an exception at site 7 where *Justicia diffusa* occurred more abundantly. Like Tamapahar, very clear domination of *Hyptis suaveolens* was observed with high figures of relative density fluctuating from 0.30 to 0.64 for this species. The barren sites of this traverse harbored *Evolvulus alsinoides, Blumea oxyodonta, Coldenium procumbens* and *Polygonum plebejum*. Species diversity and the plant richness were recorded maximum in barren zone compared to mineralized zone. Thus, in all the three traverses, there is a commonality of *Hyptis suaveolens* dominating mineralized zones along with *Cleistanthus collinus* or *Croton roxburghii* or *Justicia diffusa*. An attempt was made to know the fluctuations of population strengths of each species against soil log copper values. Species like *Croton roxburghii* exhibited a single peak close to the value of 3.7 soil log copper. Below this value and beyond it, this species registered lower numbers. Similar to *Croton roxburghii, Cleistanthus collinus* exhibited a single peak but at log copper values between 3.5 and 4. The populations of *Hyptis suaveolens* exhibited two peaks, one at 3 and the other between 3.5 and 4. These plottings indicated the copper tolerance levels of different species. This orientation survey inferred that species combination in a particular station was primarily influenced by copper level and highly mineralized stations harbored high copper tolerant plants like *Hyptis suaveolens* and *Croton roxburghii*. While moderately copper rich stations supported a combination of high copper tolerants in reduced densities along with moderately copper tolerant species. This was more explicit in the graphs between soil log copper values and plant totals (population strengths).

Studies were conducted in minepit areas and old workings like Badia, Banalapa, Mosabani, Dhobani, Netra, Laukesra, Rakha, Tamapahar, Ramachndrapahar, Tirioburu, Chakri, Bhatin, Rajdih and Narwapahar. The association of *Justicia diffusa* and *Vernonia cinerea* was recorded without exception in all these sites. This association was compounded by *Nelsonia campestris* and *Cassia alata* in Badia, Surda south and north mines while at Laukcsara and Pathargora, the occurrence of *Polycarpea corymbosa* was also observed. The important shrubs of these mine pits were *Hyptis suaveolens, Cleistanthus collinus, Croton roxburghii, Holarrhena antidysenterica* and *Combretum decandrum.* Among trees *Diospyros melanoxylon, Shorea robusta, Butea frondosa* occurred in good numbers. The dominance of *Mimosa himalayana* and *Acacia torta* was restricted in the old workings of Sidhesar. The Surda south, the plants occurred include *Annona squamosa, Butea frondosa, Cleistanthus collinus* and *Syzygium cumini.* In Pathargora close to apatite mineralization, *Polygonum lapatheifolium* profusely grows.

As a third step in the investigation, three tests transects (C1, C2 and C3) were examined to evaluate the role of observed botanical expression obtained in orientation study in the reflections of copper mineralization. These test transects displayed a good concentration of copper, chromium and manganese in locations where again a congregation of *Hyptis suaveolens* and *Cleistanthus collinus* in good densities recorded.

The second section involved biogeochemical investigations and this is complementary to geobotanical studies. These studies involved evaluating copper levels in some important plants against soil copper gradient. Forty eight plant species and a total of 528 plant samples were examined for their relationship with soil copper level in Sidhesar. A total of 24 plant species and 50 plant samples were studied in Tamapahar traverse. Of all the least, only 10 plant samples were analyzed in Dhobani. Relatively more soil samples were analyzed in all the three traverses, 451 samples from Sidhesar, 164 from Tamapahar and 105 from Dhobani. In test transects, a total of 108 soil samples were analyzed for different base metals. The elements analyzed were copper, lead, zinc, nickel, cobalt, chromium and manganese. The data presented connected to differences in the elemental concentration in different bioparts, its variation, tolerance level of a species and correlations if any with substrate copper level. The data were expressed on ash weight basis for plant samples and on dry weight basis for soil samples. Some salient findings were summarized below:

Majority of the species showed percentage ash content around 10(on dry wt. basis). In leaf parts, highest percentage ash was recorded in *Terminalia crenulata* (14.96) followed by *Morinda pubescens*

(13.84%). In stem parts, highest value was recorded in *Combretum decandrum* (14.22%) followed by *Miliusa velutina* (12.68%).

In Sidhesar, there was great variability in copper level among different species. Even in the same species, different bioparts showed variation in copper content. Twenty dominant species in the study area were selected for statistical treatment. Students 't' values estimated for *Adina cordifolia, Anogeissus latifolia, Cleistanthus collinus, Croton roxburghii, Diospyros melanoxylon, Gardenia gummifera, Lagerstroemia parviflora* and *Terminalia crenulata* had shown significant differences in copper level between leaf and bark samples.

In many cases leaf or younger stem parts apparently concentrate more of the element compared to older stems or bark samples. However, these differences were marginal in case of *Semecarpus anacardium* and *Sterculia urens.* There are few exceptions to this observation and these included *Croton roxburghii, Ehretia aspera, Pavetta crassiuscula, P. indica, Polyalthia longifolia* and *Nyctanthes arbortristis.* In these cases, copper level was recorded higher in older twigs compared to leaf samples.

Inferences were drawn on variability of copper level including maximum, minimum, median and mean in all the 20 species.

These species can be categorized into three groups basing on mean copper values in their bioparts compared to soil copper level. The first group exhibited lower mean copper values in their bioparts compared to soil copper level. The second group displayed lower mean values in their bark and higher values in leaf in relation to soil copper. While some others had shown high copper both in leaf and bark samples relative to soil copper values.

Significant positive correlations were observed between soil copper and that of plant bioparts in *Nyctanthes arbortristis, Shorea robusta, Syzygium cumini* and *Terminalia crenulata.* Such relationships were restricted to leaf parts in *Cassine glauca* and *Gardenia gummifera* and older twigs/bark samples in *Croton roxburghii* and *Mitragyna parvifolia.* Though all the 20 species dominated the entire mineralized zone, only the stated species reflected the proportional positive relationship. While others remain indifferent to substrate copper level.

A scrutiny of copper in plant bioparts revealed that copper concentration was recorded to a maximum value of 7099 ppm in bark samples and 1631 ppm in leaf samples of *Shorea robusta,* the figures were 1111 ppm in bark samples and 1234 ppm in leaf samples of *Syzygium cumini.* In addition, *Dalbergia sissoo* (1150 ppm in leaf samples), *Grewia tiliaefolia* (900 ppm in bark samples), *Indigofera cassioides* (950 ppm in leaf samples), *Lagerstroemia parviflora* (1700 ppm in leaf) and *Smilax ovalifolia* (both in twigs and leaf samples, 1000 ppm and 1600 ppm respectively) exhibited occasional high values. In Singhbhum belt, none of the plants can be graded as accumulators or hyperacumulators as the copper levels were always less than 1000 ppm on dry weight basis.

Relative accumulation figures for majority of plants were below 1. This was partially due to reduction in copper concentration in plants after attaining a limiting value in soil. Highest figures were recorded for *Carissa paucinervia* (7.0) and *Canthium dicoccum* (4.9). It is worth noting at this point that more common species in mine dumps or mineralized zones namely *Hyptis suaveolens* (RA 0.74), *Croton roxburghii* (RA 0.34), *Holarrhena antidysenterica* (RA 0.50) and *Cleistanthus collinus* (RA 0.68 and 0.22 for leaves and twigs respectively) showed lower values of relative accumulation.

The limiting copper uptake was recorded in *Buchanania lanzan, Gardenia gummifera,* and *Terminalia chebula* for leaf samples; *Pterocarpus marsupium,* and *Terminalia crenulata* for bark samples and in *Anogeissus latifolia* and *Cassine glauca* for both leaf and bark samples.

Specific Indicator value (SIV): In the present investigation, majority of the species exhibited SIV's less than 4. However, it is difficult to regard all these species as potentially good indicators due to less number of soil samples analyzed for many species. The soil samples analyzed for *Anogeissus latifolia, Buchanania lanzan,* and *Diospyros melanoxylon* were in good numbers and these species showed SIV's lower than four. Species like *Hyptis suaveolens, Holarrhena antidysenterica* and *Croton roxburghii* which are proven indicators geobotanically also exhibit low figures of SIV.

Cooper-Zinc ratio: All the plant species of Singhbhum belt showed Cu / Zn ratio higher than 0.10 indicating that this area is predominantly copper bearing.

Estimations were made with regard to other metals and a generalization of elemental levels could be drawn basing on observations in dominant plants as follows:

$$Cu > Zn > Ni >< Pb \geq Co > Cr$$

Zinc: Zinc values in plant species revealed that some species showed occasional high values. These plants do not have any indicational significance as they do not reflect soil zinc levels. These high values ranged between 650 ppm and 1700 ppm in different species. Much higher values of zinc were reported for some species growing in Zawar mines.

Lead: Highest mean values for lead were recorded in the leaf samples of *Casearia elliptica* (390.0) and in the bark samples of *Soymida febrifuga* (260.0 ppm). Some occasional high values were exhibited by leaf samples of *Smilax ovalifolia* and twigs of *Cleistanthus collinus* (300.0 ppm each). These values had no relationship with soil lead concentrations.

Nickel: Nickel values were moderate and *Pavetta indica* exhibited the highest mean value of 288.3 ppm in twigs and 910 ppm in leaf samples. *Combretum decandrum* and *Miliusa velutina* which are nickel accumulators in Sukinda valley of Orissa were found to contain not more than 130 ppm of mean value in their bioparts in Sidhesar belt.

Cobalt: Majority species of Sidhesar belt rarely exhibited cobalt concentration above 200 ppm. Exceptional high values for cobalt were recorded in *Buchanania lanzan,* (409 ppm in leaf samples) *Careya arborea* (273 ppm in leaf samples) and *Combretum decandrum* (826 ppm in leaf parts). But these values were lower than the figures obtained for plant samples from Shabah copper Arc in Zaire.

Chromium: Chromium values were below 20 ppm in a majority of species and in few instances the figures had gone up to 350 ppm in the leaf samples of *Lagerstroemia parviflora* and 170 ppm in the bark of samples of *Diospyros melanoxylon.* These values were much less in comparison to the reports obtained for *Sutera fodina, Pearsonia metallifera* and *Dicoma niccolifera* from Zimbabwe.

Accumulators: The term accumulator is defined as a species whose mean content of a particular element (expressed on ash weight basis) is greater than the content of the same element in the fine earth fractions of the substrate. As per this definition many of the plants of the Singhbhum belt can be considered as accumulators. However, a revised definition by Brooks (1977) indicated that any value 1000 ppm on dry weight basis for copper, nickel and lead refers to hyperaccumulators, for zinc the corresponding figure is 10000 ppm. As per this classification, none can be graded as accumulators or hyperaccumulators in singhbhum belt.

This investigation is able to recognize the consistency in the dominance of some shrubs in the mineralized areas. It is significant at this juncture to note that active mining is going in 10 km only out of total 250 Km of Singhbhum mineral belt. The mapping of the above said species in the entire belt would form a potential support in the location of new ore zones. The copper concentrations in some species showed significant positive relation with soil copper and can provide supplementary evidence for mineralization. Besides, the plants identified for the accumulation of different elements may be used in revegetating the deserted mining areas.

REFERENCES

Aery,N.C., 1977 Studies on the Geobotany of Zawar Mines, *Geobios*, vol. 4, pp 225-228.

________ and Tiagi,Y.D., 1985 Biogeochemical studies of the zinc deposit areas in the environs of Udaipur: on cadmium the pathfinder for Zinc. *Jour. Ind. Bot. Soc.*, vol. 64, pp 148- 155.

________, 1986 Bioindicators and accumulators in geobotanical and biogeochemical prospecting of metals. *Acta Biologica Hungarica*, vol. 37, pp 67-78.

________, 1981 Biogeochemistry of lead at Zawar mines, Udaipur (India). *Sci. Dev. and Environ.*, pp 117-129.

Anderson,R.Y. and Kurtz Jr. E.B., 1955 Biogeochemical reconnaissance of the Annie Laurie uranium prospect, Santa Cruz County, Arizona. *Econ. Geol.*, vol. 50, pp 227-232.

Antonovics,J. and Turner,B.R.G., 1971 Heavy metal tolerance in plants. *Adv. Ecol. Res.*, vol. 7, pp 1-85.

Baker, J.M. and Brooks, R.R., 1988 Botanical exploration for minerals in humid tropics. *Jour. Biogeography,* Vol. 15, pp 221 229.

Beath,O.A., Eppson,H.F. and Gilbert,C.S., 1935 Selenium and other toxic minerals in soils and vegetation. *Wyoming Agric. Exp. Sta. Bull.*, vol. 206, pp 55.

Beath,O.A., Gilbert,C.S. and Eppson,H.F., 1939a The use of indicator plants in locating seleniferous areas in Western USA. I General: *Am. Jour. Botany,* vol. 26, pp 257-269.

________, 1939b The use of indicator plants in locating seleniferous areas in Western USA. **II** *Correlation: Am. Jour. Botany,* Vol. 26, pp 269-315.

Berry,W.L., 1971 The nutrient status of zinc in Lettuce evaluated by plant analysis. *J. Am. Soc. Hort. Sci.*, vol. 96, pp 412-414.

Berry,W.L. and Ulrich,A., 1979 Interactions of environmental factors. **In** Controlled environment: Guidelines for plant research edited by Tibbitts, T.W., Univ. of Wisconsin, *Madison, Wis.*, pp 369-379.

Bhaumik,N., 1978 Geobotany in non-ferrous metal exploration in India. *Ind. Miner.*, vol.32, pp 76-81.

Brooks,R.R.,1972 Geobotany and biogeochemistry in mineral exploration. *Harper and Row Publishers,* New York, 290p.

________, 1977 Copper and Cobalt uptake by *Haumaniastrum* sp. *Plant Soil* vol.48, pp 541-545.

________, 1979 Indicator plants for mineral **prospecting - a critique**. *Jour. Geochem. Explo.*, vol. 12, pp 67-78.

________, 1983 *Biological methods of prospecting for minerals.* Wiley, New York, 460 p

________, 1987 *Serpentine and its vegetation, a multidisciplinary approach. Groom Helm. London.* 444p.

Brooks,R.R., Lee,J. and Jaffre,T., 1974 Some New Zealand and New Caledonian plant accumulators of nickel. *Jour. Ecol.*, vol. 62, pp 523-529.

Brooks,R.R., Lee,J., Reeves,R.D. and Jaffre,T., 1977 Detection of nickeliferous rocks by analysis of herbarium specimens of indicator plants. *Jour. Geochem. Explor.*, vol. 7, pp 49- 57.

Brooks,R.R. and Radford,C.C., 1978 An evaluation of background and anomalous copper and zinc concentrations in the copper plant *"Polycarpaea spirostylis"* and other Australian species of the genus. *Proc. Australas. Inst. Min. Metall.*, vol. 268, pp 33-37.

Brooks,R.R., Reeves,R.D., Morrison,R.S. and Malaisse,F., 1980 Hyperaccumulation of copper and cobalt-review. *Bull., Soc. Royal. Bot. Belg.*, vol. 113, pp 166-172.

Brooks,R.R., Morrison,R.S., Reeves,R.D., Dudley,T.R. and Akman,Y., 1979a Hyperaccumulation of nickel by *Alyssum* L., *Proc. Royal Soc. Lond. Sect B*, vol.203, pp 287-403.

Brooks,R.R., Trow,J.M. and Bolviken,B. 1979b Biogeochemical anomalies in Fennosccandia: A study of copper, lead and nickel levels in *Melandrium dioicum* and *Viscaria alpina. Jour. Geochem. Explor.* vol. 11, pp 73-87.

Brooks,R.R., Wither,E.D. and Westra,L.Y., 1978 Biogeochemical copper anomalies in Salajar Island. *Jour. Geochem. Explor.* vol. 10, pp 181-188.

Brundin,N., 1939 Method of locating metals and minerals in the ground: U.S. Pat 2158980.

Busche, F.D., 1989 Using plants as an exploration tool for gold. *Jour. Geochem. Expl.,* Vol. 32, pp 199 - 209.

Cannon,H.L., 1952 The effect of uranium -vanadium deposits on the vegetation of the Colorado Plateau. *Am. Jour. Sci.*, vol. 250, pp 735-770.

________, 1955 Geochemical relations of zinc bearing peat to the Lockport dolomite, Orleans County, New York. *U.S. Geol. Survey Bull.* 1000-D pp 119-185.

________, 1957 Description of indicator plants and methods of botanical prospecting for uranium deposits on the Colorado Plateau. *U.S. Geol. survey Bull.* 1030 M: pp 399-516.

________, 1960a The development of botanical methods of prospecting for uranium on the Colorado Plateau. *U.S. Geol. Survey Bull.,* A1085, pp 1-50.

________, 1960b Botanical prospecting for ore deposits. ***Science,*** vol. 132, pp 591-598.

__________, 1964 Geochemistry of rocks and related soils and vegetation in the Yellow Cat area, grand County, Utah. *U.S.Geol.Survey Bull.,* vol. 1176, pp 1-127.

__________, 1971 Use of plant indicators in ground water surveys, geologic mapping and mineral prospecting. *Taxon,* vol. 20, pp 227-256.

Chaffee,M.A. and Gale,C.W., 1976 The California poppy (*Eschsholtzia mexicana*) as a copper indicator plant a new example. *Jour. Geochem. Explor.,* vol. 5, pp 59-63.

Chapman,H.D., 1966 *Diagnostic criteria for plants and soils.* University of California, Division of Agricultural Science, Riverside, California. 793p.

Chenery,E.M., 1948 Aluminium in the plant world. *Kew Bull.,* vol. 2, pp 173-183.

Cole,M.M., 1971 The importance of environment in biogeographical/geobotanical and biogeochemical investigations. *Can. Inst. Min. Metall. Spec.,* vol. 11, pp 414-425.

________, 1973 Geobotanical and biogeochemical investigations in the sclerophyllous woodland and shrub associations of the Eastern Goldfields area of western Australia, with particular reference to the role of *Hybanthus floribunda* as a nickel indicator and accumulator plant. *Jour. Appl. Ecol., vol 10, pp 269-320.*

_________, 1980 Geobotanical expressions of ore bodies. *Proc. 6th Ann. Pecora Symp. Rem. Sens. Environ. Siox. Falls..*

Cole,M.M., Provan,D.M. and Tooms,J.S., 1968 Geobotany, Biogeochemistry and geochemistry in the Bulman Waimuna Springs area, Northern Territory, Australia. *Inst. Mining metall. Trans. Sec B,* pp B74-B91.

Corsel,R.L. and Taylor,R.G., 1974 Occurrence of *Polycarpaea spirostylis* at Daisy Bell copper mine, Emuford, North Queenland, Australia. *Trans. Inst. Min. Metall. Sect.B.,* vol. 83, pp 30-34.

_________,1975 A geochemical-geobotanical study of the Siberia tin-copper lode in the Emuford district of the Hemberton tin field, North Queenland, Australia. *Proc. Australas. Inst. Min. Metall.* vol. 255, pp 7-13.

Donald Carlisle, D.,1986 Mineral exploration: biological systems and organic matter.(edited) New Jersey : Prentice Hall, 465p.

Dunn, C.E. and Seagel, R.K., 1989 Tree top sampling from a helicopter a new approach to gold exploration. *Jour. Geochemical exploration,* Vol. 34, pp 255 270.

Duvigneaud,P., 1959 Plant cobaltophytes in upper Katanga (in French) *Bull. Soc. Royal. Bot. Belg.,* vol. 91, pp 111- 134.

Duvigneaud,P. and Denayer De Smet,S., 1963 Copper and vegetation in Katanga (in French). *Bull. Soc.*

Royal. Bot. Belg., vol. 96, pp 93-231.

Ernst,W., 1967 Bibliography on work on heavy metal plant communities with the exception of Serpentine (in German). *Excerpt. Bot. Sec.- B* vol. 8, pp 50-61.

Gandhi,S.M. and Aswathanarayana,U., 1975 A possible base-metal indicator plant from Mamandur, South India. *Jour. Geochem. Explo.*, vol. 4, pp 247-250.

Goodman,G.T. and Roberts,M.T., 1971 Plants and soils as indicators of metals in the air. *Nature*, vol. 231, pp 287- 292.

Hodgson,J.F., 1961 Chemistry of micronutrient elements in soil. *Adv. Agron.*, vol. 15, pp 119-159.

Howard-Williams,C., 1970 The ecology of *Bacium homblei* in Central Africa with special reference to metalliferous soils. *Jour. Ecol.*, vol. 58, pp 745-763.

Hussain, A., 1990 Biological Plant colonisation on laterite waste dumps of bauxite mines a case study *J. Mine metal Fuel* 38(2): 391 395.

Jacobsen,W.B.G., 1967 The influence of copper content of the soil on the trees and shrubs of Molly South Hill, Mangula. *Kirkia*, vol. 6, pp 63-83.

__________,1968 The influence of copper content of the soil on vegetation at Silver-side North, Mangula. *Kirkia*, vol. 6, pp 259-271.

__________,1969 Further notes on the vegetation of copper bearing soils at Silver-side. *Kirkia*, vol. 7, pp 285-290.

Jaffre,T., Brooks,R.R., Lee,J. and Reeves,R.D., 1976 *Sebertia acuminata*, a nickel accumulating plant from New Caledonia. *Science*, vol. 193, pp 579-580.

Karunakaran,C., Murthy,J.G.K. and Bandyopadhyay,S., 1969a Geobotanical and biogeochemical prospecting for basemetals in parts of Purulia, Bankura and Midnapore districts, West Bengal. *Geol. Surve. Ind., Misc. Pub.*, No. 17. p 41.

Karunakaran,C., Kurien,T.K., Das Gupta,S. and Sinha Roy,S., 1969 Some aspects of geochemical prospecting for copper in parts of North-Eastern Himalaya. *Geol. Surve. Ind., Misc. Pub.*, No. 17, p 103.

Lee,J., Brooks,R.R., Reeves,R.D. and Jaffre,T., 1977a Chromium accumulating Bryophytes from New Caledonia. *Bryologist*, vol. 80, pp 203-205.

Lee,J. Reeves,R.D., Brooks,R.R. and Jaffre,T., 1977b Isolation and identification of a citrato-complex of nickel from nickel accumulating plants. *Phytochemistry*, vol. 16, pp 1503-1505.

Lindsay,W.L., 1979 *Chemical equilibria in soils.* Wiley Interscience., New York.

Loneragan,J.F., 1975 The availability and absorption of trace elements in soil-plant systems and their relation to movement and concentrations of trace elements in plants.In *Trace elements in soil-plant-animal systems* (edtd. by Nicholas,D.J.. and Egan,A.R.) Academic Press, New York.

Lovering,T.S., Huff,L.C. and Almond,H., 1950 Dispersion of copper from the San Manuel copper deposit, Pinal County, Arizona *Econ. Geol.*, vol. 45, pp 493-514.

Lyon,G.L. and Brooks,R.R., 1969 The trace element content of *Olearia rani* and its application to biogeochemical prospecting. *New Zealand Jour. Sci.*, vol. 12, pp 200-206.

Lyon,G.L., Peterson,P.J., Brooks,R.R. and Butler,G.W., 1971 Calcium, magnesium and trace elements in a New Zealand Serpentine flora. *Jour. Ecol.*, vol. 59, pp 421--429.

McCray,C.W.R. and Hurwood,I.S., 1963 Selenium in Northwestern Qeensland associated with a main Cretaceous Formation. *Qeensland Jour. Agri.Sci.*, vol. 20, pp 475-498.

Malaisse,F., Gregotre,J., Brooks,R.R., Morrison,R.S. and Reeves,R.D., 1978 *Aeolanthus biformifolius*:A hyperaccumulator of copper from Zaire. *Science*, vol. 199, pp 887-888.

Malyuga,D.P., 1954 Experience with the use of the biogeochemical method for exploration of ore deposits in Southern Urals (in Russian). *Trudy. Biogeokhim. Lab.*, vol. 10, pp 28-59.

__________, 1958 Copper and molybdenum content of soils and plants over ore deposits (in Russian) in *Trace elements in agriculture* (edited by Peive J.) PP 105-113.

___________, 1959 Application of the biogeochemical method in prospecting for copper -molybdenum ores (in Russian). *Razv.Okhr.Nedr.* vol. 25, pp 19-22.

___________,1960 Distribution of copper and molybdenum in the soils, waters, and plants of the Armenian SSR (in Russian) *Trudy.Biogeokhim.lab.* vol.11, pp 197-207.

___________,1964 *Biogeochemical methods of prospecting.* Consultants Bureau, New York. 205p.

Menezes De Sequeira,E.M.,1968 Toxicity and movement of heavy metals in serpentine soils. (North Eastern Portugal), *Agron.Lusit,* vol. 30, pp 115-154.

Michael,P., 1984 *Ecological methods for field and laboratory investigations.* Tala Mc Graw-Hills Publishing Company Ltd., New Delhi, 404p.

Mitchell,R.L. 1964 *The spectrochemical analysis of soils,plants and related minerals* Common.Bur.Soil.Sci.Tech.commun. 44A, 225 p

Murthy,N.G.K.,1964 Report on the investigation of the copper lead, zinc deposits near Mumandur, Kallakurchi taluk (South Arcot district) Madras. Unpublished GSI report.

Negi, S.S., 1983. Geobotany of Mussoorie area *Ind. forester.*

--------- 1984. Geobotany of Western Himalaya, *Indian Journal of Forestry.*

_________ 1986. Geobotany of India. Periodical Expert book agency. Delhi.

Nesvetailova,N.G., 1961 Geobotanical investigations for prospecting for ore deposits. *Int.Geol.Rev.*, vol. 3, pp 609-618.

Nicolls,O.W., Provan,D.M.J., Cole,M.M. and Tooms,J.S., 1965 Geobotany and biogeochemistry in mineral exploration in the Duglad river area, Cloncurry district,Australia, *Inst.Mining Metall.Trans.*, vol., 74, 696-799.

Oosting, H.J. 1956 *The Study of plant communities - An introduction to plant Ecology* W.H. Freeman and company, San Francisco 440 pp.

Poddar,B.C., 1965 A probable plant indicator for zinc mineralization in the Zawar belt, Udaipur district, Rajasthan. *Curr. Sci.* vol. 34(2), pp 49.

Pradhan, M and Mishra, BB. 1991 Geobotanical investigation in the Gandamardan hill region Keonjhar District, Orissa. *Proc. Indian Sci. Congress.* Indore.

Ravikiran,M. and Bedi,S.J., 1984 *Cometes surattensis Burm.var. ambajiensis* Bedi and Madala as an indicator of copper-lead-zinc mineralization. *Jour.Geochem.Explor.* vol. 20, pp 47-53.

Reeves, R.D. et al.1978 *Trace elements analysis of geologic materials.*

Reeves,R.D. and Baker,A.J.M., 1984 Studies on metal uptake by plants from serpentine and nonserpentine populations of *Thlaspi goesingense. New.Phytol.* vol. 98, pp 191-204.

Reeves,R.D. and Brooks,R.R., 1983 European species of *Thlaspi* as indicators of nickel and zinc. *Jour.Geochem.Explor.* vol.18 pp 275-283.

Reily,C. and Stone,J., 1971 Copper tolerance in *Becium homblei .Nature* vol. 230, pp 403.

Roberts,B.A., 1980 Concentration of micronutrients "trace elements" in native plants growing on serpentine soil from Western Newfoundland. *Bot.Soc.Am.Misc.Ser.Publ.*, vol. 158, p 95.

Roy,S., 1974 Geobotany in the exploration for nickel in the ultramafics of the Sukinda valley, Orissa. Golden Jubilee volume: *Geol.Min.& Met.Soc. India*, pp 251-256.

RoyChoudhury,M.K., Venkatesh,V., Anandalwar,M.A. and Paul,,D.K., 1969 Status of geochemical prospecting in India. *Geol. Surve. Ind., Misc. Pub.*, No. 17, p 27.

Sastry, T.C.S. & K.Y. Kavathikar 1990 *Plants for reclamation of waste lands* Publication and Information Directorate, CSIR. Hillside Rd., New Delhi 684 pages.

Severne,B.C. and Brooks,R.R., 1972 A nickel accumulating plant from Western Australia. *Planta*, vol.

103, pp 91-94.

Shewry,P.R. and Peterson,P.J., 1976 Distribution of chromium and nickel in plants and soil from serpentine and other sites. *Jour. Ecol.*, vol. 64, pp 195-202.

Shrift,A., 1969 Aspects of selenium metabolism in higher plants. *Ann. Rev. Plnt. Physiol.*, vol. 20,, pp 475-494.

________, 1986 Plants points to minerals. *Sci. Today*, Sept., pp 52, 69,78.

________, 1989 Singhbhum copper belt: copper concentration in plants. *Jour. Geol. Soc. Ind.*, vol. 34, pp 174-181.

Tiagi,Y.D., 1968 Geobotanical methods of prospecting for metals. *Rep. Int. Ecol. Jaipur*, pp 1-13.

Tiagi,Y.D. and Aery,N.C., 1981 Biogeochemical studies in zinc deposit areas of Zawar mines, Rajasthan, India. *Proc. Indian Natn. Sci. Acad.*, vol. 47, no. 6, pp 867--887.

____________, 1982 Geobotanical studies on zinc deposit areas of Zawar mines, Udaipur. *Vegetation*, vol. 5, pp 65--71.

____________, 1985 Plant indicators of heavy metals. **In Symp. on** "*Biomonitoring and State of Environment.*,New Delhi, pp 207-222.

____________,1986 Biogeochemical studies at the Khetri copper deposits of Rajasthan, India. *Jour. Geochem. Explo.*, vol. 26, pp 267-274.

________ 1987 Biogeochemistry of cadmium. A review. *Jour. Trop. Forestry*, vol. 3, pp 3-36.

Tiagi,Y.D. and Singh,B.P., 1973 Geobotanical studies of the regions of copper ore deposits in Madhya Pradesh, Rajasthan and Bihar. *Sci. Rep.*, INSA, pp 1-30.

Tiffin,L.O., 1977 The form and distribution of metals in plants. An overview. **In**: *Biological implications of metals in the environment:* Proc. 15th Annu. Hanford Life Sci. Symp., Sept.,29th -Oct.,1st,1975. ERDA--TIC-CONF-750929, Oak hidge, Tenn.

Tkalich,S.M., 1938 Experience in the investigation of plants as indicators in geological exploration and prospecting (in Russian). *Vest. dal nevost. Fil. Akad. Nauk. SSSR*, vol. 32, pp 3-25.

________, 1952 Botanical methods in geological investigations (in Russian).*Bot. Zhur.*, vol. 37, pp 660-664.

________,1953 The iron content of plants as an indicator in geological exploration work (in Russian). *Priroda*, vol.1, pp 93-95.

Trelease,S.F. and Beath,O.A., 1949 *Selenium: its geological occurrence and its biological effects in relation to botany, chemistry, agriculture, nutrition and medicine.* New York,292p.

Vanselow,A.P., 1966 Nickel. **In** *Diagnostic criteria for plants and soils.* Univ. Calif. Div. Ag.. Sci., pp 302-309.

Venkatesh,V., 1964 Geobotanical methods of mineral prospecting in India. *Ind. Miner.*, vol. 18, pp 101.

_________, 1966 Geobotany in mineral exploration. *Steel Mines Rev.*, vol.6, pp 3-5.

Warren,H.V., 1962 Background data in biogeochemistry. *Roy. Soc. Canada Trans.*, vol. 61, pp 21-30.

Warren,H.V., Delavault,R.E. and Irish,R.I., 1949 Biogeochemical researches on copper in British Columbia. *Roy. Soc. Canada Trans.*, vol. 119, pp 119-137.

_________, 1951 Further biogeochemical data from the San Manuel copper deposit, Pina County, Arizona. *Geol. Soc. Amer., Bull.*, vol. 62, pp 919-929.

Warren,H.V. and Delavault,R.E., 1950a Gold and silver content of some trees and horse tails in British Columbia. *Geol. Soc. Amer., Bull.*, vol. 61, pp 121-128.

_________, 1950b History of biogeochemical prospecting in British Columbia. *Canadian Inst. Mining Metall. Trans.*, vol. 53, pp 236-242.

_________, 1954 Variations in nickel content of some Canadian trees. *Trans. Roy. Soc., Canada 111*, vol. 48, pp 71.

White,W.H., 1950 Plant anomalies related to some British Columbia ore deposits. *Canadian Inst. Mining Metall. Trans.*, vol. 53, pp 368-371.

Wild,H., 1970 Geochemical anomalies in Rhodesia Pt. 3. The vegetation of nickel bearing soils. *Kirkia*, vol. 7, pp 1-62.

_________, 1974a Indigenous plants and chromium in Rhodesia. *Kirkia*, vol. 9, pp 233-241.

_________, 1974b Variations in the serpentine floras of Rhodesia. *Kirkia*, vol. 9, pp 209-232.

_________, 1978 The vegetation of heavy metal and other toxic soils. **In** *Biogeography and Ecology of Southern Africa* edtd. by Warger,M.J.A. Junk, The Hague.

Ziauddin,M. and Roy,S., 1974 Geobotany in nickel exploration. *Geol. Surve. Ind., News*, vol. 4, pp 4-7.