SEDIMENT CHARACTERISTICS OF THE ACHANKOVIL RIVER BASIN, KERALA

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CERTIFICATE

This is to certify that the research work embodied in this dissertation entitled "**Sediment Characteristics of the Achankovil River Basin, Kerala**" has been carried out in this School for the partial fulfilment of the award of the degree of Master of Philosophy. This work is original and has not been submitted in part or full for any other Degree or Diploma in any other University.

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Dedicated to

...Late Mother

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CONTENTS

CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

CHAPTER 1

1.1 Introduction

Rivers are amongst the major natural forces changing the face of the earth. A river basin is the most active component of the hydrological cycle involving continuous mobility of water as well as erosion, transportation and deposition of dissolved suspended and tractively carried materials. Considering the fact that more than 90 ton of the continental weathering products are transported to the ocean by the rivers, Knowledge of river water chemistry and elemental flux through them is imperative for a comprehensive understanding of exogenic cycles of elements. Several studies have focussed on the transport of material within river and streams in order to establish geochemical budgets of weathering and to estimate the denudation rates of catchment areas (Meybeck, 1988; Stallard, 1995).Most of work was done on larger rivers e.g. Gibbs (1967,1970); Negrel et al (1993); Dupre et al (1996) ,Gaillardet et al (1997)on Amazon and Congo ;Dutta & Subramanian (1997) on Ganges -Brahmputra river system Krishnaswamy & Singh (1999) on Ganga-Ghagra-Indus head waters. A little information is available on the small river like Achankovil, Pamba and Manimala, which are unique to estimate the flux to ocean because of its unique lithology of small size. Bajpayee did studies about Kerala rivers & Subramanian (2002) but it covers only selected locations in a given river. Further it is also very important to study more on a smaller river basin to understand biogeochemical cycling of micronutrient and their flux to ocean and characterization of smaller river basin which serves huge population in Kerala. So environmental geochemistry of rivers were studied which represents complex interactions in the rock-water-air-life system which give rise to a 3wide range of chemical characteristics in the surface environment which consequently is of dominant importance to man. Here an integral study biogeochemistry of small river in kerala has been done.

Rivers are important geological agents for erosion, transportation and deposition. Over the part two or three decades growing awareness of wide ranging environmental significance of suspended sediment transport by river has generated a considerable body of information concerning the magnitude of sediment yields and their control by anthropogenic activity and environment. Quantitative estimate of river transport have been assembled on global scale by Haleman (1968) and Milliman and Meade (1983); on regional scale by Grow (1972), Lisizin(1972),Subramanian (1979), HuMing Hui et al. (1982) and Meade (1983) and for individual river basin of India by Raymahsay (1970),Abbas and Subramanian (1984), Ramesh and Subramanian(1986) and Bikshan and Subramanian.(1988).

1.2 Literature Review

The circulation of water through the hydrological cycle provides a mechanism for geochemical changes through weathering and transport of dissolved and solid materials. River processes form a major link in this geochemical cycle. With an estimated annual discharge of 37,000 cubic km of water, 13.5 billion tonnes of sediments (Milliman and Meadet 1983) and 3.25 billion tonnes of dissolved load weathering, in response to the uplifted materials and the chemistry of the atmosphere (Garrels and Mackenzie, 1971). Subramanian (1979) estimated that at the present rate of erosion, with no compensating uplifting mechanism, river basins in India would achieve their base levels of erosion in 5 million years.

Several attempts have recently been made to understand river transport of materials. The annual transport of sediments by the world rivers to the ocean has been estimated to be ca. 35 x1000 cubic km. (Milliman, 1991) and 15-20 billion tons (Milliman & Syvitsky, 1992), respectively. The pioneering works includes that of Gibbs (1977), Martin and Meybeck (1979), Milliman and Meade (1983). Milliman and Meade (1983) estimated that nearly 30 per cent of transport of sediments by world rivers take place in the Indian sub-continent. To understand the geochemical mass balance between land and ocean, the estimation of mass transfer from continent to ocean, is very important. Since rivers are by far the most important sunnier of materials to the ocean system, several attempts have been made to understand the river transport of materials to the world ocean. The important among these are by Gibbs (1977), Meybeck (1976), Milliman and Meade (1983), Martrin and Meybeck (1979). In the Indian sub-continent, mass transfer studies have been initiated by Jha and Subramanian (1986), Biksham and Subramanian (1985), Ramesh and Subramanian (1985),Raymahasay (1970),Subramanian (1978, 1979) and others.

Textural, mineralogical and chemical studies on reverine sediments offer an insight into river base provenance and the effect of transport on the original relationship in the geological formations. The clay minerals of river suspensions reflect in general the geological setting of the respective drainage areas. Large rivers with a heterogeneous geology in their catchment basins show a great variability in the clay mineral composition of their suspended load. Hence an attempt have been made in this study to understand the biogeochemistry of such small river in Kerala.

There is an enormous effect of human activity on weathering and erosion processes as a result of ploughing agricultural fields, deforestation, acid rain and all types of engineering works on the earth's surface. Now there is a strong growing realization that understanding of our environmental surroundings is of vital importance for the repair of prior degradation and development of future strategies (Pagenkopf, 1976). This awareness has led to a rapid increase in the number of studies involving the various aspects of natural water chemistry. (Meybeck, 1976), they are the leading transporting agents from the continents to the oceans. World rivers with 1.2 thousand cubic km. of water account for an almost insignificant (0.0001 %) of the total water in the hydrosphere (Lvovich, 1973); but taking account of the rapid circulation of this water, the world rivers annually discharge about 38,000 cubic km. of water into the oceans.

The two fundamental processes of weathering - mechanical and chemical, result in the suspended and dissolved loads of rivers and they represent quantitatively, the most important input to the oceans (Holland, 1978) . The components which are very mobile, such as silica, aluminum, iron, titanium and potassium are mainly exported by mechanical erosion processes, whereas calcium, magnesium, sodium and carbonates are removed from the basin primarily by chemical erosion (Probst, 1986). The river and stream borne soluble and suspended loads get affected in estuaries where there is continuous mixing between fresh water and seawater (Evans et al., 1977, Fukai et al., 1973, Krishnaswamy, 1976w Sholkovitz, 1976, Turekian, 1971, 1977) by processes such as flocculation, adsorption-desorption, recycling through biological processes etc. The chemical composition of the eroded matter depends on the mean composition of the minerals lifted above the sea level, on the relative effectiveness of chemical weathering compared to physical.

The mobile nature of silica during low temperature surfacial processes on Earth is apparent from the common occurrence of sedimentary silica deposits, quartz veins, slitters quartz overgrowths and replacements in sedimentary rocks and the common depletion of silica in soils. This is in spite of the fact that crystalline quartz is not particularly soluble under most near surface conditions. Accordingly, sedimentary silica is largely derived from the breakdown of other silicates (e.g., feldspar, amphiboles, olivine, pyroxene) and glass during low temperature processes, pressure solution during compaction and creep, as well as a variety of diagenetic and metamorphic reactions during high pressure and temperature conditions. There is wide agreement that a variety of sedimentary processes have affected the Martian surface and a number of workers have recognized that silica may play a role during alteration. For example, Burns proposed the possibility of "hydrous iron oxide - silica deposits" in the Argyre and Hellas basins and some models of the Martian hydrological cycle predict significant amounts of sedimentary silica . However, evidence of significant silica deposits at or near the Martian surface has been inadequately explored. Mobility of silica during surfacial processes would significantly constrain hydrological model.

I Upper Continental Crust

A upper Continental Crust is the exposed rocks that are available for weathering- igneous, metamorphic and sedimentary rocks are all represented.(http://www.ideo.columbia.edu./dees/ees/ies2/weathering1/-11k)
In general igneous and high grade metamorphic rocks are found most commonly in shield areas or in mountain belts. Sedimentary rocks cover most of the stable platfor B. Approaches to Estimate Upper Continental Crust Composition. Estimate areal or volumetric proportions of the principal exposed rock types and using typical compositions, calculate an average.

2. Wide-scale sampling with analysis of individual or composite samples.

3. Allow the geological processes of sedimentation to produce an average sample of the exposed crust

II Mechanical breaking increases available surface for chemical attack provides "fresh" surfaces with abundant soluble ions.

A. Processes of mechanical breaking.

1. frost action.
2. plant roots.
3. rock cleavage and fractures.
4. abrasion during transportation by wind, water or ice.

III Chemical dissolution weakens residue and makes it easier to break, removes soluble ions such as Na+ and Ca++ hydrates remainder," effectively replacing Na+ and Ca++ with H+".

A. The behavior of elements in weathering is controlled by their "chemistry" which can largely be inferred by their positions in the periodic table.

B. The general tendencies of different element types.

1.Alkali and alkaline earth elements are quite soluble (although larger cations such as Rb, Cs and Ba are commonly retained, adsorbed on clays).

2.Relatively immobile elements include the Al-group (Al, Ga), Ti-group (Ti, Zr, Hf), REE (including Y, Sc) and other high valency ions such as Th and Nb.

3.First row transition metals tend to be relatively immobile although some Ni and V mobility occurs.

4.Silicon is generally retained in quartz.

C. The general tendencies of different element types are exemplified in this chart of seawater residence time compared to elemental enrichment in seawater relative to Upper Continental Crust.

D. The general tendency of weathering is to enrich the residue (ultimately terrigenous clastic sedimentary rocks) in aluminum and to deplete them in alkali and alkaline earth metals. This tendency can be quantified by the **Chemical Index of Alteration (CIA).**

$$\mathbf{CIA = [Al_2O_3/(Al_2O_3+CaO^*+Na_2O+K_2O)]}$$

(molar abundances)

Feldspar >50% of Upper Continental Crust (quartz ~20%). Thus CIA effectively measures the degree of alteration of feldspars to clay minerals during weathering.

E. Comparison of the estimated composition of the upper continental crust, the source of weathering products, with river particulates, the residue of weathering provides a clear insight into the general direction that weathering changes the chemical composition of rocks. See table below.

Table of major element composition (in weight percent) of upper continental crust and selected river particulates (Taylor and McLennan. 1985, "The Continental Crust: its Composition and Evolution," Blackwell.).

Upper continental	**Upper Continental Crust**	**Amazon**	**Congo**	**Ganges**	**Garonne**	**Mekong**
SiO2	66.0	60.1	58.0	66.9	58.2	61.9
TiO2	0.5	1.3	1.6	1.0	0.8	0.6
Al2O3	15.2	22.8	25.0	16.0	22.4	22.3
FeO	4.5	7.5	10.4	5.2	7.5	7.6
MgO	2.2	2.0	1.1	2.3	2.9	2.3
CaO	4.2	2.3	1.4	4.1	2.7	0.9
Na2O	3.9	1.2	0.3	1.5	0.7	0.7
K2O	3.4	2.3	1.6	2.7	4.1	3.0

IV. Weathering of rocks is controlled by 4 main factors.

A. Properties of the parent rock.

B. Climate (rainfall and temperature).

C. Presence or absence of soil (Fig).

D. Length of exposure.

V. Mass Balance.

The chemical characteristics as well as the proportions of major rock forming minerals play a strong role in controlling chemical weathering.

Following is a list of estimated abundances of minerals in the upper continental crust (from Taylor and McLennan, 1985).

Mineral	**Weight (%)**
Plagioclase	34.9
K-feldspar	11.3
Quartz	20.3
Glass (rock composition)	12.5
Amphibole	1.8
Biotite	7.6
Muscovite	4.4
Chlorite	1.9
Pyroxine	1.2
Olvine	0.2
Oxide	1.4
Others	2.6

Take a look at this table for an overview of the relative chemical stabilities of the major rock forming minerals, with reference to Bowen's reaction series (the general order of crystallization from magma).

Refer to the diagram of the cycle of weathering, sedimentary rock formation and destruction, oceanic crust formation and alteration and the impact on the chemistry of seawater, and the ultimate fate of sediments in the subduction zone. Remember, collectively all the atoms and ions that are products of weathering are equal to all the atoms and ions of the original rock that was weathered. A rock that is weathered has produced:

1.mineral and rock fragments still recognizable as the parent rock.

2.solid, residual products of chemical alteration such as clay minerals and iron/aluminum oxides.

3.ions dissolved in rainwater and soil water. Where the mass of all these products (leaving out the water and carbon dioxide derived from the atmosphere) equals the original mass of the unaltered rock. This is the very important concept of mass balance.

1.3 STATISTICS OF GRAIN DISTRIBUTION:-

The average particle size, a fundamental property of sedimentary material, is defined by a variety of statistical parameters .The mode is the most frequently occurring particle diameter. The median is that size for which half of the particle (by weight) are coarser and half finer. The arithmetic mean is calculated using the method of moments, where the midpoint of each grade is the arithmetic mid point between the grade size limits in millimeter e.g. geometric mean (Krumbein & Pettijohn). Standard deviation measures the sorting and uniformity of particle size distribution. In a normal distribution, 68 % of sample lies within "one standard deviation" plus or minus, of mean .The arithmetic standard deviation is calculated using the method of moments. This statistic of little direct value because it can't be used to compare the sample with different mean diameter. To avoid this problem the coefficient of variation can be used. It is defined as the standard deviation divided by the mean (Simpson et, al. 1960, Snedecore & Cochran 1967). Skewness measures the asymmetry of distribution. If there is more material in the coarse tail (coarse skewed), the skewness is referred to as being negative .If there is more material in fine tail (fine skewed), it is positive. Kurtosis measures the ratio between the sorting in the "tails" of the distribution and the sorting in the central portion is better sorted than the tails the frequency curve is said to be excessively peaked or leptokurtic. If the tails are better sorted than the central the curve is said to be flaked or pltykurtic.

1.4 METALS IN SEDIMENT

Heavy metals or trace metals are present in streams as result of chemical leaching of bed rock, water drainage and runoff from banks and discharge of urban and industrial wastewater (Birch and Taylor, 1999; Soares et al..,1999). Association with suspended matter largely mediates the transfer of metals from terrestrial to the riverine and coastal environment.

The transfer and distribution of heavy metals in sediments is largely dependent on sources and input, hydrodynamics factors controlling the flow, nature and amount of suspended solids and biological processes occurring in the system (Horowitz ,1991)

The behavior of metals in natural waters is a function of the substrate sediment composition, the suspended sediment composition and the water chemistry. Sediment composed of fine sand, silt and clay minerals generally have higher levels of absorbed metals than major rock forming minerals as quartz, feldspar and detrital carbonate. Metals also have a high affinity for humic acids , organo-clays , and oxides coated with organic matter (Connel et al ; 1984)

Sediments are widely used as environmental indicators due to their ability to be trace contamination sources and monitor contaminants (Soares et al .,1999) . They play an important role in the assessment of metal contamination in natural waters (Jha et al.,,1990) .They have a high capacity to accumulate and integrate over time low concentrations of trace metal in water and hence allow the determination of metals even when the level in water may be extremely low(Sores et al;1999).

CHAPTER 2

STUDY AREA AND CLIMATE

CHAPTER –2

STUDY AREA

2.1 AREA AND LOCATION :-

The Kerala state comprises a narrow strip of land with an area of 38,863 square kilometers extending between north latitudes 8°17' 30" and 12° 27' 40" and east longitudes 74° 51' 57" and 77° 24' 47" and drained by 44 small rivers. The Western Ghats with the magnificent array of sky scrapping peaks on the east and the Arabian Sea washing its shore on the west are the natural boundaries of the state, providing it distinctive physical features.

On the basis of physical features, the state is divided into three natural divisions, namely, the low land consisting of sea board, the mid land consisting of the undulating country east of the low land and the forest clad high land on the extreme east. The hilly or the eastern portion is broken by a long spurs, extensive ravines dense forests and tangled jungles full of flora and fauna, rising terrace after terrace, to an elevation more than 275 meter above sea- level.

The present study mainly concentrated on three Rivers the Achankovil, the Pamba and the Manimala which are covering mainly four districts of Kerala i.e. ALLEPY, PATHANAMTHITTA, KOTTAM and ALAPPUZHA. The length of Achankovil, Pamba and Manimala are 128,176 and 90 km respectively(figure 3.1).

2.2 CLIMATE

2.2.1 TEMPERATURE :-

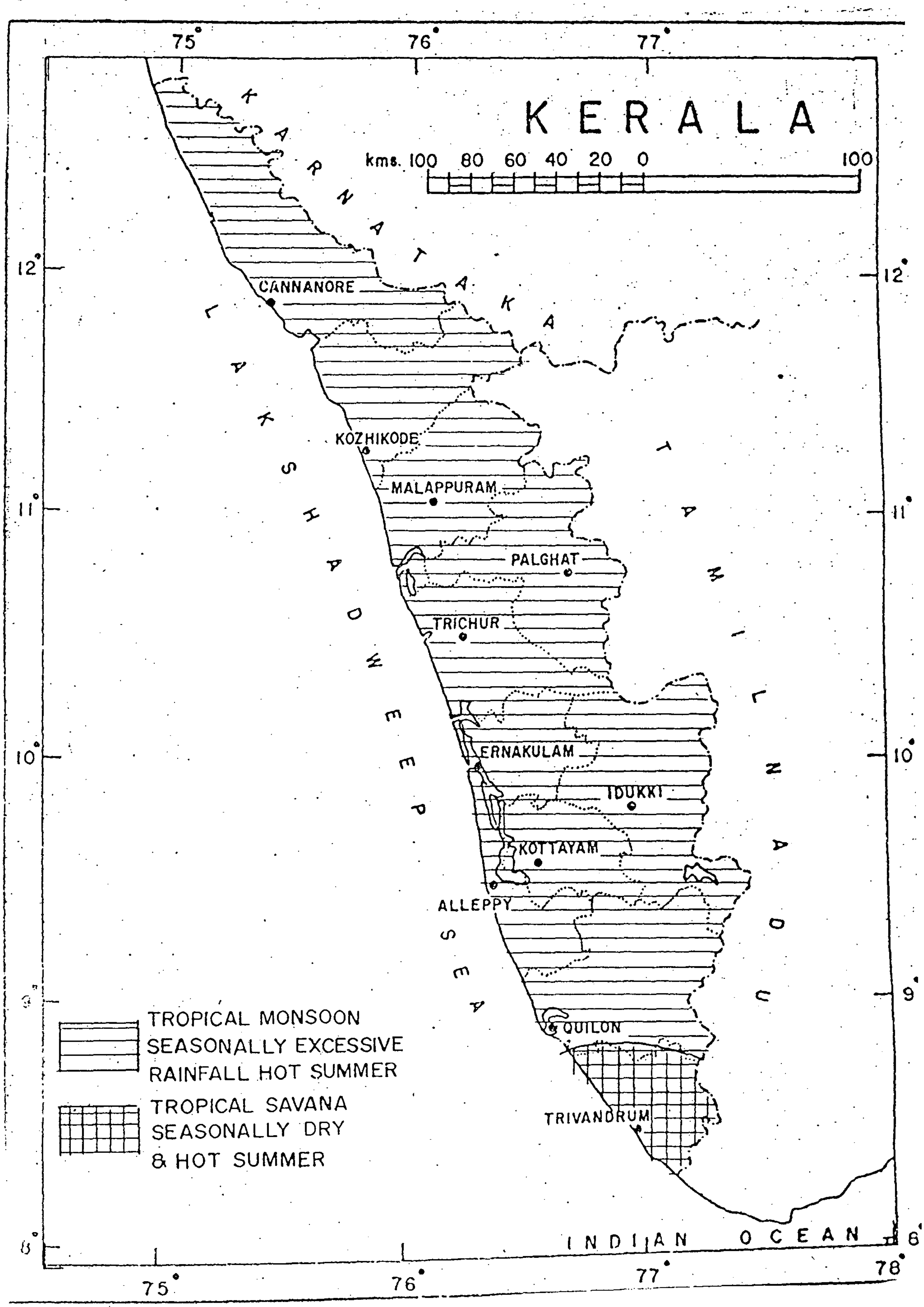
From last 30 year average data of temperature variation from Indian Meteorological Department, New Delhi, the day temperatures are more or less uniform over the plains throughout the year except during January, December and months of July when these temperature drop down by about 2 to 3° C. Both day and night temperature lower over the plateau and at high level stations than over the plain. Day temperatures of coastal places are less than those of interior places. March-April is hottest month with a mean maximum temperature range from 32°C to 37°C on different stations.

2.2.2 HUMIDITY :-

Kerala posses a very high humidity over all the year because its very close to Arabian Sea. In months December to March it possess relatively low humidity about 74 % to 77% while in months of June-July humidity rises to its peak 90% to 92 %. The humidity also varying from 35 % in the interior to 71 % in the coastal area.

The diurnal variations in relative humidity during January - March is maximum and ranges from 4 % to 16 % depending upon the proximity of sea. The diurnal variations in monsoon period is minimum and ranges from 2 % to 12 % maritime influence playing most important role in governing this variations.

CLIMATIC CLASSIFICATION



2.2.3 CLOUDINESS: -

Minimum cloudiness prevails over state in the period January to March when sky remains cloudless for 12 to 13 days per month towards the extremely southern parts of the state during this period, about 3 oktas of sky remains cloudy in months in general and cloudiness varies from 3.9 oktas of sky towards the northern coast to 2.3 oktas of sky towards interior and southern most part of state. Morning are more cloudy than evening except at southernmost and interior of the State where afternoon are more cloudy than mornings. During monsoon season skies are heavily clouded specially during June and July when about 7 oktas of sky remains covered with cloud in a month. On an average in each of these two months the sky remains overcast for more than 16 days per month and is not generally found clear even for a single day. In this season morning and evening are equally cloudy. Cloudiness starts decreasing from August and decreases till September. A secondary maxima of cloudiness is observed in the state in October when the post monsoon storms of Bay of Bengal and Arabian Sea affect the state again it decreases from November till January when the cloudiness in state is minimum (annual report of Indian Meterological Department).

2.2.4 RAINFALL: -

The total annual rainfall in the state varies from 380 cm over the extreme northern parts to about 180 cm in the southern parts. The SW monsoon (June - mid October) is the principal rainy season when the state receives about 73 % of its annual rainfall, monsoon rainfall as percentages of annual rainfall decreases from north to south and varies from 85 % in northern most district of Cannanore to 54 %

southern most district of Trivandrum. Rainfall in the NE monsoon season (mid October to February) and hot weather season (March to May) constitute 7 to 25 and 10 to 20 % . NE monsoon rainfall as percentage of annual rainfall increases from North to South and varies from 7 % in Northern most district of Cannanore to 25 % in Southern most district of Trivandrum. As from monthly average rainfall data, maximum rainfall observed in month of June - July i.e. from SW monsoon and minimum observed in month of December and January (annual report of Indian Meterological Department).

2.3 SOIL :-

The soil type of the study area is most predominantly lateritic, especially in the midlands. These are weathering product of rocks under the tropical humid conditions existing in the study area. It shows a developed AB(C) profiles, which are deep to very deep. The B-horizon is well developed in most area and has abundant a ferruginnound quartz gravels. The other dominant soil type is Hapludolls-Tropudalfs-Tropeptic-Eutrothox (loam) type of soil, which is developed on the weathered crystalline rocks in the eastern part of study area. They are rich in organic matter. Tropofluvents - Eutropepts - Dystropepts (alluvium) type of soil is well developed along the river valleys and cut across the laterite cover. They are very fertilewith high holding capacity. Tropaqualps - Tropaquepts (brown hydromorphic) type of soil is present in parches in the areas of wetlands and are rich in organic matter and potash. Troporthents (grey onattukara) type of soil is found only in Alleppey and Quilon districts. It is grey in colour, course grained and acidic in nature (Anon, 1968).

2.4 ACHANKOVIL RIVER BASIN

Achankovil river is in south of Kerala with an area of 1484km^2 and annual average discharge of water about 1.5 km^{2}yr~1 bounded by hills on three sides on the south (fig-2.1). The land lies at a height of 20-120 meters above msl level. Side slope of the valley is moderate (50-180m). The area receives an annual rainfall of 289mm. Geology is same like Pamba basin the crystalline rocks (pyroxene granulites, charnockitic gneiss, khondalites and associated calc-granulite bands). The basin displays dendritic to sub-dendritic and rarely rectangular and trellis drainage patterns.The river discharges into the Vembanad lake extends from Cochin (Kochi) to Alleppey (Alapuzha) for a distance of 83km and is the largest estuary in Kerala. Its width varies from a few hundred meters to 15km. It is elongated and oriented in NW-SE direction. Five major rivers, viz.Muvattupuzha, Meenachil, Manimala, Achankovil and Pamba dischargs into this lake.

2.5 PHYSIOGRAPHY: -

Physiographically, the State is divided into three divisions, viz., (I) The highland region in the east consisting of the forests of the Western Ghats and its slopes; (2) The midland region, and (3) the lowland region in the west coast. These three regions run nearly parallel to each other from one end of the State to the other. The topography of the highland region is mountainous with altitudes ranging from 400-2000m above the sea level. The midland (region) has a rolling or hilly topography roughening into slopes and gradually joining the mountains, the altitude varying from a few meters in the west to about 400 meters in the east. The narrow coastal belt of lowlands in the extreme west has a nearly level and flat topography. A series of natural backwaters connected together by man-made canals is characteristic feature of this region. The entire face of the land is intercepted by a number of rivers, which originate in the mountains in the east and flow towards the backwaters for the sea in the west.

2.6 GEOLOGY

The main geological formations of the State belong to the Archean period except for the coastal tracts where the more recent sedimentary formations known as the Varkalai series exists and extend almost continuously from Varkalai in the south to Kasargod in the north. The sands alluvium, organic deposits and lacustrine beds of recent formations. According to the time scale, the geological formation of Kerala are given as follows:

1. Recent: Sands alluvium, organic deposits and lacustrine beds.
2. Tertiary: Sedimentary laterites of the Varkalai series and residual laterities of the Upper tertiary.
3. Archaean: Crystalline rocks.

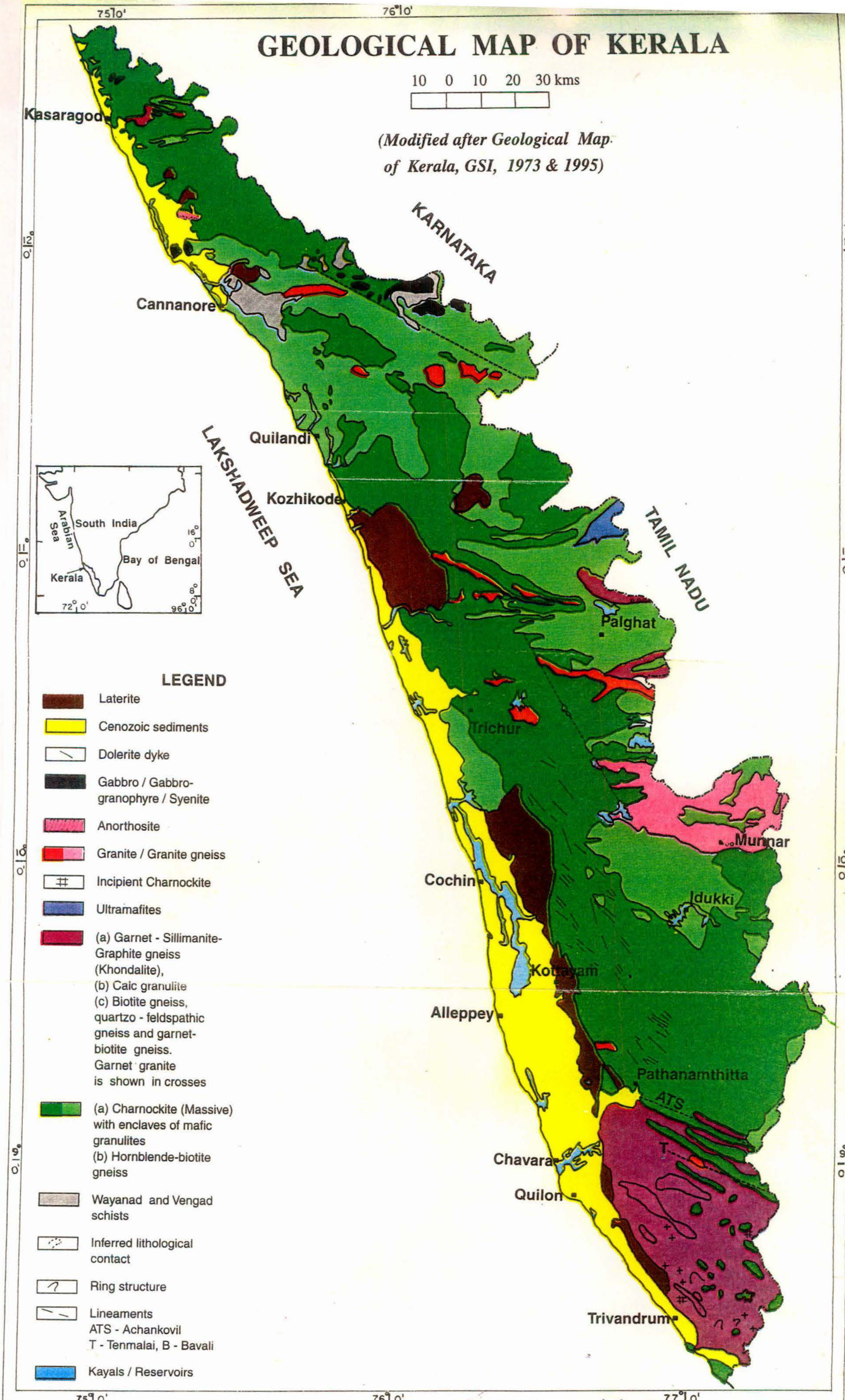
2.7 VEGETATION

In spite of the small area of the State the vegetation is extremely varied and exhibits a wide range of plant formations characteristic of the following climatic zones:

(i) The humid Temperate Zone ofthe high ranges (above 1,350 m).

(ii) The sub-tropical zone (750-1,350 m)

(ii) The monsoon forests (450-750 m).


GEOLOGICAL MAP OF KERALA
10 0 10 20 30 kms
(Modified after Geological Map of Kerala, GSI, 1973 & 1995)
75°0'
76°0'
77°0'
12°0'
11°0'
10°0'
9°0'
KARNATAKA
TAMIL NADU
LAKSHADWEEP SEA
Kasaragod
Cannanore
Quilandi
Kozhikode
Palghat
Trichur
Munnar
Cochin
Idukki
Kottayam
Alleppey
Pathanamthitta
ATS
T
Chavara
Quilon
Trivandrum
South India
Arabian Sea
Bay of Bengal
Kerala
16°0'
8°0'
72°0'
96°0'
LEGEND
Laterite
Cenozoic sediments
Dolerite dyke
Gabbro / Gabbro-granophyre / Syenite
Anorthosite
Granite / Granite gneiss
Incipient Charnockite
Ultramafites
(a) Garnet - Sillimanite-Graphite gneiss (Khondalite), (b) Calc granulite (c) Biotite gneiss, quartzo - feldspathic gneiss and garnet-biotite gneiss. Garnet granite is shown in crosses
(a) Charnockite (Massive) with enclaves of mafic granulites (b) Hornblende-biotite gneiss
Wayanad and Vengad schists
Inferred lithological contact
Ring structure
Lineaments
ATS - Achankovil
T - Tenmalai, B - Bavali
Kayals / Reservoirs

(iv) The midland and coastal region (0-450 m).

Natural vegetation is now found only in the first three zones which together constitute about 25 percent of the total area of the State. Along the lower altitudes of the humid temperate zone trees of the Cypress and Eucalyptus species are seen. Shrubby forms are rare, but many perennial herbs and grasses are found. The tea shrub, Camellia sinensis, is cultivated extensively in this region. The climate of the sub-tropical zone is suitable for the growth of huge trees such as the teak (Tectona grandis), and the rosewood (Dalbergia latifolia). Saprophytic plants like orchids and fungi grow in the decaying organic matter of the forest floor. Extensive plantations of para rubber, (Alevea brasiliensis) and of cardamom (Elettaria cardamomum), as well as that of tea are found in this region. The chief characteristic of the monsoon forests is that the trees are mainly of the deciduous type so that leaf fall occurs at the beginning of the dry seasons. The whole of the midland and coastal regions is under human habitation and the vegetation consists

CHAPTER 3

MATERIALS AND METHOD

CHAPTER 3

MATERIALS AND METHOD

3.1 FIELD METHOD: -

Systematic sampling of bed (surface) sediments and core sediments was done in the river basin. The sampling location were chosen carefully in order to get maximum representation of the diverse geoenvironment in the river along with bed sediment two core sediment was also taken from 'Viyyuvarum' and ' Mavelikara '. The sampling location are shown in figure – 3.1 and the location name are given in the table its names are given in Table – 3.1

3.1.1 SURFACE BED SEDIMENT SAMPLES:

Surface sediment samples were collected from the sampling location by scooping the top 5-10 cm layer using a small steal scoop along the river bed at sediment water interface. The surface sediment sample were then transferred to a polyethylene bag, which was sealed to air by fastening the mouth immediately. These samples were brought to the laboratory for studying geochemical properties.

3.1.2 CORE SEDIMENT SAMPLES :-

Core sediment samples were collected from the bank of ' Achankovil ' river by digging core pipe about 16-20 cm deep inside the sediment and pulled out both core pipe and tied it's both end with polyethylene bag immediately. The core pipes

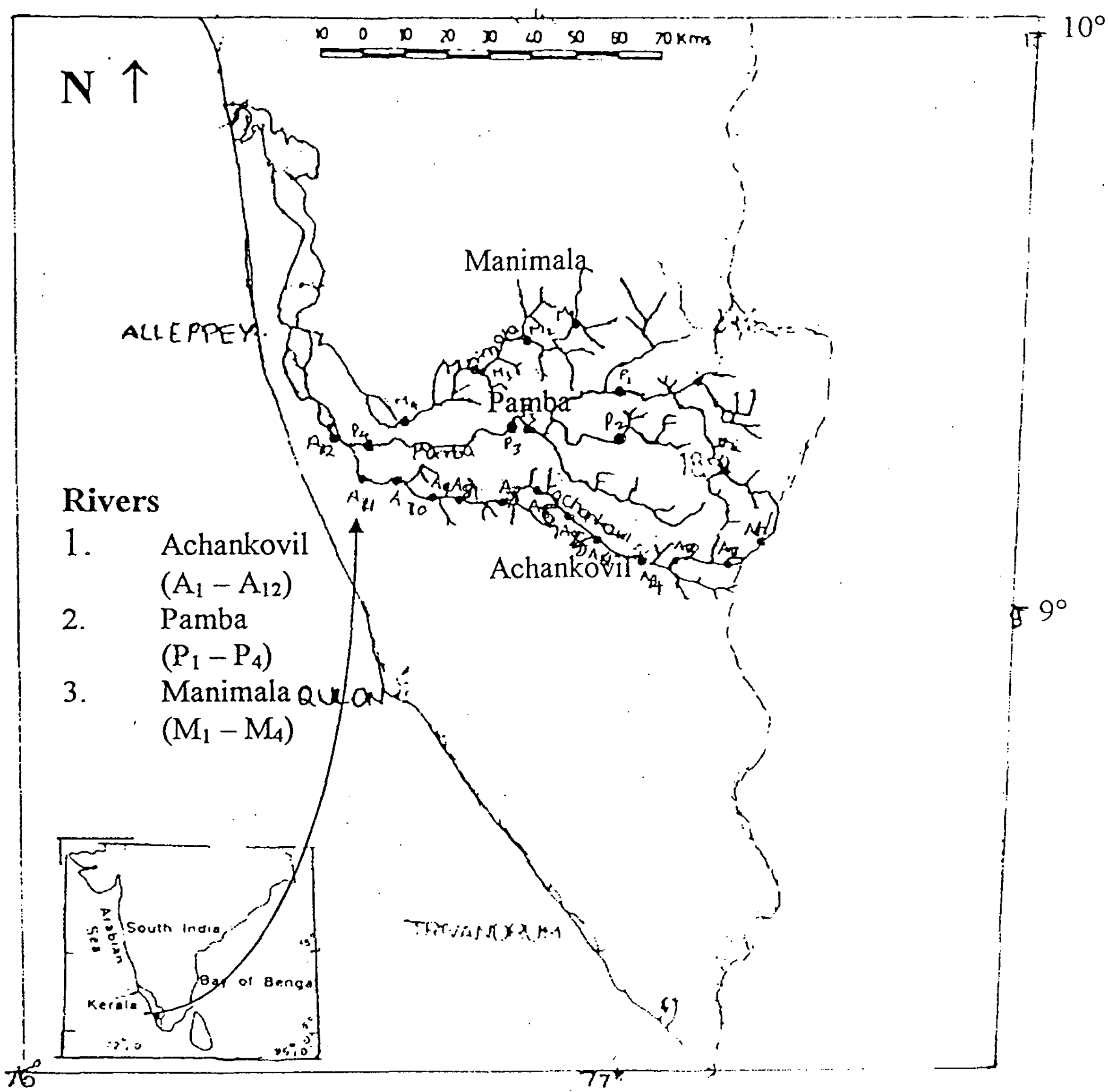


Fig 3.1 -Study Area

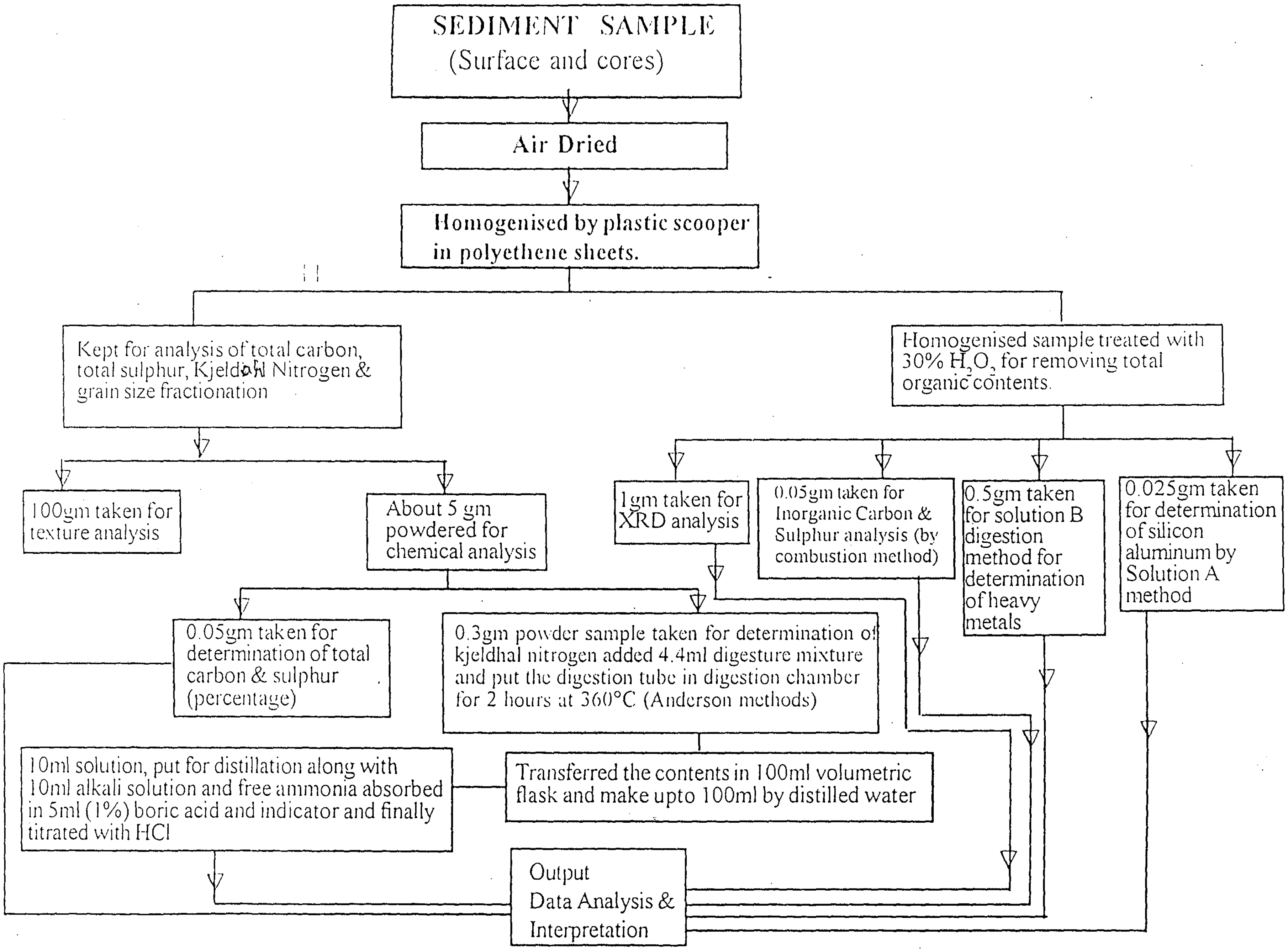


Fig 3.1 FLOW CHART FOR LABORATORY METHOD

Fig 3.3 A View of Study Area (In the bank of Achankovil)

Fig 3.3 A View of Study Area (In the bank of Achankovil)

A. Upstream

B. Down stream

Fig 3.2 Profile of cores Sediments of Achankovil rivers basin (measure of each box approx. 2 Cm) brought along with bed sediment sample to laboratory for studying its geochemical properties.

3.2 LABORATORY METHODS: -

In laboratory bed sediments spread on glass plate to became air-dried and then homogenized by hands. For Core sediment, each core pipe opened by cutting it horizontally about 2 cm length and then each divided into two parts by cutting it vertically as shown in figure 3.2

3.2.1 SEDIMENT ANALYSIS: -

3.2.1.1 CARBON AND SULFUR ANALYSIS: -

Carbon was analyzed by using ELTRA (CS 1000) CARBON ANALYSER. Before analysis sediments were made free of halogen by washing with distilled water. Untreated samples were used for determining Total carbon and Total sulfur percentage. The measuring method is based on the principle of sample combustion and analysis of gasses given off through IR absorption. The sample is put in a ceramic boat, which is made free of any carbon and pushed into the silicon carbide furnace set at a temperature 1300 °C. The combustion occurs in the presence of oxygen supplied and the carbon present in the samples is converted to CO_2. And is carried to the IR absorber by oxygen, which also acts as a carrier gas. The flow of oxygen is maintained to a constant value through and electronic flow regulator. The moisture traps ensure that dry gas mixture reaches the IR cell. The IR cell signals are selected and respond to CO_2 concentration in the gas mixture. The signals are electronically linearised integrated and percentage of carbon and sulphur in the given weight of sample is shown digitally.

3.2.1.2 KJELDAHL NITROGEN ANALYSIS: -

Nitrogen was analyzed by Kjeldahl digestion method of Anderson (1993), 0.3 gm sediments was taken in digestion tube and 4.4 ml of digestion mixture was added to each tube. This was digested at 360 °C till a solution became colourless. The solution was allowed to cool down to room temperature, 50 ml of distilled water was added in each tube and stirred. The final volume was made up to 100 ml by adding distilled water. The clear solution was used for analysis.

Digestion mixture was prepared by dissolving 0.42 gm Selenium powder and 14 mg Lithium Sulfate in 350 ml 30 % (V/V) H_2O_2 and mixed. In this mixture 420 ml H_2SO_4 was added carefully while cooling in an ice bath. The digestion mixture was kept at 4 °C for further use. Nitrogen was determined by stream distillation. Free ammonia is liberated from the solution by stream distillation in the presence of excess of alkali. The distillate was collected in the receiver containing excess of Boric acid and indicator and finally Nitrogen is determined by Acid titration.

Alkali solution was prepared by dissolving 400 gm NaOH in 1000ml distilled water. Mixed Indicator was prepared by adding 0.099 gm Bromocresol Green, 0.066 gm Methyl Red and 0.011 gm Thymol Blue in 100 ml 95 % ethanol dissolved by shaking. 1 % Boric Acid solution was prepared by dissolving 10 GM Boric Acid in 1 litter distill water.

Transferring 10 ml of aliquot to reaction chamber and adding 10 ml of alkali and starting distillation immediately does distillation process. About 50 ml of distillate was collected in 5 ml Boric Acid- Indictor solution. The distillate was titrated against N/140 HCl to gray end point, changing from green to gray using micro-burette.

Kjeldahl Nitrogen present in the sample was calculated by using the following equation.

$$\% \text{ Nitrogen} = \left(\frac{(A - B) * \text{N of HCl} * 1.4 * V}{\text{Weight of sample in gm} * W} \right)$$

A =volume (ml) of HCl used against sample.

B= Volume (ml) of HCl used against sample.

V= Total volume (ml) prepared after digestion.

W = Volume (ml) of digested sampled distilled.

TABLE 3.1- NAME OF DIFFERENT SAMPLE LOCATION AND NUMBER USED FOR THEM IN THREE KERALA RIVER

(a) DIFFERENT SAMPLE LOCATION OF THE ACHANKOVIL RIVER

SERIAL NUMBER	SAMPLE NUMBER	NAME OF SAMPLE LOCATION
1.	AC1	MAVELIKARA
2.	AC2	PANDALAM-I
3.	AC3	PANDALAM-II
4.	AC4	THUMPAVAN
5.	AC5	AMBALAKAODAV
6.	AC6	PATHANAMTHITTA
7.	AC7	KONNI
8.	AC8	HARIPAD-I
9.	AC9	HARIPAD-II
10.	AC10	PAIPPAD
11	AC11	VIYYUVARAM
12.	AC12	Before Vambnad lake

(b) DIFFERENT SAMPLE LOCATION OF THE MANIMALA RIVER

1	MN1	POTHEMPUZHA
2	MN2	KULATHURMUZHA
3	MN3	MALLAPPALLY
4	MN4	TIRUVELLA

(C) DIFFERENT SAMPLE LOCATION OF THE PAMBA RIVER

1	PB1	VADASERIKARA
2	PB2	CHENGANNUR
3	PB3	RANNI
4	PB4	VIYYUVARAM

(d) CORE SEDIMENT LOCATION

1. **MAVELIKARA ***

2. **VIYYUVARAM ***

*** Achankovil River**

3.2.2 ANALYSIS OF MAJOR AND MINOR ELEMENTS

Finally grounded homozonised sediments were taken in the beaker and boiled with 30 % (V/V) H_2O_2 (Jackson, 1973) for removal of Organic matter. The treatment is repeated until the emission of CO_2 stopped.

Analysis of major and minor elements were carried out by the two solution method (Shapiro, 1975). Solution 'A' was used for silica and aluminum and Solution 'B' was used for metal analysis.

3.2.2.1 **SOLUTION 'A'**

0.025 gm of finally powdered sediment was taken in 50 ml Nickel crucible and 3-4 pellets of NaOH were added to it. The crucible was gently heated on a furnace in order to mix the sediment and melt pellets, then the crucible was constantly heated to dull redness for 30 minute. Then the crucible was allowed to cool down to room temperature. 10 ml of distilled water was added in the crucible and kept over night. The solution was transferred to 250-ml volumetric flask with help of a policeman. 5ml of (1:1) HCl and 25 ml water was also added. This solution was boiled till it was clear and the total volume was made up to 250 ml by adding distilled water.

3.2.2.1.1 SILICA ANALYSIS

0.8 ml of solution 'A' standard solution (Canadian standards i.e. SO1 , SO2, SO3 and SO4) and sample solution were taken in a test-tube. 0.2 ml Ammonium molybdate solution was added and kept for 10-minute.4 ml 10 %(w/v) of Tartaric acid was added by swirling the beaker. 0.1 ml of reducing agent was added and sample properly stirred and kept for 30 minutes. Absorbency was measured by spectrophotometer at 650 nm.

Ammonium molybdate solution was prepared by dissolving 1.875 gm Ammonium molybdate in 19 ml distilled water and adding 6 ml 20 % (V/V) H_2SO_4. The reducing reagent was prepared by dissolving 0.07 gm Sodium Sulfite in 1.0 ml distilled water then 0.015 gm 1- amino-2-naphthol-4-Sulphonic acid was add and stirred well until dissolved 9 ml of 10 % (w/v) Sodium bisulphite solution was added to it and mixed well.

3.2.2.1.2 ALUMINUM ANALYSIS :

15 ml of solution 'A' (sample, standard and blank) were taken in 100 ml volumetric flask 2 ml of $CaCl_2$ solution (prepared by dissolving 7 gm $CaCl_2$ in 1000 ml distilled water) was added. 1 ml of Hydroxylamine - Hydrochloride (prepared by dissolving 5 gm of Hydroxylamine-Hydrochloride in 50 ml) was added by swirling the flask. 1 ml of potassium ferricyanide (0.75 %) was added to each flask and mixed 2 ml of thioglycolic acid solution (4%) was added and left for five minutes. 10 ml of buffer solution (prepared by dissolving 100 gm of sodium acetate in water and adding 30 ml of glacial acetic acid and diluted to 500 ml) was added and kept for 10 minutes .10 ml of Alizarin Red- S solution (0.05 %) was added to each flask and the volume was diluted to 100 ml sample were properly stirred and left for 50 minutes. The absorbency was measured at 470 nm using spectrophotometer.

3.2.2.2 SOLUTION 'B':

0.5 gm of finely grounded sediment sample were transferred to the Teflon crucible and 4 ml of aqua-regia (HNO_3 and HCl ratio 1:3) and 2 ml HF were added to each crucible, these were then sealed in metallic cases for 2 hrs. At 100 °C and allowed to cool down to room temperature. The solution content transferred to volumetric flask to make 100-ml volume. The solution was transferred to polypropylene bottles for storage. The sample was left undisturbed overnight to allow the formation and settling of Borosilicate from solution. This gelatinous precipitate is separated by centrifugation. The solution thus obtained is used for analysis of major and minor elements by GBC-902 double beam Atomic Absorption Spectrophotometer.

MINERALOGY OF SEDIMENT

For study of mineralogy sediments, a slide is prepared by filling clay or bulk sediment (organic content free sediments) powder (less than 50 micron) was run through XRD model number at rate of 2 ° / s. Finely XRD peaks was analysed with the help of standard 'd' value as given in different literature. For confirmation of minerals we distinguish at least three peaks of each minerals. Percentage of different minerals calculated by calculating percentage area of that particular minerals with respect to total area of peaks of all minerals.

CHAPTER 4

CHARACTERISTICS OF BED SEDIMENTS

CHAPTER 4

CHARACTERISTICS OF THE SURFACE SEDIMENT

River plays a dominant role in weathering and erosin of landmasses. The sediments carried by rivers are responsible for flooding, and create a need for maintenance of in-channel structures and navigation systems. Most important of all, the sediment particles absorb many contaminants, such as pesticides, radionuclides and toxic metals, that are transported, deposited and stored as part of sedimentary component of the river system (Milliman and Parker,1985). The total discharge of river sediment to coastal zones of the world under present day conditions is estimated to be 15-16 $*10^9$ ton/ year (Milliman and Meade1983). Keeping these goods in mind the sediment catchment of Small River system in Western Ghats of Kerala have been studied and discussed here.

4.1 RESULT AND DISSCUSSION

4.1.1 GRAIN SIZE DISTRIBUTION

The grains distribution in surface sediment of all the three Kerala river i.e. the Achankovil, the Pamba and the Manimala river basin is very well sorted up to down stream. Statistical calculation was done by method of moment (Krumbein & Pettijohn, 1938,Swan et al. 1979 and text book of R. Lindholm).

In the Achankovil river basin sediment grains are symmetrically skewed while in the Pamba river basin are coarse skewed in upstream to very coarse

Table 4.1 Grain size distribution of surface sediment (Method of moment*)

Sample	Mean	std dev.	skewness	kurtosis
AC1	0.37	0.351	2.205	7.469
AC2	0.487	0.356	1.783	5.73
AC3	0.504	0.401	1.441	4.282
AC4	0.501	0.4	1.321	3.189
AC5	0.307	0.365	2.532	8.423
AC6	0.641	0.464	0.969	2.661
AC7	0.363	0.205	2.834	16.667
AC8	0.327	0.322	2.478	9.135
AC9	0.302	0.252	2.542	12.451
AC10	0.618	0.307	3.414	13.285
AC11	0.44	0.305	1.915	7.78
AC12	0.529	0.479	0.975	2.708

Sample	Mean	std dev	skewness	kurtosis
Pb1	0.562	0.529	0.885	2.284
Pb2	0.825	0.427	0.611	1.974
Pb3	0.353	0.361	2.107	8.547
Pb4	0.462	0.475	1.453	3.465

Sample	Mean	std dev	skewness	kurtosis
MN1	0.344	0.404	5.194	6.2102
MN2	0.301	0.352	3.292	7.752
MN3	0.403	0.466	1.602	4.338
MN4	0.308	0.339	2.642	9.452

* Krumbein, W. C. and Pettijohn, F. J. 1938 Manual of Sedimentary petrography, Appleton-Century - Crofts, NewYork.

skewed in down stream, due high rate of physical weathering in down stream. The Manimala river basin also sediment grains are very coarse skewed.

In the Achankovil river basin sediment grains are leptokurtic in down stream tovery leptokurtic in middle stream and mesokurtic in down stream. While in the Manimala river sediment grains distribution are very leptokurtic. The Pamba river grains distribution are platykurtic to leptokurtic up to down a stream respectively (table 4.1).

4.1.2 MINERALOGY OF SURFACE SEDIMENTS

Almost all three river i.e. the Achankovil, the Pamba and the Manimala river surface sediment shows very high percentage of quartz. In the Achankovil concentration of quartz ranges from 60.51 to 82.88 % except Pandalom, Thumpavan and Ambakolar i.e. 36.57, 21.58 and 35.25 % shows lower because of high concentration of K-feldspar in these region. Quartz in surface sediment of Pamba ranges from 24.37 to 82.88 % and in the Manimala river ranges from 17.94 to 50.08 (Table 4.2). As we move from up to down stream concentration of clay mineral like chlorite and mica increases, shows weathering rate is more in down stream.

4.1.3 CARBON, SULPHUR AND NITROGEN

The Total carbon in Achankovil is moderately increasing as we move from upstream to down stream (Table 4.3). This shows that a high organic load predominantly in down stream i.e .in estuary of Achankovil. Almost similar trend observed in case of inorganic and organic carbon. Organic carbon is more than

Table 4.2 Mineral composition of river surface sediments (all in %)

Sample	Quartz	Orthoclase	Plagioclase	Muscovite	Biotite	Chlorite	Microcline	Fluroapatite
AC1	60.51	14.65	9.39	4.05	4.05	1.51	3.92	1.91
AC2	63.55	4.65	14.91	3.47	4.73	ND	7.77	0.9
AC3	36.57	37.94	3.97	2.86	2.1	2.9	10.51	1.56
AC4	21.58	10.97	46.47	6.09	6.09	3.03	3.24	2.51
AC5	35.25	27.78	21.49	1.91	2.42	2.22	5.3	3.62
AC6	82.41	5.18	2.31	1.65	2.84	1.41	4.23	ND
AC7	81.68	3.23	ND	ND	3.86	ND	11.23	ND
AC8	63.96	18.34	1.38	5.18	4.89	1.53	6.98	0.76
AC9	72.03	4.2	ND	8.97	3.44	3.14	4.3	3.93
AC10	64.99	5.31	6.87	3.91	2.53	5.28	7.38	3.25
AC11	78.02	3.5	7.36	3.5	4.84	1.03	3.5	ND
AC12	72.81	6.24	3.56	4.56	3.1	2.99	ND	3.1

Sample	Quartz	Orthoclase	Plagioclase	Muscovite	Biotite	Chlorite	Microcline	Fluroapatite
PB1	44.97	14.99	16.94	ND	5.89	5.87	6.06	5.47
PB2	82.88	9.1	3.33	ND	3.57	1.14	ND	ND
PB3	56.44	21.17	3.92	2.12	3.18	1.91	2.3	3.49
PB4	58.23	11.69	2.6	14.39	2.16	4.15	6.78	ND

Sample	Quartz	Orthoclase	Plagioclase	Muscovite	Biotite	Chlorite	Microcline	Fluroapatite
MN1	24.37	25.33	15.39	2.94	6.41	7.78	4.49	2.94
MN2	17.94	28.43	25.14	4.85	9.94	4.85	4.84	3.99
MN3	49.88	12.57	7.68	5.24	6.29	7.69	6.3	4.19
MN4	50.08	4.23	14.03	5.75	2.75	2.3	13.63	1.87

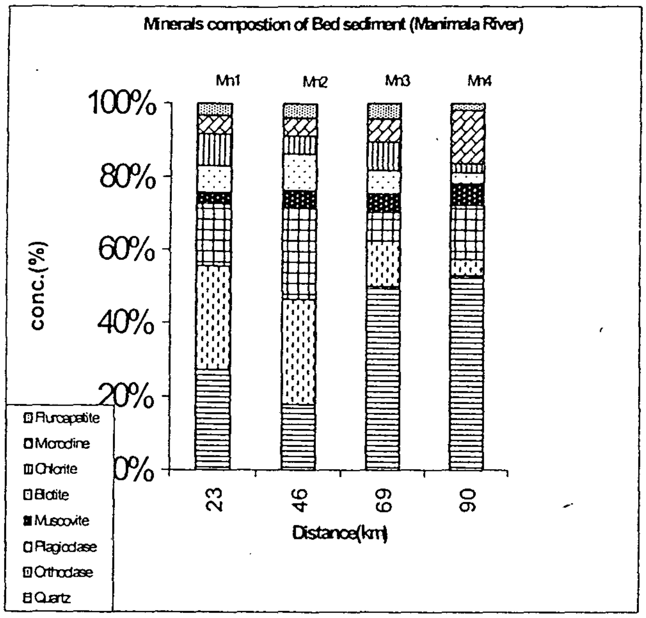


Fig 4.1 Mineral distribution in the Manimala river basin

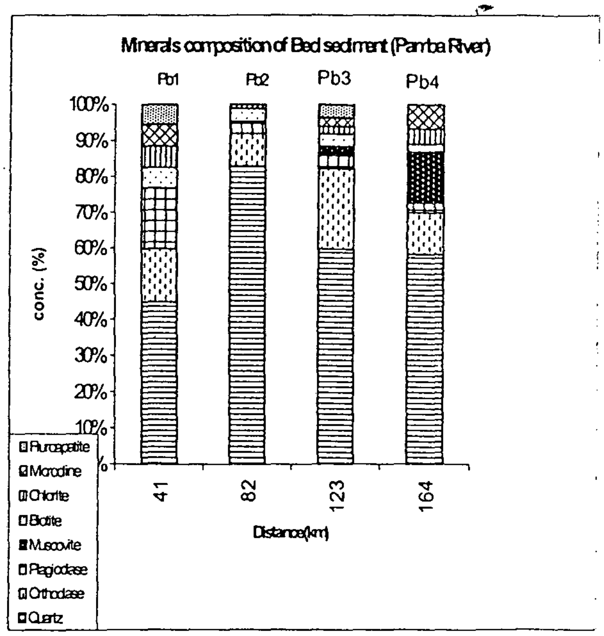


Fig 4.2 Mineral distribution in the Pamba river

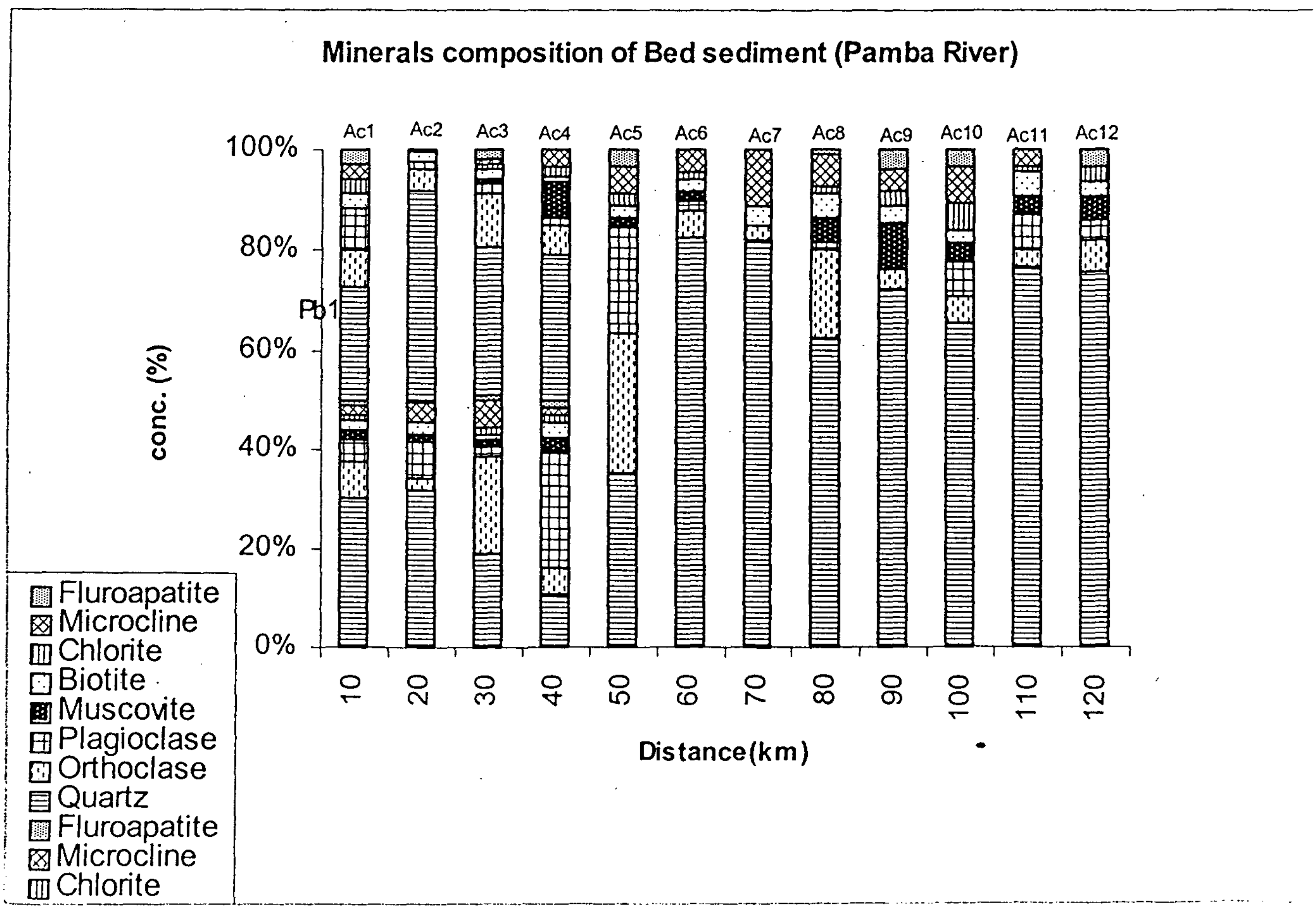


Fig 4.3 Mineral distribution in the Achankovil river Basin

Table 4.3 Biogeochemical Characteristics of Bed Sediments (all in %,except C/N)
Achankovil

Sample No.	TC	IC	OC	TS	IS	OS	TN	C/N
AC1	0.58	0.22	0.35	ND	ND	ND	0.3	0.22
AC2	0.29	0.18	0.11	ND	ND	ND	0.33	1.04
AC3	0.68	0.08	0.60	ND	ND	ND	0.31	2.53
AC4	0.54	0.02	0.52	ND	ND	ND	0.26	2.38
AC5	0.27	0.09	0.17	ND	ND	ND	0.11	2.70
AC6	0.64	0.03	0.61	ND	ND	ND	0.29	3.14
AC7	0.20	0.06	0.13	ND	ND	ND	0.06	3.10
AC8	1.63	0.20	1.42	0.07	0.041	0.03	0.31	6.01
AC9	3.17	0.83	2.34	0.04	0.02	0.01	0.5	7.40
AC10	0.45	0.11	0.33	ND	ND	ND	0.13	3.95
AC11	0.11	0.09	0.02	ND	ND	ND	0.08	1.45
AC12	1.15	0.39	0.76	ND	ND	ND	0.23	4.94

Pamba River ND= not detcted

Sample	TC	IC	OC	TS	IS	OS	TN	C/N
Pb1	0.40	0.18	0.21	ND	ND	ND	0.28	1.66
Pb2	0.34	0.17	0.17	ND	ND	ND	0.26	1.51
Pb3	0.61	0.07	0.53	ND	ND	ND	0.21	3.29
Pb4	0.49	0.10	0.39	ND	ND	ND	0.216	2.68

Manimala River

Sample	TC	IC	OC	TS	IS	OS	TN	C/N
MN1	1.07	0.22	0.85	0.02	0.006	0.013	0.38	3.26
MN2	0.90	0.25	0.65	0.03	0.003	0.026	0.46	2.25
MN3	1.49	0.33	1.15	0.01	0.004	0.006	0.38	4.54
MN4	1.25	0.13	1.12	0.03	0.02	0.01	0.33	4.40

TC= Total Carbon, IC=Inorganic Carbon, OC= Organic Carbon
C/N= Carbon/Nitrogen ratio, TS= Total Sulphur, IS=inorrganic Sulphur
TN=Total Nitrogen, OS= Organic sulphur, ND=not determined,

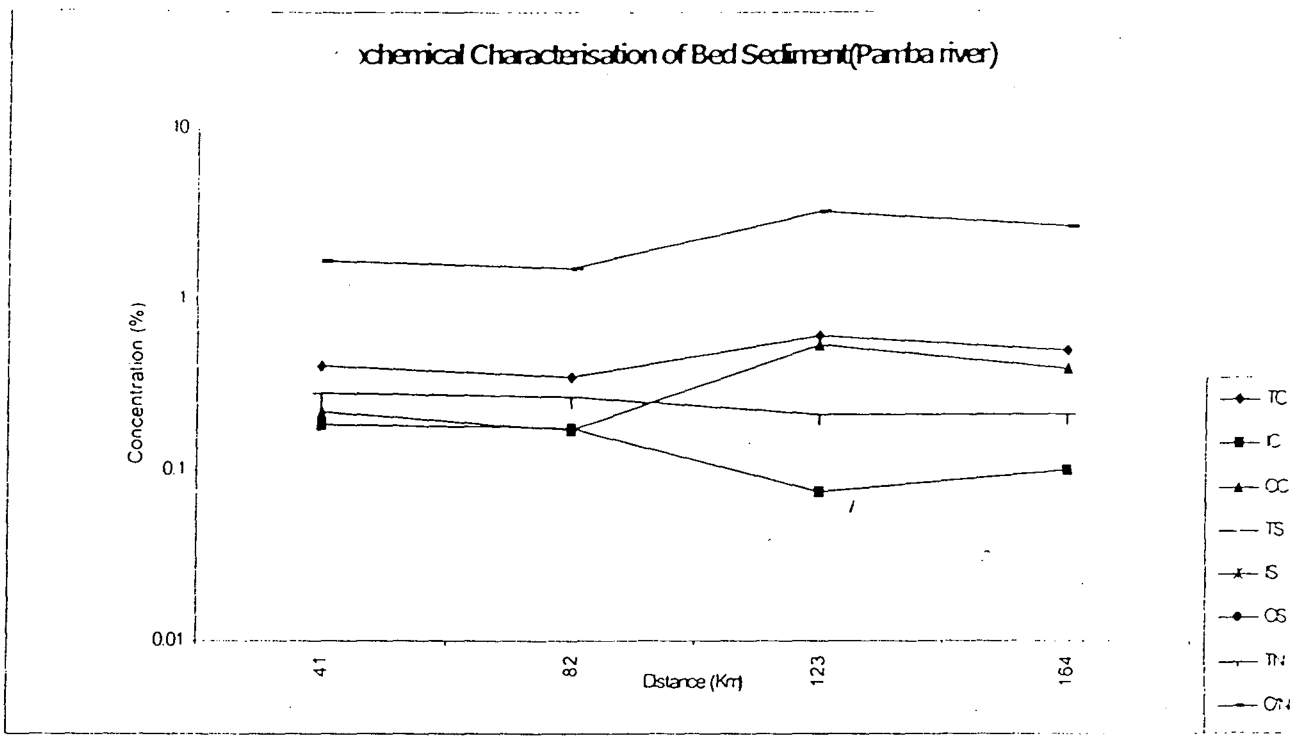


Fig 4.5 Biogeochemical characteristics of the Pamba river basin.

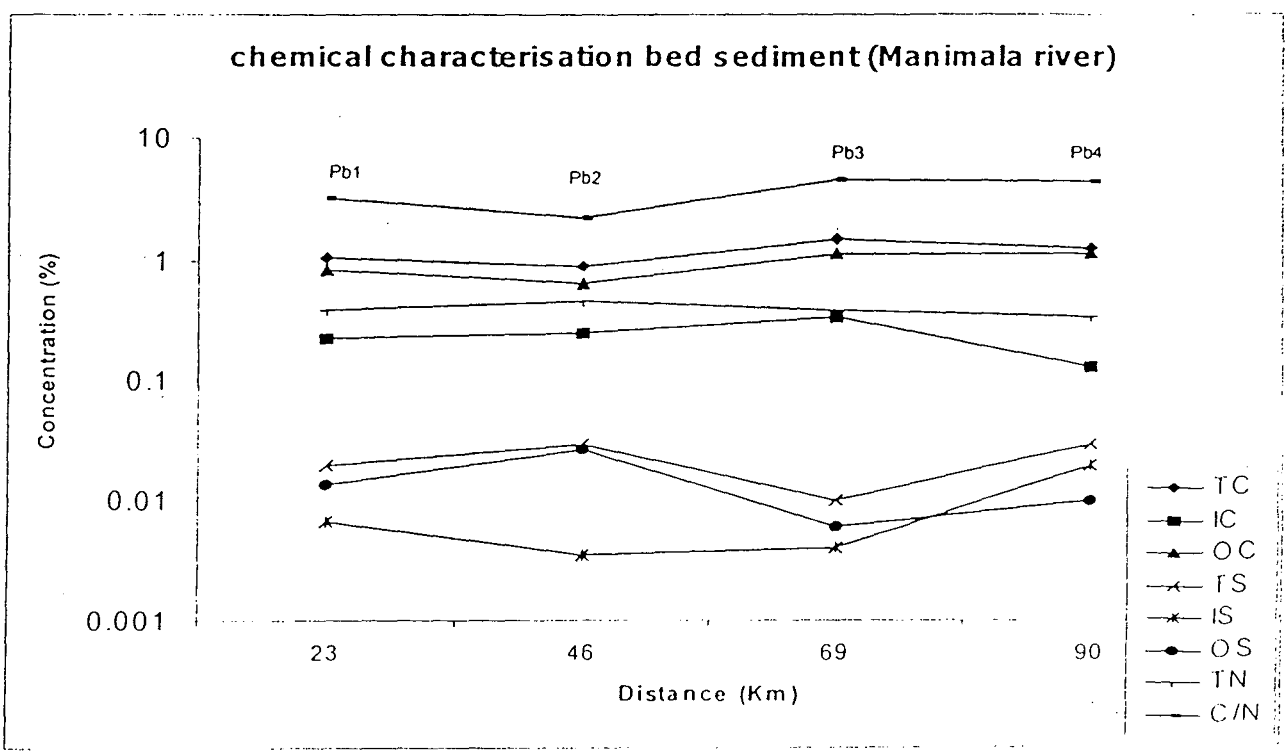


Fig 4.5 Biogeochemical characteristics of the Manimala river Basin.

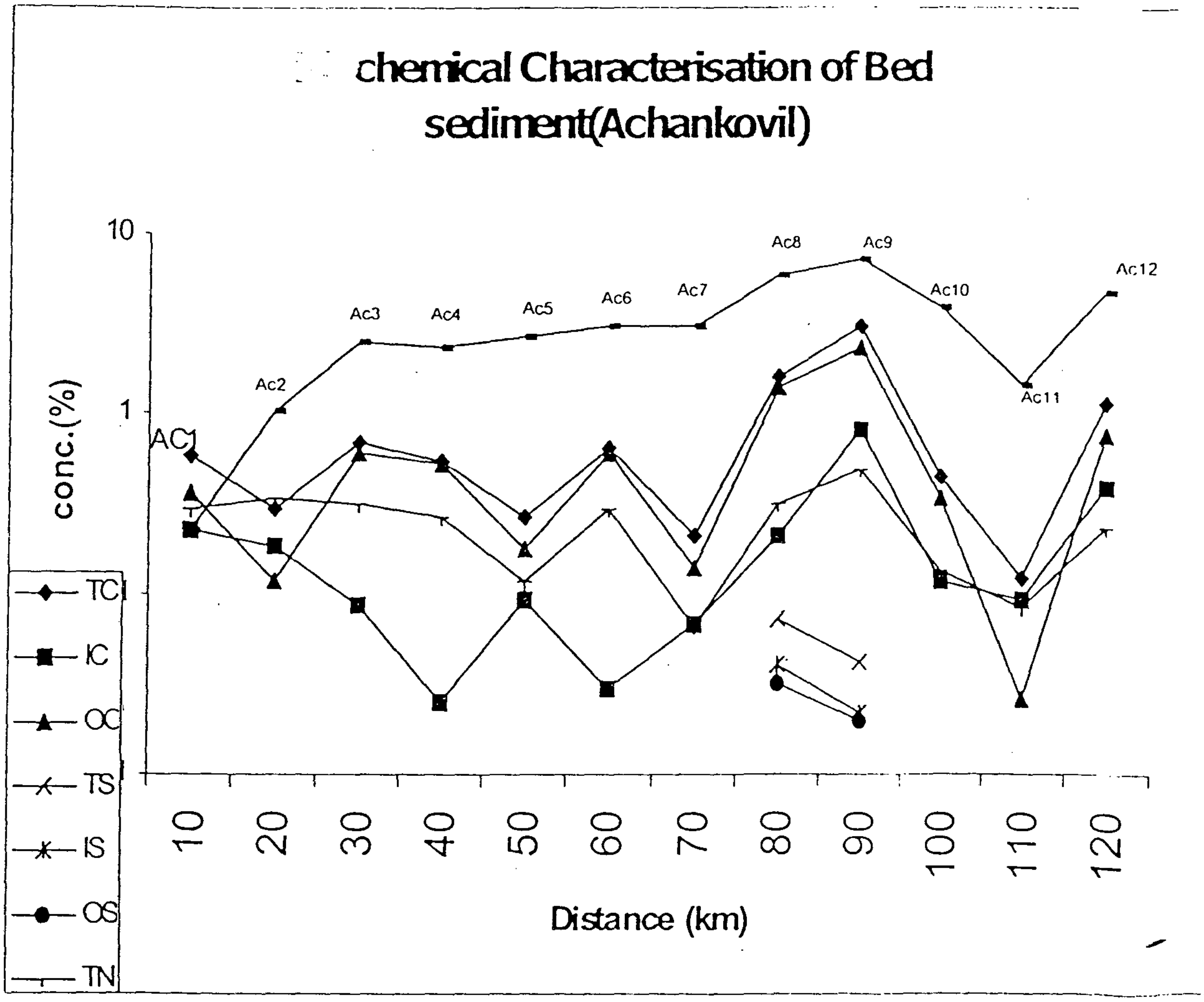


Fig 4.6 Biogeochemical characteristics of the Achankovil river basin.

inorganic carbon because there are no major anthropogenic sources for inorganic carbon, while organic input from forest resources. A high value of carbon, sulphur and nitrogen was obtained in Haripada II, due to dumping of city sewage and other effluent in such small river, which increases the percentage of carbon, nitrogen and sulphur than a normal value. The river Manimala and Pamba also shows a steady increase of carbon up to down stream. The river Manimala have a much much more organic load than the river Achankovil and the river Pamba (Table 4.3)

In Achankovil sulphur is below detectable level except in Haripada. Manimala shows a considerable value of sulphur. No sulphur is detected in the river Pamba. Total nitrogen in the river Pamba and the river Manimala remains almost constant up to down stream.

4.1.4 CARBON / NITROGEN RATIO

In the Achankovil river basin Carbon/Nitrogen ratio increases as we move up to down stream.. C/N ratio ranges from 0.23 in up stream to 7.40 in middle and 4.95 in down stream., while in the river basin of the Pamba 1.67 in up stream to 2.69 in down stream. In the river basin of Manimala C/N ratio ranges from 3.27 in up to 4.41 in down stream(Table 4.3).

4.1.5 SILICON AND ALUMINIUM

Silica concentration in surface sediments of the Achankovil ranges from 20.86 to 35.00 %, the Pamba river ranged from 8.10 to 19.83 % and the Manimala river ranged from27.07 to 32.59 %(Table 4.5)These values are higher in the Achankovil (avg. 28.48 %) and the Manimala (avg. 28.97 %) but lesser in the

Table 4.4 Comparison of observed concentrations elements in USGS rocks and Canadian soil standards w ith published data(all µg/g)

Rocks/soil	Results	AL	Si	Ca	Mg	Fe	Cu	Na	K	Mn
SO I	Pub.	93800		18000		60000	61	17000		
	Ob.	90141		18650		54987	62	16481		
SO2	Pub.		249900	19600	5400	55600			24500	720
	Ob.		253640	22200	5340	54760			24091	714
SO3	Pub.	30500	156800				17	7000	11600	
	Ob.	29700	145741				14	8200	12105	
SO4	Pub.	54600	319700		23700		22	1000	17300	
	Ob.	57440	299870		23516		21	10025	17900	

Table 4.5 Geochemical Composition of Bed sediment (Cu and Pb in µg/g and others in %)

Sample	Si	Al	Na	K	Ca	Mg	Fe	Mn	Cu	Pb
AC1	20.86	4.84	1.83	1.20	5.16	0.36	5.17	0.12	36.59	31.86
AC2	31.90	1.16	1.75	0.27	1.05	2.32	2.33	0.28	32.33	17.29
AC3	29.48	7.02	1.77	1.51	1.76	1.73	2.30	0.28	30.33	48.86
AC4	30.52	5.55	1.72	1.66	0.83	1.08	5.22	0.10	16.71	27.00
AC5	25.69	10.53	1.68	1.43	0.63	2.27	4.70	0.16	36.05	24.57
AC6	12.59	2.76	1.72	1.53	3.96	0.89	6.34	0.19	35.25	34.29
AC7	30.52	7.78	1.56	1.70	2.92	ND	1.71	0.04	18.26	7.57
AC8	33.62	7.02	1.73	0.71	1.56	1.67	6.23	0.08	15.68	22.14
AC9	24.31	1.30	2.17	1.14	1.37	1.71	5.46	0.10	18.78	24.57
AC10	35.00	8.50	1.87	0.27	1.25	1.47	1.17	0.15	11.02	12.43
AC11	34.31	9.24	1.66	1.47	1.44	0.94	2.25	0.03	15.16	14.86
AC12	32.93	9.23	1.45	1.79	1.39	1.55	3.91	0.03	41.53	12.43

Pamba River

Sample	Si	Al	Na	K	Ca	Mg	Fe	Mn	Cu	Pb
PB1	19.83	4.79	1.89	1.73	2.88	1.35	5.29	0.04	19.30	19.71
PB2	13.28	2.46	1.85	1.46	0.94	ND	0.43	0.08	13.09	112.00
PB3	10.52	2.57	1.76	1.14	3.56	1.76	3.52	0.03	14.13	7.57
PB4	8.10	2.95	1.61	1.31	3.40	2.03	4.52	0.05	26.54	-2.14

Manimala River

Sample	Si	Al	Na	K	Ca	Mg	Fe	Mn	Cu	Pb
MN1	32.59	5.09	1.95	1.61	0.89	1.36	5.40	0.04	17.23	2.71
MN2	28.79	6.29	1.84	1.86	4.20	1.58	5.53	0.04	14.13	12.43
MN3	27.07	6.61	1.80	1.57	5.63	1.35	4.83	0.03	50.84	19.71
MN4	27.41	6.60	1.89	0.99	5.20	1.44	4.43	0.04	49.29	5.14

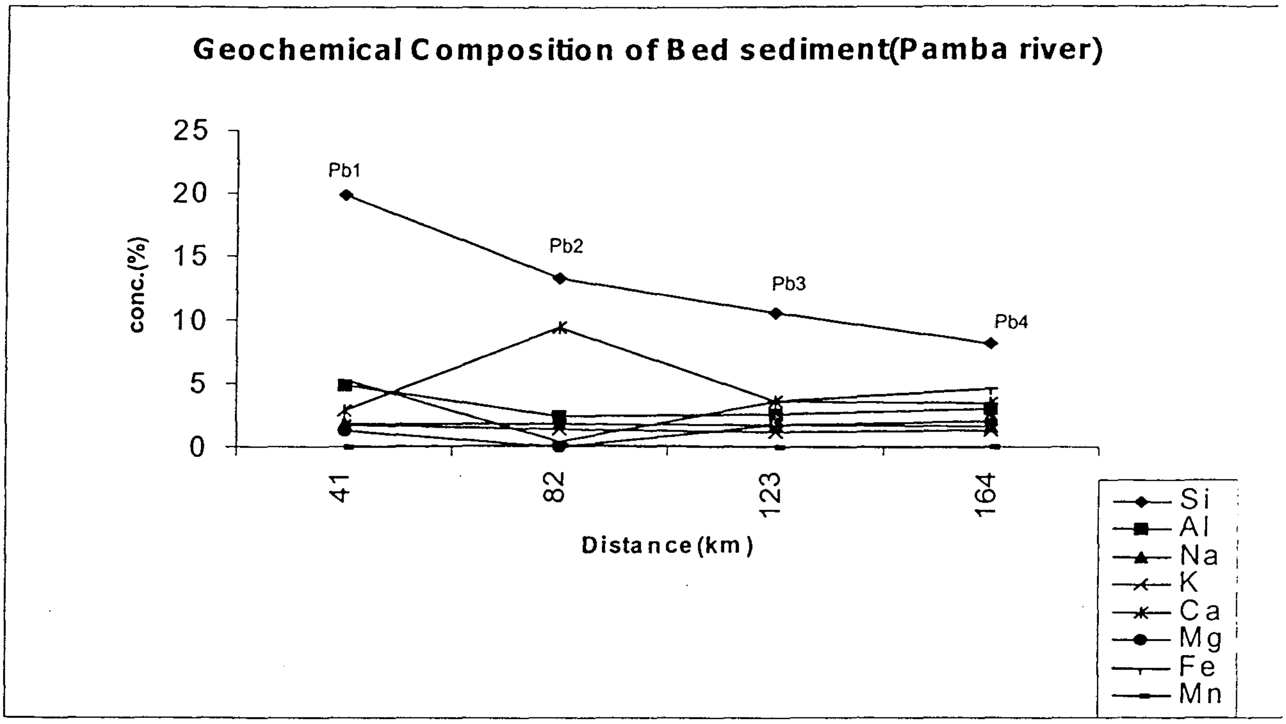


Fig 4.7 Major element distribution in the Pamba river basin

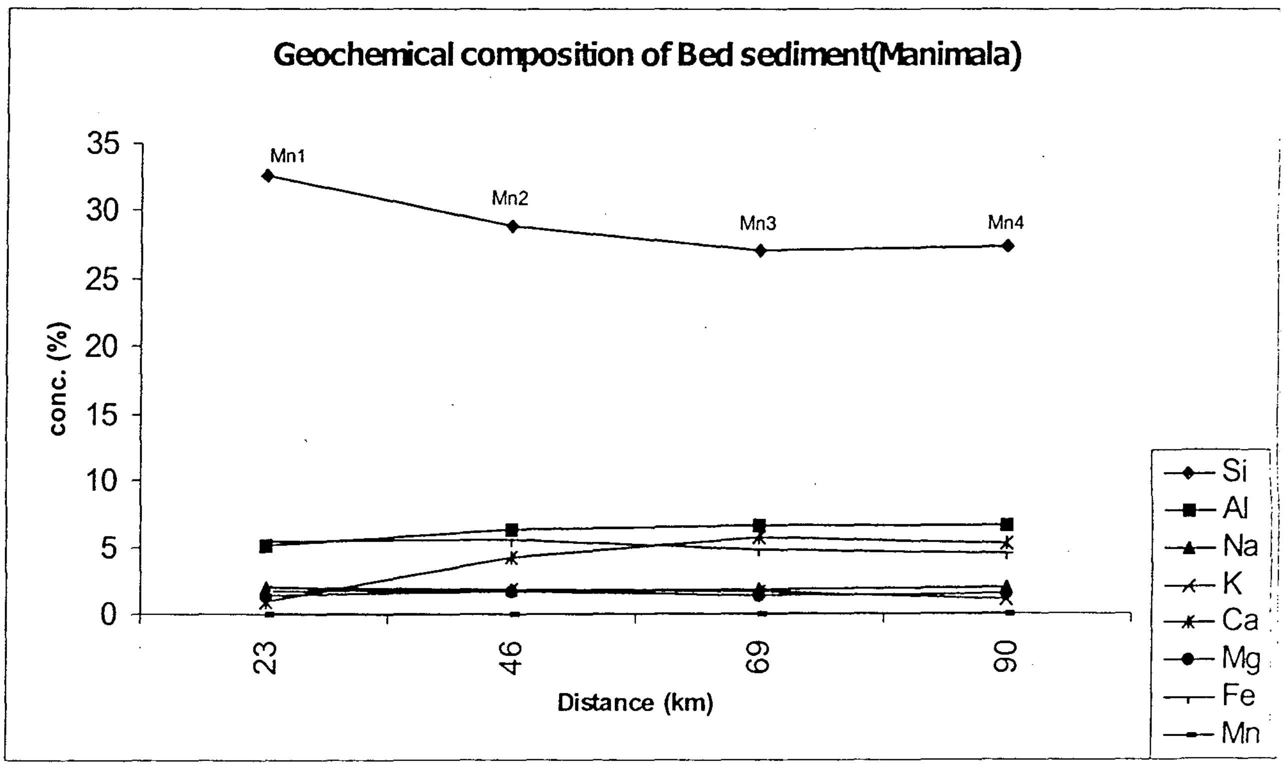


Fig 4.8 Major element distribution in the Manimala river Basin.

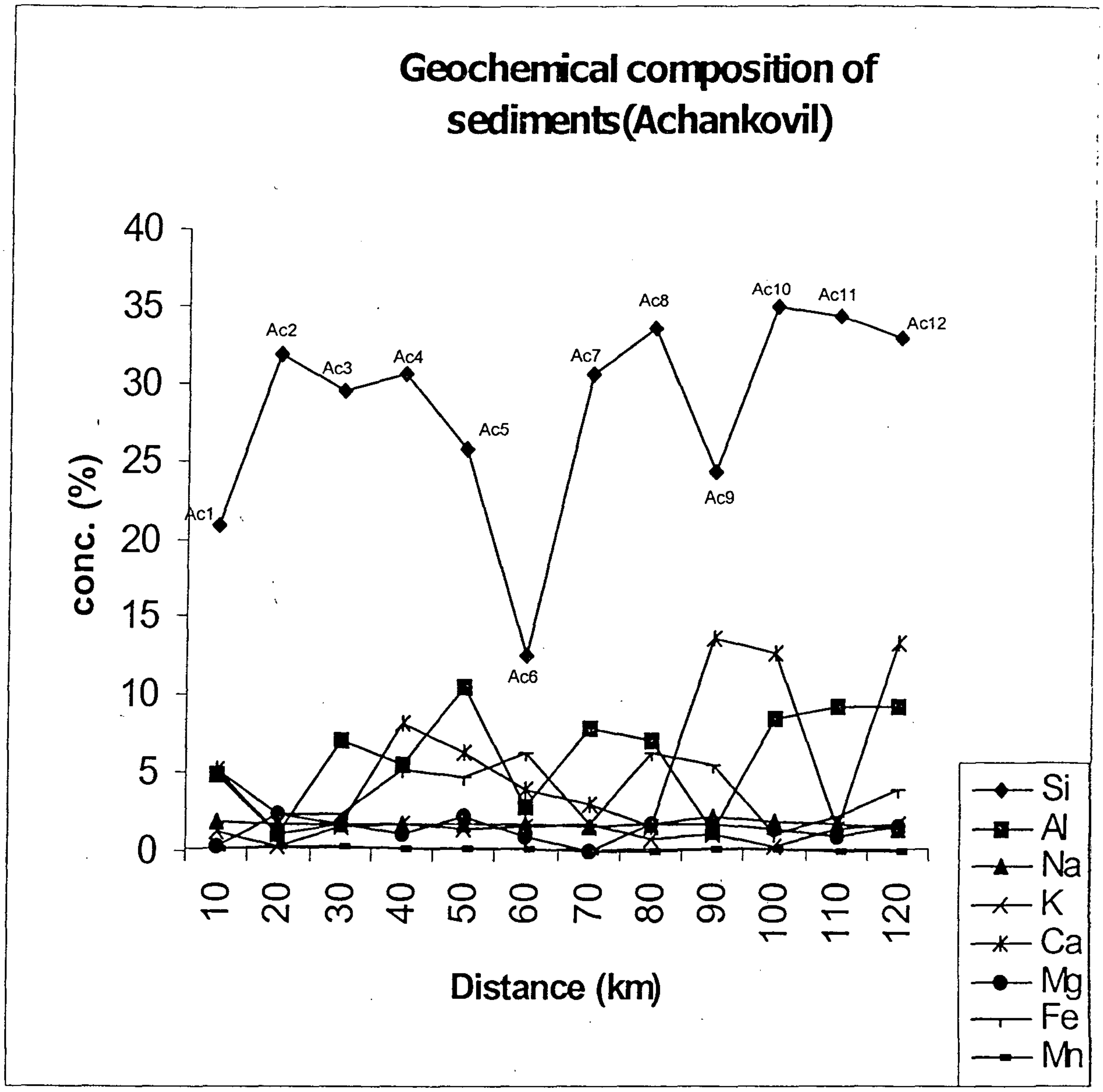


Fig 4.9 Major element distribution in the Achankovil river basin

Table 4.6: Comparative value of chemical composition of surface sediments in Indian rivers (Mn, P & Cu in µg/g, all others in %)

Elements	Achankovil *	Pamba*	Manimala*	Cauvery**	Krishana	Godavari ***	Mahanadi****	Ganga=	Brahmputra=	Indian(avg.)	Bay of Bengal+	World(avg.)
Si	28.48	12.93	28.97	27.2	26.3	27	11.94	31.2	28.4	24.5	-	28.5
Al	6.24	3.19	6.15	6.5	3.38	4.78	6.22	4.66	5.6	5	7.6	9.4
Fe	3.9	3.44	5.05	1.6	2.5	6	5.61	2.2	2.9	2.9	3.9	4.8
Mg	1.45	1.71	1.43	0.5	1.3	1.15	1.1	1.32	1.66	1.47	1.43	1.18
Ca	1.94	2.69	4.09	1.5	5.34	3.81	1.36	2.34	1.93	2.46	1.98	2.15
Na	1.74	1.77	1.87	2.4	5.56	-	-	-	-	-	-	0.71
K	1.22	1.41	1.51	0.8	3.82	1.02		1.33	1.24	1.21	-	1.42
Mn	-	-	-	655	906	1060	2020	400	644	605	529	1050
P	-	-	-	1255	774	-	-	-	-	-	-	170
Pb	23.15	34.83	9.99	-	-	-	-	-	-	-	-	-
Cu	27.14	18.27	32.87	39	35	73	57	21	17		28.26	100

* present study **Ramanathan &Subramanian (1996) *** Bikshan&Subramanian (1988) ****Chakrapani&Subramanian (1990)
+Datta, D.K. and others in thesis submitted in J.N.U. (Bajpayee) (2002)

Pamba (avg. 12.936 %) river surface sediment than average for the Indian river (avg. 24.5 %)(Table 4.6). This is due to dominance of quartz in surface bed load.

Aluminium content in the surface sediment of the Achankovil river ranged from 1.16 to 10.53 %, the Pamba river ranged from 2.57 to 4.79 % and the Manimala river ranged from 5.09 to 6.60 (Table 4.5). Which are lower in the Achankovil (avg. 3.90 %), the Pamba (avg. 3.44 %) and higher in Manimala than Indian river (5.00 %) but all three rivers shows lower aluminium concentration than the World river (avg. 9.40 %) surface sediment (Table 4.6). These indicate that most of sediments are derived from quartz rich components as orthoquartizites in the drainage basin. The low aluminium content in the sediments also indicates low amount of clay minerals and hence dominance of sand in sediments.

Aluminium shows a good correlation (0.61) with silica (Table 4.7), indicating that, as K-feldspar is one of the important minerals with sodium rich in this river basin. Silica shows a negative correlation with all elements except Mg and Mn due to variable dilution of other mineral and abundance by quartz in the bed load.

4.1.6 SODIUM AND POTASSIUM

Sodium content in the surface sediment of the Achankovil river ranged from 1.66 to 2.17 %, the Pamba river ranged from 1.61 to 1.89 % and the Manimala river ranged1.80 to 1.89 % (Table 4.3). Potassium content in surface sediment of the Achankovil river ranged from 0.27 to 1.79 %, the Pamba river ranged from 1.31 to 1.73 % and the Manimala river ranged from 0.99 to 1.86 % (Table 4.5). Al and K shows good correlation, indicating that they are both derived

Table 4.7 Correlation matrix of suface sediment

	Si	Al	Na	K	Ca	Mg	Fe	Mn	Cu	Pb
Si	1.00									
Al	0.61	1.00								
Na	-0.05	-0.45	1.00							
K	-0.16	0.20	-0.23	1.00						
Ca	0.04	0.06	0.16	-0.05	1.00					
Mg	0.10	-0.01	0.04	-0.35	-0.07	1.00				
Fe	-0.12	-0.11	0.19	0.25	-0.12	0.27	1.00			
Mn	0.10	-0.16	0.05	-0.42	-0.10	0.28	-0.19	1.00		
Cu	-0.02	0.14	-0.20	0.06	0.02	0.18	0.24	0.15	1.00	
Pb	-0.27	-0.23	0.17	0.10	0.21	-0.46	-0.36	0.28	-0.12	1.00

from weathering of rock in catchment and also dominance of K-feldspar in the sediment.

4.1.7 MAGNESIUM AND CALCIUM

The Ca in the surface sediments of the of the Achankovil river ranged from 1.05 to 8.23 %, the Pamba river ranged from 0.94 to 3.56 % and the Manimala river ranged 0.89 to 5.63 % (Table 4.5). Which are higher in the Pamba (avg. 2.69 %), the Manimala (avg. 4.09 %) and lower in the Achankovil (avg. 1.94 %) than the Indian river (avg. 2.46 %) and World river (avg. 2.15 %)(Table 4.6).

Magnesium content in surface sediment of the Achankovil river ranged from 0.36 to 2.27 %, the Pamba river ranged from 1.35 to 2.03 % and the Manimala river ranged from 1.35 to 1.58 % (table 4.5) which are same in the Achankovil (avg. 1.45 %), the Manimala (avg. 1.43 %) and higher in the Pamba (avg. 1.71 %) than the Indian river (avg. 1.45%)(Table 4.6).

Negative correlation is observed in Ca and Mg. Higher concentration of calcium in certain location can be due to the presence of calcareous organism in the sediment and also the presence of limestone and dolomite patches in the catchment.

4.1.8 IRON AND MANGANESE

Iron content in surface sediment of the of the Achankovil river ranged from 1.17 to 6.34 %, the Pamba river ranged from 0.43 to 5.40 % and the Manimala river ranged 4.43 to 5.53 % (Table 4.5). Which are higher in the Pamba (avg. 3.44 %), the Manimala (avg. 5.05 %) and in the Achankovil (avg. 3.90 %) than the

Indian River (avg. 2.90%)(Table 4.6) due to contribution of lateritic terrain weathering.

Manganese content in surface sediment of the Achankovil river ranged from 0.03to 0.28 %, the Pamba river ranged from 0.04 to 0.08 % and the Manimala river ranged from 0.03 to 0.04 % (table 4.5). Higher percentage of Iron in river sediment can be due to presence of lateritic patches in the catchment and also the presence of mineral as pyrite or ironhydroxide in the system.

4.1.9 LEAD AND COPPER

Copper in surface sediment of the Achankovil ranges from 11.02 to 41.53 µg/g, in the Pamba ranges from 13.09 to 26.54 µg/g and in the Manimala ranges from 14.13 to 50.84 µg/g. Which are higher in the Manimala (avg. 32.87 µg/g), and lower in the Achankovil (avg. 26.95 µg/g), in the Pamba (18.25) than Bay of Bengal (avg. 28.26)(Table 4.6).

4.1.10 METAL/ALUMINIUM RATIO :-

Elemental mobility in the zone of weathering results from the break down of primary minerals . Al is considered to be immobile during weathering while Ca ,Na ,K ,Si ,Mg ,and P are very mobile. The mobile elements are derived from leachable mineral in the rocks as plagioclase feldspar, micas and apatite .

Al is used to normalize elements of sediments in aquatic system because it is an non conservative elements (Window et al., 1989) .It is also am major element and chemically unreactive constituent of clay minerals. By comparing elements/Al ratio , it is possible to determine if a given metals is enriched or depleted relative to

TABLE 4.8 Element-aluminum ratio of surface sediment

The Achankovil river

Sample No	Si/Al	Na/AL	K/Al	Ca/AL	Mg/Al	Fe/Al	Mn/Al
AC1	4.31	0.38	0.25	1.07	0.07	1.07	0.02
AC2	27.51	1.51	0.23	0.90	2.00	2.01	0.24
AC3	4.20	0.25	0.21	0.25	0.25	0.33	0.04
AC4	5.50	0.31	0.30	1.48	0.20	0.94	0.02
AC5	2.44	0.16	0.14	0.59	0.22	0.45	0.01
AC6	4.56	0.62	0.56	1.43	0.32	2.30	0.07
AC7	3.92	0.20	0.22	0.38	0.00	0.22	0.01
AC8	4.79	0.25	0.10	0.22	0.24	0.89	0.01
AC9	18.74	1.67	0.88	10.56	1.32	4.21	0.07
AC10	4.12	0.22	0.03	1.49	0.17	0.14	0.02
AC11	3.72	0.18	0.16	0.16	0.10	0.24	0.00
AC12	3.57	0.16	0.19	1.45	0.17	0.42	0.00

The Pamba river

Sample No	Si/Al	Na/AL	K/Al	Ca/AL	Mg/Al	Fe/Al	Mn/Al
PB1	4.14	0.39	0.36	0.60	0.28	1.11	0.01
PB2	5.40	0.75	0.60	3.82	0.00	0.18	0.03
PB3	4.10	0.68	0.44	1.39	0.69	1.37	0.01
PB4	2.75	0.55	0.44	1.15	0.69	1.53	0.02

The Manimala river

Sample No	Si/Al	Na/AL	K/Al	Ca/AL	Mg/Al	Fe/Al	Mn/Al
MN1	6.40	0.38	0.32	0.17	0.27	1.06	0.01
MN2	4.58	0.29	0.30	0.67	0.25	0.88	0.01
MN3	4.10	0.27	0.24	0.85	0.20	0.73	0.01
MN4	4.16	0.29	0.15	0.79	0.22	0.67	0.01

the terrigenous matter and hence the mobility of the element (Sholkovity and Price, 1980). The metal / Al ratio are independent of variation due to the presence of biogenic materials in the sediments.

The Metal / Al ratio for the surface sediments of three Kerala river as given in table 4.8. Silica is a major elements in the earth crust and forms a part of all rocks. Bostram et al . (1972) contented that Si / Al ratio ~ 3 , when the alumino-silicate ,sediments serves as main source. Higher Si / Al ratio encountered in sediments contain excess amount of silica derived either from detrital Quartz or biogenic sources. The Si / Al ratio of surface sediments of the Achankovil ranges from 3.57 to 5.50 except Pandolam and Haripoda shows exceptionaly high value i.e. 27.51 and 18.74 respectively(Table 4.8). In surface sediments of the Pamba river Si/Al ratio ranges from 2.75 to 5.40 and in the Manimala ranges from 4.10 to 6.40 which are larger than standard 3 (Bostram et al, 1972), indicating to the dominance of Quartz in the system and depleted aluminum source lithology. Hence higher mobility of silica in the aquatic system.

Iron is next abundant element in the sediments. It occurs as mineral- oxide, hydroxide and sulphides as well as associated with silicates. Fe/Al ratio in surface sediment of the Achankovil river is ranges from 0.22 to 2.30 while Haripada shows very high value i.e. 4.21. The average value of iron/aluminum in the Achankovil, the Pamba and the Manimala are 1.10, 1.05 and 0.84 indicating that iron is just as immobile as Al in the system . Higher value in certain locations can be due to presence of mineral oxide of iron. All the other Elements/Al ratio indicates that these elements are quite mobile in the aquatic system and are transported fast from system. When individual river are considered they all show similar trend in elements /Al ratio despite the variation in their absolute values. Highest variation in the ratio, this is due to the presence of different amount of quartz and sands in river.

4.1.11 CHEMICAL INDEX OF ALTERATION (CIA)

Nesbitt and Young (1982) have derived a weathering index called Chemical Index of Alteration (CIA) in molecular proportions.

$$CIA = 100 \times \left(\frac{Al_2O_3}{Al_2O_3 + CaO + Na_2O + K_2O} \right)$$

The average upper crust has a CIA value of about 47 (McLeennan, 1993), CIA value of 45 to 55 indicate in essence weathering. For individual clay minerals Kaolinite, Chlorite, Gibbsite have CIA value 100. Where as smectite and illite have values in the 70-80 range. Primary minerals have much lower value of CIA (Nesbitt and Young, 1997). It follows that the proportion of clay minerals and primary minerals in a bulk samples will introduce substantial variation in the resulting CIA values. In table CIA value calculated of sediments of the Achankovil, the Manimal and the Pamba as calculated value shown in table 4.9.

The CIA for the Achankovil river ranges from 28.21 to 77.66, for the Pamba ranges from 29.45 to 60.61 and for the Manimala ranges from 52.78 to 66.31 (Table 4.9). A normal increase in CIA value of the Achankovil from up stream to down stream shows weathering increases from up to down stream in river. All three river shows similar trend as like the Achankovil. Most of the sample following in the range of 40-60 indicating very low weathering.

Table 4.9 Chemical Index Alteration (CIA) of surface sediment

Sample	Na2O	K2O	CaO	MgO	SiO2	Al2O3	Fe2O3	MnO	CIA
ACI	2.46	1.44	7.22	0.6	43.11	9.14	7.42	0.154	45.08
AC2	2.35	0.32	1.47	3.86	65.92	2.19	3.34	0.36	34.53
AC3	2.38	1.81	2.46	2.88	60.92	13.26	3.30	1.03	66.53
AC4	2.31	2.00	11.52	1.8	63.07	10.48	7.49	0.12	39.82
AC5	2.26	1.72	8.72	3.78	53.09	19.89	6.75	0.20	61.01
AC6	2.31	1.84	5.54	1.48	26.01	5.21	9.10	0.24	34.94
AC7	2.10	2.04	4.08	0	63.07	14.69	2.45	0.05	64.07
AC8	2.33	0.85	2.18	2.78	69.48	13.26	8.94	0.10	71.17
AC9	2.92	1.37	1.91	2.85	50.24	2.45	7.84	0.12	28.31
AC10	2.52	0.32	1.77	2.45	72.33	16.05	1.68	0.19	77.66
AC11	2.23	1.77	2.01	1.56	70.90	17.45	3.23	0.03	74.33
AC12	1.95	2.15	1.87	2.58	68.05	17.43	5.61	0.03	74.43

Sample	Na2O	K2O	CaO	MgO	SiO2	Al2O3	Fe2O3	MnO	CIA
MN1	2.62	1.94	4.03	2.26	67.35	9.61	7.75	0.05	52.78
MN2	2.48	2.24	1.31	2.63	59.49	11.88	7.94	0.05	66.30
MN3	2.42	1.89	4.98	2.25	55.94	12.48	6.93	0.03	57.30
MN4	2.54	1.19	4.76	2.4	56.64	12.46	6.36	0.05	59.45

Sample	Na2O	K2O	CaO	MgO	SiO2	Al2O3	Fe2O3	MnO	CIA
Pb1	2.54	2.08	1.24	2.25	40.98	9.04	7.59	0.05	60.61
Pb2	2.49	1.75	5.88	0	27.44	4.64	0.61	0.10	31.43
Pb3	2.37	1.37	7.88	2.93	21.74	4.85	5.056	0.03	29.45
Pb4	2.17	1.57	7.28	3.38	16.74	5.57	6.49	0.06	33.56

CHAPTER 5

CORE SEDIMENTS

CHAPTER 5

CORE SEDIMENT

To study the process of sedimentation and metal accumulation in river basin, it is very important to know more about geochemistry of layered sediments. Geochemistry of layered sediment give us an idea about the different natural basic process going in the environment. Since river play a dominant role in weathering and erosion of land masses. The sediments carried by rivers are responsible for flooding, and create a need for maintenance of in-channel structures and navigation systems. Most important of all, the sediment particles absorb many contaminants, such as pesticides, radionuclides and toxic metals, that are transported, deposited and stored as part of sedimentary component of the river system (Milliman and Parker,1985).

5.1 RESULT AND DISCUSSION

5.1.1 UPSTREAM (Mavelikara)

5.1.1.1 GRAIN SIZE DISTRIBUTION

The grains distribution in core sediment (Mavelikara) is well sorted with surface of core. The statistical calculation was done by method of moments (Krumbein & Pettijohn 1938,Swan et al. 1979 and text book of RLLindholm. Core sediments grains are coarse skewed at the top to very coarse skewed in the bottom and leptokurtic (Table)

Table 5.1 Grain size distribution of core sediment (Method of moment *)

SAMPLE	MEAN	STD DEV	SKEW	KURTOSIS
V1	0.373	0.372	2.285	6.909
V2	0.479	0.368	2.074	5.652
V3	0.563	0.436	1.425	3.573
V4	0.533	0.362	1.077	4.379
V5	0.49	0.385	1.6001	4.748
V6	0.51	0.391	1.512	4.723
V7	0.57	0.477	1.165	2.779
V8	0.562	0.464	1.135	2.759

SAMPLE	MEAN	STD DEV	SKEW	KURTOSIS
MA1	0.537	0.378	0.586	3.413
MA2	0.0406	0.37	1.816	6.021
MA3	0.424	0.378	1.81	5.705
MA4	0.467	0.445	1.305	5.921
MA5	0.387	0.37	1.511	4.614
MA6	0.451	0.447	1.331	3.743
MA7	0.493	0.424	1.317	3.683
MA8	0.437	0.398	1.576	8.403
MA9	0.332	0.308	1.811	6.831
MA10	0.371	0.309	1.404	5.306

* Krumbein, W. C. and Pettijohn, F. J. 1938 Manual of Sedimentary petrography, Appleton-Century - Crofts, NewYork.

5.1.1.2 MINERALOGY OF CORE SEDIMENTS

The quartz concentration decreases from bottom (61.11 %) to top (76.04 %). While high feldspar concentration increases in middle region of sediment profile. The secondary minerals dominating mainly top and bottom of core sediment profile. Fluroapatite detected in very less amount in top layer. Mica is mainly dominating in top (13.73 %) and bottom (7.82 %)(Table 5.2).

5.1.1.3 CARBON, SULPHUR AND NITROGEN

The Total carbon concentration increases in the middle part of core profile (table 5.3), due to high concentration clay. Since soil formation takes time. Due to the earlier deposited sediment shows more carbon concentration. In bottom of profile (fig.3.2) shows bed rocks, where concentration of carbon is very less .Core sediment also shows high concentration of Kjeldahl nitrogen increases bottom to top. Total sulphur increases in middle part of sediment profile.

5.1.1.4 CARBON / NITROGEN RATIO

Core sediments C/N ratio shows similar trend as like carbon. C/N ratio ranges from 9.97 in top 18.48 in middle and 8.19 in bottom. Which shows soil formation proceeds with time. Core sediment C/N ratio is much more than the soil C/N ratio10.0 (Brady & Brady)

Table 5.2 Mineral composition of river sediments (all in %)

Viyyuvaram

Sample (cm)	Quartz	Orthoclase	Plagioclase	Muscovite	Biotite	Chlorite	Microcline	Fluroaptite
V1(0-2)	78.36	7.74	5.49	0.70	3.09	2.09	1.91	0.63
V2 (2-4)	73.05	12.84	4.96	1.62	2.34	0.56	1.10	0.96
V3(4-6)	73.05	9.90	3.30	2.38	4.90	1.83	1.59	1.73
V4(6-8)	75.70	12.12	3.23	0.90	1.80	2.22	3.23	2.02
V5(8-10)	76.71	6.90	2.22	2.22	3.92	2.54	2.27	2.92
V7(10-12)	69.63	19.77	2.20	3.37	1.13	2.50	0.86	0.56
V8(12-14)	75.41	9.32	5.58	1.01	1.92	1.92	4.83	ND
V8(14-16)	56.92	24.74	3.08	6.73	7.00	ND	1.52	ND

Mavelikara

Sample (cm)	Quartz	Orthoclase	Plagioclase	Muscovite	Biotite	Chlorite	Microcline	Fluroaptite
MA1(0-2)	61.11	20.15	10.19	0.77	2.75	1.38	1.65	1.32
MA2(2-4)	62.83	9.97	9.17	ND	2.97	1.20	13.73	ND
MA3(4-6)	59.05	27.34	3.11	7.08	1.66	ND	2.21	ND
MA4(6-8)	62.21	21.45	10.15	3.52	1.23	ND	ND	ND
MA5(8-10)	63.11	20.32	9.03	2.97	1.78	1.56	1.23	ND
MA6(10-12)	65.12	19.32	10.11	3.21	1.30	0.90	ND	ND
MA7(12-14)	75.67	9.10	2.38	5.80	2.15	1.61	1.34	2.25
MA8(14-16)	80.75	7.97	2.16	2.16	2.32	2.43	2.21	ND
MA9(16-18)	76.29	11.51	ND	ND	6.50	2.80	2.88	ND
MA10(18-20)	76.04	11.10	ND	ND	7.82	1.96	2.08	ND

ND= not determined

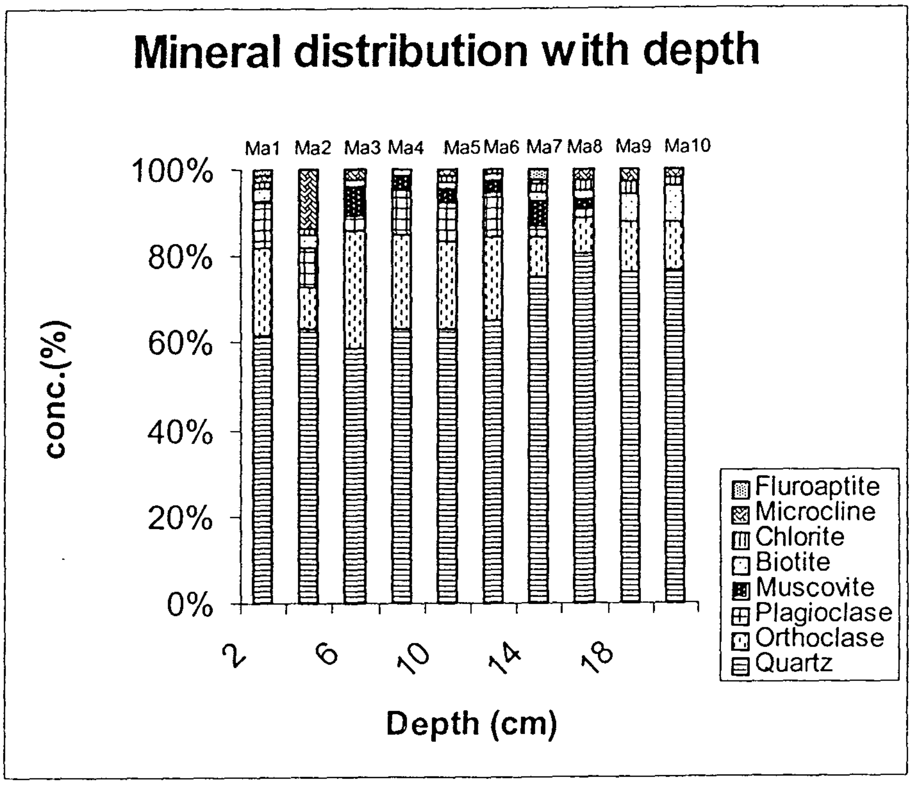


Fig 5.1 Mineral distribution with depth (up stream)

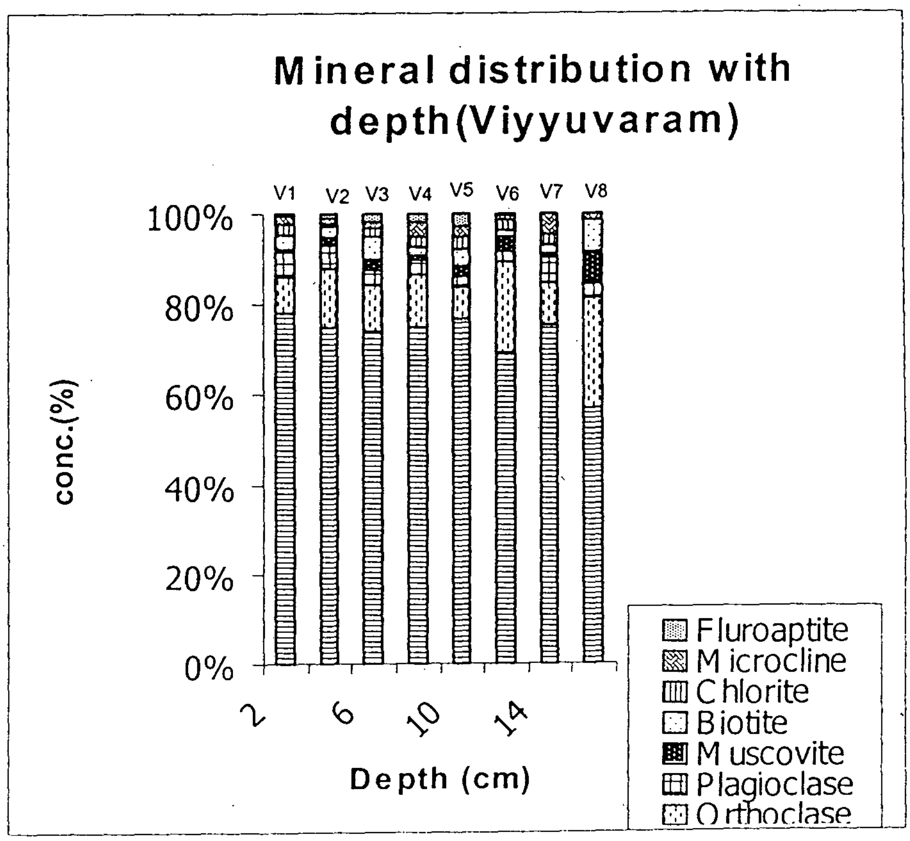


Fig. 5.2 Mineral distribution with depth (down stream)

Table 5.3: Biogeochemical Characteristics of Core Sediments

Viyyuvaram (Downstream Achankovil River)

Samples(cm)	TC	IC	OC	TS	IS	OS	TN	C/N
V1(0-2)	1.15	0.12	1.02	0.05	ND	0.05	0.23	5.73
V2 (2-4)	1.87	0.25	1.62	0.09	ND	0.09	0.20	10.92
V3(4-6)	1.98	0.34	1.63	0.14	ND	0.14	0.20	11.53
V4(6-8)	1.64	0.24	1.40	0.10	ND	0.10	0.17	11.52
V5(8-10)	1.92	0.23	1.69	0.14	ND	0.14	0.18	12.19
V7(10-12)	3.60	0.34	3.27	0.11	ND	0.11	0.32	13.28
V8(12-14)	2.58	0.28	2.31	0.06	ND	0.09	0.27	11.31
V8(14-16)	0.74	0.36	0.38	0.04	ND	0.04	0.05	17.32

Mavelikara (Upstream Achankovil River)

Samples(cm)	TC	IC	OC	TS	IS	OS	TN	C/N
MA1(0-2)	1.53	0.13	1.40	0.02	ND	0.02	0.22	8.26
MA2(2-4)	1.71	0.42	1.29	0.05	ND	0.05	0.20	9.97
MA3(4-6)	2.49	0.08	2.41	0.07	ND	0.06	0.28	10.25
MA4(6-8)	1.83	0.34	1.48	0.02	ND	0.01	0.18	11.62
MA5(8-10)	3.42	0.23	3.18	0.07	0.01	0.07	0.25	15.94
MA6(10-12)	2.90	0.07	2.83	0.05	0.01	0.04	0.18	18.48
MA7(12-14)	3.32	0.34	2.99	0.05	ND	0.05	0.27	14.55
MA8(14-16)	3.09	0.24	2.85	0.05	0.01	0.04	0.23	15.46
MA9(16-18)	0.74	0.18	0.57	0.05	0.10	0.04	0.13	6.50
MA10(18-20)	0.58	0.12	0.47	0.05	ND	0.01	0.08	8.19

TC= Total Carbon, IC=Inorganic Carbon, OC= Organic Carbon
C/N= Carbon/Nitrogen ratio, TS= Total Sulphur, IS=inorrganic Sulphur
TN=Total Nitrogen, OS= Organic sulphur, ND=not determined,

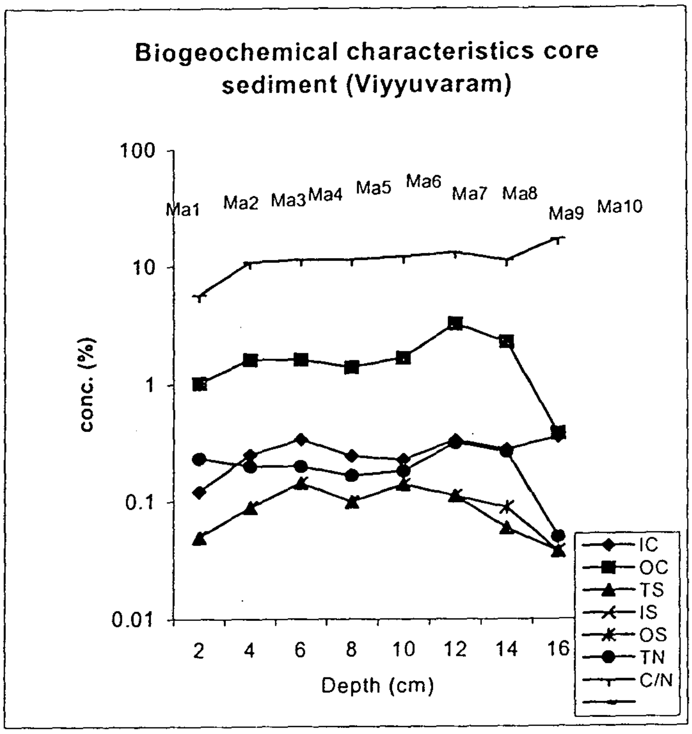


Fig 5.3- Biogeochemical characteristics of core sediment (Mavelikara)

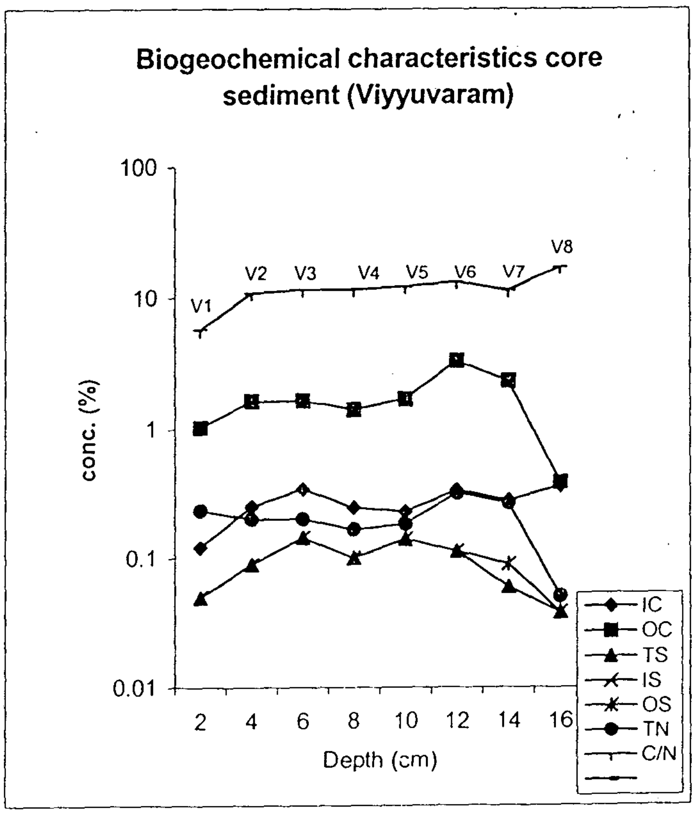


Fig 5.4 Biogeochemical characteristics of core sediment (down stream)

5.1.1.5 GEOCHEMICAL CHARATRISTICS

5.1.1.5.1 SILICON AND ALUMINUM

Core sediment of down stream shows low concentration of silica i.e. ranging bottom to top 18.79 to 22.24 %. Almost very steady rise in silicon concentration takes from bottom to top. The aluminum concentration from ranging 8.76 to 4.89 % bottom to top respectively (Table 5.4). This shows more clay formation increasing with time. Silica shows a good correlation with aluminum (0.64), sodium(0.61), potassium (0.52) and lead (0.60)(Table 5.5), indicating that K-feldspar is one of the important minerals in these river basin. Silica shows a negative correlation with Ca,Mg,Mn and Cu due to variable dilution of other mineral and due to the abundance by quartz.

5.1.1.5.2 SODIUM AND POTASSIUM

The sodium concentration ranges from 1.72 to 1.84 % while K ranges from1.06 to1.38 %, bottom to top respectively. High concentration of sodium and potassium observed in middle part of profile (Table 5.4). Sodium and potassium shows good correlation among themselves indicating that they are both derived from weathering of the rock in the catchment and also to dominance of Na-K feldspar in the sediment (Table 5.5).

5.1.1.5.3 CALCIUM AND MAGNESIUM

The calcium concentration ranges from 1.70 to 3.04 %, while magnesium concentration ranges from 0.21 to 1.25 %, bottom to top respectively (Table 5.4). Average high concentration of Ca and Mg obtained in middle region of core

Table 5: 4 Geochemical Composition of core sediment (Cu and Pb in µg/g and others in %)

Viyyuvaram (Downstream Achankovil River)

Sample (cm)	Si	Al	Na	K	Ca	Mg	Fe	Mn	Cu	Pb
V1(0-2)	33.62	9.46	1.95	1.10	4.20	0.61	3.53	0.03	21.88	12.43
V2 (2-4)	33.28	9.56	1.87	1.32	2.60	0.59	6.97	0.03	11.54	14.86
V3(4-6)	33.97	10.03	1.83	1.67	1.40	0.97	5.22	0.06	11.54	14.86
V4(6-8)	27.41	9.46	1.88	1.55	0.65	0.57	2.11	0.03	11.54	0.29
V5(8-10)	24.66	10.56	1.95	1.38	0.77	0.77	2.28	0.03	12.58	0.29
V7(10-12)	20.86	7.56	1.89	1.29	3.56	0.82	2.54	0.03	25.50	0.00
V8(12-14)	23.62	6.89	1.80	1.08	1.44	0.81	3.28	0.04	9.99	0.00
V8(14-16)	18.79	6.56	1.81	0.96	2.56	0.80	4.04	0.05	26.02	0.29

Mavelikara (Upstream Achankovil River)

Sample (cm)	Si	Al	Na	K	Ca	Mg	Fe	Mn	Cu	Pb
MA1(0-2)	22.24	4.89	1.88	1.14	-0.19	0.53	2.63	0.03	13.09	0.29
MA2(2-4)	20.86	4.99	1.83	1.11	1.84	0.21	4.00	0.10	45.15	8.96
MA3(4-6)	19.83	4.79	1.74	1.25	19.88	0.75	3.04	0.04	15.16	7.57
MA4(6-8)	18.79	4.79	1.80	1.28	17.13	0.57	4.46	0.05	17.23	9.23
MA5(8-10)	19.83	3.99	1.84	1.38	17.01	1.25	4.98	0.07	15.16	8.34
MA6(10-12)	16.38	3.12	1.84	1.32	20.76	1.36	4.75	0.08	13.61	2.71
MA7(12-14)	12.93	3.89	1.80	1.12	19.08	0.73	2.26	0.04	17.75	2.71
MA8(14-16)	13.28	3.99	1.78	1.05	13.70	0.82	1.34	0.05	14.13	1.45
MA9(16-18)	12.59	9.23	1.75	1.09	8.67	1.16	6.71	0.06	12.06	1.45
MA10(18-20)	18.79	8.76	1.72	1.06	3.04	0.82	6.33	0.08	16.20	1.11

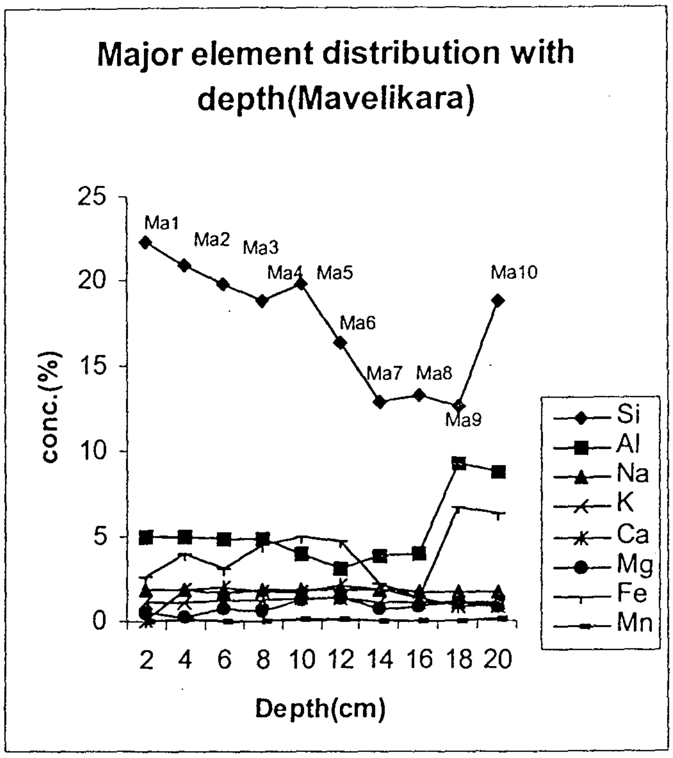


Fig. 5.5 Major Element distribution with depth (upstream)

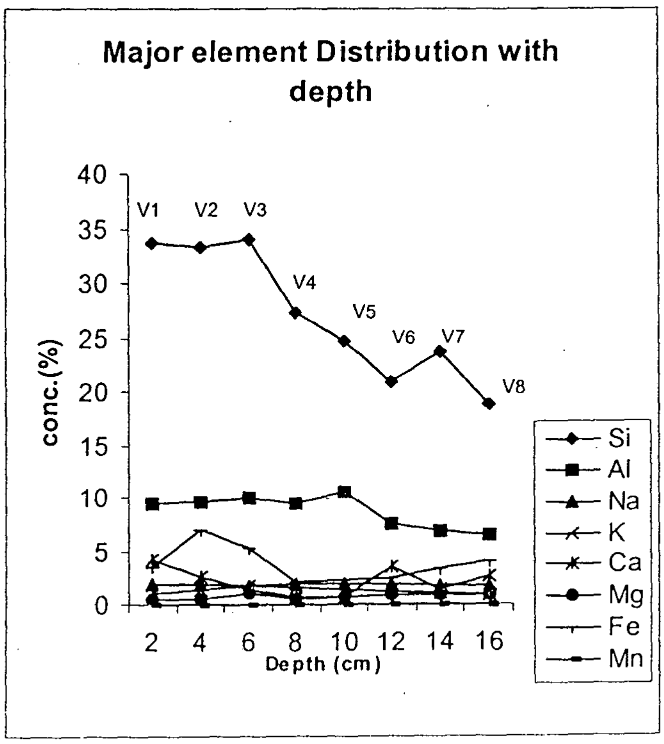


Fig 5.6 Major Element distribution with depth (down stream)

Table 5.5 Correlation matrix of core sediment

	Si	*Al*	*Na*	*K*	*Ca*	*Mg*	*Fe*	*Mn*	*Cu*	*Pb*
Si	1									
Al	0.64	1								
Na	0.60	0.35	1							
K	0.52	0.30	0.35	1						
Ca	-0.57	-0.71	-0.4	-0.04	1					
Mg	-0.30	-0.11	-0.21	0.17	0.44	1				
Fe	0.14	0.27	-0.29	0.04	-0.03	0.29	1			
Mn	-0.33	-0.30	-0.42	-0.15	0.18	0.20	0.45	1		
Cu	-0.10	-0.21	0.05	-0.34	-0.13	-0.49	-0.08	0.45	1	
Pb	0.60	0.14	0.15	0.37	0.08	-0.16	0.44	0.11	0.10	1

profile. Ca shows good correlation with Mg (0.45). Shows high concentration calcareous organism and also the presence of dolomite and limestone patches in the catchment (Soman,1997)

5.1.1.5.4 IRON AND MANGANESE

Iron concentration increases from top to bottom. Iron concentration ranges from 2.63 % in top layer 4.98 % in middle and 6.71 % in bottom. Manganese concentration in average is 0.06 % ,remains almost constant (Table 5.4).Iron and manganese shows a good correlation indicating that iron and manganese are geochemically related and may be present as coating of oxy-hydro-oxide on the sediments as have been indicated for the other rivers (Ramanathan, 1994).

5.1.1.5.5 LEAD AND COPPER

Copper and lead concentration increases from bottom to top. Copper concentration ranges bottom to top from16.20 to 45.15 µg/g, while lead ranges from 1.11 to 9.23 µg/g (table 5.4). Copper and lead shows positive correlation among each others (Table 5.5).

5.1.1.5.6 METAL/ALUMINIUM RATIO :-

The Metal / Al ratio for the core sediments of three Kerala river as given in table 5.5. Silica is a major elements in the earth crust and forms a part of all rocks. Bostram et al . (1972) contented that Si / Al ratio ~ 3 , when the alumino-silicate, sediments serves as main source. In core sediment (Mavelikara) Si/Al ratio ranges

TABLE 5.6 Element-aluminium ratio

Viyyuvaram

Sample(cm)	Si/Al	Na/AL	K/Al	Ca/AL	Mg/Al	Fe/Al	Mn/Al
V1(0-2)	3.55	0.21	0.12	0.44	0.06	0.37	0.00
V2 (2-4)	3.48	0.20	0.14	0.27	0.06	0.73	0.00
V3(4-6)	3.39	0.18	0.17	0.14	0.10	0.52	0.01
V4(6-8)	2.90	0.20	0.16	0.07	0.06	0.22	0.00
V5(8-10)	2.33	0.18	0.13	0.07	0.07	0.22	0.00
V7(10-12)	2.76	0.25	0.17	0.47	0.11	0.34	0.00
V8(12-14)	3.43	0.26	0.16	0.21	0.12	0.48	0.01
V8(14-16)	2.86	0.28	0.15	0.39	0.12	0.62	0.01

Mavelikara

Sample(cm)	Si/Al	Na/AL	K/Al	Ca/AL	Mg/Al	Fe/Al	Mn/Al
MA1(0-2)	4.54	0.38	0.23	-0.04	0.11	0.54	0.01
MA2(2-4)	4.18	0.37	0.22	0.37	0.04	0.80	0.02
MA3(4-6)	4.14	0.36	0.26	4.15	0.16	0.63	0.01
MA4(6-8)	3.92	0.38	0.27	3.58	0.12	0.93	0.01
MA5(8-10)	4.97	0.46	0.35	4.27	0.31	1.25	0.02
MA6(10-12)	5.24	0.59	0.42	6.64	0.44	1.52	0.02
MA7(12-14)	3.32	0.46	0.29	4.90	0.19	0.58	0.01
MA8(14-16)	3.33	0.45	0.26	3.44	0.21	0.34	0.01
MA9(16-18)	1.36	0.19	0.12	0.94	0.13	0.73	0.01
MA10(18-20)	2.15	0.20	0.12	0.35	0.09	0.72	0.01

from 2.15 to 4.54 , bottom to top respectively, shows weathering proceeds with time. Since younger sediment are deposited over older sediment (Table 5.6).

5.1.1.5.7 CHEMICAL INDEX OF ALTERATION (CIA)

As from Nesbit and Young (1982) formulae chemical index alteration of core sediment ranges 67.81 in bottom, 21.22 in middle to 71.71 in the top, shows more dominance of secondary minerals in top and bottom than middle (Table 5.7). The average upper crust has a CIA value of about 47 (McLeennan,1993), CIA value of 45 to 55 indicate in essenceno weathering. For individual clay minerals Kaolinite, Chlorite,Gibbsite have CIA value 100. Where as smectite and illite have values in the 70-80 range. Primary minerals have much lower value of CIA (Nesbitt and Young, 1997). It fallows that the proportion of clay minerals and primary minerals in a bulk samples will introduce substantial variation in the resulting CIA values.

5.1.2 DOWNSTREAM (Viyyuvaram))

5.1.2.1 GRAIN SIZE DISTRIBUTION

The grains distribution in core sediment (Viyyuvaram) is well sorted with surface of core. The statistical calculation was done by method of moments (Krumbein & Pettijohn 1938,Swan et al. 1979 and text book of Rhyndhol). Core sediments grains are leptokurtic to mesokurtic from top to bottom and very coarse skewed (Table 5.1).

Table 5.7	Chemical Index Alteration of core sediment					
Sample (cm)	SiO_2	Na_2O	Al_2O_3	CaO	K_2O	CIA
V1(0-2)	69.48	2.63	17.86	5.87	1.32	64.48
V2 (2-4)	68.77	2.52	18.06	3.64	1.59	69.94
V3(4-6)	70.19	2.47	18.93	1.96	2.00	74.60
V4(6-8)	56.65	2.52	17.86	0.90	1.86	77.12
V5(8-10)	50.95	2.62	19.95	1.07	1.66	78.81
V7(10-12)	43.11	2.54	14.28	4.98	1.56	61.10
V8(12-14)	48.81	2.41	13.02	2.02	1.30	69.37
V8(14-16)	38.83	2.43	12.39	3.58	1.15	63.31

Sample (cm)	SiO_2	Na_2O	Al_2O_3	CaO	K_2O	CIA
MA1(0-2)	45.96	2.53	9.24	ND	1.37	71.70
MA2(2-4)	43.11	2.46	9.41	2.58	1.34	59.60
MA3(4-6)	40.97	2.34	9.04	27.83	1.50	22.20
MA4(6-8)	38.83	2.42	9.04	23.97	1.53	24.45
MA5(8-10)	40.97	2.48	7.53	23.81	1.66	21.22
MA6(10-12)	33.85	2.47	5.90	29.06	1.59	15.12
MA7(12-14)	26.72	2.42	7.35	26.71	1.34	19.44
MA8(14-16)	27.43	2.39	7.52	19.17	1.26	24.78
MA9(16-18)	26.01	2.36	17.43	12.13	1.30	52.45
MA10(18-20)	38.83	2.32	16.54	4.25	1.27	67.81

ND = not determined

5.1.2.2 MINERALOGY OF CORE SEDIMENTS

The quartz concentration ranges from 56.92 to 78.36,bottom to top respectively. While high feldspar concentration obtained in study area of sediment. The secondary minerals dominating mainly top and bottom of core sediment profile. Fluroapatite detected in0.56 to 2.02 %. Mica is mainly dominating in bottom (13.73 %) and top (3.79 %) (Table 5.2)

5.1.2.3 CARBON, SULPHUR AND NITROGEN

The Total carbon concentration increases from top to bottom of core profile (table 5.3), due to high concentration clay in lower part of core profile. Since soil formation takes time. Thus the earlier deposited sediment shows more carbon concentration. Organic carbon is more dominating than inorganic carbon. The organic carbon concentration increases from top to bottom layer. Core sediment shows high concentration of total sulphur but inorganic sulphur is not in detectable level. A considerable amount of Kjeldhal nitrogen is obtained.

5.1.2.4 CARBON/NITROGEN

Core sediment C/N ratio ranges from 10.92 in top to 17.32 in bottom. Which shows soil formation proceeds with time. Core sediment (down stream) C/N ratio in is much more than the standard value 10.0 (Brady & Brady)(Table 5.3).

5.1.2.5 GEOCHEMICAL CHARACTERISTICS

5.1.2.5.1 SILICON AND ALUMINIUM

Core sediments of down stream shows good concentration of silicon. The silica concentration ranges from ranges bottom to top 18.79 to 33.62 %. High concentration of silicon obtained at top. Similar trend of aluminium observed i.e. ranging 6.56 to 9.46 % (Table 5.4). Silica shows a good correlation with aluminium (0.64), sodium(0.61), potassium (0.52) and lead (0.60)(Table 5.5), indicating that as K-feldspar is one of the important minerals in these river basin. Silica shows a negative correlation with Ca,Mg,Mn and Cu due to variable dilution of other mineral abundance by quartz.

5.1.2.5.2 SODIUM AND POTASSIUM

The sodium concentration ranges from 1.81 to 1.95 % while K ranges from 0.96 to 1.10 % bottom to top respectively. Concentration of sodium and potassium remains almost constant (Table 5.4). Sodium and potassium shows good correlation among themselves indicating that they are both derived from weathering of the rock in the catchment and also to dominance of Na-K feldspar in the sediment (Table 5.5).

5.1.2.5.3 CALCIUM AND MAGNESIUM

The calcium concentration ranges from 2.56 to 4.20 %, while magnesium concentration ranges from 0.53 to 0.61 % bottom to top respectively.(Table 5.4). Average high concentration of Ca and Mg obtained in middle region of core profile.

Ca shows good correlation with Mg (0.45). Shows high concentration calcareous organism and also presence of dolomite and limestone patches in the catchment (Soman, 1997)

5.1.2.5.4 IRON AND MANGANESE

Iron concentration increases from top to bottom. Iron concentration ranges from 3.53% in top layer 2.28 % in middle and 4.04 % in bottom. Manganese concentration in average is 0.06 %, remains almost constant (Table 5.4).

Iron and manganese shows a good correlation indicating that iron and manganese are geochemically related and may be present as coating of oxy-hydro-oxide on the sediments as have been indicated for the other rivers (Ramanathan, 1994) (Table 5.5).

5.1.2.5.5 LEAD AND COPPER

Copper and lead concentration increases from bottom to top. Copper concentration ranges bottom to top from 26.02 to 21.88 μg/g, while lead ranges from 0.29 to 12.43 μg/g (table 5.4). Copper and lead shows positive correlation among each others (Table 5.5).

5.1.2.5.6 METAL/ALUMINIUM RATIO :-

The Metal / Al ratio for the core sediments of three Kerala river as given in table 5.5. Silica is a major elements in the earth crust and forms a part of all rocks. Bostram et al . (1972) contented that Si / Al ratio ~ 3 , when the alumino-silicate, sediments serves as main source. In core sediment (Viyyuvaram) Si/Al ratio ranges from 2.86 to 3.55, bottom to top respectively, shows weathering is proceeds with time. Since younger sediment are deposited over older sediment (Table 5.6).

5.1.2.5.7 CHEMICAL INDEX OF ALTERATION (CIA) :-

As from Nesbit and Young (1982) formulae chemical index alteration of core sediment ranges 63.31 in bottom, 78.81 in middle to 64.49 in the top, shows more dominance of secondary minerals in Viyyuvaram (Table 5.7).

The average upper crust has a CIA value of about 47 (McLeennan, 1993), CIA value of 45 to 55 indicate in essenceno weathering. For individual clay minerals Kaolinite, Chlorite, Gibbsite have CIA value 100. Where as smectite and illite have values in the 70-80 range. Primary minerals have much lower value of CIA (Nesbitt and Young, 1997). It fallows that the proportion of clay minerals and primary minerals in a bulk samples will introduce substantial variation in the resulting CIA values.

CHAPTER 6

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSION

Rivers are amongst the major natural forces changing the face of the earth. A river basin is the most active component of the hydrological cycle involving continuous mobility of water as well as erosion, transportation and deposition of dissolved, suspended and traction load. A little information is available on the small river like the Achankovil, the Pamaba and the Maniamla, which are having homogenous lithology. The biogeochemical studies in these rivers will give us an idea about the exact nature of biogeochemical load contributed to the ocean. Hence surfacial and core sediment sample collected from these rivers and analyzed for biogeochemical parameters.

Samples are collected and chemically analyzed for various biochemical aspects in the laboratory. Surface sediments are well to very well sorted and mostly leptokurtic, some shows platykurtic to mesokurtic. The grains size distribution of the Achankovil river basin are symmetrically skewed. While in the Pamba river basin grains are coarse to very coarse skewed. High concentration of quartz obtained in all most all sides while other clay minerals are very less.

Surface sediment of the Achankovil river basin , C/N ratio ranges from 1.04 in upstream 6.02 in middle and 4.95 in down stream. High concentration of Kjeldahl nitrogen observed in all three river surface sediment. The nitrogen concentration ranges from 0.30 % in up,0.50 % in middle and 0.23 % in down stream. A high concentration of silicon is detected in almost all samples. The silicon concentration in surface sediment of the Achankovil increases from up to down stream shows weathering is more dominating in down stream. While average concentration of silicon, iron and aluminum in surface sediment is much more in the Achankovil and the Manimala while less in the Pamba than the Indian average. The CIA for the Achankovil river basin increases up to down stream shows high rate of weathering in down stream. Thus concentration of secondary minerals increases in down stream. Other two rivers CIA is less than the Achankovil shows rate of weathering is more in the Achankovil river basin.

Core sediments of Mavelikara and Viyyuvaram shows very high concentration of carbon and Kjeldahl nitrogen and sulphur in middle part of the core segments. In core sediment C/N ratio is very high ranges 8.19 to 18.19 in Mvalikara and 5.73 to 17.52 in the Viyyuvaram. A high concentration of silicon is detected in almost all samples. The CIA value of the core sediment in Mavelikara ranges from 59.60 to 67.82 top to bottom, while in Viyyuvaram ranges from 64.48 to 71.70 top to bottom respectively.

A good correlation among silicon & aluminum, sodium & potassium, iron &manganese observed in core sediment. While surface sediment shows good correlation between silicon and aluminum.

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