CHAPTER 1

INTRODUCTION

"Estuaries are a happy land, rich in the nutrients of the continent itself, stirred by the forces of nature like the soup of a French Chef, the home of myriad forms of life from bacteria and protozoan to grasses and mammals: the nursery, resting place and refuge of countless species" – Stanley. A. Cain.

To those of us who enjoy the ocean, an estuary is simply a place where the incoming ocean meets flowing rivers and streams, forming mudflats and marshes. As freshwater meets the ocean, both land and ocean contribute to a beautiful and fragile ecosystem. They are crucial transition zones between land and water that provide an environment for lessons in biology, geology, chemistry, physics, history and social issues. Since colonial times, we have used estuaries and their connecting network of rivers for transporting agricultural goods for manufacturing and trade. Estuaries, in short, are natural treasures – vital ecological and community resources – whose health affects our health and the vibrancy of our communities and economy.

Estuaries are one among the highly productive ecosystems, accounting for one-half of the living matter of the world’s ocean. Unfortunately, these ecosystems usually bear the brunt of human waste and contamination because they were and are the first areas of human settlement. Organic effluents such as domestic sewage is a serious problem - the discharge of small quantities of sewage into estuarine systems can actually increase the productivity of the ecosystem, but excessive quantities will deplete oxygen - causing severe threats to aquatic life. Industrial wastes, with its large load of heavy metals, can be toxic even at low concentrations. Estuaries receive all materials coming from the river catchments This material, fine sediments,
contaminants, and other pollutants may accumulate in the estuary and remain there for long periods before being definitely washed to the open sea - thus affecting the sustainability of an ecosystem which is immensely valuable from an ecological, social and economic perspectives.

Estuarine and coastal zones are the sites of major discharges of urban and industrial pollutants. While there are common basic biogeochemical processes, differences in time scales of mixing and transport, in biological productivity or in sedimentary regimes, lead to major differences in pollutant routes, cycling and fate in coastal zones. Data from riverine systems of differing geology, climatology and physio-graphy as well as differing anthropogenic influences are needed to better assess natural variability and to provide a basis for differentiating natural from unnatural values.

An estuary will typically contain waters in a mixing series from river water, which globally has an estimated average dissolved salt content of 120 mg/l (Livingstone, 1963), to sea water with a salinity approaching that of the open ocean, which is typically about 35%. Such an environment is an important transition zone in the series of aquatic environment in which aqueous solutions and solid phases interact during the major sedimentary cycle. The particular problems of estuarine chemistry over and above those inherent in the chemistry of any natural water system arise because of the marked gradients in ionic strength and in concentrations of individual chemical species, and the generally high concentration of suspended matter and its variable composition. The shallowness of most estuaries, with associated possibilities of sediment resuspension, together with the frequently high levels of biological activity, can introduce additional complexity.

In river waters, there are wide variations in both the total concentration of dissolved salts and the composition of the dissolved material with respect to both the major and minor constituents. Coastal sea water, by
comparison, can be regarded as of approximately uniform composition, although considerable variations occur for some of the minor constituents. Within each estuary, there will be at least one individually characteristic mixing series between dilute and saline end members.

The main factors leading to variations in the composition of river waters have been discussed by Livingstone (1963) and Gibbs (1970). Some rivers receive a major part of their dissolved salts in precipitation over the drainage area. Dissolved silicon and potassium enter largely from rock weathering (Gibbs, 1970). Variation in the composition of precipitation and in subsequent evaporation leads to regional and seasonal variations, but rivers are generally characterised by low concentrations of total dissolved salts. Where rock weathering is the dominant influence on composition, regional variations are determined primarily by the geological character of the drainage area. Temporal variations arise mainly through differences in the proportions of ground water flow and surface runoff (Livingstone, 1963). The general trend is for the latter to cause dilution of the river water, with striking effects in some cases.

The basic influence on estuarine chemical processes is related to the compositional gradient associated with it. The shallowness of most estuaries makes complexity due to the sediment resuspension and biological activity. The high river discharge creates virtually a fresh water surface layer near the head of the estuary. This flows seaward over a saline lower layer. Estuarine mixing mainly involves three processes; the precipitation of dissolved material, the uptake of dissolved material into solid phase and the release of material into solution. The relative composition of river water differs from that of sea water and their mixing yields in principle estuarine water in which the proportions of the major ions and trace elements differ from those in the oceans and rivers. The extent of mixing in an estuary depends upon a large number of factors such as the seasonally variable river flow, the tidal
cycle, the wind character, the topography and the relative temperatures of river water and the sea water.

KUTTANAD

Kuttanad is an amazing labyrinth of shimmering waterways composed of lakes, canals, rivers and rivulets. Kuttanad is called the rice bowl of Kerala, because for her wealth of paddy crops are at the very heart of the backwaters. The scenic country side of Kuttanad also has a rich crop of bananas, casava and yams, which accompany the rice bowl as "side dishes". This is perhaps the only land in the world where farming is done below sea level. Inland waterways, which flow above land level, are an amazing feature of this unique land.

Location

Kuttanad is a low-lying area, located in the State of Kerala, in the south-west coast of Indian peninsula. The area is located in central Kerala and is south of Kochi, "the Queen of Arabian Sea". Originally it was a part of the shallow coastal area of the Arabian Sea. As a result of geological uplift, a shallow bay was formed into which the rivers draining from the mountains to the east discharge. The coast has been formed by the silt deposits carried by these rivers. The bay has become an extensive brackish water lagoon and backwater system extending from Alappuzha (Alleppey) in the south to Kochi (Cochin) in the north, and connected to the sea by the Cochin channel. The Kuttanad covers parts of the districts of Alleppey, Kottayam, and Pathanamthitta, which comprise a total of 54 villages in 10 talukes (sub-districts) with a total population of 1.4 million. The area of Kuttanad extends over 1,100 km² (110,000 ha) and supports a population of over 1.4 million. The area has a monsoon climate with a wet season from mid of May to November and a dry season from December to April.
Background

The Vembanad Lake is situated at southern part of Cochin backwater system. Bunding of shallow parts of the lagoon started at least a century ago. Bunds were not intended to prevent flooding by the rivers, but to enable paddy cultivation between the end of the wet season (November) and the time when water in the southern part of the lagoon became too saline for agriculture (March), known as punja cultivation. This type of cultivation is characterized by the dewatering of land left to flood at the end of the wet season.

The area separated from the shallow parts of the lagoon by the construction of bunds is called “padasekharams”, which means a group of paddy fields. The total area of paddy fields thus reclaimed is about 55,000 ha, and some of the paddy fields thus reclaimed are located 2.5 m below mean sea level (MSL). A landscape of innumerable waterways was developed as a result of such reclamations of land.

A spillway was constructed at Thottappally in 1955 to divert floodwaters of the Pamba, Manimala and Achenkoil Rivers straight to the sea. The intention was to limit flood levels to below the bund levels, which would enable cropping in the wet season in the “padasekharams”. But its capacity was insufficient to keep flood levels below the low bund crests, partly because the channel leading to the spillway was not constructed as wide as planned. As a consequence, cropping in the wet season was limited and flood damage occurred regularly. In 1975, a salinity barrier was constructed at Thanneermukkam to retain fresh water and reduce saltwater intrusion in the dry season. South of the barrier, where water in the lagoon is fresh, is known as Vembanad Lake. While the barrier has improved crop production, the side effects, particularly on fisheries and the aquatic environment, have been
significant and have led conflicts between the farming and fisheries communities.

The four rivers draining into the Kuttanad area are the Pamba River, Manimala River, Meenachil River and Achencovil River. The Pamba River is the third longest river (176km) in Kerala. It is formed by the confluence of the Pamba Aar, the Kakki Aar, the Arudai Aar, the Kakkad Aar and Kall Aar. The drainage area of the river is 2235 sq.km. and annual yield is 4641 Mm$^3$. The Manimala River rises at an altitude of 1156 m, above MSL in Tatamala and gains shape only from Elamkadu Estate. It drains an area of 847 sq.km. and the length of the river is just 90 km. with an annual yield 1829 Mm$^3$. The Meenachil River is formed by joining of several streams originating from the Western Ghats. Although the length of the river is only 78 km, the drainage area is considerably larger (1272 sq.km) with an annual yield 2349 Mm$^3$. Several small streams originating from the Pasikida Mettu, Ramakkul Teri and Rishi Malai at altitudes ranging between +700 m and +160 m above MSL join together to form Achenkoil River. The length of the river is 128 km. The total drainage area is 1484 sq.km. with an annual yield 2873 Mm$^3$.

Economic activities

Agriculture is the major economic activity in the area, employing about 40 % of the population directly. Paddy is virtually the only crop grown in the “padasekharams” and the poor drainage conditions makes most of the land in the “padasekharams” unsuitable for other crops. Coconut is grown on the bunds and on higher areas. The main paddy crop in the Kuttanad is still the punja crop grown in the early part of the dry season, November-March.

Estuarine fisheries are another activity in the Kuttanad area employing about 21,000 full and part-time fishermen (KWBS, 1989). Estuarine fisheries are of significant commercial importance. A survey revealed an
annual production of 7,200 M.T. of fish valued at Rs.96 million in the lagoon and 70 % of the 3,000 M.T. of marine prawns landed annually at Cochin consist of species which spend part of their life cycle in the estuarine environment of the Cochin backwater (KWBS, 1989).

Secondary (predominantly coconut-based household and cottage industries) and tertiary (trade, commerce) activities are more developed in the western plains and some eastern areas. The coir production, through retting of coconut husk, is a traditional occupation and a major economic activity in the area. More than 70 % of coir produced in India comes from Kerala, which annually produces about 120,000 M.T. of the fibre. A major portion of the fibre used for coir industry is produced in Alleppey district. This industry employs approximately 3,83,000 people, about 84% of whom are women (KWBS, 1989). Coconut husk is transported from plantations to coastal area for retting. The process involves immersion of husk in shallow backwaters for 6 to 9 months. After that, decayed material is removed from the fibre by pounding. Bacteria act on the organic matter during the process and release putrefied and toxic materials into the environment. Hydrogen sulphide, methane and phenol compounds are released into water which kill fauna and flora. Several stretches of backwaters have become unusable due to this activity. pH value of water in retting area often becomes significantly lower than that in a non-retting zone. The concentration of phosphates, nitrates and hydrogen sulphide is higher (KWBS, 1989). The presence of sulphide imparts a greyish black colour to water, restricting light penetration and inhibiting photosynthesis. It damages the fragile ecosystem. The husks have to be submerged in water for a period of 4 to 12 months to obtain the fibre for further processing in the "coir" industry. About 250 ha of water area is used for this activity in the Kuttanad (KWBS, 1989). The retting process is promoted by flushing with oxygen-rich water. Thus, most sites are located in areas subject to tidal flushing. The areas used for retting become anoxic for part of the year.
The industries in and around the area are agro-based, consisting of various types of rubber processing units in the east and coconut processing plants in the west.

**Topography**

There are three identifiable topographic features: the dry (or garden) lands, wet lands and water areas. The dry lands vary in elevation from 0.50 – 2.50 m above mean sea level (MSL) and are about 31,000 ha in area. Most of the population lives on these lands, which mainly occur in the peripheral areas of the Kuttanad. The wetlands include low lying areas slightly above MSL (11,000 ha) and areas below MSL reclaimed from the lagoon (55,000 ha). Lakes, rivers and channels make up the remaining 13,000 ha.

**Rainfall, weather and climate**

The total annual rainfall of the state of Kerala, varies widely ie., from about 4500 mm in the northern part of Kerala to about 2000 mm in the south. The southwest monsoon, the principal rainy season of Kerala, accounts for about 73 % of the total annual rainfall. Further the rainfall during southwest monsoon decreases from the northern districts (85 %) to the southern districts (54 %). The northeast monsoon (7 – 25 %) and the hot weather pre-monsoon thunder showers during March- May (10 – 20 %) respectively accounts for the rest of the rainfall. The average rainfall in the Kuttanad area is about 3,000 mm/year.

From the stand point of weather and climate, the calendar year in Kerala can be divided into the following four seasons (Abdulla Bava, 1996).

1. Winter (January – February)
2. Hot weather period (March – May)
3. Southwest monsoon (June – September)
4. Northeast monsoon (October – December)

Two seasons are apparent: the wet season from June to November and the dry season from December to May. The wet season starts with southwest monsoon, which lasts until September, and continues with the northeast monsoon until November. Conditions are generally less severe in the northeast than in the southwest monsoon. Some rain usually falls in the dry season. Although significant rainfall can occur in March and April, the amounts are very variable. For the purpose of discussion, the calendar year is divided into three:

The monsoon season (June to September)
The post-monsoon season (October to January) and
The pre-monsoon season (February to May)

Thanneermukkam barrier

The Thanneermukkam barrier across the estuary was commissioned in 1975. The barrier was designed to prevent salinity intrusion into the southern part of the Cochin estuarine system (Kuttanad backwaters) in the dry season and also to retain the fresh water from the rivers flowing into the estuary. The structure has been relatively successful in keeping the water in the Kuttanad fresh and enabling cropping in the dry season to be increased. However, the barrier has had various adverse effects. Some were foreseen at the time of its conception, such as the reduction in fisheries and an increase in aquatic weed growth. Others were unforeseen, such as the effect of the elimination of tidal flushing on pollution levels. The situation has been aggravated in recent years by the introduction of high yielding paddy varieties, which require heavy doses of fertilizers and pesticides. About 20,000 M.T. of fertilizers and 500 M.T. of pesticides are used annually in the Kuttanad and
some enters the waterways and lake when water is pumped out of the paddy fields (KWBS, 1989). Since the construction of the barrier, the southern part of the Cochin backwater has been transformed into an area where salinities are too low for the prawns and fish that constitute the major resources for the estuarine fishery. Moreover, the migration routes of marine fish and prawns are interrupted by the barrier, its gates being closed during the pre-monsoon period when maximum upstream migration takes place (Kurup et al., 1990). The area south of the barrier is lost as a nursery ground for post larval prawns, which need salinities of about 15-20 % for optimal growth (Kurup et al., 1990). The edible crab, which once supported a good fishery in this part of the backwater, is no longer found south of the barrier. During the closure of the barrier in the dry season, the upstream area is no longer flushed by the tides and water is polluted by pesticides from the agricultural lands and by organic waste dumped into the Kuttanad waters. Pollution is a contributory factor to the reduction in numbers of the giant freshwater prawn.

In total, 45 % of the rural population and 35 % of the population of the town of Allepey have no proper sanitation facilities (KWBS, 1989). In certain areas where salinity is not a constraint for using the water for drinking purposes, levels of contamination were found to be in general ten times higher than the allowable level according to the Indian Standards for production of drinking water by simple disinfections (KWBS, 1989). Sabarimala, one of the largest pilgrim centers in South India, is near the Pamba River. About 10 million people reach here annually from various parts of India after the monsoon season. These pilgrims use the Pamba River for their sanitation purposes. This also has a major role in polluting the Pamba River and consequently the Kuttanad area.
Trace metals in estuary

Once the pollutants enter the environment, they are subjected to a variety of physical, chemical, geological and biological processes that bring about their disintegration or sometimes, their ultimate removal. Persistent chemicals, that do not breakdown, stand to pose serious environmental problems. Trace metals, because of their relatively long half-life and biological significance, constitute one such class among non-degradable contaminants causing great concern.

The term "trace metal" or "trace element" is used in current literature to designate those elements, which occur in small concentrations in natural systems. For all practical purposes, the terms such as “trace metals”, "trace inorganics", "heavy metals" “micro elements" and “micro nutrients” are treated as synonymous with the term trace elements (Forstner and Wittmann, 1983). Metals such as Fe, Zn, Cu, Mo, Cr, Co and Mn are essential for life but can be toxic when present at elevated levels.

Sources of metal pollution

The various anthropogenic activities by which trace metals are introduced into the aquatic systems include smelting, mining, shipping, industrial effluent discharge, urbanization, application of fertilizers, algicides, fungicides, automobile exhaust etc. Secondly, the natural processes that contribute metals to the aquatic environment include weathering of rocks, leaching of ore deposits, natural fires in the forests, terrestrial and marine volcanism etc. The above sources directly regulate the net flux of trace metals that interplay with natural/artificial systems and pose relevant questions of their cycling, transport and ultimate removal. Studies designed at quantifying these phenomena have led to the formulation of conceptual ideas of metal speciation.
In general, it is possible to distinguish between seven different sources from which metal pollution of the environment originates: (1) geological weathering (2) industrial processing of ores and metals (3) the use of metals and metal components (4) burning of fossil fuels, production of cement and bricks (5) leaching of metals from garbage and solid waste dumps (6) animal and human excretions which contain heavy metals and (7) non-point sources.

Upon attempting to locate the source of metal input of receiving water bodies, a distinction is often made between diffused non-point and point sources. Essentially, rural areas and agricultural land are regarded as non-point source, since the metal supply originates from vast regional areas.

Geological weathering is the source of baseline or background levels. It is to be expected that in areas characterized by metal-bearing formations, these metals will also occur at elevated levels in the water and bottom sediments of the particular area. Obviously, mineralized zones, when economically viable, are exploited to retrieve and process the ore. This in turn, leads to disposal of tailings, discharge of effluents and possibly smelting operations which result in atmospheric pollution. In consequence, the general problem arises of how to distinguish between natural geological weathering and metal enrichment attributable to human activities. During the processing of ores, metal bearing dust particles are formed, which may only be partially filtered out by air purification system. Appreciable quantities of metals go to waste during chemical metal refinement processes (e.g. galvanizing and pickling). Use of metals and metal compounds in industries poses another problem. For e.g., chromium salts used in processes in tanneries cause chromium pollution in the environment. Chlor-alkali industry is a major source of Hg pollution in the aquatic system. Similarly, copper compounds used as plant protection agents, zinc in water pipes and tetraethyl lead as anti-knock
agent in gasoline are anthropogenic sources of Cu, Zn and Pb in the environment. Fossil fuel mobilization is particularly high for arsenic, zinc, cadmium, copper (coal), nickel and vanadium (oil). Strong emissions of zinc, lead, selenium and arsenic result from cement production (Goldberg, 1971).

It is of special interest to note that soil cultivation has been estimated to be responsible for 95-99 % of soil erosion (McElroy et al., 1975). The sediment resulting from soil erosion is today recognized as being the largest single pollutant affecting water quality. Robinson (1973) correctly pointed out that “...sediment is our greatest pollutant”.

Concentrations of trace metals in coastal estuaries can be elevated due to high inputs from natural as well as anthropogenic sources. Thus, understanding the transport and distribution of trace metals in estuaries is a goal of environmental chemists. An assessment of the distribution of trace metals amongst various physical and chemical phases provides information which enhance our knowledge of the processes responsible for the behaviour of the metal in the estuaries, as well as the potential impact of the metal on the biota.

**Estuarine behavior of trace metals**

An estuary is a mixing zone of riverine and oceanic waters with widely varying compositions where end members interact both physically and chemically. The trace element chemistry in the estuarine environment has been an area of considerable research in the past decades. The importance of estuaries lies in the fact that they act as a mediator (filter) in the transfer of trace elements from continents to oceans. Estuaries, thus can be either a source or a sink for different trace metals. Therefore, it is imperative to study the composition of water and particles in the estuaries along with temporal fluctuations to identify different biogeochemical processes and pathways in
metal cycling. It has been suggested that exchange reactions play a major role in the behaviour and transport of trace metals in estuaries (Bourg, 1983; Forstner et al., 1990).

Once introduced into the aquatic system, trace metals undergo chemical, physical and biological reactions such as sorption at solid-water interfaces, diffusive fluxes across the sediment-water interface, uptake by planktonic organisms, sedimentation etc. As a result of these reactions, a large fraction of the trace metals introduced into the aquatic environment is normally found associated with the bottom sediments. Typically, sedimentary metal concentrations are three to four orders of magnitude higher than those in the dissolved phase.

**Uptake of trace metals by sediments and suspended particulates**

The uptake of trace metals by sediments and suspended particulate matter may generally be due to the following:

1. physico-chemical adsorption,
2. biological uptake,
3. physical accumulation of metal enriched particulate matter by sedimentation or entrainment.

The degree of physico-chemical adsorption will be influenced by the nature of the surface of the sediment or particulate matter. Electrophoretic measurements suggest that the surfaces of particulate matter are coated with a thin film of natural organics and this film will exert a significant influence over the adsorption of trace metals by natural particulate matter. Natural organic matter has a very important influence on the distribution of trace metals in aquatic systems. It may complex with the trace metal keeping it in solution.
The metal-organic complex may be sorbed by particulate matter or the organic matter may be adsorbed to particulate matter, where it may then be able to complex with trace metal ions in the solution phase.

In addition to physico-chemical uptake, trace metals may be actively taken up by bacteria and algae. This results in sediment enrichment, when the metal enriched biomass is incorporated. Sedimentation of enriched particulate matter is the other potentially important mechanism by which sediments may concentrate trace metals.

During estuarine mixing the trace metals in the dissolved and particulate forms can behave either conservatively or non-conservatively depending on various physico-chemical factors such as pH, Eh, suspended solids, ionic strength and the extent of solid-solution exchange. Another important factor, which can influence the behavior of trace metals in estuaries, is the hydrogenous precipitation of Fe and Mn oxides in the low salinity region. The freshly formed colloidal particles are excellent scavengers of substitution or surface adsorption processes.

The chemical behaviour of a trace metal during its transport within the estuary is determined to a large extent by its chemical form in which it is transported by the river as given below.

- in solution as inorganic ion and both inorganic and organic complexes
- adsorbed onto surfaces
- in solid organic particles
- in coatings on detrital particles after coprecipitation with and sorption onto mainly iron and manganese oxides
- in lattice positions of detrital crystalline material and
- precipitated as pure phases, possibly on detrital particles.
This scheme allows the distinction of trace metal as fractions that are readily available (dissolved and adsorbed), fractions that become available after chemical changes (organically bound and in oxide coatings) and forms that are practically unavailable for release (in crystal structures of suspended particles).

There are somewhat conflicting reports on the behaviour of trace metals during estuarine mixing and these conflicting reports of different workers may be accounted for reasons such as decomposition of pre-existing solids (which release the incorporated metals), differences in rate of mixing, nature of solids supplied by the end members and dependency of solids association of trace metals on the grain size distribution. Muller and Forstner (1975), Jouanneau et al. (1983), Duinker (1983) and George (1989) have reported non-conservative behaviour of particulate associated metals in various estuaries, while Windom et al. (1988), have reported the conservative behavior of particulate associated as well as dissolved metals. Bourg (1983) suggested that the uptake or release of trace elements by pre-existing solids in estuaries be probably related to ion exchange processes, at least for some elements. Some of the reports on the trace metal distribution in the Indian estuaries include that of Paul and Pillai (1983a), in the Cochin Estuary, Satyanarayana et al. (1985a & b) in Vishakhapatnam Harbour, and Zingde et al. (1988) in the Mindhola River Estuary.

Physical speciation studies are generally performed by filtration steps to determine the quantity of metals associated with operationally defined size fractions. Such physical separations are typically used to yield data on metals in the particulate vs. dissolved phase.

To assess the impact of (contaminated) sediments on the environment, information on total concentrations of metals in sediment, alone, are not sufficient. Only a part of the metals present may take part in short-time
geochemical processes or may be bio-available. For this reason, a series of different extraction procedures have been devised to gain a more or less detailed insight into the distribution of metals within the various chemical compounds and minerals. In this study an attempt is made to differentiate the metals in the sediment into exchangeable, reducible and resistant fractions in the sediments.

Some of the earlier investigations carried out to assess the trace metal content of sediments of Cochin Estuary were Murty and Veerayya (1981), Venugopal et al. (1982), Paul and Pillai (1983a), Ouseph (1987), Nair et al. (1990) and Jayasree and Nair (1995). Of these, Murty and Veerayya (1981) studied the distribution pattern of Fe, Mn, Ti, Ni, Co and Cu in the sediments of Cochin Estuary and in the Vembanad Lake. This was the only study, which reported trace metal distribution from the southern upstream part of the Cochin Estuary. This study was conducted during the period November-December 1969, before the construction of the salinity barrier at Thanneermukkam.

Scope of the present study

The impacts of developmental projects on the environment are a matter of serious concern. Kuttanad area is a typical example of such thoughtless developmental interventions. Kuttanad is a low-lying, shallow bay formed as a result of geological uplift. It has become an extensive brackish-water lagoon extending over 1100 kms through the Vembanad lake and Cochin Estuary to the Arabian Sea. Four major rivers drain into it. It supports about 1.4 million people. The major economic activity is agriculture involving 40% of the population. About 1.5% of the people are engaged in aquaculture. However, human interventions, like salinity barrier at Thanneermukkam, extensive use of chemical fertilizers and pesticides, etc., have invited ecological disasters. The declining productivity has forced farmers and fisher
folk to change their traditional professions. In this context a thorough study on the various environmental parameters of this area is of utmost concern for any environmentalist for an accurate assessment of the impact of human interventions on an otherwise pristine environment. The trace metal distribution in the Kuttanad backwaters is considerably influenced by the tropical features of the location and by human activities including agricultural activities and construction of salinity barrier. Though a number of studies on the trace metal distributions in water, particulates and sediments are available from Cochin Estuary, they are mainly concentrated on the northern part of the Cochin estuarine system. No systematic attempt has so far been made to assess the distribution of trace metals in the various environmental compartments of the southern upstream part of the Cochin estuarine system, except some scanty data reported by Murty and Veerayya (1981) and that too, before the construction of the salinity barrier at Thanneermukkam in 1975. Though total metal concentrations in sediments are useful for the assessment of metal pollution in the aquatic system, they are seldom sufficient to satisfactorily describe the various environmental processes in the aquatic system. Therefore, during the last decade, the major objectives of research on metal-polluted waters have changed from the initial surveys of sources and pathways to more detailed investigations of the mechanisms controlling the mobility and bioavailability of different metal species. Partitioning study on trace metals in sediments was conducted as it is a general experience that the environmental behavior and toxicity of an element can only be understood in terms of its physico-chemical form in which it occurs. Information on the partitioning of trace metals in sediments from Cochin Estuary and from other estuaries of Indian coast are relatively scarce. Nair et al. (1991) and Babukkutty (1991) have attempted to assess the partitioning behaviour of trace metals in sediments from the northern part of Cochin estuarine system. The objectives of the study are highlighted as:
to establish the background levels of various toxic metals (viz., cadmium, cobalt, chromium, copper, iron, manganese, molybdenum, nickel, lead and zinc) in different compartments of the aquatic system for assessing the extent of environmental pollution.

to describe the spatial and temporal variations of metals in the aquatic environment of Kuttanad.

to assess the influence of various environmental processes on the estuarine metal reactivity.

to understand the processes of transport and transformations of metals in different compartments of the aquatic system during metal transfer through the estuary.

to compare the behaviour of various metals viz., cadmium, cobalt, chromium, copper, iron, manganese, molybdenum, nickel, lead and zinc.

to study the diagenetic processes occurring within the sediment and the sediment-water inter-face.

to study the partitioning of trace metals in sediments and assess the potential mobility of these trace metals in the aquatic environment of Kuttanad.

to identify the possibility to quantify the lateral addition of trace metals and the geochemical reactivity with the help of a conceptual model.