Chapter 1

INTRODUCTION

Mangroves are the characteristic littoral plant formations of tropical and subtropical sheltered coastlines and are at the interface between the land and the sea. The importance of mangroves stems from their pivotal role in both terrestrial and aquatic production, and by the many amenities provided within and beyond its boundaries. Although these ecosystems are economically extremely valuable, they are under increasing threat of being wiped out by rapid human encroachment and environmental pollution. Thus an understanding of these ecosystems is vital to their survival. The classic work of Heald (1969) and Odum (1970) on mangrove productivity in Florida have attracted wide attention to the general significance of mangrove communities in the coastal zone. Mangrove forest areas and their associated food chain and nutrient cycles are often closely linked to those in adjacent coastal waters (Alongi et al., 1993; Alongi, 1996). The trees can be regarded as links between the terrestrial and marine ecosystem (Chale, 1993), and mangrove ecosystems are open with exchange of nutrients, detritus and sediment facilitated by tidal flushing (Woodruffe, 1985; Lee, 1995). The habitat receives nutrient and organic detritus from land and from fresh water streams (Morell and Corredor, 1993) and nutrients are effectively recycled within the ecosystem. The extent to which the mangrove systems exchange dissolved and particulate nutrients with adjacent waters depends on several factors including geomorphology, tidal regime and climate (Alongi, 1996). Mangroves are considered to play an important role in controlling coastal hydrodynamics and sediment movements (Boto, 1992; Eong, 1993).
A mangrove is a tree, shrub, palm or ground fern, generally exceeding one half meter in height, and which normally grows above mean sea level in the intertidal zone of marine coastal environments, or estuarine margins. Of late, the terms ‘mangroves’ or ‘mangal’ are being synonymously used to refer to the mangrove habitat although the former is far more popular. Mangroves are a diverse group of predominantly tropical trees and shrubs growing in the marine intertidal zone, sheltered coastlines, mudflats and river banks in many parts of the world, belong to a variety of plant families. Here they are subject to both short term rhythms of tides and seasons, as well as to longer-term changes of climate and sea level. As a group, they share several highly specialized and collectively well-known adaptations, notably exposed breathing roots and support roots, salt excreting leaves, and viviparous water-dispersed propagules. However, as individuals, these characteristics are not shared equally by all species. It is believed that the variation at particular sites influences both the types of mangroves that can become established and survive (Karim, 1991), and their morphology (Soto and Corrales, 1987: Duke, 1990). Hence, the type and condition of mangroves at particular sites reflect the physical conditions of those sites. The common characteristic they all possess is tolerance to salt and brackish waters. Furthermore, different taxa have different mechanisms for coping with high salt concentrations, and not all have salt-excreting gland on their leaves. Others exclude salt at the roots, although this creates xeric conditions for the plant. Another group also allows low concentrations of salt into their sap, but this is neutralized by its transfer into senescent leaves or by storing it in their bark or wood. Mangroves also need to cope with growth in water-saturated, often anaerobic, substrates. Some of these latter characteristics are shared with freshwater swamp trees. This lack of gaseous exchange in substrate requires them to have special breathing structures on the exposed roots and/or trunk. These may be quite different, depending on the taxon. Some species like Rhizophora have aerial prop roots bending down either from the trunk or branches, high above the substratum. Others have shallow, subsurface cable roots with series of vertical, stem-like breathing roots, called pneumatophores. By contrast in certain mangroves, there are no elaborate physical structures, instead numerous air breathing lenticels are often present on the trunk. Other essential attributes in this water-saturated environment are structures to support the above groundmass of the trees. This is very important to larger individuals, which commonly attains a
height of about ~40 meters height. Where roots are unable to penetrate more than a metre or so because of the anaerobic condition, lateral support structures are essential. In these cases, the root structures, contribute a great deal. However other support structures like trunk buttresses are also common in mangrove plants.

1.1 GLOBAL DISTRIBUTION OF MANGROVES

Mangroves are distributed according to three important scales, namely their coastal range, their location within an estuary, and their position along the intertidal profile. On the global scale, mangrove plants are found throughout tropical regions of the world. The mangrove species, the most tropical, shallow marine coastal habitats, are divided into two global hemispheres, the Atlantic East Pacific (AEP) often referred to as the New World, and the Indo West Pacific (IWP), or Old World. These more or less equal portions of the earth also have equivalent aerial extent of mangrove forests (Saenger et al., 1983). The AEP has fewer species and fewer additional genera. The most diverse flora is seen in the IWP. The dominant world mangrove zones are restricted to the Indo-West Pacific region of the Old World. The most important world mangroves are distributed in South-East Asia, North-East Australia and South-East Africa and extend mainly within the tropics and subtropics between latitude 32°00'N and 33°00'S and longitude 30°E and 165°E. In the New World zone, the mangroves are distributed in North America at Lousiana, Pacific coast of North-West Mexico, Bermuda Islands and Pacific coast of South America.

1.2 DISTRIBUTION OF MANGROVES IN INDIA

The Sunderban mangroves of Ganga delta form the largest belt covering about 4200km² area intersected by criss-crossing rivers and estuaries. These mangroves present complex ecological conditions due to their vastness in extent and ramification of the riverine system leading to the several islands. The diversity of habitats resulted in zonation and development of different associations. Physiogonomically also these mangroves are highly variable, depending upon the dominant species which may be Excoecaria agallocha, Avicennia officinalis, Sonneratia apetala or Ceriops decandra. Each of these gregarious species may constitute a pure formation. Besides these, Bruguiera gymnorrhiza, Xylocarpus granatum, X. moluccensis, Aegiceras corniculatum, Phoenix paludosa and Rhizophora mucronata are also observed (Dagar, 2000).
Chapter 1

The glory of Sunderban mangroves is, however, disappearing rapidly due to increasing biotic pressure. Many species which once dominated the mangrove stands have rare or all together are absent. Some of them have been listed as endangered (Nasker and Guha Bakshi, 1987) include *Heritiera fomes*, *Ceriops decandra*, *C. tagal*, *Rhizophora apiculata*, *R. mucronata*, and *Kandelia candal*. *Heritiera fomes* which had been a common dweller of the Sunderbans delta region is now very occasionally found in the tidal swamps. It has been exploited indiscriminately for its timber value.

The Mahanadi mangroves covering an area of about 200km² are in a degraded state due to conversion for agriculture and development of port facilities at Paradweeep. Dense forest are seen in Bhataraniya estuarine mud flats and deltaic creeks between the rivers Devi and Dharma. *Phoenix paludosa* and *Aegialitis rotundifolia* occur more towards estuarine conditions. *Rhizophora mucronata*, *Avecennia alba*, *Avecennia officinalis*, *Sonneratia alba*, *Ceriops decandra*, *Ceriops tagal*, *Bruguiera gymnorrhiza*, *B.parviflora*, *B.cylindrica*, *Xylocarpus granatum* and *Kandelia candal* grow luxuriantly in the tidal zone. *Acanthus ilicifolius* is found in elevated fringe areas. But most of the areas particularly away from the river remain highly degraded.

The mangroves of Godavari and Krishna estuaries depend on the frequency and amount of flooding of the river and configuration of the coast. During the hot season, salinity increases considerably and only certain taxa such as *Avecennia*, *Excoecaria* and *Sonneratia* with wide ecological amplitude exist. *Ceriops decandra*, *Rhizophora mucronata*, *Rhizophora mucronata*, and *R.apiculata* can be found frequently nearer to lagoons but are rare elsewhere. *Scyphiphora hydrophyllacea* once reported to be widely distributed, is found in new patches.

The mangroves of Cauvery deltaic system are discontinuous. The Pichavaram mangrove area (southeast India) support about 1100 ha, of which 50% is covered by forest, 40% by water-ways and the remaining filled by sand flats and mud flats (Krishnamurthy and Jayaseelan, 1983). The mangals of Pichavaram show a marked zonation where *Avecennia marina* forms pure stands and *Rhizophora apiculata* and *R. mucronata* grow well along the channel and creeks. These are mixed with *Bruguiera cylindrica*, *Ceriops decandra*, and *Sonneratia apetala*. Other species in this region included *Lumnitzera racemosa*, *Aegiceras corniculatum* and *Excoecaria agallocha*. The fresh water zone is generally dominated by *Acanthus ilicifolius*, *Avecennia marina* is found more towards the marine zone and *A. officinalis* towards freshwater zone influenced by Coleroon estuarine water.
Mangroves of Karnataka coast are highly degraded. These are formed on shallow coastal waters, estuaries or lagoons. *Avicennia officinalis*, *A. marina*, *Excoecaria agallocha*, *Acanthus ilicifolius*, *Rhizophora mucronata*, *Ceriops tagal*, *Sonneratia caseolaris*, *Kandelia candal*, and *Heritiera littoralis* are frequent species forming pure or mixed association.

The mangroves of Goa region cover about 200km$^2$ consisting of seven estuaries of which Zuari, Mandovi, and the Cambarjua canal connecting them with harbour cover about 75% mangrove area. *Avicennia officinalis*, *Rhizophora mucronata*, *Sonneratia alba*, are the prominent species which are associated with *R. apiculata*, *S. caseolaris*, *Kandelia candal*, *Bruguiera gymnorrhiza*, *B.paviflora*, *Aegiceras corniculatum*, *Excoecaria agallocha*, and *Acanthus ilicifolius*. These stands are not rich in their biodiversity due to excessive biotic pressure but during recent times attempts have been made to regenerate mangrove stands by planting the trees artificially (Dagar, 2000).

The mangroves of Maharashtra coast are under tremendous biotic pressure at almost all sites. Many species which were reported as common have become rare or all together absent on many of these sites. At many localities bushes of *Avicennia marina* are most prominent showing the capacity of tolerance to biotic pressure. All along Gujarat coast Rhizophoraceae element is very rare. Species of *Avicennia* form gregarious but stunted stands. (Dagar, 2000)

The Andaman and Nicobar Islands harbour some of the best developed mangroves which are comparatively less disturbed. There is a distinct zonation pattern. *Rhizophora mucronata* and *Rhizophora stylosa*, are the prominent towards sea where others cannot stand. Species of *Bruguiera*, *Sonneratia*, *Aegiceras*, *Xylocarpus*, *Aegiceras*, *Avicennia*, *Ceriops*, and *Scyphiphora* are common in the middle zone while species of *Excoecaria*, *Lumnitzera*, *Cynomitra*, and *Heritiera* are common towards land. *Nypa fruticans*, *Acanthus spp.*, and *Phoenix paludosa* are common along creeks. The distribution of *Acanthus ebractatus*, *A.volubilis*, *Lumnitzera littorea*, *Bruguiera sexangula*, *Rhizophora stylosa* and *R.lamarckii* is interesting in these islands as these are not frequent elsewhere. In recent years due to developmental activities these stands are also under high biotic pressure and many species are becoming rare.

Besides the over exploitation of these resources there are other reasons also which are responsible for the dwindling of mangrove ecosystems. Khushoo (1986) has stated that role of pollutants is very discriminatal for the deterioration of
these coastal vegetation in Bombay, Madras, Ernakulam to Trivandrum, Andhra Pradesh, Karnataka and Orissa.

1.3 DISTRIBUTION OF MANGROVES IN KERALA

Kerala once supported about 700 km$^2$ mangroves along its coast (Ramachandran et al., 1986) and what is seen now are only relics of the great past. The increasing pressure on the coastal area as the population density increases initiates a radical transformation of the natural environment. Early development of the state was mainly through sea trade in the past and more recent changes in agricultural and industrial sectors resulted in consumption of large extents of mangrove vegetation. Moreover, the ecological significance of this unique ecosystem was not at all understood. By the time the ecological importance are realized, the mangroves had dwindled from 700 km$^2$ to about 17 km$^2$.

The entry of tidal waters regularly from the sea, the enrichment of 30 estuaries and backwaters with the regular supply of fresh water flowing from the 44 perennial rivers create a peculiar ecological environment leading to the development of a unique mangrove vegetation on the fringes of the backwaters, estuaries, and creeks. The important species found are *Acanthus ilicifolius*, *Acrostichum aureum*, *Avicennia marina*, *Avicennia officinalis*, *Bruguiera gymnorrhiza*, *B. parviflora*, *Ceriops tagal*, *Dennis trifoliate*, *Exococaria indica*, *Kandelia candal*, *Lumnitzera racemosa*, *Rhizophora mucronata*, *R. apiculata* and *Sonneratia caseolaris*.

The district wise distribution of mangroves is given in a table below (Chand Basha, 1991)

<table>
<thead>
<tr>
<th>District</th>
<th>Mangrove area (approximate ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thiruvananthapuram</td>
<td>23</td>
</tr>
<tr>
<td>Kollam</td>
<td>58</td>
</tr>
<tr>
<td>Alappuzha</td>
<td>90</td>
</tr>
<tr>
<td>Kottayam</td>
<td>80</td>
</tr>
<tr>
<td>Ernakulam</td>
<td>260</td>
</tr>
<tr>
<td>Thrissur</td>
<td>21</td>
</tr>
<tr>
<td>Malappuram</td>
<td>12</td>
</tr>
<tr>
<td>Kozhikode</td>
<td>293</td>
</tr>
<tr>
<td>Kannur</td>
<td>755</td>
</tr>
<tr>
<td>Kasarkode</td>
<td>79</td>
</tr>
<tr>
<td>Total</td>
<td>1671</td>
</tr>
</tbody>
</table>
Patches of varying extent exist along the sides of the railway line especially in the Trivandrum-Quilon, Ernakulam- Alleppy and Thanur-Kasargode sectors. In most places the vegetation is in a very narrow linear strip. Bigger bits are available in some parts especially on the sides of the line from Mahe to Dharmadam, Pazhayangadi, Ezhimala, Payyannur, Edakkad and so on. These are comparatively bigger patches, and support fairly good and developed mangrove vegetation. The Quilon strip has a length of 0.75km and a varying width of 1-10metres from the water front. The total extent of this may be around 2ha. Kumarakom which is declared as a bird sanctuary supports a narrow belt of approximately one-kilometer long mangrove vegetation along the fringe of Vembanad lake varying in width from 10-20m. This area comes approximately to 4ha including vacant marshy patches.

The Vyypeen area in Ernakulam district, support about 10ha of mangroves. These forms a part of the naturally accreted area called Puthuvypu at the southern tip of Vypen Island located on the North- Western bank of Cochin bar-mouth. In Kerala some of the mangrove vegetation are under the forest department. In Ernakulam district the land called "Mangala Vanam" also support a good amount of mangrove vegetation.

1.4 ECONOMIC IMPORTANCE

The viability of an ecosystem can be judged from its diversity of species which indicate the survival value of the community. A rich gene pool means a higher adaptation potential. It leads to increased stability in an ecosystem. In mangrove ecosystem there is large accumulation of plant debris. To a wide range of animals, the litter is valuable feed either as such or after microbial degradation. Many of them make use of mangrove communities as habitat, nursery ground and source of food. The debris also serves as breeding ground for the juveniles of many types of fish, crustaceans and other fauna. Mangrove roots and branches serve as a good shelter for large number of organisms including many beautiful mosses, lichens, algae, fungi, bacteria, ciliates, nematodes and amphipods which colonize and form food for many kinds of fish. Many of the fish species utilize the mangrove water as good nursery and breeding ground. Thus mangrove ecosystems not only provide fuel wood and charcoal, timber and construction material, pulp, tannin, food and beverages, honey, fodder, medicine, and
stabilization of the coast, but also sustain diverse communities of flora by providing them with habitat, energy and nutrition. In the mangrove ecosystems, phytoplanktons and zooplanktons become supplementary source of nutrition to the small fish and other aquatic life. The fish culture ponds may be created in cleared portions or behind the mangrove without further denudation of mangroves. Low lying marshy areas connected with the sea offer good scope brackish water fish and prawn culture. Mullets grow well in mangrove waters. The prominent commercial mollusks, the black lip pearl oyster and green mussel culture offer good scope in intact mangrove areas.

1.5 MANGROVES AND NUTRIENT ELEMENTS

Carbon, nitrogen and phosphorus are the most significant micronutrients in aquatic ecosystems. In the aquatic environment, the nutrients are distributed between the water and the sediment interface in both dissolved and particulate forms. Bioavailable nutrients are taken up and metabolized by aquatic organisms in the lifecycles. In a specific aquatic ecosystem, nutrient dynamics partition the elements carbon, nitrogen, and phosphorus among water, sediment and biota to attain a natural balance. This balance may change as nutrients are introduced from agricultural, industrial and urban sources.

Sediment particles in lakes and rivers are constantly resuspended and redeposited, depending on environmental conditions. The nutrient content in particles is important in their transport from bottom sediments to the overlying water. The knowledge of their concentrations is used to understand their movement within the aquatic ecosystem, particularly at the sediment water interface.

Mangrove forests are best developed on tropical shorelines where there is an extensive intertidal zone, with an abundant supply of fine grained sediment (Walsh, 1974). While mangroves are generally associated with low-energy, muddy shorelines, particularly tropical deltas, they can grow on a wide variety of substrates, including sand, volcanic lava or carbonate sediments.

A comprehensive understanding of nutrient behavior in aquatic ecosystems requires their study in both the water and sediments. Bonanni et al. (1992) showed that sediments play an important role in the accumulation and regeneration of nutrients. Organic matter produced by phytoplankton in eutrophic shallow lakes
settles to the sediment and decompose by aerobic and anaerobic processes, during which different carbon, nitrogen and phosphorus compounds are produced (Anderson and Jensen, 1992). Further more, decomposing organic matter affects changes in oxygen concentration and redox potentials which in turn affects nitrogen and phosphorus release from sediments to the overlying water. In order to obtain a complete picture of the effects of flooded soils on plant productivity, relatively long term studies on nutrient status, redox potential, pH, soil mineralogy, and salinity changes must be made. The redox potential is a convenient measure of the extent to which the soil is in a reducing or anaerobic stage. The large positive values of redox potential indicate a well oxidized or aerated stage. As the oxygen supply is limited, it is rapidly consumed by bacterial respiration. It was found that this process takes place at an Eh range of +350 to +380mV. When all the oxygen is consumed the conversion of Mn$^{+4}$ to Mn$^{+2}$ and NO$_3$ to N$_2$ takes place. When Mn$^{+2}$ and NO$_3$ are completely consumed, then Fe$^{+3}$ is reduced to Fe$^{+2}$ and so on until the soil eventually reaches a highly anaerobic state where the reduction of dioxide to methane takes place. The rate at which all these processes depends upon the time of flooding and organic carbon present in the soil.

The ecological significance of carbon as a nutrient is manifested through its organic forms. The concentration of total organic carbon is often used in correlation with other elements. For example carbon to nitrogen and carbon to phosphorus ratio is used to characterize the association of nitrogen and phosphorus in organic matter. Nitrogen species include organic nitrogen, ammonia nitrogen, nitrate and nitrite nitrogen. Biological activities in living dead tissues produces reduced forms of organic nitrogen ranging from simple amines to complex proteins. Ammonia is the most common form of inorganic nitrogen, and is the product of decomposition of organic matter. Bacterial oxidation in the nitrification cycle produces nitrite and nitrate. Phosphorus species in the environment include organic phosphorus compounds, inorganic phosphates, and mineralized inorganic complexes with iron, calcium and aluminium. Phosphorus precipitates to form low solubility compounds and metallic complexes, and is relatively immobile compared to carbon and nitrogen. The natural abundance of nutrients of interest is carbon, nitrogen and phosphorus. Due to this sequence, phosphorus is often considered to be the limiting nutrient in the ecological cycle.
Sediments receive a mixture of labile and refractory organic and inorganic phosphorus compounds from the overlying water and the surrounding landmasses. Some of these compounds behave as inert material and are simply buried in their original form. Others decompose or dissolve and simply release the phosphate to the sediment pore water. The regenerated phosphate may be released to the overlying water, reprecipitated within the sediment as an authigenic phase or adsorbed by other constituents of the sediment. Adsorption on metal oxides in the sediment has been identified as one of the principal reactions involving phosphate. (Lijklema 1976; Krom and Berner 1981; Frolich 1988). Mangrove soils are expected to contain a high proportion of organic phosphorus compounds due to their generally high organic matter content (Boto, 1988). Boto has pointed out that much of this organic phosphorus is in the phytate form and bound to humic compounds, and has been found in lake sediments, and is not probably not available for microbial and mangrove plant nutrition. The inorganic phosphate represents the largest potential pool of plant available, soluble reactive phosphorus. Most of the inorganic phosphorus in mangrove sediments is either bound in the form of Ca, Fe, and Al phosphates or as soluble reactive phosphorus adsorbed onto, or incorporated into hydrated Fe and Al sesquioxides. Total organic P concentrations, proportionally greater in surface sediments, reflect the influence of roots, whereas the inorganic fractions mainly Fe bound phosphorus, proportionally and in real terms increase gradually with depth reflecting the influence of increasing anoxia particularly below the root layer.

Every organism participates to some extent in the phosphorus cycle by virtue of its need to assimilate organic and/or inorganic phosphorus for growth and maintenance, and by excreting phosphorus containing byproducts. Bacteria, algae and higher plants, including mangroves, take up dissolved orthophosphate; and organic phosphates are either taken up directly or first hydrolysed by extracellular alkaline phosphates. Organic phosphorus may be very resistant to hydrolysis and not readily assimilable to organisms. Orthophosphate is coupled to ADP to form ATP in cells, and is essential for energy transfer and phosphorylations, and for synthesis of nucleic acids, phospholipids and phosphoproteins (Ingraham et al., 1983). In comparison with release rate of phosphorus from mineral phosphates a refractory organic material, the turnover time for P uptake, utilization and excretion by living organisms is very short, on the order of minutes to tens of hours, depending on the rate of biological activity and the amount of available phosphorus. Once P is taken up
and used in cells as phosphate, it is eventually liberated via excretion or through mineralisation of detritus as phosphate. This means that all organisms have evolved efficient uptake mechanisms for a very small and virtually constant proportion of the earth’s P in a very competitive cycle, and P on a localized level may limit growth of biomass. Local P cycle can be very efficient in tropical mangroves, where it has been estimated that up to 88% of the forest P pool is retained within the sysem (Boto and Bunt, 1982). The cycling of phosphorus through mangrove food web is presumably similar to that in other aquatic systems. At the base of pelagic and benthic food webs, a ‘microbial loop’ exists in which interactions among bacteria, microalgae and nanoprotocoans and larger protests facilitates net release of phosphorus into the water column and pore water.

An increasing number of studies have investigated the influence of mangrove forest on coastal nutrient cycles and food chain and found that the actual amount of dissolved and particulate matter exchanged depends on the factors such as aerial extend of the forest, tidal amplitude and seasonality. Tropical mangrove forests, on average, appear to export particulate nutrients and to import some dissolved species, depending upon season, tidal amplitude and geomorphology. (Alongi et al., 1993).

1.6 SCOPE OF THE STUDY

Tropical mangrove systems in Australia and southeast Asia face continuing degradation from human activities. These include indirect effects from nutrient and toxic pollution associated with development and aquaculture (Kaly et al., 1997). Scientific investigations on mangrove systems are particularly significant allows the Kerala coastline, as the economy of this state largely depends on its coastal fisheries. In the coastal areas especially near mangrove forests, prawn culture farms are established, which produce effluents with organic and inorganic pollutants. These pollutants damage the ecology of the system. Cutting of trees for fuel and over grazing by cattle has led to soil erosion and stunted growth of the plants in this area. Although extensive areas of mangrove woodland were found along the banks of Cochin estuary most of these have now disappeared. Study sites represent some of the few remaining areas of mangroves. It is evident that the remaining mangroves are important breeding and feeding areas for the local commercial fish and prawn stocks.
Basha, (1991) reported on the mangrove vegetation of Kerala coast in its present condition, and also gave a historical background to make the reason clear for the dwindling of the mangrove forest to the present stage of discontinuous and isolated bits. Three mangrove ecosystems of Kerala, namely Veli, Quilon and Kumarakom were compared with respect to the species distribution and the hydrographical characteristics by Thomas and Fernandez (1993). The different factors, that are responsible for the colonization of the predominant vegetation, *Acanthus ilicifolius*, in mangrove areas of Cochin, were investigated by Muraleedharan and Rajagopalan (1993). About thirty three species of polychaetetes were identified in mangrove regions of Cochin (Kumar and Antony, 1994). The texture of Tellichery mangrove sediments was found as silty sand due to the prevalent high energy zone (Raghunadh et al., 1995). A pollution survey was carried out by assessing the heavy metal (Fe, Mn, Cu, Zn, Pb, Co) concentration in mangrove flora and sediments (Thomas and Fernandez, 1997). A critique on the occurrence and distribution of macro-zoobenthos in an aquaculture pond suggested a better scope for aquaculture in brackish water pond lined with mangroves in the margin (Kumar, 1998). The importance of mangroves to the estuarine ecosystem in general and for the propagation of marine shrimps in particular is emphasized in a report of Achuthankutty and Sreepada (1998). A statistically significant correlation was found between sediment size in the distribution pattern of organic carbon (TOC) and total phosphorus (TP) in mangrove sediments at Veli, Kochi and Kannur (Badarudeen et al., 1998a). Investigations on inorganic nutrient levels of interstitial waters in a mangrove forest of Cochin, revealed that dissolved phosphate, ammonium and silicate were several times higher in interstitial waters than in overlying waters (Bava and Seralathan, 1998). A comparison of the distribution of sodium and potassium in sediments of Veli, Kochi, and Kannur mangroves exposed the enrichment of potassium over sodium in sediments of Kannur mangroves (Badaruddin et al., 1998b). Subramanian (2000) reported that Cochin backwaters had many pockets of mangrove habitats with the same species diversity as any other mangrove ecosystems.

Perusal of literature, on the mangrove ecosystems of Kerala revealed that most of the investigations concentrated on the physical and biological characteristics. Biologists often view mangrove forests as highly productive sources of organic matter, from which there is a net outwelling of energy supporting
complex estuarine and near shore food webs. Geologists, on the other hand, view mangrove shore lines as sediment sinks, characterized by long-term import of sediment, as indicated by the substantial accumulation of recent sediments which underline mangrove forests and adjacent coastal planes. However chemists attempt to find exact processes by which the mangrove acts as a source or sink of organic and inorganic nutrients.

Until now, no rigorous reports exist on chemical investigations on the nitrogen and phosphorus dynamics in mangrove fringed creek waters and sediments of Cochin. Although there are several studies on the distribution and speciation of nutrients in Cochin estuary, the information regarding the same lacking at the mangrove areas of Cochin estuary. Therefore an attempt has been made to investigate nutrient distribution of selected mangrove systems of the Greater Cochin area. The main objectives of the study undertaken were,

- to determine seasonal trends of dissolved inorganic nitrogen and phosphorus in selected mangrove fringed creeks around Greater Cochin area and the main parameters affecting their variability.
- to attempt a comparison of nutrient concentration among Stations and between seasons.
- to determine the distribution of different forms of phosphorus in surface waters of mangrove-fringed creeks.
- to characterise the sediments of these creeks by monitoring properties like grain-size, moisture percentage, pH, and also the nutrient status by measuring the three important nutrient element, carbon, nitrogen and phosphorus.
- to explore the vertical distribution patterns of C, N and P in sediment cores so as to generate information on aspects that influence the sediment nutrient profile.
- to study the fractionation of phosphorus, in mangrove core sediments and to explore the impact of environmental factors on their distribution.

Clearly, a whole set of processes like mineralogical diagenesis, biotic and abiotic redox processes, biological assimilation enzymatic and non-enzymatic hydrolysis reaction etc. are operating in the sediments at any one time (Hakanson and Jansson, 1983) and the dominant process will depend, in part, upon the phosphorus species present. Therefore, knowledge of phosphorus speciation
should allow for an understanding of the mechanisms for phosphorus release or assimilation by sediments.

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Introduction


Chapter 1


