CHAPTER 1
INTRODUCTION

1.1 ESTUARINE ENVIRONMENT

An estuary has been defined as "a body of water in which the river water mixes with and measurably dilutes the sea waters" (Ketchum, 1951). Emery and Stevenson (1957) described it as the mouth of a river or an arm of the sea where the tides meet the river currents. Pritchard (1967) defined estuary as "a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage". They, by these definitions form natural mixing areas between marine and fresh water zones. Estuaries are generally regarded as one of the most productive aquatic systems and the nutrient supply through fresh water input is important in sustaining their high rate of primary production. Estuaries also function as important sinks and transformers of nutrients, thus altering the quantity and quality of nutrients transported from land to the sea. On an aerial basis of any class of ecosystems, estuaries receive some of the highest inputs of nutrients because of the local influences and from land drainage. Estuaries are important areas of human use for fisheries, transportation, aquaculture and recreational pursuits. Thus by virtue of their natural location and easy accessibility estuaries are more amenable to anthropogenic influences. Moreover many animals spend their life in estuaries either partially or wholly.

In Kerala there are 41 rivers flowing towards west and draining into the Arabian Sea through the backwaters. Major rivers of Kerala namely Chaliyar, Bharathapuzha, Chalakkudypuzha, Periyar, Pampa, Muvattupuzha, Kallada and Achankovil together carry an estimated discharge of 45060 X 10^6 m^3 of water annually into Arabian Sea. (Anonymous, 1974).

It has been estimated that 5 X 10^5 m^3 of trade effluents are being dumped into the rivers of the State every day (Joysing, 1976). Indiscriminate discharge of industrial effluents with high BOD, toxic chemicals and suspended solids has progressively been rendering many rivers unsuitable for fishing and recreation uses. In Kerala, 85% of the people depend directly on water from rivers, ponds and wells for their daily requirements.
Industrial development along with support facilities and associated township developments also place demands on natural sources of supply of water. Hence the location of any chemical industry need to be selected ensuring on the availability of reasonably good water for the process and the facilities for discharging waste into surface waters without impairing other utilities.

The Cochin backwaters including Vembanad Lake, occupy an area of about 256 square kilometers. The area is about 96 km long and 3-4 km wide on an average. It extends from about 9°30' to 10°20' lat N and 76°13' to 76°50' long E. The backwaters occupy an alluvial plain lying parallel to the coast between the Arabian Sea to the west and the Western Ghats to the east in Peninsular India. The complex system has two perennial openings to the sea, at Crangannore in the north and at Cochin in the south. The one at Thottappally, south of Alleppey is open only during the southwest monsoon and is also regulated by a spill way across the mouth of the estuary. Many rivers and rivulets discharge into the system. The average tidal range at Cochin is about one meter.

The Cochin backwaters constitute a vast estuary, under the monsoonal regime, flushed by rains and runoff from land during monsoon. After the rainy season, the intrusion of seawater into the estuary can be traced upto 15-20 km upstream during the inter-monsoon period. Progressing upstream, the seawater gradually loses its identity by admixture with freshwater from land run off.

Seasons tend to telescope into each other in intensity and duration since monsoons are variable. Thus the south west coast estuaries present themselves as highly variable environments. Despite these characteristics, however, estuaries are hospitable to those benthic species, which are able to cope with the environment. The water characteristics within estuaries change continuously under the influence of tidal forcing, land runoff and winds in some cases. Owing to the heterogeneous nature of estuarine waters the benthic animals have to endure a wide range of environmental changes when the circulation carries different kinds of water over their site or burrow (Stone and Reish, 1965). A common feature of many estuaries is a turbidity cloud or mud section. The benthic animals are often confronted with changes of the sediment in or upon which they live.
With an increase in depth in the estuarine sediments, the oxygen usually decreases, and the deeper sediment layers are characterized by low redox potentials and high amounts of hydrogen sulphide. In this sulphide system no macrobenthic animals occur without contact with the overlying water but meio and microfaunal species live there in fairly large numbers (Fenchel and Riedl, 1970). In many estuaries the preponderence of fine particles in the sediments and the high contents of organic matter make this sulphide system an important part of the estuarine habitat.

Estuaries also offer some positive advantages for benthic animals. Compared to the open coast, estuaries are relatively sheltered against wind, waves and ocean swell. Most estuaries are also rich in allochthonous material provided by river input, those from salt marshes, mangroves or from the coastal sea, augmented by high primary production within the system. Often combinations of these factors prevail. Because of the shallow depth of most estuaries, suspended food particles are readily available for benthic animals through sinking as well as through downward transport by turbulent water movements (Wolff et al., 1976 a). Estuarine and coastal waters are rich in nutrients, and hence phytoplankton productivity is high in estuaries when turbidity is low. On the other hand, in turbid estuaries, even though there are sufficient nutrients, lack of sufficient amount of light restricts primary production. In the Cochin backwaters, the estimated annual consumption of primary production by the zooplankton herbivores is approximately 25 per cent of the total production. The unconsumed basic food supports a detritus food chain. The estuarine phytoplankton production is also supplemented by the productivity of other systems such as marsh grasses, weeds and others such as mangroves (Nair and Thampy, 1980). Qasim et al. (1969), estimated that the gross production ranges from 273-293 gC/m²/year with an average of 280 gC/m²/year, while the net production is 184-202 gC/m²/year with an annual consumption by zooplankton herbivores of 30 gC/m² leaving a large surplus of basic food in the estuary. Inspite of seasonal and spatial variations the estimated annual gross production for the entire Vembanad lake comprising about 300 km² is about 1,00,000 tones of carbon (Nair et al., 1975), indicating that availability of food is unlikely to be limiting to benthic communities.
The level of primary production is increasing from the open sea towards the coast and is maximum in the coastal waters. The estimated gross production within the 50 m depth contour is $434 \text{ gC/m}^2 \text{/year}$ (James et al. 1983). Nair & Pillai (1983) found that three main ecological factors namely salinity, light and nutrients govern the rate of productivity in this ecosystem.

Madhupratap et al. (1977), estimated the secondary production of the Cochin backwaters and compared it with the reported values of primary and tertiary production from the area. Zooplankton biomass (dry weight) in the Cochin estuary ranged from 0.7 to $384.0 \text{ mg/m}^3$. The average zooplankton production was estimated to be $31.8 \text{ mg dry wt./m}^3\text{/day}$ ($11.6g/m^3$/$\text{year}$). The deeper regions of the backwaters showed higher secondary production ($52.5 \text{ mg/m}^3\text{/day}$) than the shallow reaches at the head ($14.0 \text{ mg/m}^3\text{/day}$) and between Cochin and Azhikode ($9.1 \text{ mg/m}^3\text{/day}$). The ratio of secondary production to primary production at the lower reaches (Cochin to Aroor) was found to be $12.5\%$ which closely matches Cushing's (1971) average transfer coefficient (12.4%) from primary to secondary level from the major upwelling areas of the world. A conversion factor of 0.075 g dry weight/ml displacement volume (Madhupratap & Haridas, 1990) was used to estimate the dry weight of mesozooplankton and 34.2% of it was considered for carbon estimation (Madhupratap et al., 1981).

Productivity of benthos is related to the primary production of the overlying water column (Lie, 1968). In Mandovi and Zuari estuarine system of Goa the annual primary production is $205g/C/m^2/year$ (Bhattathiri, personal communication), while the zooplankton production is reported to be $7.81 g/C/m^2/year$ (Goswami, 1979). Observed macrobenthic-standing stock is $4.08 g/C/m^2/year$, which is mainly derived from organisms like polychaetes and bivalves. Sanders (1956) suggest annual production to be about twice the standing stock and therefore, the estimated biomass production will be about $8.16 g/C/m^2/year$ (Parulekar et al, 1980).

Mean figure for tertiary production, taking 1% of primary production and 10% of secondary production (Cushing, 1971 & 1973) and raising their carbon values by the factor 7.41 to obtain wet weight for fish (Vinogradov, 1953) is approximately 2400
tonnes. Accordingly the catches of plankton-eating fishes from the Cochin backwaters were about 1470 to 2640 tonnes (Madhupratap et al., 1977). Most of the estuarine fishes are omnivorous and the common estuarine fishes like Mugil can feed at different trophic levels (Odum, 1971).

Apart from primary food, part of the secondary production also contributes to the detritus ecology of the system. Any estimate of fish production from plankton alone, without considering detritus will be an underestimate (Qasim & Sankaranarayanan, 1972). In fact organic detritus plays an important role in the food chain of the backwaters. This is evident from the higher percentage of prawns in the composition of annual fish landings and fairly high harvest of clams (88,000 tonnes of live and 1,70,000 tonnes of dead shells annually (George & Sebastian, 1970). Detritus in the estuary is derived from other sources such as land drainage; waste dumped into it, faecal pellets of the inhabitants and the decay of large quantities of the weed Salvinia brought into it during the monsoons. The availability of large quantities of detritus and phytoplankton thus provide ample scope for the expansion of culture fishery of prawns, mussels and oysters in the estuary.

1.2 BENTHOS

1.2.1 Definition and types of benthos

The term benthos refers to those organisms, which live on or in the bottom of any body of water (Bostwick, 1983). Phytobenthos is the collective name for all plants among the benthos, such as the diatoms, macroalgae and higher plants. Zoobenthos comprises of all animals occupying the bottom habitat. Those found on hard substrates, such as rocks, wood and shells are very different from those of the soft sediments such as sand and mud. Both types of substrata are occupied by species, which live upon the surface of the bottom sediments – the epifauna, in soft sediment; there is the infauna, the species living within the bottom. Benthic animals are divided into three categories according to size (1) macrobenthos (2) meiobenthos and (3) microbentos (Mare, 1942). This distinction of benthos into three size groups is arbitrary and varies according to the workers and according to the type of substratum occupied by the community. The lower size limit of macrobenthos depends upon the mesh size of the finest sieve used and usually varies
between 0.5 and 3.0mm according to different workers. The upper limit of meiobenthos depends upon the mesh size of the sieve used for separating macrobenthos from meiobenthos. This generally falls between 0.5 and 1.0 mm. In most of the meiobenthos investigations it necessary to have a lower size limit to eliminate the fine sediment in the process of extraction of organisms. This lower limit is between 0.04 and 0.1 mm (McIntyre, 1969).

1.2.2 Adaptations to estuarine environment

The adaptations of estuarine benthos should be viewed as morphological responses to physiological stresses. This postulate is supported by the high percentage of anomalies in low salinities (Muus, 1967). Physiological adaptations to the estuarine environment are widespread among benthic animals. The major adaptations are in the regulation of the osmotic and ionic composition of the body fluids, and survival under conditions of reduced oxygen.

Estuarine benthic animals make many behavioural adaptations to their environment. Burrying behaviour is widespread, although it is not limited to estuaries. Sanders et al., (1965) demonstrated that infaunal species survived in interstitial water but died in the ebb water flowing over the sediments in the locality where they were collected. It is probably for this reason that marine infaunal species occur further up the estuary than marine epifaunal species do. On the other hand burrying is also a common method to escape predator pressure and desiccation.

The small-scale distribution of benthic organisms in estuaries is related to such factors as depth, current speed and sediment characteristics. Benthic animals respond to gradients such as exposure to wave action, rate of dilution of sea water by river water, turbidity, oxygen saturation and in some cases and effect of pollutants. Of these variables salinity is the most important natural component in the estuarine environment. Turbidity caused by suspended particles may affect suspension feeders negatively and at very high turbidities such species do not occur. Oxygen shortages also have mainly negative effects. Anoxic areas are not inhabited by macrobenthic species, although meio and
microbenthos may be found. Areas influenced by organic pollution are often dominated by short-lived opportunist species, with a resilient core population.

1.2.3 Food and feeding in benthos

All kinds of organic matter in the estuarine environment – planktonic and benthic organisms, detritus bacteria and dissolved organic matter – are potential sources of food. According to the feeding habit, benthic animals are categorized as suspension feeders (species feeding on organic particles suspended in the water), selective deposit feeders (those which separate their food particles from the sediment by action of ciliated tentacles, by appendages equipped with setae, by current through inhalent siphon etc.), nonselective deposit feeders (those which ingest the sediment as a whole, use the digestible particles and pass the remainder through their gut), predators, scavengers and grazers.

1.2.4 Benthic productivity

Benthic production is of importance in assessing the biological productivity of an area. It is well recognized that the distribution and abundance of benthic animals of a region is directly related to the fisheries of that region. Benthos that, form an important source of food for demersal fishes can be good indicators of fish stocks. Benthic production in estuaries is quite high when compared to other aquatic habitats because of the relative abundance of food in estuaries, combined with the shallow depth of most of the estuaries. In such situations food becomes readily available to the bottom living animals through sinking and vertical transport by turbulent water movements caused by waves and tidal currents. Another possible cause is the presence of opportunistic species, which produce more generations per year compared to the other slower reproducing fauna.

1.2.5 Importance of benthos as indicators

Information on the composition of standing bottom communities can in a way be related to stresses undergone by the preceding community at that and adjacent areas. The concept of indicator species is of great importance in biological monitoring and benthic invertebrates are recognized as useful tools. Ideally indicator organisms are those species
that have narrow and specific environmental tolerances. The principal underlying assumption in using indicator organisms, specific assemblages or communities for water quality assessment is that the presence of an indicator is a reflection of its environment. An organism cannot survive indefinitely in an environment that does not provide its physical, chemical and nutritional requirements. Indicator organisms are used primarily to identify rather than to measure environmental changes. The use of marine invertebrate animals or populations, as indicators was first suggested by Wilhelmi (1916). Studies on benthic indicator species of marine and freshwater pollution were carried out by several workers (Belegvad, 1932; Gaufin and Tarzwell, 1952; Reish, 1957a; Hynes, 1966; Ganapati and Raman, 1970; Butler et al., 1972; Anger, 1975; Philips, 1977 and Remani et al., 1983). A variety of benthic organisms like Capitella capitata, Nereis caudata and Balanus amphitrite have been identified as possible indicators of the presence of certain chemical species in the marine environment (Reish, 1957b, Perkins, 1979 and Rege et al., 1980). The ability of many marine molluscs to concentrate metals in their tissue from the surrounding waters has become a useful tool in marine environmental research. The suitability of mussels as test animals and sentinel organisms in nature for the uptake of pollutants results from their widespread distribution and easy accessibility for collection and owing to their sedentary and filter feeding habit. The use of mussels for the purpose of monitoring coastal water quality has received much attention in recent years. Work in this field was stimulated by the suggestion made by Goldberg (1975) for Global Mussel Watch. Subsequently considerable amount of research on various aspects like physiological, cytological, cytochemical, chromosomal, bioassay, ecological consequences of stress, biochemical etc. under Mussel Watch programme was carried out by Bayne et al. (1985).

Benthic organisms can be used as bio-markers in the assessment of contamination in marine ecosystem. Biological markers have received considerable attention among environmental toxicologists as tools for detecting exposure to and effects of environmental contamination. A biological marker can be defined as a xenobiotically induced variation in cellular or biochemical components or processes, structure or function that is measurable in a biological system or sample. (McCarthy et al., 1990). The rate of bioconcentration potential of an organism is dependent on many factors such
as temperature, physiological status varying with sex and season and biomagnification potential that increases within the perfect level (Narbonne and Michel, 1993).

1.2.6 Economic importance

The penaeid shrimps such as *Penaeus monodon*, *P. indicus*, *Metapenaeus dobsoni*, *M. monoceros*, *M. affinis* and *Parapenaeopsis stylifera* are the most valuable commercial sea foods of Kerala. The life history of these species except the last one involves an estuarine phase as their post-larvae and juveniles migrate to estuaries, which are their nursery grounds. As the shrimps grow, they move into deeper waters of the estuary and from there to the sea where they contribute to the marine fishery (Gopalan *et al.*, 1983). The giant freshwater prawn *Macrobrachium rosenbergii* used to contribute to a lucrative fishery in the middle and lower half of the Vembanad Lake. *Scylla serrata*, *Portunus pelagicus*, *P. sanguinolentus* and *Charybdis cruciata* are the four species of crabs, which are commercially important. Crab fishery in India is yet to be recognized as a major fishery, despite the abundant occurrence of food crabs all along the Indian coastal and inland waters. The export figure of crabs reached 654 tones in 1990-1991 indicating the potential for future (Marichamy, 1993). Molluscs as such have great importance in that they form valuable fisheries and a very cheap source of protein. Besides, they are used as source of lime and as constituents of medical preparations. When they are exploited for these purposes indiscriminately, a large number of young ones are also caught, causing depletion in the population. Extensive beds of oysters and clams of commercial importance were available in the backwaters. Of particular importance is the edible estuarine oyster *Crassostrea madrasensis*. Remnants of their beds known as “Muringa Madu” still exist in the Cochin backwaters. Reduction in the area of backwaters by dredging and reclamation as well as for mining the subsoil shells and salt water extrusion projects have affected this fishery adversely. Major species contributing to the fishery like *Villorita* are adapted to saline conditions and thrive at salinities as high as 15 ppt. The existing subsoil shell deposits might be available for a few more years more for commercial exploitation. But in the long run the regeneration of the shell resources will be hampered by the changing ecology of this region (Gopalan, *et al.*, 1983).
1.2.7 Estuarine pollution and benthos

Owing to their easy accessibility and consequent high human influences, rivers, estuaries and coastal areas are more susceptible to effects of pollution. Estuaries are the transition regions of freshwater streams to the tidal saline ocean. The flow in an estuary is affected by the conditions at both ends of this transitional zone and are modified by the configuration of the estuary, by winds and by point discharges. Man modifies the configuration of estuaries, the freshwater flows and waste discharges. These modifications affect the currents, suspended solid concentration and dissolved materials in the estuary. All biota are subjected to these effects. It is evident that perturbation of any type whether natural or man-made, may cause shifts in the kinds and number of species and relative sizes of population. This also affects the reproductive success, prey-predator relationship and various interactions between species.

Rivers being often used as disposal areas for domestic and industrial wastes, estuaries act as transit area for pollutants on their way to marine environment. Hence it is important to consider effects of pollutants on the estuarine sediment, water and biota. Knowledge of the ecological requirements of an aquatic organism can be of considerable value in determining the changes that occur in aquatic habitat due to pollution. Pollutants may alter stream environment thereby affecting the aquatic life in a numbers of ways. These changes may include an increase in contents of dissolved nutrients, decrease or increase in amount of dissolved oxygen, increase in turbidity value or a change in the character of the stream bottom. The degree or extent of the effect of these changes on the aquatic life varies with the type and amount of the pollutant and character of the biota.

Benthic populations are structural communities with numerous connecting links. Disruption of these communities by external stress like pollution can affect the entire aquatic food web. Continuous discharge of industrial wastes into the aquatic environment endangers the safety of aquatic life and can reach the human body through the food chain. Although pollution may be caused by chemical or physical agencies it is essentially a biological phenomenon. Klein (1962) stated that after years of chemical and physical testing of river water the boards are today experiencing difficulties in the setting up of
standards for effluents and it will only be in the light of biological surveys and tests that these standards can eventually be successfully determined. A knowledge of the biological aspects of pollution is not only of interest but also essential to study the problems of pollution in a given area. Biologists recognized the limitations of chemical and physical measurements of water quality and have searched for organisms, which could serve as indicators of different degrees of pollution. Because of their sedentary habit benthos form a reliable parameter for biological monitoring. Until 1963, the study of marine bottom living animals and plants were primarily, the province of basic research, but for some studies devoted to the productivity of bottom fishing grounds. Emphasis was placed on satisfying our own scientific curiosity as to life history studies of non-commercial bottom animals, physiology, composition and abundance of benthic communities. In the intervening years between 1963 and 1972 there has been a steady shift in the study of benthic communities from the basic to the applied aspects such as the effect of oil pollution on the benthic standing crop and productivity. The sand deposits, where oil accumulates, will have characteristic benthic assemblages, which reveal their linkage to the ancient shoreline. These clues supplied by benthic studies, have been of help to locate new deposits of oil and gas (Parker, 1974).

Most of the bottom dwelling animals are a detritus feeder. The role of predators decline as depth increases and detritus feeders and other bottom feeders become the predominant forms. Benthic fauna has a direct relationship with the type of the bottom and the physical nature of the substratum act as a limiting factor to a considerable extent (Sanders, 1958). Benthos therefore may be treated as sensitive indicators of the conditions of accumulation of organic matter in sediments and its nature (Bordovskiy, 1964). The changes brought about by the deposition of pollutants on the bottom greatly affect the bottom fauna and flora. Generally pollution affects stream community structure, predominantly by reducing species diversity. The elimination of non-tolerant species is often accompanied by a) increase in stream productivity of benthic invertebrates due to lack of predation and competition b) changes and simplification in food chain and c) in the case of organic pollution a seemingly inexhaustible allochthonous source of food for the remaining tolerant species. A reduced production and biomass of
macrofaunal species contributing to the higher trophic level due to pollution will have a
direct impact on demersal fishes.

Recently the Cochin backwaters has undergone vast anthropogenic environmental
alterations, leading to an estimated reduction of its extent by about 35% as a result of
construction of bunds and reclamation for agriculture, harbour and urban development.
Since 1970, an area covering 176 hectares has been reclaimed for harbour and urban
development. The growing inflow of effluent from industrial, agricultural, domestic and
retting sources compound its deterioration. The decreased volume of backwaters with
limited exchange with the sea reduces the diluting capacity of the backwaters. The
physical alteration also play their role in changing the abundance of flora and fauna
(Gopalan et.al., 1983).

1.3 EARLIER WORK ON ESTUARINE AND COASTAL BENTHOS

Studies on bottom fauna was first made by Annandale (1907), Peterson (1913)
and Annandale and Kemp (1915) in the 20th century in India. The bottom fauna of the
brackish water of Madras was studied by Panikkar and Aiyar (1937). The benthos of
Malabar and Trivandrum coasts were studied by Seshappa (1953) and Kurian (1953)
respectively. The studies on benthos in the Vellar estuary and Chilka Lake were done by
Balasubramanian (1961) and Rajan (1964) respectively. Kurian (1967) has given an
account of benthos of south west coast of India. A comparative study of the marine and
estuarine fauna of nearshore region of the Arabian sea was made by Desai and Krishnan
Kutty (1967 b). Capitella capitata – an indicator species of Vishakapatnam harbour was
studied by Ganapati and Raman (1970). Work on benthos of the mud banks of Kerala
coast was done by Damodaran (1973). Ansari (1974) has investigated the macrobenthic
production in the Vembanad Lake. The benthic population of estuarine region of Goa was
studied by Parulekar and Dwivedi (1974). Kurian et al. (1975) have investigated the
distribution of bottom fauna of Vembanad Lake. A seasonal change in the benthic
production of the Kali estuary was investigated by Harkantra (1975). Parulekar et al.
(1976) have worked on the distribution and abundance of benthic fauna off Bombay.
Ansari et al. (1977) have made observations on the distribution of macrobenthos in five
shallow bays of central west coast of India. The quantitative distribution of benthos in
the depth range 20 – 1700m from the Bay of Bengal was studied by Ansari et al. (1977). Parulekar et al. (1980) have made an observation on the benthic macrofauna annual cycle of distribution, production and trophic relations in Goa estuaries. Harkantra et al. (1980) have worked on the benthos of shelf region along the west coast of India. Murugan et al. (1980) studied the bottom fauna of Veli Lake. Harkantra and Parulekar (1981) attempted a study of the qualitative and quantitative differences in the spatial and temporal distribution and production of benthic macrofauna in the coastal zone of Goa. Divakaran et al. (1981) studied the benthic community of Ashtamudi estuary. Parulekar et al. (1982) have given an account of the benthic production and assessment of demersal fishery resources of Indian seas. The ecology and distribution of benthic fauna of Ashtamudi estuary was carried out by Nair et al. (1984c). The benthic production of northern Vembanad Lake was studied by Anvar Bachan (1984). Distribution and abundance of benthos of the Ashtamudi estuary was studied by Nair and Abdul aziz (1987). Benthic fauna in relation to physico-chemical parameters and sediment composition of Vellar estuary was investigated by Chandran (1987). Murugan and Ayyakannu (1991) have given an account of benthic macrofauna in Cuddalore – Uppanar backwaters. Vijayakumar et al. (1991) have made observations on the macro and meiofauna from Kakinada bay and backwaters. Ansari et al. (1994) has worked on macrobenthos of Marmagao harbour. Harkantra and Parulekar (1994) have studied the macro invertebrates of Rajpur bay. The mangrove environment of Maharashtra coast was studied by Jagatap et al. (1994). Manikandavelu and Ramadhas (1994) have worked on the bioproduction dynamics of mangrove bordered brackish water along Tuticorin coast. Bijoy Nandan and Abdul Azis (1995a) have made observations on the benthic polychaetes of the retting zone in the Kadinamkulam kayal. Fish mortality from anoxic and sulphide pollution in the estuaries of Kerala was studied by Bijoy Nandan and Abdul Azis (1995b). Studies on the benthos of the Veli estuary, Thiruvananthapuram was made by Asha Nair and Abdul Aziz (1995). Prabha Devi et al. (1996) have given an account of the water quality and benthic fauna of the Kayamkulam backwaters and Arattupuzha coast. Chandra Mohan et al. (1997) have given an account of the role of Godavari mangroves in the production and survival of prawn larvae. The mangrove ecosystem fringing on the Mandovi – Zuari estuaries on the central west coast of India was investigated by Wafar et al. (1997). The ancient mangrove of Goa was studied by Antonio Mascarenhas and Onkar Chauhan.
Phytoplankton and macrobenthos in the nearshore waters off an oil terminal at Uran (Maharashtra) was studied by Jiyalal Ram et al. (1998). The estuarine and nearshore benthos of Vashishti estuary, Maharashtra was studied by Vijalakshmi et al. (1998).

1.3.1 Studies on benthos from the Cochin backwaters

The bottom fauna of Cochin backwaters was studied by Desai and Krishnan Kutty (1967a). Kurian (1972) has worked on the ecology of benthos of Cochin backwaters. The biochemical constituents of some faunal components of the Cochin backwaters were studied by Gopalakrishnan et al. (1977). Incidence of fish mortality due to industrial pollution from the upper reaches of Cochin backwater was reported by Unnithan et al. (1977). Ansari (1977) and Pillai (1978) have studied the distribution of macrobenthos of the Cochin backwaters. The effect of pollution on benthos was made by Remani (1979). Fish mortality due to ammonia poisoning in Chitrapuzha was reported by Venugopal et al. (1980). Nair et al. (1983) have studied the population dynamics of estuarine amphipods in Cochin backwaters. Remani et al. (1983) have reported on the indicator species of organic pollution in the Cochin backwaters. Effect of pollution on the benthic communities in Cochin backwaters was studied by Saraladevi (1986). The spatial and temporal distribution of benthos in northern limbs of Cochin backwaters was made by Saraladevi and Venugopal (1989). Saraladevi et al. (1991) have given an account of the benthic communities and co-existence in the northern limb of Cochin backwaters. Benthic ecology of the prawn culture fields in the Cochin backwaters was studied by Aravindakshan et al. (1992). Studies on the benthic fauna of the mangrove swamps of Cochin area was conducted by Sunilkumar (1993). Impact of environmental parameters on polychaetous annelids in the mangrove area was investigated by Sunilkumar and Antony (1994). The comparative study on the community structure and distributional ecology of benthos in the mangrove swamps of Cochin estuary was made by Sunil Kumar (1995). The effect of dredging on benthic fauna in and around Cochin harbour was studied by Rasheed (1997). A new record of five species of polychaetes from the mangrove ecosystem of Cochin backwaters was reported by Sunilkumar (1999).
1.4 SCOPE AND PURPOSE OF THE STUDY

For sustainable fishing and aquaculture activities in the coastal areas, maintenance of water quality is very important. Proper understanding of the environmental parameters and their effects on biota is a pre-requisite in the management of any ecosystem. Sediments are indicators of the quality of water overlying them and hence their study is useful in the assessment of environmental pollution. The grain size distributions described for a given habitat may be very different from those within the ambit of the organism. In addition to grain size, other proposed causative factors include organic content, microbial content, food supply and trophic interactions, but no single mechanism has been able to explain patterns observed across many different environments. Benthic production is of importance in assessing the biological productivity of an area. It is well recognized that the distribution and abundance of benthic animals of a region are directly related to the demersal fishery of that region. Since the pollution effects are more conspicuous in the bottom a qualitative and quantitative study of the bottom dwelling animals, sediment characteristics and the hydrographical features of the overlying water will be useful to evaluate the extent of pollution affecting the system.

A remarkable extent of information is available dealing with various aspects such as hydrography, nutrients, primary productivity, plankton, benthic fauna and crustacean and molluscan fishery resources of Cochin estuary. Considering the importance of benthos, an attempt has been made to study their composition, distribution, abundance and diversity in relation to the environmental parameters in three different environments. Only one attempt to study the overall effects of industrial pollution on benthos and water quality has been made so far. This study was based on material collected from northern limb of Cochin backwaters in 1981 and published by Saraladevi (1986). The above stations were covered in this study also. The present data is examined against the backdrop of this available information and an attempt is made to evaluate the changes if any, over time (about 15 years) on benthic communities in a system subjected to ongoing stress from industrial effluents. The environments selected were (1) the lower reaches of Cochin backwaters on the northern and southern limb of the mouth of the estuary (2) the mangrove ecosystem of Paduvypin, an island formation bordering the estuary and (3) the
dredging and disposal sites of Cochin Port Trust area. The data generated will be helpful in assessing the present status of benthic productivity of these vital ecosystems and for ecological monitoring and future evaluations.