CHAPTER - II
ENVIRONMENTAL CHARACTERISTICS OF COCHIN BACKWATER

PRESENT STATE OF THE ENVIRONMENT

Cochin backwaters (Lat. 9°28' and 10°N and Long. 76°13' and 76°31') is the longest among Kerala backwaters and extends from Cranganore in the north to Alleppey in the South (Fig.1). It consists of a system of interconnected lagoons, swamps and mangrove biotopes. The northern portion of Cochin backwater is called Varapuzha lake and the southern portion is termed as the Vembanad lake. The backwater system has a total length of about 110 Kms. and a maximum width of 15 Kms. (average 3.2 Kms.) and covers an area of 256 sq. Km. During the pre-Christian era, this backwater system appears to have been cordoned off from the sea by a narrow strip of land, lying south of Munambam and north of Quilon, formed by the interaction of detritus loaded river water and the ocean ground swell (Bristow, 1959). It opens into the Lakshadweep Sea at Cochin and Munambam, about 18 Kms. north of Cochin. Since 1928, the opening at Cochin is periodically dredged to maintain sufficient depth for navigational purpose while the other remains undisturbed.

According to Pritchard (1967) 'An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which sea water
Fig. 1 COCHIN BACKWATER SYSTEM
is measurably diluted with fresh water derived from land drainage." As per this definition, this backwater system can be considered as an estuary because the fresh water discharge from the rivers and land run off make the backwater a typical estuary. The run off plus precipitation exceeds evaporation and hence it is a positive type estuary (Balakrishnan, 1957). Thus in the following discussions both the terms backwater and estuary are used.

In Cochin backwaters, the tides are of a mixed semidiurnal type, the maximum range being about 1 m. With the increase in distance towards the upper reaches of the estuary the magnitude of its influence progressively decreases as the time lag in the tidal height increases and the tidal range decreases (Quasim and Gopinathan, 1969) The physico-chemical properties of estuarine waters vary considerably. They depend on volume and contents of the river water released, structural components of the estuarine bed, tides and macroclimate of the general geographic area (Kinne, 1966). A number of rivers originating from the western ghat flow into the backwaters at various points. Five rivers, viz., Achanccil, Pamba, Manimala, Meenachil and Moovattupuzha with its tributary Ithypuzha meet the backwaters south of Cochin while two rivers viz., Periyar and Chalakudy meet it north of Cochin. These
rivers bring in huge quantities of fresh water into the backwaters during the south-west and north-east monsoon.

The backwater system undergoes remarkable seasonal changes which is reflected by considerable changes in its various physico-chemical characteristics during different seasons of the year. A number of workers who studied the various hydrographic parameters have reported three definite seasons viz., pre-monsoon, monsoon and post-monsoon based on the environmental parameters existing in the backwaters during these periods (Sankanarayanan and Quasim, 1969; Haridas et al. 1973; Joseph, 1974; Manikoth and Salih, 1974; and Balakrishnan and Shynamma, 1976).

The seasonal changes in environmental characteristics influence the flora and fauna of the backwaters. Carikkar (1967) classified estuarine organisms as (a) oligohaline organisms (b) true estuarine organisms (c) euryhaline organisms, (d) stenohaline organisms and (e) migrants. During the dry months, the estuary forms a conducive habitat for marine organisms while during monsoon period it satiates the physiological needs of freshwater organisms. Besides these marine and fresh water organisms that occupy the estuary during different seasons of the year, there are numerous true estuarine organisms with the physiological capacity
to adapt to highly changing environmental parameters.

Numerous studies carried out in various parts of the world throws much light on the significance of estuaries as a separate entity. It is inevitable for the successful completion of the life history of several organisms. It forms the nursery of a multitude of shellfishes and fin fishes. Estuaries, as a rule, are biologically more productive than the adjoining bodies of fresh water and sea water (Abbott et al. 1971). Productivity studies carried out by various workers in the Cochin backwaters have showed that this water body is a highly productive one. Gopinathan (1972) reported 120 species of phytoplanktons commonly occurring in this backwaters with two peaks of abundance, one during monsoon (May-July) and the other during post-monsoon (October-December). Nair et al. (1975) using C\textsuperscript{14} technique estimated the total annual production for Cochin backwaters as 100,000 tons of carbon. The average annual rate of gross production ranged from 150 to 650 g C/m\textsuperscript{2}/yr. at different regions. Unlike in the inshore regions of the west coast where maximum production occurs during monsoon periods, in the Cochin estuary relatively higher rate of production is observed during the pre and post-monsoon periods. Of the gross production, 20-45 are considered to be used for respiration and of the net production available to the next
trophic level, only a very small portion (30 g C/m²/yr) is used by zooplankters leaving a large surplus of basic food in the estuary (Quasim et al. 1969).

Large quantities of surplus basic food left in the estuary forms a rich source of food for benthic fauna. Pillai (1978) has reported that, judged by any standards, the benthic production in the Cochin backwaters is quite rich. His study has showed that the production of macrobenthos, in terms of annual mean standing crop (wet wt.) is 352.05 Kg/ha. According to Townes (1938) a natural lake yielding 300 Kg/ha of bottom fauna is normally rich. Thieneman (1925) has classified a lake bed producing 1000 animals or less per m² as oligotrophic, one producing above 2000/m² as eutrophic and one between 1000 and 2000 as mesotrophic. In Cochin backwater the average number of macrofauna recorded is 2332/m². This indicates that the lake is eutrophic.

The highly productive waters of the estuary supports a good resource of fin fishes and shell fishes. A number of commercially important penaeid prawns like *Penaeus indicus*, *Metapenaeus dobsoni* and *M. monoceros* are fished in appreciable quantities from the estuary. Similarly the estuary is noted for the species variety and abundance of fin fishes. The
well esteemed food fishes such as chanos, mullet and etroplus abound in the estuary. Huge quantities of bivalve molluscs are collected from the backwaters which form the raw material for a number of industries.

Accelerated human activities for exploitation of the estuarine resources, utilisation of estuary for various developmental purposes and stress of population from the highly dense hinterlands, all have a negative impact on the ecology of the estuary.

POLLUTION AND OTHER ECOLOGICAL PROBLEMS

It seems that there is an inherent notion in the human beings that the water bodies are meant for waste disposal. This attitude shown to the aquatic systems has resulted in the rapid deterioration of the aquatic environmental quality throughout the world. Cochin backwater system is no exception in this respect. Many scientific reports of the investigations conducted in Cochin backwaters unquestionably prove that this rich and dynamic ecosystem is undergoing detrimental ecological alterations, in varying paces at different points, which will undermine the resource potential of the estuarine system.

Toxic industrial effluents from a number of industries, municipal and urban sewage, agriculture and land run off containing pesticides, fertilisers and their
residues are the major pollutants which have a negative impact on the ecosystem. Rapid development of Cochin as a major port has augmented the pollution problems several folds due to the discharge of waste from cargo ships and oil spills from tankers. Widespread use of the backwater system for transport, coconut husk retting and other human activities also contribute to the ill-health of the estuarine complex. Construction of the Thanneermukkom bund across the backwater system can be deemed as a major 'ecological offence' done to this system.

**INDUSTRIAL POLLUTION**

There are a number of industries situated on the banks of all the rivers which empty their contents into the estuary. Thus, fairly wide areas of the rivers have lost ability to keep the natural equilibrium (Nair & Pillai 1982). The Periyar river brings in a major share of the industrial effluent as the Eloor industrial complex is on the banks of Periyar. Table I lists the industries, their products and effluents.

The estuary receives $1.86 \times 10^6$ L. of industrial effluents per day. The effluent contains a number of toxic ingredients like acids, alkali, heavy metals, suspended solids and a number of other chemicals which have immediate and long term effects on the organisms.
A number of instances of fish mortality reported from the backwaters indicate the magnitude of industrial pollution in this area. All these reports (Unnithan et al. 1977; Venugopal et al. 1980; Nair et al. 1980; Shynamma and Vijayakumar 1980) show that high ammonia and pH was the causative factor for the fish mortality. Unnithan et al. (1977) have reported ammonia values as high as 172.2 ppm and pH of 11.7. Morphological observation of dead fish showed widely opened mouth, distended opercula and ruptured abdomen. Heavy damage to the gill filament also was noticed. Ramani (1979), has reported high concentration of copper and zinc, high suspended material and COD in the region receiving industrial effluents. Unchecked discharge of industrial effluent has converted certain regions of the estuary into biological deserts.

According to Kilby et al. (1972) phosphate content in excess of 200 µg/l is a prima facie evidence of pollution and a potential cause for eutrophication. Ketchum (1967) stipulates that 2.55 µg at/l is the maximum limit of PO₄ concentration which could be accepted as the danger signal in evaluating the eutrophication of an estuary. Concentrations above 0.01 mg of inorganic phosphorus/l will support growth of aquatic organisms (Albaster, 1964). Joseph (1974) has reported very high
concentration of plant nutrients especially inorganic phosphate (40 μg at/l) and nitrite (5 μg at/l) in Periyar near the industrial belt. Due to this high nutrient enrichment, the backwater system is under constant threat of eutrophication. Though not on a massive scale eutrophication is noticed in the backwater occasionally.

**SEWAGE POLLUTION**

About 10,000 people are added to the urban population of the fast growing city of Cochin. Total consumption of water is estimated as eighty million litres/day. A good portion of this water finds its way into the drainage. The drainage system at present does not cover the entire city and sewage treatment are facilities available inadequate. Hence a good amount of raw sewage and sullage water mixed with domestic waste is carried along the six major canals and drained into the backwaters (Vijayan et al. 1976). Another source of sewage is from the ships and other vessels. Cole (1979) has clearly stated that as far as living resources of the sea are concerned, de-oxygenation in estuaries and coastal water, and the deposit of organic rich sediments and substantial load of metals and persistent organics, are the principal adverse characteristics of sewage. Highly destructive and irreversible physical, chemical and biological changes in the surroun-
Dung environments are noticed in areas of continuous sewage outfalls. Drastic changes in the abundance and diversity of benthic organisms and fishes and prevalence of diseases like fin erosion are the immediate aftermath of sewage dumping in coastal waters. Microbial contaminations of fishes is another serious problem which makes sea food unacceptable to consumers. Gore et al. (1979) have reported intense faecal contamination in the backwaters resulting in a high density of coliform bacteria in the water and sediments. The fishes and bivalves collected from the backwaters also contained a rich percentage of these coliforms.

Due to the high organic load of the sewage, oxygen consumption rate far exceeds the replenishment rate which results in anaerobic conditions. Vijayan et al. (1976) have reported very low oxygen values (0.05 ml/l) and very high BOD values (420.6 ppm) in the areas of estuaries receiving sewage. Similarly high sulphide (4.92 ppm) was also noticed in the polluted areas. Another serious disadvantage of sewage is its high nutrient contents which can lead to eutrophication. In addition to the high nutrient load brought to the estuary by the sewage it is mentioned elsewhere that the factory effluents also form an important source of plant nutrients. Thus a 15 Km. stretch of the estuary from Thovara to Varapuzha can be considered as a highly susceptible area for eutrophication.
OIL POLLUTION

Though oil is handled since the last 30 years no major oil spill has occurred in the port waters. About 200 to 250 oil tankers are transporting more than 4 million tons of oil in an year through the Cochin Port. The sources of oil pollution are spillage from tankers, pumping out of oily ballast water by the tankers and pumping out of oily bilge water by the cargo vessels. Out of these the major contributor is spillage in the operation of oil carrying tankers. Numerous mechanised vessels plying through the waters also are a source of oil pollution. Oil films floating in the waters are frequently encountered especially in the port waters.

Crude oil is a complex mixture and whereas all fractions have some effects on living organisms; some fractions of the aromatic hydrocarbons like benzene, toluene etc. are acute poisons to the organisms. It is found that hydrocarbons incorporated into a particular marine organism are stable regardless of their structure and are passed through many members of the marine food chain without alteration (Blumer, 1969). This is made possible because the hydrocarbons entering the body of the marine organisms become part of the lipid pool.
The harmful effects of oil on the aquatic organisms are numerous and varied. For marine organisms, disruption of chemoreception by oil is viewed as both likely and of important ecological consequence (Blumer, 1969; Olla et al., 1980). Chemosensory disruption by various petroleum hydrocarbons and oil fractions have been reported in lobsters (Atoma and Stein, 1974) and in shore crabs (Takahashi and Kittredge, 1973). Anaesthesia, narcosis, cell damage etc., are some other effects of oil on marine organisms.

DREDGING

Due to silting, the port area is periodically dredged to maintain necessary depth for navigational purposes. Approximately one to one and a half metres of semi-solid silt deposited is annually dredged and this mud is used for reclamation of large portions of the water front which are potential areas for fish farming. Heavy siltation occurring in the backwaters, resulting from the dumping of dredged material has led to the formation of several small islands close the harbour areas. The reclamation work going on leads to the depletion of available water body and a consequent loss in fauna and flora (Quasim and Madhupratap 1979). According to Balakrishnan and Lalithambike Devi (1983), the dredging operations caused damage to the benthic, nektonic and planktonic communities by dislocation,
clogging, blinding etc. The operation is repeated every year at the time when most of the animal and plant communities are about to spawn. This not only affects the population as is evident from the decline of rock oyster (*Crassostrea spp.*) in the dredging area but affects the food web also. The larvae of Oyster form one of the important food items of several organisms including fish larvae. Dredging operation also brings up pollutants, particularly the less dredgeable ones which are settled along with the sediment, to the biologically active zone.

**COCONUT HUSK RETTING**

Another source of pollution in the backwater is due to retting of coconut husk. Considerable areas of the estuary are at present used for husk retting. Thus at Vaduthala (5 Km. upstream from harbour mouth) more than 40 wells covering an area of 2,000 sq. meters are used for this purpose.

As a result of retting large quantities of organic substances like pectin, pentosan, fat and tannin are liberated into the medium by the activity of bacteria and fungi. Decomposition of pectin results in the production of sulphide. Strong smell of hydrogen sulphide is characteristic of retting zones.
Roman (1979) has reported increase in organic content with low and fluctuating oxygen values (0.05 ml/l), high BOD (513.7 mg/l) and sulphide (4.97 mg/l) resulting in the decline of the abundance of fauna, a high population density of tolerant indicator organisms and decline in the fish catch in the retting area. Decaying of coconut husk result in the formation of a black layer of organic material which besides affecting the production of benthic fauna also spoils the spawning ground of commercially important fishes.

THANNEERMUKKOM BUND AND ASSOCIATED PROBLEMS

Construction of a 1.4 Km. long barrage across Vembanad lake at Thanneermukkam has resulted in widespread ecological changes in the backwater. It has upset the natural balance of the system. The decision to construct the bund was taken at a time when the terms ecology and environment were alien to planners and developers. It was constructed to protect the incursion of salt water to facilitate and augment rice production in the low lying Kuttanad paddy fields. With the closure of the bund, free flow of water was curtailed and stagnation resulted. This has resulted in multifarious environmental problem. Thus acidity of soil and water increased resulting in low primary production and less yield from paddy fields. The paddy
cultivation practiced here is with the intensive use of fertilisers and pesticides. It is estimated that more than 46 different formulations of pesticides amounting to 1000 tons are used in these areas on every crop season (State of the Environment in Kerala - First report - 1982). Similarly, on an average 27,200 tons of phosphate fertilisers in the form of mussori phosphate, factorphos etc., 13,300 tons of potash in the form of murate and 41,200 tons of urea are also used in each crop season. This gives an indication of the quantities of pesticides and fertilisers reaching the backwater system. Before the construction of the bund all these leached out pesticides and fertilisers were amply diluted and discharged into the sea due to the free flow of water. Now these are accumulated in the sediment and water of this region along with numerous other wastes generated by the people of this thickly populated area.

Before the construction of the bund, Kuttanad waters supported a rich fishery resource. This region was renowned for the high priced and well relished fresh water shrimp *Macerobrachium rosenbergii*. With the construction of the bund the catch of it declined from a substantial 5 ton a day to a meagre 500 Kg. (Balakrishnan and Lalithambika, 1983) Similarly there is a rapid reduction in the quantity of other crustaceans, fin fishes and molluscs. The reason for the
considerable reduction in the stock of Macrobranchium is positively due to the prevention of its breeding migration.

So far, no investigation is carried out to assess the damage caused by the pesticides and their residues in the area. Studies carried out in other parts of the world has shown that pesticides even at very minute quantities inhibit photosynthesis. 100% mortality is noticed in shrimps and crabs exposed to DDT at concentrations of less than 0.2 ppb (Butler, 1965) and at 0.1 ppb levels at interferes with the growth of oysters (Butler, 1966).
<table>
<thead>
<tr>
<th>Name</th>
<th>Products</th>
<th>Effluent qty (10^6 l/day)</th>
<th>Major toxicants</th>
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<td>Rayon manufacturing</td>
<td>Rayon yarn, sodium sulphate, sulphuric acid</td>
<td>18.0</td>
<td>Low pH, suspended solids sulphides, zinc, lead, BOD, COD, SO₂ and H₂S</td>
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<tr>
<td>Fertilizer</td>
<td>Sulphuric acid, Phosphoric acid, NPK fertilizer, Gypsum, Ammonium chloride</td>
<td>55.0</td>
<td>Low pH, suspended solids phosphates, fluorides, ammonial nitrogen, free ammonia, SO₂</td>
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<tr>
<td>Rate Earth Salts</td>
<td>Rate earth chloride, Trisodium phosphate, Rare earth oxide, Thorium concentrate, Rare earth fluoride</td>
<td>3.0</td>
<td>High pH, suspended solids phosphate, fluoride, Lead, radioactive material</td>
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<tr>
<td>Insecticides</td>
<td>Technical DDT, Technical BHC, 50% Formulated DDT, BHC, Orthotoluidine, Benzene, Para dichlorobenzene</td>
<td>1.2</td>
<td>DDT, BHC, chlorinated hydrocarbons, residual chlorine, low pH, chlorine</td>
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<td>Metallurgical Industry</td>
<td>Slab zinc, cadmium, sulphuric acid ammonium ingots</td>
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<td>Low pH, suspended solids, sulphides, arsenic, cadmium, copper, zinc, lead,</td>
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<td>Industry</td>
<td>Product</td>
<td>Quantity</td>
<td>Pollutants</td>
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<td>------------------------------------------------</td>
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<td>Rectified spirit</td>
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<td>SO₂, fluoride, Colour, suspended solids, BOD, COD</td>
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<td>Chloralkali</td>
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<td>News print</td>
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