

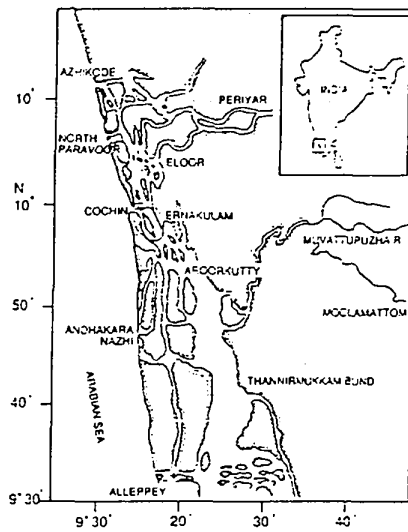


Cochin Backwaters: A Sad Story of Manipulation

Along the southern half of the west coast of India, the state of Kerala, has been endowed with an expansive body of brackish waters, which constitutes a number of backwaters, lakes, lagoons and estuaries including mangrove swamps. Of the various sectors of backwaters in Kerala, the Cochin backwaters, which are the largest of the kind along the west coast of India, are located between Azhikode and Alleppey (09°3'–10°10'N; 76°15'–76°25'E) forming a bar built estuary with a channel at the entrance to the Cochin harbor at Cochin, and another opening further north at Azhikode. The major rivers Achankovil, Pampa, Manimala, Meenachil, Muvattupuzha and Periyar, along with a network of canals, debouch in the region. The backwaters are tidal over approximately 60 km southwards where the spring-tide range is 20 cm. Rainfall in the region averages 300 cm yr⁻¹. The configuration of the land, with drainage and rivers flowing in one direction—and with the extensive backwater system receiving much of this flow—a densely populated narrow low-lying belt bordering the system, and a uniformly distributed highly productive ecosystem make this region sensitive to interference. The Cochin backwater system is believed to have attained its present configuration in the 4th century A.D. It was primarily a marine environment with an alluvial bar boundary, running parallel to the coastline and interrupted at intervals by the Arabian sea. As a result of the catastrophic deluge which took place in 1341 A.D., a number of islands were formed thereby separating a distinct waterbody from the sea. During this period the river Periyar took a diversion to open into the Cochin channel.

Since time immemorial, this backwater system has played a major role in the socioeconomic and cultural history of Kerala. Fish landings in Cochin form ca. 8% of the total of the state. The habitat plays an active role in completing the life cycle of many commercially important prawn species. The development of Cochin port has ushered in a new life and fresh activities, leading to the establishment of a series of industrial networks in the region for the manufacture of fertilizers, chemicals, insecticides, rare earths, petroleum products, etc. Simultaneously, plans for increasing rice production in the deltaic regions—locally known as Kuttanad and consisting of 840 km²—were also moved. Major modifications that have taken place in the morphology and ecology of the system in the course of its history can be seen as combinations of natural processes and human interferences of which the latter has led to serious alterations to the Cochin backwater system.

The booming city of Cochin, which is the biggest city along the west coast of India after Bombay, has a population of over 1 million and 70% of all chemical industries in the state



Map of the Cochin backwater system.

are situated in the vicinity of the city. An estimated 260 million m³ day⁻¹ of effluents from these industries are the major source of pollution. In addition, the backwater system receives organic wastes from domestic sewage, coconut husk retting yards, fish-processing plants, etc.

The project to develop Cochin into a major port on the west coast of India commenced in 1920 under the direction of the eminent harbor engineer Sir Robert Bristow and was completed in 1936. During this period of constant dredging, Willington Island, the present location of Cochin port with an area of nearly 365 ha, was reclaimed. This was followed by an integrated development project under which Vallarpadam-Ramanthurath Candle Island complex, with an area of 141.7 ha, was reclaimed. A similar area has been reclaimed as a southerly extension to Willington Island port. Since then, urban development and town planning, for the construction of a foreshore road, of a shipyard, and also for additional berth facilities, have resulted in areas of about 200 ha being reclaimed. There are also plans by the Cochin Development Authority, to reclaim 270 ha on the northern foreshore of the city.

The Cochin port was opened for shipping by removing the sand bar at the mouth of the port by cutting a channel 10 m deep, 120 m wide and 3300 m long. Provision for annual dredging has been initiated to remove the semisolid silt deposited in the approach channels—this silt reaches a thickness of 1–1.5 m. Studies invariably indicated that dredging operations cause much damage to the benthic, nektonic and planktonic communities by dislocation, clogging, blinding, etc. The operation was to be repeated every year during a period when most of the

animal and plant communities are about to spawn. This would not only affect the population as is evident from the decline of rock oyster (*Crassostrea* spp.) in the dredging area, but would also affect the food web. Oyster larvae form one of the important food items of several organisms including fish larvae. Dredging operations also disturb pollutants which rise to the biologically active zones, particularly the less degradable ones, found in sediment.

The increase in shipping activity has increased pollution loads as a result of discharge from ships as well as from spillage during loading, unloading, and storage. This is particularly evident when petroleum products, both crude and refined, and raw fertilizer materials are handled. In addition to aquatic pollution, air pollution problems have also begun to exceed permissible limits. The main source of air pollution is the handling and storage of large quantities of sulfur, rock phosphate, liquid ammonia and other chemicals in the port area. Despite the consequences for the ecosystem, plans for extended modifications and development in the port are predicted.

Over the past 150 years the Cochin backwater system has been subjected to continuous reclamation for agricultural expansion, aquaculture, the construction of large engineering structures, and harbor development. These environmental alterations have led to horizontal and vertical decreases in the backwaters, causing an alarming reduction of the total area by ca. 35%. Siltation caused by river discharge and tidal influx was a major factor in the decrease in the water depth of the backwater system. The available data indicated that in the course of 50 years, the average depth of the backwater system has been reduced to 6.7–4.4 m. Studies on the sediment deposition rate showed a deposit of 0.2 cm yr⁻¹.

Rivers that connect to the backwaters contribute towards siltation in the region. The ebb tide is not able to remove the incoming material. Thus, an estimated 2.5 mill. m³ sediment yr⁻¹ are dredged out from the channels. Studies have also shown that there is substantial variation in mixing capabilities, due to the deepening and widening of the channels.

The increase in industrial development, has generated more and varied effluent discharge. These effluents are discharged either directly into the ecosystem, after only partial treatment. There may be several reasons for this situation, the chief being a lack of appropriate technology in the treatment processes; high cost of pollution control measures, lack of awareness of the interaction of pollutants in the ecosystem, and disregard for the ecosystem are others. Environmental problems began to arise in the industrial belt, and have escalated in the last decade; e.g. the

salinity intrusion upstream in the river Periyar has negatively affected drinking water supplies. Temporary bunds have been constructed to check further influx of saltwater. The free flow of water was thus restricted resulting in an increase in toxic substances in the effluents discharged to the downstream region. The pH of the ambient water has dropped to between 3 and 4. Massive mortality in aquatic populations has resulted. Mortality in aquatic organisms has also been noted in areas where the pH and concentration of ammonia in effluents and ambient water are high. The continued discharge of toxic effluents from industrial complexes appears to have affected the fishing grounds and downstream fisheries. Yields of prawns (*Penaeus indicus* and *Metapenaeus dobsoni*) were reduced from 500 kg and 1500 kg in the 1940s to less than 250 and 400 kg ha⁻¹ per season, respectively.

The government, in efforts to increase rice production, implemented development programs for the Kuttanad region. More than 60% of this region lies below sea level. The paddy fields are 0.5 to 2.0 m below the water level in the adjoining canals and rivers. The area remains submerged in water during the South-West monsoon floods, and is protected by raising bunds. In most places, paddy cultivation was practiced in alternate years. In order to control the floods, spillway construction at Thottappally, 20 km south of Alleppy, was commenced during 1951 and completed in 1955. The 340 m long spillway was designed to handle 64 000 m³ s⁻¹ of floodwater, out of the 180 000 m³ s⁻¹ brought down by rivers into the deltaic region. However, only 30% of the intended capacity could be handled. Changes in the flow pattern in the waterways during floods, the occurrence of high water levels at the mouth of the spillway during the monsoon period, the formation of sand bars across the mouth, and related factors, all appear to have been ignored in selecting the site for the spillway. If the desired flood-control level is to be realized, substantial investments are needed.

The construction of dams on the upper reaches has not significantly reduced flood problems in the delta. The construction of a 1.4 km-long barrage across the Cochin backwater system at Thannirmukkam was begun in 1955, but after 18 years only 60% of the work had been carried out. However, in 1974 a crash program was started to block the remaining 40% with sand, mud, rubble, stakes and gravel. The regulators on either side of this area remain closed for about 6 months from December to May, until salinity levels drop to zero with the onset of the SW monsoon.

The spillway and barrage were constructed on the assumption that the first cropping season could be started early by draining the floodwater through the spillway and checking the intrusion of seawater towards the end of the second cropping season. However, the floodwater could not be controlled to the required level. In addition, the temporary bunds separating the fields from waterways had to be raised and reinforced for effective agricultural operations. Over and above these physical problems, it was observed that nutrient-rich detritus, carried by the flood-

water, was directly drained into the sea, decreasing natural fertility. By checking the influx of saltwater, it was possible to extend paddy cultivation, particularly in the northern region. Initially, production was better, but the steep drop in rice prices, increased cost of production, constant care of the hybrid rice varieties, as well as low yields, disillusioned the growers.

As soon as the barrage was closed, the free flow of water was curtailed and stagnation resulted. A series of problems caused this. In general, the acidity in Kuttanad is higher than in brackish water or seawater. Soil pH varies between 4.8 and 6.4. This acidity is reduced by adding slaked lime and by flooding after sowing. The acidic flooding-water is then pumped back into the waterways, adjoining the paddy fields. The acidity of the water in the canal and adjoining waterbodies decreases after pumping, with pH varying between 5.17 and 6.3. Before pumping, the pH values of the canal water ranged between 5.6 and 6.57. The pH of the upstream is 6.7, increasing to 7.0 towards the seaward site at Thannirmukkam. Due to stagnation, water exchanges between sea and lake are restricted, thus acidity is not neutralized.

The prevention of saltwater intrusion into the Kuttanad region has increased the spread of *Salvinia* weeds, which have grown wild in the upper reaches since 1950. Almost all the paddy fields, puddles, and waterways are literally carpeted by this green weed. In most of the waterbodies, the weeds accumulate in dense clusters, sometimes several layers thick. These layers also trap carcasses and excreta (only a few houses in the area have septic tank facilities) garbage, agricultural waste and other materials. This condition further degrades water quality, and the problem becomes acute when paddy fields are cleared of weeds during cropping seasons. Besides holding much dead and decaying matter, the *Salvinia* not only restricts water traffic, but occasionally impedes canoes. It reduces primary production, cutting off solar radiation and absorbing the available nutrients. When compared to freshwater ecosystems, the dissolved oxygen values are very low, with surface values ranging from 4.2 and 6.9 ml L⁻¹ and bottom values of 1.9 to 5.9 ml L⁻¹.

During each cropping season (December-March), about 1100 tons of pesticides are used, and ultimately the stagnant water receives pesticide residues. More than 80% of the population depend on this poor quality water for cooking, drinking, washing, bathing, feeding domestic animals, irrigation, etc. The ecosystem also receives an average of 27 200 tons of potash in the form of murate and 4200 tons of urea. Changes to the ecosystem due to accelerated agricultural activity, stagnation of the waterbody, absence of brackish water, etc. have caused mortality in many crustacean species, resulting in decreased supply. Recently, the availability of many high priced crustaceans have declined from an average of 5 tons a day to less than 500 kg a day during the fishing season. Other crustaceans have also declined, as have the fin and molluskan fisheries. From time immemorial, a rich juvenile shrimp fishery has existed in the less saline upper reaches of the estuary.

The commissioning of the Thannirmukkam bund has in effect cut off the brackish water lying south of the backwaters and reduced the extent of nursery grounds, which has led to the total collapse of juvenile shrimp fishery in this region. Bunding and prevention of saline influx has led to the extinction of practically all migratory species, which depend on both fresh- and brackish waters for the completion of their life cycle. The giant freshwater prawn *Macrobrachium rosenbergii*, which used to contribute to a lucrative fishery in the mid- and lower half of the backwater system is now nearly extinct, because of disruptions to the characteristic annual breeding migration of this species from the freshwater region to the highly saline lower reaches. As a result, fishermen and their families have lost their traditional source of livelihood.

In effect, the development programs formulated to improve the region did not solve the previous problems, but created new and varied problems. The stagnant waterbodies with decaying organic materials and increased concentrations of pesticides as well as low ambient oxygen have become contaminated, disease-prone, weed infested and unproductive.

The vertical and horizontal decrease in the backwater system has affected the carrying capacity of the estuary. The growing influx of effluents from industries, agricultural lands, and domestic sources, together with siltation has seriously affected the natural resource base. The decreasing volume of the backwaters and the limited exchange rate with the open sea reduced the diluting capacity of the system, and anoxic conditions occur in some parts all through the year except during the monsoon. Eutrophication and associated characteristics, e.g. high BOD and low dissolved oxygen values, have been reported. Concentrations of sulfide, nitrate and phosphate have also increased considerably to unacceptable levels. Although the backwater system is dominated by tidal currents and strong river flow, and is a highly dynamic system, the emerging trends are alarmingly similar to those in more developed estuaries worldwide. Overall the physical variability of the system has been reduced.

Recognizing the important and significant role played by the Cochin backwater system from the socioeconomic and cultural points of view, the need to protect the system is obvious. New methodologies need to be evolved to ensure a healthy future for this backwater. The vast modifications that have taken place need to be incorporated into contemporary management strategies. All proposals for future development projects should be evaluated in terms of the potential consequences to the ecosystem and effects on other resources. The situation calls for immediate attention and appropriate measures if a total disaster is to be avoided.

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