

ESTUARINE BIOLOGY AND MANAGEMENT

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Estuaries are highly productive and areas of intense activity such as fishing, harbour development and aquaculture. They are also nursery grounds for many organisms. However, they are often subject to heavy human interference. Many of them receive large dosage of industrial effluents and domestic sewage. India is blessed with a large number of rivers and estuaries, but very few have received scientific attention or proper management. The case of the Cochin backwaters which has been fairly well documented point to this. Heavy industrial pollution in some areas of the estuary has caused substantial reduction of the biota. Reclamations for urban development is affecting the nursery grounds. Pollution is causing diseases to its fish fauna. Engineering follies have rendered the whole upper reaches stagnant, covered with weeds and devoid of fauna. Steps necessary to avoid such problems, protect the biota and for proper scientific management are outlined.

Key Words : Estuary, Pollution, Fisheries, Management

India has several major river systems. These and many more smaller rivers empty themselves into the Arabian Sea and the Bay of Bengal. Near their mouth regions, seawater mixes with freshwater and estuarine conditions develop. The extent of estuarine conditions up the river (sometimes a few hundred kilometers) would chiefly depend on tidal influx and fresh water flow.

Estuaries are thus buffer zones having intrinsic features coevolved with limnetic and marine environments. They form important areas for fishing, transport and recreation. They are known to be highly productive and also contribute a lot to the productivity of coastal environments. More

importantly, they are the breeding and nursery grounds for many commercially important crustaceans and fishes. With depleting marine resources and increasing population, our focus has shifted to mariculture to produce more protein. Estuaries because of their accessibility and semienclosed nature, have emerged as ideal sites for these activities. However, these are areas of very high clash of interest for human activities.

OVER VIEW

Events in the past few decades force us to realise and admit some of the follies in the management of our natural resources. This is not confined to the Indian context alone, but ecologists from all over the world are concerned about the abuses committed to the mother nature with scant regards for scientific baseline studies or ecological balance.

Estuaries have suffered a lot from the onslaught of mankind. Most of our major cities and industrial complexes are located along the course of rivers or at their mouth regions. Very often these rivers and estuaries are turned into receptacles of large quantity of sewage and industrial effluents. Many of the major harbours are also located at river mouths and considerable oil spill occurs in these areas. Further, they are often subjected to other engineering activities like reclamation and dredging.

The major riverine/estuarine systems in the east coast of India are the Hooghly, Mahanadi, Godavari, Krishna and Cauvery. On the west coast we have the Narmada of Gujrat and Mandovi-Zuari estuaries of Goa. The Pulicat and Chilka Lakes of the east coast and the Vembanad Lake (Cochin backwaters) of the west coast are large bodies of brackish water. Apart from these, many (over a hundred) medium and small rivers also contribute to the estuarine wealth of India. The rivers together have a catchment area of more than 3 million sq. km. and a runoff of 1600 million cu. m (Rao, 1975).

ASPECTS OF (MIS) MANAGEMENT

The tendency in resource utilisation often concerns only immediate returns without foreseeing future impacts. This holds especially true for areas

like estuaries where virtually no programme or plan for management exists. Uniqueness of estuaries necessitates the study of the adjoining limnetic and coastal regions as well, for meaningful management.

Of course, economics is an important aspect of management, but the policies should have long term strategies. Management of estuaries would involve careful consideration of the opinions and interests of the administrator, industrialist, politician, ecologist, engineer, farmer, fisherman, society at large and aesthetics. However, in most cases there are no corporate bodies to consider all these varied interests. Decisions are often unilateral, port authorities are not concerned with the ill effects of oil spills or dredging on the biota; factory managements refuse to see the harms the effluents cause to the biota or the aesthetic aspects; government/ private organisations may decide to reclaim large areas for urban/other developments. Another flaw is that, often, where there is a clash of interests, the administration or management consider the state of water quality or the biological information available as only some of the many factors to be considered.

The fact remains that most of our authorities or organisations responsible for the fishery management are blissfully unaware of the extent of our estuarine resources. Regulations of any kind hardly exist restraining fishing during breeding season, size regulation of fishes caught or for protection of endangered species. Nor have any significant steps been taken in studying their biology with respect to particular systems or about culture and stocking of important species.

The scientific community is far from vindicated in this respect. The Vellar estuary on the east coast and the Cochin backwaters and Mandovi-Zuari estuaries of the west coast form the better understood estuaries of India. Some scattered information is available on a few more, but pathetically little scientific background exists on most estuaries. A review of the proceedings of some symposia conducted in our country on estuaries (Kurien, 1977; Natarajan, 1975; Nair, 1987) also point to this. The following study shows how bad the state of affairs are.

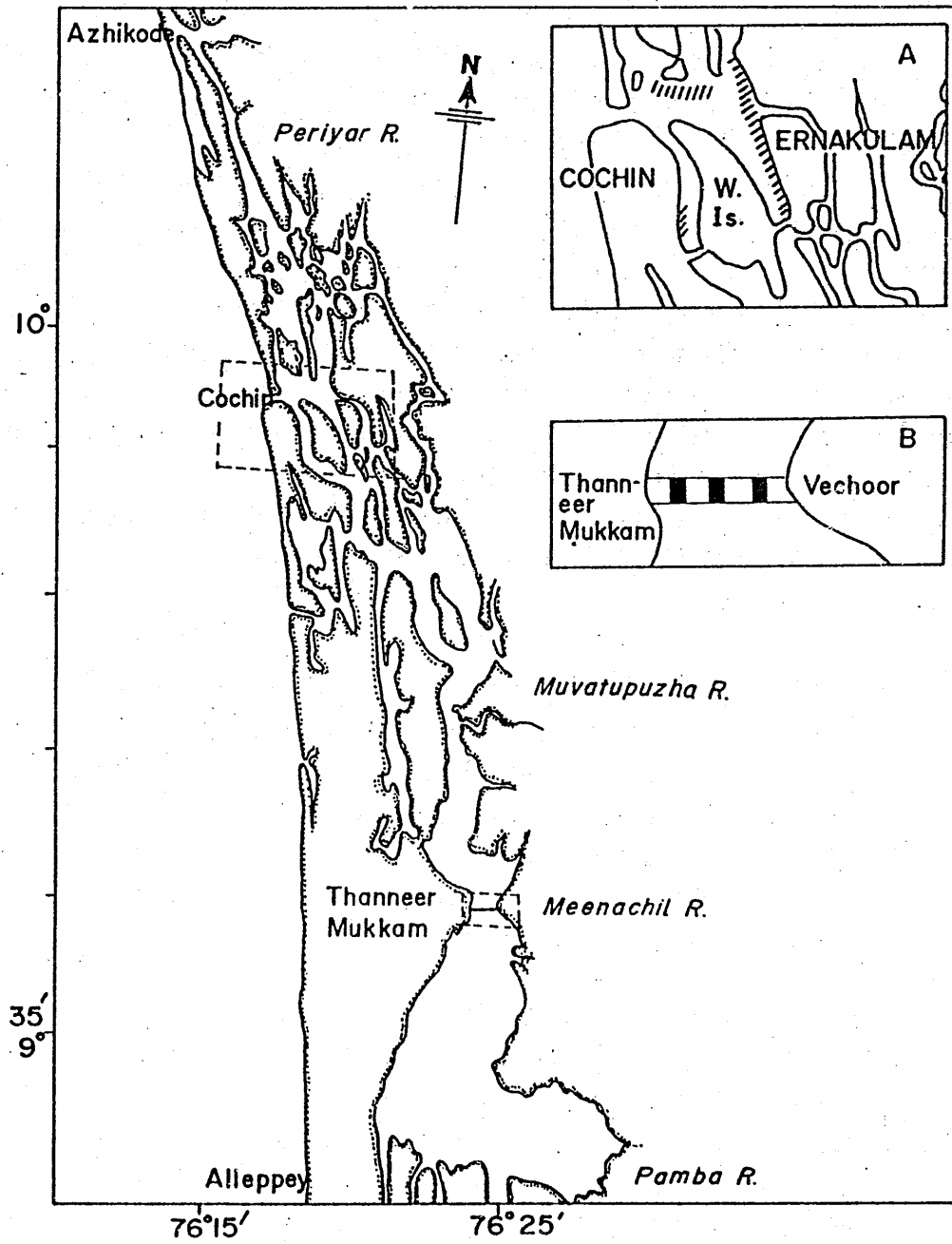


Fig. 1. Map of the Cochin backwaters. Hatched areas in insert A indicate reclaimed areas, insert B shows the Thanneermukkam barrier (modified from Qasim and Madhupratap, 1979).

A CASE STUDY - THE COCHIN BACKWATERS

The Cochin backwaters of Kerala (Fig. 1) is one of the important estuarine environments of India on which quite a few scientific studies have been conducted. A review of the data available over the past couple of decades shows that considerable alterations in the ecology of this system have occurred owing to man's interference which by and large have proven to be unimaginative (Qasim and Madhuratap, 1979).

The backwater has its main connection with the Arabian Sea at Cochin and several rivers empty into it. The southern part of the estuary is commonly known as the Vembanad Lake. The Periyar, one of the major rivers of Kerala feeding this estuarine system, receives large quantities of industrial effluents from a variety of chemical factories situated a few kilometers up the river mouth. The Cochin city with a population of over a million, discharges mostly untreated sewage at various points near the mouth. There are several coconut husk retting areas in the estuary and many shrimp peeling sheds dispose their wastes into it. Oil spills from port traffic and constant dredging add to the hazards of estuarine life.

Mass mortality of fishes have been reported from several areas in the estuary receiving chemical effluent discharges. Benthic biomass and shrimp population show sharp decrease in these areas (Nair *et al.*, 1988; Sarala Devi and Venugopal, 1989). Further, the shrimp population of the estuary is plagued by fungal diseases causing decay of their appendages. Considerable reduction of benthic population has been observed with time and this has been attributed to increasing pollution (Ansari, 1977). The waters are often discoloured and murky with persistent smell of ammonia. Intense faecal contamination resulting in high densities of coliform bacteria in water, sediments and organisms inhabiting the estuary has been reported (Gore *et al.*, 1979). In some polluted areas BOD values reach 513 mg/l, sulphide 4.9 mg/l and oxygen values become less than 0.05 ml/l (Remani, 1979). Sediments in the polluted areas are often black due to production of sulphide. They have high organic carbon content ranging from 1.56 to 9.4% while it is usually between 1.1 to 2.9% in healthy areas. Some of the benthic organisms like oysters and mussels have zinc accumulation higher than permissible limits (Purushan, 1978).

However, no significant steps have been taken so far to abate the effects of pollution. The situation is approaching a critical state and this system would have become irretrievable but for the periodic flush out during the monsoon.

The same estuary is a paradigm of the follies brought through unimaginative engineering changes. A large area of the estuarine front has been reclaimed for urban development. Part of the area near the mouth was retrieved for construction of super tanker berths although the project was later abandoned. These have caused changes in the circulation pattern affecting oyster beds and a reduction in spat fall and settlement of oyster larvae (Purushan, 1978). Dumping of dredged material has resulted in the formation of several small islands close to the harbour (Gopinathan and Qasim, 1971).

Paradoxically, the Thanneermukkam barrier (Fig. 1) constructed upstream (ca. 30 km from the mouth) with high hopes, and at an approximate cost of 80 million rupees, has proved to be disastrous. The barrier cuts off the entire Vembanad Lake from the rest of the backwaters and was built with a view of preventing salt water entering the hinterland during summer months to facilitate paddy cultivation in the area. Water flow is regulated by spillways which are closed during the saline period (November-May).

The project started in 1955 and after long delays was completed in 1975. However, the socio-economic changes over the span or the alterations the barrier might bring to the ecosystem were apparently not thought of. In fact, the project has brought about more problems than it solved (see KSSP, 1978). The main argument for constructing the barrier was the expectation of raising a second crop of paddy in the hinterlands by preventing the incursion of saline water in this area (Kuttanad) of about 1,40,000 acres. However, the only area that benefited from the scheme was about 45,000 acres. The rest of the area was out of reach of the benefits of the regulator and in fact in these areas salinity was never a problem even before. There is nothing to indicate that an indepth study was undertaken on salinity problem before going ahead with the construction of the salt water barrier. Ironically, with the increasing expenditure on paddy cultivation and poor

returns, most farmers have ceased to raise a summer crop.

The "African Payal", *Salvinia* sp. appeared in the fresh water canals and lagoons of Kerala in the early 60s and was apparently imported and introduced as a food for the fish minnow Tilapia (*Sarotherodon mosambica*). The prolific spreading of this weed has remained a major menace since then. Prior to the completion of the barrage, most of the *Salvinia* used to decay with the saline water incursion during the summer months. But now the weed, a fresh water 'Dinosaur', forms a thick carpet over the water surface choking the entire freshwater area of the Kuttanad. The weed prevents light penetration in the water column severely affecting primary productivity, benthos and fisheries. The water transport in the Kuttanad has also become seriously hampered.

Earlier, the Kuttanad (upper Vembanad Lake) used to have regular flushing of the water from tidal influence. At present the water is stagnant during postmonsoon months. About 2,000 tonnes of pesticides are annually used in the area for paddy cultivation. The problem from stagnation are accentuated by accumulation of residual pesticides. This has affected the water quality, led to an increase of mosquito population and is causing health problems to the people inhabiting the surrounding areas.

The once rich population of giant fresh water prawn *Macrobrachium* and other fishes such as pearl spot *Etroplus suratensis* has virtually disappeared from the Vembanad Lake and adjacent canals. Other estuarine fishes which used to enter the area along with salinity incursion are also blocked by the barrier. The rich clam beds of the Lake (dead shells are being excavated for manufacture of cement, chemicals and lime) are depleted. Only a few air-breathing fishes are able to survive in the choked water ways.

These events have severely affected the ecology of the area and rendered thousands of people jobless. The matter has taken a more serious and worse turn since 1991. Almost all the fishes of the Cochin backwaters and upper Kuttanad area (including air-breathing fishes like snake heads and others such as *Heteropneustes*, *Wallago*, *Etroplus* etc.) have deep oozing ulcers all over the body including tails and fins (see CMFRI,

1991 for details). The entire fisheries of the area have come to a stand still since there are no consumers. The precise cause of the disease (tentatively identified as "Epizootic Ulcerative Syndrome") has not been identified yet.

ASSESSMENT OF THE PRESENT

It is conceivable that some of our other estuaries like the Hooghly might be similarly, if not more, polluted. However there are no data from any indepth studies from most estuaries to assess the situation. The Mandovi-Zuari estuaries are relatively clean but for the heavy suspended load arising from mining activities (NIO, 1979). Even here there is evidence of destruction of mangroves and benthic population in upstream areas (Parulekar *et al.*, 1986). The diversity and abundances of benthic fauna in the Bombay harbour and inshore waters off Bombay are severely affected by pollution (Parulekar *et al.*, 1986).

A more recent survey of the estuaries of Kerala indicate that most of them are not in a very healthy condition (Venugopal, pers. comm.). Some of them like the Kallai and Beypore have poor benthic biota and high BOD and COD values. The former is extensively used for timber conditioning and the latter receives effluents from a rayon factory.

The effects of pollution in the once beautiful Thames River is still green with us. Salmon fishery in several countries has been affected by construction of dams and want of proper fish passages for migration. We are aware that the Hilsa fishery of the Ganges is affected by the Farakka barrage.

It is known that the larvae of almost all commercially important shrimps (exports of which earn us about 1300 crores annually in foreign exchange) migrate to estuaries for initial growth and development. If our estuaries are allowed to get polluted, this migration can become seriously hampered affecting capture fishery and the multi-crore industry would slowly grind to a halt. The shrimp exporter who conveniently dumps his factory wastes into the estuary does not realise that he is digging at his own toe! Another aspect is that there are no regulations against indiscriminate

capture of immature shrimps inside the estuaries which can also ultimately affect the fishery. The present system of management, if any exists, is at best amateurish. We cannot afford to be euphemistic in planning the future. What is more, even the little we know about our environments is not being made any use of.

We are complacent enough to let things go by perhaps relying too much on the natural resilience of the ecosystems. Many do not seem to realise that the ecological balance of these systems could become irreversibly altered once the changes pass a threshold. The present system is so permissive that those who commit the abuses get away scot free. Leaving our water ways open, clean and abound with life is one of the best legacies we can offer to future generations.

RECOMMENDATIONS

The foremost requirement is perhaps to fill the lacunae in collecting baseline data on the health of our estuaries. It may not be an easy task, but should be feasible if the scientific and fishery management bodies of various areas cooperate under a general programme.

It would be best if there is a central authority to coordinate such studies. The authority should be empowered to look into uses of the estuaries and take appropriate actions. Any effluent discharge or structural changes even at the upper reaches of rivers should be scientifically studied before being undertaken.

Fishery management authorities should pay more attention against indiscriminate capture and destruction of wild stock inside the estuary, especially of migrant organisms like shrimps since it would ultimately affect the capture fishery. Even for aquaculture programmes emphasis should be given in developing techniques for seed stocking through development of hatcheries. This will also safeguard the interests of the aquaculturists by being able to stock the required species.

Regrettably, our estuarine aquaculture programmes are yet to gain footings on a commercial scale. One main drawback with estuarine farms

is the lowering of salinity below the requirements of many marine organisms during the monsoons. However, there should be very good scope in culturing organisms like *Macrobrachium* which is in great demand and requires saline as well as freshwater conditions for development and exhibits considerable salinity tolerance. Attention should also be paid to the farming of fast growing organisms like shell fish. One important aspect to be considered is that no two estuaries are exactly similar and the selection of organisms suitable for culture in a particular estuary would depend on its own conditions. This brings us back in a full circle to the need of collecting scientific data on our estuaries.

REFERENCES

- Ansari, Z.A. 1977: Macrobenthos of the Cochin backwaters. *Mahasagar*, **10**: 169-171.
- CMFRI. 1991: Newsletter No. **54**: 1-3.
- Gopinathan, C.K. and Qasim, S.Z. 1971: Silting in the navigational channels of the Cochin harbour area. *J. Mar. Biol. Assn. Indian*, **13**: 14-26.
- Gore, P.S., Raveendran, O. and Unnithan, R.V. 1979: Pollution in the Cochin backwaters with reference to indicator bacteria, *Indian J. Mar. Sci.*, **8**: 43-46.
- KSSP (Kerala Sastra Sahitya Parishad). 1978: Problems of Kuttanad, a study report. 73pp. (in Malayalam).
- Kurien, C.V. (edited) 1977: Contributions to estuarine biology. *Univ. Cochin, Dept. Mar. Sci.*, 1004 pp.
- Nair, N.B. (edited) 1987: Estuarine Management. State Committee on Science and Technology, Government of Kerala, 550 pp.
- Nair, K.K.C., Sankaranarayanan, V.N., Gopalakrishnan, T.C., Balasubramanian, T., Lalithambika Devi, C.B., Aravindakshan, P.N. and Kutty,

- M.K. 1988: Environmental conditions of some paddy cum prawn culture fields of Cochin backwaters, south west coast of India. *Indian J. Mar. Sci.*, 17: 24-30.
- Natarajan, R. (edited) 1975: Recent researches in estuarine biology. Hindustan Publishing Corporation, 321 pp.
- NIO (National Institute of Oceanography) 1979: Master plan for pollution control of the rivers Zuari and Mandovi. *Tech. Rep. 02/79*, 114 pp.
- Parulekar, A.H., Ansari, Z.A. and Ingole, B.S. 1986: Effect of mining activities on the clam fisheries and bottom fauna of Goa estuaries. *Proc. Indian Acad. Sci.*, 95: 325-340.
- Parulekar, A.H., Ansari, Z.A., Harkantra, S.N. and Rodrigues, C. 1986: Long-term variations in the benthic macroinvertebrate assemblages of Bombay, India. In: M.F. Thompson, R. Sarojini and R. Nag-abhushanam (edited) *Biology of benthic marine organisms*. Oxford and IBH, New Delhi. 211-229.
- Purushan, K.S. 1978: Ecological studies on oysters- *Crassostrea* species in Cochin backwaters. M.Sc. Thesis, University of Cochin.
- Qasim, S.Z. and Madhupratap, M. 1979: Changing ecology of Cochin backwaters. Contributions to marine science dedicated to Dr. C.V. Kurien, 137-142.
- Rao, K.L. 1975: India's water wealth. Orient Longman Limited, New Delhi, 267 pp.
- Remani, K.N. 1979: Studies on effects of pollution with special reference to benthos of Cochin backwaters. Ph.D thesis, University of Cochin.
- Sarala Devi, K and Venugopal, P. 1989: Benthos of Cochin backwaters receiving industrial effluents. *Indian J. Mar. Sci.*, 18: 165-169.