

A LOOK AT THE CHANGING ENVIRONMENT ALONG THE INDIAN COASTS

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INTRODUCTION

India has a long coastline of over 7000 kms. About 25% of the population in India live in the coastal areas. The coastal areas have provided excellent harbours around which large human settlements and industries have developed. The coastal seas, estuaries and rivers have been extensively used for transport, food, communication, waste disposal and recreation.

The increased human activities along the coast has exerted more pressure on the coastline and its ecology. Several places along the coast have been reclaimed and several artificial structures are made along coast altering the natural setting of the coastline. The coastal ecosystems are very productive and fisheries concentrate in the nearshore zone along the coast. Now the awareness is increasing on the protection of environment and the idea of sustainable development.

THE CHANGING COASTLINE

It is evident that the world's coastline undergoes changes from time to time. The proportion of the world's coastline that has retreated during the past century exceeds that which has advanced, although extensive sectors have remained stable or have shown no definite evidence of advance or retreat (Milliman 1985). According to Ahmad (1972) about 55% of the Indian coastline is beach fringed, the beaches have been generally either stable or receding in the past few decades.

On the west coast of India, there have been episodes of submergence due to earthquake subsidence (in 1819 and 1845) followed by alluviation and progradation, particularly around Gulf to Kutch. The Gulf of Cambay is an area of continuing swampy progradation and, around and between the estuaries of Narmada, the Tapi and the Ulhas, and further south, there is a large sediment discharge derived partly from gully erosion in the coastal plain. Gradual accretion of silt and clay has been observed on islands at the mouth of the Narmada (Bedi and Vaidyanathan, 1982). In Goa, Wagle (1982) concluded that the coastline was prograding along the beaches while retreating along the cliffs and headlands. But on the sandy Kerala coast, there has been sustained recession in several parts. It appears that some of the protection measures themselves are responsible for spreading the erosion to other areas.

On the east coast, the chief prograding sectors are on the deltas, Krishna, Godavari, Mahanadi and Ganges where these rivers supply large quantities of sediment. These deltaic shorelines are generally muddy, but where sand is present beaches and spits have been formed. The general progradation of the Krishna delta was interrupted by the erosion during the cyclones (Rao and Vaidyanathan, 1979). On the Mahanadi delta, alternate advance and retreat were observed, while the coastline bordering the Brahmani river mouth has recently undergone erosion (Meijerink, 1982). The artificial structures of the harbours along the east coast have affected the sediment movement along the coast and beach erosion has been reported near these harbours.

Some of the factors responsible for morphological changes in the coastline are subsidence, rising sea level, storms and storm surges, sediment input from rivers, sediment redistribution and artificial structures along the coast.

Subsidence

The subsidence results partly from coastal processes often caused by relative movement along continent-crust boundaries and partly reflects isostatic compensation and consolidation of the sediment deposited by rivers. Removal of groundwater or petroleum from the underlying strata can also increase local subsidence. In deltaic area, river-borne sediment generally deposit at a rate equal to or greater than the rate of subsidence, maintaining the delta in its position relative to sea level or progrades seaward. However, this natural process will change if the sediment input pattern changes.

Damming of rivers

One of the main factors for change of sediment input to the coast by rivers is the increasing damming and diverting of the rivers draining into the sea. The total river discharge into the Bay of Bengal is about 1529 km³ including Ganga and Brahmaputra. The total discharge along the west coast is about 298 km³. Probably, one of the causes for erosion along Kerala coast may be the changes in the input of sediment due to damming of rivers. However, this aspect needs a detailed study. Usually oceanographers who deal with the coastal problems are not consulted on this aspect and have no control on this problem since the damming of rivers takes place in the hinterland.

Diverting or eliminating water and sediments discharge of river can result in tremendous changes to the coastal environment. And we are often unable to predict accurately the possible effects on the coastal ecosystems. The decrease in freshwater input can drastically alter the productivity within the estuaries and mangrove swamps. The biological impact may be felt within a short period after the damming of the river. Such is not the case with geological effects, where the ultimate impact might not be felt until long after the damming and the problems may become increasingly worse with time. It is essential to document the coastal environmental conditions prior to and after damming to study the environmental impact. Such studies appear to be little in India.

Sea Level rise

It has been observed that the sea level is rising globally. With the end of the last glacial epoch about 15000 years ago, world sea level rose about 100 m, in response to the melting of glacial ice cover. Sea level more or less reached its modern level 5000 years ago and since then has risen by a fraction of a mm per year. This natural situation changed, however, with the increased burning of fossil fuel in this century initiating much debated greenhouse effect. Concentrations of atmospheric CO₂ and other greenhouse gases continue to rise rapidly which in turn produce a larger global warming. This will enhance the rate of sea level rise faster than the rise in the past century. Presently global sea level is rising at an average rate of 1mm per year, although it varies from place to place. The secular change in sea level is about 1mm/year along the Indian coast.

Although the current knowledge is inadequate to predict precisely the future sea level rise, it is sufficient to predict the likely range. Various scenarios predict total rises ranging from 25cm to more than 2m by the end of the next century (Hoffman et al, 1983). When it is added to regional subsidence, it is possible that several areas along the Indian coastline will experience submergence. Along the Indian coastline, the region most vulnerable to the consequences of the anticipated sea level rise is the Lakshadweep Archipelago and Andaman and Nicobar islands (Shetye et al, 1988). The east coast of India is more vulnerable than the west coast and likely to suffer from increased storm surges. The coastal belt between 12° and 18°N on the west coast appears to be the 1st vulnerable.

The expected consequences of sea level rise are land loss and property damage due to submergence, accelerated coastal erosion, increased damage for storm surges and coastal flooding, damage to aquifers from salt & water intrusion, increased saltwater intrusion into rivers, coastal inlets and agricultural lands, damage to coastal ecosystems, habitats and fisheries.

POLLUTION AND COASTAL ECOSYSTEM

Large quantities of liquid and solid waste of domestic and industrial origin are being released in the rivers, bays and creeks which ultimately find their way into the coastal sea. Because of the total volume of water is too large, one would think apparently that the waste released into the sea is so insignificant in volume, and that the sea can assimilate it without causing pollution. Such is not the case, as the material dumped into the seas is not evenly spread throughout the volume of the seawater. Many industries have sprung up along the Indian coast in the last two or three decades. Little attention was paid to treatment of effluents before disposal. It is only recently that some awareness has been created towards deterioration of the coastal environment due to waste disposal and the necessity for treatment of effluents before discharge. The industrial waste added to the sea by the industries along the Indian coast is estimated to be about $0.41 \times 10^9 \text{ m}^3/\text{year}$. The domestic sewage added to the sea by the coastal population is $4.1 \times 10^9 \text{ m}^3/\text{year}$. It has been estimated that approximately 5 million tonnes of fertilizers, 55,000 tonnes of pesticides and 125,000 tonnes of synthetic detergents are used annually in India. A substantial portion of these find their way to the coastal waters. A considerable quantity of these substances are biodegradable while others are not. Their cumulative effect over a long period could be quite harmful to the coastal marine environment. These effects are, as yet, not very perceptible generally on the Indian coast, but in the vicinity of metropolitan cities and industrial conglomerates, the effects are indeed alarming (Qasim & Sengupta, 1988). For example, the phosphate phosphorus concentration in the nearshore waters of Bombay increased from 0.82 to $2 \mu\text{mol l}^{-1}$ during the period from 1959 to 1984 (Sengupta et al, 1975 & Zingde, 1985).

Several toxic heavy metals are expected to be transported to the sea by the rivers. An examination of the suspended and particulate metals in the estuarine region of the Ganges shows that about 10% settles in the lower estuarine region, 50% at the confluence of the river water with the seawater and 40% finally flows out into the open Bay of Bengal. Examination of data on metals shows that about 85% of the dissolved metals settle within the river leaving only 15% to flow out (NIO, 1986). Data collected on mercury in water, zooplankton, fish and sediments along the Indian coast indicate a few localised 'hot spot' regions off Bombay (Zingde & Desai, 1981). However, these 'hot spot' regions merit a close watch. Investigation on the levels of toxic metals in marine biota at a few locations in the Indian waters indicate that the levels are below the maximum limits prescribed by WHO, for human consumption (Kureishy et al, 1978, 1983, Kureishy, 1985). However, the presence of the toxic metals in water, sediments and marine biota calls for a continuous monitoring programme.

Recent studies on the pesticides residues in sediments along the east and central west coasts of India detected nine organochlorine pesticides their metabolites (Sarkar & Sengupta, 1987, 1988). Concentration of the residues of these compounds are found to occur at ppm level on the east coast and while they are in ppb scale on the west coast. Concentration of pesticide residues in zooplankton in the Arabian Sea decreases away from the shore indicating their terrestrial origin and aerial transport (Kannan & Sengupta, 1987). A recent study has shown that the fine sediments brought to the west coast by rivers confine themselves to the nearshore region. Although these sediments are transported along the shelf and cross-shelf transport appears to be minimal. This leads to the conclusion that sediment bound pollutants discharged on the west coast is likely to be accumulated only in the innershelf and do not get dispersed to the offshore areas (Ramaswamy & Nair, 1989).

One of the most polluted areas on the Indian coast is the waters around Bombay. Bombay city discharges about 365 million tonnes of sewage and effluents to the sea annually. The Mahim Bay alone receives about 64 mt of municipal sewage and 0.9 mt of industrial wastes every year. In the beginning, these wastes were discharged untreated, but now these are partially treated. The contribution from Mahim river is only about 15% of the total wastes received by the coastal waters of Bombay (Zingde, 1985). The release of the effluents containing hydrocarbons has so heavily contaminated the creek so much so that it has become a common practice to recover oil by soaking sorbents. There was a time when this region had good fisheries, flourishing oyster beds, lush fringing mangroves and migratory birds. Now the fisheries are non-existent as no fauna can survive there and birds are hardly seen there (Qasim & Sengupta 1988).

Thana Creek is the largest single receiver of the industrial waste water in the Bombay region. Variety of pollutants released in the creek is reported to have adversely affected the fish life. The fish catch has dwindled considerably and most of the varieties caught are found to be contaminated. Mercury levels in crabs caught from the creek ranged between 1.6 to 20 ppm which by international standards can be classified as contaminated. The mercury enriched layer in the sediment cores was about 10-25 cm and excess mercury to the tune of 14 tonnes has been reported in the sediment. The fish production from Bassein Creek- Ulhas River which also receives large quantities of industrial waste dwindled from 4,500 tonnes per annum prior to 1955 to meagre 100 to 150 tonnes per annum today. Even this small quantity of fish caught is not of much value.

Several estuaries in Gujarat State have been studied recently. Damanganga, Kolak, Par, Ambika, Tapi and Mindola estuaries which mainly received industrial wastes through point discharges have been found to be grossly polluted (NIO,

1980). Not only the fish catch has decreased considerably, but in some estuaries the fish die during low tide due to restricted dilution of waste water and concentrated dose of pollutants to which the animal is exposed. The intensely polluted estuaries are characterised by wide fluctuations in zooplankton biomass during the flood and ebb tides. Dominance of zooplankton groups varied with the level of pollution. Diversity of different groups of zooplankton is relatively low in polluted estuaries (Desai et al 1983). In fact, there are only a very few estuaries in the entire country which are not polluted to some degree or the other by either sewage or industrial effluents.

Several other forms of pollution like dumping of dredge spoils and mining rejects in the marine environment, affect the ecology. Depletion of fisheries and benthic fauna due to mine tailings, and mining rejects and washings in the estuaries have been observed causing damage to the ecosystem (Parulekar et al, 1986). Several other wastes which pollute Indian coastal waters are garbage, scrap material from ship-breaking yards, damaged and rejected fishing nets and other gear, disposal of unwanted trashfish, waste generated by tourism industry, etc. Quantitative data on these are however lacking (Sengupta et al, 1990).

Transportation of about 60% of the world's crude oil and its products along the oil tanker routes across the Indian Ocean has rendered the Indian seas prone to oil pollution. Oil pollution in the sea occurs either from maritime accidents due to fire, collision or grounding, intentional discharge of oil or oily wastes or by accidental spillages. Added to this is the oil production activities in the coastal sea. Oil floating on the sea slowly loses its lighter fractions by evaporation and is attacked by micro-organisms which were adapted to use hydrocarbons as a source of energy. As a result of this the oil appears to increase in density and finally to join the sediment on the sea bed. The heavy lumps which are so frequently found during May-September on the west coast beaches represent these tar residues stirred up because of the development of strong shoreward component of the currents during May-September along the west coast of India. Observations on several west coast beaches conducted during 1975 and 1976 gave the average tar deposition of 28 and 20 g/m² respectively. This means that about 1000 tonnes of tar are deposited on the west coast of India alone. Deposition of tar balls is also considerable on the east coast beaches during December-January.

All these studies indicate that the indiscriminate release of sewage, industrial and other wastes has created pockets of pollution along the Indian coasts affecting the ecology.

Coral Reefs

In Indian waters, reef building corals occur at Palk Bay, Gulf of Mannar, Gulf to Kutch, and central west coast along the mainland, Andaman-Nicobar Islands in the Bay of Bengal and

Lakshadweep Islands in the Arabian Sea. Food fishes and aquarium fishes constitute the pelagic resources of coral reefs. Over exploitation of coral resources is a serious threat to Indian reefs. Coral sands to the extent of about a million tonnes are dredged annually in the Gulf to Kutch which led to the destruction of about 50% of coral life. In the Gulf of Mannar, selective overexploitation of massive corals has already affected several reefs. Coral mining also leads to shore erosion as observed in the Lakshadweep Islands. The trade in corals for ornamental purposes is also a contributing factor to the decline of coral resources. Present management and conservation measures for Indian coral reefs are inadequate (Wafar, 1986).

Mangroves

The estimates of the mangrove areas along the Indian coast are widely varying from 3500 to 7000 km². These mangroves form unique ecosystem along the coast and provide habitats for fish and wildlife. Several commercially important species use this area as nursery grounds. Mangrove forests are considered to be economically important, productive and specialised ecosystem. They play an important role in the estuarine and coastal fisheries, in the protection of shoreline, in providing wood for paper and pulp industry, firewood tannin, etc.

On account of modern development, the mangroves suffered loss from reclamation, deforestation and pollution. Thousands of hectares of mangrove forests of Gangetic Sundarbans, Cochin Backwaters, Bombay, Gulf of Kutch and other regions have been reclaimed for the purpose of either agriculture or urban development. These activities caused considerable reduction in mangrove areas along the coast. Mangrove areas have been used for discharge of industrial effluents, sewage and garbage etc. As a result, the general productivity of the mangrove waters decreases. The industrial effluents have destroyed the mangrove forests along the creeks in Bombay area.

Fauna and Fisheries

The marine fisheries in India is concentrated in the nearshore waters upto a depth of about 60 m. The capture fisheries in the coastal belt appears to be on the decreasing trend. This is attributed either to pollution or over exploitation. In the busy ports and harbours, pollution from ships and dredging reduces the availability of oxygen in bottom waters rendering conditions near anoxic. Benthic fauna is badly depleted resulting in significant loss of fisheries. Fisheries near Bombay harbour are, for example, receding further and further from shore and fishermen have to go beyond 10 km from shore (Sengupta et al., 1990). Fisheries in the inshore and estuarine regions at few locations also appear to have depleted considerably along the coasts of India due to pollution from industrial effluents and

sewage disposal as mentioned in earlier sections. The untreated sewage and unrestricted industrial discharge into the coastal environment have made some water bodies oxygen-deficient. The biological effects of pollutants in the marine environment of India are not very well studied. However, the effects at the population and community levels have been noticed in restricted environments along the coast, estuaries and creeks (Sengupta et al, 1990). Studies on the effect of mining activities on clam fisheries and bottom fauna of Goa estuaries indicated a reduction of 70% in less than 10 years in clam production, near extinction of resident fauna and the reappearance of a low diversity bottom fauna comprising of tolerant but vagrant species (Parulekar et al, 1986).

It has been reported that the extent of organic pollution in some areas in Cochin backwaters is well above tolerance level of estuarine fauna (Unnithan et al, 1975). Although, at present, the impact of pollution on marine fisheries, in general, is not alarming, the sign of damage to the living resources as evident at certain localities may emerge in serious proportions in the near future. Hence, it is essential to understand the long-term biological effects of pollution.

CONCLUSION

It may be noted that whatever have been described here are only indicative of few aspects of the changing marine environment along the Indian coasts, though there are several more studies and data available. However, the following are some of the aspects which need to be considered as prerequisites for devising better strategies for rational management of the coastal zone.

It is necessary to record the existing coastal features along with their recent evolutionary history. For monitoring the coastline changes, remote sensing technique can be applied. The pattern and volume of discharge of water and sediments to the coast through rivers need to be monitored regularly. Data on pre-damming and post-damming situations are needed to evaluate the impact of damming on the coastal ecosystem. As sea level rise due to greenhouse effect appears to be a reality, a rigorous monitoring of sea level changes is very essential to plan the coastal development programmes. Sites for future development along with coastline should be selected after detailed studies on the regional coastal processes in the past as well as present. The supply of sediments to the coastal region is essential to contain erosion processes, although there may be problems of siltation in harbours. Hence, it is wise to minimise or abandon such activities, that deplete supply of sediment to the coastal zone. Wherever developmental activities have interfered with natural sediment transport, replenishment may be a good alternative. Not only local but regional scale studies may be required before interfering with the natural settings along the coast. The ecology of the coast needs better attention. Although some of the changes in the coastal

marine environment and ecosystem are discernible, the cause and effect studies or environmental impact assessment are not adequately attempted. One of the problems making this task difficult is that the effects of pollution is superimposed on the natural changes taking place in the marine environment at different time and space scales. The vastness of the area to be under surveillance makes it more complex. As the population and industries increase in the coastal belt, the amount of wastes dumped into the coastal zone also will increase. Therefore, the pollution monitoring along the coast needs to be continued along with impact assessment. And, special attention is required for identifying the causative factors and their effects separately rather than the combined effect. This will enable to adopt better control measures. For achieving these goals, modern tools like remote sensing and ocean platforms have to be used alongwith establishing coastal monitoring stations along the coast.

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