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BIOLOGICAL MONITORING FOR CONSERVATION OF MARINE LIVING RESOURCES ALONG THE INDIAN COAST — AN UNEASY EXPERIENCE

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ABSTRACT

Responses of marine biota project the actual effect of any change — environmental or anthropogenic — in the biosphere. Primary impact of any type of input is on living populations, as they integrate the combined effects of variegated stresses through changes and modifications. Such changes or shifts in the habitat, spatial distribution, relative abundance and production of biota, as observed from long term biological monitoring of the environment, realistically helps in the conservation of self-generating marine living resources. Some of the experiences in the biological monitoring of coral, coastal, estuarine and island ecosystem along the Indian coastline, are documented.

Key-words : Living resources, Conservation, Monitoring, Indian coast.

INTRODUCTION

Through ages, marine and estuarine organisms are subjected to environmental and man-made changes and as an evolutionary response, they have developed adaptive capabilities to overcome such nature induced stresses. However, in recent years, the magnitude of man-made interferences in the marine environment, has increased so greatly, that the self-cleansing capacity of the most affected coastal ecosystems, is not only losing its high potentials for generating the exploitable living resources but is also posing an imminent human health hazard.

In any marine biotope, imports and exports continually occur from land run-off, tidal action, oceanic circulation, atmospheric fallout and exchanges with adjoining water bodies and the biota (Ketchum 1973). Any type of input would have primary impact on the biota. The manifestation of impact may be recorded as a reduction in the number of sensitive species; increase in the population of hardy and tolerant species; appearance of exotic species; a change in the community structure and alternations in the behaviour, ecology, reproduction and physiology of the organisms.

In order to assess the impact of any stress, either environmental or man-made, it is necessary to acquire information on the conditions before, during and after the addition of an input, say a pollutant. Information on the physical, chemical and geological characteristics of an ecosystem; the distribution, abundance and variability of biota and the normal variations in these parameters over a long period of time scale, will lead not only to the realistic appraisal of the extent of damage to the ecosystem but will also aid in devising appropriate conservation measures.

THE PROBLEM

The post-independence years, while heralding the era of overall development in India, also coincided with the increasing deterioration of environmental quality of the marine biosphere. Massive industrialization accompanied by rapid urbanization of large tracks of coastal regions, has exerted tremendous pressure on the highly productive and naturally balanced coastal ecosystems of India. Spectacular green revolution has its own contribution in reducing the prospects of a blue revolution in seas around India. Due to the ever increasing use of fertilizers, pesticides and insecticides in agricultural operations, and the discharge of untreated and poisonous industrial effluents in large quantities, the marine environment, serving as an universal sink, is overladden with some of the long lasting toxic substances. To worsen the delicate marine environment, still further, the rampant deforestation has added millions of tonnes of top soil in the coastal ecosystems, causing severe siltation and resulting in the deleterious changes in the ecology and habitat of estuarine and marine living populations.

The paradox of the whole situation is that though major changes in the marine environment, as a whole and in the coastal ecosystems, in particular, are discernible, not many, cause and effect analysis, are on record. One of the major constraints in devising conservation strategy, is the paucity of relevant baseline information on ecology and biota of the extensive marine environment of India.

However, some attempts in the form of long term studies, pertaining to biological monitoring of coastal ecosystems, threatened by man-made changes, are on record, and few of them, as specific case studies of cause and effect relationship are presented and discussed, in the following pages.

CAUSE AND EFFECT STUDY

1. **Effect of dredging on coral ecosystem:** The Gulf of Kutch is one of the few places along the mainland coastline of India, where live coral reefs are still found. Pirotan and Deda (between lat. 22°36′N and long. 69°57′E), two small islands in the Gulf of Kutch, were, earlier characterized by extensive coral reefs, lush green mangroves and sparkling white sandy beaches (Parulekar and Untawale 1976). Except for four persons manning the lighthouse on the Pirotan, both these islands and their marine environs, were almost free from any major anthropogenic perturbations.

However, since 1965, the coral stones and sands from the environs of these islands, were extensively dredged, as a raw material in cement production, and thus the stable coral ecosystem got subjected to destructive forces of man-made changes. A detailed study undertaken through 1969–1971, on the natural history of terrestrial, intertidal, subtidal and mangrove ecosystems in the environs of Pirotan and Deda island, revealed that the biota was healthy and highly diverse. More than 200 taxa of plants and animals, each having moderate to high population density and natural distributional range were recorded.

Within a span of less than eight years, the deterimental changes, caused by indiscriminate dredging of coral stones, cutting of mangroves and increasing removal of beach sand, were evident (Parulekar and Untawale 1978). Some of the important adverse effects, observed were :

i – severe erosion and high percentage of suspended solids in the water.

ii – replacement of terrestrial grasslands by mud flats.

iii – blanketing of coral reefs, by 2–3 inch thick layer of silt and clay particles.

iv – decline in the relative abundance and growth of marine plants due to highly turbid waters.

v – considerable decrease in the number of suspension feeders and photosynthesizers.

vi – more than 40% reduction in the occurrence of marine plant and animal species.

Prompt action taken by the concerned authorities, in imposing a total and immediate ban on dredging and cutting of mangrove vegetation and further implementation of the proposed conservation plan has resulted in the revival and the protection of the unique coral ecosystem in the Gulf of Kutch.

2. **Environs of a highly industrialized metropolitan city:** Bombay (lat. 18°55′; long. 72°49′E) with a population of over 8 million and having more than 3,000 industial units is aptly described as the economic capital of India. An urban conglomeration of seven islands, connected. either through sea reclamation or causeways, the estuarine and marine environs of Bombay are subjected to a high pressure of man-made changes.

Since 1973, a long term study on the relative abundance of biota in relation to environmental quality in the coastal ecosystem of Bombay, is being carried out and some of the observed changes, in comparison to 1973 status (Parulekar, Nair, Harikrisna & Ansari, 1976) are as follows :

i – major differences in the occurrence of marine fauna were observed. Gradual depletion, leading to the total disappearance of biota in the most affected shallow coastal ecosystem; within 30 meter depth and upto about about 20 kms off the coast, took place, within a decade, between 1973 and 1983.

ii – relative abundance of fauna gradually declined from 1973 to 1983. In less than 7 years, between 1976 and 1983, the abundance decreased by more than 50%.

iii – standing crop, within 30 meter depth, which on an average was 21.6 g/m^2 in 1973 decreased to 0.2 g/m^2 in 1977 to 0.1 g/m^2 in 1981 and nil biomass in 1983.

iv – high faunal density as represented by 3 faunal taxa in 1973, gradually reduced to low diversity, with the presence of a single taxon in 1983.

v – dissolved oxygen concentration declined from a mean value of 4.73 ml/l in 1973 to 2.58 ml/l in 1976 to 2.13 ml/l in 1977 to 1.61 ml/l in 1981 to 0.76 ml/l in 1983. Deoxygenation of near bottom water was mainly caused by the heavy discharge of high organic input of sewage and domestic wastes.

vi – organic carbon content in the seafloor sediments increased from 1.27% in 1973 to 1.85% in 1977 to 2.12% in 1981 to 2.77% in 1983. Such a two fold increase within 10 years is ascribed to ever increasing sewage discharge.

vii – slow deterioration of environmental quality accompanied by the impoverishment of biota, within a decade (1973–83) and the unabated disposal of industrial, sewage and domestic wastes, has resulted in the near-extinction of marine life in the environs of the metropolis of Bombay. In fact mangroves have totally degenerated or disappeared from many places along the Bombay coast.

3. **Onshore mining and an estuarine ecosystem:** Very little is known about the long term effects of onshore mining on the ecology and biota of coastal ecosystems. In the Union Territory of Goa (between lat. 14°54′ – 15°48′N and long. 73°41′–74°20′E) the mining of surficial iron, manganese and bauxite deposits is a major industrial activity. Over the last 15 years or so, the export of iron ores from Goa, has steadily increased from 6 million tonnes/year in 1971–72 to 14 million tonnes/year in 1980–81.

All the mining operations, including excavations, extractions, stacking, loading and transport, take place on the river bank and through the riverine and estuarine waterways. Extraction of one tonne of export quality ore, generates about 1.5 tonne of mining rejects. Consequently, more than 300 milion tonnes of mining rejects are estimated to have accumulated in Goa (Annon 1981). Due to heavy southwest monsoon precipitation, these mining rejects get eroded due to flooding and are transported downstream of the rivers. It is estimated that 8 to 10% of the ore fine is lost in transit from the mining area to the harbour. Ultimately a major part of mining rejects settle down in the benthic biotope within the estuarine ecosystem.

A twelve year (1971–83) long continuing study on the ecology and productivity of commercially important shellfishes and its associated biota in Goa estuaries, gave an opportunity to assess the impact of mining on the highly productive tropical estuaries. In 1971–73, the ecosystem was observed to possess the characteristics of a healthy ecosystem (Parulekar, Dwivedi and Dhargalkar, 1973).

However, continuing studies revealed the following, adverse changes by 1982–83, i.e. within a span of 12 years:

- i – an overall 66% reduction in the dissolved oxygen concentration of waters overlying the shellfish grounds;
- ii – suspended solids in the estuarine waters increased by more than three times;
- iii – retrogressive changes in the structure and composition of bottom deposits. From soft sediments, dominated by an admixture of medium grain sand and silt as observed in 1971–73, the substratum got blanketed with red clay and lateritic cobble and pebbles, by 1983;
- iv – standing crop of exploitable shellfish resources, which on an average was over 500 g/m^2 in 1971–73, declined to a mean value of 10 g/m^2. by the year 1982–83;
- v – population density of shellfish decreased from $893/m^2$ in 1971–73 to $36/m^2$ in 1982–83;
- vi – more than 50% reduction in the occurrence of bottom dwelling organisms;
- vii – major qualitative changes in biota. While the animal communities of 1971–73 were dominated by filter feeding and detritovorous organisms, an overwhelming dominance of scavenger species was observed in 1982–83.
- viii – species diversity index decreased from 5.4 ± 0.91 in 1971–73 to 1.5 ± 0.53 in 1982–83;
- ix – glaring shift in community structure due to displacement of resident species of 1971–73 by opportunistic and migratory species of 1982–83;
- x – great deal of disintegration of assimilative capacity and partial instability of estuarine ecosystem was the end result.

4. **Industrial effluents and a coastal island ecosystem:** The environs of Karwar (between 14–15°N; 74–75°E), endowed with a healthy continental island ecosystem and harbouring a rich and highly diverse biota (Parulekar 1973 & 1976), was devoid of any major industrial activity, almost till the year 1973–74. However, since 1976–77, a caustic soda plant started discharging the effluents through a marine outfall in the coastal island ecosystem off Karwar. Consequently, in less than eight years, between 1976 and 1984, following deleterious effects could be observed.

- i – frequent mass mortality of commercially important marine organisms.
- ii – considerable destruction of rich bivalve beds, due to the release of highly alkaline effluents into the adjoining creek.
- iii – mercury contamination of water, sediments and biota.

The above mentioned, four case studies, are just a "tip of the iceberg" of the magnitude of deterioration of coastal ecosystem, in particular, and the extensive marine environment of India, in general.

MONITORING AND CONSERVATION

The extent to which the marine living resources of India are affected due to man-made changes of recent years, is rather difficult to quantify, as only few long term studies have so far been undertaken. However, on a macroscale, major changes in the quality and quantity of marine biota have been observed. Even a slight change in the behaviour, physiology and pattern of distribution of biota, can be taken advantage of and used as a warning system, for a greater damage in later years (Thomas, Wilcox and Goldstein, 1976). This is of great relevance in the management, protection and conservation of marine living resources.

It is generally considered (Annon, 1979) that the assimilative capacity of an aquatic ecosystem is that level of stress which an ecosystem can withstand without causing an irreversible change in the ecology and productivity of the biota. Most commonly, an irreversible change is projected as being a measured deleterious effect wherein a potential health hazard to human being is on the card.

For ecological and resource considerations, it is well recognized (Gaufin 1974) that a system to evaluate water, based on the assessment of biota, would reflect directly on the conditions existing, therein. The advantages of biological monitoring, especially in the conservation of marine living resources, are that it directly reflects the effect of waste materials and toxic substances on the biota. The marine and estuarine organisms, integrate the overall effect of a combination of pollutants (Ketchum, *Op Cit.)* and, hence, the damage that can be done to living organisms, by the discharge of complex waste, becomes comprehensible from studies on biological monitoring. While the chemical and bacteriological quality analysis, gives the effect of a pollutant at the time of analysis, the biological analysis, indicates the severity of impact, through the period of time (Widdows 1983). Thus, the biological monitoring which helps in understanding the interrelationship between living organisms and their environment, for the assessment of impact and monitoring the harmful effects of environmental and man-made changes, also provides a realistic and efficient tool for the conservation of all important living resources.

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