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**BENTHIC WATCH : A CASE STUDY OF BIOLOGICAL MONITORING OF
MARINE ENVIRONMENT**

A. H. PARULEKAR

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BENTHIC WATCH : A CASE STUDY OF BIOLOGICAL MONITORING OF MARINE ENVIRONMENT

A. H. PARULEKAR

Biological Oceanography Division, National Institute of Oceanography, Dona Paula, Goa 403 004

ABSTRACT

A decade (1974 to 1983) long monitoring, of bottom living communities, in relation to water quality characteristics in the coastal zone off Bombay, indicated drastic changes in the distribution, composition, relative abundance and standing crop of benthic macroinvertebrates. Dissolved oxygen concentration, which on an average, was 4.77 ml/l in 1974, decreased to almost depletion level of 0.76 ml/l, by the year 1983. Organic matter content of the sediments, increased from 1.87% in 1977 to 2.77% in 1983. Low dissolved oxygen values and significant increase in organic matter content is ascribed to extremely high discharge of domestic and industrial effluents, in the recent years.

Consequent to environmental deterioration, population density decreased from 1260/m² to 173/m² in the time span of a decade, with total depletion of fauna, in the severely affected nearshore regions of less than 40 meter depth. Similar decreasing trend in biomass production, ranging from 42.2 gm⁻² in 1974 to 9.14 gm⁻² in 1983, was observed. A time related impoverishment in the relative abundance of benthic fauna was observed. Tolerant species of polychaete, were the sole faunal component in later years, as against the rich and diversified macroinvertebrate fauna in the year 1974.

Time bound deterioration of the water quality, has resulted in the disappearance of many species. Unless abated, within no time, total extinction of marine bottom life in the most productive, nearshore environs off Bombay, is in the offing.

KEY-WORDS

Environment, Marine, Life, Pollution.

INTRODUCTION

A system to evaluate water quality based on the assessment of biota, reflects directly on the conditions existing therein. Any type of input, either industrial effluent or domestic wastes, entering an aquatic ecosystem, has the primary impact on the biota. Deviation, howsoever minor, in the water quality, upsets the natural balance and alters the ecosystem which manifests itself as a change in the qualitative and quantitative nature of the living organisms therein. If this change or shift in the natural balance can be detected and measured, it gives an indication of the extent of damage done by the pollutants. Biological monitoring, thus, precisely aims at locating such adverse effects in terms of damage done to biota.

The marine ecosystem includes all of the biological, chemical, geological and physical components of the environment and their highly complex interactions (KETCHUM 1973). In the marine environment, imports and exports continually occur from coastal runoff, tidal action, oceanic currents, atmospheric fallouts and exchanges with adjacent water bodies and with the benthos. In order to assess the impact of any stress, either environmental or man-made, it is essential to acquire information on the conditions existing before, during and after the addition. Information on the physical and chemical characteristics of the ecosystem, on the distribution and abundance of biota, and on the

normal variations of these characteristics over a long period of time scale, will lead to realistic assessment of environmental impact on marine living organisms.

A long term, study, extending from the year 1974 to 1983, on the distribution, relative abundance, standing crop, faunal composition and environmental variations in the marine environs off the metropolitan city of Bombay (Lat 18° 10' to 19° 50'N and Long. 70° 30' to 72° 40'E), revealed major changes in the qualitative and the quantitative aspects of benthic macroinvertebrate populations. These changes are discussed and a strategy for the biological monitoring of the marine environment, presented.

MATERIAL AND METHODS

Sea floor area, admeasuring about 66000 sq. km and lying in the depth profiles of 11 to 130 m, was sampled at pre-determined points (Fig. 1), along a transect running perpendicular to the mainland. Collection, processing and analysis of the benthic samples was done by standard procedures (PARULEKAR *et al* 1976). Environmental parameters of bottom salinity, dissolved oxygen concentration and the organic matter content of the sediments, were investigated by well-accepted methods (STRICKLAND & PARSONS 1968; EL WAKEEL & RILEY 1956). Sampling programme covered a major part of the annual cycle, however, no sampling could be undertaken during the southwest monsoon season (June-September), for obvious reasons, of inclement weather.

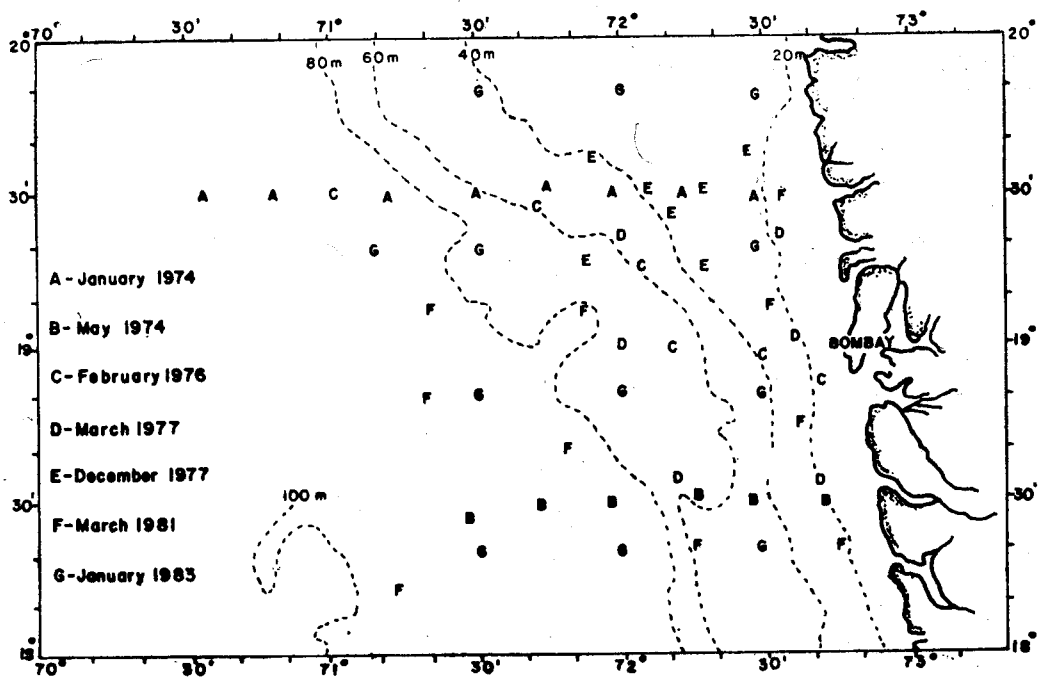


Fig. 1. Marine Environs off Bombay : Sampling sites shown by different symbols (A-G) For different year.

RESULTS AND DISCUSSION

Distribution : Qualitative differences in the distribution of benthic macroinvertebrate fauna, were observed. Changes were relevant not only with the passage of time but also with the habitat. While in the earlier part of the present investigation i. e.

between 1974-80, the shallow regions, below 30 meter depth, harboured uniformly rich and diverse fauna, in the post-1980 years, a total absence of benthic fauna was observed at most of the nearshore sites. Such differences, either could be due to biological interactions or due to temporal variations and animal behaviour (MASSE 1972). Differences in the distribution though retrogressive, were gradual and, therefore, the ultimate disappearance of fauna, obviously, was the consequence of environmental changes, originating from various human activities, including severe pollution of Bombay (ANNON, 1975).

Relative Abundance : Faunal abundance was observed to be gradually declining from 1974 through 1983. Highest population density of $1872/m^2$ was recorded in 41-60 m depth zone in 1976 and the minimum of $23/m^2$ in the 21-40 m depth zone, during 1983. Decline in the faunal abundance, though gradual, was most striking in the shallow coastal waters of less than 40 m in depth, and was observed to be more pronounced in the later part of the investigation, especially during 1977-83 period. In an earlier report, PARULEKAR *et al.*, (1976) observed a mean population density of $58/m^2$ for depths less than 40 m off Bombay. When compared with the value of $23/m^2$ observed in 1983, for the similar depth region, it could be inferred that in less than 7 years, between 1976 and 1983, the abundance of benthic macroinvertebrates has decreased by more than 50%. Such a deterioration in the distribution and relative abundance of bottom fauna, could be explained with reference to high magnitude of sewage and industrial pollution, of recent years, in the coastal waters of Bombay (ZINGDE *et al.*, 1979).

Standing Crop : Consequent to decrease in relative abundance, the biomass distribution also varied, rather reciprocally. Accordingly, in shallow waters of less than 20 m depth average standing crop value (wet weight) which was $21.67 g/m^2$ in 1976, decreased to $0.24 g/m^2$ in 1977; to $0.18 g/m^2$ in 1981 and to nil biomass in 1983. Similar changes were also observed in 21-40 m depth zone, wherein the mean standing crop value of $15.37 g/m^2$ in 1976, declined to $0.12 g/m^2$ in 1983. Relatively, the variations in standing crop in off shore areas of above 60 meter depth, were of low magnitude, with a decline of about 50% ($8.97 g/m^2$ in 1976 and $4.98 g/m^2$ in 1983) within a time span of 7 years. In higher depths (> 100 m), no significant changes in the standing crop as well as in the relative abundance of benthic macroinvertebrate fauna were observed, in the period of study of 10 years.

Composition : The infaunal population, in the harbour basin and also in the nearshore region of less than 40 m depths, was characterized by low population density and was comprised of only polychaete worms. In 1974, the fauna was more diverse and was represented by 3 faunal taxa, namely polychaetes, bivalve molluscs and amphipod crustaceans, as against a single taxon i.e., polychaetes in 1983.

SANDERS (1968) found polychaete-bivalve, together constituting more than 80% of the benthic fauna, in depths less than 25 m off Bombay. In a later study, PARULEKAR *et al.*, (1976) also reported 3 faunal taxa in shallow and nearshore waters of 40 m and less in depth, off Bombay coast. In the post-1976 years, total absence of bivalves and amphipods, was noticed, and the benthic community was observed to be solely comprised of polychaete worms.

Such differences in the faunal composition, could be a direct consequence of the major changes, leading to extreme deterioration in the marine environment off Bombay (GAJBHIYE *et al.*, 1981). The coastal and nearshore regions, receive the maximum impact of sewage, domestic and industrial effluent (ANNON, 1975) and, consequently, drastic changes in the composition of benthic fauna, become discernible (BOZZINI 1975). It results in the dominance of more resistant species of polychaete worms, especially deposit feeders, which

are reported to be the biological indicators of organic pollution (MEARNS 1981). Thus, the causes of depopulation and major changes in faunal composition especially in the nearshore regions have direct relevance to increasing environmental perturbations, arising out of anthropogenic and related activities. In contrast, in the off shore regions, above 40 m. depth, no major time bound changes in the faunal composition were evident. Here, the fauna was more diverse and was represented by polychaetes (59%), bivalve molluscs (16%), crustaceans (10%), echinoderms (9%) and miscellaneous taxa (6%).

Environmental Inventory : Bottom salinity, values, varied within a small range of less than 1.2% (35.1-36.3%) and no significant time bound changes, were observed. In contrast, the dissolved oxygen concentration, exhibited wide variations (0.76 to 5.37 ml/l) in the time span of 10 years. While the average value in the shallow regions below 40 m depth, was 4.77 ml/l in 1974, it gradually decreased to 2.5 ml/l in 1976 to 2.1 ml/l in 1977; to 1.6 ml/l in 1981 and to 0.76 ml/l in 1983. Abnormally low dissolved oxygen concentration in the coastal waters of Bombay, has been ascribed (ZINGDE *et al*, 1979) to extremely high organic enrichment due to domestic and industrial discharges. Organic matter content of the seafloor sediments, exhibited a significant increasing trend ($p = > 0.10$). In the nearshore areas of less than 30 m depths, the average value which was 1.85% in 1977 rose to 2.77% in 1983. The increase was gradual with intermittent value of 2.12% recorded in 1981. Comparatively, though the organic enrichment in the offshore regions, above 30 m depth was observed, the increase was of low magnitude, ranging from 1.21% in 1977 to 1.58% in 1983. While the organic matter content of the sediments is an indication of the well-being of benthic organisms, values above 1.25% reflect on the deterioration of the environment (LIE 1968). Increasing trend in organic matter content has been observed (ANNON. 1975) to be correlated to the increasing organic inputs, in the Bombay harbour, especially in the post-1970 years. Recently, BHOSLE *et al*, (1983) observed very high lipid values in the nearshore marine environs of Bombay and have traced them to anthropogenic inputs, such as industrial effluents, municipal sewage and domestic waste dumping in the coastal areas.

Environmental and biological parameters, studied during the course of the present investigation, are essential to correlate the frequency of occurrence, faunal composition, distribution, association and community structure of benthic macroinvertebrates off Bombay. Animal and plant community responses, project the actual effect of the altered environment. Relative abundance and changes in spatial and temporal distribution, give very good indication of the magnitude of organic pollution. In the absence of detailed information about the responses of individual species to varying environmental stresses, it is speculative to assess the extent to which the benthic assemblages are affected by environmental perturbations. However, *prima facie*, the adverse impact on a macroscale level, is obvious.

Marine organisms, specifically the benthic fauna, can profitably be used as full time monitors, for recording the environmental stresses originating from pollution (THOMAS *et al*, 1976). Bottom fauna make better indicators of ecological conditions than plankton or nekton, because of their long life-histories and sedentary or sessile style of life. A slight change in their behaviour, physiology and pattern of distribution can be taken advantage of and used as a warning system, for a greater damage, in later years. This is of great significance in the management, protection and conservation of marine living resources.

Though water quality standards, for different types of aquatic ecosystems, are laid down by World Health Organization and National Water Pollution Control Boards, a system has still to be established for assessing the water quality, based strictly on biological

parameters. Nevertheless, it is well recognized (GAUFIN 1974; THOMAS *et al*, 1976) that a system to evaluate water quality based on the assessment of the biota, would reflect directly on the conditions, existing, therein. The advantages of biological monitoring, as compared to chemical and/or bacteriological analyses are that it directly reflects the effect of toxic substances on living organisms. When once established, it requires a simple biological examination of the sample for assessing and interpreting the water quality.

As it is well recognised (KETCHUM 1973), that the marine organisms integrate the overall effect of a combination of pollutants, and, hence, the damage that can be done to living organisms, by the discharge of complex waste, becomes comprehensible from studies on biological monitoring. Chemical analyses does not permit the assessment of impact of several environmental parameters, as a whole. While the chemical analysis gives the effect of a pollutant at the time of analysis, the biological analysis indicates the severity of impact, through a period of time. The manifestation of hazard may be recorded from a reduction in number of sensitive species; increase in the population density of the tolerant species; alteration in the physiology and behaviour of the organism or a change in the community structure. Elimination or decrease in the abundance of an organism or life stage might disturb the entire pattern of energy flow throughout the marine food chain. It is therefore essential to understand the interrelationship, among organisms and between organisms and their environment for evaluation of impact and for monitoring the subtle and secondary effects of marine pollution.

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