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# Environmental Conditions off Mumbai with Reference to Marine Fisheries

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**Abstract**

The coastal waters of Mumbai indiscriminately receive tremendous input of untreated domestic wastewater and industrial effluents Continuous environmental monitoring of the coastal and marine areas off Mumbai for the period 1996-2001 showed spatial and temporal variations based on seasonal and tidal fluctuations. The DO in the creeks frequently recorded nil values, particularly during low tide. Salinity was observed to be very low in the creek and nearshore areas during low tide and monsoon. The plankton and fishery showed a decline in their diversity and catch over the years. From the study area, 25 groups of zooplankton were recorded. Experimental fishing revealed the presence of 96 species of marine living resources representing seaweeds, corals, gorgonids, echinoderms, crustaceans, molluscs, pelagic & demersal fishes and other groups. Microbiological studies indicated fluctuations during premonsoon, monsoon and postmonsoon periods particularly in total coliforms, faecal coliforms and faecal streptococci that indicate faecal contamination.

*Keywords: aquatic environment, Mumbai coast, fisheries*

## Introduction

Rapid urbanization and industrial developments over the years have drastically changed the coastal marine environment of Mumbai, the second most populist city in the world, particularly due to the indiscriminate discharge of partially treated and untreated domestic sewage and industrial effluents. The coastal flora and fauna have also suffered the effects of pollution with changes in its ecological niche and biodiversity.

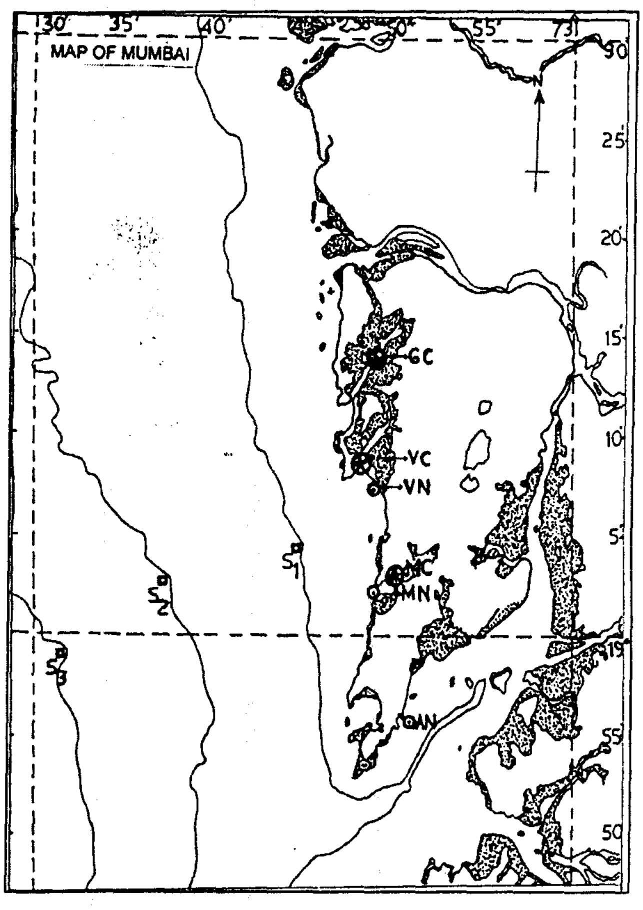
The present study highlights the environmental conditions along the coast of Mumbai for the period 1996 to 2001 with special emphasis on the coastal marine environment in relation to pollution and fisheries.

## Materials and Methods

A total of nine stations along the coast of Mumbai (Fig.1) were included in the study. Water samples were collected both during the flood and the ebb tides for the study of physico-chemical (sea surface temperature, pH, dissolved oxygen, salinity, phosphate, silicate, nitrite and nitrate as per standard methods (APHA, 1992; Parsons *et al.* 1984) and biological parameters (zooplankton by using plankton net of mesh 0.33 mm, total plate count, faecal coliforms, total coliforms and faecal streptococci as per Malik (1992). Synoptic experimental fishing was conducted onboard M.F.V. Narmada in the year 2001 to study the fishery of the area.

Resultant values for different parameters were averaged monthly and tabulated for pre-monsoon, monsoon and post-monsoon seasons separately for the flood and the ebb tides.

Fig. 1 Map of India




GC, Gorai Creek; VC, Versova Creek; VN, Versova Nerashore; MC, Mahim Creek; AN, Apolo Bander Near shore

**Results and Discussion**

Average sea surface temperature (SST) during the period of study (Fig. 2) for the creek stations varied between 28.6 and 29.4 °C during the flood tide while during the ebb tide, it varied from 27.4 to 29.7 °C. SST range during the period was found to vary between 20 °C (Gorai Creek, January 2002-the flood) and 33.5 °C (Versova creek, May 2001-the flood). In the nearshore stations the average SST varied from 28.4 to 29.5 °C during the flood tide and 27.9 to 29.5 °C during the ebb tide. The minimum SST was observed to be 21.0 °C (Versova nearshore, January 2002 –the flood) while maximum was observed to be 33.5 °C (Versova nearshore, May 1997-the ebb). In the openshore stations, average temperature varied from 26.25 to 31.50 °C.

The variations in SST are in correspondence to the normal atmospheric temperatures for winter and summer months respectively at Mumbai. The wider range of SST values in the creek and nearshore areas compared to the openshore values is due to the influx of domestic wastewater and surface runoff from the adjacent land mass.

The average pH values in the creeks varied from 7.5 to 7.7 during the flood tide while during the the ebb tide, these observations ranged from 6.9 to 7.6. Similarly in the nearshore stations also, lower averages were recorded ranging from 7.4 to 7.7 during the flood and the ebb tides. In the openshore stations pH was frequently around 8.0 with a maximum value of 8.4. Seasonal variations in the pH are illustrated in the chart (Fig. 3).

The normal pH of oceanic waters is maintained by the carbonate system at around 8.0 (±0.2) (Singh and Raje, 1998) but comparatively lower average values in the creek and nearshore areas indicate the extent of pollution in these areas. However, the openshore pH indicated comparatively cleaner waters.

Average salinity values in the creeks varied from 7.90 to 33.34 ppt. The lower salinity values were observed in the month of July and August due to the heavy rains in the monsoon months. In the same manner, the nearshore salinity varied from 18.57 to 34.09 ppt. At Mahim, both in the nearshore and creek, very low salinity values were observed. These can be attributed to the direct influx of domestic sewage in the region. In the openshore stations average salinity varied from 27.98 to 39 ppt (Fig. 4).

As per the receiving seawater standards in India, DO for the SW-II (Fishery and Non-contact Recreation) should be 4.0 mg $l^{-1}$ (Anon, 1993). During the period of study, DO was frequently observed to be nil in the Versova and Mahim creeks. The average DO values varied from 0.87 to 2.75 mg $l^{-1}$ during the flood tide and 0.41 to 1.44 ml $l^{-1}$ during the ebb tide. Frequent absence of the DO in creek stations coupled with the load of other pollutants creates deleterious environment making it unsuitable for marine organisms (Singh and Raje, *op.cit.*). The lower DO values could be mainly because of additional oxygen demand by the suspended load brought in by the organic waste transported by runoff and effluent discharge. Average DO content in the nearshore stations varied between 2.3 and 3.58 ml $l^{-1}$ during the flood tide to 2.18 - 3.5 ml $l^{-1}$ during the ebb tide. Occasional instances of DO being nil at Mahim nearshore can be ascribed to the increase in oxygen demand by the sewage discharge into the system. In the openshore stations average DO values ranged from 3.86 to 6.26 ml $l^{-1}$ during the flood tide and 3.68 - 5.68 ml $l^{-1}$ during the ebb tide. The openshore DO value compared well with the normal values. Seasonal variations in the DO are illustrated in Fig. 5.

Inorganic nutrients such as phosphates, silicates and nitrates play a significant role in maintaining the fertility of an ecosystem. Silicates are generally abundant in the marine ecosystem and are rarely considered as a limiting factor in marine productivity. Average silicate values in the creeks ranged between 31.817 and 102.602 µg at $l^{-1}$ during the flood tide and the ebb tide values varied from 30.067 to 93.563 µg at $l^{-1}$. The lowest observed was 1.390 µg at $l^{-1}$ while the highest one was 203.640 µg at $l^{-1}$. In two instances, during September 1997 and February 2000, silicates have been observed to be below the detectable limit in the Versova Creek. In the nearshore stations average silicate values ranged from 2.030 to 116.304 µg at $l^{-1}$. In two instances, silicates were observed to be non-detectable (Versova nearshore and Apollobunder nearshore in June 1998). In the openshore stations, silicates varied from 3.33 to 31.39 µg at $l^{-1}$ during the flood tide while during the ebb tide, it varied from nil to 21.49 µg at $l^{-1}$ (Fig. 6).

Average phosphate values in the creeks varied between 5.403 and 32.091 µg at $l^{-1}$ during the flood and 5.617 to 23.935 µg at $l^{-1}$ during the ebb tides. The minimum value observed was 0.810 µg at $l^{-1}$ and the maximum was 56.190 µg at $l^{-1}$. In the nearshore stations, phosphate values varied from 1.360 to 12.965 µg at $l^{-1}$ in the flood tide and 1.562 to 10.882 µg at $l^{-1}$ during the ebb tide. The minimum phosphate value recorded in the nearshore stations was nil while maximum was 78.650 µg at $l^{-1}$. The abnormally high values are associated with the domestic and industrial wastewater inputs particularly at Versova Creek,

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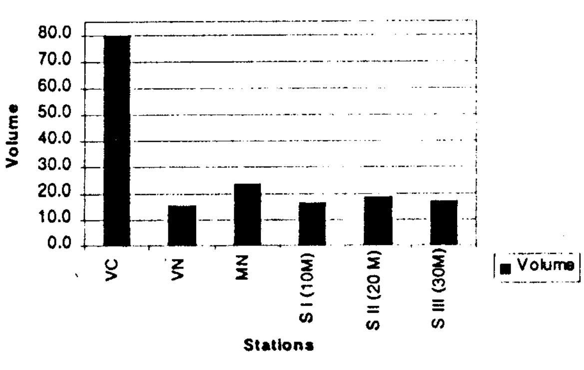
Mahim Creek, Versova Nearshore and Mahim Nearshore. In the openshore stations phosphates ranged from 0.15 to 1.88 μg at $l^{-1}$ during the flood tide and 0.52 to 2.77 μg at $l^{-1}$ during the ebb tide (Fig. 7).

Average nitrate values in the creek ranged between 0.36 and 16.33 μg at $l^{-1}$ during the flood tide and 1.00 to 12.64 μg at $l^{-1}$ during the ebb tide. The minimum nitrate value observed was nil and maximum was 61.936 μg at $l^{-1}$. In the nearshore stations average nitrate values varied from 0.353 to 24.488 μg at $l^{-1}$ during the flood tide and 1.894 to 16.655 μg at $l^{-1}$ during the ebb tide with the range varying from nil to 51.764 μg at $l^{-1}$. High levels of nitrate must have resulted from the mineralization of nitrogenous compounds present in sewage and industrial wastewaters from fertilizer complexes containing high levels of nitrates. In the openshore stations, nitrate values varied from nil to 5.14 μg at $l^{-1}$ during the floodtide and nil to 5.61 μg at $l^{-1}$ during the ebb tide (Fig. 8). Nitrite levels were mostly found to be very low (Fig. 9) during the study period. When compared with the reference values of the nutrients for the state of Maharashtra (Radhakrishna, 1989), it is found that waters around Mumbai are constantly being enriched from various anthropogenic sources. Present investigations are also confirmed by the Coastal Ocean Monitoring and Prediction Systems (Anon, 2001) indicating that coastal waters of Mumbai continue to be degraded with relatively high levels of nutrients.

Determination of Total Plate Count in water is a useful test in microbiological monitoring of water quality. Bacterial number gives an indication of the amount and type of organic matter present in water (WHO, 1970). Geldreich (1970) stated that human health hazards from waterborne pathogens exist in any faecally contaminated water. However, risks increase substantially when faecal coliforms are above 200 counts per 100 ml. The total coliform count is one of the most useful indicators of water pollution (Geldreich, 1972; Bagley and Seidler, 1977). The

Fig 10. **Zooplankton volume (ml/100m3) Feb'01-Jan'02**




finding of faecal streptococci is confirmatory evidence of faecal pollution (WHO, 1970). Microbiological observations in the creek stations revealed a very high load, particularly in the Versova and Mahim creeks. Faecal coliforms ranged from $7.3 \times 10^4$ to $2.0 \times 10^8$ c.f.u. / 100 ml, total coliforms ranged from $1.0 \times 10^5$ to $2.3 \times 10^8$ c.f.u. / 100 ml, faecal streptococci ranged from $1.5 \times 10^4$ to $3.7 \times 10^7$ c.f.u. / 100 ml. Total plate count values ranged from $2.24 \times 10^3$ to $9.52 \times 10^6$ c.f.u. / ml. In the nearshore stations faecal coliforms ranged from $2.3 \times 10^3$ to $2.0 \times 10^6$c.f.u. / 100 ml, total coliforms ranged from $4.0 \times 10^3$ to $1.2 \times 10^7$ c.f.u. / 100 ml, faecal streptococci ranged from $4.6 \times 10^{2}$ to $1.4 \times 10^6$ c.f.u. / 100 ml. Total plate count values ranged from $1.68 \times 10^3$ to $1.17 \times 10^7$ c.f.u. / ml. In the openshore stations total plate count values ranged from $3.0 \times 10^2$ to $5.27 \times 10^4$ c.f.u. / ml. Zooplankton volume was measured from the six selected stations. In the creek station it varied from 7.127 to 233.348 ml / 100 $m^3$, in the nearshore stations it varied from 1.23 to 76.145 ml / 100 $m^3$ while in the openshore stations it ranged from 2.935 to 90.422 ml/100 $m^3$ (Fig.10). In the Versova Creek, high biomass of zooplankton was frequently recorded with lower species diversity.

From the above account, it is evident that creek and nearshore waters off Mumbai show progressively deteriorating and non-conducive environmental conditions. COMAPS (Anon, 1994) identified Mahim and Versova creeks as the hotspots. The adjacent openshore fishing grounds are relatively cleaner. Results of experimental fishing have revealed the presence of 96 species of marine living resources.

Recently, two marine outfalls have started functioning at Worli and Bandra. With the commissioning of these outfalls, the effect of pollution is going to be dissipated into a larger marine area that incidentally is a rich fishing ground. Hence, a closer and continuous monitoring is required to develop long-term environmental use models for formulating suitable corrective measures through integrated efforts.

Substantiating the widespread pollution around Mumbai and its lethal effects on the aquatic fauna, the media and researchers have frequently reported recurring incidences of fish mortalities. The exigency for an appropriate strategy to combat the ill effects of increasing pollution off Mumbai is the need of the hour and requires to be implemented by involving all stakeholders, policymakers and planners. This is possible through the development of a balanced Coastal Zone Management Plan.

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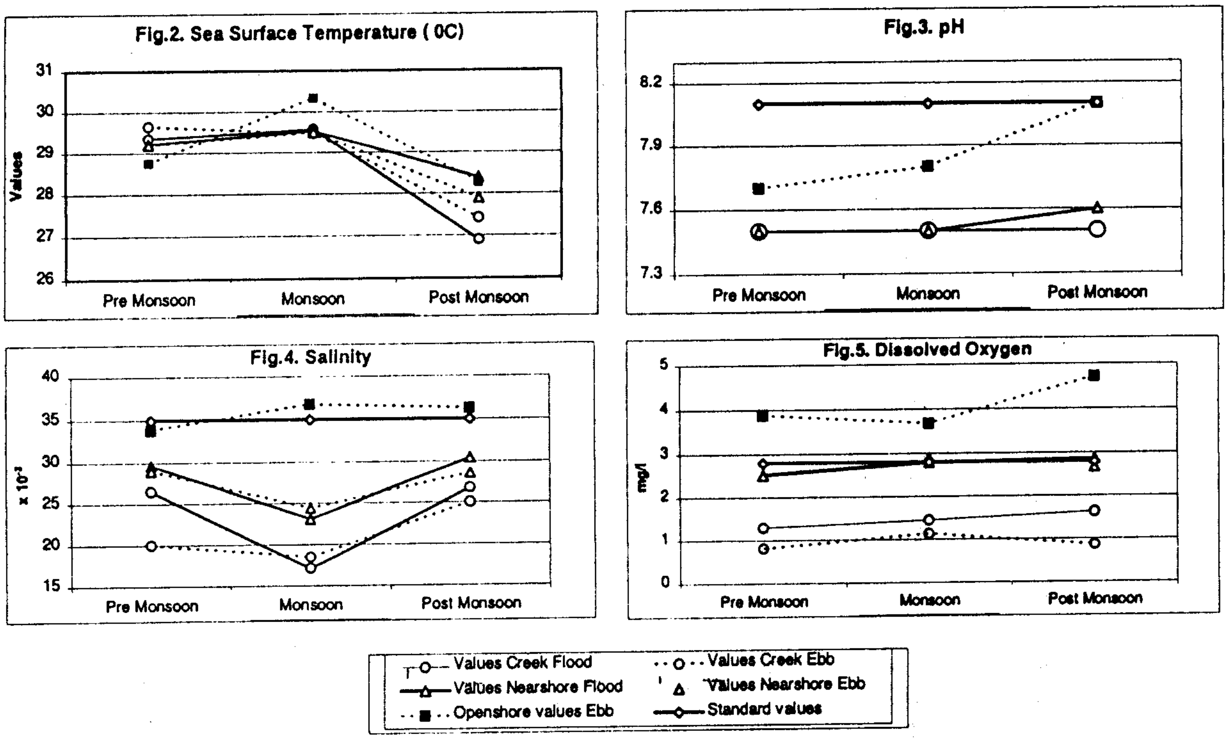
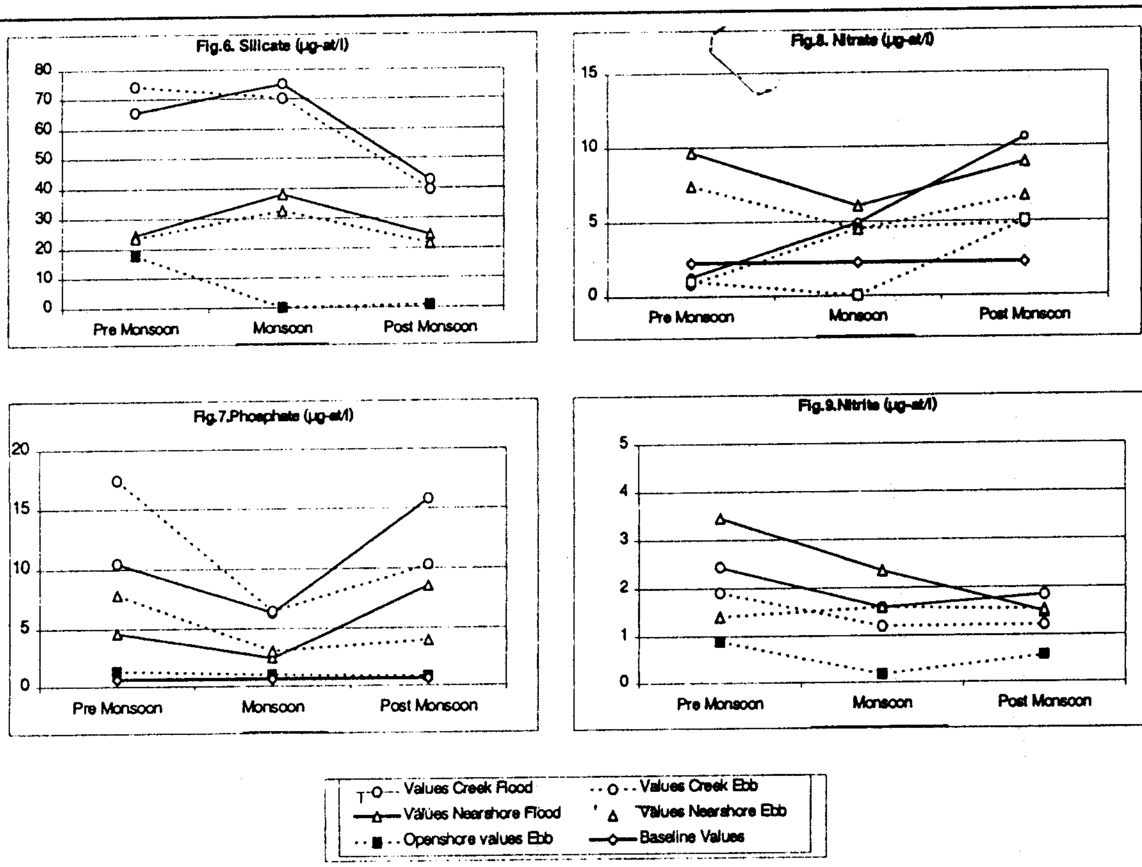



**Variations In Environmental Parameters off Mumbai ( 1996 - 2001)**




VARIATIONS IN NUTRIENTS OFF MUMBAI (1996-2001)

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