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MACROBENTHOS OF INTERTIDAL ZONE OF VERSOVA ALONG THE COAST OF MUMBAI

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ABSTRACT

To assess the biodiversity of macrobenthos in the changing environment along the coast of Mumbai, the intertidal zone of Versova was identified. The water quality in this intertidal region was poor with low pH, salinity and dissolved oxygen, and high nitrite, nitrate, phosphate and ammonia. The substratum was sandy with 1.29% organic matter in it. Mean faunal density of 2257 no./m^2 was recorded during the study which was mainly contributed by polychaetes (83.5%) followed by amphipods (14.5%), while other groups represented were isopods, crabs, hermit crabs, unidentified decapods, pelecypods and gastropods. Average biomass of 34.83 g/m^2 (93.7%) was contributed by polychaetes. Shannon and Wiener Index (0.4107) indicated heavy pollution in the intertidal area of Versova.

Key words: Macrobenthos, intertidal, density, biomass, pollution, Shannon and Wiener index

INTRODUCTION

The intertidal areas of Mumbai have been polluted due to the discharge of industrial waste and sewage. Pollution of the intertidal areas of Mumbai has resulted in the loss of biodiversity from the coastal areas. Some of the localities have become completely barren. Benthic organisms are the most disturbed group among the affected fauna of the intertidal area. Versova Creek and the intertidal area along the Versova Village are the examples of such affected areas. This small creek with an aproximate area of 1.36 km^2 receives sewage (131,000,000 l/d) and industrial wastes (600,000 l/d) from the adjacent areas.

The production potential of demersal fishery of the near-shore region is dependent on the production of benthos of the region. To assess this production potential of macrobenthos, a large number of investigations on fauna have been carried out at different intertidal areas of Mumbai (Varshney, 1982; Padmakumar, 1983; Dwivedi and Varshney, 1986; Jaiswar, 1999). However, information on the

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intertidal fauna of Versova Creek is scanty (Sreeramamurthy, 1980). Therefore, the present study on the intertidal macrobenthos of Versova in the prevailing environmental conditions was taken up.

MATERIAL AND METHODS

Study Area

Versova Creek is the mouth of the Malad Creek in the northwest part of Mumbai. It opens into the Arabian Sea in south. At the northern extremity, it has a dense forest of mangroves, which has been continuously destroyed and reclaimed. The common mangrove species reported is *Avecinea marina*. Versova beach is sandy and partially protected by the Madh Island, which is northward of Versova opposite to Malad.

Three sampling stations were identified and fixed in the intertidal zone in the upper littoral, mid littoral and lower littoral zones in a transect (Stephenson, 1953). The sampling for environmental and biological parameters was done during spring low tide of every month from September 2001 to February 2002. The environmental parameters included air and water temperatures, pH, alkalinity, chloride, salinity, dissolved oxygen, free CO_2, ammonia, nitrite, nitrate, phosphate, organic matter, iron, and manganese in water. Sediment was differentiated into sand, silt and clay using sieves of different mesh sizes (Holme and McIntyre, 1984). The water and sediment samples were analyzed following the method of Strickland and Parsons (1968). The analysis of benthic samples was done following the method of Holme and McIntyre (1984). For the estimation of density and biomass, sediment from 0.1-m^2 area was collected in replicates from each zone, and was sieved with 0.5-mm mesh sieve and preserved with rose Bengal solution for identification and analysis in the laboratory. The benthic population in the 0.1-m^2 area was considered to assess the density and biomass. Averages of ten random samples of benthos each from 1-m^2 area at marked stations of the fixed transect were computed. For biomass estimation, benthic animals found in 1-m^2 area were weighed.

To correlate the distribution and abundance patterns with pollution in different months, Shannon and Wiener index was calculated by the formula:

$$H' = \sum_{i=1}^{S} \ln Pi \ln$$

where, H' = diversity index, S = total number of species in the community sample and Pi = proportion of i^{th} species in the community sample.

RESULTS

The results of environmental parameters studied for Versova are presented in Table 1.

Temperature

Both air and water temperatures recorded at Verosva varied form 22.0 to 32.5^{O}C and from 19.5 to 29.0 ^{O}C, respectively. The highest air (32.5^{O}C) and water (29.0^{O}C) temperatures were recorded

Table 1: Environmental parameters of Versova intertidal area

Parameter	Sep. 2001	Oct. 2001	Nov. 2001	Dec. 2001	Jan. 2002	Feb. 2002	Average	sd
Air temperature (^{O}C)	25.00	32.50	29.00	29.00	22.00	22.00	26.58	4.27
Water temperature (^{O}C)	25.00	29.00	28.00	27.00	19.50	21.00	24.91	3.80
pH	7.40	7.40	8.00	8.10	8.20	8.20	-	0.038
Alkalinity (mg/l)	140.00	152.00	160.00	163.00	167.00	170.00	158.60	11.50
Chlorides (mg/l)	16285.00	17914.00	17914.00	18457.00	18728.00	19000.00	18049.70	967.47
Salinity (‰)	30.00	33.00	33.00	34.00	34.20	35.00	33.20	1.74
Dissolved oxygen (mg/l)	4.00	4.00	4.60	4.40	4.20	4.20	4.20	0.23
Free CO_2 (mg/l)	8.00	5.00	4.00	4.20	4.50	4.60	5.00	1.40
NH_3-N (mg/l)	0.80	0.83	0.85	0.87	0.89	0.90	0.85	0.03
NO_2-N (mg/l)	0.86	0.87	0.85	0.86	0.88	0.90	0.87	0.01
NO_3-N (mg/l)	1.38	1.40	1.43	1.45	1.47	1.47	1.43	0.03
PO_4-P (mg/l)	0.12	0.12	0.13	0.14	0.15	0.15	0.13	0.03
Organic matter (mg/l)	78.00	80.00	82.00	84.00	87.00	87.50	83.08	3.80
Iron (mg/l)	0.023	0.023	0.024	0.025	0.025	0.025	0.024	—
Manganese (mg/l)	0.012	0.012	0.012	0.012	0.012	0.012	0.012	—

in the month of October 2001, while the lowest was recorded in the month of January 2002. The average air and water temperatures for the six months were 26.58 and 24.91°C, respectively.

pH

The pH values varied form 7.4 to 8.2. The maximum pH (8.2) was recorded in January and February 2002, and the lowest pH (7.4) was observed in September and October 2001. It was also noticed that pH increased gradually from October to February.

Alkalinity

The alkalinity ranged from 140 to 170 mg/l. The alkalinity gradually increased from September to February and the maximum alkalinity (170 mg/l) was recorded in February. The average alkalinity for the six months was 158.6 mg/l.

Salinity

The salinity varied within the range of 30 to 35‰. The maximum salinity was noticed in February 2001 and the lowest one was recorded in September 2001. The average salinity for the six months was 33.2‰.

Dissolved Oxygen

The dissolved oxygen content ranged form 4.0 to 4.6 mg/l. The average dissolved oxygen content for the entire period was 4.2 mg/l. The highest value (4.6 mg/l) was observed in November 2001 while the lowest dissolved oxygen content (4 mg/l) was recorded in September and October 2001.

Free Carbon Dioxide

The free carbon dioxide ranged between of 8.0 mg/l in September 2001 to 4.0 mg/l in November 2001. The average value was 5.05 mg/l for the entire period.

Ammonia-Nitrogen

The ammonia-nitrogen ranged from 0.80 to 0.90 mg/l and the average value for the entire period was 0.85 mg/l. The ammonia-nitrogen content gradually increased from September to February and the highest value was observed in February 2002.

Nitrite-Nitrogen

The values of nitrite-nitrogen varied within a narrow range of 0.85 mg/l in November 2001 to 0.90 mg/l in February 2002 and the average value for the entire period was 0.87 mg/l.

Nitrate-Nitrogen

The nitrate-nitrogen contents varied from 1.38 mg/l in September 2001 to 1.47 mg/l in February 2002. The nitrate content increased gradually from September 2001 to February 2002. The average nitrate-nitrogen content for the six months was 1.43 mg/l.

Inorganic Phosphorous

The inorganic phosphate-phosphorus content was poor. The values varied from

0.12 to 0.15 mg/l. The average value of phosphate-phosphorus during the course of study was 0.13 mg/l.

Organic Matter in Water

An increasing trend in the organic matter from September 2001 (78.0 mg/l) to February 2002 (87.5 mg/l) was seen. The average value of organic matter in water for six months was 83.08 mg/l.

Iron and Manganese

The iron content ranged between 0.023 and 0.025 mg/l. However, manganese remained constant (0.012 mg/l) throughout the study period.

Sediment

The sediment at Versova beach was basically sandy in nature as it comprised 98.5% sand, 1.0% silt and 0.5% clay. Analysis of the sediment revealed 0.75% organic carbon, 1.29% total organic matter, 0.0075% total nitrogen and pH 7.5.

Population Density

A general pattern of density distribution was observed where low density occurred at upper littoral level, and higher values in mid and lower littoral levels. The highest population density of macrobenthos was observed at mid littoral (6900 no./m^2) in the month of February 2002, chiefly contributed by polychaetes. The monthly average population density varied from 837 no./m^2 in January to 4720 no./m^2 in February (Table 2).

Table 2: Population density (no./m^2) of intertidal macrobenthic organisms at Versova

Taxon/Group	Sep. 2001			Oct. 2001			Nov. 2001			Dec. 2001			Jan. 2002			Feb. 2002		
	UL	ML	LL	UL	ML	LL	UL	ML	LL	UL	ML	LL	UL	ML	LL	UL	ML	LL
Polychaetes	750	1860	3420	890	1210	950	170	950	5110	260	270	1790	170	1720	520	250	6900	6750
Amphipods	—	1920	30	—	290	80	—	50	390	—	10	3090	50	20	—	—	—	—
Isopodes	—	—	—	—	—	—	—	—	—	—	—	210	—	—	—	—	—	—
Crabs	—	10	—	—	—	—	—	—	10	—	—	—	—	—	—	—	—	10
Pelecypods	—	—	—	30	—	30	—	10	—	140	10	10	-	—	—	120	—	130
Gastropods	—	—	10	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unidentified decapods	—	—	—	—	—	—	—	—	—	—	—	—	30	—	—	—	—	—
Total	750	3790	3460	920	1500	1060	170	1010	5510	400	290	5100	250	1740	520	370	6900	6890
Average density		2667			1160			2230			1930			837			4720	

Faunal Composition

The benthic fauna of Versova beach was mainly constituted by polychaetes, amphipods, isopods, crabs, hermit crabs, pelceypods and gastropods. Polychaeta was the dominant group contributing 83.5% to the total population chiefly constituted by *Lumbrinereis hartmani* (Lumbrinereidae) and *Nephthys* sp. (Nephthydae). Amphipoda was the second dominant group, which contributed 14.5% to the total. Isopods, crabs, hermit crabs, pelecypods, gastropods (*Natica lineata*) and decapods were occasionally represented.

Biomass

The average monthly biomass (wet weight) recorded was 23.63 g/m^2 in September, 12.29 g/m^2 in October, 28.30 g/m^2 in November, 29.98 g/m^2 in December, 28.05 g/m^2 in January and 86.46 g/m^2 in February (Table 3). Higher values of biomass were recorded from mid (0.154-118.160 g/m^2) and lower (2.499-124.936 g/m^2) littoral regions, while low values of were recorded from upper littoral zone (1.516-26.840 g/m^2). Polychaetes alone contributed 93.78% of the total biomass for the entire period followed by pelecypods (5.00%), decapods (0.47%) and amphipods (0.26%).

Shannon and Wiener diversity index calculated during the study period varied from 0.094 in February 2002 to 0.920 in December 2001 with an average of 0.4107 for entire period (Table 4).

Table 3: Biomass (g/m^2 wet weight) of intertidal macrobenthic organisms at Versova

Group/Taxon	Sep. 2001			Oct. 2001			Nov. 2001			Dec. 2001			Jan. 2002			Feb. 2002		
	UL	ML	LL	UL	ML	LL	UL	ML	LL	UL	ML	LL	UL	ML	LL	UL	ML	LL
Polychaetes	3.803	63.705	1.806	0.481	0.653	32.537	5.822	32.537	45.133	17.180	0.146	61.307	5.082	58.190	17.810	8.0156	118.160	115.593
Amphipods	—	0.518	0.003	—	0.078	0.002	—	0.014	0.0105	—	0.003	0.856	0.014	0.055	—	—	—	—
Isopodes	—	—	—	—	—	—	—	—	—	—	—	0.116	—	—	—	—	—	—
Crabs	—	0.370	—	—	—	—	—	—	0.690	—	—	—	—	—	—	—	—	0.373
Pelecypods	—	—	—	1.035	—	2.070	—	0.690	—	9.660	0.005	0.690	—	—	—	8.280	—	8.970
Gastropods	—	—	0.690	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unidentified decapods	—	—	—	—	—	—	—	—	—	—	—	—	3.000	—	—	—	—	—
Total	3.803	64.593	2.499	1.516	0.731	34.609	5.822	33.241	45.834	26.840	0.154	62.969	8.096	58.245	17.810	16.295	118.160	124.936
Average biomass		23.63			12.29			28.30			29.98			28.05			86.46	

Table 4: Monthly Shannon and Wiener index at Versova

Month	Diversity
September 2001	0.573
October 2001	0.423
November 2001	0.264
December 2001	0.920
January 2002	0.190
February 2002	0.094

DISCUSSION

The lower values of pH, alkalinity, salinity, ammonia, nitrite and nitrate observed in September may be due to the land run off during monsoon, and the higher values thereafter may be due to the precipitation during post monsoon. Similar results have been observed by earlier workers (Varshney, 1982; Varshney *et al.*, 1988; Anandan, 2002) for Mumai waters. Sediment was sandy in nature, *i.e.*, it contained 98.50% of sand with very low (0.75%) organic carbon and 1.29% total organic matter. This type of result was also recorded by Damodaran (1973). The water quality at Versova was unhealthy as compared to that at Seven Bungalows (Anandan, 2002). The reason may be due to the separation of the Seven Bungalows beach by about 1km from the creek mouth. Versova beach being linked to the creek receives concentrated pollutants directly discharged into the creek. This results in high concentrations of nutrients, comparatively lower salinity and low dissolved oxygen.

Low population density and biomass were recorded at the upper littoral zone during the present study. Anandan (2002) also observed similar results for Seven Bungalows, Versova, Madh Island and Gorai Creek. It is the general pattern of distribution of organisms in the intertidal area (Jaiswar, 1999) and polychaetes dominate in the benthos of the coastal regions (Varshney, 1982). In the present study also, they were the dominant group contributing 83.5% to the total population. The important species reported to contribute were *L. hartmani* and *Nephthys* sp. The second dominant group was amphipods followed by isopods, crabs, hermit crabs other decapods, pelecypods and gastropods. Pelecypoda was represented by *Donax* sp., while *Natica lineata* represented Gastropoda. These species were also reported from the adjacent Seven Bungalows beach (Anandan, 2002). The low population density and biomass at the Versova intertidal area may primarily be due to the pollution stress and secondarily due to the sandy substratum. Damodaran (1973) and Varshney (1982) also linked the preference of organisms with sediment composition.

Coefficients of correlation (r) calculated to determine the dependence of biomass production on the organic matter content of sediment and the salinity of the overlying water were found to be 0.657 and 0.680, respectively. These values indicate that 66% of biomass production is influenced by the organic matter deposited in the intertidal area and 68% of biomass production is influenced by salinity of overlying water. Sreeramamurthy (1980) also found a high correlation between these two parameters.

Generally, Shannon and Wiener

diversity index of 3.0-4.5 indicates slight, 2.0-3.0 light, 1.0-2.0 moderate and 0.0-1.0 heavy pollution of water (Staub *et al.*, 1970). During the present study, it varied from 0.094 to 0.920, which revealed heavy pollution in the intertidal area of Versova. A community dominated by relatively few species would indicate environmental stress (Plafkin *et al.,* 1989) that gives very low diversity indices for the particular water body. Community becomes more dissimilar as stress increases and accordingly, species diversity decreases with decreasing water quality. From the study, it is confirmed that the Versova intertidal area is highly polluted and therefore, appropriate measures should be taken to check the increasing levels of pollution.

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