

Macrobenthic communities of the coastal waters of Dabhol, west coast of India

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Macrobenthic community of a shallow subtidal (5-20 m) muddy deposit off Dabhol was investigated. Sediment comprised mainly of silt and clay with less of sand. Dominance of clayey-silt fraction reflects on active flocculation of fine grain particles. The sediment organic carbon with a mean value of 1.42% was rather high. The population density of macro-invertebrates varied from 250 to 600 no.m⁻² (mean=395±111) during December 1994. The values increased significantly during December 1996 and ranged between 400 and 975 no.m⁻² (mean = 621±194). Macrofaunal community comprised of typical near-shore species, numerically dominated by polychaetes. The sediment organic content reflects on the high biological productivity of the area, particularly benthic production that was evident from a good fish catch in the experimental bottom trawling. Values for species diversity followed more or less similar trends and less variability among the sampling stations in Dec.1994 and Dec. 1996. However, species composition indicated the dominance of different taxa among the sampling locations during two sampling years. The occurrence of juvenile forms of decapods (shrimps and crabs) in the benthic samples suggest that the coastal waters of Dabhol provide favourable environmental conditions for feeding and breeding of commercially important prawn and crab species.

Subtidal macrobenthic communities of the central Maharashtra, west coast of India (between lat. 15° 30' to 18° 00' N; long. 72° 30' to 73° 30' E) have not been studied in detail as compared to other areas along the west coast of India. Opening of many small and big rivers makes the coastal belt of Maharashtra a unique biological habitat. A number of coastal areas show a high marine biodiversity and are unique with regards to the flora and fauna of Maharashtra^{1,2}. However, some of the coastal areas such as Dahanu - Vadhavan, Culaba-Alibag and Dabhol-Ratnagiri have been exposed to a rapid industrialization resulting into severe environmental degradation and due to persistent pollution. The backwaters and mangroves of Dabhol coast are very productive and contribute substantially to the fishery production of the region¹. The coastal zone of Dabhol has been undergoing major changes due to coastal development especially in connection with the building of a super power plant (Dabhol Power Company) and therefore, it is necessary to assess and evaluate the benthic community, an important biological component in order to create a baseline for predicting the magnitude of environmental impact in the near future.

In the light of an Environmental Impact Assessment study an investigation was carried out to evaluate the macrobenthic community and the relevant

sediment parameters in an area along the Dabhol coast, which has been proposed for harbour development for the power plant.

Materials and Methods

The study area is a marginal marine biotope, characterized by an estuarine delta and a shallow bay. Such habitats are continuously influenced by changes in salinity due to freshwater discharge, temperature fluctuations characterizing shallow coastal ecosystems, high-suspended load, high deposition of organic matter and high biological productivity. Dabhol port (Fig.1) is approximately 170 km south of Mumbai (Bombay). Western Ghats bound the coastal segment in this region in the east and Arabian Sea in the west. A number of headlands and cliffs intersect the coast. Shoals and sandbars are present at the mouth of the Vashishti River and they show a seasonal shift³. The river Vashishti joins the Arabian Sea at Dabhol, forming the Dabhol creek system. A long sandy beach is present near Guhagar about 7 km south of the Vashishti river confluence with the Arabian Sea. Tidal flats are also present at a few places. The nearshore is relatively shallow and close to the river mouth. Dabhol Power Company (DPC) has set up a Natural Gas based power project at Dabhol and a service jetty has been constructed at the river mouth.

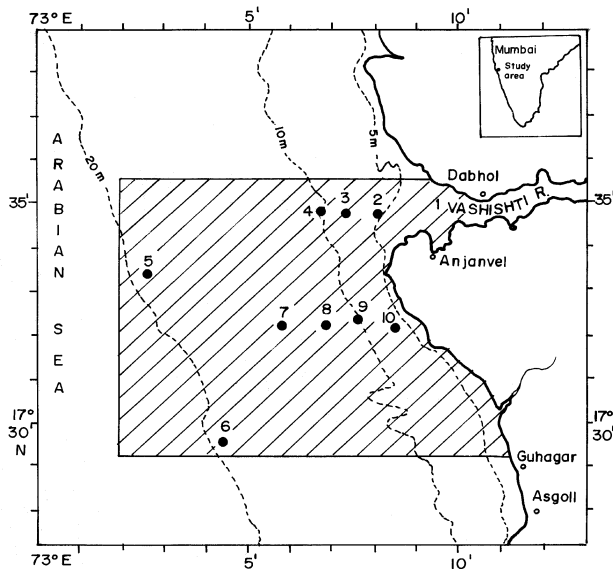


Fig. 1—Location of the sampling stations

The Vashishti River near Anjanvel and the sub-tidal area, south of the river mouth was selected for the present investigation. The wave climate in the area is characterized by the prevailing three seasons viz., southwest monsoon (June-September), postmonsoon (October-January) and the fair weather period (pre-monsoon: February-May). The southwest monsoon with an average precipitation of 2500 mm rainfall and strong winds is the most severe season of the year in this region.

Sediment samples for benthos were collected using a van Veen grab, covering an area of 0.04 m² and penetration of 10 cm. Sediment samples were collected from ten stations in Dec.1994 located in the three depth zones viz.: 5,10 and 20-meters (Fig. 1), while sediment samples in Dec. 1996 were collected only from seven stations. Minimum three grabs were taken at each station. The samples were washed through a 0.5 mm mesh sieve and preserved in 10% seawater formalin-Rose Bengal solution. The samples were again washed through 0.5 mm mesh in running water in the laboratory to clear adhering sediments. All organisms were sorted into major groups and preserved in 90% alcohol for further identification. Subsequently specimens were identified and counted group-wise. For some specimens for which species level identification could not be done, were put under a generic group. All unidentified species are referred by their generic/family names and are considered single taxonomic categories. Identification was based on the works by Fauvel⁴, Parulekar⁵, and Day⁶.

Macrofaunal species diversity (H') was measured by the Shannon-Weaver information function. Evenness (J) was calculated after Pielou⁷ and species richness (SR) was estimated⁸ by the function $s-1/\ln N$, where s is the number of species and N the total number of individuals in a sample. The Bray & Curtis⁹ similarity measure was used to produce the similarity matrix and the similarity percentage was used to determine the degree of similarity of the assemblages between the stations.

For sediment analysis, about 15-20 g (depending upon the fine material present) sediment was removed from each grab sample with 4.0 cm diameter core tube. The sediment was repeatedly washed in distilled water until all the chloride ions detectable with 4% silver nitrate were removed¹⁰. These samples were treated with 10% sodium hexametaphosphate and kept overnight for dispersion before being subjected to grain size analysis. The samples were sieved on 62- μ m (at 4 ϕ) screen. The finer fraction (down to 10 ϕ) was analysed by the pipette method¹⁰. The sediment types were expressed as percentage on dry weight basis. Sediment organic carbon was estimated by digesting a known amount of sediment sample in chromic acid and digested matter, which was titrated with ferrous ammonium sulphate using phenanthroline as an indicator¹¹.

Results

Sediment texture and organic matter content

With the exception of station 1, the sediment (Table 1) consists predominantly of fine-to-very fine particles at most of the sampling stations. The substratum at the near-shore station 1, located in the mouth of Vashishti River was of moderately sorted sand, whereas it was clayey in the proposed navigational channel area i.e., st. 4. In deeper waters (20 m) the sediment was of fine type with more clay content (sts. 5 and 6). The grain size of the sediment to be dredged (sts. 2-4) and the area where the sediment was to be deposited (sts. 5 and 6) was of a similar type having sand 1.92 \pm 2.34%; silt 74.36 \pm 6.1% and clay 23.71 \pm 7.40%. Sand fraction carried by the river is deposited at the mouth of the river (sts.1 and 2) and silt-clay is transported further seaward where it is deposited.

Organic carbon in the sediment varied from 0.40% (st. 2) to 2.92% (st.7) of dry weight of sample. Generally sandy sediments had low organic carbon values

whereas; silty sediments had relatively higher values (Table 1). Although no distinct distributional pattern was perceived in the organic carbon, sediment samples from sts. 4, 6 and 7 had relatively higher (>2.0%) content of organic carbon as compared to other stations.

Composition and abundance of macrofauna

Macrofauna comprised of Polychaeta, Amphipoda, Bivalvia, Oligochaeta and Gastropoda (Table 2). Although the macrofaunal composition did not show any major changes for both sampling periods, the percent occurrence of major faunal groups differs significantly

during both sampling. Nevertheless, Polychaeta was the most dominant group followed by Crustacea and Bivalvia. Polychaetes, mainly those belonging to the family Spionidae were dominant at all stations. The population density (no.m²) of macro-invertebrates varied from 250 to 600 (mean=395±111) during December 1994. The density values increased significantly (p<0.05) during December 1996 and ranged between 400 and 975 no.m² (mean = 621 ± 194). The maximum population density was observed at st.1, located at the mouth of river Vashishti in Dec. 1996. The sediment at this station was of a medium sand grain size, which supported a good benthic crop. A

Table 1 — Station-wise position, depth of each station and organic carbon of the sediment and results of grain size analysis.

St.no.	Depth (m)	Sediment texture			Sediment type	Org. C (%)
		Sand (%)	Silt (%)	Clay (%)		
1	3.0	89.90	9.25	0.85	Sand	0.72
2	5.0	99.73	0.16	0.09	Sand	0.40
3	6.0	7.11	76.61	16.28	Clayey - silt	1.80
4	9.0	0.42	80.77	18.81	Clayey - silt	2.16
5	20.0	2.69	84.54	12.77	Clayey - silt	0.50
6	20.0	2.92	74.51	22.57	Clayey - silt	2.44
7	14.0	0.22	68.48	31.31	Clayey - silt	2.92
8	12.0	1.06	73.75	25.19	Clayey - silt	0.58
9	10.0	0.35	66.60	33.05	Clayey - silt	0.55
10	6.0	0.62	69.67	29.70	Clayey - silt	2.13

Table 2 — Macrobenthic abundance (no. m⁻²) from the coastal waters off Dabhol

Taxon	Stations										Mean	%
	1	2	3	4	5	6	7	8	9	10		
December 1994												
Polychaeta	350	100	350	125	250	400	150	250	300	150	242.5	61.3
Amphipoda	-	75	25	75	25	-	50	100	-	150	50.0	12.6
Bivalvia	50	25	-	50	150	100	25	50	25	-	47.5	12.0
Oligochaeta	25	50	-	-	-	-	-	-	50	125	25.0	6.3
Gastropoda	-	-	-	25	125	25	-	-	-	-	17.5	4.4
Decapoda												
Cumacea	25	-	-	-	25	-	-	-	-	-	5.0	1.2
Shrimps	-	-	-	-	25	-	25	-	-	-	5.0	1.2
Nemertinea	25	-	-	-	-	-	-	-	-	-	2.5	0.6
Total density	475	250	375	275	600	525	250	400	375	425	395 ± 111	
December 1996												
Polychaeta	425	325	250	200	350	275	150	0	0	0	282.1	45.2
Oligochaeta	225	100	-	50	50	-	-	0	0	0	60.7	9.7
Bivalvia	50	150	-	50	50	200	50	0	0	0	78.5	12.6
Gastropoda	50	50	25	-	50	-	-	0	0	0	25.0	4.0
Amphipoda	100	-	100	50	-	50	100	0	0	0	57.1	9.1
Decapod larvae	75	50	50	50	100	100	50	0	0	0	67.8	10.9
Shrimps	-	-	50	-	50	50	50	0	0	0	28.5	4.5
Cumacea	50	50	-	-	50	-	-	0	0	0	21.4	3.4
Total density	975	725	475	400	700	675	400	0	0	0	621.4 ± 194.3	

total of 24 species were recorded of which 10 belonged to Polychaeta, 2 to Coelenterata and 3 to Crustacea (Table 3). The rest of the species belonged to Porifera, Aschelminthes, Mollusca, Echiurida and Brachiopoda.

Species diversity and similarity

Stations 1 and 3 were highest in terms of species diversity (H') and species richness (R) (Fig.2). Maximum H' value (3.75) was observed at st. 3 during Dec. 1996 and minimum (2.87) at st. 6 during Dec.1994. The values for species diversity were between 2.87 and 3.40 (mean = 3.32 ± 0.24 sd; $n=7$) during Dec.1994 and 3.12 and 3.76 (mean = 3.47 ± 0.26 sd; $n=7$) during Dec. 1996. However, the diversity, evenness and species richness differed between the sampling stations. The highest diversity (H') value was registered at st. 3 and highest evenness at sts. 2, 5 and 7. The values for species dominance (D) showed greater variation among the sampling stations as well as seasons (Fig. 2). Stations 1 and 6 showed maximum dominance. A nephthid polychaete species *Nephtys oligobranchia* was dominant in terms of density and was recorded at all the sampling stations.

Among others the spionid polychaete *Streblospio benedicti* and *Prionospio polybranchiata* were next in the order of dominance. The mollusc *Cavolina longirostris*, the coelenterates *Eudendrium* sp., *Gorgonia* sp., were present in moderate densities and showed a patchy distribution. Specimens of the edible bivalve *Perna viridis*, which normally occur on the rocky substratum, were collected from sts. 1 and 3. Since the beds of *P. viridis* were observed in the intertidal and subtidal rocky areas along the Dabhol coast (in the vicinity of sts.1 and 3), therefore the specimens of *P. viridis* found in the present collection could actually belonged to these subtidal mussel beds.

Discussion

The benthic macrofaunal community of the soft sediment off the Dabhol coast had moderate to high standing crop comparable with similar biotopes along the west coast of India^{1,2,12-15}. Comparative data on macrobenthos collected during postmonsoon seasons of Dec. 1994 and Dec. 1996 suggest the abundance of typical nearshore community dominated by polychaetes (Tables 3, 4).

Table 3-- Macrobenthic species (range and mean density no. m⁻²) collected from the subtidal waters of Dabhol during the present study

Species	Range	Mean	± SD
Phylum: PROTOZOA; Class: RHIZOPODA; <i>Polystomella</i> sp.	***	***	
Phylum: CNIDARIA; <i>Gorgonia</i> sp.	0-25	10.7	13.4
<i>Eudendrium</i> sp.	25-50	17.9	18.9
Phylum: ASCHELMINTHES; Class: Nematoda	100-300	178.6	69.9
Phylum: ANNELIDA; Class: Polychaeta;			
Family: Nephthyidae; <i>Nephtys oligobranchia</i>	25-150	64.3	45.3
Family: Spionidae; <i>Streblospio benedicti</i>	25-50	21.4	22.5
<i>Prionospio polybranchiata</i>	25-100	32.1	34.5
Family: Eunicidae; <i>Eunice savignyi</i> Grube	0-25	7.1	12.2
Family: Magelonidae; <i>Magelona rosea</i>	25-50	25.0	20.4
Family: Syllidae; <i>Syllis (Haplosyllis) spongicola</i> Grube	25-50	21.4	17.3
Family: Nereidae; <i>Nereis (Nereis) chilkaensis</i> Southern	25-100	67.9	31.3
Family: Goniadidae; <i>Goniada</i> sp.	25-100	28.6	36.6
Family: Maldanidae	25-50	32.1	12.2
Family: Pisionidae	0-25	7.1	12.2
Class: Oligochaeta	25-50	14.3	19.7
Phylum: ARTHROPODA Order: Stomatopoda, Family: Squillidae,			
<i>Squilla</i> sp.	25-50	21.4	17.3
Order: Cumacea; Family: Bodotriidae, <i>Cyclaspis</i> sp.	25-250	75.0	87.8
Order: Amphipoda; Family: Gammaridae; <i>Ischyrocerus</i> sp.	25-175	57.1	60.7
Phylum: MOLLUSCA, Class: Gastropoda; <i>Cavolina longirostris</i>	25-50	28.6	22.5
Unidentified gastropods	25-150	89.3	57.5
Class: Bivalvia, <i>Perna viridis</i> (L)	25-125	21.4	46.6
Phylum: ECHIURIDA	100-150	35.7	62.7
Phylum: BRACHIOPODA; Family Lingulidae; <i>Lingula anatine</i> (L)	25-100	21.4	36.6
Unidentified brachiopods	25-50	10.7	19.7

***: Brocken pieces.

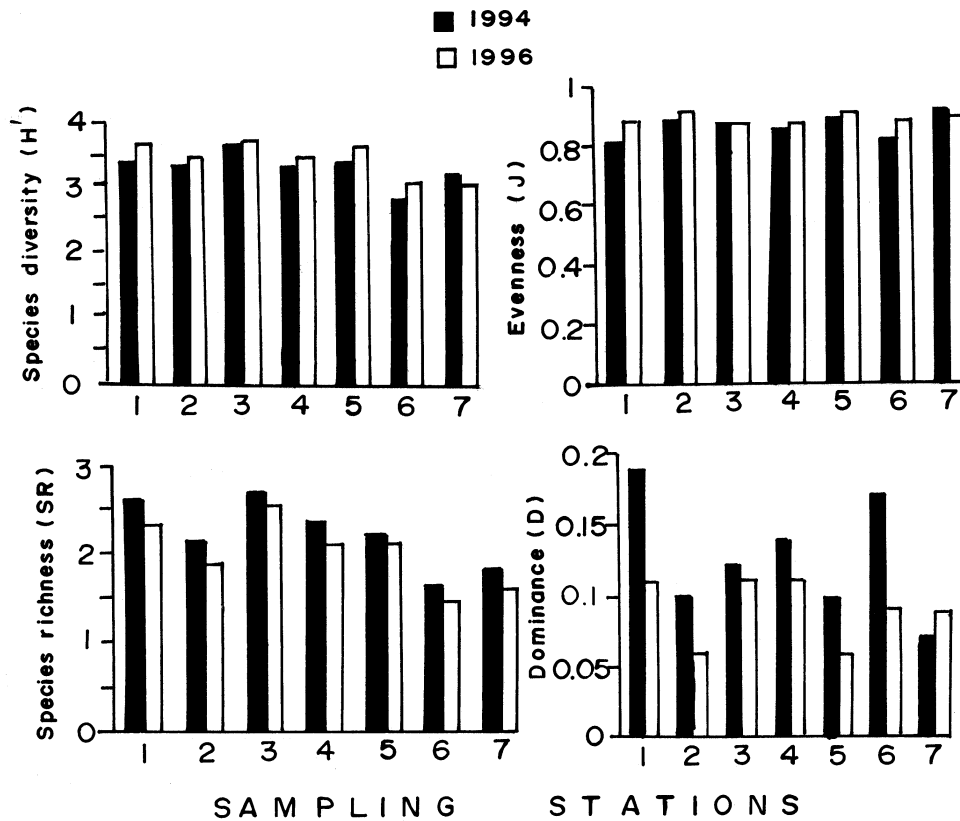


Fig. 2—Species diversity, evenness, richness and dominance of macrofauna during Dec. 1994 and Dec. 1996

Table 4—Comparison of benthic data collected from the near shore waters off Dabhol

Parameters	Dec.1994	Dec.1996
Study period	1 - 2 Dec.	6 Dec.
Sampling depth (m)	6 - 20	5 - 20
Sediment type	Clayey - silt	Clayey - silt
Organic carbon (yearly mean %)	2.13	2.45
Total number of groups	08	15
Total number of species	14	24
Mean macrofaunal density (no. m ²)	395±111	621.4 ± 194.3

Although the sampling stations were located in different areas they were similar to each other in terms of abundance of taxa, occurrence and species diversity (Fig.2). The seasonal changes over a period of two years within the macrobenthic community and the association between species were investigated using the percent similarity index. The dendrograms derived from the similarity coefficient calculated for the seven stations are shown in Fig. 3. Two major clusters A and B emerged, corresponding to the type of organisms recorded at those stations. Cluster A was found

to have an association of the order of 80-86 %. There was a deviation in cluster B during 1996, especially due to the st. 1, which showed similarity with sts. 5 and 6 during Dec. 1994 (Fig.3a). The abundance of deposit feeding polychaete species significantly reduced during Dec. 1996. This change was clearly reflected in the cluster B (Fig.3b) and could have been due to the benthic disturbance at st. 1 caused during jetty construction. In general, there was very close association between the offshore sts. 4 and 7 and in-shore st. 2 and this association persisted for two years (Fig. 3). Thus, the area studied could be divided into two different ecotopes viz., sts. 1 - 4 as estuarine habitats located near the mouth of the Vashishti River and sts. 5-10 as marine stations located away from the estuarine opening. This indicates that the macrobenthic assemblages from Dabhol coast consisted of very stable euryhaline communities, which can tolerate both estuarine as well as marine conditions.

The near-shore areas along the Dabhol-Guhagar coast are traditionally known for their rich fishing grounds^{2,3}. Among the environmental parameters temperature and salinity of the seawater are regarded

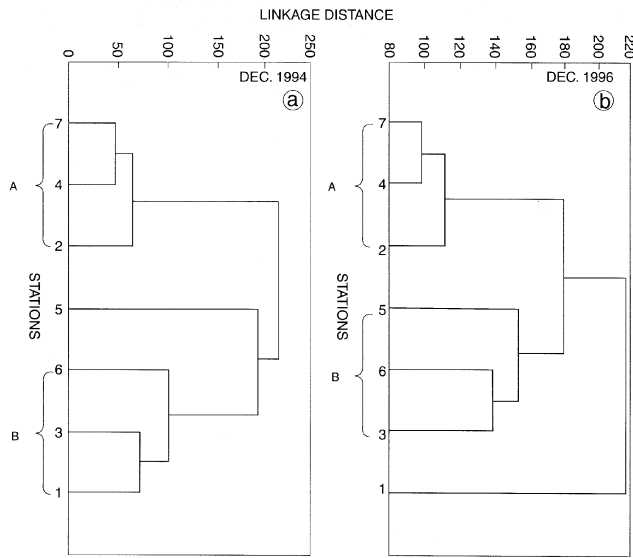


Fig. 3—Dendrogram showing the similarity between different sampling stations during Dec. 1994 (a) and Dec. 1996 (b)

as important regulators of the reproductive cycle of marine invertebrates^{16,17}. Marine species inhabiting the tropical region generally have a very narrow range of temperature tolerance since they normally live in a temperature regime that is closer to their upper tolerance limit. Therefore, the important variables controlling the distribution and abundance of benthic organisms in tropical regime are salinity^{18,19} and sediment stability^{20,21}. Although, most of the benthic animals collected from the Dabhol coast (Table 2), may tolerate the expected range of temperature change, their ability to survive brief period of exposure to higher temperature and physiological response of individual species inhabiting a specific environment may vary and could be important to their survival.

Generally, the sediment around the Dabhol coast had higher percentage of silt fraction and had high sediment organic carbon content ($r=0.44$, $n=11$). The high organic matter values obtained in the present study reflected on the high biological productivity of the area, particularly of benthic production. While discussing the biological characteristics of the Vashithi river Nair *et al.*² also reported high biological production in the estuarine system. The presence of large numbers of juveniles of commercially important decapods in macrofauna indicated that the environment around Dabhol coast was very conducive to the breeding and nursery grounds of commercially important crustaceans such as shrimps, crabs and lobsters. This was substantiated by good catches com-

prising of juveniles in the experimental bottom trawling carried out in the coastal waters of Dabhol. Large catches during postmonsoon season have been reported from the Dabhol coast^{1,2}.

Although restricted to the December 1994 and 1996 (postmonsoon season), the present set of data gives an insight into the spatial variability of macrofaunal community. However, the temporal variability, particularly due to southwest monsoon, which is expected to be more intense and large scale in this area, needs to be evaluated in order to understand the macrofaunal community structure.

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