

# IMPACT OF MARINE POLLUTION OF LIVING RESOURCES – CASE STUDIES ON THE EFFECT OF MINING ACTIVITY AND ORGANIC ENRICHMENT OF BENTHIC FAUNA

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## Introduction

Benthic community structure is being widely used in programmes on monitoring pollution effects (Warwick, 1986). With pollution perturbation of a community, the conservative species are less favoured and are the first casualties while the opportunistic species are more favoured and often become the biomass as well as numerical dominant (Gray, 1979). A further increase in disturbance may lead to elimination of some of the opportunistic species so that the diversity continue to decrease.

Organic wastes such as domestic sewage, trash fish and washing from the fishing boats are essentially rich in nutrients and when introduced into the environment, may cause changes in the enclosed bays and estuaries. Benthos appears to respond in a characteristic manner with distance from the source of organic inputs or enrichment (Pearson and Rosenberg, 1978; Ansari *et al*, 1984). Generally three zones are recognized: grossly polluted, polluted and unpolluted. Pearson and Rosenberg (1976) reported a fourth zone called enriched zone where individual number, biomass and species may increase above the levels encountered in the normal zone.

This paper deals with the impact of mining rejects and organic enrichment including sewage on benthic life in the Mandovi estuary of Goa.

## Materials and Methods

Data presented here are based on studies carried out over a long period of time in Mandovi estuary. Study area and stations position are shown in Fig. 1. Benthic samples were collected from these stations at monthly intervals using a van Veen grab of 0.04 m<sup>2</sup>. Meiofauna were collected by means of a core tube of 4.5 cm inner diameter. Details of sampling procedure are given in Ansari *et al* (1984, 1986).

## Results and Discussion

### A. Effect of mine rejects and sand excavation on benthic life

Benthic animals have shown great deal of variations in population density and biomass consequent to

environmental disturbances caused by human activity (Parulekar *et al*, 1986). Fig. 2 gives the range, mean and variability in the environmental parameters at 'A'.

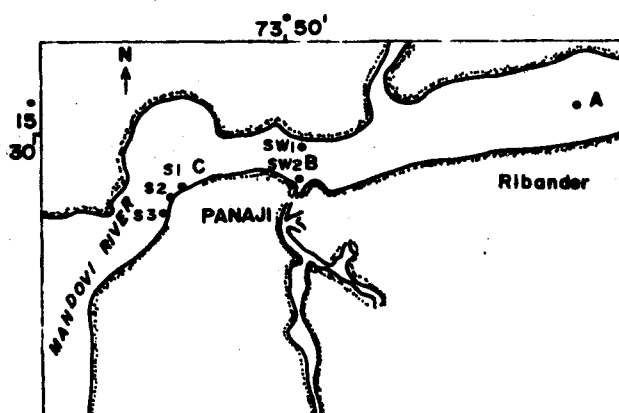


Fig.1: Map showing the study area

- A – Site to study the effect of mine rejects
- B – Site for the study of organic enrichment
- C – Site for the study of effect of sewage pollution on meiofauna.

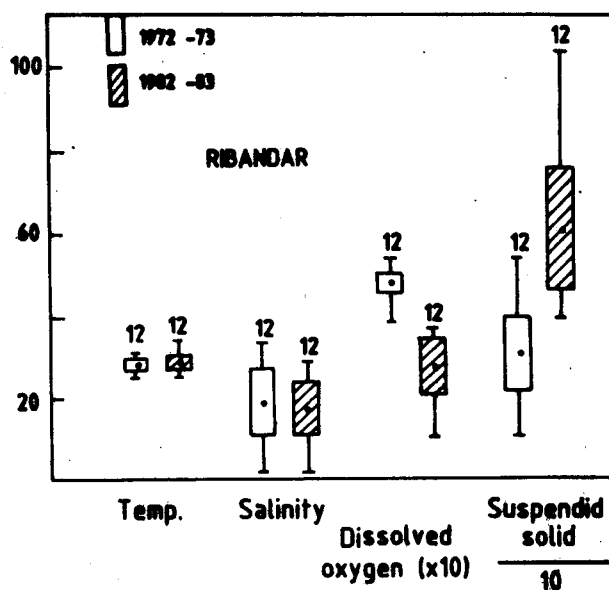


Fig.2: Range mean and variability in environmental factors at Ribandar in 1972-73 and 1982-83.

site (Ribandar) in the Mandovi estuary during 1972-73 and 1982-83. The bottom water temperature, salinity and dissolved oxygen showed relatively small annual as well as seasonal variations. However, major changes in suspended solid content of the bottom water were evident. The values were significantly higher during 1982-83 than in 1972-73, suggesting considerable increase in suspended solids during the past ten years. This was associated with the retrogressive changes in the composition of bottom deposits. The sandy and muddy sand deposit of 1972-73 were found to have been covered with thick red clay and cobble and pebble specially during monsoon time (personal observation).

Benthic animals are amenable to numerical quantification and hence they are ideally suited for assessing the impact of pollution in estuarine and marine environment (McIntyre and Pearce, 1980). A comparison of the data on benthic animals collected during

1972-73 and 1982-83 is given in Table 1. Over the last ten years there is a 44% reduction in the population density, 51% in the total benthic biomass and about 37% in species richness and diversity. The faunal composition during the two study periods indicated that while the prevalence of a particular faunal taxa underwent minor changes within a span of ten years, there were noticeable changes both qualitatively and quantitatively in the presence or absence of species (Table 2).

The dominance of polychaete and bivalves during 1972-73 was replaced by polychaetes and crustaceans indicating radical changes in the fauna. The settlement of fine solid of the mine rejects can blanket the bottom and kill benthic life (Portmann, 1972). Also the fine material stirred up due to excavation and extraction of sand in this estuary may affect the production of benthic bivalves and its fishery (Parulekar *et al*, 1986). It is known that benthic animals are sensitive to environ-

Table 1: Comparison of quantitative data on macrofauna in 1972-73 and 1982-83 period at site A

	1972-73	1982-83
Maximum faunal density ( $m^{-2}$ ) recorded	4382	2425
Maximum biomass ( $g/m^2$ ) recorded	233.79	113.45
Total number of species	111	69
Dominant benthic fauna	polychaete, bivalves	polychaetes, crustaceans
Clam ( <i>Meretrix casta</i> ) biomass ( $m^{-2}$ )	1.8 kg	0.128 kg

Table 2: Number of species, population density and index of diversity of benthic fauna at Ribandar in 1972-73 and 1982-83.

Month	Species	RIBANDAR		Species	1982-83 Population density	Index of diversity
		1972-73 Population density	Index of diversity			
Jan.	23	1200	7.1	12	1075	3.6
Feb.	21	1780	6.1	11	1475	3.1
Mar.	22	1300	6.7	17	1025	5.3
Apr.	24	1975	6.9	16	725	5.2
May	2	2225	5.9	17	1125	5.2
June	17	725	5.6	10	200	3.9
July	9	648	2.8	11	425	3.8
Aug.	10	2750	2.6	7	250	2.6
Sep.	16	1325	4.8	9	475	2.9
Oct.	19	2687	5.2	16	1125	4.9
Nov.	22	3900	5.8	15	1500	4.4
Dec.	22	1855	6.4	13	575	4.3

mental changes and they integrate the combined effect of many stresses through changes in their morphology and physiology. In a recent study Parulekar *et al* (1986) observed about 70% decline in clam production from 1972-73 to 1982-83 which they attributed to changes in the bottom deposits and suspended solids developed due to human interference in the Mandovi estuary.

#### B. Effect of organic enrichment on benthic fauna

Introduction of organic enriched effluent into marine and estuarine water and its effect to biota is determined by the circumstances of the specific situation. The gradual increase in the organic input to the sediment may increase the rate of carbon input to the subtidal benthos approximately 55 times the natural rate (McIntyre, 1977) and influence the benthic productivity. However, the addition of such effluents in excess in the enclosed water bodies may result in stressed conditions for the survival of living organisms.

Table 3 summarises the data on environmental parameters of two stations designated as moderately polluted (SW1) and controlled (SW2) to study the effect of enrichment on benthic fauna. SW1 is situated at a point where lot of organic matter in the form of sewage and trash fish is dumped. The environmental parameters of both stations did not indicate significant variation except the sediment organic matter which was higher at SW1. The BOD5 values do not suggest any severe pollution at SW1.

A comparison of the community (polychaete) data at the two sites is given in Table 4. The mean biomass and density showed a fluctuating trend as indicated by high value of standard deviation. The species diversity

Table 3: Comparison of environmental parameters at the two sites SW1 and SW2

Parameters	SW1	SW2
Depth (m)	6±1.5	4±1.5
Mean grain size (m)	0.052	0.059
Sorting coefficient	0.33	0.41
Percentage silt clay	69.00	55.00
Percentage organic matter	2.6	1.2
Salinity (‰)	26.12	27.76
Dissolved oxygen (ml/l)	3.79	4.63
BOD5 (ml/l)	3.92	5.56

(H') and evenness (E) were higher at SW1 site. The presence of few species like *Dendronereis aestuarina*, *Prionospio polybranchiata* and *Lumbriconereis polydesma* in significantly high number at SW1 clearly indicate the influence of organic enrichment and preference by these species. Other studies which have recorded enhanced density and biomass in association with increased input of organic material are mainly due to settlement of few so called opportunistic species (Mearn and Greene, 1979). Some species take advantage of the changing conditions as in the present study, and develop large population. Thus the addition of organic enriched effluent seems to have abiostimulating effect on the benthic polychaete population of the present study. The negative effect of such effluent, however, can not be overlooked possibly on a long term basis.

#### C. Impact of domestic sewage on sand beach meiofauna

Table 5 summarises the data on environmental parameters and meiofaunal density of the study car-

Table 4: Comparison of community variables (m<sup>2</sup>) between two sites SW1 and SW2

Site	Biomass	No. of individuals	No. of species	H'	E
SW1	1.19 ± 0.75	947 ± 284.4	9.82 ± 1.80	2.79 ± 0.6	2.8 ± 0.3
SW2	0.35 ± 0.27	476 ± 162.3	7.25 ± 1.04	2.25 ± 0.6	2.27 ± 0.2

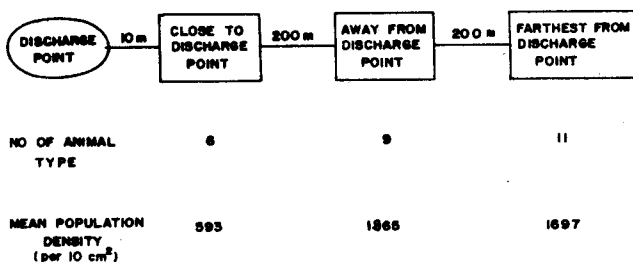
Table 5: Sediment and interstitial water characteristics and meiofaunal density at three stations at site C. Values are mean ± S.D.

St.	Sed. pH	Sed. temp. °C	Sand %	Silt & clay %	Sed. org. matter %	Salinity ‰	D.O. ml/l	PO <sub>4</sub> ug at P/l	NH <sub>3</sub> ug at N/l	Meiofaunal density
S1	7.86	31.6	93.52	6.48	4.07	17.73	0.42	9.68	106.35	593
	± 0.25	± 2.8	± 7.18	± 0.14	± 0.09	± 6.45	± 0.03	± 1.23	± 22.08	± 85
S2	7.72	32.3	96.05	3.95	2.02	26.24	1.94	4.49	19.62	1965
	± 0.32	± 4.6	± 11.25	± 0.92	± 0.11	± 9.12	± 0.22	± 0.62	± 4.16	± 134
S3	7.95	32.5	97.12	2.88	1.32	28.66	2.45	1.52	2.44	1697
	± 0.18	± 6.2	± 9.86	± 0.34	± 0.32	± 5.32	± 0.76	± 0.31	± 0.15	± 162

ried out at three sites, S1, S2 and S3, on a beach receiving domestic sewage from the urban areas. Site S1 was close to the discharge point, S2 representing enriched zone and S3 controlled site. Significant changes in the abiotic factors were evident at the three sites due mainly to the introduction of domestic sewage. While temperature and salinity of the interstitial water did not show appreciable difference among the stations, other parameters like dissolved oxygen,  $\text{PO}_4^{3-}$ ,  $\text{NO}_3^-$  and  $\text{NH}_4^+$  showed significant differences in the value at S1, S2 and S3 respectively.

The meiofaunal data indicates highest value of density at S2 followed by S3 and the lowest density at S1 (Fig. 3). The faunal taxa observed were maximum at S3. The present study showed pronounced effect of sewage pollution near the discharge point, as is evident from the impoverished fauna at S1 and a characteristic response gradient of meiofauna with distance from the source of pollution. A high meiofaunal density at S2, representing intermediate conditions, shows that moderate quantity of sewage discharge may enhance the benthic productivity. It corroborate the earlier observation of Pearson and Rosenberg (1978). Similar results were reported on meiofauna by Goving and Hulings (1976) from Lebanese sandy beaches affected by sewage pollution.

Fig.3: Effect of Sewage Pollution on Benthic meiofauna – A Case Study



The major effect of sewage is that it reduces the oxygen content and stimulates the formation of hydrogen sulphide which is harmful to the benthic fauna. This effect was largely seen at S1 where the oxygen content of the interstitial water was very low compared to the values at S2 and S3. It was further supported by the presence of a black sulphide layer below 6 cm of the sediment at S1. Thus it appears that the enriched sediment attract benthic population and encourage settlement of the favoured species.

It may be concluded that measurement of biological impact, as in the present study has a significant role in

the management and conservation of productive estuarine environment. In the absence of any severe pollution in the Mandovi estuary, the causes for the decline in the benthic productivity could be related to the bioturbation of the sediment due to settlement of mine rejects and sand excavation. Unless preventive measures are taken to minimize the human interference in these sensitive environments, it may result in heavy loss of the estuarine life and extinction of fauna on a long term basis.

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