

Biological Impact of Mining On the Coastal Zone of Goa

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The environmental impact that contaminants may have on an aquatic ecosystem should be assessed by an interpretative study of the physiochemical characteristics in relation to the biota. Goa exports over 14 million tonnes of iron and manganese ores per annum from Marmugao port. All the ore extraction work is carried out in the vicinity of river Mandovi and Zuari and ores are transported for shipment by barges, plying through the waterways of Mandovi, Zuari and connecting Cumbarjua canal (Fig. 1). Extraction of ore, produces mining rejects and over the years about 300 million tonnes of rejects are estimated to have accumulated in the mining belt of Goa (Anonymous 1981). These rejects get eroded due to flooding during heavy southwest monsoon, and are transported down the river and a substantial part of it (33%) settle in the estuarine benthic environment.

In 1972-73 a detailed study on the ecology of clam bed, and associated fauna was carried out in Mandovi and Cumbarjua canal (Parulekar et al., 1980). In 1982-83 the area was studied again to find out the changes, if any, in environmental and biotic components (Ansari et al 1986).

Material and Method

Benthic samples including clam were collected from the beds at Ribandar and Banastrim (Fig. 1). Method of collection of benthic and abiotic parameters as also analyses are given elsewhere (Parulekar et al., 1986).

Results and Discussion

Environmental Features

Bottom water temperature at Ribandar and Banastrim displayed comparable trend in range, mean and variability, both in 1972-73 and 1982-83 with no significant change during the period (Fig. 2). Range of salinity values at Ribandar in 1982-83 was relatively small and of lower magnitude than in 1972-73. In contrast, the range, mean and magnitude of variability, in salinity values at Banastrim, was comparable in both the period of observations. The dissolved oxygen concentration near bottom in 1982-83 showed major changes in range, mean and magnitude of variability at both the sampling sites. The range showed high mean values with low variability during 1972-73 and low mean and high variability during 1982-83, showing an overall 60-65% depletion in dissolved oxygen within 10 years.

Changes in the suspended solid were evident (Fig. 2). The range, mean and variability was high at Ribandar during 1982-83 while at Banastrim the values showed high mean and low variability. Retrogressive changes in the bottom deposit were also observed. During 1972-73 the bottom deposit at Ribandar and Banastrim were characterised by sandy to muddy sediments with mean grain size of 0.25-0.125 mm (Parulekar et al., 1980). However, in 1982-83, the sandy and muddy deposits were observed to be covered with red clay silt and further blanketed by cobble and pebbles of lateritic origin.

Biotic Characteristics

Fig. 3 shows the biotic properties and its variability at Ribandar and Banastrim. The clam biomass in two different periods of observation, showed overall decrease in range, mean and variability. At Ribandar, the mean biomass was 538.4 gm^{-2}

during 1972-73 which decreased to a mean value of 10 gm^{-2} . Similar trend was observed at Banastrim both in range and mean values of clam biomass. Population density also exhibited similar trend in variability, mean and range values. There was an overall reduction from $393/\text{m}^2$ and $3969/\text{m}^2$ in 1972-73 at Ribandar and Banastrim respectively to $360/\text{m}^2$ in 1982-83 at the respective stations.

The benthic standing crop, estimated as benthic biomass, varying from 0.1 to 228 gm^2 at Ribandar in 1972-73 declined to 0.5 to 190 gm^2 in 1982-83. Benthic standing crop at Banastrim also showed similar trend and lowering in biomass from 1972-73 to 1982-83. Population density of benthic fauna at Ribandar displayed comparable magnitude of variability during both the periods of observation (Fig. 3). The fauna declined from a mean density of $1364/\text{m}^2$ in 1972-73 to $831/\text{m}^2$ in 1982-83. Similar magnitude of variability in range and mean was also observed at Banastrim during the two periods of observation.

The composition of benthic fauna at the two sites during the two periods of observation is shown in Table I. It is evident that while the prevalence of a particular faunal taxa underwent minor changes, within a span of 10 years, there were noticeable changes both qualitative and quantitative, in the presence or absence of species. While the number of species increased from 24 in 1972-73 to 31 in 1982-83 at Ribandar, the number of species at Banastrim decreased from 15 in 1972-73 to 12 in 1982-83.

Changes in species composition that has taken place during the past 10 years was investigated by studying the feeding types. During 1972-73 the benthic fauna was dominated by filter feeders such as *Meretrix casta* and detritus feeders (*Corophium* sp) at the two sites which reflects the availability of food material in the water column. However in 1982-83, the scavenger species, epibenthic or migratory in habitat attained the dominance.

Table 2 gives the index of diversity at Ribandar and Banastrim during the two study period. It is evident that diversity was high in 1972-73 than in 1982-83 with high magnitude of variability during the 1982-83 period. Decrease in the faunal density over past 16 years is a reflection of environmental degradation

and perturbation (Lie 1968). The change in diversity can be correlated to simultaneous changes in the suspended solids and the sediment composition which made benthic environment unsuitable for colonization by many sensitive and rare species.

Field observations on the impact of environmental perturbation, as in the present study, has a significant role in monitoring which can be carried out at any level of biotic organization. There are a number of reports papers which have described the effect of pollution on benthic organisms (Rosenberg, 1977, McIntyre 1977, Pearson & Rosenberg, 1978, Parulekar et al 1985). Very little is known about the marine pollution as a result of mining operations of metal ore (Portmann, 1972, Morris et al 1981) and its effect on the biota of estuarine and coastal marine environment.

Although the iron and manganese in particulate or dissolved state are not toxic to the benthic fauna, the suspended solids principally of inorganic origin, will result in the choking of filtration apparatus with possible mortality of the infaunal assemblage. Also the settlement of mining rejects (red clay, cobble and pebbles) on the floor has resulted in the considerable reduction of the assimilative capacity of the clam bed ecosystem at Ribandar & Banastri. These man made changes are recurring in nature and unless abated, will affect the estuarine living resources adversely.

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Faunal composition, number of species and feeding types in associated fauna of clams at Ribandar and Banaswini
in 1972-73 and 1982-83

	<i>Ribandar</i> (No. of sp.)	<i>Banaswini</i> (No. of sp.)	<i>Total</i>	<i>Feeding Types</i>	<i>Percentage Composition</i>
<i>Faunal taxa</i>	1972-73	1982-83	1972-73	1982-83	
<i>Formicifera</i>	1	—	1	—	
<i>Actinaria</i>	—	2	—	—	
<i>Polychaets</i>	12	12	6	5	1972-73 24
<i>Gastropoda</i>	1	3	2	1	1982-83 30
<i>Pelecypoda</i>	4	4	2	1	1972-73 15
<i>Cirripedia</i>	1	—	—	—	1982-83 12
<i>Amphipoda</i>	2	4	1	1	1972-73 13
<i>Aphidida</i>	—	—	—	—	1982-83 6
<i>Decapoda</i>	3	3	3	2	1972-73 12
<i>Teleostei</i>	—	1	—	1	1982-83 6
No. of species	24	30	15	12	
No. of common species	8	—	4	—	
Total No. of species	46	—	23	—	

TABLE II-2

Number of species, population density and index of diversity in associated fauna of Mata de Itabuna and Ilha das

In 1972-73 and 1982-84

Month	Species	Population density	Ribandar			B. maristri			Popula-		
			1972-73	1982-83	1972-73	1982-83	Index of species diversity	Index of species diversity	Population density	Population density	Index of species diversity
Jan.	23	1200	7.1	12	1075	3.6	13	1987	3.2	6	1300
Feb.	21	1780	6.4	11	1475	3.1	14	1538	4.0	6	225
Mar.	22	1300	6.7	17	1025	5.3	12	1200	3.5	8	600
Apr.	24	1975	6.9	16	725	5.2	10	2887	2.6	4	300
May.	21	2225	5.9	17	1125	5.2	12	22350	2.5	2	1225
June	17	725	5.6	10	200	3.9	12	875	3.7	7	650
July	9	648	2.8	11	425	3.8	7	1675	1.8	3	50
Aug.	10	2750	2.6	7	250	2.5	8	3112	2.0	2	350
Sept.	16	1325	4.8	9	475	2.9	11	2812	2.9	2	875
Oct.	19	2687	5.2	16	1125	4.9	10	2700	2.6	4	1575
Nov.	22	3900	5.8	15	1500	4.4	9	1800	2.4	5	1050
Dec.	22	1855	6.4	13	575	4.3	14	5362	3.4	7	800

TABLE I

Faunal composition, number of species and feeding types in associated fauna of data beds at Kilanadar and Banastria in 1972-73 and 1982-83

	<i>Kilanadar</i>		<i>Banastria</i>		<i>Total</i>	<i>Feeding Types</i>		<i>Percentage Composition</i>		
	(No. of sp.)	(No. of sp.)	(No. of sp.)	Locality	Year	Species	Filter	Pelagic	Cloud	Susp.
<i>Faunal taxa</i>	1972-73	1982-83	1972-73	1982-83						
<i>Foraminifera</i>	1	—	1	—						
<i>Actinaria</i>	—	2	—	—						
<i>Polychaeta</i>	12	12	6	5	Kilanadar	1972-73	24	33.3	29.0	12.5
<i>Gastropoda</i>	1	3	2	1	1982-83	30	13.3	13.3	6.6	66.6
<i>Pelecypoda</i>	4	4	2	1						
<i>Cirripedia</i>	1	—	—	—	1972-73	15	26.7	33.3	20.0	20.0
<i>Amphipoda</i>	2	4	1	1	Banastria	1982-83	12	8.3	8.3	83.3
<i>Aphididae</i>	—	1	1	1						
<i>Decapoda</i>	3	3	3	2						
<i>Teleostei</i>	—	1	—	1						
<i>No. of species</i>	24	30	15	12						
<i>No. of common species</i>	8	—	4	—						
<i>Total No. of species</i>	46	—	23	—						

A CASE STUDY OF BIOLOGICAL IMPACT
(Ansari et al 1985)

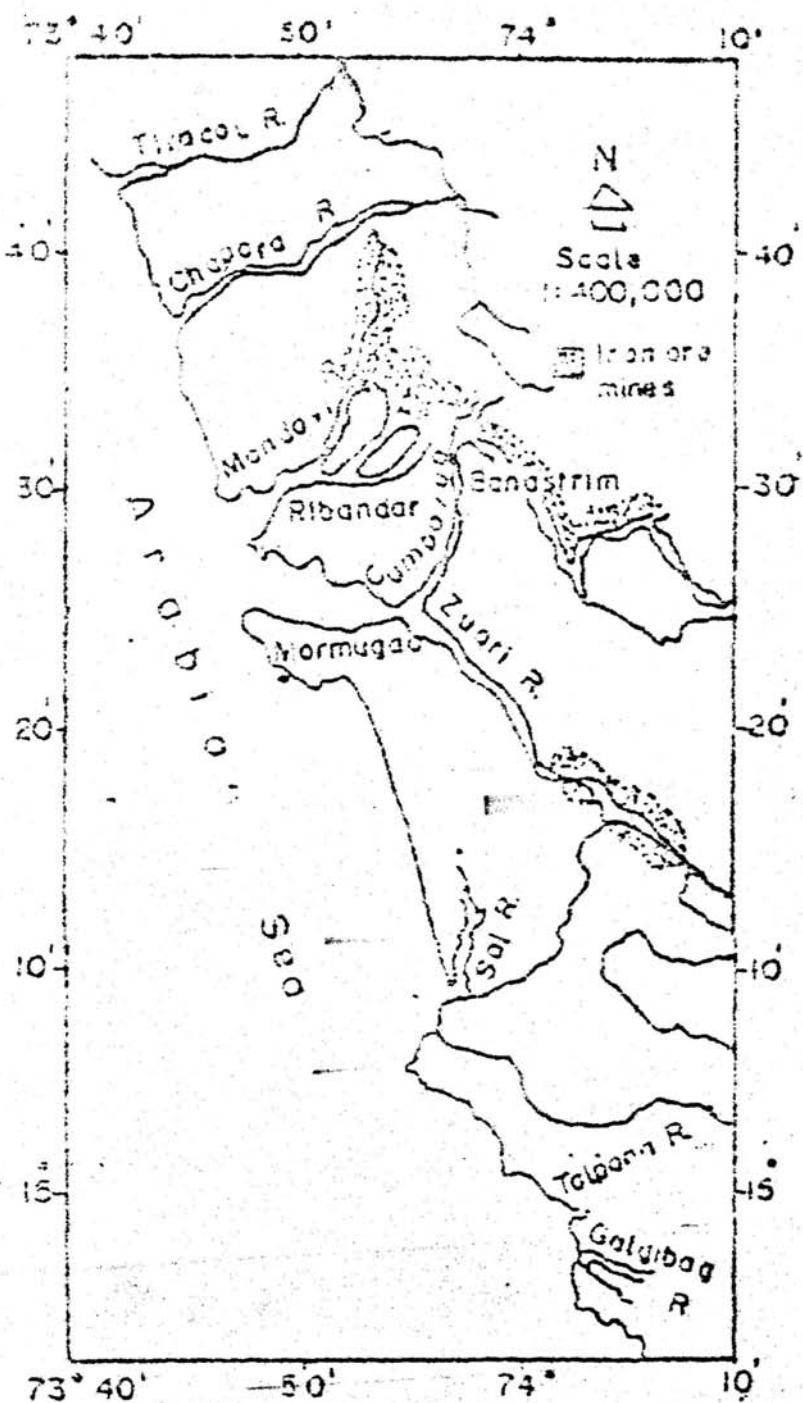


Fig. 1—Map of Goa showing the mining and the study area -Ribandar and Banastrim.

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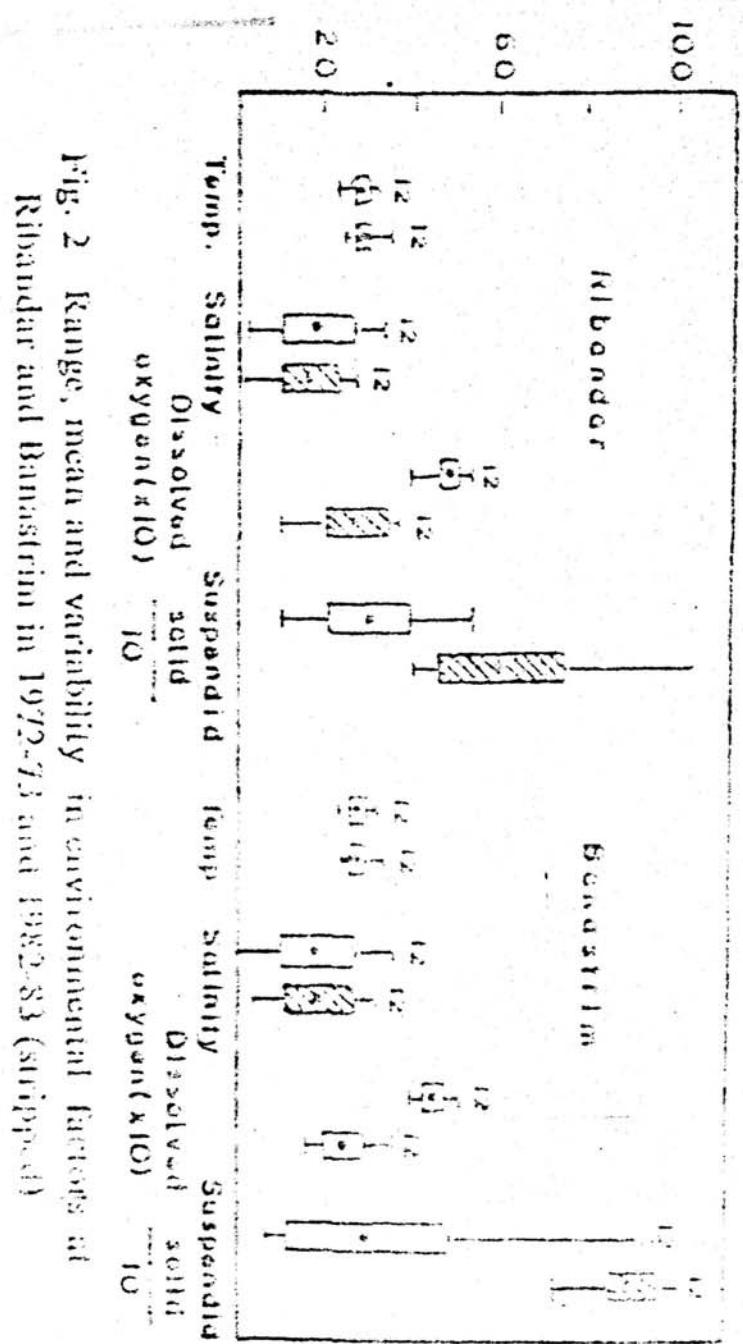


Fig. 2 Range, mean and variability in environmental factors at Rihandar and Banastri in 1972-73 and 1982-83 (stripped)

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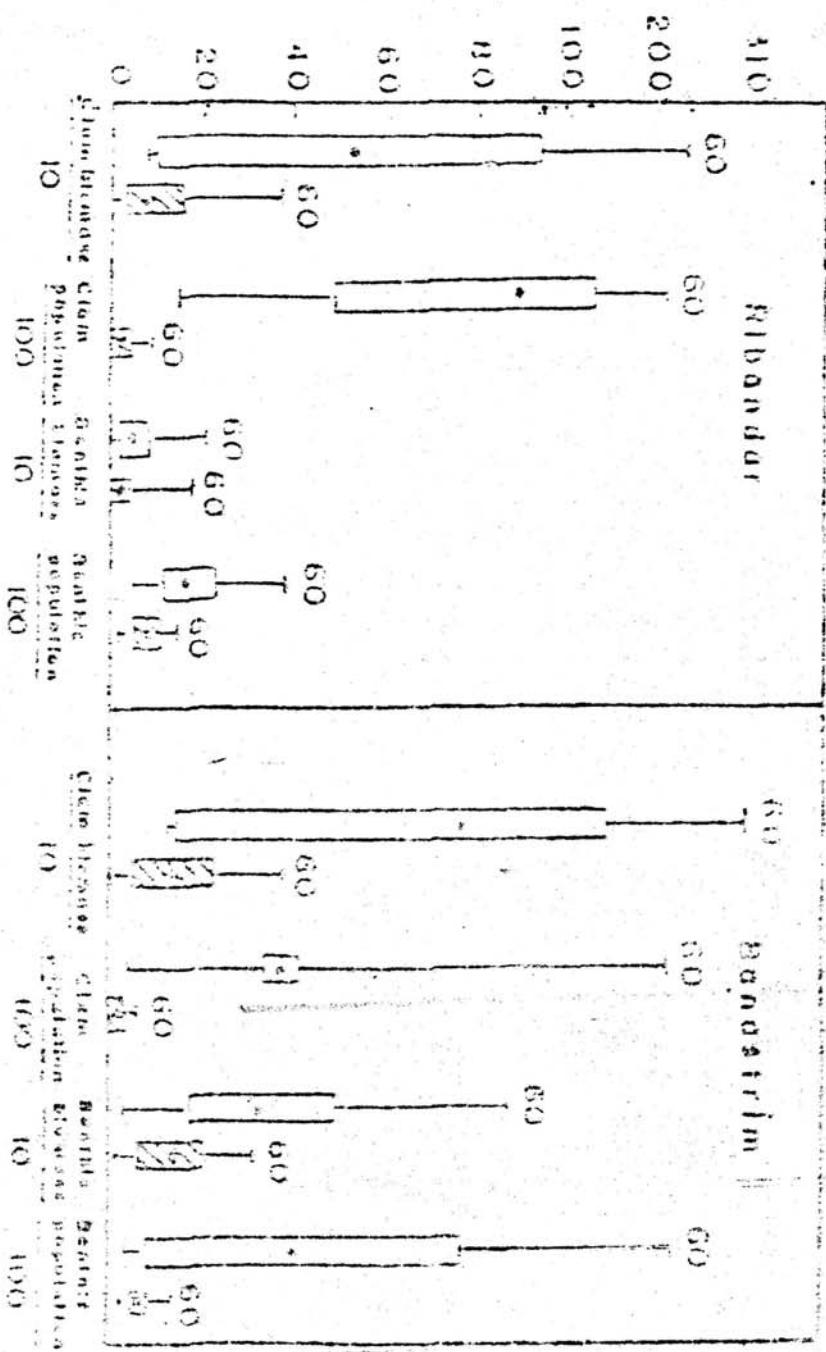


Fig. 3. Range, mean and variability in biotic characteristics at Ribandar and Banastri in 1972-73 & 1982-83 (Stripped).