

ENVIRONMENTAL IMPACT ASSESSMENT OF BENTHIC COMMUNITY STABILITY IN AN ESTUARINE COMPLEX

ZAKIR A. ANSARI* AND S.A.H. ABIDI**

* National Institute of Oceanography,
Dona Paula, Goa 403 004,

** Department of Ocean Development, New Delhi.

Comparison of macrobenthic communities of an estuarine complex at Goa revealed significant changes in faunal structure, in time and space, in less than ten years (1972-73 - 1982-83). The composition of the community was influenced by increasing environmental disturbances caused by human activities such as mining and sand excavation. High suspended solids by mining rejects and disturbance of bottom resulted in more than 40% reduction in macrobenthic crop and about 50% reduction in species diversity. There was also a substantial decrease in clam production during the 10 year time under consideration. The implication of ever increasing mining rejects in the estuarine system and the utilization of quantitative benthic parameters in environmental impact studies are discussed.

INTRODUCTION

There is an increasing awareness of the usefulness of benthic community research in the detection and monitoring of coastal and estuarine changes (Reish, 1972). Being sessile and burrowing in habit, the bottom dwelling organisms are the major casualties of any major environmental or man-made changes (McIntyre and Pearce, 1980). During last two decades human activities around coastal and estuarine systems have increased enormously and in many cases these activities have produced adverse effects on the environment (Qasim and Kureishy, 1986). There is speculation that man impacted the biological components of estuarine water bodies through alterations of habitats and additions of pollutants and nutrients.

Goa situated on the central west coast of India, gets a major portion of its economy from the export of over 10 million tonnes/year of iron and manganese ores from Marmugao port. Ore extraction is carried out in the riverine belt and the transport of ore is done by barges plying the inland waterways of Mandovi-Cumbarjua canal-Zuari estuarine system (Fig.1). Extraction of ore generates large amount of mining rejects. Due to heavy monsoon these rejects get washed and transported down stream by strong bottom currents. They settle in the benthic environment of the estuarine system, thus blanketing the bottom deposits. A substantial damage of benthic system is also caused by the excavation and extraction of sand from the riverine belt.

During 1972-73 a detailed study of the benthos of the Mandovi-Cumbarjua canal-Zuari estuarine system was carried out (Parulekar *et al*, 1973). A similar study was carried out during 1992-83 to compare the data of 1972-73 and to assess the environmental impact assessment of the benthic population in the estuarine system. This paper compares the structural parameters such as density, biomass and species diversity and discusses the changes which occurred during the 10 years time.

MATERIALS AND METHODS

Benthic samples were collected from Mandovi-Cumbarjuna canal-Zuari estuarine system, at monthly interval by means of a van Veen grab of 0.1 m² area and 15 cm penetration. Replicate samples were collected from each station on each sampling date. Animals were sorted out and the mean value of biomass (wet weight) and population density was estimated. Details of sampling stations are given in Parulekar *et al*. (1973, 1987) for both the sampline period; 1972-73 and 1982-83. Environmental parameters were studied simultaneously at each station, following the standard methods. The interpretation of data of the two periods were tested statistically for density, biomass and species diversity (Margalef index, 1968).

RESULTS AND DISCUSSION

Environment: Mandovi and Zuari are tide dominated coastal plain

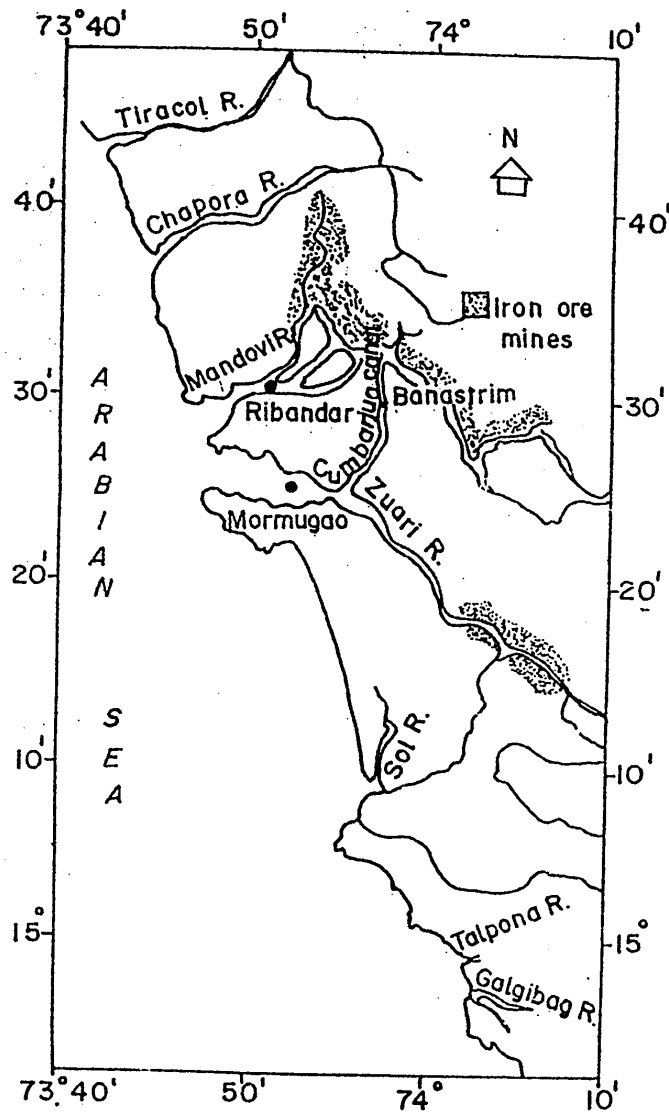


Fig. 1. Map of Goa showing the mining areas and the study area.

estuaries in which the chemical, physical and biological processes are adapted to a seasonal rhythm induced by the annual cycle of the south-west monsoon (Qasim and Sen Gupta, 1981). The estuaries become stratified and wedge of high salinity water is formed at the mouth region during the monsoon season. This is followed by a recovery during the post-

monsoon season, when the marine components begin to develop. During the pre-monsoon period the stratification disappears, the estuary is well mixed, and the salt water intrusion is detectable as far as 65 km upstream, leading to a predominantly marine regime.

A comparison of the environmental parameters of the two periods is presented in Fig. 2. Bottom water temperature showed a comparable trend in range, mean and variability, in 1972-73 and 1982-83. The range and mean of salinity was also similar during the two period with intense variability in Mandovi estuary during 1972-73. Dissolved oxygen concentration in 1982-83 showed major changes in range, mean and magnitude of variability in the estuarine system. While the range and mean values in 1972-73 was uniformly high but with low variability, in 1982-83 it showed high variability and the mean value of 2.69, 2.55 and 2.48 ml/l in Mandovi, Cumbarjua canal and Zuari estuary, respectively, clearly indicates that an overall 60-65% depletion in dissolved oxygen has taken place in the estuarine environment in a span of ten years (1972-73 to 1982-83) (Ansari *et al.*, 1986; Parulekar *et al.*, 1986).

Major changes took place in suspended solid content of the overlying water during ten years time (Fig. 2). The range, mean and variability were higher in 1982-83 than in 1972-73. The relative increase in suspended solid was of high magnitude in Cumbarjua canal. This is attributed to the flow characteristic of water in the canal and transportation of iron ore through this water way (Das *et al.*, 1972). Retrogressive changes in bottom deposits were also noticed during this period. The sandy and silty mud bottom which predominantly found during 1972-73, changed to red clay with pebbles and gobbles, in 1982-83. The changes in sediment properties were more evident near the mining sites. All these changes are attributable to increased mining activities along the riverine (Parulekar *et al.*, 1986). Surprisingly there was no significant change in the organic content of the two periods. It suggest that organic load has not increased in the estuarine system (Ansari *et al.*, 1986).

Biotic characteristics: A comparison of biotic parameters of the two periods of observation is illustrated in Fig. 3. The most important change was noticeable in the clam biomass. There was an overall decrease in range, mean and variability. An average value of 538 g m⁻² in 1972-73

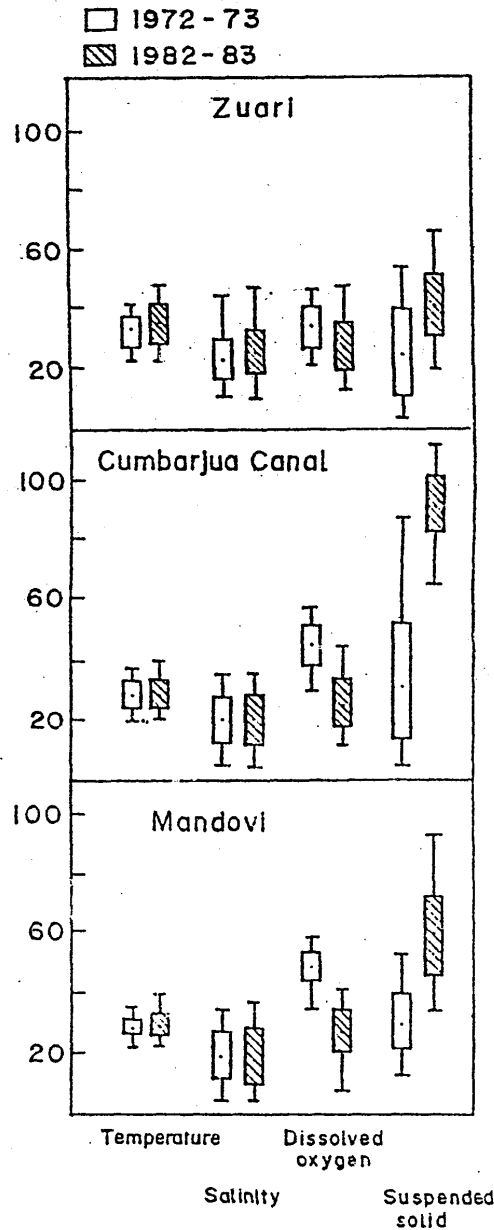


Fig. 2 Range, mean and variability in environmental factors.

reduced to 10 g m⁻² in 1982-83 in Mandovi estuary. Similar trend was also noticed in Cumarjua canal and Zuari estuary. The population density of *Meretrix casta*, in space and time showed that from the high mean value of 893/m², 3969/m² and 1200/m² in 1972-73, there was an observed decline in density during 1982-83, with range and mean values at their lowest.

Table 1: Comparison of quantitative data on biological parameters of the estuarine complex.

Parameters	1972-73	1982-83
Maximum faunal density/m ²	4382	2425
Average biomass g/m ²	233.79	113.45
Total number of species	111	69
Maximum diversity (average)	5.6	3.9
Dominant taxa	Polychaete, bivalve	Polychaete crustacean

There was retrogressive changes in the overall benthic population density and standing crop. Benthic biomass varying from 0.1 - 228.9 g m⁻² (mean 56.8 g m⁻²) but with moderately high variability as observed in 1972-73 in Mandovi declined to 0.5 - 190.6 g m⁻² (mean 23.8 g m⁻²) with low variability in 1982-83. Similarly in Cumbarjua canal the high mean value (3.39.6 g m⁻²) in 1972-73, declined to 153.2 g m⁻² in 1982-83. In Zuari also a considerable decline in benthic biomass was observed in a ten years time (Fig. 3). The population density of macroinvertebrate also declined in the corresponding period in the estuarine complex.

Faunal composition in the estuarine complex during the two periods of observation indicated (Table 1) that while the prevalence of a particular faunal taxa underwent minor changes, within a span of ten years, there were clear changes, both in quantity and quality, in the presence or absence of species. The number of species reduced in the whole estuarine complex during 1982-83. The polychaetes and bivalves dominated the fauna in 1972-73. After a span of ten years the polychaetes remained the most dominant group while the bivalves were replaced by crustaceans as the second largest group in 1982-83. A total of 111 species were recorded in 1972-73 in the estuarine complex (Parulekar *et al.*, 1980). In a span of ten years about 50% reduction in species composition was noticed (Table 1).

Changes in species composition, for a period of ten years, was further investigated by studying the density of some dominant species (Table 2). Large changes occurred in the dominant species. Among polychaetes

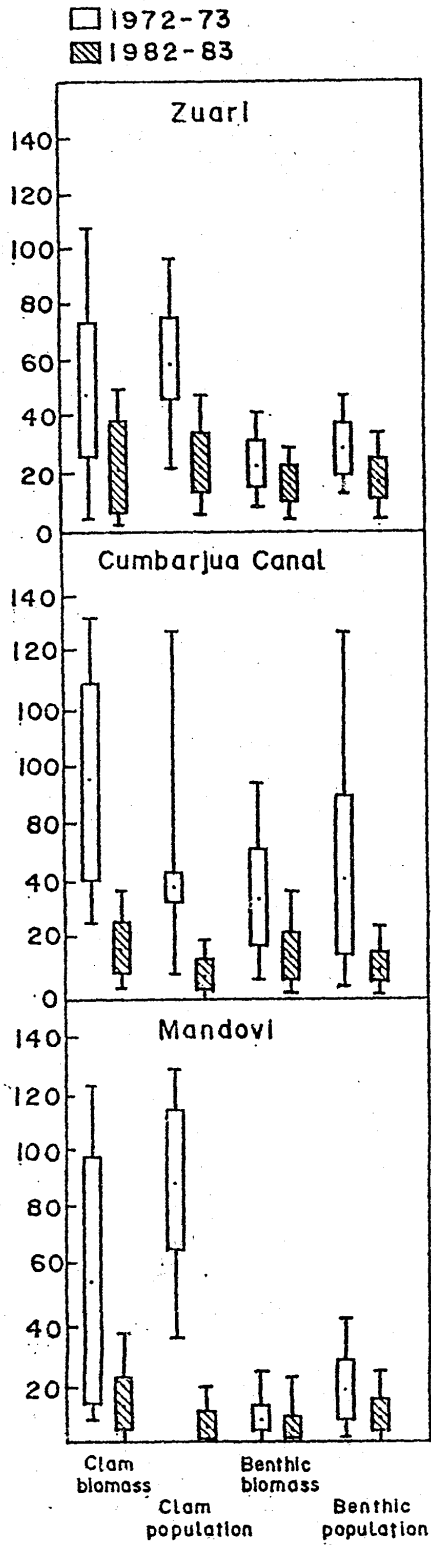


Fig. 3. Range, mean and variability in biological parameters.

Table 2: Comparison of total density of dominant species during two periods.

Species	1972-73	1982-83	U test
<i>Diopatra neapolitana</i>	4357	1175	12.5*
<i>Glycera alba</i>	1384	750	16.00*
<i>Prionospio pinnata</i>	783	1500	8.5**
<i>Cerithedia fluviatilis</i>	1359	309	7.0*
<i>Meretrix casta</i>	893	326	7.6*
<i>Paphia malabarica</i>	2467	350	2.5*
<i>Corophium</i> sp.	1980	2700	17.4**
<i>Apeudes chilkensis</i>	-	795	6.5**

* Significantly higher in 1972-73; ** Significantly higher in 1982-83.

Diopatra neapolitana and *Glycera alba* were significantly less common ($p > 0.05$) while *Prionospio pinnata* has increased significantly. The bivalves, *Meretrix casta* and top shell. *Cerithidia fluviatilis* showed reduction in density. However, there was a significant increase in the density of opportunistic species like *Corophium* sp., *Apeudes chilkensis* and *Mesopodopsis* sp. during the same period.

The index of diversity as assessed from the temporal changes (Table 3) revealed that there was higher species diversity in 1972-73 than in 1982-83 in the estuarine complex. The magnitude of variation was, however, not high, as in the case of density and biomass. This could be due to the emergence of opportunistic species in place of vagrant species (Parulekar *et al.*, 1986). The changes in diversity could be correlated to simultaneous changes in the suspended solids and sediment composition as inferred by Ansari *et al.* (1986).

Environmental disturbance and community structure: The deposition of red clay particles, both in suspension as also settled on the bottom alongwith the lateritic cobbles and pebbles and the massive inorganic inputs in the form of mining rejects has resulted in considerable reduction of benthic community and serious ecosystem instability in the estuarine complex. The impact of severe environmental stress can be seen on biological parameters of density, biomass and diversity. The impact

Table 3: Temporal changes in benthic diversity

Month	Mandovi		Cumbarjua canal		Zuari	
	1972-73	1982-83	1972-73	1982-83	1972-73	1982-83
Jan.	7.1	3.6	3.3	1.6	5.6	3.8
Feb.	6.1	3.1	4.0	2.1	6.2	3.6
Mar.	6.7	5.3	3.5	2.5	5.5	2.9
Apr.	6.9	5.2	2.6	1.2	5.2	4.3
May	5.9	3.9	2.5	1.2	3.5	3.5
Jun.	4.6	3.3	3.7	2.1	3.9	3.2
Jul.	2.8	2.1	1.8	1.1	2.9	2.6
Aug.	2.6	2.9	2.0	0.4	2.8	2.9
Sep.	4.8	4.9	2.9	0.3	3.8	3.5
Oct.	5.2	4.4	2.6	3.2	6.2	4.6
Nov.	5.8	4.3	2.4	1.3	5.8	4.1
Dec.	6.4	5.2	3.4	2.0	5.3	3.7

of pollution can be judged by the presence of low diversity or the presence of a particular indicator species (Rainer, 1981). Therefore the pattern of diversity indices could be considered as a better parameter in environmental impact study. Heip (1980) has also suggested the importance of diversity indices in monitoring of benthic system.

Benthic organisms 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). Environmental and biological parameters studied in the present investigation, are essential to correlate the frequency of occurrence, faunal composition, standing crop and community structure of benthic ecosystem, in relation to man made changes. The relative changes in the spatial and temporal distribution of benthic fauna gives a good indication of the magnitude of environmental changes in the Mandovi-Cumbarjua canal-Zuari estuarine system of Goa. Such environmental disturbances, caused by man made changes, are recurring in nature, and are needed to be monitored for the existence of estuarine living resources in the long run.

REFERENCES

- Ansari, Z.A., Ingole, B.S., Banerjee, G. and Parulekar, A.H. 1986: Spatial and temporal changes in benthic macrofauna from Mandovi Zuari estuaries of Goa, west coast of India. *Indian J. Mar. Sci.*, **45**: 223-229.
- Das, P.K., Murthy, C.S. and Varadachari, V.V.R. 1972: Flow characteristic of Cumbarjua canal connecting the two estuaries of Mandovi and Zuari. *Indian J. Mar. Sci.*, **1**: 95-102.
- Heip, C. 1980: Meiobenthos as a tool in the assessment of quality of the marine environment. *Rapp. P.V. Reun. Cons. Int. Explor. Mer.*, **179**: 182-187.
- McIntyre, A.D. and Pearce, J.B. 1980: Forward *In Rapp. P.V. Reun. Cons. Int. Explor Mer.*, **179**: 5-11.
- Parulekar, A.H., Dwivedi, S.N. and Dhargalkar, V.K. 1973: Ecology of clam beds in Mandovi, Cumbarjua canal and Zuari estuarine system of Goa. *Indian J. Mar. Sci.*, **2**: 122-126.
- Parulekar, A.H., Dhargalkar, V.K. and Singbal, S.Y.S. 1980: Benthic studies in Goa estuaries. Part III. Annual cycle of macrofaunal distribution, production and trophic relation. *Indian J. Mar. Sci.*, **9**: 189-200.
- Parulekar, A.H., Ansari, Z.A. and Ingole, B.S. 1986: Effect of mining activities on the clam fisheries and bottom fauna of Goa estuaries. *Proc. Indian Acad. Sci. (anim. sci.)*, **95**: 325-339.
- Qasim, S.Z. and Gupta, R. Sen 1981: Environmental characteristics of the Mandovi-Zuari estuarine system in Goa. *Estar. Cstl. Shelf Sci.*, **13**: 557-578.
- Qasim, S.Z. and Kureishy, T.W. 1986: Biological diversity in the seas around India: Present status and major threats. *Proc. Indian Acad. Sci. (Anim. Sci./Plant Sci.) Suppl.*, 1-17.

Rainer, S. 1981: Temporal pattern in the structure of macrobenthic communities of an Australian estuary. *Estuar. Cstl. Shelf Sci.*, **13**: 597-604.

Reish, D.J. 1973: The use of benthic animals in monitoring the marine environment. *J. envir. Plan. Poll. Cont.* **1**: 32-38.