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Does mining pollution affect foraminiferal distribution in Mandovi estuary, Goa, India ?

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Abstract

A total of 10 surface sediment samples were collected in the premonsoon season in 1990 from the Mandovi estuary, Goa. Study revealed presence of 14 species of foraminifera. The foraminiferal data is of special significance because the same can be compared with foraminiferal data of RAO (1974) based on the samples collected in 1972 from the same area.

The study reveals that during 18 years total foraminiferal number (TFN) came down considerably (2 to 42 specimens/gm in 1990 as compared to 10 to 139 specimens/gm in 1972). Similarly, total species number (TSN) also declined from 18 (in 1972) to 14 (in 1990). It is postulated that decline in fauna is due to continuously increasing suspended load (2-4 mg/l in 1972, 4.5 - 8 mg/ l in 1982 and 6.69 - 114.49 mg/l in 1990) in the estuary. This increased suspended load can be attributed to mining activities in the catchment area of Mandovi River along with its tributaries. Extraction of one tonne of iron ore generate about 1.5 to 4 tonnes of mining reject, and over the years more than 1 billion metric tonnes of mining reject is estimated to have accumulated in mining belt of Goa. The loose mining reject gets eroded due to flooding during monsoon and transported downstream, thus increasing suspended load in river. In view of the foregoing it is surmised that decrease in foraminiferal population in Mandovi estuarine sediments during 1972-1990 indicates influence of mining pollution.

Key-words

Marine Geology, Foraminifera, Sediments, Mining, Pollution effects, Estuaries, Goa.

I. INTRODUCTION

Pollution is a phenomenon, which is always associated with more and more industrialization to attain fast economic growth. Sea is the ultimate home for waste of most industries in general and coastal area in particular. The massive pollution causes the fall in live products of the sea (like fishes) and thus negatively compensates some of the benefits of industrialization. Therefore, there is a worldwide awareness to control pollution for which detection / monitoring is the first step. Being very sensitive to environmental changes, foraminifera (marine micro-organisms) have been used to monitor marine pollution in coastal areas (ELLISON *et al.*, 1986; NAGY & ALVE, 1987; SHARIFI *et al.*, 1991; YANKO *et al.*, 1998; DEBENAY *et al.*, 2001b; SAMIR & EL-DIN, 2001, etc.). In India too, a number of researchers have published their results (RAO & RAO, 1979; SETTY, 1982; SETTY & NIGAM, 1984; NAIDU *et al.*, 1985; BHALLA & NIGAM, 1986; RAO, 1996; JAYARAJU & REDDI, 1996, etc.) in this field.

Most of these studies were aimed to discuss the changes in foraminiferal fauna through the spatial distribution with reference to proximity and distal zones from effluent discharge point of a factory. This approach is found useful to deduct pollution restricted to small areas i.e. to a particular factory with particular effluent. Prolonged pollution in rather large areas can be attempted through quantitative comparison of faunal data of surface sediments collected with sufficient time gap. The present study is an attempt in this direction.

Mandovi estuary provides an opportunity to test this conceptual framework. This area is selected for two reasons. The catchment area of this estuary is known for its open cast mining of iron ores, and foraminiferal distribution data for the premonsoon season of 1972 is available (RAO, 1974). We, based on samples collected in premonsoon season of 1990, generated the data of foraminiferal distribution in Mandovi estuary and compared the results.

II. MATERIAL AND METHODS

In the year 1990, surface sediment samples were collected at 19 stations from Mandovi and Zuari estuaries as a part of research project "Studies on sediment flux of rivers, estuaries and adjoining coastal waters of Goa, west coast of India". BUKHARI (1994)

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later used these samples for detailed sedimentological investigations. For the present foraminiferal investigations, out of the available set of samples from the repository of Marine Sciences and Biotechnology Department, Goa University, 10 sediment samples (Fig. 1), which were collected during premonsoon season are selected.

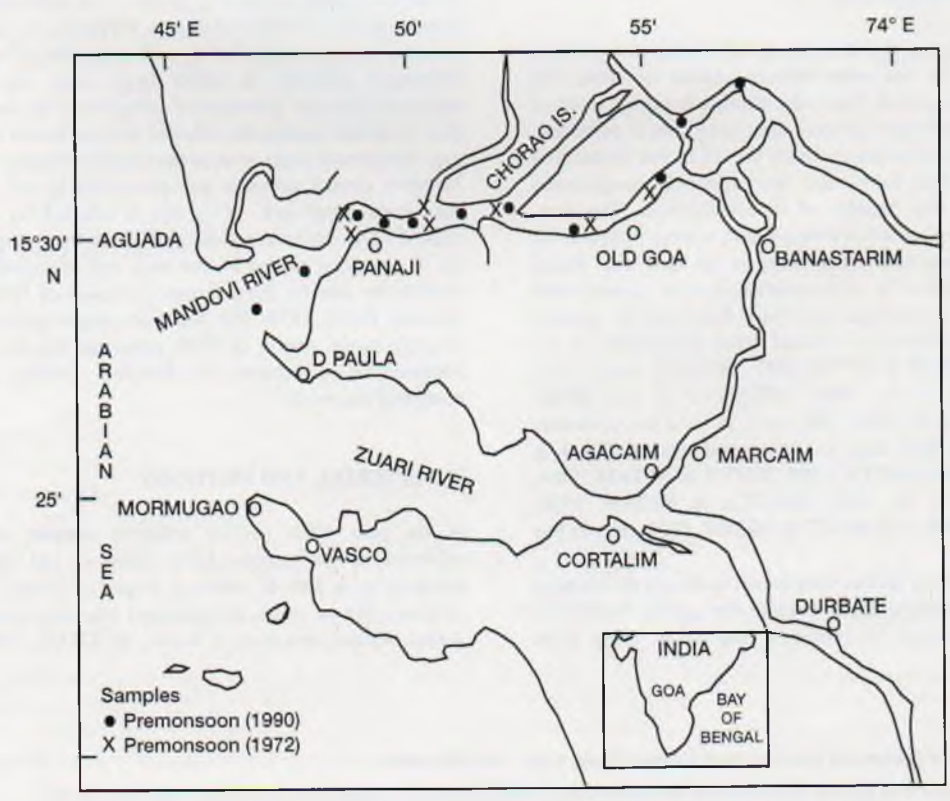
In order to carry out foraminiferal investigations, small volume of each sample was first kept in the oven for drying at 60ºC temperature for 1-2 days. The dried samples were soaked in water for overnight and next day hydrogen peroxide was added and kept overnight to disintegrate organic matter present. Similarly to disperse the lumps of clay present in the samples, sodium hexa meta-phosphate was added and kept overnight. Samples were washed through 63 μ sieve using a slow shower with low water pressure to prevent foraminiferal test breakage. A small fraction of the dried sediment sample was weighed and approximately 300 foraminiferal specimens (100 in few samples from upper reaches having rare fauna) from each sample were picked by moist brush. The percentage abundance of all the species in each sample was computed and total foraminiferal numbers were standardized to 1 gram.

For comparison, data was taken from published Report of RAO (1974), which was based on samples collected in 1972 during premonsoon season from the same area (Fig. 1).

III. PHYSICAL SETTING OF THE STUDY AREA

Geologically the state of Goa forms part of the Karnataka craton of the south Indian shield, and is mostly covered by the greenschist facies of metamorphic rocks of Archaean-Proterozoic age, except where the Decan traps cover a small area along the northeastern border of Goa. These rocks are covered by thick layer of laterite formed during Recent to Sub-Recent time, covering most of the region. The important drainage channels are Mandovi and Zuari. The numbers of navigable perennial rivers and streams have rendered

Fig. 1: Location of samples.



the economic exploitation of mineral wealth, as these rivers form the main transport network for the iron ores. Climate is humid tropical with moderate temperature, because of nearness to the sea. The annual average rainfall in sector 23 of the meteorological subdivision of India (in which Goa is included) is 253 cm (PARTHASARATHY *et al.*, 1995). However the annual average rainfall for the Goa region is 276 cm. Most of the rain is received during the southwest monsoon from June to September.

IV. RESULTS

The study of premonsoon samples revealed the occurrence of 14 species of foraminifera. Of these, Rotaliidae and Elphidiidae families are the most dominant, represented by 5 species (20.68%) each. Of the remaining, 2 species belong to Nonionidae and 2 species to Trochamminidae. These species are *Ammonia sobrina, Ammonia tepida, Asterorotalia dentate, Asterorotalia inflata, Elphidium articulatum, Elphidium crispum, Elphidium incertum, Elphidium minutum, Florilus scaphum, Nonion boueanum, Nonion elongatum, Rotalidium annectens, Trochammina globigeriniformis var.pygmaea* and *Trochammina inflata.*

V. DISCUSSION

Fortunately foraminiferal data based on samples (only for premonsoon season) collected about 18 years ago is available (RAO, 1974). This give us an opportunity to compare premonsoon data of samples collected in 1972 with our present data based on 1990 collection and probe foraminiferal response to changing environment in Mandovi river. While comparing we found that out of 32 species of foraminifera recorded by RAO (1974) from the Mandovi-Zuari estuarine complex, only 18 species were present in Mandovi estuary sediments. However, only 14 species (as mentioned above) were found in present investigation in premonsoon samples. This comparison reveals that there is a decline in total species number (TSN) from 18 to 14 during a time gap of 18 years (1972-1990). Similarly, the estimates of total foraminiferal number (TFN) in 1 gm of dry sediment also show a considerable decline. Combining the data given in table 2 (percentage of sand) and 3 (total foraminifer in 100 gm wet sample) of RAO (1974), TFN in 1 gm of dry sediment revealed a variation from 10 to 139 specimen/gm. Whereas, only 2 to 42 specimen/gm were recorded in the present investigation. Therefore, decline in TSN and TFN need to be explained. Some of the changes in TSN may (or may not) be due to development in taxonomy. However, change in environment over the years only can bring change in TFN.

Absence of any specimen of planktonic foraminifers in surveys, based on samples collected in 1972 and 1990 eliminates the possibility of large scale onshore transport of foraminiferal specimens in the study area.

One possibility for decline in quality and quantity of foraminiferal population could be sediment dilution - the number of foraminifer produced each year may not have changed but the volume of the sediment has markedly increased. However, if the volume of the sediment has increased markedly, considerable shallowing of the estuary should reflect the same. Bathymetric records do not show any such phenomena. No dredging was also made during the period under consideration.

Climatic changes also affect the quantity and the quality of foraminiferal fauna. The most important factor in this region is monsoonal rainfall. The annual rainfall preceding the years of collection (1972 and 1990) are 258 cm and 263 cm. Therefore, this factor may not be very important for the period under consideration as variation is less than 2%. The 10% variations with average of 276 cm are considered as normal rainfall for this region.

The most probable reason for the decline in fauna can be visualized in terms of an increase in suspended load due to mining activities in this area (Fig. 2). Extraction of one tonne of export quality ore generates about 1.5 to 4 tonnes of mining rejects and over the years, more than 1 billion metric tonnes of mining rejects are estimated to have accumulated in mining belt of Goa (NAYAK, 1994).

Due to heavy southwest monsoon rains, part of the mining rejects is washed into the sea through rivers. Thus with increasing mining activity, large part of the mining rejects result in a considerable increase in suspended load. The data of the suspended load recorded in 1972 (2 to 4 mg/ l) and in 1982 (4.5 to 8 mg/ l) by PARULEKAR *et al.* (1986) and in 1990 (6.69 to 114.49 mg/ l) by BUKHARI (1994) showed a considerable and continuous increase in suspended load in water of Mandovi estuary during the last 18 years (Fig. 3) and thus confirmed the postulation about the mining effect. The increase in suspended load creates turbidity like environment leading to reduction in light penetration and finally affecting foraminiferal population. Earlier studies also reported the adverse affect of high suspended load on foraminiferal population (NIGAM, 1984). Unusual benthic foraminiferal patterns off the Cameroon coast, Africa, were also attributed to influence of turbid river water, which increased the amount of suspended material in the water (BERTHOIS *et al.*, 1968). Similar is the case for our area of investigation. Some workers noticed morphological abnormalities in foraminiferal specimens

Fig. 2: Mining activities in the area surrounding the sampling locations in the Mandovi estuary.

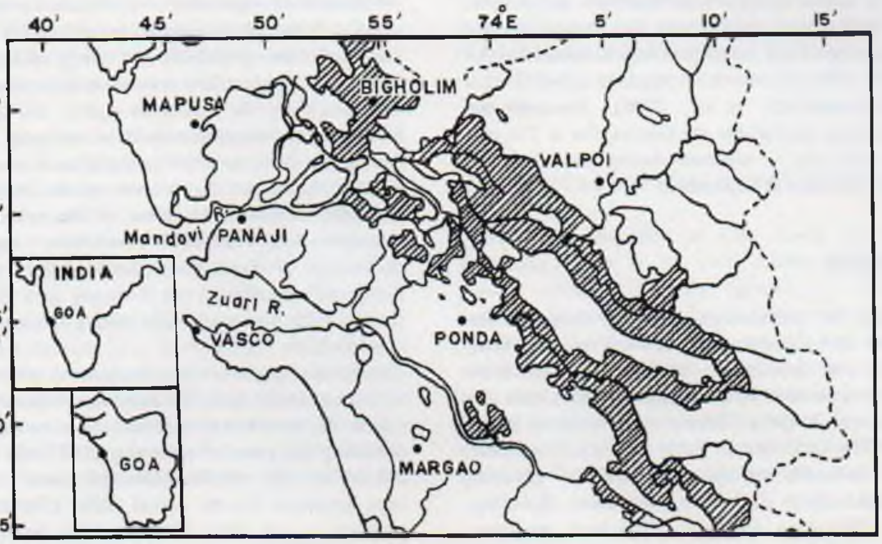
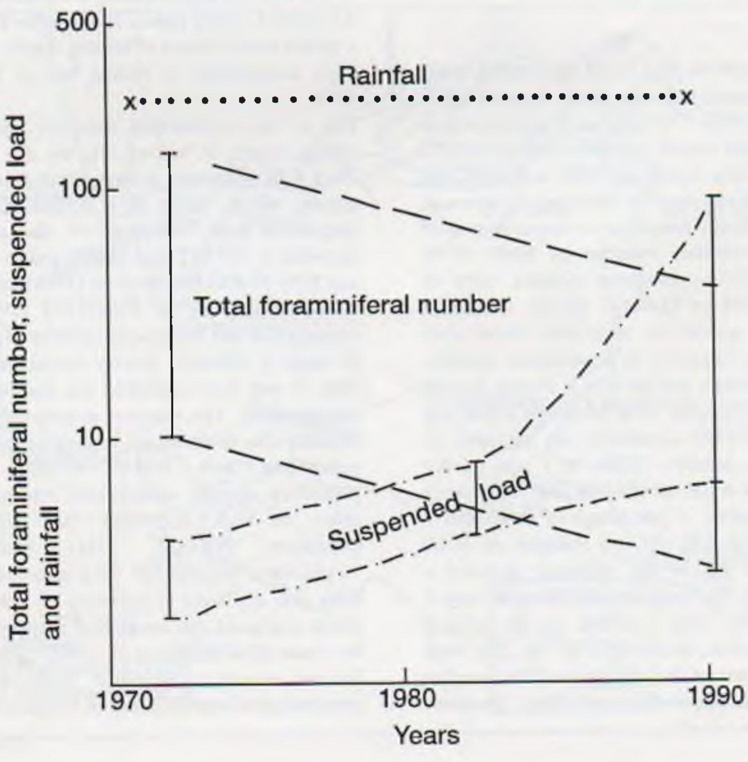


Fig. 3: Variations in total foraminiferal number (TFN) in 1gm of dry fraction (>63μ) surface sediments collected in 1972 (RAO, 1974) and 1990 (this study); Suspended load (mg/ l) in Mandovi estuary for three (1972, 1982 and 1990) years [PERULEKAR *et al.* (1986)], and annual rainfall with reference to years of collection of sediment samples.



and attributed the same to "high salinity conditions and to changes in salinity' (DEBENAY *et al.*, 2001a) and "pollution" (BHALLA & NIGAM, 1986). In view of this, it would have been interesting to compare shape and size of specimens of foraminiferal population 20 years ago with those of today. However, due to non-availability of material collected earlier we restricted our approach to comparison of TSN and TFN.

In view of the foregoing discussion, it is surmised that decrease in the number of the foraminiferal specimen and species in the Mandovi river estuarine sediments during a time gap of 18 years may be considered as adverse effect of mining pollution. The study also indicates the utility of cataloging foraminiferal abundance in the areas where large-scale industrialization is likely to take place. Such data will be of immense use in deciphering extent and intensity of marine environmental pollution (if any) with reference to different type of industrialization.

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