

## Studies on Pollution Ecology of Foraminifera of the Trivandrum Coast

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Received 2 March 1978; revised received 27 September 1978

Analysis of sediment samples collected from the beach sand and from 5, 10 and 20 m of water depths along 3 traverses off Thumba, Trivandrum Titanium Plant (T.T.P.) and Sankhamugham revealed the occurrence of 85 species of Foraminifera belonging to 42 genera under 26 families. Based on taxonomic assemblages, 3 faunal groupings were recognized, viz. beach fauna at 0-1 m, nearshore fauna at 1-5 m and offshore fauna at 5-20 m depth. Total foraminiferal population sizes were higher in February and March than in December. In general, it was observed that the stations were independent of each other with respect to seasonal variations of foraminiferal abundance. Solution effect on the tests of Foraminifera was observed at the outfall area as well as on the polluted parts of the beach. The species diversity was relatively low at the T.T.P. site when compared to stations along Thumba and Sankhamugham.

Significant contributions to the taxonomy of benthic Foraminifera of the continental shelf of south-west coast of India have been made<sup>1-3</sup>. The present work forms part of the sponsored project "Oceanographic survey for effluent disposal and submarine pipeline route for the Travancore Titanium Products Ltd, Trivandrum" conducted by NIO during December 1976 to April 1977. The principal objectives of this study are: (i) to investigate distribution and abundance of foraminiferal species; (ii) to study monthly variations of total and living populations of Foraminifera; (iii) to ascertain relationship between foraminiferal assemblages and marine pollution; and (iv) to know the effects of industrial effluents on Foraminifera.

### Methods

Monthly collections of sediment samples were made from water depths of 5, 10 and 20 m along the 3 traverses at Thumba, T.T.P. (Trivandrum Titanium Plant) and Sankhamugham (Fig. 1) using Van-veen grab. Samples were washed on a 200-mesh sieve (0.063 mm mesh size) for counting and calculation of percentage occurrence of individual species of Foraminifera based on counts of 300 specimens. Also, sand samples (0-1 m) collected from the beaches were examined for Foraminifera. Live specimens were stained before sorting with rose bengal. In order to study the corrosive effect on the specimens of Foraminifera, obtained at the polluted sites, they were scanned by an electron microscope [Cambridge Stereoscan Model S4-10].

### Hydrography

Both surface and littoral currents along the Trivandrum coast were studied in order to trace the dispersion trends of the effluents<sup>4</sup>. Coastal surface currents were weak and showed southward movement during February to April 1977. From January to March 1977, the littoral currents had a southerly drift and the effluents were traced up to Sankhamugham. At other times, they moved towards north up to Thumba. The polluted patch had a width of about 0.5 km seaward from the shore.

Salinity of the surface waters at the stations covered ranged from 34.38 to 34.9‰ and temperature from

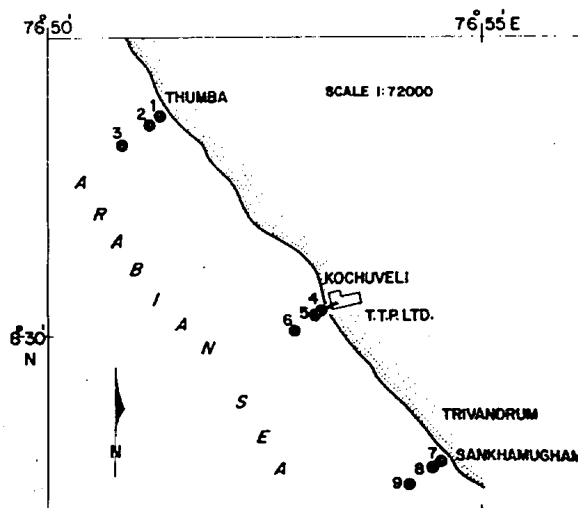


Fig. 1—Location of sampling stations

28.8 to 29.4°C. There was not much variation of these parameters during the period of collection of samples and their influence on the distribution of foraminiferal assemblages was not significant.

Temperature of the effluent as it came out of the factory, was about 45.8°C. At the region where the effluent mixed with the sea water on the shore it was about 36°C, and at the surf zone it was 29.1°C. Salinity of sea water at the site where the mixing with the effluents occurred was about 26.64‰.

pH of the effluent at the point of discharge was 1.4. In the vicinity of outfall area pH of sea water was 2 and seaward, away from discharge point, pH of sea water was > 7.5.

### Results and Discussion

Eighty-five species of Foraminifera belonging to 42 genera under 26 families were identified. The percentage occurrence of individual species in total populations at the 9 stations for the 5 months was calculated. The abundant species along the coast were: *Miliolids*, *Elphidium* spp, *Neoconorbina patelliformis*, *Ammonia beccarii* (variants), *Operculina ammonoides*, *Amphistegina radiata*, *Nonion asterizans*, *Hanzawaia concentrica*, and *Hyalinea balthica*, and species which were rare being *Textularia candeiana*, *Trochammina nana*, *Clavulinoides jarvisi*, *Spiroloculina lucida*, *Sorites marginalis*, *Bolivina tortuosa*, *Legena pertucida*, *Rosalina concinna*, *Spirillina vivipara*, var. *runiana*, *Elphidium poeyanum*, *E. hispidulum*, *Cibicides cicatricosus*, *C. lobatulus*, *Planorbulinella larvata*, *Nonionella pulchella*, *Nonionella* cf. *grateloupi*, and *Gyroidina neosoldanii*.

**Distribution of total population**—The number of foraminiferal specimens per gram of dry sediment varied from 120 to 7720 showing consistently high values at stations 2, 5 and 9 particularly during December to April. Live specimens were more abundant at stations 2, 3, 6 and 9 when compared with stations 1, 4, and 7. No marked seasonal variations were noticed at stations 1, 3, 4 and 7 (Fig. 2 A). There was a general decreasing trend of Foraminifera in the offshore areas, except at station 9, with the increase in depth. Resig<sup>5</sup> and Cockbain<sup>6</sup> had also observed a similar trend.

Changes of the most abundant species which form the greater part of the total population are shown in Fig. 3. Miliolids are relatively less at the outfall area (station 4) in December and January and highest in March at station 3. There was gradual increase in concentration of miliolids away from the outfall area (with depth) along the traverse of T.T.P. *Ammonia beccarii* variants attained maximum population in January at stations 2 and 5. These forms, in contrast to miliolids, are pollution tolerant and decreased in

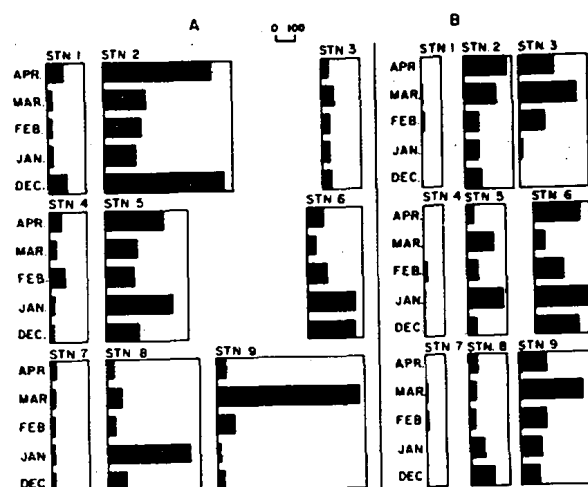


Fig. 2—Distribution of total (A) and living (B) populations of Foraminifera during December to April [Values indicate number of specimens/g dry sediment in A and number of specimens/g wet sediment in B]

abundance away from the shore along the transect of T.T.P. Another form, *Neoconorbina patelliformis* showed maximum abundance in April at station 1 and was almost absent at the site of outfall during the study. *Elphidium* spp and *Nonion asterizans* reached maxima in December and the abundance of the latter was comparatively poor along the traverse of T.T.P. *Operculina ammonoides* indicated maximum population at station 3 in December and January and the population of this species was somewhat poor along the traverse of T.T.P. The larger foraminifer, *Amphistegina radiata* increased in concentration at station 6 in December and the large sized foraminifers of this species were found in the offshore areas away from the region of outfall. The shallow water foraminifer, *Hanzawaia concentrica*, showed maximum population in April at station 5. *Hyalinea balthica* showed increased frequency at stations 1 and 4 in February at 5 m depth. Faunal abundance was independent of others with respect to monthly changes.

**Distribution of living populations**—Living individuals were sporadic in their occurrence along the coast up to a depth of 5 m. As in the case of total population, living population also showed increase in abundance at some of the stations during February to April as compared to December (Fig. 2B). Living population increased in the offshore areas away from the T.T.P. discharge site (station 4). The most common living species along the coast were *Quinqueloculina seminulum*, *Bolivina nobilis*, *Ammonia beccarii* variants, *Operculina ammonoides*, *Elphidium advenum*, *E. crispum* and *Nonion asterizans*.

**Faunal groupings**—Based on characteristic assemblages of Foraminifera, 3 faunal groups have been recognized, viz. beach, nearshore and offshore fauna which could be included in the respective depths of 0-1,

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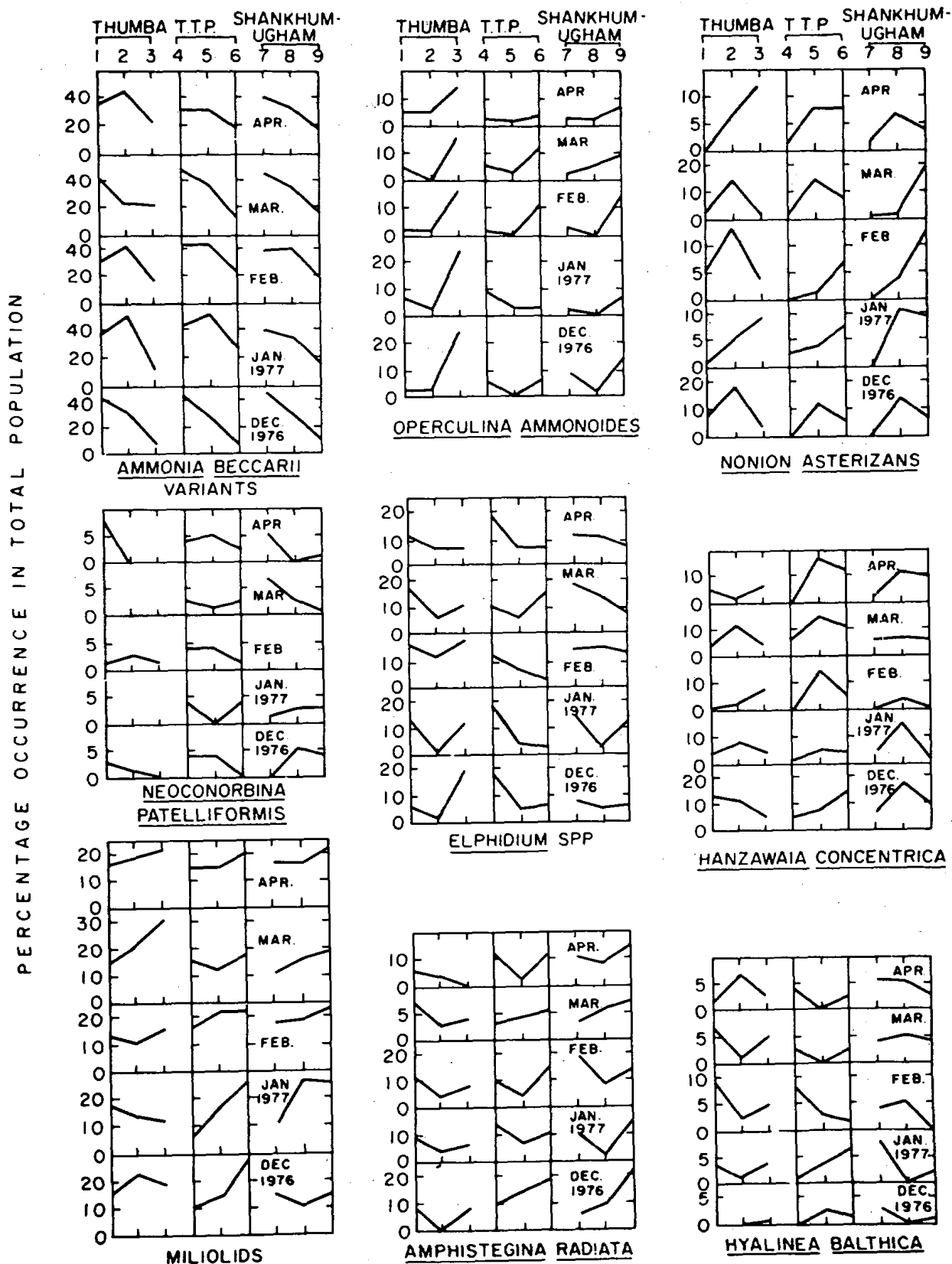


Fig. 3—Monthly distribution of abundant foraminiferal species in total population

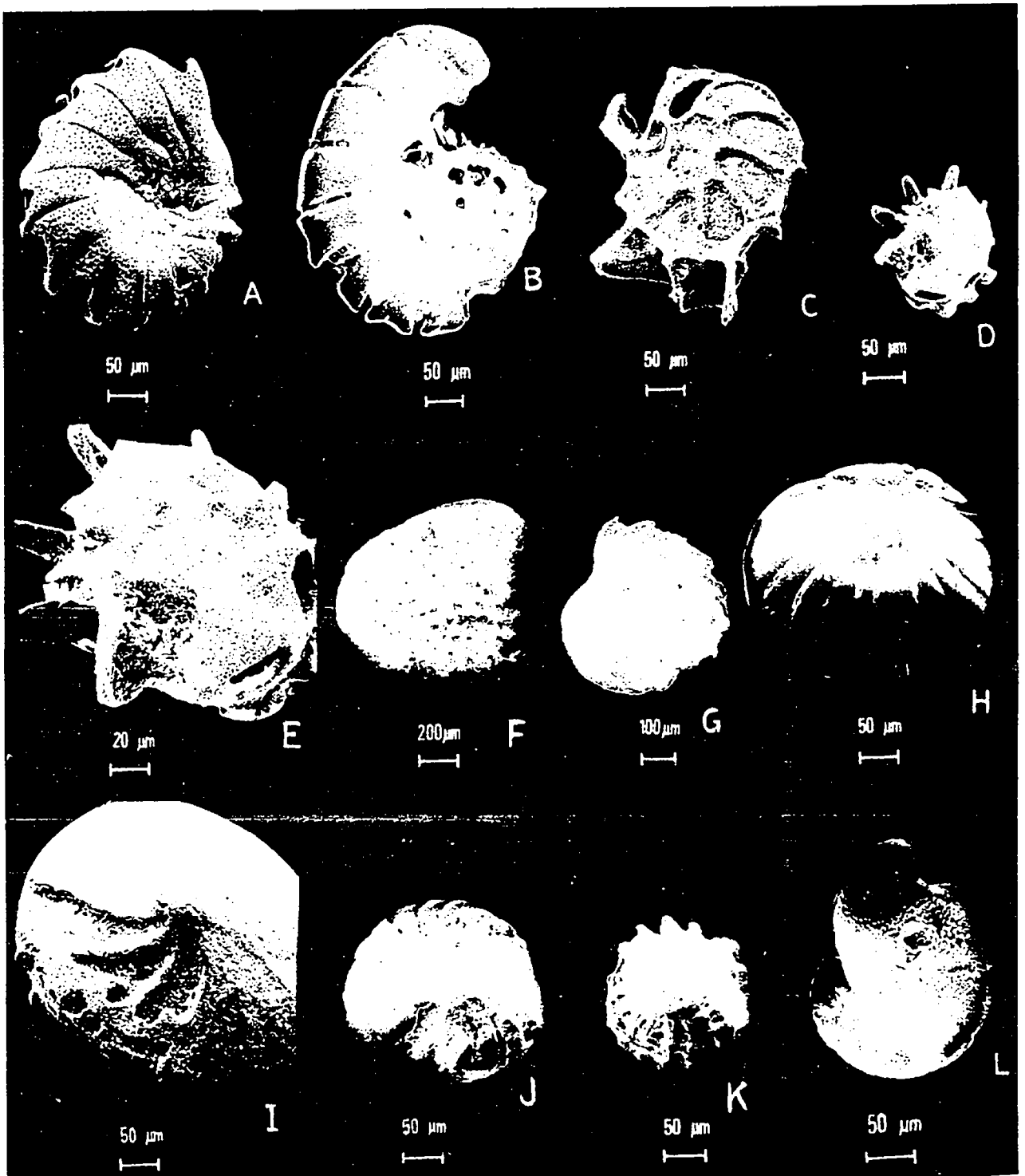


Fig. 4—Solution or corrosive effect shown on the surface of calcium carbonate foraminiferal tests by the acid wastes discharged from T.T.P. at the outfall area [A, *Peneroplis pertusus* (Forskal); B to E, *Ammonia beccarii* (Linne) variants; F, *Operculina ammonoides* (Gronovius); G, *Elphidium crispum* (Linne'); H, J & K, *Elphidium craticulatum* Fichtel and Moll; I, *Amphistegina radiata* (Fichtel and Moll); and L, *Hanzawaia concentrica* (Cushman)]

1-5 and 5-20 m. Similar faunal zones were defined by Todd and Bronnimann<sup>7</sup>. While the substratum of the nearshore region is mostly sandy, the sediments of the offshore region are either silty sand or sandy silt.

Beach fauna: It includes the dominant species

*Ammonia beccarii* variants, *Poroepionides lateralis*, *Elphidium crispum*, *E. discoidale*, *E. craticulatum* and *Amphistegina radiata*, and the rare species *Operculina ammonoides*, *Peneroplis pertusus* and *Hanzawaia concentrica*. The specimens were in good state of

preservation in the sand samples collected from Thumba and Sankhamugham but the surface of the test had been corroded or solution effect was seen in the case of specimens sorted from the material of polluted beach of Kochuveli where T.T.P. is located.

**Nearshore fauna:** This zone was characterized by the presence of forms like *Quingueloculina seminulum*, *Q. vulgaris*, *Neoconorbina patelliformis*, *Ammonia beccarii* variants, *Operculina ammonoides*, *Elphidium advenum*, *Amphistegina radiata* and *Nonion asterizans*. The presence of some offshore forms like *Lagena*, *Textularia* spp and planktonic Foraminifera could be attributed to the action of bottom currents and wave action.

**Offshore fauna:** Species diversity was relatively high in this zone as compared with other environmental zones of the coast and had a distinct assemblage of Textulariidae, Miliolidae, Soritidae, Nodosariidae, Bolivinitidae, Buliminidae, Rotaliidae, Elphiidae, Globigerinidae, Nonionidae and Anomalinidae.

**Foraminifera as related to pollution**—Foraminiferal studies concerned with marine and estuarine pollution in India and elsewhere were reported<sup>8-17</sup>. In the present study, an attempt was made to note the effects of industrial effluents on Foraminifera. It was observed that the nearshore waters of the Kochuveli beach were very much polluted due to the daily discharge of effluents in large volumes (1600 m<sup>3</sup>/day) from T.T.P. The main constituents of effluents are sulphuric acid and ferrous sulphate, besides suspended material.

Near the acid waste dumping area and also on either side of the runnel formed on the beach by the effluent, flecks were observed with low pH values ranging from 1.4 to 2.5. No Foraminifera were found in the sand material beneath the acid fleck.

In order to study the effects of industrial effluents on Foraminifera, samples were collected from the polluted beach, stagnant pools on the beach formed by the effluents and also at the outfall area. Due to acid wastes along the coast the surface of the tests of Foraminifera was corroded. This was observed in the scanning electron-micrographs of Foraminifera specimens (Fig.

4). Some of the tests had chalky appearance, suggesting solution effect on their calcium carbonate content. Number of species was relatively less at the outfall area (station 4) as compared with the unpolluted sites (stations 1 and 7) at the same depth. The polluted sites near the vicinity of T.T.P. showed definite adverse effects on Foraminifera fauna and thus, as stated by Bandy<sup>13</sup>, provided an ideal means of demonstrating relationships between marine animals and ocean pollution.

#### Acknowledgement

The authors are grateful to Dr S Z Qasim, Director, for facilities and to Dr D Lal, Director, and Dr B L K Somayajulu, Scientist, Physical Research Laboratory, Ahmedabad, for providing facilities for taking SEM photographs and to Mr V G Shah of PRL for operating the scanning electron microscope. Thanks are due to Shri Babu Paul, Managing Director and Dr V S Vijayan Nair, Works Manager of T.T.P. (Ltd), for their cooperation and interest. Financial support for this study was provided by T.T.P., Trivandrum.

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