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BENTHIC FORAMINIFERA AS POLLUTION INDICES IN THE MARINE ENVIRONMENT OF WEST COAST OF INDIA

M. G. ANANTHA PADMANABHA SETTY & RAJIV NIGAM

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Abstract. Two ecosystems affected by acidic pollutants (Thana Creek, Bombay and inshore area of Trivandrum, Kerala) and two other ecosystems affected by alkaline pollutants (Cola Bay, Goa and inshore area of Karwar, Karnataka) were studied for pollution effects monitoring through Foraminifera. In the Thana Creek area, Bombay, the magnitude of corrosive effect, lower–than–normal ornamentation, deepening of grooves and sutural thickenings, enlargement of pores, widening of apertures in Foraminifera were taken as indices of pollution effect. In the Cola bay area, Goa, the environment becomes hypertrophic resulting in large–sized, robust, mostly megalospheric forms of *Ammonia. Elphidium* and *Florilus scaphum* are recorded at the proximal zone near the discharge point; miliolids in the transitional zone and dominantly smaller–sized *Nonionella, Fursenkoina pontoni, Bulimina marginata* at the distal zone quite far from the discharge point where pollutants are diluted and dissipated. In the Karwar area, Karnataka, pollutant causes reduced diversity with a decrease in foraminiferal population. Moreover, there is a reduction in size followed by test wall thinning in *Nonion* and *Ammonia*, increase of agglutinated forms near shore, and dispersal and dilution of the pollutants resulting in foraminiferal abundance. In the Trivandrum area, Kerala, the effluent effect presents morphological anomalies (*Operculina, Cibicides*), erosion along peripheries, induced growth in last few chambers, inferred dissolution and consequent destruction of small, thin–walled forms suggested by their absence, thus leaving only the larger ones in the entire area. Living/dead ratio is negatively oriented at all sites.

Introduction.

Foraminifera cannot remain insensitive to environmental deterioration. Sensitivity of Foraminifera is highly variable and is related to the type and nature of pollutants. Some effluents may cause abiotic conditions at the site of discharge and its immediate vicinity causing adverse conditions resulting in total destruction of some of the sensitive biota while other effluents induce hypertrophic conditions and high productivity. Hence diversity is used as a tool for assessing the degree of adverse effects of pollution. An estimation of the degree of pollution of an area can be attempted by comparing a quantitative faunal data with the known time integrated data of the Most Recent top

— National Institute of Oceanography Dona Paula, Goa, 403 004, India.

layer of the bottom sediment. Further, the living/dead ratio of the benthic fauna establishes a clear definition of the zones affected by pollution. Benthic Foraminifera serve as good indices, hence are considered very useful in assessing the effects of pollution in the marine environment.

The term "pollution" has different definition (e.g. McKee, 1967, Cronin & Flemer, 1967). According to Wass (1967) the U.S. President's Advisory Committee stated that, "Environmental pollution is the unfavourable alteration of our surroundings, wholly or largely as a byproduct of man's action, through direct or indirect effects of changes in energy patterns, radiation levels, chemical and physical constitution and abundance of organisms". In this paper the term "pollution" is used with this significance.

Two ecosystems affected by acidic pollutants namely Thana Creek, Bombay and inshore area off Trivandrum, Kerala; and two other ecosystems affected by alkaline pollutants namely Cola bay, Goa and offshore region off Karwar, Karnataka form the study areas for monitoring the relative sensitivity of tolerance of biota but particularly through Foraminifera.

Laboratory methods.

Several grab samples were collected from each study area at close intervals from regions proximal to the discharge point and the surroundings, and spread out radially into the sea towards the distal end. The number and spacing of stations depends upon the amount and nature of pollutant discharged, location of discharge point, depth, and current pattern at each site. A Van Veen grab is gently lowered and with extreme care the substrate is sampled. On retrieving the sampler to the deck, temperature of the sediment is measured immediately by inserting a thermometer through one flap opening and recorded, while through the other flap, a graduated plastic liner tube of 38 mm diameter is inserted. The trapped water (of the sediment water interface) and three centimeters of the topmost layer are collected in the liner. Now by closing firmly with the palm of the right hand the sample containing tube is carefully lifted by the left hand and held over a flat bottomed container/large petridish. By gently lifting this tube and by careful manipulation of letting the air through the tightly held right palm, two centimeters of the trapped sample is carefully extruded and cut out using a clean knife or spatule. This fraction is later transferred to a sample jar. Next the topmost one centimeter of the sediment and the overlying water still left in the liner are transferred to another sample jar. The one centimeter sediment sample is dyed with 10 ml of rose Bengal (Walton, 1952) to stain and preserve the living. Then 25 ml of 10% formalin is added to both the fractions to preserve the living. The rose Bengal stained material was processed in the laboratory within a few days after collection.

While the topmost one centimeter layer sediment gives the living/dead ratio with other parameters like nature of the substrate, temperature, depth, pH, oxygen content and information of the present ecosystem (at the time of collection), the 2 cm layer sediment presents the diversity and total foraminiferal ratio of dead populations immediately Before the Present (BP) and the consequent ecosystem prevailing at the time of its deposition. The comparison of the two assemblages unfolds the differences of the faunas and the cause/effect relationship of the normal marine environment on the one hand and the enforced (pollution induced) modified environment of the Present.

Thana Creek, Bombay region.

Thana Creek is a small fresh water stream which empties into the Arabian Sea at Bombay. Both banks of the creek, are crowded with several types of industries whose effluent volume and load discharge are high though variable (Fig. 1–A). This fresh water creek flooded with several kinds of pollutants is subject to periodic influences of tides from the Arabian Sea. There is low inflow of fresh water which coupled with pollutants and high organic carbon content (1.19 to 1.60%) causes the pH of the water to turn acidic in the upper reaches. The pH gradually decreases downstream and turns alkaline near the harbour by mixing with tidal «fresh» sea water. This condition alters gradually (due to tidal effect) from the upper reaches to the harbour area (Fig. 1–A, sta. nos. 1–4). The sediment is very fine–grained, mostly clayey, dark to steel gray when wet, thick and very sticky.

In the upper reaches of the Creek where the water is highly polluted, calcareous Foraminifera are very small, dull looking, and highly corroded while the agglutinants become dwarfed or stunted. Large–sized, well preserved Foraminifera are rare, but if present, they are fragmented, pitted, and worn out due to transport and occur in various stages of dissolution. Living Foraminifera are totally absent (Setty, 1982).

The corrosive effect on the Foraminifera is manifest in such morphological modifications as thinning (of the test), diminishing of ornamentation (such as knobs and pustules), reduction of spines and keel due to dissolution, deepening of grooves and reduction of surface thickenings (as seen in *Ammonia* sp.), widening of apertures as in some miliolids, and sharper and more profound thinning effect on the last chamber as in *Nonion, Nonionella, Florilus* and *Fursenkoina* sp. These effects are due to highly toxic, unfavourable and hostile environment created by the effluent discharge and post–depositional post–mortem solution effect. It is observed that some dead Foraminifera are transported in the tidal waters up the creek, but by chance if there are any living ones carried by the tide they will soon die off. Further, the character of the substrate is inhibitive to encourage benthic productivity or let survive any standing crop in the region, as the substratum is layered with solid wastes and nonsoluble rejects from the factories (Setty, 1982).

This toxic environment soon changes towards the harbour where it is marked by abundant Foraminifera, high diversity, better preservation and marked decrease in dissolution and destructive effect on the tests. This proves that Foraminifera are very good indicators of pollution effect in the marine environment.

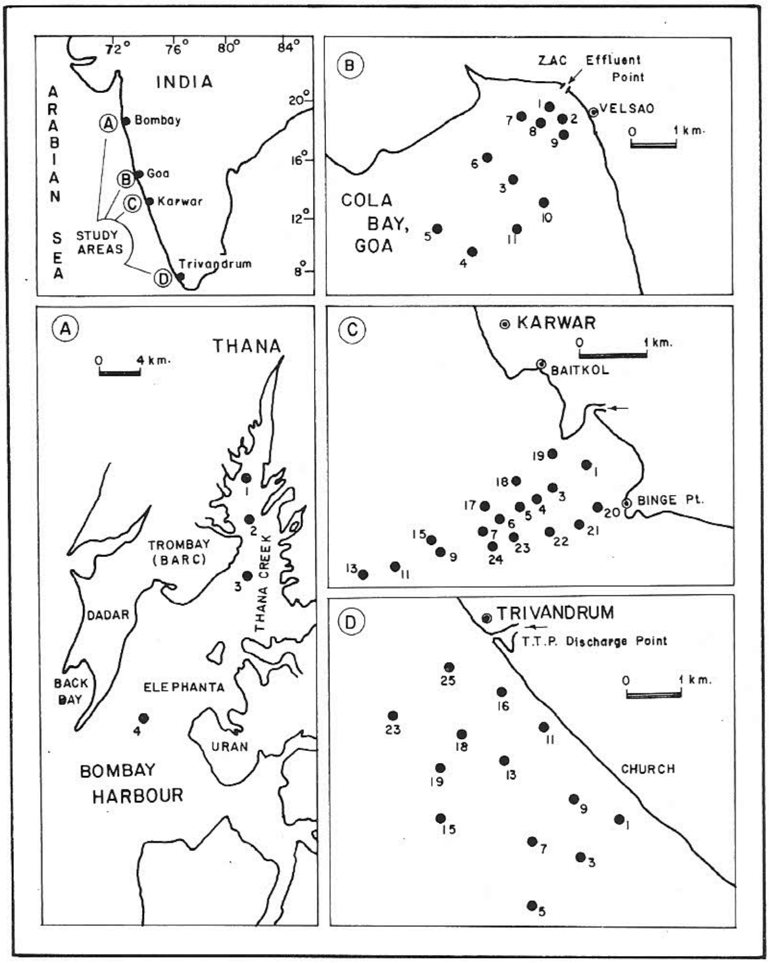

Fig. 1 – Location map of pollution study areas along the west coast of India. A) Thana Creek, Bombay region; B) Cola Bay, Goa region; C) Inshore region of Karwar, Karnataka; D) Inshore region of Trivandrum, Kerala.

Cola Bay, Goa region.

This bay (Fig. 1–B) is characterized by a sandy apron followed seaward by clay and a patch of silt. The effluent discharge point of a fertilizer factory is connected from the shore to a downsloping channel in the bed of this bay. This factory discharged hot ammoniacal waters containing a high percentage of arsenic in it. The organic carbon content in the top sediment layer varies from 0.09 to 3.98%. Twelve out of the 25 species identified from the topmost 1 cm layer were found to be living at the time of collection (Setty, 1976). The area adjacent to the channel is dominated by *Ammonia – Elphidium – Florilus* suite of species. Not only they tolerate pollutant influx but appear to be encountered to thrive well having large populations in the modified environment as evidenced by their thick–shelled, large–sized megalospheric, robust and many chambered forms near the effluent discharge; but yet they show some signs of pollution effect.

Ammonia annectens, Florilus scaphum, F. boueanum, Elphidium crispum, and *Pararotalia* sp. are very abundant at or close to the effluent discharge point and also along the downslope channel. The increase in the foraminiferal number is directly attributed to the increase in the nutrients provided by the pollutants (Setty & Narayanan, 1979). Similar conclusions were drawn by Watkins (1961) from his study around Orange County, California. The dominance is several times magnitude here than elsewhere which shows their ability to compete successfully to an extent of total exclusion/elimination of other species (Setty, 1976). This is considered to be a pollution effect which is a positive result for these species.

The agglutinated species (*Miliammina fusca, Textularia agglutinans* and *Trochammina* sp.) and *Gavelinopsis complanata, Brizalina striatula, Gyroidinoides* sp., *Nonionella* sp. and *Cibicides* sp. are less tolerant but become abundant only at the distal end where toxicity of pollutant is made ineffective by dilution, dispersion and distance from the discharge point. This indicates that foraminiferal response to the effects of effluents is clearly negative hence inhibited. The foraminiferal abundance trends normally parallel to the shoreline as observed by Bandy et al. (1965) in California but here it is more radial to the discharge point than parallel to the shore line.

Inshore region of Karwar, Karnataka.

The effluent outfall of a caustic soda and chlorine complex plant is through a small creek, which enters the sea at a point between two small promontories known as Baitkal and Bhinge points, south of Karwar town (Fig. 1–C). A total of 24 samples were collected from various substrates: clay substrate at stations 2 to 16, 18 and 20 – 23 whose depth ranged up to 15 m, and sand (sta. no. 1) up to 8.3 m; sandy clay (sta. nos. 17, 19 and 24) interspersed between 8 – 12 m depth. These samples were spread out from a sandy shore to about 6 km into the open Arabian Sea.

The effluent discharge is alkaline and the organic carbon content of the substrate ranges from 0.50 to 3.63% . The resulting effect on the Foraminifera is a drastic fall in number of species and foraminiferal population. These parameters increase at the farther end being due to dilution and dispersion of the pollutants.

Further, the size of the individual specimen as seen in *Florilus boueanum, F. scaphum, Ammonia sobrina, A. annectens, A. tepida* and a few others, is reduced at and near the discharge area and the transitional zone; but at the distal end their size resumes normal and the total foraminiferal content also increases. Bhatia and Kumar (1976) had reported that *F. scaphum* constitutes as much as 58.95% of the population in this region. This condition no longer prevails beyond 15.36% (max.) since the erection of the Plant as this taxon is adversely affected by pollution today.

Nonionella sp., *Bulimina exilis*, and *Brizalina striatula* are extremely rare where the organic carbon content in the sediment increases as at sta. nos. 3 – 5, and 18 – 23. Miliolids (*Quinqueloculina curta, Q. seminulum, Spiroloculina antillarum* and *S. scita*) are confined to sandy substrate but the calcareous tests are scattered (to rare) in other substrates. The agglutinated species (*Ammobaculites agglutinans, Trochammina inflata,* and *Eggerella advena*) are restricted to areas nearer the creek where estuarine conditions prevail. *Eggerella advena* and *Trochammina pacifica* seem to favour the modified environment as evidenced by their large size (Plate 32), increased number and direct proportionality to high organic carbon content in the sediment. Earlier, Bandy et al. (1965) and Schafer (1970) made attemps to establish the relationship between organic carbon present in the sediment and foraminiferal assemblage in it. It is observed that certain levels of organic carbon as a pollutant may favour certain species of Foraminifera while the same level prove lethal to others (Setty & Nigam, 1982).

Ammonia sp. and its variants are in their peak of abundance nearer the discharge point irrespective of the amount of organic carbon present in the substrate. Among these *Ammonia tepida* and *A. sobrina* followed by *A. annectens* form the major constitutents. Next in abundance are *Eponides tenera, Florilus scaphum, F. boueanum, Pararotalia nipponica, Pseudoeponides nakazotowensis, Eggerella advena, Ammobaculites agglutinans* and *Trochammina inflata* in order of decreasing importance.

At the vicinity of the discharge point, *Elphidium indicum, E. minutum, E. advenum, Asterorotalia dentata, Nonionella* sp. and *Bulimina exilis* are not present. In the transitional zone *Nonionella* sp., *Florilus boueanum, F. scaphum,* and *Pararotalia nipponica* are present. *Ammonia* sp. is however concentrated to nearly 52 – 75% in this zone.

In the distal zone, *Brizalina striatula, Bulimina exilis, Florilus grateloupi, Lagena leavis, Pseudoeponides nakazotowensis, Quinqueloculina laevigata,* and *Q. seminulum* are dominant.

Inshore region of Trivandrum, Kerala.

A titanium processing plant near Trivandrum, discharges hot, acidic effluent (a mixture of sulphuric acid, soluble iron and other metallic salts, with suspended particles of sand and some titanium dioxide) into the surf zone (Fig. 1–D). The effluent is highly acidic – (ph varies between 0.8 – 1.00); and hot (temperature 45 – 50°C) whereas the sea surface temperature is only 23 – 30°C and the weight of total suspended solids in the waste being 10 – 15 g/1 (a specific gravity of 1.01 to 1.02). At the present rate of production, it is estimated that the effluent discharge would be at least 4000 m^3/day. (NIO unpublished Report 1980). The effluent floats as a reddish brown coloured mass on the water because of the complex, soluble, multiphase and particulate matter in it. This coloured patch gives a spread of about 500 m wide and extends alongshore to a distance of 6 km to the south and about 8 km towards the north depending upon the wave/current pattern and season of the year. The nearshore bottom sediment is mostly sandy with shell debris, and its retention capacity for organic matter in the sediment is limited. Hence dispersal is chiefly by currents. Some observations on distribution of Foraminifera and pollution effects of this area were made by Rao and Rao (1979).

In this highly polluted area, living planktonic Foraminifera are totally absent. Among the benthics, only a very few species are present and invariably show morphological anomalies (Pl. 33, figs. 3, 6, 7). Morphological deformity or abnormal growth in some species caused by pollution effect was also observed earlier in other regions (Lidz, 1965; Boltovskoy & Boltovskoy, 1968; Wright, 1968, and Sieglie, 1971). The total population is very low which may be attributed to quick and continuous removal by dissolution of the dead tests. This accounts for the very low density of smaller benthic forms. Plate 33 shows that the larger Foraminifera (*Operculina, Amphistegina, Heterostegina, Borelis*) which appear to be abundant, show a high degree of corrosion, pitting, thinning due to digestion, enlargement of apertural faces and chamber walls, widening of sutural ridges, abraded ornamentation, total chalky appearance, smoothening of surfaces and rounded off angular terminals. The differential acidic action and dissolution of the test gives rise to various shapes and sizes resulting in some interesting sculptural features (Plate 32, fig. 23).

Some of the dead miliolids (*Quinqueloculina akneriana, Q. vulgaris, Q. pygmaea, Austrotrillina striata, Triloculina tricarinata, T. trigonula,* and *Spiroloculina planissima*) show chalky appearance, pitted chambers with gaping holes (Plate 33, figs. 24–36). Sometimes the solution effect is stronger at the curved ends. In the case of agglutinated miliolids and *Reophax* sp., the sand grains stand out prominently and precariously as a result of thinning and several stages of removal of calcareous cementing material. In case of pyritized *Textularia* the mould alone is present. In *Florilus* sp., *Nonion* sp., and *Nonionella* sp. the pores are widened and the last chamber is badly damaged due to digestion. In *Hanzawaia concentrica*, the last two chambers show aberrations by unusual enlargement and distortion in its coiling symmetry (Pl. 33, fig. 20). *Elphidium* is characterized by widening of its sutural flutes (Pl. 33, figs. 9 – 13).

Larger Foraminifera are common in the entire region. Some smaller and juvenile forms are believed to have been eliminated due to digestion while a few others show a high degree of fragmentation. Further, they show abrasion effects on the peripheries and wear as a result of digestion.

In teh transitional zone, the living forms make their first appearance. Among the living ones *Cibicides refulgens*, and *Elphidium opimum* exhibit induced growth in their last two chambers which become characteristically larger and broader than normal (a case of aberration). *Operculina complanata* adds four highly abnormal chambers at the end. The living forms of *Florilus* and *Nonion* are few, small and thin–walled. They rapidly disappear after death due to solvent action of diluted acidic waters. Among the recently dead forms, the corrosive action is less severe, but tends to result in breakage of the thin–walled tests, though wear and tear and solution action are much reduced. This suggests a post–mortem change. Partial solution and partial destruction of test wall is progressive here.

At the distal end, the foraminiferal population is mixed in having the living (in fairly good number), the *in situ* dead, the transported and the corroded forms. Normal populations with high productivity and biomic condition is restored here. Some of the planktonics begin to appear. This is suggestive of harmless or inert effect of pollutants due to travel time, increased degree of dilution, and dissipation.

Discussion.

It is thus well established that the species found in a given environment result from a complex set of interrelationships between many environmental factors of varying importance. Many researchers believe that temperature, salinity and sediment type are the major factors affecting the benthics in an environment. It is now recognized that the pollution parameters appear to be the principal factors affecting the foraminiferal diversity in regions where environment is altered (study areas). Changes in the species diversity index are related to levels of waste (pollutants) constituents in the sediment. Stores et al. (1969) have shown that high sediment concentrations of sulphide and a high index of putrecibility were associated with decreased benthic diversity as observed in San Francisco bay. The study areas reveal the following.

The levels of toxic wastes in disposals in all the areas studied are very high at the sites of discharge. It is found to be highly lethal resulting in mass die–offs in the upper reaches of Thana Creek, Bombay, and off Trivandrum, Kerala as the effluents cause a low pH and make the water more acidic. The chemical perturbations in these areas have an adverse impact and retardation (dwarfing) in growth. There is no biologic productivity and the transported dead fauna becomes corroded easily and quickly, dissolution effects on the smaller and thin–walled tests being quicker and faster. The bio–degradation is acute. The proximal region in all these regions is a major area of concern and the response relationship is unfavourable. The hardy and resistant larger forms showed morphological aberrations and sculptural distortions also. However, the alkaline discharge of pollutants at and near the unloading point at Cola bay, Goa and the inshore area of Karwar appears to stimulate some of the benthic fauna to develop and increase their monospecific population resulting in over–abundance and also to the detriment of others.

The dilution and dispersion in the buffer condition of sea water of the transitional zone of all the study areas appears to reduce the toxicity and digestive character of the acidic effluents, thus initiating conditions that favour productivity and decrease the destructive power. Similarly the highly vulnerable heterotrophic conditions which favoured only a few species changed to accommodate more species, thus allowing the species diversity to become expanded.

In the distal zone, the dilution and dispersal under the influence of currents assisted by the buffering effect of the sea water yields to more normal marine conditions irrespective of the type and strength of the effluent, finally giving rise to an equitable distribution of Foraminifera.

It is thus well established that benthic Foraminifera are very good indicators in monitoring the synergistic and antagonistic effects of pollutants and the vagaries in the stabilisation of marine ecosystem.

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PLATE 32

Plate showing effects of pollution on Foraminifera in inshore region of Karwar, Karnataka.

Fig. 1 – 8 – *Ammonia annectens* (Parker & Jones), showing various stages of pollution effects. 1, ventral view (x 39), development of large number of chambers in the outer whorl and dissolution effect in the last chamber (sta. no. 1); 2, dorsal view (x 39), destruction of surface ornamentation, sutures, chamber walls and chalky appearance (sta.no.4); 3, dorsal view (x 39), regeneration of last 4 chambers (sta. no. 19); 4–5, dorsal views (x 39) of relatively smaller young forms affected by pollution as in no. 2 (sta. no. 22); 6–8, dorsal views (x 39) showing pitting and destruction of test in various stages (sta. nos. 17 and 24).

Fig. 9, 10 – *Ammonia sobrina* Shupack; ventral view showing thinning of the test and erosion of ornamentation and smoothened surface; x 46 (sta. no. 1).

Fig. 11 – *Quinqueloculina seminulum* (Linné), showing pitting and smoothened wall; x 39 (sta. no. 1).

Fig. 12 – *Spiroloculina antillarum* d'Orbigny, showing pitting and thinning; x 46 (sta. no. 1).

Fig. 13 – *Quinqueloculina elegans* d'Orbigny, showing partial dissolution of last chamber; x 46 (sta. no. 19).

Fig. 14 – 21 – *Ammobaculites agglutinans* (d'Orbigny), showing abrasion of cementing material; x 46 (sta. no. 19).

Fig. 15 – *Ammonia tepida* (Cushman); side view showing chalky surface; x 39 (sta. no. 1).

Fig. 16,17,20 – *Trochammina inflata* (Montagu). 16, abnormal growth of chambers; x 39 (sta. no. 19); 17, damage to one of the chambers; x 39 (sta. no. 1); 20, ventral view showing double aperture; x 39 (sta. no. 1).

Fig. 18, 19 – *Trochammina pacifica* Cushman. 18, abnormal growth of one chamber; x 46 (sta. no. 19); 19, ventral view; x 46 (sta. no. 19).

Fig. 22 – *Florilus scaphum* (Fichtel & Moll), showing dissolution effect on chambers in the regenerated chambers; x 46 (sta. no. 24).

Fig. 23 – *Nonionella* sp., showing dissolution effect in the last few regenerated chambers; x 46 (sta. no. 17).

Fig. 24, 26 – *Florilus boueanum* (d'Orbigny), showing regeneration and abnormal growth in last few chambers; x 39 (sta. nos. 4, 5).

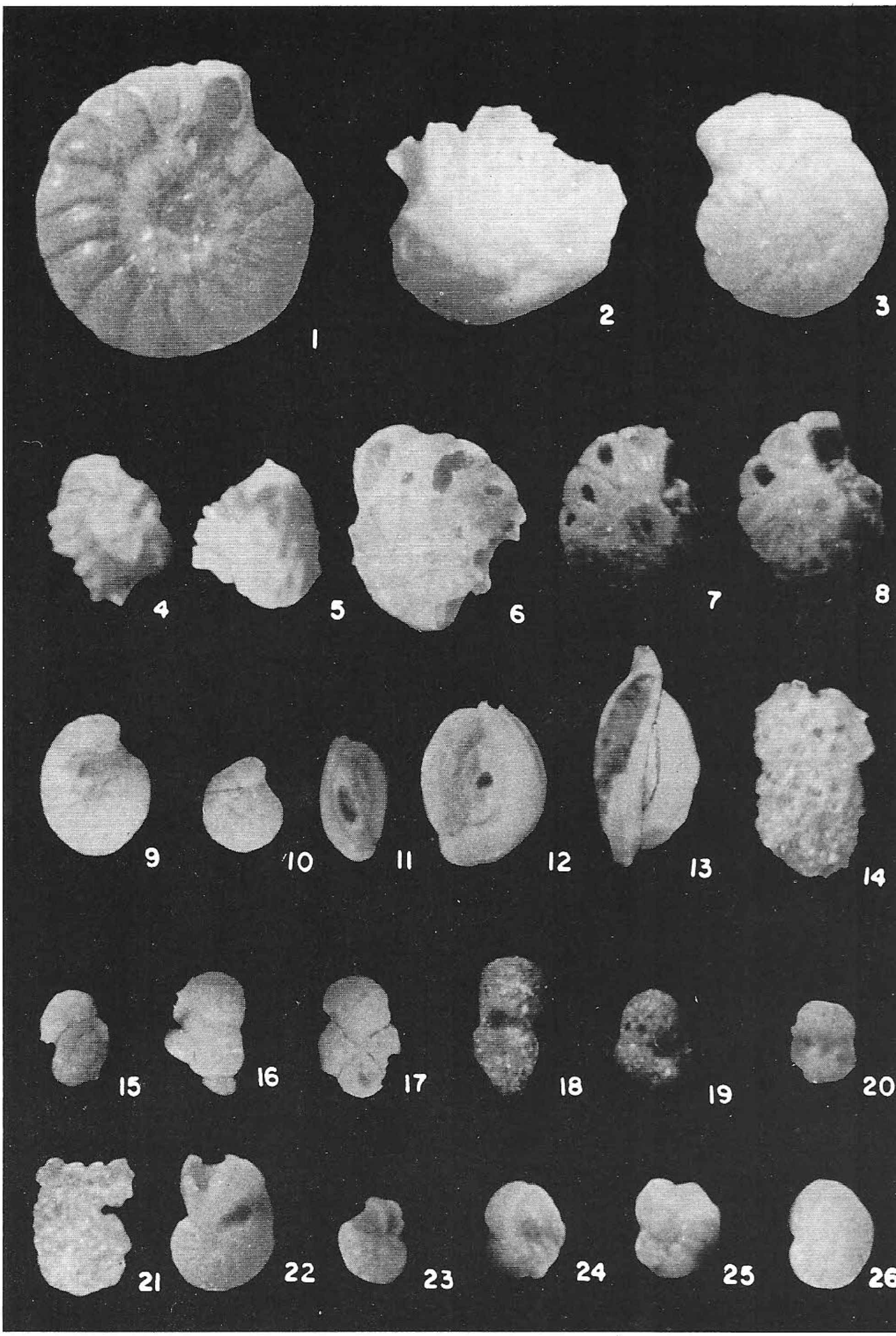
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PLATE 33

Plate showing effect of pollution on Foraminifera in inshore region of Trivandrum, Kerala.

Fig. 1, 2, 4–8 – *Operculina ammonoides* d'Orbigny. 1–2 showing corrosive action in chambers and thinning of ornamentation and chalky surface; x 15 (sta. nos. 18 and 25); 4, partial destruction of the test; x 15 (sta. no. 11); 5, pitting, thinning and less of ornamentation; x 39 (sta. no. 1); 6–8, abnormal growth and development in the last few chambers; x 39 (sta. nos. 1 and 18).

Fig. 3 – *Operculina complanata* (Defrance); abnormal growth and development; x 10 (sta. no. 19).

Fig. 9 – *Elphidium simplex* Cushman, showing widening of sutural flute; x 45 (sta. no. 25).

Fig. 10 – *Elphidium advenum* (Cushman), showing widening of sutural flutes and smoothening of test; x 45 (sta. no. 13).

Fig. 11, 13 – *Elphidium craticulatum* (Fichtel & Moll), showing infilling, abrasion, and smoothening of test; x 60 (sta. nos. 25 and 11).

Fig. 12 – *Elphidium crispum* (Linné), showing partial destruction of chambers; x 60 (sta. no. 16).

Fig. 14 – *Eponides repandus* (Fichtel & Moll); ventral view showing enlargement of apertural face and abrasion; x 60 (sta. no. 16).

Fig. 15 – *Pararotalia nipponica* Asano; ventral view showing pitted chambers and widening of umbilical region; x 75 (sta. no. 25).

Fig. 16 – *Austrotrillina striata* Todd & Post; dorsal view showing corroded deep cavities; x 75 (sta. no. 11).

Fig. 17 – *Elphidium minutum* (Reuss), showing dissolution effect on the marginal chambers; x 75 (sta. no. 16).

Fig. 18 – *Cibicides refulgens* de Montfort, showing partial destruction of test and enlargement of apertural faces; x 39 (sta. no. 16).

Fig. 19 – *Cibicides lobatulus* (Walker & Jacob), showing widening of apertural faces and thinning of chamber walls; x 39 (sta. no. 13).

Fig. 20 – *Hanzawaia concentrica* (Cushman), showing regeneration by addition of four new chambers; x 39 (sta. no. 13).

Fig. 21 – *Nonion elongatum* (d'Orbigny), showing pitting and thinning of test; x 60 (sta. no. 23).

Fig. 22 – *Cancris auriculus* (Fichtel & Moll), showing deep cavity in the last chamber; x 60 (sta. no. 23).

Fig, 23 – *Borelis* sp., showing sculptural features due to differential dissolution effect; x 18 (sta. no. 25).

Fig. 24 – *Quinqueloculina agglutinans* d'Orbigny, showing differential solution effect causing pores and fragile condition; x 75 (sta. no. 13).

Fig. 25 – *Spiroloculina planissima* Wiesner, showing partial destruction of last chamber and pitting; x 39 (sta. no. 16).

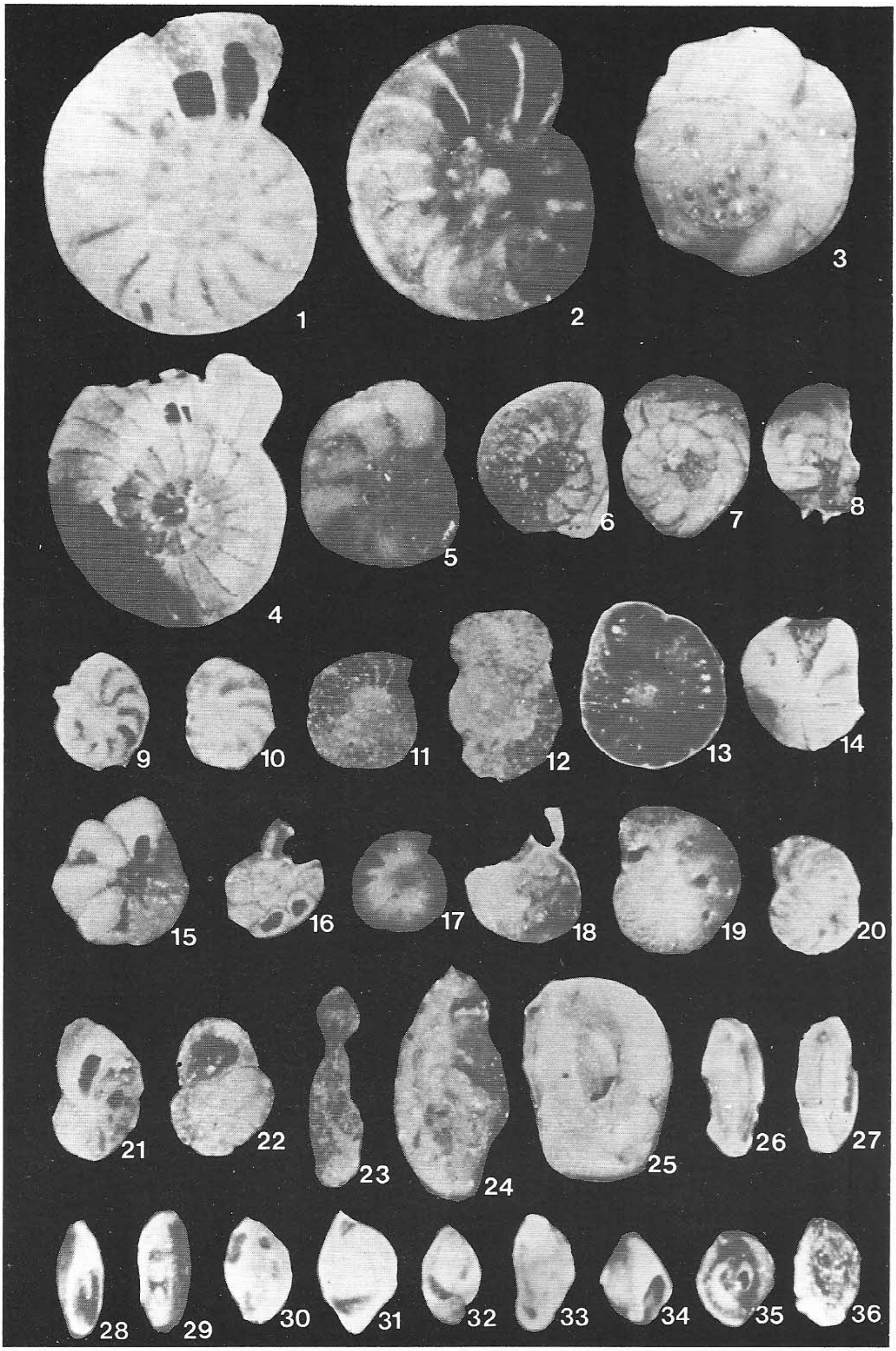
Fig. 26, 27 – *Quinqueloculina akneriana* d'Orbigny, showing abrasion, destruction and chalky appearance; x 60 (sta. no. 16).

Fig. 28, 29 – *Quinqueloculina pygmaea* Reuss, showing deep corrosion cavities; x 75 (sta. no. 1).

Fig. 30, 31 – *Triloculina trigonula* (Lamarck), showing corrosive cavities and chalky appearance; x 75 (sta. no. 16).

Fig. 32–34 – *Triloculina tricarinata* d'Orbigny, showing solution effect being stronger at curced ends; x 75 (sta. no. 13).

Fig. 35, 36 – *Quinqueloculina vulgaris* d'Orbigny, showing pitted chambers (sta. no. 1).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