

Faunal Composition in Polluted Nearshore Environment

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Faunal density and distribution in a nearshore environment at Trivandrum, into which effluent from a titanium dioxide factory is discharged has been studied. The effluent chiefly contains sulphuric acid, ferrous salts and titanium dioxide. Analysis of samples from the affected and unaffected areas shows a decrease of intertidal and benthic fauna in the polluted areas. Gross ecological variations appear to have not taken place and the marginal changes that occur in the environment can be considerably reduced by controlling the pollution.

Awareness of the role of ecological monitoring in pollution studies has been growing in the recent past. The Travancore Titanium Products Ltd (TTP), situated at Kochuveli, Trivandrum (08°30' N; 76°55' E), discharges effluents into the beach which go into the coastal waters of the Arabian Sea. Recognizing the hazards of pollution caused by the effluent discharge, the TTP requested the National Institute of Oceanography to survey the area and suggest, if necessary, remedial measures. Some studies on the effects of the effluent on interstitial fauna have been conducted^{1,2}. Aspects of pollution caused by the effluent discharge gauged from faunal abundance and distribution form the subject of this study.

Materials and Methods

The effluent discharged (~ 4000 m³/day), chiefly containing sulphuric acid (~ 3%), ferrous salts (10-40 g/litre) and titanium dioxide, mixes with the sea water and spreads along the coast, northward or southward, depending on the direction and force of the littoral drift. The oxidation of the ferrous salts into ferric salts on mixing imparts a reddish brown colour to the sea water with very poor transparency and this patch extends to a width of 0.3 to 0.5 km (5 to 7 m depth) from the shore. The coastal zone in this area is thickly populated and fishing activities mainly using country crafts, hook and line, shore seines and gill nets are conducted throughout the year.

Studies were conducted from November 1976 to December 1977 to assess the possible harmful effects of the effluent on the biota. Samples were collected at monthly intervals from 3 stations, viz. TTP effluent

outfall area, Thumba-Vikram Sarabhai Space Centre which is about 5 km north of TTP and Sankhamugham, located about 5 km south of TTP. Samples were also taken from Kovalam (15 km south) which remains more or less 'clean' throughout the year. Intertidal fauna were collected from high to low tide levels using a metal quadrant (area 10 cm², depth 16 cm). Collections were also made from the swash zone. Benthic fauna were collected using a van Veen grab (area 0.048 m²) along traverses perpendicular to the coastline at these stations at 5, 10 and 20 m depths. Fauna from these were collected by washing the samples through a 0.5 mm screen and preserved in 4% formalin. They were identified, counted and dry weight recorded (shells were removed whenever present). Zooplankton samples were collected from the effluent patch and beyond, along the coast, using the Heron-Tranter (HT) net (mesh size—300 μ) with a flow meter attached and analysed both for quantitative and qualitative data. Direction of the littoral drift was ascertained using Rhodamin B dye as a tracer. Measurements of pH, oxygen, salinity and temperature were also made at all the stations.

Results and Discussion

The intertidal fauna consisted of archiannelids, polychaetes, nematods, mysids, harpacticoid copepods, cumaceans, amphipods, decapods, lamellibranchs and gastropods. The effluent outfall area at TTP was virtually devoid of any beach fauna, except on 2 occasions when also the density of population and the biomass were comparatively low (Fig. 1) consisting of a few archiannelids. Benthic organisms encountered off Trivandrum coast consisted of polychaetes, nematods, sipunculids, mysids, tanaidaceans, cumaceans, ostracods, amphipods, decapods, lamellib-

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ranchs, gastropods and *Amphioxus*. The substratum consisted of sandy silt or silty sand.

From the general distribution pattern of the organisms it was observed that in the intertidal zone, archiannelids formed the dominant component (76.7% of the total annual counts) occurring more or less consistently followed by amphipods (18.1%) and *Emerita* sp. (3.8%). But the latter 2 contributed to the majority of the biomass. *Donax* sp. which was reported to be a dominant component of intertidal fauna from Shertallai and Cochin beaches³, did not occur at the Trivandrum beaches during the present study. However, during the present observation they were absent at Cochin also but occurred in very large numbers at the Mopla Bay and Payyambalam beaches, Cannanore and West Hill beach at Calicut, Kerala during the premonsoon months. The average biomass at the unaffected area, viz. Kovalam (3.5 g/m²) is higher than the reported figures from Shertallai (1.5 g/m²) and Cochin (1.7 g/m²) beaches. In the surf sand, mysids dominated the counts (44%) followed by archiannelids (28.6%), *Emerita* sp. (22.4%) and amphipods (4.6%). Polychaeta dominated the total counts (34.6%) followed by Amphipods (27.2%), *Amphioxus* (17.1%), Cumacea (14.6%), Nematoda (3%) and Mysidacea (1.6%) in the benthic fauna.

The effluent on mixing with the sea water causes changes in the temperature, pH and oxygen content (through oxidation of Fe²⁺ to Fe³⁺) and thus affects the organisms. Although the temperature of the effluent was high (45-50°C), at the discharge point, its effect on the fauna was less owing to rapid reduction

in temperature on mixing with the sea water. The littoral drift showed a northerly direction during most months except in June and July when it became southerly (towards Sankhamugham). During February-April also, when the littoral drift was weak, the effluent was observed to spread both towards Sankhamugham and Thumba regions, with a net flow towards south. The direction of the drift of the effluent was also discernible from the distribution of pH in sea water and values of different parameters from representative months are given in Table 1.

Although acute toxic levels were reduced as the effluent mixed with sea water moved away from the outfall area, constant exposure to the suspended precipitate and solids from the effluent present in the sea water, which washes the intertidal zone, resulted in depletion/death of the fauna. A decrease was observed in diversity owing to prolonged sublethal effects such as slow choking of the respiratory and feeding organs particularly of benthic fauna. Experimental studies on mussels fed with ferric hydroxide flakes along with other food⁴ showed that although this did not bring about acute toxicity, caused a decrease in their body weight and high mortality rate. The effect of the effluent was further confirmed in toxicity study experiments conducted in the laboratory⁵ on selected benthic organisms and fishes. Concentrations up to 0.6% of the effluent were acute toxic levels (pH 4.1, oxygen depletion 70%) causing death of the organisms within 2 to 10 min. Prolonged exposure to the precipitate from neutralised effluent also caused mortality. This effect was apparent from the distribution of organisms at

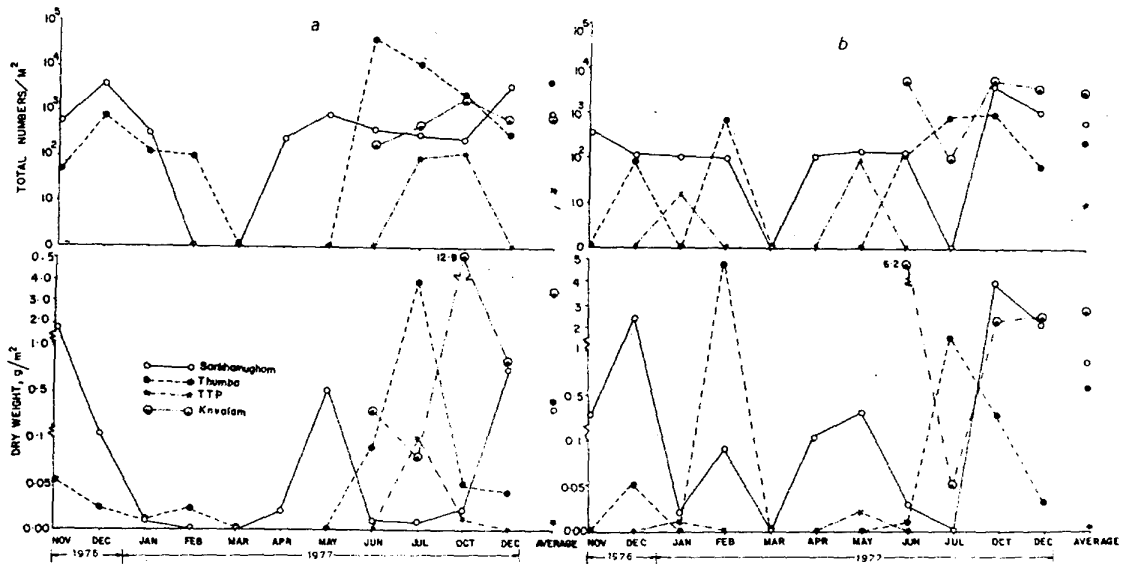


Fig. 1—Distribution of (a) intertidal and (b) wash zone fauna (total numbers and biomass) at different stations

Table 1—Physical and Chemical Parameters of Effluent and Surface Water at the Point of Mixing and at Different Distances from the Effluent Discharge Point in February and December 1977
[December values are in parentheses]

Parameter	Effluent	At mixing point	100 m S	200 m S	2 km S	100 m N	200 m N	2 km N	0.5 km offshore	1 km offshore	2 km offshore
Temperature °C	46.5	28.5 (31)	28.5 (30)	28.4 (30)	27.8 (30)	28 (31.5)	28 (30.5)	28.7 (30.5)	28.5 (30)	28.4 (30.1)	28.5 (29.5)
pH	1	2.4 (2)	3.3 (6.9)	5.7 (7.6)	7.8 (7.7)	7.9 (1.8)	7.9 (2.3)	7.8 (7.5)	2.4 (7.6)	8.4 (7.7)	7.9 (7.8)
Total solids mg/litre	850	59 (34.8)	33 (15.8)	— (8)	22 (7.7)	— (—)	— (48.3)	10 (66.6)	9 (13.3)	9 (13.3)	10 (—)
O ₂ mg/litre	—	5.9 (0.7)	7 (5.9)	7 (6.1)	7.7 (6.4)	4 (—)	5 (0.4)	7 (6.3)	8 (4.5)	8 (7.2)	7 (6.3)
Salinity (‰)	—	33.4 (33.2)	33.2 (33.4)	33 (34)	33.4 (33.9)	33.1 (33.2)	33.9 (34)	33.7 (33.9)	34.6 (34)	33.9 (33.9)	33.9 (34.1)

S = South; N = North

— = No data

Sankhamugham and Thumba. Sharp decrease in faunal abundance and biomass was observed in February-March and later in June-July at Sankhamugham when the effluent spreads in a southerly direction. Similarly, a recovery of faunal abundance was observed at Thumba consisting chiefly of archiannelids in June-July when this area became free from the effluent. Kovalam, which was an unaffected area, sustained higher numbers of organisms and biomass. Differences in average numbers and biomass of organisms in various habitats and areas highlighting variations between polluted and non-polluted areas are given in Table 2.

Effects of pollution were manifested on the benthic organisms also. At the 5 m depth zone, where the overlying water column was contaminated with effluent precipitate and the substratum covered with sediments from the effluent, the numbers of benthic organisms and biomass were very poor compared with the same depth zone at the unaffected Kovalam area (Fig. 2). This was especially so at the effluent outfall area. Thumba region which was exposed to the effects of the effluent for most part of the year, showed lesser benthic faunal abundance compared to Sankhamugham transect.

A general increase in the abundance of benthic fauna was observed with the increase of depth. At 10 and 20 m, which are unaffected depths, the abundance of fauna was comparable at all stations. The extent of depletion of benthic fauna at various stations due to the effluent could be further assessed from the depthwise increase of faunal abundance towards offshore. The average increase from 5 to 20 m in terms of numbers was 4 times at Sankhamugham, 19.5 times at Thumba and 195 times off TTP; for biomass, it was 18.5, 84 and 270 times respectively. On the other hand at Kovalam, the increase was only 1.4 times for numbers and 5.2 times for biomass.

Table 2—Average Increase in Number and Biomass of Organisms at Various Stations

[Figures are given as times higher than at TTP]

	Sankhamugham	Thumba	Kovalam
		Intertidal organisms	
Numbers	49	268	42
Biomass	31	37	127
		Swash zone organisms	
Numbers	55	29	350
Biomass	273	193	886
		Benthic organisms (at 5 m depth zone)	
Numbers	37	10	119
Biomass	12	4	52

Zooplankton abundance between the affected and unaffected areas did not show any consistent variation. These being organisms with feeble locomotory powers get carried with water movements to the affected area. Further, determination of the period of sojourn of these populations in the polluted waters would be difficult and therefore, sublethal effects, if any, would be too subtle to be demonstrated. Qualitative analysis of zooplankton also failed to specify any indicator species associated with polluted water.

Investigation on the effluent disposal area of TiO₂ factory off Helgoland⁶ showed emigration of new species into the area which gradually tended to outnumber the common species. In the present investigation, no similar gross ecological changes or dominance of any particular group of organism in the polluted environment were observed. This alongwith the recovery of faunal abundance at a particular zone when it becomes free of the effluent due to change in the direction of the drift indicates that a radical transformation of the ecology of the system had not been brought about yet, although the long term accumulation of pollutants and its sublethal effects could well alter ecosystems irretrievably.

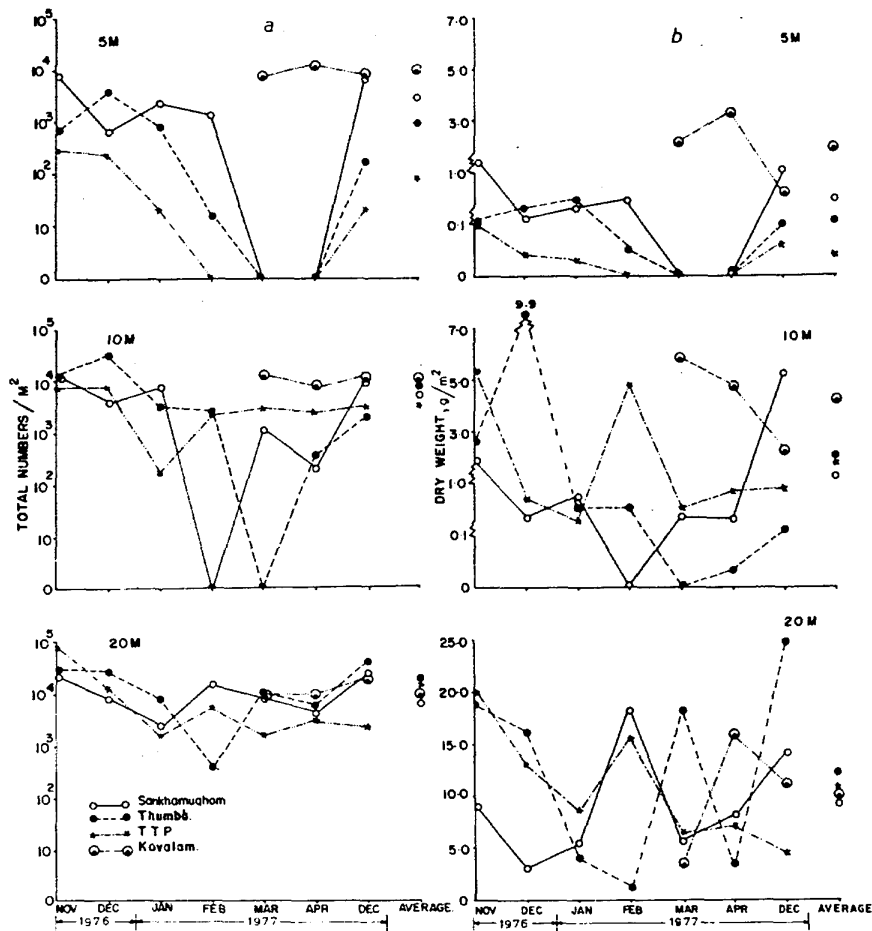


Fig. 2—Distribution of (a) total number and (b) biomass of benthos at 5, 10 and 20 m depths at different stations

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References

- 1 Nair N B & Rajan K C, *Biol Inst Oceanogr Univ Oriente*, 13(1974) 197.
- 2 Rajan K C & Nair N B, *Biol Inst Oceanogr Univ Oriente*, 13(1974) 107.
- 3 Trevallion A, Ansell A D, Sivadas P & Narayanan B, *Mar Biol*, 6 (1970) 268.
- 4 Winter J E, in *Marine pollution and sea life* edited by M Ruivo (Fishing News, Books Ltd, England) 1972, 392.
- 5 Madhupratap M, Haridas P, Gopalakrishnan T C, Sankaranarayanan V N & Gopala Menon P, *Indian J mar sci*, 8 (1979) 41.
- 6 Rachor E, in *Marine pollution and sea life* edited by M Ruivo (Fishing News, Books, Ltd, England) 1972, 390.