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Macro Benthic Community Structure on Tuticorin Coastal Waters, Gulf of Mannar, South East Coast of India

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Abstract: Macro benthic community in three stations in Tuticorin coastal waters of Gulf of Mannar was studied for a period of one year (Feb 2002 to Jan 2003). Station-I, situated close to thermal effluent discharging area recorded high water temperature (mean 37.5±1.31). The mean percentage of organic carbon in sediment was 0.79±0.24 and showed the lowest percentage composition of benthic organisms. Species diversity (sh').Throughout the study period benthic fauna was recorded only in six months (March, April, May, June, July and September) in Station-I. The mean water temperature, 29.5±2.57 was recorded in Station-II, situated closed to the fishing harbour area and the mean percentage sediment organic value was 0.89±0.43. The distribution of Bivalves was higher in Station-II with *Donax spinosus* and *Donax faba* in high numbers. Station-III situated near sewage discharging area showed the percentage mean organic carbon value as 1.59±0.48. The highest percentage composition of gastropod (96) was recorded at Station-III. It was concluded that organic carbon content and dissolved oxygen (4.42±0.39) were observed higher than the remaining two stations.

Key words: Benthic fauna · Sediment · Organic carbon · Thermal effluent · Sewage waste · South east coast of india

INTRODUCTION

Study of the macro benthos has received considerable attention due to their significance as biological indicators of environmental change in aquatic ecosystem and also as sources of fish food organisms. When streams, rivers and estuaries are subjected to the influence of sewage and industrial pollution, a considerable stress on their faunal communities result as evidences by the population elasticity of the macro benthos [1]. The abundance of benthic animals in an area has close relationship with its environment and is regarded as an indicator organism in discussing the conditions of nature and characteristics of that ecological niche [2, 3]. Benthic organisms play an important role in the aquatic ecosystem because of their importance in the marine food chain and the potential demersal fishery resources is dependent on benthos [4]. Structural changes in marine benthic communities caused by different disturbances such as organic enrichment and physical forces seem to be rather predictable and were followed by the models presented by Pearson and Rosenberg [5] and Rhoads and Germano [6]. Benthic macro faunal structural changes in relation to various degrees of disturbance and on the impact of the internal activity for biogeochemical process in the sediment [7].

Specific species or species types can provide information on the condition of the benthic environment. There are for instance "indicator" species, especially sensitive to pollution, organic enrichment (or) physical disturbance of the seabed [8]. Dumping of fly ash and colliery wastes also cause the water to become turbid, covers the seabed and decrease the reduction potential of the substrate, thus lowering the density and diversity of the benthic community [9, 10]. Oil spills result in a decrease of dissolved oxygen and toxification of the substratum that may cause a massive die-off of benthic communities [11]. Benthic communities usually have a long life cycle and stable community composition and therefore can often be used as a monitoring index for pollution [12].

Changes in benthic community structure are widely used in pollution assessment studies [13]. Ecological succession consists of the sequence of change in

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community structures that occur after a site has been disturbed [14]. One of the aims of benthic ecologists is to understand the ecological process, which is achieved by examining the interrelationship between environmental parameters and benthic community structure, anthropogenic impacts and modeling of the ecosystem [15, 16]. The discharge of heated effluent in the coastal waters by Tuticorin Thermal Power Station (TTPS) is a regular problem. Thermal effluent not only can produce adverse effects on the coastal water but also can affect the aquatic organisms such as planktonic community and bottom fauna [17, 18]. Being sedentary and sessile, the benthic fauna are the major causalities of any environmental changes [19].

In this study the benthic macro invertebrate community of three different sites in Tuticorin coastal waters was studied to obtain basic information on benthic macro fauna and to assess the impact of the pollution effect on distribution of macro benthic community.

MATERIALS AND METHODS

The study was carried out in three different stations of Tuticorin Coast (Fig. 1), Southeast coast of India for a period of one year (February 2002 to January 2003). Station I is situated near the TTPS and this station is also located very close to the Liquid Waste Discharging Point (LWDR). Station II is located near the fishing harbour area, about 2.5 km away from Station I. The Station III is in Thirespuram, a main fishing village in Tuticorin and about 2.5 km away from Station II and one of the heavily polluted areas with organic enrichment of sewage waste effluent directly discharged into the sea.

Water, sediment and benthic fauna samples were collected from three sites at monthly intervals for a period of one year (February 2002 to January 2003). A hand operated cylindrical corer (6.5 cm diameter) was used for collecting bottom fauna and sub samples were collected for sediment analysis. The water temperature was determined using thermometer having an accuracy of 0.5°C. Salinity and dissolved oxygen was estimated by Strickland and Parsons [20] method and organic carbon was estimated as described by Wakeel and Riley [21] method. The sediment particle size composition was analysed by following standard procedures [22]. Benthic fauna were separated by passing the sediment through a 0.5 mm mesh sieve. The organisms retained on the sieve were considered for macro benthic fauna analysis. After sieving, the fauna were preserved in 5% formalin solution for further analysis and identification. Species composition, population density of benthic fauna, species diversity, richness and evenness were calculated by following standard methods.

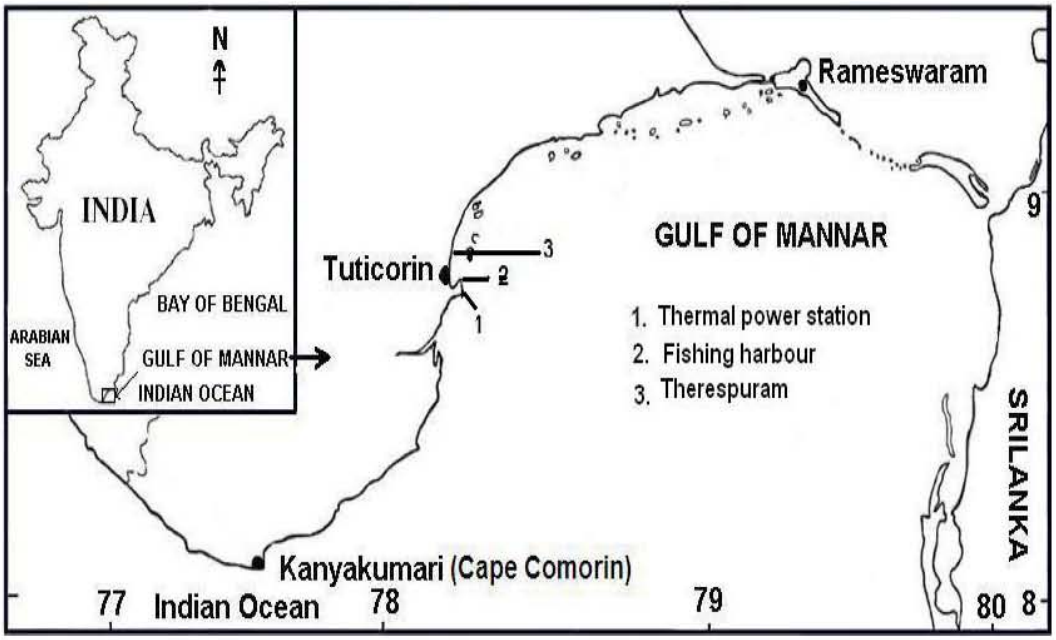

Fig. 1: Map showing the study area

RESULTS

Physico-chemical Parameters: The annual mean variance of physico-chemical parameters such as temperature, salinity, dissolved oxygen, pH and organic carbon are given in (Table 1) Water temperature at Station I recorded the highest value of 37.5±1.31. Station-II and Station-III had recorded of 29.5±2.57 and 29.8±2.79, respectively. Station- I had highest range of temperature recorded compared to other stations. High salinity was recorded at Station-III (34.41±1.32), followed by Station-II and Station-I as 34.2±1.21 and 33.85±0.94, respectively.

The dissolved oxygen recorded at Station-I was 4.11±0.32 whereas Station-II and Station-III showed 4.08±0.26 and 4.42±0.39, respectively. Dissolved oxygen was slightly higher in Station-III compared to Station-I and Station-II. The highest pH was recorded at Station-I (8.16±0.2). Station-II and Station-III had small variations. ANOVA shows that there is a significant difference ($P<0.01$) between months and stations in the case of dissolved oxygen and between months in the case of temperature. But, there was no significant difference among stations in the case of temperature. Salinity was found to be insignificant among months and stations.

Sediment Composition and Organic Carbon Content: The annual mean variance of sediment composition and organic carbon are presented in (Table 1). Among sediment particle size composition, medium sand ranged from 18% (Station-I) to 92.6% (Station-II), fine sand ranged from 6.37% (Station-II) to 56.46% (Station-III) and very fine sand ranged from 0.41% (Station-II) to 53.36 (Station-I). In general, Station-II had a highest percentage composition of medium sand. Station-III had the highest mean value of fine sand. Station-I had the highest mean value of very fine sand. The mean percentage organic carbon was 0.79±0.24 at Station-I, whereas Station-II and Station-III showed 0.89±0.40 and 1.59±O.48, respectively. Organic carbon values obtained for the 3 stations are given in (Fig. 3).

ANOVA (Table 2) shows that there is a significant difference between stations ($P<0.01$) and insignificant between months.

Species Composition and Distribution: The percentage of benthic organisms found in three stations is shown in (Fig. 2a-c). Gastropods were the dominant group in all stations followed by bivalves, crustaceans, polychaetes and echinoderms. 96% was the highest percentage composition of gastropods recorded at Station-III during June 2002. 40.6% was the lowest percentage composition recorded at Station- II during March 2002. Regarding bivalves, the highest percentage composition recorded was 41.5% at Station-I and 4.3% was the low percentage composition recorded at Station-III. Very low percentage composition of polychaetes (2.5%) was recorded at Station-I for the month of March 2002 and this was the only % of polychaetes found in Station-I during the study period. In Station-II, 9.75 and 1.3% was the maximum and the minimum % of polychaetes recorded during the months of April and June 2002 respectively. In Station-III, the maximum % of polychaetes was observed as 9.67 during the month of April 2002 and the minimum was found to be 0.73% during the month of September 2002.

Table 1: Mean variation of Physico-chemical parameters of water and sediments (Mean± SD) N =12.

Parameters	Station-I	Station-II	Station-III
Temperature (°C)	37.5±1.31	29.5±2.57	29.8±2.79
Salinity (ppt)	33.85±0.94	34.2±1.21	34.41±1.32
Dissolved Oxygen (ml/l)	4.19±0.328	4.08±. 26	4.42±0.39
PH	8.166±0.27	7.8±0.31	7.7±0.21
Organic carbon (%)	0.792±0.241	0.892±0.403	1.594±0.485
Medium sand (%)	43.97±11.71(18-60.12)	79.266±6.127(71.22-92.6)	49.065±9.08(32-62.57)
Fine sand (%)	29.892±9.75(14.67-44.78)	16.863±5.63 (6.37-28.02)	34.252±9.20 (21.36-56.46)
Very fine sand (%)	24.926±17.39 (3.36-53.36)	3.233±2.11 (0.41-7.38)	15.148±5.373 (7.34-24.42)

Table 2: Analysis of variance of organic carbon in sediments

Source	SS	df	MS	F	P
Total Variance	10.55	35	-	-	-
Between months	1.2767	11	0.1160	0.5945	0.8132
Between stations	4.2949	2	2.4930	12.7698	0.000208
Error variance	4.2949	22	0.19	-	-

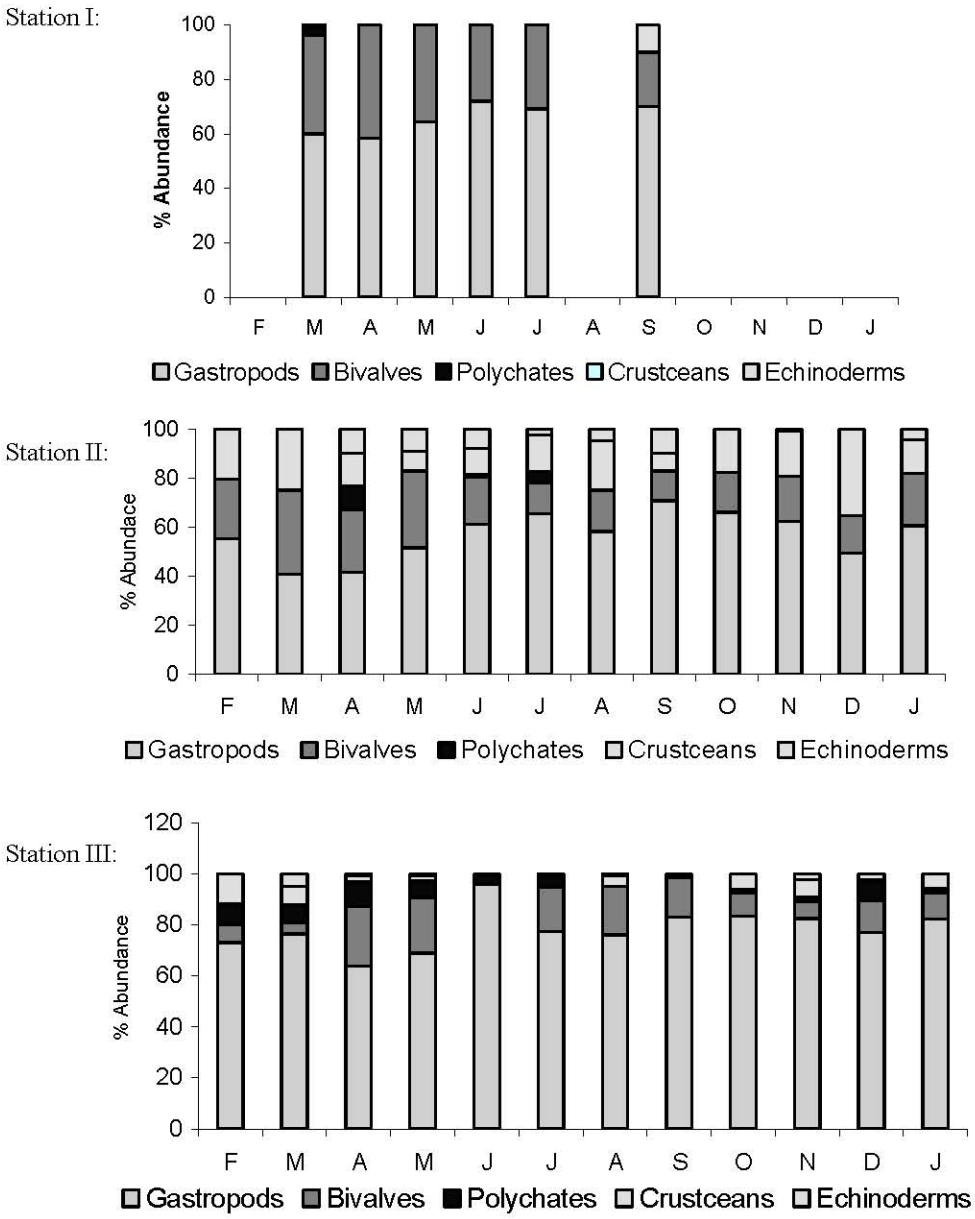

Fig. 2: Percentage composition of benthic fauna at Station I, II and III

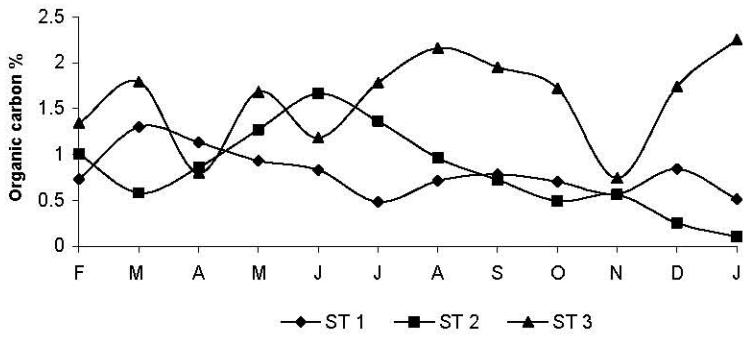

Fig. 3: Organic carbon in sediments at stations I, II and III

Table 3: Name list of benthic fauna in three stations

Species Name	Station-I	Station-II	Station-III
Gastropods			
Umbonium vestiarium	-	+	+
Trochus tentorium	-	+	+
Trochus radiatus	+	+	+
Agaronia nebulosa	-	-	+
Calyptrea extinctorium	-	-	+
Euchelus asper	+	+	+
Phasianella solida	-	-	+
Nassarius sp	+	+	+
Harpulina lapponica	-	-	+
Cyprea sp (Juvenile)	+	-	+
Bulla ampulla	-	-	+
Cerithidea cingulata	-	+	+
Certhium spp	-	-	+
Rhinoclavis spp	-	-	+
Littoraria scabra	-	+	-
Planaxis sulcates	-	+	-
Ancilla cinnamomema	-	-	-
Hemifusus cochlidium	-	+	-
Clypeomorus bifasuata	-	+	-
Cowrie Juvenile	-	+	-
Pyrene zebra	+	-	-
Cerithidium morus	+	-	-
Mitra sp	+	-	-
Calliostoma spp	-	-	+
Bivalves			
Donax spinosus	-	+	+
Donax sp.	-	-	+
Donax faba	+	+	-
Saccostrea cucullata	-	+	-
Mactra violacea	-	+	-
Modiolus phillipinarium	-	+	-
Placenta placenta	+	+	-
Tellina ala	-	+	+
Vasticardium assimile	-	+	-
Timoclea costellipera	-	+	-
Atactodea striata	-	+	-
Septifer bilocularis	-	+	-
Cardita bicolor	-	+	-
Epicodakia sp	-	-	+
Anodontia edentula	-	-	+
Semele sp	+	-	-
Glycemeris sp	+	-	-
Gafarium tumidum	+	+	+
Polychaetes			
Neris sp.	+	+	+
Heteroneris sp	+	+	+
Crustacea			
Clibanarius clibanarius	-	+	+
Amphipods	-	-	+
Cthamalus sp	-	+	-
Isopod	-	-	+
Echinoderms			
Peronella Lesueuri	+	+	+
Brittle star	-	+	+
Pentaceraster regulas	-	-	+

+ = Present; - =Absent

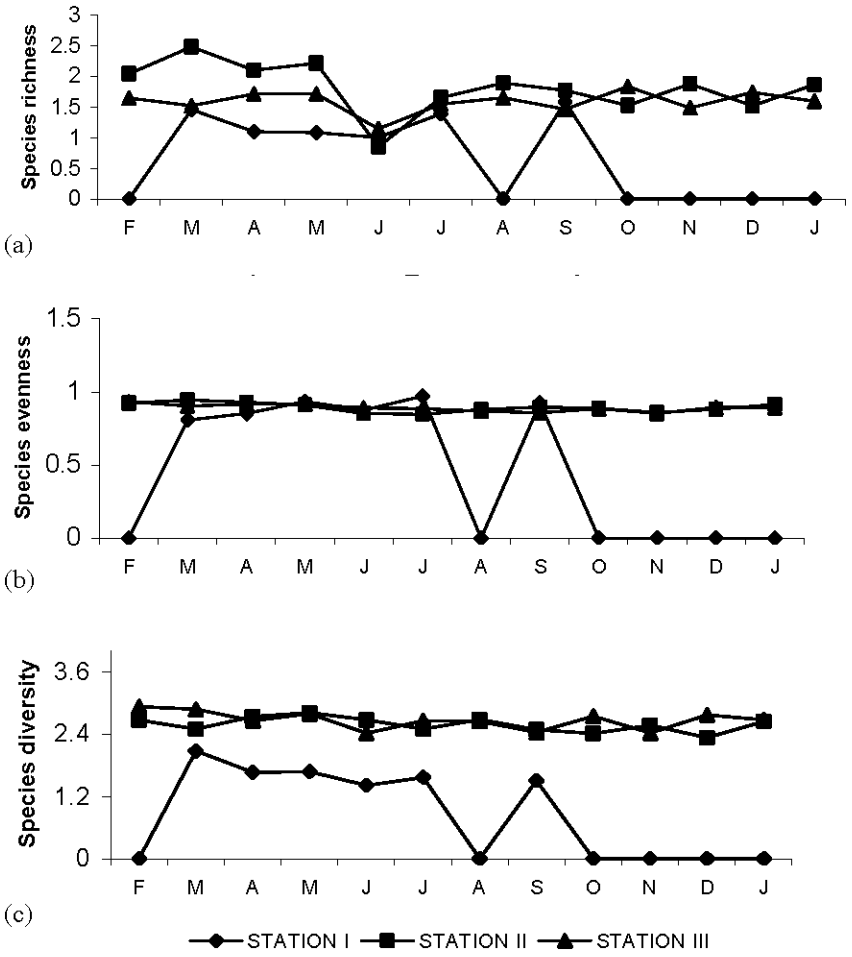

Fig. 4(a-c): Species diversity, richness and evenness variation between benthic fauna of three stations

The Crustaceans were totally absent in Station-I and the same was found to be maximum (35.3%) during December 2002 and minimum (7.31%) during October 2002 at station II. Station-III recorded the maximum crustaceans (11.6%) during February 2002 and 0.63% as minimum during January 2003. The percentage composition of echinoderms ranged between 1.25 (minimum) and 10% (maximum) for the months of March and September 2002 at Station-I. Station-II showed minimum percentage composition of echinoderms as 0.87 during November 2002 and maximum as 9.75 during April 2002. The lowest percentage was recorded as 0.61 during August 2002 and the highest percentage was 6.25 during October 2002 in Station-III.

A total of 50 species of macrobenthic organisms (Table 3) belonging to five major groups namely Gastropods, Bivalves, Polychaetes, Crustaceans and Echinoderms were recorded. Station- III had 15 species of gastropods in that most commonly observed species are Umbonium vesterium, Trochus tentorium, Trochus radiatus, Bulla ampulla, Cerithidea cingulatum and *Certhium* sp., Station-II had 12 species of gastropods. Station I had only 7 species of gastropods namely; Trochus radiatus, Euchelus asper, Nassarius sp, cyprea sp, Pyrene zebra, Cerithidium morus and Mitra sp. A total of 18 species of Bivalves were recorded at three stations, Gafrarium tumidum is observed in all stations during the study. Two species of polychaetes namely; Neris and Heteroneris were recorded in all the three stations. A total of 4 species of crustaceans were found in all the stations and among them 3 species namely; Hermit crab (*Clibanarius clibanarius*) Amphipods, Isopods were found in Station-III. Station-II has two species of crustaceans namely, Hermit crab (Clibanarius clibanarius) and barnacles (Cthamalus sp.). Crustaceans were not recorded at Station-I. A total of 3 species of Echinoderms, sand dollar Peronella lesuri, brittle star and star fish pentaceraster regulas were recorded at Station-III and

Station-II recorded *Peronella lesueri* and Brittle star whereas sand dollar *Peronella lesuri* was the only species recorded at Station-I.

Species Diversity, Richness and Evenness: The monthly variance of species diversity (Shannon's index), richness (Margalef's index) and evenness is given in Fig. 4a-c. The highest species diversity (Sh') 2.922 was recorded at St III during the month of February 2002. Station II has the highest Species diversity of 2.81 during May 2002. Whereas Station-I had the highest Species diversity 2.07 recorded for the month of March 2002. Regarding Species richness (R), the highest was 4.57 recorded at Station II during May 2002, whereas the lowest species richness 1.24 was recorded at Station-I during June 2002. In Station-III the highest species richness was found to be 4.22 recorded during October 2002. In Station-II and Station-III, evenness was recorded at small variations. Station-I had highest evenness of 0.972 recorded for the month of July 2002.

DISCUSSION

Distribution of benthic organisms, species diversity, species richness and species evenness were closely accompanied by changes in the physical and chemical characters of the water and sediment resulting from anthropogenic affect on the ecosystem [23]. In this study, Station-I had the highest mean water temperature compared to Station-II and III because there was a continuous discharge of thermal effluent from the TTPS and this made the temperature to be high in this area. The density of benthic fauna could be largely decreased when associated with the increased temperature range of 34.0°C-37.0°C produced by the power plant [24] and the above statement was in agreement with our observations. In present study, the diversity and abundance of macrobenthic organisms were very low at Station-I compared to Station-II and Station-III. The average annual mean temperature of 37.5°C were recorded at Station-I, thus showing the higher temperature may be one of the factors influencing the density of benthic organisms [25]. Ahmed *et al.* [25] reported that high temperature regime can alter the normal physiological functions of aquatic fauna by creating stress to the organisms and thereby affecting the population density which have reported reduction of benthic organisms at Kalpakkam coast due to increased water temperature caused by heated effluents [26]. The heated effluents discharged by thermal power stations into the sea increased the water temperature and thereby affected the benthic populations. When compared between Station-I and Station-II, the present study reveals that the benthic diversity is low at Station-II and this may be due to the high traffic of mechanized trawler boats in that area which might disturb the bottom benthic organisms. The present study revealed that the dissolved oxygen did not act as a limiting factor in the distribution and relative abundance of the benthic fauna and this is in accordance with the report from Cochin backwaters [27]. The organic carbon content of sediment is an important parameter for benthic population [26]. The abundance of benthic fauna and carbon in the sediment showed significant positive relationship. Station-III had a highest percentage value of organic carbon and also highest percentage abundance of benthic organisms. Very high benthic population density was seen in the Hudson River in the New York Bight, which receives large amounts of sewage and industrial waste [27]. In the present study, Station-III had high benthic population density among the coastal water of Tuticorin, because Station-III might be attributed to the nutrient rich sediment resulting from the influx of organic matter through sewage discharged into the seawater. Our findings concluded that the macrobenthic community Tuticorin coastal waters showed that the benthos could be differentiated into distant communities separated by the sediment texture and organic carbon.

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