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Studies on Benthic Polychaetes from Ennore, Cuddalore and Nagapattinam Estuaries, Tamil Nadu, Southeast Coast of India

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ABSTRACT

Present study to evaluate the density and diversity of benthic polychaetes in the estuarine environment, by the influence of physico-chemical parameters. The variability of temperature 26 to 35ºC, salinity 10 to 36 ppt, pH 7.9 to 8.1, DO 4.63 to 5.98 mg/l was observed. Shannon – Wiener index value expressed the value between 1.42 and 2.60, evenness (J´) varied from 0.78 to 1.00 and the richness (d´) value varied from 0.72 to 2.17 respectively. Among the three stations dominated two polychaete species in station 1, *Pisione indica* and *P. africata* ; station 2, *Notomastus aberans* and *Capitella capitana* species, and *Prionospio pinnata* species was in station 3. The high population of benthic polychaetes was observed in station 3, while low density in station 2 which is more close to the industrial area. Interpretation of the study exposed that density and diversity of polychaete community based on the increasing industrial disturbance which alter the environmental parameters and was affected by the benthic polychaetes population in the estuarine environment.

Keywords Estuarine, Physico-chemical parameters, Polychaetes, Diversity, Population.

INTRODUCTION

Rapid industrialization and urbanization attribute to environmental pressure on the coastal region with decreasing water quality. Widespread aquatic pollution due to indiscriminate waste disposal causes severe ecosystem modifications and depletion of fishery resources (Sanagoudra and Bhat 2013). Estuaries are the most important sink of pollutants derived from anthropogenic activities (Saravanan et al. 2014). An assessment of the health of a particular ecosystem can be achieved only through a careful analysis of fauna and flora. In short, the faunal components a dynamic element of the marine environment, are considered a good tool for monitoring the interaction of coastal pollution and intertidal ecology. The intertidal benthic assemblages and the community variations are mainly affected by the anthropogenic stress. Thus the studies on the biological compartments are needed to assess the environmental status, especially benthic biota and particularly those related to macrobenthos, are the most useful tool in environmental impact assessment. The effects produced by polluted water or sediments on the environment are determined well through the study of benthic communities than analyses of

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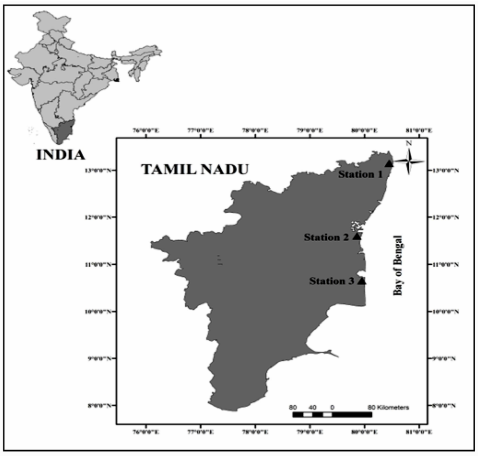


Fig.1. Study areas.

chemical features (Chapman 2007). Polychaetes are one of the most important groups of the marine benthic community (Gendy et al. 2012). In addition, polychaetes have a high level of tolerance to adverse effects – both to pollution and natural perturbation (Bryan and Gibbs 1987, Burd and Brinkhurst 1990, Levings et al. 1985).

The dominance of some species belonging to the families *Spionidae* and *Capitellidae* is an indicator of organic pollution (Tsutsumi 1990). Polychaetes have been used as bioassays for monitoring toxic compounds and as indicators of perturbed environments at the community, population and specific levels. Few studies have been carried out on the macro-fauna particularly on the polychaetes in the East coast of India. In the present study perform continuous monitoring of polychaete diversity in the three different estuaries, therefore very limited study about macrobenthic polychaete diversity with the environmental variable in these areas. Hence, the present study emphases to assess the polychaete diversity with the environmental variables three different stations in Tamil Nadu coast, Southeast coast of India.

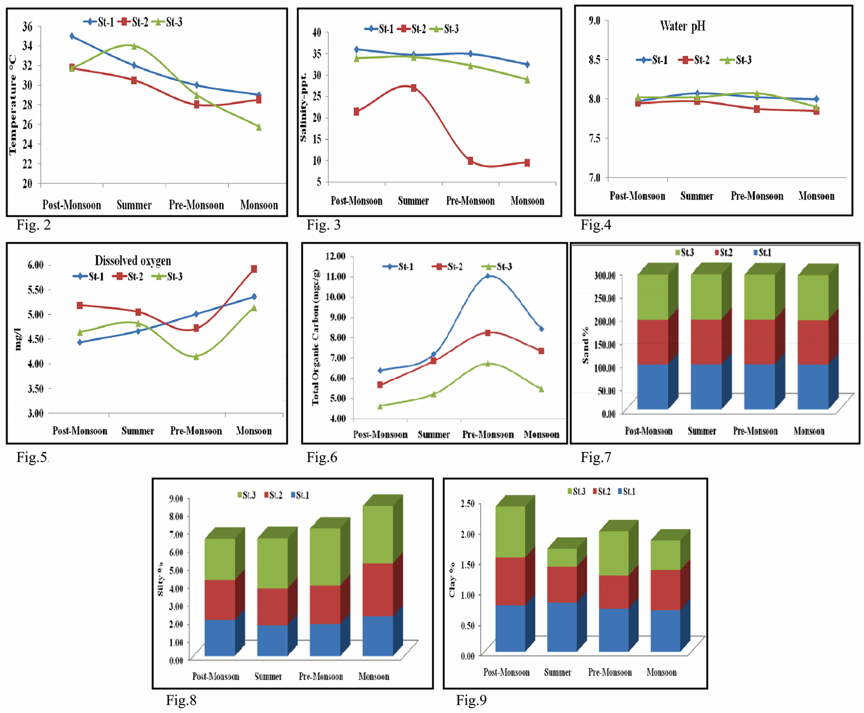
MATERIALS AND METHODS

Study area

Station 1 named as Ennore estuary located in Chennai city with the latitude and longitudinal position 13º13.982´ N and 080º19.845´ E. Station 2 Uppanar estuary present in Cuddalore coastal area and this geographical direction latitude 11º40.124´ N longitude 079º45.236´ E across this station contain the number of the chemical industry, especially in SIPCOT. Station 3 is named as Kaduvaiyar estuary situated in Nagapattinam coastal area and this latitude and longitudinal position 10º45.287´ N and 079º50.976´ E, this area contains fishing harbor and fish processing unit near the coastal area. This three-station located in Tamil Nadu state in India covered by Southeast coastal on India showed in Fig. 1.

Sample collection and analysis of physico-chemical and biological samples were collected from the middle of the estuary by used plastic container for water samples and triplicate soil sampling was carried out using a long-armed Peterson grab followed by Mackie (1994). Physical parameters of temperature were measured by the help of digital thermometer and salinity estimated with the help of hand refractometer (model ATAGO, Japan), pH measured used digital pH meter. Water samples collected for dissolved oxygen estimation were transferred carefully to BOD bottles. The dissolved oxygen was immediately fixed and the samples were brought to the laboratory for further analysis. The modified Winkler's method, described by Strickland and Parsons (1972) was adopted for the estimation of dissolved oxygen. Sediment soil sample 100 g were collected and transferred to polythene bag and allowed for air dry. The dried soil sample was used for physical (soil texture) and chemical (total organic carbon) were estimated used slandered methods (Buchanan 1984, Wakeel and Riley 1957, Mackie 1994). Collected polychaete animals were preserved in 5% formalin and taxonomical identification were followed by Fauvel (1953), Day (1967), Srikrishnadas et al. (1998).

Statistical analyses of macro benthic polychaetes collected from the beds were identified and listed. Pearson correlation coefficient was employed for a better understanding of the relationship between the concentration of various sediment nutrients, sediment composition and pH by using the statistical package (SPSS 20.0). Their settlement was analyzed using several indices: Univariate measures such as Margalef's species richness (d), Shannon – Wiener



Figs. 2—5. Described the season and station wise variation of temperature, salinity, pH and dissolved oxygen in St 1, 2, 3. **Figs. 6—9.** Described the season and station wise various percentage level of total organic carbon, soil texture (sand, silt and clay).

diversity (H´ log) and Pielou's evenness (J´) and multivariate tool such as Bray – Curtis similarity after suitable transformation of sample abundance data, classification (hierarchical agglomerative clustering using group-average linking) and ordination (multi-dimensional scaling, MDS) were used for treating the data and were calculated using of computer software of PRIMER (Plymouth Routines In Multivariate Ecological Research ver 6.0).

RESULTS AND DISCUSSION

Environmental parameters

The physical parameters of water and sediment were observed in all stations throughout the study period. Temperature, salinity. Do and pH in water samples were recorded and the values from 26ºC to 35ºC, 10 to 36 ppt, 4.16 to 5.98 mg/l and 7.9 to 8.1 respectively. In sediments, the total organic carbon varied from 4.63 and 11.02 mg/g (Figs. 2–6). Sediment texture in terms of sand, silt and clay (%) ranged from 94.17 to 99.46, 0.43 to 5.21 and 0.11 to 1.64 was reported in all the three stations respectively (Figs. 7–9). In the present study, the water quality parameters showed marked variation between three regions, particularly temperature and salinity. The maximum temperature recorded in St 1 is might be due to its vicinity as it is situated close to discharge point, the heated water from the Ennore power plant which might have caused the temperature level. A heated effluent increases the temperature level significantly, which in turn trigger the salinity level. This is stated previously (Kailasam 2004, Murugesan et al. 2011) at Tuticorin bay. The maximum temperature of 36º C and salinity of 36 ppt was recorded in station 1. Dissolved oxygen was observed minimum at station 1 ; this may be due to the increased water temperature which reduces the dissolved O_2 in the coastal waters. The temperature and salinity affect the dissolution of oxygen in their previous reports (Vijayakumar et al. 2000). Hydrogen ion concentration (pH) in surface waters remained alkaline at all sites throughout the study period with

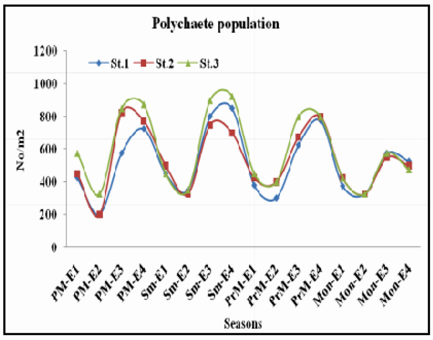
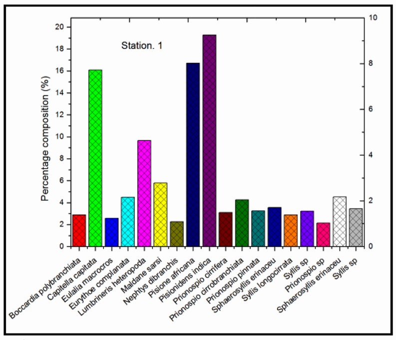


Fig.10



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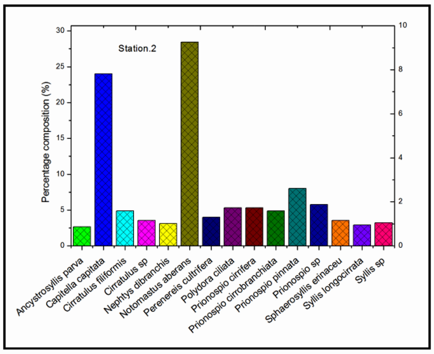

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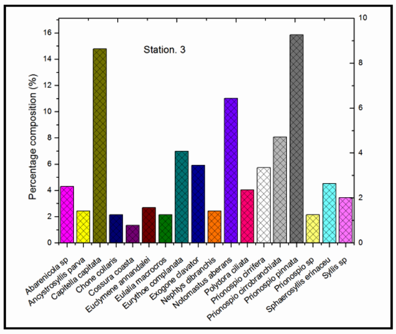

Fig.13

Fig. 10. Density of the polychaetes were different between the seasons and stations. **Figs. 11—13.** Population variation within the stations 1, 2, 3 respectively.

the maximum value during summer seasons and the minimum during the monsoon. Maximum temperature and salinity with low dissolved oxygen did not show any variation on the polychaete abundance in St 1. Sediment texture plays an important role in the ecology of benthic invertebrates (Sanders 1956, Maurer 1969). These considerations on the macrobenthic assemblages and the environmental variables in the east coast were observed by earlier studies (Sekar et al. 2013, Chandrasekar et al. 2014). Sediment character has been identified as one of the driving forces in determining the polychaetes communities. But the present study showed there is no considerable variation in the sediment composition between study areas. Total organic carbon was high in St 1 and the low value was recorded in St 3 respectively.

Density and diversity of polychaetes

A total of 29 species belongs to 16 families were recorded from the study area. Predominantly *Capitellidae*, *Pisionidae* and *Spionidae* were the most abundant in all the stations. *Pisionidens indica* (19.29%) and *Pisione africana* (16.72%) were the dominant species in station 1. *Notomastus aberans* (28.44%) and *Capitella capitata* (24.00%) were found to be the dominant species at station 2. *Prionospio pinnata* (15.86%) and *Capitella capitata* (14.78%) were dominant species in station 3 (Figs. 10–12). In the present study *Pisione africana* and *Pisionidens indica* were recorded more in station 1 (Ennore). *Pisionidae* recorded almost in the polluted environment and several studies were reported by various authors (Rivero et al. 2005, Ajmalkhan and Murugesan 2005). *Notomastus aberrant* and *Capitella capitata* were the most dominant species in station 2, these tolerant species are common in organic polluted areas and this was mostly represented by deposit feeders and it was the dominant genus in west and east coast, their occurrence was not substratum specific and also they were found dominating both at low and high organic carbon (Gray 1981, Belan 2003, Musale and

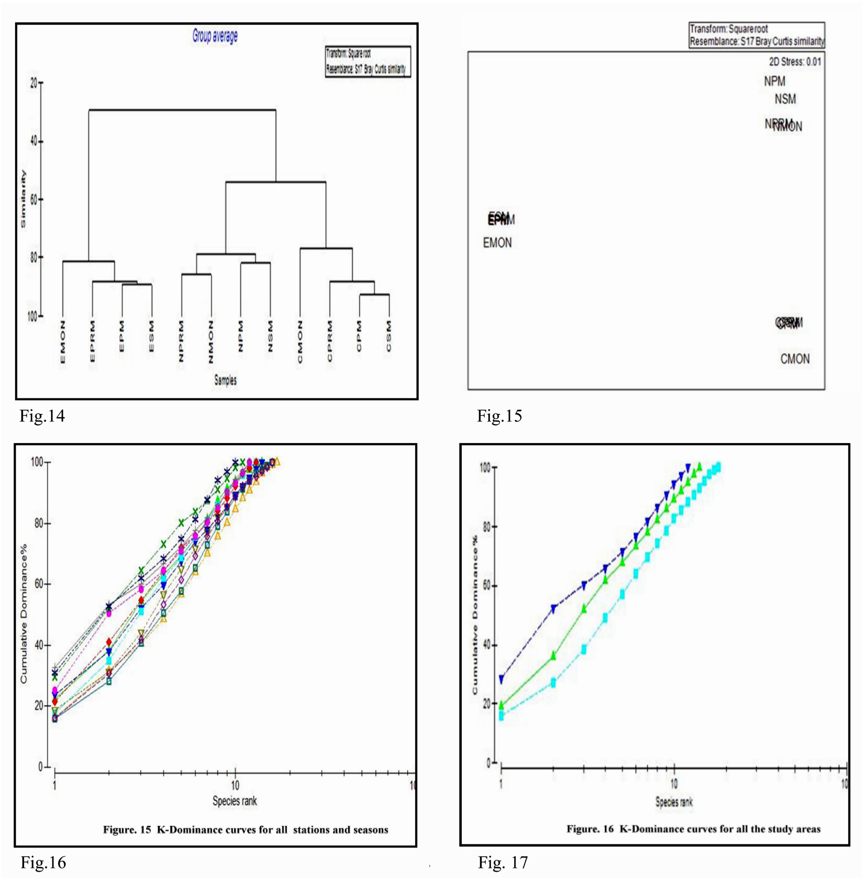

Fig. 14. Dendrogram similarity between stations and seasons. **Fig. 15.** MDS plot value between stations and seasons. **Fig. 16.** K-Dominance curve between stations and seasons. **Fig. 17.** K-Dominance between the stations.

Desai 2011), The polychaetes species of *Prionospio pinnata* was dominant in station 3. In this observation was previously reported by Rygg (1985), Yokoyama (1990), Quiroga et al. (2007). The deposited feeding polychaete *Prionospio pinnata* was maximum observed at Southern sites of Zuari estuary (Harkantra and Rodrigues 2004) and it observation very high in the harbors of the Central West coast of India (Ingole et al. 2009). The total number (No/m^2) of polychaete density was recorded during the study period. The range of polychaete density from 300 to 800, 125 to 550 and 225 to 290 No / m^2 was noticed at stations 1, 2 and 3 respectively. The maximum number of polychaetes was recorded during the summer season at the all station, totally 29 species of polychaete were recorded in the study area. Among that 15, 12, 18 species of polychaetes was recorded at stations 1, 2 and 3 respectively. Various observations were noticed from authors, a healthy environment the Shannon diversity values are higher and in the ranges between 2.5 and 3.5 (Ajmalkhan et al. 2004). However, in the present study stations 1 and 2 had their value below 2.5, except station 3 (H´ = 2.6). Thus, the study areas had moderate Shannon diversity values (1.73 – 2.6), suggesting environmental deterioration associated with anthropogenic activities (Quadros et al. 2009, Ajmalkhan et al. 2014).

Season-wise observation of polychaete density

Classification analyses (using Bray – Curtis similarity) followed by ordination through MDS on

Table 1. Correlation coefficient (r) between physico-chemical and polychaete population at St 1.

Station 1	Diversity	Richness	Even-ness
Water tempe-rature	0.38	0.411	− 0.191
Salinity	0.215	0.26	− 0.259
DO	0.325	0.209	0.263
Water pH	−0.046	− 0.057	0.041
Sand	−0.548*	− 0.499*	0.109
Silt	0.44	0.383	−0.066
Clay	0.608*	0.584*	−0.158
TOC	0.491	0.456	−0.325
Diversity	1	0.968	−0.011
Richness		1	−0.21
Evenness			1

abundance data (individual / m^2) independently for polychaetes (29 species) were undertaken. The 12 investigation stations (four seasons with three stations) have been divided into three groups: Station 1 : Ennor post - monsoon (EPM), Ennor summer (ESM), Ennor pre-monsoon (EPRM), Ennor monsoon (EMON), Station 2 : Cuddalorepost - monsoon (CPM), Cuddalore summer (CSM), Cuddalore pre-monsoon (CPRM), Cuddalore monsoon (CMON) and Station 3 : Nagapattinam post-monsoon, (NPM), Nagapattinam summer (NSM), Nagapattinam pre-monsoon (NPRM) and Nagapattinam monsoon (NMON). Figures 13 and 14 showed results of MDS ordination and hierarchical clustering, on species abundance data representing the four seasons in each three study area (post-monsoon, summer, pre-monsoon and monsoon). Cluster analysis showed that the clear seasonality and samplings of polychaetes abundance in all the sampling sites. All the sites were clearly found in the 80% similarity level. The 2D stress value (0.01) indicated that the results are credible. From the dendrogram results, it is possible to classify the results according to stations and also for seasons. In the MDS plot, it is found that all season samples are separated conforming to the dendrogram.

Multiple k-dominance plots facilitate the discrimination of macrobenthic polychaetes according to species- relative contribution to standard stock. The k-dominance curves obtained for different stations and seasons show diversity. The stations NPRM and NPM show maximum diversity as the curves for all three stations are lying lower than others whereas the curve of the CPRM and CMON are lying in the top and has a stiff elevation indicating the lowest diversity (Fig. 15). The k-dominance plot is plotted according to the station (Fig. 16) ; it shows the plot for pooled data it shows curve indicating the high diversity of macrofauna in station 3, less disturbance when the curves were drawn separately among the three stations. The cluster analysis showed that the seasonal abundance of polychaetes species in the three regions. St 1 got grouped separately from St 2 and 3 indicating species dissimilarity (Fig. 17). The k-dominance plot points out the diversity varied among the stations, lower with station 2 and higher with station 3.

The correlation coefficient was plotted between polychaete diversity and environmental variables. Species diversity is negatively correlated with water pH and sand soil, while water temperature, salinity, DO and soil nature of silt, clay and TOC positively correlated ; richness is very much correlated with the diversity and clay at $p < 0.05$ level at station 1 (Table 1). In station 2, species diversity is negatively correlated with water pH and sand ; hence, the water temperature, salinity, DO, silt, clay and TOC were positively correlated and the diversity is very much correlated with the richness at $p < 0.05$ level (Table 2). In station 3, species diversity is negatively correlated with water pH and silt ; while, water temperature, salinity, DO, sand, clay and TOC positively correlated ; diversity is very much correlated with the richness at $p < 0.05$ level (Table 3). Overall this study showed a similar tendency on the polychaete abundance and species diversity among the station's slight variations. The diversity value below 2.60 in stations 1 and 2 this could be attributed to the existence of many industries situated close to the study areas. Generally, the benthic community in an unstable environment is typically dominated by opportunistic species characterized by higher reproduction rate and genetic variation and is, therefore, more stress-tolerant (Jernelov and Rosenberg 1976). In a pollution-stressed environment, the conservative species are replaced by opportunistic species characterized by small body size and a short-life span which dominate numerically resulting in low species diversity (Warwick 1986). Therefore, it is inferred that the polychaetes could be effectively

Table 2. Correlation coefficient (r) between physico-chemical and polychaete population at St 2.

Station 2	Diversity	Richness	Even-ness
Water temperature	0.198	0.363	– 0.323
Salinity	0.261	0.537*	– 0.622*
DO	0.241	0.521*	0.263
Water pH	– 0.19	– 0.213`	0.11
Sand	– 0.164	– 0.117	0.687**
Silt	0.112	0.168	– 0.704*
Clay	0.25	0.047	0.446
TOC	0.359	0.102	0.543*
Diversity	1	0.930	0.293
Richness		1	–0.05
Evenness			1

Table 3. Correlation coefficient (r) between physico-chemical and polychaete population at St 3.

Station 3	Diversity	Richness	Even-ness
Water temperature	0.385	0.379	– 0.459
Salinity	0.202	0.209	– 0.595*
DO	0.161	0.139	– 0.263
Water pH	– 0.08	– 0.114	0.409
Sand	– 0.234	– 0.135	0.062
Silt	– 0.327	– 0.234	– 0.037*
Clay	0.321	0.318	– 0.06
TOC	0.305	0.291	0.336
Diversity	1	0.979*	0.081
Richness		1	0.01
Evenness			1

utilized to assess ecological changes in disturbed due to the environmental conditions. In this present study observed polychaete species are *Spionids, Capitellids* and *Pisionids* were found to be potentially adaptive in these environments. Because of the *Spionids* and *Capitellids* were universal indicators. In the case of pisionids species it may be the potential species in station 1.

CONCLUSION

The present study concluded that polychaete is an important species to monitor the environmental changes through organic and inorganic pollution indication. Moreover, polychaete is a pollution indicator species, from this study to understand the physico-chemical variability and polychaete density and diversity in three major estuarine. According to this present study to focused that variation of species density based on the environmental condition. Thus, this study concluded in station 2 (Uppanar estuary, Cuddalore) had lower polychaete density than station 1 and 3 respectively. The reason for changes valued from environmental factors especially nature of soil condition in the study area.

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REFERENCES

Ajmalkhan S, Manokaran S, Lyla PS (2014) Assessment of ecological quality of Vellar and Uppanar estuaries, Southeast coast of India, using Benthos. Ind J Geomarine Sci 43 (10) : 1—7.

Ajmalkhan S, Murugesan P (2005) Polychaete diversity in Indian estuaries. Ind J Mar Sci 34 : 1144—1149.

Ajmalkhan S, Murugesan P, Lyla PS (2004) A new indicator macro-invertebrate of pollution and utility of graphical tools and diversity indices in pollution monitoring studies. Curr Sci 87 : 1508—1510.

Belan TA (2003) Marine environmental quality assessment using polychaete taxocene characteristics in Vancouver Harbor. Mar Environ Res 7 : 89—101.

Bryan GW, Gibbs PE (1987) Polychaetes as indicators of heavy-metal availability in marine deposits. Oceanic Processes in Marine Pollution. Malabar, Publ Co 1 : 194—200.

Buchanan JB (1984) Sediment analysis. In: Holme NA, Mclntyre AD (eds). Methods for the Study of Marine Benthos. Blackwell Scientific Publications. Oxford and Edinburgh, pp 641—645.

Burd BJ, Brinkhurst RO (1990) Vancouver harbor and Burrard inlet benthic infaunal sampling program, October 1987. Canadian Tech Rep Hydrogr and Ocean Sci 122 : 1—49.

Chandrasekar N, Saravanan S, Joevivek V, Sivaperumal M (2014) Macrobenthic diversity in black sand enrichment area along the coast between Poompukar to Nagoor, India. J Mar Sci Dev 2 (4) : 1—8.

Chapman PM (2007) Determining when contamination is pollution–Weight of evidence determinations for sediments and effluents. Environ Int 33 : 492—500.

Day JH (1967) A monograph on the polychaete of Southern Africa. Part 1 and 2, British Museum (Nat Hist), London, pp 878.

Fauvel P (1953) The fauna of India including Pakistan, Ceylon, Burma and Malaya. Annelida: Polychaeta, Allahabad, pp 507.

Gendy A, Farraj S, Kahtani S, Hedeny M (2012) The Influence of marine pollution on distribution and abundance of polychaetes. Cur Res J Biol Sci 4 (1) : 40—47.

Gray JS (1981) The ecology of marine sediments. An introduction to the structure and function of benthic communities. In: Cambridge Studies in Modern Biology. Cambridge University Press, pp 185.

Harkantra SN, Rodrigues NR (2004) Environmental influences on the species diversity, biomass and population density of soft bottom macrofauna in the estuarine system of Goa, West coast of India. Ind J Mar Sci 33 (2) : 187—193.

Ingole B, Sivadas S, Nanajkar M, Sautya S, Nag A (2009) A comparative study of macrobenthic community from harbours along the Central West coast of India. Environ Monit Assess 154 : 135—146.

Jernelov A, Rosenberg R (1976) Stress tolerance of ecosystem. Environ Conserv 3 : 43—46.

Kailasam M (2004) Effect of thermal effluent discharge on benthic fauna off Tuticorin bay, Southeast coast of India. Ind J Mar Sci 33 (2) : 194—200.

Levings CD, Anderson EP, O'Connell GW (1985) Biological effects of dredged - material disposal in Alberni Inlet. Wastes in the Ocean. Malabar, Publ 6 : 131—155.

Mackie ASY (1994) Collecting and preserving polychaetes. Polychaete Res 16 : 7—9.

Maurer D (1969) Diversity of soft-bottom benthos in a tropical estuary: Gulf of Nicoya, Costa Rica. Marine Biol 81 : 97—106.

Murugesan P, Muniasamy M, Muthuvelu S, Vijayalakshmi S, Balasubramanian T (2011) Utility of benthic diversity in assessing the health of an ecosystem. Ind J Geomarine Sci 40 (6) : 783—793.

Musale AS, Desai DV (2011) Distribution and abundance of macro benthic polychaetes along the South Indian coast. Environ Monit Assess 178 : 423—436.

Quadros G, Sukumaran S, Athalye RP (2009) Impact of the changing ecology on intertidal polychaetes in an anthropogenically stressed tropical creek, India. Aquatic Ecol 43 : 977—985.

Quiroga E, Quinones RA, Gonzalez RR, Gallardo VA, Jessen G (2007) Aerobic and anaerobic metabolism of *Paraprionospio pinnata* (Polychaeta : Spionidae) in Central Chile. J Mar Biol Assoc UK 87 : 459—463.

Rivero MS, Elias R, Vallarino EA (2005) First survey of macrofauna in the Mar del Plata Harbor (Argentina) and the use of polychaetes as pollution indicators. Rev Biol Mar Oceanogr 40 : 101—108.

Rygg B (1985) Distribution of species along pollution induced diversity gradients in benthic communities in Norwegian Fjords. Mar Pollut Bull 16 (12) : 469—474.

Sanagoudra N, Bhat UG (2013) Species diversity and environmental relationships of marine macrobenthic in Gulf of Kutch, Gujarat, West coast of India. Am J Mar Sci 1 (1) : 33—37.

Sanders HL (1956) Benthic studies in Buzzards Bay. Animal sediment relationships. Limnol Oceanogr 3 : 245—258.

Saravanan N, Uma T, Madhu Magesh K, Ramachandraprabhu S, Vinoth A (2014) Environmental pollution monitoring: Comparison of histological variation of tissues of two different sampling site Pulicat and Ennore 4 (7) : 1405—1410.

Sekar V, Prithiviraj N, Savarimuthu A, Rajasekaran R (2013) Macro faunal assemblage on two mangrove ecosystems, Southeast coast of India. Int J Rec Sci Res 4 (5) : 530—553.

Srikrishnadas B, Murugesan P, Ajmalkhan SA (1998) Monograph on the Polychaetes of Parangipettai coast. Annamalai University, India, pp 110.

Strickland JDH, Parsons TR (1972) Practical handbook of seawater analysis. Bull Fish Res Canada 167 : 310.

Tsutsumi H (1990) Population persistence of *Capitella* sp. (Polychaeta ; Capitellidae) on a mud flat subject to environmental disturbance by organic enrichment. Mar Ecol Prog Ser, pp 147—156.

Vijayakumar S, Rajesh KM, Mendon MR, Hariharan V (2000) Seasonal distribution and behavior of nutrients with reference to tidal rhythm in the Mulki estuary, Southwest coast of India. J Mar Biol Assoc India 42 (182) : 21—31.

Wakeel El SK, Riley JP (1957) The determination of organic carbon in marine muds. ICES J Mar Sci 22 (2) : 180—183.

Warwick R (1986) A new method for detecting pollution effects on marine macrobenthic communities. Mar Biol 92 (4) : 557—562.

Yokoyama H (1990) Life history and population structure of the spionid polychaete *Paraprionospio* sp. (form A). J Exp Mar Biol Ecol 144 (2–3) : 125—143.