*Available online at* www.pelagiaresearchlibrary.com

Pelagia Research Library

Advances in Applied Science Research, 2011, 2 (6):554-562

ISSN: 0976-8610
CODEN (USA): AASRFC

# Biodiversity and abundance of benthos along the South East Coast of India

**Manoharan J, Varadharajan D*, Thilagavathi B and Priyadharsini S**

*Faculty of Marine Sciences, Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai, Tamil Nadu, India*

---

## ABSTRACT

*Habitat plays an important role in the life cycle of many benthic organisms. Deposit composition is vital to the marine benthic organisms which provide shelter and foodstuff in the structure of organic matter. The macro, meio and micro fauna and flora maximum was recorded in muddy shores and minimum was recorded in sand beaches. Biotic and abiotic factors are directly or indirectly affect an organism in its environment.*

**Key words**: Macro, meio and micro fauna and flora, biodiversity.

---

## INTRODUCTION

The diversity of marine life is most obvious on the bottom where animals have adapted to a multitude of niches and with extremely diverse looks and behaviour. Benthic organisms macro, meio and micro fauna and flora play an important role in food chains [1], including as food for humans and some play a critical role in the breakdown of organic matter [2] living macro, meio and micro fauna and flora are more sensitive to environment disturbances making them potential bio indicators of the changes in the water and soil environment [3,2]. Benthic animals have an intimate relationship with the substratum and the components, texture and chemical attributes of the sediment has a regulatory effect on the species that can live in any particular area [4]. For this reason the benthos is often use as an environmental indicator for determination of the impacts of pollutants, hydrologic alterations and sediment disturbance [5, 6]. Simply in very severely polluted and otherwise disturbed areas are benthic communities can be absent [7]. It can be provide information regarding the integrated effects of stress due to disturbances, if any and hence are good indicators of early warning of potential damage benthic fauna spatial and temporal distribution. Any variation in their living environment will directly affect the abundance of fish and shellfishes that are important fishery resources in the coastal [8; 7; 9]. Studies on benthos are limited (10, 7, 11-15) of Indian coastal environment. However, the differences in benthic organisms on a marine transect, in the coastal water zone, of a beach with different kinds of sediments. The intended to compare our theoretical expectations of the distribution of benthic fauna influenced by changing abiotic factors.

**Table 1. Checklist of species recorded in four stations**

| S. No. | Macrobenthos | No/ $m^2$ | | | |
|---|---|---|---|---|---|
| | Stations | I | II | III | IV |
| **I** | **Polycheates** | | | | |
| 1 | *Cossuridae* sp. | * | * | 4 | * |
| 2 | *Neries vireins* | 1 | * | * | * |
| 3 | *Pisionidae* sp. | * | * | * | 123 |
| 4 | *Polydora ciliate* | 3 | * | * | * |
| 5 | *Tomopterus* sp. | * | * | * | 7 |
| **II** | **Bivalves** | * | * | * | * |
| 1 | *Arca veliger* | 4 | 5 | * | * |
| 2 | *Meretrix meretrix* | 5 | 2 | * | * |
| 3 | *Meretrix casta* | 2 | 3 | * | * |
| **III** | **Amphipoda** | | 9 | 1 | * |
| **IV I** | **Gastropods** | | | | |
| 1 | *Litorina* sp. | * | 2 | * | * |
| | **Meiobenthos** | **No/$cm^3$** | | | |
| **V** | **Nematoda** | 87 | 206 | 557 | 385 |
| **VI** | **Cumacea** | * | * | 18 | * |
| **VII** | **Tardigrata** | * | * | 15 | * |
| **VIIII** | **Ciliophora** | * | * | 8 | * |
| **IX** | **Ostracoda** | * | * | 24 | * |
| **X** | **Tanaidacea** | | * | 1 | * |
| **XI** | **Oligochaeta** | * | * | 1 | 34 |
| **XII** | **Turbellaria** | * | * | 39 | 27 |
| **XIII** | **Halacaroidea** | * | 5 | 18 | * |
| **XIV** | **Insecta** | * | 7 | * | * |
| **XV** | **Harpacticoid copepods** | | | | |
| 1 | *Euterpina acutiferans* | 4 | 28 | 15 | 23 |

| | | | | | |
|---|---|---|---|---|---|
| 2 | *Macrosetella* sp | 2 | 20 | 9 | 18 |
| **XVI** | **Foraminiferans** | | | | |
| 1 | *Textularia* sp. | 16 | * | * | * |
| 2 | *Quinqueloculina* sp. | 28 | 42 | * | * |
| 3 | *Eponides repandus* | 14 | 44 | * | * |
| 4 | *Nonion depressulum* | 17 | * | * | * |
| 5 | *Bolivina* sp. | 24 | 12 | * | * |
| 6 | *Cibicids* sp. | 14 | * | * | * |
| 7 | *Rotalia translucens* | * | 58 | 18 | * |
| 8 | *Rotalia pulchella* | * | 16 | 9 | * |
| 9 | *Cornobodies* sp | * | 28 | 27 | * |
| 10 | *Ammonia beccari* | * | 10 | * | * |
| 11 | *Oridosalis* sp. | * | 36 | * | * |
| 12 | *Peneroplis pertusus* | * | 4 | * | * |
| 13 | *Legena* sp. | * | 7 | * | * |
| 14 | *Elphidium* sp. | * | * | 3 | * |
| 15 | *Operculina* sp. | * | * | 6 | * |
| 16 | *Nodellum* sp. | * | * | 30 | * |
| **XVII** | **Microflora** | | | | |
| 1 | *Cossinodiscus* sp. | 26 | 38 | 132 | * |
| 2 | *Pleurosigma* sp. | * | 15 | * | * |
| | **Total** | **247** | **597** | **935** | **617** |

*(*absent of species)*

## MATERIALS AND METHODS

The study was carried out for one year from September 2009 to August 2010 in four station viz., (Station1) Chennai Merina Beach, (Station2) Karikal, (Station3) Tranquebar and (Station4) - Nagapattinam at Tamil nadu east coast of India. The water and sediment samples were collected in every month four times at all stations. A hand corer with 4.3 cm inner diameter was used to collect samples at all stations, sieved and retained through 0.5Mm size sieve screen for macrobenthos, 45 Mm sieve for meio and micro flora and preserved in 5% formalin. The animals were separated, counted, identified up to species level using standard references and expressed in No/$cm^3$. Water and Sediment samples were nutrient analysis by adopting standard procedure of [16, 17]. The identification of species was referred standard references.

## RESULTS

**Table 2. Percentage composition of benthic community**

| Group of benthic community | Sts.1 | % | Sts.2 | % | Sts.3 | % | Sts.4 | % |
|---|---|---|---|---|---|---|---|---|
| Polycheates | 4.0 | 1.6 | 0 | 0.0 | 4.0 | 0.4 | 130.0 | 21.1 |
| Bivalves | 11.0 | 4.5 | 10.0 | 1.7 | 0 | 0.0 | 0 | 00 |
| Amphipoda | 0 | 0.0 | 9.0 | 1.5 | 1.0 | 0.1 | 0 | 00 |
| Gastropods | 0 | 0.0 | 2.0 | 0.3 | 0 | 0.0 | 0 | 00 |
| Nematoda | 87.0 | 35.2 | 206.0 | 34.5 | 557.0 | 59.6 | 385.0 | 62.4 |
| Cumacea | 0 | 0.0 | 0 | 0.0 | 18.0 | 1.9 | 0 | 00 |
| Tardigrata | 0 | 0.0 | 0 | 0.0 | 15.0 | 1.6 | 0 | 00 |
| Ciliophora | 0 | 0.0 | 0 | 0.0 | 8.0 | 0.9 | 0 | 00 |
| Ostracoda | 0 | 0.0 | 0 | 0.0 | 24.0 | 2.6 | 0 | 00 |
| Tanaidacea | 0 | 0.0 | 0 | 0.0 | 1.0 | 0.1 | 0 | 00 |
| Oligochaeta | 0 | 0.0 | 0 | 0.0 | 1.0 | 0.1 | 34.0 | 5.5 |
| Turbellaria | 0 | 0.0 | 0 | 0.0 | 39.0 | 4.2 | 27.0 | 4.4 |
| Halacaroidea | 0 | 0.0 | 5.0 | 0.8 | 18.0 | 1.9 | 0 | 0.0 |
| Insecta | 0 | 0.0 | 7.0 | 1.2 | 0 | 0.0 | 0 | 0.0 |
| Harpacticoid copepod s | 6.0 | 2.4 | 48.0 | 8.0 | 24.0 | 2.6 | 41.0 | 6.7 |
| Foraminiferans | 113.0 | 45.8 | 257.0 | 43.1 | 99.0 | 10.6 | 0 | 0.0 |
| Microflora | 26.0 | 10.5 | 53.0 | 8.9 | 132.0 | 14.1 | 0 | 0.0 |
| Total | **247.0** | **100.0** | **597.0** | **100** | **935.0** | **100.0** | **617.0** | **100.0** |

**Table 3: Average water quality parameters in all the station**

| Months | JAN | FEB | MAR | APR | MAY | JUNE | JULY | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | Temperature | | | | | | | | | | | |
| Water | 28.5 | 28.5 | 31.0 | 32.0 | 32.5 | 33.0 | 33.5 | 34.5 | 31.5 | 29 | 28.0 | 28.5 |
| Sediment | 28 | 30 | 32 | 31.5 | 32.0 | 32.5 | 33.0 | 34 | 30 | 28 | 26.0 | 26.5 |
| | Salinity | | | | | | | | | | | |
| Water | 27.5 | 34.0 | 34.5 | 35.0 | 35.5 | 34.5 | 34.0 | 33 | 32 | 30 | 26.0 | 26.5 |
| Sediment | 27 | 33 | 34 | 34.5 | 35 | 34 | 33 | 32 | 30 | 28 | 25.5 | 26.0 |
| | pH | | | | | | | | | | | |
| Water | 7.9 | 8.1 | 8.0 | 8.3 | 8.1 | 8.0 | 8.2 | 8.1 | 8.0 | 7.9 | 7.8 | 8.0 |
| Sediment | 7.7 | 8 | 7.9 | 8.2 | 8.0 | 7.8 | 8.1 | 8.0 | 7.6 | 7.3 | 7.5 | 7.8 |
| | Total phosphorus | | | | | | | | | | | |
| Water ( µ mole/l ) | 1.63 | 1.49 | 1.71 | 0.98 | 1.58 | 1.25 | 1.76 | 1.98 | 2.57 | 2.34 | 3.71 | 2.89 |
| Sediment mg/g | 1.98 | 1.78 | 2.15 | 1.27 | 1.97 | 1.78 | 2.31 | 2.75 | 2.98 | 3.17 | 4.25 | 3.21 |
| | Total organic carbon | | | | | | | | | | | |
| Water ( µ mole/l ) | 0.59 | 1.83 | 2.72 | 0.25 | 1.74 | 0.89 | 2.32 | 1.28 | 0.25 | 0.94 | 2.32 | 1.28 |
| Sediment mg/g | 0.82 | 0.95 | 3.17 | 0.71 | 1.56 | 1.24 | 2.79 | 2.45 | 1.73 | 1.26 | 3.75 | 2.46 |

The total number of fauna and floras are recorded in percentage composition of Foraminiferans (45.8%) (*Textularia sp., Quinqueloqulina sp., Eponoides repandus, Nonion depressulum, Bolivina sp. Cibicids sp*) > Microflora (10.5%) (*Cosinodiscus sp*) >Nematodes (35.2%) > Bivalves (4.5%)> Herpacticoid copepods (2.4%)> Polychaetes (1.6%) was recorded in Station 1(Table1&2)

The total number of fauna and floras are recorded in percentage composition of Foraminiferans (43.1%) (*Quinqueloqulina sp., Eponoides repandus, Bolivina sp Rotalia transulances.., Rotalia pulchella, Cornobodies sp., Ammonia beccari, Oridosalis sp., Peneroplis pertusus, Legena sp)* >

Microflora(8.9%) (*Cosinodiscus sp.*, *Plerosigma sp*) > Nematodes (34.5%)> Herpacticoid copepods (8%) > Bivalves (1.7%) > Amphipods (1.5%) >Insecta (1.2%)> Halacaroidea (0.8%)> Gastropods (0.3%) was recorded in Station 2 (Table1&2).

The total number of fauna and floras are recorded in percentage composition of Nematoda (59.6%) > Herpacticoid copepods(41%) > Microflora (14.1%) (*Cossinodiscus sp)* > Foraminiferans(10%) (*Rotalia translucens, Rotalia pulchella, Cornobodies sp. Ammonia beccari. Elphidium sp. Operculina sp. Nodellum sp)* > Turbellarians (4.2%)> Ostracoda(2.6%) >Cumacea(1.9%) > Halacaroidea(1.9%) >Tardigrata(1.6%)> Ciliophora(0.9%)> Polycheates (0.4%) > Amphipods(0.1%) > Tanaidacea (0.1%) > Oligochaeta(0.1%) was recorded in Station 3 (Table1&2). The total number of fauna and floras are recorded in percentage composition of Nematoda (62.4%)> Polycheates (21.1%)> Herpacticoid copepods (6.7) > Oligochaeta (5.5%)> Turbellaria (4.4%) was recorded in station4 (Table1&2).

In the present study the maximum temperature was recorded water 32.5 and sediment 32.0 in the month of May and minimum was recorded water 28.0 and sediment 26.0 in the month of November. Maximum salinity was recorded water 35.5 and sediment 35.0 in the month of May and minimum was recorded water 26.5 and sediment 25.5 in the month of November and the pH maximum was recorded water 8.3 and sediment 8.2 in the month of April and minimum was recorded water 7.8 and sediment 7.5 in the month of November. The total phosphorus maximum was recorded water 3.71 and sediment 4.25 in the month of November and minimum was recorded water 0.98 and sediment 8.2 in the month of April. Maximum total organic carbon was recorded water 2.32 and sediment 3.75 in the month of November and minimum was recorded water 0.25 and sediment 0.71 in the month of April (Table3).

## DISCUSSION

Benthic organisms, such as macro, meio and micro fauna and flora have adapted many different styles that influence their exposure to sediment contaminants. Some species live on the sediment surface and feed in the water column, others live on the sediment surface in tubes and feed on detrital materials that are at the surface of the sediment or suspended in the water column. Other organisms live within mucous lined burrows within the sediment and obtain their food supplies from the surface of the sediment adjacent to the burrows [18]. The species of benthic organisms for which have the most information are those that value as a food source. The biology and habitat of benthic organisms, often to determine the causes of cycles of abundance and decline and to determine the impacts of pollution and habitat degradation [19]. Most benthic organisms have a high rate of fecundity. A high rate of fecundity enables many species to recover from environmental disturbances rapidly and to colonize new habitats quickly and in high numbers. The spatial variability has been inferred to be related to oxygen availability, sediment structure and point sources of organic matter. Organic detritus are the major source of food for coastal benthos [8].

Sea bed composition such as sand, silt and clay, indicated a diverse nature of the benthic substratum along the study area [20]. Granule size is thus a vital factor determining faunal distribution and abundance in all environmental areas. The Grain size composition is influenced by many environmental factors, such as exposure to wave action, currents and the nature and amount of suspended matter [21, 22]. In the present study the sand beaches (station1 & 2) occur only where wave action is light coarse ones where it is heavy is that, in heavy wave action, the smaller particles remain suspension so long that they are carried away from the beach. It can be providing as a habitat, food, serving as breeding grounds, resting area and nursery for a number of animals [23, 24]. In the open sand beaches tent to have lesser amount of organic debris from various sources finds its way to the beach to be a reliable source of food for certain organism. Since these detritus materials is often carried up and down the beach suspended in the wave wash rather than being deposited on the bottom, therefore, the burrowing benthic organisms clearly observed in higher animals for feeding [10,25, 26,13], major problems of the benthic organism can be destroyed and migration of inhabitant. Muddy shores (station3) are restricted to intertidal areas completely protected from open ocean wave activity. Muddy shores are best developed where there is a source of fine grained sediment particles. In these areas developed where water movements is minimal the slope of mud shores tends to be much flatter observed for sand beaches. Organic films and bacterial composition are clearly less likely to play a role in attracting settlement on high energy sandy beaches, because benthic communities are permanent residents of the coastal and they are highly sensitive to poor water quality and sediment quality. The muddy shores are limited mobility of species and cannot migrate to avoid stressful situations, several benthic groups have been used as indicators of stress conditions, such as amphipods [27], cumaceans [28] and polychaetes [29]. Muddy flats (station4) tend to accumulate organic materials, which mean that there is an important potential food supply for the benthic resident organisms [3, 30]. Since wave action is essentially absent on these mudflats, there necessity for development of either burrowing or heavy bodies to positions, the large number of species possesses a wide range of responses to stressors [31] and also the predation and pollution problem present in coastal environments [30].

In the present study sediment inhabiting benthic community is a major role in ecosystem. Study on the benthos has increased considerably during recent decays and attempts have been made to relate standing stocks with various environmental factors. The diversity and density of benthic community is high (station3) than other stations. The high faunal abundances may have also occurred because of organic detritus settle on sediments were a food rich environment (station3), this study agree with earlier study [32, 33, 34] While the quantity of organic deposition in the beach is not unusually high for coastal wastes, this input primarily composed of organic polluted and detritus, may contain an unusually could have thrived because of spatial segregation of meiofauna and macrofauna [35]. While Meiofauna were concentrated at the sediment water interface, most macrofauna were subsurface deposit feeders.

The physico chemical characteristics affect distribution and growth of the benthic organisms [14]. Unlike predator, benthos cannot move around much so they are less able to escape the effects of sediment and other pollutants that diminish water quality [36, 37]. Climatic characteristic influences the water quality and quantity affects the benthic biodiversity. Temperature is one of the most important factors among the external factors which influence the benthic production. Increased or decreased temperatures and future changes in water currents may severely affect benthic life and their ability to recover from extreme climatic events. As result of the increase in water temperature, since this effects the food supply of the benthic organisms besides its effect on its metabolism. Salinity remains one of the most important benthic community structuring forces [38]. Its effect on the population growth under favorable environment conditions rather than from a sudden change in growth rate. pH is a main factor of benthic animals life cycles [39]. Phosphorus is not toxic to benthic animals [40]. Effluent, rich in phosphorus, results in `eutrophication. Microbial breakdown of dead algae can cause oxygen deficiencies and benthic animals stress. Benthic organisms generally have a range of TOC tolerance, above and below which population densities decreases. In benthic communities, it is generally expected that increases concentrations of TOC in sediment will result in increases abundance and productivity, with decreased species richness and diversity in changes to benthic communities structure and possibly to functions [36, 37].

Nutrients are considered as one of the most important parameters in the marine environment by influencing the growth, reproduction and metabolic activities of benthic organisms, therefore, the nutrient settle on the coastal the occurrence of bulk of rainfall during northeast monsoon and pollutions [41]. The monsoon season at both the stations indicated effective assimilation of organic loads. Abundance of benthic macro, meio and micro fauna and flora to the higher percentage of organic matter in the sediments [19]. The phytoplankton detritus accumulated in the sediments during the postmonsoon and that the benthos responded to this store of food when temperatures rose rapidly in the summer. By late summer the stored detritus was an exhausted and the benthos declined. However, the rapidly increasing sediment temperatures during this time may also strongly affect benthic communities [42, 43, 44]. Benthic assemblages such as macro, meio and micro fauna and flora impact in where pollution since wastewaters brings nitrogen, phosphorus and organic carbon into coastal systems, this study agree with previous studies [45, 46, 47]. Therefore, benthos can give us reliable information on coastal water quality.

## CONCLUSION

The dominant benthic groups can be muddy shores are the same as these encountered on sand beaches. Because of the grater amount of organic matter present in and on muddy shores and increased productivity due to settlement there is vastly more food available on muddy shores than on sand beaches. In these coastal regions close to industrial area and urban areas sediment acts as sink and is the greatest potential source of inorganic and organic contaminants in the marine environment. Anthropogenic impacts those are most destructive to benthic communities. In the present study benthic organisms to be highly sensitive to environmental stress due to the pollution and differences observed in the species abundance can be owing to the little variations in the physico-chemical and sediment quality of the coastal water habitat and also the weather, season and exposure of the shore will affect the distribution and abundance of intertidal organisms and hence timing of the survey is important.

## REFERENCES

[1] Snelgrove PVR, *Biodiv. Conserv*, **1998,** 7, 1123-1132.
[2] Somerfield PG, and Gage, JD, *Mar. Bio.*, **2000**, 136: 1133-1145.
[3] Alongi DM, *Oceanogr. Mar. Bioi. Annu. Rev.*, **1990**, 28: 381-496.
[4] Sanders HL, *Am. Nat.*, **1968**.102: (925) 243-282.
[5] Thrush SF, Pridmore RD, and Hewitt JE, *Ecological Applications*, **1994**, 4, 31–41.
[6] Knox GA, CRC Press, New York, **2000,** 555 pp.
[7] Parulekar AH, Harkantra SN, and Ansari ZA, *Indian J.Mar.Sei.*, **1982**, 11: 107-114.

[8] Ansari Z A, Harkantra SN, Nair SA, and Parulekar AH, *Mahasagar-Bull. Natnl. Inst. Oceanogr.*, **1977b,** 10 (1 & 2): 55-60.
[9] Herman PMJ, Middelburg JJ, Widdows J, Lucas CH, Heip CHR,Marine Ecology Progress Series, **2000**, 204, 79–92.
[10] Harkantra SN, *Indian J Mar. Sci.*, **1982**, 11: 75-78.
[11] Joydas TV, and Damodaran R, Paper presented at IAPSO/IABO Ocean Odyssey Conference held at Mar Del Plata, Argentina on, **2001,** 21-28.
[12] Joy Das TV, Dept. Marine Biology, Ph. D. Thesis of Cochin University of Science and Technology, **2002**, 151 pp.
[13] Mahapatro D, Orissa Coast. M.Phil Dissertation, Berhampur University, Berhampur, Orissa, India, **2006.**
[14] Jayaraj KA, Jayalakshmi KV, Saraladevi K, *Environ. Moni. Asses* , **2007**, 127: 459-475.
[15] Joydas TV, Damodaran R, *Indian J. Mar. Sci.*, **2009**, 38 (2): 191-204.
[16] Walkley A, and Black IA, *Soil Sci.*, 1934, 37: 29-38.
[17] Strickland and Parsons TR, *J. Fish. Res. Bd. Canada.* **1972,** 167: 311 pp.
[18] Alongi DM, *Oceanogr. Mar. Bioi. Annu. Rev.* **1990**, 28: 381-496.
[19] Ansari Z A, *Indian J. Mar. Sci.*, **1984,** 13 (3): 126-127.
[20] Perillo GME, Ripley MD, Piccolo MC, and Dyer KR, Mangroves and Salt Marshes **1996,** 1(1): 37-46.
[21] Dittmann S, *Journal of sea Research*, **2000,** 43: 33-51.
[22] Lizarralde Z, Ferrari S, Pittaluga S, and Albrieu C, *Ornitologia Neotropical*, **2010,** 21:283–294.
[23] Crisp DJ, IBP Handbook 16, *Blackwell Scientific Publications Oxford*, **1971,** 197-279.
[24] Shou L, Huang Y, Zeng J, Gao A, Liao Y, and Chen Q, *Aquatic Ecosystem Health & Management*, **2009,** 12(1), 110–115.
[25] Harkantra SNS, Nair A, Ansari Z A, and Parulekar AH, *Indian J Mar. Sd.*, **1980,** 9: 106-110.
[26] Ingole BS, Rodrigues N, Ansari ZA, *Indian J. Mar. Sci.*, **2002,** 31(2): 93-99.
[27] Gomez Gesteira J L, and Dauvin JC, *Marine Pollution Bulletin*, **2000**, 40, 1017–1027.
[28] Corbera J, and Cardell MJ, *Scientia Marina*, **1995,** 50, 63–69.
[29] Samuelson GM, *Marine Pollution Bulletin*, **2001,** 42 (9), 733–741.
[30] Ansari ZA, Sreepada RA, and Kanti A, *Ind .J. Mar. Sci.*, 1994, 23: 225-231.
[31] Bordovsky OK, *Mar. Geol.*, **1964,** 3 (1&2): 34-79.
[32] Malone T C, Crocker LH, Pike S E, Wendler B W, *Mar. Ecol. Prog. Ser.* **1988,** 48: 235-249
[33] Kemp WM, and Boynton, Maryland Sea Grand College. College park, Maryland, **1992**.
[34] Malone T C, Maryland Sea Grant, College Park, **1992,** p. 61-148.
[35] Achuthankutty CT, *Indian J. Mar. Sd.*, **1976**, 5: 91-97.
[36] Daur D M, Luchenback HG, and Rodi AJ, *Marine Biology*, **1993**.
[37] Alden R, Dauer W, Ranasinghe DM, Scott JA, and Llanso RJ, *Environmetrics*, **2002,** 13, 473–498.
[38] Vizakat L, Harkantra SN, Parulekar AH, *India J. Mar. Sci*. **1991,** 20:40-42.
[39] Harkantra SN, and Parulekar AH, Mahasagar, **1981,** 14(2): 135-139.
[40] Jordan TE, Correll Dl, and Weller DE, *Journal of the American Water Resources Association*, **1997b,** 33:631-646.
[41] Sanders HL, *Limnol. Oceanogr.* **1958,** 3: 245-258.
[42] Pearson TH, Rosenberg R, Oceanography and Marine Pollution Annual Review**1978**.

[43] Marsh AG, and Tenore KR, Limnology and Oceanography, **1990,**35:710–724.
[44] Diaz RJ, and Rosenberg R, Oceanography and marine biology. An Annual Review, **1995,** 33:245-305.
[45] Day, JR, Hall CAS, Kemp WM, and Yanez Aran Cibia A, *Estuarine ecology*, John- Wiley& Sons, New York **1989**.
[46] Veloso VG, Cardoso RS, and Fonseca DB, *Oecologia Brassiliensis*, **1997,** 3,213-225.
[47] Das Neves LP, da Silva P de SR, and Bemvenuti CE Iheringia, *Serie Zoologia*, **2008,** 98 (1): 36-44.