DIVERSITY INDICES OF SELECTED MACROBENTHOS IN KARANJA CREEK (DISTRICT – RAIGAD), MAHARASHTRA, WEST COAST OF INDIA

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ABSTRACT

The diversity indices can be used as a good measure for studying the effect of industrial pollution because industrial wastes and sewage almost always reduce the diversity of natural systems into which they are discharged. A measurement of diversity often provides a better index of pollution than a direct measurement of pollutants. The assessment of macrobenthos diversity with respect to diversity indices reflects the marine population and habitat disturbance, and also serves as an important indicator of environmental conditions. The present study was designed to investigate the diversity indices of selected macrobenthos at two ecologically distinct locations on the Karanja creek (District – Raigad), Maharashtra, west coast of India. Results on various diversity indices like Index of Frequency (F) or Importance Probability (Pi), Index of Dominance (c), Rarity Index (R), Shannon's Index of General Diversity (H^1), Margalef's Richness Index (R_1) and Evenness Index (e) did not vary significantly. This demonstrates that at present, Karanja creek harbours varied forms of macrobenthic community showing no effect of human disturbance, but in future, measures must be taken for the protection and conservation of macrobenthic community of the creek.

Keywords: Diversity indices, conservation, macrobenthos, container freight stations, Jawaharlal Nehru Port Trust

INTRODUCTION

Macrobenthos constitutes a dominant functional component in marine ecosystem and reveals a wide range of adaptability to different marine and coastal habitats. Worldwide, a number of researchers have investigated the biodiversity of the benthic ecosystems for formulating adequate marine conservation and protection measures. Pillai (1977) reported that benthos play a vital role in the marine food chain and in the recycling of essential life sustaining elements. According to Duda *et al.* (1982), macrobenthic fauna prey on all lower forms of life, and help to process organic matter helping nutrient recycling in the energy cycle of benthic ecosystem. Savich (1972) and Harkanta (1998) showed that bacteria are major source of food for meiobenthos and meiobenthos are food for macrobenthos, which in turn, serve as an important source of food for demersal fishes. Naqvi *et al.* (1992), Sandens *et al.* (2000), and Pennifold and Davis (2001) reported that macrobenthos create bioturbation during their movement and feeding activities which

conditions the sediments for meiofauna and macrofauna, and as a stimulant for nutrient regeneration. Varshney *et al.* (1988) showed that the study of macrobenthos could act as an indicator of demersal fishery potential. Bilyard (1987), Engle and Summers (1999), and Khan and Murugesan (2005) reported that benthos, due to the differential tolerance, have been considered as the best indicator organisms of environmental stress or aquatic pollution. Macrofauna are a highly sensitive group of metazoans and a slight change in their natural environment could induce a high stress on the organisms already adapted to the stable deep-sea conditions (Ingole *et al.*, 2005).

A diversity index is a mathematical measure of species diversity in a community. Diversity indices serve as a valuable tool to quantify diversity in a community and to describe its numerical structure. In biodiversity investigations, the assessment of diversity indices is essential to determine the community structure of a particular ecosystem (Dash, 2002). Many reports have been published on macrobenthos diversity in and around Mumbai (Govindan, 2002; Quadros and Athalye, 2002; Venkatachalam and Kale, 2002; Jaiswar and Kulkarni, 2005; Jaiswar *et al.*, 2006), but the analysis of diversity indices of macrobenthos has not been reported adequately (Annie and Govindan, 1995; Venkatachalam and Kale, 2002).

Karanja creek (Lat. 18^0 50' 15" N and Long. 72^0 57' 15" E) located along the eastern shore of Mumbai harbour opposite to Coloba, encircles the village Karanja. The creek is continuous with Dharamtar and Pen-Khopoli creeks joining the Arabian Sea near Uran (Fig. 1) on the west coast of India. Recently, the whole coastal belt of Uran is under the

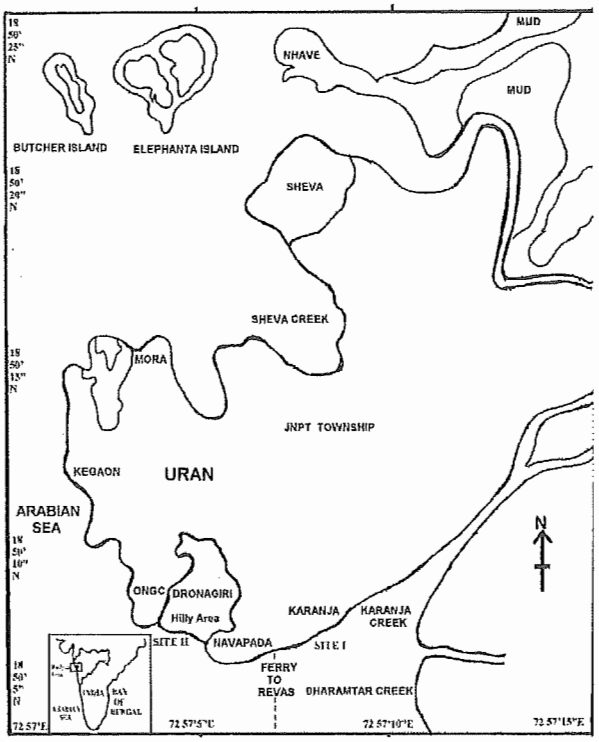

Fig. 1: General map of the Karanja creek showing the sampling sites I and II

heavy process of urbanization due to a number of industries settled on the coast line. A major port called Jawaharlal Nehru Port Trust (JNPT) lies near Uran, which is 10 km away from Karanja. JNPT is one of the busiest international ports in the country and supports a variety of maritime activities. The area of Uran shore and Karanja creek became the ground for hectic activities of many container freight stations that are created along the stretch of Karanja creek. As a result of these activities, the macrobenthic fauna of the creek is affected. Hence, this area was identified for the study of diversity indices of selected macrobenthos in relation to the changing environmental conditions. Further, no earlier reports are available on

macrobenthic diversity in Karanja creek; so, the data presented can be considered as the baseline data for better management of the creek in future.

MATERIAL AND METHODS

The Study Area

During the present investigation, a detailed monitoring of macrobenthos diversity was done along the 17-km stretch of Karanja creek for two consecutive years (January 2004 to December 2005). Two study sites representing the wider pan (seaward end) and narrow pan were selected along the creek and at each site. The intertidal area was measured and marked into upper littoral zone (ULZ), mid littoral zone (MLZ) and lower littoral zone (LLZ) following Bhatt (1959) and Parulekar (1973). The selected sites were visited fortnightly at spring low tide from January 2004 to December 2005, and macrobenthos were collected and processed as per the recommendations of Holme and McIntyre (1984). Identification of macrobenthos was done following the works of Subrahmanyam *et al.* (1949, 1951, 1952), Chhapgar (1957, 1958), Apte (1988), Fish and Fish (1996), and Khan and Murugesan (2005). Macrobenthos collected from all the sites were analyzed for diversity indices following standard methods (Parulekar *et al.*, 1976; Eleftheriou and Holme, 1984).

Diversity Indices

The following indices were calculated for the quantification of biodiversity and comparison of species diversity;

1. Index of Frequency (F) or Importance Probability (Pi) (Smith and Smith, 1988)

   Pi or F = ni/N

   Where, ni = Number of individuals of each species in the community

   N = Total number of all individuals of all species in the community

2. Index of Dominance (c) (Simpson, 1949)

   $c = \sum (ni/N)2$

   Where, ni = Number of individuals of each species in the community

   N = Total number of all individuals of all species in the community

3. Rarity Index (R) (Ludwig and Reynolds, 1988)

   R = 1/F

   Where, F = Index of frequency

4. Shannon's Index of General Diversity (H') (Shannon and Weaver, 1949)

   $H' = - \sum Pi. \text{Log e } Pi$

   Where, Pi = Importance Probability

   loge = ln (log natural)

   = log10 x 2.303

5. Margalef's Richness Index (R1) (Margalef, 1968)

   R1 = (S-1)/(Log N)

   Where, S = Number of species in the community

   N = Total number of all individuals of all species in the community

6. Evenness Index (e) (Pielou, 1966)

   e = H'/(Log S)

   Where, H' = Shannon's Index of General Diversity

   S = Number of species in the community

RESULTS

The faunal groups encountered at Karanja creek were polychaetes, gastropods, crustaceans, pelecypods and echinoderms. Since species like *Bursa tuberculata, Nerita oryzarum and Trochus radiatus* of gastropods, *Arca symmetrica* of pelecypods, *Eupagurus prideauxi* of crustaceans and *Perinereis cultrifera* of polychaetes were recorded abundantly, their diversity indices were assessed during the present investigation.

The index of frequency (F) or importance probability (Pi) of the selected macrobenthos showed seasonal variation and the values were high in premonsoon and postmonsoon than the monsoon (Fig. 2). The highest F was recorded for P. cultrifera during premonsoon (0.741, March 2004) followed by *B. tuberculata*

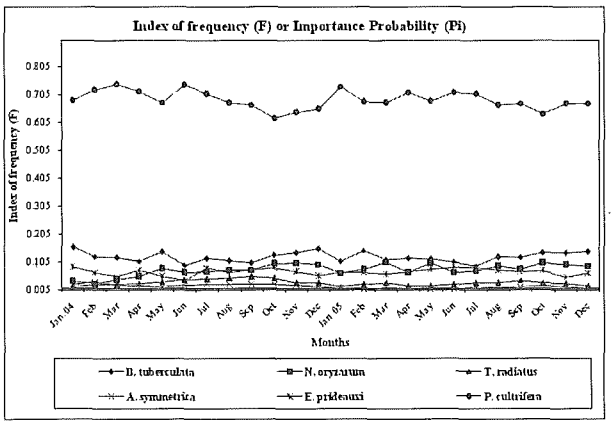

Fig. 2: Index of frequency or importance probability at Karanja creek

during postmonsoon (0.158, January 2004), whereas the lowest values were recorded for *A. symmetrica* (0.007, May 2005). The index of frequency can be placed in the order *P. cultrifera* > *B. tuberculata* > *N. oryzarum* > *E. prideauxi* > *T. radiatus* > *A. symmetrica.*

The index of dominance was uniform at the three sites where the dominance of the species can be placed in the order *P. cultrifera* > *B. tuberculata* > *E. prideauxi* > *N. oryzarum* > *T. radiatus* > *A. symmetrica.* The data on index of dominance show that the pelecepod species *A. symmetrica* was dominated over by other species (Fig. 3).

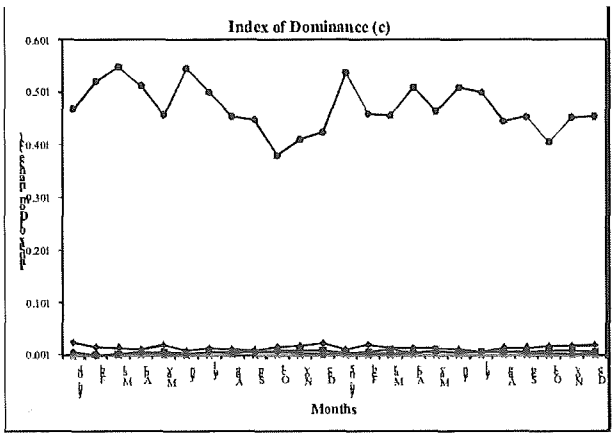

Fig. 3: Index of dominance at Karanja creek

The rarity index was according to the index of dominance (Fig. 4). In this case,

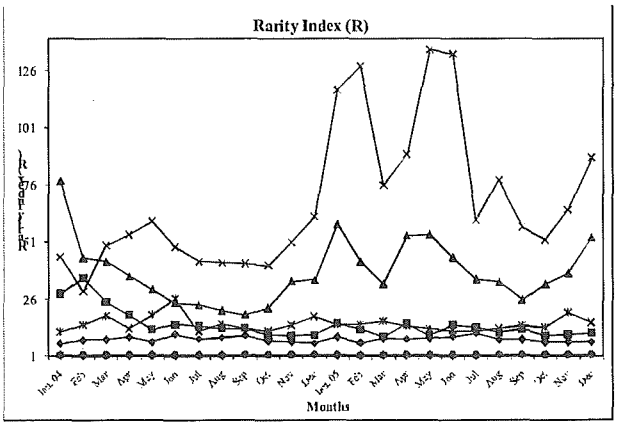

Fig. 4: Rarity index at Karanja creek

A. symmetrica showing the highest rarity index was found to be rare with respect to population density as well as biomass. The lower rarity index of polychaetes marks the higher density of it. Among the

other species, *Bursa* spp. were found to be dominant over the *Trochus* spp. and *Nerita* spp. assessed. The pattern of rarity index was not significantly varied throughout the period of investigation, although, slight seasonal variation of rarity index was recorded for all macrobenthos.

Among the gastropods, the Shannon's index of general diversity (H') was found to be uniform during the period of investigation (Fig. 5). Among all the selected species, maximum H' was

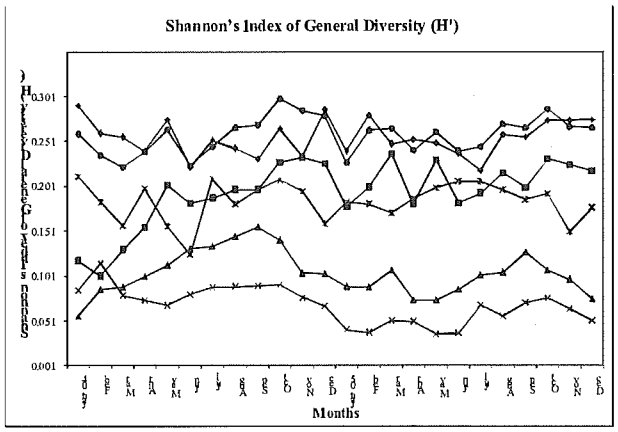

Fig. 5: Shannon's index of general diversity at Karanja creek

observed for *B. tuberculata,* which was followed by *P. cultrifera, E. prideauxi, N. oryzarum, T. radiatus* and *A. symmetrica.* The H' of all the species studied was uniform throughout the period of investigation. The diversity of A. symmetrica, i.e., H', was less than 0.05. Data on richness index recorded is in agreement with H' and was uniform throughout the period of investigation (Fig. 6).

The evenness index was uniform for *B. tuberculata* and *A. symmetrica* showing slight seasonal variation (Fig. 7). The evenness index for *P. cultrifera* was in the range of 0.286 to 0.383, whereas the range

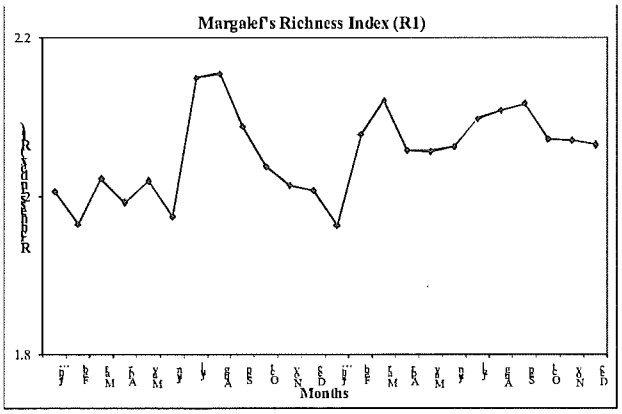

Fig. 6: Margalef's richness index at Karanja creek

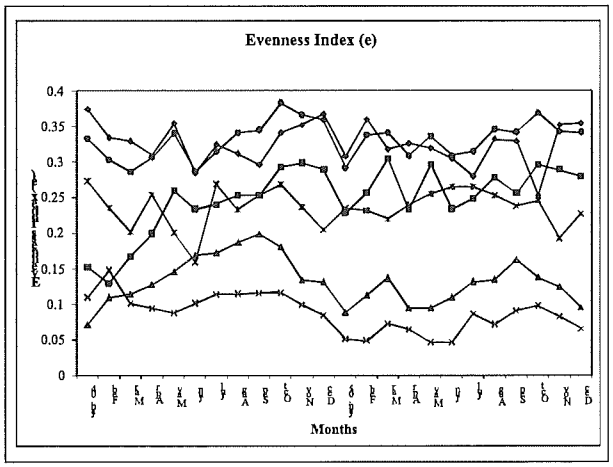

Fig. 7: Evenness index at Karanja creek

for *B. tuberculata* was 0.253 to 0.374. Further, for *A. symmetrica*, it was minimum showing a range of 0.047 to 0.148. The evenness indices of *E. prideauxi* and *N. oryzarum* were in the ranges of 0.160 to 0.273 and 0.130 to 0.305, respectively.

DISCUSSION

The index of frequency is used in knowing the abundance of a given species in the community. Fig. 2 shows the abundance of *P. cultrifera* to be more than other macrobenthos recorded at selected sites. A minimum index of frequency was noted for *A. symmetrica*. Non-significant

variation of indices of frequency observed in different months at both the sites shows that the distribution of different species was uniform throughout the period of investigation. Further, a higher index of frequency of *P. cultrifera* was also supported by its index of dominance. The data on index of dominance shows a positive relationship in between index of frequency and index of dominance (Fig. 3).

The index of dominance is the degree to which dominance is concentrated in one, a few or several species in a community. The species that largely control the energy flow and/or strongly affect the other species are described as "Ecological dominants". During the present investigation, the index of dominance was not significantly varied and was found to be the lowest for *B. tuberculata, T. radiatus, N. oryzarum, A. symmetrica* and *E. prideauxi* during monsoon. A high index of dominance of *P. cultrifera* was observed during monsoon. The results of the index of dominance, therefore, indicate the insignificant effect of monsoon conditions on *P. cultrifera.*

The rarity index is the expression how uncommon or rare is a particular species in the community. It (Fig. 4) shows an inverse relationship in between the rarity index and the level of dominance, e.g., the rarity index of *A. symmetrica* was the highest, whereas its dominance index and evenness index were the lowest. The rarity index also revealed the dominance of *P. cultrifera* throughout the period of investigation.

Shannon's index of general diversity is used as an indication of richness of the community in terms of general species diversity. The data on H' (Fig. 5) shows that the species richness of *P. cultrifera, B. tuberculata* and *E. prideauxi* was more or less the same, whereas the minimum species richness was observed in *T. radiatus* and *A. symmetrica.* These results of H' are in agreement with the index of frequency, index of dominance and rarity index, and did not vary significantly.

The richness index is a measure of the number of different kinds of organisms present in a particular area or the number of species present per sample. The more species present in a sample, the 'richer' is the sample. A community with one or two species is considered to be less diverse than one in which several different species have a similar abundance. Therefore, the macrobenthic community present at Karanja creek is diverse and rich (Fig. 6).

The evenness index is a measure of the relative abundance of the different species making up the richness of an area or it compares the similarity of the population size of each of the species present. Fig. 7 shows that macrobenthos of different species at Karanja creek are evenly distributed and make up the richness of an area.

Barring few reports on the west coast of India, in general, and on coast of Maharashtra, in particular, the analysis of diversity indices of coastal macrobenthos has not been reported adequately (Annie and Govindan, 1995; Venkatachalam and Kale, 2002). Therefore, the community structure of a particular intertidal area is not available for comparison. In such circumstances, the data on diversity

indices presented here could be helpful in future in knowing the status of macrobenthic community and the effect of industrial development on it.

In conclusion, it can be stated that the data on diversity indices of selected macrobenthos at Karanja creek indicate that at present, the creek harbours varied biodiversity. Since baseline data on the macrobenthic community in the intertidal areas of Karanja creek are not available, the effect of human disturbance on it cannot be seen. The data on diversity presented here could be helpful in future as the baseline data in knowing the status of the macrobenthic community and the effect of industrial development on it. The present study reveals higher values of evenness index, better condition of the creek and the suitability of the creek for the growth of biota present therein. The maximum values of Shannon's index of general diversity reveal that all the species in Karanja creek are equally abundant.

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REFERENCES

Annie, M. and Govindan, K., 1995. Macrobenthos in the near shore coastal system of Bombay. *Proc. Nat. Acad. Sci. India,* **65(B)IV:** 412-430.

Apte, D. A., 1988. The Book of Indian Shells. Oxford University Press, Calcutta, 115 pp.

Bhatt, Y. M., 1959. A Study of Intertidal Organisms of Bombay. Ph. D. Thesis, University of Bombay, Bombay.

Bilyard, G. R., 1987. The value of benthic infauna in marine pollution monitoring studies. *Mar. Poll. Bull.* **18(11):** 581-585.

Chhapgar, B. F., 1957. On the marine crabs (Decapoda – Brachyura) of Bombay state. *J. Bombay Nat. Hist. Soc.,* **54:** 399-439.

Chhapgar, B. F., 1958. More additions to the crab fauna of Bombay state. *J. Bombay Nat. Hist. Soc.,* **65(3):** 608-617.

Dash, M. C., 2002. Systems concept in ecology. *In:* Dash, M. C. (ed.), Fundamentals of Ecology. Tata McGraw-Hill Publishing Company Limited, New Delhi, pp. 35-144.

Duda, A. M., Lenat, D. R. and Penrose, D. C., 1982. Water quality in urban streams – What we can expect? *J. Water Poll. Contr. Fed.,* **54(7):** 1139-1147.

Eleftheriou, A. and Holme, N. A., 1984. Macrofauna techniques. *In:* Holme, N. A. and McIntyre, A. D. (ed.), Methods for the Study of Marine Benthos. IBP Handbook No. 16. Blackwell Scientific Publications, Oxford, 344 pp.

Engle, V. D. and Summers, J. K., 1999. Refinement, validation and

application of a benthic condition index for Northern Gulf of Mexico estuaries*Estuaries,* **22(3A):** 624-635.

Fish, J. D. and Fish, S., 1996. *A Students Guide to the Seashore* (2nd edition). Cambridge University Press, Cambridge.

Govindan, K., 2002. Marine benthos - A future prospective. *In:* Proceedings of the National Seminar on Creeks, Estuaries and Mangroves – Pollution and Conservation, **28** – 30 November 2002, pp. 28-30.

Harkanta, S. N., 1998. Benthos and demersal fishery resources assessment in the shelf region of Indian coast. *In:* Proceedings of the International Symposium on Large Marine Ecosystems: Exploration and Exploitation for Sustainable Development, 25 – 27 November 1998, Kochi, pp. 54-58.

Holme, N. A. and McIntyre, A. D., 1984. Methods for the Study of Marine Benthos. Blackwell Science Publications, Oxford, 387 pp.

Ingole, B. S., Pavithran, S. and Ansari, Z. A., 2005. Restoration of deep-sea macrofauna after simulated benthic disturbance in the Central Indian Basin. *Mar. Geores. Geotechnol.,* **23(4):** 267-288.

Jaiswar, A. K. and Kulkarni, B. G., 2005. Conservation of molluscan biodiversity from intertidal area of Mumbai coast. *J. Natcon.,* **17(1):** 93-105.

Jaiswar, A. K., Kulkarni, B. G. and Chakraborty, S. K., 2006. Assessment of coastal pollution through bioassay and transplantation of intertidal clams. *J. Environ. Sci. Engg.,* **48(2):** 119-22.

Khan, S. A. and Murugesan, P., 2005. Polychaetes diversity in Indian estuaries. *Indian J. Mar. Sci.,* **34(1):** 114-119.

Ludwig, J. A. and Reynolds, J. F., 1988. Statistical Ecology: A Primer on Methods and Computing. John Wiley & Sons, New York, 377 pp.

Margalef, R., 1968. Perspectives in Ecological Theory. University of Chicago Press, Chicago, 111 pp.

Naqvi, S. W. A., Noronha, R. J., Shailaja, M. S., Somasundar, K. and Sengupta, R., 1992. Some aspect of nitrogen cycling the Arabian Sea. *In:* Desai, B. V. (ed.), Oceanography of the Indian Ocean. Oxford & IBH, New Delhi, pp. 285-312.

Parulekar, A. H., 1973. Studies on intertidal ecology of Anjidiv Island. *Proc. Indian Nat. Sci. Acad.,* **39(B):** 611-631.

Parulekar, A. H., Nair, S. A., Harkanta, S. N. and Ansari, Z. A., 1976. Some quantitative studies on the benthos off Bombay. *Mahasagar,* **9:** 51-56.

Pennifold, M. and Davis, J., 2001. Macrofauna and nutrient cycling in the Swan River Estuary, Western Australia: Experimental results. *Hydrobiol. Proc.,* **15(13):** 2537-2553.

Pielou, E. C., 1966. The measurement of diversity in different types of biological collections. *J. Theoret. Biol.,* **13:** 131-144.

Pillai, N. G., 1977. Distribution and seasonal abundance of macrobenthos of the Cochin backwaters. *Indian J. Mar.* **Sci., 6:** 1-5.

Quadros, G. and Athalye, R. P., 2002. Intertidal macrobenthos from Ulhas River estuary and Thane creek. *In :* Proceedings of the National Seminar on Creeks, Estuaries and Mangroves – Pollution and Conservation. 28 – 30 November 2002, pp. 216-222.

Sandens, J., Forbes, T., Hansen, R. and Sandens, B., 2000. Influence of particle type and faunal activity on mixing of di (2-ethlehexyl) phthalate (DEHP) in natural sediments. *Mar. Ecol. Progr. Ser.,* **197:** 151-167.

Savich, M. S., 1972. Quantitative distribution and food value of benthos from the West Pakistan Shelf. *Oceanology,* **19:** 257-279.

Shannon, C. E. and Weaver, W., 1949. The Mathematical Theory of Communication. University of Illinois Press, Urbana, 117 pp.

Simpson, E. H., 1949. Measurement of diversity. *Nature,* **163:** 681-688.

Smith, R. L. and Smith, T. M., 1988. Elements of Ecology. Wesley Longman Inc., California.

Subrahmanyam, T. V., Karandikar K. R. and Murti, N. N., 1949. The marine Pelecypoda of Bombay. *J. Univ. Bombay,* **17:** 50-81.

Subrahmanyam, T. V., Karandikar, K. R. and Murti, N. N., 1951. Marine gastropods of Bombay, Part I. *J. Univ. Bombay,* **20(1):** 21-34.

Subrahmanyam, T. V., Karandikar, K. R. and Murti, N. N., 1952. Marine gastropods of Bombay, Part II. *J. Univ. Bombay,* **21(3):** 26-73.

Varshney, P. K., Govindan, K., Gaikwad, U. D. and Desai, B. N., 1988. Macrobenthos of Versova (Bombay), west coast of India, in relation to environmental conditions. *Indian J. Mar. Sci.,* **17:** 222-227.

Venkatachalam, S. and Kale, P. G., 2002. Benthic macrofauna of Thane Creek: Seasonal variations. *In:* Proceedings of the National Seminar on Creeks, Estuaries and Mangroves – Pollution and Conservation. 28 – 30 November 2002, pp. 186-195.