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Seasonal variations of trace metals in clam (*Meretrix casta*) at Tharangampadi and Vanjur Estuaries, Southeast coast of India

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Abstract

Accumulation of trace metals (Zn, Cu, Fe and Mn) in water, sediments and clam *Meretrix casta* at Tharangampadi and Vanjur estuaries of Nagapattinam District lying along the southeast coast of India were studied during January 2000 to December 2001 using atomic absorption spectrophotometer. The study showed spatial and temporal differences for all the metals studied. Accumulation of trace metals were observed in the order of sediments>clam>water. In water, the order of accumulation of trace metals was found to be Fe>Zn>Cu>Mn in Tharangampadi estuary and Fe>Zn>Mn>Cu in Vanjur estuary respectively. Higher values were recorded for Zn (146.0mg.1^{-1}) during monsoon, Fe (225.20 ug.1^{-1}) during monsoon and Mn (68.90 mg1^{-1}) during summer at Vanjur estuary for Cu (75.08 µg1^{-1}) during post monsoon at Tharangampadi estuary. In sediments, the order of trace metals accumulation was found to be Fe>Mn>Zn>Cu at both the stations. In the sediment samples higher values of Zn (181.80 µg.g^{-1}) were recorded during monsoon, Cu (64.98 µg.g^{-1}) during summer and Mn (143.10 µg.g^{-1}) during monsoon at Tharangapadi estuary and higher values of Fe (44000 µg.g^{-1}) during monsoon at Vanjur estuary. In the clam *Meretrix casta*, the order of trace metal accumulation was found to be Fe>Mn>Zn>Cu in Tharangampadi estuary and Fe>Zn>Mn>Cu in Vanjur estuary, respectively, with the values being higher for Zn (377.2 µg.g^{-1}) during pre monsoon, Fe (1505.2 µg.g^{-1}) during pre monsoon and Mn(312.4 µg.g^{-1}) during monsoon at Tharangampadi estuary and for Cu(156.80 µg.g^{-1}) during summer at Vanjur estuary.

Keywords: bioaccumulation, *Meretrix casta*, Tharangampadi, trace metals, vanjur

INTRODUCTION

Estuary is an important part of marine environment and owing to increased industrial activities and failure to take sufficient safety measures it is becoming increasingly polluted by human activities. Among the shell fishes in estuarine ecosystem, mollusks form an important group of animals noted for their ability to take up large amount of metal ions from surrounding environment. Trace metal accumulations by estuarine mollusks have been studied by Bonadonna *et al.* (1990), Kumaresan *et al*. (1998), Rajathy (1997), Senthilnathan *et al*. (1998). Bivalves have also been considered as indicators of marine pollution by non -radioactive trace metals (Krishnanambisan *et al*. (1997). A study on distribution of heavy metals in sea water is very important to understand their roles in various biogeochemical processes of the sea. Significant contributions have been made with reference to oceanic and coastal distribution of various heavy metals (Govindasamy and Azariah, 1999; Martin Deva Prasath *et al*., 2005). Further, earlier studies reveal that heavy metals are biologically nondegradable and through food chain they may finally pass on to man (Thomas and Jacquet, 1976). This paper describes the pattern of accumulation of Zinc, Copper, Iron and Manganese in water, sediment and a clam M*eretrix casta* in Tharangampadi estuary (Station 1) and Vanjur estuary (Station 2) in South India for a period of two years (January 2007 to December 2007).

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MATERIALS AND METHODS

Samples of water, sediment and bivalve *Meretrix casta* were collected at monthly intervals from station 1 and 2 (Fig. 1) for a period of 2 years from January 2000 to December 2001. Station 1 is Tharangampadi estuary (Lat. 11° 2′N; Long. 79° 49′E) which is a rocky area and a tourist centre in the Nagapattinam district of Tamil Nadu, South India. There is no input of industrial effluents, but a number of shrimp farms are functioning on the banks of this estuary. Station 2 is Vanjur estuary (Lat. 10° 2′N; Long. 79° 59′E), Union Territory of Pondicherry, crowded with 36 industries which include chemical, petro chemical, cement, paint, paper, pulp, detergent, plastic, tyre, steel and electrical apparatus industries. Vanjur estuary receives effluents mainly from the above mentioned industries along with domestic and agricultural sewages. The distance between station 1 and 2 is 20 km.

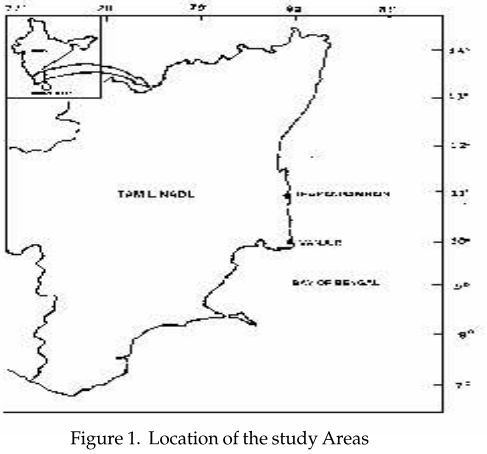

Figure 1. Location of the study Areas

Surface water samples were collected in precleaned and acid washed poly propylene bottles and these water samples were filtered in millipore filter paper (pore size 0.45m). The samples were preconcentrated with APDC – MIBK extraction method (Brooks *et al.,* 1967). The resulting solution was aspirated to the flame atomic absorption spectrophotometer (Perkin – Elmer model 373) for the determination of Zn, Cu, Fe and Mn.

Sediment samples were collected in precleaned acid washed PVC corer and were washed with metal free double distilled water. They were then dried in hot air oven at 110°C for 5-6 hours, ground to powder in a glass mortar and stored in precleaned polythene bags. 500 mg of a sample was taken and digested with a mixture of 1 ml of conc. H_2SO_4, 5 ml of conc. HNO_3 and 2 ml of $HClO_4$. A few drops of HF was added to achieve complete digestion and the sample was filtered and made up to 25ml with metal free double distilled water for the estimation of Zn, Cu, Fe and Mn in flame atomic absorption spectrophotometer (Chester and Hughes, 1967).

The bivalve *Meretrix casta* samples were collected and were washed. These were then kept in filtered seawater system to purge the gut content. Whole body tissues of animals were removed, washed with deionized water and brought to the laboratory in frozen condition and stored in the deep freezer at - 20°C for further analysis. The dissected portions of body muscles were washed and dried in an oven for 24 hrs at 110°C to constant weight and then powdered. Exactly 500 mg of a powdered sample was digested with 3:1 of HNO_3 and $HClO_4$ in a hot plate for 4 to 6 hours until a clear solution was obtained. The digested samples were diluted to make up to 25 ml with metal free double distilled water and stored for analysis. Subsequently, these samples were quantified using atomic absorption spectrophotometer (Topping, 1973).

RESULTS

Monthly variations of Zn, Cu, Fe and Mn in water, sediment and muscle tissues of clam were recorded from stations 1 and 2. Minimum, maximum, mean, standard deviation and standard error values of Zn, Cu, Fe and Mn during the study period are given in tables 1-3. At station 1, concentration of Zn in water varied from 3.02 mg.l-1 (April 2000) to 129.3 mg.l-1 (November 2000) and it varied from 19.03mg.l-1 (May 2000) to 146.2 mg.l-1. (November 2000) at station 2 (Fig. 2). Cu varied from BDL (July and December 2001) to 75.08mg.l-1 (February 2001) at station 1 and it varied from 2.89 mg.l-1 (December 2001) to 45.36mg.l-1 (September 2000) at station 2 (Fig. 3). Concentration of Fe varied from 21.4 mg.l-1 (February 2001) to 201.6 mg.l-1 (October 2000) at station 1 and it varied from 2.30 mg.l-1 (September 2000) to 225.2mg.l-1 (October 2000) at station 2 (Fig. 4). Mn varied from 1.22 mg.l-1 (January 2000) to 63.76 mg.l-1 (June 2000) at station 1 and it varied from 9.4mg.l-1 (March 2001) to 68.9 mg.l-1 (June 2000) at station 2 (Fig. 5).

Concentration of Zn in sediments varied from 0.4mg.g-1 (May 2000) to 181.8mg.g-1 (December 2001) at station 1 and it varied from BDL (January, April, May 2000) to 95.30mg.g-1 (February 2001) at station 2 (Fig. 6). Cu varied from BDL (February, August and November 2000) to 64.98 mg.g-1, (June 2000) at station 1 and it varied from BDL (February, August 2000; October, November 2001) to 48.18mg.g-1 (June 2000) at station 2 (Fig. 7). Fe concentration varied from 443.8mg.g-1 (May 2000) to 22,800mg.g-1 (February 2000) at station 1 and it varied from 302mg.g-1 (March 2000) to 44000 mg.g-1 (November 2000) at station 2 (Fig. 8). Mn varied from 43.50mg.g-1 (August 2000) to 943.10 mg.g-1 (October 2001) at station 1 and it varied from 36.0mg.g-1 (October 2000) to 443.6 mg.g-1 (November 2000) at station 2 (Fig. 9).

Concentration of Zn in *Meretrix casta* varied from 10.80mg.g-1 (May 2000) to 377.2mg.g-1 (September 2001) at station 1 and it varied from 11.40 mg.g-1 (May 2000) to 284.4mg.g-1 (August 2001) at station 2 (Fig. 10). Concentration of Cu varied from BDL (September 2000) to 146.0 mg.g-1 (July 2001) at station 1 and it varied from BDL (September 2000; August, September, November 2001) to 156.80mg.g-1 (May 2001) at station 2 (Fig. 11). Fe concentration varied from 160.8 mg.g-1 (September 2000) to 1505.2 mg.g-1 (July 2001) at station 1 and it varied from 78.7mg.g-1 (November 2000) to 1346.0 mg. g-1. (February 2001) at station 2 (Fig. 12). Concentration of Mn varied from 10.9 mg.g-1 (September 2000) to 312.4 mg.g-1 (December 2001) at station 1 and it varied from 29.34 mg.g-1 (March 2000) to 264.30 mg.g-1 (November 2000) at station 2 (Fig. 13). In general, higher values of Zn, Mn, and Fe were observed during premonsoon and monsoon seasons.

DISCUSSION

In water, the accumulation of trace metals was observed in the order of Fe > Zn > Cu > Mn at station 1 and Fe > Zn > Mn > Cu at station 2, respectively. The concentration of Zn in water at both the stations was high during monsoon season due to heavy land runoff and drainage of industrial discharges. The low values during summer seasons are due to the less discharges of the above mentioned sources (Martin Deva Prasath *et al.,* 2005). The Cu and Fe concentrations were high in pre monsoon season at both the stations as both the estuaries received considerable quantities of Cu and Fe from the direct disposal of agricultural, domestic and municipal wastes and particularly the discharge of industrial effluents in station 2. Further, salinity is also considered to have a direct influence on Cu concentration in water by the process of greater desorption from sediments (Church and Tramontano, 1982). The low concentration of Cu and Fe registered during summer season at both the

Table 1. Trace metal concentrations in the water of the two stations during January 2000 to December 2001 (BDL = Below Detectable Level) (See text for details of stations)

	Zn ($\mu g.l^{-1}$)		Cu ($\mu g.l^{-1}$)		Fe ($\mu g.l^{-1}$)		Mn ($\mu g.l^{-1}$)	
	St. 1	St. 2	St. 1	St. 2	St. 1	St. 2	St. 1	St. 2
Minimum	3.02	19.03	BDL	2.89	21.4	2.3	1.22	9.4
Maximum	129.3	146.2	75.08	45.36	201.6	225.2	63.76	68.9
Mean	25.73	67.06	25.36	22.4	127.93	132.35	21.4	33.65
SD	24.02	28.02	16.4	11.34	55.31	57.97	18.2	17.35
SE	4.9	5.71	3.34	2.31	11.33	11.83	3.71	3.54

Table 2. Trace metal concentrations in the sediment of the two stations during January 2000 to December 2001 (BDL = Below Detectable Level) (See text for details of stations)

	Zn ($\mu g.g^{-1}$)		Cu ($\mu g.g^{-1}$)		Fe ($\mu g.g^{-1}$)		Mn ($\mu g.g^{-1}$)	
	St. 1	St. 2	St. 1	St. 2	St. 1	St. 2	St. 1	St. 2
Minimum	0.4	BDL	BDL	BDL	443.8	302.0	43.5	36.0
Maximum	181.8	95.3	64.98	48.18	22800.0	44000.0	943.1	443.6
Mean	43.63	24.29	8.65	7.04	2220.56	3738.06	293.45	175.4
SD	50.75	31.39	13.64	9.99	4465.5	8963.3	180.73	92.97
SE	10.35	6.4	2.78	2.03	911.5	1829.6	36.89	18.97

Table 3. Trace metal concentrations in the bivalve *M. casta* collected from the two stations, during January 2000 to December 2001 (BDL = Below Detectable Level) (See text for details of stations)

	Zn ($\mu g.g^{-1}$)		Cu ($\mu g.g^{-1}$)		Fe ($\mu g.g^{-1}$)		Mn ($\mu g.g^{-1}$)	
	St. 1	St. 2	St. 1	St. 2	St. 1	St. 2	St. 1	St. 2
Minimum	10.8	11.4	BDL	BDL	160.8	78.7	10.9	29.34
Maximum	377.2	284.4	146.0	156.8	1505.2	1346.0	312.4	264.3
Mean	130.92	111.13	30.55	37.66	785.42	767.8	137.51	109.0
SD	113.47	71.21	37.54	48.9	399.8	395.8	83.07	69.77
SE	23.16	14.53	7.66	9.8	81.61	80.79	16.95	14.24

stations could be attributed to the decrease of river runoff and utilisation by phytoplankton(Rao and Rao, 1974). Higher values of Mn in water noted during summer season is due to direct anthropogenic influences coming from the nearby areas and lesser dilution by sea water in the estuaries due to the closure of river mouth.

In sediments, the accumulation of trace metals was found in the order of Fe > Mn > Zn > Cu at both the stations. The sediment metal concentrations are mainly controlled by river inflow, sediment particle size, type and organic matter content which influence the absorption and accumulation of metals (Armstrong *et al.,* 1976; Leland *et al.*, 1973 and Loring, 1978). At the same time, reduction condition arising from microbial activity in sediments with higher organic content may result in dissolution with release of heavy metals. Higher concentration of Zn, Cu, Fe and Mn in sediments during the monsoon season could be ascribed to the heavy flood of freshwater entering the estuary which carries metal originated from the land. Further, high concentrations might also be due to erosion, scrap metal and paint from boat jetty along with industrial and urban sewages at station 2. The lower values during summer season might be due to low freshwater inflow, biological utilisation, dominance of high saline water, precipitation of particulate matter and decreased land drainage. However, distribution of heavy metals in sediments are also controlled by various other factors especially parent rock, climatic condition, site of deposition, stability of minerals, density, grain size and transporting media (Hanamgond *et al.,* 1999).

In *Meretrix casta*, the accumulation of trace metals was found in the order of Fe > Mn > Zn > Cu at station 1 and Fe > Zn > Mn > Cu at station 2, respectively. In general, marine mollusks are well known for their ability to accumulate heavy metals (Greig *et al.,* 1976). Higher accumulation of metals in the clam during the monsoon season at both the stations could be due to inundation of freshwater and low salinity and due to mixing of industrial effluents at station 2 containing $CuSO_4$ and $ZnSO_4$ from the nearby Cu and Zn based industries. Fe and Mn loads in bivalves at station 2 were high because of the nearby metal processing industries like National Steel Products, P.S.P. Steel Private Limited, M.M. Steel Limited, Kannappan Iron and Steel Company. The low concentration of metals in summer is due to non availability of metal ions, incorporation of metals by phytoplankton as detritus and chelation (Rathabai and Vijayalakshmi, 2000). Further, the inorganic and organic

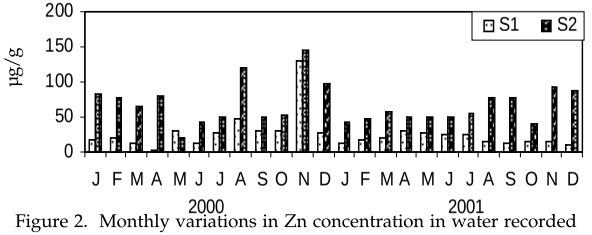

Figure 2. Monthly variations in Zn concentration in water recorded from station 1 and station 2 during January 2000 to December 2001.

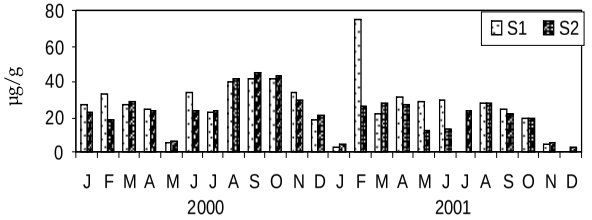

Figure 3. Monthly variations in Cu concentration in water recorded from station 1 and station 2 during January 2000 to December 2001.

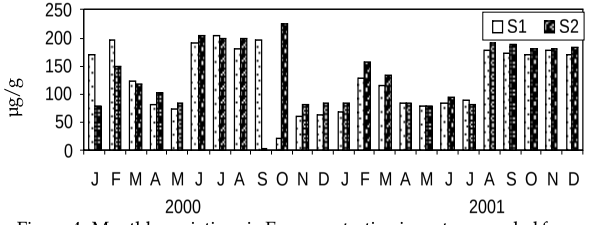

Figure 4. Monthly variations in Fe concentration in water recorded from station 1 and station 2 during January 2000 to December 2001.

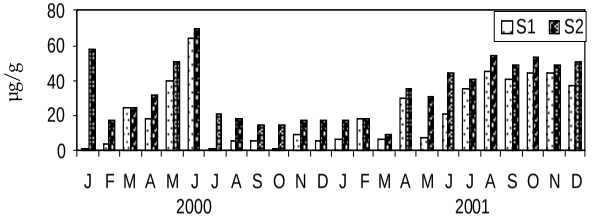

Figure 5. Monthly variations in Mn concentration in water recorded from station 1 and station 2 during January 2000 to December 2001.

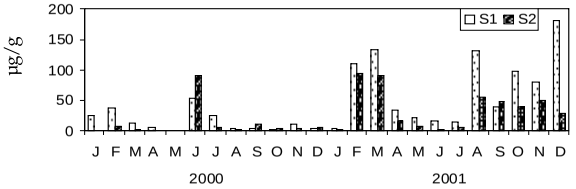

Figure 6. Monthly variations in Zn concentration in sediment recorded from station 1 and station 2 during January 2000 to December 2001.

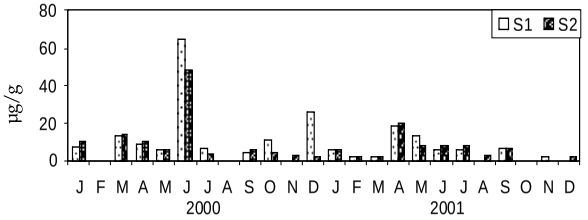

Figure 7. Monthly variations in Cu concentration in sediment recorded from station 1 and station 2 during January 2000 to December 2001.

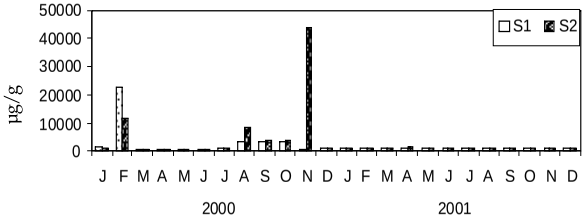

Figure 8. Monthly variations in Fe concentration in sediment recorded from station 1 and station 2 during January 2000 to December 2001.

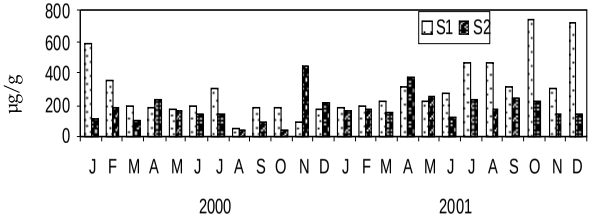

Figure 9. Monthly variations in Mn concentration in sediment recorded from station 1 and station 2 during January 2000 to December 2001.

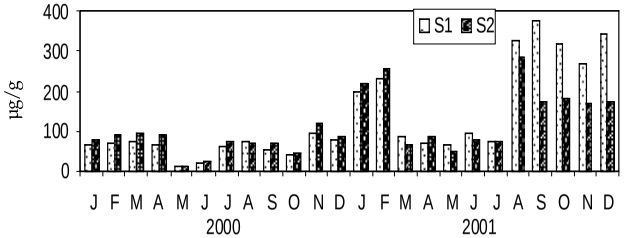

Figure 10. Monthly variations in Zn concentration in *Meretrix casta* recorded from station 1 and station 2 during January 2000 to December 2001.

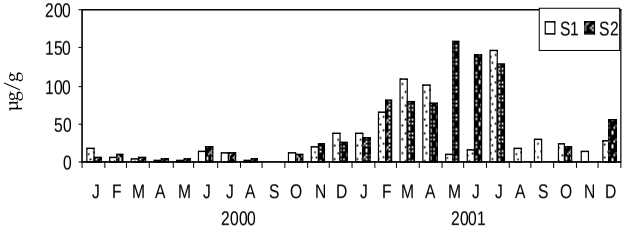

Figure 11. Monthly variations in Cu concentration in *Meretrix casta* recorded from station 1 and station 2 during January 2000 to December 2001.

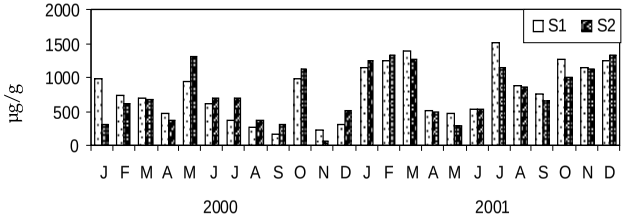

Figure 12. Monthly variations in Fe concentration in *Meretrix casta* recorded from station 1 and station 2 during January 2000 to December 2001.

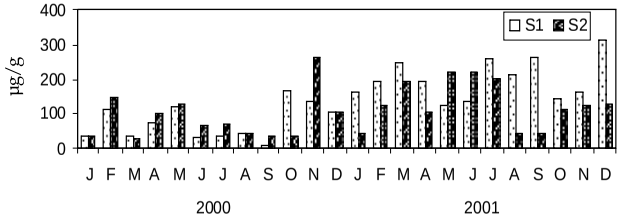

Figure 13. Monthly variations in Mn concentration in *Meretrix casta* recorded from station 1 and station 2 during January 2000 to December 2001.

dissolved and particulate matter which forms the food of the clam might also play a significant role in the accumulation of heavy metals in the animals (D' Itri, 1973). Therefore bioaccumulation of Zn, Fe and Mn in the clam showed higher concentrations in Tharangampadi estuary than in Vanjur due to natural weathering of rocks and the discharges that are largely from the shrimp farms, agricultural wastes and anthropogenic activities in this area.

CONCLUSION

In general, the accumulation of trace metals observed in the three samples were found in the order of sediments > clam > water. Many of the earlier works revealed that trace metals were more concentrated in the tissues of marine animals than in sea water (Klein and Goldberg, 1970; Leatherland *et al.*, 1973) due to biomagnifications. The same trend was observed in the present study. Further, the present study apparently showed significant variations in the accumulation of trace metals in water, sediments and the clam *Meretrix casta* at both the stations. Therefore, it is concluded that shell fish can be used as monitors of aquatic trace metal pollution on a long term basis as this species showed greater metal accumulation capacity.

REFERENCES

Armstrong, P.B., Hanson, G.M. and Gandette, H.E. 1976. Minor elements of Great Bay estuary, New Hampshire. *Env. Geol.* 1: 207.

Bonadonna, L., Volterra, L., Aulicino, F.A. and Mancini, L. 1990. Accumulation power of some bivalve molluscs. *Mar.Poll. Bull.* 21: 81-84.

Brooks, R.R., Presley, B.J. and Kalpan, I. R. 1967. APDC-MIBK extraction system for the determination of trace metal in saline water by atomic absorption spectroscopy. *Talanta* 14: 809-816.

Chester, R. and Hughes, M.J. 1967. A chemical technique for the separation of ferromanganese minerals, corbonate minerals and absorbed trace element from pelagic sediments. *Chem. Geol.* 2: 249-263.

Church, T.M. and Tramontano, J.M. 1982. Geochemistry of trace metal burdens in the mixing zone of the Delware estuary. *Eos. Trans. An. Geophys*. Union 63: 48-49.

D'Itri, F.M. 1973. Mercury in aquatic ecosystem. *In: Bioassay techniques and environmental chemistry*. Ann Arbor Science Publishers, Michigan. P. 3-7.

Govindasamy, C. and Azariah, J. 1999. Seasonal variations of heavy metals in coastal waters of the coromondal coast, Bay of Bengal. *Indian J. Mar. Sci.* 28: 249-256.

Greig, R.A., Wenzloff, V.R. and Pears, J.B. 1976. Distribution and abundance of heavy metals in finfish, invertebrates and sediments collected at a deep water disposal site. *Mar. Poll. Bull.* 7: 185-187.

Hanamgond, P.T., Gawali, P.B. and Chavadi, V.C. 1999. Heavy mineral distribution and sediment movement at Kwada and Belekeri Bay beaches, westcoast of India. *Indian J. Mar. Sci.* 28: 257-262.

Klein, D. and Goldberg, E.A. 1970. Mercury in the marine environment. *Environ. Sci. Technol.* 4: 765-768.

Krishnanambisan, P.N., Lakshman, P.T. and Mohammed Salih, K.Y. 1997. On the uptake of Copper (II) in *Meretrix casta*, an indicator species of metal pollution. *Curr. Sci.* 45: 437-440.

Kumaresan, S., Vinithkumar, N.V., Balasubramanian T. and Subramanian, A.N. 1998. Trace metals (Fe, Mn, Zn and Cu) in sediments in the Gulf of Mannar region, southeast of India. *Indian J. Mar. Sci.* 27: 256-258.

Lapin, T.A. and Krassyukov, V.N. 1977. Toxicity of copper on the bivalve *Villorita cyprinoides* var. *cochinensis*. *Indian J. Mar. Sci.* 6: 83-85.

Leatherland, P.M., Burton, J.D., Culkin, F., Mccartney, M.J. and Morris, R.J. 1973. Concentration of some trace metals in pelagic organisms and of mercury in north Atlantic ocean. *Deep Sea Res.* 20: 679-685.

Leland, H.V., Shukla, S.S. and Shrimp, N.F. 1973. Factors affecting distribution of lead and other trace elements in sediments of Southern Lake Michigan. *In: Trace metals and metal-organic interactions in natural waters*. (Ed. P.C. Singer), Ann Arbor Science Publishers, Ann Arbor, Michigan. P. 89-129.

Loring, D.H. 1978. Environmental biogeochemistry and geo –microbiology: methods, metals and assessment. *In: Ann Arbor Michigan Proc. of 3rd International Symposium on Environmental Biogeochemistry*, Wolfenbuttal, W. Germany. Ann Arbor Science Publishers, Ann Arbor, Michigan. P. 1025-1040.

Martin Deva Prasath, P., Rajaram, R. and Hidayathulla Khan, T. 2005. Bioaccumulation of trace metals in fish (*Mugil cephalus*) at Tharangambadi and Vanjur Estuaries. *Indian J. Environ. Prot.* 25: 877: 884.

Rajathy, S. 1997. Mercury in water, sediment and in some estuarine organisms of the Ennore estuary, Madras, Tamil Nadu. *J. Mar. Biol. Ass. India* 39: 174-178.

Rao, C.V. and Rao, S.T.S. 1974. Distribution of the trace elements Fe, Cu, Mn and Co in the Bay of Bengal. *J. Mar. Biol. Ass. India* 16: 94-122.

Rathabai, V. and Vijayalakshmi, K. 2000. Changes in the metal concentrations in relation to season and stages of clam meretrix casta. *J. Ecotoxicol. Environ. Monit.* 10: 93-96.

Senthilnathan, S., Balasubramanian, T. and Venugopalan, V.K. 1998. Metal concentration in Mussel *Perna viridis* (Bivalvia/Anisomyaria) and oyster *Carassostrea madrasensis* (Bivalvia/Anisomyaria) from some parts in southeast coast of India. *Indian J. Mar. Sci.* 27: 206-210.

Srivastava, C.B.L. 1985. *A textbook of fishery science and Indian fisheries,* Kiramanal publication, Allahabad,pp. 307.

Thomas, R.L. and Jaquet, J.M. 1976. Distillation and sources of polycyclic aromatic hydrocarbons in the sediments of Lake Erie, Part 1. Spatial distribution, Transport and deposition. *Fish. Res. Board, Canada* 33: 404.

Topping, G. 1973. Heavy metals in fish from Scottish waters. *Aquaculture* 1: 373-377.