HEAVY METALS IN THREE MOLLUSCS AND SEDIMENTS FROM VELLAR ESTUARY, SOUTHEAST COAST OF INDIA

Kaila KESAVAN, Santhanam RAJAGOPAL, Velayudham RAVI & Annaian SHANMUGAM

Centre of Advanced Study in Marine Biology Annamalai University, Parangipettai - 608 502. India, k7til@yahoo.co.in

Abstract: The intensity of heavy metals (Mg, Fe, Mn, Zn, Cd, Co, Cu, Pb) were estimated in sediment, shell and tissue of the molluscs *Cerithidea cingulata, Crassostrea madrasensis* and *Meretrix meretrix* from two stations of Vellar Estuary, Southeast coast of India. The concentrations of the heavy metals analyzed exhibited variations in sediments, tissue and shell of the study animal from the 2 stations. Zn and Cu concentration were below the alarming level, whereas Mg (274.0±12) content was higher in shell and tissue. The Fe (416.6±1.7) content was higher in sediment in Station 1, but it was the second highest metal to be recorded in sediment, shell and tissue. To understand the background concentration the level of these metals were studied in the sediment**.** Cd and Co were minimum accumulated in all the metals estimated in sediment and animal whereas Mg was maximum in sediment. Similarly all the metals analysed were within the safety level. The combined correlation of both the stations between the sediment verses. sediment, tissue verses. tissue, shell verses. Shells were positively correlated and significant at $P<0.001$ and $P < 0.05$ level. The result revealed that continuous input of pollutant due to human activities, industries might have a significant contribution of these metals in all the stations.

Keywords: Heavy metals, Mollusc, Gastropod, Bivalves, Vellar

1. INTRODUCTION

Contaminants can stay in the water layer in dissolved form or they can be removed from the water column to the bottom sediments in particles. After discharge into the sea Organisms can take up contaminants from the water or in particles and accumulate them in the body (Stewart, 1999). If organisms are not able to remove the substances from their body, these can be passed on to next level in food chains. Certain group of animals may accumulate large amounts of contaminants without any harmful effects, while other groups might get lethal effects already in lower concentrations (Levinton, 1995; Clark, 1997). High metal concentrations in the environment are the result of both natural and anthropogenic sources. The accumulation of metals in waters and sediments affects various organisms in the environment; influencing their functions in several different ways (Regoli & Principato, 1995).The sediments at the water-sediment interface are more important to biological fauna as compared with subsurface sediments since miofauna live above the reduced zone in sediments. Therefore, the composition of surface sediments has a significant influence on the living conditions of some marine organisms. The trace metal results obtained by sediment analysis, unlike sea water analysis, are generally above the detection limit and contamination risks are significantly reduced (Brügmann, 1981). Sediment data are, therefore, utilized as a tool for assessing sources and distribution of some elements in aquatic environments.

It is known that molluscs accumulate organic and metallic pollutants at concentrations several orders of magnitude above those observed in the field environment (Bryan et al., 1983). Owing to the widespread application of bivalves as biomonitoring organisms in the aquatic environment, they have been the subject of several studies on the interaction of heavy metals. Fewer studies have been done on gastropod molluscs, some of which are also considered as useful biomonitors of certain metals (Bryan et al., 1983). Most metals are generally concentrated many times over within an organism's soft tissue, rather than the shell, and so the vast majority of studies concentrate on the soft tissue. However, some studies of the shell material have also been conducted, and many authors suggest that shells can provide a more accurate indication of environmental change and pollution; they exhibit less variability than the living organism's tissue, and they provide a historical record of metal content throughout the organism's life time, with this record still preserved after death (Huanxin et al., 2000).

In the present study, three species of molluscs from Vellar estuary living in three different habitats were selected to analyse the accumulation of heavy metals in tissue and shell. *Cerethidea cingulata* (Gmelin, 1791) is found creeping on the sediments and grasps the organic matter and algae, *Crassostrea madrasensis* (Preston, 1908) is a sedentary filter feeder and *Meretrix meretrix* (Linnaeus, 1758) is a burrowing filter feeder.

The present investigation was undertaken to study the status of bioaccumulation of heavy metals (Magnesium, Iron, Zinc, Manganese, Cadmium, Cobalt, Lead, Copper) in the soft tissue and shells of three different species of molluscs apart from the sediments in two stations of Vellar estuary.

2. MATERIALS AND METHODS

Trace metal content (Magnesium, Iron, Zinc, Manganese, Cadmium, Cobalt, Lead, Copper) were analysed in the soft tissue, shells and sediment of three different species of molluscs such as *Cerithidea cingulata, Crassostrea madrasensis* and *Meretrix meretrix* collected from two stations of Vellar Estuary, Southeast coast of India.

2.1 Sediments

Sediment samples were collected using PVC corer and kept immediately in an ice box for further analysis. The sediment samples were washed by free metals with double distilled water. Then samples were dried in an oven at 60ºC for about 5-6 hours and then they were ground in a glass mortar to reduce into fine particles.

2.2 Tissues and shells

The molluscs were collected from the study areas by hand picking. The soft tissue was removed from the shells with a plastic knife and dried at 60ºC. The dried tissue were reduced into fine powder using pestle and mortar and was then stored in desiccator for further analysis. The shell of individual samples was also finely ground. The resulting powder was selected, using a plastic sieve with 0.2mm opening size and was stored in desiccator for further analysis.

To estimate the trace metal content, samples were digested (1g) with conc. HNO_3 and conc. $HClO_4$ (4:1) and analysed in Optical Emission Spectrophotometer (Optima 2100DV) (Topping, 1972). The metal content in sediment was determined by following the method of Chester and Hughes (1967). The values were expressed in ppm. The standard deviation and the Correlation Coefficient Analyses were also performed.

3. STUDY AREA (VELLAR ESTUARY)

The Vellar estuary originates from the Shervarayan hills of Salem district in Tamil Nadu, India. After traversing a distance of about 480 km it forms an extensive estuarine system with Bay of Bengal at Parangipettai. It is one among the fertile estuaries in terms of variety of biotopes such as mangroves, backwaters and fisheries.

3.1 Geographic description of study area

This estuary receivies seasonal and marginal discharges from agricultural fields. It is fairly high in production and rich in diversity of flora and fauna. The width of estuarine mouth is about 100 m. However, the position of the mouth and width are changing frequently due to sand bar formation as freshwater inflow is very much reduced in summer. This estuary experiences semidiurnal tides, the tidal effect extends upstream to a distance of 15 km, and the tidal amplitude is approximately 1 m (Fig. 1). Average depth of the estuary is 2.5 m and the maximum depth is 5 m during high tide. The physical and chemical nature of the Vellar Estuary is an impact by the residues receiving from the four channels situated along the sides of Vellar Estuary; they are Long Channel, Dog channel, Buckingham channel and Railway. Besides these large numbers of drain channels were joined along the course of the Estuary. Both the sides Vellar Estuary is filled by agricultural lands (about 3000hac – upto 10km upstream area).The residue from this area cause main impact on the living things in Vellar Estuary. Insecticides, fungicides, herbicides, weedicides and rodenticides which contain the heavy metal used in these fields ultimately enter the Estuary and the other channels on the northern bank drain agri and muncipal water and domestic sewage into the river. Apart from these, there are a number of feeder draining channels used for agricultural purposes also enter the river water.

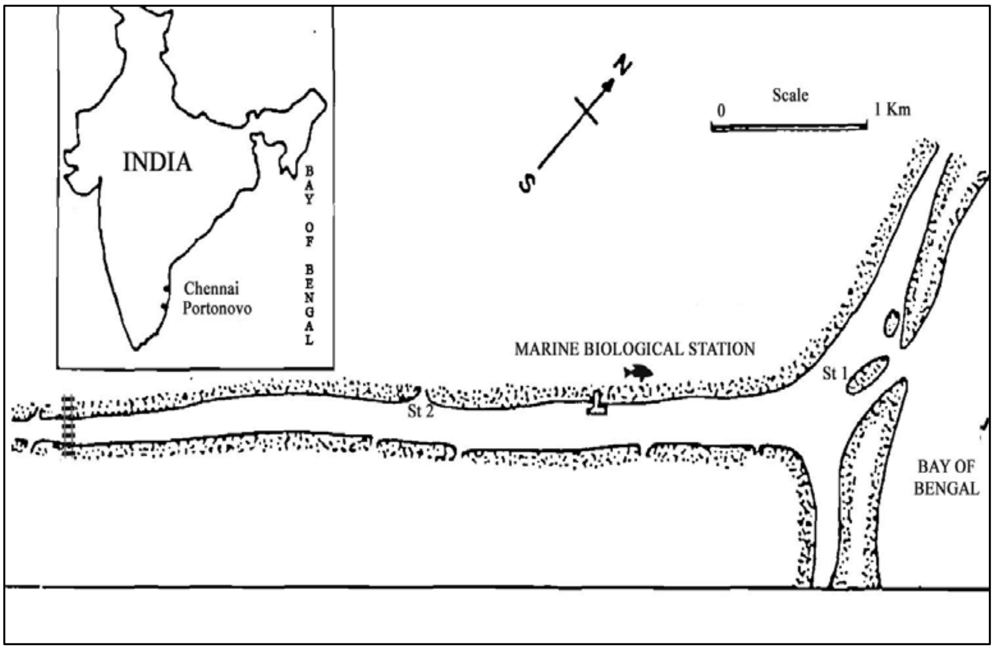

Figure 1. Vellar Estuary and station sampling

3.2 Mineralogical description

The Fourier transform infrared (FTIR) spectral analysis has been carried out for sediments of Vellar river, Tamilnadu collected at various depths from twenty seven different locations. The minerals such as quartz, feldspar (microcline and orthoclase), kaolinite, palygorskite, calcite, aragonite, montmorillonite, cerussite, hematite, sepiolite, magnesium oxalate and organic carbon are identified. Among these, quartz, feldspar and kaolinite are the major minerals and palygorskite, calcite, aragonite, montmorillonite, cerussite, hematite, sepiolite, magnesium oxalate and organic carbon are minor and trace (Ramasamy et.al, 2009). The mine drains of the Neyveli Lignite Corporation are also indirectly drained into the river course during the monsoon period due to surface land run off. These are the main source for the geological source of the accumulated heavy metals in the sediments and molluscs.

Station 1 – Landing centre (Lat 11^0 30’N; Long. 79^0 46’E): This station is situated at the mouth of Vellar estuary in the marine zone, near Annankoil fishing hamlet.

Station 2 – Buckingham canal (Lat 11^o 29’N; Long. 79^o 46’E): It is located about 1.5 km upstream from the mouth of the estuary (*i.e*.,) in the tidal zone of the Vellar estuary.

4. RESULTS

4.1 Sediments

In station 1 the values of heavy metals in sediment ranged from 0.045 ppm (Cd) to 416.6 ppm (Fe) (Tab. 1 and Fig. 2).

In the station 2, the values of heavy metals in sediment were from 0.004 ppm (Cd) to 15.27 ppm (Mg) (Table 2 and Fig. 3).

4.2 Meretrix meretrix

In station 1 (Fig. 1), the tissues samples recorded were higher in magnesium content (120.1 ppm) than in cobalt concentration (0.061 ppm). In shells, the magnesium content was 12.10 ppm and the cobalt concentration was lower 0.003 ppm.

While the concentration of the heavy metals in the shell was ranging from 12.10 ppm (Mg) to 0.003 ppm (Co) (Table 1 and Fig. 2).

In station 2 (Fig. 1), the tissue recorded highest magnesium content of 132.1 ppm and lowest lead concentration of 0.134 ppm. While the concentration of the heavy metals in the shell was ranging from 18.20 ppm (Mg) to 0.000 ppm (Co) (Table 2 and Fig. 3).

4.3 Cerethidea cingulata

In station 1, tissue recorded the highest concentration of, 120.1 ppm (Mg) and lowest of 0.061 ppm (Cd) whereas in shell it was 12.1 ppm (Mg) and lowest 0.003 ppm (Co) respectively (Table 1 and Fig. 2). In station 2 also tissue recorded the highest concentration of, 202.3 ppm (Mg) and lowest of 0.026 ppm (Cd) whereas in shell it was high 39.64 ppm (Mg) and low 0.004 ppm (Co) respectively (Table 2 and Fig. 3).

Figure 2. Level of Heavy Metals in Sediment and Species in Station 1

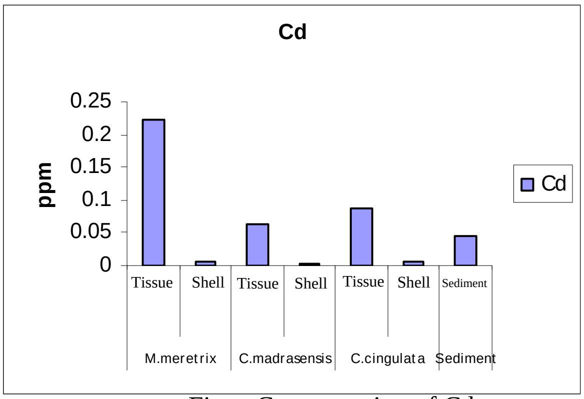

Fig a. Concentration of Cd

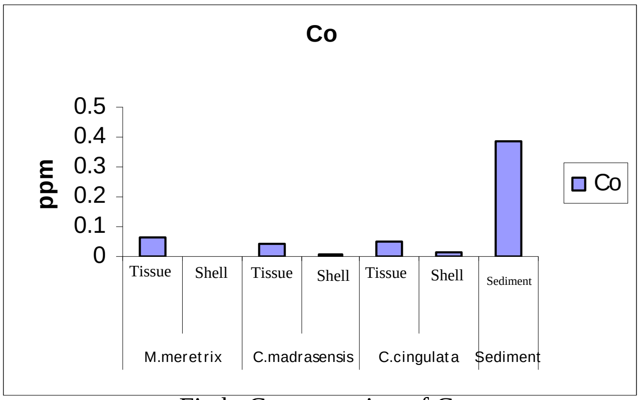

Fig b. Concentration of Co

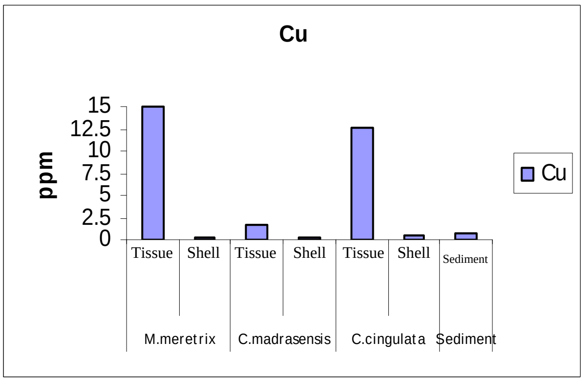

Fig c. Concentration of Cu

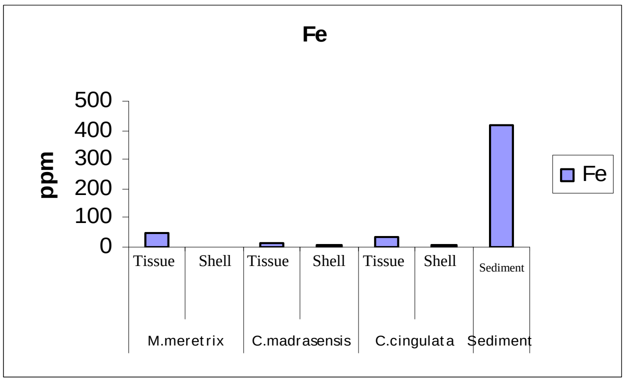

Fig d. Concentration of Fe

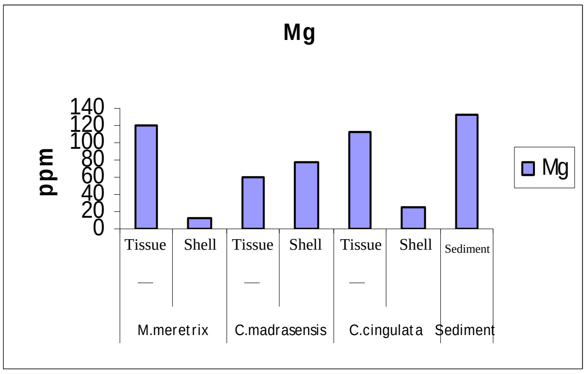

Fig e. Concentration of Mg

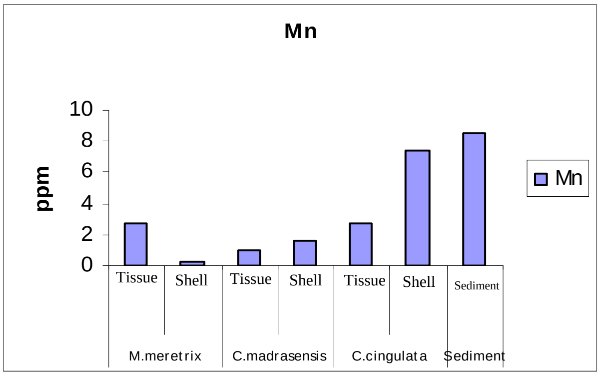

Fig f. Concentration of Mn

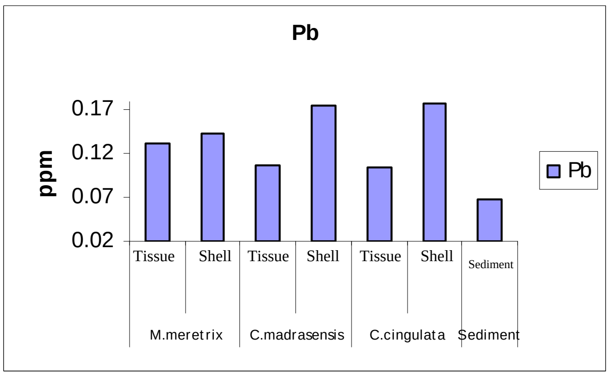

Fig g. Concentration of Pb

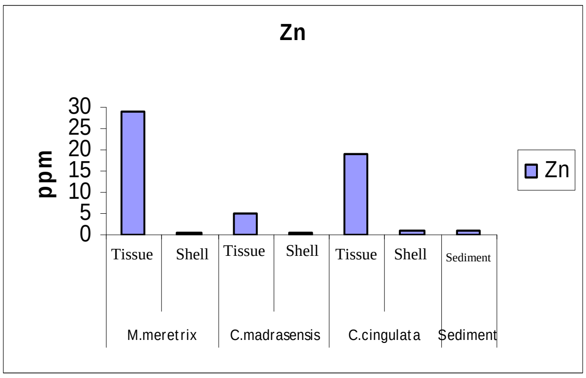

Fig h. Concentration of Zn

Table 1: Station 1- Vellar (Landing center)

S.No	Species	Metals							
		Cd	Co	Cu	Fe	Mg	Mn	Pb	Zn
		ppm							
1	*M. meretrix* Tissue	0.222 ± 0.001	0.061 ± 0.001	14.98 ± 0.01	46.19 ± 0.773	120.1 ± 7.040	2.77 ± 0.146	0.131 ± 0.02	29.25 ± 0.65
2	*M. meretrix* Shell	0.005 ± 0.001	0.003 ± 0.001	0.277 ± 0.001	1.729 ± 0.112	13.03 ± 0.950	0.262 ± 0.016	0.143 ± 0.04	0.337 ± 0.03
3	*C. madrasensis* Tissue	0.062 ± 0.001	0.044 ± 0.001	1.773 ± 0.03	17.04 ± 0.940	60.6 ± 4.05	0.976 ± 0.025	0.107 ± 0.002	5.01 ± 0.97
4	*C. madrasensis* Shell	0.004 ± 0.001	0.007 ± 0.001	0.28 ± 0.02	6.906 ± 0.291	76.59 ± 5.78	1.605 ± 0.05	0.176 ± 0.012	0.434 ± 0.152
5	*C. cingulata* Tissue	0.086 ± 0.001	0.049 ± 0.001	12.6 ± 0.095	34.45 ± 1.373	112.6 ± 2.73	2.68 ± 0.22	0.104 ± 0.003	19.16 ± 0.76
6	*C. cingulata* Shell	0.005 ± 0.001	0.013 ± 0.001	0.372 ± 0.006	9.354 ± 0.299	24.14 ± 4.00	7.452 ± 0.30	0.177 ± 0.002	0.865 ± 0.026
7	Sediment	0.045 ± 0.001	0.385 ± 0.001	0.8 ± 0.1	416.6 ± 1.708	131.3 ± 4.16	8.479 ± 0.76	0.067 ± 0.003	1.070 ± 0.009

Table 2: Station 2- Vellar (Buckingham Canal)

S.No	Species	Metals							
		Cd	Co	Cu	Fe	Mg	Mn	Pb	Zn
		ppm							
1	*M. meretrix* Tissue	0.151 ± 0.008	0.134 ± 0.001	1.255 ± 0.05	22.03 ± 5	132.1 ± 12	0.992 ± 0.5	0.127 ± 0.05	4.452 ± 0.5
2	*M. meretrix* Shell	0.007 ± 0.0008	0.000 ± 0.000	0.664 ± 0.05	5.261 ± 5	18.20 ± 12	0.198 ± 0.01	0.164 ± 0.05	0.407 ± 0.469
3	*C. madrasensis* Tissue	0.020 ± 0.0008	0.123 ± 0.001	4.137 ± 0.05	107.1 ± 5	274.0 ± 12	10.99 ± 0.5	0.124 ± 0.05	3.327 ± 0.5
4	*C. madrasensis* Shell	0.007 ± 0.0008	0.010 ± 0.001	0.360 ± 0.05	9.387 ± 5	112.1 ± 12	1.777 ± 0.5	0.189 ± 0.05	1.045 ± 0.5
5	*C. cingulata* Tissue	0.026 ± 0.0008	0.030 ± 0.001	1.130 ± 0.05	13.83 ± 5	202.3 ± 12	5.859 ± 0.5	0.229 ± 0.05	2.022 ± 0.5
6	*C. cingulata* Shell	0.004 ± 0.0008	0.006 ± 0.001	0.280 ± 0.05	5.843 ± 5	39.64 ± 12	5.250 ± 0.5	0.186 ± 0.05	0.311 ± 0.329
7	Sediment	0.004 ± 0.0008	0.011 ± 0.001	0.160 ± 0.05	8.203 ± 5	15.27 ± 12	0.475 ± 0.1	0.312 ± 0.05	0.704 ± 0.5

4.4 Crassostrea madrasensis

In staion 1 magnesium reported the highest values 59.80 ppm and cobalt the lowest value of 0.043 ppm in the tissue. At the same time, the shell recorded the maximum magnesium content of 76.59 ppm and minimum cadmium content of 0.004 ppm (Table 1 and Fig. 2). In station 2 magnesium recorded the highest values 274.0 µg /l and cadmium the lowest value of 0.020 ppm in the tissue at the same time, the shell recorded the maximum magnesium content of 112.1 ppm and minimum cadmium content of 0.007 ppm (Table 2 and Fig. 3).

Figure 3. Levels of Heavy Metals in Sediment and Species in Station 2

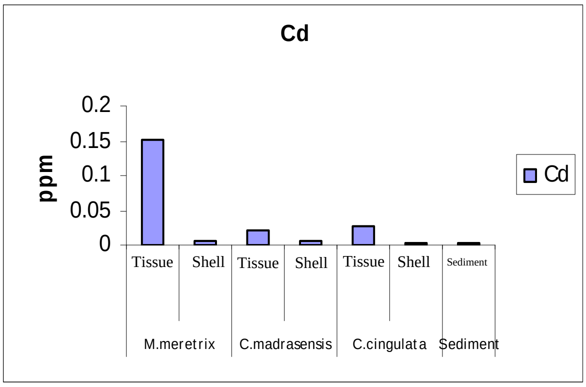

Fig a. Concentration of Cd

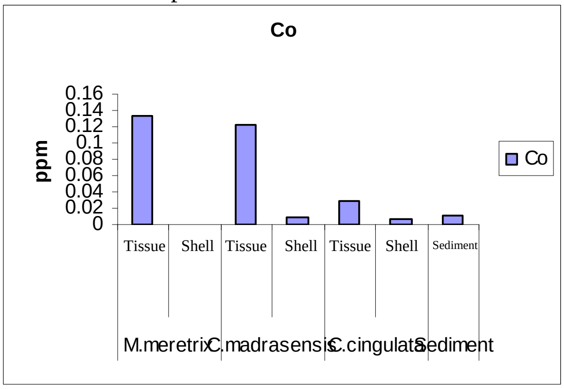

Fig b. Concentration of Co

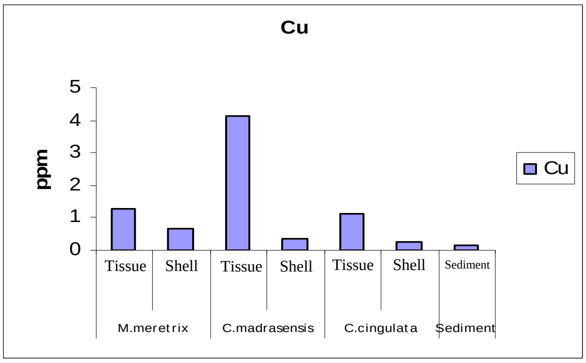

Fig c. Concentration of Cu

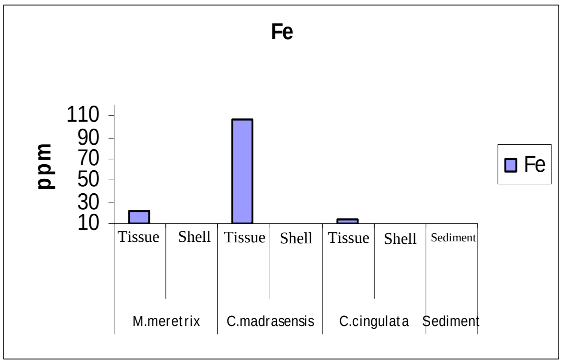

Fig d. Concentration of Fe

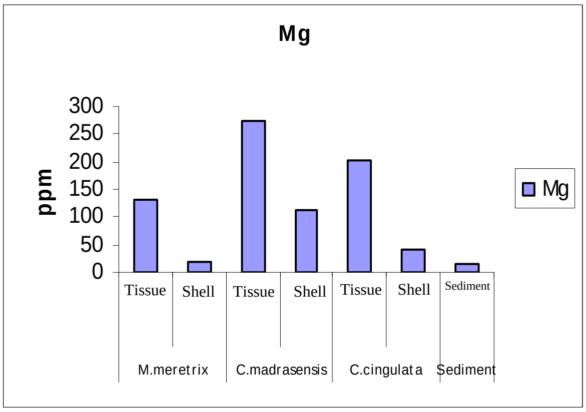

Fig e. Concentration of Mg

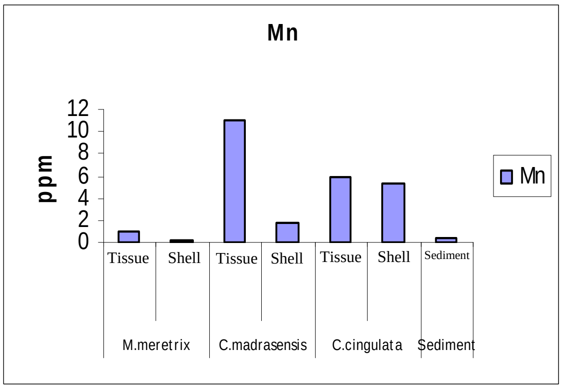

Fig f. Concentration of Mn

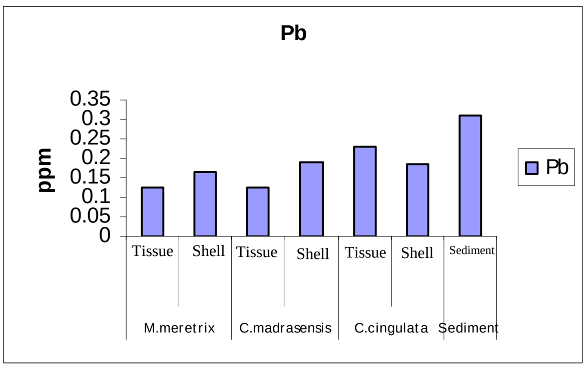

Fig g. Concentration of Pb

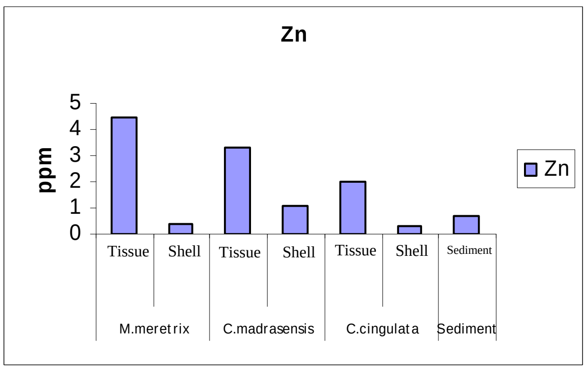

Fig h. Concentration of Zn

Correlation between the sediment and the animals was made. The result between the sediment vs. *Meretrix meretrix* shell and *Cerethidea cingulata* tissue was not found significant. But, the sediment vs. *Meretrix meretrix* tissue ($r = 0.969$, $P < 0.01$), *Crassostrea madrasensis* tissue ($r = 0.974$, $P < 0.01$) and shell ($r = 0.976$, $P < 0.01$) were positively correlated and significant at $P<0.01$ level. Whereas the sediment vs. *Cerethidea cingulata* shell ($r = 0.634$, $P < 0.05$) showed positive correlation and significant at $P < 0.05$ level.

One way ANOVA was performed between the two stations of the study area in Vellar estuary. There was no considerable variation in metal concentration between the animals collected from two stations in Vellar estuary, but there was significant variation in metal concenteration between tissue and shell where tissue concentration was dominating. The values obtained in sediment was (F=.469, p=NS), *Meretrix meretrix* tissue (F=.750, p=NS), *Meretrix meretrix* shell (F=.120, p=NS), *Cerethidea cingulata* tissue (F=.115, p=NS), *Cerethidea cingulata* shell (F=.001, p=NS), *Crassostrea madrasensis* tissue (F=.020, p=NS) and *Crassostrea madrasensis* shell (F=.761, p=NS).

5. DISCUSSION

Trace metals can be divided in to essential elements and nonessential elements. Essential elements occur naturally in all organisms. In high doses also essential elements can be poisonous and cause hazardous effects on organism. The non-essential elements do not have any positive effects on organisms and they are harmful already in low doses. They can inhibit an essential element to bind to enzyme and disturb the normal enzymatic function in the body.

Concentration of the heavy metals in sediment, tissues and shells of molluscs from two stations were determined. The Vellar estuary is located in a zone where there is not much industrial or anthropogenic activity. Anthropogenic effects, processes, objects, or materials are those that are derived from human activities, as opposed to those occurring in natural environments without human influences. Anthropogenic sources from industry, agriculture, mining, transportation and concentration of human activities in discrete zones lead to the concentration of waste products, sewage, and debris. The heavy metals transfer between sediments and mollusks are through the algae, plankton since these mollscs are herbivores/filter feeders.

The sediment of St.1 had higher concentration of the metal Iron (416.6± 1.7 ppm); Magnesium (131.3± 4.1 ppm) but in St. 2 these two metals were recorded at minimum level. Lead was also recorded in minimum level at all the stations**.** Similar kind of accumulation has been recorded by Ananthan *et al*. (2006) where the distribution of heavy metals in Vellar estuary for the Iron concentration in sediment was from 285 to 355 µg g^{-1}. Whereas the highest value was recorded during monsoon and lowest during pre monsoon, this value is comparatively lower than that of the present study in both the study areas. The concentration of the Iron in these study area are within the range reported by previous workers (Magendran, 1985; Ananthan, 1990; Senthilnathan & Balasubramainam, 1999). Iron plays an important role as an essential element in all systems but high level in the environment may reflect the bioaccumulation in the marine organisms such as bivalves, gastropods, coral reefs and fish.

Ayyamperumal et al. (2006) recorded moderate enrichment in the surface layers (0-5cm) for Iron (1607-1905 µg g^{-1}) and higher enrichment in the middle layers (15-20 cm) (4582 µg g^{-1}). The present study in Vellar indicates higher concentration (416.6±1.7 ppm) than the earlier study. This might be due to continuous anthropogenic input. Ravichandran *et al* (1995) studied Cadmium level in Vellar estuary (0.41, 0.43, 0.50 µg g^{-1}). But in the present study it was recorded from BDL to (0.222±0.001), this can also be attributed to industrial inputs and it is worth mentioning here that cadmium is not an essential element for plants, animals and human beings. Moreover plating process in these industries involve surface preparation and pickling, which also produce acidic and alkaline waste water with elevated metal concentration**.**

The concentration of Iron in sediments was higher at St. 1 than at St. 2 in Vellar estuary and this could be due to the nature of sediments; its texture and size as the former station are clayey in nature while the later is sandy.

The other metals such as Zinc, Manganese, Cobalt, Lead, Copper, were exhibited in medium concentrations. Metals such as cadmium and cobalt were below the detectable limit at all stations in the estuary. The concentration in the sediment had a major influence in the molluscan tissues and shells. At both the stations Magnesium (131.3±4.16–15.27±12) could be recorded in the sediments. The distribution and characterization of minerals in Ponnaiyar River sediments are carried out using Fourier Transform Infrared (FTIR) spectroscopic technique. The minerals such as quartz, feldspar in different structure, kaolinite, calcite, gibbsite, montmorillonite, smectite, organic carbon and palygorskite are identified (Venkidasamy Ramasamy et.al, 2010).

Bivalves and gastropods are frequently used as biomonitors for heavy metal pollution in the estuarine environment. Each class includes bioaccumulating species that may be sedentary, filter-feeding and tolerant of the varying salinity levels and pH values found in the estuaries (McLusky, 1989)**.** In the present investigation, molluscs (*Cerethidea cingulata,,Crassostrea madrasensis* and *Meretrix meretrix)* were subjected to heavy metal accumulation studies. The present study has recorded maximum concentration of Magnesium (120.1±7.04-274±12) in the tissues and shell of all the molluscs at both the stations of Vellar. However, Iron, Lead and Zinc were also present in considerable quantities. Cobalt and Cadmium concentration was the lowest, especially in the case of tissue of *Meretrix meretrix*, Cadmium and Cobalt were detected in significant quantities. In all the cases the concentration of metals in tissues was higher than the shell. Between the animals *Meretrix meretrix* showed more accumulation of metals when compared to *Cerethidea cingulata* and *Crassostrea madrasensis*. There was no considerable variation in metal concentration between the animals collected from two stations in Vellar estuary, but there was significant variation in metal concenteration between tissue and shell where tissue concentration was dominating.

The concentration of heavy metals in the biota collected also showed a similar trend as of the Vellar estuary. Concentration of Iron (107.1±5-1.729±0.11), Magnesium (120.1±7.04-274±12), Manganese (10.99±0.5-0.104±0.003) was more in the molluscan tissue at the both the station of the Vellar estuary. As also Cadmium and Cobalt concentrations were low invariably in all cases. This might be due to the industrial inputs and other activities, whereas other stations did not show much alarming concentrations. At both stations in the two estuaries no significant correlation was obtained between sediment concentrations and the tissue/shell concentration of the metals studied in the present study.

In concordance with the present study, several relevant studies have been made by researchers earlier. The heavy metal accumulation in the gastropod *Cerithium scabridum* from Kuwait coast has been analysed by Bu – Olayan and Thomas (2001) and it was reported that the concentration of the cadmium in the gills was ranging between (7.06 $\mu g/g^{-1}$- 0.90 $\mu g/g^{-1}$), which is comparatively lower than that of the present study in both the stations at Vellar.

Szefer et al. (1998) estimated the concentration of Cd, Pb, Zn, Cu, Ag, Cr, Co, Ni, Mn and Fe in soft tissue and byssal threads of *Mytella strigata* in tropical mangrove lagoon of Mexico. In tissue and byssal threads Cadmium are close unity. The soft tissue of Mytilidae, in contrast to byssus, is a sensitive biomonitor of Cadmium pollution. The study conducted in the soft tissues of *M. strigata* appeared to contain (0.1 to 0.12 $\mu g/g^{-1}$) of Cadmium which is (2220 – 0.010 $\mu g/g^{-1}$) higher than the values obtained in present study of Vellar.

Ravera et al. (2003) quantified the Magnesium level in tissue and shell of *Uniopictorium mancus* from Italy. They reported that the values of Magnesium were found to be 3338.02 mg/g in tissue and 211.10 mg/g in shell. The values were relatively lower than the present study in both the study area.

The giant clam shell *(Tridacna maxima*) have been analysed for Cadmium. The results showed the Cadmium concentration (1.32 to 1.82 $\mu g/g^{-1}$) in two sites, which is lower than the present study. This shows that the present study area for Cadmium accumulation is below the standard level. In the present study the concentration of heavy metals in the tissue was also generally more than that of the shell concentration. The accumulation of Cadmium in the bivalve *Anadara ovali* was found as(0.0058-0.0605 $\mu g/g^{-1}$) (Augusto *et al*., 2006), which is lower than that recorded during the study in Vellar estuary. Cravo *et al*. (2004) has described the partitioning of Cadmium between the soft tissue and shell of the gastropod mollusc, *Patella aspara* and reported that Cadmium was detected in soft tissue as 1.6 µg/g, which it is relatively lower than that of the present study. In shell the Cadmium was not detected, as in the present study, which may be due to lesser store and function of metals. In the present study both the estuaries, the sediment, molluscan tissue and shells accumulation Cadmium was below detectable limit.

Shanmugam et al. (2007) determined the bioaccumulation of heavy metals such as Magnesium, Iron, Zinc and Copper concentration in different body parts and shell of *Cymbium melo* and also studied the sediment of its habitat. The bivalves take up metals from solution and suspended material (food source), but oysters *Crassostrea rhizophorae* are particularly recommended as biomonitors given their strong accumulation patterns for many trace metals, their large size and their local abundance. In shell size and weight along with the age is an important factor which determines bioaccumulation and has been reported by several researchers (Quensen & Woodruff, 1997**;** Jordaens et al., 2006 and Lodge et al., 1987).

This study revealed that the levels of heavy metals are elevated in some stations that received effluent from human activities and these contributed the levels of metals in the estuary. Sixty percent of metals analyzed measured from surface sediment are from anthropogenic activities only. The levels of heavy metals need to be monitored periodically as the development of shrimp ponds and aquaculture activities are in progress in the area.

5. ACKNOWLEDGMENTS

Authors are thankful to the Director, CAS in Marine Biology and authorities of Annamalai University for providing with necessary facilities. The author (KK) is also thankful to the Ministry of Environment & Forests, New Delhi for the financial assistance.

BIBLIOGRAPHY

Ananthan, G., 1990. *Monsonal study in hydrography and trace metal distribution in the Vellar estuary. M.Sc., dissertation,* Annamalai University, p. 24,

Ananthan, G., P. Sampathkumar, C. Palpandi & L. Kannan, **2006.** *Distribution of heavy metals in Vellar estuary, southeast coast of India, J. Excotoxicol.* Environ. Monit., 16(2): 185 – 191.

Augusto, S.C., R. Brian, D. Smith & P.S. Rainbow, 2006. *Comparative biomonitors of coastal trace metal contamination in tropical South America (N. Brazil).* Mar. Environ. Res., 61: 439 – 455.

Ayyamperumal, T., M.P. Jonathan, S. Srinivasalu, J.S. Armstrong - Altrin, & V. Ram Mohan, 2006. *Assessment of acid leachable trace metals in sediment cores from River Uppanar, Cuddalore, Southeast coast of India.* Environ. Poll. 143: 34-45.

Brügmann, L., 1981. *Heavy metals in the Baltic Sea. Mar.* Pollut. Bull., 12(6): 214-218.

Bryan, G.W., W.J. Langston, L.G. Hummerstone, G.R. Burt & Y.B. Ho, 1983. *An assesment of the gasteropod, Littorina littorea, as an indicator of heavy-metal contamination in United Kingdom estuaries.* J. Mar. Biol. Assoc. UK., 63:327 – 345.

Bu-Olayan, A.H. & B.V. Thomas, 2001. *Heavymetal accumulation in the gastropod, Cerithium scabridum L., from the kuwait coast.* Environ. Mon. Assess., 68: 187–195.

Chester, R., & Hughes, M. J.A, 1967. *Chemical technique for the separation of ferro-manganese minerals. Carbonate minerals and adsorbed trace elements from pelagic sediments.* Chem. Geol. 2: 249 – 262.

Clark, R.B., 2004 *Marine Pollution. 4. (Ed).* Clarendon Press, Oxford. 161 pp,

Cravo, A., M.J. Bebianno & P. Foster, 2004. Partitioning of trace metals betweensoft tissues and shells of *Patella aspera*. Environment International. 30: 87–98.

Huanxin, W, Z. Lejun & B.J. Presley, 2000. *Bioaccumulation of heavy metals in hydrocarbon and artificial radionuclide data.* Environ. Sci. Technol., 17,490–496.

Jordaens. K., H. De Wolf, B. Vandecasteele, R. Blust & T. Backeljau. 2006. *Associations between shell strength, shell morphology and heavy metals in the land snail Cepaea nemoralis (Gastropoda, Helicidae).* Sci. Total Environ., 363: 285–293.

Levinton, J.S., 1995. *Marine Biology - Function, Biodiversity, Ecology. 1.* Ed. Oxford University Press, New York. pp 420.

Lodge, D.M., K.M. Brown, S.P. Klosiewski, R.A. Stein, A.P. Covich & B.K. Leathers, 1987. *Distribution of freshwater snails: spatial scale and the relative importance of physicochemical and biotic factors.* Am. Malacol. Bull., 5:73 – 84.

Magendran, A., 1985. *Cycling of zinc in the Vellar estuary.* M. Phil., thesis, Annamalai University, p. 104.

Mclusky, D.S., 1989. *The estuarine ecosystem (2nd Ed),* Chapman & Hall, London, Blackie.

Quensen, J.F. & D.S. Woodruff, 1997. *Associations between shell morphology and land crab predation in the land snail.* Cerion. Func. Ecol., 11:464–471.

Ramasamy V., P. Rajkumar & V. Ponnusamy. 2009. *Depth wise analysis of recently excavated Vellar river sediments through FTIR and XRD studies.* Indian. J. Physics., 83(9), 1295-1308.

Ravera, R.C, G.M. Beone, M. Dantas & P. Lodigiani, 2003. *Trace element concentrations in freshwater mussels and macrophytes as related to those in their environment.* J. Limnol., 62(1): 61 – 70.

Ravichandran, M., M. Baskaran, P.H. Santschi & T.S. Bianchi, 1995. *History of trace-metal pollution in Sabine-Neches estuary, Beaumount, Texas.* Environ. Sci. Technol. 29 (6): 1495 – 1503.

Regoli, F. & G. Principato, 1995. *Glutathione, glutathioned ependent and antioxidant enzymes in mussel, Mytilus galloprovincialis, exposed to metals under field and laboratory conditions,* Toxicol., 31: 143 – 164.

Senthilnathan, S. & T. Balasubramanian, 1999. *Heavy metal distribution in Pondicherry harbor, Southeast coast of India.* Indian J. Mar. Sci., 28: 380 – 382.

Shanmugam, A., C. Palpandi & K. Kesavan, 2007. *Bioaccumulation of some trace metals (Mg, Fe, Zn, Cu) from begger's bowl Cymbium melo (Solander, 1786) (a marine neogastropod).* Research Journal of Environmental Sciences, 1(4): 191– 195.

Stewart, A.R., 1999. *Accumulation of Cd by a freshwater mussel (Pyganodon grandis) is reduced in the presence of Cu, Zn, Pb, and Ni.* Canadian J. Fish. Aqua. Sci., 56, 467 – 478.

Szefer, P., J. Geldon, A.A. Ali, F. Paez-Osuna, A.C. Ruiz-Fernandes & S.R. Guerrero Galvan, 1998. *Distribution and association of trace metals in soft tissue and byssus of Mytella strigata and other benthal organisms from Mazatlan Harbour,* *mangrove lagoon of the northwest coast of Mexico.* Environ. Int., 24: 359 – 374.

Venkidasamy Ramasamy, Govindasamy Suresh, Venkatasubramanian Meenakshisundaram & Velladurai Ponnusamy. 2010. *Distribution And Characterization Of Minerals And Naturally Occurring Radionuclides In River Sediments,* Carpathian Journal of Earth and Environmental Sciences, **5**(1), 41 – 48.

Topping, G. 1972. *Heavy metals in shellfish from Scottish waters.* Aquaculture, 1: 379-384.

Received 05.11. 2009
Revised at: 25. 03. 2010
Accepted for publication at: 14. 04. 2010
Published online at: 24. 04. 2010