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COPPER, ZINC, IRON AND MANGANESE IN SEDIMENTS, AND IN THE ROCK OYSTER *SACCOSTREA CUCULLATA* IN MUMBAI COAST

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ABSTRACT

Sediment and oyster (*Saccostrea cucullata*) samples were collected at Dhanda, a fishing village in Mumbai, Maharashtra. The samples were analysed for copper, zinc, iron and manganese contents. Metal concentrations in the sediments and bioaccumulated levels in oysters were correlated. There is no positive correlation between the total sedimentary levels of metals analysed and the bioaccumulated levels of respective metals in oyster. A positive correlation between the bioavailable fractions of zinc, iron and manganese, and the bioaccumulated levels exists. Copper, however, shows a negative correlation with respect to the bioaccumulated levels.

Key words: Zinc, iron, manganese, copper, oyster, sediment

INTRODUCTION

All metals, including the essential metallic micronutrients are invariably toxic to aquatic organisms, with toxicity depending on the nature of metal, exposure time and dosage, other metals present, etc. Metals are required in life processes, and most organisms have the capability of concentrating them. This capability is enhanced by certain feeding and metabolic processes, which can lead to enormously high concentrations. Invertebrates, in particular, seem to possess greater ability to concentrate metals, along with other foreign materials found in their environment, when they filter plankton during feeding. Phillips (1977) listed out the ideal characteristics of biological indicators and suggested molluscs belonging to the genera *Mytilus, Perna, Ostrea* and *Crassostrea* to be universal indicators. Scanes (1996) reported oysters to be useful indicators of trace metal contamination of the marine environment.

Sediments form the ultimate receptacle of heavy metals. Iron and manganese are generally present as oxyhydroxides, which are involved in surface precipitation and adsorption of trace elements, and therefore, can influence the chemical behaviour of other heavy metals (Sadiq, 1992). Watzin and Roscigno (1997) suggested that zinc

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contamination of sediments could influence the ecology of benthic community. Meiofauna are affected upon regular exposure to metals in the interstitial space rather than a single exposure (Maguire and Roberts, 1976). Luoma and Bryan (1982) observed the bioavailable fraction to be providing more information on the bioavailability of the metals than the other fractions. In the present study, an attempt was made to correlate the heavy metals present in the sediment, and the bioavailable fraction and the concentration of these metals in oysters.

MATERIAL AND METHODS

The oysters *Saccosstrea cucullata* were collected in the year 2000 at Dhanda, a fishing village in Mumbai (Maharashtra State), and brought to the laboratory on ice. In the laboratory, animals were shucked with a stainless steel scalpel and the soft parts removed. The muscle was then homogenized, collected in polyethylene bags and stored at -20^0C. The samples were digested with 10 ml of freshly prepared 1:1 (v/v) H_2O_2/HNO_3. Boiling was continued until the volume was reduced to 2-5 ml. The solution was then filtered and volume made to 25 ml with double-distilled water. Blanks were prepared simultaneously (FAO/SIDA, 1983).

Sediment samples were collected during low tide in polyethylene bags and transferred to the laboratory in an icebox. The samples were then processed by physically removing large shells and stones, drying at 60°C for 24 hours and digestion as per Tam and Yao (1999). The bioavailable fractions of the sedimentary metals were obtained by the extraction of dry sediments with 1 *N* HCl (Luoma and Bryan, 1982).

RESULTS AND DISCUSSION

The concentrations of sedimentary metals are presented in Table 1. The peak concentrations were observed during the month of May for both copper and iron, while for zinc and manganese, these were in April and October, respectively. The bioavailable fraction of iron (Table 2) was negligible (6.2375 ± 1.0849 mg/g) when compared to the mean bioavailable fractions of manganese (300.1625 ± 27.8864 mg/g), zinc (63.8375 ± 7.7351 mg/g) and copper (31.6375 ± 8.5192 mg/g). The concentrations of iron, zinc, manganese and copper bioaccumulated by *S. cucullata* are given in Table 3. The seasonal and temporal variations of the bioaccumulated, sedimentary and bioavailable fractions are presented in Fig. 1. Two-way analysis revealed significant differences among the different metals and not between the months of sampling. Significant difference was also observed between the bioaccumulated, sedimentary and bioavailable fractions for all the metals.

The values of iron and manganese recorded in the present study were comparable to the earlier works at Mumbai Coast (Matkar *et al.*, 1981; Patel *et al.*, 1985) though higher than the reported values. The value of iron was, however, less than the value reported at Chennai and Visakhapatinam (Pragatheeswaran *et al.*, 1986). The higher value of iron in these areas has been attributed to the

Table 1: Concentration (mg/kg dry wt) of heavy metals in sediment

Months of sampling	Fe	Mn	Zn	Cu
Feb.	2885.5	605.5	109.0	68.5
Apr.	2804.0	652.0	133.0	84.0
May	2931.0	635.0	129.5	87.5
Jul.	2665.0	683.0	95.5	53.5
Aug.	2695.0	692.5	96.0	52.3
Oct.	2767.0	772.5	100.5	52.5
Nov.	2830.0	514.0	114.5	76.0
Dec.	2894.0	650.5	117.5	66.5
Mean	2808.94	650.63	111.94	67.60
SD	95.56	74.26	14.41	14.13

Table 2: Bioavailable fractions (mg/kg dry wt) of the heavy metals in sediment

Month	Fe	Mn	Zn	Cu
Feb.	1.5	2.4	6.0	6.1
Apr.	3.5	11.1	8.6	7.5
May	7.1	3.1	9.0	5.7
Jul.	7.9	7.1	5.2	6.5
Aug.	4.7	7.7	5.2	7.2
Oct.	3.5	5.3	5.3	6.8
Nov.	4.3	2.0	6.1	6.1
Dec.	7.8	4.9	5.5	4.0
Mean	5.03	5.88	6.36	6.24
SD	0.82	1.09	0.55	0.38

Table 3: Bioaccumulated levels (mg/g wet wt) of heavy metals in *Saccostrea cucullata*

Months of sampling	Fe	Mn	Zn	Cu
Feb.	96.4844	2.9573	81.3270	133.8213
Apr.	101.6562	6.4451	86.0318	148.6270
May	107.9271	5.3757	89.7325	77.1203
Jul.	125.9361	11.5803	80.0972	157.782
Aug.	236.4617	4.1900	166.2820	44.5166
Oct.	119.2002	11.2151	266.9187	192.2584
Nov.	78.5742	2.8747	189.0091	72.1359
Dec.	108.5766	2.1290	244.2214	203.4672
Mean	121.8521	5.8459	150.4525	128.7161
SD	48.4821	3.7037	77.1449	58.3655

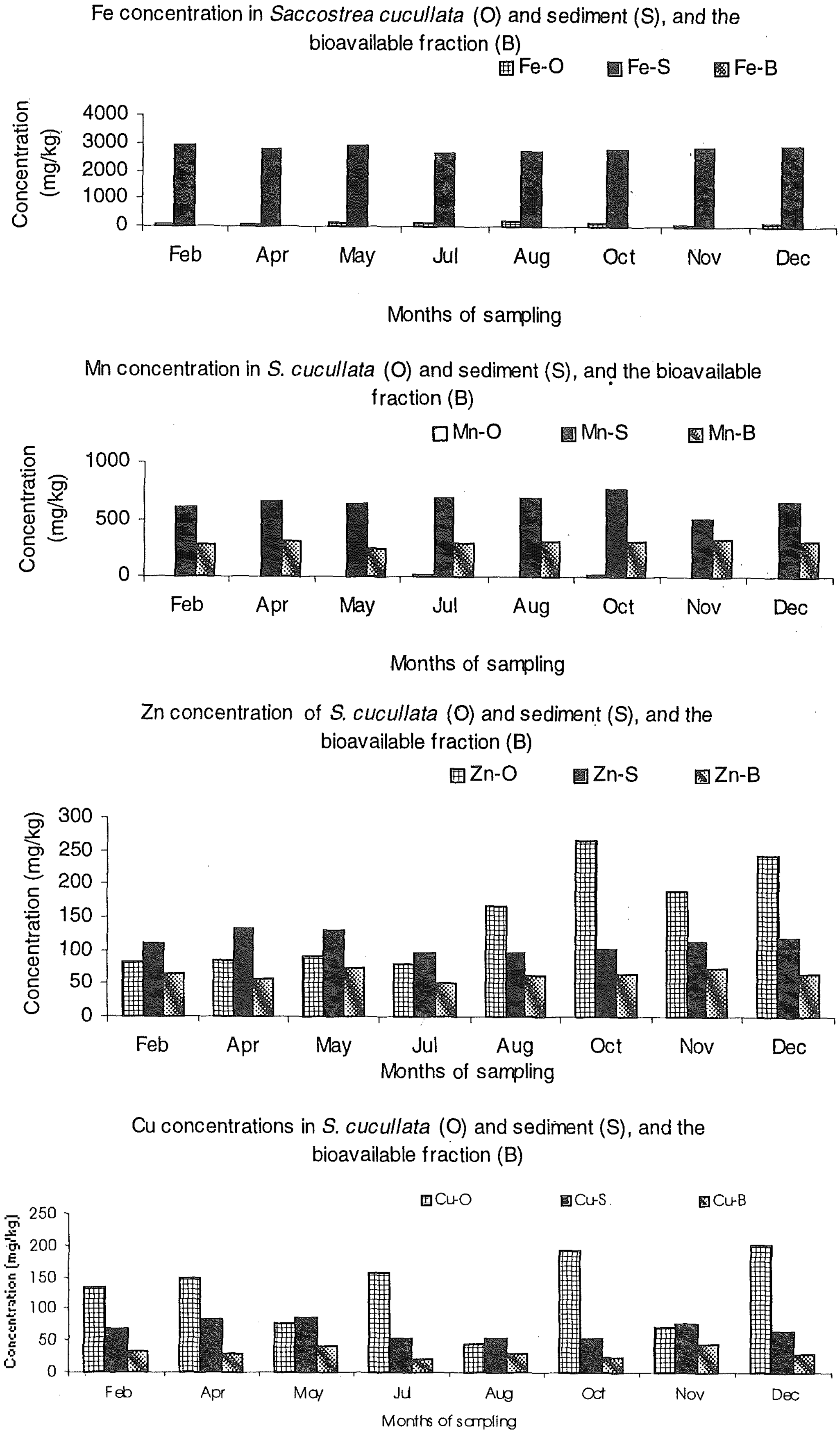

Fig. 1. Spatial and temporal variations in the sedimentary (dry-weight basis), bioavailable (dry weight basis) and bioaccumulated (wet-weight basis) fractions of metals

anthropogenic activities, particularly the development of urban centres. The values of copper and zinc were, however, less than the values recorded earlier in Ulhas River, Mumbai (Sahu and Mukherjee, 1983). The value of zinc was comparatively less than the value reported in the Mumbai Harbour Bay (Matkar *et al.*, 1981). All the metals analysed in the present study gave higher values than those recorded at Tuticorin Coast (Aanand, 1998). The increase in metal concentrations indicates the impact of the higher level of urbanization and industrialization in Mumbai.

The analysis of the levels in *S. cucullata* shows a positive correlation for all metals except copper, with respect to the bioavailable fraction. As far as the total sedimentary metal levels are concerned, only manganese showed a positive correlation for bioaccumulated levels. Though significant difference could not be observed for both sediment and bioaccumulated metal levels, fluctuations in metal levels could be observed mainly during the months of May and August for all the metals (Fig. 1). This indicates a post-monsoon influence in metal concentrations. Such seasonal fluctuations have been reported for *Crassostrea madrasensis* and *Donax cuneatus* in Tuticorin Coast (Aanand, 1998), and for *Mytilus edulis* in the Belgian coast (Meeus-Verdinne *et al.*, 1983). The order of accumulation was Zn>Cu>Fe>Mn. This order of accumulation was similar to that reported for *C. madrasensis* (Zn>Cu>Mn), but different from that for *D. cuneatus* (Zn>Mn>Cu) reported earlier at Tuticorin Coast. Earlier workers (Lakshmanan and Nambisan, 1983; Ikuta, 1987; Rajendran *et al.*, 1988; Morse *et al.*, 1993; Nady, 1996; Senthilnathan *et al.*, 1998) have observed the order Zn>Cu>Mn.

The higher levels of bioavailable manganese were not found to contribute to bioaccumulated manganese as observed by the low level of its bioaccumulation. The bioaccumulated levels of copper showed erratic changes irrespective of changes in the bioavailable or sedimentary levels (Fig. 1). An unexplainable increase in copper levels in the burrowing bivalve *Scrobicularia plana* was observed in estuaries of England (Luoma and Bryan, 1982), and it has been suggested that under very anoxic conditions, the availability of copper could be very high. This can also be observed statistically wherein there exists a negative correlation for bioavailable copper (- 0.5824) and sedimentary copper (- 0.2310). However, there existed a positive correlation between bioaccumulated levels in the green mussel and all other three metals, *viz.*, iron (0.3559), manganese (0.0545) and zinc (0.3715). Any positive correlation of bioaccumulated levels with sedimentary metal levels could not be observed for any of the four metals. Iron was the lowest of the bioavailable fractions in the metals studied and manganese was the least accumulated fraction. Zinc was the highly accumulated metal among the four metals studied. A similar higher accumulation of zinc has been reported in *M. edulis* in the Belgian coast (Meeus-Verdinne *et al.*, 1983). Thus, it could be seen that the control on the bioaccumulation of metals is different among different metals. A similar observation has also been made in the case of *S. plana* (Luoma and Bryan, 1982).

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