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Bioaccumulation of Cu, Zn, Mn, Fe and Pb in gastropods, *Bursa spinosa* and *Nerita oryzarum* from Uran coast, near Mumbai (India)

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***Abstract**: Bioaccumulation of five heavy metals (Cu, Zn, Mn, Fe, Pb) in the gastropods, Bursa spinosa and Nerita oryzarum from three stations along Uran coast (near Mumbai) was studied during 2005-2007.The coast receives discharges from the heavily industrialized and highly populated settlements. Bioaccumulation of heavy metals in Bursa spinosa followed the order Cu>Fe>Zn>Cd>Mn>Pb and Nerita oryzarum Fe>Cu>Zn>Mn>Cd>Pb. Seasonal variations in accumulation in these heavy metals in soft tissue of the gastropods were also noticed. Though the observed concentration of heavy metals in the bivalves were below the recommended limits, environmental surveillance of the creek is required for contaminant-free gastropods.*

Key words: Bioaccumulation, Heavy metals, *Nerita oryzarum, Bursa spinosa*, Uran coast.

Introduction

Heavy metals accumulation in marine ecosystem is of global concern (Bhattacharya *et al*., 1994; Frias-Espericueta *et al.,* 1999a, b; Goksu *et al*., 2005). They enter in the aquatic environment through atmospheric deposition, erosion of geological matrix or due to anthropogenic activities such as industrial effluents, domestic sewage and mining wastes (Kennish, 1992; de Astudillo *et al.*, 2005; Reddy *et al*., 2007). The detection of pollutants like petroleum hydrocarbons and heavy metals in the marine environment has been investigated by employing bio-indicators/sentinel organisms (Bryan *et al*., 1979; Kennish, 1992; Phillips and Rainbow, 1993). Gastropods are filter-feeders and thus uptake of heavy metals in these organisms is not only from food and water but also from ingestion of inorganic particulate materials too (Fang *et al.,* 2003; El-Silkaly *et al*., 2004, Sidoumou *et al.*, 2006). Since they accumulate most of the contaminants at much higher level than those found in the water column as such they are representative of the pollution of area and considered as appropriate indicators as they are spatially distributed, relatively large in size and easy to collect (Anderlini *et al*., 1982; Turkmen and Turkmen, 2004). High concentrations of trace metals have been detected in whole soft bodies of several species of marine bivalves in many parts of the world (Ikuta, 1986; Ikuta *et al*., 1990; Bu-Olayan and Subrahmanyam, 1997; Goksu *et al.*, 2005).

Due to their economic and ecological importance as well as their sedentary mode of life, molluscs, especially bivalves, play major role in monitoring contaminants throughout the world and are well established as bio-indicators for the concentration of heavy metals in aquatic ecosystems (Powell and White, 1990; Sarkar *et al*., 1994; Al-Mafda *et al.*, 1998; Gundacker, 1999; Neuberger-Cywiak *et al*., 2003). Since rapid industrialization and urbanization during the recent years have led to the significant increase in heavy metal pollution in the coastal ecosystems throughout the world (Phillips, 1980; Kennish, 1992; Kavun *et al*., 2002; Phillips and Rainbow, 1993; Fang *et al.,* 2003), an attempt was made to record the accumulation of heavy metals such as copper (Cu), zinc (Zn), iron (Fe), manganese (Mn), cadmium (Cd) and lead (Pb) in the two species

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of gastropods, *Bursa spinosa* and *Nerita oryzarum,* inhabiting three different sites of Uran coast (near Mumbai).

Materials and Methods

At the beginning of investigation, the coast of Uran was surveyed for recording intertidal gastropods. This coast is mixture of rock, sand and muddy shores. Gastropods were found attached to the rocks, in the crevices and below large stones. Three sites of Uran coast were selected for the present study(Fig. 1a, b). **Site - I was** located along the eastern shore of Bombay Harbour opposite Colaba, the substratum being rocky (Fig. 2). **Site - II was** located near Karanja village, the substratum formed of basalt rock. Due to constant movement of ferries, water of nearby areas at this point is muddy showing sporadic oil patches (Fig. 3). **Site - III was** located 5 km away from site II and situated at Naval Base, Dronagiri. Here upper part of inter-tidal zone is rocky whereas substratum of remaining part is sandy (Fig. 4). Since all the above sites were exposed to the environment

Fig.1b: Magnified to show the sampling sites.

Fig.1a: General map of the area.

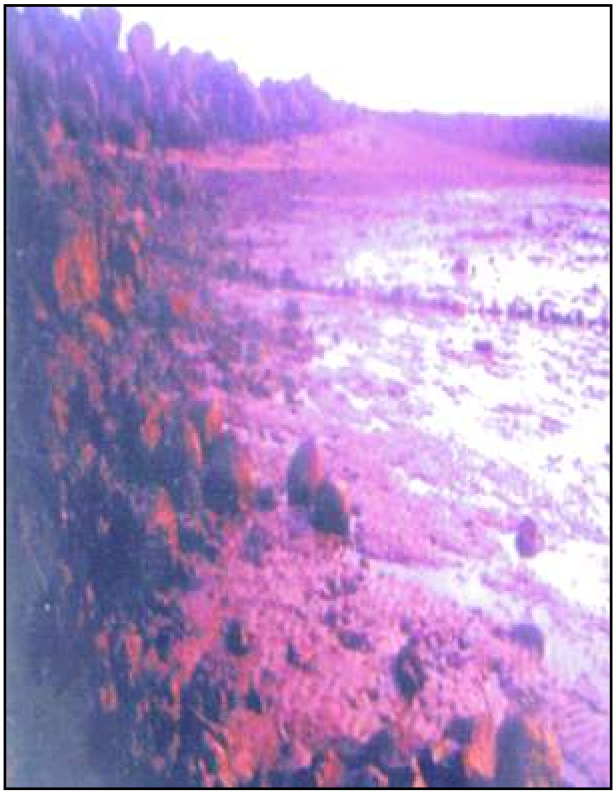

Fig. 2. Site-I opposite to Colaba, Mumbai.

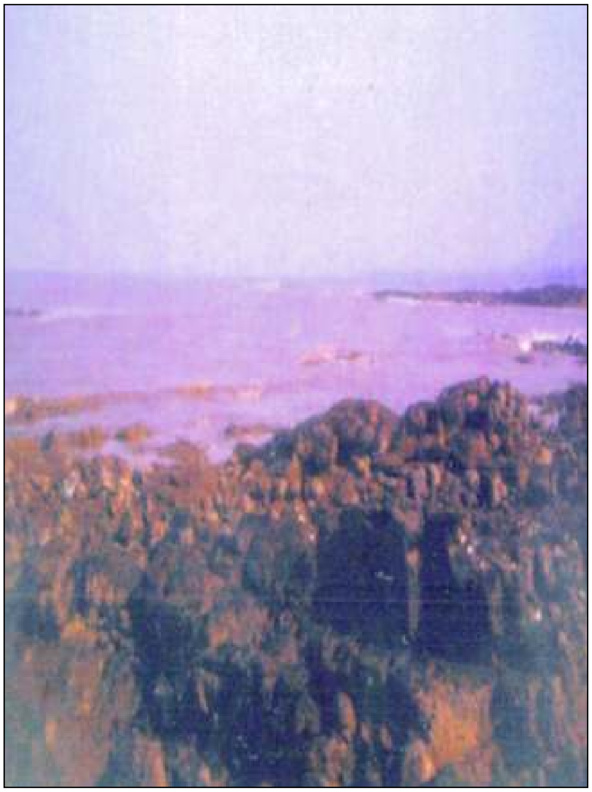

Fig. 3. Site-II located near Karanja.

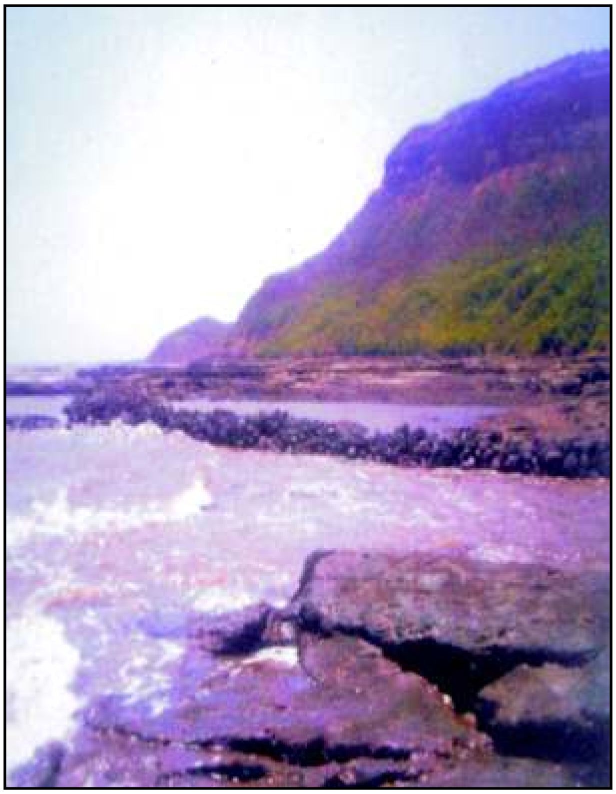

Fig. 4. Site-III near Naval Base, Dronagiri.

during neap tide, collection of animals was possible throughout the year.

Bursa spinosa (Lamarck, 1843) and *Nerita oryzarum* (Recluz 1841), found in intertidal zone, were collected during the low tide from the three selected sites of Uran coast between January to December during 2005-2007. They were of uniform size and their whole soft tissues carefully removed by shelling with plastic knife (Chiu *et al*., 2000). Samples were dried at 60^0 to constant weight. Atomic absorption spectrophotometer (GBC 93ZAA) was used to estimate metals in the samples. Briefly, an accurately weighed dried powdered sample was taken in a beaker. To this, 20 ml 70% HNO_3 was added and subjected to digestion till brown fumes completely disappeared and residue became whitish. 1 ml 30% $HClO_4$ added after the residue was cooled. This was digested for 10-15 minutes to dryness. The dried residue was cooled and the final volume made to 25 ml with 2 M HNO_3. All the reagents were of analytical grade. Metals were estimated from the samples using acid as a blank. The metal concentration in the tissue of the molluscs was calculated by using standard calibration curve.

Results and Discussion

Bivalve clams are employed as bio-monitor to determine the effect of marine pollution (Al-Mafda *et al.,* 1988; Zorba *et al*., 1992; Tomazelli *et al*., 2003; El-Silkaly *et al.,* 2004). The concentration of metals in molluscs not only dependent on levels of the elements in environment but also on other factors *viz.* size, age, growth, sex and reproductive conditions (Phillips, 1980; Phillips and Rainbow, 1993; Boening, 1999; Frias-Espericueta *et al.,* 1999 b; Fang *et al.,* 2003). In the present study, the intertidal clams, *Bursa spinosa* and *Nerita oryzarum* were identified from Uran coast near Mumbai. Both the species have been reported among intertidal molluscan diversity of Mumbai coasts (Apte, 1993; Datta *et al*., 2010; Pawar, 2012). Bioaccumulation of heavy metals in the soft tissues of *Bursa spinosa* and *Nerita oryzarum* have been summarized in Table 1-2 while the average values of bioaccumulation are given in Table 3. Accumulation of Heavy metals in *Bursa spinosa* followed the order Cu>Fe>Zn>Cd>Mn>Pb (Table 1) while in *Nerita oryzarum,* the decreasing order was Fe>Cu>Zn>Mn>Cd>Pb (Table 2). The concentration of heavy metals showed significant variations between the two species of gastropod (Table 3). Seasonal variations in accumulation in these heavy metals in soft tissue of the gastropods were also noticed (Table 1, 2). Accumulation of cadmium (Cd) and lead (Pb) in noticeable amount in *Bursa spinosa* and *Nerita oryzarum* clearly showed that the effluents containing these heavy metals enter into the coastal waters of Uran from the adjacent industries. Bioaccumulation of heavy metals in *Tympanotonus fuscatus* followed the order Cu>Zn>Cd (Daka *et al*., 2006) whereas in *Donax trunculus* and *Donax faba,* the accumulation was found in order as Zn>Cu>Pb>Cd in two contaminated sites in Gulf of Annaba, Algeria (Beldi *et al.,* 2006) and in the four beaches of Eayong Provice, Thailand (Dungchangwat *et al*., 2011). In the latter case, the highest concentration of Zn and Cd were recorded in the hot season, Cu in cool season and Pb during the rainy season (Dungchangwat *et al*., 2011). In the present investigation, higher level of Fe, Cu, Zn and Cd were accumulated by *Bursa spinosa* and *Nerita oryzarum* (Table 3). A trend in accumulation of metals in decreasing order Fe>Zn> Mn>Cu>Cd>Hg has also been found in *Cerithidea cingulata*, *C. obtuse*, *Telescopiun telescopiun*, *Thais lacera* and *Nerita articulata* of Sundarban wetland ecosystem of India (Sarkar *et al*., 2002). Bioaccumulation of heavy metals in *Meretrix meritrix* in estuaries of Sabah, North Borneo showed the decreasing trend like Zn>Cu>Cd>Cr>Pb (Abdullah *et al*., 2007) whereas in the edible soft tissue of *Perna viridis* inhabiting Mahe estuary, Pondicherry followed the order Zn>Cu>Pb>Ni>Cr (Gopinathan and Sobhana Amma, 2009).

In the present study, essential metals were accumulated in higher concentration than non-essential metals in *Bursa spinosa* and *Nerita oryzarum* as high level of Cu, Zn and Fe were detected than that of Mn, Cd and Pb. Accumulation of high levels of Cu, Zn and Fe in soft-bodied gastropods can be attributed to their metabolic requirement where these metals act as a co-factor in metabolic processes. Similar correlations between trace element accumulations and metabolic activities have been reported in other bivalves too (Gundacker, 1999; Frias-Espericueta *et al*., 1999a; Ke and Wang, 2001; Wang and Ke, 2002). Further, seasonal variations noticed in accumulation of heavy metals by both the gastropods (Table 1, 2) may probably be associated with food supply, changes in run-off, particularly the material to the sea precipitation and variations related to the reproductive cycle (Fowler and Oregioni, 1976; Lotouche and Mix, 1981; Turkmen and Turkmen, 2004, Beldi *et al.,* 2006; Dungchangwat *et al*., 2011). It is well known that Cu, Zn and Fe are biologically essential metals and play as cofactor in enzymatic processes (Singh and Steinnes, 1994; Gundacker, 1999), however, their accumulations in higher side affect biological processes in marine vertebrates (Kennish, 1993; Phillips and Rainbow, 1993). In conclusion, higher level of heavy metals detected in *Bursa spinosa* and *Nerita oryzarum* present in Uran coast may affect the life processes of the gastropopds. Though the observed heavy metals concentrations in both the clams were below the recommended limits, environmental surveillance of the creek for contaminant-free gastropods is required for safe human health (Fang *et al.,* 2003; Modassir and Sivadas, 2003; Babu *et al*., 2010).

Table 1 - Bioaccumulation of heavy metals in *Bursa spinosa* (mg/g).

Heavy Metals	Site	February	March	April	May	June	July	August	September	October	November	December	Average	Average SD
Zn	I	0.311	0.275	0.305	0.348	0.319	0.301	0.316	0.326	0.491	0.312	0.446	0.339	±0.025
	II	0.309	0.274	0.304	0.339	0.315	0.321	0.212	0.291	0.422	0.362	0.432	0.324	
	III	0.313	0.279	0.308	0.351	0.321	0.412	0.326	0.336	0.516	0.491	0.502	0.373	
Cu	I	0.973	0.546	0.748	0.662	0.530	0.682	0.649	0.511	0.414	0.408	0.439	0.593	±0.009
	II	0.969	0.534	0.742	0.652	0.538	0.689	0.691	0.522	0.410	0.419	0.429	0.595	
	III	0.979	0.551	0.753	0.670	0.551	0.699	0.703	0.530	0.421	0.441	0.445	0.609	
Mn	I	0.280	0.213	0.238	0.110	0.453	0.090	0.055	0.032	0.203	0.053	0.155	0.195	±0.012
	II	0.275	0.195	0.213	0.103	0.445	0.078	0.073	0.029	0.195	0.055	0.130	0.186	
	III	0.285	0.223	0.248	0.120	0.460	0.103	0.078	0.066	0.218	0.065	0.173	0.209	
Pb	I	0.152	0.186	0.146	0.169	0.118	0.163	0.163	0.129	0.129	0.208	0.180	0.161	±0.016
	II	0.146	0.174	0.118	0.152	0.107	0.174	0.118	0.068	0.158	0.186	0.163	0.145	
	III	0.158	0.197	0.163	0.186	0.124	0.186	0.180	0.146	0.180	0.219	0.174	0.177	
Cd	I	0.218	0.255	0.250	0.236	0.345	0.132	0.186	0.141	0.145	0.186	0.182	0.210	±0.017
	II	0.200	0.232	0.236	0.223	0.323	0.095	0.209	0.145	0.141	0.195	0.191	0.202	
	III	0.223	0.277	0.255	0.250	0.355	0.141	0.214	0.177	0.186	0.255	0.236	0.236	
Fe	I	0.505	0.524	0.581	0.519	0.552	0.490	0.533	0.533	0.538	0.514	0.548	0.527	±0.010
	II	0.495	0.519	0.562	0.500	0.538	0.500	0.538	0.529	0.543	0.519	0.538	0.522	
	III	0.510	0.543	0.595	0.524	0.562	0.505	0.552	0.543	0.557	0.538	0.557	0.541	

Table 2: Bioaccumulation of heavy metals in *Nerita oryzarum* (mg/g).

Heavy Metals	Site	January	February	March	April	May	June	July	August	September	October	November	December	Average	Average (SD)
Zn	I	0.242	0.211	0.364	0.354	0.256	0.311	0.322	0.316	0.412	0.312	0.312	0.311	0.310	±0.023
	II	0.239	0.209	0.358	0.351	0.251	0.309	0.361	0.411	0.316	0.411	0.291	0.322	0.319	
	III	0.248	0.214	0.371	0.356	0.258	0.314	0.411	0.416	0.417	0.512	0.416	0.322	0.355	
Cu	I	0.411	0.755	0.225	0.536	0.534	0.501	0.581	0.672	0.407	0.408	0.456	0.435	0.493	±0.010
	II	0.399	0.744	0.221	0.538	0.511	0.491	0.567	0.662	0.391	0.419	0.443	0.429	0.485	
	III	0.418	0.763	0.229	0.544	0.543	0.505	0.616	0.676	0.417	0.433	0.468	0.447	0.505	
Mn	I	0.255	0.305	0.280	0.385	0.140	0.220	0.078	0.050	0.058	0.065	0.078	0.058	0.164	±0.017
	II	0.250	0.298	0.275	0.373	0.130	0.215	0.055	0.065	0.073	0.223	0.103	0.105	0.180	
	III	0.273	0.310	0.288	0.403	0.143	0.225	0.105	0.078	0.078	0.243	0.105	0.125	0.198	
Pb	I	0.169	0.146	0.146	0.129	0.163	0.158	0.152	0.152	0.174	0.118	0.174	0.163	0.154	±0.021
	II	0.163	0.135	0.135	0.113	0.135	0.146	0.141	0.168	0.146	0.146	0.264	0.169	0.155	
	III	0.225	0.163	0.146	0.158	0.174	0.169	0.163	0.208	0.186	0.203	0.281	0.203	0.190	
Cd	I	0.227	0.209	0.250	0.232	0.223	0.101	0.141	0.113	0.150	0.095	0.178	0.141	0.172	±0.020
	II	0.136	0.195	0.245	0.223	0.205	0.099	0.095	0.101	0.095	0.132	0.155	0.159	0.153	
	III	0.314	0.218	0.250	0.245	0.232	0.111	0.159	0.116	0.159	0.141	0.181	0.186	0.193	
Fe	I	0.486	0.519	0.490	0.505	0.481	0.519	0.495	0.481	0.505	0.519	0.510	0.510	0.502	±0.010
	II	0.481	0.505	0.476	0.495	0.471	0.495	0.495	0.49	0.502	0.51	0.514	0.505	0.495	
	III	0.500	0.519	0.500	0.514	0.495	0.529	0.500	0.495	0.566	0.529	0.519	0.514	0.515	

Table 3: Average values of heavy metals (mg/g) accumulated in the gastropods at Site I, II and III.

	Zn	Cu	Mn	Pb	Cd	Fe
spinosa	0.345 ±0.025	0.599 ±0.009	0.197±0.012	0.161±0.016	0.216 ±0.017	0.530±0.010
oryzarum	0.328 ±0.023	0.494± 0.010	0.181±0.017	0.166 ±0.021	0.173 ±0.020	0.504±0.010

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