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Accumulation of cadmium, copper, lead, zinc and iron in the edible oyster, *Saccostrea cucullata* in coastal areas of West Bengal

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The coastal region of West Bengal has exhibited signs of impaired ecological health due to rapid urbanization and industrialization. In the last century, these regions were highly polluted with heavy metals which caused a great concern to the health of ecosystem as well as human beings. There is high probability of bioaccumulation of these metals because most of them are non biodegradable or poorly biodegradable. The present study deals with the accumulation of heavy metals like cadmium, copper, lead, zinc and iron in the tissue of oysters (*Saccostrea cucullata*). Specimens of *S. cucullata* (Born) were collected from Shankarpur of East Midnapur and Satgelia of Sundarbans. The physico-chemical parameters like temperature, salinity, pH of water bodies of these two experimental sites were also determined and recorded. It appears that the accumulations of cadmium, copper, lead, zinc and iron were high in this edible oyster tissue of both regions.

Key words: Edible oyster, *Saccostrea cucullata*, heavy metals, urbanization, industrialization.

INTRODUCTION

Coastal regions are dynamic interface zones involving the meeting of atmosphere, land and sea which provide an important buffer zone and filtering system for the coastal ecosystem. All these components are controlled by physical and biological processes which can be imbalanced by natural or human-induced perturbations (Viles and Spencer, 1995). The interaction between human societies and the environment of these zones is pronounced in the coastal regions of West Bengal (Talaue-McManus, 2001). The Indian Sundarbans (4267 sq. km), with rich floral and faunal diversity, forms a productive and protective margin for coastal West Bengal. This is the part of the largest Ganges delta formed at the estuarine phase of the Hooghli-Matla river systems. It has been acclaimed as the World Heritage tropical forest site in Asia, and also considered as a global biodiversity hotspot (Sarat Babu, 1999; Sayer et al., 2000). Shankarpur lies in East Midnapore district which is located 10 km from Digha, at the northern end of the Bay of Bengal (Figure 1). This area is a popular tourist spot as well as fishing port. Both regions of West Bengal are highly diverse having rich flora and fauna with economic importance. The edible oyster, *Saccostrea cucullata* is used as food by local people and marketed by them. But during the last century, these virgin areas have been polluted remarkably due to rapid urbanization and industrialization, affecting the flora and fauna as well as *S. cucullata* of these regions. Various kinds of pollutants are being introduced into the coastal water of Hooghly estuary, among which are different heavy metals like

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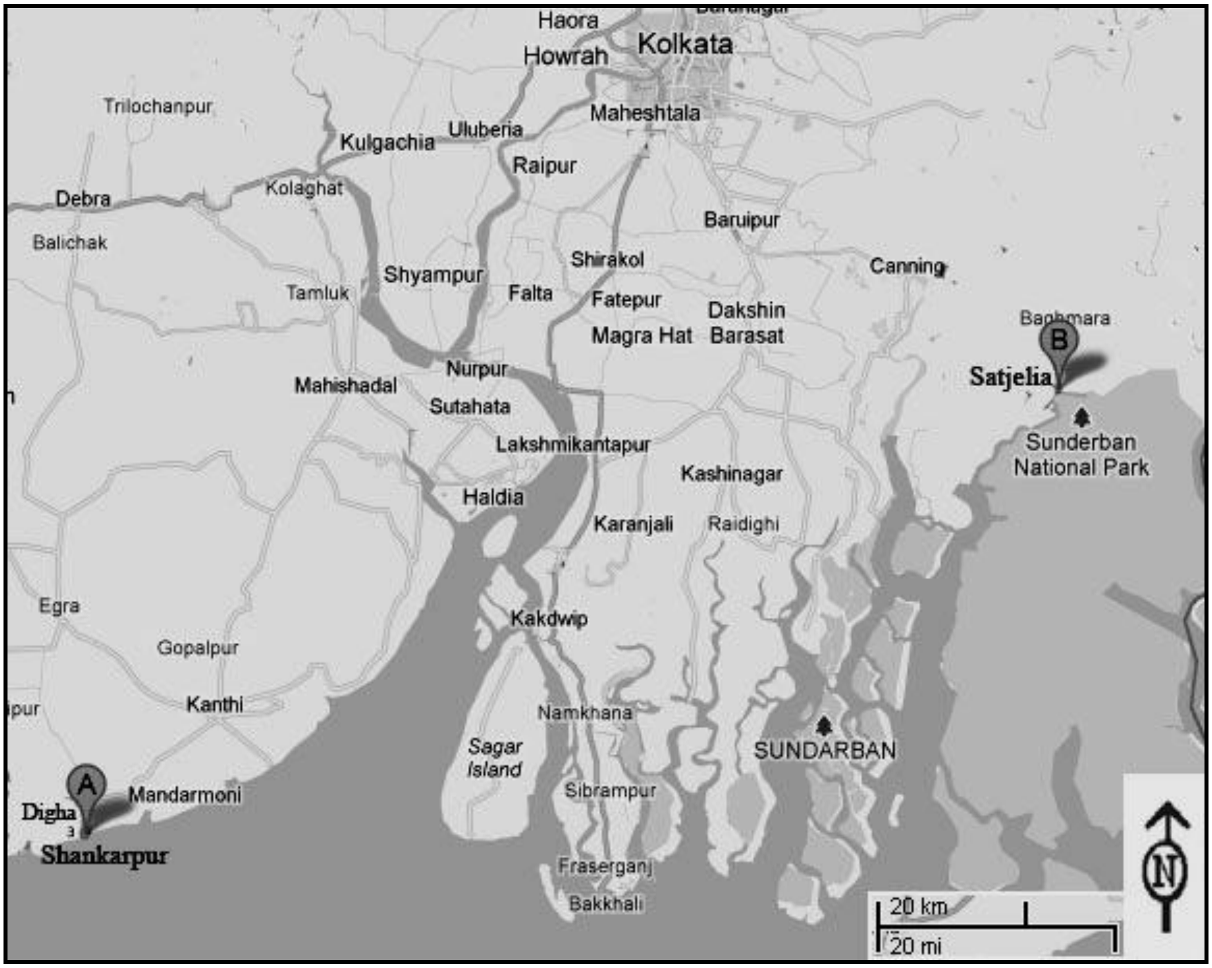

Figure 1. Geographic situation of the stations of sampling: Site A denotes Shankarpur (87°34′E, 21°38′N) and Site B denotes Satjelia (88°50′43″E, 22°11′52″N).

cadmium, copper, lead, zinc and iron which are of great concern to the environment and human health (Pattnaik et al., 2006). There are multifarious industries like paper, textile, chemical, pharmaceuticals, plastic, shellac, food, leather, jute, tires and cycle rims near the lower part of the estuary. The discharge of industrial effluents, from printing, dyeing, oil refineries, antifouling paints at the bottom of the boats, trawlers and ships, also contain heavy metals (Mitra et al., 1993). These non-biodegradable heavy metals are transferred to the sediment and coastal water and accumulate in the organisms living or feeding on it. Oysters also absorb heavy metals and these heavy metals may enter the human system through consumption of contaminated edible oysters leading to the harmful consequences. The objective of this work was to analyze the heavy metal concentrations, mainly cadmium, copper, lead, zinc and iron in the edible oyster, *S. cucullata* collected from Shankarpur of East Midnapore and Satgelia of South 24 Parganas during pre-monsoon and post-monsoon seasons. The relationship between heavy metal concentrations in oysters and selected water quality parameters was determined. Whether the pollution level in this region poses any harmful effects on the edible oyster as well as the human beings who consumed these oysters are also under consideration.

MATERIALS AND METHODS

S. cucullata were sampled from two sites, Shankarpur (87°34′E, 21°38′N), Contai Sub Division near Digha of East Midnapore District and Annpur (88°50′43″E, 22°11′52″N) in Satgelia Island of South 24 Parganas District of Indian Sundarbans region during the period of pre-monsoon and post-monsoon seasons, respectively. From each sites, 50 samples were collected during pre-monsoon and post-monsoon seasons and were kept in polyethylene bags and brought to the laboratory for examination. Oysters were scrubbed and cleaned with double distilled water. The soft oyster tissue was removed after opening the shell. The tissue of each oyster was rinsed with double distilled water and dried in an oven at 60°C till a constant weight was achieved. 1 g of the dried tissue was weighed and treated with concentrated nitric acid (Merck India Ltd.) following standard method until a clear solution was obtained (Harper et al., 1989). The digested solution was filtered through Whatman filter paper and diluted with double distilled water and analyzed for

Table 1. Average metal concentrations (µg/g dry weight) in *S. cucullata* of Shankarpur and Satgelia during pre-monsoon and post-monsoon seasons.

Metal concentration (µg/g)	Post-monsoon		Pre-monsoon	
	Shankarpur (Mean ± S.E.)	Satgelia (Mean ± S.E.)	Shankarpur (Mean ± S.E.)	Satgelia (Mean ± S.E.)
Cadmium	29.187± 0.365	05.3 ± 0.33	37.01±1.442	11.57±0.599
Copper	726.813± 4.912	106.986 ± 3.955	294±2.375	119.323±4.866
Lead	13.783± 0.505	5.343 ± 0.653	23.533±1.018	31.369±1.266
Zinc	769.197± 2.171	181.333 ±.8.053	573±5.264	216.123±1.95
Iron	1096.163 ± 5.166	452.066 ± 3.061	975±9.941	652.856±3.87

Table 2. Average temperature (°C), salinity (%) and pH of the aquatic bodies around Shankarpur and Satgelia during pre-monsoon and post-monsoon seasons.

Environmental parameter	Post-monsoon		Pre-monsoon	
	Shankarpur (mean ± S.E.)	Satgelia (mean ± S.E.)	Shankarpur (mean ± S.E.)	Satgelia (mean ±S.E.)
Temperature (°C)	26.93± 0.31	26.17± 0.15	29.53±0.06	28.23±0.25
Salinity (%)	23.97±0.54	22.15±0.19	25.88±0.21	25.24±0.38
pH	8.31±0.04	8.25±0.03	8.24± 0.04	8.23± 0.02

Table 3. Permissible limits on heavy metals for food safety set by different countries (Source: Yap et. al, 2004).

Council / regulation	Cd (µg/g)	Cu (µg/g)	Pb (µg/g)	Zn (µg/g)
Malaysian Food Regulations (1985)	1.00	30.0	2.00	100
International Council for the Exploration of the Sea (ICES, 1988)	1.80	-	3.00	-
Brazilian Ministry of Health (ABIA, 1991)	5.00	150	10.0	250
Ministry of Public Health, Thailand (MPHT, 1986)	-	133	6.67	667
Food and Drug Administration of the United States (USFDA, 1990)	25.0	-	11.5	-
Australian Legal Requirements (NHMRC, 1987)	10.00	350	-	750
Hong Kong Environmental Protection Department (HKEPD, 1997)	2.00	-	6.00	-

cadmium, copper, lead, zinc and iron by spectrophotometric methods (FAAS on a Varian Spectra AA240).

Physico-chemical parameters like temperature, salinity, pH of surface water of both sites during pre-monsoon and post-monsoon seasons were examined. Temperature was measured by mercury thermometer. Water salinity was checked by an optical refractometer in the field which was cross checked by employing Mohr- Knudsen method in the laboratory. On spot measurement of pH was done by using a portable pH meter.

RESULTS AND DISCUSSION

Heavy metal estimation in coastal zone is of great importance to determine the metal contamination in the marine environment. In the aquatic environment, conventional methods for monitoring heavy metals were basically the determination of the heavy metal in water, sediment and biota having many drawbacks. The integrated measure of the amount of bioavailability of each metal to the oyster is the accumulated concentration of heavy metals in oyster tissue over time (Li et al., 2001). In the case of bivalves, accumulation of metals is produced through feeding, by incorporating the bioavailable forms of the metal (Azarbad et al., 2010 and Rainbow et al., 1990). According to Bhosle and Matondkar (1978), metals from solution are taken in the body through food and in the course of time are accumulated in the cells. The study shows that the concentration of cadmium, copper, lead, zinc and iron metal concentrations are found higher in the tissue of *S. cucullata* during pre-monsoon and post-monsoon seasons. The selected metal concentrations (µg/g dry weight) in *S. cucullata* of Shankarpur and Satgelia in the pre-monsoon and post-monsoon season are shown in Table 1. Similarly, Table 2. depicts average temperature (°C), salinity (%) and pH of the aquatic bodies

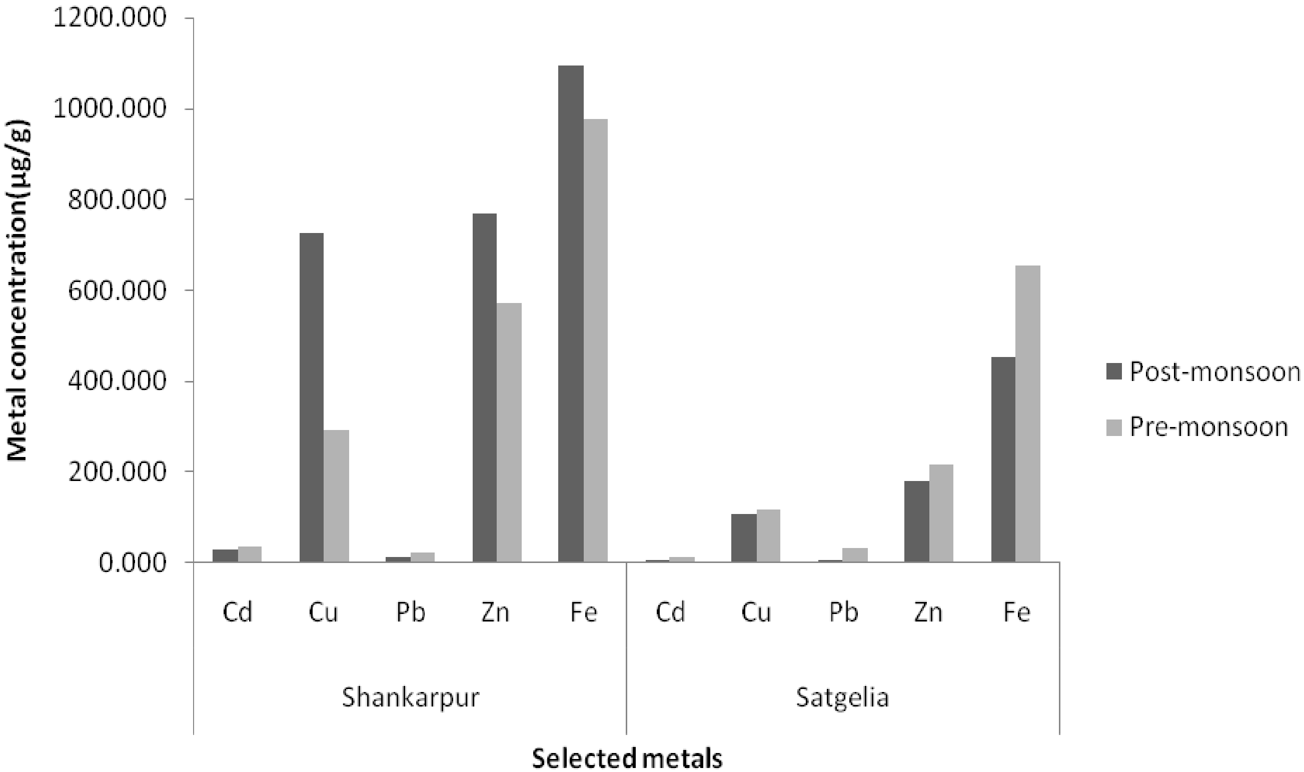

Figure 2. Metal concentrations (in µg/g dry weight) in *S. cucullata* of Shankarpur and Satgelia during pre-monsoon and post-monsoon seasons.

around Shankarpur and Satgelia during pre-monsoon and post-monsoon seasons. The permissible limits of heavy metals for food safety set by different countries are shown in Table 3.

The present study shows that oysters accumulated a considerable amount of metals in their body cells. The concentration of the metals like cadmium, copper, lead, zinc and iron in oyster tissue collected from Shankarpur was higher than that of oysters of Satgelia in both seasons (Figure 2). The higher concentration of heavy metals in oysters in Shankarpur was due to more human interference and man-made pollution. The higher concentrations of heavy metals in the oysters prove that the bioavailability of these heavy metals has been increased during the last century due to urbanization and industrialization as suggested by Cheung et al. (1992). The fast industrialization and urbanization of the Kolkata, Howrah and Haldia complex in the state of West Bengal has created considerable ecological imbalance in the adjacent coastal areas (Mitra and Choudhury, 1992; Mitra, 1998). The lower part of the estuary has different industries such as paper, textiles, chemicals, pharmaceuticals, plastic, shellac, food, leather, jute, tires and cycle rims industries (UNEP, 1982). These units are the principal sources of heavy metals in the water. The downward order of the concentration of heavy metals present in the oyster tissue are iron, zinc, copper, cadmium and lead in Shankarpur and iron, zinc, copper, lead, cadmium in Satgelia during both seasons (Figure 2). The concentration of iron, zinc and copper were much higher than cadmium and lead in oysters in both sites. It is suggested that iron, zinc, and copper were preferentially accumulated by the oysters. The elevated level of zinc probably decreased the rate of cadmium uptake in oyster. Zinc and cadmium levels in an organism are usually inversely related (Corrill, 1976). The concentrations of the all selected metals in *S. cucullata* were significantly variable at the 0.05 level ($P<0.05$) by multiple comparisons (ANOVA) in Shankarpur and Satgelia during pre-monsoon and post-monsoon seasons. Figure 3 represents the temperature, salinity and pH of the aquatic body around Shankarpur and Satgelia during pre-monsoon and post-monsoon seasons.

It is to be mentioned that the pH, salinity, and temperature may have affected the concentration and rate of uptake of the metals in oyster (Figure 3). Accumulation of the metals by mussels is affected by salinity, temperature and concentration of the trace metals in the water (Boyden and Romerill, 1974). Phillips (1976) found that in *Mytilus edulis,* cadmium, lead and zinc uptake was affected by temperature and salinity.

Corrill (1976) reported that mercury and cadmium uptake in crab are affected by salinity and temperature and cadmium distribution is also influenced by temperature.

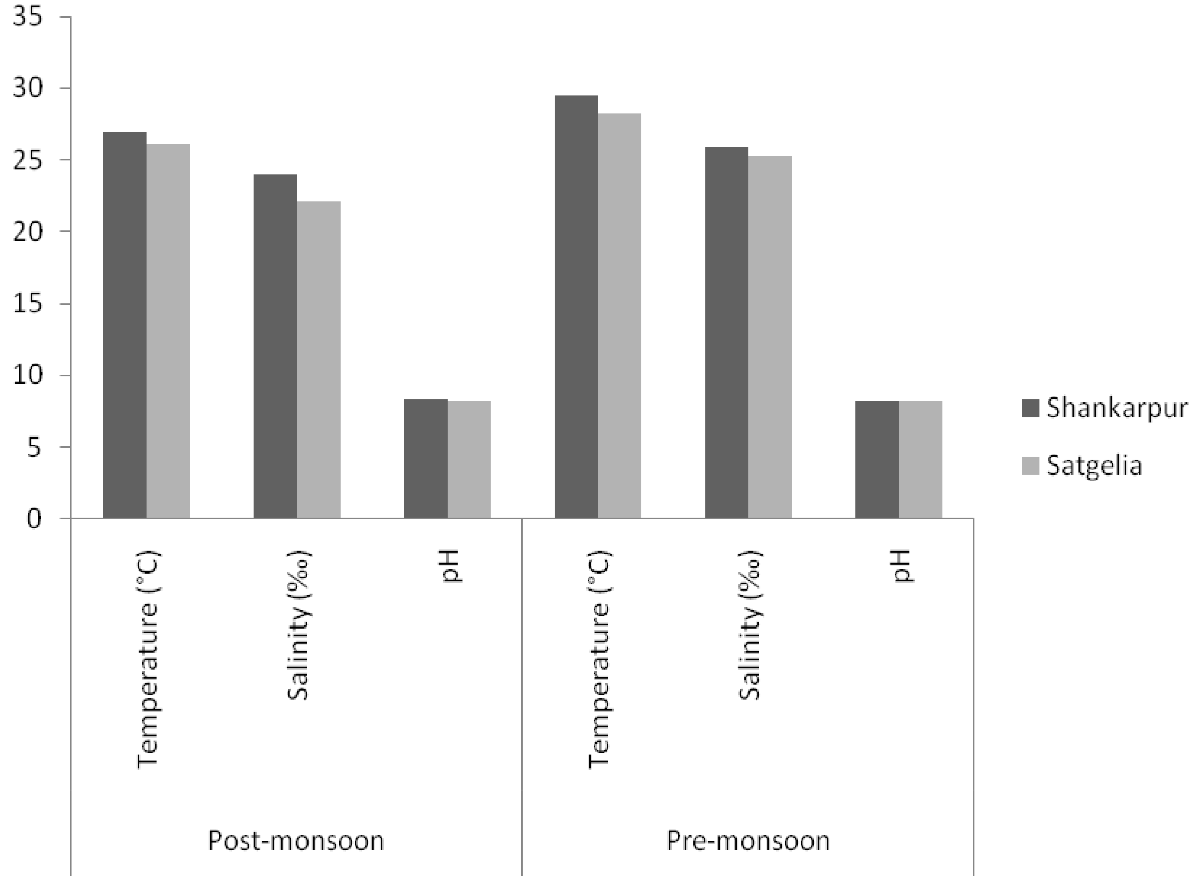

Figure 3. Temperature, salinity and pH of the aquatic body around Shankarpur and Satgelia during pre-monsoon and post-monsoon seasons.

The rate of absorption and accumulation of cadmium and lead by oyster species *Saccostrea echinata* was favoured by low salinities (Denton and Burdon-Jones, 1981). This study shows that the concentrations of the Cd in *S. cucullata* of Shankarpur and Satgelia during pre-monsoon and post-monsoon seasons were positively correlated with temperature and salinity at the 5% level ($P<0.05$). The concentrations of Pb in *S. cucullata* also showed highly significant positive correlation with respect to temperature and salinity at the 1% level ($P<0.01$) in both sites. The concentrations of Cu in *S. cucullata* of Shankarpur and Satgelia during pre-monsoon and post-monsoon seasons were correlated only with pH at the 5% level ($P<0.05$). Zn and Fe concentrations of both sites were not correlated ($P>0.05$) with any of the selected environmental parameters.

Although, heavy metals like cadmium, copper, lead, zinc and iron are normal constituents of marine and estuarine environments, they may be introduced into the biogeochemical cycle through industrial wastes and sewage and create adverse impact on the biotic community. The metals like cadmium, copper, lead and zinc are toxic to the animals causing death or inhibiting the development and growth of young marine animals (Gosavi et al., 2004; Principi et al., 2006). All the five selected heavy metals studied in the present investigation are potential hazards that can endanger both animal and human health (Mance, 1987). The edible oyster, *S. cucullata* having a good economic value is one of the important food sources preferred by the local inhabitants of the study areas. So, the elevated concentration of these heavy metals in it may create health hazards.

The metal concentrations in the tissues of *S. cucullata* from both sites and seasons are compared with the permissible limits set by the Malaysian Food Regulation (1985), the International Council for the Exploration of the Sea (ICES, 1988), the USFDA (1990), the Hong Kong government (HKEPD, 1997), the Ministry of Public Health of Thailand (MPHT, 1986), the Australian Legal Requirement for Food Safety (NHMRC, 1987) and the limits established by the Brazilian Ministry of Health (ABIA, 1991) (Table 3). In most cases, the metal concentrations in the present study are found higher than the recommended guidelines for cadmium, copper, lead and zinc. In India, although no specific standards have yet been stipulated with respect to cadmium, copper, lead, zinc and iron accumulation in the commercial marine bivalves, the present data indicate that the studied species is not suitable for consumption due to acute toxicities of these heavy metals. As the concentration of the heavy metal in the oyster tissue depends on the bioavailability of metals in the aquatic environment due to the urbanization and industrialization, proper steps should be taken to check the discharge of industrial wastes into the water bodies of these coastal regions.

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