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Concentrations of Heavy Metals in Edible Dominant Oyster (*Saccostrea cucullata*) Inhabiting Sagar Island, West Bengal

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Abstract

The heavy metals from the ambient environment enter the tissues of marine molluscs very frequently as they feed on the plankton of marine and estuarine water. Sagar island, situated in the northeast coast of Bay of Bengal, is the habitat of three major species of oysters namely *Saccostrea cucullata, Crassostrea cuttackensis* and *Crassostrea madrasensis*. By virtue of their sedentary nature, these species are exposed to all categories of pollutants, which have put them in the domain of indicator species. In this present paper, the concentrations of zinc, copper and lead were assessed in *Saccostrea cucullata* inhabiting Sagar island, Indian Sundarbans. A unique seasonal variation is observed in the accumulation of the selected heavy metals. A more detailed study is needed to establish the species as indicator of heavy metals.

Keywords: *Saccostrea cucullata*; Heavy metals; Zinc; Copper; Lead

Introduction

The estuarine sector is a vivid sector comprising world's major diversity. The world heritage site, Indian Sundarbans is regarded as a deltaic complex at the north-eastern Bay of Bengal. It has its unique ecological and economic value. Aquatic systems (e.g., estuaries) are the ultimate reservoir for wastes of multifarious origin. The coastal zone receives major amount of toxic metal load from anthropogenic activities like industrialization, urbanization etc. [1]. The potential ecological effects of increasing levels of heavy metals in the fluvial environment are of great concern due to their notable bioaccumulative nature and higher toxicity to the biotic compartment. These toxic chemicals get biomagnified in the food chain during progression from lower to higher trophic levels and result into damaging effects in aquatic organisms. Molluscs are regarded as one of the potential bioindicator tool due to their ability to accumulate moderate amount of toxic heavy metals from the ambient environment. Heavy metals, present at concentrations common in ambient marine waters can result in adverse effects in aquatic organisms. Such effects gradually impact the overall trophic structure of any biological community. Uptake and accumulation of heavy metals are dependent on both geochemical and biological factors [2]. Bivalves are no exception to this rule. The bivalve molluscs have several interesting properties like - ability to accumulate the heavy metals without suffering observable mortality, habitation within and continuous exposure to the contaminated environment etc., and these are the reasons why they are regarded as useful biomonitors for a host of inorganic contaminants [3].

Oysters are one of the most valued seafood and are farmed extensively. The meat of oyster contains essential food components like protein (10%), carbohydrate (6%), fat (4%), vitamins (like A, B, B_{12} etc.) and minerals (Na, K, P, Ca etc.). Every year, 4.7 million tonnes of oysters are eaten all round the world. 92% of world production of oyster comes from Asia [4]. In India, the commercial production of oysters has been started during the late 1990s and at present more than 50000 tonnes of oysters is produced annually. In India *Crassostrea madrasensis*, *Crassostrea gryphoides*, *Crassostrea rivularis* and *Saccostrea cucullata* are available species of oysters.

Reports on metal accumulation in bivalve mollusc like-oysters under natural environmental conditions of Indian Sundarbans deltaic complex are limited [3,5,6]. Hence, regular investigation for the levels of heavy metals in these is necessary in order to judge whether the concentration is within the permissible level and will not pose any hazard to the consumers or not [7]. In this paper, concentrations of three heavy metals namely - zinc, copper and lead in the muscle of a commercially important dominant oyster species found abundantly in the estuarine sector of Indian Sundarbans namely, *Saccostrea cucullata* is presented with an objective to monitor the status of this species in context to safe consumption by human.

Materials and Methods

Site selection

A delta complex - Indian Sundarbans is situated at the confluence of the River Ganga and the Bay of Bengal. Because of the presence of a diverse array of gene pool, this deltaic complex has been declared as World Heritage Site by UNESCO. The Sundarbans estuarine sector is regarded as a Biosphere Reserve (SBR) having an approximate area of 9630 sq. km with some 102 islands [8]. Sagar island is situated at the confluence of river Ganges and Bay of Bengal (Figure 1). It is the largest known island in Indian Sundarbans. Beside various physical processes (like coastal erosion by waves, tidal activities etc.) observed in the selected site, the biological diversity is also a matter of concern there. Crabs, oysters, lobsters, conches, prawns etc., can be easily viewed there. A lot of pilgrims come every year here from different corners of India to take holy bath during 'makarsankranti mela'.

Collection of specimens

Fresh and live oysters were collected manually during high tide

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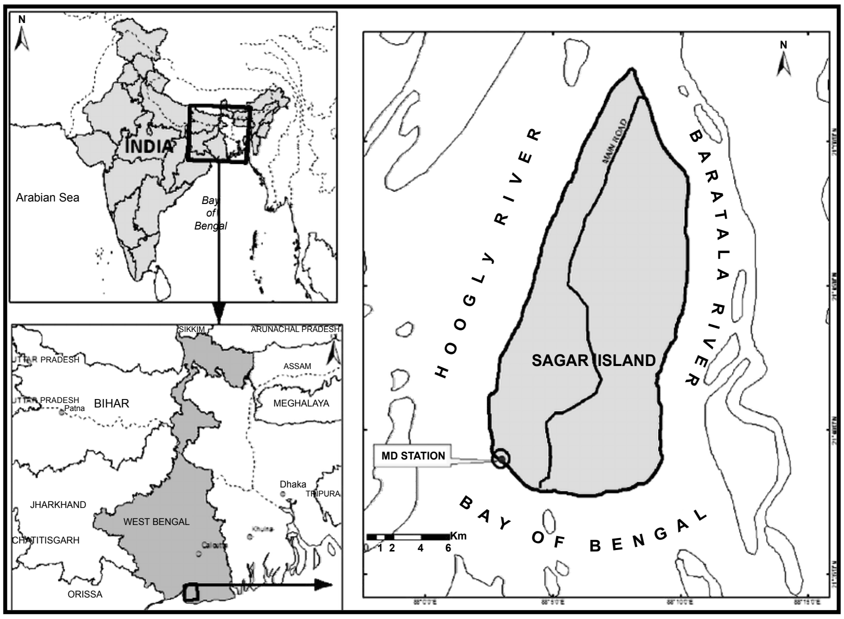

Figure 1: Map showing location of selected study site.

condition from the selected station. This was done separately during three seasons namely - premonsoon, monsoon and postmonsoon. After collection, the samples were stored in a container and preserved in crushed ice. Then these were brought to the laboratory for further analysis. Similar sized 20 specimens of the species were sorted out for analyzing the metal level in the muscle. 2 g muscle from each specimen was scooped out and pooled to get a representative picture of heavy metal accumulation in the selected station.

Analysis of oyster muscle metal

Inductively Coupled Plasma: Mass Spectrometry (ICP-MS) is now-a-day accepted as a fast, standard means of various element analyses for a wide variety of sample types [9]. A Perkin-Elmer Sciex ELAN 5000 ICP mass spectrometer was used for the proximate analysis of selected heavy metals in the collected oyster muscle. A standard torch for this instrument was used with an outer argon gas flow rate of 15 L/min and an intermediate gas flow of 0.9 L/min. The applied power was observed as 1.0 kW. The ion settings were generally standard settings as recommended, when a conventional nebulizer/spray was used for this case with a liquid sample uptake rate of exactly 1.0 mL/min. A Moulinex Super Crousty microwave oven of 2450 MHz frequency magnetron and 1100 W maximum power Polytetrafluoroethylene (PTFE) reactor of 115 Ml volume, 1 cm wall thickness with hermetic screw caps, were also used for the digestion of the collected oyster muscles. All reagents used were of standard purity and of analytical reagent grade. High purity water was obtained with a popular Barnstead Nanopure II water-purification system. All glasswares were soaked in 10% (v/v) nitric acid for 24 h and then washed with deionized water before the use.

The analyses were done on composite samples of 20 specimens of oysters (*Saccostrea cucullata*) mentioned, having nearly uniform size. This was a measure to reduce variations expected in metal concentrations arising from difference in sample size and age. 20 mg of the composite samples from the oyster specimens were weighed (after overnight oven drying) and then treated with 4 mL aqua regia, 1.5 mL HF and 3 mL H_2O_2 in a hermetically sealed PIFE reactor, inside a microwave oven, at the power levels ranging from 330W to 550 W, for exactly 12 minutes to get a clear solution. After complete digestion, 4 mL Boric acid (H_2BO_3) was added and the mixture was kept in a hot water bath for 10 min and then diluted with distilled water to make the volume up to 50 mL. Replacement of the samples with double distilled water was done and then all the standard treatment steps were followed to prepare the blank sample. The final volume was made up to 50 mL. Then the sample and process blank solutions were analyzed by ICP-MS. All analyses were done in triplicate to get accuracy.

Results

The selected heavy metals' concentrations show the trend as: monsoon>postmonsoon>premonsoon irrespective of all the heavy metals. The concentrations of selected heavy metals in the tissue of *Saccostrea cucullata* was observed to occur in the order as Zn>Cu>Pb irrespective of all seasons. Zn concentration in the oyster muscle ranged from 187.23 ppm dry wt. (during premonsoon) to 216.58 ppm dry wt. (during monsoon) whereas, Cu concentration ranged from 102.05 ppm dry wt. (during premonsoon) to 132.90 ppm dry wt. (during monsoon) and Pb concentration was found to ranged from 13.12 ppm dry wt. (during premonsoon) to 17.97 ppm dry wt. (during monsoon) (Figure 2).

Discussion

This unique seasonal variation of selected heavy metals may be attributed to several factors like precipitation, evaporation, dilution etc. [10]. The sources of Zn in this present area may be the galvanization units, painting industries and pharmaceautical processing industries. Among the main sources of Cu, anti-fouling paint is most important whereas, Pb finds its way to the aquatic system via. painting and dyeing industries, battery manufacturing units etc. The significantly high levels of accumulated heavy metals in the muscle tissue of *Saccostrea cucullata* may be attributed to large amount of industrial discharges from highly industrial belt areas like Haldia petro-cum-port-complex and Howrah situated beside the river Ganges. Zn and Cu are biologically essential elements though, above a permissible limit these becomes toxic. Pb is a toxic and biologically non-essential element [11,12]. The permissible limits of oyster muscle Zn, Cu and Pb are 100 ppm dry wt., 30 ppm dry

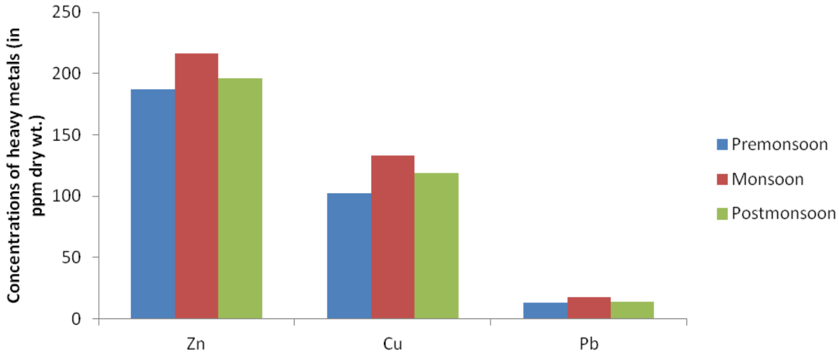

Figure 2: Concentration of heavy metals (in ppm dry wt.) in *Saccostrea cucullata* collected from sagar island during the study period.

Heavy metal	Permissible limit (in ppm dry wt.) (as per WHO, 1989)	Range of metal concentrations found in oyster muscle in the present study (in ppm dry wt.)
Zn	100	187.23-216.58
Cu	30	102.05-132.90
Pb	0.05	13.12-17.97

Table 1: Comparison between permissible limit of heavy metals by WHO, 1989 and metal level found in the present study.

wt. and 0.05 ppm dry wt., respectively (WHO, 1989). Concentrations of heavy metals found in this study are much above the permissible limit (Table 1), hence it is not at all safe for consumption. This high level of toxic metals in this indicator species is a cause of concern and requires regular monitoring of water quality in future around the point sources present near the station. For the safety purpose, the oysters can be cultured in some inland water bodies and these can be harvested.

Future Prospect

As oyster (*Saccostrea cucullata*) is useful for making palatable dishes throughout the world, the toxicological study like this is very much necessary for health perspectives. Moreover, ecologically this study is also significant as oyster belongs to a particular trophic level in complex food-web in the estuarine ecosystem. Future studies are necessary in this sector to confirm the pollution status in this species of dominant edible oyster.

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