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BIOACCUMULATION PATTERN OF TRACE METALS IN EDIBLE SHRIMPS FROM COASTAL CITIES OF SOUTHERN INDIA

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ABSTRACT

Increasing population, rapid industrialization and urbanization have contaminated the riverine and coastal ecosystems to a great extent. To evaluate such kind of contamination on aquatic ecosystem and living things, the eight sea water and sediment, and eight prawns/ shrimps belonging to *Penaeus* genera (*Penaeus monodon* and *Penaeus merguiensis*) were collected from coastal cities (Cuddalore and Pondicherry) of southern India during April – May 2014 for heavy metal analysis. The higher concentrations of heavy metal parameters were observed from the Cuddalore site than the Pondicherry site due to the receiving of Cuddalore harbor waste and the waste from large beachgoer's. Both the sites drained large amount of municipal sewage, industrial, shipyard, agricultural and ballast water waste which contributed higher trace metal pollution in these regions. The shrimps got higher concentration of all trace metals followed by sea sediment and seawater. The trace metals were highly accumulated in *Penaeus merguiensis* than *Penaeus monodon*. The orders of decreasing trace metal values were: Edible crab > Sea sediment > Sea water. The metal contents of *Penaeus merguiensis* samples such as Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.30 – 0.51, 0.15 – 0.25, 1.04 – 1.85, 8.74 – 11.65, 0.11 – 0.20, 0.15 – 0.23 and 1.46 – 3.56 mg kg^{-1}, respectively. In all the samples, the results of metal concentrations were revealed that the order of metals are Fe > Zn > Cu > Cd > Pb > Ni > Cr. These observations and ensuing inferences of this study are useful for managing pollution outfall from sewage and industrial sources into an aquatic environment. Hence, the coastal regions needed throughout impoundment.

INTRODUCTION

Due to industrialization, the number of factories and population has increased rapidly. Massive amounts of domestic waste water and industrial effluents are transported by rivers and discharge into the sea, contaminating rivers and coastal waters. Such anthropogenic pollutants are the main sources of heavy metal contaminants in the ocean (Suresh Kumar et al., 2013). The discharge of these wastes without adequate treatment often contaminate the estuarine and coastal water with conservative pollutants (like heavy metals), many of which bioaccumulate in the tissues of resident organisms like fishes, oysters, crabs, shrimps, seaweeds etc. In many parts of the world, especially in coastal areas and on smaller islands, shellfish is a major part of food, which supplies all essential elements required for life processes in a balanced manner (Iyengar, 1991). Heavy metal pollution is one of the major types of pollution in coastal and marine environment. Heavy metals are conventionally defined as elements with metallic properties such as ductility, conductivity, stability as cations, ligand specificity, etc.

Metals generally enter the aquatic environment through atmospheric deposition, erosion of geological matrix or due to anthropogenic activities caused by industrial effluents, domestic sewage and mining wastes (Reddy et al., 2007). Although some information is available on the bioaccumulation of metals in some coastal living things (Öztürk et al. 1996). In general, they are not biodegradable and have long biological half lives. According to the World Health Organization (WHO, 1995), non-degradable heavy metals are regarded as hazardous to aquatic ecosystems of their environmental persistence and their tendency for bioaccumulation Heavy metals must be controlled in food sources in order to assure public safety. Excessive concentration of food heavy metals is associated with the etiologic of a number of diseases, especially cardiovascular, renal, neurological, and bone diseases (Chailapakul et al. 2008). In aquatic ecosystems, contaminants are often rapidly removed from the water column *via* sorption processes. Given that heavy metals are not subjected to degradation processes, they tend to accumulate in benthic sediments and living things.

Prawns are an important food source for larger animals from fish to whales. As with other sea food, prawns are high in calcium, iodine and protein but low in food energy. It's consumption is considered healthy for the circulatory system because the lack of significant levels of saturated fat in prawns. Consumption of prawns from rivers and streams polluted by heavy metals by humans is thought to lead to disorders or diseases like: Liver dysfunction, Parkinson's disease, heart failure, decreased fertility, still births, some types of cancers, poisoning etc (Adedeji and Okocha, 2011). The toxic potential of Cd is enormous, since continuous exposure of marine organisms to a low concentration of Cd can result in bioaccumulation and subsequent transfer to humans through the food web (Kljakovic Gaic et al. 2002). They bioaccumulate in the tissues of prawns, this portends public health risk for human consumers.

In this study, the trace metals were analyzed from the sea water, sea sediment and two different marine edible prawns (*Penaeus monodon* and *Penaeus merguiensis*) of coastal cities of southern India. At the same time, to find the source of trace metal pollutions and the interaction between the trace metals and coastal living things.

MATERIALS AND METHODS

Sampling and processing

The eight water and sediment, and eight prawns belonging to *Penaeus* genera (*Penaeus monodon* and *Penaeus merguiensis*) samples were collected from coastal cities of southern India during April – May 2014 (Sampling dates: April 25th & May 24th). The Cuddalore and Pondicherry fishing horbor was selected for sample collection due to its pollution level and recreational purposes. The 2000 ml of marine water samples were collected from 0–20 cm below the surface with a 2500 ml sterile container in each location. Approximately 250 g of surface sediment samples were collected (0–5 cm depth) with a sterile spatulum and stored in aseptic polyethylene bags. All samples were kept in iceboxes and processed within 10 h of collection. For heavy metal analysis, the one liter of sea water was acidified immediately with concentrated nitric acid (HNO_3).

For trace metal study, acidified sea water samples were filtered by Whatman No.1 filter paper and processed (APDC + MIBK) for metal analysis. Sea sediment samples were air-dried and smaller than (>) 63 µm in size were retained in pre-cleaned properly. Thereafter, the dried sediment and crab samples were crushed by agate mortar and pestle. Both the samples were treated with aqua-regia mixture (i.e. $HCl:HNO_3$= 3:1) in Teflon bomb and were incubated at 140 °C for 2-3 days after dried and sieved samples. After incubation, the reaction mixture was filtered with Whatman No.1 filter paper. The trace metals in the sea water, sea sediment and crab samples were determined by the atomic absorption spectrophotometry (GBC SensAA - AAS, Australia) in flame mode.

RESULT AND DISCUSSION

Toxic chemicals and trace metals are very important pollutants which affects all ecosystem at large extent. Heavy metals in environment mostly come from lithogenic and anthropogenic sources (Fu et al., 2014). Chemical leaching of bedrocks, water drainage basins and runoff from banks are the lithogenic contribution of heavy metals while discharge of urban/ industrial waste water, combustion of fossil fuels, mining and smelting operations, processing and manufacturing industries and waste disposal including dumping are anthropogenic sources of metal pollution (Vignesh, 2012). Concentrations of various trace metals in the water and soil samples are shown in table 1 and 2. The concentration of Cu in sea water and sea sediment ranged from 0.32 – 0.46 mg l^{-1}, and 1.89 – 3.08 mg kg^{-1}, respectively. In sea sediment, concentration of Cd was found in the range from 0.52 - 0.94 mg kg^{-1}. For water, Cr concentration ranged from 0.06 - 0.18 mg l^{-1} while in sediment, Cr ranged from 0.26 – 0.62 mg kg^{-1}. The Fe concentrations of water and sediment ranged from 1.64 – 2.26 mg l^{-1} and 10.12 – 14.65 mg kg^{-1}, respectively. The average Zn concentration in water and sediment was 0.70 mg l^{-1} and 8.96 mg kg^{-1}, respectively. In sediment, Ni concentrations were in the range of 0.34 - 0.72 mg l^{-1} with an average of 0.21 mg kg^{-1} while in water average was 0.08 mg l^{-1}. The mean value of Pb concentration in water was 0.19 mg l^{-1} and the sediment mean value was 0.84 mg kg^{-1}. The values of heavy metals in coastal waters were crossing the TNPCB prescribed level (TNPCB, 2000).

In seawater, the concentration of Cr and Ni were slightly varied when compared to the sediment and shrimp samples. Through the natural process of biomagnifications, minute quantities of metals become part of the various food chains and concentrations become elevated to levels which can prove to be toxic to human, animal, plant and other living organisms (Bryan, 1971). Heavy metals were easily transferred from edible crab to human food chain and were caused to harmful effects on humans. In April month, metal contents of *Penaeus merguiensis* samples such as Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.30 – 0.42, 0.15 – 0.22, 1.04 – 1.36, 8.74 – 10.85, 0.11 – 0.16, 0.15 – 0.22 and 2.96 – 3.56 mg kg^{-1}, respectively while in may month, Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.36 – 0.51, 0.19 – 0.25, 1.34 – 1.85, 9.11 – 11.65, 0.15 – 0.20, 0.23 – 0.31 and 1.46 – 2.46 mg kg^{-1}, respectively.

The bioavailability of trace metals is the key factor determining tissue metal levels in the marine biota. Trace metal uptake occurs directly from surrounding marine water/ sediment across the permeable body surface and from food along with the seawater to the gut (Depledge and Rainbow, 1990). Fish, crab and prawn form an important link as possible transfer media to human beings and they cause serious health hazards (Shukla et al., 2007). Metal accumulation is more rapid than metal elimination probably due to the presence of metal binding proteins in tissues (Kendrick et al., 1992). The *Penaeus merguiensis* got the high concentrations of trace metals than *Penaeus monodon*. In April month, metal contents of *Penaeus monodon* samples such as Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.24 – 0.30, 0.10 – 0.17, 0.92 – 1.08, 7.65 – 9.44, 0.08 – 0.15, 0.22 – 0.28 and 1.25 – 1.84 mg kg^{-1}, respectively while in may month, Cd, Cr, Cu, Fe, Ne Pb and Zn concentrations were between 0.20 – 0.38, 0.08 – 0.12, 1.05 – 1.26, 8.22 – 9.28, 0.12 – 0.10, 0.15 – 0.21 and 1.53 – 1.62 mg kg^{-1}, respectively.

Heavy metals in the environment may accumulate to acutely toxic levels without visible signs. The discharge of heavy metals into the sea through rivers and streams results in the accumulation of pollutants in the marine environment especially within shrimps (Yusof et al., 1994). The nutritional implication is that consumers of these food materials may be exposed to heavy metal toxicity if bioaccumulation results due to regular consumption (Goyer, 1997). The orders of decreasing trace metal values were: Edible crab > Sea sediment > Sea water. Unfortunately, the nil value of trace metals was not observed in any study sites as well as any samples. The high concentration of trace metals were observed in Cuddalore region than Pondicherry region in all the samples. The results of metal concentrations were revealed that the order of metals are Fe > Zn > Cu > Cd > Pb > Ni > Cr.

CONCLUSION

In the present study, the heavy metals in the coastal shrimp tissue show a more than sea water and are similar order as that in sea sediment. The highest concentrations of heavy metals in all the samples were found at Cuddalore while the lowest concentrations were observed at Pondicherry. Alarming levels of heavy metals has been appeared from the bioaccumulation data trend in Indian coastal shrimp tissue indicated that these areas were drained many waste from different sources and the gradual deterioration of the coastal ecosystems in terms of heavy metals. In this study, the orders of decreasing trace metal values were: Edible crab > Sea sediment > Sea water. The values of heavy metals were crossing the heavy metal levels than TNPCB prescribed levels. This study provides awareness about heavy metals in prawns and sediment is important both with respect to nature management and human consumption. The present study is therefore important not only from the safety point of view of human health, but also from the quality point of view as the species have high export value.

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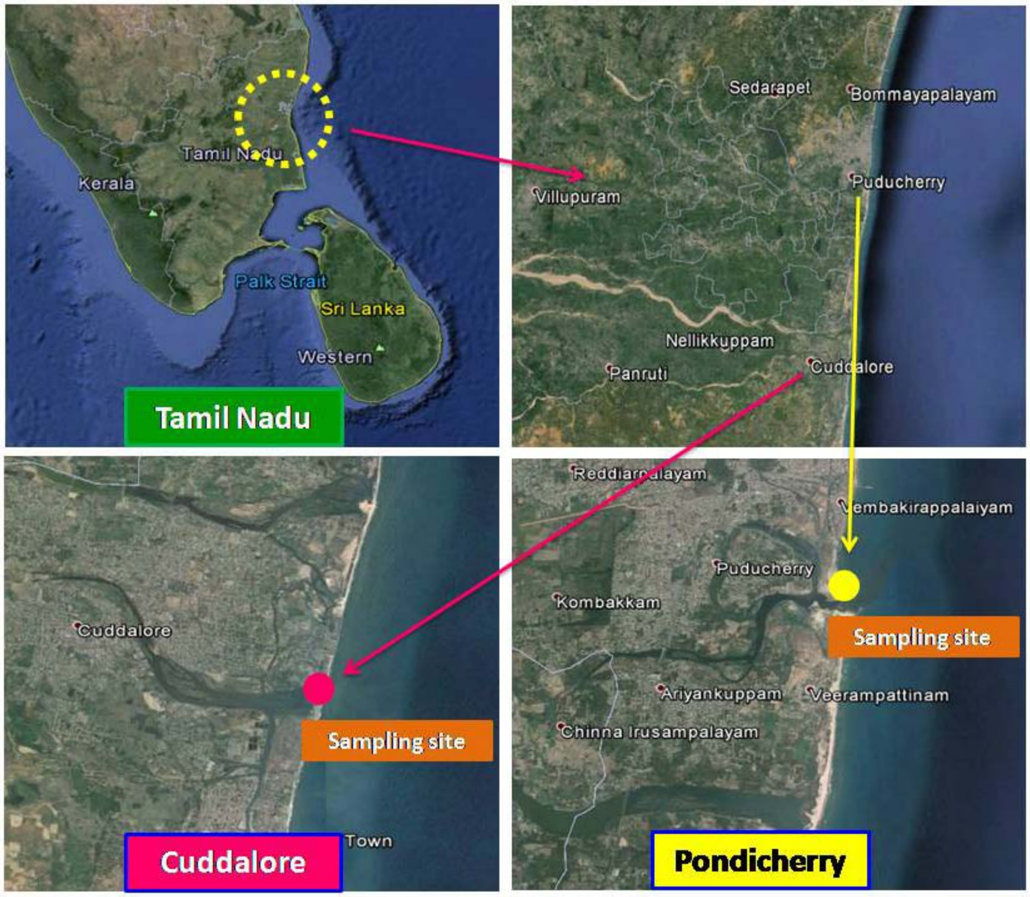

Figure 1. Sampling sites of the study area

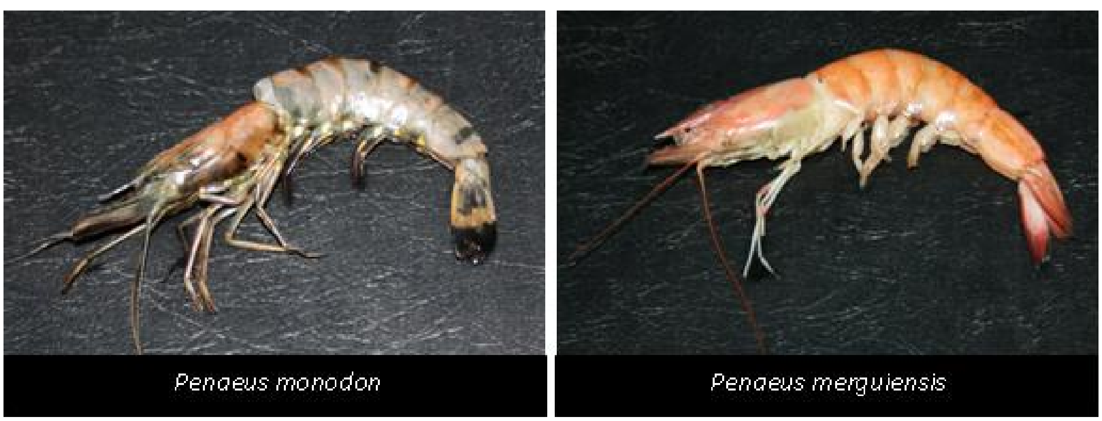

Figure 2. The pictures show sea water shrimp of *Penaeus monodon* and *Penaeus merguiensis* from Bay of Bengal

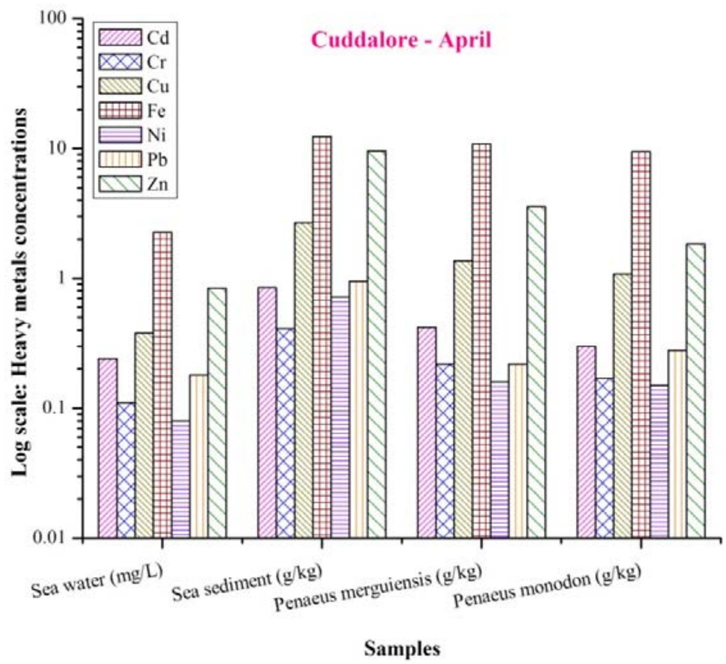

Figure 3. Concentration of heavy metals in different samples of Cuddalore coast at April month

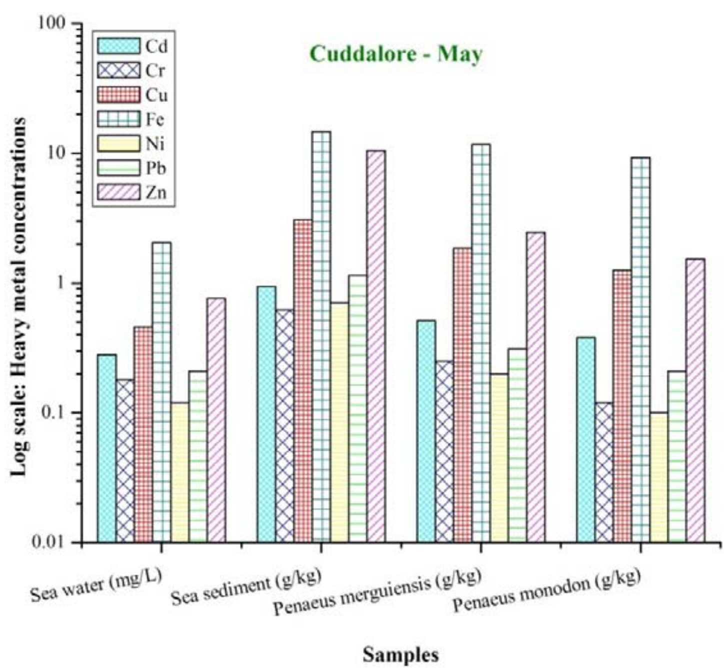

Figure 4. Concentration of heavy metals in different samples of Cuddalore coast at May month

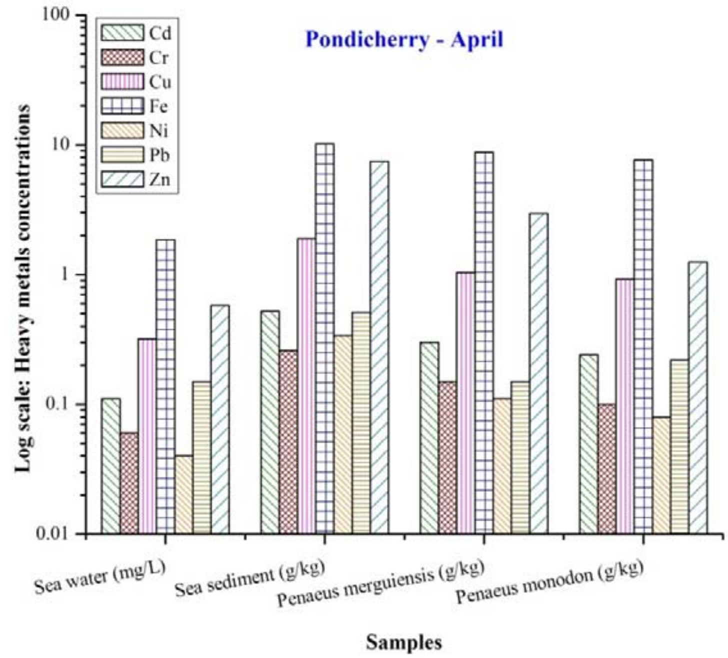

Figure 5. Concentration of heavy metals in different samples of Pondicherry coast at April month

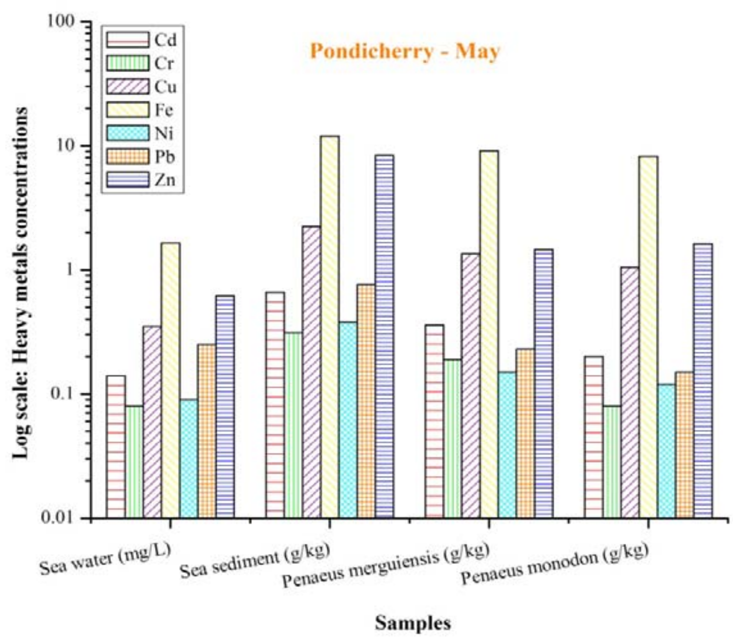

Figure 6. Concentration of heavy metals in different samples of Pondicherry coast at May month