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Determination of Heavy Metal Concentrations in Aquatic Animals from Ennore Estuary

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Abstract: Heavy metals are being utilized in a variety of ways in industries, agriculture, food processing and household. Metals are unique environmental and industrial pollutants in the sense that they are neither created nor destroyed by human beings but are only transported and transformed into various products. The present study deals with the findings of various investigators on the effect of heavy metal accumulation such as Copper, Iron, Zinc, Manganese and Nickel on the important seafood's consumed by humans like fish, shrimp, crab, mussel and lobster collected from Ennore estuary. The result showed that the essential heavy metals are within the permissible limit except a few. In view of importance of fish nutrition and human health, it is necessary to maintain regular biological monitoring of the Ennore estuary waters and aquatic animals to ensure the continuing safety consumption of seafood.

Keywords: Pollution, Toxicology, Seafood, Accumulation, Fish, Heavy metals

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Introduction

Increasing environmental pollution throughout the world, particularly aquatic pollution, has become one of the global problems. Heavy metals and toxic chemicals, when released into water bodies without proper treatment are most prevalent in developing countries. Such toxic metals and chemicals and their indiscriminate use resulted in problems with contaminants and polluted the marine environment, which threatened the survival of aquatic organisms like fish (Mohan *et al.*, 2020; Vardi and Chengi, 2020a). Marine organisms can take up heavy metals from water, suspended particulate matter, and sediment in ambient environments and accumulate the heavy metals in their tissues, where they may cause severe damage and toxic effects to the organs at high levels (Mohan *et al.*, 2013a; Raknuzzaman *et al.*, 2016; Gu *et al.*, 2017). Fish is high in omega-3 and protein that the human body needs to stay healthy. However, potentially dangerous heavy metals are absorbed into the body tissues of fish that are transferred to humans on consumption of this affected fish. Good quality of food for human consumption can only be produced in an environment free from contamination and pollution. Fish are of great economic importance, but are affected immensely by various chemicals including heavy metals directly or indirectly in different ways.

Some marine animal species may be reliable bio-indicators for monitoring heavy metal contamination in coastal and estuarine waters because heavy metal concentrations in tissues are generally influenced by the sampling location as well as dietary preferences (Baki *et al*., 2018). Many common species of bivalves, including mussels, oysters and clams have been used to monitor coastal water quality at various spatiotemporal scales because of their specific filtering and bioaccumulation characteristics (Liu and Wang, 2018). Fish and crabs can also be considered excellent biomonitors for estimating heavy metal contamination of water (Zhou *et al*., 2008; Ololade *et al*., 2011). Fish are at the top of the aquatic ecosystem, which makes them valuable for bio-monitoring (Zhou *et al*., 2008). Crabs are typical benthic organisms and can be used as indicators for measuring the contamination of the surface sediment (Ololade *et al*., 2011).

At low levels, some heavy metals such as copper, cobalt, zinc, iron and manganese are essential for enzymatic activity and many biological processes. Other metals, such as cadmium, mercury, and lead have no known essential role in living organisms, and are toxic at even low concentrations (Yi and Zhang, 2012; Copat *et al*., 2013). Heavy metal bioaccumulation in marine organisms can eventually lead to adverse effects and poses a potential health risk to humans through the consumption of contaminated seafood (Guérin *et al*., 2011). Seafood is a primary source of animal protein for humans, because it generally contains all of the essential amino acids but has few calories and low fat content (Liu *et al*., 2018). The deficiency of essential elements in the fish body, such as Na, K, P, Ca, Mg, Mn, Fe, Cu and Zn, may lead to improper or poor enzymatic functions, which will cause organ malfunctions, chronic diseases and finally death (Lourenco *et al*., 2012). As metals have different affinity for organs in the fish body, a fact explained by the metabolic role of each metal (Vijayan *et al*., 2016), trace and ultra-trace elements as Zn, Fe, Cu, Mn, Cr and Ni are essential elements and important components of hormones and enzymes, and also for enzyme activation.

Estuaries, the important contributors of fisheries in India, suffer from severe loss of fish production due to increased industrialization and urbanization along the coastal zone by continuous discharge of industrial effluents (Padmini *et al*., 2004; Mohan *et al*., 2013b). Ennore estuary is highly dynamic with geographic changes in the bar mouth and characterized by the influence of discharge from various industries and wastewater from municipal sewage (Mohan *et al*., 2013). As a result, availability and distribution of metals in water, sediment and biotic compartments of Ennore estuary exhibited seasonal and spatial changes. Ennore estuary has been extensively studied for its biodiversity, fishery resources, metal concentration and their biological effects on selective resident species (Jayaprakash *et al*., 2005). In the present study, we analysed the concentrations of Cu, Fe, Zn, Mn, and Ni in muscle tissue of fish, shrimp, crab, mussel and lobsters collected from the Ennore estuary, Tamil Nadu, India.

Materials and Methods

Assorted aquatic animals which included fishes, shrimps, crabs, mussels and lobsters were collected from the Ennore estuary. Later the samples were brought to the laboratory rinsed with distilled water and sealed in sterile polythene zip lock covers and were preserved at -20°C for further analysis. The samples were thawed and dissected on a clean polypropylene board to separate the muscle tissue. Four gram of sample was weighed and the tissues were diluted overnight with 7 ml of pure nitric acid and 3 ml of hydrogen peroxide. Sample digestion was done using microwave digester (Ethos plus High Performance Microwave Lab station, Milestone, USA). The microwave parameters were 800 W powers for 45 min (15 min temperature increasing, 15 min temperature holding and 15 min ventilation). The digested sample was made up to 100 ml with double distilled water and analysed by using Atomic Absorption Spectrophotometer (GBC 932AA, GBC Scientific Instruments, Australia) following the AOAC method (AOAC, 2000).

Results and Discussion

The concentrations of different metals detected in the edible portion of muscle of fish, shrimp, crab, mussel and lobster are shown in the Table 1. In the present study remarkable differences of essential metal concentrations are observed in the muscles of fish, shrimp, crab, mussel and lobster (Fig. 1).

Copper is a micronutrient required for proper growth, development and maintenance of bone, connective tissue, brain, heart and many other organs. Copper is commonly found in aquatic systems as a result of both natural and anthropogenic sources. A major source of copper in the marine environment is antifouling paints, used as coatings for ship hulls, buoys, and underwater surfaces, and as a contaminant from decking, pilings and some marine structures that used chromatid copper arsenate treated timbers (Annie *et al*., 2020). In the present study copper in shrimp and crab recorded was 0.522 ppm and 0.334 ppm, respectively which is in agreement with observations of Nayem *et al*. (2011). Prawn samples from local market showed concentration of Cu from 0.01 to 0.11 ppm. In contrast Krishnamurti *et al*. (1999) have determined the concentration of metals in shrimps and crabs from the Thane-Bassen creek system, Maharashtra and the amount of copper was found in *Parapenaeopsis hardwickii* between 22.6 ppm to 30.50 ppm; in *Macrobrachium rude* 21.9 ppm; in *Metapenaeus brevicarnis* 41.3 ppm; in *Exapalemon stylifera* 33.0 ppm; and in *Penaeus indicus* 25.4 ppm, which were above the permissible limit.

In food the allowed amounts of heavy metals vary from country to country and based on both WHO recommendations and local requirements. Seafood's are good source of dietary copper, which is an essential element available to humans (WHO, 1996). However, Cu is very toxic when consumed excessively, and the presence of Cu in seafood was limited (FAO, 1983) for fish and fishery products to 30 mg/kg. In the present study, the mean values of copper in fish, shrimp, crab, mussel and lobster were in between 0.334 to 0.737 ppm which was relatively similar with findings of Aditi *et al*. (2009).

The major source of iron in coastal waters is due to decrease in grain size and an increased input of organic matter and anthropogenic metals from industrial pollution and also due to direct discharge of sewage and hospital waste into the water bodies (Satheeshkumar and Senthilkumar, 2011). The concentration of Fe in fish was 15.997 ppm (Table 1; Fig. 1). Similarly, in a previous study the level of Fe detected was 4.32 µg/g in the muscle of *Leiognathus daura* (Salam *et al*., 2019). Concentrations of Fe vary widely among marine crustaceans (Eisler, 1981). Maximum Fe concentration was observed in fish as 15.997 ppm and the minimum Fe concentration was observed in mussel was 0.138 ppm. In the shrimp it was 12.007 ppm. Likewise, shrimp collected from east coast contained 18.09 ppm (Rao *et al*., 2016) which is in agreement with the present study. The Fe tends to accumulate in hepatic tissue due to the physiological role of the liver in the synthesis of blood cells and haemoglobin (El-Moselhy *et al*., 2014).Higher concentrations of Fe in tissue samples could be due to an increased input of organic matter and anthropogenic metals from industrial pollution.

The measured values of zinc in fish in the present study was 5.141 ppm and comparable with results of Roksana *et al*. (2014,) indicating lower metal contamination in the environment. The highest concentration of Zn was 10.553 ppm

Table 1: Heavy metal concentration in aquatic animals

Metals (ppm)	Fish	Shrimp	Crab	Mussel	Lobster
Copper	0.452±0.02	0.522±0.08	0.334±0.01	0.668±0.07	0.737±0.01
Iron	15.997±0.07	12.007±0.05	0.269±0.09	0.138±0.06	0.321±0.07
Zinc	5.141±0.06	10.553±0.02	0.537±0.05	1.073±0.01	0.678±0.06
Manganese	0.015±0.07	0.009±0.06	0.005±0.01	0.010±0.03	0.012±0.07
Nickel	1.003±0.01	0.856±0.09	0.023±0.02	0.298±0.09	1.098±0.06

Values expressed as mean ± SD

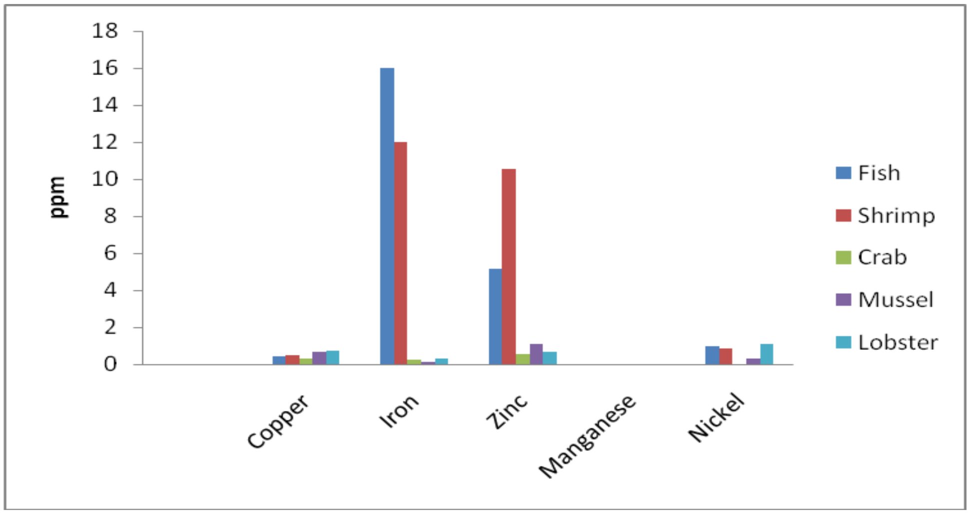

Fig. 1: Heavy metal concentration in aquatic animals.

in shrimp and lowest concentration was in crab 0.537 ppm. Although, heavy metal uptake depends on various factors such as age, geographical distribution, feeding behaviour, trophic level and species specific factors that varied from organ to organ (El-Moselhy *et al.,* 2014). Similar observation was found in *Fernneropenaeus indicus* which contained 14.40 µg/g of zinc (Salam *et al.*, 2019). The concentration of Zn in crab, mussel and lobster were within the acceptable limit which is 3 mg/kg according to FAO/WHO standards. Zinc, an essential metal, is regulated by many organisms because it does not bio-magnify in the aquatic organism. This is because many aquatic animals absorb Zn majorly from water and sediments but not in what they consume (Vardi and Chenji 2020b).

Manganese concentrations were 0.015 ppm in fish and the lowest 0.005 ppm was recorded in crab. The present study revealed that the mean concentrations obtained were lower than the permissible regulatory limit of 0.2 ppm and indicated that it has lesser bioavailability than the other metals. It is essential to know that besides being an essential metal needed by animals in the biological systems, the concentration should not be higher than the required limit (Raji *et al.*, 2010). The Mn is an essential micronutrient, and it is a component of metalloenzymes and an activator for other enzymes. The results showed that Mn levels determined in this study are not higher than the WHO limits. The major sources of Mn are reported to be from iron, steel and alloy industries and to the lesser extent from production units of dry cell batteries, fertilizers and fungicides. Ennore is a hub of a wide range of industrial projects which let their untreated waste water flow into the Ennore creek. A survey along the coast particularly Buckingham canal indicated the presence of above small scale manufacturing industries acting as a source of this metal at different places of Chennai (Smita *et al*., 2017).

Nickel is naturally occurring in soil and surface water with concentration lower than 100 and 0.005 ppm, respectively (Rathor *et al*., 2014). However, anthropogenic activities such as smelting, metal mining, vehicle emission, fossil fuel burning, disposal of household, municipal and industrial wastes, application of fertilizer and organic manures also contributing Ni in aquatic environment. In this study, the concentration of Ni was found to be in the range of 0.023 to 1.003 ppm which is below the permissible level recommended by WHO (0.5 ppm to 1.0 ppm), except the concentration of Ni in lobster.

Conclusion

This study revealed that the levels of heavy metals in all samples were within the acceptable limit. The concentration values revealed that the studied fish, shrimps, crabs, Mussel and lobster species should not be considered as a threat to consumers. The data obtained from this study can be used as a safeguard for sustenance of both native and export market of fish industries. In view of importance of the fish nutrition and consumer health, it is necessary to maintain regular biological monitoring of the Ennore estuary waters and aquatic animals to ensure the continuing safety consumption of seafood. Finally, safe disposal of domestic wastes and industrial effluents should be ensured and these wastes should be recycled if possible to avoid their accumulation in the marine environment.

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