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Original Research Article

Heavy Metal Concentration in Fishes from the Coastal Waters of Kasaragod, Northwest Part of Kerala, India

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A b s t r a c t

Although fish is a significant source of protein, they are currently affected by rapid industrialization and mechanized agricultural activities, resulting in increased concentrations of heavy metals in fishes. Concentrations of heavy metals, namely, Zn, Fe, Cu, Ni, Cd and Pb, were estimated in the muscle, liver, and gills of commercially important marine and fresh water fishes, namely, *Nemipterus japonicus*, *Nibea soldado*, *Mugil cephalus*, *Rastrelliger kanagurta*, *Oreochromis mossambicus* and *Plicoffilis dussumieri* were collected directly from the landing places at Kasaragod district during January to March 2014. The results showed that the muscle had the lowest metal concentrations compared with the liver and gills. Among the estimated heavy metal concentrations, those of Zn and Cd were the highest and the lowest, respectively, for all species in muscle, liver and gills. Moreover, our results indicated that, none of the values in the muscles exceeded the standard guideline values and hence would not pose any health hazard to consumers.

K e y w o r d s

Contamination
Fish tissue
Heavy metals
Toxicity

Introduction

Fish is one of the most indicative factors in freshwater systems and toxic levels in fish can be used for the estimation of trace metals pollution. They can also be used to estimate potential risk for human consumption (Barak and Mason, 1990). Liver and gills are considered as storehouse of metals in fish and muscle tissue shows some amount of metal accumulation as well (Kalay et al., 1999). Over a few decades there has been growing interest to determine heavy metal levels in the marine environments and attention was drawn to find the contamination level of public food supplies particularly fish (Ashraf, 2005). Heavy metals include lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag), chromium (Cr), copper (Cu), iron (Fe), and the platinum group elements (Duruibe et al., 2007). Cadmium is released as a by-product of zinc (and occasionally lead) refining. Lead is emitted during mining and smelting activities, from automobile exhausts (by combustion of petroleum fuels treated with tetraethyl lead antiknock) and from old leads paints. Mercury is emitted by the degassing of the earth's crust. Generally, metals are emitted during their mining and processing activities (Duruibe et al., 2007; Lenntech, 2004).

Heavy metals from manmade pollution sources are continually released into aquatic systems, and they are a serious threat because of their toxicity, long persistence, bioaccumulation, and biomagnifications in the food chain (Eisler, 1988). Agricultural and geochemical structures and industrial waste affect physiochemical characteristics of the water, sediment and biological components, and thus the quality and quantity of fish stocks (Zyadah, 1999). Under certain environmental conditions, heavy metals may accumulate to toxic level and cause ecological damage (Guven et al., 1999).

In this study some commercially important fish are selected and muscle, gill and liver tissues have been studied for heavy metal (Zn, Fe, Cu, Ni, Cd and Pb) accumulation. The aim of the study helps to estimate potential risk for human consumption of marine as well as freshwater fishes.

Materials and methods

Sample collection

Fresh fish samples [*Nemipterus japonicus*, *Nibea soldado*, *Mugil cephalus*, *Rastrelliger kanagurta*, *Oreochromis mossambicus* and *Plicoffilis dussumieri* were collected directly from the landing places at Madakkara , Azhithala , Balla and Kasaragod during January – March 2014. Different species were collected in separate polyethylene bags and kept on ice in a thermo insulator box and transported to the laboratory. The samples were washed with deionised water and labelled. The samples were then stored in the -80°C freezer prior to preparation. Then the fish were identified by using a standard manual (The FAO Species Identification Sheets) and also with the help of fisheries expert. The total length (cm), standard length (cm) and weight (gm) of each fishes were measured. Each sample collected was dissected and care was taken to avoid contamination to the samples. Rust free stainless steel kit was sterilized to be used to separate muscle, gills and liver and dried at 60ºC. The dried tissue was reduced into fine powder in a pestle and mortar and 100mg of each tissue powder was collected, in a plastic sieve with 0.2 mm opening size and it was stored in desiccators for further analysis.

The residue was dissolved in 25 % nitric acid, and the samples were slowly heated to dissolve the residue. The solutions were then transferred to a 25 ml volumetric flask and made up to the mark with double distilled water prior to analysis (Vaidya and Rantala, 1996). All samples were analyzed for Pb, Cd, Fe, Ni, Cu and Zn concentration using flame atomic absorption spectrophotometer (FAAS), GBC, Australia, at the Department of Marine Science, Bharathidasan University, Thiruchirapalli. Chemical standards from MERCK were used as standards. 25% nitric acid was used as blank samples during every run of the analyses. The values were expressed in ppm and presented in fishes.

Results

Heavy metals entering the fish body have a possibility to get accumulated in different parts of the body and the residual amount can build up to a toxic level. The accumulation of heavy metals in tissues of the fish is in the order as follows, in the muscle Fe>Zn>Cu>Ni>Cd>Pb, in the gills Zn>Fe>Cu>Ni>Cd>Pb and that of the liver Zn>Fe>Cu>Ni>Cd>Pb. Details of four species of marine fish and two species of freshwater fish analyzed in this study are shown in Figs. 1 to 6. Fish is one of the dominant bio-indicator species used for acute toxicity assay of pollutants such as heavy metals since much attention has been drawn due to the wide occurrence of metal pollution in aquatic ecosystem.

The rapid development of industries has promoted the increase of environmental pollution. Although heavy metals in aquatic system can be naturally produced by slow leaching from rocks and soil into water which occurs at low levels. Metals are usually present at significant levels in water system which may pose high toxicities on the aquatic organisms. Their accumulation in biotic tissues causes toxic effects. The present study is undertaken to know the level of accumulation of heavy metals such as Pb, Cd, Fe, Ni, Cu and Zn in fish tissues.

Fig. 1: Distribution of heavy metals (Pb, Zn, Fe, Cd, Cu and Ni) in muscle, gills and liver tissues of *Nemipterus Japonicus.* The data are expressed as mean ± SD.

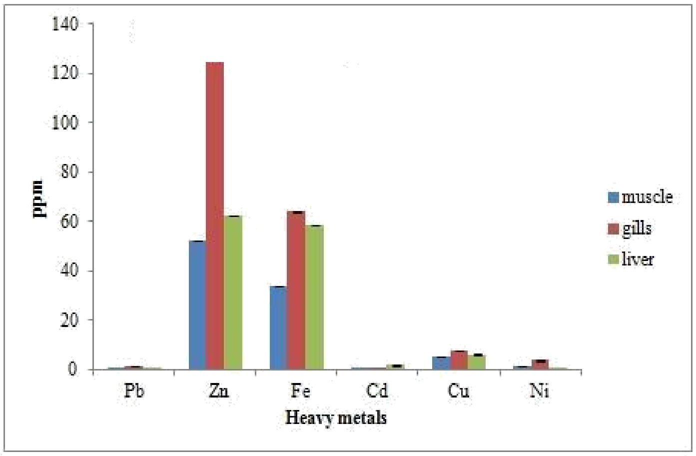


Fig. 2: Distribution of heavy metals (Pb, Zn, Fe, Cd, Cu and Ni) in muscle, gills and liver tissues of *Nibea japonicus*. The data are expressed as mean ± SD.

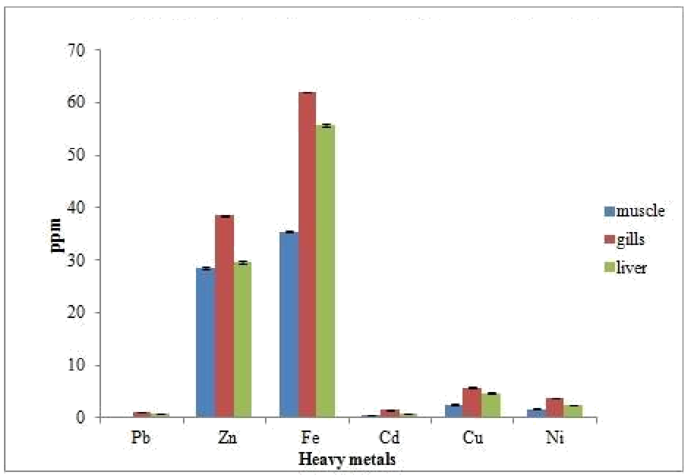


Fig. 3: Distribution of heavy metals (Pb, Zn, Fe, Cd, Cu and Ni) in muscle, gills and liver tissues of *Mugil cephalus*. The data are expressed as mean ± SD.

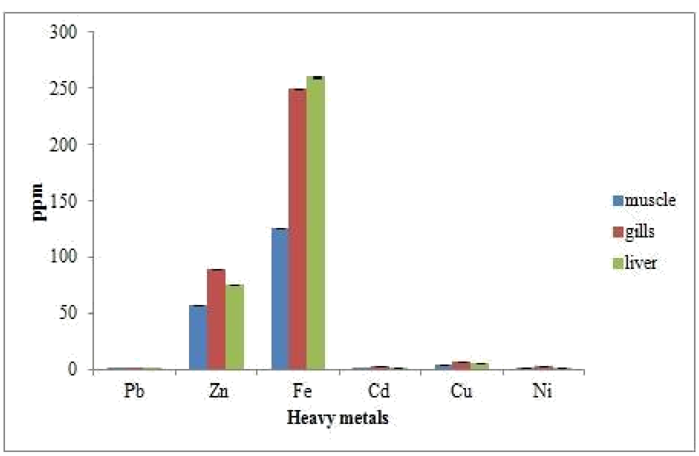


Fig. 4: Distribution of heavy metals (Pb, Zn, Fe, Cd, Cu and Ni) in muscle, gills and liver tissues of *Rastrelliger kanagurta*. The data are expressed as mean ± SD.

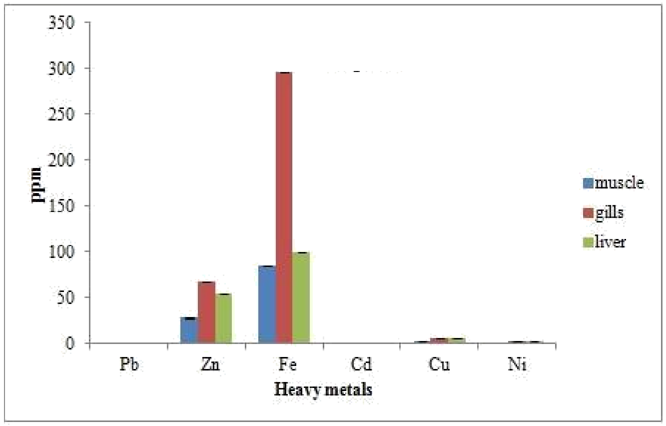


Fig. 5: Distribution of heavy metals (Pb, Zn, Fe, Cd, Cu and Ni) in muscle, gills and liver tissues of *Oreochromis mossambicus*. The data are expressed as mean ± SD.

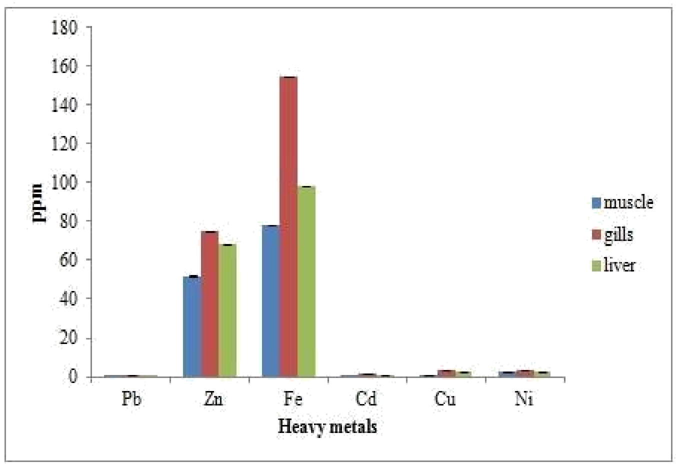
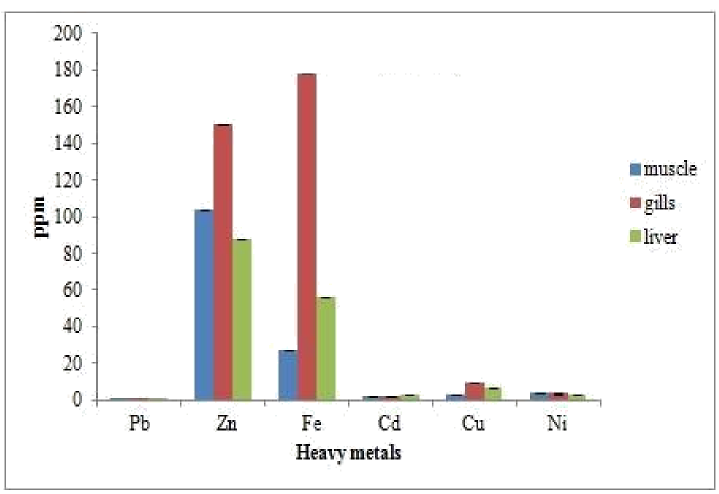


Fig. 6: Distribution of heavy metals (Pb, Zn, Fe, Cd, Cu and Ni) in muscle, gills and liver tissues of *Plicoffilis dussumieri*. The data are expressed as mean ± SD.



Heavy metals have the tendency to accumulate in various organs of marine organisms, especially fish, which in turn may enter into the human metabolism through consumption causing serious health hazards. Hence, the present study is conducted to evaluate the metal concentrations in the fish samples (muscle, gills and liver). The analysis of the selected metals revealed that, all the samples showed heavy metal concentration. The concentrations of Pb, Cd, Fe, Ni, Cu and Zn in gut and muscle of six fish species for each metal respectively is shown in Figs.1-6. The results show significant differences in the accumulation levels of metals in the tissues throughout species. Comparatively, higher levels of metal in gills followed by liver and muscle were observed by it present study.

Discussion

Zinc is an essential micronutrient for healthy functioning of the human body. Though present in tiny amounts, it is critical to life and its deficiency can have a variety of adverse consequences. Zinc deficiency may occur due to diets containing inadequate amount of bio-available Zinc. Certain diseases like diarrhoea may occur as a result of loss of zinc during processing of food. Zinc is found in so many essential enzymes and has critical roles in both protein synthesis and molecular genetics. Accumulation of Zn in the fish samples were in the order *P. dussumieri>N. japonicus> M. cephalus>O. mossambicus>R. kanagurta>N. soldado.* Gills were the major sites of Zn accumulation in all six species. In *P. dussumieri*, Zn concentrations were markedly higher in gill than in liver and Muscle (Fig. 6). The muscle of all species contained low concentrations of Zn. Zn level (150.35 ppm) in gill of *P. dussumieri* was significantly higher than at the other fishes. Zn levels 28 ppm were much lower in muscle of *R. kanagurta* than in other fishes (Fig. 4). However, there was no evidence to suggest that gills were the major organ of Zn accumulation. Zn is an essential trace metal for both animals and humans. Carpene et al. (1994) stated that the high Zn concentration in gonads due to Zn is a necessary element for embryo development and is important to reproductive organs. On the other hand, the stomach has a key role in basic metabolism and is the major site of accumulation, biotransformation and excretion of contaminants in fish (Pawert et al., 1998). Zn toxicity is rare but, at concentrations in water up to 40 mg/kg, may induce toxicity, characterized by symptoms of irritability, muscular stiffness and pain, loss of appetite, and nausea (NAS-NRC, 1974).

Iron is an essential element in diet for human beings. Infact, iron is present in the red blood cells hemoglobin. The important role of iron in the blood is the hemoglobin carries oxygen from lungs or gills to the tissues and it releases the oxygen. The iron deficiency causes the most common disease like Anemia. Iron in the fish samples accumulated in the order *M. cephalus>R. kanagurta> O. mossambicus >P. dussumieri>N. japonicus>N. soldado.* Our observations indicated that, the concentrations of iron (295.95 ppm) were much higher in gills of *R. kanagurta* (Fig. 4) and in liver of *M. cephalus* (260.08 ppm) (Fig. 3) where as the lower concentration of iron levels were observed in muscle (27.62 ppm) of *P. dussumieri* (Fig. 6) and in muscles (34.04 ppm) of *N. japonicus* (Fig. 1) than in other fishes. Maheswari et al. (1997) reported that, the iron content in the muscle tissue of *R. kanagurta* were higher than all other species of fish, gathered from the near shore waters off Cochin. Carvalho et al. (2005) reported that, the Fe concentrations were measured in species with more affinity for rocky bottoms and species with more affinity to sandy/muddy bottoms. Moreover, Maruthanayagam (1998) stated that high concentration of Fe along the East Coast might be due to a large number of barges transport iron ores through Gulf of Mannar coastal region.

Copper is an essential trace element in plants and animals, but not some microorganisms. The human body contains copper at a level of about 1.4 to 2.1 mg per kg of tissue. In *P. dussumieri*, Cu concentrations appeared considerably higher in gills than in other tissues. In *P. dussumieri* high Cu concentrations is found in gills (9.94 ppm) (Fig. 6) and in *N. japonicus* (7.8 ppm) (Fig. 1) as well. Cu levels are lower in muscle *O. mossambicus* (Fig. 5) and *R .kanagurta* (Fig. 4) than in other fish. Muscle of all species contained low concentrations of Cu. Copper content obtained from the various species of fish is similar with the reported copper content (2.01 ppm) of the muscle tissue of *R. kanagurta* from Cochin shore (Maheswari et al., 1997). However, the value is higher than the reported copper content (1.40 ppm) of the muscle tissue of *Lates calcarifer* from the shore of Mumbai (Asha and Vijyalakshmi, 1999). Rejomon et al. (2010) observed minimum level of Cu in muscles of species like *L. calcarifer, N. japonicus, R.kanagurta* and *C. macrostomus* collected from Mangalore and Kochi.

Nickel belongs to the transition metals and is hard and ductile. Thyssen et al. (2007) stated that Nickel allergies affecting pierced ears are often marked by itchy and red skin. Observed Ni is in very low concentrations in the samples. High Ni (4.33 ppm) concentration is found in muscle of *P. dussumieri* (Fig. 6). Muscles of all species contained low concentrations of Ni. There are little differences in Ni concentrations among fish. Ni levels are lower in muscle of *N. japonicas* (Fig. 1) than in other fish. Nickel content of all the species of fish is higher than the reported nickel content (0.30 ppm) of muscle tissue of *L. calcarifer* from the near shore of Mumbai (Asha and Vijyalakshmi, 1999) which is below the limit of the estimated maximum guideline (USFDA, 1993). The concentrations of Ni in all the samples are far below the stipulated limit.

Cadmium is a non-essential toxic metal, and elevated concentrations are often a threat to marine biota. The source of Cd in humans is through food consumption. In humans, cadmium may accumulate from food chain magnification and may induce kidney dysfunction, skeletal damage and reproductive deficiencies (Commission of the European Communities, 2001). Tissues of all species contained only negligible amount of Cd. In *P. dussumieri* liver (3.2ppm) seems to accumulate more Cd than muscle and gills (Fig. 6). Among the studied fish Cd levels occurred in low level in muscle of *R. kanagurta* and *O. mossambicus* (Figs. 4 and 5). Similar investigation was made by Palanichamy and Rajendran (2000) which showed Cadmium content in the water and sediments levels were higher in Gulf of Mannar region.

Hasyimah et al. (2011) stated that higher amount of Cd accumulation in gut of *R. kanagurta*, *Epinephelus sexfasciatus*, *L. calcarifer* and *Decapterus maruadsi* as fish intestine compared to the other organs acts as a transient site for heavy metal bioaccumulations in fish body. Fish intestine involved in the uptake of particulate heavy metal fractions via alimentary tract in which the rate of heavy metals uptake being controlled by specific transport system through simple diffusion mechanism across the intestinal epithelium. The concentrations of Cd in all fish samples, however, fell below the FAO guideline (FAO, 1983) of 0.5-1.0 mg/kg.

Pb is classified as one of the most toxic heavy metals which implies that it has no known function in biochemical processes. Lead causes renal failure and liver damage in humans. Lead, at certain exposure levels, is a poisonous substance to animals as well as for human beings. It damages the nervous system and causes brain disorders (Commission of the European Communities, 2001). In *R. kanagurta* (1.87ppm) Pb concentration is markedly higher in liver than in gills and muscle (Fig. 4). The lowest concentration of Pb is measured in muscle of *M. cephalus* (Fig. 3) and *O. mossambicus* (Fig. 5) (0.03ppm) while the highest concentration is measured in gills of *O. mossambicus* and *R. kanagurta* (Figs. 4 and 5) (1.87ppm). However, Rejomon et al. (2010) observed maximum muscle Pb concentration in *R. kanagurta* from Mangalore coast. However all the estimated samples are below the FAO guideline (FAO, 1983) of 0.5 mg/kg.

This study fills a gap by providing information on heavy metal concentrations in commercially valuable marine and fresh water fish species from Kasaragod, Northern Kerala. Based on the sample collected, metal concentrations found in edible muscle are below the proposed limit values for human consumption. The relatively high content of metals founds in liver and gills might be due to the metal concentrations in this ecosystem and time of exposure, which is a function of fish age. However, since muscle is the major consuming portion, and internal organs are rarely consumed, there should not be any health threat to the public resulting from the consumption of fish meat.

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