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ORIGINAL ARTICLE

BIOACCUMULATION OF HEAVY AND ESSENTIAL METALS IN THE SELECTED FRESHWATER FISH SPECIES FROM PREUMAL LAKE CUDDALORE DISTRICT, TAMILNADU, INDIA.

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Abstract:

The present study was conducted to determine the heavy and essential metals, chromium, cadmium, copper, lead, iron, zinc and manganese concentrations in gill, liver, kidney, intestine and muscle of the available freshwater fish Mystus vittatus, Heteropneustes fossilis, Glossogobius giuris, Notopterous notopterous and Tilapia mossambica of the Perumal lake Cuddalore district, Tamilnadu, India collected during the January 2011- December 2011. Heavy and essential metals concentrations varied in significantly depending upon the type of fish tissues and locations. In the selected freshwater fish, liver tissues appeared to have significantly higher tendency to bioaccumulation of chromium followed by Cd, Cu, Pb, Fe, Zn and Mn. The maximum level of chromium was found in the liver tissue of Heteropneustes fossilis, while the minimum level of zinc was observed in the muscle tissue of Notopterous notopterous. Among the analyzed metals chromium, cadmium, iron, zinc and manganese levels were exceed the WHO recommended limits. Copper and lead levels within the permissible limits for human consumption might be representing a risk for human health.

KEYWORD:

Bioaccumulation, Freshwater Fish, Heavy and essential metals, Perumal Lake.

INTRODUCTION

Water is the one of the most precious natural resources that exists in our planet and freshwater is vital to human life and economic well being. Heavy metals are the introduced in to the environment by a wide spectrum of natural sources such as volcanic activities, erosion and anthropogenic ones including industrial wastes as well as a leakage. Some of these metals including lead, nickel, cadmium and mercury are toxic to living organism's even quite low concentrations, while others such as copper, iron, zinc and manganese are biologically essential and natural constituents of the aquatic ecosystem and become toxic only at very high concentrations (Storelli et al., 2006; Karadede- Akin and Unlu, 2006). Heavy metals contamination may have devastating effects on the ecological balances of the recipient environment and diversity of aquatic organisms (Farombi et al., 2007; Vosyliene and Jankaite, 2006). Pollutants enter in to the fish through a number of routes: Via skin, gills, oral consumption of water, food and non-food particles. On absorption of pollutants are transported in the blood stream to either a storage points (i.e. bone) or to the liver for transformation and or storage (Nussay et al., 2000).

Heavy metals concentrations in fish samples and consider its potential impacts on the food chain and its human health risks. Pollutants are transferred in to the liver it is stored there or excreted in bile or passed back to the blood for possible excretion via gills or kidney or stored in fat (Heath, 1991). These dynamic processes, which take place simultaneously within the body of the fish, eventually, determine the concentrations of the pollutants in the fish. As fish constitute an important link in the food chain its contaminations by toxic metals causes a direct threat, not only to the entire aquatic environment, but also to humans that utilize it as food. In the body organs of both herbivorous- and carnivorous fish species, the accumulation of Cd, Cu, Cr, Mn and Zn were accumulated significantly in gill, liver, kidney, intestine and muscle. The mechanism of trace metals bioaccumulation in fish is complex and diversified, varying with their chemistry, mode of action and metal species. The function and ability of specific organs to regulate metals are the factors to affect the accumulation differences in various tissues. The differences in various tissues for the accumulations of Cd, Cu, Cr and Zn might be the result of their capacity to induce metal-binding proteins such as metallothioneins (Canli and Atli, 2003). Bioaccumulation of metals in the fish tissues in River and Lakes were reported by many author (Alaa and Osman, 2012; Adeyemi, 2011; Malik et al., 2010). Hence the present study was carried out to investigate the bioaccumulation of heavy metals such as, chromium, cadmium, copper, lead, iron, manganese and zinc in the selected tissues of available freshwater fish Mystus vittatus, Heteropneustes fossilis, Glossogobius giuris, Notopterous notopterous and Tilapia mossambica collected from Perumal Lake Cuddalore district, Tamilnadu, India.

2. MATERIALS AND METHODS

2.1 Description of the study area

The area chosen for study is Lake Perumal, which are located in Cuddalore district of Tamilnadu. The Lake Perumal is lies between north latitudes 11 0 30' to 11 0 45' N and East longitudes 79 0 30' to 79 0 47'30'' E. It falls in the survey of India top sheet no. 58 M/10. The study area is bounded by Gadilam River in the north and Coleroon River in the sout. It has good network of roads and railways.

2.2 Collection of fish samples and analysis of heavy metals

The selected freshwater fish Mystus vittatus, Heteropneustes fossilis, Glossogobius giuris, Notopterous notopterous and Tilapia mossambica of Perumal Lake Cuddalore district, Tamilnadu were caught by the local fishermen using gill net of various sizes. The fish species were ice-packed and transported to the laboratory and identified with the help of fishes of India (Day, 1978). The selected fish organs were removed and put it in Petri dishes to dry at 120° until reaching a constant weight. The dried tissue was placed into digestion flask and ultra pure concentrated nitric acid and hydrogen peroxide [1: I V/V] [SD fine chemicals] were added. The digestion flask was heated to 130°C until all the material was dissolved (Yilmaz, 2003). Digest was diluted with double distilled water appropriately. The elements like cadmium, chromium, copper, lead, manganese, iron and zinc were assayed using ELICO's SL-176 Double Beam Atomic Absorption Spectrophotometer.

3. RESULTS

The analyse concentration of heavy metals in the selected organs via. Liver, gill, kidney, intestine and muscle of the selected freshwater fish Mystus vittatus, Heteropneustes fossilis, Glossogobius giuris, Notopterous notopterous and Tilapia mossambica were presented in Figure 1-5. The distribution of heavy metals in selected organs analyzed were in the order of magnitude as liver > kidney > gill > intestine > muscle. The distribution of heavy metal in the all fish organs analyzed were in the order of Cr > Cd > Cu > Pb > Fe > Zn and Mn.

Figure 1: Mean concentrations of heavy metals in the selected organs of freshwater fish Mystus vittatus caught at Perumal Lake from January 2011 - December 2011

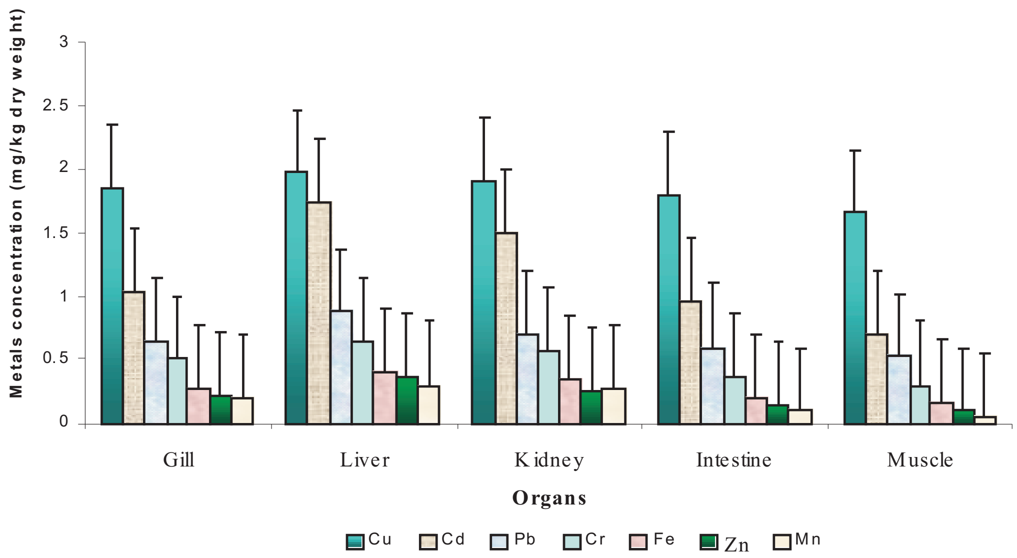


Figure 2: Mean concentrations of heavy metals in the selected organs of freshwater fish Heteropneustes fossilis caught at Perumal Lake from January 2011 - December2011

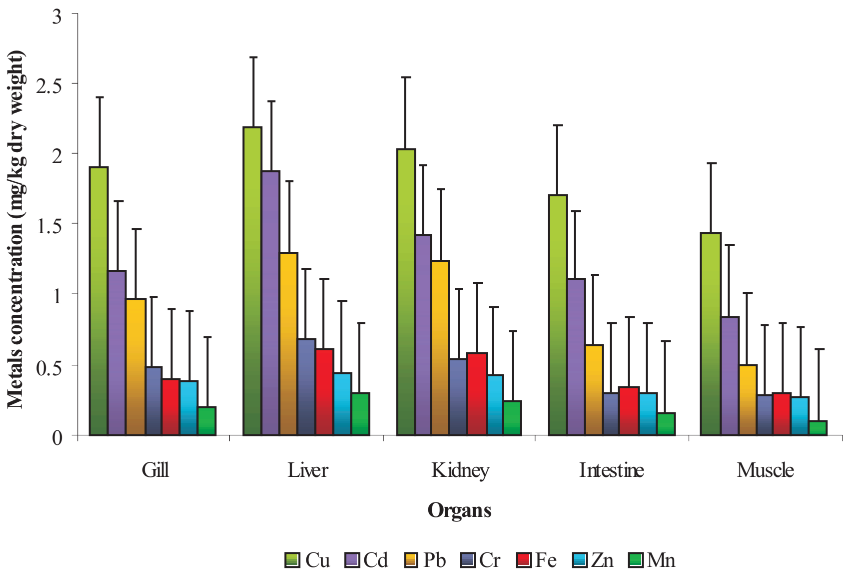


Figure 3: Mean concentrations of heavy metals in the selected organs of freshwater fish Glossogobius giuris caught at Perumal Lake from January 2011 - December 2011

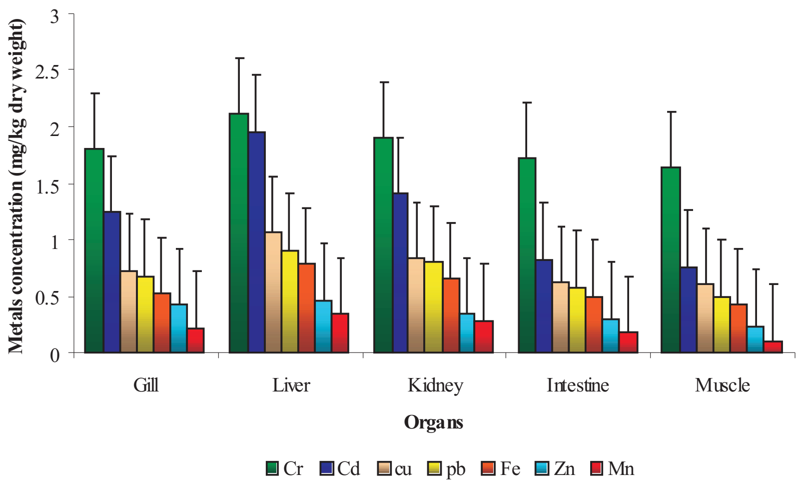


Figure 4: Mean concentrations of heavy metals in the selected organs of freshwater fish Notopterous notopterous caught at Perumal Lake from January 2011 - December 2011

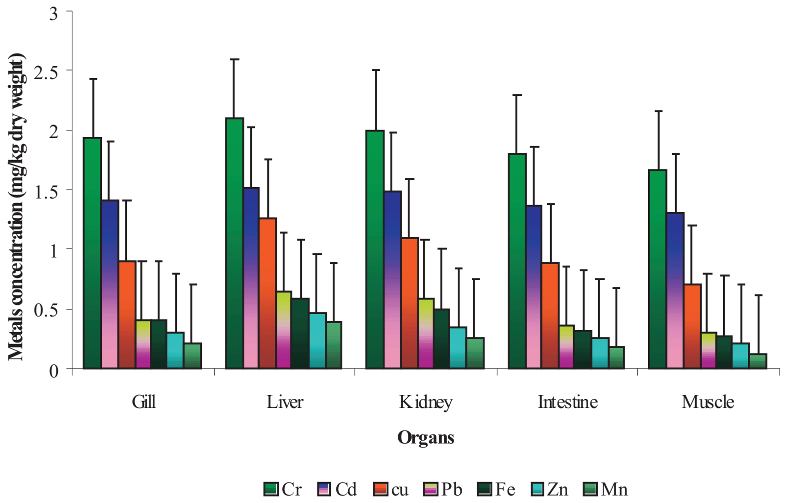
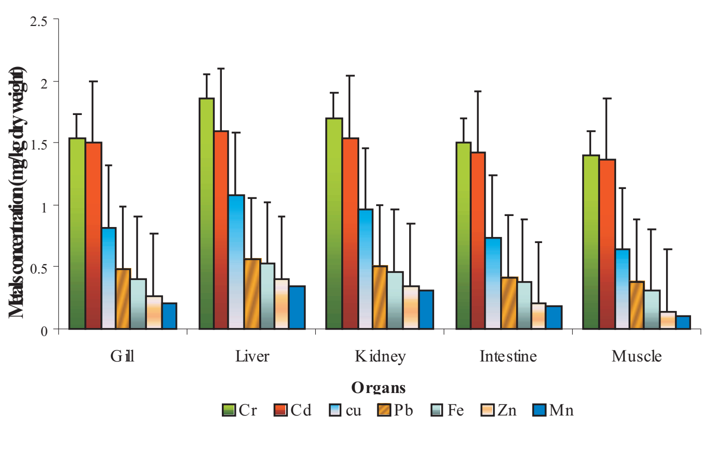


Figure 5: Mean concentrations of heavy metals in the selected organs of freshwater fish Tilapia mossambica caught at Perumal Lake from January 2011 - December 2011



The highest concentration level of Cr 1.98±0.075 mg/kg dry weight were found in the liver tissue of selected fish Mystus vittatus while the least concentration level of Mn 0.02±0.001 mg/kg dry weight were observed in the muscle tissue of selected fish (Figure 1). Figure 2 showed the maximum level of Cr 2.18±0.096 mg/kg dry weight were found in the liver tissue of Heteropneustes fossilis while the minimum level of Mn 0.10±0.003 mg/kg dry weight were recorded in the muscle tissue of selected fish. Figure 3 showed the maximum level of Cr 2.12± 0.089 mg/kg dry weight were found in the liver tissue of Glossogobius giuris while the minimum level of Mn 0.10±0.003 mg/kg dry weight were recorded in the muscle tissue of selected fish. Figure 4 showed the maximum level of Cr 2.10± 0.097 mg/kg dry weight was observed in the liver tissue of Notopterous notopterous, while the minimum level of Mn 0.12±0.004 mg/kg dry weight was detected in the muscle tissue of selected fish. Figure 5 showed the highest concentration of Cr 1.86+ 0.078 and Cd 1.52±0.055 mg/kg dry weight were observed in the liver tissue of Tilapia mossambica, while the lowest concentration level of Mn 0.10±0.004 mg/kg dry weight were observed in the muscle tissue of in the selected fish (Figure 5).

4. DISCUSSIONS

Among the metals analyzed in Figure 1-5 showed the highest concentration of chromium 2.18±0.096 mg/kg dry weight were observed in the liver tissue of Heteropneustes fossilis (Figure 2) while the least concentration of chromium 1.40±0.050 mg/kg dry weight also were detected in the muscle tissue of Tilapia mossambica (Figure 5). Chromium bioaccumulation in fish has been reported to causes impaired respiratory and osmoregulatory functions through the structural damage to gill epithelium (Heath, 1991). The values of Cr 2.18 ± 0.096 and 1.40±0.050 mg/kg dry weight were recorded in the selected fish organs. In the present study showed above the (FEPA, 2003) limiting standards of 0.15 mg/kg for fish food. Perumal Lake could presumably lead to Cr induced health hazards. The maximum concentration of cadmium 1.96 ±0.053 mg/kg dry weight were recorded in the liver tissue of Glossogobius giuris (Figure 3), while the declined concentration of cadmium 0.70 ± 0.027 mg/kg dry weight also were detected in the muscle tissues of Mystus vittatus (Figure 1). Mercury and cadmium are the important environmental pollutants due to their highly toxic nature and widespread occurrence in aquatic system (Tsui and Wang, 2004).

The values of Cd 1.88 ±0.060 and 0.70 ± 0.027 mg/kg dry weight were found for the selected fish. In the present study shows the cadmium was above the WHO (1985) maximum permissible limits of 0.005 ppm for fish food. Cadmium is highly toxic Non–essential heavy metal and it does not have a role in biological process in living organisms. Thus even in low concentration, cadmium could be harmful to living organisms (Tsui and Wang, 2003). The high concentration of Cd present in the selected organs of available freshwater fish may be due to industrial and agricultural operations in the investigated area (Ambedkar and Muniyan, 2012). The increased concentration level of copper 1.30±0.036 mg/kg dry weight were observed in the liver tissue of Heteropneustes fossilis (Figure 2), while the least concentrations level of copper 0.52±0.021 mg/kg dry weight were detected in the muscle tissues of Mystus vittatus (Figure 1). In the present study shows the copper level not exceeded the FEPA standards limits of copper 3.0 mg/kg in inland freshwater fish. Cu bioaccumulation has been reported to be related to copper toxicity and the pH of water is a determinant factor in the process (Carvalho and Fernandez, 2006).

The maximum concentration of lead 0.90 ±0.034 mg/kg dry weight were found for the liver tissue of Glossogobius giuris (Figure 3), while the minimum concentration of lead 0.28±0.014 mg/kg dry weight were recorded in the muscle tissues of Heteropneustes fossilis (Figure 2). In this findings, lead concentration were not exceeded the FEPA standards limit of 2.0 mg/kg for fish food. Cd and Pb are toxic elements which have no biological functions and show their carcinogenic effect on aquatic biota and humans. Lead toxicity is known to cause musculo-skeletal, renal, ocular, neurological, immunological, reproductive and developmental effects (ATSDR, 1999). The high concentration level of iron 0.78±0.030 mg/kg dry weight were recorded for the liver tissue of Glossogobius giuris (Figure 3), while the low concentration of Iron 0.16 ± 0.006 mg/kg dry weight were detected in the muscle tissues of Mystus vittatus (Figure 1). In this study, the observed values of iron level were exceeded the FEPA recommended standards limits of 0.5 mg/kg in fish food. It is necessary element in human diet. They are play significant role in metabolic process. The increased concentration level of zinc 0.46±0.021 mg/kg dry weight were observed in the liver tissue of Glossogobius giuris (Figure 3), while the decreased concentration of zinc 0.10± 0.003 mg/kg dry weight also were detected in the muscle tissues of Mystus vittatus (Figure 1). Zn is the essential minerals for both animals and humans. The maximum concentration level of manganese 0.34±0.013 mg/kg dry weight were observed in the liver tissue of Tilapia mossambica (Figure 5), while the minimum concentration level of manganese 0.10 ± 0.003 mg/kg dry weight also were found in the muscle tissues of Heteropneustes fossilis (Figure 2).

Similar result was observed by Dural et al. (2007) and Ploetz et al. (2007) reported highest levels of cadmium, lead, copper, zinc and iron in the liver and gills of fish species viz. Sparus aurata, Dicentrachus labrax, Mugil cephalus and Scomberomorus cavella. Yilmaz et al. (2007) reported that in Leuciscus cephalus and Lepornis gibbosus, cadmium, cobalt and copper accumulations in the liver and gills showed highest while these accumulations were least in the fish muscle.

Rauf et al. (2009) reported the fish liver exhibited highest tendency to accumulate cadmium and chromium metals. The accumulation of both cadmium and chromium was the minimum in fish gills Fish liver and kidney accumulated significant quantities of all metals while these accumulations were significantly lowest in muscle.

Fish kidney as its role to detoxify metals has also accumulated significant amounts of heavy metals (Vinodhini and Narayanan, 2008). A liver tissue of fish is responsible for the digestion, filtration and storage of glucose. Concentrations of metals were lower in muscles compared to liver, kidney gills and Intestine. Liver of the examined fish contained the highest concentration of all the detected metals, while muscles appeared to be the least preferred site for the bioaccumulation of metals as the lowest metal concentrations were detected in this tissue. Higher metal concentrations in the gills could be due to the element complexion with the mucus that is impossible to completely remove from the gill lamellae before tissue is prepared for analysis (Khalil and Faragallah, 2008).The adsorption of metals onto the gills surface, as the first target for pollutants in water, could also be an important influence in the total metal levels of the gill (Hemens and Connell, 1975). Concentrations of metals were lower in muscles compared to liver, kidney, gills and Intestine. This is particularly important because muscles contribute the greatest mass of the flesh that is consumed as food.

5. CONCLUSION

In this study given valuable information on the heavy metals in the selected freshwater fish from Perumal Lake. Heteropneustes fossilis liver tissue exhibited maximum tendency to accumulate chromium and minimum accumulation of zinc in the muscle tissues of Notopterous notopterous. Among the metals analyzed chromium, cadmium, iron, zinc and manganese levels were exceed the WHO recommended limits. Copper and lead levels within the permissible limits for human consumption might be representing a risk for human health.

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