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Heavy Metal Contamination of Some Fresh Water Fishes: A Market Based Study to Highlight the Possible Health Risk

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Abstract: Heavy metal concentrations were determined in different fishes from three wholesale fish markets of Dhaka city from August, 2016 to December, 2017. The heavy metals concentrations were measured by X-Ray fluorescence (XRF) in order to evaluate the potential health risks of consuming the fish. The differences in heavy metal concentration in different organs of five fish species were quantified. The heavy metal concentrations in fish species are ordered as Zn>Br>Fe>Sr>Cu>As>Se>Pb>Rb>Hg. The highest concentration of Zn (205.16±34.31µg/g) was found in *Pangascus pangascius* and the lowest concentration of Hg (0.32±0.04µg/g) was found in *Labeo rohita*. The concentrations of Pb, As and Hg in fish exceeded the limits of international standards. The concentration of heavy metals in gills and skin were higher than the tolerable level, which indicates the possible human health risk to the consumers of those fish.

Key words: Heavy metals, Fish, Health risk, Concentration

Introduction

The contamination of aquatic environment with heavy metals has become a worldwide concern in recent years because of its bioaccumulation capacity, potential toxic and non-degradable properties. The presence of heavy metals in aquatic ecosystems is the result of two main sources of contamination; natural processes or naturally occurring deposits and anthropogenic activities (Wu, *et al.*, 2010). In the fresh water environment, toxic metals are potentially accumulated in nature and subsequently transferred to man through the food chain. Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments and biota (Camuso *et al.*, 1995).

Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, since they are highly persistent and all have the potential to be toxic to living organisms (Storelli, 2008).

Fish have been recognized as a good accumulator of organic and inorganic pollutants (Gado et al., 2003). Age of fish, lipid content in the tissue and mode of feeding are significant factors that affect the accumulation of heavy metals in fish. Minerals present in food can be essential, non-essential or toxic to human consumption. Minerals such as Fe, Cu, Zn and Mn are essential and play important roles in biological systems. Meanwhile, Hg, Pb, and Cd are toxic, even in trace amounts. However, essential minerals can also produce toxic effects at high concentrations (Sivaperumal, *et al.*, 2007). The toxicity of an element depends on the dose, the chemical form, route of exposure, bio-viability and distribution in the body and storage and excretion parameters. In recent years, considerable interest has been focused on assessing the human health risk posed but metals, metalloids and trace elements in the environment.

The most important sources of heavy metals in the environment are anthropogenic activities such as mining, melting procedures, steel and iron industry, chemical industry, traffic and agriculture as well as domestic activities (Sucin *et al.*, 2008). Heavy metal contamination of the food chain is well documented in Bangladesh (Islam *et al.*, 2014). Heavy metals considered most toxic to humans are As, Cd, Pb and Hg (Govind and Madhuri, 2014). There is limited understanding of how these pollutants are removed from the body (Mitra *et al.,* 2005). In general, the major adverse health effects of exposure to these heavy metals, even at low concentrations, are neurotoxicity and carcinogenicity (Jomova and Vaiko, 2010). Therefore this study sought to quantify the contamination level of heavy metals in cultured and captured fishes in various markets of Dhaka City, and calculate the health risk to humans upon consumption of contaminated fish species based on Daily

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Intake of Metal (DIM), along with established safety limits.

Materials and Methods

Sample collection and Preparation

Five species of fish locally known as Pangas (*Pangasius pangasius),* Rui (*Labeo rohita*), Katla (*Catla catla*), Tilapia (*Orepchromis niloticusus*) and Ilish (*Tenualosa ilisha*) were collected from three different fish markets (Karwan Bazar, Mohammadpur Bazar and New Market Bazar) of Dhaka City from August, 2016 to December, 2017. Fish samples were immediately preserved in an ice box and transferred to the laboratory, where they were classified, weighed, measured and kept in a refrigerator at -22℃ for further analysis.

The fish samples were washed several times with tap water and rinsed with deionized water. Then they were sliced into small pieces (2-3 cm) with ceramic scissors, and separated into flesh (muscle), skin, gills and bones. The organ samples were again washed with deionized water and dried in an oven at 60℃ until a constant weight was observed. The dried samples were finely pulverized in a carbide mortar or hand grinder with a pestle and preserved in desiccators.

Figure 1. Preparation of fish samples and ingredience.

Analytical procedure and analysis

Dried fish samples were prepared according to the method of Jolly (2006). To prepare the samples for analysis, the dries material was transformed into pellets by applying hydraulic pressure of approximately 3 tons for 1-2 min. The powdered material (0.1 gm) was pressed to make 25 mm pellet using a pellet marker (Specac Ltd, UK). The pellets were preserved in 60 mm Petridis and kept in desiccators for subsequent analysis using Energy Dispersive X-ray Fluorescence (EDXRF) Spectrometry (Epsilon 5, PANalytical, Australia). The pellets were loaded into an X-ray excitation chamber using an automatic sample changer system and irradiated with an X-ray beam for 1000 secs. The sample irradiation was controlled by a software package provided with the system.

The main concern in this method is that both standard and sample should have a similar matrix so that they can produce identical sensitivity and the matrix effects are nullified. All samples were collected and analyzed in triplicates and the average results were used to represent the data. All calculations were performed by Microsoft Excel 2010.

Results and Discussion

The analysis of the data depicted an order of heavy metal accumulation in organs of fishes that was Zn> Br> Fe> Sr> Cu> As> Se> Pb> Rb> Hg. Bio-accumulation is related with feeding, swimming and metabolic activities of the individual and species. These heavy metal concentrations were compared with other International Organization Standards. The concentration of Zn was higher than other metals in fish organs, however Zn concentration did not exceed international standards (table 2). The levels of heavy metals in fish organs in this study were relatively lower than that of other food standards, except Pb, As, and Hg concentrations in fish.

Zn is an essential trace metal for both animals and humans. Its deficiency may be responsible for retardation of growth, loss of taste and hypogonadism, leading to decreased fertility (Siveperumal, *et al*., 2007).The mean concentration of Zn in fish muscles from different fish species is 50.40±23.40 µg/g (Table 2). The maximum concentration of Zn was found in fish species *P. pangasius* (205.16±343.13µg/g) and the minimum concentration of Zn was observed in *T. ilisha* (59.68±26.72µg/g) respectively. Comparing our observed values with International safe limits, the values of Zn are lower than the safe limits (Table 2).

Table 1. Heavy metals concentrations (Mean±SD) in fish species of Dhaka City.

Name of Fish species	Elements (µg/g)								
	Fe	Cu	Zn	Se	Rb	Sr	Hg	Pb	As
T. ilisha (Ilish)	77.90± 39.16	17.76± 5.48	59.68± 26.72	4.67± 1.44	1.44± 0.54	81.42± 78.13	0.35± 0.09	3.06± 6.18	12.98± 5.96
O. niloticus (Tilapia)	88.38± 39.52	13.16± 4.94	62.31± 77.42	4.07± 1.81	3.93± 2.66	46.84± 28.97	0.34± 0.02	7.33± 8.67	6.03± 5.44
C. Catla (Katla)	84.04± 69.09	16.72± 6.29	86.50± 63.38	4.30± 1.75	2.32± 1.22	104.87± 131.64	0.35± 0.15	4.59± 7.80	8.53± 4.61
L. Rohita (Rui)	74.36± 14.68	11.79± 5.75	67.82± 77.17	3.02± 1.64	2.41± 1.47	74.55± 87.00	0.32± 0.04	10.83± 9.92	5.96± 3.91
P. Pangasius (Pangas)	111.40± 83.23	19.75± 8.56	205.16± 343.13	12.13± 25.74	7.55± 6.58	47.20± 46.47	0.32± 0.05	1.32± 3.07	10.44± 4.61

Table 2. Heavy metal concentration in fish muscles (µg/g d.w.b) and comparison with International safe standard limits.

Organization/Country	ELEMENTS (µg/g d.w.b)						
	Zn	Fe	Cu	Pb	As	Hg	References
Present Study	50.40	74.97	15.64	3.08	10.97	0.32	
FAO/WHO	100	333.3	30		1.4	0.5	WHO, 2010
India	50	-	30	0.3	1.1	0.5	FSSAI, 2011
Malaysia	100	-	30	0.3	-	-	MFA, 1983
China	-	-	50	02	0.5	0.3	CNSMD, 2001
Saudi Arabia	50	-	20	-	1	-	SASO, 1997
European Commission	40-100	-	-	02	-	0.5-1.0	EC, 2001
International criterion	60	-	15	0.3	2	0.5	Summers, *et.al.*, 1995; HC , 2007

Cu is an essential trace element, high levels of intake can cause symptoms of acute toxicity. Cu combines with certain proteins to produce enzymes that act as catalyst to help in body functions and it is also necessary for the synthesis of heamoglobin (Sivaperumal *et al*., 2007). The mean concentration of Cu in fish muscles was15.64±4.24 µg/g. The maximum concentration of Cu was found in *P. pangasius* (19.75± 8.56µg/g) and the minimum concentration was observed in *L. rohita* (11.79±5.75µg/g) respectively.

As is acutely toxic to humans and animals. The inorganic arsenic forms are more hazardous to humans than the organic ones. It has been established that fish and seafood can accumulate a particular amount of organic arsenic from their environment. The mean concentration of As in fish muscles were found as 10.97±4.62 µg/g. The minimum and maximum As contents were found as 5.96±3.91µg/g in *L. rohita* and 12.98±5.96

µg/g in *T. ilisha* respectively. According to Bangladesh Standard, the maximum permitted concentration for As is 5.00 mg/kg, which is beneath the proposed acceptable limit for human consumption (USFDA, 1993).

Mercury (Hg) is a non-essential heavy metal and cannot be excreted easily. It can be retained in the tissues for long periods, resulting behavioral and cognitive changes, neurological impairment and lesions (Authman *et.al*., 2015). Moreover, during pregnancy, mercury can pass through the placenta to the fetus and may affect the development of central nervous system (Renieri *et.al*., 2014). The mean concentration of Hg in fish muscles was observed to be as 0.32±0.05 µg/g. The minimum and maximum Hg contents were found as 0.32±0.04 µg/g in *L. rohita* and 0.35±0.15 µg/g in *C. catla* respectively. The European Commission Regulation as well as Bangladesh Government Act stated permitted Hg concentration is 0.5 mg/kg, which is higher than our values found for selected fish species.

Lead (Pb) is a non-essential heavy metal and endures many adverse health effects including neuro toxicity and nephrotoxicity (Gercia-Leston, *et al.,* 2010). The minimum and maximum Pb levels in *P. pangasius* were observed to be at 1.32±3.07 µg/g and 10.83±9.92 µg/g in *L. rohita* respectively. The mean concentration of Pb in fish muscles was found to be at 3.08±0.73 µg/g. the maximum legislative value of Pb as described by the Commission Regulation (EC) No.1881/2006 and Bangladesh Gazette S.R.O.No.233-Act 2014 (Khalil *et. at*., 2008) is 0.30 mg/kg based on weight. The present observation showed that the levels of Pb in every fish species was above the proposed acceptable limit for human consumption.

Accumulation of metals were generally found to be species specific which may be related to their feeding habits and the bio-concentration capacity. However, the efficiency of metal uptake from contaminated water and food may differ in relation to ecological needs, metabolism and the contamination gradients of water, food and sediment as well as salinity and temperature (Mason, 2000). The concentration of heavy metals may be dependent on size, feeding habits, the bio concentration capacity of each species or ecological zone (Kwok *et.al*. 2014). The concentrations of heavy metals in fish organs were generally lower than those in current world standards except Pb and Hg (Huang, 2003 and Kumar *et.al*. 2012). Therefore, it is strongly recommended that a monitoring system be deployed, especially in polluted areas. Stricter regulations for fish culturing and farming could satisfy health and safety considerations in the fish market. The high, hazardous levels of Pb and Hg in the fish organs is alarming, since Pb and Hg in the human body tend to cause deadly diseases.

Conclusion

The international official regulatory agencies like WHO and FAO have set limits for trace metal concentrations above which the fish and fishery products are unsuitable for human consumption. However, in Bangladesh the safety levels are not monitored although fishes are major part of the human diet in Bangladesh. The average concentration of Pb, Hg and As in the present study were above permissible limits. Long-term intake of contaminated fishes could lead to toxicity of heavy metals in human beings. The results found in the present study are just a warning for us and our future generation.

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