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Heavy Metal Concentrations in Four Cultured and Captured Fishes of Rajshahi City, Bangladesh

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Abstract

The concentration of four heavy metals; chromium (Cr), zinc (Zn), cadmium (Cd) and lead (Pb) were evaluated in skin, muscle and gills of four fish species (*Labeo rohita, Oreochromis niloticus, Eutropiichthys vacha, Aspidoparia jaya*) from Rajshahi City, Bangladesh. The fishes were collected from a fish cultured pond and the river Padma, Rajshahi from October, 2017 to May, 2018 and were detected heavy metal concentrations using Atomic Absorption spectrophotometer (AAS flame machine, Japan) to highlight the importance of species and tissue selection in monitoring research, contaminant studies and human health risk assessment. The average heavy metal concentration in fish skin, muscle and gills varied in a decreasing order of Zn>Pb>Cr>Cd. The highest concentration of Zn (24.23 ± 2.35 μg/g wet wt) was found in the gills of *A. jaya*, while lowest concentration of Cd was noted in skin (0.03 ± 0.01 μg/g wet wt) of *E. vacha*. The differences in the accumulation of heavy metals may be owing to the different diet of the four species of fishes as well as the difference in the growth rates, size and environmental factors. The heavy metal concentrations of Zn,Pb,Cd and Cr were below the guideline values. Thus, the presence of these elements in the freshwater fishes may not cause any serious health risk to consumer.

Keywords

Capture; Culture; Heavy metals.

Introduction

Fresh water contamination, with heavy metal has become a matter of great concern over the last few decades, not only because of the threat it poses to public water supplies, but also because of the hazard to human consumption of fish [1-4]. Domestic, industrial and other man-made activity have affected the contamination of heavy metals in freshwater [5]. Among the environmental pollutants, heavy metals constitute one of the most dangerous groups because of their subsistence in nature, toxicity, tendency to accumulate in organisms and bio-magnifications potential and contain non-degradable chemical properties [6]. Fishes are good indicators of trace metals pollution and potential risk of human consumption [7,4] and cannot escape from the detrimental effects of these pollutants [8]. In the aquatic ecosystem, fishes are often considered as important bioindicator, because they obtain a high trophic level and are the main source of protein in the human diet [9]. It has low saturated fat and also contains omega-3, calcium, phosphorus, iron, trace elements like copper and a fair proportion of the B vitamin known to support good health [10]. It is necessary to always analysis the bioaccumulation capacity of heavy metals in the edible organisms in order to measure potential risk to human health [11]. Recently, many developing countries are continuously being contaminated with heavy metal like Bangladesh [12]. The present work was aimed at studying to determine the accumulation of heavy metal (Zn,Pb,Cd,Cr) in skin, muscle and gills of very common four fish species (*L. rohita*, *O. niloticus*, *E. vacha, A. jaya*) and their toxic effect to the consumers.

Materials and Methods

Sampling Site

The Rajshahi city is situated on the north-western part of Bangladesh, on the bank of the river the Padma. The sampling sites were located between 24°23´ N and 24°24´ E and 24°22´ N and 24°22´ E (Figure 1). The Rajshahi city has covered with hundreds of ponds and ditches. At present fish culture is very popular in this area. Rui (*L. rohita*) and Tilapia (*O. niloticus*) were collected from mixed culture pond from Katakhali of Motihar thana in Rajshahi city. Bacha (*E. vacha*) and Pioli/Jaya (*A. jaya*) were collected directly from the fishing spot of the Padma River, located near the city of Rajshahi. The greater Rajshahi District has vast fisheries resources, covering 2,39,292 ha, nearly one-third of the total land mass. There are 18,991 ha of rivers and canals, 19,889 ha of beels and 1,85,043 ha of flood plains. Temperatures in

Figure1: Location of sampling areas in Rajshahi City, (Motihar) Bangladesh.

Table 1: Length-weight, food and feeding habit of four freshwater fishes.

Species	Scientific name of the fish	Total length (cm) Mean ± Sd	Total weight(gm) mean ± Sd	Food and artificial feed	Source
Labeo rohita	Rui	27.05 ± 1.50	224.35 ± 14.33	Fish meal, mustard cake, rice bran, wheat bran, pellets etc.	Mixed culture pond
Oreochromis niloticus	Tilapia	22.13 ± 1.13	186.45 ± 11.56	Fish meal, mustard cake, rice bran, wheat bran, pellets etc.	Mixed culture pond
Eutropiichthys vacha	Bacha	14.45 ± 4.30	29.02 ± 19.58	Phytoplankton, algae, copepods, rotifers, diatoms etc.	Padma river
Aspidoparia jaya	Pioli	10.86 ± 1.73	10.44 ± 1.98	Phytoplankton, algae, diatoms, copepods, rotifers etc.	Padma river

summer reach an average of 32.9 °C, and average rain fall was recorded as about 1419 mm with great intensity for two months (July-August), causing floods.

Sample Collection

A total 40 fish sample from four species was collected from semi-cultured fish pond and the river Padma of Rajshahi city. The fish species are locally known as Rui (*L. rohita*), Tilapia (*O. niloticus*), Bacha (*E. vacha*), Pioli/Jaya (*A. jaya*). The fishes were killed with percussive stunning [13]. Then fishes were transferred in a cooler packed with ice block in order to maintain the freshness and later brought to the laboratory. The fishes were washed with tap water, and were measured total length (cm) and total weight (gm) (Table 1). Each sample carefully dissected for its skin, muscle and gills.

Sample Preparation and Digestion

To prevent metal contamination, special care was taken and tissues were dissected with special ceramic knife, scissors and plastic forceps (Miyako, California, USA). Then the skin, muscles and gills were separated carefully from the fishes. All parts of the sampling fishes were washed under distilled water and cut into small pieces. Then, for each of the sample, desired weight were taken with the help of an electric weight machine. Following that, each sample was sunk into 100% Nitric acid solution in the separate beaker and covered with foil paper to preserve it for further use. Nitric acid was taken at different conc. according to the demand of different weighted parts of the experimental fishes. Every sample was kept assiduously from 2 to 3 hours. The mixture of the samples was slowly heated using a magnetic hot plate for 15 to 20 minutes at 100°C of Nitric acid solution [14].

After cooling, the solutions were kept in different vials with proper labeling and 1ml solutions from these were mixed with 99 ml water for each of the samples. This system is applicable for every solution. Every solution was filter using filter paper to remove waste. By using pipette 20 ml solution was taken from every solution and kept in the different vials with proper labeling owing to the assessment of heavy metal by AAS Flame machine. Sample analysis was done to determine the concentration of heavy metal (Zn, Pb, Cd and Cr) in different fish organs. Analysis was done in Central Science Laboratory, Rajshahi University with the help of atomic absorption spectroscopy (AA-6800) Flame, Japan.

Results

The average length and weight of the four species are shown in Table 1. The average length and weight of *L. rohita* (n=10) were 27.05 ± 1.50 cm and 224.35 ± 14.33 gm, 22.13 ± 1.13 cm and 186.45 ± 11.56 gm for *O. niloticus* (n=10), caught from sampling pond. *E. vacha* (n=10) and *A. jaya* (n=10) were caught from Padma river with average length and weight were 14.45 ± 4.30 cm, 29.02 ± 19.58 gm as well as 10.86 ± 1.73 cm, 10.44 ± 1.98 gm.

The mean concentrations in three tissues (skin, muscle and gills) of the four fish species are presented in Table 2. The accumulation of different metals varied depending on the fish species and tissues. In *L. rohita*, the mean concentration of Zn, Pb, Cd and Cr in skin were recorded as 13.24 ± 1.33, 0.83 ± 0.28, 0.05 ± 0.02 and 0.73 ± 0.27 µg/g wet wt respectively. The mean concentration of Zn in muscle was calculated as 8.19 ± 0.77 µg/g wet wt, Pb 0.67 ± 0.41 µg/g wet wt, Cd 0.09 ± 0.03 µg/g wet wt, Cr 0.91 ± 0.33 µg/g wet wt. Zn concentration detected in gills 21.23 ± 2.87 µg/g wet wt, for Pb, Cd and Cr concentrations were calculated as 1.25 ± 0.39, 0.17 ± 0.02 and 1.15 ± 0.41 µg/g wet wt respectively. The orders of average heavy metal concentrations in skin, muscle and gills of *L. rohita* were Zn>Pb>Cr>Cd; Zn>Cr>Pb>Cd and Zn>Pb>Cr>Cd respectively.

The mean concentrations of Zn, Pb, Cd and Cr in skin of O. niloticus were calculated as 7.89 ± 1.01, 0.87 ± 0.23, 0.04 ± 0.13 and 0.67 ± 0.18 µg/g wet wt respectively. In muscle, concentrations were calculated as 12.09 ± 0.72 µg/g wet wt for Zn, 0.78 ± 0.18 µg/g wet wt for Pb, 0.06 ± 0.07 µg/g wet wt for Cd and 0.81 ± 0.21 µg/g wet wt for Cr. The mean concentrations of Zn, Pb, Cd and Cr in gills samples were 17.19 ± 1.56, 1.06 ± 0.21, 0.16 ± 0.10 and 0.91 ± 0.23 µg/g wet wt respectively. From the comparison of the heavy metals concentrations in skin, muscle and gills of O. niloticus followed the order Zn>Pb>Cr>Cd; Zn>Cr>Pb>Cd and Zn>Pb>Cr>Cd respectively.

In case of E. vacha, the mean concentration of Zn in skin 11.23 ± 0.47 µg/g wet wt, Pd 0.37 ± 0.16 ug/g wet wt, Cd 0.03 ± 0.01 µg/g wet wt and Cr 0.26 ± 0.28 µg/g w wt. In muscle Zn 9.61 ± 0.21 µg/g wet wt, Pd 0.29 ± 0.13 µg/g w wt, Cd 0.05 ± 0.03 µg/g wet wt and Cr 0.34 ± 0.17 µg/g wet wt. In gills Zn 19.77 ± 0.24 µg/g wet wt, Pd 0.47 ± 0.21 µg/g wet wt, Cd 0.08 ± 0.02 µg/g wet wt and Cr 0.45 ± 0.17 µg/g wet wt. The orders of heavy metal concentrations are Zn>Pb>Cr>Cd in skin, Zn>Cr>Pb>Cd in muscle and Zn>Pb>Cr>Cd in gills.

In A. jaya, the mean concentration of Zn in skin 6.10 ± 0.88 µg/g wet wt, Pb 0.29 ± 0.11 µg/g wet wt, Cd 0.04 ± 0.01 µg/g wet wt and Cr 0.35 ± 0.13 µg/g wet wt. In muscle Zn 11.46 ± 1.17 µg/g wet wt, Pd 0.45 ± 0.27 µg/g wet wt, Cd 0.05 ± 0.03 µg/g wet wt and Cr 0.37 ± 0.17 µg/g wet wt. In gills Zn 24.23 ± 2.35 µg/g wet wt, Pd 0.53 ± 0.25 µg/g wet wt, Cd 0.12 ± 0.01 µg/g wet wt and Cr 0.56 ± 0.21µg/g wet wt. The order of heavy metal concentrations in skin was Zn>Cr>Pb>Cd, in muscle was Zn>Pb>Cr>Cd, in gills were Zn>Cr>Pb>Cd. The average heavy metal concentration in fish skin, muscle and gills varied in a decreasing order of Zn>Pb>Cr>Cd.

Discussion

In four fish species, the gills contained the highest concentration of most of the heavy metals, followed by skin, while the muscle tissue appeared to be the least preferred site for the bioaccumulation of heavy metals.

Table 2: Concentration (µg/g wet wt) of heavy metal in different organs of four freshwater fishes.

Species	Organs	Amount of heavy metal (ug/g wet wt)			
		Mean ± Sd			
		Zn	Pb	Cd	Cr
Labeo rohita	Skin	13.24 ± 1.33	0.83 ± 0.28	0.05 ± 0.02	0.73 ± 0.27
	Muscle	8.19 ± 0.77	0.67 ± 0.41	0.09 ± 0.03	0.91 ± 0.33
	Gills	21.23 ± 2.87	1.25 ± 0.39	0.17 ± 0.02	1.15 ± 0.41
Oreochromis niloticus	Skin	7.89 ± 1.01	0.87 ± 0.23	0.04 ± 0.13	0.67 ± 0.18
	Muscle	12.09 ± 0.72	0.78 ± 0.18	0.06 ± 0.07	0.81 ± 0.21
	Gills	17.19 ± 1.56	1.06 ± 0.21	0.16 ± 0.10	0.91 ± 0.23
Eutropiichthys vacha	Skin	11.23 ± 0.47	0.37 ± 0.16	0.03 ± 0.01	0.26 ± 0.28
	Muscle	9.61 ± 0.21	0.29 ± 0.13	0.05 ± 0.03	0.34 ± 0.17
	Gills	19.77 ± 0.24	0.47 ± 0.21	0.08 ± 0.02	0.45 ± 0.17
Aspidoparia jaya	Skin	6.10 ± 0.88	0.29 ± 0.11	0.04 ± 0.01	0.35 ± 0.13
	Muscle	11.46 ± 1.17	0.45 ± 0.27	0.05 ± 0.03	0.37 ± 0.17
	Gills	24.23 ± 2.35	0.53 ± 0.25	0.12 ± 0.01	0.56 ± 0.21

HMs pollutants gradually accumulate in food chain and cause the antagonistic effects, even death. Generally, metal concentration, time of exposure, way of metal uptake, environmental conditions such as water temperature, pH, hardness, salinity and intrinsic factors such as fish age, feeding habits are the major causes of HMs accumulation [15]. Always heavy metals and trace elements are not harmful to the environment and human health but when cross the standard level they are potentially toxic to the environment [16-18]. Though Zn is an essential element in human diet but lower concentration can cause serious damage to human health [19].

Zn may show toxicity when the concentrations up to 40 mg/kg, characterized by symptoms of irritability, muscular stiffness and pain, loss of appetite as well as nausea [20] though the toxicity of Zn rare. For Zn the concentration was 6.10 ± 0.88 µg/g wet wt to 24.23 ± 2.35 µg/g wet wt in selected organs at four fishes. Pb causes behavioral deficits in vertebrates for its neurotoxin effect [21] and can cause decreases in survival, growth rates, learning, and metabolism [22,23]. The obtained results of Pb in different organs of four fishes are ranged from 0.29 ± 0.11µg/g wet wt to 1.25 ± 0.39 µg/g wet wt. If Cd accumulated higher than the guideline it injures kidneys causes severe toxic effects in higher animals [24], including impairment of kidney function, poor reproductive capacity, hypertension, tumors and hepatic dysfunction [25]. The Cd concentration was 0.03 ± 0.01 µg/g wet wt to 0.17 ± 0.02 µg/g wet wt in skin, muscle and gills at selected fishes. Depending on its concentrations and oxidation state Cr can be either beneficial or toxic to humans and animals. Because of increasing Cr(III) concentrations, it can interfere with several metabolic processes[26]. Analyzing Cr concentration was 0.26 ± 0.28 µg/g wet wt to 1.15 ± 0.41 µg/g wet wet in different fish organs. For *L. rohita* the level of Zn was 23.13 ± 2.32, Pd 6.63 ± 2.29, Cd 0.76 ± 0.27 and Cr 10.50 ± 3.54 (µg/g dry wet) and in case of *E. vacha,* Zn was 64.88 ± 46.67, Pb 12.13 ± 4.97, Cd 0.61 ± 0.81 and Cr 10.00 ± 3.92 (ug/g dry wt) detected by other authors in Nepal [27].The highest level of Cd was observed in fish samples collected from Gharbia (0.31 ± 0.05 µg/g d wt), Pb concentration was (1.05 ± 0.7 µg/g dry wet) found in fish samples from Minya, highest value of Cr was (0.57 ± 0.39 µg/g d wt) recorded in samples from Minya among the 10 province in Egypt for *O. niloticus* [28] and the level of Zn was (0.5 - 0.9 µg/g) in muscle and fish gills in Sudhan for *O. niloticus* [29].The other author suggested that concentration of Zn, Cd and Pb was 4.78 ± 0.07, 0.80 ± 0.02 and 1.37 ± 0.04 (mg/kg dry wt), in Muscles and gills of *O. bimaculatusin* Bhadra River, Karnataka (India) [30], Cr was 604.7 ± 163.0 (µg/g wet wt) in muscles and gills at River Kabul, Khyber Pakhtunkhwa (Pakisthan) [31] which is the related species of *A. jaya*. Enough research documents are not available for *A. jaya.* In our study we analyzed that the highest concentration of Zn (24.23 ± 2.35 µg/g wet wt) was found in the gills of *A. jaya*, while lowest concentration of Cd was noted in skin (0.03 ± 0.01µg/g wet wt) of *E. vacha,* the concentration of all metal stay below the guideline of FAO/WHO in the katakhali pond and Padma river (Rajshahi, Bangladesh). Cultured fishes contain more Pb, Cr and Cd (without Zn) compared to the captured fishes. The Joint FAO/WHO Expert Committee on Food Additives, suggested that there was no health risk for humans through the consumption of these fish [32].

Conclusion

This study suggests that there are low concentrations of heavy metals in the studied fish, so its consumption has no serious health risk to the consumers. Thus, regular monitoring of these toxic heavy metals in fishes are essential to prevent potential health risk to the consumers.

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