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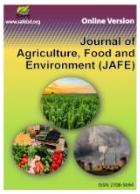

Original Article

Heavy metal contamination in tilapia, *Oreochromis niloticus* collected from different fish markets of Mymensingh District

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A B S T R A C T

The study was conducted to determine heavy metals viz; lead (Pb), Zinc (Zn), Arsenic (As), Chromium (Cr), and Cadmium (Cd) concentration in tilapia (*Oreochromis niloticus*) collected from different fish markets (Borobazar fish market, Shesmore fish market, Kamal-Ranjit market, Sutiakhali fish market, Machuabazar fish market and Shamvuganj fish market) of Mymensingh district from July 08, 2018 to January 15, 2019. After collection, electro-thermal heater digestion of the samples was carried out in Nutrition Laboratory, Department of Aquaculture, Bangladesh Agricultural University (BAU) and finally heavy metal concentrations were determined by Atomic Absorption Spectrometer (AAS) in the Interdisciplinary Institute for Food Security (IIFS) Laboratory, BAU. The average Pb, Zn, Cr, and Cd concentrations (mg/kg) in the examined samples were 1.67 mg/kg, 118.68 mg/kg, 0.97 mg/kg, and 0.59 mg/kg, respectively. The average Arsenic concentrations in all tilapia samples were found to be below detectable limit (BDL). The study revealed that the average Zn and Cr concentration of tilapia flesh samples in Mymensingh were considerably higher than maximum recommended limit of World Health Organization (1989) and Food and Agricultural Organization (1983) and hence human health safety issues for the local consumer should be taken into consideration by the concerned authorities.

Introduction

Bangladesh is the largest active deltaic country of the world. It produces massive amount (384737 MT in FY 2017-2018) of tilapia, *Oreochromis niloticus* every year (DoF, 2018) for its high nutritive values (Arruda *et al.*, 2006), containment of PUFAs (Navarro *et al.*, 2012) as well as high market demand. After being introduced in our waters, this global species has contributed in our aquaculture (10.68%) significantly to exert its roles in combating mal-nourishment, creating employment opportunities (Jim *et al.*, 2017).

Heavy metals, an important chemical pollutant group, is one of the major concerns over the decades due to their slow degradation rate, long half-life period (Ahmad *et al.*, 2018) and their entry into human body through food chains (Kaplan *et al.*, 2011), although they can be exposed to human through other media like water, air and soil, (Alexander *et al.*, 2010). Heavy metal pollution can be caused by both anthropogenic and natural intervention to the ecosystem (Yilmaz *et al.*, 2009). As being non-degradable, metals are deposited, assimilated or incorporated in water, sediment and finally bio-accumulated into aquatic animals (Abdel-Baki *et al.*, 2011) and thus aquatic organisms are most vulnerable victims of heavy metal pollution (Bernet *et al.*, 1997). Along with its carcinogenic effects (Nordberg *et al.*, 2011), in aquatic ecosystems, heavy metals like Hg, Pb, Sn, Ni, Se, Cr and As are considered as the most dangerous category of pollutants (Hassaan *et al*., 2007) that cause serious threats like liver damage, cardiovascular diseases, renal failure in human even at low concentration (Forstner and Wittman, 1981). Fish living in polluted waters tend to accumulate heavy metals in their tissues.

Generally, accumulation depends on metal concentration, time of exposure, way of metal uptake, environmental conditions (water temperature, pH, hardness, salinity), and intrinsic factors (fish age, feeding habits).

Zinc might cause nausea, vomiting, diarrhea, metallic taste, kidney and stomach damage, and other side effects. Ingestion of any significant amount of cadmium causes immediate poisoning and damage to the liver and the kidneys. Compounds containing cadmium are also carcinogenic. The bones become soft (osteomalacia), lose bone mineral density (osteoporosis) and become weaker.

Chromium may cause health problems including: allergic reactions, skin rash, nose irritations and nosebleed, ulcers, weakened immune system, genetic material alteration, kidney and liver damage, and may even go as far as death of the individual. Young children are particularly vulnerable to the toxic effects of lead and can suffer profound and permanent adverse health effects, particularly affecting the development of the brain and nervous system. Lead also causes long-term harm in adults, including increased risk of high blood pressure and kidney damage. Long-term exposure to arsenic from drinking-water and food can cause cancer and skin lesions. It has also been associated with cardiovascular disease and diabetes. In utero and early childhood exposure has been linked to negative impacts on cognitive development and increased deaths in young adults. Tilapia is widely cultured and high demandable fish species in Mymensingh as well as whole Bangladesh. It is tasty and low price fish. Hence, with the aim of evaluating whether fish are safe for human consumption or not the heavy metal concentration in tilapia collected from different markets were analyzed.

Materials and Methods

Study Area

The study was carried out in six selected markets of Mymensingh district (24.7500°N 90.4167°E), namely Shesmore fish market, Kamal Ranjit (KR) fish market, Shamvuganj fish market, Borobazar fish market, Machuabazar fish market and Sutiakhali fish market. These fish market were selected because all these markets are very popular and nearby Bangladesh Agricultural university.

Sample Collection

A total 120 (twenty from each market) fish samples were collected from six selected markets. Average size of each fish was 550-600 g. After collection the fish in icebox, the samples were immediately transported to the Fish Nutrition Laboratory, Bangladesh Agricultural University (BAU), cleaned with distilled water, stored in pre-cleaned plastic bags, sealed, labeled accordingly and kept frozen in an ice box.

Electro-Thermal Heater Digestion

After acid treatment by 10 ml of nitric acid and 5 ml of perchloric acid solution, exactly 1 g of sample was digested at 80˚C for 30 minutes in an electro-thermal heater. After cooling in room temperature, in a clean volumetric flask double distilled water was added to the digestion to make the volume exactly 100 ml. The solution was then filtered through Whatman filter paper No. 42 and finally kept in the air tight plastic bottle with proper labeling.

A blank containing same digestion inputs except samples was prepared using identical procedure to ensure that the samples and chemicals used were not contaminated (Shovon *et al.,* 2017).

Sample Analyses

Analysis of the heavy metal content of the samples was performed with a flame atomic absorption spectrophotometer (Model Shimadzu AA-7000) using acetylene gas as fuel and air as an oxidizer. Digested samples were aspirated into the fuel-rich air acetylene flame and the metal concentrations were determined from the calibration curves obtained from standard solutions (Skoog *et al.,* 2005). Each determination was based on the average values of three replicate samples. The term BDL (below detectable limit) is defined as the limit (0.001 mg/kg) under which concentration of heavy metals can't be determined by the flame atomic absorption spectrophotometer (Model Shimadzu AA120 7000). To prevent the precipitation of metals and to avoid microbial activity samples are acidified.

Data processing

After the analysis of heavy metals of collected tilapia, all the recorded data were collected and processed using Microsoft-Excel (2010).

Results and Discussion

This study was undertaken to investigate heavy metal concentrations in edible parts (muscles) of a commercially important fish species (*Oreochromis niloticus*) in Mymensingh, Bangladesh and to detect whether their levels are potentially harmful for human health or not. The overall findings are tabulated on Table 1.

Table 1. Analyzed value of heavy metal concentration in tilapia collected from different fish markets in Mymensingh.

Different Fish Markets	Level	Concentration of heavy metals (mg/Kg)				
		Pb	Zn	As	Cr	Cd
Shesmore	*Av.	1.6432	96.6767	**BDL	1.6091	1.1379
	***Max.	2.6977	101.7921	BDL	2.0211	1.9801
	****Min.	BDL	93.0217	BDL	BDL	0.0443
Kamal Ranjit (KR)	Av.	3.2441	98.6234	BDL	0.8893	0.3502
	Max.	4.0271	121.1952	BDL	1.7211	0.7250
	Min.	2.4372	81.1623	BDL	0.2431	BDL
Shamvuganj	Av.	1.0562	137.8550	BDL	0.5876	0.9833
	Max.	2.1423	140.7759	BDL	1.3024	1.6522
	Min.	0.0521	134.8446	BDL	BDL	0.1913
Borobazar	Av.	1.4535	87.0777	BDL	0.9351	0.3523
	Max.	2.7011	87.2961	BDL	1.6911	0.9821
	Min.	0.8245	86.7523	BDL	0.0492	0.0246
Machuakhali	Av.	0.3058	150.5175	BDL	0.5423	0.5201
	Max.	1.0448	151.0121	BDL	1.6521	1.0511
	Min.	BDL	150.0219	BDL	BDL	BDL
Sutiakhali	Av.	2.3195	141.3503	BDL	1.2775	0.2055
	Max.	2.8711	143.0211	BDL	2.0561	0.5236
	Min.	1.9774	140.0211	BDL	1.9728	BDL

*Av=Average, **BDL=below detection limit, ***Max=Maximum, ****Min=Minimum

Lead (Pb) concentration

The maximum concentration (3.24 mg/kg) of Pb was found in fish from KR market and the minimum concentration (0.31 mg/kg) was from Machuabazar (Table 2). Though Average Pb concentration in tilapia from different fish markets in the Mymensingh was below the maximum limit (2.00 mg/kg) recommended by WHO (1989) and FAO (1983), Pb found in the fish from KR market (3.24 mg/kg) and Sutiakhali (2.32) were considerably higher. The causes of high amount of metals in fish was may be source of fish. Fish may be cultured in heavy metal contaminated water body or the feed used in those farm were made from contaminated feed ingredient.

Table 2. Average Pb concentrations (mg/kg) of tilapia collected from different fish market in Mymensingh district compared to the maximum recommended limit of WHO (1989) and FAO (1983).

Market	Pb Concentration (mg/kg)	Max. recommended limit (WHO, 1989 and FAO, 1983)
Shesmore	1.6432	2.00
KR market	3.2441	
Shamvuganj	1.0562	
Borobazar	1.4535	
Machuakhali	0.3058	
Sutiakhali	2.3195	

The Pb does not have a significant biological function in the fish rather Pb consumed by human are not metabolized and hence accumulate in the body (Yousafzai *et al.,* 2009). The resulted Pb concentrations in the fish sample analyzed ranged from 0.3058 to 3.2441 mg/kg with an average of 1.149683 mg/kg. The finding is far higher than the findings from Taweel, 2013 and little lowers than Das e*t al.,* 2017. However, result from current study below the max. recommended level by WHO (1989) and FAO (1983) indicates that the lead contamination in tilapia fish tissue are not so significant from the aspect of human health safety issues.

Zinc (Zn) concentration

Maximum concentration of Zn was found 150.52 mg/kg in the samples from Machuabazar while the minimum was recorded 87.08 mg/kg from Borobazar (Table 3). Fishes collected from Shesmore fish market, KR market and Borobazar fish market retained Zn near the recommended level.

Table 3. Average Zn concentrations (mg/kg) of tilapia collected from different fish market in Mymensingh district compared with the maximum recommended limit of WHO (1989) and FAO (1983).

Market	Zn Concentration (mg/kg)	Max. recommended limit (WHO, 1989 and FAO, 1983)
Shesmore	96.6767	100
KR market	98.6234	
Shamvuganj	137.8550	
Borobazar	87.0777	
Machuakhali	150.5175	
Sutiakhali	141.3503	

Though Zinc serves as a co-factor of enzymes involved in the metabolism of the fish (Tapia *et al.,* 2012; Irerhievwie and Akpoghelie, 2015), bio-accumulation of excessive Zn in the flesh of fish can cause toxicity, slow growth and reproductive disorders (Ntiforo *et al.,* 2012), dizziness, rapid fatigue and decrease of immune system functions (Ugokwe and Awobode, 2015) in human. In present study, the average concentrations of Zn in tilapia samples ranged from 87.08 to 150.52 mg/kg with an average value of 118.68 mg/kg. The observations on Zn were higher than the other studies (Dural *et al.,* 2007; Ahmad and Naim, 2008; Turkmen *et al.,* 2008 and Raja *et al.,* 2009; Rejomon *et al.,* 2010; Fariba *et al.,* 2009). Though fishes from KR market, Borobazar and shesmore has a quite lower, average value crossed the max. recommended limit of WHO (1989) and FAO (1983). This insists that fishes from these areas are not safe for human consumption.

Arsenic (As) concentration

The experiment revealed that all fish samples contained Arsenic below detectable level (BDL) in Mymensingh region that was far below from the maximum recommended limit of WHO, (1989) and FAO (1983) (Table 4). Kumar *et al.* (2012) estimated the lower amount of As content in fish muscle collected from North East coast of India which is harmonious to our finding. The causes of low amount of As in experimental fish was may be source of fish is good source. Fish may be cultured in heavy metal free water body or the feed used in those farm were made from contamination free feed ingredient or fish was come contamination free natural water body. Further research need to be done to know the source of the heavy metal in fish.

Table 4. Average As concentrations (mg/kg) of tilapia collected from different fish market in Mymensingh district compared with the maximum recommended limit of WHO (1989) and FAO (1983).

Market	As Concentration (mg/kg)	Max. recommended limit (WHO, 1989 and FAO, 1983)
Shesmore	BDL	0.05
KR market	BDL	
Shamvuganj	BDL	
Borobazar	BDL	
Machuakhali	BDL	
Sutiakhali	BDL	

Chromium (Cr) concentration

Study revealed that the concentration of Cr can be ordered as follows: Shesmore > Sutiakhali>Borobazar >KR market> Shamvuganj> Machuabazar with the values of 1.61mg/kg, 1.28mg/kg, 0.94mg/kg, 0.89mg/kg, 0.59mg/kg and 0.54 mg/kg, respectively (Table 5). All values crossed the maximum recommended limit of WHO (1989) and FAO (1983).

Table 5. Average Cr concentrations (mg/kg) of tilapia collected from different fish market in Mymensingh district compared with the maximum recommended limit of WHO (1989) and FAO (1983).

Market	Cr Concentration (mg/kg)	Max. recommended limit (WHO, 1989 and FAO, 1983)
Shesmore	1.6091	0.05
KR market	0.8893	
Shamvuganj	0.5876	
Borobazar	0.9351	
Machuakhali	0.5423	
Sutiakhali	1.2775	

The present study revealed that the range of Cr in different fish market was 0.54 to 1.61 mg/kg and average concentration of Cr in fish sample was 0.97 mg/kg. The finding is far lower than Eneji *et al.*, (2011), though more or less similar to Das *et al.,* (2017). Containment of Cr concentration much higher than max. recommended level by WHO (1989), European Union (2003a), and FAO (1983) elicits the long-term sufferings from Cr toxicity in human upon consumption of contaminated fish.

Cadmium (Cd) concentration

As shown in Table 6, the average concentrations of Cd were in a range of 0.21 to 1.14 mg/kg. However, 1.00 mg/kg was the maximum recommended limit of WHO (1989) and FAO (1983) and average Cd concentration was lower than the maximum recommended limit of WHO (1989) and FAO (1983).

Table 6. Average Cd concentrations (mg/kg) of tilapia collected from different fish market in Mymensingh district compared with the maximum recommended limit of WHO (1989) and FAO (1983).

Market	Cd Concentration (mg/kg)	Max. recommended limit (WHO, 1989 and FAO, 1983)
Shesmore	1.1379	1.00
KR market	0.3502	
Shamvuganj	0.9833	
Borobazar	0.3523	
Machuakhali	0.5201	
Sutiakhali	0.2055	

Cadmium exposure even at low level can cause DNA damage and stress, toxicity and carcinogenicity and usually accumulates profoundly in kidney and liver **(**Matovic *et al.* 2011). The concentrations of Cd in the analyzed fish samples ranged from 0.21 to 1.14 mg/kg and average concentration of Cd in fish sample was 0.59 mg/kg. The value is quite similar to the concentration in tilapia liver (Hossain *et al*., 2016) and lower than the outcomes Das *et al.* (2017). Kumar *et al.* (2012) recorded Cd concentration in fish tissue were 0.01-1.10 µg g-1 dry wt. from North East coast of India. Ashraf and Hamami (2006) studied 57 samples of canned tuna fish and found the concentration of Cd ranged between 0.08 and 0.66 mg/kg which is lower than the present findings. Ahmed *et al*. (2009) investigated the heavy metal concentration in fish from the Shitalakhya River, Bangladesh and found seasonal variation of Cd, ranged from 1.09 to 1.21 mg/kg which was so much higher than the present findings. However present study revealed that Cd in fishes are lower than recommendation of WHO (1989) and FAO (1983).

According to the study the resulted ranking of heavy metals followed the Zn>Pb>Cr>Cd>As ascending order that is quite agreed with the findings from Das *et al.*, (2017) and Hossain *et al.*, (2016).

Conclusion

It is an evidence from this study that the presence of heavy metals in the aquaculture environment is of global importance as they play a critical role in the bioaccumulation of heavy metals especially when they passed on to human being through the consumption. Therefore, to maintain the food chain safe from the entering of heavy metals and the subsequent consequences, it is necessary to have definite standards for heavy metals for all possible pathways towards food chain. Further research should be done to ensure the source of heavy metal contamination both in farm and natural water body tilapia. After identify the source of contamination, the responsible authority should take the necessary steps to avoid bioaccumulation of heavy metal in fish.

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