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Concentration of Heavy Metals in Available Fish Species (Bain, *Mastacembelus armatus*; Taki, *Channa punctatus* and Bele, *Glossogobius giuris*) in the Turag River, Bangladesh

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Abstract. This study was conducted to assess the concentration level of heavy metals in three available fish species (Bain, *Mastacembelus armatus*; Taki, *Channa punctatus* and Bele, *Glossogobius giuris*) of the Turag river, Bangladesh during the months from January to March, 2014. In case of bio-concentration of heavy metals in fish, the levels of Pb, Cd, Cr, Cu and Fe ranged from 0.01-0.13 mg/kg, 0.001-0.02 mg/kg, 0.17-0.48 mg/kg, 0.30-0.74 mg/kg and 4.05-46.86 mg/kg, respectively while Hg was below detection level. These values indicate that the heavy metals were concentrated in fish flesh at a higher level than water. The highest values of Pb, Cd and Cr were found in Bain fish, Fe was found in Taki fish and Cu was found in Bele fish. Most of the heavy metals have crossed the permissible limits in fish, especially for the values of Cr, Cu and Fe. From the results of the present investigation, it can be concluded that the available fish species are harmful for their consumers.

Keywords: heavy metals, river fish, bio concentration, ecosystem

Introduction

Environmental problems related to heavy metals have a long history worldwide (Khan, 2008). Heavy metals can cause harm to human, animals and other organisms. As fish are often at the top of aquatic food webs and may concentrate large amounts of metals from the water and sediments, heavy metals can enter into human body very easily (Mansour and Sidky, 2002). But people commonly have no awareness about this problem and most of them have no knowledge about heavy metal exposure and its effects on health, especially in the developing countries.

The river Turag running by the side of the Dhaka City, the capital of Bangladesh, is one of the most polluted rivers in Bangladesh (DoE, 2003) and has been steadily experiencing complicated problems like pollution and encroachment that have almost suffocated the valuable lifelines of the city (Hossain, 2011). Main pollution sources of the Turag river water are various consumer goods industries and most of the industries discharge their effluents directly or indirectly into the Turag river without any treatment causing pollution of the surface water (Rahman *et al.,* 2012).

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The river water is already polluted by various heavy metals discharging from industrial wastewaters and contamination of freshwater fish with heavy metals (HMs) is a recognised environmental problem (Staniskiene, 2006). Fish resources play an important role in the economy of Bangladesh, accounting for about 5% of GDP and it is an important source of protein (MFL, 1998). Fisheries in Bangladesh contribute its role in mitigating animal protein shortage as well as providing jobs to millions of people. Fish provides 63% of the total animal protein supply and the per capita annual fish intake is about 15.04 kg (Sarder, 2007). As fish is an important natural resource and good food source, it is very much needed to know the concentration levels of harmful heavy metals in fish living in polluted water. The present study was conducted by considering this reason for leading a safer and better life. As Turag river water is very much polluted, only the fish species that can survive in polluted water and in low DO level of water are available here. In the present study, 3 available fish species i.e., *M. armatus* (Bain), *C. punctatus* (Taki), and *G. giuris* (Bele) were collected from Turag river and analysed for some heavy metals to know their concentra-tions in the muscles of those fish species.

Fig. 1. Map showing the Turag River and the study area.

Materials and Methods

Sample collection. Samples of three fish from each of the 3 available species *(Mastacembelus armatus, Channa punctatus,* and *Glossogobius giuris)* were collected from Ashulia bridge area (Table 1) and kept them in an ice-box.

Fish samples were collected for 3 times in January, February and March, 2014. After collection, the samples were preserved and labeled properly and kept at -20 °C. Then the fish samples were analysed for heavy metals (Pb, Cd, Cu, Cr, Hg and Fe) at Institute of National Analytical Research and Service (INARS), BCSIR Laboratories, Dhaka, Bangladesh.

Table 1. Fish specimens (3 specimens for each species) recollected from Turag river in Bangladesh

S. No.	Local name	Scientific name
Species 1	Bain	*Mastacembelus armatus*
Species 2	Taki	*Channa punctatus*
Species 3	Bele	*Glossogobius giuris*

Sample analysis. ***Sample preparation.*** For heavy metal analysis, ashing process was followed for fish samples except Hg. At first the fish were gutted and flesh was separated. The flesh was put in a watch glass for each sample. Then they were weighted (above 10 g for each sample) properly and taken in dry beakers. The beakers were put in furnace at 100 °C for 1 h, then at 200 °C for 1 h, then at 300 °C for 1 h and then at 450 °C for 4-5 h until the samples became totally dry or ash. After drying in furnace, concentrated HNO_3 and distilled water (1:1) were added in the beakers to make them wet. Then the beakers were put in hot-plate and evaporated until they were dry again. After that the beakers were kept in the furnace at 550 °C for 5-6 h. After taking out from the furnace, 20 mL HNO_3 was put into each beaker. Then they were put on the hot-plate by keeping watch glass on each beaker and heated until boiling.

After boiling the beakers were taken out from the hot-plate. Then the samples were taken in 50 mL volumetric flasks and filled with distilled water up to the mark. At last they were filtered and preserved in labeled containers for each sample.

For Hg analysis in fish, acid digestion process was followed. At first the weight (above 10g for each sample) of the fish samples were taken properly and then 20 mL HNO_3 and 10 mL $HClO_4$ were added to each sample in beakers. The beakers were boiled on the hot-plate until the samples became totally colourless. Then they were taken in 50 mL volumetric flasks and filled with distilled water up to the mark. After that the samples were filtered properly and kept in separate containers (APHA, 1998).

Instrumental analysis. The Pb, Cd and Cr concentrations of fish samples were analysed using Zeeman Atomic Absorption Spectrometer (Model: Varian, AA 240Z and Method: APHA 3113.B). The prepared samples were taken in vials and put in specific positions of Atomic Absorption Spectrometer (AAS) (AA 240 Z). Hg concentration of water samples was analysed using Cold Vapor Hydride Generation Atomic Absorption Spectrometer (Model: Varian, AA 220FS and Method: APHA 3112.C). Cu and Fe concentrations of water samples were analysed using Flame Atomic Absorption Spectrometer (Model: Varian, AA 240FS and Method: APHA 3111.B) (APHA, 1998). The recovery ranges for each parameter were 100% ± 20%. The detection limit for Fe, Cu, Cr, Cd, Hg and Pb were 0.027, 0.01, 0.0035, 0.00012, 0.00019 and 0.003 ppm, respectively. For lower concentration of heavy metals, the samples were pre-concentrated and for higher concentration of heavy metals, the samples were diluted. The standards used for Pb, Cd, Cr, Cu, Hg and Fe were 30 ppb, 2 ppb, 10 ppb, 10 ppb, 5 ppm and 1 ppm, respectively.

Results and Discussion

Heavy metals in fish. ***Lead (Pb).*** The highest value (0.13 mg/kg) of Pb was observed in species 3 in January and the lowest (0.01 mg/kg) was observed in species 2 in January (Table 2). The order of Pb accumulation in fish is kidney> gill> liver> muscle (Abdel-Baki, 2011). Afrin *et al.* (2014) found the highest value of Pb in Ashulia bridge area of the Turag river water as 0.005 mg/L in March, 2014.

Lead (Pb) can affect every organ and system in the body (CHSR, 2009). The symptoms of acute lead poisoning are headache, irritability, abdominal pain and various symptoms related to the nervous system. Long-term lead exposure may also give rise to kidney damage and long-term low-level lead exposure in children may lead to diminished intellectual capacity. Experiment suggests a weighted mean decrease in IQ of 2 points for a 0.48 μmol/L (10 μg/dL) increase in blood lead level (Jarup, 2003).

Ahmad *et al.* (2010) found the highest level of Pb in chapila (*Gonialosa manmina*), (13.52 mg/kg) during monsoon and the lowest in tatkeni, *Cirrhinus reba* (8.03 mg/kg) during pre-monsoon in the Buriganga river. Ahmed *et al.* (2009b) studied the heavy metal concentration in fish from the Dhaleswari river, Bangladesh and found the seasonal variation of Pb from 7.03 to 12.18 mg/kg. Ahmed *et al.* (2009a) investigated the heavy metal concentration in fish and oyster from the Shitalakhya river, Bangladesh and found seasonal variation of Pb ranging from 9.16 to 13.09 mg/kg. These values differ from the present study because the values of Pb were observed in the whole body in the previous results. But it was observed only in the muscle or flesh of fish in the present study, where the bio-accumulation level is very low.

According to Indrajith *et al.* (2008), concentration of Pb ranged from 0.01-0.08 mg/kg in *E. suratensis* and 0.004-0.06 mg/kg in *A. commersoni* in Negombo estuary, Srilanka. Nwani *et al.* (2010) studied the mean concentration of Pb in the muscle of the six fish species which

Table 2. Concentrations of heavy metals (mg/kg) in fish (flesh) samples

Heavy metals	Species 1			Species 2			Species 3		
	Jan 2014	Feb 2014	Mar 2014	Jan 2014	Feb 2014	Mar 2014	Jan 2014	Feb 2014	Mar 2014
Pb	0.03	0.1	0.03	0.01	0.03	0.06	0.13	0.02	0.03
Cd	0.003	0.02	0.005	0.001	0.01	0.007	0.003	0.002	0.003
Cr	0.48	0.36	0.27	0.27	0.17	0.30	0.42	0.30	0.43
Cu	0.61	0.74	0.72	0.43	0.30	0.60	0.76	0.48	0.63
Hg	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.	N. D.
Fe	7.08	5.83	8.41	4.85	8.46	46.86	8.03	4.05	5.70

*N. D. = Not Detectable

varied from minimum of 0.10±0.01 mg/kg to a maximum value of 0.31 ± 0.01 mg/kg in lotic freshwater ecosystem at Afikpo, Nigeria. Daka *et al.* (2008) obtained 0.01-0.06 mg/kg for Pb in fish species from Azuabie Creek in the Bonny Estuary, Nigeria. Oguzie (2003) reported Pb concentration of 0.007-0.03 mg/kg in fishes from Ikpoba River Nigeria. Burgera and Gochfeld (2005) found Pb ranged from 0.04 to 0.12 mg/kg in some marine fish of New Jersey, USA. The previous values are mostly similar to the present study.

Cadmium (Cd). Here, the highest value (0.02 mg/kg) of Cd was observed in species 1 in February and the lowest (0.001 mg/kg) was observed in species 2 in January (Table 2). The order of Cd accumulation in fish is liver > gill > kidney > muscle (Abdel-Baki, 2011). Afrin *et al.* (2014) found the highest value of Cd in Ashulia bridge area of the Turag river water as 0.00003 mg/L in January, 2014.

Cadmium and their compounds are known human carcinogens. Ingesting very high levels severely irritates the stomach, leading to vomiting and diarrhoea. Long-term exposure to lower levels leads to a buildup in the kidneys and possible kidney disease, lung damage, and fragile bones (CHSR, 2009).

According to Ahmad *et al.* (2010), Cd concentration was the highest in batashi, *Neotropius atherinoides* (1.25 mg/kg) during monsoon and the lowest in tatkeni, *Cirrhinus reba* (0.73 mg/kg) during post-monsoon in Buriganga river. Ahmed *et al.* (2009b) studied the heavy metal concentration in fish from the Dhaleswari river, Bangladesh and found the seasonal variation of Cd (0.52-0.8 mg/kg). Sharif *et al.* (1993) studied the heavy metal concentration in *T. vagina* and found the concentration of Cd as 0.11 ± 0.00 mg/kg (dry weight basis). All these values differ from the present study due to different accumulation levels of Cd in different organs of fish and also for abundance of Cd enriched pollutants in water.

According to Indrajith *et al.* (2008), concentration of Cd ranged from 0.002 to 0.048 mg/kg in *E. suratensis* and 0.001-0.030 mg/kg in *A. commersoni* in Negombo estuary, Srilanka. Burgera and Gochfeld (2005) found Cd ranged from 0.0001 to 0.01 mg/kg in some marine fish of New Jersey, USA. The values of the previous study are mostly similar to the present study.

Chromium (Cr). The highest value (0.48 mg/kg) of Cr was observed in species 1 in January and the lowest (0.17 mg/kg) was observed in species 2 in February (Table 2). The order of Cr accumulation in fish is kidney > gill > liver > muscle (Abdel-Baki, 2011). Afrin *et al.* (2014) found the highest value of Cr in Ashulia bridge area of the Turag river water as 0.024 mg/L in March, 2014.

Chromium (VI) compounds are toxins and known human carcinogens, whereas breathing high levels of chromium (III) can cause irritation to the lining of the nose, nose ulcers, runny nose, and breathing problems; such as asthma, cough, shortness of breath, or wheezing. Skin contact can cause skin ulcers. Allergic reactions consisting of severe redness and swelling of the skin have been noted. Long term exposure can cause damage to liver, kidney circulatory and nerve tissues, as well as skin irritation (CHSR, 2009).

According to Ahmad *et al.* (2010), Cr concentration was the highest in chapila, *Gonialosa manmina* (7.38 mg/kg) during monsoon and the lowest in tengra, *Mystus tengara* (5.27 mg/kg) during monsoon in the Buriganga river. Ahmed *et al.* (2009b) studied the heavy metal concentration in fish from the Dhaleswari river, Bangladesh and found the seasonal variation of Cr (9.38-19.65 mg/kg). Ahmed *et al.* (2009a) investigated the heavy metal concentration in fish and oyster from the Shitalakhya river, Bangladesh and found seasonal variation of Cr ranged from 8.12 to 9.07 mg/kg. All these values differ from the present study due to different accumulation levels of Cr in different organs of fish and also for abundance of Cr enriched pollutants from tannery industries in river water.

According to Indrajith *et al.* (2008), concentration of Cr ranged from 0.02-0.28 mg/kg in *E. suratensis* and 0.01-0.24 mg/kg in *A. commersoni* in Negombo estuary, Srilanka. Nwani *et al.* (2010) studied the mean concentration of Cr in the muscles of fish species which varied from minimum of 0.28 ± 0.04 mg/kg in *M. tapirus* and *C. anguillaris* to a maximum of 0.66 ± 0.04 mg/kg in *C. nigrodigitatus* and *T. zillii* in lotic freshwater ecosystem at Afikpo, Nigeria. These values are in line to the present study.

Copper (Cu). Here, the highest value (0.74 mg/kg) of Cu was observed in species 1 in February and the lowest (0.30 mg/kg) was observed in species 2 in February (Table 2). The order of Cu accumulation in fish is liver > kidney > gill > muscle (Abdel-Baki, 2011). Afrin *et al.* (2014) found the highest value of Cu in Ashulia bridge area of the Turag river water as 0.09 mg/L in March, 2014.

Cu is one of the essential elements for humans and the adult daily requirement is about 2.0 mg (De, 2005). But long term exposure to Cu has deleterious effects on human health. In case reports of humans intentionally or accidentally ingesting high concentrations of copper salts (doses usually not known but reported to be 20-70 g copper), a progression of symptoms was observed including abdominal pain, headache, nausea, dizziness, vomiting and diarrhoea, tachycardia, respiratory difficulty, hemolytic anemia, massive gastrointestinal bleeding, liver and kidney failure, and death (Stern *et al.,* 2007).

Ahmed *et al.* (2009b) studied the heavy metal concentration in fish from the Dhaleswari river, Bangladesh and found the seasonal variation of Cu (7.55-11.50 mg/kg). Ahmad *et al.* (2010) studied that Cu level was the highest (6.34 mg/kg) in chapila, *Gonialosa manmina* during post-monsoon and the lowest in tatkeni, *Cirrhinus reba* (3.36 mg/kg) during the same time in the Buriganga river. Ahmed *et al.* (2009a) investigated the heavy metal concentration in fish and oyster from the Shitalakhya river, Bangladesh and found seasonal variation of Cu ranged from 5.47-8.19 mg/kg. All these values differ from the present study due to different accumulation levels of Cu in different organs of fish and also for abundance of Cu enriched pollutants in water.

According to Indrajith *et al.* (2008), concentration of Cu ranged from 0.02 to 0.37 mg/kg in *E. suratensis* and 0.01-0.25 mg/kg in *A. commersoni* in Negombo estuary, Srilanka. Nwani *et al.* (2010) studied the mean concentration of Cu in the muscles of fish species which varied from minimum of 0.56 ± 0.03 mg/kg in *C. anguillaris* to a maximum of 1.33 ± 0.06 mg/kg in *T. zillii* in lotic freshwater ecosystem at Afikpo, Nigeria. These values are mostly similar to the present study.

Mercury (Hg). Here, the level of concentration of Hg was not detectable for all fish species (Table 2) because there was no or a very little source of Hg containing pollutants in the Turag water. Normally the order of Hg accumulation in fish is kidney > liver > muscle > gill (Abdel-Baki, 2011). Afrin *et al.* (2014) found Hg as not detectable in Ashulia bridge area of the Turag river water.

Mercuric chloride and methyl mercury are possible human carcinogens. The nervous system is very sensitive to all forms of mercury. Exposure to high levels can permanently damage the brain, kidneys, and developing fetuses (CHSR, 2009). A high dietary intake of mercury from consumption of fish has been hypothesised to increase the risk of coronary heart disease (Jarup, 2003). According to Indrajith *et al.* (2008), concentration of Hg ranged from 0.03 to 0.33 mg/kg in *E. suratensis* and 0.04-0.26 mg/kg in *A. commersoni* in Negombo estuary, Srilanka. All these values differ from the present study due to different accumulation levels of Hg in different organs of fish and also for abundance of Hg enriched pollutants in water.

Iron (Fe). The highest value (46.86 mg/kg) of Fe was observed in species 2 in March and the lowest (4.05 mg/kg) was observed in species 3 in February (Table 2). Afrin *et al.* (2014) found the highest value of Fe in Ashulia bridge area of the Turag river water as 6.33 mg/L in March, 2014.

Iron is an essential element in human nutrition. Estimates of the minimum daily requirement for iron depend on age, sex, physiological status, and iron bioavailability and range from about 10 to 50 mg/day. The average lethal dose of iron is 200-250 mg/kg of body weight, but death has occurred following the ingestion of doses as low as 40 mg/kg of body weight. Adults have often taken iron supplements for extended periods without deleterious effects and an intake of 0.4-1 mg/kg of body weight per day is unlikely to cause adverse effects in healthy persons (WHO, 2003).

Nwani *et al.* (2010) studied the concentration of Fe in the muscles (mg/kg) of the fish species which varied from minimum of 186.00 ± 0.07 mg/kg in *M. tapirus* and *C. anguillaris* to maximum of 443.20 ± 0.08 mg/kg in *C. nigrodigitatus* and *T. zillii,* respectively. These values differ from the present study due to different accumulation levels of Fe in different organs of fish and also for abundance of Fe enriched pollutants in water.

Conclusion

According to this study, heavy metals can be concentrated in fish species. The study observed a great amount of heavy metals especially Cr (0.17-0.48 mg/kg), Cu (0.30-0.74 mg/kg) and Fe (4.05-46.86 mg/kg) in fish flesh or muscle that can be lethal to fish, humans and other organisms. Concentrations of Pb (0.0-0.13 mg/kg) and Cd (0.001-0.02 mg/kg) were very low in fish and Hg was below the detection level. According to the previous studies, fish flesh or muscle has the lowest level of bio-concentration. So, the concentration levels of heavy metals are comparatively low in the present study. The concentration levels of Cd, Cr and Cu were highest in bain, *Mastacembelus armatus* (species 1).

Concentration of Pb was highest in bele, *Glossogobius giuris* (species 3) and Fe in taki, *Channa punctatus* (species 2). Highest bio-concentration levels of Pb and Cr were observed in January, Cd and Cu were observed in February and Fe in March.

In the present investigation, some heavy metals concentrations (Cr, Cu, Fe) are higher than the safe recommended values, which suggest that the Turag river is partly a heavy metal polluted river and the water and fish are not fully safe for human health and ecosystem. Again lower concentration of heavy metals (Pb, Cd) can be harmful to human health and organism in case of long term exposure.

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