Leadership in Sustainable Infrastructure

Leadership en Infrastructures Durables

Vancouver, Canada

May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

ASSESSMENT THE PRESENCE OF HEAVY METAL (HM) CONCENTRATION IN RIVER WATER AND FISH SPECIES AND ASSOCIATED HUMAN HEALTH HAZARD DUE TO THE FISH CONSUMPTION OF TURAG RIVER IN BANGLADESH

Rashid, Abdur[1, 4], Siddika, Afia[2] and Rahman, Md Tauhid Ur [3]

[1,2,3]Department of Civil Engineering, Military Institute of Science and Technology (MIST), Mirpur-1216, Dhaka, Bangladesh

[4] arashid7002@gmail.com

Abstract: Dhaka city, the capital of Bangladesh is surrounded by mainly four rivers. One of the main rivers around Dhaka city is Turag River which is highly polluted. Wastes and effluents generated from industries and houses are directly discharged into this river without any treatment. Fishes eat wastes and deposit in their tissues as a form of Heavy Metal (HM) and through food chain HM transforms to human body and create health hazard. This study focuses on assessment of concentration of HM and potential human health hazards due to consumption of two fish species namely Banded Snakehead (*Channa striata)* and Stinging Catfish (*Heteropneustes fossilis*). Concentration of four HM i.e. chromium (Cr), cadmium (Cd), lead (Pb) and arsenic (As) in river water and two fish species was measured by atomic absorption spectrophotometer and presence were further confirmed by Scanning Electron Microscopy**.** Average concentration of HM in river water varied in descending order: Cr(16.67-20.07)>As(8.84-116.2)>Pb(6.4-8.56)>Cd(0.42-0.84) µg/L, respectively. Both non-carcinogenic risk (NCR) and carcinogenic risk (CR) on human health due to HM were calculated. It is found that both total target hazard quotients (TTHQ) and total hazard index (THI) exceeds the limiting value for both female and children consumers reflecting higher potential of developing NCR. Though for male, both THI and TTHQ are below limiting value but is not considered safe as their hazard index (i.e. THI and TTHQ) are approaching to limiting values. Again, considering CR, arsenic indicated potential risk. Therefore, to consume these fish species from this river is not safe to consume.

1. Introduction

At present the aquatic environments contamination by heavy metals is a great alarm in the world as because they are toxic and long-term persistence creates subsequent accumulation in aquatic habitats. The contaminated heavy metals accumulate in microorganisms, flora and fauna, and in turn, enter into the human food chain and result in health hazards. The important causes that creates pollution of aquatic environments are manifold: untreated industrial effluentsdischarge, unplanned and rapid urbanization,use of pesticides and fertilizers, atmospheric deposition of dust/aerosols, and waste water practice in irrigation. Uncontrolled application of sewage sludge and vehicular emissions also creates aquatic environment pollution. In the developing world, urban rivers are generally used as endpoints of industrial effluents and municipal sewage discharges. Likewise, random industrialization and unplanned urbanization in Dhaka city have evidently influenced the water quality in Turag river (Islam et al., 2015).

Dhaka city which is the capital of Bangladesh is surrounded by mainly four rivers; namely the Buriganga on the south, the Tongi Khal (Drainage channels are locally known as ‘Khal’) on the north, the Turag on the west and the river Balu on the east (Fig. 1a). All the rivers around Dhaka city are highly polluted. Now-a-days, Dhaka city generates about 3500 to 4000 metric tons of solid wastes per day. Moreover, a huge number of industries have set up in and around the City during the last few years and the number of new industries are alarmingly increasing which produces huge waste and directly discharge into these rivers without any treatment (Ahmad, M. K et al. 2010). Many dyes and textile industries are established beside these rivers which are the main sources of heavy metal (UNEP-2001). Again, due to discharging untreated domestic wastes into the river leads to increase of heavy metals in river water (Khadse et al., 2008). Fishes eat wastes from the water of these rivers and deposit the pollutants in their tissues as a form of heavy metals. Lead (Pb), barium (Ba), cadmium (Cd), mercury (Hg), chromium (Cr), and arsenic (As) are mainly well-known as toxic heavy metals. The heavy metals are accumulated in tissues of fishes and bones through absorption, and transmission of these metals occurs in the human body via the food web. Heavy metals, unlike organic pollutants, cannot be chemically degraded or biodegraded by microorganisms.

Now-a-days pollution of heavy metal in fish is a great concern worldwide, as because not only a great threat to fish, but also have a huge negative effect on human health due to consumption. Among the heavy metals, it was found that Cd, Cr, Pb and As is the most toxic and create health hazards to human health. For example, Pb causes renal failure and liver damage (Lee et al., 2011). Moreover, prolonged exposure to Pb may cause mental retardation to human body and even death (Al-Busaidi et al., 2011). Cadmium directly attacks on kidney and creates the symptoms of chronic toxicity that includes impaired kidney function, poor reproductive capacity, tumors, hepatic dysfunction and hypertension (Al-Busaidi et al., 2011; Rahman and Islam, 2010). Cr and Cu cause nephritis, anuria and extensive lesions in kidney (Rahman and Islam, 2010). The type of effects can be toxic (acute, chronic or sub-chronic), carcinogenic, neurotoxic, teratogenic or mutagenic (European Union, 2002). Cr and Pb are toxic in nature and may cause carcinogenic impact on humans (Malik et al., 2010). Therefore, trace metal contamination in fishes is increasing global attention.

Bangladesh is one of the most important inland fishing nations of the world. In 2014, Bangladesh produced 1,591,190 tons of fish which were fifteenth highest in the world (FAO, 2016). At present 3.8 percent of GDP is being contributed by fisheries sector, which is 55% of animal protein intake in Bangladesh. Therefore, the heavy metal accumulation in fish and their associated health hazard is a crying need to identify. Although a number of studies have investigated heavy metal concentrations in fishes (Dhanakumar et al., 2015, Islam et al., 2015), but so far, no research has been conducted on profile of heavy metals, particularly in flesh and bones of the fish species, Stinging Catfish (*Heteropneustesfossilis*) (locally known as 'Shing') and Banded Snakehead (*Channa striata)* (Locally known as 'Taki')and their evaluation of associated health risks of the Turag river. Therefore, the present study focuses on (1) determination of concentration levels of Cd, Pb, Cr and As in water and in the edible muscle tissues (flesh) and bones of Stinging Catfish (*Heteropneustesfossilis*) & Banded Snakehead (*Channa striata)* and bio-concentration of heavy metals and (2) examination of associated human health risk potential (non-carcinogenic and carcinogenic) due to consumption.

2. Materials & methods

2.1 Study site

The study site is confined within Turag River, which surround the Dhaka City, the capital of Bangladesh. A huge number of fishermen catch fishes from these rivers which is consumed by people of Dhaka city. Since Turag River runs beside Dhaka, therefore this river was selected for study purpose. Stinging catfish and banded snakehead are the main fish species found from this river. Total 9 water samples and fish species stinging catfish and banded snakehead were collected from (N 23°53'09'', E 90°23'32.6'') and (N 23°52'51'', E 90°23'44.3'') from Turagriver. The study site is shown in Fig. (1b).

2.2 Sample collection and preparation

Fish species, including Stinging catfish and Banded Snakehead were collected directly from Turag at the end of March 2016 by catching fishes using casting fishing nets. The month March is the dry season in Bangladesh. In 2016, there was only 48 mm precipitation in the month of March in Dhaka (AccuWeather, 2016). As both the rivers are highly polluted and there was very little rain in Dhaka in march 2016, the level of Dissolved Oxygen (DO) was extremely low (0.45-0.60 mg/L). Therefore, it is too difficult to survive for fish in the lower level of DO except fishes like Stinging Catfish and Banded Snakehead.

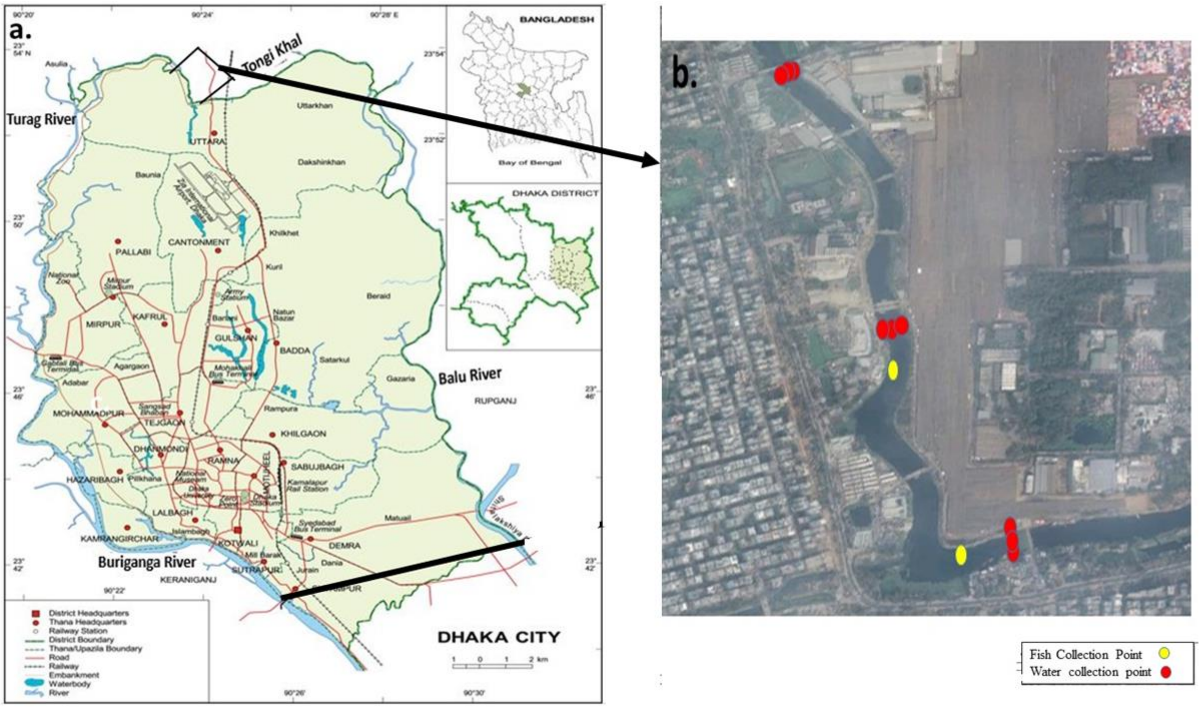

Fig. 1. Location of rivers around Dhaka City (a), Sampling points of Turag River (b)

Therefore, only two types of fishes were found from Turagriver. After collecting, the samples were kept in the refrigerator at -18^{0}C for 3 days after the arrival of environment laboratory, MIST, Dhaka, Bangladesh. The samples were divided into two major parts as bones and edible muscle tissue (flesh) using a steam cleaner stainless steel knife. Samples were washed with distilled water and made oven dry for twenty four hours at temperature 105 degree Celsius. Then it was ground and sieved using a USS #10 sieve to ensure more grinding.

2.3 Metal Extraction

1 g dry weight of the sample was taken for digestion. 10 ml of 1:1 nitric acid (HNO_3) was added and heated to 105^{o}C and refluxed for 15 minutes. The sample was cooled and 5 ml concentrated HNO_3 was added and refluxed for more 30 minutes. The sample was heated at 105^{o}C for two hours and cooled. Then 2 ml of water and 3 ml of 30% H_2O_2 was added and heated for two more hours. The sample was cooled and diluted to 100 ml with water and then filtered by the membrane filter (pore size =0.45µm). Finally, solutions were made for testing and preserved in glasses for analysis by AAS. Some dried ground samples were preserved for analysis by SEM-EDS.

2.4 Testing methods

The test was carried out according to the method 3050 B (USEPA, 2007) for fish species. Only one season data (in the month of March 2016) were measured. The amount of toxic metal analysis was carried out by atomic absorption spectrophotometer (AAS) (Model AA-6800, made in Japan) and the result was further confirmed by Scanning Electron Microscopy with Energy-dispersive X-ray spectroscopy (SEM -EDS) **(**JEOL JSM-7600F Field Emission Scanning Electron Microscope (made in USA)).

2.5. Bio-concentration factor (BCF)

Bio-concentration factor (BCF) which is the ratio between bioaccumulation of metal in fish to water provides the ability of fish to accumulate chemicals from river water. If the value of BCF >1 indicates the fish has potential to accumulate the metal. It is not considered as significant unless the value is >100. (USEPA, 1991). The formula for BCF:

[1] $BCF = C_{fish}/C_{water}$

Where, C_{fish} = concentration of metal in fish; C_{water} = concentration of metal in river water (Islam et al., 2015)

2.6. Health Risk Assessment

2.6.1 Estimated Weekly Intake (EWI)

The weekly consumption values for each species were multiplied by the measured value of Cd, Cr, Pb, and As and were divided by the average of an adult female, male and child's body weight in Bangladesh. The equation for EWI (Ozkan and Nuray, 2016):

[2] EWI = weekly fish consumption (g) × concentration of contaminant (µg/g) /body weight (b.w.) (kg).

Fish consumption in Bangladesh per capita per day in urban area is 59.9 g (Bangladesh Bureau of Statistics, 2014). Therefore, weekly fish consumption per capita was considered 419.3 g/week (wk). The average adult female, male (age 14-65 years) and child (age 0-13 years) body weight in Bangladesh are 54 kg, 46 kg and 22 kg, respectively. (Nasreen et al., 2009).

2.6.2 Hazard Index (HI) and Total Hazard Index (THI)

Hazard Index is found out by Estimated Weekly Intake (EWI) dividing Provisional Tolerable Weekly Intake (PTWI) (Ozkan and Nuray, 2016; Antonijevic et al., 2011). Therefore, equation for Hazard Index (HI):

[3] HI = EWI/PTWI

Calculated weekly intake for a specific contaminant/provisional tolerable weekly intake (PTWI): Provisional tolerable weekly intake was reported 7 µg/kg body weight (bw)/week (wk) for Cd, 25 µg/kg bw/wk for Pb (Ozkan and Nuray, 2016; JECFA., 2011), 3.5 µg/kg bw/wk for As (Joint FAO WHO Food Standards Programme, 2011) and 304 µg/kg bw/wk for Cr (Islam et al., 2015).

Total Hazard Index (THI) is calculated with the following equations:

[4] THI: $HI_{Cd} + HI_{Cr} + HI_{Pb} + HI_{As}$; HI<1, acceptable risk (AMEC E&I, INC, 2010).

2.6.3 Non-Carcinogenic and Carcinogenic risk

Non-Carcinogenic risk is assessed by total hazard Quotient. A hazard quotient provides a ratio of the potential exposure of any substance and the level at which no adverse effects are expected. If the value of Hazard Quotient is less than 1, then it is expected to have no adverse health effects as a result of exposure. If the Hazard Quotient is greater than 1, then it is likely to have adverse health effects. Hazard Quotient exceeding 1 does not mean that adverse effects will occur. The equation used to determine Target Hazard Quotient (THQ):

[5] THQ = (EF ×ED × FIR× C× 0.001)/ (RfD × WAB × TA)

EF is exposure frequency (365 days/year); (USEPA, 1989). ED is the exposure duration (years), over lifetime 70 years for non-carcinogens. FIR is the fish ingestion rate (g/day) which is approximately 59.9 g/day (fish consumption in Bangladesh per capita per day in Urban area 59.9 g) (Bangladesh Bureau of Statistics, 2014) and this consumption rate was used in health-risk assessment. *C* is the metal concentration in fish (µg/g); RfD is the oral reference dose [Cr = 3×10^{-3} µg/g/day, Cd = 1×10^{-3} µg/g/day, As = 3×10^{-4} µg/g/day (USEPA 2016), Pb = 4×10^{-3} µg/g/day (Ozkan and Nuray, 2016; Storelli and Barone, 2013)]. WAB is the average body weight. The average adult female, male (age 14-65 years) and body weight of the child (age 0-13 years) in Bangladesh are 54 kg, 46 kg and 22 kg, respectively. (Nasreen et al. 2009). TA is the averaging exposure time for non-carcinogens (365 days/year × ED). Total THQ (TTHQ) of heavy metals in individual fish is the sum of the following equation: [6] TTHQ (individual fish) =THQ (toxicant 1) +THQ (toxicant 2) +THQ (toxicant n)

Carcinogenic risk is estimated as probability of cancer developing over the lifetime exposure to that potential carcinogens. Acceptable risk levels for carcinogens 6×10^{-6} (risk of developing cancer over a human lifetime is 6 in 1,000,000)for adults and 2×10^{-6} (risk of developing cancer over a human lifetime is 2 in 1,000,000)for adolescents (AMEC E&I, INC., 2010). The equation used to determine the carcinogenic risk (CR) (Islam et al., 2015):

[7] $CR = (EF \times ED \times FIR \times C \times CSF_o \times 0.001)/ (WAB \times TA)$

CSFo is the oral carcinogenic slope factor of the integrated risk information system (USEPA, 2016) database, which were 1.5 and 8.5 × 10−3 $(mg/kg\text{-}day)^{-1}$ for As and Pb, respectively.

3. Results and discussion

Research on heavy metal concentration was carried for various tissues of fish such as muscles, gills, kidneys and liver (Dhanakumar et al., 2015) but this research was carried out by determining heavy metal concentration of water and fish species of bones and edible tissues as because Bangladeshi people consume only edible tissues and bones. In the following sections, results are mentioned.

3.1 Determination of trace metal of River water by AAS

Heavy metal concentration in water of Turagriver is presented in Table 1. In 2016, the average concentration of heavy metals in descending order is: Cr (16.67-20.07 µg/L) >As (8.84-16.2 µg/L) >Pb (6.4-8.56 µg/L) > Cd (0.42-0.84 µg/L). But in 2012, the concentration of heavy metals was, in descending order: As>Cr>Pb>Cd and Cr>As>Pb>Cd respectively. Considering the toxicity Reference Value (TRV) for fresh water (Islam et al., 2015; USEPA, 1999), it is observed in the Turag River that Cr, Cd and As <TRV and Pb>TRV in 2012 whereas in 2016 Cd and As<TRV and Cr and Pb>TRV. From Table 1 it is also clear that four heavy metals increased in 2016 from 2012 in Turag River because of alarmingly growing industries near river Turag. Again, Cr and Pb higher than the TRV value indicate water from this river is not safe for human use (Islam et al., 2015).

Table 1: Heavy metal concentration in river water of Turag (mean±SD)

Duration	Cd µg/L	Cr µg/L	Pb µg/L	As µg/L	Reference
March, 2016	0.63±0.21	18.37±1.70	7.48±1.08	12.52±3.68	This study
	0.42-0.84	16.67-20.07	6.40-8.56	8.84-16.2	
Feb-Mar, 2012	0.30 ± 0.007	11 ± 0.37	3.7 ± 0.05	12 ± 0.24	(Islam et al., 2015)
	0.29-0.31	10.63-11.37	3.65-3.75	11.76-12.24	
TRV*	2.2	11	2.5	150	

TRV*= Toxicity Reference Value for fresh water (USEPA, 1999)

3.2 Determination of trace metal of fish species by AAS

Four heavy metals of fish species were measured by AAS and the results are presented in Table 2. Among the three samples, highest value was noticed for Cr (2.71 µg/g) which was found in the bone of Banded Snakehead and lowest value was found in the flesh of Banded Snakehead. Ranking order of mean concentration of heavy metals are Cr (2.51 µg/g) >Pb (2.01 µg/g) >As (0.06 µg/g) > Cd (0.045 µg/g), respectively. Stinging catfish was found in the 0.04, 2.66, 2.11 & 0.05 µg/g, respectively for Cd, Cr, Pb and As. The highest value was noticed for Cr (2.66 µg/g) and lowest value was noticed for As (0.05 µg/g). Similarly, trace elements in bone and flesh of banded snakehead in the Turagriver (TTB & TTF) separately were found 0.07, 2.71, 1.59 and 0.06 µg/g and 0.03, 02.65, 1.98 and 0.06µg/g, respectively. In the bone and flesh of banded snakehead maximum value was found in Cr (2.71 and 2.65 µg/g) and minimum value was in As (0.06 µg/g).

Table 2: Concentration of heavy metal in fish species of Turag river

Sample*	Cd µg/g	Cr µg/g	Pb µg/g	As µg/g
TS(B+F)	0.04	2.66	2.11	0.05
TTB	0.07	2.71	1.59	0.06
TTF	0.03	2.66	1.98	0.06
Mean	0.05	2.67	1.89	0.06
Std Deviation	0.01	0.02	0.22	0
	0.03-0.06	**2.65-2.7**	**1.67-2.11**	**0.05-0.06**

*TS(B+F)=Turag-Shing-Bone+Flesh, TTB=Turag-Taki-Bone, TTF=Turag-Taki-Flesh

3.3 Determination of BCF

BCF is the indicator to evaluate the ability of aquatic organism to accumulate chemicals from river water. The values of BCF of Cd, Cr, Pb and As from Turag river were found to be 74.55, 145.44, 252.89 and 4.57, respectively. In all cases, the values of BCF>1 which indicate from Turag River fish species have the potential to accumulate metals. But for Cr, Pb>100 which indicate a significant value of BCF. Pb was found to be the most potential bio-concentrated element in the fish species.

3.4 Determination of HI and THI

It is calculated that consumption of heavy metal weekly is more of the children than adult female and male. Again estimated weekly intake of heavy metals consumed by an adult male, female and child was measured in mean following descending order: Cr (19.5-47.9 µg/g) >Pb (15.6-38.3 µg/g) > As (0.42-1.05 µg/g) >Cd (0.35-0.86 µg/g). (EWI) were compared with Provisional Tolerable Weekly Intake (PTWI) for Cd, Cr Pb and As which was the hazard index to determine risk to human health.World Health Organization established a 'Safe' tolerable intake for the heavy metals which is known as PTWI that is 7, 304, 25 and 3.5 µg/Kg b.w./week for Cd, Cr, Pb and As**.** HI for heavy metals of Cd, Cr, Pb and As is presented in Table 3. Considering HI for male, female and children is provided in following ranking order: Pb (0.62-1.53) >As (0.12-0.30) > Cr (0.064-0.158) > Cd (0.05-0.124). Since HI of individual heavy metal of Cr, Cd and As<1 except Pb for children (1.53), therefore Pb can be considered as most toxic heavy metal. Pb is well-known as cumulative poison. In human health many effects are observed, including Hematological effects, neurological and behavioral effects, cardiovascular effects, renal effects, and effects on the reproductive system due to accumulation of Pb. Results show that children are more vulnerable to the effects of Pb than adults. Impaired neurobehavioral development was considered to be the most critical effect (IPCS, 1995).Various systemic manifestations such as chronic obstructive and/or restrictive pulmonary disease, chronic lung disease characterized by chronic bronchitis, bronchiectasis; liver diseases such as non-cirrhotic portal fibrosis; polyneuropathy; peripheral vascular disease; hypertension; non-pitting edema of feet/hands; conjunctival congestion; weakness; and anemia are produced due to effect of As.High concentrations of arsenic, greater than or equal to 200 µg/L were found to be associated with a six fold increased risk for stillbirth during pregnancy. Skin, lung, and urinary bladder cancer are the important cancers associated with this toxicity. Specific skin diseases like pigmentation and keratosis occur due to chronic As toxicity. (Guha et al., 2011). Cr release of leather products poses problems to Cr-allergic individuals since such exposure may cause severe dermatitis. (Yolanda et al., 2014). Consumption of Cd contaminated food attacks on kidney which leads to renal dysfunction and formation of kidney stone, the skeletal system and the respiratory system in human health. (IPCS, 1992).In all cases, Children and adult women are most vulnerable (THI>1). Though THI<1 for adult men, but they are not out of danger.

Table 3: Hazard Index (HI = EWI/PTWI) and Total Hazard Index (THI) considering mean body weight of female, male and children

Sample Number	Sample	Cd PTWI µg/Kg BW/wk	Cd HI	Cr PTWI µg/Kg BW/wk	Cr HI	Pb PTWI µg/Kg BW/wk	Pb HI	As PTWI µg/Kg BW/wk	As HI	THI
					Considering Mean Body weight of female					
1	TS(B+F)	7	0.06	304	0.08	25	0.77	3.5	0.13	1.04
2	TTB	7	0.09	304	0.08	25	0.58	3.5	0.19	0.94
3	TTF	7	0.04	304	0.08	25	0.72	3.5	0.17	1.02
	Mean		0.06		0.08		0.73		0.16	1.03
					Considering Mean Body weight of male					
1	TS(B+F)	7	0.048	304	0.07	25	0.66	3.5	0.11	0.88
2	TTB	7	0.048	304	0.07	25	0.50	3.5	0.14	0.78
3	TTF	7	0.048	304	0.07	25	0.61	3.5	0.13	0.85
	Mean		0.051		0.07		0.63		0.12	0.86
					Considering Mean Body weight of Children					
1	TS(B+F)	7	0.117	304	0.17	25	1.61	3.5	0.28	2.17
2	TTB	7	0.182	304	0.17	25	1.22	3.5	0.34	1.91
3	TTF	7	0.085	304	0.17	25	1.51	3.5	0.32	2.08
	Mean		0.128		0.17		1.44		0.31	2.05

*TS(B+F)=Turag-Shing-Bone+Flesh, TTB=Turag-Taki-Bone, TTF=Turag-Taki-Flesh

3.5 Determination of THQ and TTHQ

Table 4**:** Target Hazard Quotient (THQ) and Total Target Hazard Quotient (TTHQ) considering mean body weight of female male and children.

Ser. No	Sample	Cd THQ	Cr THQ	Pb THQ	As THQ	TTHQ
			Considering Mean Body weight of female			
1	TS(B+F)	0.11	0.0023	0.69	0.22	1.02
2	TTB	0.17	0.0023	0.52	0.27	0.97
3	TTF	0.08	0.0023	0.64	0.25	0.98
	Mean	0.12	0.0023	0.66	0.24	1.01
			Considering Mean Body weight of male			
1	TS(B+F)	0.10	0.0019	0.58	0.19	0.87
2	TTB	0.15	0.0020	0.44	0.23	0.82
3	TTF	0.07	0.0019	0.55	0.22	0.84
	Mean	0.10	0.0019	0.56	0.20	0.86
			Considering Mean Body weight of Children			
1	TS(B+F)	0.23	0.0048	1.44	0.46	2.13
2	TTB	0.36	0.0049	1.08	0.57	2.02
3	TTF	0.17	0.0048	1.35	0.53	2.05
	Mean	0.26	0.0048	1.29	0.52	2.07

*TS(B+F)=Turag-Shing-Bone+Flesh, TTB=Turag-Taki-Bone, TTF=Turag-Taki-Flesh, HI and THI were further confirmed by THQ and TTHQ (Table 4). Considering THQ, it was observed that all individual values of Cd, Cr and As were below the reference dose except Pb for children. Considering TTHQ it was observed that TTHQ>1 for women and children. Therefore, reference doses were crossed which indicate likely to cause adverse health effect for children and adult women. Though TTHQ<1 for adult men, which indicate not likely to cause any adverse health effects during life time but it approaches to 1. Therefore, adult male is not out of danger.

3.6 Determination of CR

Carcinogenic Risk for As and Pb due to consumption of these fishes were calculated. Mean Values of Pb and As was 2.23×10^{-5} and 1.08×10^{-4} for female, 1.89×10^{-5} and 9.16×10^{-5} for male and 4.97×10^{-5} and 2.43×10^{-4} for children. Cancer risk above 10^{-4} is considered unacceptable and below 10^{-6} is considered to be negligible (USEPA, 1989, 2010) and risk lying between 10^{-6}-10^{-4} are generally considered acceptable range (Islam and Ahmed 2014)(Islam et al., 2015). For Pb, carcinogenic risk was within acceptable range (10^{-6}-10^{-4}) whereas for As the values were found higher than acceptable value. Therefore, potential carcinogenic risk due to consumption of these fish species from these rivers cannot be ignored.

3.7 Determination of trace metals by SEM-EDS

The presence of heavy metals is further confirmed by SEM-EDS (Fig. 2).Total 13 heavy metals were selected to confirm the presence of heavy metals. With Turag River,mass% in the fish flesh and fish bone combined (TS-B+F) of *Heteropneustesfossilis* were found in the 4.85, 0, 30.84 and 7.66%, respectively for Cd, Cr, Pb and As. The highest value was noticed for Pb (30.84%) and no value was noticed for Cr**.**

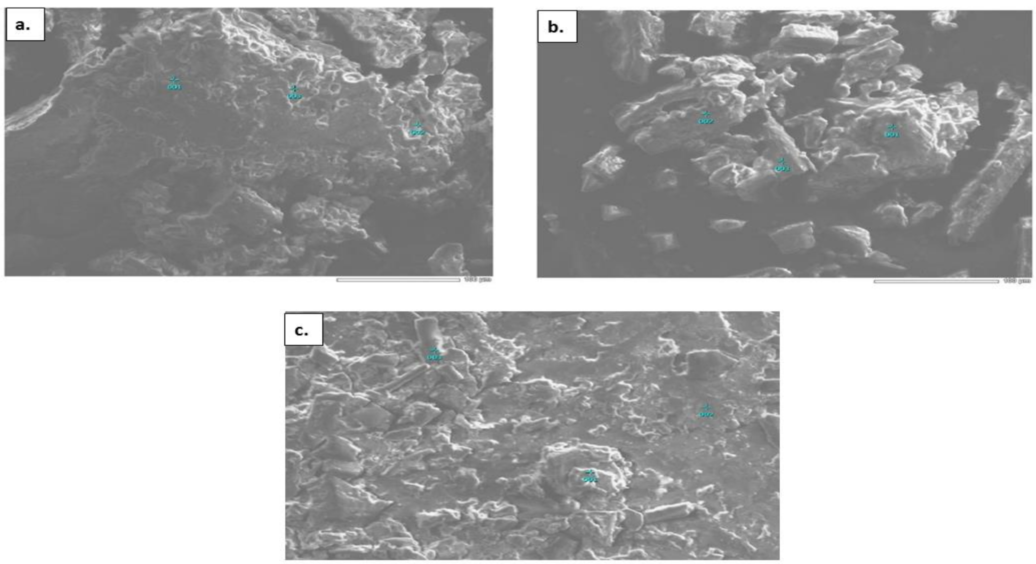

Figure 2. SEM images of surface characterization of sample (magnification 10000 µm).

TS(B+F)=Turag-Shing-Bone+Flesh (a), TTB=Turag-Taki-Bone (b), TTF=Turag-Taki-Flesh (c)

Similarly, trace elements in bone and flesh of *Channa striata* (TTB & TTF) separately were found 0, .48, 27.77 and 2.26% and 9.43, 0, 14.06 and 4.36%, respectively. In the bone and flesh of *Channa striata* maximum value was found in Pb (27.77%) and no value for Cd in bone and Cr in the flesh.

4. Conclusions

This study has shown the presence of four heavy toxic metals such as Cd, Cr, Pb and As both in water and fish of Turag River which were measured by AAS. The presence of Cd, Cr, As and Pb were further confirmed by SEM. Among the four heavy metals, Cr was found maximum in both the rivers as because of the presence of tannery and dying industries available near both the rivers and these industries directly discharges effluents into the water without treatment. Bio-concentrated Factor (BCF) shows that Pb is the most bio-concentrated element in both rivers. NCR is mainly associated with the development of hematological, neurological, behavioral, renal and cardiovascular effects. Whereas CR relates to the possibility of cancer development in different organs of the human body. Considering health point of view to human, for NCR, THI>1 for children and female which indicates the potential health risk, whereas THI<1 for male, which indicates less health risk for male in Bangladesh due to consumption of fish species. The health risk was further confirmed by TTHQ which shows identical results for children, adult female and male. Taking CR into account it was observed As is to be hazardous to human health. No step is taken to save Turagriver. More necessary steps such as discharge of effluents into the river after proper treatment of effluent treatment plant is to be ensured from industries. Further studies should investigate the ways to reduce heavy metals up to a tolerable limit acceptable to human health.

Acknowledgements

This work was supported by Higher Education Quality Enhancement Project (CP-3143) funded by the Ministry of Education, Government of the People's Republic of Bangladesh and World Bank and implemented by University of Grand Commission of Bangladesh. The authors are grateful to the authorities of Military Institute of Science and Technology (MIST), Bangladesh to complete this study. Furthermore, authors are thankful to 7 Riverine Engineer Battalion. Sincerely acknowledged to the technician and engineers of Environment Laboratory, MIST and Department of Glass and Ceramic Engineering, Bangladesh University of Engineering and Technology (BUET) for their support to complete this research.

References

AccuWeather, Inc. and AccuWeather.com, 2016.

Ahmad, M.K., Islam, S., Rahman, S., Haque, M.R., Islam, M.M., 2010. Heavy metals in water, sediment and some fishes of buriganga river, Bangladesh. *Int. J. Environ. Res. 4*, 321–332.

AMEC E&I, INC. (2010). Updated human health risk assessment report, Olin Mcintosh operable unit 2, 14 November 2011, MciNTOSH, Alabama: Author. Available online at: https://www.epa.gov/sites/production/files/201403/documents/nov_14_2011_revised_part3_updated_human_health.pdf.

Antonijevic, B., Jankovic, S., Curcic, M., Durgo, K., Stokic, E., Srdic, B., Tomic, N.D., 2011. Risk characterization for mercury, dichlorodiphenyltrichloroethane and polychlorinated biphenyls associated with fish consumption in Serbia. *Food Chem. Toxicol*. **49**, 2586–2593.

Al-Busaidi, M., Yesudhason, P., Al-Mughairi, S., Al-Rahbi, W.A.K., Al-Harthy, K.S., Al-Mazrooei, N.A., Al-Habsi, S.H., 2011. Toxicmetals in commercial marine fish in Oman with reference to national and international standards. Chemosphere 85, 67–73.

Bangladesh Bureau of Statistics, 2014. Statistical year book Bangladesh (34thed) (13 January 2016).

Bhuiya, A., Mostafa, G., 1993. Levels and differentials in weight, height and body mass index among mothers in a rural area of Bangladesh. *J Biosoc Sci.* 1993 Jan; 25(1):31-8.

Dhanakumar, S., Solaraj, G., Mohanraj, R., 2015.Heavy metal partitioning in sediments and bioaccumulation in commercial fish species of three major reservoirs of river Cauvery delta region, India. *Ecotoxicol. Environ. Saf.***113**, 145-151.

European Union, 2002. Heavy Metals in Wastes, European Commission on Environment, Available online at: http://ec.europa.eu/environment/waste/studies/pdf/heavymetalsreport.pdf.

FAO (Food and Agriculture Organization of the United Nations), 2016. Fisheries and aquaculture Department, National Aquaculture Sector over view Bangladesh.

FAO (Food and Agriculture Organization of the United Nations), 2016. Fishery and Aquaculture Statistics-2014. Rome.

Guha, M.D., Dasgupta, U.B., 2011. Chronic arsenic toxicity: Studies in West Bengal, India (Review), *Kaohsiung Journal of Medical Sciences*, Volume 27, Issue 9: 360-370.

Islam, M. S., Ahmed, M. K., Al-Mamun, M. H., Shigeki M., 2015. Assessment of trace metals in fish species of urban rivers in Bangladesh and health implications. *Environmental toxicology and pharmacology* 39, 347-357.

Programme on Chemical Safety, 1995. 2000 with reference to Environmental health criteria for inorganic lead, Food Additives Series 44.

JECFA (Joint FAO WHO Expert Committee on Food Additives), 2011. Safety evaluation of certain food additives and contaminants. WHO Food AdditSer 64.

Joint FAO WHO Food Standards Programme, 2011. Codex Committee on Contaminants in foods. Fifth Sessions.

Khadse, G.K., Patni, P.M., Kelkar, P.S., Devotta, S., 2008. Qualitative evaluation of Kanhanriver and its tributaries flowing over central Indian plateau. Environ. Monit. Assess. 147, 83–92.

Lee, K., Kweon, H., Yeo, J., Woo, S., Han, S., Kim, J.H., 2011. Characterization of tyrosine-rich Antheraeapernyi silk fibroinhydrolysate. Int. J. Biol. Macromol. 48, 223–226.

Malik, N., Biswas, A.K., Qureshi, T.A., Borana, K., Virha, R., 2010. Bioaccumulation of heavy metals in fish tissues of a fresh water lake of Bhopal. *Environ. Monit. Assess*. **160**, 267–276.

N. Mansouri, N. Khorasani, A.R. Karbassi , B. Riazi, M. Panahandeh , 2013, Assesing Human Risk of Contaminants in Anzali Wetland Fishes, International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 2, Issue 11.

Nasreen I. K., David B., Ravi N., Gary O., 2009. Implementation of food frequency questionnaire for the assessment of total dietary arsenic intake in Bangladesh: Part B, preliminary findings. Environ. Geochem. Health. 31, 221–238.

Ozkan, O., Nuray, E., 2016. Evaluation of risk characterization for mercury, cadmium, lead and arsenic associated with seafood consumption in Turkey. Expo Health 8, 43–52.

Rahman, M.S., Islam, M.R., 2010. Adsorption of Cd (II) ions from synthetic waste water using maple sawdust. Energy Sources Part A: Recov. Util. Environ. Effects 32, 222–231.

Storelli, M.M., Barone, G., 2013. Toxic metals (Hg, Pb, and Cd) in commercially important demersal fish from Mediterranean Sea: contamination levels and dietary exposure assessment. *J Food Sci***78**(2), 362–366.

UNEP (United Nations Environment Programme), 2001. Bangladesh State of the Environment Report p-48.

USEPA (US Environmental Protection Agency), 1989. Risk Assessment Guidance for Superfund, vol. I: Human Health Evaluation Manual. EPA/540/1–89/002, Office ofEmergency and Remedial Response, Washington, DC.

USEPA (US Environmental Protection Agency), 1999. Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, vol. 3, Appendix E: Toxicity Reference Values. EPA 530-D99-001C,http://www.epa.gov/epaoswer/hazwaste/combust/eco-risk/voume3/appx-e.pdf.

USEPA (US Environmental Protection Agency), 2010. Risk-Based Concentration Table, Available at: <http://www.epa.gov/reg3hwmd/risk/human/index.htm>.

USEPA (US Environmental Protection Agency), 2016. Regional Screening Levels (RSLs) - Generic Tables (May 2016) Summery Table (TR=1E-6, THQ=1).

Yolanda S. H., Carola L., Inger O. W., 2014. Correlation between bulk- and surface chemistry of Cr tanned leather and the release of Cr (III) and Cr (VI).Journal of Hazardous Materials 280: 654–661.

Zarith S. B., Mohd Y. I., 2015. Determination of heavy metal accumulation in fish species in Galas River, Kelantan and Beranang mining pool, Selangor. Procedia Environ. Sci. 30, 320 – 32.