Concentration within the prescribed limits. target hazard quotients

Concentrationof heavy metals (Cr, Cu, Zn, As, Pb and Cd) were determined to evaluate thepotential human health risks in nine different indigenous fish species inNoakhali region. Among the metals apex value was found 1. 53 mg/Kg and the nadirvalue was found 0. 51 mg/kg. The resultsrevealed that all the heavy metals were less than the permissible levels statedby the European Union, Food and Agriculture Organization, World HealthOrganization guidelines, Western Australian Food and Drug regulations, UK, Spanish, and Turkish legislations. Moderate positive correlations was found between Cuand Pb (r = 0.

57); and As and Cd (r = 0. 52). Estimated daily intake (EDI) withinthe prescribed limits. Target hazard quotients (THQ) and carcinogenic risk (CR)was calculated for find out passible health risks. Except As there was no health risk in thestudied fishes. Therefore, the examined fish species in this area can beconsidered safe for human consumption and can be exported worldwide. Inrecent decades, the quantity of fish consumed worldwide has been increasingrapidly, due to its nutritional value, with beneficial high quality proteins, low saturated fat and high omega-3 fatty acid content (Tuzen, 2009; Bosch et al., 2016; FAO, 2016; Golden et al.

, 2016). However, at present fishbecome an important worldwide concern due to heavy metals pollution, because ofthe threat to fish and the health risks associated with fish consumption. Metal concentrations when exceed certainlevel, are treated most important pollutions and do considerable harm to theenvironment (Pejman et al., 2016; Zhang et al., 2016; Otansev et al., 2016). In fishes metalbioaccumulation create long-term impacts on biogeochemical cycling (Sapkota et al., 2008; Yi et al.

, 2011; Gu et. al., 2015a). In the aquatic ecosystem, metals continuously penetrate from naturaland anthropogenic sources where they bio accumulate in the food chain andcarriage a serious threat because of their toxicity, long persistence (Papagianniset al.

, 2004). Significant sourcesare industrial waste, agricultural drainages, sewage discharge, emit fluids ofurban water supplies and gasoline from fishing boats (Mishra et al., 2007; Satheeshkumar and Kumar, 2011; Velusamy etal.

, 2014; Mathivanan and Rajaram, 2014). Heavy metals accumulate in waterand sediment columns, enter into fish body through feeding the benthic andpelagic species (Galay Burgos and Rainbow, 2001). Therefore, due to toxiceffects and bioaccumulation in food chains, heavy metals gaining priority instudied (Tao et al., 2012). Heavy metals concentrate mostly in fishmuscles. Therefore, in this study, we selected muscles as a primary site ofmetal uptake.

Since fishes are an essential component of the human diet, theyneed to carefully monitor so that, via fish consumption unnecessary high levelof heavy metals are not being transferred to human population. In Bangladesh limited number of studieshave been conducted on the concentration of trace metals in water, sediments, fish and other aquatic animals (Ahmad etal., 2010; Rahman et al., 2012; Islam et al., 2014a). Although no detailed study on trace metalsconcentration in the studied fish species has been conducted so far and metaltoxicity data severely insufficient to accomplish the risk assessment. Accordingly, there is a need for detailedinformation in order to achieve health risk assessment for the fish consumersin Bangladesh.

Therefore, the presentstudy aimed to evaluate the concentration of heavy metals in nine indigenousfish species of Meghna River in Noakhali region and to assess the human healthrisk due to fish consumption. 2. 2 Sample collection and preparation Fish samples of nine species arecollected directly from fish market which was harvested in Meghna River shownin Fig. 2. It was assured by asking some questionnaire to the fisherman.

Immediately after collection fish samples were washed thoroughly with freshwater in order to remove mud or other fouling substances and put in cleanpolythene bag and preserved at -20? C. After transportation to the laboratory, the fish samples were allowed to reach room temperature and non-edible partswere removed with the help of a steam cleaned stainless steel knife. The edibleportion of the fish samples (muscle) were then washed with distilled water andcut into small pieces (2–3 cm) using the cleaned knife over a cleanpolyethylene sheet. The samples were then air dried to remove the extra water. The processed samples were than brought to BARI (Bangladesh agricultureresearch instituted for chemical analysis 2. 3. Sample Preparation 0.

25 mg Samples were weighted individuallyby electric balance. Digestion reagents that were used included 5 mL 65% HNO_3 acid and 2 mL 30% H_2O_2. The weighed samples were then placed into thedigestion reagent in a Teflon vessel. Samples were digested in a microwavesystem (Berghof-MWS2, Berghof speed wave, Eningen, Germany). After digestion, the solution was

then filtered using Whatman 0. 42 µm filterpaper and stored in 50 mL polypropylene centrifuge tubes (Nalgene, New York). 2. 4.

Analytical methods For trace metals, samples were analyzed by using inductively coupled plasma mass spectrometer (ICP-MS, Agilent 7700 series). Multi-element Standard XSTC-13 (Spex CertiPrep, Metuchen, USA) solutions was used to prepare calibration curve. The certified reference materials were analyzed to confirm analytical performance and good precision (relative standard deviation bellow 20%) of the applied method. 2. 5 Calculations 2. 5. 1.

Estimated daily intake of metal Estimated daily intakes (EDI) for theanalyzed metals were calculated by the weight consumption an average individualin Bangladesh multiplying average concentration in composite fish samples andusing the following formula (USEPA, 1989; Ahmed. M. K at el, 2015): EDI= FIR × C (1)Where, FIR is the food ingestion rate g/person/day (Fish consumption rate for adult (60kg) residents was 49. 5 g on fresh weight basis (BBS, 2011); C is the metal concentration in fish mg/kg, wet weight (ww).

2. 5. 2. Non-carcinogenic risk In this study, the non-carcinogenichealth risks associated with the consumption of fish species were assessedbased on the target hazard quotients (THQs) and calculations were made usingthe standard assumption for an integrate USEPA risk analysis as follows (USEPA, 1989), (2) Where, THQ is the target hazard quotient; EFr is the exposure frequency (365 d/ year); ED is the exposure duration (70 years) equivalent to the average human lifetime; FIR is the food ingestion rate

(g/person/d); C is the metal concentrationin samples (mg/ kg, wet weight); BW is the average body weight (adult, 60 kg); AT is the averaging time for non-carcinogens (365 d/ year* number of exposureyears, assuming 70 years). The RfDs represent an estimate of the daily exposureto which the human population may be continually exposed over a lifetime withoutan appreciable risk of deleterious effects. RfD is the oral reference dose (mg/kg/d); RfDs are based on 1. 5, 0. 02, 0.

04, 0. 0003, 0. 001, 0.

004, 0. 3 and 0. 14 mg(kg/bw /d) for Cr, Ni, Cu, As, Cd, Pb, Zn, Mn respectively (USEPA, 2010). Ifthe THQ is less than 1, the exposed population is unlikely to experienceobvious adverse effects. If the THQ is equal to or higher than 1, there is apotential health risk (Wang et al.

, 2005), and related interventions andprotective measurements should be taken. 2. 5. 3. Carcinogenic risk   Carcinogenic risks were estimated as theincremental probability of an individual to develop cancer over a lifetimeexposure to that potential carcinogen.

Acceptable risk levels for carcinogensrange from 10/4 (risk of developing cancer over a human lifetime is 1 in 10000)to 10-6 (risk of developing cancer over a human lifetime is 1 in1000 000). The equation used for estimating the target cancer risk (lifetimecancer risk) is as follows (USEPA, 1989), (3)   Where, TR represents the target cancer risk or the risk of cancer over a lifetime; CSFo is the oral carcinogenic slope factor from the Integrated Risk InformationSystem (USEPA, 2010) database was 1. 5 (mg/kg/ d) for arsenic and 0. 0085 (mg/kg/ d) for lead. 3. Results and discussion 3. 1.

Heavy metal concentrations in fish muscles Though liver, kidneys, gills, gonad, andmuscles of fish are able to present element concentrations (Ahmed et al., 2014), the present research was done only fish muscles. Because in Bangladeshpeople do not habitually consume the other parts of fish. Table-1 shows the characteristics of 9 fish species used in thepresent study. Concentrations of heavy metals (Cr, Cu, Zn, As, Pb and Cd) inthe muscles of fish are provided in Tables-2. And their corresponding estimated daily intake (EDI) and maximum tolerable dailyintake (MTDI) for each of the elements are presented in Table-3.

Accumulation in the fish species in the study was comparedwith different published literature in Table-4. The concentration of heavy metals decreasingin fish samples were, As (1. 53) > Zn(1. 42) > Cr (1. 31) > Cu (0. 92) > Pb (0.

54) > Cd (0. 51) (mg/ Kg ww), respectively. 3. 1. 1 Chromium (Cr) Chromium is a non-essential element and does not normally accumulate in fish.

In this study the lowest mean concentrations of Cr was found as 1. 01 mg/Kg in X . cancila and the highest mean concentration was found as 1. 47 mg/Kg in G. youssoufi. In the literature Cr concentrations in Turag River was 2. 2 mg/kg, Buriganga River was 2.

8 mg/Kg, Shitalakha River was 2. 1 mg/kg which is higher than the present study. According to RDA (1989) the estimated daily intake (EDI) of chromium was 0.

20 mg/kg through fish consumption but in the present study chromium was found 0. 065 mg/Kg which is within the legal limits. The Western Australian Food and Drug regulations stated concentration of 5. 5 mg/kg for Cr which was higher than our values (Plaskett & Potter, 1979). The concentrations of Cr in studied area might be due to agricultural run- off, feeding, and farm waste.

3. 1. 2.

Cupper (Cu) Cu is an essential nutrient for human health (Demirezen and Uruc, 2006). However, high intake of Cu has been recognized to cause adverse health problem (Gorell et al., 1997). The mean lowest and highest concentrations of copper in fish species were found as 0. 59 mg/Kg in C. punctate and 1.

22 mg/Kg in H. fossilis respectively. Cu contents in the literature 2. 9 mg/Kg in Turag River, 4. 5 mg/Kg in Buriganga River, 3. 8 mg/Kg. Others value ranged from 0. 51-7.

05 mg/Kg in Aegean and Mediterranean Sea, 12. 3-20. 8 mg/Kg in Southern California. Therefore, copper levels in the fish samples were within the safe limits in terms of EDI. The maximum copper level for consumption is 30 mg/Kg wet weight (FAO, 1983). According to Australian National Health and Medical Research Council (ANHMRC) is also 30 mg/Kg (Bebbington et al., 1977; Dural et al.

, 2007). Other legislation established by UK, Spanish, and Turkish for Cu level is 20 mg/Kg (Cronin et al., 1998; Demirak et al., 2006). Considering these limit Cu concentration in the present study not exceeded the permissible limits. 3. 1.

3. Zinc (Zn) Zn plays a vital role in the physiological and metabolic process of many organisms. Nevertheless, higher concentrations of Zn can be toxic to the organism. Among the fishes G. youssoufi showed the lowest concentration and M. tengara showed the highest concentration which was 0.

97 mg/kg and 1. 92 mg/kg respectively. In the literature Zn contains ranged 3.

51-53. 5 mg/Kg in Mediterranean Sea Aegean and, 2. 88-5. 85 mg/Kg in Kichera River, 27.

8-54. 8 mg/Kg in Southern California. The maximum permissible limit of Zn in fish and fish products is 100 mg/Kg proposed by the FAO/WHO (1989). According to the England guidelines maximum limits for Zn is 50 mg/Kg (MAFF, 2015). EU set 30 mg/Kg for Zn maximum limits (EC, 2008; 2014). The estimated daily intake (EDI) of cadmium through fish consumption was found as 1.

42 mg/ d which is lower than WHO (1996). According to the present concentrations none of the fish sample found toxic for human health. 3.

1. 4. Arsenic (As) As concentrations regard a great concern due to its contamination and toxicity. Fish and other seafood account for 90% of total As exposure (USFDA, 1993). The mean zenith concentrations of As in fish samples were 1.

96 mg/Kg and the mean minor concentrations were 1. 07 mg/Kg. The estimated daily intake (EDI) of arsenic through fish consumption was found as 0. 075 mg/ d. In literature As concentrations in fish samples reported 0.

22 mg/Kg in Turag River, 0. 27 mg/Kg in Buriganga River, 0. 26 mg/Kg in Shitalakha River which were higher than present study. According to Australia New Zealand Food Standards Code and EPA, maximum As concentrations was 2mg/Kg and 1.

3 mg/Kg respectively (ANZFA, 2011; Burger & Gochfeld, 2005). None of the concentrations of As in the study exceed the permissible limits. 3.

1. 5. Lead (Pb)   Pb can cause neurotoxicity, nephrotoxicity, and many others adverse health effects (Garcia-Leston, et al., 2010). Humans can be exposed to Pb through chronic inhalation (Sankar and Ashok Kumar, 2014). Among fish species A. testudineus showed the lowest concentration 0.

09 mg/Kg and O. pabda showed the highest concentration 0. 87 mg/Kg. The maximum permitted concentration of Pb proposed by Australian National Health and Medical Research Council (ANHMRC) and UK standard committee report is 2. 0 mg/kg as wet weight basis (Cronin et al., 1998; Bebbington et al.

, 1977; Plaskett & Potter, 1979). According to Spanish legislation maximum concentration for Pb is 2 mg/kg (Demirak et al., 2006). Pb concentrations according to FAO is 0. 5 mg/Kg (FAO, 1983).

The EDI of Pb was found as 0. 026 mg/Kg which was within the limit of JECFA (2000). Pb concentrations was within the permissible condition compare with above value. 3. 1.

6. Cadmium (Cd) Cd is non-essential element and negatively affects several organs such as kidney, lung, bones, placenta, brain and the central nervous system (Castro-González and Méndez Armenta, 2008). The lowest and the highest Cd in fishes were found in 0. 02 mg/Kg and 0. 93 mg/kg in A. testudineus and P. ticto respectively.

In the literature Cd levels in fish samples reported in Turag River was 0. 018 mg/kg, Shitalakha River was 0. 036 mg/kg, Aegean and Mediterranean Sea was 0. 01-0.

39 mg/Kg, Kichera River was 27. 8-54. 8 mg/Kg which is lower than present study. But our present study within the ranged of Southern California fish species. The estimated daily intake (EDI) of cadmium through fish consumption was found as 0.

025 mg/ d which was in the limit of FAO (1983). According to the Australian National Health and Medical Research Council (ANHMRC) and Spanish legislation standard for Cd in seafood is 2. 0 mg/kg and 1. 0 mg/Kg respectively (Plaskett & Potter, 1979; Demirak et al., 2006). Other standard for Cd is 0. 5 mg/Kg; 0. 5 mg/Kg; 0.

3 mg/Kg and 0. 2mg/Kg for FAO/ WHO, EU, FAASI and England respectively (FAO/ WHO, 1989; EC, 2008, 2014; FSSAI, 2015; MAFF, 2000). Cd in the present study not exceed the value of above organization. 3.

2. Non-carcinogenic health hazard and carcinogenic risk Fish is an important dietary component. Therefore, it is essential to assess the health risks of these fish species.

Target hazard quotients (THQs) of trace metals in nine fish species are presented in Table 5. The THQ values increased in the following order As > Cd > Pb > Cu > Zn > Cr. The THQ of each metal due to fish consumption is generally less than 1. 0, except for AS. This indicate that As above the tolerable values (due to lower RfD value) in fish samples and were assessed to pose a potential risk for human consumption.

Table 5- Target hazard quotient (THQ) and Target carcinogenic risk (TR) of toxic elements dueto consumption of fish. The target lifetime carcinogenic risk (TR) of As and Pb due to exposure from fish consumption are listed in Table 5. The TR values for As and Pb from fish consumption were 1.

24 x 10-3 and 7. 01 x 10-6. In general, the excess cancer risk lower than 10-6 are considered to be negligible, cancer risk above 10-4 are considered unacceptable. And risks lying between 10-6 and 10-4 are generally considered an acceptable range (USEPA, 1989, 2010). The carcinogenic risk for Pb was within the acceptable range of 10-6 to 10-4, whereas for As was higher than the unacceptable value (10-4). Therefore, the potential health risk for the inhabitants due to metal exposure through fish consumption should not be ignored.

In addition, there are also other sources of metal exposures, such as consumption of other foodstuffs and dust inhalation, which were not included in this study. It is thus suggested that constant monitoring of both toxic and essential elements in all food commodities is needed in order to evaluate if any potential health risks of the study area do exists. 3. 3. Correlation between heavy metals in the fishes samples of three regions in Bangladesh Relationship between heavy metals among fish species evaluated with Pearson's correlation coefficient are presented in Table-6. The correlation analysis used in this study revealed that the concentrations of the metals varied in different fish samples.

Moderate significant positive correlation was noted in the fish muscle samples between Cu and Pb (r = 0. 57); and As and Cd (r = 0. 52). We hypothesize that metals with a positive correlation are possibly from the same pollutant sources (U stu n, 2009; Mansouri and Ebrahimpour, 2011), and metals with a negative correlation are possibly from different pollutant sources. The amount of trace metals accumulation in fish depends on fish's metabolic capacity, contamination in water, as well environment parameter.