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Research Paper

Assessment of Heavy Metals Contamination in Some Selected Fish Species in Ajiwa Dam and Their Impact on Human Health

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ABSTRACT
Chemical pollution in marine ecosystems is leading towards an increase in the concentrations of heavy metals in fish body, which might have a negative impact on human health through consumption of fish. This study revealed that the highest EDI value in the studied fish species (Tilapia zillii, Catfish, Marcusenius brachiystius and Bagrus bayad) was found to be for Zn followed by Fe> Pb >Cu>Cd; respectively. THQ values for all studied metals for all the fish species were>1, which indicates cancer risk due to consumption of those fish species. On the other hand, the target cancer risk for Pb was found to be within an acceptable level (10^{-4} to 10^{-6}).

KEYWORDS*: Pollution, aquatic environment, toxic metals, carcinogenicity and consumption.*

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I. INTRODUCTION

In recent years, the pollution of aquatic environment with heavy metals has become a worldwide problem because of their potential toxic effect and accumulation in tissues and organs of aquatic organisms. Heavy metals can enter the human food through water, air, soil, plants and animals[1]. The determination of toxic elements in food has prompted studies on toxicological effects of these elements in food. Fish is an important component of the human diet. It is generally appreciated as one of the healthiest and cheapest source of protein; with amino acid compositions that are richer in cysteine than most of the other sources of protein[2]. Aquatic environment is one of the receiving ends for pollutants, particularly heavy metals which are ploughed back into the food chains through bioaccumulation in plankton and invertebrates; to fishes and finally biomagnified in man. Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments and associated biota, which generally exist in low levels in water and attain considerable concentration in sediments and biota. Sediments are important sinks for various pollutants like pesticides and heavy metals while also playing a significant role in the remobilization of contaminants in aquatic systems under favorable conditions and in interactions between water and fish species[2,3].

Heavy metals pollution in fish has become a crucial worldwide concern, not only because of the threats to fish, but also due to the public health risks combined with fish consumption[4-8]. Unfortunately, however, published research concerning heavy metals contamination in most commercial fish species and their health risk assessment is very limited. Therefore, this study was designed with the aim of filling that gap, with the following specific objectives: estimating the concentrations of chromium (Cr), copper (Cu), zinc (Zn), and cadmiun (Cd) in some commercially important fish species, assessing the present status of heavy metals pollution in commercially important fish species, and assessing the human health risk for heavy metals by consuming the fishes under the study.

II. MATERIALS AND METHODS

2.1 Study Area

The area of the study covered by this work is Ajiwa dam fishing sites in Katsina state, North-western Nigeria.

The whole samples of *Tilapia zillii, Catfish, Marcusenius brachiystius* and *Bagrus bayad* fish species were collected at Ajiwa dam fishing sites through the fishermen. The samples were parked in a container of ice and transported to the laboratory for the analysis. Muscle tissues of the fish species were used in this study because people consume the muscle tissue of fish more than any other edible part of the fish.The fish tissues were cut and oven dried at 110^0C to a constant weight. At this stage, adequate care was taken to avoid any source of contamination especially for micro nutrient analysis. The dried fish tissues were individually grounded and homogenized into tiny powder with mortar and pistil before been stored in polythene bags prior to digestion[9].

2.3 Wet Digestion

5gdryweightsamplewasputinto50mLbeaker and5mLofHNO_3followed by5mLH_2SO_4 were added.WhenthefishtissuestoppedreactingwithHNO_3andH_2SO_4,the beakerwasthenplacedonahotplateandheatedat60^0Cfor30min.Afterallowingthebeakertocool,10mLofHNO_3,wasaddedandreturnedtothe hotplateandheatedslowlyat120^0C.Thetemperaturewasincreasedto150^0C,andthebeakerwasremovedfrom thehotplatewhenthesample turnedblack.ThesamplewasthenallowedtocoolbeforeaddingH_2O_2until thesamplewasclear.Thecontentofthebeakerwastransferredintoa50mLvolumetricflaskanddilutedtothemarkwith ultrapurewater.Allthestepswereperformedinafumedhood.The digested samples weretransferredintoreagentbottlesfor AAS analysis by adopting the procedure proposed by Parkin Elmer.

2.4 Health Risk Estimation

Human health risk has been estimated considering the metal concentrations in the fish species, in relation with the estimated daily intake (EDI) of the studied heavy metals by human through oral reference dose[10]. Assessment of non-carcinogenic risk was also conducted through the target hazard quotient (THQ) equation. Subsequently, human health risk assessment was also conducted for this study through carcinogenic slope factor (CSF).

2.4.1 Estimated Daily Intake (EDI)

Health risk was estimated considering the average concentrations of all fish muscles and daily heavy metal intake (EDI) following equation (1) below, as reported by [11].

$$EDI = \frac{C \times FIR \times ED \times EF}{BW \times At} \times 10^{-3} \dots\dots\dots\dots\dots (1)$$

Where:

C is the average concentration of heavy metals in fish (mg/kg dry weight); *FIR* is the rate of fish consumption (49.5 g/day/person) as reported by the BBS[12].*ED* is the exposure duration (70.65 years as average lifetime), according to the submission of [13].*EF* is the exposure frequency (365 days/year); *BW* is the average adult body weight (60 kg) as reported by [14], while*AT* is the average exposure time for non-carcinogens (assuming 70 years).

2.4.2 Non-Carcinogenic Health Hazard

Several methods for estimating the potential risks of heavy metals to human healthvia the consumption of fish, have been proposed. In this current study, the methodology of estimating target hazard quotient (THQ) provides indications of the human health risks level due to exposure to pollutants. The risks for fish consumption were assessed based on target hazard quotients (THQs) following the Eq. (2) and Eq. (3) as proposed and reported by [11 and 15], respectively. Higher THQ values mean a higher probability of experiencing long-term non-carcinogenic effects. In general, if the THQs value is less than 1, toxic effects are not expected to occur[10]. If the THQ is equal to or higher than 1, there is a potential health hazard[14]; and therefore, related interventions and protective measurements should be taken.

$$THQ = \frac{C \times FIR \times ED \times EF}{BW \times AT \times RFD} \times 10^{-3} \dots\dots\dots\dots\dots\dots (2)$$

$$THQ = \frac{EDI}{RFD} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (3)$$

By evaluating the health risk posed by the consumption of fishto local people in the area of study,the data of the heavy metals concentration from the fish muscle samples were used for risk assessment. The daily intake of heavy metals was estimated on the basis of the concentration of heavy metals in the muscle samples of the fish species under this study. The THQ values were calculated based on the following oral reference doses (RfDs) i.e. 0.004, 0.70, 0.04, 0.30 and 0.001 mg/kg/day for Pb, Fe, Cu, Zn and Cd[13,16,17].

2.4.3 Carcinogenic Risk

For carcinogens, risks were estimated as the incremental probability of an individual to develop cancer over a lifetime, as a result of exposure to that potential carcinogen (incremental or excess individual lifetime cancer risk[15]. Acceptable risk level for carcinogens ranges from 10^{-4} (risk of developing cancer over a human lifetime is 1 in 10,000) to 10^{-6} (risk of developing cancer over a human lifetime is 1 in 1,000,000).

$$TR = \frac{C \times FIR \times ED \times EF \times CSF}{BW \times AT} \times 10^{-3} \dots\dots\dots\dots\dots\dots (4)$$

All trace metals do not have carcinogenic effects. However, cadmium and lead among the studied heavy metals are considered as carcinogenic, and their carcinogenic effects have been calculated accordingly using oral carcinogenic slope factor (i.e. CSF), which has been reported by the Integrated Risk Information Systemdatabase[13, 17]. The reported CSF values for Cd (6.3) and Pb (8.5×10^{-3} mg/kg/day) were used for this study.

III. RESULTS AND DISCUSSION

Table 1: Results of Heavy Metals Analysis (in mg/kg)

Sample	Pb (mg/kg)	Fe (mg/kg)	Zn (mg/kg)	Cd (mg/kg)	Cu (mg/kg)
Tilapia Zillii	0.1647	0.5871	1.6484	0.0700	0.0298
Catfish	0.00370	0.2864	0.8023	0.0270	0.0208
MarcuseniusBrachiystius	0.1078	0.2662	0.7954	0.02013	0.0112
Bagrus Bajad	0.1184	0.3092	0.8434	0.0244	0.0256
WHO limit (mg/kg)	0.5	392	50	0.49	100

Table 2: The EDI and Hazard Analysis for Carcinogenic Risk Evaluation Expressed in mg/kg body weight/day

Metal	Fish Type	EDI(mg/kg body weight/day)	THQ	Cancer Risk
Pb	*Tilapia Zillii*	0.050	1.250	4.25×10^{-4}
	Catfish	0.001	12.810	9.56×10^{-6}
	Marcusenius Brachiystius	0.033	8.190	2.78×10^{-4}
	Bagrus Bajad	0.036	9.000	3.06×10^{-4}
Fe	*Tilapia Zillii*	0.170	12.550	N.A
	Catfish	0.087	12.400	N.A
	Marcusenius Brachiystius	0.081	11.160	N.A
	Bagrus Bajad	0.094	13.400	N.A
Zn	*Tilapia Zillii*	0.500	1.670	N.A
	Catfish	0.240	18.130	N.A
	Marcusenius Brachiystius	0.240	18.060	N.A
	Bagrus Bajad	0.256	18.540	N.A
Cd	*Tilapia Zillii*	0.021	12.130	1.34×10^{-2}
	Catfish	0.008	8.210	5.17×10^{-2}
	Marcusenius Brachiystius	0.006	6.120	3.85×10^{-2}
	Bagrus Bajad	0.007	7.420	4.67×10^{-2}
Cu	*Tilapia Zillii*	0.009	12.260	N.A
	Catfish	0.006	8.210	N.A
	Marcusenius Brachiystius	0.003	185.100	N.A
	Bagrus Bajad	0.007	19.500	N.A

N.A = not available

IV. DISCUSSION

The World Health Organization's (WHO) standard and permissible levels for the analysed metals are 0.5 mg/kg, 50mg/kg, 0.49mg/kg 100mg/kg, and 393mg/kg for lead, zinc, cadmium, copper and iron, respectively. The results indicate that the analysedmetals did not reach the permissible levels for adequate intake in human body system, this means that, the selected fish species samples from Ajiwa dam catches would not give an immediate impact in the human body with regards to the normal functioning of the cells, tissues and organs, including protein synthesis, carbohydrates metabolism, cell growth and cell division. However, excessive intake of zinc may damage the body cells and tissues, and may also interfere with smooth synthesis of DNA and protein [12, 14, 15].

From Table 1, the average concentration of lead in *Tilapia* is 0.1647mg/kg, *catfish* 0.0037mg/kg, *Marcusenius brachiystius* 0.1078 mg/kg, and for *Bagrus bajad*it is 0.1184mg/kg dry weight.The concentration of iron (Fe) in *Tilapia* is 0.537mg/kg, *Catfish* 0.2864mg/kg, *Marcusenius Brachiystius* 0.2662mg/kg, and for *Bagrus bajad*it is 0.3092mg/kg dry weight.

The concentration of zinc in the fish tissues were found as *Tilapia* 1.6484mg/kg, *catfish* 0.8023mg/kg, *Marcusenius brachiystius* 0.7954mg/kg, *Bagrus bajad* 0.8434mg/kg dry weight. The *tilapia* showed high concentration of iron among other fish tissues analysed, but does not exceed the permissible limit of WHO standard. The copper concentration in *tilapia* is 0.0298mg/kg, *catfish* 0.0208mg/kg, *Marcusenius brachiystius* 0.0192mg/kg, *Bagrus bajad* 0.0256mg/kg dry weight. The values obtained for each of the analysed samplesdid not exceed the permissible limits by World Health Organization (WHO).

For the concentration of cadmium in the fish muscle tissue, it was 0.0700mg/kg for *tilapia*, 0.0227mg/kg for catfish, while for*Marcusenius Brachiystius* it was 0.0201mg/kg, and *Bagrus bajad* has 0.0244mg/kg dry weight. The values obtained are at the permissible limits by WHO. Iron plays important role in human body metabolism. It acts as a catalyst and is present in amount to any other trace element. Iron is a constituent a haemoglobin in blood cells which transport oxygen to the various part of the body in human and animal. The excessive intake of iron caused the destruction of body cells and the system of metabolism, in addition, Raw intake of iron caused anaemia.

Copper is essential also in human body system more essential in biological activities of aminoxide and tryosinace enzymes. The enzymes are used as catalysts in many biological process. The excessive intake of copper my cause hemolytic. The excessive intake or raw intake of these metals via fish consumption may be hazardous or harmful for human body over a long period of time.

The estimated daily intake (EDI) values for each heavy metal are essential to get the non-carcinogenic effect (i.e. THQ) as well as carcinogenic (i.e. TR) effect on human; and non-carcinogenic health hazard is the ratio of EDI and reference dose (RfD). A reference dose is the United States Environmental Protection Agency's maximum acceptable oral dose for a toxic substance[13].The EDI values of the studied metals in the studied fish samples are presented in Table 2. This study revealed that the highest EDI value in the studied fish species was found to be Zn followed by Fe, Pb, Cu and Cd in that order. This result is in agreement with results obtained by[18].

The target hazard quotient (THQ) results for heavy metals in all the fish species revealed that THQ values for all metals were above 1 (Table 2), which indicates that there is health risk due to consumption of the studied species of fishes considering the present heavy metal levels.

The TR values of Pb and Cd due to exposure from different species of fishes were calculated and are presented in Table 2. It was observed from this study that TR values forPb ranged from $9.56 \times 10^{-6}$to 2.78×10^{-4}in the studied fishes. This study showed that TR values for Pb for the studied fishspecies were lower than 10^{-6} and regarded as negligible; while thecarcinogenic risk for As was not evaluated due to very low concentration(< 0.41 mg/kg). It should be mentioned here that in general, theexcess cancer risks lower than 10^{-6} are considered to be negligible,cancer risks above 10^{-4} are considered as unacceptable[13, 15]. However, risks lying between 10^{-6} and 10^{-4} are generallyconsidered as an acceptable range[19].

V. CONCLUSION AND RECOMMENDATIONS

Fishes are one of the most important food sources obtained from Ajiwa dam and the intake of toxic elements especially heavy metals from fish is of pronounced alarm as a human health risk. Metals and metalloids, for example Cr, Mn, Cu, As, and Zn, from natural and anthropogenic sources unremittingly enter the aquatic environment and pose a serious threat to ecosystems and eventually to human health. Fortunately, this study revealed that the heavy metals concentrations in all the analysed fish species from the study sites were generally low and safe for consumption.

Regular and long-term monitoring of the aquatic body and its fish species should be continued. The findings from this study could be used as future reference data (as well as fish uses as biomarker to monitor pollution status) for comparing/monitoring aquatic contamination and toxicity.

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REFERENCE

[1]. Edward J. B., Idowu E. O., Oso J. A., and Ibidapo O. R. (2013): Determination of heavy metals concentration in fish samples, sediment and water from Odo-Ayo River in Ado-Ekiti, Ekiti-State, Nigeria.*International Journal of Environmental Monitoring and Analysis*.**1**(1), pp.27-33. Available online at:www.sciencepublishinggroup.com/j/ijema. doi: 10.11648/j.ijema.20130101.14).

[2]. Igwemmar N. C., Kolawole S. A., Odunoku S. O., (2013): Heavy Metal Concentration in Fish Species Sold in Gwagwalada Market, Abuja. *International Journal of Science and Research (IJSR)*.**2**:*11*pp. 7-9. ISSN (Online): 2319-7064. Available at www.ijsr.net. Retrieved July, 2019.

[3]. Taweel, A., Shuhaimi-Othman M., and Ahmad A. K. (2011): Heavy metals concentration in different organs of tilapia fish (Oreochromis niloticus) from selected areas of Bangi, Selangor, Malaysia. *African Journal of Biotechnology*.**10**(55), pp. 11562-11566.Available online at http://www.academicjournals.org/AJBDOI: 10.5897/AJB11.1663 ISSN 1684–5315. Accessed on May 2019.

[4]. Vieira, C., Morais, S., Ramos, S., (2011): Mercury, cadmium, lead and arsenic levels in three pelagic fish species from the Atlantic Ocean: intra- and inter-specific variability and human health risks for consumption. *Food Chem. Toxicol.* 49 (4), 923–932

[5]. Yi, Y.J., Wang, Z.Y., Zhang, K., Yu, G.A., Duan, X.H., (2008): Sediment pollution and its effect on fish through food chain in the Yangtze River. *Int. J. Sediment Res.* 23, 338–347.

[6]. Alhashemi, A.H., Sekhavatjou, M.S., Kiabi, B.H.(2012): Bioaccumulation of trace elements in water, sediment, and six fish species from a freshwater wetland, *Iran. Microchem. J.* 104, 1–6.

[7]. Pan, K., and Wang, W.X.(2012): Trace metal contamination in estuarine and coastal environments in China. *Sci. Total Environ.* 421, 3–16.

[8]. Saha, N., Molla, M.Z.I., Alam, M.F., Rahman, M.S.(2016): Seasonal investigation of heavy metals in marine fishes captured from the Bay of Bengal and the implications for human health risk assessment. *Food Control* 70, 110–118.

[9]. Tuzen, M. (2009): Toxic and essential trace elemental contents in fish species from the Black Sea, Turkey. *Food Chem. Toxicol*. 47, 1785–1790.

[10]. Wang, X., Sato, T., Xing, B., 2005. Health risks of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish. *Sci. Total Environ.* 350, 28–37.

[11]. Chien, L.C., Hung, T.C., Choang, K.Y., (2002): Daily intake of TBT, Cu, Zn, Cd and As for fishermen in Taiwan. *Sci. Total Environ*. 285, 177–185

[12]. BBS (Bangladesh Bureau of Statistics), (2011); Household Income and Expenditure Survey, Bangladesh Bureau of Statistics, Bangladesh.

[13]. US EPA, (2010): Risk-Based Concentration Table. Available at http://www.epa.gov/reg3hwmd/risk/human/index.htm (Accessed April 15, 2018).

[14]. FAO (Food and Agriculture Organization), 2006. Arsenic Contamination of Irrigation Water, Soil and Crops in Bangladesh: Risk Implication for Sustainable Agriculture and Food Safety in Asia. FAO Regional Office for the Asia and Pacific, Bangkok, Thailand.

[15]. US EPA, (1989):Health Effect Assessments Summary Tables (HEAST) and User's Guide, Office of Emergency and Remedial Response.

[16]. Nadal, M., Ferre-Huget, N., Mart´ı-CidR.(2008): Exposuretometalsthroughtheconsumption of fish and seafood by population living near the Ebro River in Catalonia, Spain: health risks. *Hum. Ecol. Risk Assess*. 14, 780–795.

[17]. Islam, G.M.R., Habib, M.R., Waid, J.L., Rahman, M.S., Kabir, J., Akter, S., Jolly, Y.N., 2017. Heavy metal contamination of freshwater prawn (Macrobrachium rosenbergii) and prawn feed in Bangladesh: a market-based study to highlight probable health risks. *Chemosphere 170*, 282–289.

[18]. Murtala, B.A., Abdul, W.O., Akinyemi, A.A.(2012): Bioaccumulation of heavy metals in fish (Hydrocynus forskahlii, Hyperopisus bebe occidentalis and Clarias gariepinus) organs in downstream Ogun coastal water, Nigeria. *J. Agric.* Sci. 4, 51.

[19]. Fryer, M., Collins, C.D., Ferrier, H.(2006): Human exposure modeling for chemical risk assessment: a review of current approaches and research and policy implications.

[20]. *Environ. Sci. Pollut. Res.* - Int. 9, 261–274.