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HUMAN HEALTH RISK ASSESSMENT OF HEAVY METAL LEVELS IN *Clarias gariepinus* AND *Parachanna obscura* FROM THE IKPOBA RIVER, EDO STATE, NIGERIA

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Abstract: *The purpose of this paper is to evaluate the accumulation of heavy metals (Ni, Zn, Pb, Fe and Cr) in two commercially available fishes Clarias gariepinus and Parachanna obscura, and estimate the health risks they pose to humans through consumption. Fish samples were collected between July and October, 2017. Heavy metals were determined using the Atomic absorption Spectrophotometer while health risk to consumers was evaluated using Estimated Daily Intake (EDI), Target Hazard Quotient (THQ) and Hazard Index (HI). Heavy metal accumulation followed the order Fe>Cr>Zn>Pb>Ni and Cr>Fe>Zn>Pb>Ni in the liver and muscle of Clarias gariepinus while concentrations in the liver and muscle of Parachanna obscura followed the order Fe>Pb>Cr>Zn>Ni and Fe>Cr>Zn>Pb>Ni respectively. Chromium and lead exceeded the permissible limits for fish food. Target Hazard Quotient was Cr >Pb> Ni with values of 0.040, 0.014 and 0.002 for C. gariepinus and 0.013, 0.010 and 0.002 for P. obscura. The Hazard Index was 0.056 and 0.025 for C. gariepinus and P. obscura respectively. The hazard indexes for the two fishes were below one and thus indicate minimal risk of health concerns to consumers of these fishes. Regular monitoring of heavy metal levels in fishes is recommended.*

Keywords: *Heavy metals, Consumption, health risk, Hazard Index, C. gariepinus, P. obscura, Ikpoba River*

1. Introduction

Worldwide, there has a global concern over the contamination of rivers, water bodies and aquatic animals by heavy metals. As a result of the increasing rate of industrialization in Nigeria, a lot of harmful substances, including heavy metals, are now being discharged into the environment particularly water bodies. This has translated to an increase in the concentration of various heavy metals in the aqueous environment beyond their natural levels [1] However, the severity of these effects depends on the type, properties, dosage and exposure duration [2].

In the aquatic environment, heavy metals may affect organisms directly by accumulating in their body or indirectly by transferring to the next trophic level of the food chain. Fish are often at the top of aquatic food chain and may concentrate large amounts of these metals from the water [3]. In humans, heavy metal accumulation has hazardous effects on the brain, liver, kidneys, lungs, and muscles [4,5]. Reported damages include enhanced lipid peroxidation, DNA damage, enzyme inactivity and the oxidation of protein sulfydryl groups [6,7]. Excessive levels of heavy metals in food is associated with the etiology of a number of diseases, especially cardiovascular, renal, neurological,

cancer and bone diseases [6,8]. For these reasons, evaluation of heavy metal levels in commercially important fish species is necessary in verifying whether there is a significant health risk arising from the consumption of these fishes.
Human health risk assessment is considered as the characterization of the potential adverse health effects of humans as a result of exposures to environmental hazards [9]. The Target Hazard Quotients (THQ) has been recognized as a reasonable index for the evaluation of heavy metals intake by consumption of contaminated food [10]. THQ is a ratio of consumed dose of a toxic metal via an oral reference dose (RfD). A THQ value above 1 means that contaminated food intake has likely some noticeable harmful effects on the exposed population. Higher THQ value indicates a higher probability of hazard risk. The Hazard index (HI) is the sum of THQs of all the metals in the fish and it is calculated in view of the fact that more than one metal can often be bioaccumulated in fish tissue and could have interactive or synergistic effects.
This study is aimed at assessing heavy metal levels in *Clarias gariepinus* and *Parachanna obscura* and to estimate the human health risk of consumption of these two fishes which are of great economic importance to Nigerians.

2. Materials and methods

2.1. Study area

The Ikpoba River a fourth order stream is located in Benin City, Edo State, Nigeria. It lies between Longitudes 5° 25' E and 5^0 40' E and Latitudes 6° 20' N and 6^0 30' N (Fig 1) Water samples were collected from two sampling points between the hours of 9:00 am and 12:00 noon from July to October 2017.

Standard methods and procedures were followed during sample collection. Physico-chemical parameters were determined according to procedures outlined in the Standard Methods for the Examination of Water and Wastewater. The surface water temperature was taken in-situ with the use of mercury-in-glass thermometer [11].The extracted liver and muscle portions were wrapped in foil paper, labeled and oven dried at a temperature of 105°C for 1 hour. The dried samples were ground to powdered form with plastic mortar and pestle, sieved to obtain a uniform particle size and preserved in well-labelled containers. Heavy metals – Nickel (Ni), Zinc (Zn^{2+}), Lead ($Pb2^{+}$), Iron (Fe^{2+}) and Chromium (Cr^{2+}) in both water and fish were determined using Atomic Absorption Spectrophotometer (AAS).

Data Analysis

The levels of selected heavy metals in the liver and muscle of *C. gariepinus* and *P. obscura* were characterized using basic statistical measurement of central tendency and dispersion. Paired sample t-test was used in comparing levels of heavy metals in the liver and muscle of the two fishes.

Human Health Risk Assessment for fish Consumption

The concentration of heavy metals in the muscles of the two fishes was used in calculating the Estimated Daily Intake (EDI), Target Hazard Quotient (THQ) and Hazard Index (HI).

Estimated Daily Intake of Metals (EDI)

$$\text{EDI (mg/kg} - \text{bw/day/week)} = \frac{MI_f \times CM_f}{BW}$$

Where M I_f = Mass of fish Ingested per day; C M_f = Concentration of Metal in Fish and BW = Body Weight (60kg for adult). The per capital consumption of fish and shellfish in Nigeria for human food is 9.0kg, which is equivalent to 24.7kg per day [12].

Target Hazard Quotient

The THQ is an estimate of the non-carcinogenic risk level due to pollutant exposure and calculated by the following equation:

$$THQ = \frac{EF \times ED \times MI \times CM}{ORD \times BW \times AT} \times 10^{-3}$$

Where; THQ is the Target Hazard Quotient, EF = Exposure Frequency (365 days/year); ED is the Exposure Duration (52.62 years) which corresponded to average life expectancy of a Nigerian (male and female); AT = Average exposure Time for non-carcinogens (365 days/year x ED). The Oral Reference Dose (ORD) is an estimate of daily exposure to human population (including sensitive subgroup) that is likely to be without an appreciable risk of deleterious effect during a life time. The Oral Reference Dose (ORD) (mg/kg/day) used were Ni - 2.0×10^{-2}, Zn - 3.0×10^{-1}, Pb - 3.5×10^{-3} Fe - 7.0×10^{-1} and Cr - 1.5×10^{-3} [10].

Hazard Index

The hazard index (HI) from the consumption of *Clarias gariepinus* and *Parachanna obscura* obtained from Ikpoba and Owan Rivers, Edo state was calculated as the sum of THQs of all the metals in the fish samples and was expressed as follows;

HI = THQPb + THQCr + THQZn + THQFe+THQNi

Where HI is the hazard index;THQPb = The Target Hazard Quotient for Pb intake; THQCu = The Target Hazard Quotient for Cu intake THQZn = The Target Hazard Quotient for Zn intake; THQFe = The Target Hazard Quotient for Fe intake and THQNi = The Target Hazard Quotient for Ni intake

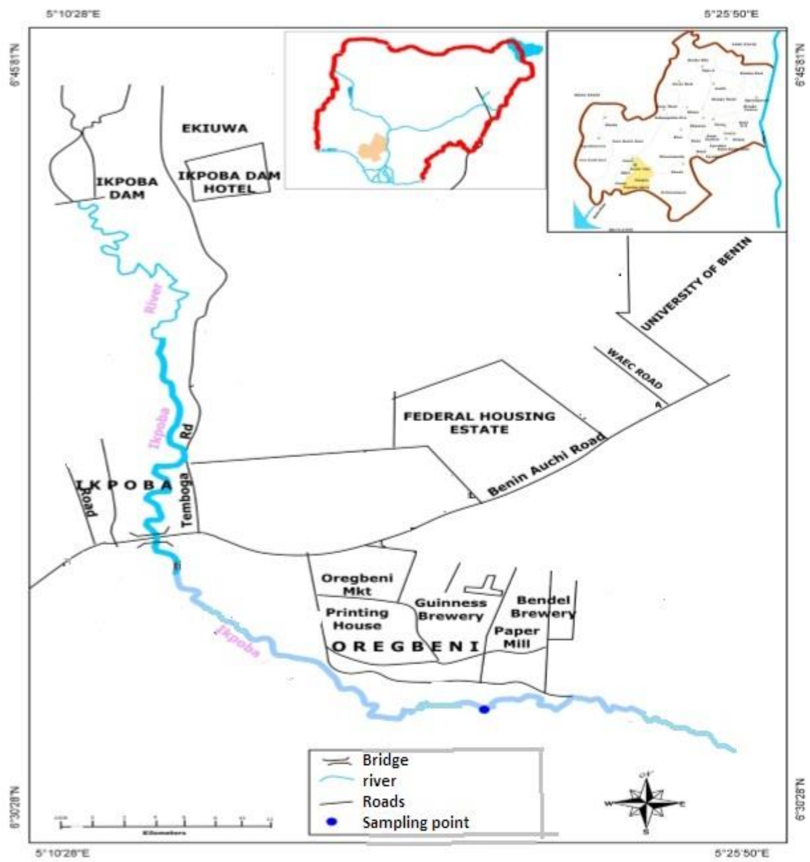

Fig. 1: Map of the Ikpoba River showing sampling point; Insert (A) Nigeria (B) Edo State

3. Results and discussion

A human health risk assessment process uses the tools of science, engineering, and statistics to identify and measure a hazard, determine possible routes of exposure, and finally use that information to calculate a numerical value to represent the potential risk [13]. Heavy metals concentrations varied in the two organs (liver and muscle) and also in the two fishes species studied. Significant factors that influence differential accumulation of heavy metals in fishes include age of fish, lipid content in the tissue and mode of feeding [14].

In *Clarias gariepinus*, mean levels of Ni, Zn, Pb, Fe and Cr in the liver were 0.16 mg/kg, 0.93 mg/kg, 0.21 mg/kg, 2.81 mg/kg and 1.91 mg/kg while mean levels in the muscle were 0.18 mg/kg, 0.48 mg/kg, 0.26 mg/kg, 1.24 mg/kg and 1.63 mg/kg respectively. *Parachanna obscura* recorded mean levels of 0.18 mg/kg, 0.39 mg/kg, 0.99 mg/kg, 3.74 mg/kg and 0.63 mg/kg in the liver and 0.18 mg/kg, 0.28 mg/kg, 0.19 mg/kg, 0.77 mg/kg, 0.52 mg/kg in the muscle. Significant differences ($p < 0.05$) were observed between the Zinc concentrations in the liver and muscle of both *C.gariepinus* and *P. obscura.* The order of accumulation of heavy metals in the liver and muscle of *Clarias gariepinus* were Fe > Cr > Zn >Pb> Ni and Cr > Fe > Zn >Pb> Ni respectively, while the order observed in the liver and muscle of *P. obscura* was Fe >Pb> Cr > Zn > Ni and Fe > Cr > Zn >Pb> Ni (Tables 1 and 2). The levels of Chromium and Iron in both fishes exceeded the WHO permissible limits for fish foods. Observation from this study correlates with results from other studies on bioaccumulation of heavy metals in tissues and organs, which revealed that fish muscle has a lower concentration in comparison to other tissues. This could be attributed to the low metabolic activity of the muscles. In addition, the liver is the principal organ responsible for the detoxification, transportation, and storage of toxic substances and it is an active site of pathological effects induced by contamination [15].

Health risk assessment for consumption of *C. gariepinus* and *P. obscura* are shown in Tables 3 and 4. Estimated Daily Intakes (EDI) for *Clarias gariepinus* were in the order Cr > Fe > Zn > Pb > Ni while the THQ was Cr >Pb> Ni > Fe = Zn with risk values of 0.040, 0.014 and 0.002 respectively. An EDI order of Fe > Cr > Zn >Pb> Ni was observed for *P. obscura* while the THQ was in the order Cr >Pb> Ni with risk values of 0.013, 0.010, and 0.002. The Hazard index was 0.025. For both fishes with Cr being the highest contributor.

E\stimated Daily Intake (EDI) values in this study were higher than values reported for *Scomber scrombus* [16]. Although the concentrations of chromium and lead were above recommended limits for food fish [17] they may not pose human health risk in view of the fact that their EDI values were less than their respective RfD values.

Target hazard quotient (THQ) for the metals were in the order Cr >Pb> Ni > Fe > Zn with all values < 1, suggested minimal risk of non-carcinogenic consequence. Target Hazard Quotient > 1 is known to indicate potentials of non-carcinogenic risk to human exposures [18-20] particularly with increase in metal exposure. The THQ of metals in this study were all < 1 and this is consistent with the findings of previous researchers [21 and 22].

Table 1

Summary of Heavy metals in tissues of *Clarias gariepinus* from the Ikpoba River

n=4	**Organs**						**P- value**	**Standards**
	Liver			**Muscle**				
Heavy metals (mg/kg)	Mean±SD	Min	Max	Mean±SD	Min	Max		
Ni	0.16±0.13	0.01	0.32	0.18±0.18	0.02	0.42	p>0.05	0.5 [17]
Zn	0.93±0.11	0.82	1.04	0.48±0.26	0.13	0.70	p<0.05	30 [23]
Pb	0.21±0.08	0.12	0.31	0.26±0.24	0.04	0.60	p>0.05	0.5 [17]
Fe	2.83±1.89	1.34	5.60	1.24±0.35	0.95	1.73	p>0.05	0.5 [17]
Cr	1.91±0.79	0.88	2.80	1.63±0.65	0.87	2.46	p>0.05	0.15[17]

Table 2

Summary of Heavy metals in tissues of *Parachanna obscura* from the Ikpoba River

n=4	**Organs**						**P- value**	**Standards**
	Liver			**Muscle**				
Heavy metals (mg/kg)	Mean±SD	Min	Max	Mean±SD	Min	Max		
Ni	0.18±0.05	0.11	0.22	0.18±0.06	0.10	0.23	p>0.05	0.5 [17]
Zn	0.39±0.17	0.16	0.53	0.28±0.17	0.05	0.46	p<0.05	30 [23]
Pb	0.99±0.46	0.40	1.50	0.19±0.08	0.10	0.29	p>0.05	0.5 [17]
Fe	3.74±3.07	1.34	8.20	0.77±0.27	0.40	1.01	p>0.05	0.5 [17]
Cr	0.63±0.40	0.20	1.05	0.52±0.57	0.07	1.36	p>0.05	0.15[17]

Table 3

Health Risk Assessment for the consumption of *Clarias gariepinus* and *Parachanna obscura* from Ikpoba River

	Clarias gariepinus			***Parachanna obscura***		
Heavy Metals	Risk Model		% Contribution of metal to HI	Risk Model		% Contribution of metal to HI
	EDI	THQ		EDI	THQ	
Ni	0.08	0.002	0.40	0.07	0.002	8.0
Zn	0.20	0.000	0.00	0.12	0.000	0.0
Pb	0.11	0.014	25.00	0.08	0.010	40.0
Fe	0.51	0.000	0.00	0.32	0.000	0.0
Cr	0.67	0.040	71.43	0.22	0.013	52.0
HI		**0.056**	**No Risk**		**0.025**	**No Risk**

Hazard index (HI) values for *C. gariepinus* and *P. obscura* were < 1, an indication of minimal risk exposure of no significant health risk to consumers of these fishes. This agrees with the findings of [24] for *Hemichromis fasciatus* and [25]. Several studies have reported that HI should not be > 1 in order to ease public health concern [26, 27]. Chromium contributed the highest value to the HI and this corroborates with the reports of [28] for *Sarotherodon melanotheron*.

4. Conclusion

Assessment of heavy metals in fish from contaminated areas can be extremely important in evaluating the potential health risks to humans associated with consumption of fish from these contaminated catchments to safeguard human health. It also improves our knowledge on the biological status of the aquatic ecosystems and how it adapts or changes according to the change in the surrounding environmental conditions. The Hazard Index showed that the fishes do not pose any health risk to humans through consumption. However, it is recommended that routine assessment of heavy metal bioaccumulation in fishes of the Ikpoba River be carried out to provide baseline data for accurate estimation of health risks to humans and to protect the health of the aquatic ecosystem.

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