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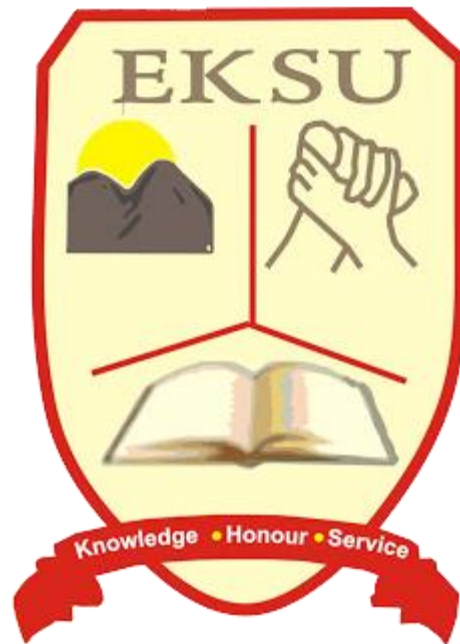
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Heavy Metals Concentration in African Mud Catfish (*Clarias gariepinus*) and Obscure Snakehead (*Parachanna obscura*) from River Ogbese, Ondo State, Nigeria

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Abstract

Wastes from domestic, industrial, and other anthropogenic activities are sources of heavy metal pollution in aquatic environments. Heavy metals contamination has been a source of concern because of the devastating effects on the ecological balance of the aquatic environment and the diversity of organisms, especially fish which bioaccumulate them in their muscles causing pituitary damage, testicular degeneration and decrease in offsprings and extinction of fish stocks. This study assessed the concentrations of heavy metals in the head, trunk, and tail regions of African mud catfish (*Clarias gariepinus*) and obscure snakehead (*Parachanna obscura*) collected from River Ogbese, Ondo State using standard methods. The results show that the head portions of the two fish species contained the highest concentrations of the heavy metals which differed significantly from the fish trunks while the tails contained the least amounts. The heavy metal concentrations in the head portions were 8.02 ± 1.32 , 30.19 ± 2.63 , 7.39 ± 1.02 and 68.45 ± 3.24 mg g⁻¹ in *C. gariepinus* and 2.02 ± 0.12 , 11.85 ± 1.55 , 9.09 ± 1.99 and 108.45 ± 5.85 mg g⁻¹ in *P. obscura* for Cu, Zn, Pb, and Fe respectively. In the head and trunk regions, *P. obscura* (carnivore) bioaccumulated heavy metal than *C. gariepinus* (omnivore) fish. The variations were significant ($P < 0.05$) among the fish samples except in the tail parts of *P. obscura* with the variation not significant ($P > 0.05$) due to low concentrations of the heavy metals in the region. *C. gariepinus* tail revealed low concentration as well. The heavy metals levels were in the order head > trunk > tail in the fish samples. The range of values was slightly above permissible / recommended limit in *C. gariepinus* except for Cu and Zn which had non-significant values for head and tail regions. Cu was higher in *C. gariepinus* than in *P. obscura*, sediment, and water. Hence, the result obtained indicated bioaccumulation of heavy metals can be aided by feeding habits and environmental conditions. The *P. obscura* and *C. gariepinus* are likely to be exposed to pollutants from anthropogenic substances as indicated by the bioaccumulation level of heavy metals on the fish samples from the environment, therefore, there is need for surveillance to safe guide fish and environment for healthy fish food for consumers.

Keywords: Heavy metals, River Ogbese, *Clarias gariepinus*, *Parachanna obscura*

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Introduction

The contamination of aquatic environments with pollutants from domestic, industrial, and other man-caused activities has become a matter of concern

(Adamu *et al.*, 2015). Heavy metal contamination may have devastating effects on the ecological balance of the recipient environment and a diversity

of aquatic organisms, especially fish which are notorious for the ability to bioaccumulate heavy metals in their muscles and tissues (Ahmed *et al.*, 2015a). The heavy metal bioaccumulation is largely attributed to differences in uptake and depuration period for various metals in different fish species (Erhunmwunse *et al.*, 2013). The heavy metals cause pituitary damage, testicular degeneration, and decrease in fry numbers (Zaki *et al.*, 2015). Also, the exposure of fish to heavy metals could exert deleterious effects on the reproductive organs leading to a decline in the number of offspring and hence to the eventual extinction of fish stocks.

Fish species play important roles in human nutrition and are widely used to evaluate the health of the aquatic ecosystem because pollutants build up in the food chain being responsible for adverse effects and death in the aquatic ecosystem (Bai *et al.*, 2011). The aquatic environments are exposed to varying levels of pollutants and accumulation of heavy metals in aquatic organisms can pose a long-lasting effect on

biogeochemical cycling in the ecosphere (Hayat *et al.*, 2007). Therefore, it is imperative to investigate the fish of economic importance to know the status of the environment. African mudfish (*Clarias gariepinus*) and Obscure snakehead (*Parachanna obscura*) are fish species of economic importance in the freshwater environment in Nigeria. The objective of this study is to determine the concentrations of heavy metals: iron (Fe), lead (Pb), copper (Cu) and zinc (Zn) in the tissue of *Parachanna obscura* and *Clarias gariepinus* in River Ogbese, Ondo State, Nigeria.

Materials and Methods

Study area

The study was carried out in River Ogbese, Ondo State, Nigeria. River Ogbese is one of the major perennial rivers in south Western Nigeria, runs through Ogbese town, and lies between longitude 5°26'E and latitude 6°43'N (Olawusi-Peters *et al.*, 2014).

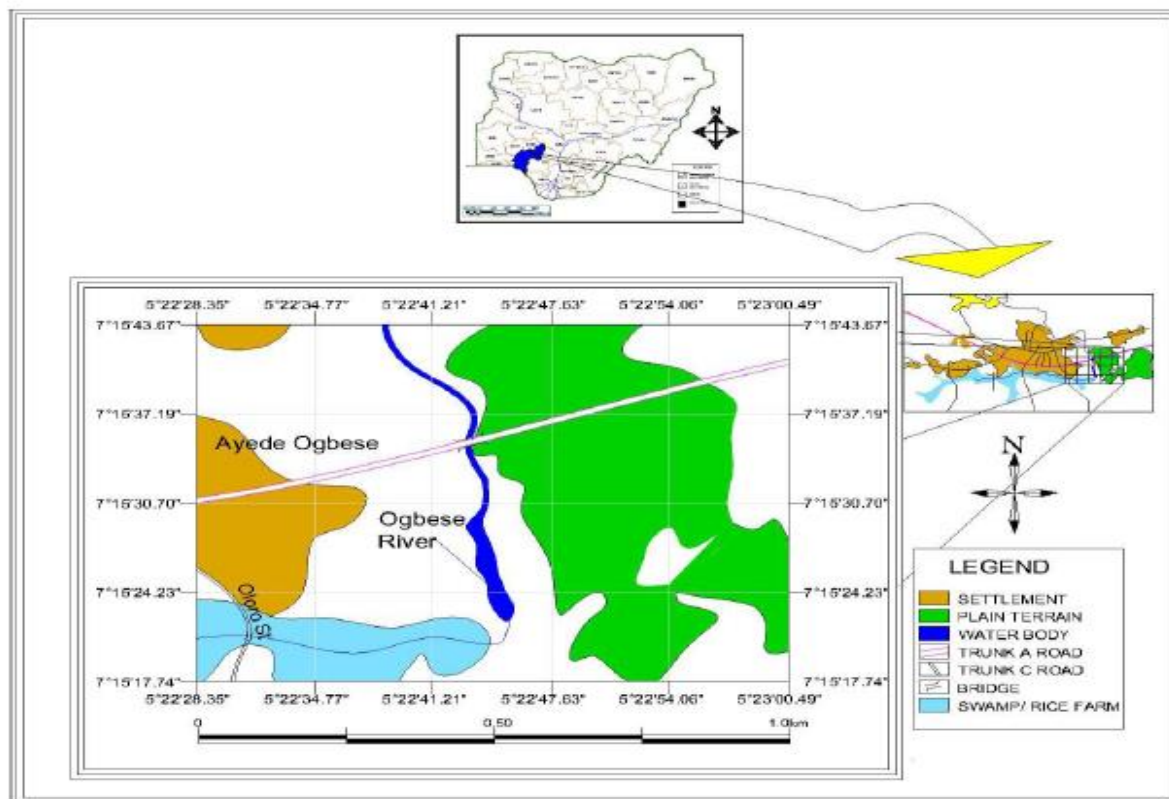


Fig. 1: Map of River Ogbese

Collection of samples

Thirty (30) *Clarias gariepinus* and 30 *Parachanna obscura* fish species were randomly collected by the

assistance of fishermen from River Ogbese and transported to the laboratory for heavy metal determination. Water samples were collected at 10 cm depth within River Ogbese while sediments of the river were collected using a grab.

Measurements of fish: The lengths (cm) of the fish species were measured using graduated ruler and weights (g) of the fish species measured using Mettler Toledo sensitive electronic weighing balance (Model: PBS001).

Determination of heavy metals in *Clarias gariepinus* and *Parachanna obscura*

The fish samples (divided into head, trunk and tail) and soil samples were oven-dried, weighed into crucible and heated in muffle furnace for two hours at 750 °C and milled. 5 g of the milled samples were weighed into 100 ml beaker, 15 ml freshly prepared mixture of nitric acid/hydrogen peroxide at 1:1 ratio

added to each sample, covered with wash glass and allowed to stand for 30 minutes during which initial reaction subsided. The fish, soil and water samples were digested on hot plate with gradual increase in temperature to a maximum of 160 °C in a fume cupboard for 2 hours to evaporate and reduce in volume. The beakers and contents were air cooled and the content filtered into 50 ml volumetric flask and made up to mark with distilled water (AOAC, 2005). The samples were analyzed for Pb, Zn, Cu and Fe using Buck 211 Model atomic absorption spectrophotometer with aqueous calibration standard prepared from the stock standard solutions of the respective elements.

Percentage metal Concentration of Fe, Pb, Cu and Zn heavy metals determined respectively in sediment, water and fish species (*P. obscura* and *C. gariepinus*) were carried out using the formula:

$$\% \text{ Metal Concentration Index (MCI)} = \frac{\text{Metal concentration value (mg/g)}}{\text{Total Metals concentration Values ((mg/g))}} \times 100$$

Statistical analysis

The data were analyzed with descriptive statistics of means and standard error at $P < 0.05$; and significance among samples was determined using Duncan's Multiple Range Test in to SPSS Statistics package 18th edition.

Results

The mean lengths and weights of the two fish species collected from River Ogbese are shown in Table 1.

The lengths of *C. gariepinus* ranged from 12.26 to 18.41 cm while *P. obscura* was 14.47-21.22 cm long with the means at 14.7 ± 2.55 and 17.05 ± 3.04 cm respectively. The weight of *C. gariepinus* was 234.14-382.85 g and *P. obscura* ranged from 313.46 to 456.38 g with mean values of 260 ± 73.54 and 348 ± 93.34 g respectively.

Table 1: Means and standard deviations of length (cm) and weight (g) of *C. gariepinus* and *P. obscura*

Fish Species	No of samples	Mean $\pm$ SD Length (cm)	Mean $\pm$ SD Weight (g)
<i>Clarias gariepinus</i>	30	14.7 ± 2.55	260 ± 73.54
<i>Parachanna obscura</i>	30	17.05 ± 3.04	348 ± 93.34

The heavy metals contained in the head, trunk and tail portions of *Clarias gariepinus* and *Parachanna obscura* are shown in Table 2. The head portions of the two fish species contained the highest concentrations of the heavy metals which differed significantly from the fish trunks while the tails contained the least amounts. In *C. gariepinus*, the highest concentrations of the head portion were 8.02 1.32, 30.19 0.63, 7.39 1.02 and

68.45 0.24 mg g⁻¹ of Cu, Zn, Pb and Fe respectively. The trunk followed the head for every heavy metal and differed significantly with the tail portion except the Cu content. The heavy metal content followed the same trend in *P. obscura* with the highest values of Cu, Zn, Pb and Fe at 2.02 0.12, 11.85 1.55, 9.09 1.99 and 108.45 1.85 mg g⁻¹ respectively in the head portion. The slight variations in the trend of

concentrations are: similar values of Zn in the head and trunk; Pb in the trunk and tail did not differ while Cu content was not different in the fish parts.

Table 2: Mean Concentrations of Heavy Metals in *C. gariepinus* and *P. obscura*
Heavy Metals (mg g⁻¹)

Fish Parts	Fe	Pb	Cu	Zn
<i>Clarias gariepinus</i>				
Head	68.45 ± 0.24a	7.39 ± 1.02a	8.02 ± 1.32a	30.19 ± 0.63a
Trunk	26.05 ± 1.04b	3.32 ± 0.32b	4.22 ± 2.82b	11.99 ± 1.05b
Tail	3.01 ± 0.98c	2.82 ± 1.62b	0.85 ± 0.15c	3.64 ± 0.52c
<i>Parachanna obscura</i>				
Head	108.45 ± 1.85a	9.09 ± 1.99a	2.02 ± 0.12a	10.69 ± 1.49a
Trunk	86.05 ± 3.96b	4.86 ± 3.79b	0.92 ± 0.48a	11.85 ± 1.55a
Tail	3.01 ± 0.98c	2.82 ± 1.62b	1.25 ± 0.45a	3.64 ± 0.52b
Permissible limits	146.00 mg g ⁻¹ (IAEA-407 (Wyse <i>et al.</i> , 2003))	0.12 mg g ⁻¹ (IAEA-407 (Wyse <i>et al.</i> , 2003))	3.28 mg g ⁻¹ (IAEA-407 (Wyse <i>et al.</i> , 2003)) 0.03 mg g ⁻¹ (Khayazadeh and Abbasi, 2010)	3.00 mg g ⁻¹ (WHO, 2003)

The heavy metals concentrations in whole fish species samples, sediments and water are shown Table 3. The highest heavy metal in *P. obscura* was Fe (65.84±3.59 mg g⁻¹) and followed by Zn (26.18±3.56 mg g⁻¹). The concentrations of Fe, Zn and Pb (5.59±2.47 mg g⁻¹) were higher in *P. obscura* than in *C. gariepinus* samples which contained more Cu (4.36±1.43 mg g⁻¹). The heavy metal concentrations were higher in the sediments than in the water samples. The highest heavy metal in the sediments and water samples was Fe (152.57±6.34;

5.65±1.28 mg g⁻¹ respectively) followed by Zn (1.47±0.08 and 0.14±0.04 mg g⁻¹ in the sediments and surface water samples respectively) while Cu was least.

Relationship and contributions of the environment to heavy metals accumulation in fish from River Ogbese was determined and results were indicated in Figure 2. Which shows the comparative levels of heavy metals in the fish, sediment and water samples collected.

Table 3: Mean Heavy Metals Concentrations in Whole Fish, Sediments and Water samples from River Ogbese Compared to Recommended Limits

Heavy metals (mg g ⁻¹)	<i>Clarias gariepinus</i>	<i>Parachanna obscura</i>	Ogbese Water	Ogbese Sediments	Recommended limits*
Fe	32.5±0.28c	65.84±3.59b	5.65±1.28d	152.57±6.34a	146.00 mg g ⁻¹ (IAEA-407 (Wyse <i>et al.</i> , 2003))
Pb	4.51±1.24b	5.59±2.47a	0.12±0.02c	0.15±0.04c	0.12 mg g ⁻¹ (IAEA-407 (Wyse <i>et al.</i> , 2003))
Cu	4.36±1.43a	3.00±0.21b	0.04±0.00d	0.11±0.01c	3.28 mg g ⁻¹ (IAEA-407 (Wyse <i>et al.</i> , 2003)) 0.03 mg g ⁻¹ (Khayazadeh and Abbasi, 2010)
Zn	15.57±2.26	26.18±3.56	0.15±0.04	1.47±0.08	3.00 mg g ⁻¹ (WHO, 2003)

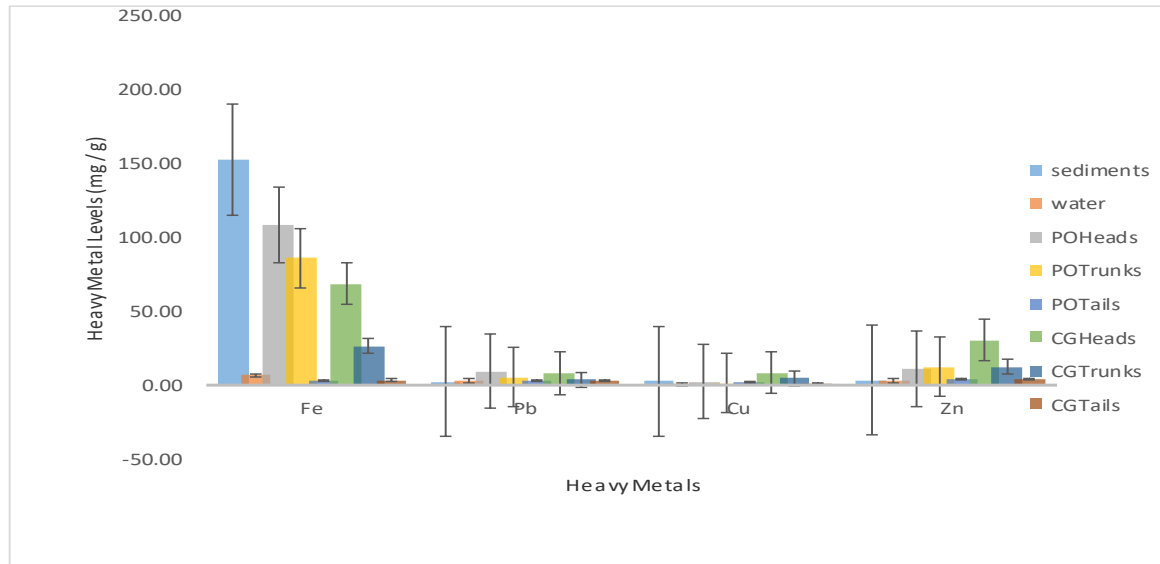


Figure 2: Mean heavy metal levels in fish parts, water and sediments samples collected from River Ogbese
PO: *Parachanna obscura*, CG: *Clarias gariepinus*

The percentage concentration of Zn, Cu, Pb, and Fe heavy metals determined respectively in sediment, water and fish parts (Head, Trunks and

Tail) of *P. Obscura* and *C. gariepinus* samples is shown in Figure 3. The highest-ranking heavy metal was Fe>Zn>Pb>Cu.

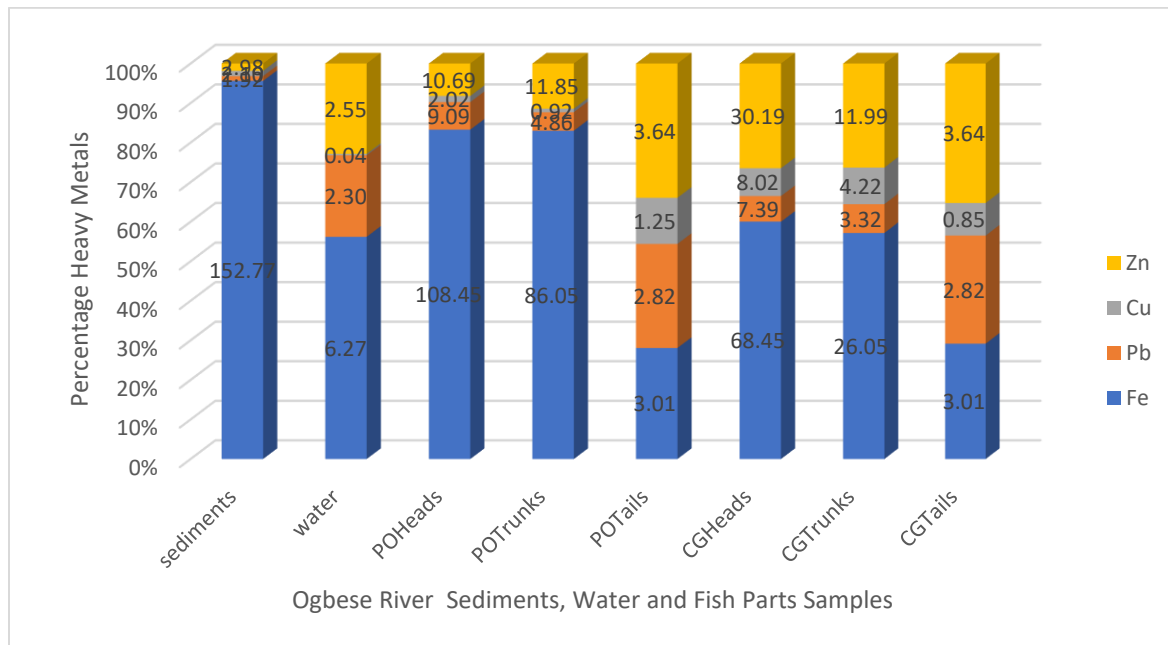


Figure. 3: Percentage heavy metal in fish, water and sediments samples from River Ogbese

Comparative description of heavy metals determination in *C. gariepinus* and *P. obscura* is revealed by the mean concentrations of the heavy

metals (Figure 4). The heavy metals determined in *P. obscura* are higher than in *C. gariepinus* samples except Cu which had a slightly lower concentration.

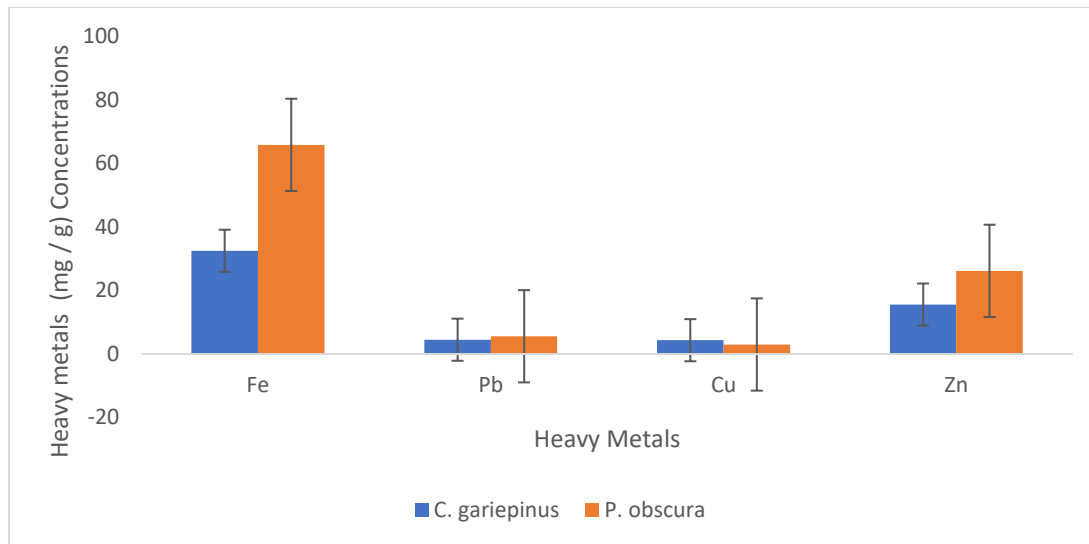


Fig. 4: Comparative description of heavy metals determination in *C. gariepinus* and *P. obscura*

Discussion

The heavy metals varied among the fish parts and between fish species from River Ogbese. The variations were significant ($P < 0.05$) among the fish samples except in the tail parts of *P. obscura* with variation not significant ($P > 0.05$) due to low concentrations of the heavy metals at the region. *C. gariepinus* tail has low heavy metal concentration as well. The heavy metals levels were in the order head > trunk > tail in the fish samples. The range of values were slightly above permissible / recommended limit (WHO, 2003, Wyse *et al.*, 2003) in *C. gariepinus* except for Cu and Zn which had non-significant values for head and tail regions.

Cu was higher in *C. gariepinus* than in *P. obscura*, sediment and water; and this corroborated with the work of Babatunde *et al.*, (2012) who reported *C. gariepinus*, an omnivorous fish had higher Cu than *P. obscura* which is carnivorous. High concentration of copper can alter haematology (James *et al.*, 2008); respiratory and cardiac physiology (Sorensen, 1991). Iron (Fe) ranked highest in the sediment, followed by the head and trunk of *P. obscura*, water; *C. gariepinus* head and trunk. It is low with no significant difference ($P < 0.05$) in tails of *P. obscura* and *C. gariepinus*; and it ranked lower than permissible limit in head, trunk and tail of the fish species. Fe is essential for production of hemoglobin, myoglobin and its deficiency can cause anemia (Anderson and Fitzgerald, 2010) while excess Fe in biological tissues causes rapid increase in pulse rate and coagulation of blood in blood vessels, hypertension and drowsiness; this is implicative on

state of well-being and haematology of fish to stress conditions (Davies *et al.*, 2006).

Zinc (Zn) accumulations in samples were higher than the permissible limit. Highest concentration recorded in *C. gariepinus* head is indicative of the benthic nature of the fish and is supported by the feeding habit of the fish as stated by Arvind *et al.*, (2002) and Amiard *et al.*, (2006); indicated pollution from the environment. Limit toxicity may be characterized by symptoms of irritability, muscular stiffness and pain, loss of appetite, and nausea (Jeyaraj *et al.*, 2016); and bioaccumulation of zinc result in decreased plasma protein, it affects tissue respiration leading to death by hypoxia, (Kori- Siakpere *et al.*, 2005).

Lead (Pb) was lowest in sediment and higher in water than sediment. Pb was highest in *P. obscura* head than *C. gariepinus*; and the result is in line with the work of Hashim *et al.*, 2014 and Babatunde *et al.*, (2012), who reported feeding habit influence Pb accumulation in fish, and that carnivore's bioaccumulated Pb than omnivore and herbivore fishes. The value determined in samples were slightly higher ($P > 0.05$), having no significant difference among the head, trunk and tail samples. Pb causes lamella shrinkage degeneration of epithelium; branchial arterial rupture and ischemia; reduction in growth rate and loss in body weight; neurological defect, renal tubular dysfunction, anemia which result in stress condition (Olojo *et al.*, 2005).

The result revealed evidence of pollution, hence, need for public health and environmental guidance

toward pollution mitigation to ensure the fish species of the Ogbese River are fit for consumption without health hazard.

Conclusion

Heavy metals accumulation in the *C. gariepinus* and *P. obscura* heads, trunks and tails indicated level of pollution within the environment. Absorption of heavy metal from the environment through fish gills suggest the cause of increased heavy metal in fish

head. The result on Ogbese River therefore, suggested evident of fish been prone to toxicity. This calls for public health concern if consumed over a long period of time. Therefore, a long-term monitoring program of heavy metals bioaccumulation in fish from River Ogbese and nearby waste sites would be necessary to assess and mitigate potential biological risks to human health and the environment.

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