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BIOACCUMULATION OF HEAVYMETALS IN SOME FRESHWATER FISHES FROM OGBESE RIVER, OGBESE, ONDO STATE

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ABSTRACT

The heavy metal concentrations in the organs of freshwater fishes and sediments from Ogbese River, Ogbese, Ondo State, Nigeria was studied. The heavy metals included Chromium (Cr), Cadmium (Cd), Nickel (Ni), Lead (Pb), Copper (Cu), Zinc (Zn), Iron (Fe) and Manganese (Mn). The freshwater fishes studied were *Clarias gariepinus* (Burchell, 1822), *Parachanna obscura* (Teugels and Daget, 1984) and *Oreochromis niloticus* (Linnaeus, 1758). The different heavy metal concentrations in the sediments as well as liver and flesh of the fish species were determined using Buck 200 Atomic Absoption Spectrophotometer (AAS). The increasing order of heavy metal concentration in the sediment and fish were Cd<Pb<Cr<Ni<Cu<Mn<Zn<Fe. The mean concentration of each heavy metal was higher in the sediment than those of the fish (for example lead concentrations of 0.15 ± 0.01 mg/kg and 0.03 ±0.001 mg/kg in sediment and in fish respectively); also, in the liver than in the flesh of each fish species (for example manganese concentrations of 9.77 ± 0.32 mg/kg in the liver and 8.33±0.34 mg/kg in the flesh). Bioaccumulation factor (BAF) of *P. obscura* was higher than that of *O. niloticus* for all of the metals except manganese. Also, BAF of Cd (0.18) and Cr (0.29) were same for *C. gariepinus* and *O. niloticus* while Pb, Ni, Fe, Mn, Cu and Zn showed lesser bioaccumulation in *C. gariepinus* as compared to *O. niloticus*. The results showed that the total mean concentrations of Cr (0.37 ± 0.02 mg/kg), Fe (159.99 ± 2.00 mg/kg), Mn (8.33 ± 0.34 mg/kg) and Cu (5.73±0.35) in the different fish species exceeded WHO permissible limits of 0.15 mg/kg, 123.5 mg/kg, 0.5 mg/kg and 3.0 mg/kg respectively. In view of the toxicity associated with heavy metal accumulation, safe disposals of domestic sewage and industrial effluents as well as enforcement of enacted laws to protect our environment are therefore advocated.

Keywords: Heavy metal, WHO, Sediment, Ogbese, Concentration.

INTRODUCTION

Environmental pollution is a worldwide problem and has become a serious threat to organisms (Ibrahim *et al*., 2013). Although environmental pollution can be as a result of natural causes, most are caused by human activities. Urbanization and industrialization have led to increased disposal of pollutants like heavy metals into the environment (Praveena *et al*., 2013). In Nigeria, pollution of freshwater ecosystems is becoming high with attendant public health effects on humans. Due to feeding and living in the aquatic environments, fish are particularly vulnerable and are a convenient indicator of ecosystem health (Authman *et al*., 2015).

Bioaccumulation is an increase in the level of a chemical/toxicant in a biological organism over time, compared to chemical/toxicant level in the environment (Gupta, 2013). The contamination of heavy metals and metalloids in water and sediment, when occurring in higher concentrations, is a serious threat because of their toxicity, persistence, bioaccumulation and biomagnification in the food chain (Moustafa and El-Sayed, 2014).

Abiona *et al*. (2012) from their study in Dandaru Reservoir in Ibadan found out that the concentrations of the metals found in all the water samples are lower than that in the fish species. Ololade and Ajayi (2009) reported that of the four metals (Cd, Cu, Pb and Zn) assessed in *Clarias gariepinus* obtained from rivers (Oluwa, Owena, Ogbese and Ose) along the highways in Ondo State, only Cd was recorded at toxic level in both water and sediment based on WHO and sediment quality guidelines respectively. Aladesanmi and Awotoye (2014) assessed the heavy metal content in the organs/tissues of *C. gariepinus* from Yah, Arula and Rara Streams and their associated fish ponds in Osun State, South West, Nigeria. In their study, the liver showed the highest concentration of all the detected heavy metals, followed by the gills and muscle, while the fins had the lowest metal concentration. In Ogun Estuary, Babatunde *et al*. (2012) reported that bioaccumulation of the heavy metals was species-related as the accumulations of the heavy metals analysed in the sampled fishes were of the following trend: *Hydrocyanus forskahlii* > *Hyperopisus bebe occidentalis* > *Clarias gariepinus* and the pattern of distribution was Ni > Cr > Co > Cd > Pb for all the fish species. Upadhi *et al*. (2013) stated that heavy metals in water of Owubu creek were in the order Cu>Pb>Fe>Mg, with Cu having the highest bioaccumulation. Abalaka (2015) revealed liver bioaccumulations of the metals were in the order of Zn > Fe > Cd > Pb after assessment of heavy metals concentration of the liver of *Auchenoglanis occidentalis* collected from Tiga dam, Kano State. Uneke and Aloh (2015) assessed heavy metals in kidney and gills of catfish in Ebonyi River. Copper was the most abundant metal in the studied tissues of the fishes. Copper showed its maximum accumulation in the kidney and gills of the three species. Uwem *et al*. (2013) reported that the maximum concentration of heavy metals studied was observed in the liver tissues, while bone tissues had the least concentration.

Ogbese River, which flows from Ekiti State through Ogbese town, fluctuates with respect to seasons. The volume of water is highest between August and October while it reduces drastically and sometimes dries up between January and April (Otuaga, 2015). Heavy metal concentration in rivers is dependent on factors such as volume and flow of the water, physico-chemical parameters, season, residues and degree of pollution from tributaries. On the other hand, sediments tend to accumulate, store and release toxic elements to water bodies (Nwadinigwe *et al*., 2014). Considering the fact that heavy metals concentration in inland water is highly dynamic, sediments from water bodies have been described as a convenient measure of heavy metal pollution (USEPA, 2000; Nwadinigwe *et al*., 2014).

Commercial activities in Ogbese town are on the increase especially due to the expansion of the Ogbese market. This has in turn led to increased discharge of effluents into Ogbese River. Therefore, this present study investigated the concentration of heavy metals in the liver and flesh of the freshwater fishes from Ogbese River Ogbese, Ondo State.

MATERIALS AND METHODS

Study Area

Ogbese River is located at Ogbese village few kilometers away from Akure, Ondo State, Nigeria. It has an annual rainfall of about 1600mm to 2100mm, which covers the month of April to October and drainage area of 2039km² (Otuaga, 2015). For the purpose of this study, the river was divided into three reaches: the upper (7^o 16'N 5 ^{o} 22'E), middle (7^o 15'N 5 ^{o} 22'E) and lower reach (7^o 15'N 5^o 23'E) (Figure 1).

Sample Collection and Identification

Nine adult fish samples, three each of *Clarias gariepinus*, *Oreochromis niloticus* and *Parachanna obscura* were procured from fishermen fishing in Ogbese River. These fish species, caught within the upper and lower reaches of the river, were taken to the laboratory alive in buckets containing water from the point of fishing. The fish species were authenticated at the Department of Fisheries and Aquaculture Technology, Federal University of Technology, Akure.

Sample Preparation

Each fish sample was dissected with a sterile knife to remove the liver and flesh. The liver and flesh of each fish were separately dried in a laboratory oven at 65^0C for three days to obtain a constant dry weight. Each of the dried samples was ground to powder using laboratory ceramic mortar and pestle, and sifted with $2mm^2$ sieve. These ground samples were then transferred into sterile ziplock bags, labelled and kept for digestion and analysis of heavy metals.

Collection and Processing of Sediment

Sediments from each reach of the river were collected from the river bank. It was transferred into ziplock bags and taken to the laboratory. The sediments from each reach of the river were separately dried in a laboratory oven at 65^0C for three days to obtain a constant dry weight. Each sample was sifted with $2mm^2$ sieve. These samples were then transferred into sterile ziplock bags, labeled and kept for digestion and analysis of heavy metals.

Digestion of Samples

The digestion of sample was done using the wet digestion procedure described by Jones and Case (1990). For each of the dried samples of fish parts and sediments, 0.5g was carefully weighed into the tubes such that all samples got to the bottom of the tubes. To each of the tubes, 10ml of concentrated H_2SO_4 was added. These were set into the appropriate hole of the Digestion Block heaters in a fume cupboard. The digestion was continued for 4 hours, after which a clear colourless solution was left in the tube. The digest was cooled and carefully transferred into 100ml volumetric flask, thoroughly rinsing the digestion tube with deionized water.

Determination of Heavy Metals

The determination of heavy metals was carried out at Institute of Agricultural Research and Training, Ibadan (IAR and T). The digest of each sample was washed into 100ml volumetric flask with distilled water and made up to mark. The diluent was aspirated into the Buck 200 Atomic Absorption Spectrophotometer (AAS) through the suction tube. Each of the heavy metal was read at their respective wavelengths with their respective hollow cathode lamps using appropriate fuel and oxidant combination as contained in Table 1. The determination of the heavy metals was carried out in triplicates.

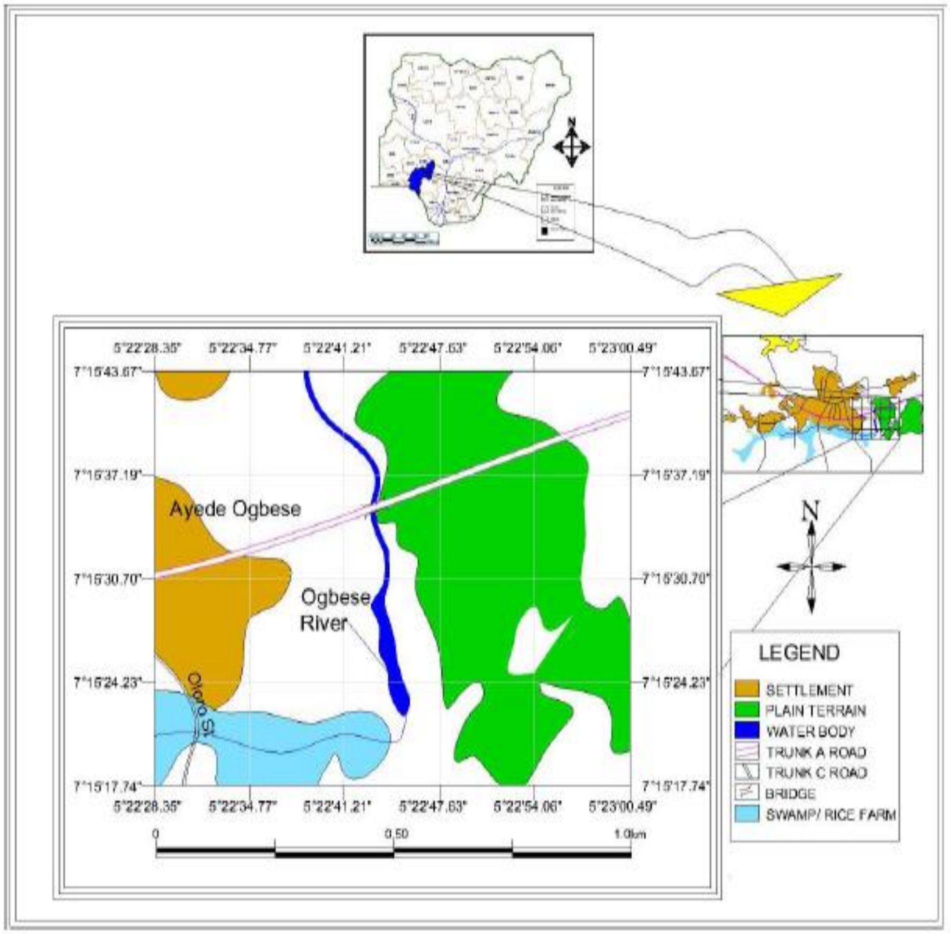

Figure 1: The Map of Ogbese River (Olawusi-Peters *et al*., 2014).

Table 1: Instrument setting for Atomic Absorption Spectrophotometer

H	A	B	C	D	E	F
Cadmium (Cd)	228.8	0.5	0.5-5	0.03	15.0	Air- C_2H_2
Chromium (Cr)	425.4	0.2	7-40	0.5	25.0	Air- C_2H_2
Lead (Pb)	283.3	0.5	4-40	0.2	440.0	Air- C_2H_2
Nickel (Ni)	352.4	0.5	6-30	0.2	25.0	Air- C_2H_2
Iron (Fe)	372.0	0.2	20-80	0.5	30	Air- C_2H_2
Manganese (Mn)	279.5	0.2	1-10	0.06	5.0	Air- C_2H_2
Copper (Cu)	324.7	0.5	1-20	0.1	15.0	Air- C_2H_2
Zinc (Zn)	213.9	0.5	0.5-5	0.03	15.0	Air- C_2H_2

H = Element, A = Wavelength (nm), B = Slit Width (nm), C = working Range (µg/ml), D = Sensitivity (µg/ml), E = Lamp Current, F= Flame Type

Bioaccumulation Factor (BAF)

Bioaccumulation Factor (BAF) was expressed as the ratio of the concentration of the contaminant in the organism to that in the ambient environment (USEPA, 2000).

$$Bioaccumulation\ Factor\ (BAF) = \frac{concentration\ of\ heavymetal\ in\ fish}{concentration\ of\ heavymetal\ in\ sediment}$$

Statistical Analysis

Results were presented as mean ± standard error of mean. Comparison was carried out using One-way analysis of variance (ANOVA) and means with significant differences were separated using New Duncan's Multiple Range Test at p = 0.05 (SPSS, 2012).

RESULTS

Heavy Metal Concentration in Fish Species of Ogbese River

Increasing order of heavy metal concentration in the liver and muscle of the fish type was Cd<Pb<Cr<Ni<Cu<Mn<Zn<Fe. Total heavy metal concentration in the liver was greater than that of the flesh for each fish type (Tables 1 and 2). In both flesh and the liver of the different fish types, Cadmium, Chromium, Lead, Nickel and Copper showed no significant difference (P>0.05) (Tables 2 and 3). The concentration of other heavy metals (Iron, Manganese and Zinc) showed no significant differences in the livers of *O. niloticus* and *P. obscura* but both were significantly different from *C. gariepinus* (Table 2). In the flesh of the fish, the concentrations of Iron, Manganese and Zinc showed no significant difference in *C. gariepinus* and *O. niloticus* while both were significantly different from *P. obscura* (Table 3).

The concentrations of Cadmium, Lead and Zinc in the liver and flesh of all the fish species (Tables 2 and 3) were within the recommended safe limit by WHO (1989). Alongside Cadmium, Lead and Zinc, Nickel was also within WHO recommended safe limit of 0.60 mg/kg, in the liver of *C. gariepinus* and flesh of all fish types; otherwise it exceeded this limit in the liver of *O. niloticus* and *P. obscura* with concentrations of 0.6083 ± 0.036 mg/kg and 0.788 ± 0.029 mg/kg respectively.

Manganese levels of 8.367 ± 0.35 mg/kg, 10.733 ± 0.36 mg/kg and 10.200 ± 0.42 mg/kg in the liver and 6.883 ± 0.34 mg/kg, 8.550 ± 0.28 mg/kg and 6.600 ± 0.31 mg/kg in the flesh of *C. gariepinus*, *O. niloticus* and *P. obscura* respectively were all high compared to the WHO (1989) standard of 0.5 mg/kg limit. Also, Chromium concentration in the flesh and liver of fish species exceeded 0.05-0.15 mg/kg WHO recommended limit in fishes (Tables 2 and 3).

Recommended limits for Iron and Copper are 123.5mg/kg and 3.0 mg/kg and respectively (WHO, 1989). Although, the mean concentration of copper in the flesh of *C. gariepinus* was within the 3.0 mg/kg safe limit of WHO (1989), in the flesh of other fish species as well as the liver of all fish species this limit was exceeded.

In the case of iron, the concentration recorded in the flesh of *C. gariepinus*, *O. niloticus* and *P. obscura* were 141.13 ± 1.71 mg/kg, 151.90 ± 2.96 mg/kg and 158.53 ± 2.00 mg/kg; and 164.87 ± 1.53 mg/kg, 169.15 ± 0.39 mg/kg, 174.35 ± 0.13 mg/kg for liver respectively. All exceeded the WHO (1989) limit of 123.5 mg/kg.

Table 2: Mean Concentration (mg/kg) of heavy metals in the liver of different fish species as compared to WHO standards

Heavy Metals	*C. gariepinus*	*O. niloticus*	*P. obscura*	WHO Limit
Cadmium	0.0135 ± 0.0009^{a}	0.0163 ± 0.0023^{a}	0.0235 ± 0.0013^{a}	2.0
Chromium	0.3917 ± 0.0317^{a}	0.3850 ± 0.01727^{a}	0.5733 ± 0.0273^{a}	0.15
Lead	0.0293 ± 0.0018^{a}	0.0347 ± 0.0021^{a}	0.0385 ± 0.0022^{a}	2.0
Nickel	0.5017 ± 0.0305^{a}	0.6083 ± 0.0361^{a}	0.7883 ± 0.0294^{a}	0.60
Iron	164.8667 ± 1.5294^{e}	169.1500 ±0.3882^{d}	174.3500 ± 0.1251^{d}	123.5
Manganese	8.3667 ± 0.3461^{c}	10.7333 ± 0.3639^{b}	10.2000 ± 0.4235^{b}	0.5
Copper	5.5333 ± 0.3018^{b}	6.8333 ± 0.2906^{b}	8.6667 ± 0.2261^{b}	3.0
Zinc	29.7167 ± 0.5160^{d}	33.9833 ± 0.4868^{c}	34.4833 ± 1.033^{c}	75

Results of the mean of triplicate results ± standard error. Values of different lowercase alphabets within the column are significantly different at $p<0.05$ using New Duncan's Multiple Range Test.

Table 3: Mean Concentration (mg/kg) of heavy metals in the flesh of different fish species as

Heavy Metals	*C. gariepinus*	*O. niloticus*	*P. obscura*	WHO Limit
Cadmium	0.009 ± 0.0011a	0.0053 ± 0.0011a	0.00967 ± 0.0009a	2.0
Chromium	0.2050 ± 0.0118a	0.2200 ± 0.0208a	0.4417 ± 0.0329a	0.15
Lead	0.0145 ± 0.0010a	0.022 ± 0.0017a	0.0298 ± 0.0014a	2.0
Nickel	0.2783 ± 0.0274a	0.3767 ± 0.0141a	0.4900 ± 0.0320a	0.60
Iron	141.1333 ± 1.708e	151.900 ±2.9645e	158.533 ± 2.0003d	123.5
Manganese	6.8833 ± 0.3428c	8.5500 ± 0.2766c	6.6000 ± 0.3077b	0.5
Copper	2.8333 ± 0.2459b	5.0167 ± 0.6916b	4.4667 ± 0.3084b	3.0
Zinc	24.5000 ± 0.2459d	25.48 ± 0.4074d	27.8667 ± 0.6249c	75

compared to WHO standards

Results of the mean of triplicate results ± standard error. Values of different lowercase alphabets within the row are significantly different at $p<0.05$ using New Duncan's Multiple Range Test.

Heavy Metal Concentration in Sediment

The concentration of cadmium, chromium and lead were not significantly different ($P>0.05$) from each other at the different river reaches. Nickel, iron, copper, manganese and zinc showed no significant difference in heavy metal concentration at only the upper and middle reaches (Table 4).

Bioaccumulation Factor (BAF) of Heavy Metals in Fish

Clarias gariepinus

The BAF of the liver was more than that of the muscle for each of the heavy metals. The increasing order of absorption was Pb<Cd<Ni<Cr<Fe<Zn for Liver and Pb<Cd<Ni<Cr<Cr<Cu<Mn<Zn<Fe for muscle (Table 5).

Oreochromis niloticus

Similar to *Clarias gariepinus*, the BAF of the liver of *Oreochromis niloticus* was more than that of the flesh for each heavy metal but order of heavy metal concentration for Liver was Pb<Cd<Cr<Ni<Fe<Cu<Zn<Mn and Cd<Pb<Cr<Ni<Cu<Zn<Fe<Mn for flesh (Table 6).

Table 4: Mean Heavy Metals Concentration in the Sediment at Different River Reaches

Heavy metals	Upper Reach	Middle Reach	Lower Reach
Cadmium	0.0590 ± 0.0010a	0.0770 ± 0.0010a	0.0465 ± 0.0015a
Chromium	0.8700 ± 0.0100b	1.1400 ± 0.0100b	1.0700 ± 0.0100b
Lead	0.1400 ± 0.0100a	0.1800 ± 0.0100a	0.1200 ± 0.0100a
Nickel	1.3950 ± 0.0150c	1.8900 ± 0.0100c	1.4700 ± 0.0100b
Iron	296.4000 ± 0.1000g	314.9000 ± 0.1000g	289.6000 ± 0.1000f
Manganese	13.4000 ± 0.1000e	14.6500 ± 0.1500e	12.7500 ± 0.3500d
Copper	11.2500 ± 0.1500d	13.0500 ± 0.1500d	11.9500 ± 0.1500c
Zinc	52.4500 ± 0.0500f	55.3000 ± 0.1000f	53.9000 ± 0.1000e

Results of the mean of triplicate results ± standard error of mean. Values of different lowercase alphabets within the column are significantly different at $p<0.05$ using New Duncan's Multiple Range Test.

Table 5: Bioaccumulation Factor of Heavy metals in the Liver and Flesh of *Clarias gariepinus*

Heavy Metals	Sediment	Liver	BAF Liver	Flesh	BAF Flesh
Cadmium	0.0608	0.0135	0.22	0.0090	0.15
Chromium	1.0267	0.3917	0.38	0.2050	0.20
Lead	0.1467	0.0293	0.20	0.0145	0.10
Nickel	1.5850	0.5017	0.32	0.2783	0.18
Iron	300.3000	164.8667	0.55	141.1333	0.47
Manganese	13.6000	8.3667	0.62	5.5000	0.40
Copper	12.0833	6.5333	0.54	2.8333	0.23
Zinc	53.8833	29.7167	0.55	24.5000	0.45

Parachanna obscura

Liver BAF which was higher than that of flesh showed bioaccumulation order of Pb<Cd<Ni<Cr<Fe<Zn<Cu<Mn while that of the flesh was Cd<Pb<Ni<Cu<Cr<Mn<Zn<Fe. Iron recorded the highest BAF of 0.53 while cadmium had the lowest of 0.16 for flesh. BAF of 0.75 was recorded for manganese while the lowest of 0.26 was recorded for lead (Table 7).

Table 6: Bioaccumulation Factor of Heavy metals in the Liver and Flesh of *Oreochromis niloticus*

Heavy Metals	Sediment	Liver	BAF Liver	Flesh	BAF Flesh
Cadmium	0.0608	0.01633	0.27	0.0053	0.09
Chromium	1.0267	0.3850	0.37	0.2200	0.21
Lead	0.1467	0.03467	0.24	0.0220	0.15
Nickel	1.5850	0.60833	0.38	0.3767	0.24
Iron	300.3000	169.1500	0.56	151.9000	0.51
Manganese	13.6000	10.7333	0.79	8.5500	0.63
Copper	12.0833	6.8333	0.57	5.0167	0.42
Zinc	53.8833	33.9833	0.63	25.4833	0.47

Table 7: Bioaccumulation Factor of Heavy metals in the Liver and Flesh of *Parachanna obscura*

Heavy Metals	Sediment	Liver	BAF Liver	Flesh	BAF Flesh
Cadmium	0.0608	0.0235	0.39	0.0097	0.16
Chromium	1.0267	0.5733	0.56	0.4417	0.43
Lead	0.1467	0.0385	0.26	0.0298	0.20
Nickel	1.5850	0.7883	0.50	0.4900	0.31
Iron	300.3000	174.3500	0.58	158.5333	0.53
Manganese	13.6000	10.2000	0.75	6.6000	0.49
Copper	12.0833	8.6667	0.72	4.4667	0.37
Zinc	53.8833	34.4833	0.64	27.8667	0.52

DISCUSSION

Increasing order of heavy metal concentration in each of the fishes was Cd<Pb<Cr<Ni<Cu<Mn<Zn<Fe. This was similar to reports of Olawusi-Peters *et al*. (2014) with heavy metal concentration in the order of Fe>Zn>Cu>Pb in their study of heavy metal concentration in the gills and flesh of *O. niloticus and C. gariepinus* in Ogbese River. Abalaka (2015) reported increasing order of metal concentration of Pb<Cd<Fe<Zn. Differences in heavy metal concentrations may be due to varying types and quantities of environmental pollutants in the different regions.

Heavy metal concentration in the liver was observed to be greater than that of the flesh for all fish samples. This is in line with reports by Aladesanmi and Awotoye (2014) and Abalaka (2015) that the liver accumulates more heavy metals than the flesh. This could be due to the fact that the liver is involved in many different functions including bile production, storage of vitamins, detoxification of blood, synthesis of a variety of proteins and regulating the levels of many chemicals found in the bloodstream (Yan-Jun *et al*., 2004).

Parachanna obscura showed the highest Bioaccumulation Factor (BAF) for all metals except manganese which was highest in *O. niloticus*. This could be due to its voracious bottom feeding behaviour which could promote accumulation of heavy metals from sediment and its mean weight of 494.47 ± 140.99g as compared to 227.87 ± 51.74g of *C. gariepinus* and 197.47 ± 25.01g of *O. niloticus*.

Toxic effects of Chromium and Copper in fish include: hematological, histological and morphological alterations, inhibition/reduction of growth, production of reactive oxygen species (ROS) and impaired immune function (Varanka *et al*., 2001; Vera-Candioti *et al*., 2011). Omar *et al*. (2014), in their study, proved that the fish liver is the target organ for iron and it interferes with metabolic functions.

In man, the toxicity of chromium stems from its tendency to be corrosive and to cause allergic reactions (Authman *et al*., 2015). Exposure to nickel may lead to various adverse health effects, such as nickel allergy, contact dermatitis, and organ system-toxicity. According to the Institute of Medicine (Institute of Medicine, 2003), nickel can cause respiratory problems and is carcinogenic (ATSDR, 2004). Copper is essentially needed but in high doses, anaemia, liver and kidney damage, and stomach and intestinal irritation may occur (Pandey and Madhuri, 2014).

CONCLUSION

The results of this study showed that Ogbese River is contaminated with some heavy metals. The sediment and fishes of the river were contaminated with the heavy metals; cadmium, chromium, lead, nickel, iron, manganese, copper and zinc. The results further showed that the concentration of Cr, Ni, Fe, Mn and Cu all exceeded the WHO limits.

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