Net Journal of Agricultural Science
Vol. 9(3), pp. 51-58, September 2021
ISSN: 2315-9766
Full Length Research Paper

Heavy metals level in *Oreochromis niloticus* collected from Lake Geriyo, Yola, Adamawa State, Nigeria

Kefas M.[1]*, Micheal K.G.[1], Haziel H.[2] and Adokwe J. B.[3]

[1]Department of Fisheries, Modibbo Adama University, Yola, P.M.B 2076, Adamawa State, Nigeria.
[2]Department of Food Science and Technology, Modibbo Adama University, Yola, P.M.B 2076, Adamawa State, Nigeria.
[3]Department of Environmental Quality Control, National Environmental Standards and Regulations Enforcement Agency (NESREA), Nigeria.

Accepted 30 August, 2021

ABSTRACT

Oreochromis niloticus is an important species of fish that is a major component and source of animal proteins in most diets of the people of Yola in particular, and Nigeria in general. This work assessed concentrations of some heavy metals: Zinc, iron, copper, manganese and lead (Zn, Fe, Cu, Mn and Pb) in *O. niloticus* organs (muscle, gills and liver) from Lake Geriyo, using Atomic Absorption Spectrophotometer, after wet digestion for the period of six months. The concentrations of the metals differed significantly in the organs of the fish species at the different sites. Zinc, Iron and Copper (Zn, Fe, and Cu) at sites A, B and C recorded concentrations (1.77, 11.65 and 1.77 mg/kg) within the permissible limits in fish organs. Manganese (Mn) and Lead (Pb) recorded concentrations (2.33 and 0.11 mg/kg) above the permissible limit in fish organs. Gills and liver of *O. niloticus* contained the highest concentrations of most of the detected heavy metals, while muscles appeared to be the least preferred site for the bioaccumulation of heavy metals. The liver and muscle of *O. niloticus* showed higher levels of Manganese (Mn) and Lead (Pb) in the study area. This may be due to bioaccumulation over a period of time in the liver and muscles of *O. niloticus.* Generally, the concentrations of the metals in the different organs of the fish were significantly higher ($P < 0.05$) compared to the FAO/WHO and WHO permissible limits of these metals in fish. This shows a possible high risk of heavy metal toxicity consequent upon the consumption of this fish from these sources.

Keywords: Pollution, AAS, *Oreochromis niloticus*, heavy metals, Lake Geriyo.

*Corresponding author. E-mail: kmgaya10@yahoo.com. Tel: +2347063072452.

INTRODUCTION

Modern societies are faced with serious concerns about some global environmental challenges; developing countries in particular currently experience growing and complex pollution problems. Global environmental pollution, water pollution and waste management, in particular, have attracted international public health attention. From the perspective of chemicals or hazardous substances, river, lake water samples, sediments and some species of fish in Nigeria have been investigated (Unyimadu et al., 2019). The contamination of the waters, sediments and organisms of our rivers, lakes and other surface water bodies with a wide range of pollutants has become a matter of great concern the world over especially in the last few decades (Kori-Siakpere and Ubogu, 2008).

Water containing levels of pollutants so low that the water is deemed potable (fit to drink) can still be a source of problems due to bio-magnifications, a phenomenon whereby chemical substances become increasingly more concentrated at successively higher trophic levels, which is a characteristic of substances that are fat-soluble and difficult to be degraded to harmless substances (Kamaruzzaman et al., 2010). Metals are non-biodegradable and form part of environmental pollutants in which elevated concentrations pose threats to human health through the food chain (Kusemiju et al., 2012).

Heavy metals are natural components of the aquatic environment, but their concentrations have increased due to domestic, industrial, mining and agricultural activities (Bakan and Büyükgüngör, 2000; Altas and Büyükgüngör, 2007; Bat et al., 2012). The discharge of industrial wastes containing toxic heavy metals into water bodies may have significant effects on fish and other aquatic organisms, which may endanger public health. Aquatic organisms such as fish accumulate heavy metals to concentrations many times higher than present in water or sediment (Bat et al., 2012). When metals enter the aquatic environment, a great portion settles and are absorbed by the bottom mud (Ada et al., 2012). They could be recycled by chemical, physical and biological processes such that some quantity remains dissolved in the water column and some part absorbed by the inhabitants (Ada et al., 2012; Kori-iakpere and Ubogu, 2008). Metal ions can be incorporated into food chains and concentrated in aquatic organisms to a level that affects their physiological state. Of the effective pollutants are heavy metals which have a drastic environmental impact on all organisms. Trace metals such as Zn, Cu and Fe play a biochemical role in the life processes of all aquatic plants and animals; therefore, they are essential in the aquatic environment in trace amounts (Samir and Ibrahim, 2008).

Fish is often used as a biomarker of the quality of water bodies since the quality of the fish depends on the quality of the water (Fakankun et al., 2012; Olusola and Festus, 2015; Obot et al., 2016; Bawuro et al., 2018). Organic and inorganic chemical fertilizers often constitute the main water pollutants and their levels are some of the measures to determine the water quality. Apart from the implications for human health (Kayode et al., 2011), the presence and/or the levels of inorganic and organic substances in water bodies pose threats to the health of aquatic organisms including fish (Jacquin et al., 2020; Adewuyi et al., 2010). Fishes are therefore useful for sentinel species and bio-indicators of metal pollution because they can help to understand the risk to the aquatic ecosystem and humans (Peakall and Burger, 2003). Many biological factors of the fish such as age, lipid contents, mode of feeding and body size could play a role in the bioavailability of metals (Peakall and Burger, 2003). The use of wild fishes as biomonitors of metal pollution in the aquatic ecosystem is becoming popular throughout the world (Indrajith et al., 2008). Generally, the higher the metal concentration in the environment, the more the amount taken up and accumulated by fish. The quantity of metal accumulated has been reported to be directly related to the concentration to which the organisms are exposed and the period of exposure (Kusemiju et al., 2012; Kamaruzzaman et al., 2010). Metals are also preferentially accumulated by different organs of the body (Kusemiju et al., 2012, Rauf et al., 2009).

Oreochromis niloticus is a very important source of animal protein in the human diet. It forms a significant percentage of captured fish from Lake Geriyo, Yola, Adamawa State, Nigeria, and is consumed in large quantities by the inhabitants. Therefore, this work on a fish species is to determine the levels of contamination and the bioaccumulation of some heavy metals such as Zinc, Iron, Copper, Manganese and Lead (Zn, Fe, Cu, Mn, and Pb) in fish organs (muscles, gills and liver) of commercially important fish species (*Oreochromis niloticus*) in Lake Geriyo, Yola, Adamawa State, Nigeria.

MATERIALS AND METHODS

Study area

Lake Geriyo is located at the outskirts of Jimeta-Yola metropolis in the northwest region (Longitude 12° 25' E and between latitude 9° 81' N and 9° 17' N). It has a high level of 750 ha and a low level of 200 ha. The storage is at a level of about 7,500,000cm^3. The area amiable to fisheries development is about 250 ha; consequently, most of the settlers around the lake are fishermen (Upper Benue River Basin Development Authority, 1985).

Lake Geriyo is a natural lake that started as a small gulley but was later filled with water from rains and some influx from River Benue. The lake came into recognisable existence in 1950. Initially, the lake was not used for fishing. It has now become a major fishery site, with fishing activities taking place all year round. It is also a major source of water for irrigation, during the dry season farming that takes place around the lake.

Lake site A is found to be a great domestic and industrial wastes dump and agricultural activities, site B is found to be the fishing landing site, washing of utensil, clothes and agricultural activities and site C intense agricultural activities, where agrochemicals may have been applied on both rainy and dry seasons (Figure 1). The lake receives a lot of dissolved substances through runoff, soil drainage and soil erosion from its tributaries from far and surrounding Yola metropolis. All these are believed to cause devastating effects on the aquatic fauna and flora.

The lake experiences two seasonal periods the rainy and dry seasons. The rainy season starts in May and lasts till October. The dry season on the other hand is from late October to April.

Duration of sampling

The study was conducted for six months (July to December 2020). The concentration of heavy metals in *O. niloticus* organs (muscles gills and liver) were evaluated in the laboratory for the period of this study by taking the sample monthly.

Sampling methods

Fishing was done late at night with the help of professional local fishermen. Fish samples were collected from site A, site B and site C during the period of this study for evaluation of heavy metals concentration. The fish samples were kept refrigerated and transferred cold to the laboratory for analysis.

Digestion and determination of heavy metals in fish samples

Fish species (*O. niloticus*) were collected monthly from each site for heavy metals analysis. The fish samples were separated. Scales were removed and washed with running water before dissecting with sterile scissors to remove gills, liver and muscles. The wet digestion technique was used as described by AOAC (1990). The digests were kept in plastic bottles and heavy metal Zinc (Zn), Iron

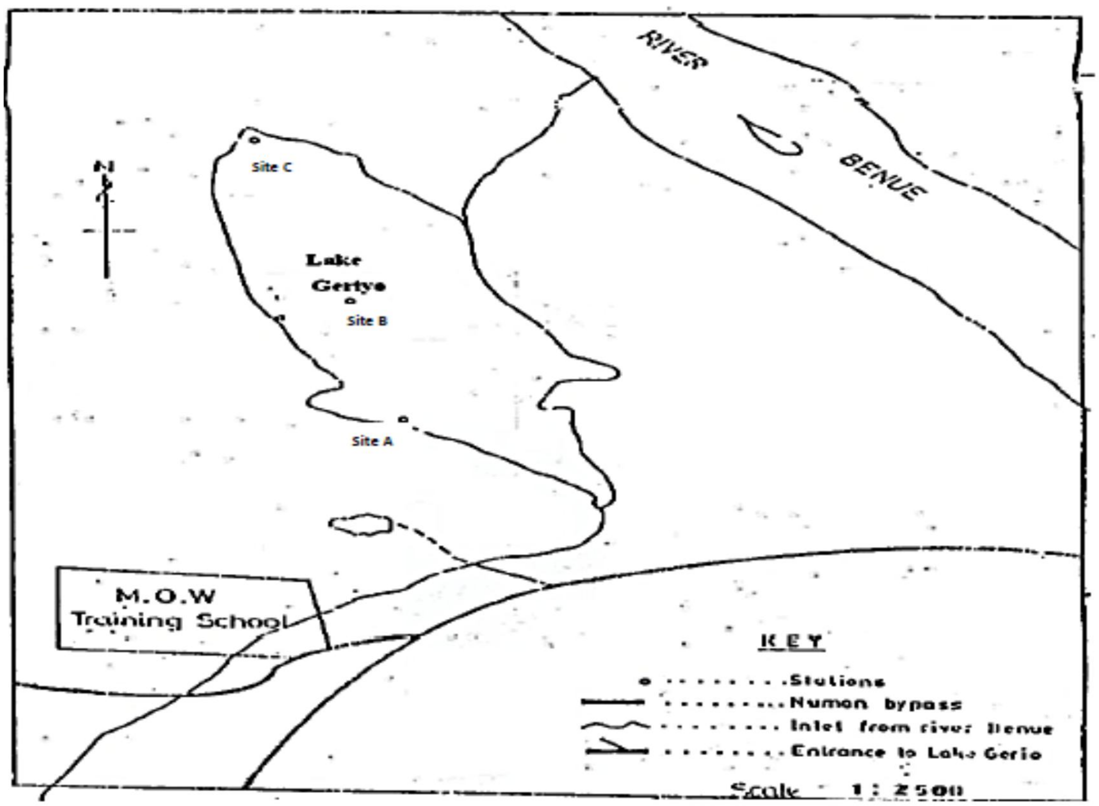

Figure 1. Map of Lake Geriyo showing sampling sites.

(Fe), Manganese (Mn), Cupper (Cu), and Lead (Pb) concentrations were determined using an Atomic Absorption Spectrophotometer (AAS)-VGP210.

Statistical analysis

Data collected were presented as mean ± SD after calculation using Microsoft Office Excel 2008. The data were also subjected to analysis of variance (ANOVA) and post hoc (LSD) for levels of significance using SPSS version 16.0. A P-value of 0.05 or less was considered statistically significant.

RESULTS

Zinc

The monthly mean concentrations of zinc in the muscles of *O. niloticus* ranged from 0.17 to 1.49 mg/kg (Table 1). The highest zinc concentration (1.49 mg/kg) was recorded in November site B while the lowest mean concentration (0.17 mg/kg) was recorded in sites A and C in September and October. There was a significant difference ($p < 0.05$) in sites A, B and C in the months respectively. The results showed that gills of *O. niloticus* site C recorded the lowest concentrations (0.63 mg/kg) of Zinc in July while the highest mean concentrations (1.77 mg/kg) were recorded at site A in November (Table 1). The results showed that the monthly mean concentrations of Zinc were significantly different ($p < 0.05$) higher in November compared to July, August, September, and October. For the monthly mean concentrations of Zn in the liver of *O. niloticus*, site A recorded the lowest (0.14 mg/kg) and highest (1.68 mg/kg) in site C in December (Table 1). The results showed that for monthly mean concentrations of Zinc in the liver, sites A, B and C in November and December are significantly different ($p < 0.05$) compared to other months.

Iron

The monthly mean concentrations of Iron in the muscles of this fish ranged from 1.23 to 7.60 mg/kg in October and December, respectively (Table 2). The results showed a monthly mean significance difference ($p < 0.05$) in all the months. The monthly mean concentrations of Fe in the gills of *O. niloticus* shows that for gills, site A (11.65 mg/kg) has the highest monthly mean concentrations of iron in December while site A (2.48 mg/kg) has the lowest monthly mean concentrations of iron in October (Table 2). The results showed a significant difference ($p < 0.05$) in June and July compared to August to November. The monthly mean

Table 1. Monthly mean concentration of Zn (mg/kg) in *Oreochromis niloticus* muscles, gills and liver from July to December, 2020.

Month	A			B			C		
	Muscles	Gills	Liver	Muscles	Gills	Liver	Muscles	Gills	Liver
July	0.36 ±0.09^{b}	0.66 ± 0.09^{a}	0.42 ± 0.04^{a}	0.46 ± 0.17^{a}	0.69 ± 0.11^{a}	0.36 ± 0.06^{b}	0.46 ± 0.07^{a}	0.63 ± 0.12^{a}	0.48 ± 0.16^{a}
August	0.46 ± 0.11^{b}	0.73 ± 0.14^{b}	0.55 ± 0.08^{a}	0.53 ± 0.17^{a}	0.90 ± 0.05^{a}	0.54 ± 0.19^{a}	0.59 ± 0.12^{a}	0.74 ± 0.18^{b}	0.59 ± 0.2^{a}
September	0.17 ± 0.04^{b}	0.92 ± 0.80^{b}	0.19 ± 0.14^{c}	0.22 ± 0.05^{a}	1.09 ± 0.04^{a}	0.31 ± 0.13^{a}	0.23 ± 0.02^{a}	0.88 ± 0.18^{c}	0.24 ± 0.09^{b}
October	0.19 ± 0.01^{a}	0.66 ± 0.13^{b}	0.14 ± 0.03^{b}	0.18 ± 0.04^{a}	0.73 ± 0.08^{a}	0.17 ± 0.05^{b}	0.17 ± 0.03^{a}	0.77 ± 0.32^{a}	0.25 ± 0.09^{a}
November	0.90 ± 0.20^{c}	1.77 ± 1.13^{a}	1.38 ± 1.04^{a}	1.49 ± 0.50^{a}	1.49 ± 0.79^{b}	0.80 ± 0.21^{b}	1.35 ± 0.19^{b}	1.29 ± 0.25^{c}	0.78 ± 0.19^{b}
December	0.69 ± 0.14^{b}	1.01 ± 0.12^{a}	1.67 ± 0.66^{a}	1.10 ± 0.41^{a}	1.08 ± 0.25^{a}	1.67 ± 0.55^{a}	1.05 ± 0.15^{a}	1.17 ± 0.12^{a}	1.68 ± 0.62^{a}

Table 2. Monthly mean concentration of Fe (mg/kg) in *Oreochromis niloticus* muscles, gills and liver from July to December, 2020.

Month	A			B			C		
	Muscles	Gills	Liver	Muscles	Gills	Liver	Muscles	Gills	Liver
July	1.58 ± 0.35^{a}	2.95 ± 0.44^{c}	3.67 ± 1.28^{b}	1.45 ± 0.17^{b}	4.40 ± 0.42^{a}	3.44 ± 1.38^{c}	1.44 ± 0.11^{b}	3.35 ± 0.35^{b}	4.74 ± 1.56^{a}
August	1.49 ± 0.15^{b}	2.48 ± 0.20^{c}	3.58 ± 0.29^{a}	1.53 ± 0.13^{a}	2.73 ± 0.30^{a}	3.42 ± 0.37^{b}	1.59 ± 0.17^{a}	2.60 ± 0.29^{b}	3.44 ± 1.36^{b}
September	1.25 ± 0.09^{c}	8.39 ± 0.74^{a}	2.86 ± 1.18^{b}	1.34 ± 0.17^{b}	6.07 ± 2.33^{c}	4.81 ± 2.36^{a}	1.42 ± 0.29^{a}	7.84 ± 0.27^{b}	4.67 ± 2.56^{a}
October	1.33 ± 0.09^{b}	9.75 ± 1.06^{a}	2.92 ± 0.92^{c}	1.23 ± 0.05^{c}	7.17 ± 0.16^{b}	4.36 ± 0.53^{a}	1.61 ± 0.04^{a}	7.40 ± 0.69^{b}	3.97 ± 1.48^{b}
November	4.18 ± 2.88^{b}	10.11 ± 1.51^{a}	9.22 ± 2.33^{a}	3.74 ± 0.88^{c}	8.92 ± 0.94^{b}	8.34 ± 1.42^{b}	5.03 ± 1.55^{a}	10.33 ± 0.97^{a}	9.06 ± 1.72^{a}
December	7.60 ± 0.96^{a}	11.65 ± 0.78^{a}	10.73 ± 1.92^{a}	5.23 ± 1.65^{b}	10.22 ± 0.82^{b}	10.76 ± 0.63^{a}	5.65 ± 1.61^{b}	11.23 ± 0.81^{a}	10.69 ± 1.76a

concentrations of Fe in the liver recorded the lowest (2.86 mg/kg) in site A while the highest (10.76 mg/kg) in September and December respectively (Table 2). The months of November and December are significantly different ($p < 0.05$).

Copper

The monthly mean concentrations of copper in the muscles of *O. niloticus* ranged from 0.48 to 1.27 mg/kg. The highest (1.27 mg/kg) monthly mean concentration of this metal was recorded in site C in August while the lowest (0.48 mg/kg) was recorded in the muscles in site A in October (Table 3). The results showed no significant difference ($p > 0.05$) in the monthly mean concentrations of copper in the different fish sites. The monthly mean concentrations of Cu in gills of *O. niloticus* recorded the lowest (0.37 mg/kg) and the highest (1.44 mg/kg) in September and July site C (Table 3). There was a significant difference ($p < 0.05$) higher in June compared to August while the other monthly mean concentrations showed no statistical difference. The monthly mean concentrations of Cu in the liver show that site B and site A recorded the highest (1.77 mg/kg) and lowest (0.87 mg/kg) monthly mean concentrations of Cu in July and October respectively (Table 3). The results showed that the monthly mean concentrations of copper (Cu) in the liver of *O. niloticus* are not significantly different ($p > 0.05$).

Manganese

The monthly mean concentration of manganese in the muscles ranged from 0.04 to 0.88 mg/kg. The highest (0.88 mg/kg) monthly mean concentration of Mn was detected at site B in November while the lowest (0.04 mg/kg) concentration of Mn was recorded at site A in September (Table 4). The results showed a significant difference ($p < 0.05$) in November and December when compared to the other months. The concentrations of Mn in the gills of *O. niloticus* ranged between 0.37 and 1.59

Table 3. Monthly mean concentration of Cu (mg/kg) in *Oreochromis niloticus* muscles, gills and liver from July to December, 2020.

Month	A			B			C		
	Muscles	Gills	Liver	Muscles	Gills	Liver	Muscles	Gills	Liver
July	1.22 ± 0.17^{a}	1.13 ± 0.23^{b}	1.77 ± 0.68^{a}	1.15 ± 0.35^{b}	1.12 ± 0.02^{b}	1.25 ± 0.51^{b}	1.18 ± 0.14^{b}	1.44 ± 0.19^{a}	0.89 ± 0.72^{c}
August	1.17 ± 0.71^{b}	1.19 ± 0.07^{a}	1.66 ± 0.18^{a}	1.14 ± 0.23^{b}	1.18 ± 0.09^{a}	1.46 ± 0.13^{b}	1.27 ± 0.05^{a}	1.16 ± 0.07^{a}	1.47 ± 0.14^{b}
September	0.79 ± 0.43^{c}	0.69 ± 0.02^{a}	0.93 ± 0.07^{c}	0.88 ± 0.55^{b}	0.67 ± 0.12^{a}	1.28 ± 0.10^{a}	0.95 ± 0.21^{a}	0.37 ± 0.22^{b}	1.14 ± 0.23^{b}
October	0.48 ± 0.22^{c}	0.65 ± 0.15^{a}	0.89 ± 0.60^{a}	0.69 ± 0.20^{a}	0.59 ± 0.11^{a}	0.87 ± 0.07^{a}	0.56 ± 0.06^{b}	0.59 ± 0.12^{a}	0.96 ± 0.17^{a}
November	0.81 ± 0.19^{a}	0.86 ± 0.13^{b}	0.99 ± 0.17^{b}	0.82 ± 0.11	0.86 ± 0.09^{b}	1.01 ± 0.23^{a}	0.88 ± 0.15^{a}	0.98 ± 0.04^{a}	0.89 ± 0.22^{c}
December	0.85 ± 0.16^{a}	0.84 ± 0.08^{a}	1.17 ± 0.15^{a}	0.60 ± 0.34^{c}	0.82 ± 0.17^{a}	1.14 ± 0.08^{a}	0.79 ± 0.26^{b}	0.88 ± 0.08^{a}	1.19 ± 0.10^{a}

Table 4. Monthly mean concentration of Mn (mg/kg) in *Oreochromis niloticus* muscles, gills and liver from July to December, 2020.

Month	A			B			C		
	Muscles	Gills	Liver	Muscles	Gills	Liver	Muscles	Gills	Liver
July	0.21 ± 0.03^{b}	0.61 ± 0.12^{b}	0.17 ± 0.01^{b}	0.33 ± 0.05^{a}	0.75 ± 0.04^{a}	0.29 ± 0.17^{a}	0.28 ± 0.03^{b}	0.69 ± 0.11^{b}	0.17 ± 0.02^{b}
August	0.23 ± 0.06^{a}	0.51 ± 0.04^{a}	0.22 ± 0.02^{a}	0.22 ± 0.04^{a}	0.50 ± 0.05 ^{a}	0.27 ± 0.04^{a}	0.25 ± 0.02^{a}	0.53 ± 0.09^{a}	0.24 ± 0.06^{a}
September	0.04 ± 0.04^{a}	0.58 ± 0.13^{b}	0.10 ± 0.05^{a}	0.10 ± 0.02^{a}	0.75 ± 0.40^{a}	0.30 ± 0.21^{a}	0.07 ± 0.03^{a}	0.47 ± 0.05^{c}	0.15 ± 0.03^{a}
October	0.05 ± 0.08^{a}	0.41 ± 0.05^{a}	0.16 ± 0.04^{a}	0.07 ± 0.01^{a}	0.41 ± 0.08^{a}	0.15 ± 0.04^{a}	0.05 ± 0.01^{a}	0.37 ± 0.06^{b}	0.16 ± 0.05^{a}
November	0.07 ± 0.13^{b}	0.67 ± 0.02^{b}	2.33 ± 1.78^{a}	0.88 ± 0.40^{a}	1.59 ± 0.02^{a}	1.88 ± 2.20^{b}	0.66 ± 0.21^{a}	0.98 ± 0.32^{b}	1.42 ± 1.97^{b}
December	0.55 ± 0.26^{b}	0.65 ± 0.06^{a}	1.11 ± 0.08^{a}	0.47 ± 0.31^{b}	0.67 ± 0.11^{a}	1.13 ± 0.16^{a}	0.75 ± 0.26^{a}	0.76 ± 0.09^{a}	1.16 ± 0.20^{a}

mg/kg (Table 4). The lowest and highest concentrations of 0.37 and 1.59 mg/kg were detected at sites C and B in October and November respectively. There were statistical differences in the concentrations of Mn in November at P>0.05, site B compared to other months. The concentrations of Mn in the liver of *O. niloticus* ranged between 0.15 and 2.33 mg/kg (Table 4). The highest (2.33 mg/kg) monthly mean concentrations of manganese in November while the lowest (0.15 mg/kg) monthly mean concentration of manganese was also recorded in the liver in site A in September and October. The results showed a significant difference ($p < 0.05$) in November compared to July, August, September, October and December in the liver of *O. niloticus*.

Lead

The monthly mean concentrations of lead in the muscles ranged from 0.01 to 0.11 mg/kg (Table 5). The highest (0.11 mg/kg) monthly mean concentrations of lead (Pb) was recorded in fish muscles in site C in July while the lowest (0.01 mg/kg) monthly mean concentrations of lead was recorded in the muscles in sites A, B and C in July, August, September and October respectively. There was a significant difference ($p < 0.05$) in the monthly mean concentrations of lead in the muscles in July. The results showed that gills of *O. niloticus* in sites A and B has the highest (0.04 mg/kg) monthly mean concentration of lead in October and December. The lowest (0.01 mg/kg) monthly mean concentration of lead was recorded in gills in sites A, B, C in August, September, November and December (Table 5). The results showed a significant difference ($p < 0.05$) in the monthly mean concentrations of lead in October and December. The results showed that liver of *O. niloticus* in site A recorded the highest (0.05 mg/kg) monthly mean concentration of lead in July while the lowest (0.01 mg/kg) monthly mean concentrations of lead (Pb) was also recorded in liver in sites A, B and C in August and September (Table 5). The results showed a significant difference ($p< 0.05$) in the liver of *O. niloticus* recorded in July.

Table 5. Monthly Mean Concentration of Pb (mg/kg) in *Oreochromis niloticus* muscles, gills and liver from July to December, 2020.

Month	A			B			C		
	Muscles	Gills	Liver	Muscles	Gills	Liver	Muscles	Gills	Liver
July	0.04 ± 0.01[b]	0.02 ± 0.01[a]	0.05 ± 0.04[a]	0.01 ± 0.01[b]	0.02 ± 0.00[a]	0.04 ± 0.03[a]	0.11 ± 0.17[a]	0.02 ± 0.01[a]	0.04 ± 0.01[a]
August	0.01 ± 0.01[a]	0.01 ± 0.01[a]	0.04 ± 0.02[a]	0.02 ± 0.02[a]	0.02 ± 0.01[a]	0.01 ± 0.01[a]	0.02 ± 0.01[a]	0.01 ± 0.01[a]	0.01 ± 0.01[a]
September	0.02 ± 0.0[a]	0.03 ± 0.02[a]	0.01 ± 0.01[a]	0.02 ± 0.02[a]	0.02 ± 0.01[a]	0.02 ± 0.02[a]	0.01 ± 0.01[a]	0.01 ± 0.01[a]	0.02 ± 0.01[a]
October	0.01 ± 0.01[a]	0.04 ±0.03[a]	0.02 ± 0.01[a]	0.01 ± 0.01[a]	0.03 ± 0.01[a]	0.03 ± 0.01[a]	0.01 ± 0.01[a]	0.02 ± 0.02[a]	0.02 ± 0.02[a]
November	0.01 ± 0.01[a]	0.01 ± 0.0[a]	0.03 ± 0.02[a]	0.02 ± 0.02[a]	0.01 ± 0.02[a]	0.02 ± 0.01[a]	0.02 ± 0.02[a]	0.02 ± 0.00[b]	0.02 ± 0.01[a]
December	0.03 ± 0.01[a]	0.01 ± 0.01[a]	0.04 ± 0.02[a]	0.03 ± 0.01[a]	0.04 ± 0.02[a]	0.04 ± 0.03[a]	0.03 ± 0.02[a]	0.03 ± 0.01[a]	0.04 ± 0.04[a]

Values are Mean ± SD, (n = 3).
[a]Higher concentration of heavy metal in fish Muscles, Gills and Liver within the row at $p < 0.05$.
[b]Higher concentration of heavy metals in fish Muscles, Gills and Liver in the column at $p < 0.05$.

DISCUSSION

The concentrations of Zinc (Zn) obtained from this study in gills, liver and muscles were within the permissible limits of 100 mg/kg for food fish set by FAO, (1985), APHA, (1990) and (5.0 mg/kg) set by WHO (2003). The results agreed with Zira et al. (2015) who reported high levels of zinc in the liver and gills. This is a good pointer to the fact that the gill is in frequent contact with the environmental water, and being studded with blood vessels, tends to absorb more of the heavy metals from the environment. The liver, on the other hand, is the principal storage organ for these metals, compared to other tissues (Odey et al., 2020). Samir and Ibrahim (2008) attributed the high accumulation of heavy metals in the liver and gills tissues to the metallothionein proteins which are synthesized in these organs when fishes are exposed to heavy metals and detoxify them. These proteins are thought to play an important role in protecting them from damage by heavy metal toxicants. Also, gills are the site directly exposed to the ambient conditions and also are known for their excretory function even for some metals like zinc (Samir and Ibrahim, 2008). Zinc is an essential element in an animal's diet, but it is regarded as a potential hazard for both animals and human health (Datar.and Vashishtha, 1990; Odey et al., 2020).

The study revealed that the concentration of Iron in muscles, gills and liver were below the recommended maximum permissible limit of 100 mg/kg set by WHO (2003) and FOA (1985). During the period of the study Iron (Fe) was the highest in bioaccumulation among the heavy metals investigated. This may be due to the unique nature of Iron metabolism which toxicity is the most common metal toxicity worldwide (Kontohuorghes et al., 2004). The symptom of Iron overload especially in the context of disease hemochromatosis is skin hyperpigmentation (to a bronze or grey colour) due to deposits of Iron toxicities is also associated with joint disease, arrhythmia, heart failure, increase risk of liver-related disorder, and breast cancer (Nelson et al., 1995).

The concentrations of copper recorded in the fish organs were lower than the permissible limit (2.25 mg/kg) set by WHO (2003). The results showed similarities with the work reported by Zira et al. (2015) who reported that the liver and gills have a high accumulation of copper with the liver serving as the primary storage, which is particularly susceptible to overload and related damage. Although copper plays an important role in human nutrition, toxicity at elevated exposure has been reported. Excessive copper (through overexposure or from copper metabolism disease like Wilsons disease) can be neurotoxic (Wright and Baccarelli, 2007) and acute unintentional copper toxicities are more frequently reported than those of arsenic (Bronstein et al., 2011).

The concentration of manganese recorded was higher than the permissible limit (0.50 mg/kg) set by WHO (2003) and FAO/WHO permissible limits of heavy metals in fish of 0.1 mg/kg (FAO/WHO, 2007). The results revealed that *O. niloticus* muscles, gills and liver recorded a high concentration of manganese. This is a reflection of the fact that the effluents from the industries and domestic wastes occasionally dumped into and around the lake may be the major contributors of heavy metals in this aquatic environment. A high concentration of manganese interferes with the central nervous system of vertebrates by inhibiting dopamine formation as well as interfering with other metabolic pathways.

High levels of manganese are a source of concern as consumption of fish contaminated with manganese could result in certain disorders (Zira et al., 2015).

The results revealed that the concentrations of lead were higher than the permissible limit (0.01 mg/kg) set by WHO (2003) in fish for human consumption; however, the highest values were observed in fish muscles. The accumulation of lead in fish muscles could be attributed to the fact that lead is naturally found on the surface waters due to weathering of materials and soil erosion (Zira et al., 2015). This source of water supply is susceptible to pollution due to heavy human dependency on this Lake Geriyo and it may be because of runoff from waste dumps around the Lake. Notably, there is indiscriminate dumping of waste and agricultural practices taking place around the Lake. Lead is categorised as a priority hazardous substance. It affects the central and peripheral nervous systems, causes brain damage, cardiovascular disease, adverse effects on the developmental stages of the foetus (WHO, 2019). According to Zira et al. (2015), pregnant women exposed to lead were found to have high rates of stillbirths and miscarriages.

Conclusion

In conclusion, essential metals such as Zinc, Iron, Copper and Manganese investigated were found to have accumulated in varying degrees but within the maximum permissible limits except for Manganese. Non-essential metal Lead was found to have bio-accumulated beyond the permissible limit. The present results show that the Fish at Lake Geriyo is polluted with Manganese and Lead and it can risk getting polluted with other heavy metals and may pose a health challenge to human and fish species. There is a need for constant monitoring of pollutants in Lake Geriyo. The present results also show that heavy metals concentration in fish organs (muscles, gills and livers) follows this order Fe>Zn>Cu>Mn>Pb, with Iron (Fe) significantly more concentrated than other metals investigated.

REFERENCES

Ada FB, Ekpenyong E, Bayim BP, **2012**. Heavy metal concentration in some fishes (Chrysichthys nigrodigitatus, *Clarias gariepinus* and *Oreochromis niloticus*) in the Great Kwa River, Cross River State, Nigeria. Global Adv Res J Environ Sci Toxicol, 1(7): 183-189.

Adewuyi GO, Babayemi JO, Olabanji AA, **2010**. Assessment of toxicity of effluents discharged into waterways by some industries in Nigeria: a case study of Ibadan. Pac J Sci, 11(2): 538-543.

Altas L, **Büyükgüngör** H, **2007**. Heavy Metal Pollution in the Black Sea Shore and Offshore of Turkey. Environ Geol, 52(3): 469476.

AOAC, **1990**. The Official Methods of Analysis Association of Official Analytical Chemists, 17th Edition; Washington DC.

APHA, **1990**. Standard methods for examination of water and wastewater, Clesceri LS; AA agreenberg and R.R Trussel 17th Edition. 3144.

Bakan G, **Büyükgüngör** H, **2000**. The Black Sea. Mar Pollut Bull, 41(1-6): 24- 43.

Bat L, Sezgin M, Üstün F, Sahin F, **2012**. Heavy Metal Concentrations in Ten Species of Fishes Caught in Sinop Coastal Waters of the Black Sea, Turkey. Turkish J Fish Aquat Sci, 12, 371-376.

Bawuro AA, Voegborlo RB, Adimado AA, **2018**. Bioaccumulation of Heavy Metals in Some Tissues of Fish in Lake Geriyo, Adamawa State, Nigeria. J Environ Public Health, Article ID 1854892, 7 pages. https://doi.org/10.1155/2018/1854892.

Bronstein AC, Spyker DA, Cantilena LR Jr, Rumack BH, Dart RC, **2011**. Annual Report of the American Association of Poison Control Centers' National Poison Data System (NPDS): 29th Annual Report. ClinToxicol (Phila), 50(10): 911–1164.

Datar MD, **Vashishtha** RP, **1990**. Investigation of heavy metals in water and silt sediments of Betwa River. Indian J Environ Prot, 10(9): 666-672.

Fakankun OA Babayemi JO, Akosile SO, **2012**. Evaluation of fish gills as potential target organ for accumulation of heavy metals. Afri J Anim Biomed Sci, 7(1): 15-18.

FAO, **1985**. Codex Alimentarius Commission: Contaminants: Joint FAO/WHO Food Standard Programme. Codex Alimentarius, Vol. XVII, Ed, Roma. 1-13.

Indrajith H, Pathiratne KAS, Pathiratne A, **2008**. Heavy Metal Levels in two Food Fish Species from Negombo Estuary, Sri Lanka: Relationship with the Body Size. Sri Lanka J Aquat Sci. 13, 63-81.

Jacquin L, Petitjean Q, Côte J, Laffaille P, Jean S, **2020**. Effects of Pollution on Fish Behavior, Personality, and Cognition: Some Research Perspectives. Front Ecol Evol, https://doi.org/10.3389/fevo.2020.00086.

Joint **FAO/WHO** Expert Committee on Food (JECFA) **2007**. Database of food additives and pollutants. Retrieved October 10, 2011, from ttp://jecfa.ilsi.org/search.cfm, visited 10-10-2011.

Kamaruzzaman BY, Akbar B, Jalal KCA, Shahbudin S, **2010**. Accumilation of metals in the gills of Tilapia fingerlings (*Oreochromis niloticus*) from invitro toxicology study. J Fish Aquat Sci. 5(6): 503509.

Kayode AAA, Babayemi JO, Abam EO, Kayode OT, **2011**. Occurrence and health implications of high concentrations of Cadmium and Arsenic in drinking water sources in selected towns of Ogun State, South West, Nigeria. J Toxic Environ Health Sci, 3(15): 385-391.

Kontohuorghes GJ, Pattichis K, Neocleous K, Kolnagou A, **2004**.The Design and Development of Deferiprone and other Iron chelatorsfor clinical use: targeting method and application prospects. Curr Med Chem, 11(16): 2161-2183.

Kori-Siakpere D, **Ubogu** E, **2008**. Sub lethal haematological effects of Zinc on the fresh water fish, *Heteroclarias* sp. (*Osteichthyes: Claridae*). Afr J Biotechnol. 7(12): 2068 – 2073.

Kusemiju V, Amoruwa P, Aderinola JO, **2012**. Accumulation of lead in the tissues of freshwater catfish Clarias gariepinus exposed to static nominal concentrations of lead nitrate. Agric Biotechnol J North Am, 3(12): 510-515.

Nelson RL, Davis FG, Persky V, Becker E, **1995**. Risk of neoplastic and other disease among people with Heterozygosity for Hereditary Hemochromatosis. Cancer, 76(1): 875-879.

Obot OI, Isangedighi AI, David GS, **2016**. Heavy metals concentration in some commercial fishes in the lower Cross River estuary, Nigeria. Nig J Agric Food Environ, 12(4): 218-223.

Olusola JO, **Festus** AA, **2015**. Levels of Heavy Metal in Some Selected Fish Species Inhabiting Ondo State Coastal Waters, Nigeria. J Environ Anal Toxicol, 5: 303.

Peakall D, **Burger** J, **2003**. Methodology for Assessing Exposure to Metals: Speciation Bioaavailbility of Metals and Ecological Host Factors. Ecotoxicol Environ Safety, 56: 110-121.

Rauf A, Javed M, Ubaidullah M, **2009**. Heavy metal levels in three major carps (Catla catla, Labeo rohita and Cirrhina mrigala) from the river ravi, Pakistan. Pak Vet J, 29: 24-26.

Samir MS, **Ibrahim** MS, **2008**. Assessment of Heavy Metals Pollution in water and sediments and their effect on *Oreochromis niloticus* in the Northern Delta Lakes, Egypt. 8th *International Symposium on Tilapia in Aquaculture*. 475-490

Unyimadu JP, Osibanjo O, Babayemi JO, **2019**. Concentration and Distribution of Organochlorine Pesticides in Sediments of the Niger River, Nigeria. J Health Poll, 9(22): 190606.

Upper Benue River Basin Development Authority (UBRBDA) **1985**. Feasibility study of Lake Geriyo, 50-57.

WHO, **2003**. Heavy Metals Regulations; Legal notice no.66 www.discoverlife.2008.

WHO, **2019**. Lead poisoning and health. https://www.who.int/news-room/factsheets/ detail/ lead-poisoning-andhealth#:~:text=Health %20effects%20of%20lead%20poisoning%20on%20children&text=At %20 high%20levels%20of%20exposure,mental%20retardation%20 and %20behavioural%20disorders.

Wright RO, **Baccarelli** A, **2007**. Metals and Neurotoxicology.Journal of Nutrition. 137(**12**): pp2807-13.

Zira JD, Abubakar KA, Badejo BI, Kefas M, **2015**. Assessment of Heavy Metals in *Clariasgariepinus*Organs (Gills, Liver and Muscles) at Kiri Reservoir, Adamawa State, Nigeria. J Agric Vet Sci, 8(5): 79-85.

Citation: Kefas M, Micheal KG, Haziel H, Adokwe JB , 2021. Heavy metals level in *Oreochromis niloticus* collected from Lake Geriyo, Yola, Adamawa State, Nigeria. Net J Agric Sci, 9(3): 51-58.