97

Bioaccumulalation of some heavy metals in selected fish species in Shiroro Lake, Niger state, Nigeria.

Yusufu, F.O, Kolo, R.J, Ojutiku, R.O and Ibrahim, S.U
Department of Water Resources, Aquaculture and Fisheries Technology,
Federal University of Technology, Minna, Niger State, Nigeria.
***corresponding author:** E-mail-Fridale2003@yahoo.com, Phone No-+2347034062997*

Abstract
The main purpose of this study was to determine heavy metals accumulation in the body tissue (gill, liver and tissue muscle) of the selected four fish species, *Clarias gariepinus, Bagrus bayad, Tilapia zilli and Lates niloticus* that are of commercial importance from Shiroro Lake, Niger State, Nigeria. Water samples were taken from five (5) stations in the lake, stations selected based on the entry points of effluent. The fish samples were bought from the landing site, Kwata Zumba monthly for 12 months (October 2018-September 2019).The weight of the fish species was recorded. One (1g) of the target organs (gill, liver and muscle tissue) of each sample were dissected out and digested, heavy metal concentration in them and that of water were determined using Atomic Absorption Spectrophotometer (AAS). The results showed that heavy metal concentrations in both water and fish tissues descended as follows Fe>Zn>Mn>Cu>Pb.Clarias gariepinus liver recorded the highest concentration of Fe (13.76 mg/l) .while in March (peak of dry season) the mean value of Fe in water was 3.99 mg/l (the highest).The lowest mean values,0.80mg/l were recorded in September. There were significant difference ($P<0.05$) between dry and wet seasons mean values of heavy metals in both fish organs and water. The results showed presence of some heavy metals in the organs of the selected commercially important fish species found in Shiroro Lake. Muscle tissue of all the selected species accumulated less metals compared to their gills and livers.

Keywords: Bioaccumulation, heavy metals, fish species, Shiroro Lake.

Introduction
Occurrence of heavy metals in the aquatic environment is of major ecological and public health concern because of their toxicity at certain concentration, translocation through food chains, non-biodegradability and threat to life and the environment (Eneji *et al.*, 2012).Aquatic environments are being polluted due to increasing natural and anthropogenic activities.(Ojutiku *et.al.,2017*).

In Nigeria as well as other parts of the world, due to rapid urbanization, industrialization and high population pressure, we now experience increased domestic and waste disposal into nearby water courses as well as pollution from agricultural activities, hence aquatic environment are being polluted with heavy metals (Yusufu, 2015).

The consumption of fish worldwide has increased speedily in recent years particularly with the awareness of its nutritional and therapeutic benefits (Baruwo *et.al. 2018*). Fish serves as one of the major sources of protein that is low in saturated fat and contains sufficient omega 3 fatty acids (*Ojutiku et al.,2017*).The American Heart Association recommended consumption of fish at least twice per week in order to reach the daily intake of omega-3 fatty acid .However, fish normally accumulate heavy metals from food, water, and sediments and this is a good indicator of heavy metals contamination in water (*Baruwo et al.,*2018).

Bio-accumulation refers to an increase in the concentration of a metal in a biological organism over time, compared to the normal concentration in the environment. The presence of toxic heavy metals in fish can invalidate their beneficial effects and pose potential threat to both the environment and human health like, renal failure, liver damage, cardiovascular diseases or even death (Baruwo *et al., 2018*).

Shiroro Lake was primarily dammed for hydro-electric power generation, but with secondary objectives in Fisheries and Agriculture. Recently, anthropogenic activities near the lake for economic development have intensified continually and rapidly. This study therefore examined the bioaccumulation of some heavy metals in water and fish from Shiroro Lake, Niger State, Nigeria.

MATERIALS AND METHODS

Study Area

Shiroro Lake is a man-made hydro-electric power generation dam constructed on River Kaduna in Shiroro Gorge in Niger State. It is located on latitude 9°57′N Longitude 6°13′E.

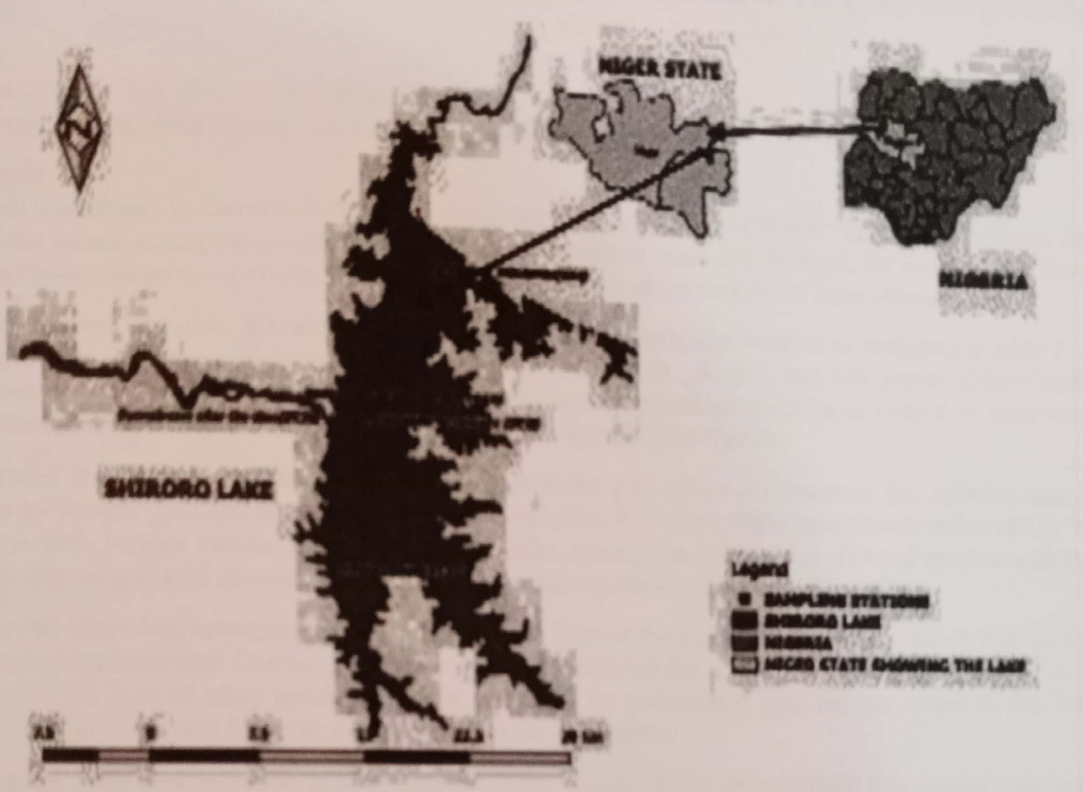

FIGURE 1: STUDY AREA

Sampling stations and collec

Water samples were collected from five stations, I, II, III, IV and V. Station I is on River Kaduna entry point (tributary), station II, on open water at the dam site, station III on point near the Zumba market (Kwata Zumba) where market activities take place, station IV on downstream (immediately after the dam) and station V, open water of the downstream, Water and fish samples were taken monthly for 12 months, three(3) water samples were taken from each sampling station as well as three samples of the selected fish species (October 2018 to September, 2019). Niger State Ministry of Animal and Fisheries surveillance boat was engaged in accessing sampling stations. Four fish species (*Clarias gariepinus, Bagrus bayad, Tilapia zilli and Lates niloticus)* were selected and bought from the Fishermen at the landing sites. The fish samples were transported in ice chests to the Water Resources, Aquaculture and Fisheries Technology Laboratory of the Federal University of Technology, Minna, Niger State.

Digestion of water sample:

Wet method of digestion was used to carry out this analysis (APHA,2005).10 ml was measured from lake water sample, 10 ml of nitric acid was added to it in a conical flask then digested on a hot plate at temperature of 150 ^{0}C till it reached a boiling point. The solutions were allowed to cool and distilled water added to make the volume up to 100ml then it was transferred into the pre-cleaned sample bottle and taken for further Atomic Absorption Spectrophotometer (AAS) analysis.

Digestion of fish samples:

Wet method of digestion was used to carry out these analyses (APHA, 2005). The fishes were dissected into separate organs, flesh, gills and liver using stainless steel dissecting instrument. 1g of the gills, flesh tissue and liver was each weighed from various fish species.20 ml of nitric acid was added to each sample and digested on hot plate at 150^{0}C till sample fully dissolved. To the digested sample, 100ml distilled water was added and poured in a sample bottled appropriately labelled for further analysis.

Metal Extraction:
Bulk scientific Atomic Absorption Spectrophotometer (AAS), model Accusy 211; manufactured in USA was used for determining the bio-accumulation factors of the heavy metals examined.

Statistical Analysis: One-way statistical analysis of variance (ANOVA) was used to determine the significant difference ($P<0.05$) in the concentration of the metals both in the water and the fish at ($P\leq 0.05$) probability using SPSS package.

RESULTS
The concentration of Iron (Fe), Copper (Cu), Zinc (Zn), Manganese (Mn), Lead (Pb) and Cadmium and fish tissue (gills, liver and muscle) from Shiroro Lake were as presented in tables 1-6

Water sample:
Heavy metals were found to decrease in the following order Fe>Zn>Mn>Cu>Cd>Pb. There was significant difference ($P<0.05$) in the metals among the months for Cu and Fe with highest value of 3.99 mg/L for Fe in March. Results also showed significant difference ($P<0.05$) between the metals except in the months of June –September.

Season: Mean season variation in heavy metal concentration in Shiroro lake water is as indicated in table 2. . Results showed significant difference ($P<0.05$) between the dry (November –April) and wet season (May-October).The average concentration of heavy metals is higher during the dry season which could be as a result of high temperature and concentration effect .The decreasing value is as follows Fe>Zn>Mn>Cu>Pb.

Table 3 showed the mean concentration of heavy metals in the gills of the experimental fish species, result showed that *Clarias gariepinus* gills had the highest concentration of Fe, 8.18 mg/l while least concentration of Cu, 0.02 mg/l was found in both *Bagrus niloticus* and *Tilapia zilli gills*. Among the gills of the selected species with the heavy metals, only Clarias gill with Zn and Lates gills with Cu had significant difference ($P<0.05$).

Table 4 showed mean concentration of heavy metals in the liver of the experimental fish species in Shiroro Lake. The results obtained revealed that *Clarias gariepinus* liver accumulated the highest concentration of Fe,13.76 mg/100g compared with the liver of other species which is far above the permissible limit recommended by the WHO .The least concentration of Pb was found in the liver of *Clarias gariepinus*.

Table 5 showed mean concentration of heavy metals in the muscles of the experimental fish species showing *Clarias gariepinus* recording the highest mean value of 4.39 which is below the permissible level. All the experimental fish recorded zero or not detected level of both Pb and Cd.

Table 6 showed all the experimental fish studied with the level of heavy metals accumulated by the gills, liver and the muscle tissue .The results showed that Clarias gariepinus liver recorded the highest value For Fe, 13.76 mg/l which exceed the maximum permissible limit recommended (WHO, 2011).The level of accumulation in target organs is in the following descending order Liver > Gills >Muscle. This variation is in line with previous studies by (Eneji et. al., 2012, Ojutiku et. al., 2017).

Table 1: Monthly mean variation of heavy metal concentration in water samples.

Months	Fe(mg/l)	Cu(mg/l)	Zn(mg/l)	Mn(mg/l)	Pb(mg/l)	Cd(mg/l)
October	2.47c	0.01ab	0.13e	0.04de	0.00	0.01b
November	2.41c	0.01ab	0.13e	0.05e	0.00	0.01b
December	3.27d	0.01ab	0.10d	0.04d	0.00	0.00a
January	2.97d	0.01b	0.09d	0.03c	0.00	0.00a
February	2.43c	0.01ab	0.07c	0.04d	0.00	0.00a
March	3.99e	0.02c	0.07c	0.05e	0.00	0.01c
April	3.06d	0.01ab	0.03b	0.01b	0.00	0.00a
May	2.19c	0.00a	0.01a	0.00ab	0.00	0.00a
June	1.75b	0.01b	0.01a	0.01ab	0.00	0.00a
July	1.51b	0.01b	0.01a	0.00aab	0.00	0.00a
August	1.41b	0.01b	0.01a	0.00a	0.00	0.00a
September	0.80a	0.00a	0.01a	0.00a	0.00	
WHO (2011)	-	2	-	0.4	0.01	0.00
±S.E	0.07	0.00	0.00	0.00	0.00	

Mean in the same Col[illegible] are not significantly different (P>0.05)

Table 2: Mean season variation of heavy metal concentration in water samples

Season	Fe(mg/l)	Cu(mg/l)	Zn(mg/l)	Mn(mg/l)	Pb(mg/l)
Dry	3.02a	0.01a	0.08a	0.03a	0.00a
Wet	1.69b	0.01b	0.03b	0.01b	0.00b
±S.E	0.97	0.01	0.05	0.02	0.01

Mean in the same Column carrying same superscript are not significantly different (P>0.05)

Table 3: Mean concentration of heavy metals in the gills of the experimental fish species

Fish Species	Fe (mg/100g)	Cu (mg/100g)	Zn (mg/100g)	Mn (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CG	8.18b	0.31a	1.13b	0.39ab	0.00a	0.00a
TG	6.00a	0.20a	0.77a	0.41ab	0.00a	0.00b
BG	6.84ab	0.20a	0.69a	0.36a	0.00a	0.00ab
LG	6.40a	0.83b	0.82a	0.46b	0.00a	0.00ab
Permissible limit (FAO/WHO, 2011)	10	3	10	2-9	0.05	0.05
±S.E	0.27	0.06	0.05	0.01	0.00	0.00

Mean in the same Column carrying same superscript are not significantly different (P>0.05)

Table 4: Mean concentration of heavy metals in the liver of the experimental fish species

Fish Species	Fe (mg/100g)	Cu (mg/100g)	Zn (mg/100g)	Mn (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CL	13.76b	0.75a	2.46b	0.80ab	0.01b	0.00a
TL	12.47ab	0.33a	1.22a	0.70ab	0.00a	0.01ab
BL	12.61ab	0.36a	2.35b	0.56a	0.00ab	0.01b
LL	9.68a	1.99b	2.48b	0.96b	0.00a	0.00a
Permissible limit (FAO/WHO,2014)	10	3	10	2-9	0.05	0.05
±S.E	0.66	0.12	0.15	0.06	0.00	0.00

Mean in the same Column carrying same superscript are not significantly different (P>0.05)

Table 5: Mean concentration of heavy metals in the muscles of the experimental fish species

Fish Species	Fe (mg/100g)	Cu (mg/100g)	Zn (mg/100g)	Mn (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CM	4.39b	0.25a	0.77b	0.37bc	0.00a	0.00a
TM	3.71ab	0.13a	0.34a	0.25a	0.00a	0.00a
BM	3.39a	0.18a	0.84b	0.27ab	0.00a	0.00a
LM	3.41a	0.48b	0.67b	0.43c	0.00a	0.00a
Permissible limit (FAO/WHO,2011)	10	3	10	2-9	0.05	0.05
±S.E	0.14	0.03	0.04	0.02	0.00	0.00

Mean in the same Column carrying same superscript are not significantly different (P>0.05)

Table 6: Mean concentration of heavy metals in the gills, liver, and muscle tissue of the experimental fish species

Fish Species	Fe (mg/100g)	Cu (mg/100g)	Zn (mg/100g)	Mn (mg/100g)	Pb (mg/100g)	Cd (mg/100g)
CG	8.18de	0.31a	1.13b	0.39ab	0.00a	0.00a
CL	13.76f	0.75bc	2.46c	0.80de	0.01b	0.00a
CM	4.39abc	0.25a	0.77ab	0.37ab	0.00a	0.00a
TG	6.00	0.20a	0.77ab	0.41ab	0.00a	0.00a
TL	12.47f	0.33ab	1.22b	0.70cd	0.00a	0.01a
TM	3.71ab	0.13a	0.34a	0.25a	0.00a	0.00a
BG	6.84cd	0.20a	0.69ab	0.36ab	0.00a	0.00a
BL	12.61f	0.36ab	2.35c	0.56	0.00a	0.01b
BM	3.39a	0.18a	0.84ab	0.27a	0.00a	0.00a
LG	6.40cd	0.83c	0.82ab	0.46ab	0.00a	0.00a
LL	9.68e	1.99d	2.48c	0.96e	0.00a	0.00a
LM	3.41a	0.48abc	0.67ab	0.43ab	0.00a	0.00a
Permissible limit (FAO/WHO,2011)	10	3	10	2-9	0.05	0.05
±S.E	0.29	0.05	0.06	0.02	0.00	0.00

DISCUSSION

The gills liver and muscle of the selected fish species (Clarias gariepinus , Bagrus bayad, Tillapia zilli and Lates niloticus) from Shiroro lake accumulate heavy metals though not at the same rate. The concentration of iron, Fe both in the water and fish constituted the major portion of the total heavy metal ions determined while Pb concentration was the lowest. This is in line with other studies *(Abraham et..al., 2012, Ojutiku et. al., 2017.,Egbeja et.,al.,2019)*.

The concentration of Fe in *Tilapia zilli* and *Bagrus bayad* liver were high above the recommended level by FAO/WHO.(2011).*Clarias zilli* gills also exhibited high level of metal accumulation but below the permissible limit. This is not surprising based on difference in feeding habit, habitat and the multiple uses of their gills. This is in line with previous studies by *Eneji et., al,2012* and *Egbeja et.,al.,2019)*.The low level of metal accumulation in *Tillapia zilli* also confirmed this.

Seasonal variations in heavy metals both in water and fish tissues noticed, and their concentrations higher in dry season due to temperature increase and other physicochemical interactions.

CONCLUSION

This study examined the bioaccumulation of heavy metals in the gills, liver and muscle of the selected fish species from Shiroro lake and it was clear from the study that heavy metals especially iron,Fe in liver of both Tilapia zilli and *Bagrus bayad* were a little above the permissible limit , it was observed that Zn,Mn,Cu,Cd and Pb were within the permissible limits set by WHO for now, however this calls for effective management of this valuable resource.

RECOMMENDATION

It is therefore advised that proper and regular monitoring of heavy metals effluent in water and fish should be done to avoid excessive accumulation.

REFERENCES

Abraha, G.A.,Malu, B.D and Yirgaalem, W.G.(2012).Bioaccumulation of heavy metals in Fishes of Hahenge Lake, Tigray, Northern highland of Ethiopia, American Journal of chemistry.2(6):326-334

American Public Health Association (2005).Standard methods for the examination of water and waste water.15th edition Washington D.C PP 119

Baruwo, A.A, Voegborlo, R.B and Adimado, A.A. (2018).Bioaccumulation of heavy metals in some tissues of fish in lake Geriyo, Adamawa, Nigeria. *Journal of Environmental and Public Health.https://doi.org/10.1155/2018/1854892.*

Eneji, I.S, Sha'Ato, R,& Annune, P.A(2012).An assessment of heavy metals loading in River Benue in the Makurdi metropolitan Area in Central Nigeria. Environmental monitoring and assessment.184 (1)201-207

Egbeja , T.I.,kadiri, J.U,Onoja,A.O and Isah, A.O(2019). Determination of heavy metals in water,sediments and tissues of *Clarias gariepinus* and *Oreochromis niloticus* from Kpata river, Lokoja,Nigeria, International Journal of Fisheries and Aquatic studies.7(5):25-29

Ojutiku, R.O., Olayode, H.F and Kolo, R.J. (2017). Bioaccumulation of some heavy metals in three commercially important fish species tissues relative to their concentrations in Agaie-Lapai Dam, Minna, Niger State, Nigeria. *Journal of Agriculture and Agricultural Technology*, 8(1) 63

World Health Organization (2011).Guidelines for Drinking-Water quality vol. 1 Recommendations, Geneva Switzerland.145-220.

Yusufu, F.O (2015). Effect of Domestic effluent on water quality, abundance and distribution of zooplankton in Geriyo, Yola, Nigeria.M.Tech. Thesis, Dept. of Fisheries, Modibo Adama University of Tech. Yola, Nigeria