

SEASONAL VARIATION OF IRON AND ZINC CONCENTRATION IN TISSUES OF SOME SELECTED FISH SPECIES FROM SHIRORO LAKE, NIGERIA

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ABSTRACT

Seasonal variation of iron and zinc concentration in tissues of some selected fish species (*Clarias gariepinus*, *Copton zilli*, *Lates niloticus* and *Bagrus bajad*) and their bioaccumulation in the gills, liver and muscle tissues of the four fish species from Shiroro Lake, were studied. Samples were stored and transported in ice chest to the Laboratory for determination of iron and zinc. The target organs (gills, liver and muscle tissue) of each sample were dissected and digested, heavy metal concentration in them were determined using atomic absorption spectrophotometer (AAS). The results indicated that, there was a significant difference seasonally in the mean value of iron and zinc accumulated. Rainy season had the highest while dry season had the least. *Clarias gariepinus* liver contained the highest concentration of zinc and iron. While *Copton zilli* had the lowest. The concentration of heavy metals in the target organs can be represented as; liver > gills > muscles for iron and zinc. Heavy metals found in the target organs were within and some below the WHO (2011) recommended permissible limits for consumption apart from iron found in the liver and gills of the fish species studied. Anthropogenic activities within the vicinity of Shiroro lake should be monitored and regulated.

Keywords: Bioaccumulation, gills, livers and muscles

INTRODUCTION

Globally, all living organisms largely depend on water for their livelihood while some live in it, some drink from it. Also, plants and animals require water that is moderately pure, and they cannot survive if their water is highly polluted Yusufu (2023). Concern about heavy metals contamination of fish has been motivated largely by the adverse effects on humans, given that consumption of fish is the primary route of heavy metal exposure. Heavy metals are defined as metallic elements that have a relative density compared to water (APHA, 2015). Heavy metals are also considered as trace elements because of their presence in trace concentrations in various environmental matrices. The origin of metals in the natural environment is either geogenic or anthropogenic releases (Nguyen *et al.*, 2005). In Nigeria, due to increase population pressure and rapid urbanization, there has been increase in municipal water (sewage and industrial) effluent which eventually discharge in streams, lakes or rivers that flows through these cities and farmlands which constitute environmental pollution (Yusufu, 2023). Pollution arising from anthropogenic substance can alter a lake ecosystem and reduces its economic productivity. Heavy metals enter fish through gills, skin, oral in food and water. In the fish body the metals are transported through the blood stream and either stored, transformed or eliminated

in the liver, kidney or the gills (Kigbu and Annune, 2019).

Concentration of heavy metal in aquatic organism varied between species, ages, sex and organs. Many field and laboratory studies showed that heavy metals accumulation in fish tissues depends on series of abiotic and biotic factors and their complexity, for example: fish species, its trophic levels, feeding habits, age and size, interspecific differences in sensitivity to various metals, concentrations of pollutants in water and sediment, the type of food, physical and chemical properties of water, the chemical element speciation and metal bioavailability (Canli and Atli, 2003).

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. Aquatic organisms bio-accumulate these trace metals in minute amount over time which later increases over a period. Fishes have been observed to be a good accumulator of the organic and inorganic pollutants in water (King and Jonathan, 2003).

The increasing importance of fish as a source of protein and the interest in understanding the accumulation of heavy metals at the tropic levels of food chain, extend the focus towards fish. Fish represents an important dietary and source of animal protein to Nigerians (FAO, 2017).

Therefore, the main purpose of this study was to assess seasonal variation of iron and zinc in the gills, liver and muscle tissues of *Clarias gariepinus*, *Coptodon zilli*, *Lates niloticus* and *Bagrus bajad* in Shiroro lake, Nigeria.

MATERIALS AND METHODS

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. It has an installed power generating capacity of 600 MW (Suleiman and Ifabiyi, 2015).

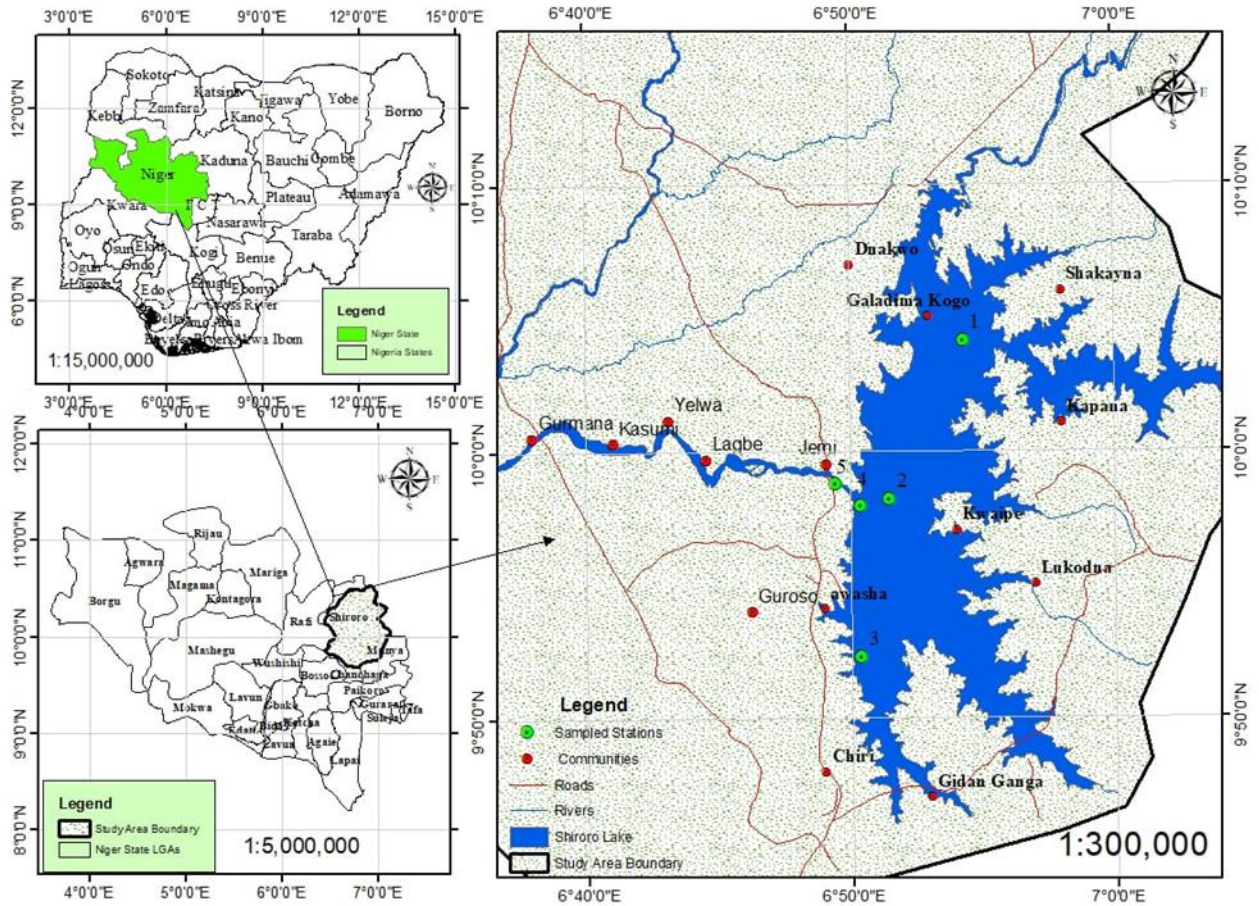


Figure 1: Location of the study area (Shiroro Lake)

Collection of Fish Samples

Fish samples selected were bought from the Fishermen at the landing sites, samples were stored and transported in ice chest to the Laboratory of Water Resources, Aquaculture and Fisheries Technology, Federal University of Technology, Minna, Nigeria for proper identification and examination. Fish identification was made to the lowest taxonomic level using identification guide book prepared by Olaosebikan and Raji (1998). Fish samples were collected monthly from October 2018-September 2020. The seasons were classified as May-July, Early rainy season (ERS), August – October, late rainy season (LRS), November –

January , early dry season (EDS) and February – April , late dry season (LDS) .

Digestion of Fish Samples

Wet method of digestion was used as described by (APHA, 2015). Both the gills, tissue and liver were weighed (1g each) from various fish species, 20 ml of nitric acid was added and digested on hot plate at 150 °C till samples fully dissolved. Then 100 ml of distilled water was later added to the digested samples. It was then poured in a labelled sample bottle for further analysis.

Atomic absorption spectrophotometer was used to determine the level of various heavy metals in the different samples.

Determination of Metals using Atomic Absorption Spectrophotometer (AAS) (APHA, 1995)

Iron (Fe)

Stock Iron solution was prepared by dissolving 5.0503 g Iron (II) ammonium sulphate, $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2$ in 1 litre distilled water. Standard iron solution was prepared from stock solution in 1 litre of water from where different concentrations were prepared and determined for iron with AAS using iron cathode lamp at 248.3 nm. The samples were also run through AAS to determine for iron, the concentration of iron ions was extrapolated from the standard graph of the calibrated curve of the metal and presented in g/100g.

Iron was calculated using the equation:

$$\text{Fe (mg/l)} = \text{reading from the curve} \times D$$

Where $D = \frac{\text{ml sample} + \text{ml water} + 1\text{ml acid}}{\text{ml of water}}$ (APHA, 1995)

Zinc (Zn)

Stock Zinc solution was prepared by dissolving clean 100 mg Zinc metal in 1 ml Hcl and to be made up to 1 litre with distilled water. Standard Zinc solution was prepared by making 10 ml of Zinc stock solution to 1 litre with distilled water. Different concentrations were also prepared from standard solution in the range of 0.1-0.5mg/l which was determined for Zinc with AAS using cathode lamp at 213.8 nm. The concentration of Zinc ions were extrapolated from the standard graph of the calibrated curve of the metal and presented in g /100g .It was calculated using the equation:

$$\text{Zn (mg/l)} = \text{reading from the curve} \times D$$

Where $D = \frac{\text{ml sample} + \text{ml water} + 1\text{ml acid}}{\text{ml of water}}$ (APHA, 1995)

Data Analysis

One-way statistical analysis of variance (ANOVA) was used to determine the significant difference ($P < 0.05$) in the mean concentration of iron and zinc in the fish tissue using Statistical Package for Social Science (SPSS) version 20.0 software. The differences among the means were separated using Duncan Multiple Range Test.

RESULTS

Table 1 shows the sub seasonal variation in iron and zinc concentration in the gills of the fish. The highest mean value of 9.67 mg/100g iron was recorded for late raining season (LRS) while the least mean value of 6.75 mg/100g was recorded for late dry season (LDS). Similarly, higher concentration of 1.14 mg/100g of zinc was also recorded for late raining season (LRS) while early dry season had the lowest concentration of 0.65 mg/100g. There was no significant difference ($p > 0.05$) in the mean concentration of iron for early raining season and late dry season. A significant difference ($p < 0.05$) was recorded in the mean concentration of others (late raining season and early dry season) sub season. In contrast, a significant difference ($p < 0.05$) was recorded in the concentration of zinc among all the sub seasons

The sub seasonal variation in iron and zinc concentration in the liver of the fish. The highest mean value of 24.96 mg/100g of iron was recorded for late raining season (LRS) while the least of 11.66 mg/100g was recorded for late dry season (LDS). Similarly, higher concentration of 5.35 mg/100g of zinc was also recorded for late raining season (LRS) while the least of 1.74 mg/100g was recorded for early dry season. There was no significant difference ($p > 0.05$) in the mean concentration of iron for early raining season and early dry season. There was significant difference ($p < 0.05$) in the mean concentration of zinc among all the sub season.

The sub seasonal variation in iron and zinc concentration in the muscles of the fish. The highest mean value of 4.72 mg/100g of iron was recorded for early dry season (EDS) while the least, 3.49 mg/100g was recorded for early raining season (ERS). In contrast, higher mean concentration of 1.29 mg/100g of zinc was also recorded for late raining season (LRS) while the the least, 0.38 mg/100g was recorded for early dry season. There was a significant difference ($p < 0.05$) in the mean concentration of early raining season and those of late dry season, early dry season and late dry season. The sub-seasonal mean variation of heavy metals concentration in the muscles of the experimental fish species. Except for iron that early dry season, EDS mean levels of iron found in the muscle was higher, other heavy metals had late rainy season, LRS with the highest mean value. There was significant difference ($P < 0.05$) observed, and levels of heavy metals studied fell within the acceptable limits.

Table 1: Sub seasonal variation of iron and zinc Concentration in the gills, livers, and muscles of fish species

Season	Gills		Livers		Muscles	
	Fe(mg/100g)	Zn(mg/100g)	Fe(mg/100g)	Zn(mg/100g)	Fe(mg/100g)	Zn(mg/100g)
ERS	6.77 ^a	0.87 ^b	16.85 ^b	3.62 ^c	3.49 ^a	0.96 ^{ab}
LRS	9.67 ^c	1.14 ^c	24.96 ^c	5.35 ^d	4.54 ^b	1.29 ^b
EDS	8.07 ^b	0.65 ^a	16.12 ^b	1.74 ^a	4.72 ^b	0.38 ^a
LDS	6.75 ^a	0.79 ^{ab}	11.66 ^a	2.77 ^b	4.01 ^{ab}	0.83 ^b
Permissible Limits			4.3	1	4.3	1
WHO,2011	4.3	1			0.14	0.07
±S.E	0.22	0.04	0.76	0.19		

Mean in the same Column carrying same superscript are not significantly different ($P>0.05$) Fe= Iron, Zn=Zinc, ERS= Early Rainy Season, LRS= Late Rainy Season, EDS= Early Dry Season, LDS= Late Dry Season

Table 2 shows that *Lates niloticus* liver accumulated less iron (13.65 mg/l) compared to other species examined. Also, *Lates niloticus* muscle tissue accumulated the least mean iron concentration of 3.54 mg/l. There was significant difference ($P<0.05$) between the mean concentration of iron in the gills, liver and muscle. *Copton zilli* gill had the least mean iron concentration, 6.35 mg/100g. There was significant difference ($P<0.05$) in the levels of iron concentration between the gills of the experimental fish species and above the permissible standard limits. Result also indicated that *Clarias* gill accumulated the highest level of zinc concentration, 1.20 mg/100g, while *Bagrus* gills recorded the lowest when compared to gills of other species. There was significant difference ($P<0.05$) in the level of iron deposited in the gills of the different fish species.

The mean concentration of heavy metals in the liver of the experimental fish species as shown in table 2. Among the heavy metals examined, iron, had the highest mean concentration level in the liver of all the fish species studied, which is above the (WHO, 2011) recommended limits.

The mean concentration of heavy metals found in the muscles of experimental fish species follows the trend of decreasing order; Fe>Zn. Iron among the heavy metals had the highest mean concentration level in the muscle of *Clarias*, 5.21 mg/100g while *Lates* had the least mean iron concentration found in the muscle, 3.54 mg/100g. There was significant difference ($P<0.05$).

Table 2: Mean Concentration of heavy metals in the gills, livers, and muscles of fish species

Fish Species	Gills		Livers		Muscles	
	Fe(mg/100g)	Zn(mg/100g)	Fe(mg/100g)	Zn(mg/100g)	Fe(mg/100g)	Zn(mg/100g)
<i>Clarias gariepinus</i>	10.04 ^c	1.20 ^b	23.17 ^b	4.14 ^b	5.21 ^b	1.42 ^b
<i>Coptodon zillii</i>	6.35 ^a	0.80 ^a	16.22 ^a	2.76 ^a	3.89 ^a	0.55 ^a
<i>Bagrus bajad</i>	7.72 ^b	0.68 ^a	16.55 ^a	3.83 ^b	4.11 ^a	0.91 ^a
<i>Lates niloticus</i>	7.15 ^{ab}	0.77 ^a	13.65 ^a	2.75 ^a	3.54 ^a	0.58 ^a
Permissible limit (FAO/WHO,2011)	4.3	1	4.3	1	4.3	1
±S. E.	0.22	0.04	0.76	0.19	0.14	0.07

Mean in the same column carrying same superscript are not significantly different ($P>0.05$) Fe = Iron, Zn = Zinc

DISCUSSION

The study revealed that tissues of all the fish species assayed contaminated iron and zinc into their respective gills, muscles and liver. The liver of the fish species had the highest concentration of iron followed by the gills while the muscle had the least. This agrees with Opaluwa *et al.* (2012) on heavy metals concentration in fish and sediments of Uke stream and Ekelemu and Okoro (2020) in the study of bioaccumulation of heavy metals in fish species in the lower Niger River at Illah, Delta State, Nigeria. Comparing among the four fish species studied, the level of Fe accumulated in their gills is in this order *Clarias gariepinus* > *Bagrus bajad*>*Lates niloticus*>*Coptodon zilli*. The result is traceable to their feeding habits, habitat (benthic or pelagic) and the multiple uses of gills, the higher mean value of Fe concentration recorded in the liver of *Clarias gariepinus* compared to other species could be attributed to its benthic habitat that has direct contact with sediment and feeding/habit. Eneji *et al.*(2011) in the study of bioaccumulation of heavy metals in fish organs from river Benue also reported that differences in the levels of accumulation in different organs of fish can primarily be attributed to the differences in the physiological role of each organ, other factors such as regulatory ability, behaviour and feeding habits may also play a significant role in the accumulation differences noticed in the different organs. Also, the chemical nature of the metal ionic strength and pH tends to be a major variable in the accumulation process. In acidic conditions, there are enough hydrogen ions to occupy many of the negatively charged surfaces and little space is left to bind heavy metals, hence more heavy metals remain in the soluble phase. The least mean value of iron was recorded in *Coptodon zilli* liver which agrees with Ekelemu and Okoro (2020). This study also revealed the presence of Fe in the muscle following the above concentration trend which agreed with the work of Eneji *et al.* (2012). The study revealed that the mean concentration of Fe found in the gills of all four fish species exceeded WHO (2011) set limit of 5.0mg/100g. *Clarias gariepinus* muscle recorded the highest value of 5.21 mg/100g while *Lates niloticus* recorded the least value of 3.54 mg/100g. The concentration fell below WHO (2011) limit.

Zinc concentration in fish tissues was below permissible limit WHO (2011). Eneji *et al.*

(2011) reported higher values of zinc concentration in fish tissues in river Benue and Yehia and Sebae (2012) recorded higher zinc concentration in fish tissues in Rosetta branch of river Nile, Egypt. The results indicated higher zinc concentration in fish tissue in dry season compared with wet season which could be as a result of concentration effects. *Clarias gariepinus* liver accumulated the highest mean value of 4.14mg/100g followed by *Bagrus bajad* liver, 3.33 mg/100g, then *Coptodon zilli* liver 2.75 mg/100g. The organ with the least mean concentration was *Coptodon* muscle, 0.55 mg/100g. The trend for BAF for zinc in liver of the species in this study is *Clarias gariepinus* liver>*Bagrus bajad* liver>*Copton zilli* liver >*Lates niloticus* liver, 82.8,76.6,55.5 and 55 respectively. The result is due to the fact that target organs are metabolically active, hence can accumulate heavy metals in higher levels. This agrees with results in both the gills and intestine of *Coptodon zilli* and *Clarias gariepinus* from river Benue, Eneji *et al.* (2011). Zinc is an essential trace element that is easily bioaccumulated by aquatic life, however it is toxic at levels above permissible limits.

CONCLUSION

The study clearly indicates bioaccumulation of heavy metals in different tissue organs of fish species studied in the lake. The mean concentration of iron and zinc in different organs followed a particular trend (liver>gills>muscle) in the four fish species studied. Concentration of iron exceeded the acceptable limits for consumption WHO (2011) in different tissue parts of all fish species, while Zn is within the permissible limits in both the gills and muscle tissues (all species) with the exception of the liver, this however calls for effective management of this valuable lake resource. Season has effect on the concentration of both Fe and Zn (raining season concentration higher than dry season). Shiroro lake should be assessed regularly in terms of heavy metals deposits occasioned by indiscriminate use of fertilizers, pesticides, herbicides, petrol discharge by merchants at Zumba market. Consumers of fish and fish products should be advised to concentrate on eating the muscle which is less contaminated, especially *Clarias gariepinus* and *Lates niloticus* (that are the most sorted for) whose livers are prone to heavy metals accumulation. Further research should be carried out on the health hazards associated with consumption of liver of *Clarias gariepinus* from Shiroro Lake.

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