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Heavy metals bioaccumulations in *Chrysichthys nigrodigitatus* (Silver catfish) from River Oli, Kainji Lake National Park, Nigeria

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ABSTRACT

Heavy metals have become a public health problem worldwide in recent years due to their potential toxic effect and ability to bio-accumulate in aquatic ecosystems. Therefore, this study examined heavy metals bioaccumulation in *Chrysichthys nigrodigitatus* from River Oli, Kainji Lake National Park. The concentrations of Pb, Cd, Fe, Cr, Zn and Cu in fish body part samples (mg/kg) were determined with AAnalyst 200 model of Atomic Absorption Spectrophotometer (AAS).

The results showed that there were significant variations in heavy metals concentration across fish muscles, vertebral bone and gills. The level of Fe accumulation is significantly varied in all fish body parts where muscles accumulated most (218.33±7.50) while gills had least (185.33±19.50). Concentration of Pb was significantly higher in muscles (6.55±0.51) and lower in gills and vertebral bones (5.71±0.07 and 0.66±0.10, respectively). Concentration of Cd showed no significant difference in all samples and its bioaccumulation in fish parts was relatively low. In muscles, the bioaccumulation profile was Fe>Cu>Zn>Pb>Cr>Cd. While in gills, the profile was Fe>Zn>Cu>Pb>Cr>Cd and it was Fe>Zn>Cu>Cr>Pb >Cd in vertebral bones.

Results showed that fish accumulated essential metals in their muscles with higher levels than non-essential metals. However, considering the importance of this species to food security and ecological stability of the study area, the level of Pb and Fe accumulation in various fish parts are of great concern because both elements exceed the WHO minimum permissible limits of 2 mg/kg and 100 mg/kg for Pb and Fe respectively in food and food products.

INTRODUCTION

Fish are commonly situated at the top of the food chain and therefore, they can accumulate large amount of toxicants (Yilmaz *et al*., 2007). Fish are also considered as one of the most susceptible aquatic organisms to toxic substances present in water (Alibabic *et al*., 2007). Since the fish meat represents a major components of human diet, the presence of heavy metals in the aquatic environment and their accumulation in fish call for concern (Erdogrul and Erbilir, 2007; Alibabic *et al*., 2007 and Keskin *et al*., 2007). The contamination of fresh waters with a wide range of pollutants has become a matter of concern over the last few decades. Among the various toxic pollutants, heavy metals are particularly severe in their action due to persistence in biological amplification through the food chain (Vutukuru, 2005; Erdogrul and Erbilir, 2007 and Honggang *et al*., 2010). Heavy metals have long been recognized as serious pollutants of the aquatic system because contamination may have devastating effects on the ecological balance of the recipient environment and a diversity of aquatic organisms (Farombi *et al*., 2007). The heavy metals that are toxic to many organisms at very low concentrations and are never beneficial to living beings are Cd and Pb (Dural *et al*., 2006); while metals such as copper, iron, chromium and zinc are essential metals, since they play an important role in biological systems (Fernandes *et al*., 2008). Heavy metals that are deposited in the aquatic environment may accumulate in the food chain and cause ecological damage as well as threat to human health (Van de Broek *et al*., 2002 and Gagnaire *et al*., 2004). Hence, fish are usually used in bioaccumulation tests because they are higher tropic level organisms and they are usually eaten by man; thus, the pollution of the aquatic environment with heavy metals has become a public health problem worldwide. For the normal metabolism of the fish, the essential metals must be taken up from water, food or sediment (Canli and Kalay, 1998). These essential metals can also produce toxic effects when the metal intake is excessively elevated (Tuzen, 2003). Studies have shown that fish accumulate these heavy metals from the surrounding water bodies thereby leaving a health risk if taken as food (Prusty, 1994 and ATSDR, 2005).

Therefore, it is important that regular monitoring of water bodies for some of these heavy metals in the fishes as well as the surrounding water is an effective method of protecting aquatic life as well as humans from the toxic effects of heavy metals. Hence, this study assessed the heavy metals bioaccumulation in different body parts of *Chrysichthys nigrodigitatus* from Oli river, Kainji Lake National Park, Nigeria.

MATERIALS AND METHODS

Study location

Kainji Lake National Park is located in the North West central part of Nigeria between latitude $9^0 45'^N$ and $10^0 23'^N$ and longitude $3^0 4'^E$ and $5^0 47'^E$. It is made up of two sectors (Borgu and Zugurma) situated in Borgu and Kaima/Baruten Local Government Areas of Niger and Kwara State respectively. It covers a total land area of 5,340.825q (Ayeni, 2007). Kainji Lake National Park was established in 1979 by the amalgamation of two formal game reserves Borgu and Zugurma under decree 46 of 29^{th} July 1997, thereby making Kainji Lake National Park the premier National Park in Nigeria (Ayeni, 2007). River Oli is the major river in the Park that supports the lives of aquatic and terrestrial wildlife species and domestic animals. The farmers and their families in the villages that share boundaries with the Park also depend on the river for their livelihood both in the dry and wet seasons.

Fish sampling and processing:

Nine samples of the fish species (*Chrysichthys nigrodigitatus*) were collected randomly weekly for ten weeks from River Oli and transported to the laboratory. A clean washed high quality corrosion resistant stainless knife was used to cut 1g wet weight of the fish tissue (muscle) along the lateral line. The operculum of each fish sample was opened and the gill removed while whole fish was dissected to remove vertebra bone. After dissection, all the samples were labeled accordingly. The entire sample (gills, muscles and vertebra bone) were separately dried in a laboratory oven at 175^0C for 3 hours.

The dried samples were each ground with laboratory ceramic mortar and pestle to powder and sieved with 2mm sieve. After being grinded, the samples were heated at temperature of 45^0C in a muffle furnace till the aroma of the sample disappeared. The powdered samples were digested according to Kotze *et al.* (2006) with little modification. Each sample was treated with 1ml 60% per choleric acid and 10ml 40% hydrofluoric acid. The contents were reheated to dryness on a sand bath to approximately 180^0C. After cooling, 15ml 10% hydrochloric acid was added and the mixture was heated in a close crucible to dryness. The digested sample was diluted with de-ionized distilled water appropriately and filtered using 0.5micron filter membrane. The digested samples were poured into auto analyser cups and concentration of Lead (Pb), Cadmium (Cd), Iron (Fe), Chromium **(**Cr), Zinc (Zn) and Copper (Cu) in each sample (mg/kg) were determined with Atomic Absorption Spectrophotometry (AAS) Perkin-Elmer spectrophotometer (AAnalyst 200 model) using their respective lamps and wavelengths in the laboratory. Operational conditions (such as lamp selection and wave length) were adjusted to yield optimal determination. The machine was standardized by aspirating distilled water to obtain zero absorbance. The samples were aspirated into the machine and absorbance value was read and recorded.

Data analysis

Results obtained for the heavy metal analysis was subjected to one-way analysis of variance (ANOVA) to find out the significant differences in heavy metals concentration of the different fish parts using Statistical Package for Social Sciences (SPSS).

RESULTS

Heavy metals concentration in body parts of *Chrysichthys nigrodigitatus*:

The heavy metals concentration (mg/kg) in the muscles, gills and vertebral bones of *Chrysichthys nigrodigitatus* collected from River Oli in Kainji Lake National Park, Nigeria showed that there were significant variations in heavy metals concentration across the fish body parts. The iron (Fe) was the most accumulated of all metals. The level of Fe accumulation was significantly varied in all body parts. Fish muscles had most accumulation (218.33±7.50 mg/kg), while gills had the least (185.33±19.50 mg/kg). Concentration of Pb was significantly higher (6.55±0.51 mg/kg) in muscles and it decreased to 5.71±0.07 mg/kg and 0.66±0.10 mg/kg in gills and vertebral bones respectively. The concentration of Cd showed no significant difference in all samples and its bioaccumulation in fish parts is relatively low. The concentration of Cu, Zn and Cr also varied in different fish body parts (Table, 1).

Table 1: Heavy metals concentrations (mg/kg) in the muscles, gills and vertebral bones of *Chrysichthys nigrodigitatus* from River Oli in Kainji Lake National Park, Nigeria.

Body parts	**Heavy metals concentrations (mg/kg)**					
	Pb	**Cr**	**Zn**	**Cu**	**Fe**	**Cd**
Muscles	$6.55±0.51^c$	$3.65±0.17^a$	$14.56±0.48^a$	$28.20±1.79^a$	$218.33±7.50^b$	$0.001±0.001^a$
Gills	$5.71±0.07^b$	$4.25±0.22^a$	$46.60±4.50^b$	$31.10±0.98^b$	$185.33±19.50^a$	$0.001±0.001^a$
Bones	$0.66±0.10^a$	$5.85±0.97^b$	$51.82±2.75^b$	$27.93±1.03^a$	$202.67±2.08^{ab}$	$0.002±0.001^a$

Note: Values are mean values ± standard error
Mean with different superscript within the same column are significantly different ($p<0.05$)

Source: *Laboratory Analysis, 2019.*

Patterns of heavy metals accumulation body parts of *Chrysichthys nigrodigitatus*:

The mean profiles of heavy metals in all fish sample parts revealed variations in bioaccumulation patterns. In muscles, the profile was Fe>Cu>Zn>Pb>Cr>Cd, while profile was Fe>Zn>Cu>Pb>Cr>Cd in gills and it varied to Fe>Zn>Cu>Cr>Pb >Cd in vertebral bones. This showed that Fe, Zn and Cu were the most abundant metals in the fish parts while Pb, Cr and Cd were at comparatively minimal levels (Table, 2).

Table 2: Patterns of accumulation of heavy metals in the muscles, gills and vertebra bones of *Chrysichthys nigrodigitatus* from the study area

Fish body parts	Patterns of accumulation/association of metals
Muscles	Fe>Cu>Zn>Pb>Cr>Cd
Gills	Fe>Zn>Cu>Pb>Cr>Cd
Vertebra bones	Fe>Zn>Cu>Cr>Pb >Cd

Source: Laboratory Analysis, 2019.

Mean concentrations of heavy metals in body parts of *Chrysichthys nigrodigitatus*:

The result confirmed that *Chrysichthys nigrodigitatus* muscles gave the highest concentration of Fe and it contained a comparatively lower amount of Zn comparing with other fish body parts. Also in vertebral bones, concentration of Cr was significantly higher and Cu was lower when compared to other fish body parts (Figure, 1).

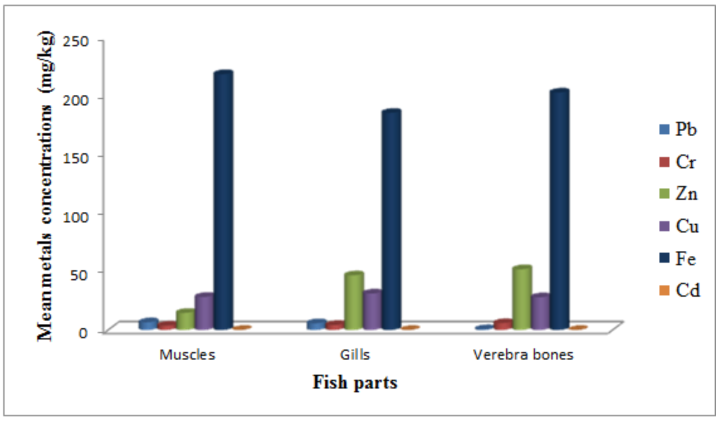

Fig. 1: Mean concentrations of heavy metals in the muscles, gills and vertebra bones of *Chrysichthys nigrodigitatus* from River Oli in Kainji Lake National Park, Nigeria.

DISCUSSION

This study was undertaken to investigate heavy metals concentrations in body parts (muscles, gills and vertebral bones) of *Chrysichthys nigrodigitatus*, an abundant fish species in River Oli, and to detect whether their levels are potentially harmful for human health if included in the diet. The body parts are selected due to their different roles in the fish bioaccumulation process and are those more frequently used for analyses (Evans *et al*., 1993). This investigation showed that different fish body parts of *Chrysichthys nigrodigitatus* contained different concentrations of a certain metal. Erhabor *et al.* (2010) reported that fish species bioaccumulated metals in their body parts in significantly different values. Moreover, Agbon and Omoniyi (2010) reported that levels of heavy metals in fish were varied in various parts.

On the other hand, Farkas *et al.* (2000) attributed the differences of concentrations of metals between fish parts to the bio-concentration capacity of each part and to the biochemical characteristics of the metal. In addition Romeo *et al.* (1999) described that the ability of fish to accumulate heavy metals depends on ecological needs, metabolism, and degree of pollution in sediment, water and food, as well as salinity and temperature of water.

Iron (Fe) concentration was the highest of all metals in all fish parts. This agrees with several studies on many rivers (Erhabor *et al.* 2010; Agbon and Omoniyi, 2010 and Akan *et al.* 2012). Erhabor *et al.* (2010) found that the order of concentrations of six heavy metals in the whole fish *Chrysichthys nigrodigitatus* from Ibiekuma stream in Ekpoma Nigeria decreasing as: Fe>Zn >Mn>Cu> Cr>Cd which is similar to Fe>Zn>Cu>Cr>Pb>Cd found in the vertebral bones during this study.

Generally, in the present study, concentrations of non-essential elements (Pb, Cr and Cd) in fish muscles, gills and vertebral bones were lower than those of essential metals (Fe, Zn, and Cu). This result is consistent with what Huang *et al.* (2003) who reported that the accumulation levels of the essential metals in fish are generally higher and more homeostatic than the non-essential metals.

CONCLUSION

Generally, fish in present study accumulated essential metals in their muscles in higher levels than non-essential metals. However, considering the importance of this species to food security and ecological stability of the study area, the level of Pb and Fe accumulation in various fish parts are of great concern in the study area because both elements were above WHO (2008) minimum permissible limit of 2 mg/kg and 100 mg/kg respectively in food and food products. Presence of other non-essential metals is also of major ecological concerns because there is possibility of future bioaccumulation of these elements in fish, water and sediment.

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