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# Distribution of metals in *Labeo coubie* (Ruppel, 1832) from a National Park river in Nigeria

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**ABSTRACT:** This study assesses heavy metals distribution in body parts of *Labeo coubie* (African carp) from River Oli, in Kainji Lake National Park as pollution index of the ecosystem. Fish parts samples (gills, muscles and vertebra bone) were prepared and specifically analyzed for the levels of Pb, Cr, Zn, Cu, Fe and Cd using Atomic absorption spectrophotometry. The concentration of metals in the samples at different concentrations ranged from 0.001±0.000 μg/g for Cd to 224.87±4.07 μg/g of Fe in the fish gill. There is significant ($p<0.05$) differences in the Pb, Zn, Cu and Fe concentrations across the different fish parts with gills accumulated the highest levels metals while Cr levels significantly ($p<0.05$) differed in the fish body parts and accumulated more in the muscles (10.75±0.15 μg/g). The mean concentrations of metal elements in the fish parts had shown some distinguish connection in its distributions with Pb and Cu; Gills > Muscles > Vertebra bones, Fe and Zinc; Gills > Vertebra bones > Muscles while Cr was distributed in Muscles > Gill > Vertebra bones. However, it is revealed that *Labeo coubie*, a euryphagus fish probably absorb these metals through ingestion of contaminated food or absorption by the gills and bioaccumulate in different fish parts. It is therefore established that River Oli is contaminated with heavy metals as presence of these metals in fish is an indication of its immediate environment.

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Environmental pollution is generally defined as the contamination of water, soil, or the atmosphere by the discharge of substances that are harmful to living things (Obianime *et al.*, 2017). In this realm, heavy metals are typical pollutants in aquatic environments which are of immediate concern due to their persistence in the environment and toxicity to humans (Alhassan *et al.*, 2016). In different water bodies, heavy metal pollution results from direct atmospheric deposition, geologic weathering or through the discharge of agricultural, municipal, residential or industrial waste products (Dhanakumar *et al.*, 2015; Garcia *et al.*, 2015 and Demirak *et al.*, 2006) and they can have a negative impact on aquatic ecosystems, the food chain and human health (Arantes *et al.*, 2016). Heavy metals can be taken up into fish either from ingestion of contaminated food via the alimentary tract or through the gills and skin (Sfankianakis *et al.*, 2015 and Drevnick *et al.*, 2006). The quantification of potential contaminants in fish tissues can be an important part of water quality assessment programs (Oliveira-Ribeiro *et al.*, 2005) because it can reflect levels found in sediment and water and its distribution in the particular aquatic environment from which they are sourced (Nhiwatiwa *et al.*, 2011). Heavy metals have been reported to change the genetic, physiological, biochemical and behavioral parameters of aquatic organisms including fish (Mahboob *et al.*, 2016). Fish have been the most popular choice as test organisms for heavy metals because they are presumably the best understood organisms in the aquatic environment and are an important source of protein to man (Murtala *et al.*, 2012). Accumulated heavy metals may lead to morphological alterations in the tissues of fish (Monteiro *et al.*, 2005) and many cause death or sub-lethal pathology of liver, kidneys, reproductive system, respiratory system or nervous system in both invertebrate and vertebrate aquatic animals (Mahboob *et al.*, 2016). However, heavy metals have devastating effects on ecological balance of the recipient environment and a diversity of aquatic organisms (Farombi *et al.*, 2007). Concentrations of these heavy metals in the fish tissues are a critical issue that needs to be addressed as levels of metals in fish usually reflects its presence in water and sediment of the particular water body. There is need for a better understanding of heavy metals composition in different body parts of fish. Therefore, this study

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assesses distribution of heavy metals in *Labeo coubie* (African carp) parts (muscles, gills and vertebra bones) from Kainji Lake National Park. This research is essential if wildlife ecological balance of the park is to be sustained from the metals adverse effects especially with regard to water dependent species.

## MATERIALS AND METHOD

*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$47'E. It is made up of two sectors (Borgu and Zugurma) situated in Borgu and Kaima/Baruten Local Government Areas of Niger and Kwara State, respectively. It covers a total land area of 5,340.825 Km$^2$ (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 29th 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:* Five sub-adult specimen of *Labeo coubie* (African carp) were caught weekly using gill nets for ten weeks from River Oli and transported to the laboratory.

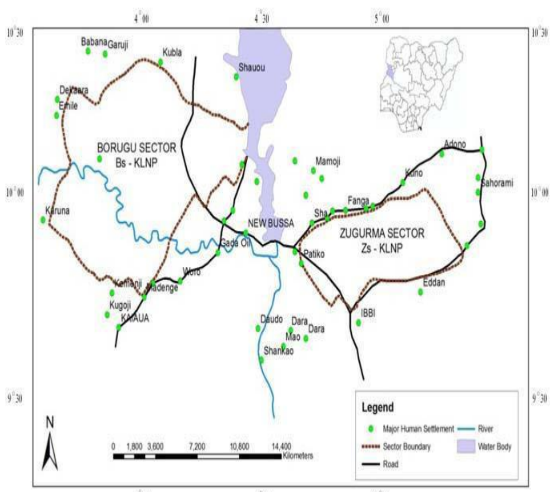


**Fig 1**. Kainji Lake National Park Showing River Oli and major human settlements (Ayeni, 2007)

A clean-washed high-quality corrosion-resistant stainless knife was used to cut 1g wet weight of the fish tissue (muscles) 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 samples (gills, muscles and vertebra bone) of each fish species were separately dried in a laboratory oven at $175^0$C for 3 hours. The dried samples were each ground with laboratory ceramic mortar and pestle to powder and sieved with 2mm sieve. After being ground, the samples were heated at the temperature of $45^0$C in a muffle furnace till the aroma of the sample disappeared. The powdered samples were digested according to procedures described by Novozamsky *et al.* (1983). The digested samples were diluted with de-ionized distilled water appropriately and filtered using a 0.5 micron 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 (µg/g) 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 wavelength) 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:* Data obtained were statistically analysed using ANOVA in SPSS 18 and $p<0.05$ were considered to indicate statistical significance while the means were compared and separated using Duncan's Multiple Range Test (DMRT) as a post-hoc test (Steele and Torrie, 1980).

## RESULTS AND DISCUSSION

*Heavy metals concentrations in different body parts (muscles, gills and vertebra bones) of Labeo coubie*: The mean concentration of heavy metals in the fish body parts were presented in table 1. The results show that there are metals bioaccumulated in the samples at different concentrations ranged from below detectable level (BDL) of Cd to 224.87±4.07 µg/g of Fe in the fish gills. There is significant ($p<0.05$) differences in the Pb concentrations in the different fish parts with gills accumulated the highest level (3.20±0.16 µg/g). Chromium levels significantly ($p<0.05$) differed in the fish body parts and accumulated more in the muscles (10.75±0.15 µg/g) where Zn concentration is relatively lower (14.75±0.04 µg/g) compares to 29±l0.87 µg/g and 30.60±2.49 µg/g found in vertebra bones and gills respectively. Cu accumulation in muscles (27.35±0.23 µg/g) and vertebra bone (25.65±5.54 µg/g) demonstrate no significant difference ($p>0.05$) but the concentration is significantly higher ($p<0.05$) in the gills with 53.55±3.23 µg/g. Fe in all fish parts are relatively high and ranged from 180.33±4.19 μg/g in fish muscles to a significant high value of 224.87±4.07 μg/g in the gills. There are low levels of Cd in the fish samples where concentration in gill is below detectable level while 0.001±0.000 and0.001±0.001 were recorded for muscles and vertebra bones respectively. Figure 2 depicted the mean concentrations of heavy metals in different body parts of the fish against the maximum tolerable level as recommended by World Health Orgainsation, 2008. Pb levels in muscles and bones are lower but its concentration of 3.20±0.16 μg/g in the gills is exceed 2 μg/g maximum tolerable level recommended. Cr levels that ranged from 0.35±0.04 μg/g and 10.75±0.15 μg/g, Zn (14.75±0.04 μg/g and 30.60±2.49 μg/g) and Cd (0.001 μg/g) are below tolerable level of 50 μg/g (Cr), 75 μg/g (Zn) and <1 (Cd) recommended for corresponding elements. More also Fe concentrations in all fish parts are considerably above the allowable limit of 100 μg/g while only Cu level of 53.55±3.23 μg/g in gills exceeded the acceptable level of 30 μg/g . Presence of some these metals at high concentrations are considered as a dangerous source of water pollution, because of its consequential effects on the aquatic resources. These metals are known to induce oxidative stress and/or carcinogenesis by mediating free radicals/reactive oxygen species (Javed *et al.*, 2015). At trace levels, some heavy metals (e.g. Cu, Fe, Zn and Cr) are essential to maintain important biological roles including metabolism of the biological organism such as fish (Abadi *et al.*, 2014) while inadequate supply of these micronutrients could results in a variety of deficiency diseases or syndromes (Kennedy, 2011). However, toxicity could also occur at excessive concentration of these metals (Sivaperumal *et al.*, 2007) leading to a variety of adverse effects and fish diseases. On the other hand, non-essential metals such as Cd and Pb have no proven biological function and their toxicity rises with increasing concentrations (Sfakianakis, 2015) and therefore can lead to poisoning (Binkowski, 2012). From the study, the presence of heavy metals in the different body parts of *Labeo coubie* confirmed the report that heavy metals entering the water bodies can be deposited into aquatic organisms through the effects of bioconcentration, bioaccumulation and the food chain process (Abdel-Baki *et al*., 2011). It is further evident that heavy metals accumulate in the fish muscles, internal organs and bones as earlier reported in various studies (Kehinde and Adelakun, 2019; Agbon and Omoniyi, 2010; Golonova, 2008 and Dural *et al.,* 2007). Presence of Pb in all fish parts examined in the study agreed with Omwenga, (2003) that Pb accumulates in the bones and soft tissues of fish. Aquatic organisms bio accumulate Pb from water and diet, although there is evidence that Pb accumulation in fish, is most probably originated from contaminated water rather than diet (Creti *et al.*, 2010). Although Pb is a naturally occurring substance, its environmental concentrations are significantly increased by anthropogenic sources including lead containing pesticides, through precipitation, fallout of lead dust, road runoff, and community wastewater (Sepe, 2003). Lead (Pb) concentrations recorded in the study (table 1) are comparatively higher to the findings of Okafo *et al.,* (2018), who reported range of 0.30±0.15 μg/g and 0.39±0.18 μg/g for *Labeo species* from River Kaduna. Similarly, lower concentrations ranges between 0.002±0.001 μg/g to 0.024±0.004 μg/g in gills and 0.002±0.000 μg/g to 0.004±0.001 μg/g in muscles of economic important fishes of Aiba reservoir, Nigeria has been documented (Atobatele and Olutona, 2015). However, even at low levels, Pb pollution could cause some adverse effects on fish health and reproduction (Delistry and Stone, 2007).

Highest accumulation of Pb found in gills from the study affirmed its deposition in various fish organs including fish gills (Jezierska and Witeska, 2006), leading to disorders in fish body. The characteristic symptoms of chronic Pb toxicity include changes in the blood parameters with severe damage to erythrocytes and leucocytes and damage in the nervous system (El Badawi, 2005). The concentration of Cr significantly varied in all samples and below the tolerable level of 50μg/g (WHO, 2008), though higher than the concentrations of 0.02±0.01 μg/g to 0.40±0.13 μg/g in the different organs of the six species of fishes from Lake Chad in Doron Buhari, Maiduguri, Borno State, Nigeria (Akan *et al.*, 2009). Chromium is an essential nutrient metal, necessary for metabolism of carbohydrates (Farag *et al.,* 2006). Fish assimilate Cr by ingestion or by the gill uptake tract and accumulation in fish tissues, mainly liver, occurs at higher concentrations than those found in the environment (Pacheco *et al.,* 2013 and Ahmed *et al.,* 2013). The overall toxic impact on organs like gill, kidney and liver may seriously affect the metabolic, physiological activities and could impair the growth and behavior of fish (Vinodhini and Narayanan, 2008). Toxic effects of Cr in fish include: hematological, histological and morphological alterations, inhibition/reduction of growth, production of reactive oxygen species (ROS) and impaired immune function (Reid, 2011 and Vera-Candioti *et al.,* 2011). The mean levels of Zn in this study fall within 14.56±0.48 μg/g and 51.82±2.75 μg/g reported for *Chrysichthys nigrodigitaus* in the same study area (Adelakun and Kehinde, 2019), much higher than 2.19±0.39 μg/g reported for *Labeo species* from River Kaduna (Okafo *et al.,* 2018) but lower than 65.33 μg/g documented for *Tilapia Zilli* from the lower reaches of River Niger (Obodo, 2002). Zn plays a vital role in the physiological and metabolic process of many organisms (Rajappa *et al.,* 2010). It is essential element in animal diet because it helps in protein synthesis (Amundsen *et al.,* 1997) but may be become toxic to fish at concentration above 75 µg/g (WHO, 2008) and could result to mortality, growth retardation, and reproductive impairment (Giardina *et al.*, 2008). However, Zinc does not appear to present a contaminant hazard to *Labeo coubie* within the River Oli catchment of Kainji Lake National Park. For Cu, which can get into aquatic ecosystems from diverse sources for example, from Cu compounds used in agro chemicals, wood preservatives, tie and dye manufacture (Akan *et al.,* 2010). Also, from Cu compounds added in fertilizers and animal feeds as a nutrient to support plant and animal growth. Cu recorded in the study is higher than 7.04±0.03 µg/g in *Chrysichthys nigrodigitatus* and 9.51±0.10 µg/g in *Parachanna obscura* from Ibiekuma stream, Ekpoma, Nigeria (Erhabor *et al.,* 2010) as well as 1.57±0.26 µg/g in *Cynothrissa mento* from Ologe Lagoon, Lagos, Nigeria (Kumolu-Johnson *et al.,* 2010) but is lower than the range of 860-1620 µg/g reported by Anetekhai *et al*. (2007) in *M. vollenhovenii* (a non-fin fish) from the same Ologe Lagoon. This has been associated to greater metal load in Ologe Lagoon because of the presence of Agbara Industrial Estate, which discharges its waste into the lagoon (Kusemiju *et al*., 2001). However, Cu concentration in gills of the fish in the present study exceeded maximum tolerable level of 30 µg kg-1 (WHO, 2008) and high doses of Cu may cause anaemia, liver and kidney damage, stomach and intestinal irritation (Tirkey *et al.,* 2012). The high Cu levels in *Labeo coubie* in the study could be attributed to agricultural activities in the catchment especially the use fertilizers and agro chemicals. The River Oli catchment is a high potential area for agricultural practices including crops farming and animal husbandry, therefore Cu compounds added in fertilizers and animal feeds get into river through surface runoff especially during the rainy season. This study show that Iron (Fe) is the most bioaccumulated of all metals in the fish body parts (Table 1), though fall within 126.23 ± 0.06 µg/g and 560.63 ± 0.03 µg/g reported for different body parts of *Chrysichthys nigrodogitatus* and *Parachanna obscura* from Ibiekum stream, Nigeria (Erhabor *et al.,* 2010). However, the values reported for Fe in the study exceed maximum tolerable level of 100µg/g (WHO, 2008). High concentration of Fe in fish gills as evident in the study could cause respiratory distress in fish due to physical clogging of the gills (Dalzell and Macfarlane, 1999) because the precipitated Fe compounds could reduce the gills area available for respiration causing damage to the respiratory epithelium and eventual suffocation of the fish (Abbas *et al.,* 2002). This investigation revealed that Cd values obtained in this study fall within 0.002 ± 0.000µg/g reported for muscles of *Labeo species* in Aiba reservoir, Nigeria (Atobatele and Olutona, 2015). However, small quantities of cadmium could interfere with fish enzymes and cause diseases (Rajappa *et al.*, 2010) including bone defects in animals (Tirkey *et al.*, 2012). Cd was practically less bioaccumulated by the sampled fish species in this study. This could be attributed to the fact that the fishes were conceivably able to excrete the metal at a rate that exceeded the uptake of the metal (Wangboje *et al*., 2013).

*Patterns of heavy metals accumulation in body parts (muscles, gills and vertebra bones) of Labeo coubie*: The mean concentrations of metal elements in the fish parts had shown some connection in its bioaccumulation patterns. Pb and Cu had similar bioaccumulation forms of Gills > Muscles > Vertebra bones. Fe and Zinc, which are important essential metals exhibited Gills > Vertebra bones > Muscles accumulation pattern while Cr differed with all other metals forms with Muscles > Gill > Vertebra bones order of bioaccumulation in *Labeo coubie* (see table 2). It is apparent from the study that gill samples accumulated highest level of Pb, Cu, Zn and Fe, thus corroborated Storelli *et al.* (2006) and Rashed (2001); that gill is the centre of metal accumulation in fish as a results of its important role in interface with the environment in performing its functions in gas exchange, ion regulation, acid balance and waste excretion (Bajc *et al.,* 2005; Filazi *et al.,* 2003; Shukla *et al.,* 2007). The distribution pattern (gills < muscles < bones) of most metals in the study conformed closely with the work done by (Golonova, 2008) this could be as a result of gills direct metal uptake from water (Storelli *et al.,* 2006) which can be influenced by absorption of metals on to the gill surface (Erdogrul and Erbilir, 2007; Dural *et al.,* 2006) while muscles (Uysal *et al.* 2009; Bervoets and Blust, 2003) and bones (Akan *et al.,* 2009) comparably considered to have weak accumulation potential.

**Table 1**. Mean (±) concentration of heavy metals in muscles, gills and vertebra bones of *Labeo coubie* from the study area (µg/g dry weight).

| Fish parts | The mean concentration of heavy metals in fish flesh (µg/g) | | | | | |
|---|---|---|---|---|---|---|
| | **Pb** | **Cr** | **Zn** | **Cu** | **Fe** | **Cd** |
| **Muscles** | 1.50±0.02$^{b}$ | 10.75±0.15$^{c}$ | 14.75±0.04$^{a}$ | 27.35±0.23$^{a}$ | 180.33±4.19$^{a}$ | 0.001±0.000 |
| **Gills** | 3.20±0.16$^{c}$ | 3.80±0.22$^{b}$ | 30.60±2.49$^{b}$ | 53.55±3.23$^{b}$ | 224.87±4.07$^{b}$ | BDL |
| **Bones** | 0.45±0.02$^{a}$ | 0.35±0.04$^{a}$ | 29±l0.87$^{b}$ | 25.65±5.54$^{a}$ | 196.30±21.00$^{a}$ | 0.001±0.001 |

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

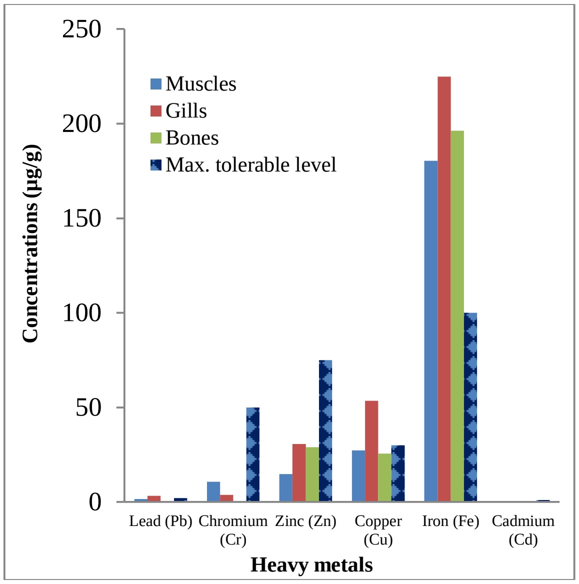


**Fig 2.** Mean concentrations of heavy metals in the muscles, gills and vertebra bones of *Labeo coubie* from the study area against WHO (2008) maximum tolerable level.

**Table 2.** Bioaccumulation patterns of heavy metals in body parts (muscles, gills and vertebra bones) of *Labeo coubie*

| Metal elements | Pattern of the bioaccumulation of heavy metal fish parts |
|---|---|
| **Pb** | Gills > Muscles> Vertebra bones |
| **Cr** | Muscles > Gill > Vertebra bones |
| **Zn** | Gills > Vertebra bones > Muscles |
| **Cu** | Gills > Muscles > Vertebra bones |
| **Fe** | Gills > Vertebra bones > Muscles |

*Conclusion:* There is the possibility of the heavy metals originating from the chemical fertilizers and all forms of pesticides in the surrounding communities of the Park possibly being washed down into the river through runoff. Hence, *Labeo coubie*, a euryphagus fish probably absorb these metals through ingestion of contaminated food or by absorption by the gills and bioaccumulate in different body parts. It is then pertinent to facilitates appropriate action towards protection and sustainable environment for wildlife conservation in the Park and its surrounding communities.

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