



waters high in turbidity and low in dissolved oxygen, and is often the last or only fish species found in remnant pools of drying rivers [9][10]. *Oreochromis niloticus* is native to central and North Africa and the Middle East. It is a tropical freshwater and estuarine species. It prefers shallow, still waters on the edge of lakes and wide rivers with sufficient vegetation [11]. The aim of this research was to assess the level of lead, cadmium and chromium in *Clarias gariepinus* and *Oreochromis niloticus* as indicators of contamination of river Kaduna.

## 2. Materials and Methods

### 2.1 Sample Collection

Water and fish samples were collected from river Kaduna at seven sampling locations (Malali, Anguwan Rimi, Makera, Nassarawa, Kudandan, Anguwan Mu'azu, and Kabala West) as shown in Figure 1. After which, 50 ml of thoroughly shaken water sample was measured accurately into a beaker and digested with 5 ml of conc.  $\text{HNO}_3$ . The solution was allowed to cool again then filtered with 125 mm filter paper into 100 ml standard flasks and made to the mark with de-ionized water. Fish samples were dissected and the muscle and liver were collected and washed with deionized water and sun dried for a week. Thereafter, dried in the oven for 3 hours at  $80^\circ\text{C}$ . Fish samples (muscle and liver) weighing 2-10 g were transferred into 50 ml quartz crucible and dried in an oven at  $120^\circ\text{C}$ . One gram of the dried sample was placed in a muffle furnace and ashed in a quartz crucible over night at temperature of  $450^\circ\text{C}$ . The next day, the sample was removed from the furnace and cooled to room temperature, and then 1ml of concentrated nitric acid was added and dried on a hot plate. The sample was placed in a muffle furnace for the second time and the temperature was raised to  $450^\circ\text{C}$  and kept for about 1 hour, until the ash became carbon free. The sample was removed from the muffle furnace and cooled at room temperature, and the ash was dissolved in 20 ml of 1 N hydrochloric acid and heated on a hot plate to further make the metals soluble. The residue obtained was dissolved in 50 ml de-ionized water, and filter into a 100 ml volumetric flask and made up to the mark with de-ionized water.

### 2.2 Analytical Procedure

Concentration of mercury, arsenic and copper in samples were determined in triplicates using atomic absorption spectroscopy (Thermo scientific iCE 3000 series AA spectrometers were used). Concentration each heavy metal was expressed in mg/kg dry weight.

### 2.3 Data Analysis

Data obtained were subjected to analysis of variance using SPSS software. Mean separation was done using least significant difference.

## 3. Results

### 3.1 Bioaccumulation of lead

Lead concentration in the muscle and in the liver of each of the two freshwater fish species were not significantly different ( $P > 0.05$ ) as shown in Figure 2. Over-all concentration of lead in each of the two freshwater fish species were also not significantly different, values obtained were 0.89 mg/kg dry weight in *C. gariepinus* and 2.71 mg/kg dry weight in *O. niloticus* (Figure 3). Over-all mean concentration of lead in the muscle and in the liver were 1.82 mg/kg dry weight and 1.76 mg/kg dry weight respectively (Figure 4).

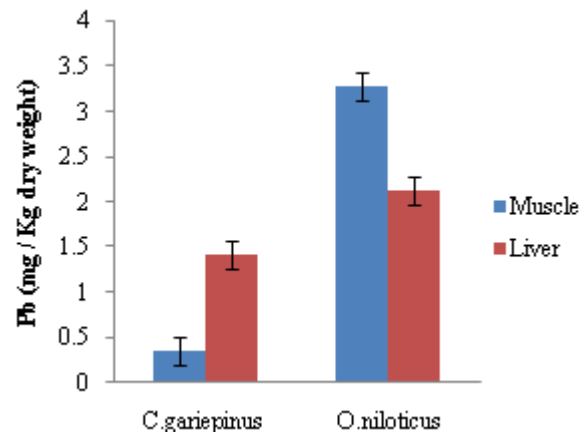


Figure 2: Concentration of lead (mg/kg dry weight) in different tissues of two freshwater species from river Kaduna.

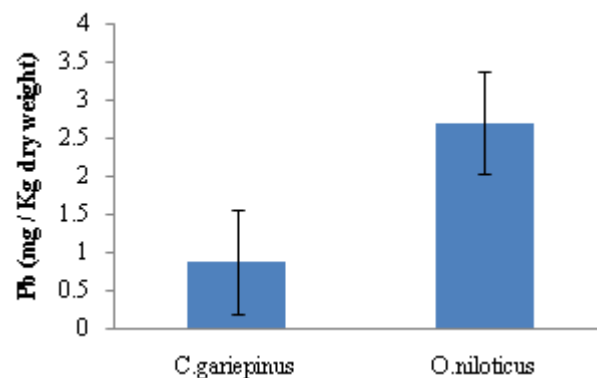


Figure 3: Concentration of lead in two freshwater fish species from river Kaduna.

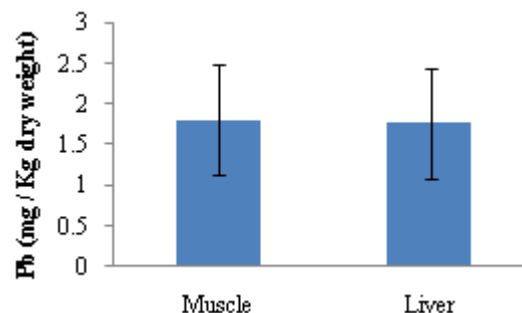


Figure 4: Concentration of lead in different tissues of two freshwater species from river Kaduna.

3.2 Bioaccumulation of Cadmium

Cadmium levels in the muscle and in the liver of each of the two freshwater species were not significantly different at 5 % probability level (Figure 5). The over-all concentration of cadmium in the each of the two fish species was likewise not significantly different. Mean values obtained were 0.74 mg/kg dry weight in *C. gariepinus* and 0.53 mg/kg dry weight in *O. niloticus* (Figure 6).

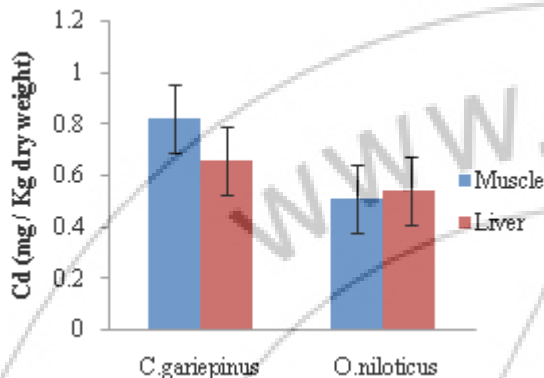


Figure 5: Concentration of cadmium (mg/kg dry weight) in different tissues of two freshwater species from river Kaduna.

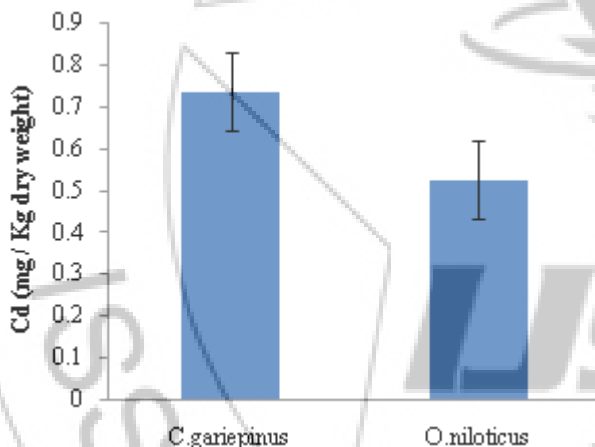


Figure 6: Concentration of lead in two freshwater fish species from river Kaduna.

Over-all cadmium levels in the muscle and in the liver of the two fish species were 0.67 mg/kg dry weight and 0.60 mg/kg dry weight respectively (Figure 7). These mean values were not significantly different.

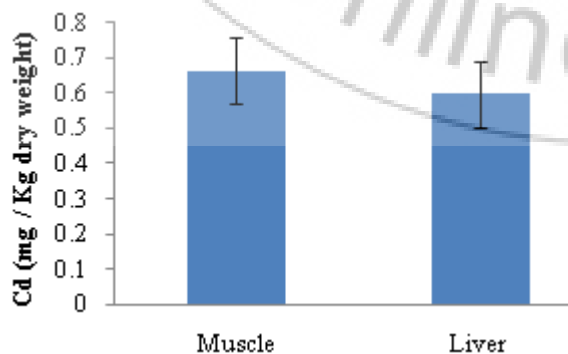


Figure 7: Concentration of cadmium in different tissues of two freshwater species from river Kaduna.

3.3 Bioaccumulation of Chromium

Chromium levels in the muscle and in the liver *C. gariepinus* were not significantly different. However, values obtained in *O. niloticus* were significantly different ( $p < 0.05$ ) as shown in Figure 8.

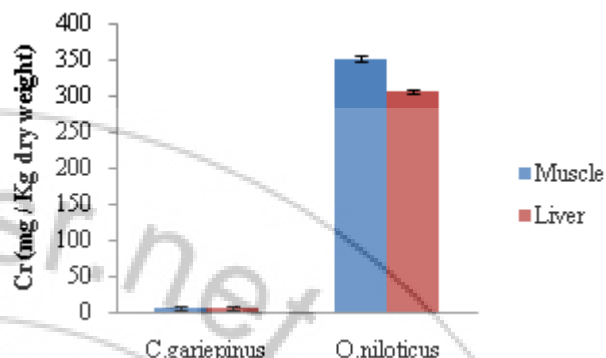


Figure 8: Concentration of chromium (mg/kg dry weight) in different tissues of two freshwater species from river Kaduna.

Over-all chromium concentration in each of the fish species were significantly different ( $p < 0.05$ ). Mean values obtained were 1.41 mg/kg dry weight in *C. gariepinus* and 329.71 mg/kg dry weight in *O. niloticus* (Figure 9).

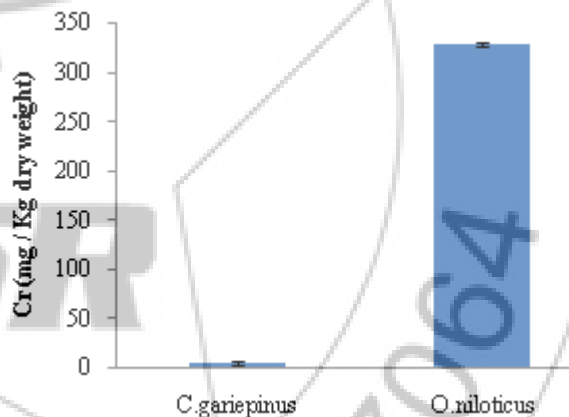
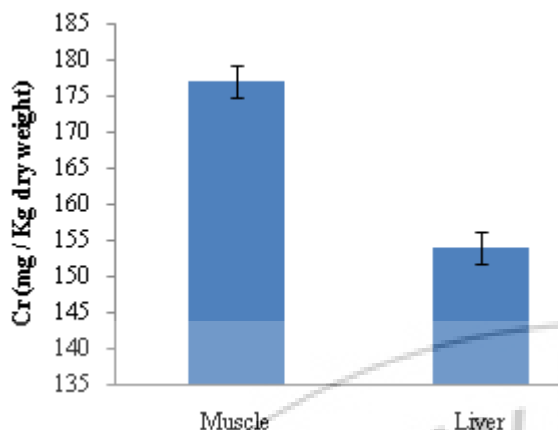


Figure 9: Concentration of chromium in two freshwater fish species from river Kaduna.

Over-all concentration of chromium in the muscle and in the liver of the fish species were 177.10 mg/kg dry and 154.00 mg/kg dry weight respectively (Figure 10). These mean values were significantly different at 5 % probability level.



**Figure 10:** Concentration of chromium in different tissues of two freshwater species from river Kaduna.

## 4. Discussion

### 4.1 Bioaccumulation of Lead, Cadmium and Chromium in the Muscle and Liver of Each Fish Species

Bioaccumulation of lead and cadmium in the muscle and in the liver of each of the two fish species was not significantly different implying that these tissues contain similar levels of the metal binding protein called metallothioneins. These proteins play an important role in the homeostasis of metals and protection against heavy metal toxicity [2]. Imam *et al.* [12] reported that a positive correlation occurred between metallothioneins levels and cadmium levels in tilapia obtained from selected farms in Egypt. Significant variation in chromium levels in the tissues of *O. niloticus* was observed implying that it accumulates this heavy metal in a tissue-dependent manner which could be attributed to variation in metallothioneins level among the two tissues analyzed.

### 4.2 Over-all Mean Concentration of Each Heavy Metal in Each Fish Species

It is noteworthy, to mention that the over-all mean concentration of lead and cadmium were beyond permissible limits as recommended by Codex alimentarius commission ( $\leq 0.5$  mg/kg for lead) and heavy metals regulations legal notice no. 66 ( $\leq 0.05$  mg/kg for cadmium). Over-all chromium level in each of the fish species was significantly different. This could be due to interplay of a number of factors which include: habitat, seasonal variations, and individual affinity for metal uptake, differences in life history patterns that influence exposure (including trophic levels and geographic distribution of life stages), biomagnifications, seasonal changes in the taxonomic composition of the different trophic levels affecting the concentration and accumulation of heavy metals in the body of the fish, adaptation capacity of the fish to heavy metal load and distance of the organism from the contamination source. Over-all chromium level in each fish species was also above permissible limit set by FAO [13] and FEPA [14] (0.15 mg/kg). High level of these heavy metals in these fish species did not only signify contamination of river Kaduna with these metals but also show that *C. gariepinus* and *O. niloticus* from this river are not safe for consumption. Short-term exposure to high levels of lead can cause brain damage,

paralysis (lead palsy), anaemia and gastrointestinal symptoms. Long-term exposure can cause damage to the kidneys, reproductive and immune systems in addition to effects on the nervous system. The most critical effect of low-level lead exposure is on intellectual development in young children and, like mercury, lead crosses the placental barrier and accumulates in the foetus. Infants and young children are more vulnerable than adults to the toxic effects of lead, and they also absorb lead more readily. Even short-term, low-level exposures of young children to lead is considered to have an effect on neurobehavioural development [15]. The principal toxic effect of cadmium is its toxicity to the kidney, although it has also been associated with lung damage (including induction of lung tumours) and skeletal changes in occupationally exposed populations Food Safety Authority of Ireland [16]. Bioaccumulation of chromium in fish has been reported to cause impaired respiratory and osmoregulatory functions through structural damage to gill epithelium [17].

### 4.3 Over-all Mean Concentration of Heavy Metals in Each Fish Tissue

Results of this study show that the muscle is more bioaccumulative for chromium than the liver which could be explained in terms of variation in metallothioneins level. Metallothioneins have been discovered in varying amounts in different tissues including muscle [18], kidney, liver and brain [2].

### 4.4 Sources of Contaminants

The presence of high levels of lead, cadmium, and chromium in *C. gariepinus* and *O. niloticus* shows that river Kaduna is highly polluted with these heavy metals as earlier mentioned. This is not surprising because farmlands and industries are cited close to the river (Figure 1). Run-off from farmlands could be a contributing factor to the pollution of this river due to application of inorganic fertilizers, pesticides and herbicides on these farmlands. Improper discharge of industrial wastes could also be one of the major causes of pollution of river Kaduna [5]. One of the ways to circumvent this challenge is by judicious use of chemicals on farmlands which can be achieved by using more of organic materials (organic manure, organic pesticides, biological control of pests and diseases, cultural practices in weed control) and proper industrial wastes management.

## 5. Conclusion

This research has established that River Kaduna is polluted with lead, cadmium, and chromium. Both fish species contain these heavy metals at levels above permissible limits hence, are unsafe for human consumption. Both fish species are good bioaccumulators of these heavy metals however, *O. niloticus* is better than *C. gariepinus*. Furthermore the muscle accumulated these heavy metals more than the liver. Therefore, there is an urgent need for development and implementation of policies to reduce the pollution of river Kaduna for the good wellbeing of consumers of these two fish species.

## 6. Future Studies

Future research will focus on the effect of these heavy metals on consumers of the fish species. Also, relationship between these heavy metals and metallothionein levels will be investigated.

## 7. Acknowledgements

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## References

- [1] Kucuksezgin FA, Kontas, O, Altay, E, Uluturhan DE. Assessment of marine pollution in Izmir Bay; Nutrient heavy metal and total hydrocarbon concentrations. *Environment International* 2006; 32: 41-51.
- [2] Papagiannis I, Kagalou I, Leonardos J, Petridis D, Kalfakakou V. Copper and zinc in four freshwater fish species from lake Pamvotis (Greece). *Environment International* 2004; 30:357-362.
- [3] Krishna PV, Madhusudhana Rao K, Swaruparani V, Srinivas Rao D. Heavy metals concentration in fish *Mugil cephalus* from Machilipatnam coast and possible health risks to fish consumers. *British biotechnology journal* 2014; 4:126-135.
- [4] Opaluwa OD, Aremu MO, Ogbo LO, Magaji JI, Odiba IE, Ekpo ER. Assesment of heavy metals in water, fish and sediments from UKE stream, Nasarawa state, Nigeria. *Current World Environment* 2012; 7:213-220.
- [5] Emere MC, Dibal DM. Metal accumulation in some tissues/organs of a freshwater fish (*Clarias Gariepinus*) from some polluted zones of River Kaduna. *Journal of Biology Agriculture Healthcare* 2013;3:112-117.
- [6] Ali N, Onyie AN, Balarabe SJ, Auta J. Concentration of Fe, Cu, Cr, Zn and Pb in maker drain, Kaduna Nigeria. *chem class journal* 2005; 2: 69-73.
- [7] Ekpo FE, Agu NN, Udoakpan UI. Influence of heavy metals concentration in three common fish, sediment, and water collected within quarry environment, Akamkpa L.G. Area, Cross River State, Nigeria. *European Journal of Toxicological Sciences* 2013; 2013: 1-11.
- [8] Pouomogne V. Capture-based aquaculture of *Clarias* catfish: case study of the Santchou fishers in western Cameroon. In A. Lovatelli & P.F. Holthus (eds.). *Capture based aquaculture. Global overview.* FAO Fisheries Technical Paper FAO, Rome, Italy 2008; 508:3-108.
- [9] Safriel O, Bruton, MN. A cooperative aquaculture research programme for South Africa. *South African National Scientific Programmes Report 89 CSIR, Pretoria, 1984, p. 79.*
- [10] Van der Waal BW. Survival strategies of sharptooth catfish *Clarias gariepinus* in desiccating pans in the northern Kruger National Park. *Koedoe - African Protected Area Conservation and Science* 1984; 41: 131-138.
- [11] Picker MD, Griffiths CL.. *Alien and Invasive Animals – A South African Perspective.* Randomhouse/Struik, Cape Town, South Africa 2011 p. 240
- [12] Iman KA, Mohammad NA, Wafaa TA. Heavy Metal Pollution and Metallothionein Expression: A Survey on Egyptian Tilapia Farms. *Journal of Applied Sciences Research* 2013; 9: 612-619.
- [13] FAO: *Compilation of legal limits for hazardous substances in fish and fishery products.* FAO Fishery Circular 1983; 464:5-10
- [14] FEPA. *Guideline and Standards for Environmental Polution and Control in Nigeria.* Federal Environmental Protection Agency, Nigeria 2003.
- [15] WHO. *Lead poisoning and health.* Fact sheet N<sup>o</sup> 379 2013.
- [16] Food Safety Authority of Ireland. *Mercury, Cadmium, Lead, Tin and Arsenic in food.* Issue No 1, 2009.
- [17] Heath, A.G. (1991): *Water Pollution and Fish Physiology.* Lewis Publishers. Boca Raton, Florida, USA 359pp.
- [18] Allen-Gil SM, Martynov VG. Heavy metals burdens in nine species of freshwater and anadromous fish from the Pechora River, nothern Russia. *The Science of the Total Environment* 1995;160– 161:653– 659.

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