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Assessment of Heavy Metal Bioaccumulation in Wild Fish (*Clarias gariepinus*) Consumed in Wukari Area of Taraba State, Nigeria

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Abstract
A study was carried out on the assessment of heavy metal bioaccumulation in wild fish (*Clarias gariepinus*) consumed in Wukari area of Taraba State in Nigeria between July and November 2016. Twenty-two (22) market sizes smoke-dried fish (*C. gariepinus*) were randomly bought from the Wukari markets in Taraba State in July 2016 and burned to ashes with a furnace at a temperature of 400°C for two hours and stored in sample bottles prior to acid digestion. Concentration of heavy metals (Cd, Pb, Cu, Ni, Mn and Co) in the dried fish samples was analyzed using Buck Scientific Atomic Absorption Spectrophotometer (AAS). The results showed that the mean concentration of highly toxic Cd and Pb was below the World Health Organization's (WHO) guideline limits of 0.05 ppm and 1.0 ppm respectively. The essential Cu concentration in the liver (32 ppm) exceeded the WHO set limit of 30 ppm while the other organs were below it. Fifty percent (50%) of the organs (bones, liver and muscles) exceeded the WHO guideline limit of 0.07 ppm for Ni, while the gills, fins and skin were below it. The mean Mn concentration in all the organs were below the FEPA guideline limit. The results showed that the mean toxic heavy metal Cd and Pb in the organs of the fish *C. gariepinus* were below the World Health Organization (WHO) limit and therefore safe for human consumption. Essential heavy metals like Cu and Ni were slightly above WHO guideline limit in some organs which means consumption quantity should be in moderation. It is therefore recommended that regular biomonitoring studies on heavy metals should be carried out on fish species widely consumed in the area for public health good.

1. Introduction

Fish is in high demand due to its wide availability, affordability and as a safe source of animal protein (FAO, 2012). Fisheries may involve capture of wild fish (captured fishery) or raising fish through fish farming or aquaculture (culture fisheries) (Olaoye *et al*, 2015). The bioaccumulation/biomagnification of heavy metals in living organisms describes the processes and pathways of pollutants from one trophic level to another (Akan *et al*, 2012). The prevailing conditions of the aquatic environment could cause free divalent ions of some heavy metals to be absorbed by the gills and skin of fish

(Part *et al*, 1985). Heavy metals constitute one of the most dangerous groups among the water pollutants because of their persistent nature, toxicity, tendency to accumulate in organism and become transferred from one trophic level to another in the food chain (Alinnor *et al*, 2016). The concentration of heavy metals in the organs of fish is an indication that the aquatic ecosystem is polluted and a measure of food safety (Farkas *et al*, 2000). Fish are the most important organisms in the aquatic food chain and are sensitive to heavy metal contamination which has lethal and chronic effects on them (Akan *et al*, 2012). Amongst the different organs, the liver accumulates higher concentration of metals and has been used widely to investigate the process of bioaccumulation while the kidneys play a vital role in excretion of heavy metal ions (Wepener *et al*, 2001).

Previous studies have shown heavy metal contamination in surface water and fish in Nigeria. Akan et al (2012) studied bioaccumulation of some heavy metals in fish samples from River Benue in Vininkilang, Adamawa State of Nigeria and the results indicated that the highest level of all the heavy metals studied was observed in the gills and liver of the fish with the other organs remarkably contaminated. A study by Wangboje and Ekundayo (2013) on heavy metals in surface water of Ikpoba reservoir, in Benin City, Nigeria revealed that the concentration of heavy metals in surface water was variable exceeding the WHO maximum permissible level for drinking water. Tyokumbur et al (2014) showed that the mean concentration of the heavy metals arsenic, cadmium, copper and lead in Sarotherodon galilaeus from the Alaro Stream in Ibadan exceeded the World Health Organization (WHO) guideline limits set for most of the organs. This means that Alaro stream was polluted and that fish (S. galilaeus) caught from the stream was unfit for human consumption due to the public health consequences posed in consuming the contaminated fish. This study is aimed at assessing the heavy metal bioaccumulation in fish (Clarias gariepinus) that is widely consumed in Wukari area of Taraba State, Nigeria.

2. Materials and methods

2.1. Study Area

The study area Wukari town is the headquarter of Wukari Local Government Area located in Taraba State, Nigeria. It is geographically located on the coordinates Latitude 7°51′N and Longitude 9°47′E. Captured fishery (wild fish) from rivers within the catchment hydrology, notably Rivers Benue and Donga, are caught, smoked and dried for sale in the area. It has an area of 4,308 km² and a population of 241,546 based on the 2006 census.

2.2. Sample Collection and Processing

Twenty-two (22) market size smoke-dried whole fish (*C. gariepinus*) were randomly bought from Wukari market in Taraba State in July 2016 and packaged in sampling bags as muscle, liver, gills, bones, fins and skin. The fish samples were burned to ashes with a furnace at a temperature of 400°C for two hours and stored in sample bottles prior to acid digestion. 0.5 g of each charred sample was digested in 2.0 mL 70% nitric acid and allowed to stay overnight. After 24 hours, 1.0 mL of 30% hydrogen peroxide was added to each of the digested sample and allowed to simmer down. The digested was filtered with acid-resistant filter paper and made up to the 10.0 mL mark with distilled water and taken for analyses.

2.3. Heavy Metal Analyses

The concentration of heavy metals in the dried fish samples was analyzed using Buck Scientific Atomic Absorption Spectrophotometer at the Multidisciplinary Central Research Laboratory (MCRL), University of Ibadan. Each analysis was done in triplicates while standard and blank samples were analyzed for all the 22 samples. The results were expressed in units of parts per million (ppm).

2.4. Data Analysis

The data will be presented as means of the heavy metal concentration in the fish samples while histograms will be plotted to show the differences in concentration and to compare with World Health Organization (WHO) and Federal Environmental Protection Agency (FEPA) guideline limits for food safety.

3. Results and Discussion

Mean Concentration of Heavy Metals in the Organs of *C. gariepinus* in Wukari

Results of the mean Cd concentration in the fish (*C. gariepinus*) is shown in Fig. 1. The mean Cd concentration was highest in the liver (0.04 ppm) while the least was in the muscle and fins (0.01 ppm). The mean Cd concentration in all the organs were below the World Health Organization (WHO) guideline limit of 0.05 ppm (WHO, 2004) in the order: muscle/fin< skin< bone/gills<liver. The high Cd concentration in the liver could be due to its role in detoxification of chemical substances in the fish (Moses, 1992).

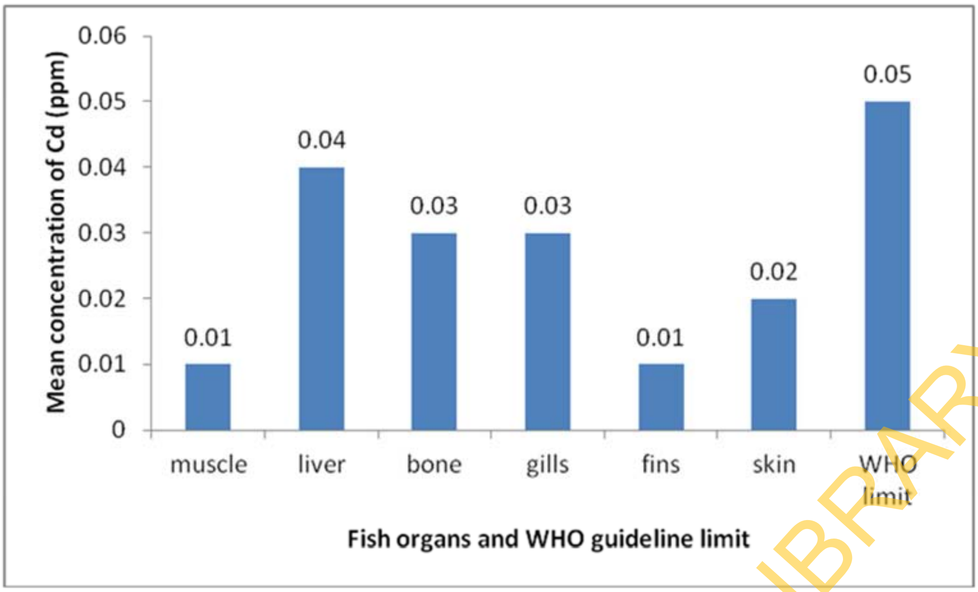

Figure 1. *Mean Cd concentration in the organs of C. gariepinus and WHO limit.*

The mean Pb concentrations in the organs of the fish are shown in Fig. 2. The highest mean Pb concentration was in the muscle (0.86 ppm) while the lowest was recorded in the skin (0.21 ppm) in the order: skin<fins<gills<bone<liver<muscle. All the mean Pb concentrations in the organs were below the WHO guideline limit of 1 ppm (WHO, 2004). Similar findings have been reported by Olatunji and Osibanjo (2012). The Pb levels in the organs of *C. gariepinus* could be due to the bioavailability of lead in the aquatic ecosystem from leaded gasoline, industrial effluents and geogenic sources (Akaahan *et al*, 2010; Akan *et al*, 2012).

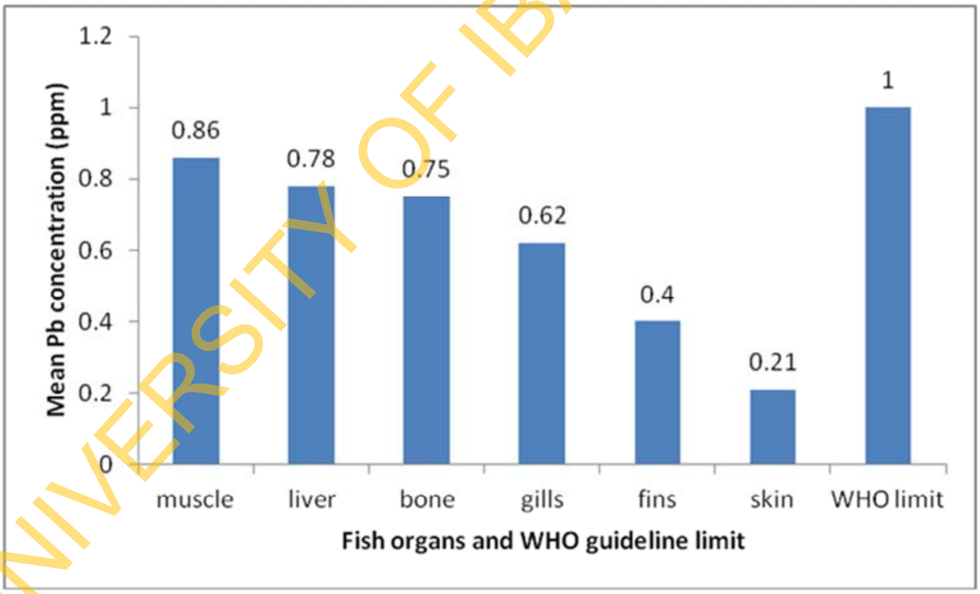

Figure 2. *Mean Pb concentration in the organs of C. gariepinus and WHO limit.*

The mean Cu concentration in the fish is shown in Fig. 3. The highest mean Cu concentration was recorded in the liver (32.0 ppm) while the least was in the skin (7.3 ppm) in the order: skin<fins<gills<muscle<bone<liver. With the exception of the liver (32.0 ppm), all the other organs had mean Cu concentrations below the WHO guideline limit (30 ppm). Similar high Cu concentration in the liver of the fish *Sarotherodon galilaeus* have been reported by Tyokumbur *et al* (2014) which could be due to the detoxifying role of the liver.

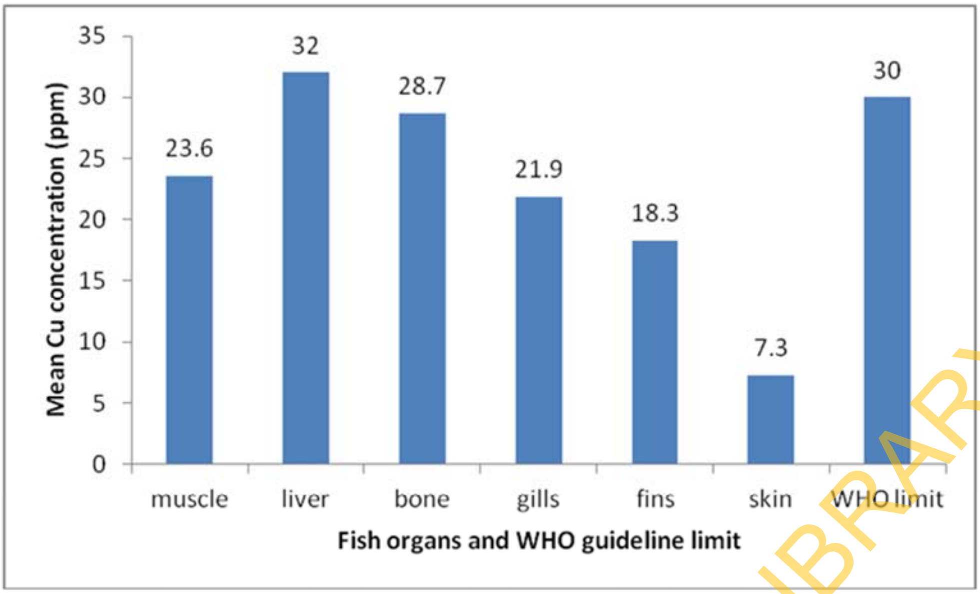

Figure 3. *Mean Cu concentration in the organs of C. gariepinus and WHO limit.*

The mean Ni concentrations in the organs of fish are shown in Fig. 4. The highest mean Ni concentration was recorded in the muscle (0.31 ppm) while the least was in the skin (0.03 ppm) in the order: skin<fins<gills<liver<bone<muscle. The mean Ni concentration in the liver, bone and muscle were above the WHO guideline limit of 0.07ppm while that of the gills, fins and skin were below it. Ni is however an essential micronutrient in the body of animals (Akan *et al*, 2012).

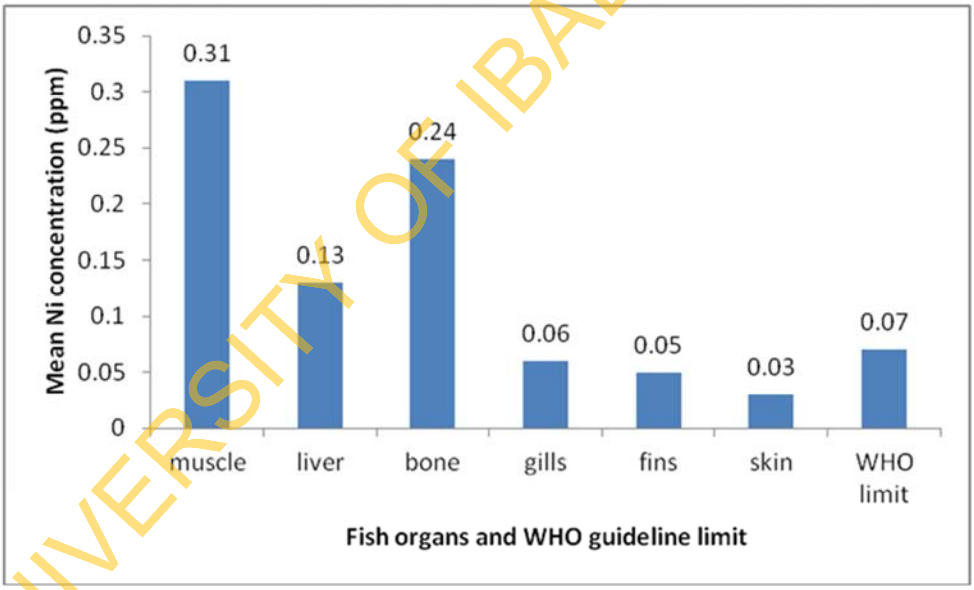

Figure 4. *Mean Ni concentration in the organs of C. gariepinus and WHO limit.*

The mean Mn concentration in the organs of the fish *C. gariepinus* is shown in Fig. 5. The highest mean Mn concentration was recorded in the gills (4.53 ppm) while the least was in the skin (0.06 ppm) in the order: skin<fins<bones<muscle<liver gills. The high Mn in the gills could be due to its role as an exchange organ in constant contact with the water (Moses, 1992). All the mean Mn concentration in the organs were below the FEPA (Federal Environmental Protection Agency (FEPA) guideline limit of 5 ppm (FEPA, 1991), since there is no set WHO limit.

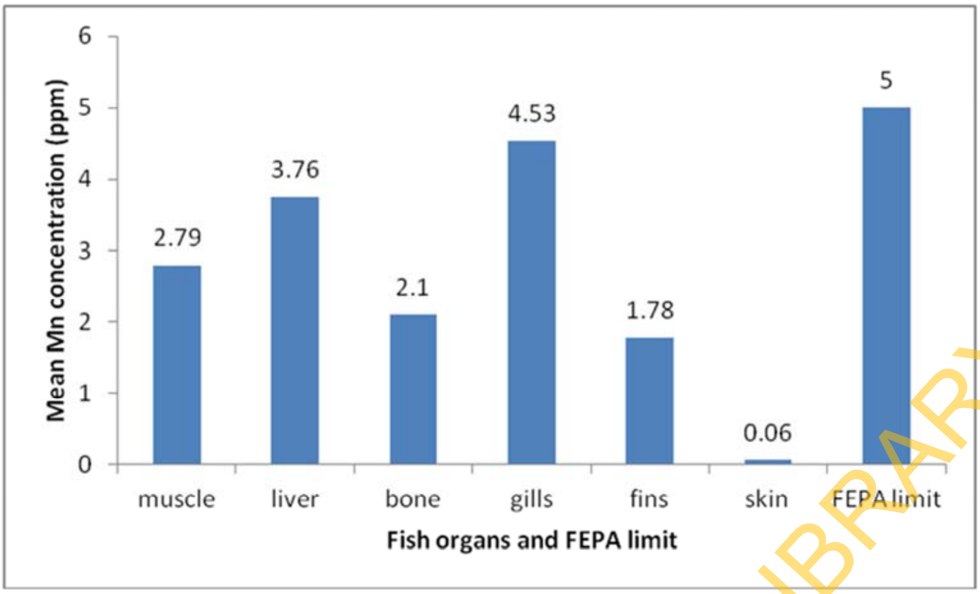

Figure 5. *Mean Mn concentration in the organs of C. gariepinus and WHO limit.*

The mean Co concentrations in the organs of the fish are shown in Fig. 6. The highest mean Co concentration in the fish organs was recorded in the muscles (0.49 ppm) while the lowest was in the gills (0.12 ppm) in the order: gills<skin<bones<fins<liver<muscle. There is no WHO guideline limit for cobalt (Co).

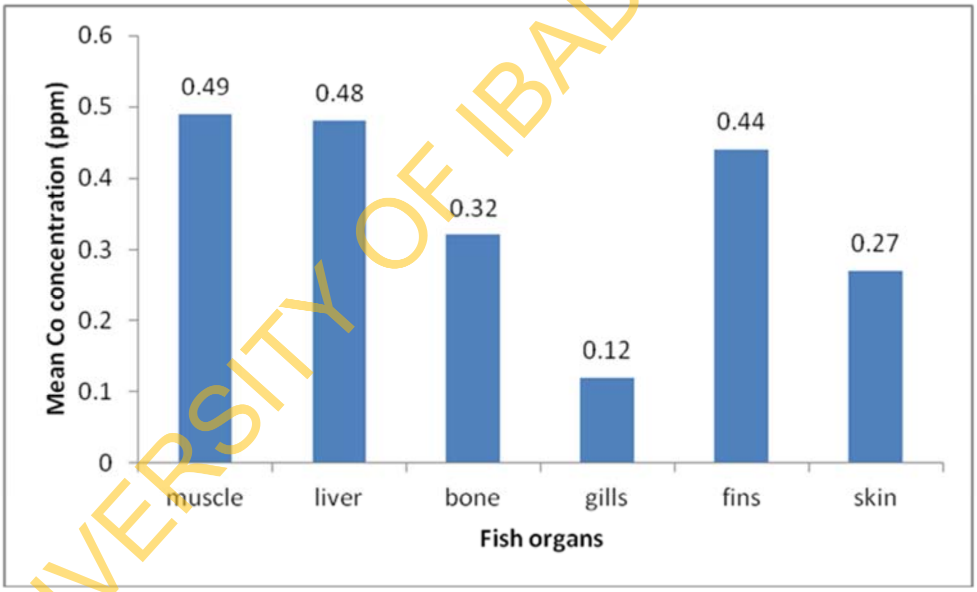

Figure 6. *Mean Co concentration in the organs of C. gariepinus and WHO limit.*

4. Conclusion and Recommendation

The study showed that the mean toxic heavy metal Cd and Pb in the organs of the fish *C. gariepinus* were below the World Health Organization (WHO) limit and therefore safe for human consumption. Other essential heavy metals like Cu and Ni were slightly above WHO guideline limit in some organs which means consumption quantity should be in moderation while Mn was below FEPA guideline limit. Co has no WHO guideline limit. It can be concluded that the fish *C. gariepinus* consumed in Wukari, Taraba State is safe for human consumption as shown in the study. It is recommended that regular biomonitoring studies on heavy metals and other pollutants be carried out on all fish species widely consumed in Wukari, Taraba State for public health good.

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