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Incidence of Heavy Metals (Pb, Cu, Zn) in Fish Species in Afikpo North Local Government Area of Ebonyi State

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Abstract This study was conducted to evaluate the concentration of lead, copper and zinc on the gills, viscera and muscle parts of three fish species- *Clarias gariepinus*, *Channa obscura*, and *Tilapia zilli* from Uwana river in Afikpo in Ebonyi State, Nigeria. Lead concentrations did not differ significantly ($p > 0.05$) among the fish species and were 0.025 ± 0.045 ppm in *C. gariepinus*, 0.024 ± 0.041 ppm in *C. obscura* and 0.036 ± 0.056 ppm in *T. zilli*. However copper was significantly ($p < 0.05$) higher in *T. zilli* 0.067 ± 0.116 ppm compared to *C. gariepinus* 0.033 ± 0.038 ppm and *C. obscura* 0.030 ± 0.041 ppm. Zinc concentrations were similar ($p > 0.05$) in the 3 fish species of *C. gariepinus* (0.454 ± 0.256 ppm), *C. obscura* (0.518 ± 0.246 ppm), and *T. zilli* (0.514 ± 0.279 ppm). Gills (0.026 ± 0.044 ppm), Viscera (0.029 ± 0.051 ppm) and Muscle (0.030 ± 0.048 ppm) did not differ significantly ($p > 0.05$) in lead content but viscera contained more copper (0.084 ± 0.114 ppm) compared to the gills (0.035 ± 0.039 ppm) and muscle (0.011 ± 0.013 ppm). Significant differences ($p < 0.05$) were observed in the zinc contents of the body parts as Gills contained more zinc (0.590 ± 0.209 ppm) compared to viscera (0.0567 ± 0.291 ppm) and muscle (0.329 ± 0.188 ppm). In all cases, the heavy metal concentrations in the fish species were lower than the maximum limit set by FAO/WHO/ FEPA.

Keywords: *gills, muscle, viscera, lead, copper, zinc*

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1. Introduction

Aquatic environment is an important ecosystem a factor in development of various civilizations, the abode for some organisms, water supply, a recreation center, means of transportation, and fishing pot for both the fishing trawlers and artisanal fishermen. Water is an important natural resource for man both directly and indirectly by means of the fish and seafood resources. In the water bodies, both nutritive substances and polluting substances enter the fish body through the gills and through the hundreds of capillaries existing at this level [1]. Hence, the aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both cultured and wild fishes and other sea foods [2].

Fisheries are an integral part of Agriculture sector in Nigeria which maintains a steady contribution of 3.5 to 4% to total GDP in 2008 to 2012. This translates to about 10% of agricultural GDP, which itself contributed between 35 and 40 percent within the same period. However, Nigeria’s abundant fisheries resources notwithstanding, the country is still largely a protein deficient nation. Total protein consumption is below the UN/FAO’S estimated minimum of 75 g of daily per capita intake. The findings from Federal Department of Fisheries [3] and Food and Agriculture Organization [4] records also show that Nigeria’s self-sufficiency ratio in fish production was as high as 98.8% in 1983 but dwindled between 40% and 19.2% in 2005 and 2014 with an annual average of about 49%. Statistical surveys [5] have shown that the current fish demand in Nigeria put at over 1.5 metric tons has not been met which led to annual fish importation of about US$ 400 million annually. As of 2009, the Nigeria foreign exchange expenditure on total expenditure on food import was valued at $3 billion while proportions of fish import alone amount to about $1.3 billion or 43.33% [6].

In recent years, fish has become favorite foodstuff for the majority of societies because of several health reasons [7]. Fish is a worldwide distributed food commodity. A researcher [8] reported that fish received increased attention from time to time as a potential source of animal protein and some minerals for human diets. In addition to nutritional value, fish is also a good source of income. Fish is a cheap source of high protein; so there is a need to produce it as an alternative way of fulfilling animal protein requirement for the poor rural communities [7].

Fish is a food of excellent nutritional value, providing a high quality of protein and a wide variety of vitamins and minerals including Vitamin A and Vitamin D, phosphorus, magnesium, selenium, zinc and iodine in marine fish. Its protein is similar to that of meat. It is easily digestible and favorably complements dietary protein provided by cereals and legumes that are typically consumed in many developing countries. Even in small quantities, fish can have a significant positive impact in improving the quality of dietary protein by complementing the essential amino acids that are often present in low quantities in vegetable based diets [9]. Fish oils particularly those of fatty fishes are the richest sources of a type of fat that is vital to normal brain development in babies and infants [10].

Heavy metals are those metals which possess a specific density of more than 5 g/cm^3 and adversely affect the environment and living organisms [11]. These heavy metals are commonly found in the environment and diet. These metals are necessary for maintaining various biochemical and physiological functions in living organisms when in very low concentrations, however they become harmful when they exceed certain threshold concentrations. Although it is well known that heavy metals have many adverse health effects and last for a long period of time, heavy metal exposure continues and is increasing in many parts of the world. Heavy metals are significant environmental pollutants and their toxicity is a problem of increasing significance for ecological, evolutionary, nutritional and environmental reasons [12,13]. The most commonly found heavy metals in waste water include arsenic, cadmium, chromium, copper, lead, nickel, and zinc, all of which cause risks for human health and the environment [14]. Heavy metal toxicity can lower energy levels and damage the functioning of the brain, lungs, kidney, liver, blood composition and other important organs. Long-term exposure can lead to gradually progressing physical, muscular, and neurological degenerative processes that imitate diseases such as multiple sclerosis, Parkinson's disease, Alzheimer's disease and muscular dystrophy. Repeated long-term exposure of some metals and their compounds may even cause cancer [11,15]. The toxicity level of a few heavy metals can be just above the background concentrations that are being present naturally in the environment.

Since fish is known for the bioaccumulation of heavy metals in its body, it is a suitable biomonitor of the presence of heavy metal (lead, zinc and copper) in their water. In rural areas, fish is an important source of food for the human population and its procurement is not always controlled, therefore, there is more often a risk for those people who consume contaminated fish. The broad objective of this study was to investigate the level of heavy metals (Pb, Zn, and Cu) in of the gills, Viscera and muscle parts of fish species inhabiting the water bodies of Ebonyi State.

2. Materials and Methods

Afikpo local government area (Lat5^o 45-N and Log8^{o}01-E) is situated in the southern part of Ebonyi State Nigeria. It is bounded to the north by the town Akpoha in Amoha local government area, to the south by Uwana and Edda in Ubeyi and Afikpo south local government areas respectively, to the east by Cross River and to the west by Amasiri in Amaoha local government Area.

2.1. Sample Collection

Samples of three fish species *Clarias gariepinus*, *Channa obscura* and *Tilapia zilli* were collected from fishermen at Uwana fresh water ecosystem. The samples were kept in an ice pack temporally from the sampling site and later stored frozen until the analysis took place. The fish samples were dissected and the gills, viscera and muscle parts obtained.

2.2. Digestion of Samples

The samples were digested using the aqua regia digestion standard method [16]. The samples were left to thaw and three grams of each of the samples were weighed into digestion flasks containing 28 ml aqua regia (21 ml HCl and 7 ml HNO_3) fitted with water condenser. The mixture was kept overnight at room temperature. It was then boiled for 2 hours on an electrothermal heater. The content of the flask was allowed to cool then filtered using the Whatman filter paper No 1 and diluted to 100 ml with deionised water.

2.3. Determination of Heavy Metals

The heavy metals were determined according to standard methods [16]. The various standards of the metals were prepared from 1000 ppm stock solution of each metal using the formular: $P_1V_1 = P_2V_2$

The system was put on and allowed to initialize. The various standards were aspirated into the flame and got atomized by the flame. The graph of the standard was plotted and displayed on the monitor. The various samples were aspirated and analysed and the heavy metal concentrations

2.4. Data Analysis and Experimental Design

The experimental design was a 3×3 split-plot design. Statistical analysis was carried out by analysis of variance (ANOVA) [17]. Means with significant differences were separated using the Duncan’s multiple range test ($p < 0.05$).

3. Results and Discussion

3.1. Concentration of Lead, Copper and Zinc in Fish Species

Table 1 shows the Lead (Pb), Copper (Cu) and Zinc (Zn) contents of the three fish species. For lead, the concentration values of the fish samples ranged from 0.024 ± 0.041 ppm in *Channa obscura* to 0.036±0.056 ppm in *Tilapia zilli*. There were no significant differences ($p > 0.05$) in the lead accumulation for the three species. The values obtained in this research work was lower than the findings of a researcher [18] who recorded a range of 0.01 ± 0.00 ppm to 0.25 ± 0.20 ppm on the bioaccumulation of heavy metals in fish organs in downstream Ogun coastal water. The findings from this work is below the maximum permissible limit set by World Health Organisation [19] and Federal Environmental Protection Agency [20] limit (< 2.0 ppm) in foods.

Table 1. Pb, Cu and Zn contents of the three species of fish

Species	Pb (ppm)	Cu (ppm)	Zn (ppm)
Clarias gariepinus	$0.025^a \pm 0.045$	$0.033^b \pm 0.038$	$0.454^a \pm 0.256$
Channa obscura	$0.024^a \pm 0.041$	$0.030^b \pm 0.041$	$0.518^a \pm 0.246$
Tilapia zilli	$0.036^a \pm 0.056$	$0.067^a \pm 0.116$	$0.514^a \pm 0.279$

Not*e:* Values are means ± standard deviation of triplicate readings. Means with same superscript in the same column are statistically similar (p > 0.05).

Copper concentration (ppm) ranged from 0.03 ± 0.041 to 0.067 ± 0.116. Clarias and Channa species were similar (p > 0.05) but there was a significant difference (p < 0.05) when compared with Tilapia specie (p < 0.05). The findings from this research work where higher than the findings of a previous researcher [21] (0.56 ± 0.03 to 2.10 ± 0.01). These values are below the WHO [19] and FEPA [20] permissible limit of (< 3 ppm) in fish foods.

Zinc concentration (ppm) was highest in Channa specie (0.518 ± 0.246) and lowest in Clarias specie (0.454 ± 0.256). There were no significant differences (p > 0.05) among the species (p < 0.05). These values were higher than the findings of a researcher [22] (0.117 to 1.63 ppm) who compared the heavy metal contamination of *Clarias gariepinus* from a lake with that from a fish farm in Ibadan, Nigeria.

3.2. Heavy Metal Concentrations in Fish Body Parts

Table 2 shows the Pb, Cu and Zn concentration in the gills, viscera and muscle. The accumulation (ppm) of lead in the body parts ranged from 0.026 ± 0.044 in the gills to 0.030 ± 0.048 in the muscle. There was no significant difference (p > 0.05) in the accumulation of lead in the body parts. The value obtained for the gills in this research work is similar to the values obtained by a previous researcher [18] whose values ranged from 0.01 ± 0.00 in the gills of *Clarias gariepinus* to 0.25 ± 0.20 in the gills of *Hydrocynus forskahlii*.

Table 2. Heavy metal accumulation in the body parts

Parts of fish	Heavy Metal Concentration (ppm)		
	Pb	Cu	Zn
Gills	$0.026^a \pm 0.044$	$0.035^b \pm 0.039$	$0.590^a \pm 0.209$
Viscera	$0.029^a \pm 0.051$	$0.084^a \pm 0.114$	$0.567^a \pm 0.291$
Muscle	$0.030^a \pm 0.048$	$0.011^b \pm 0.013$	$0.329^b \pm 0.188$

Note: Values are means ± standard deviation of triplicate readings. Means with same superscript along the same column are statistically similar (p > 0.05).

The values obtained in the three body parts were also similar to the findings of a researcher [23] who obtained 0.01-0.06 in fish species from Azuabie creek in Bonny estuary. These findings were lower when compared with the findings of another researcher [24] (0.395 – 0.62 ppm) and a researcher [25] (9 ppm) who researched on lead in some fishes from Lagos Lagoon. A researcher [26] obtained values that ranged from 0.73 to 4.12 ppm in *C. gariepinus* from Ogun state Nigeria. Another researcher [27] also had the values that ranged from 0.10 to 0.83 ppm in some fishes from Ogba river. Also a researcher [28] obtained values of 2.67 to 3.53 ppm in *Mormyrops delicisus* and *Mormyrus macrophthalmus* from Ikpoba river dam. However, the data from this research work were lower than the standard permissible limit for lead (< 2 ppm) in fish food [20].

Copper mean concentration value (ppm) for the three body parts ranged from 0.011 ± 0.013 ppm in the muscle to 0.084 ± 0.114 ppm in the viscera. There were significant differences between the gills and the viscera (p < 0.05) but there was no significant difference (p > 0.05) between the gill and the muscle parts. The values obtained in this research work were similar to the findings of a researcher [22] who obtained a Cu concentration of 0.0125 (ppm) and 0.0072 (ppm) in the gills during the rainy and dry seasons respectively, 0.16 ppm in the intestine for both seasons as well as 0.05 and 0.07 (ppm) in the muscle for rainy and dry seasons, respectively.

3.3. Comparism of Heavy Metal Concentration in Fish Species According to Fish Species and Body Parts.

Table 3 compared the relationship between the species and the body part on the accumulation of the metals of interest. The range for Pb concentration was from 0.019 ± 0.037 in the viscera of Clarias species to 0.047 ± 0.071 in the viscera of Tilapia species. There was no significant difference in lead accumulation (p > 0.05). Cu concentration ranged from 0.010±0.013 in the muscle of Channa species to 0.156 ± 0.169 in the viscera of Tilapia species. There was a significant difference in the accumulation of copper in the fish species (p < 0.05).

Table 3. Lead, Copper and Zinc Contents of the Different Body Parts and of the Three Species of Fish

Species	Body parts	Pb (ppm)	Cu (ppm)	Zn (ppm)
	Gills	$0.024^a \pm 0.048$	$0.034^b \pm 0.02$	$0.545^a \pm 0.195$
Clarias	Viscera	$0.019^a \pm 0.037$	$0.052^b \pm 0.05$	$0.501^{ab} \pm 0.306$
	Muscle	$0.033^a \pm 0.052$	$0.012^b \pm 0.016$	$0.316^b \pm 0.207$
	Gills	$0.022^a \pm 0.04$	$0.037^b \pm 0.06$	$0.634^a \pm 0.230$
Channa	Viscera	$0.020^a \pm 0.036$	$0.045^b \pm 0.029$	$0.596^a \pm 0.218$
	Muscle	$0.028^a \pm 0.047$	$0.010^b \pm 0.013$	$0.324^b \pm 0.168$
	Gills	$0.032^a \pm 0.046$	$0.035^b \pm 0.027$	$0.592^a \pm 0.205$
Tilapia	Viscera	$0.047^a \pm 0.071$	$0.156^a \pm 0.169$	$0.603^a \pm 0.345$
	Muscle	$0.029^a \pm 0.048$	$0.010^b \pm 0.01$	$0.346^b \pm 0.198$

Note: Values are means ± standard deviation of triplicate readings. Means with same superscript in the same column are statistically similar (p > 0.05).

Zn concentration ranged from 0.316 ± 0.207 in the muscle of Clarias species to 0.634 ± 0.230 in the gills of Channa species. There was a significant (p < 0.05) difference. The lowest level of accumulation was found in Clarias species while the highest level of accumulation was found in Tilapia species. These differences in level of accumulation could be linked to the fact that organisms of various species have different metabolic rates. This is in line with the report of a researcher [21] that Tilapia species accumulated more metals than the other species. Another researcher [29] reported that different organisms have different metabolic rates and different food requirements. Organisms that tend to consume more food materials are likely to accumulate more metals. The trend for accumulation of metals in the specie was Clarias<Channa<Tilapia. The trend for accumulation in the body part was Muscle<Gill<Viscera.

4. Conclusion

This study shows that the concentrations of Zinc, Copper and Lead in the gills, muscles and viscera parts of *Clarias gariepinus*, *Channa obscura* and *Tilapia zilli* from Uwana river in Afikpo North Local Government were below the maximum safe limits set by WHO and FEPA. Thus, the quarrying and mining sites close to the rivers did not influence the heavy metal concentrations of the rivers and the three fish species studied in the water bodies.

Conflict of Interest

The authors hereby declare that there is no conflict of interest.

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