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Assessment of Heavy Metals in Fish Tissues of Some Fish Species in Oguta Lake, South-Eastern Nigeria

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Abstract
The study was carried out in Oguta Lake from January, 2012 to December, 2013 at five different stations (Onu Utu, Okposha, Ogbe Hausa, Osemotor and Ede Ngwugwu) to study the concentration of heavy metals in fish tissues (muscle, gonads, liver, gill and kidney). Fish samples were collected twice monthly using hook and line, gill net, cast net, bag net and local fish traps. A total of 180 fishes were used. The levels of heavy metals Copper (Cu), Lead (Pb), Cadmium (Cd), Arsenic (As) were determined in three common edible fish species these include *Tilapia zillii, Citharinus citharus* and *Heterotis niloticus* by air-acetylene flame Atomic Absorption Spectrophotometer. The mean values of the heavy metals in fish tissues were found to be 0.67 µg, 0.58 µg, 0.64 µg and 0.21 µg for Cu, Pb, and Cd and As, respectively. From the result mean concentration of Arsenic range thus; *Citharinus* citharus>*Heterotis niloticus*>*Tilapia zillii*, Copper-*Heterotis niloticus*>*Tilapia zillii*>*Citharinus citharus*, Lead-*Tilapia zillii*>*Heterotis niloticus*>*Citharinus citharus*, Cadmium- *Heterotis niloticus*> *Tilapia zillii*> *Citharinus citharus*. The results obtained showed that the values of all the heavy metals in the fish samples were lower than the values recommended by W.H.O and the Food and Agricultural Organization of the United Nations suggesting that the fishes found in the Lake could be suitable for human consumption.

Keywords: Heavy metals, atomic absorption, spectrophotometer

1.0. Introduction

Heavy metals are natural trace components of the aquatic environment, but their levels have increased due to industrial wastes, geochemical structure, agricultural and mining activities (Singh, Chavan & Sapkale. (2006); Sprocati, Alisi, Segre, Tasso, Galletti & Cremisini (2006). These sources of pollution affect the physiochemical characteristics of the water, sediment and biological components, and thus the quality and quantity of fish stocks (Al-Rawi 2005; Mantovani, Pigozzi & Bittante 2005; Singh, Chavan & Sapkale 2006). Heavy metals like copper, iron and zinc are essential for fish metabolism while some others such as mercury, cadmium, arsenic and lead have no known role in biological systems (Sallam Kh, El-Sebaey & Morshdy 1999; Schmitt, Hinck, Blazer, Denslow, Dethloff & Coyle 2005; Has-Schon, Bogut, Kralik, Bogut, Harvatic & Cacic 2007). The term heavy metal refers to any metallic element which is relatively of high density and toxic or poisonous even at low concentration (Lenntech, 2004). Bio-concentration is the net accumulation of a substance from water into an aquatic organism resulting from the simultaneous uptake and elimination of the substance. The consequence of heavy metal pollution is not only a threat to fish and other aquatic lives but also of significant health risk to consumers (Yi, Yanh & Zhang 2011). Once these metals enter the environment their potential toxicity is determined by the form of existence (Nwaedozie, 1998). Fish is the most susceptible of the aquatic fauna to these metals, it is cheap, easy to get and it is consumed in different forms such as boiling, frying in deep oil, smoking, sun drying amongst others (Nriagu, 1988). Fish is one of the reliable indicative factors in freshwater systems and accumulation levels in fish can be used for estimation of trace metal pollution (Kalyoncu, Kalyoncu & Arslan 2012). Heavy metals cause the mutation of fish inner organs, disturb immune reactions, change blood parameters, reduce an organism's adaptation qualities, vitality, resistance to diseases, loss of fry and degeneration and diminution of valuable varieties of fish are observed as a result of heavy metal pollution (De Burbure, Buchet, Leroyer, Nisse, Haguenoer, Mutti & Smerhovsky 2006). Usually, many toxic compounds affect organisms in nature at the same time, each of them having a specific effect on physical and chemical processes that influence an organism's condition and reactions therefore, in order to maintain the quality of food, it is important to regularly monitor and evaluate the pollution levels in fish as well as in water bodies. Reports on the effects of distribution and accumulation of some trace metals at different levels in the various tissues of fish and water bodies are well documented (Pulatsu and topcu 2015; Javed and Usmani 2014).

Recent studies have shown for instance that human activities have created ecological pressure on the natural habitat of fish and other aquatic organisms over time in the study area. There has been a steady increase in discharges that reaches the aquatic environment from industries and oil wells (Atta, Els-sebale, Naoman & Kassab 1997). All these sources of pollution affect the physiochemical characteristics of the water, sediment and biological components, and thus the quality and quantity of fish stocks (Al-Rawi, 2005; Mantovani, *et al.,* 2005; Singh, *et al.,* 2006). The environment more than before is receiving vigorous attention due to the recognition of the damaging effects of intense human activities on the ecosystem and this necessitated the study area. *Tilapia zillii, Citharinus citharus* and *Heterotis niloticus* are freshwater fishes that are of great commercial importance and in abundance in the study area. The study was therefore designed to determine the concentration of Copper, Lead, Cadmium and Arsenic in tissues of the fish species and to assess the potential risks that may be associated with consuming fishes obtained from Oguta Lake.

2.0. Materials and Methods

2.1. Study Area

Oguta Lake is the largest natural lake in Imo State and originated from a natural depression. Oguta is bounded between longitude 6° 41' – 6°50' East and latitude 5°41' – 5°44' North of the equator. Oguta land mass is approximately 2,025.75 km^2 (Nwadiaro, 1989). This region is located within the equatorial rain forest belt with an average annual rainfall of 3,100 mm. Oguta is bounded on the north by Ogwu-Aniocha in Anambra State. It shares its north eastern border with Egbuoma, Mgbidi and Egwe in Imo State. On the south to the eastern flank, Oguta is limited at approximately latitudes 5^{0}38' to 5^{0}39' north, western and south eastern boundaries of Oguta are defined by the Niger, from upstream of Okpai to beyond Abo, Kwale and Umuoru (River Niger) (Nwadiaro, 1989). Four rivers are associated with the

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Lake; (Figure 1) two of the rivers (Njaba and Awbana) flow into the Lake while the third (Orashi) flows by the Lake at its south eastern end and the fourth (Utu) flows into the Lake only during the rainy season (Nwadiaro, 1989).

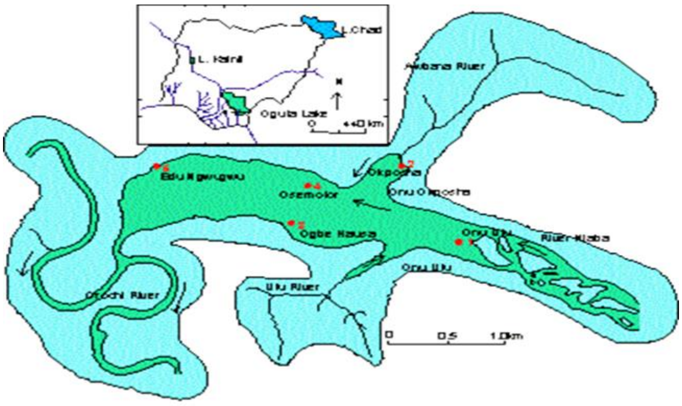

Figure 1: Sketch map of Oguta Lake showing the sampling stations.

Five sites along the main course of the lake were chosen as the sampling stations. The description of the stations is as follows; station 1 represent Onu Utu which cover up to Ossai Uhamiri very close to Njeaba River. Station 2 represents Onu Okposha where Awbana River flows into the Lake. Ogbe Hausa is station 3 which extend to Eze Ogwe and is near the Utu River. Station 4 is Osemotor, while station 5 is the Ede Ngwugwu, which extends to Agbata Uhamiri near Orashi at the confluence, where the two water bodies show distinct colours differentiating Oguta Lake from Orashi River. These sites are accessible throughout the year.

2.2. Fish sampling and Analysis

Three commonly available fish species (*Tilapia zillii, Citharinus citharus* and *Heterotis niloticus)* of commercial importance were caught from the five stations through the services of a hired fisherman. Samples were collected bi-monthly from January 2012 to December 2013. A total of 180 fishes were collected, 15 fishes from each station. The fish samples were kept in the ice pack from sampling stations and later stored in the refrigerator (-4°C) before analysis. The fish samples were allowed to defrost wash and dissected then 2g tissue of each of the fish samples were digested separately using 25 ml of 1:1 concentrated Nitric acid (HNO_3) and Hydrogen peroxide (H_2O_2) ratio at 105°C respectively, in a fume cupboard. The digested samples were diluted to 50 ml with distilled water and analysed using Atomic Absorption Spectrophotometer (AAS) (Buck scientific 200A) (FAO 2004). The heavy metals concentration of the edible liver, gill, kidney, muscle and gonads tissues of *Citharinus citharus, Tillapia zilli and Heterotis niloticus* were carried out twice during the study and presented in µg/g of the wet weight.

2.3. Statistical analysis

Statistical Package for Social Science (SPSS) version 20.0 (SPSS Inc. Chicago, IL, USA) and data were subjected to one–way analysis of variance (ANOVA) to assess the differences in fish, tissues and stations. The results were expressed as mean ± standard error.

3.0. Results

The mean concentration of heavy metals in fish muscle is shown in Table 1, Arsenic (As) had the highest mean concentration value of 0.67 µg/g, Copper (Cu) had a mean concentration value of 0.58 µg/g while Cadmium (Cd) and Lead (Pb) had mean concentrations of 0.58 and 0.21µg/g respectively. Table 2 shows the mean concentration of heavy metals in fish gonads. Arsenic (As) had the lowest mean concentration value of -55.41 µg/g, Cadmium (Cd) had a mean concentration value of 3.74 µg/g while Copper (Cu) and Lead (Pb) had mean concentrations of 2.28 and 0.78 µg/g respectively. The mean concentration of heavy metals in fish liver is shown in the Table 3, Arsenic (As) had the lowest mean concentration value of -19.88 µg/g, Copper (Cu) had the highest mean concentration value of 8.77 µg/g while Cadmium (Cd) and Lead (Pb) had mean concentrations of 1.79 and 1.05 µg/g respectively. Table 4, shows the mean concentration of heavy metals in fish gill, Arsenic (As) had the lowest mean concentration value of -4.29 µg/g, Cadmium (Cd) had the highest mean concentration value of 0.72 µg/g while Copper (Cu) and Lead (Pb) had mean concentrations of 0.71 and 0.45 µg/g respectively. The results revealed that Arsenic had the lowest value among all the tissues in *Tilapia zillii* and was very low in the gonads and kidney but was high in the liver (muscle>gill>liver>kidney> gonad). Data on heavy metal concentration in the gill, kidney, muscle, liver and gonad of *H. niloticus, C. citharus* and *T. zillii* showed that heavy metals were accumulated in the different organs as follows; Gill- Cd>Cu>Pb>As, Kidney- As>Pb>Cu>Cd, Muscle- As>Cu>Cd>Pb, Liver- Cu>Cd>Pb>As, Gonad- Cd>Cu>Pb>As; while the accumulation in the different fish species showed the following; in *H. niloticus,* As>Cu>Cd>Pb, *C. citharus,* As>Pb>Cu>Cd and *T. zillii*, Pb>Cd>Cu>As.

Table 1: The Mean Concentration of Heavy Metals in Fish Muscle in the stations

Fish species	Family	Concentration of trace elements (µg/g dry weight)			
		As	**Cd**	**Cu**	**Pb**
Tilapia zilli	Cichlidae	5.43	0.80	1.06	0.28
Citharinus citharus	Citharinidae	1.68	0.73	0.33	-0.05
Heterotis niloticus	Arapaimidae	-5.10	0.22	0.53	0.39
Mean values		**0.67**	**0.58**	**0.64**	**0.21**
Standard Deviation		**0.3372**	**0.3166**	**0.3772**	**0.2290**
FAO*/WHO guideline**		**1.4****	**0.5***	**10**/30***	**4****

Cu> Copper, Pb> Lead, Cd> Cadmium, As> Arsenic

4.0. Discussion

The Australian National Health and Medical Research Council (ANHMRC) acceptable level for Cd in fishes is 2.0ppm. Abdulrahman and Tsafe (2004) reported 0.013 ppm of Cd in in their study of Sokoto Rima River in Nigeria reported Cd concentration of mean value 0.013ppm in *Synodontis clarias* found in Rima River in Sokoto, Nigeria. Also Ibok *et al.* (1989) documented 0.45 ppm of Cd in *A. fasciatus* in streams located at Ikot Ekpene in Nigeria. The result of this study indicates that Cd found in *H. niloticus* from Oguta Lake was above the ANHMRC standard while *C. citharus* and *T. zillii* were below ANHMRC standards. This could be from fertilizers used in the farming activities along the bank of the lake. Currie (1986) and Trueman (1965) observed that some sources of phosphate in fertilizers contain cadmium up to 100mg/kg which could be washed into the lake through soil erosion. Cadmium shows no indication of being an essential element in biological processes; instead it is known to be toxic (Gupta *et al.* 2009). It causes slight anaemia due to reaction between iron and Cd in the body resulting to iron deficiency (Lauwerys 1979).

Table 2: The Mean Concentration of Heavy Metals in Fish Gonads in the stations

Fish species	Family	Concentration of trace elements (µg/g dry weight)			
		As	Cd	Cu	Pb
Tilapia zilli	Cichlidae	-46.09	2.25	1.03	0.17
Citharinus citharus	Citharinidae	-150.41	1.94	2.07	0.77
Heterotis niloticus	Arapaimidae	30.26	7.02	3.73	1.41
Mean values		**-55.41**	**3.74**	**2.28**	**0.78**
Standard Deviation		**0.6951**	**2.8477**	**1.3618**	**0.6201**
FAO*/WHO guideline**		**1.4****	**0.5***	**10**/30***	**4****

Cd> Cadmium, Cu> Copper, Pb> Lead, As> Arsenic

Table 3: The Mean Concentration of Heavy Metals in Fish Liver in the stations

Fish species	Family	Concentration of trace elements (µg/g dry weight)			
		As	Cd	Cu	Pb
Tilapia zilli	Cichlidae	-7.37	0.38	0.35	0.49
Citharinus citharus	Citharinidae	-18.17	0.91	1.67	2.02
Heterotis niloticus	Arapaimidae	-34.09	4.08	24.28	0.65
Mean values		**-19.88**	**1.79**	**8.77**	**1.05**
Standard Deviation		**13.4415**	**2.0008**	**13.4511**	**0.8410**
FAO*/WHO guideline**		**1.4****	**0.5***	**10**/30***	**4****

Cu> Copper, Cd> Cadmium, Pb> Lead, As> Arsenic

Table 4: The Mean Concentration of Heavy Metals in Fish Gill in the stations

Fish species	Family	Concentration of trace elements (µg/g dry weight)			
		As	Cd	Cu	Pb
Tilapia zilli	Cichlidae	-4.96	0.91	0.66	1.19
Citharinus citharus	Citharinidae	-8.84	1.56	0.88	-0.42
Heterotis niloticus	Arapaimidae	0.92	-0.30	0.60	0.58
Mean values		**-4.29**	**0.72**	**0.71**	**0.45**
Standard Deviation		**0.9140**	**0.9439**	**0.1474**	**0.8128**
FAO*/WHO guideline**		**1.4****	**0.5***	**10**/30***	**4****

Cd> Cadmium, Cu> Copper, Pb> Lead, As> Arsenic

Table 5: The Mean Concentration of Heavy Metals in Fish Kidney in the stations

Fish species	Family	Concentration of trace elements (µg/g dry weight) As	Cd	Cu	Pb
Tilapia zilli	Cichlidae	-29.65	3.59	3.57	6.54
Citharinus citharus	Citharinidae	92.57	3.56	3.56	6.08
Heterotis niloticus	Arapaimidae	-7.97	2.91	3.85	4.22
Mean values		**18.32**	**3.35**	**3.66**	**5.61**
Standard Deviation		**5.2125**	**0.3842**	**0.1646**	**1.2284**
FAO*/WHO guideline**		**1.4****	**0.5***	**10**/30***	**4****

Cd> Cadmium, Cu> Copper, Pb> Lead, As> Arsenic

Heavy metals are easily absorbed by aquatic life forms and accumulation may occur in higher concentration than in parent water bodies (Deb and Santra 1997; Omoregie 2002). Fish can take up heavy metals either in their diets or through their gills (Dallinger *et al.* 1987) and bio- accumulate them at different rates in their muscles and organs (Philips and Rainbow 1994). According to Rainbow *et al*. (1980), the rate of accumulation and the ability of the fish to detoxify particular metals differ greatly. This may account for the variation in the concentration of heavy metals found in the different species of fish investigated in this study. The result of this study showed that all the fish samples were contaminated with copper. The present of copper in all the samples could be attributed to various activities within the lake and the contributing river e.g. Awbana, Orashi where road construction, effluent from the zinc manufacturing company are wash in the Nyaba River which flows in the Orashi. Copper could also enter the lake through natural processes such as wind blow dust, decay of vegetation and forest file. It could also be from municipal effluents due to corrosion copper plumbing. *Tilapia zillii* had copper concentration of mean value 6.67ppm, while *Citharinus citharus* and *Heterotis niloticus* had copper concentrations of mean values 1.70 and 6.54 ppm, respectively. Okoye *et al*. (2002) working on Warri River in Nigeria reported Copper mean value of 2.02 ppm in aquatic organisms. Alinnor (2005) also reported Copper concentration mean value of 0.229 ppm in *Oreochronis niloticus* from Aba River. The level of Copper in the fish species from Oguta Lake is low as compared to the Australian National Health and Medical Research Council (ANHMRC) permissible limit for Copper in seafood of 30.0 ppm. The mean concentrations of heavy metals in the Gonad of the three species of fish studied were found to be higher than other tissues analysed.

Lead is classified as one of the most toxic heavy metals. The lowest mean concentration of 0.21±0.23 mg/kg was measured in the muscle while the highest mean concentration of 1.05±0.84 mg/kg was measured in the liver. The highest concentration, 1.05±0.84mg/kg measured in the liver was however, above FAO (1983) guideline of 0.5 mg/kg. Lead causes renal failure and liver damage in humans. This result was lower compare to the findings of Doherty *et al.* (2010) (0.395 – 0.62ppm) and Okoye *et al.* (1991) (9ppm) of lead from some fishes in Lagos Lagoon. Farombi *et al. (*2007) reported 0.73 - 4.12ppm in *C. gariepinus* from Ogun River, Obasohan *et al. (*2006) obtained 0.10 – 0.83ppm in some fishes from Ogba river and Oronsaye *et al.* (2010) (3.53ppm and 2.67ppm) in *Mormyrops delicisus* and *Mormyrus macrophthalmus* from Ikpoba river dam.

The accumulation and bio-magnification depend upon available heavy metal concentration in water, food, organisms and sediments (Lloyd 1992). Ecological and human risk assessments assume that evaluation is based on exposure of representative of important components of the investigated ecosystem (Dusek, *et al.* 2005). The levels of metals measured in aquatic organisms are the net results of accumulation, metabolism, storage and elimination processes. This observation is supported by Burger, *et al*. (2002) and Dusek, *et al.* (2005) who reported that fish species accumulate heavy metals relative to their position in the food web. Regardless of the physiological and environmental conditions, which regulate metal content within an organism, it is often visualized that metal ions are moving along the food chain from prey to predator with concentrations either decreasing or increasing in the organism's tissue at each successive trophic level (Hossain and Ahmed 2008).

5.0. Conclusion

The different levels of some metals in the fish samples suggested that the fish were capable of absorbing the metals in their bodies from the aquatic environment. The difference noticed in the levels of accumulation in different organs of a fish could be attributed to the differences in their physiological roles toward maintaining homeostasis, feeding habits, regulatory ability and behaviour of each fish. The levels of heavy metals found in this study did not exceed the limits set by World Health Organization (WHO) and Food and Agriculture Organization (FAO) thereby making the fishes wholesome for human consumption. There is need for further extensive study and particularly the accumulation of heavy metals in sediment, the lake water and humans, because elevated levels of these heavy metals in the aquatic environments may adversely affect the fish population and other organisms. In view of the importance of fish to diet of man, it is necessary for continuous monitoring of these water bodies in order to ensure that the measures put in place to reduce the heavy metals concentrations in the fishes in Oguta Lake is actually maintain. There is need for stakeholders to be watchful of autogenic and anthropogenic threats, activities and harmful practices which may cause the extinction of fish species in the Oguta Lake and the effects of this extinction and the ways by which it could be prevented. This is to protect the spawning stock of commercially valued species.

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