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The effects of heavy metals concentration on some commercial fish in Ogun River, Opeji, Ogun State, Nigeria

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A study was conducted on commercially important fish species of heavy metals in water bodies. The primary objectives were to find out the amount of heavy metals concentration in the fish species, sediments and water samples at the deep and shallow part of the river, to determine the toxicity and relationship between the collected samples and the rate at which it pollutes the water. Atomic absorption spectrophotometer (AAS) evaluates their wholesomeness for human consumption. Four heavy metals (lead, cadmium, copper and zinc) were analyzed and only copper and zinc were found to be present in the digested samples. The concentration of copper in the fish (flesh) was 0.09 mg/l and that of zinc was 0.25 mg/l. In the bone samples, copper was found to have 0.17 mg/l and zinc 0.22 mg/l. In the water samples analyzed, the concentration of copper is 0.035 mg/l while that of zinc is 0.047 mg/l. In the sediment sample, the amount of copper is 310.0 mg/kg while that of zinc is 2050.0 mg/kg. This however signifies that the fish species in the Ogun River as well as the water is suitable for consumption which was found to be less than the World Health Organization (WHO) maximum recommended acceptable limits in the food.

Key words: Heavy metals, fish species, water samples, toxicity.

INTRODUCTION

Metals are solids materials that are opaque, lustrous elements that are good conductors of heat and electricity. A study by Skeat (2005) showed that the heavy metals are members of a loosely defined subset of elements that exhibit metallic properties which include solubility in water, non- degradability and strongly attachment of polypeptides and protein. Over seventy five percent (75%) of everything on the planet Earth are directly or indirectly associated with metals. The recent activities of nature and that of human beings on most water bodies

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have led to a mass deposition of these minerals called metals.

Heavy metals occur naturally in the ecosystem with large variations in concentrations. Most metals in the streams and rivers come from industrial, municipal and urban run-offs which can be harmful to life (Tolcin, 2011). Increased urbanization of industrialization could be the cause for an increased level of trace metals, especially the heavy metals in our waterways (Njar and Al-Doush, 2012). The presence of toxic materials in ecosystems is presently related with increased concentrations of heavy metals ions, which enter water sources with sewage waters.

In recent years, world consumption of fish has increased simultaneously with the growing concern of their nutritional and therapeutic benefits. In addition to its important source of protein, fish typically have rich contents of essential minerals, vitamins and unsaturated fatty acids (Medeiros et al., 2012). The American Heart Association recommended eating fish at least twice per week in order to reach the daily intake of omega-3 fatty acids (Kris-Etherton et al., 2002).

However, fish are relatively situated at the top of the aquatic food chain; therefore, they can accumulate heavy metals from food, water and sediments (Yilmaz et al., 2007; Zhao et al., 2012). The content of toxic heavy metals in fish can counteract their beneficial effects; several adverse effects of heavy metals to human health have been known for long time (Castro-Gonzalez et al., 2008). This may include serious threats like renal failure, liver damage, cardiovascular diseases and even death (Al-Busaidi et al. 2011; Rahman et al., 2012). Therefore, many international monitoring programs have been established in order to assess the quality of fish for human consumption and to monitor the health of the aquatic ecosystem (Meche et al., 2010).

Heavy metals have various levels of toxicity as the surrounding environment affects it through certain factors. Even when it comes to fish, the toxicity of these heavy metals (lead, mercury, copper and zinc) plays certain roles that may even be hazardous. Sometimes, these heavy metals combine with soil organic matter and clay (WHO, 2007). As a result of drinking water and eating fish contaminated with heavy metals, diseases occur due to the bioaccumulation of these heavy metals in the body system of human being, thus leading to serious health problems and eventual death. Also, a lot of these metals are carcinogens and cannot be destroyed by heat.

Studies have been done to detect the presence of the heavy metal pollutants in water bodies in Nigeria (Olaifa et al., 2004; Omoregie et al., 2002; Oguzie, 2000). Ogun River with its tributaries is the main river that traverses the length and breadth of Opeji and Abeokuta metropolis in Ogun State where it serves as the source of domestic, agricultural and water consumption. It is the major source of freshwater fish for the inhabitants of Opeji, and is highly exploited by artisanal fishermen. It is also the final drain discharge for all waste-water from domestic and agricultural source within and around Opeji and environs.

The problem facing any living organisms will be related to measurable chemical or biological parameters such as a flow rate turbulence, inter and intra- specific competition, feeding behavior, disease, parasitism, commensalism and symbiosis. This work is evidence to ascertain the metallic concentration in most fish species at the River Ogun (Opeji). Some of these elements are actually necessary for humans in minutes or lower amounts (cobalt, copper, chromium, manganese, nickel) while others are carcinogenic or very toxic, affecting among others, the central nervous system (mercury, lead, cadmium, copper). In view of the strategic and important role of Ogun River to Opeji people and environs as a source of freshwater fisheries for the inhabitants, hence this study determine the amount of heavy metals (lead, cadmium, copper and zinc) concentration in the body parts of some commercial fish species, the water environment and the sediments (soil) samples of the River Ogun (Opeji village) and to evaluate the toxicity and relationship between the heavy metals concentration in the fish, water and sediments (soil).

MATERIALS AND METHODS

Description of the study area

Lower Ogun River is located in Abeokuta North Local Government of Ogun state. It lies between Longitude 3° 28ˈE to 3° 40ˈE and Latitude 7° 14ˈN to 7° 20ˈN of Abeokuta (Ogun State Bureau of Lands and Survey).

The study was carried out at lower Ogun River, Akomoje in Abeokuta, Ogun State. The river is located in Abeokuta North Local Government of Ogun State and lies between longitude 3°21'S and latitude 7°21'E North of Abeokuta with a size of 1000 hectares. Ogun River (Figure 1) as a perennial river in Nigeria has a coordinate of 3°28'E and 8°41'N from its source in Oyo State to 3°25'E and 6°35'N in Lagos State where it enters Lagos Lagoon. The dry season lasts from November to March while the wet season lasts from April to October. The annual rainfall ranges from 900 mm in the North of the River to 200 mm towards the South. Total annual potential evapotranspiration is 1600 and 190 mm. The Ogun River catchment is located in South West Nigeria, bordered geographically by latitude 6°26'N and 9°10'N and longitude 2°28'E and 4°4'E. The land is about 230 km^2. The relief is generally low, with the gradient in the North-south direction. The water source is from the Igaran hills at an elevation of about 540 m above the sea level and flows directly southward over a distance of 480 km before it discharge into the Lagos Lagoon. The major tributaries of the river are Ofiki and Opeki River.

Collection of samples

The study was carried out for 10 weeks between January and March 2011 by collecting water samples once in a month. The Fish samples and water parameters were determined according to APHA (1985) and Adeosun et al. (2011).

Fish samples were collected from Ogun River, Opeji village three times a week. The samples were collected for 10 weeks. Samples

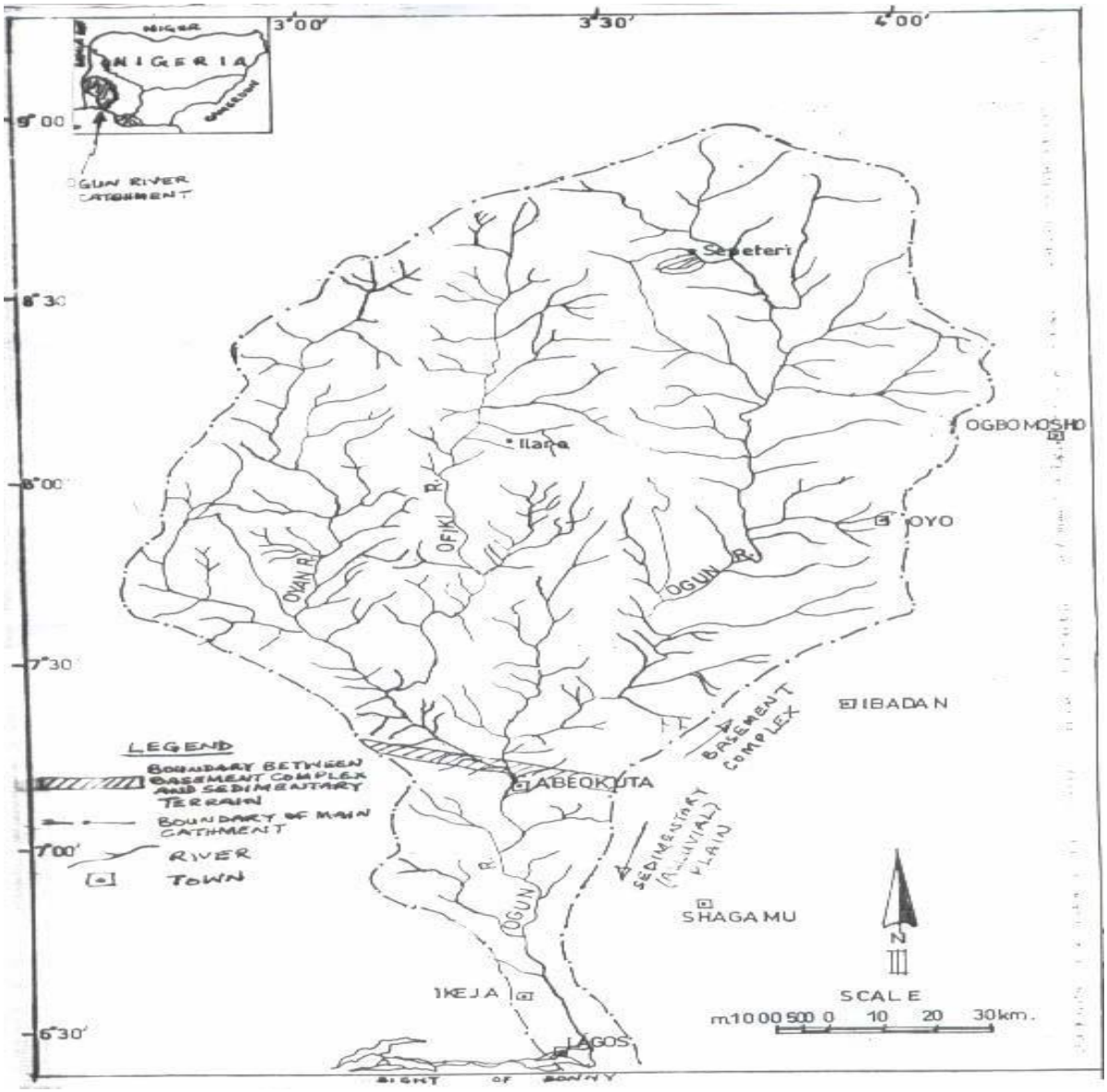

Figure 1. A map showing River Ogun.

of fish species were taken with the use of set gill nets and cast nets of three different mesh sizes of 1, 2 and 4 mm. Soil and water samples were collected from the deep and shallow parts of the water.

Ten (10) different fish species were harvested and brought to the laboratory and dissected with clean stainless steel instruments over a ten week period. One gram of each wet fresh tissue of fish, water sample and soil samples were weighed out and digested. The digests were allowed to cool, filtered, transferred to 100 ml volumetric flasks and made up to mark with 1% nitric acid (FAO, 1983). The digests were kept in plastic bottles and later, the heavy metal concentrations were determined using an atomic absorption spectrophotometer (AAS). This analysis were validated by diluting the salt solutions of the metals in various concentrations of 0.2, 0.4, 0.6, 0.8 and 1.0 ppm to enable the spectrophotometer to measure the metals from the samples of fish, water and soil. The following formula is used to calculate the concentration of heavy metals in the samples:

$$\mu/g = \frac{ppm \times v}{W \times 10^3}$$

Where ppm is mg/l (AAS reading), v is the volume of the digested sample and W is the weight of the sample used for digestion. The four different metals analyzed were lead (Pb), cadmium (Cd), copper (Cu) and zinc (Zn). The amounts of heavy metals concentration in the samples were then measured and recorded.

RESULTS

Table 1 shows that lead and cadmium are absent in the samples of fish while copper and zinc appear to be present in the flesh of the samples. From the result, it was observed that the average concentration of copper is

Table 1. Concentration of heavy metals in the flesh (tissue) of fish species.

Species	Pb (mg/l)	Cd (mg/l)	Cu (mg/l)	Zn (mg/l)
Hepsetus odoe	0.000	0.000	0.025	0.104
Chrysichthys nigrodigitatus	0.000	0.000	0.000	0.563
Tilapia mariae	0.000	0.000	0.020	0.145
Malapterurus electricus	0.000	0.000	0.069	0.340
Heterobranchus bidorsalis	0.000	0.000	0.054	0.203
Parachanna obscura	0.000	0.000	0.030	0.145
Tilapia zilli	0.000	0.000	0.045	0.202
Brycinus nurse	0.000	0.000	0.593	0.126
Heterotis niloticus	0.000	0.000	0.000	0.103
Oreochromis niloticus	0.000	0.000	0.015	0.520

Source: Field survey.

Table 2. Concentration of heavy metals in the bone of fish species.

Species	Pb (mg/l)	Cd (mg/l)	Cu (mg/l)	Zn (mg/l)
Hepsetus odoe	0.000	0.000	0.068	0.232
Chrysichthys nigrodigitatus	0.000	0.000	0.022	0.168
Tilapia mariae	0.000	0.000	0.058	0.271
Malapterurus electricus	0.000	0.000	0.058	0.100
Heterobranchus bidorsalis	0.000	0.000	0.031	0.249
Parachanna obscura	0.000	0.000	1.058	0.607
Tilapia zilli	0.000	0.000	0.054	0.213
Brycinus nurse	0.000	0.000	0.272	0.128
Heterotis niloticus	0.000	0.000	0.117	0.111
Oreochromis niloticus	0.000	0.000	0.000	0.129

Source: Field survey.

Table 3. Analysis of variance of heavy metals concentrations in the flesh and bone of the fish samples.

Source	Df	Sum of squares	Variance	F	F5%
Factors (flesh and bone)	1	0.336	0.336	7.23*	2.320
Treatment (metals)	3	2.960	0.987	21.44**	
Interaction (metals x factors)	3	2.624	0.875		
Residual (error)	57	1.973	0.035		
Total	64	7.893			

Lead (Pb) and cadmium (Cd) are absent because they were not observed.

found to be the highest in the flesh of *Brycinus nurse* amounting to 0.593 mg/l and is very minute or rather absent in the flesh of *Chrysichthys nigrodigitatus* while the average concentration of zinc was also found to be highest in the flesh of *Chrysichthys* spp. with an amount of 0.563 mg/l and lowest in the flesh of *Hepsetus odoe* containing about 0.104 mg/l.

In Table 2, lead and cadmium are absent as well while copper and zinc were observed to be present. The average concentration of copper is found to be highest in bone of *Parachanna obscura* with an amount of 1.058 mg/l and lowest or perhaps absent in the bone of *Oreochromis niloticus* while for zinc, it was observed to be highest in the bone of *P. obscura* having an amount of 0.607 mg/l and found to be lowest in the bone of *Malapterurus electricus* with an amount of 0.100 mg/l

Table 3 shows that at 50% significant level, it is clear that the interaction effect is significant. This effect was

Table 4. Distribution of average concentration of heavy metals in the flesh and bone of the fish species samples

	Flesh		Bone	
Treatment	Cu	Zn	Cu	Zn
Metals (mg/l)	0.09	0.25	0.17	0.22
95% CI	0.09±0.05	0.25 ± 0.05	0.17 ± 0.05	0.22 ± 0.05

95% CI means 95% confidence interval.

used to find out the average concentration of heavy metals in the fish samples (flesh and bone). From the analysis of the variance table, the independent effects of the factors and treatment are significant at the 5% level.

Table 4 shows that the average concentration of the metals in the flesh and bone of the ten fish species samples are 0.09, 0.25 and 0.17 and 0.22 mg/l, respectively. Also included are the confidence intervals of the average concentration of the metals in the flesh and bone of the fish samples.

DISCUSSION

The toxicity and accumulation of heavy metals in River Ogun (Opeji village) is very low and the villagers solely depend on it for their livelihood. The heavy metal concentration in the water body shows that it is within a safe limitation as it meets the recommended maximum acceptable limits of the World Health Organization (WHO, 2007).

The concentration of zinc was found to be the highest in the river followed by copper; this may be as a result of the fishing and agricultural activities and biological breakdown of rocks in the river (weathering). Based on the analysis ran on the concentration of heavy metals in the fish species, it should be a thing of note that the fishes at River Ogun (Opeji) are safe for consumption.

Due to the various activities such as dredging and clothes washing, the fish species in the River Ogun might go into extinction unless proper regulatory measures and action are taken by the state and federal government, the law makers of the country and IFSERAR (Institute of Food Security, Environmental Resources and Agricultural Research, FUNAAB) by passing out the information to the villagers, that their activities around the river can increase the concentration of heavy metals which can cause harmful effects on the fish species and the inhabitants when it exceeds the World Health Organization recommended maximum acceptable limits.

Conclusion

From the data presented, it can be concluded that the values of these heavy metals were found to be below the acceptable limit in fish food. However, these fish can be said to be wholesome for human consumption, there is need for caution as they have the potential to bio-concentrate some of these heavy metals in food chain over time.

Conflict of interest

The authors did not declare any conflict of interest.

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