

Heavy Metal Concentration in Gills and Bones of Tilapia (*Oreochromis niloticus*) from Jega River, Kebbi State, Nigeria

D. Y. Bawa, M. I. Ribah, I. S. Jega, V. O. Oyedepo

Abstract—A study was conducted to assess some heavy metal concentration (Cadmium (Cd), Copper (Cu), Iron (Fe), Lead (Pb) and Zinc (Zn)) in the gills and bones of *Oreochromis niloticus* obtained from Jega river. 30 fish samples were collected from March to July 2014 (fortnightly). Bones and gills were used for the assessment of some heavy metals using Atomic Absorption Spectrometer. Results indicated that Pb was not detected in both gills and bones but Fe, Cd, Zn and Cu were present in both the gills and bones of the fish samples. The concentrations of heavy metals in gills were; Fe 3.37±1.10, Cd 0.62±0.08, Zn 6.21±0.11 and Cu 1.28±0.10 mg/kg. The concentrations of heavy metals in bones: Fe 13.08±1.00 mg/kg, Cd 0.99±0.06 mg/kg, Zn 1.28±0.10 mg/kg and Cu 2.23±0.20 mg/kg. The results were found to be within the internationally acceptable standard limits. However, the consumption of small amounts of the identified heavy metals in fish could lead to gradual accumulation over a long period of time and exert toxic effects to consumers. Efforts should be made by the Government to provide appropriate channels for waste disposal to reduce impact on fish.

Keywords—Gills and bones, heavy metal concentration, Jega river, *Oreochromis niloticus*.

I. INTRODUCTION

PUBLIC health concern with regards to fish consumption is very vital since fish is a high source of protein, and according to [1], insufficiency of protein sources for the vast increased population in the developing countries led to fish farming gaining more popularity as an alternative source of cheap protein. However, in most of these countries, fish resources are often obtained in streams or rivers of mainly recycled water from agricultural activities, industrial wastes and even domestic sewage. These sources of recycled water could pose serious health challenges either to the fish raised in it, to the ecosystem or to humans consuming the fish as a result of emission and accumulation of heavy metals in the water and fish resources. Heavy metals, as reported by [2], include any metal exposure to which is clinically undesirable and which constitute a potential hazard to humans.

Heavy metals were reported to be natural components of the earth's crust that cannot be degraded or destroyed and are having density greater than 5 g/cm³ [3]. They are also referred

to as transition metals. Smaller amounts of these metals gain entrance into the bodies of human beings via food, air and drinking water. Though as trace elements, some of these heavy metals are essential in the body to maintain proper metabolism of the body, at high concentrations however, they can ultimately lead to poisoning.

It was reported by [4] that heavy metals pose a dangerous threat in an aquatic environment because of their potential toxicity and threat to the lives of animals and plants [4]. According to [5], fish living in polluted waters tend to accumulate heavy metals in their tissues depending on metal concentration, time of exposure, way of metal uptake, environmental conditions and intrinsic factors of fish. Various metals show different affinity to fish tissues and tend to accumulate predominantly in the liver, gills and kidney. However, compared to the other body tissues, fish muscles are usually low in levels of heavy metals [5]. Metal distribution in various organs is time-related. Fish accumulates heavy metals directly from water and diet, where residues may ultimately rise to concentrations that are hundreds or thousands times above those found in the water, sediment and food [6]. Heavy metals are reported by [7] to be usual constituents of marine environment, occurring as a result of pollution principally due to the discharge of untreated wastes into rivers by many industries and domestic activities. The contamination of the aquatic systems with heavy metals from natural anthropogenic sources has become a global problem which poses threats to ecosystems and natural communities [8].

The implication of the accumulation of heavy metals in gills and bones of fishes could be the consequent potential accumulation of heavy metals in human tissue and bio-magnification through food chain which could create both human health and environmental problems. Inorganic Pb is known to inhibit enzyme systems necessary for the formation of hemoglobin through its interactions with sulfhydryl groups known to cause brain damage leading to mental retardation, irritability and aggressive tendencies in children and young people. Some cases of acute anemia, headache, paralysis, renal and gastrointestinal disorders have been attributed to Pb poisoning.

In view of the potential health hazard that may be occasioned by fishing along rivers, it therefore become important to evaluate the concentrations of the heavy metals (Pb and Cd) in the gills and bones of fishes in Jega River to ascertain if the levels of the metals were within the limits allowable for humans.

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Several studies both from Nigeria and elsewhere [1], [5], [6], [8]-[14] reported the accumulation of varying concentrations of heavy metals in fish species of both freshwater and marine ecologies as a result of natural and anthropogenic activities within and around the water bodies. The surroundings of Jega river are characterised with dumped wastes, dyeing activities, block industries, car washing, agricultural and other commercial and domestic activities that discharge untreated effluents directly in to the stream where fishing activities are carried out on daily basis. Despite these pollution sources, the river seems to have little or no scientific attention. Hence, studying the presence and concentrations of some heavy metals in the bones and gills of the most commonly available fish species (*Oreochromis niloticus*) in the locality is necessary to ascertain its toxicity levels based

on international standards.

II. MATERIALS AND METHODS

A. Study Area

The samples for the study were obtained from Jega River, Kebbi State, Nigeria. Jega River is a subsidiary of the River Niger in Nigeria with all year round flow of water. Among the community, fishing is the second agricultural activity in the dry season after crop farming which is principally under irrigation taking advantage of the river. Other industrial activities around the river include dyeing, car washing, laundry and other domestic activities that directly or indirectly discharge untreated effluents in to the river. Fig. 1 is the map showing an aerial location of Jega River.

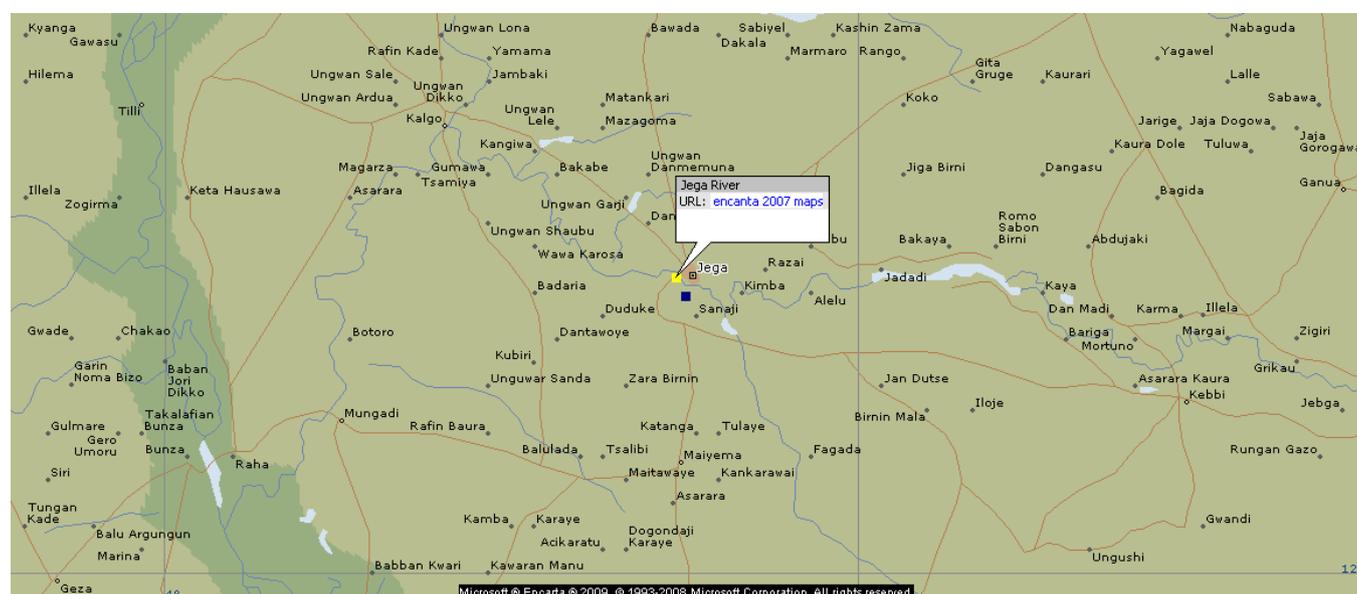


Fig. 1 Map showing location of Jega River [15]



Fig. 2 At the Bridge (domestic and industrial activities discharge untreated effluent into the receiving stream)

B. Sample Collection

A total of 30 fresh fish samples were randomly purchased from fishermen by the river fortnightly for a period of five months between March and July, 2014. This is the period at which intensive agricultural, domestic and industrial activities

discharge untreated effluents in to the river. All the fish samples were then separately stored at about -10°C overnight. The fish were dissected with sterile scissors to remove gills and bones. These were transferred into sterile sample bottles and labeled. The samples were separately dried in a laboratory oven at 65°C for three days to obtain a constant dry weight of 0.5 g from each sample. The dried samples were each ground to powder and sieved with 2 mm sieve. Fig. 2 shows the image of Jega River. From the image, it can be noticed that anthropogenic activities that could be sources of contamination of the water are practiced along the river.

C. Digestion of Samples

The powdered samples were digested using the following procedure:

1. 0.200 g of dry, powdered gills and bone samples were each weighed into a 50 ml digestion tube and 2.5 ml of selenium/sulfuric acid mixture was added to each tube and to 5 blanks, used for standards. These were placed in an aluminum block on a hotplate and heated at

approximately 200 °C at which the sample fumes.

- The tubes were then removed from the hotplates and allowed to cool for 10 minutes. 1 ml of 30% H₂O₂ was carefully added to the samples and standards. After the reaction subsides, this was followed with additional 2 ml H₂O₂.
- Tubes were replaced on hotplates and a heavy 15 ml glass vial was placed on top of each tube, and the tubes were heated up to 330 °C. This was left on the hot plates until the solutions were clear.
- The samples were allowed to cool and 0, 0.2, 0.4, 0.6 and 0.8 ml of stock solutions for each of the heavy metals to be analyzed were added to the 5 prepared standard solutions. The samples and standards were then diluted to the 50 ml mark [15].

D. Determination of Heavy Metals

Samples were then poured into auto analyzer cups and concentration of heavy metals (Cd, Fe, Zn, Cu and Pb) in each was determined using Atomic Absorption Spectrophotometer (AAS). The values of the heavy metal concentrations in the tissues were calculated based on dry weights.

E. Statistical Analyses

Results are presented as means ± SEM. Results from all the organs were compared using ANOVA 5% statistical significance.

III. RESULTS AND DISCUSSION

Results in Tables I and II show that the observed heavy metals in gills are in the decreasing order as 8.37 > 6.21 > 1.28 > 0.62 for Fe, Zn, Cu and Cd respectively; and in bones it was as follows: 13.08 > 2.23 > 1.28 > 0.99 for Fe, Cu, Zn and Cd respectively. The highest concentration of Fe with the mean value of 13.08± 1.00 mg/kg was observed in the bone, while the lowest concentration with the mean value of 8.37±1.10 mg/kg was observed in the gills.

TABLE I

CONCENTRATION OF HEAVY METALS IN THE GILLS AND BONES OF *OREOCHROMIS NILOTICUS* FROM JEGA RIVER

Organ	Fe mg/kg		Cd mg/kg		Pb mg/kg
	Mean	Range	Mean	Range	Mean
Gill	8.37±1.1	7.5-9.6	0.62±0.08	0.25-1.1	ND
Bone	13.08±1.00	10.1-12.1	0.99±0.06	0.98-1.0	ND

TABLE II

CONCENTRATION OF HEAVY METALS IN THE GILLS AND BONES OF *OREOCHROMIS NILOTICUS* FROM JEGA RIVER

Organ	Zn mg/kg		Cu mg/kg	
	Mean	Range	Mean	Range
Gill	6.21±0.11	6.7-7.0	1.28±0.10	1.2-1.25
Bone	1.28±0.10	1.2-1.25	2.23±0.20	2.0-2.6

Similar lower values were observed for Cd by [6] in three fish species. The highest concentration of Cd with the mean value of 0.99± 0.06 mg/kg was observed in the bone of *Oreochromis niloticus*, while the lowest value of 0.62±0.08 mg/kg was observed in the gills of *Oreochromis niloticus*. Reference [13] reported similar lower value for tilapia fish gills. Similar low values for Fe, Zn and Cd were reported by [9] in *Oreochromis niloticus* and [14] in gills of three fish species. Pb concentration was not detected in both gills and bones of *Oreochromis niloticus*.

The bone of *Oreochromis niloticus* has high concentration of metals in the following order; Fe (13.08±1.00 mg/L); Cu (2.23±0.20 mg/L); Zn (1.28±0.10 mg/L); Cd (0.99±0.06 mg/L); this maybe because the bone is an organ in which heavy metals are deposited. Reference [16] reported lower concentration of heavy metals in both bones and gills of *Oreochromis niloticus*. The gills of fish are the site directly exposed to the ambient conditions and are also known for their excretory functions even for some metals like Pb. However, these order of accumulation in the fish organ maybe attributed to the different uptake, metabolism and detoxification of metals in fish. The relative concentrations of the heavy metals assessed in fish are illustrated in Fig. 1.

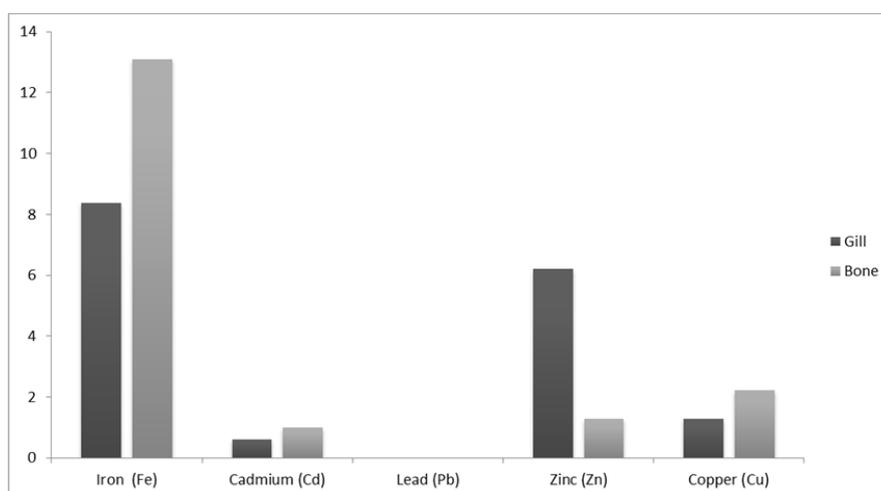


Fig. 3 Concentration of heavy metals in the gills and bones of *oreochromis niloticus* from Jega River

IV. CONCLUSION

The study concluded that heavy metals were detected in fish in Jega River pointing to the fact that the river itself contains these heavy metals. Pb was not detected in the study. However, among the observed heavy metals in the fish organs, all were found to be within the requirement ranges for fish, and the concentrations are all within acceptable limits for human consumption. Government should develop policy and regulations to monitor pollution discharge into the aquatic environment (water bodies) and enforce the existing laws and anthropogenic activities in Jega River should be regulated and controlled by law enforcement agencies.

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REFERENCES

- [1] M. Z. Moustafa and E. M. El-Sayed "Impact of Water Pollution with Heavy Metals on Fish Health: Overview and Updates". *GIO. Vet.*, Vol. 12, no. 2, pp 219-231, 2014.
- [2] R. B. Dianne and J. M. William "Heavy metal poisoning and its laboratory investigation". *Ann. Cl. Bioch.*, Vol. 36, no. 3, pp. 267 – 314, 1999.
- [3] J. Barbara and W. Malgorzata "The metal uptake and accumulation in fish living in polluted waters". *Soil and Water Pollution Monitoring, Protection and Remediation*, Vol. 3, no. 23, 2006. Pp. 107-114.
- [4] Ibemenuga, KN. Bioaccumulation and toxic effects of some heavy metals in freshwater fishes. *Ani. Res. Internl.*, 2013; 10(3): 1792 – 1798.
- [5] A. M. Babatunde, O. A. Waidi and A. A. Adeolu "Bioaccumulation of heavy metals in fish (*Hydrocynus forskahlii*, *Hyperopisus bebe occidentalis* and *Clarias gariepinus*) organs in Downstream Ogun coastal water, Nigeria. *Transnational J. Sc. & Tech*, Vol. 2, no. 5:pp 119-133, 2012.
- [6] K. N. Ibemenuga "Bioaccumulation and toxic effects of some heavy metals in Freshwater fishes". *Ani. Res. Internat.*, Vol. 10, no. 3, 2010: pp 1792 – 1798.
- [7] B. I. Uneke and I. Aloh. Concentration of Heavy Metals (Zn, Cd, Pb) in Kidney and Gill of Catfish (*Clarias* spp.) in Ebonyi River, Southeastern Nigeria. *AASCIT Journal of Bioscience* 2015; 1(2): 9-14.
- [8] Z. Zheng, H. Li, L. Jin, W. Zhen-bin "Analysis of Heavy Metals of Muscle and Intestine Tissue in Fish – in Banan Section of Chongqing from Three Gorges Reservoir, China". *Pol. J. Environ. Stud*, Vol. 16, no. 6): pp 949-958, 2007.
- [9] H. H. Essa and H. Z. Rateb "Residues of Some Heavy Metals in Freshwater Fish (*Oreochromis niloticus* and *Labeo niloticus*) in Assiut city markets". *Assiut University Bulletin of Environmental Resources*, Vol. 14, no. 1, 2011:pp 31-39.
- [10] F. H. Bashir, M. S. Othman, A. G. Mazlan, S. M. Rahim and K. D. Simon "Heavy Metal Concentration in Fishes from the Coastal Waters of Kapar and Mersing, Malaysia". *TurK J. Fish. & Aqu. Sci.*, Vol.13, 2013: pp 375-382.
- [11] S. Benzer, H. Arslan, N. Uzel, A. Gül and M. Yılmaz "Concentrations of metals in water, sediment and tissues of *Cyprinus carpio* from Mogan Lake (Turkey)". *Iranian J. Fish. Sci.*, Vol. 12, no. 1, 2013: pp 45-55.
- [12] J. M. Muiruri, H. N. Nyambaka and M. P. Nawiri "Heavy metals in water and *tilapia* fish from Athi-Galana-Sabaki tributaries, Kenya". *Inter. Food Res. J.*, Vol. 20, no. 2: pp891-896. 2013.
- [13] C. K. Shivakumar, B. Thippeswamy, M. V. Tejaswikumar and S. M. Prashanthakumara "Bioaccumulation of Heavy Metals and its Effect on Organs of Edible Fishes Located in Bhadra River, Karnataka". *Int. J. Res. Fis. & Aqu.*, Vol.4, no.2:pp 90-98, 2014.
- [14] Location of Jega River. Retrieved on 15th May, 2016 from Microsoft Encarta, 2007).
- [15] I. Novozamsky, V. J. G. Houba, R. van Eck and W. van Vark "A novel digestion technique for multi-element plant analysis". *Communications in Soil Science and Plant Analysis*, Vol. 14, 1983: pp 239-248.
- [16] S. M. Al-Weher "Levels of Heavy Metal Cd, Cu and Zn in Three Fish Species Collected from the Northern Jordan Valley, Jordan". *Jordan J. Bio. Sc.*, Vol. 1, no. 1, 2008: pp41-46.

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