Bioaccumulation of Heavy Metals on Some Organs of Oreochromis Niloticus (Nile Tilapia Fish)

Samson A. Achide * & Asheshi O. Omame
Department of Basic Sciences,
College of Agriculture,
P.M.B 33 Lafia Nasarawa State,
Nigeria
*gistwitachide@yahoo.com,achidesamson@gmail.com

Abstract
Bioaccumulation of metals in the bones, liver, gills, and muscles of Oreochromis Niloticus collected from polluted Shabu River as a result of anthropogenic activities and domestic wastes was investigated. The accumulations of metals in the organs were nearly similar, though lower than the maximum permissible dietary intake limits set by the EU, 2006 (0.5mg/kg for Cu, 0.30 mg/kg for Pb, 1.00mg/kg for Zn and 0.8mg/kg for Fe) and with all the tissues seem to accumulate more copper than the rest of the metals of interest. These observations suggest that the disposal of untreated waste and other waste disposal into the Shabu River if not proactively addressed could eventually turn the study area to biologically dangerous zone.

Keywords: *Oreochromis Niloticus, Contamination, Bioaccumulation of metals*

1. Introduction

Oreochromis Niloticus (Nile Tilapia Fish) is one of the major protein foods available in the tropics. It plays an important role in food security and alleviation in both rural and urban areas of Nigeria. Fish makes up about 60% of the world protein supply and there is an increasing demand for fish which is a delicacy with demands cutting across socioeconomic, religious, educational or age groups (Adebayo-Tayo et al, 2008). This has made fishery an important aspect of study.

The contamination of aquatic systems with a wide range of pollutants has become a matter of concern since the last few decades (Canli et al., 1998; Dirilgen, 2001; Vutukuru, 2005; Amaraneni, 2006; Rao and Rao, 2007; Vinodhini and Narayanan, 2008; Gupta et al., 2009). The natural water bodies may extensively be contaminated with various heavy metals released from domestic, industrial effluents, idol immersion, draining of sewage, dumping of hospital wastes and anthropogenic activities, etc. (Conacher et al.,1993; Velez and Montora, 1998; Chandra Sekhar et al., 2004; Vinodhini and Narayanan, 2008; Malik et al.,2010; Laxmi-Priya et al., 2011). Aquatic environment is constantly polluted from a variety of sources and presently it has assumed a dangerous proportion for aquatic life and fish species are no exception. A significant proportion of the Nigerian population still relies on surface water for drinking, washing, swimming and fishing. Heavy metal contamination may cause devastating effects on the ecological balance of the recipient environment and its diversity of aquatic organisms (Farombi et al., 2007; Vosyliene and Jankaite, 2006; Ashraj, 2005; Vinodhini and Narayanan, 2008).

Fish occupies higher level in the food chain and is an important source of protein food for human beings. The heavy metals in aquatic ecosystem are transferred through food web into human beings. Some heavy metals can cause health problems to fish consumers (Uysal et al., 2008;

Taweel et al., 2011). Flooding from heavy downpour may lead to horizontal leaching from dump sites causing metal uptake by root of crops; the rest may find their way into open water bodies and the entire aquatic ecosystem. The entry into food chain of these metals leads to increased susceptibility and exposure to metal poisoning of the local population. A number of serious health problems can develop as a result of excessive intake of dietary heavy metals. Furthermore, the consumption of heavy metal-contaminated fish can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho social behaviors, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer (Arora et al, 2008).

Bioaccumulation of metals reflects the amount ingested by the fish, the way in which the metals are distributed among the different tissues and the extent to which the metal is retained in each tissue type.

Fish accumulate toxic heavy metals directly from water and diet, and contaminant residues may ultimately reach concentrations hundreds or thousands of times above those measured in the water, sediment and food (Goodwin *et al.,* 2003; Labonne *et al.*, 2001; Osman *et al.*,2007). Heavy metals are normal constituents of marine environment that occur as a result of pollution principally due to the discharge of untreated wastes into rivers by many industries. Bioaccumulation of heavy metals in tissues of marine organisms has been identified as an indirect measure of the abundance and availability of metals in the marine environment (Kucuksegin *et al.*,2006). For this reason, monitoring fish tissue contamination serves an important function as an early warning indicator of sediment contamination or related water quality problems (Mansour and Sidky, 2002; Barak and Mason, 1990) and enables us to take appropriate action to protect public health and the environment. Multiple factors including season, physical and chemical properties of water can play a significant role in metal accumulation in different fish tissues (Hayat *et al.,* 2007; Romeo *et al.,* 1999). Several studies (Ademoroti, 1996; Cusimano *et al.,* 1986; Heath, 1987; Allen, 1995; Karthikeyan *et al.,* 2007) have also indicated that fish are able to accumulate and retain heavy metals from their environment depending upon exposure concentration and duration as well as salinity, temperature, hardness and metabolism of the animals. Adeyeye *et al.* (1996) also showed that the concentration of metals was a function of fish species as it accumulates more in some fish species than others. Fish have been the most popular choice as test organisms because they are presumably the best-understood organisms in the aquatic environment (Buikema *et al*. 1982) and also due to their importance to man as a protein source (Kime *et al.*, 1996). Accumulation of metals in various organs of fish may cause structural lesions and functional disturbances (Jezierska and Witeska, 2001). A survey of heavy metals toxicity shows that heavy metals cause several hematological and biochemical disorders on aquatic organisms (Vosyliene 1999, Shah 2006). Accumulation in the different aquatic system has been reported (Mortazavi and Sharifian, 2011). These heavy metals have the tendency to accumulate in the various aquatic animals and the accumulation depends upon the intake and elimination from the body. (Karadede et al, 2004). This work intends to provide more information on the bioaccumulation of heavy metals in the tissue/organs of a Nile Tilapia fish using the Atomic Absorption spectrometry Technique.

2. Theoretical Background

Amodu (2010) has listed some nuclear techniques in determining metals concentration to include the Atomic Absorption Spectrometer (AAS), X-Ray Fluorescence (XRF), Particle Induced Gamma Ray Emission (PIGE), Instrumental Neutron Activation Analysis (INAA), Particle

Induced X-ray Emission (PIXE) and the Inductively Coupled Plasma Optical Emission Spectrometry Technique (ICP OES).
In atomic absorption spectrometry (AAS), light of a wavelength characteristic of the element of interest is shone through this atomic vapor. Some of this light is then absorbed by the atoms of that element. The amount of light that is absorbed by these atoms is then measured and used to determine the concentration of that element in the sample. (Boss & Fredeen, 1997)

3. Materials and Methods

Shabu River is located in Lafia Local Government Area of Nasarawa State, Nigeria. The details of its location, climate, relief, as well as geology of the area had previously been discussed by Obaje et al, 2007.

3.1 Sample Collection/Preparation

The sample was collected in Shabu River of Lafia, the study area. The sample collection was done during the dry season.
Specimens of Nile Tilapia fish (Oreochromis Niloticus) were obtained from local fishermen who fish along the course of river Shabu. The fish were identified and their mean length of 23.13cm and mean weight of 282.67g of the whole fish were taken. The fish were then dissected and in each liver, gills, bone, and muscle were removed and their mean weight corresponding to 3g, 11g, 25g and 118g respectively were measured in a crucible of known weight.
The samples were oven dried to a constant weight and transferred while arranged into the muffle furnace for ashing at a very high temperature for four (4) hours. The ash obtained was cooled before extraction. The extraction of the sample was done by the use of Aqua Regia solution.

3.2 Preparation of Aqua Regia

Inside a 200mL volume flask, a little of ultra pure water was poured inside the volumetric flask. A 400mL of Conc. HCl and 133mL of Conc. Nitric acid was added. The mixture was shaken well.

3.3Extraction of Ashed Samples

The ashed samples were transferred inside the crucible to the centrifuge tubes, rinsed with 5mL of ultra pure water. A 7.5mL of Aqua Regia solution was dispensed inside the crucible and rinsed. Also another 7.5mL of Aqua Regia solution was dispensed to rinse inside the centrifuge tube. The centrifuge tubes were covered and shaken on the shaker for 5min. Finally, the supernatants (clear solution) were transferred into glass vials for reading in the AAS machine of the Faculty of Agriculture, Nasarawa State University. The machine was calibrated with metals of interest which are Copper (Cu), Zinc (Zn), Lead (Pb), and Iron (Fe).

4.0 Results

The heavy metals concentrations of the tissues of Oreochromis Niloticus from the study area were tested by AAS technique. The results are as shown in table 1.

Table 1:Result of heavy metal accumulation (mg/Kg) in tissues of Fish

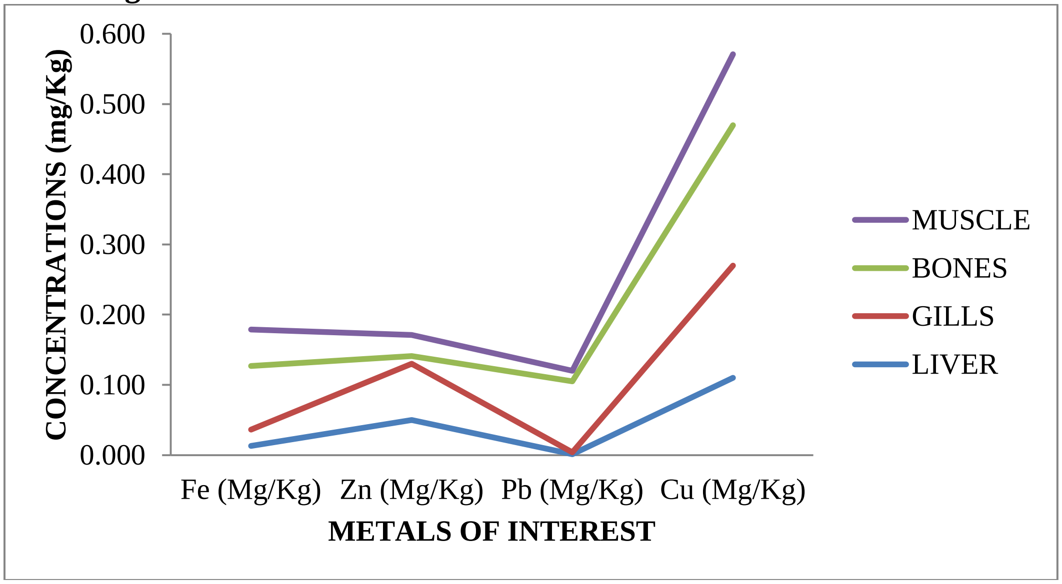
S/NO	SAMPLES	Fe	Zn	Pb	Cu
1	LIVER	0.013	0.050	0.001	0.110
2	GILLS	0.023	0.080	0.003	0.160

3	BONES	0.091	0.011	0.101	0.200
4	MUSCLE	0.052	0.030	0.015	0.101
	MEAN	0.045	0.043	0.030	0.143
	S.D	0.035	0.030	0.048	0.046

The results shown in Figure 1 that;

i. The bones accumulated more Cu> Pb > Fe > Zn
ii. The Liver accumulated more Cu > Zn > Fe > Pb
iii. Gills accumulated more Cu > Zn > Fe > Pb
iv. Muscles accumulated more Cu > Fe > Zn > Pb

Fig. 1: Metal accumulation in tissues of fish



5. Discussion

Aquatic environment is constantly polluted from a variety of sources generated by domestic homes, industrial effluents, idol immersion, draining of sewage, dumping of hospital, other wastes. There was presence of heavy metals in the tissue of fish from the study area. These elevated levels can be attributed to both natural and anthropogenic sources. The accumulations of metals in the organs were nearly similar, though lower than the maximum permissible dietary intake limits set by the EU, 2006 (0.5mg/Kg for Cu, 0.30mg/Kg for Pb, 1.00mg/Kg for Zn and 0.8mg/Kg for Fe) and with all the tissues seen to accumulate more copper than the rest of the metals of interest. Metal accumulation by the liver could be due to its functions such as detoxification. Alloway and Ayres (1994) had reported that in humans and higher animals, metabolic conversion of compounds not essential for normal biological functions takes place mainly in the liver. The gills are the first point of contact with water during respiration. Goel (2006) had observed that fish and other organisms that respire through the gills can absorb metals through their respiratory surfaces.

6. Conclusion

The natural levels of heavy metals are usually harmless to the organism but contamination from industrial effluents, agricultural chemicals and the direct contamination of Shabu river with untreated wastes if not proactively addressed could eventually turn the study area to biologically dangerous zone.

Acknowledgement
We remain grateful to the Faculty of Agriculture, Nasarawa State University Keffi, for the preparation and analysis of the samples.

Reference

Adebayo – Tayo, B.C., Onilude, A.A., and Patrick, U.G.(2008). Mycoflora of smoked – dried fishes sold in Uyo, Ea;stern Nigeria. *World Journal Agricultural Science*, 4, 346 – 350.

Ademoroti, C.M.A. (1996). Environmental Chemistry and Toxicology, Foludex Press Ltd.,Ibadan pp. 171 – 204.

Adeyeye, E.I., Akinyugha, R.J., Febosi, M.E. and Tenabe, V.O. (1996).Determination of some metals in *Clarias gariepinus* (Cuvier and Valenciemes), *Cyprinus carpio* (L) and *Oreochromis niloticus* (L) fishes in a polyculture fresh water pond and their environment. *Aquacut.*, 47, 205-214.

Allen, P. (1995). Chronic Accumulation of Cadmium in the edible Tissues of *Oreochromis aurus* (Steindachner): Modification by Mercury and Lead. *Arch. Environ. Contam. Toxicol.*, 29, 8-14.

Alloway, B. J., and Ayres, D.C (1994). Chemical principles of environmental pollution. Alden press oxford. Pp 194.

Amaraneni, S.R. (2006). Distribution of pesticides, PACs and heavy metals in prawn ponds near Kolleru Lake wetland, India. Environ. Int., 32(3):294-302.

Amodu, A.E (2010). The use of nuclear technique for elemental analysis of limestone's in part of Nigeria. Msc thesis, physics Department, University of calabar, Calabar Nigeria.

Arora, M., Kiran, B., Rani, S., Rani, A., Kaur, B.,and Mittal, N. (2008). Heavy metal accumulation in vegetables irrigated with water from different sources. Food Chem.(11):811–815.

Ashraf, W. (2005). Accumulation of heavy metals in kidney and heart tissues of *Epinephelus microdon* fish from the Arabian Gulf. *Environ Monit Assess.* 101,311.

Barak, N. and Mason, C. (1990). "A Survey of Heavy Metal Levels in Eels (Anguilla anguilla) from Some Rivers in East Anglia, England - The Use of Eels as Pollution Indicators," *Internationale Revue Der Gesamten Hydrobiologie*, Vol. 75, No. 6, pp. 827-833.

Boss B.B. & Fredeen K.J.(1997). Concepts, Instrumentation and Techniques in Inductively Coupled Plasma Optical Emission Spectrometry. 2nd Edition Perkin-Elmer, U.S.A, 5.

Buikema, A. L. (Jr), Niederlehner, B. R. and Cairns, J. (Jr) (1982). Biological Monitoring: Part IV – Toxicity Testing. Water Res. 16: 239-262.

Canli M, Ay, O., and Kalay, M. (1998). Level of heavy metals (Cd, Pb, Cu and Ni) in tissues of *Cyprinus carpio*, *Barbus capito* and *Chondrostoma regium* from the Seyhan River. Tur. J. Zool. 22(3):149-157.

Chandra –Sekhar, K, Chary, N.S., Kamal, C.T., Suman-Raj, D.S., and Srinivas-Rao, A. (2004). Fractional studies and bioaccumulation of sediment bound heavy metals in Kolleru Lake by edible fish. Environ. Int. 29(7):1001-1008

Conacher, H.B., Page, B.D., and Ryan, J.J. (1993). Industrial chemical contamination of foods, (Review). Food Addit. Contam. 10(10):129-143.

Cusimano, R.F., Brakke, D.F. and Chapman, G.A. (1986). Effects of pH on the Toxicity of Cadmium, Copper and Zinc to Steelhead trout (*Salmo gairdneri). Can. J. Fish Aquat. Sci.,*43, 1497-1503.

Dirilgen, N. (2001). Accumulation of heavy metals in freshwater: Assessment of toxic interactions. Turk. J. Chem. 25(3):173-179.

European Union, EU (2006). Regulation 1881

Farombi, E.O., Adelowo, O.A. and Ajimoko, Y.R. (2007). Biomarkers of oxidative stress and heavy metals levels as indicators of environmental pollution in African catfish (*Clariasgariepinus)* from Ogun River. *Int. J. Environ. Res. Public Health*, 4(2): 158-165.

Goel, P. K (2006). Water pollution Causes, Effects and Control, Revised Second Edition, New Age International Publishers, New Delhi. 418pp.

Goodwin, T. H., Young, A., Holmes, M., Old, G., Hewitt, N., Leeks, G., Packman, J. and Smith, B. (2003). "The Temporal and Spatial Variability of Sediment Transport and Yields within the Bradford Beck Catchment, West Yorkshire," *Science of the Total Environment*, Vol. 314, pp.475-494.

Gupta, A., Rai, D.K., Pandey, R.S., and Sharma, B (2009). Analysis of some heavy metals in the riverine water, sediments and fish from Ganges at Allahabad, Environ. Monit Assess. 157(1-4):449-58.

Hayat, S., Javed, M. and Razzaq, S. (2007). "Growth Performance of Metal Stressed Major Carps viz. *Catla Catla, Labeo Rohita and Cirrhina Mrigala* Reared under Semi-Intensive Culture System," Pakistan Veterinary Journal, Vol. 27, No. 1, pp. 8-12.

Heath, A.G. (1987). Water Pollution and Physiology. CRC press Inc., Boca Raton. 145 pp.

Jezierska, B., and Witeska, M. (2001). Metal toxicity of fish, Wydawnictwo Akademi Podlaskiej, siedlce Pp 318

Karadede, H., Oymak, S.A., and Unlu, E. (2004). Heavy metals in mullet, Liza abu, and catfish, Silurus triostegus, from the Ataturk Dam Lake (Euphrates), Turkey. *Environmental International*, 30:183–188.

Karthikeyan, S., Palaniappan, P.L.R.M. and Sabhanayakan, S. (2007). Influence of pH and water hardness upon Nickel accumulation in edible fish *Cirrhinus mrigala. J. Environ. Biol.,***28**,484-492.

Kime, D.E., Ebrahimi, M., Nysten, K., Roelants, I., Rurangwa, E., Moore, H.D.M. and Ollevier, F. (1996). Use of computer assisted sperm analysis (CASA) for monitoring the effects of pollution on sperm quality of fish, application to the effects of heavymetals. *Aquatic Toxicology*. 36: 223-237.

Kucuksezgin, F.A., Kontas, O., Altay, E. and Uluturhan, D. E. (2006). Assessment of marine pollution in Izmir Bay; Nutrient heavy metal and total hydrocarbon concentrations: *Environ. Int.,* 32: 41-51.

Labonne, M., Basin, S., Othman, D. and Luck, J. (2001). "Lead Isotopes in Muscels as Tracers of Metal Sources and Water Movements in a Lagoon (Thau Basin, S. France)," *Chemical Geology*, Vol. 181, No. 1-4, pp. 181-191.

Laxmi-Priya, S., Senthilkumar, B., Hariharan, G., Paneer-Selvam, A., Purvaja, R., and Ramesh, R. (2011). Bioaccumulation of heavy metals in mullet (*Mugil cephalus*) and Oyster (*Crassostrea madrasensis*) from Pulicat lake, south east cost of India, Toxicol. Ind. Health 27(2):117-126.

Malik, N., Biwas, A.K., Qureshi, T.A., and Borana, K. (2010). Bioaccumulation of heavy metals in fish tissues of a freshwater lake of Bhopal. Environ. Monit. Assess. 160:267-276.

Mansour, S. and Sidky, M. (2002). "Ecotoxicological Studies. Heavy MetalsContaminating Water and Fish from Fayoum Governorate, Egypt," *Food Chemistry*, Vol. 78, No. 1, pp. 15-22.

Mortazavi, M. S. and Sharifian, S. (2011). Mercury Bioaccumulation in Some Commercially Valuable Marine Organisms from Mosa Bay, Persian Gulf. *Int. J. Environ. Res*., 5(3):757-762.

Obaje, N. G., Lar, U. A., Nzegbuna, A. I., Moumouni, A., Chaanda, M. S. and Goki, N. G. (2007). GeographicalPerspective on Nasararwa State. *A publication of the department of Geography, Nasarawa StateUniversity, Keffi Nasarawa State Nigeria*. Onaivi printing and publication co. Ltd Keffi. Pp 21, 35.

Osman, A., Wuertz, S., Mekkawy, I., Exner, H., and Kirschbaum, F. (2007). "Lead Induced Malformations in Embryos of the African Catfish Clarias Gariepinus (Burchell, 1822)," *Environmental Toxicology*, Vol. 22, No. 4, pp. 375-389.

Rao, S.R and Rao,P.R (2007). Heavy metal concentrations in the sediments from Kolleru Lake, India, *Indian* J Environ Health. 43(4):148-153.

Romeo, M., Siau, Z., Sidoumou, Y. and Gnassia, M. B. (1999). "Heavy Metal Distribution in Different Fish Species from the Mauritania Coast," *Science of the Total Environment*, Vol.232, No. 3, pp. 169-175.

Shah, S. L (2006). Hematological Parameters in tench *Tinica tinica* after short term exposure to lead, *Journal of Applied Toxicology 26(3)* 223-228.

Taweel, A., Shuhaimi-Othman, M., and Ahmad, A.K (2011). Heavy metal concentration in different organs of tilapia fish (*Oreochromis niloticus*) from selected areas of Bangi, Selangor, Malaysia. Afr. J. Biotechnol. 10(55):11562-11566.

Uysal, K., Emre, Y., and Kose, E. (2008). The determination of heavy metal accumulation ratio in muscle, skin and gills of some migratory fish species by inductively coupled plasma-optic emission spectrometry in Beymelek Lagoon, Antalya/Turkey. Microchem. J. 90(1):67-70.

Velez, D, and Montora, R (1998). Arsenic speciation in manufactured seafood products: a review. J. Food Prot. 61(9):1240-1245.

Vinodhini, R., and Narayanan, M. (2008). Bioaccumulation of heavy metals in organs of fresh water fish *Cyprinus carpio* (Common carp). Int. J. Environ. Sci. Technol. 5(2):179-182

Vosyliene, M.Z, and Janakaite, A. (2006). Effect of heavy metal model mixture on rainbow trout biological parameters. Ekologia 4:12-14.

Vosyliene, M.Z. (1999). The Effect of Heavy Metals on Heamatological Indices of fish *Acta zoological Lituanica*, *9(2)*:76-82.

Vutukuru, S.S. (2005). Acute effect of Hexavalent chromium on survival, oxygen consumption, hematological parameters and some biochemical profile of the Indian Major carp, *Labeo rohita*. Int. J. Environ. Res. Public Health 2(3):456-462.