Websites:
http://www.nbmedicine.org
http://www.sciencepub.net/nurse

Emails:
editor@sciencepub.net
nbmeditor@gmail.com

Biomedicine and Nursing

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Heavy Metal Accumulation in the Liver, Gills and Kidney of *Heterotis niloticus* as an Indicator of Aquatic Pollution from Lake Chad, Nigerian Sector.

Jonathan, B. Y[1]. Maina, H.M[2] and Barminas, J.T[2]

1.Federal College of freshwaters Fisheries Technology, Maiduguri, PMB 1060, Maiduguri, Borno State.
2.Chemistry Department, Modibbo Adama University of Technology, PMB 1076, Yola Adamawa State
berny2025@yahoo.com

Abstract: The accumulation of cadmium(Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Manganese (Mn), Lead (Pb) and Zinc (Zn) in the liver, gills and kidney of *Heterotis niloticus* (*H. nitilocus*) was analyzed by energy dispersive X-ray fluorescence (EDXRF) at Dumba 1 and Dumba 2 of Lake Chad, Nigerian Sector. The aim was to determine the heavy metal accumulation in organ tissues (liver, gills and kidney) of *H. nitilocus*. The highest heavy metals concentration Fe: 175.50 +10.02 mg/kg was observed in the liver at Dumba 2, while Cd: 0.01mg/kg, was the lowest concentration also in the liver at Dumba 2. At Dumba 1, Fe showed the highest concentration and Cd was the lowest. Cd, Cu, Fe, Mn, and Pb concentrations in the liver, gills and kidney of *H. nitoticus* are above the maximum permissible limits by WHO (1989) and FEPA (2003). The results obtained in this study indicated that, the organ tissues of *H. nitoticus* are good indicators of heavy metal pollution in the aquatic environment. Zn is the only heavy metal that is within the allowable standard limits by WHO (1989) and FEPA (2003). The liver gills and kidney of *H. nitoticus* was polluted with Cr, Cu, Fe, Mn and Pb. Its consumption by humans may cause health hazards.
[Jonathan, B. Y. Maina, H.M and Barminas, J.T. **Heavy Metal Accumulation in the Liver, Gills and Kidney of *Heterotis niloticus* as an Indicator of Aquatic Pollution from Lake Chad, Nigerian Sector.** *Biomedicine and Nursing* 2021;7(2): 20-24]. ISSN 2379-8211 (print); ISSN2379-8203 (online).http://www.nbmedicine.org
4. doi:10.7537/marsbnj070221.04.

Keywords: Accumulation, Heavy Metal, *Heterotis niloticus*, Organ tissues, Pollution.

INTRODUCTION

Nowadays environmental pollution by heavy metals poses a serious threat of global concern (Ali *et al*., 2013; Hashem *et al*., 2017). Heavy metals have the habits of accumulating in fish, water and sediments and they are nonbiodegradable, with some toxic effects and persistent in the environment, and they contaminate the food chains, with many health challenges because of their toxicity. The bioaccumulation of toxic heavy metals in fish species of the aquatic ecosystems may have detrimental effects on fish and human beings (Malik and Maurya 2014). Higher concentrations of heavy metals in fish species can have adverse effects on the ecological health of fish species and may contribute to degeneration in their populace (Luo *et al*., 2014)

The environmental risk assessment and water quality management are increasingly receiving more attention due to the fact, that a large number of pollutants entering aquatic environment are harmful (Van Leeuwen, 1990). The background concentration of heavy metals maybe increased through natural and anthropogenic sources. The natural sources of heavy metals include weathering of rocks, soils and soil erosions containing heavy metals, and volcanic eruptions, while the major anthropogenic sources include municipal wastes, industrial effluents, mining and sewage sludges. Agricultural activities like application of phosphate fertilizers and pesticides (Wieczorek-Da̧browska *et al*., 2013). These heavy metals find their way into aquatic ecosystem through rain water and surface runoffs, emission into the water bodies and flood, whenever they are introduced into the environment. Heavy metals can accumulate in the organ tissues of fish species in the aquatic environment, which can be transferred to human beings through the consumption of polluted fish species causing serious health hazards (USEPA, 1991).

Bioaccumulation of heavy metals can only take place if the rate of uptake by the fish species exceeds the rate of elimination. Bio concentration may occur in the fish issue by means of metabolic and bio sorption processes (Wicklund -Glynn, 1991). Based on environmental analysis, bio concentration is very important due to the fact that, heavy metal ions usually occur in low concentrations in the aquatic environment and slight physiological effects go over looked until complete chronic changes in structures becomes apparent. Cu^{2+} and Zn^{2+} are readily concentrated in different fish species organ tissues, leading to altered physiological processes (Wepener *et al*., 2001).

Heavy metals are classified into essential and nonessential. Essential heavy metals are Mn, Fe, Cu, and Zn, they are important for living organisms and they are needed in the body in low concentrations. Nonessential heavy metals are Cd, Pb, and Hg they are highly toxic with no known biological role in living organisms, they are considered as biologically nonessential (Rahim *et al*., 2016). The aim of monitoring heavy metal pollution in lake and river systems by using fish organ tissues (liver, gills and kidney) helps to assess the quality of aquatic ecosystem. Heavy metals enter fish through food\, gills, water and skin and into the blood, and are carried to either a storage point or to the liver for its transformation or storage. The liver is the main site of accumulation on, biotransformation, and excretion of pollutants in fish species (Jabeen, 2010, Adam, 2002). The region of accumulation of heavy metals within fish species varies with the route of uptake, heavy metals, and species of fish concerned.

The aim of this study is to determine the heavy metal accumulation in organ tissues (liver, gills and kidney) of *Heterotis nitoticus* and the evaluation of water quality of Lake Chad, Nigerian Sector to the content heavy metals.

Material and Methods.

Study Area

This study was carried out at Baga, Nigerian Sector of Lake Chad, Baga is in Kukawa Local Government of Area of Borno State. Baga lies on latitude 12^0 55′N and Longitude 13^0 35′E. The major economic activities of the population in Baga are agriculture, stock breeding and fishing. The sampling sites are Dumba 1 and 2.

Fish Sampling and Chemical Analysis.

H. niloticus was bought from the local fishermen at the bank of the Lake and was transported to the laboratory in a plastic bag for further analysis of fish samples. Five samples of *H. niloticus*, weighing 3.05kg was washed with water in the laboratory.
Map of Lake Chad, Nigerian Sector and Surrounding Regions was presented in Figure 1.

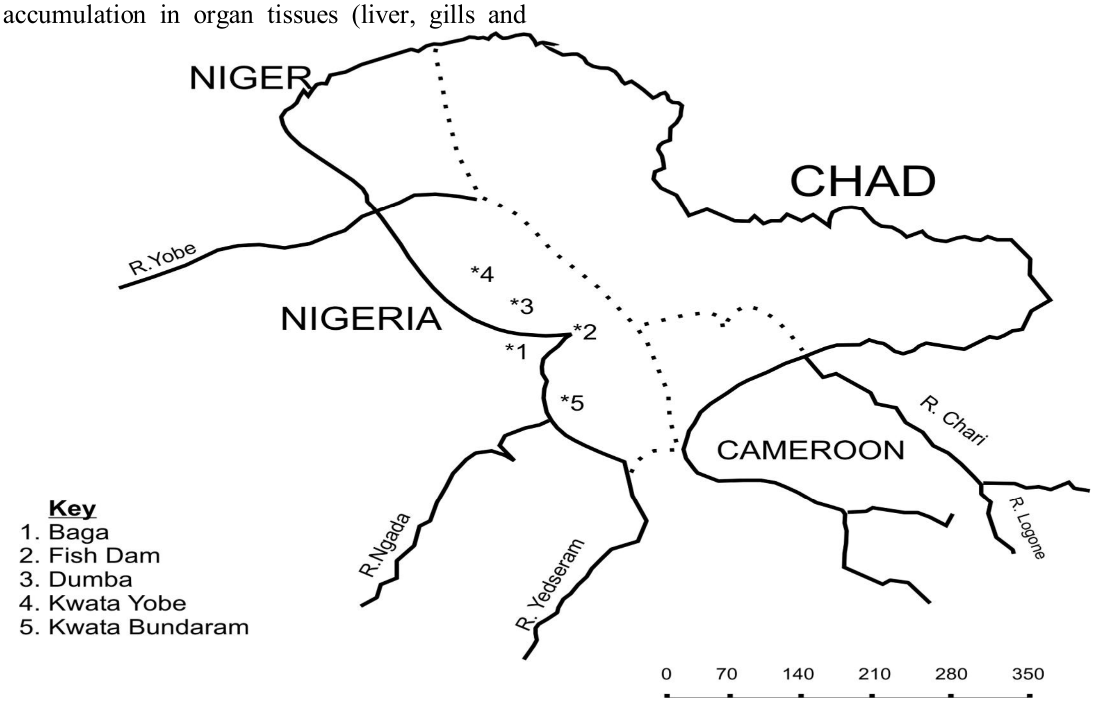

Fig. 3.1: Map showing location of sampling area in Lack Chad, at Baga Nigerian Portion
(***Source:*** *World Lake Database, 1983)*

The gills, liver and kidney were removed using stainless steel and were air dried to a constant weight Ozturk *et al*, 2009). The dried gills liver and kidney of *H. niloticus* were ground separately to powder with mortar and pestle to grain size of less than 125mm and were homogenized. A quality of 0.5g of powdered gills, liver and kidney separately were mixed with three drops of organic binder and pressed with 10 tons hydraulic press to produce pellets of 19mm diameter. Three replicate of pellets each organ tissues (gills, liver and kidney) were prepared. The resulting pellets were used to anal sized heavy metals in the samples.

Pellets of gills, liver and kidney were separately put into the x-ray fluorescence spectrometer sample holder and was bombarded ^{109}Cd as the excitation source that emits Ag-k X-rays (22.1kev) in which case all the elements with lower characteristics energies were accessible for detection in the samples. Fluorescent X-rays was produced which passes to the Si (Li) detector, through Mo target. The intensity of the fluorescent X-rays on the detector is proportional to the concentration of the individual element of interest in the sample organ tissues.

Statistical Analyses.

The results obtained are presented as mean and standard deviations

Results.

The mean concentration of heavy metals (mg/kg dry wt) in the liver, gills and kidney of *H. niloticus* from Dumba 1 and 2, Lake Chad Nigerian Sector are shown in Table 1.

The results of this study showed significant differences in the values of heavy metals in the organ tissues of *H. nilotiscus*. In the liver of *H. niloticus*, the mean concentration of heavy metals, varies between, Cd (<10-8 and 0.01mg/kg) Cr (0.84±0.04mg/kg and 0.90±mg/kg), Cu (10.70±2.16mg/kg and 11.50±1.01mg/kg), Fe (169.45±5.18mg/kg and 175.50±10.02mg/kg) Mn (24.50±1.01mg/kg and 38.00±5.21mg/kg), Pb (2.00±0.25mg/kg and 2.62±0.03mg/kg), Zn(8.71±2.04mg/kg and 24.40±2.02mg/kg).

In the liver, Fe was the highest concentration and Cd was the lowest. The order of heavy metals accumulation in the liver was given as Fc> Zn> Pb> (Cr). In the gills, the mean concentration of heavy metals ranged between Cd (<10-8 and 0.02mg/kg/kg), Cr (0.73±0.03mg/kg (0.73±0.03mg/kg and 1.21±0.00 1mg/kg), Cu (5.25± 0.05mg/kg and 8.84±1.04mg/kg), Fe (135.10±2-50mg/kg and 142.22±5.03mg/kg), Mn (22.33±2.15mg/kg and 25.17±2.16mg/kg), Pb (1.51±0.01mg/kg and 3.07±0.05 mg/kg) and Zn (6.33±0.28mg/kg and 26.61±4.02mg/kg. The highest heavy metal concentration in the gills was Fe and Cd was the lowest. The order of heavy metals accumulation in the gills of *H. niloticus* in both sampling sites was Fe> Mn>Zn>Cu>Pb>Cr>Cd. Lastly in the kidney of *H. niloticus* from both sampling sites, the mean concentration of heavy metals ranged between: Cd(<10-8 and 0.10mg/kg), Cr(<10-8 and 0.78±0.05mg/kg) Cu (5.60±2.01mg/kg and 8.70±0.17mg/kg) Fe (128.52±5.01mg/kg and 161.13±10.05mg/kg) Mn (16.70±1.17mg/kg and 36.40±5.01mg/kg), Pb (1.95±0.01mg/kg and 2.61±0.02mg/kg) and Zn (4.50±0.04mg/kg and 9.06±0.05mg/kg. The highest concentration of heavy metals in the kidney of *H. niloticus* was Fe and the lowest was Cd. The order of heavy metals in the kidney of *H. niloticus* w a s Fe>Mn<Zn>Cu> Pb > Cr>Cd.

Discussion

When fish come in contact with water borne heavy metals, they can absorb and accumulate heavy metals through the gills and skin or ingesting polluted water and food. Therefore, heavy metals in organ tissues of fish can be many times higher than their corresponding water values (Jabeen and Chaudhry, 2010).

Table 1: Mean Concentration of Heavy Metals in Liver, Gills and Kidney of *Heterotis niloticus* from Dumba, Lake Chad, Nigerian Sector.

Sampling Sites/Fish Species/Organ tissue	Heavy Metals (mg/kg dry wt)						
	Cd	Cr	Cu	Fe	Mn	Pb	Zn
Dumba 1 Gills	$<10^{-8}$	1.21 ±0.01	5.25 ±0.05	135.10 ±2.50	25.17 ± 2.16	3.07 ± 2.05	26.61 ±4.02
H. niloticus Liver	$<10^{-8}$	0.90 ±0.05	10.70 ±2.16	169.45 ±5.18	38.00 ±5.21	2.00 ±0.25	24.40 ±2.02
Kidney	$<10^{-8}$	0.78 ±0.05	8.70 ±0.17	161.13 ±10.05	36.40 ±5.01	2.61 ±0.02	9.06 ±0.05
Dumba 2 Gills	0.02	0.73 ±0.03	8.84 ±1.04	142.22 ±5.03	22.33 ±2.15	1.51 ±0.01	6.33 ± 0.28
H. niloticus Liver	0.01	0.84 ±0.04	11.50 ±1.01	175.50 ±10.02	24.50 ±1.01	2.62 ±0.03	8.71 ±2.04
Kidney	0.10	$<10^{-8}$	5.60 ±2.01	128.52 ±5.01	16.70 ±1.17	1.95 ±0.01	4.50 ±0.04
WHO 1989	0.1	0.15	3.0	100.00	0.5	2.00	10-75
FEPA 2003	0.1	0.15	3.0	100.00	0.5	2.00	10-75

Values are mean ± Standard Deviation

The present results showed that the concentration of heavy metals in the liver, gills and kidney of *H. niloticus* varies significantly in the two sampling sites. The liver accumulated a higher concentration of Fe at Dumba 2 compared to Dumba 1. Cd in the liver and Cr in the liver of *H. niloticus* at Dumba 2 have their values belowat Dumba 2 have their values below the higher values of Cr, Cu, Fe and Mn found in the liver, gills and kidney in both sampling sites. Higher values of Pb was found in the gills and kidney at Dumba 1 and in the liver at Dumba 2, the rest of Pb were found to be normal and below the maximum permissible limit (2.00 mg/kg) by WHO (1980) and FEPA (2003). The values of Zn in both sites were found to be below the maximum permissible limit (10 – 75-00mg/kg) by WHO (1989) and FEPA (2003).

The liver, gills and kidney are commonly the primary target organ for pollution. Gill surfaces are the first target of waterborne heavy metals. They act as a route of uptake of heavy metals. The liver plays a vital role in accumulation, biotransformation and detoxification. When fish species are exposed to higher levels if heavy metals, metalations proteins (MT) are synthesized, which are heavy metal binding proteins (Philips and Rainbow, 1989). M.T has high affinities for heavy metals, and by so doing, accumulate, concentrate metals in the liver. High concentration of heavy metals in the liver is due to the fact that the liver acts for storage and metabolism (detoxification). The liver is therefore, analyzed to prove that it is an indicator of heavy metal pollution in freshwater environment. The high levels Cr, Cu, Fe, Mn and Pb in the Liver, gills and Kidney of *H. niloticus* are an indication that the fish is under the influence of anthropogenic pollution. Fe is an essential metal and the most abundant element in the earth crust. It transports oxygen from the lungs to the organ tissues. It is an important enzyme system in the various tissues. Its high concentration levels in the liver and gills is attributed to the fact that, liver and gills synthesis MT. Jobling, (1995).. Mn is an essential metal for both plant and animal and is possibly homeostatically controlled and to some extent non toxic to aquatic biota and is rarely a problem in freshwater. The high concentration of Mn in the liver, gills and kidney could be attributed to the complex formation between manganese ion and the proteins in the liver and gills which contain sulphur (Jobling, 1995). Cu is an essential element for all living organism and is thought to be strictly regulated in the fish tissues. It is an essential part of several enzymes and is necessary for synthesis of hemoglobin. The high concentration of Cu in the liver and gills could be attributed to MT proteins metabolic processes. The liver protein haemocuprein and hepatocuprein, as well as several oxidative enzymes need Cu as an important component to function effectively (Wittmann, 1979). Zn is an essential element, but at high concentration, it can be toxic to fish species (Forstner and Wittmann, 1981). It was generally believed that fish actively regulate Zn. The highest Zn concentration was found in the gills of *H. niloticus*. The gills of fish are the main sites of heavy metal uptake and Zn is taken up directly from the water by mucus and gills. *H. niloticus* is a surfaces feeder with higher protein which enables them to accumulate Zn from their food (Cogun *et al*., 2006). The Zn concentrations in the liver gills and kidney in this study are below the maximum permissible limit (10 – 75-00mg/kg) by WHO (1989) and FEPA (2003) respectively. Cr is a non-essential element used in inks, in the leather industry, and in the processing of steel. High concentration of Cr was observed in the gills of *H. niloticus*,_is usually correlated with structural damage to the gill epithelium as well as marred respiratory and osmoregulatory function. The concentration of Cr in the organ tissues of *H. niloticus* are above the maximum permissible limit (0.15mg/kg) by WHO (1989) and FEPA (2003). The high concentration of Cr in this study could attributed to domestic and industrial wastes, sewage, and agricultural activities. Pb is a non – essential and toxic even at low concentrations and has no known function in biochemical processes. The gills have the highest concentration of Pb at Dumba 1 followed by the liver at Dumba 2. The gill is the first site for Pb uptake in fish and that a strong connection may exist between the gill Pb load and toxicity. The high concentration of Pb in the organ tissues of *H. niloticus* could be attributed to its large size and the agricultural activities within the vicinity of Lake Chad._The concentration of Pb in the gills and the kidney at Dumba 2 are above the maximum permissible limit (2.00 mg/kg) by WHO (1989) and FEPA (2003). Cd is a non – essential toxic metal and is not part of natural biochemical processes and highly toxic and is a hazardous heavy metal. It can be incorporated, stored and then concentrated by fish species through food chain. The presence of Cd in organ tissue of *H niloticus* could be attributed to the up surging and flooding of nutrient rich waters that normally occurs in November and December of each year. The concentration level of Cd in this study in the organ tissues of *H. niloticus* in both the sampling sites are within the maximum permissible limit (0.1mg/kg) by WHO (1989) and FEPA (2003). The accumulation of Cd, Cr, Cu, Fe, Mn, Pb, and Zn in the organ tissue of *H. niloticus* indicated variations in the heavy metal's concentration. The Cr, Cu, Fe, Mn, and Pb investigated were found to be agreeably in high concentrations.

Conclusion

This study confirms the presence of Cd, Cr, Cu, Fe, Mn, Pb and Zn in the Lake Chad, Nigerian sector.

Apart from Cd and Zn all the other heavy metals investigated showed notably higher concentrations in the liver, gills and kidney of *H. niloticus* The order of heavy metal accumulation was Fe>Mn>Zn>Cu>Pb>Cr>Cd

Acknowledgement

I'm very grateful to Prof. H.M. Maina and Dr. O.N. Maitera of Chemistry department Modibbo Adama University of technology, Yola for their support and encouragement, I would like to thank the laboratory technologist at Centre for energy Research and Training Zaria.

References

Adam, S.M (2002). Biological indicators of aquatic ecosystem stress. *American Fisheries Society*, Bethesda PP 656

Ali, H., Khan, E. and Sajad M. A (2013). Phytoremediation of heavy metals-Concepts and applications, Chemosphere. 91(7): 869–881

Federal Environment Protection Agency (2003) Guidelines and standards for *Environ.* Pollution and control in Nigeria 2:3

Forstner, U and Wittmann, (1981). Metal Pollution on aquatic Environment Be in Heidelberg. Germany: Springerveruig 272: pp 486

Hashem, M. A., Nur-A-Tomal, M. S., Mondal, N. R and Rahman, M. A (2017). Hair burning and liming in tanneries is a source of pollution by arsenic, lead, zinc, manganese and iron," Environmental Chemistry Letters 15(3): 501–506

Jabeen, F and Chaudhry, A.S (2010). Environmental I impacts of anthsopogenic activities on the minereal uptake in *oreochsomis Mossambicus* from Indus River in Pakistan. *Environ*. *Monit. Assoc.* pp 641 – 65

Jobling, M (1995). Environmental Biology of Fisheries 1st ed. Pointed in great Britain. *Chapman* and Hall, London

Luo, J., Ye, Y., Gao, Z and Wang, W (2014) Essential and nonessential elements in the red-crowned craneGrus japonensis of Zhalong Wetland, northeastern China," Toxicological & Environmental Chemistry 96 (7): 1096–1105.

Malik, D. S and Maurya, P. K (2014) Heavy metal concentration in water, sediment, and tissues of fish species (Enteropneusta's fossilis and Puntius ticto) from Kali River, India," Toxicological Environmental Chemistry 96 (8): 1195–1206, 2014.

ÖztÜrk, M., Ozozen, G., Minareci, O and Minareci, E. (2009). Determination of Heavy Metals in fish. Water and Sediments of Avsar Dam Lake in Turkey, *Health Sci. Eng.* 6(2): 73-80.

Philips, D.J.H and Rainbow, P.S (1989). Strategies of trace metals sequestration in aquatic organisms, *Mar. Environ*. *Ress*; 28:207 – 210.

Rahim, M., Ullah, I., Khan, A and Harris, M. R. H. M (2016) Health risk from heavy metals via consumption of food crops in the vicinity of District Shangla, Journal of the Chemical Society of Pakistan 38 (1): 177–185

USEPA, (1990) Methods for determination of metals in environmental samples U.S Environmental protection Agency Cincinnati, OH. EPA – 600/491 – 010

Van Leeuwen, K (1990). Ecotoxicological effects assessment in the Netherland Recent developments. *Environ*. *Manage* 14: 779 – 792

Wepener, V., Van Vuren, J.H.J and Du preez, H.H (2001). Uptake and distribution of coppers and zine mixture in the gills, liver and plasma of a fresh water tempest. Tilapia spar manii. *Water SA* 27: 99 – 108

Wicklund – glynn, A (1991). Cadmium and Zinc Kinetic in fish: Studies on water – borne Cd 109 and Zn 65 tumover and intracellular distribution in minnows, Phoxinus. *Pharmacal Toxicol*., 65: 485 – 491

Wieczorek-Dąbrowska, M., Tomza-Marciniak, A., Pilarczyk, B and Balicka-Ramisz, A (2013). Roe and red deer as bioindicators of heavy metals contamination in north-western Poland, Chemistry and Ecology 29(2): 100–110

Wittmann, G.T.W (1979). Toxic Metals. In: metals pollution in the aquatic environment (eds. U. Forstner ad G.T.W Wittmann). PP 3 – 68, Springer – Rerlag, Berlin, Germany.

World Health Organization (1989). Environmental health criteria 108: Nickel. International programmer on chemical safety. World Health Organization.

6/2/2021