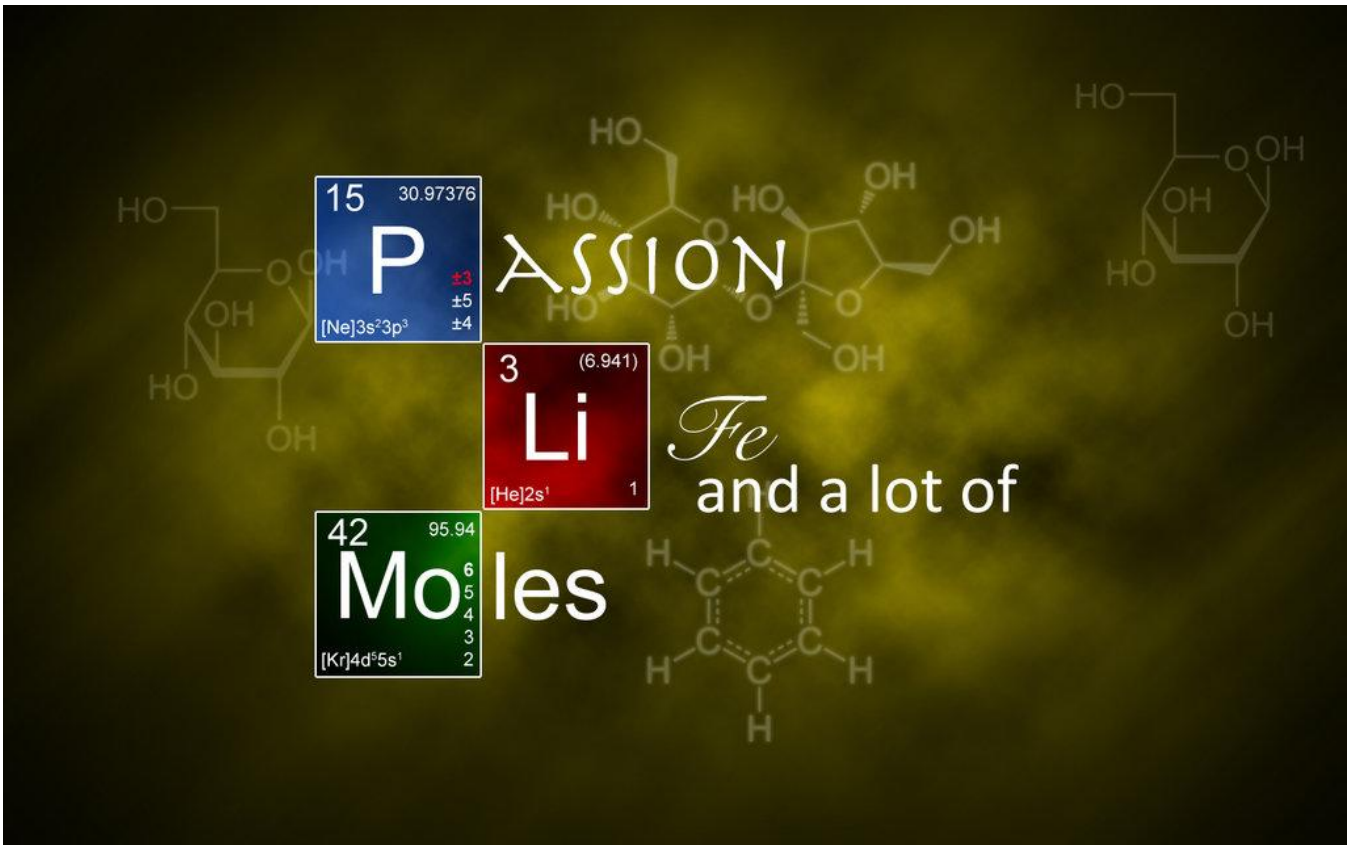

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HEAVY METALS LEVELS IN TILAPIA SAMPLES FROM NORTH CENTRAL NIGERIAN RIVERS

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ABSTRACT

The determination of Cd, Cr, Mn, Ni, Pb contents in Tilapia zilli of North Central Nigeria Rivers were made using Atomic Absorption spectrophotometric technique. The method of acid digestion in 1.5.1, 70% perchloric, conc. nitric and conc. sulphuric acid was used to liberate the metals. The concentration of heavy metals (mg/kg) during the wet season ranged between from 0.0-25.4, 0.1-40.2, 1.4-435.1, 0.5-15.7, 0.4-25.4, for Cd, Cr, Mn, Ni and Pb respectively, while In the dry season the concentrations ranged between 0.3-13.0, 0.8-31.2, 5.2-344.2, 0.6-25.1, 0.1-45.6, for Cd, Cr, Mn, Ni and Pb respectively. The mean concentration of the heavy metals follow the pattern Mn>Cr>Pb>Ni>Cd during both seasons showing that once heavy metals are bioaccumulated they are lost slowly or not all. The results also show that the concentrations recorded for Cd, Cr, Mn, Ni and Pb are above the guideline values of WHO and FEPA and are not fit for human consumption.

Key words: Bioaccumulate, aquatic organisms, heavy metals, pollution, river

Heavy metals are reasonably dangerous to the aquatic environment. This can be due to their toxicity, wide sources, lack of biodegradable properties, and accumulative potential (Mansouri *et al.,* 2012; Rezaee *et al.,* 2011; Salati and Moore, 2010). Heavy metal concentrations in aquatic ecosystems are usually monitored by measuring its concentration in water, sediments, and biota, which generally exist in lower levels in water and attain considerable concentration in sediments and biota (Ebrahimpour and Mushrifah, 2008).

Aquatic ecosystem is the ultimate sink of almost everything including heavy metals. Pollution of heavy metals in aquatic environment is a growing problem globally and currently it has assumed an alarming rate. There are various sources of heavy metals; such as anthropogenic activities like draining of sewage, dumping of hospital wastes and recreational activities. Conversely, metals also occur in small amounts naturally and can enter into aquatic system through leaching of rocks, airborne dust, forest fires and vegetation (Fernandez and Olalla, 2000). Since it is impossible to degrade heavy metals, they are continuously being deposited and incorporated in water, sediment and aquatic organisms (Linnik and Zubenko), thus causing heavy metal pollution in water bodies.

In urban areas, the careless disposal of industrial effluents and other wastes in river and lakes may contribute greatly, to the poor quality of river water (Chindah *et al*., 2004; Emongore *et al*., 2005; Furtado *et al*., 1998 and Ugochukwu 2004). Among environmental pollutants, metals are of particular concern due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems (Censi *et al.,* 2006). Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology, to be toxic to living organisms (Storelli *et al.,* 2005). Bioaccumulation and magnification is capable of Leading to toxic level of these metals in fish even when the exposure is low. This work set out to investigate the concentration of *Tilapia zilli* in the rivers of North Central Nigeria.

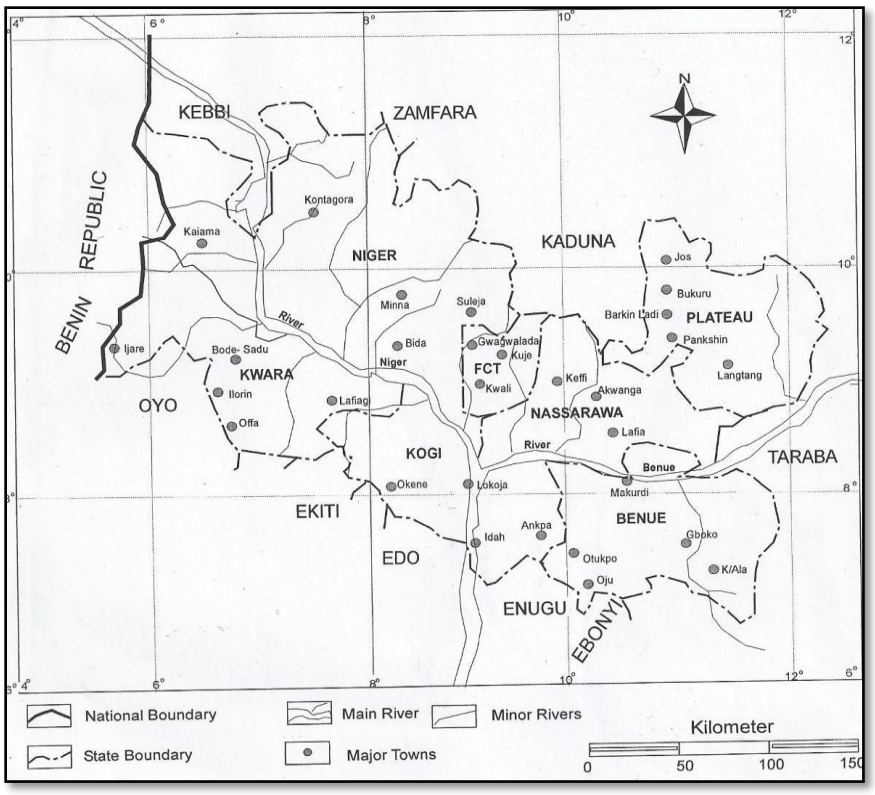

Figure 1: Map of North Central Nigeria Showing the Major and Minor Rivers.

Sample Collection

Samples (water and fish) were collected at the peak of both the dry (February-March) and wet season (August-September). Dugout canoes with paddles were used for sampling from the stations. Fish samples were collected using gill nets, baited hook and lines and traps. The fish samples were placed in plastic bags and stored in ice box and taken to the laboratory after cleaning with distilled water to remove any adhering dirt.

Sample Treatment

The fish samples after defrosting were dissected into gills, liver and muscle, using stainless steel dissection instruments, while wearing surgical gloves. After dissection, all tissue samples were separately oven-dried at 105 ^{o}C to constant weight and were each ground to powder. 1 gram of each powdered sample was digested using a mixture of 1.5.1, 70% perchloric, conc. nitric and conc. sulphuric acid at 80 $\pm$ 5 ^{o}C in a fume chamber, until colourless liquid was obtained.

Stock Solutions

Cadmium: 1.000 g of cadmium metal was dissolved in 20 ml of 1+1 HCl and then diluted to 1000 mL to make 1000 mgL^{-1} Cd stock solution. An intermediate stock solution of 100 mgL^{-1} Cd was made from the stock solution and a series of working standards of the following concentrations were prepared: 0.0, 0.5, 1.0, 2.0, 3.0, 5.0 mgL^{-1} Cd. The absorbance was determined on AAS and wavelength set at 228.9 nm.

Chromium: 2.828 g of anhydrous potassium dichromate ($K_2Cr_2O_7$) was dissolved in 200 mL distilled water and 1.5 mL concentrated HNO_3 was added and then diluted to 1000 mL with distilled water to make 1000 mgL^{-1} Cr. An intermediate stock solution of 100 mgL^{-1} Cr was made from the stock solution and a series of working standards of the following concentrations were prepared: 0.0, 0.5, 1.0, 2.0, 3.0, 5.0 mg L^{-1} Cr. The absorbance was determined on AAS and wavelength set at 357.9 nm.

Manganese 1.000 g of manganese metal is dissolved in 50 mL of conc. HCl. The solution was then made up to 1L in a volumetric flask with distilled deionized water

Nickel: 1.000 g of nickel is dissolved in 20 mL of conc. HNO_3. The solution was diluted to 1L in a volumetric flask with distilled deionized water.

Lead: 1.598 g of lead nitrate $Pb(NO_3)_2$ was dissolved in 200 ml distilled water and 1.5 ml concentrated HNO_3 was added and then diluted to 1000 mL to make 1 000 mgL^{-1} Pb. An intermediate stock solution of 100 mgL^{-1} Pb was made

from the stock solution and a series of working standards of the following concentrations were prepared: 0.0, 0.5, 1.0, 2.0, 3.0, 5.0, mgL^{-1} Pb. The absorbance was determined on AAS and wavelength set at 283.7 nm (APHA, 1990).

Instrumentation: The measurements were performed using the Perkin Elmer® Analyst 400 atomic absorption spectrophotometer (PerkinElmer, Inc. Shelton, CT, USA) equipped with WinLab32™ for AA version software, which featured all the tools needed to analyze samples, report and archive data and ensure regulatory compliance. PerkinElmer high efficiency double beam optical system and solid–state deuterium background correction eliminates most interference. A PerkinElmer corrosion – resistant nebulizer, which can be used for solutions containing HF, was used for all the flame absorption measurements. A single slot air-acetylene 10cm burner head was used for all air-acetylene experiments.

Table 1: Elemental concentrations in organs of *Tilapia zilli* (mg/L) during the wet season

	Gill					Liver					Muscle				
	Cd	Cr	Mn	Ni	Pb	Cd	Cr	Mn	Ni	Pb	Cd	Cr	Mn	Ni	Pb
A	3.1	0.9	1.4	3.0	12.0	0.8	5.4	13.3	2.9	11.1	0.3	7.0	23.6	5.0	13.2
B	0.3	8.7	79.5	9.4	7.0	5.8	22.3	31.1	2.8	13.4	0.1	4.5	22.3	0.9	12.6
C	0.7	13.1	17.6	1.3	0.7	2.8	25.5	26.3	11.6	1.2	3.8	18.3	5.3	3.6	4.4
D	0.0	31.8	94.4	6.6	4.1	15.1	9.3	11.9	2.2	14.2	8.7	4.9	27.7	0.5	0.4
E	10.8	40.2	70.4	12.6	0.7	18.2	4.6	31.4	1.7	13.2	1.6	4.8	3.0	12.2	4.2
F	13.0	20.2	8.2	2.1	12.1	1.6	26.7	27.6	14.0	6.9	11.6	2.4	30.8	0.9	4.4
G	2.6	9.7	171.5	10.6	14.4	0.2	7.8	435.1	4.5	12.0	0.5	5.2	40.3	10.8	1.1
H	2.1	7.7	165.3	1.6	6.4	0.7	16.6	220.4	0.8	3.4	0.8	26.4	12.8	0.9	12.6
I	1.5	17.1	12.8	1.3	15.2	0.5	6.9	24.6	0.7	25.4	0.6	6.9	28.4	1.2	7.8
J	1.4	12.5	23.6	6.5	2.1	1.6	15.2	14.4	0.7	0.9	7.8	4.2	38.2	3.7	0.5
K	4.7	21.6	80.0	5.7	9.8	3.4	24.0	35.6	15.7	11.2	0.9	16.0	9.2	0.8	0.9
L	0.6	24.8	40.0	8.4	13.1	2.5	16.9	40.4	9.7	2.7	0.3	6.0	36.0	1.5	0.5

Table 2: Elemental concentrations in organs of *Tilapia zilli* (mg/L) during the dry season

	Gill					Liver					Muscle				
	Cd	Cr	Mn	Ni	Pb	Cd	Cr	Mn	Ni	Pb	Cd	Cr	Mn	Ni	Pb
M	2.5	10.5	112.1	7.3	0.1	13.0	26.6	142.4	16.7	15.1	2.0	1.2	11.0	1.2	16.8
N	5.3	27.9	178.1	1.1	13.4	2.2	0.9	66.8	17.4	13.5	1.4	22.1	11.0	1.4	7.0
O	2.8	28.4	5.2	1.8	1.0	3.8	23.0	68.2	21.4	7.0	1.4	11.9	16.2	1.2	14.2
P	1.5	20.5	6.4	12.3	4.5	0.8	25.1	18.4	7.8	41.4	6.0	17.3	12.0	3.7	6.7
Q	4.0	19.5	21.2	7.6	5.3	1.6	19.3	18.4	1.3	10.4	1.5	5.0	8.0	12.2	1.1
R	6.7	8.1	13.7	1.0	14.2	2.2	1.0	21.5	1.22	23.0	3.1	31.2	394.7	8.5	8.2
S	10.6	1.2	179.6	1.6	1.0	10.6	0.0	77.9	1.7	14.5	1.2	17.4	16.3	15.5	1.7
T	2.7	29.0	105.1	6.6	7.2	2.7	17.8	38.3	6.9	3.4	1.2	9.4	33.2	2.8	0.3
U	2.1	23.0	105.1	0.6	8.2	11.0	19.7	344.2	4.1	11.4	2.0	23.0	15.9	1.0	12.6
V	0.5	15.1	37.8	6.6	0.7	1.5	19.5	152.5	1.1	14.2	0.3	21.2	94.1	1.2	9.6
W	11.0	7.3	104.9	1.9	10.6	2.4	15.8	39.2	7.2	3.9	2.3	8.9	10.0	0.8	7.4
X	0.6	26.0	134.0	1.5	7.0	1.6	29.1	33.6	12.0	1.0	2.6	20.8	59.7	25.1	45.6

The concentrations of cadmium in the different organs of Tilapia during the wet season and dry season are as presented in Table 1 and 2 respectively. The maximum concentration of cadmium during the wet season (25.4 mg/kg) was detected in the muscle while the minimum 0.0 mg/kg was also in the muscle (Table 1), while the lowest and maximum detected concentrations of Cd during the dry were 0.3 mg/kg (muscle) and 13.0 mg/kg (gill) respectively Table 2.

Cadmium is a highly toxic non–essential heavy metal and it plays no role in biological process in living organisms. As a result, even in low concentration, cadmium could be harmful to living organisms (Tsui and Wang, 2004). The levels of Cd present in the selected organs of *T. zilli* may be due to agricultural activities in the investigated area (Ambedkar and Muniyan, 2011).

The maximum concentration of chromium during the wet season was 40.2 mg/kg while the minimum concentration was 0.1 mg/kg (muscle). However, the peak and least concentrations of chromium during the dry season were 31.2 mg/kg and 0.8 mg/kg respectively.

Chromium levels were above the WHO and FEPA standards limits of 0.15mg/kg for fish food. Cr plays an important role in glucose metabolism. Chromium bioaccumulation in fish has been implicated in impaired respiratory and osmoregulatory functions through structural damage to gill epithelium [Heath, 1991].The concentration of chromium levels in the different organs of the freshwater fish and their presence could be linked to waste water discharge from the agricultural related activities that are prevalent in the investigated areas.

The concentrations of Mn were highest in all the organs investigated. The maximum concentration of Mn during the wet season (435.1 mg/kg) was detected in the gill while the minimum 1.4 mg/kg was also in the gill (Table 1), while the lowest and maximum detected concentrations of Mn during the dry were 344.2 mg/kg (liver) and 5.2 mg/kg (gill) respectively (Table 2).

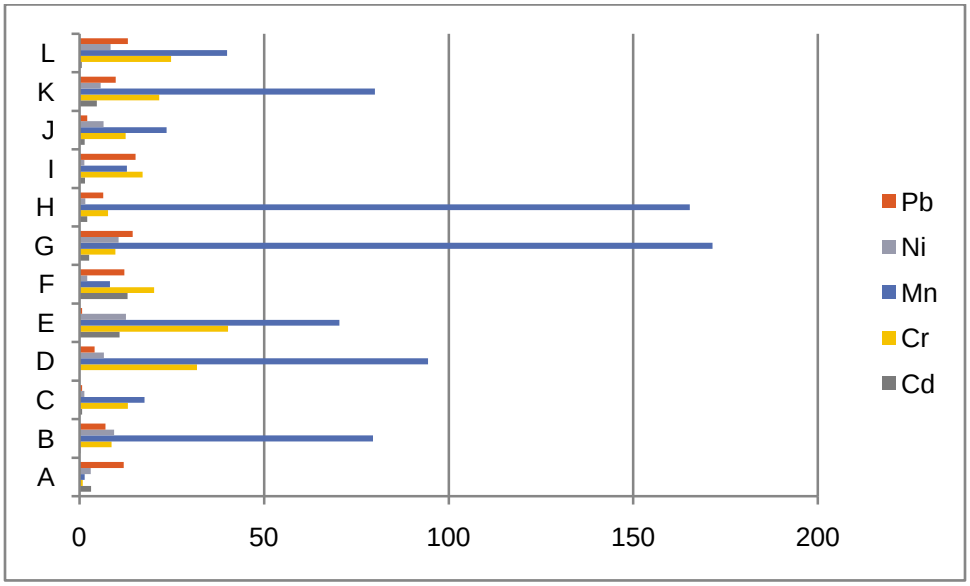

Figure 2: Concentration of heavy metals in gills during the wet season

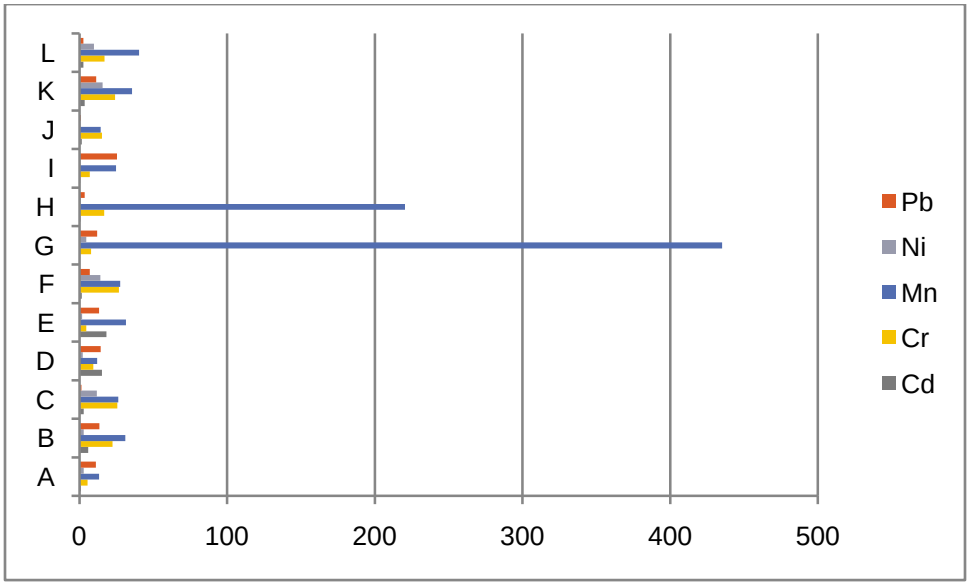

Figure 3: Concentration of heavy metals in liver during the wet season

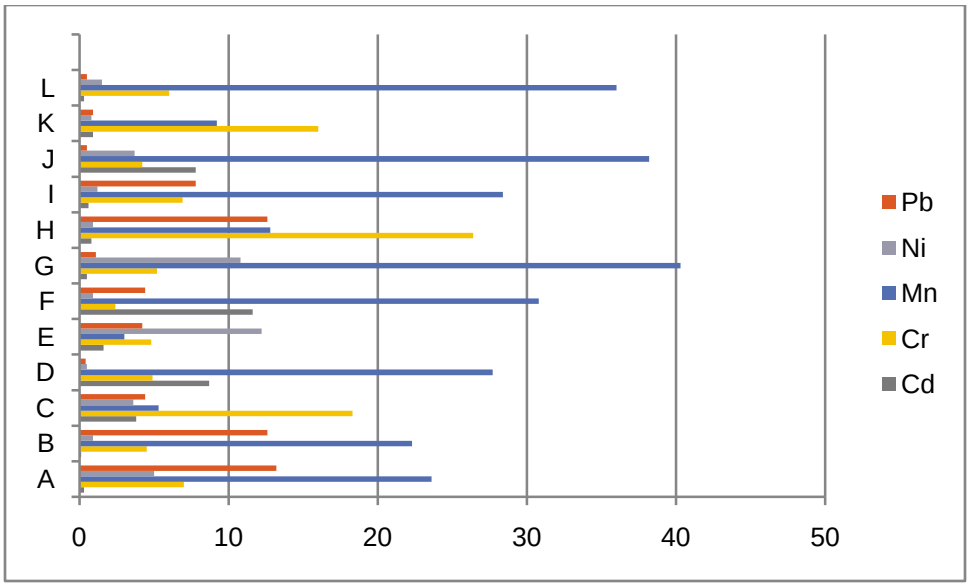

Figure 4: Concentration of heavy metals in muscle during the wet season

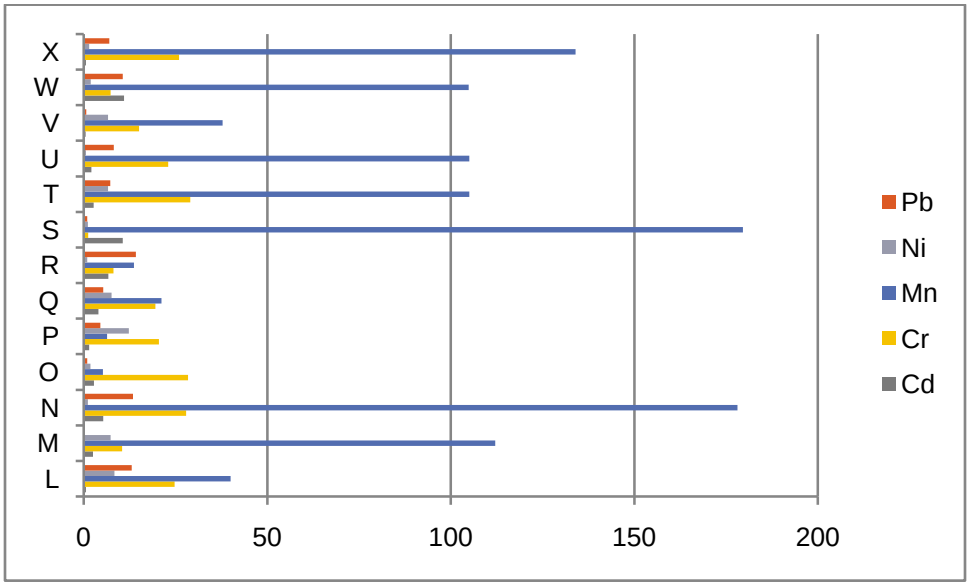

Figure 5: Concentration of heavy metals in gills during the dry season

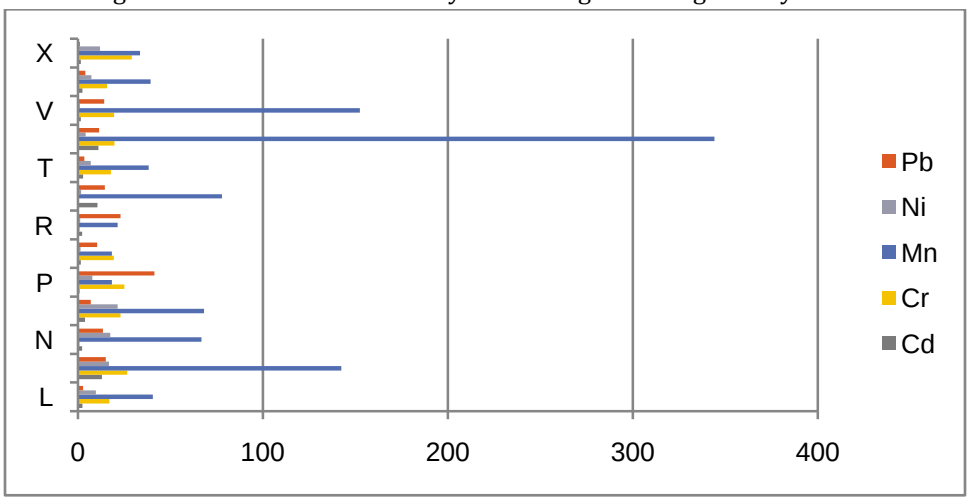

Figure 6: Concentration of heavy metals in liver during the dry season

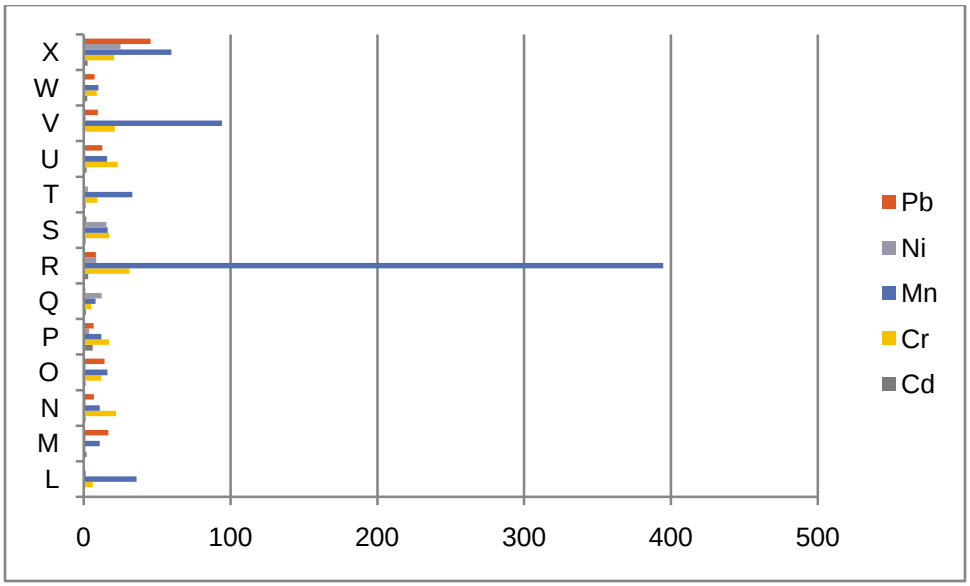

Figure 7: Concentration of heavy metals in muscle during the dry season

The highest reported concentration of nickel during the wet season was 15.7 mg/kg (liver) while the least concentration was 0.5 mg/kg (liver). The maximum and minimum concentrations of nickel during the dry season were 25.1 mg/kg and 0.6 mg/kg respectively.

The health effects of manganese exposure in humans are not well understood. Although dietary

manganese is an essential nutrient, high intake of manganese have been shown to be toxic (Institute of Medicine Food and Nutrition Board 2002). Manganese is best characterized asneurotoxin, occupational exposures are associated with characteristic syndrome called manganism which involves both psychiatric symptoms and Parkinsonism features (Dobson, *et al.,* 2004).

The maximum concentration of Pb during the wet season (25.4 mg/kg) was detected in the liver while the minimum 0.4 mg/kg was in the muscle, while the lowest and highest detected concentrations of Pb during the dry season were 0.1 mg/kg (gill) and 45.6 mg/kg (muscle) respectively.

The estimated maximum guideline (USFDA, 1993b) for Ni is 70-80 mg/kg. Thus the concentrations of Ni in all the samples were far below the stipulated limit. The major source of Ni for humans is food and uptake from natural sources, as well as food processing. Increased incidence of cancer of the lung and nasal cavity caused by high intake of Ni has been also been reported in workers in Ni smelters.

Lead is a well-known toxicant that has several deleterious effects even at very low concentrations (Eneji *et al.*, 2011). the maximum tolerable limit (MTL) of Pb in fish meat is 0.4 mg/kg, whereas in the European Union it is 0.2 mg/kg (European Commission, 2000). It is highly toxic to aquatic organisms, especially fish and the biological effects of sublethal concentrations of lead include delayed embryonic development, suppressed reproduction, and growth inhibition, elevated mucous formation, neurological problems, and kidney dysfunction (Rompala, *et al.,* 1984, Leland and Kuwabara. 1985).

The pattern of metal concentration in *Tilapia zilli* was Mn>Cr > Pb > Ni > Cd during both the wet and dry seasons. On the other hand, the concentration of heavy metals in the organs were Cd: liver>gills>muscle, Cr: gills>liver>muscle, Mn: liver>gills>muscle, Ni: gills>liver>muscle, Pb: liver>gills>muscle, during the wet season while the pattern for Cd, Cr and Mn was liver>gills>muscle but for Ni and Pb it was liver>muscle>gills.

Conclusion

Heavy metals have been proven to undergo bioaccumulation in the tissue of aquatic organisms. On consumption of fish and other aquatic organisms these metals could climb up the food chain to man. It can be seen that the fishes in these Rivers have been severely affected by heavy metals based on the results obtained from this study (Cd, Mn and Pb) and pose serious health implications for human consumption. The study also reveals that the heavy metals concentrations in the fish species are not sensitive to the seasonal changes as heavy metals are lost slowly or not at all once bioaccumulated.

REFERENCES

[1]. Ambedkar G., Muniyan M. (2011). Bioaccumulation of some heavy metal on the five freshwater fish from kollidam River, Tamilnadu India. *Advan in appl Scis Res* 2 (5):221-225.

[2]. APHA (1990), Standard Methods for the Examination of water and wastewater, 17th edition, New York.

[3]. Censi, P, Spoto S. E., Saiano F, Sprovieri M, and Mazzola S, 2006. Heavy metals in coastal water system. A case study from the North Western Gulf of Thailand. *Chemosphere*. 64: 1167-1176.

[4]. Chindah A.C., Braide A.S., Sibeuda O.C. (2004). Distribution of hydro-carbons and heavy metals in sediment and a crustacean [shrimps – notialis] from the bonney / new Calabar river estuary, Niger Delta; *Ajeam – Ragee*, 9, 1-14. Day, Fishes of India 1978. Today and Tomorrow's book Agency New Delhi Volume-II.

[5]. Dobson, A.W., Erickson K.M., Aschner M., (2004). Manganese neurotoxicity. Ann NY Acad Sci., 1012: 115-128.

[6]. Ebrahimpour M., Mushrifah I. (2008) Heavy metal concentrations in water and sediments in Tasik Chini, a fresh water lake, Malaysia. *Environmental Monitoring and Assessment* 141: 297–307.

[7]. Emongore V., Kealotswe E, S.Sankwasa Keikanetswe S. (2005). Pollution indicators in Gaborone Industrial effluents. J*. Appl. Sci.*, 5 147-150.

[8]. European Commission (2000). Amending Commission Regulation (EC) No 194/97. Brussels, pp.2–28.

[9]. FEPA (Federal Environmental Protection Agency) (2003). Guidelines and standards for Environmental Pollution Control in Nigeria, 238pp.

[10]. Fernandez L.G and Olalla H.Y. (2000). "Toxicity and bioaccumulation of lead and cadmium in marine protozoan communities", *Ecotoxicology and Environmental Safety*, vol. 47, pp. 266-276, 2000.

[11]. Furtado A.A.L, Albuquerque Leite R.T Leite S.G, Pecanha F. R.P (1998). Effect of hydraulic retention Time on nitrification in an airlift Biological reactor. *Brazilian J. Chemical engineering*, 15 pp. 1-7.

[12]. Heath A.G (1991).Water pollution and fish physiology. Lewis publishers. Boca Raton, Florida, USA 35pp.

[13]. Ishaq S. E., Sha'Ato R., and Annune P. A. (2011). Bioaccumulation of Heavy Metals in Fish (*Tilapia Zilli* and *Clarias Gariepinus)* Organs from River Benue, North Central Nigeria. *Pak. J. Anal. Environ. Chem.* Vol. 12, No. 1 & 2 pp 25-31.

[14]. Leland, H.V. and J. S. Kuwabara (1985). Trace metals. G. M. Rand and S. R. Petrocelli, eds. Fundamentals of aquatic toxicology Hemisphere Publ. Co. New York, pages 374-415.

[15]. Linnik, P. M.; Zubenko, I. B., (2000). Role of bottom sediments in the secondary pollution of aquatic environments by heavy metal compounds. Lakes and Reservoirs. Res. Manag., 5 (1), 11-21.

[16]. Mansouri B., Baramaki R., and Ebrahimpour M. (2012). Acute toxicity bioassay of mercury and silver on Capoeta fusca (black fish). Toxicology and Industrial Health 28(5): 393–398.

[17]. Rezaee K., Saraee E., Abdi M.R., Naghavi K., Saion E., Shafaei M.A. (2011) Distribution of heavy metals in surface sediments from the South China Sea ecosystem, Malaysia.

[18]. Environmental Monitoring and Assessment 183(1–4): 545–554.

[19]. Salati S., Moore F. (2010) Assessment of heavy metal concentration in the Khoshk River water and sediment, Shiraz, Southwest Iran. *Environmental Monitoring and Assessment* 164: 677–689.

[20]. Storelli M.M., A, Storelli R.D., Morano. R. B. and Marcotrigiano G.O. (2005). Trace Elements in loggerhead turtles *(Caretta caretta)* from the Eastern Mediterranean: *Overview and Evaluation Environ. Pollute 135*: 163-170.

[21]. Tsui M. T. K. and Wang W.V. (2004). Uptake and elimination routes of inorganic mercury and methyl mercury in Daphnia manga. *Environ. Sci. Tecno*. 38, 808-816.

[22]. USFDA (1993b). Food and drug administration, Guidance document for nickel in shell fish. DHHS/PHS/FDA/CFSAN/office of seafood, Washington D.C.

[23]. WHO (World Health Organization) 1985). Guidelines for drinking water quality.Vol.1.Recomentations, WHO Geneva.130pp.