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Full Length Research Paper

Heavy metal concentration in some fishes (*Chrysichthys nigrodigitatus, Clarias gariepinus and Oreochromis niloticus*) in the Great Kwa River, Cross River State, Nigeria

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Heavy metal concentration in the tissues of three important food fishes namely: *Chrysichthys nigrodigitatus, Clarias gariepinus* and *Oreochromis niloticus* were investigated. This was aimed at finding their fitness for consumption become fish is usually at the apex of aquatic food chain capable of bioaccumulating heavy metals. Specimens were purchased once a month from the local fishers at Ekpene Esuk Essighi and Esuk Mba landing sites. Gills, kidney, liver, stomach and muscles were washed and oven dried at 105 ^{0}C until constant weight. Heavy metals concentrations were obtained spectophotometrically using Perkin-Elmer Analyst 300 Atomic Absorption spectroscopy (AAS). A one way Analysis of variance (ANOVA) was used to test the difference in concentrations of heavy metals in the different tissues. Differences in means were separated by the use of Duncan's multiple range tests (DMRT). In Chrysichthys, zinc was highest in stomach (177.70±1.48 mg/kg) and lowest in muscle (32.37±1.00 mg/kg) Chromium was not detected in muscle but highest in gills (0.34±0.01 mg/kg). Cadmium ranged from 0.004±0.001 mg/kg in muscle to 0.02 in kidney. Nickel was 0.00±0.00 mg/kg in kidney to 0.012±0.001 mg/kg in liver. Lead was high in the gills of *Chrysichthys. Clarias* has the highest concentration of zinc in gut (99.43± 0.87 mg/kg and lowest in muscle. Chromium and Nickel were the least concentrated metal in tissues of Clarias. Cadmium was high in the gills (0.06±0.01 mg/kg) and lowest in muscle (0.002±0.001 mg/kg). Lead had the highest concentration in gills (0.044±0.014 mg/kg) and 0.001±0.001 mg/kg in muscle. In *Oreochromis*, lowest zinc was in muscle (28.41±0.58 mg/kg) highest in kidney (66.48± 0.002 mg/kg) Chromium was not detected in any tissue. Cadmium was found in gills (0.002±0.001mg/kg), kidney (0.05±0.001 mg/kg) and liver (0.273±0.01mg/kg). Nickel was found in liver in trace amount only. Lead was not present in muscle but highest in gills (0.213±0.025 mg/kg). Of all the tissues, muscle was the one with least concentration of metals. These concentrations were allowable in food fish.

Keywords*:* *Chrysichthys, Clarias, Oreochromis*, Heavy metals, Great Kwa River.

INTRODUCTION

Heavy metals are those metallic elements with high atomic weight that is at least five times greater than that of water. Several elements have been listed in this group. The presence of heavy metals in the aquatic environment in trace concentration is important for normal development of the organisms (Kori-Siakpere and Ubogu, 2008). They could be detected in the aqueous medium

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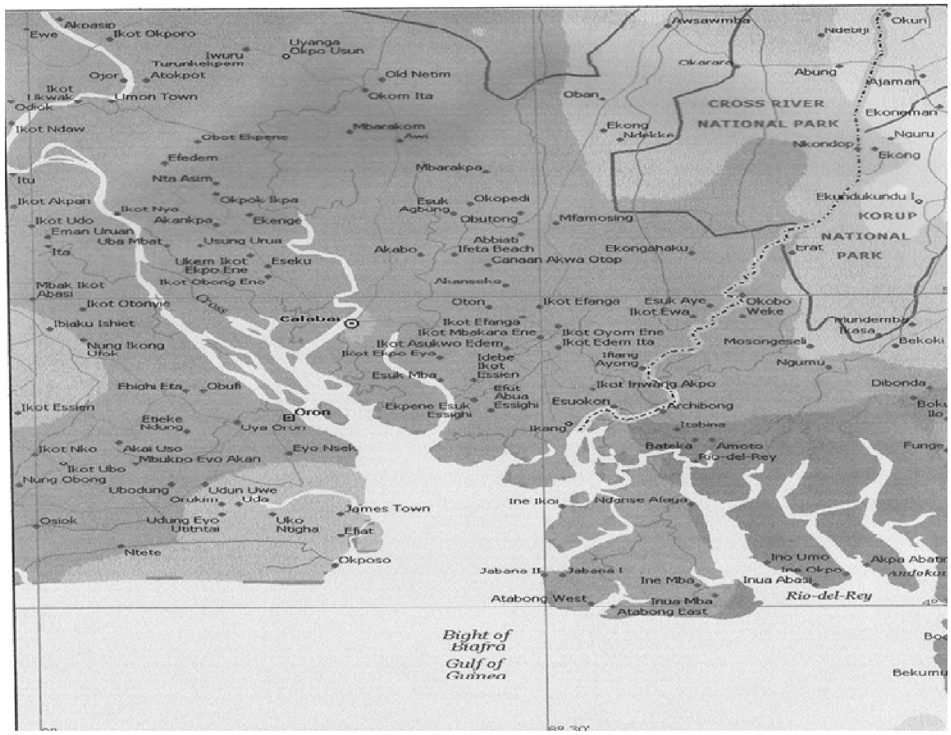

Figure 1. Map of Calabar showing study area, Nigeria
Source: Microsoft Ecarta, 2009

and in the bottom. Some however, are completely deleterious and need to be monitored continuously in the bodies of organisms as they are capable of bioaccumulation (entilator ations), resulting to morbidity and often mortality of organisms (Ayotunde *et al.*, 2011 and 2012; and Ada, et al., 2012). Heavy metal human health concern has stimulated a lot of research in this area. Some of which include the works of Muchuweti *et al.,* (2006), Satarug *et al.* (2000) and Adefemi *et al.* (2012),

When metals enter aquatic environment, a great portion settles and is absorbed by the bottom mud (Ayotunde, 2012). They could be recycled by chemical, physical and biological processes such that some quantity remains dissolved in the water column and some part is being absorbed by the inhabitants (Rayms-Keller *et al.*, 1998 and Kori-Siakpere and Ubogu, 2008). Fishes are at the apex of the food chain and can bioaccumulate some of these substances into their tissues (Olaifa *et al.,* 2004).

Kori-Siakpere and Ubogu, (2008) observed decreased haematological parameter values and haemodilution in fish exposed to sub lethal concentration of Zinc for 15days. They explained that Zinc accumulates in gills of fish and it is an indication of depressive effect on respiration in tissues. It may lead to death due to hypoxia, reduced hatchability of eggs, changes in entilator heart physiology and general change in fish behaviours such as lack of balance, agitated swimming, air gulping, period of quiescence and death.

Some heavy metals are not biodegradable and can continue to be accumulated in the tissue of organisms until they reach intolerable levels resulting in morbidity or mortality (Offem and Ayotunde, 2008). Man being higher in the food chain stands the result of higher bioaccumulation. The dangers of heavy metal have been long noted, but the symptoms are poorly diagnosed and patients could be treated for some other illnesses thereby aggravating heavy metal pollution problems of man (Kaye *et al.*, 2002 and Nolan, 2003).

The fish species under investigation are important sources of animal protein in human diet. They form a significant percentage of captured fish in the Great Kwa River South Eastern Nigeria, and are consumed in great quantities by the local duelers. This study was aimed at investigating the concentration of the some metals namely, Lead (Pb), Cadmium (Cd), Zinc (Zn), Chromium (Cr) and Nickel (Ni) in *Chrysichthys nigrodigitatus, Clarias gariepinus* and *Oreochromis niloticus* obtained from the Great Kwa River with a view to having an insight into the pollution status of the river and ascertaining the suitability or otherwise, of the fish for human consumption.

MATERIALS AND METHODS

Great Kwa River is a tributary of Cross River and empties into it just before they supply their water to Calabar

Table 1. Showing the means concentrations of Zinc in the different tissues of *Chrysichthys nigrodigitatus, Clarias gariepinus and Oreochromis niloticus* in Great Kwa River. Means bearing superscripts that are the same letters are statistically not significantly different while those bearing different letters are significantly different ($p < 0.05$).

Tissue	Chrisichthys nigodigitatus	Clarias gariepinus	Oreochromis niloticus
Gills	83.988^{b}	91.367^{b}	65.789^{ab}
	±1.392	±0.568	±2.000
Kidney	69.377^{d}	70.889^{d}	66.476^{a}
	±1.011	±0.866	±0.002
Liver	78.703^{c}	73.715^{c}	$63..274^{ab}$
	±1.554	±0.662	±1.00
Stomach	177.766^{a}	99.426^{a}	60.003^{b}
	±1.408	±0.516	±0.667
Muscle	32.365^{e}	47.338^{e}	28.412^{c}
	±1.001	±0.572	±0.577

Estuary at the Atlantic Ocean. It situates in Calabar between latitude 4^{0} 15″ and 5^{0} N and longitude 8^{0} and 8^{0} 30″ E. Unlike other parts of the state, the climate of Calabar is characterised by a long wet season of between April and October each year (nine months per year), while the dry season last for the remaining part of the year. Its basin includes the Oban Hills (part of the Cross River National Park) and the eastern part of Calabar city. The Cross River National Park is made of heavy rain forest formation.

Specimens were purchased once a month from the local fishers. Samples were collected at Ekpene Esuk Essighi and Esuk Mba landing sites. Samples from the two sites were pooled together to give average values. (Figure 1)

Specimens were washed and dissected to remove gills, kidney, liver, stomach and muscles, which were thoroughly washed and placed in labelled plastic bottles rinsed with nitric acid. The tissues were oven dried at 105 ^{0}C until constant weight was obtained after which they were grinded with laboratory mortar and pistil. They were kept in a furnace for fours hour at a temperature of 550^{0} C and later digested in tri acid mixture (HNO_3: $HClO_4$: H_2SO_4 in the ratio of 10 : 4 ; 1) in the proportion of 10 sample : 1 acid portions. Digestion was carried out at a temperature of 100^{0}C until mixture became clear (AOAC, 2002). Mixture was filtered through 54 µm millipore Whitmann's filter paper. The volume was made to 100 cm^3 (Ada *et al*., 2012) by adding distilled water. Heavy metals concentrations were obtained spectophotometrically using Perkin-Elmer Analyst 300 Atomic Absorption spectroscopy (AAS). A one way Analysis of variance (ANOVA) was used to test the difference in concentrations of heavy metals in the different tissues. Differences in means were separated by the use of Duncan's multiple range tests (DMRT).

RESULTS

Zinc was observed to be highly concentrated up to 177 mg /Kg in the stomach of *Chrysichthys nigrodigitatus*. It was observed that heavy metal concentration in *Chrysichthys* was high compared to *Oreochromis* particularly. *Oreochromis* had less concentration of Zinc in tissues ($p < 0.05$) compared to the siluriformes (*Clarias* and *Chrysichthys)*. In *Chrysichthys*, Lead was observed to be higher in all the tissue except in the muscles. The stomach of *Clarias* also had higher concentrations of Zinc compared to the same organs in *Oreochromis.* See Table 1. (Figure 2, 3, 4 and 5)

DISCUSSION

Some substances are poisons at certain concentrations. Those that are poisonous at low concentration (such as some heavy metals) are the ones that have actually been classified as poisons. All chemical substances have one thing in common, that they could be used safely at recommended concentrations and procedures (Akobundu, 1978). Toxicity is defined as the adverse effect caused by the interference of specific agent to the structure and/or processes which are essential for the survival and proliferation of a particular organism (Chinalia *et al.,* 2007). The toxicity of a substance is a function of concentration and duration of exposure of an organism to the toxicant (Ogundele *et al*., 2004).

Hydrogen ion concentration (pH) can influence the soluble form of metal in aquatic system. Solubility of metals in water and pH has inverse relationship. This is because low pH favours hydrogen ions in the competition between metals and hydrogen ions for binding sites in solution. Hydrogen ions compete favourably for these sites, thereby releasing the heavy metals into the water system. Physical disturbance also releases heavy metals

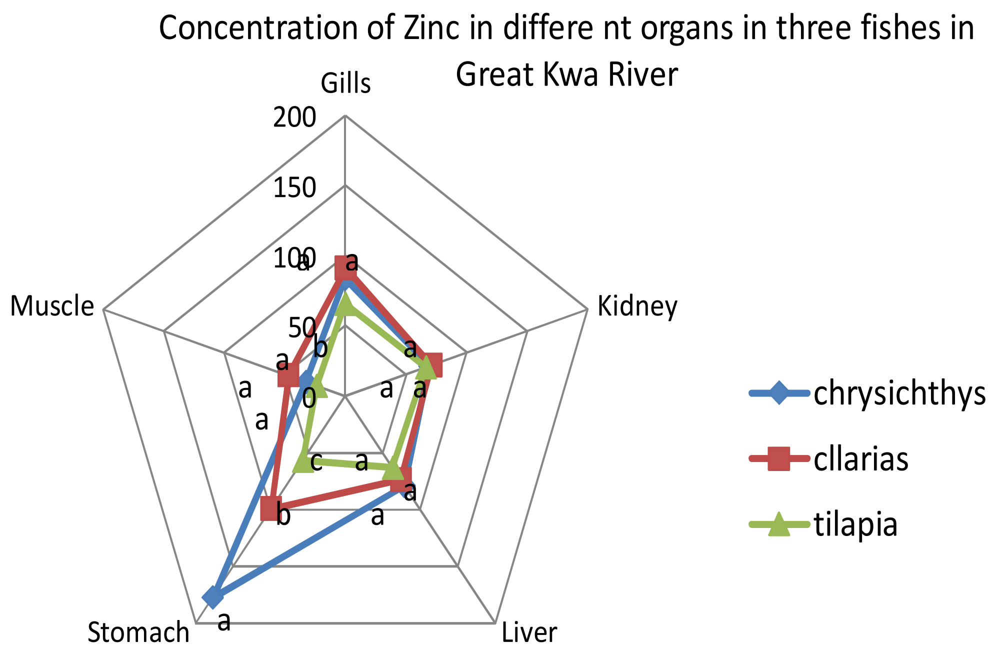

Figure 2. Concentration of Zinc in different tissues of three fishes, *Chrysichthhys nigrodigitatus, Clarias gariepinus* and *Oreochromis niloticus* in Great Kwa River.Same letters on the same axis showing a particular organ represent insignificant difference in concentration of Zinc in that organ (eg. liver, kidney and muscle) in the three fishes. Different letters represent significant differences in concentrations of Zinc in the three fishes as observed in the stomach and gills of the three fishes. Means carrying same letters are statistically the same while those carrying different letters are statistically different ($p < 0.05$)

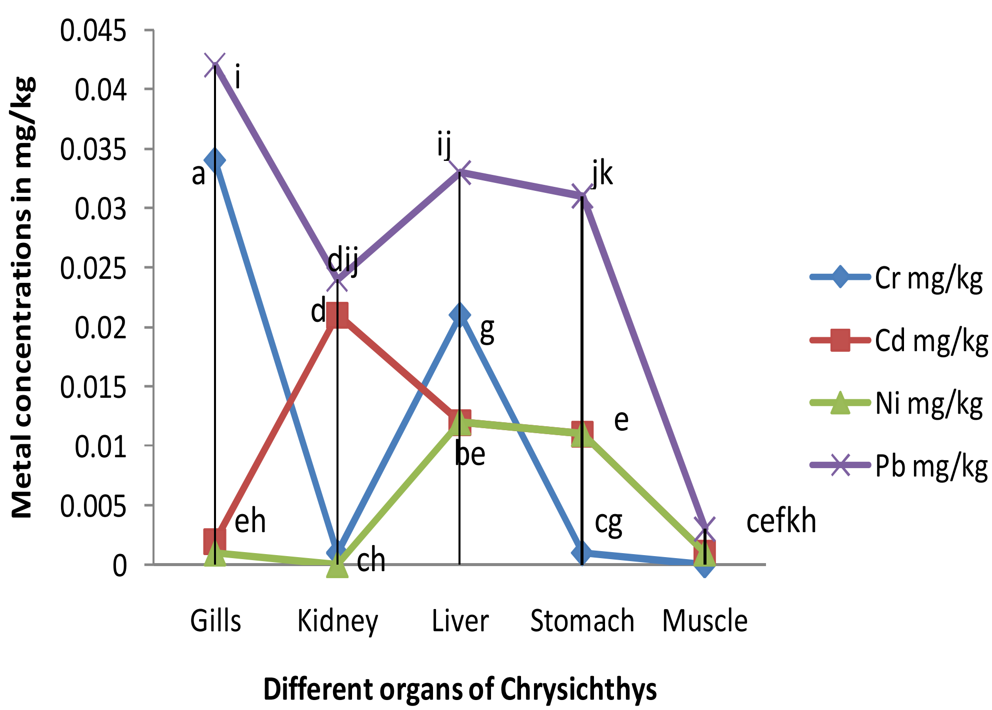

Figure 3. The concentrations of Cr (a - c), Cd (d - g), Ni (h - g) and Pb (I - k) in the tissues of *Chrysichthys nigrodigitatus*. For a particular metal, letters which are the same show that there were no significant difference between the mean concentrations in the metals in the different tissues while different letters show that there were significant differences between the mean concentration of the various metals in the tissues ($p < 0.05$).

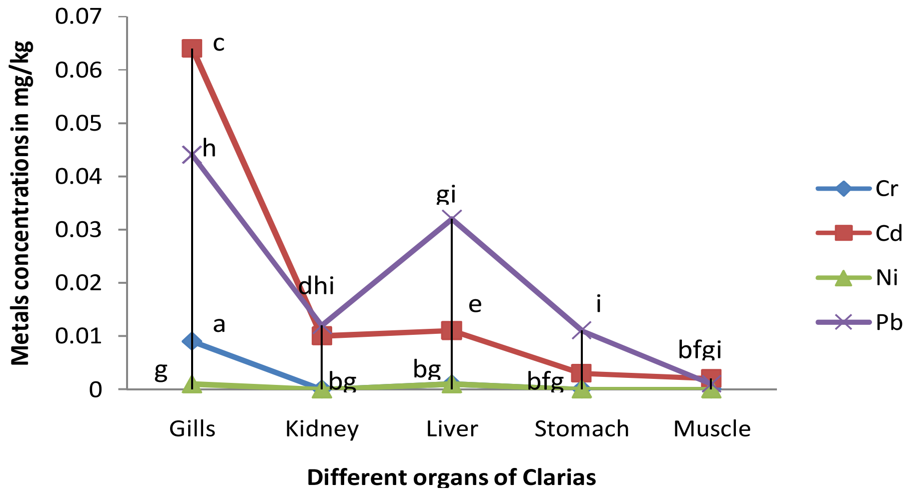

Figure 4. Showing the concentrations of Cr (a - b), Cd (c - f), Ni (g) and Pb (h -i) in the tissues of *Clarias gariepinus*. The same letters for a particular metal in the tissues were the same while different letters show that the mean concentrations were significantly different in different tissues (p < 0.05).

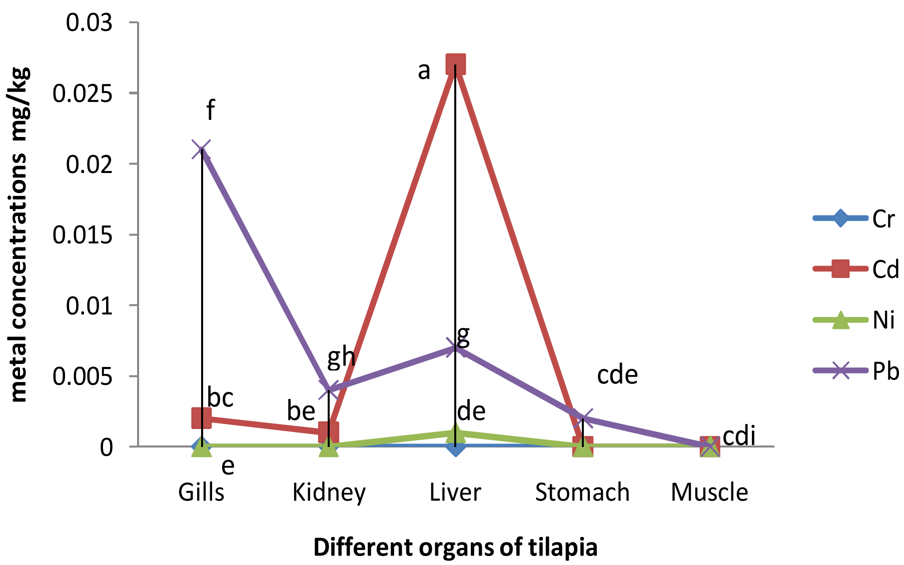

Figure 5. Showing the concentrations of Cr (not detected), Cd (a - c), Ni (d - e) and Pb (f - i) in tissues of *Oreochomis*. Similar superscripts show that mean concentration of metals are not significantly different, while dissimilar superscripts show that the means are significantly different (p < 0.05).

into the water body (Idodo and Oronseye, 2006) from the bottom. The catfishes may have higher concentration of metals due possibly to their age compare to *Oreochromis*, omnivorous feeding habits and their benthic life style. Heavy metals could bio-accumulate with age (National Library of Medicine, 2010, Shallangwa and Auta, 2008, Mahonia Ecological Consulting, 2005). The highest concentration of Cadmium (0.006 mg/kg body weight) observed in the gills of *Clarias* was higher than the concentration allowable by World Health Organisation (WHO, 1985) of 0.005 mg/kg body weight but lower than that of Federal Environmental Protection Agency of Nigeria (FEPA, 2003) < 1.0 mg/kg body weight and United State Environmental protection Agency (USEPA, 1987) of 0.008 mg/kg body weight

(Ayotunde *et al.*, 2011 and 2012 and Ada *et al.*, 2012). According to Lawrence *et al.* (2009) the accumulation of organic contaminants in the tissue of aquatic organisms is a complex function of the physic-chemical properties of the contaminants, its distributions in the aquatic system, the feeding behaviours and metabolism of the aquatic organism.

These metals have health implication for example; Cadmium (Cd) causes high blood pressure, kidney and liver damage, destruction of testicular tissues and red blood cells leading to haemodilution (Tort and Torres, 1988, in Kori-Siakpere and Ubogu, 2008). Other effects include cancer, bronchitis, osteomalacia, epithelium necrosis, inactivated enzymes, abnormal pains (Idodo and Oronseye, 2006). It leads to anaemia because it displaces iron in hemoglobin. Cadmium was less concentrated in tissues of *Oreochromis* possibly due to midstream to pelagic habitation. Cadmium was observed to be higher in surface water compared to ground water by Ada et al. (2012). It is a component of tyres, batteries and woody herbaceous materials (Svbodova, 1993). Because of this, it was found to be absorbed in bottom debris. The bottom dueling species are more likely to accumulate these metal elements due to their proximity to the bottom. The higher concentration of Zinc in the siluriformes than in the cichlid could be explained from the fact that most of these metals are more concentrated in the bottom of water.

Lead (Pb) causes loss of appetite, nausea, abdominal cramps, anaemia, kidney infection (nephritis), brain damage and mental deficiencies. In *Dapnia magna* and Cyclops, Ofem and Ayotunde (2008) observed that Lead produce spiral movement, change in colour and rapid disintegration of the skin. The concentration of Lead which could invoke these symptoms was 0.19 mg/kg for Daphnia and 0.3 mg/kg for Cyclops.

The concentration of metals in the water column and in the bodies of organisms is influenced by the amount of rainfall (Idodo and Oronseye, 2006; and Larwal-Are and Kusemiju, 2006) due to dilution. Kori-Siakpere and Ubogu (2008) explained that the muscle of fish is a water exchange tissue with the blood. Different metals could use this to cause haemodilution or haemoconcentration. The concentration of metals in animal bodies is also influenced by age of the animal in that environment. The presence of these pollutants in the environment should not necessarily cause panic because; their accumulation in the animal bodies also depends on feeding and migratory habit of the organism (Larwal-Are and Kusemiju, 2006). But Vrhovnik *et al*. (2012) pointed out that metals which are bind to sediments are bio available for accumulation in animals bodies. This may be the reason why these metals were higher in the catfishes (Siluriformes) with benthic habits. Tilapia also has a shorter life span compared to the catfishes and lower in the trophic level. Biomagnifications of metals is expected in the animals which are higher in the trophic level as well as higher longevity.

Chromium was not detected in the kidney, stomach, and liver of *Clarias*. This shows that the route of intake of chromium may not be via the gut. It was found in the gills and liver in less quantities ($p<0.05$). This pattern of concentration was equally observed in C*hrysicthys nigrodigitatus* and *Oreochromis niloticus* to further strengthen the suggestion that route of chromium intake is via gills and skin rather than gut. Ikem et al. (2003) suggested that the higher concentration of trace elements such as lead and Cadmium in the liver is due to the presence of matallothionein protein, which bind with these elements. Allen-Gill and Martynov's (1995) work supported this view when they pointed out that these binding proteins are lacking in muscle. The present work agrees with the earlier works as muscle recorded less concentration of the metals.

CONCLUSION

Heavy pollution problem is not new. Patients suffering from heavy metal poisoning are rarely diagnosed and are usually treated for other ailments. This usually aggravates the symptoms due to remediation. It is therefore important to constantly monitor our environment especially that which contain our food organisms. The investigation shows that no particular metal pose health problem because they diid not exceed allowable level in these fishes. However, it is agued that no level of heavy metal greater than zero could be regarded as safe. Especially man who can bio-accumulate them from his food over his life span.

REFERENCES

Ada FB, Ayotunde 0, Offem BO (2012). Surface and ground waters concentrations of metal elements in Central Cross River State, Nigeria, and their suitability for fish culture. Int. J. Environ. Sustainability1 (2): 9 – 20 http://www.sciencetarget.com/Journal/index.php/IJES

Adefemi OS. Ibigbami OA, Awokunmi EE (2012). Level of heavy metals in some edible plants collected from selected dumpsites in Ekiti State, Nigeria. Global Advanced Research Journal of Environmental Science and Toxicology 1(5): 132-136

Akobundu IO (1987). *Weed Science in the tropics: Principles & practices.* John Wily and sons ltd, New York. 522pp

Allen-Gill SM, VG Martynov (1995). Heavy metals burdens in nine species of freshwater and anadromous fish from the Pechora River, Northern Russia. Sci. Total Environ. 160-161: 653-659.

AOAC (2002). *Official Method of Analysis*, Association of Official Analytical Chemists, 19th ed. Maryland Chemists, USA

Ayotunde EO, Offem BO, Ada FB (2011). Heavy Metal profile of Cross River: Cross River State, Nigeria: Using Bioindicators Indian J. Animal Res. *45(4):* 232 – 246. 232 - 246. www www..ar arccjour ccjourccjournals.nals.com / indianjourindianjournals.nals.com

Ayotunde EO, Offem BO, Ada FB (2012). Assessment of Heavy Metal profile of Water, Sediment and Fresh water Cat Fish, *Chrysichthys nigrodigitatus* (Lecepede 1802), of Cross River, Cross River State, Nigeria. International Rev. Biol. Trop. (Int. J. Trop. Biol. ISSN-0034-7744) Vol. 60 (3):

Chinalia FA, Regali-Seleghin MH, Correa EM (2007). Terrestrial and Aquatic Environmental Toxicity. *Global Science Books 1(2):* 24 – 33

Federal Environmental Protection Agency (FEPA) (2003). *Guidelines and Standards for Environmental Pollution Control in Nigeria*, Nigeria

Idodo-Umeh G, Oronseye JAO (2006). Heavy Metal Pollution in Ololomoro, Niger Delta, Nigeria. *Journal of Fisheries, 2/3(2): 267 – 279.*

Ikem A, NO Egiebor, K Nyavor (2003). Trace elements in water, fish and sediments from Tuskegee lake, Southeastern USA. Water Air

Soil. Pollut. 149: 51-75.

Kaye P, Young H, O'Sullivan I (2002). "Metal fume fever: a case report and review of the literature", *Emergency Medicine Journal*, Vol. 19 No. 3, pp. 268 – 269

Kori-Siakpere D, Ubogu E (2008). Sub lethal haematological Effects of Zinc on the fresh water fish, *Heteroclarias sp. (Osteichthyes: Claridae). African Journal of Biotechnology, 7(12): 2068 – 2073*

Larwal-Are AO, Kusemiju K (2006). Trace Metal content in the Blue Crab, *Callinectes amnicula* (De Rocheborne) of Lagos Lagoon. Niger. J. Fisheries*, 23(2): 372 – 385*.

Lawrence E, Thomas I, Isioma T (2009). Distribution of Propoxur in water, sediment and fish from Warri River Niger Delta, Nigeria. Turkish J. Biochem. *34(3): 121 – 127.*

Mahonia Ecological Consulting (2005). Aquatic Herbicide Management Prescription. 59pp.

Microsoft Encarta Premium (2009). Map Comprehensive: Calabar, Nigeria.

Muchuwiti M, Birkett JW, Chinyanga E, Zvauya R, Scrimshaw MD, Lester JN (2006). Heavy metal content of vegetable irrigated with mixture of waste water and sewage sludge in Zimbabwe.Implications for human health. *Agriculture, Ecosystem and Environment.* 112: 41- 48.

National Library of Medicine HSDB Database (2010). *Mhtml:file://C:* 8/4/2010

Nolan K (2003). "Copper Toxicity Syndrome", *Journal of Orthomol. Psychiatry*, Vol. 12 No. 4, pp. 270-282

Offem BO, Ayotunde EO (2008). Toxicity of Lead to Fresh Water Invertebrates (Water fleas; *Dapnoia* and *Cyclop sp.)* in Fish Ponds in a Tropical Floodplain. *Water, Air Soil Pollution, Spinger Science*, 192: 39 – 46.

Ogundele O, Ihuahi JA, Omojowo FS, Bitrus P (2004). Toxicity of Linear Alkynbenzene Sulphonate (LAS) Detergent of *Clarias girepinus* Fingerlings. *In. the proceedings of the 19th Annual Conference of the Fisheries Society of Nigeria. 29th* November – 3rd December, 2004, held in Ilorin: 273 – 276

Olaifa FE, AK Olaifa, AA Adelaja, AG Owolabi (2004). Heavy Metal contamination of *Clarias gariepinus* from a lake and fish farm in Ibadan, Nigeria. Afr. J. Biomed. Res. 7: 145-14

Rayms-Keller A, Olson E, McGraw M, Oray C, Carison JO, Beaty BJ (1998). Effects of heavy metals on Aedes egypti (Diptruculicidea) lavae *Ecotoxicology and Environmental safety 39*: 41 – 47.

Satarug S, Haswell - Elkins MR, Moore MR (2000). Safe levels of cadmium intake to prevent renal toxicity of human subjects. British J. Nutr. 84: 791-802.

Shallangwa SM, Auta J (2008). Sub Lethal Effect of 2, 4 – Dichlorophenoxy Acetic Acid on Growth and Food Utilization of the African Cat Fish. *Bulletin of Fisheries International 3(3)*: 65 – 67.

Svobodova Z, Lloyd R, Machova J, Vykusova B (1993) water quality and fish health EIFAC Technical paper 54. 76pp.

Torr L, Tores P (1988). The Sub lethal Concentration of Cadmium on Haematological Parameters in Dog fish (*Scyliorhnus canicula).* J. fish Biol. *32.277 – 282*

USEPA (1987). *Quality Criteria for Water*, EPA Publication 440/5-86-001*,* US Government Printing Office, Washington D.C. USA

Vrhovnik P, Šmuc NR, Dolenec T, Serafimovski T, Dolenec M (2012). The distribution of Rare Earth Elements (REE) in surficial lake sediments before and after tailings dam failure (FYR Macedonia) Glo. Adv. Res. J. Environ. Sci. Toxicol. 1(5) : 97-109

World Health Organisation (WHO) (1985). *Guidelines for Drinking Water Quality (II),* Health Criteria and Supporting Information, WHO, Geneva, Switzerland