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Heavy Metal Accumulation in Fish of Ivo River, Ishiagu Nigeria

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Abstract: Heavy metal accumulation in fish from Ivo River at Ishiagu was carried out to assess the level of Pb and Zn concentrations. Five healthy fish were collected and divided into groups for this assessment using group (I) as the primary control. The other four groups (II-IV) were exposure to single and joint sublather concentration for 150 h and 17 days, respectively. The level of heavy metal concentrations in the selected fish were determined using Chromosomal Aberration Test (CAT) induced in the branchial arches or gill arches in the fish. From the result, the groups (II-IV) were significantly higher ($p<0.05$) than the control (I) in their chromosomal aberration abundance. While binary mixture of lead and zinc in equimolar concentration revealed significantly lower ($p<0.05$) incidence of chromosomal aberrations compared to group II-III containing the individual graded metal (lead and zinc) acting alone. Biological risk assessment based on chromosome morphology in aberration test revealed the mutagenicity of lead, zinc and their binary mixture. The single actions of the two metals were evidently observed to be significantly higher in toxicity than the equimolar mixture in chromosomal aberration abundance. There is high indication that lead and zinc would pose greater danger to health for the Ishiagu community if there is continuous consumption of fish from the river over a period of time.

Keywords: Assessment, heavy metal, Ivo river and fish

INTRODUCTION

The deteriorating conditions of surface water resources by heavy metal pollution have led to the study of Ivo River in Ishiagu area of Ebonyi State Nigeria. Most pollutions result from uncontrolled discharge of untreated effluent from mining companies and industries in the area. These industries are sited at Ishiagu Lead-Zinc mine site, less than a kilometre to Ivo River in Ishiagu. According to Rashed (2001) and Vinikour *et al*. (1980), metal pollutants in water are not degraded, rather they are deposited, and some of them are assimilated by the aquatic animals posing serious threats to human health when they are consumed. Some heavy metals such as Zn and Fe are essential micronutrients for animals and plants but are dangerous at high levels, whereas Pb have no well defined physiological functions but are detrimental at certain limits (Nadal *et al*., 2004; Ochieng *et al*., 2007; Kar *et al*., 2008; Aktar *et al*., 2010). The concentration of Pb may cause neurological impairment and central nervous system malfunctioning. The detection of toxic level of these pollutants in the aquatic organisms observed in this vicinity in recent times necessitated this study and this has attracted the attention of various non-governmental organizations and researchers. Fish diagnoses are often used to detect and monitor these heavy metal contaminations in aquatic ecosystem. This study is embarked upon to determine the levels of heavy metals in fish samples from Ivo River in Ishiagu Ebonyi State, Nigeria. Most inhabitants in Ishiagu depend on the fish for consumption, rearing and trading due to the fact that they are abundant and affordable. Water pollution has been observed for Alayi-Ovim area a nearby area and this was attributed to proximity to Lead (Pb)-Zinc (Zn) and Chloride-rch formations of the Turonian Eze-Aku and the Albian Asu River group (Ibe and Akaolisa, 2011). This study is very important since the Ivo River in this study area is underlain by the Ezeaku Formation (Reyment, 1965). The surface drainage in the study area is irregular and consists of a number of small streams forming a dendritic pattern. The streams generally flow in the north-south direction into the Ivo River. Ivo River is the main drainage channel in Ishiagu area and environs. The river basin is a booming fish farming area during dry and rainy seasons. Most industrial activities in the area include: stone crushing, metal mining (Pb-Zn) and smelting. These are located near the river and they discharge their wastes directly into the river. When fish bioaccumulates these pollutants, it becomes a threat to human health since consumers depend heavily in the fish for their dietary. In addition, the streams also become undrinkable since it endangers human health while the

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surrounding soils could be infiltrated thereby causing environmental hazards to farm produce.

MATERIALS AND METHODS

Chromosomal aberration test: Biological risk assessment of sublethal concentration of lead and zinc on test animal: In order to investigate the capability of lead and zinc to induce mutagenic effects (chromosomal aberrations) in biological systems of organism as health effect assessment, *Oreochromis niloticus* fish were chosen and employed because of its karyotypic stability. This was undertaken after the establishment of the lead and zinc concentration in Ishiagu groundwater samples at sublethal concentrations. Five fish species were collected from Ivo River by trained fishermen in the study area. These were weighed with respect to length and documented before acclimatizing to laboratory condition for fifteen days before experiment. Fish samples were identified taxonomically using standard reference sources (www.fishbase.org, 2011). The fish were fed twice daily on the fine fish commercial diet and good conditions were maintained for the fish. Water in the bioassay container was changed every alternate day after feeding. The physicochemical properties of holding water were determined using standard APHA, AWWA, Andrew *et al*. (1995). No mortality was recorded for the period of acclimatization.

For the experiment, the fish were divided into five groups with five fish in each group. Group I served as the primary control and was maintained under normal conditions. The experimental Group II, III and IV were exposed to sublethal concentrations of lead (as Pb $(NO_3)_2$), zinc (as $ZnSO_4$. $7H_2O$) and their binary mixture in water, i.e., 35 mg (Zn/Pb) L and equimolar mixture (70mg Zn.Pb/L), respectively for 120hrs; while experimental Group V was expose to groundwater from Ishiagu for 17 days. After 120 h and 17 days, respectively, fish of all groups were injected with 0.5% colchicines four hours prior to dissection to arrest the metaphase stage.

Chromosomal preparation and analysis: Chromosome preparations were made following the procedure described by Obiakor *et al*. (2010) using the gill arches, since gills represent the first target organ for contaminant. More than 100 well-spread metaphase plates were analysed for chromosomal aberrations at magnification of X400 oil immersion for all the groups, selecting 10-20 metaphases from each slide.

RESULTS AND DISCUSSION

The heavy metals Pb-Zn was analyzed in fish gill arch of the five selected fish from Ivo River in Ishiagu, using a controlled fish surviving mechanism in natural water system. The accumulation of heavy metals in the fish species were analyzed at the end of the experiment which were exposed to Pb-Zn concentration at single and sublather concentration (Table 1).

From the analysis, the biological risk assessment of lead, zinc and their mixture portrayed toxicity to test animal at sublethal concentrations. In regard to chromosomal aberrations, our observations in the present study revealed ring chromosomes, stickiness, and chromosome breaks. The differential responses of *Oreochromis niloticus* to metal compounds can be attributed to several factors such as the permeability of body membrane, metabolism, excretory capacity, sex, age, body size, site of action, and behavior (Don-Pedro, 1996). Although the specific underlying reasons for the observed differential responses of the test animal was not evaluated in this study, conjectural explanations based on available literature and observations on their ecology, morphology, and biology suggest that the nature of *Oreochromis niloticus* favours its test utility. An increase in these chromosomal aberrations in *Oreochromis niloticus* may involve disruption of DNA synthesis, DNA repair or protein synthesis directly by enzymatic inhibition or indirectly by some other mechanism. Obiakor *et al*. (2010) made similar observations in *Clairais gariepinus* (Burchell, 1822) from the Anambra River based on karyomorphological analysis of the resident species. Consequently, Alink *et al.* (2007) also reported Sister Chromatid Exchange (SCE) in Eastern mudminnow (*Umbra pygmaea* L.) after different days exposures to surface water of River Rhine used for drinking in the Netherlands.

There is indication of genotoxicity of lead and zinc against biological systems as revealed in the present study and human beings occupying higher trophic level along the energy and feeding pathways standing at the brink of the toxicity hit. The gill happens to be an important site for the entry of heavy metals provoking lesions and gill damages. This was inconsistent with work of Bols *et al*. (2001) and Lock and Van Overbeeke (1981). According to them, metals may be high in gill, lungs and digestive gland because of relatively high potential for metal accumulation. Accumulation of metal in different species is the function of their respective membrane permeability and enzyme system, which is highly species specific and so different metals accumulated in different order in different fish samples. The presence of higher amount of heavy metals in any parts of the body will definitely induce changes in biochemical metabolisms and other induced stresses. Based on that, studies on the accumulation of heavy metals Pb and Zn in fish gills when exposed to single and sublethal concentration is very important because the information is used to evaluate the biochemical changes in the fish metabolism. Plate 1-4 show pictures of the changes in

Table 1: Frequency of chromosomal aberration induced in fish gill cells of *Oreochromis niloticus* after exposure to lead, zinc and their mixture, and Ishiagu groundwater for 120 h and 17 days, respectively

Group	Evaluated metaphase No.	RC	SK	CB	Total No. of aberrations	Occurrence (%)
I	105	0	2	3	5	2.4
II	103	26	18	22	66	31.7*
III	110	19	23	17	59	28.4*
IV	120	8	5	9	22	10.6**
V	112	20	22	14	56	26.9***

RC**:** Ring chromosome; SK: Stickiness; CB: Chromosome breaks *: Significantly different ($p<0.05$), compared to the control; **: Significantly different ($p<0.05$), compared to Group II and III; ***: Significantly different ($p<0.05$), compared to the control; Authors laboratory analysis and computations (2010)

Plate 1: Photomicrograph showing normal mitotic metaphase of *Oreochromis niloticus*; Author's laboratory bioassay (2010)

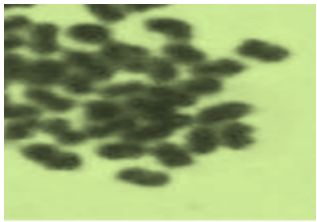

Plate 2: Photomicrograph showing mitotic metaphase of *Oreochromis niloticus* with Ring chromosomes (RC); Author's laboratory bioassay (2010)

Plate 3: Photomicrograph showing mitotic metaphase of *Oreochromis niloticus* with Stickiness (SK); Author's laboratory bioassay (2010)

Plate 4: Photomicrograph showing mitotic metaphase of *Oreochromis niloticus* with Chromosome breaks; Author's laboratory bioassay (2010)

the metabolism of the fish gills with chromosomal breaks, rings and stickiness.

CONCLUSION

This study reveals the levels of toxicity of Pb and Zn in five selected fish from Ivo River at Ishiagu in Ebonyi State Nigeria. Based on the results obtained, it is evident that most fish found in Ivo River could be toxic to human if consumed for a long period of time. Therefore, a long term monitoring program of metal bioaccumulation in fish from Ivo River and nearby mining sites would be valuable in the assessment of the potential biological risks to human health and the environment.

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REFERENCES

Aktar, M.W., M. Paramasivam, M. Ganguly, S. Purkait and D. Sengupta, 2010. Assessment and occurrence of various heavy metals in surface water of Ganga River around Kolkata: A study for toxicity and ecological impact. Environ. Monitor. Assess., 160(1-4): 207-213.

Alink, G.M, J.T. Quik, E.J. Penders, A. Spenkelink, S.G. Rotteveel, J.L. Maasc and W. Hoogenboezemb, 2007. Genotoxic effects in the eastern mudminnow (*Umbra pygmaea* L.) after exposure to rhine water, as assessed by use of the SCE and comet assays: A comparison between 1978 and 2005. Mutat. Res., 631(2): 93-100.

Andrew, D.E., S.C. Lenore, E.G. Arnold and M.A.H. Franson, 1995. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, New York.

Bols, N.C., J.L. Brubacher, R.C. Ganassin and L.E.J. Lee, 2001. Ecotoxicology and innate immunity in fish-dev. Comp. Immunol., 25: 853-873.

Burchell, 1822. Arsenic, copper and zinc occurrence at the wangaloa coal mine, Southeast Otago, New Zealand. Int. J. Coal Geol., 45(2-3): 181.

Don-Pedro, K.N., 1996. Investigation of single and joint fumigant insecticidal action of citruspeel oil components. Pest. Sci., 45: 79-84.

Ibe, K.K. and C.C. Akaolisa, 2011. Water pollution in relation to mineral exploration: A case study from Alayi-Ovim area of southeastern Nigeria. Env. Monitor. Assess., 184(5): 2699-708.

Kar, D., P. Sur, S.K. Mandal, T. Saha and R.K. Kole, 2008. Assessment of heavy metal pollution in surface water. Int. J. Environ. Sci. Tech., 5(1): 119-124.

Lock, R.A. and A.P. Van Overbeeke, 1981. Effects of mercuric chloride on mucus secretion in rainbow trout, Salmo gairdneri, Richardson. Comp. Biochem. Phys., 69(1): 67-73.

Nadal, M., M. Schuhmacher and J.L. Domingo, 2004. Metal pollution of soils and vegetation in an area with petrochemical industry. Sci. Total Environ., 321: 59-69.

Obiakor, M.O., J.C. Okonkwo, C.D. Ezeonyejiaku and C.O. Ezenwelu, 2010. Genotoxicology: Single and joint action of copper and zinc on synodontis clarias and tilapia nilotica. J. Appl. Sci. Env. Manag., 14: 59-64.

Ochieng, E.Z., J.O. Lalah and S.O. Wandiga, 2007. Analysis of heavy metals in water and surface sediment in five Rift Valley Lakes in Kenya for assessment of recent increase in anthropogenic activities. Bull. Environ. Contam. Toxicol., 79: 570-576.

Rashed, M.N., 2001. Monitoring of environmental heavy metals in fish from Nasser Lake. Environ. Int., 27: 27-33.

Reyment, R.A., 1965. Review of nigerian crecetaceous-cenozoic stratigraphy. J. Mining Geol., 3: 61-80.

Vinikour, W.S., R.M. Goldstern and R.V. Anderson, 1980. Bioaconcentration pattern of zinc, copper, cadmium and lead in selected fish species from the Fox River Illonois. Bull. Environ. Contain Toxicol., 24: 727-734.