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Afr. J. Biomed. Res. 14 (May 2011); 105 - 111

Research Article

Copper Level in Fish, Selected Fresh and Marine Aquatic Ecosystems in Nigeria

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ABSTRACT: Fish have been valued as excellent indicators of water quality because they integrate all the stresses placed on the aquatic ecosystem. This study was conducted to investigate the level of copper in selected Freshwater (Awba Dam, Asejire and Eleyele rivers), Marine waters (Lekki Lagoon and Victoria Island Ocean) and fishes that live in these ecosystems in Nigeria. Upstream and downstream samples of water and fish were collected monthly for a period of five months. The results obtained shows that the level of copper in fresh water was non-significantly ($p=0.39$) higher (1.1mg/l) than that of marine water (0.8 mg/l) at 95% confidence limit. The concentration of Cu in fish was a reverse relation since marine fish accumulated a higher (5.2mg/kg) copper relative to freshwater fish (4.27mg/kg). The difference in values was also not significant ($p>0.05$). The Bio-concentration factors was significantly ($p<0.05$) higher in the marine environment (6.4) relative to freshwater (4.2). This study suggests that the monitoring of Nigerian marine and freshwater for copper and other heavy metals is important to protect human health.

Keywords: Copper, Water pollution, Marine, Freshwater, Fish, Nigeria.

INTRODUCTION

The increasing degradation of the aquatic environment by anthropogenic contaminants has been given an intensive effort to evaluate the effects of pollutants in numerous biological systems (Herkovits *et al.*, 1997). The need to determine critical concentrations of toxicants in rivers and other water resources have become inevitable (Van der Merwe *et al.*, 1993). Limnological studies on water resources would contribute significantly to the understanding of tropical freshwater ecosystems and the impact of anthropogenic activities on them (Araoye, 2002). The introduction of metals and other pollutants into rivers can decrease the health of natural aquatic ecosystems. Since, rivers constitute the main inland water resources for domestic, industrial and irrigation purposes, it is imperative to prevent and control the rivers pollution and to have reliable information on the quality of water for effective management. In view of the spatial and temporal variations in the hydrochemistry of rivers, regular monitoring programs are required for reliable estimates of the water quality.

Water resources in most parts of Nigeria are severely polluted by wastewater, which contains heavy metals, bacteria (pathogenic) etc. In Lagos, untreated excreta, together with the commercial and industrial wastewater are usually discharged into the Lagos lagoon system. The existence of heavy metals in aquatic environments has led to much concern over their influence on plant and animal life in these environments and indeed on man's need for wholesome water (Stephen, 1988). The accumulation of these elements, many of which are highly toxic, can have direct consequences on man and animal life in the

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Received: March, 2011; Accepted: May 2011

aquatic ecosystem. Interest in metals like Fe, Mn, Zn and Cu which are required for metabolic activity in organisms lies in the "narrow window" between their essentiality and toxicity (Muyssen and Janssen, 2001). Copper is plentiful in the environment and it is essential for growth, metabolism and reproduction in all living organism when present in the right quantity (James *et al.*, 1998).

Copper is also an essential element that serves as a cofactor in a number of enzyme systems for most living organisms but, at high concentration, copper become a toxic pollutant. Copper has been used for many years as an effective algaecide in farm ponds and in aquaculture operations. Copper sulfate (CuSO4) is applied periodically to commercial fish ponds as an algicide or parasiticide. But with its use only a thin line separates effective algae-treatment levels from lethal overdoses to fish. Current understanding of the chemistry of copper in soil–water systems suggests that copper may accumulate in pond sediments, although the forms and potential bioavailability of copper is not fully known. Toxic metals can alter many physiological processes and biochemical parameters, either in blood or in tissues including structural deformations in aquatic animals (Cengiz and Ünlü, 2002). Concern about heavy-metal contamination of fish has been motivated largely by adverse effects on humans, given that consumption of fish is the primary route of heavy metal exposure (Nsikak, *et al*, 2007). The accumulation of metals in an organism's body can take place, if the rate of uptake by the organism exceeds the rate of elimination (Oguzie, 2003). In a study conducted in Benin City, Nigeria, Copper level in fish from Ogba river ranged from 3.82 to 6.28mg/kg. These levels exceeded WHO and FEPA recommended limit (3.0mg/kg) in inland freshwater fish, thereby portending significant public health consequences. In this study, the level of copper in both marine and fresh water and fishes sourced from these aquatic ecosystems were investigated.

MATERIALS AND METHODS

Study Areas

Fresh water samples were purposively selected from three (3) inland aquatic systems. Awba Dam (07°26' N, 03°53'E) and Eleyele River (07°25'N, 3°55' E) are located in Oyo state while Asejire Dam (07°21'N, 04°07'E) is located in Osun State. The marine samples were sourced from Lagos State, which is also located in southwestern Nigeria on the West Coast of Africa, within latitudes 6° 23' N and 6°41' N and longitudes 2°42' E and 3°42' E. A considerable part of the study area is made up of Lagoons and creeks. The samples were collected from Victoria Island and Lekki Lagoons. In each of the study areas, water samples were collected from two different points in 1 liter pre-cleaned polyethylene bottles. Water samples were passed through filtered 0.45 micron Millipore membrane. The filtered sample was treated with diethyl-dithio-carbamate and extracted with carbon tetrachloride. The extract was evaporated to dryness and the residues was mineralized with 1mL HNO_3 and kept for analyses. Fish were also purchased from artisanal fishermen and transported live to the laboratory where they were killed and frozen for further processing.

Analysis of Samples

Fish were dissected and the muscle tissue was dried digested with concentrated nitric and perchloric acid (2:1 v/v) at 120°C for 3 hours and completed to 5 ml with distilled water (ASTM, 1986). After dilution copper concentrations of acidified processed water and fish were measured using atomic absorption spectrophotometer (UNICAM 929 AA Spectrometer). The concentration of copper was read at the wave length of 324.7 nm. The concentrations read were blank-corrected and expressed as mg/l of Cu in water samples and mg/kg dry weight of fish (APHA, 1998).

Statistical analysis

Results were computed and presented as mean ± standard deviation. The level of significance of differences in the concentrations of copper between sites at 95% confidence limit was assessed using student's *t*-test.

RESULTS

Figures 1 and 2 shows that copper was generally higher in freshwater (1.1 ± 0.4 mg/l) compared with marine water (0.8 ± 0.03 mg/l). However, in figures 3 and 4, the bioaccumulation level of copper in fish sourced from freshwater (4.3 ± 0.5mg/kg) was generally lower than those sourced from marine water (5.2 ± 0.11 mg/kg). However, the differences were not significant. Bioconcentration Factor (BCF) of copper in the muscle of fish significantly higher ($p<0.05$) in marine fish (6.4 ± 0.36) compared to freshwater fish (4.2 ± 0.96) and is presented in figures 5 and 6.

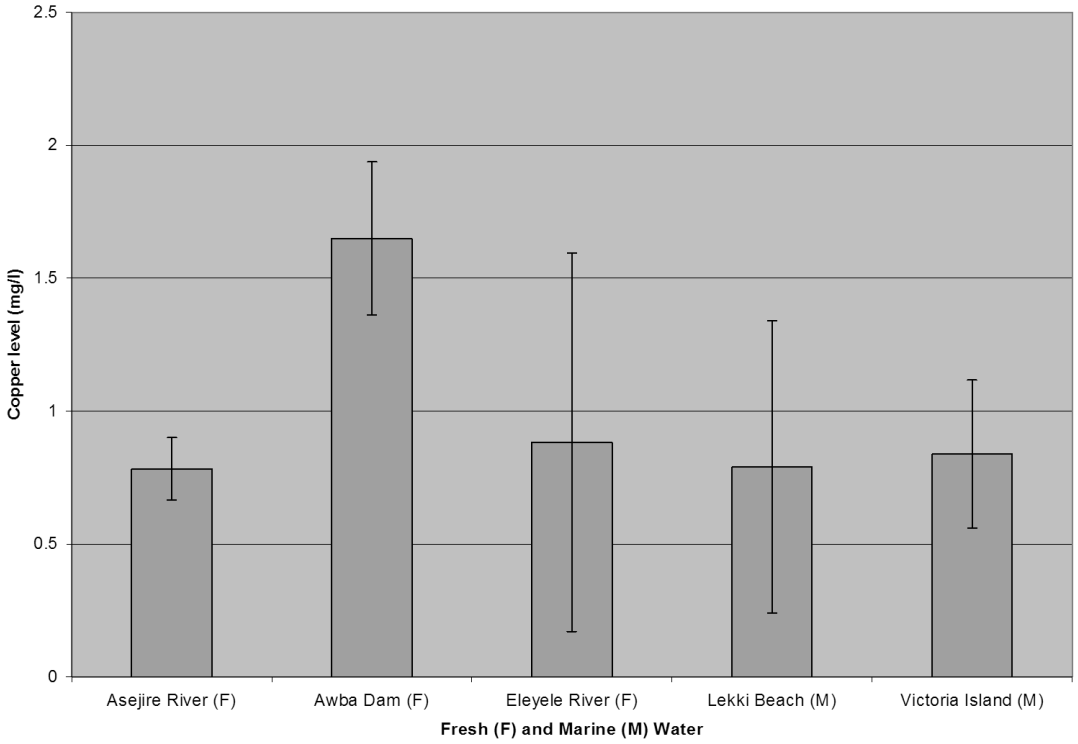

Figure 1:
Level of Copper in the Different Aquatic Systems

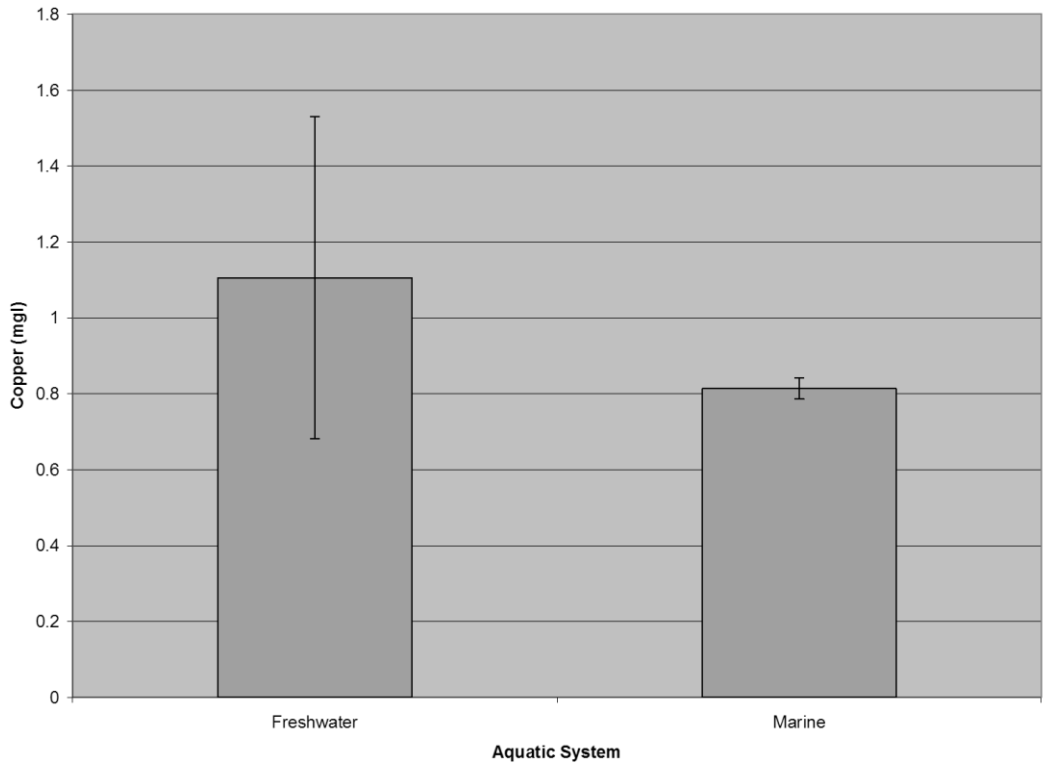

Figure 2:
Comparative Copper Level in Fresh and Marine Water\

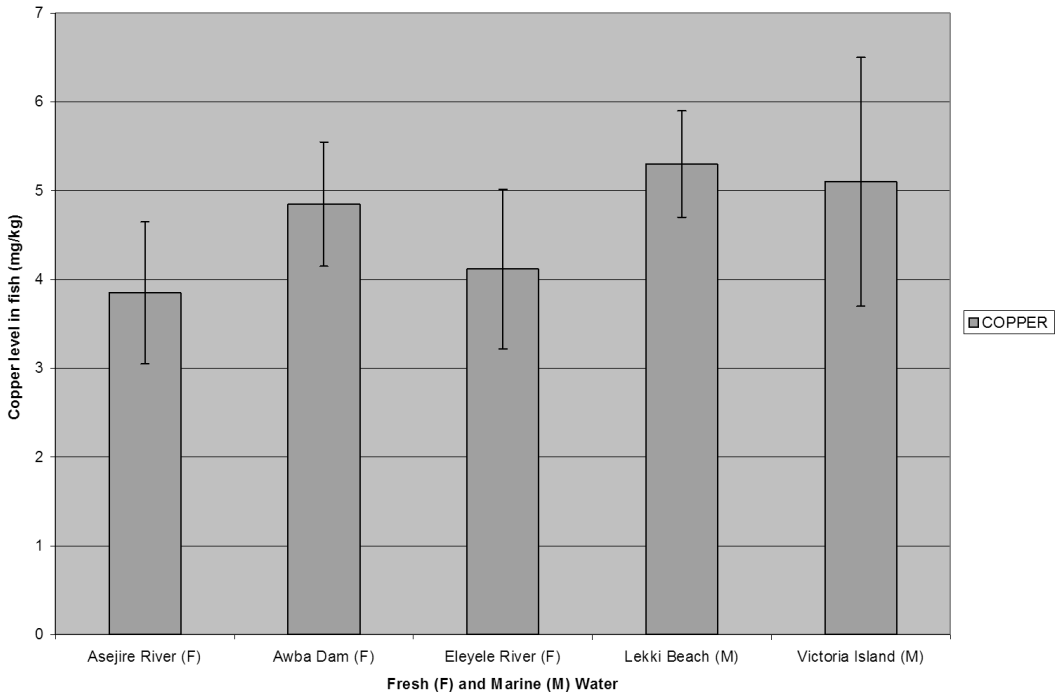

Figure 3:
Level of Copper in the Muscles of Fish from Different Aquatic Systems

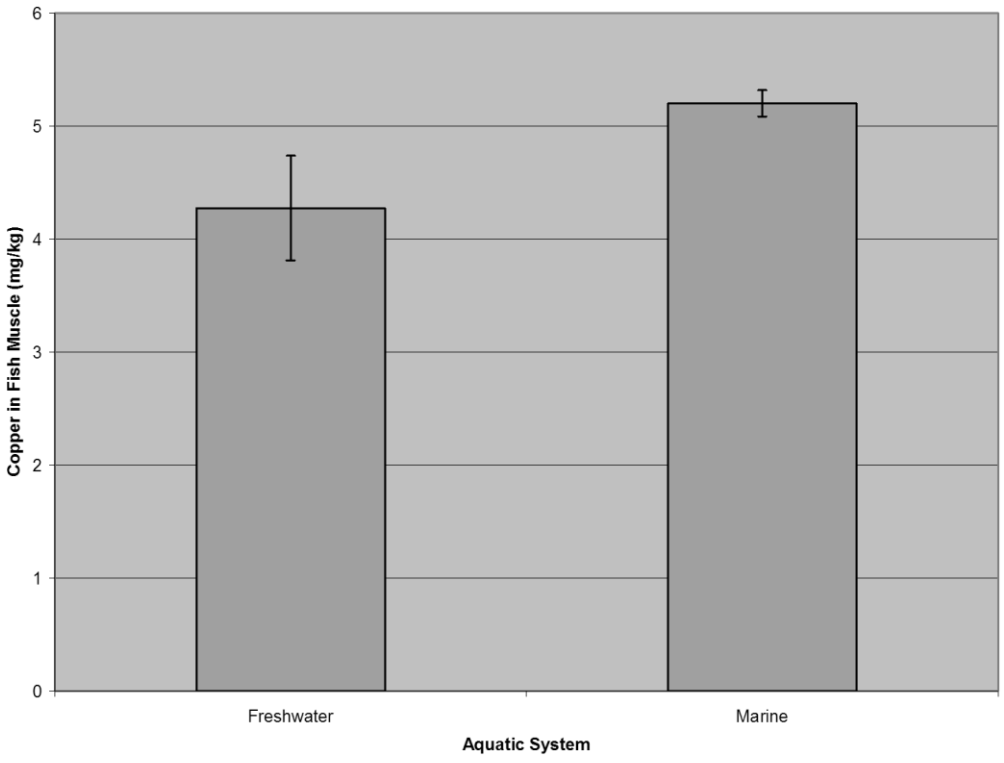

Figure 4:
Comparative Copper Level in the Muscle of Fresh and Marine Fishes

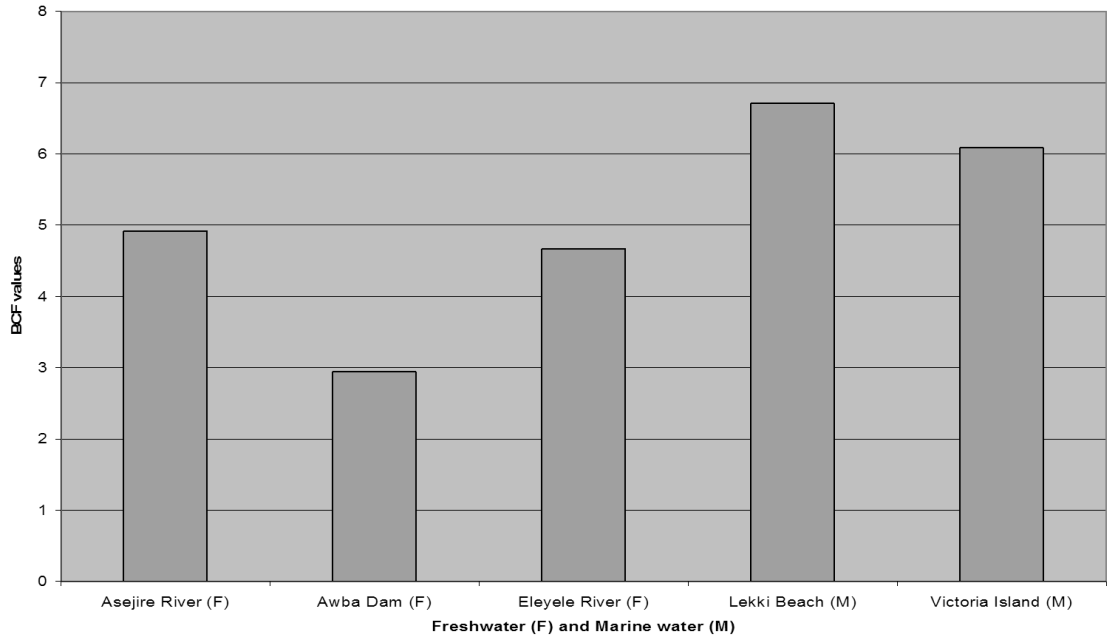

Figure 5:
Bio-concentration Factor (BCF) Of Copper in the Muscles of Fish

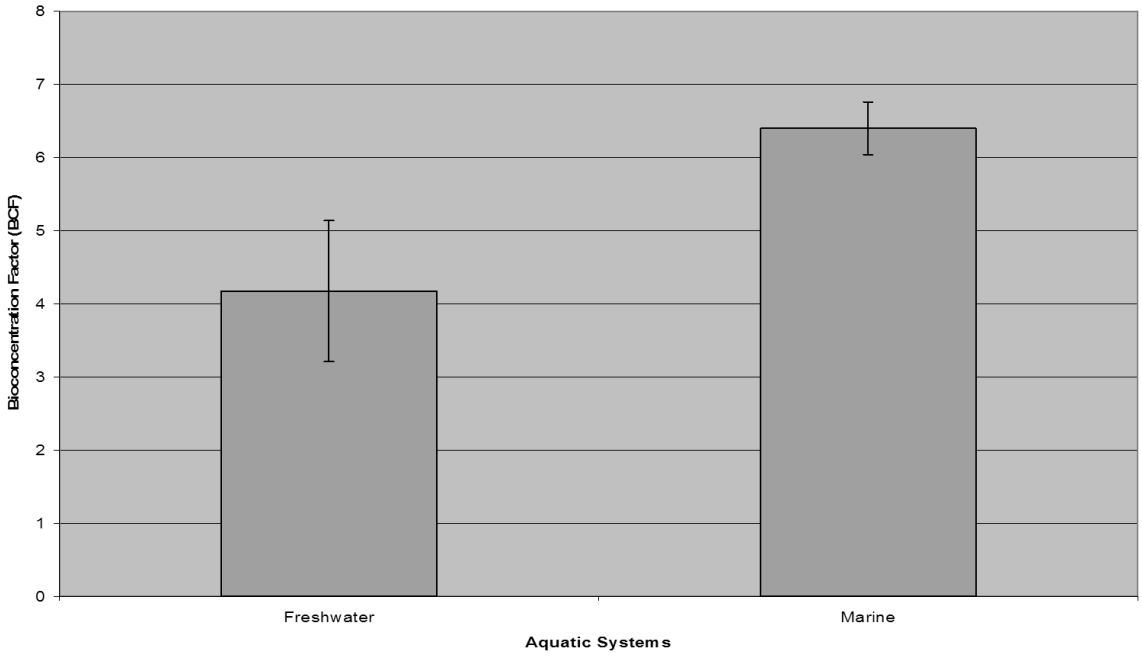

Figure 6:
Comparative Bio-concentration Factor (BCF) of Copper in the Muscle of Fresh and Marine Fishes

DISCUSSION

The increased awareness and subsequent surge in practice of aquaculture in Nigeria has invariably increased the use of copper, taking into consideration that most aquaculturists in Nigeria are not well informed, their usage of copper as an algaecide could be subject to abuse and excessive application. The excess copper from this and other anthropogenic activities will end up in surface waters and streams, and could subsequently bioaccumulate in aquatic flora and fauna (Latif, *et al.*, 1982). In the present study, copper level in freshwater was 1.1 ± 0.4 mg/L and the bioaccumulation level of copper in freshwater was 4.3

± 0.5mg/kg. This level exceeded WHO and FEPA recommended limit (3.0mg/kg) in inland freshwater fish.

The level of copper (0.8 ± 0.03 mg/l) recovered from marine water is within the range of copper level (0.11-1.59mg/l) reported by Oshisanya *et al*, 2011 in different sites of Lagos Lagoon. But, the bioaccumulation level (5.2 ± 0.11 mg/kg) of copper revealed by this study is much higher than that reported (2.59-3.7mg/kg) by Oshisanya *et al*, 2011. The results of this study is in agreement with Birge *et al*., (2000); who reported that marine biota is known to accumulate Cu in the environment. In addition, some researchers have suggested that Cu exposure in salt water may also disturb osmoregulation, resulting in a net gain of Na+ (Grosell. 2004). Global population increase and industrial development have led to an increase in the contamination of the marine environment by metals over the last three decades (Franca *et al*., 2005). This trend will impact negatively on sustainable livelihood of many human settlements, which are socially and economically dependent on increasingly unstable exploitation of fishery resources,

The accumulation of heavy metals in the tissues of aquatic organisms is affected by physical and chemical factors such as temperature, water hardness, pH and salinity. Bioconcentration factors (BCF) of copper in the muscles of fish was significantly higher ($p<0.05$) in marine fish (6.4 ± 0.36) compared to freshwater fish (4.2 ± 0.96). Salinity affects various vital factors such as osmoregulation, nitrogen excretion and oxygen consumption (Aarset and Aunas, 1990). The toxicity of heavy metals to fish has been reported to be a function of the free metal ion concentration, which is controlled by the chloride content of the water (Erickson, 1996). Heavy metal residues in contaminated habitats accumulate in microorganisms, aquatic flora and fauna, thereby through the food chain, it constitutes public health hazard to humans. Although copper is clearly essential for a wide range of biochemical processes which are necessary for the maintenance of good health, copper is also a potentially toxic substance. Accumulation of copper in fish body has also been reported to result in drastic reduction in growth, gonad weight, fry production and breeding frequency (James *et al*, 2003). These have a grave impact on aquaculture development and food security.

Conclusion

There is an urgent need for action to prevent further increase in copper pollution in the study areas. This is because, though trace metals act as valuable micronutrients at low concentrations; at higher levels they become toxic depending on the prevalent chemical form (i.e. speciation) of the trace element in water. Also the occurrence of bioaccumulation and food chain magnification of trace metals may constitute severe public health hazard to people, who consume fish from such contaminated sources.

REFERENCES

Araoye P.A. (2002): Man-made lakes, ecological studies and conservation need in Nigeria. Rev. Biol. Trop. 50: 857-864.

Aarset A.V., Aunas, T., (1990): Influence of Environmental Salinity on Oxygen Consumption and Ammonia Excretion of the Arctic Under-Ice Amphipod Onismus glacialis. Marine Biology. 107, 9-15.

APHA (1998): Standard methods for the examination of water and wastewater, 19th edn., Am. Publ. Health Assoc., Am. Water Works Assoc. and Water Poll. Contr.F ed. (APHA, AWWA, WCPF), Washington DC, 1200 pp.

American Society for Testing and Materials ASTM (1986): Annual book of ASTM standards, 11.01, D3559-85, Philadelphia PA 19103.

Birge W, Price D, Shaw J, Spromberg J, Wigginton A (2000): Metal body burden and biological sensors as ecological indicators. Environ Toxicol Chem. 19, 1199–1212

Cengiz E.İ., Ünlü E., (2002): Histopathological Changes in the Gills of Mosquitofish, Gambusia affinis Exposed to Endosulfan. Bull. Environ. Cont. Tox. 68 (2), 290-296.

Erickson, R.J., Benoit, D.A., Mattson, V.R., Nelson, H.P., Leonard, E.N., (1996): The Effects of Water Chemistry onthe Toxicity of Copper to Fathead minnows. Environmental Toxicology and Chemistry. Vol. 15. No.2, 181-193.

F.E.P.A. (Federal Environmental Protection Agency). (2003): Guidelines and Standards for Environmental Pollution Control in Nigeria. 238pp.

Franca S., Vinagre C., Cacador I., Cabral H.N. (2005): Heavy metal concentrations in sediment, invertebrates and fish in three salt marsh areas subjected to different pollution loads in the Tagus Estuary (Portugal). Mar. Pollut. Bull. 50, 993-1018.

Grosell M., McDonald M.D., Wood C.M., Walsh P.J. (2004): Effects of prolonged copper exposure in the marine gulf toadfish (*Opsanus beta*) I: Hydromineral balance and plasma nitrogenous waste products. Aquat Toxicol. 68, 249–262

Herkovits J., Cardellini P., Pavanati C., Perez-Coll C.S. (1997): Susceptibility of early life stages of *Xenopus laevis* to cadmium. Environ Toxicol Chem. 16, 312-316.

James R.; Sampath, K., Edward D.S. (2003): Copper Toxicity on Growth and Reproductive Potential in an Ornamental Fish, *Xiphophorus helleri.* Asian Fisheries Science. 16, 317-326

James R., Sampath K., Selvamani P. (1998): Effect of EDTA on reduction of copper toxicity in *Oreochromis mossambicus* (Peters). Bull. Environ. Contam. Toxicol. 60, 487-493.

Latif A., Khalaf A.N., Khaliol B.Y. (1982): Bioaccumulation of Cu, Cd, Pb, and Zn in two cyprinid fishes of Iraq. J. Fish Biol. 13 (2), 45-64.

Muyssen B.T.A., Janssen C.R. (2001): Multigeneration zinc acclimation and tolerance in Daphnia magna: implications for water-quality guidelines and ecological risk assessment. Environ Toxicol Chem. 20(9), 2053-2060.

Nsikak, U.B., Joseph, P.E., Akan, B.W., David, E.B. (2007): Mercury accumulation in fishes from tropical aquatic ecosystems in the Niger Delta, Nigeria. Current Science. 92(6): 781–785.

Obasohan E.E. (2008): Bioaccumulation of chromium, copper, maganese, nickel and lead in a freshwater cichlid, *hemichromis fasciatus* from Ogba River in Benin City, Nigeria. African Journal of General Agriculture. 4 (3) 141-152.

Oguzie F.A (2003): Heavy metals in fish, water and effluents of lower, Ikpoba River in Benin City, Nigeria. *Pakistan Journal of Science and Industrial Research.* 46 (3) 156–160.

Oshisanya K.I., Nubi O.A., Amusan, E.E., Salaudeen, M.M. (2011). Pollution assessment of the aquatic resources in the Lagos lagoon system. Journal of American Science. 7(3): 380-383.

Stephen W.I. (1988): Zinc, cadmium, mercury and lead. In T.S. West & H.W. Nurnberg (eds.) *The Determination of Trace Metals in Natural Waters*. Blackwell Scientific Publications. Oxford.

Van Der Merwe M., Van Vuren J.H.J., Du Preez H.H. (1993): Lethal copper concentration levels for *Clarias gariepinus* (Burchell, 1822) – a preliminary study. Koedoe. 36 (2), 77-86.

WHO (World Health Organization) (1985): Guidelines for drinking water quality.Vol. 1. Recommendations, W.H.O. Geneva. 130pp.