Advances in Biological Research 10 (4): 257-263, 2016
ISSN 1992-0067

DOI: 10.5829/idosi.abr.2016.10.4.1118

Assessment of Heavy Metals in the Muscles and Bones of Fish and Shellfish from Epe Lagoon, Nigeria

[1]*I.O. Taiwo,* [2]*F.I. Adeosun,* [1]*B.T. Adeniyi and* [1]*N.A. Bamidele*

[1]IFSERAR, Federal University of Agriculture, Abeokuta, Nigeria
[2]Department of Aquaculture & Fisheries, Federal University of Agriculture, Abeokuta, Nigeria

Abstract: This study measured the concentrations of heavy metals in bones and muscles of fish and shellfishfrom the Epe Lagoon, Nigeria. The fish landing site at Epe Lagoon is a large commercial fishing town. It is strategically located close to Lagos State which is the commercial capital of Nigeria. The muscle andbones of five commercially important fishery organisms (*Tilapia 'wesafu', Chrysichthys s*pp., *Macrobrachium*spp*., Mormyrusrume*and *Gymnarchusniloticus*) were tested to determine the levels of heavy metalcontents.The four heavy metals (Mn, Cu, Zn and Fe) were tested by atomic absorption spectrometry. Results exhibited that the concentration of heavy metals in the water followed the order:Fe >Mn> Cu = Zn. The result also showed that there were no any significant differences ($p>0.05$) in Mn, Zn and Fe concentrationsin the muscle of the organisms but there werefound significant differences ($p<0.05$) in Cu levels with *Mormyrusrume* having the highest concentration, *Gymnarchusniloticus* and *Macrobrachium*spp.having the least concentration.The concentration of heavy metalsin the bone and carapace showed that there was non-significant differences ($p>0.05$) in the levels of Fe, Cu and Zn, but there was significant difference in Mn ($p<0.05$) with the highest concentration found in *Chrysichthys*spp. and *Tilapia 'wesafu'*, followed by *Gymnarchusniloticus,* with *Mormyrusrume* and *Macrobrachium* spp. Having the least concentration. It was also observed that the water and the five fishery organismsfrom Epe Lagoonwere polluted with heavy metals above the safe limits for human consumption.

Key words: Lagoon · Heavy metals · Bones · Pollution · Muscle · Fish

INTRODUCTION

Nigeria has vast expanse of inland and marine ecosystems. The surface area of marine and brackish water resources covers an estimated area of 233, 000km^2 [1] and [2] estimatedthe brackish and marine fishery potential of Nigeria as 800, 000 metric tonnes per annum. Lagos State which is surrounded by water and through which the Atlantic Ocean passes is the industrial and commercial centre of Nigeria, therefore, it has the highest number of industries and people per m^2 in Nigeria and in Africa. As the commercial hub and the industrial nerve centre of Nigeria with an estimated human populationof over 20 million, there are environmental concerns. Over60% of Nigeria's industries are cited in LagosState, each discharging variousforms of effluents containing heavy metals into the terrestrial and aquatic ecosystems [3].

The sustainability of lagoon fisheries is being threatened by coastal degradation considering that a lot of species spend their earliest stages near the coast, estuarine, brackish or freshwater environments. [4] observed that lagoon systems are places of great biological importance where fishery is the main economic activity but intensive agriculture, industry and tourisms have degraded theseenvironments.

The pollution of the aquatic environment with heavy metals has become a worldwideproblem, because these metals are indestructible and most of them have toxic effects onorganisms [5]. Bioaccumulation and magnification leads to toxic levels of metals infish, even when the exposure is low. The presence of heavy metals in fresh water has been known todisturb the delicate balance of aquatic ecosystems. Fishes have the ability to accumulate heavy metals in their muscles, bones and entrails. This is of great significance since they play a

Corresponding Author: I.O. Taiwo, IFSERAR, Federal University of Agriculture, Abeokuta, Nigeria.

vital role in human nutrition, hence the need to carefully screenfish from heavily industrialised areas to prevent the transfer of some toxic heavy metalsto man through the consumption of fish [6, 7].

Lagoons are directly exposed to different contaminants from various sources and the Epe Lagoon is not an exception. It is a shallow expanse of water with restricted circulation in a micro tidal environment. This aquatic resource receives inputs of domestic sewage, industrial waste waters, sawdust and particulate wood wastes, petroleum hydrocarbons and cooling water from a thermal power station is of major concern to resource managers and public health officials [3].

The Epe lagoon is part of the Lagos lagoon system which is the largest of the four Lagoon systems of the Gulf of Guinea. Epe lagoon is one of the lagoons whichact as a sink or reservoir, receiving effluents of over 10, 000 m^3 daily from drainages through differentparts of the Lagos metropolis and hinterland [8, 9]. Therefore, this study seeks to determine whetherorganisms in Epe Lagoonare polluted with certain heavy metals by assessing the levels of five heavy metals (Mn, Cu, Zn, FeandPb) in the water, muscles, bones and carapace of five fishery organisms (*Chrysichthys* sp., Tilapia 'Wesafu', *Mormyrusrume*, *Gymnarchusniloticus* and *Macrobrachium*spp.).

The Tilapia fish is an ideal species of organism for an assessment study on effects of heavy metal contamination in aquaculture ponds [10]. Tilapia can survive in bad environmental conditions because their resistance to disease is physically powerful and their respiratory demands are slight so that they can accept low oxygen and high ammonia levels [11]. Fish are often at the top of the aquatic food chain and may concentrate large amounts of some metals from the water [12]. Some metals are essential to human health. Metals are naturally occurring elements that become contaminants when human activities increase their concentrations above normal levels in the environment [13]. Heavy metal pollution is a serious and widespread environmental problem due to their toxicity. They enter the environment through various natural methods and human activities and can accumulate in fish and other organisms [14]. Fish are the final organism in the aquatic food chain and a significant food source for man. Consequentially, heavy metals in aquatic environments are transferred throughout the web chain into humans. It is well known that fish muscle is not an active tissue to accumulate heavy metals, but it was discovered that heavy metal levels in the edible portion (muscle) of some fish in contaminated regions exceeded permissible levels. Therefore, determination of heavy metal levels of fish is tremendously important for the health of human beings [15]. Metals are very toxic because, as ions or compound form, they are soluble in water where the fish live and may be easily absorbed into the fish and bind to structural proteins and enzymes. In humans, some metals can cause severe physiological and health effects [16]. Humans are exposed to different levels of heavy metals directly from the water, air and food. Fish consumers may be exposed to relatively higher levels of heavy metals by eating fish that contains heavy metals from local rivers, ponds, lakes and seas. Edible fish are often contaminated with heavy metals as a result of agricultural technology, industrial pollution, sewage drainage and other sources, which could affect human health and cause chronic diseases [17].

Heavy metals such as Cd, Zn, Hg, Cr and Cu cause heavy pollution, particularly in the ponds, lakes and river systems in zones affected by effluents released from industries, sewage and agricultural drains. Among the animal species, fish are inhabitants that cannot escape the detrimental effects of these pollutants [18]. The concentration of the essential elements, Zn and Cu were relatively higher in the muscle and liver tissues than the non-essential metals, Pb and Cd [19]. Different fish tissues can take heavy metals like Pb and Cdfrom surrounding environment, thus allowing humans to be exposed to pollution. Heavy metals were studied through three different fish organs (liver, gills and muscles) because of the affinity between each of them. Rivers, ponds and lakes are major sources of drinking water. However, the pollution of these natural waters is one of the most critical environmental problems in recent years [20]. 21 classified Tilapia fish as one of the safest fish that could be consumed because the levels of heavy metals (Cu, Zn, Ni, Pb and Cd) in the liver, gills and muscles did not pose a health risk to consumers as they were within the acceptable tolerable limits for consumption.

The aquatic environment with its water quality is considered the main factor controlling the state of health and disease in both cultured and wild fishes. Pollution of the aquatic environment by inorganic and organic chemicals are major factors of serious threat to the survival of aquatic organisms including fish [22].

MATERIALS AND METHODS

Study Site: Epe lagoon is located in Lagos State, South-West, Nigeria. It lies between longitude N 06° 33.710' E 004° 03'.710' and latitudes N 06° 31.893' E 003° 31.912' (Fig. 1). It has a surface area of about 243 km^2. It is a shallow water body with a maximum depth of about 6 m.

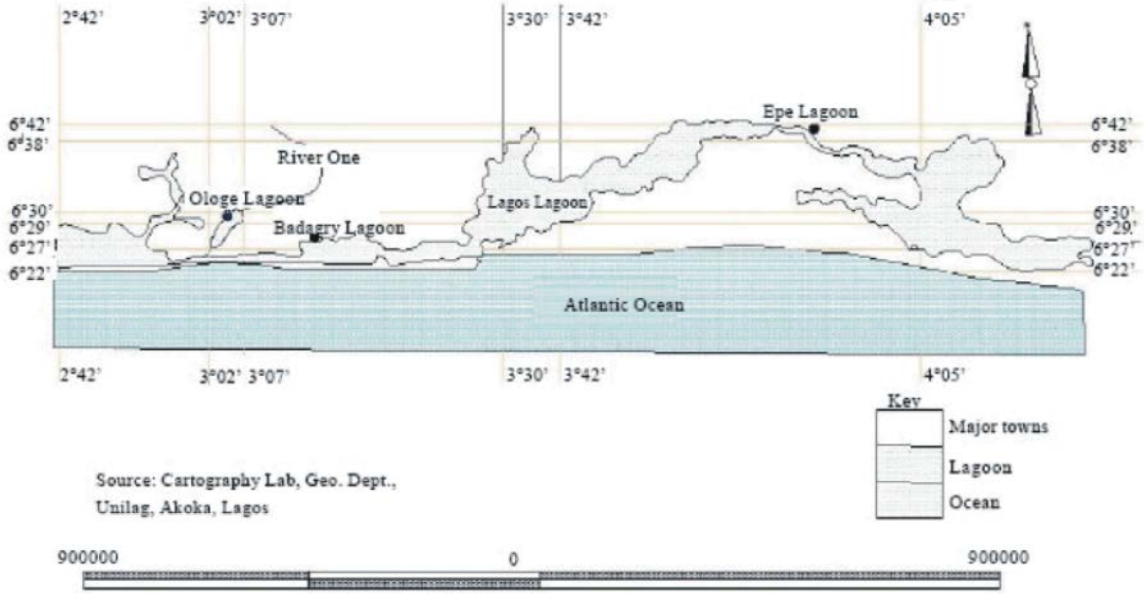

Fig. 1: Map of Epe Lagoon, Lagos State, Nigeria

The lagoon is sandwiched between two lagoons, Lekki lagoon (freshwater) in the east and Lagos lagoon (brackish) in the south with the Osun River being the main river discharging into the lagoon. The Epe lagoon connects to the sea via Lagos harbour and the vegetation around the lagoon is characterized by stilt rooted trees with dense undergrowth of shrubs and herbs [23]. This lagoon also subjected to heavy fishing due to its proximity to Lagos, the commercial megacity of Nigeria.

Water Sample Collectionand Analysis: Heavy metal concentrations in water were determined by Perkin Elmer(model 2280) atomic absorption spectrophotometer (AAS). Concentrated sulphuric acid (0.50 ml) was added to 50 ml of unfiltered water sample. The mixture was boiled till white fumeswere obtained. It was then cooled and 1.0 ml of 60% HCl and 5.0 ml of concentrated HNO_3 were added to the cooled mixture. This mixture wasdigested until it was clear. It was then cooled and filtered, using No. 44 Whatman paper filter, into 500 ml volumetric flask; diluted to volume and mixed. The heavy metal concentration was determined using the following formula:

$$\text{Heavy metal concentration (ppm)} = \frac{\text{Reading of atmic absorption} \times \text{Volume of dilutad solution}}{\text{Volume of water sample}}$$

Fish Sample Collection and Preparation: Twentyfish of each fish species (*Tilapia 'wesafu'* (Tw), *Chrysichthys*spp. (Cs), *Macrobrachium*spp. (Ms), *Mormyrusrume* (Mr), *Gymnarchusniloticus* (Gn)) werecollected monthly from Epe Lagoonduring the months of October, 2013 to February, 2014. The fish speciesselected for this study are of commercial and economic importance, that is, theyare marketable, command premium prices and are highly favoured by consumers. The fish muscles (tissues) and bones was prepared and analysed, while for shellfish it was the muscles and body carapace that was analysed and referred to in this study as bones.

The fish samples were kept cool in a cooling chamber/flask, to prevent deterioration and spoilage, and transported to the laboratory. In the laboratory, extreme care was taken during sample preparation to avoid contamination. All glassware used were washed and rinsed with distilled water and then washed in 10% HCl. The fish samples were analysed for five heavy metals*viz.,* Mn, Fe, Cu, Zn and Pbcontent in their muscles and bones. The fish muscles and bones were separated and dehydrated to a constant weight in an oven at 60°C for 2 days. Each specimen was then pulverized with a mortar and pestle to a uniform particle size and dried.

The muscles and bones of the five fish species sampled were digested separately according to the wet digestion procedure of FAO [24]. Thedigestion was done by digesting 0.5g of dried fish samples in 60ml of freshly prepared 2:1 HNO_3/H_2O_2 solutions at 115°C on a hot plate for about two and half hours until the content dehydrated to about 5ml. The content was then filtered and the filtrate was transferred to a standard flask and made up to 25ml with distilled de-ionized water. The Atomic Absorption Spectrophotometer (AAS) Buck Scientific Model 210VGP was used to determine theconcentrations of heavy metals (like Mn, Fe, Cu, Zn and Pb) in the muscles and bones of the fish samples digested.

Statistical Analysis: The data obtained were subjected to Analysis of Variance (ANOVA) test to determine the differences between treatments mean at significant level of 0.05using SPSS (23.0) and following the procedure of [25]. Significant means was separated using the Duncan's multiple range test.Graphs were drawn usingMicrosoft excel (2010).

RESULTS

Concentration of Heavy Metals in Epe Lagoon Water: The heavy metal concentrations in the water from EpeLagoon wasin the following order: Fe>Mn> Zn > Cu. Iron (1.508) was highly significant ($P<0.05$), followed bymanganese (0.064) with Copper (0.022) and Zinc (0.024) not significantly different from each other.

Concentration of Heavy Metals in Fish Muscle: The mean concentration of heavy metals in fish muscle is shown in Fig. 2. There were no significant differences ($P>0.05$) in Manganese, Iron and Zinc in the muscles of the organisms. However, there was significant differences ($P<0.05$) in the Copper levels: Mr>Tw>Cs>Gn>Ms. Comparing the monthly average concentrations of heavy metals in the muscle of the organisms (October to February), *Chrysichthysspp* had the highest concentration in January and*Macrobrachium*spp. had the lowest concentration of heavy metals in January (Table 1).

Concentration of Heavy Metals in Fish Bones: Manganese differed significantly ($P<0.05$) in its concentration in the bones of the organisms: Tw>Cs>Gn>Mr>Ms. However, there were nosignificant differences in the levels of Iron, Copper and Zinc (Fig. 3). *Macrobrachium*spp.had the lowestconcentration of heavy metals in the month of December while *Mormyrusrume* had the highest concentration in themonth of November. The concentration found in *Chrysichthys*spp was equally high in the month of February (Table 2).

Table 1: Mean monthly concentrations of heavy metals in the muscle of organisms (mg/g)

	Chrysichthys Spp					*Tilapia* 'Wesafu'					*Mormyrusrume*					*Gymnarchusniloticus*					*Macrobrachium* spp.				
Heavy Metals	Oct	Nov	Dec	Jan	Feb	Oct	Nov	Dec	Jan	Feb	Oct	Nov	Dec	Jan	Feb	Oct	Nov	Dec	Jan	Feb	Oct	Nov	Dec	Jan	Feb
Manganese	40	50	91	82	41	42.6	84	93	28	13.5	45.5	41	51	10	15	10.5	15	8	10	15	41.5	50	41	30	50.5
Iron	250.5	228	215.5	284	243	225	241	158	306	179	274	198	224	171.5	217	206.5	215	200	242	201	149	199	164	129	202
Copper	1	4	18.5	6	84	60.5	84	10	4	5	69.5	40	25	72.5	46	0	5	0	7	9.5	0	1.5	4	0	0.5
Zinc	52.5	80	74	128	92	51.5	58	28	50	43.5	97	89	41	91	64	41	72	80	21	34	47.5	84	53	38	190
Total	344	362	399	500	460	379.6	467	289	388	241	486	368	341	345	342	258	307	288	280	259.5	238	334.5	262	197	443

Table 2: Mean monthly concentrations of heavy metals in the bones of organisms (mg/g)

	Chrysichthys Spp					*Tilapia* 'Wesafu'					*Mormyrusrume*					*Gymnarchusniloticus*					*Macrobrachium* spp.				
Heavy Metals	Oct	Nov	Dec	Jan	Feb	Oct	Nov	Dec	Jan	Feb	Oct	Nov	Dec	Jan	Feb	Oct	Nov	Dec	Jan	Feb	Oct	Nov	Dec	Jan	Feb
Manganese	40	65	89	70	124	56	128	34	81	56	16	18	41	30.5	50.5	56	40	28.5	50	40.5	10	20	15.5	9.5	10
Iron	192	221	171.5	200.5	201	191	121	259	162	173	193.5	289	172	150.5	212	201	181	192	210	199	178.5	160	141	173	164
Copper	0.5	8	0.2	2.5	2	4.5	15	1.5	2	3	4	0.5	2	1.8	4	4	2	0.5	1	1.5	2.5	2	0	0.5	1
Zinc	26.5	94	25.5	62	85	62.5	45	48	25	74	53.5	125	31	24	63	61	42	52	70	61	57	93	70.5	89	57

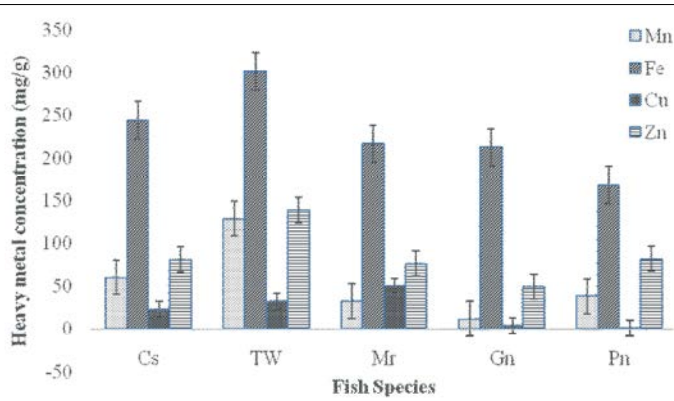

Fig. 2: Concentration of Heavy metals in fish muscles showing error bars

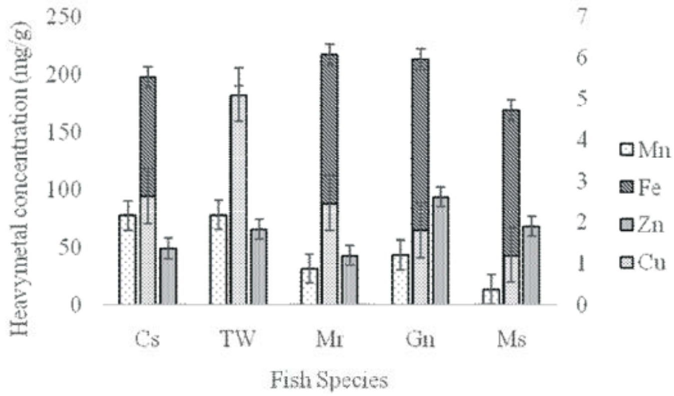

Fig. 3: Concentrations of heavy metals in fish bones with error bars (mg/g)

DISCUSSION

The concentration of heavy metals in the water of 0Epe Lagoon in this studyis similar to that conducted by [26], on the same water body where they reported the following: Mn±0.00, Cu±0.05, Zn±0.00, Pb±0.00. This study had similar results of Mn±0.07, Fe±1.51, Cu±0.02, Zn±0.02. It was observed that the water of Yewa Lagoon, an off shoot of the Badagry Lagoon (Fig. 1) contains more heavy metals than the water of the Epe Lagoon [27]. In a similar study conducted on Ilo River, Ota, a heavily industrialised suburb of Lagos State, the heavy metals tested in the water were lower than the WHO standards [28].

The level of Fe in the muscle of the organisms analysed was greater than the maximum standard while Mn in all organisms was below the maximum standard set by 29. Zinc (Zn) was above the minimum standard in the organisms with the exception of*Gymnarchusniloticus,* which was within the range set by WHO(WHO standard: Mn (500), Fe (100), Cu (30)and Zn (10-75).

In the muscles of the fish there was a significant difference ($p<0.05$) in the presence of copper (Cu) across the treatments with the muscle of *Mormyrusrume* (50.50 mg/g) containing more than the other organisms. *Tilapia 'Wesafu'* also had a Cu content (32.70 mg/g) was slightly higher than the standard. This corroborates study of 26that Epe Lagoon contains copper above the acceptable limits.

*Gymnarchusniloticus*had more heavy metals in its bones than in its muscles with thehighest concentration of zinc (93.6 mg/g) well above acceptable WHO limits. The concentration of iron (Fe) in the muscles and bones of all organisms was above the safe limits set by WHO. The levels of Fe and Zn concentration in the bones of the organisms exceeded the WHO standard. The level of heavy metals in the samples analysed could constitute a health hazard. Therefore, fishery organisms from the EpeLagoon could be considered unsafe for human consumption and the need for continuous monitoring to prevent bioaccumulation is necessary [8].

CONCLUSIONS

The organisms (*Tilapia 'wesafu', Chrysichthys*pp, *Macrobrachium*spp., *Mormyrusrume, Gymnarchusniloticus*) from Epe Lagoon contained iron and zinc above the safe limits for human consumption. There is the possibility of chronic toxicity from the consumption of these metals through the fishes tested from the Lagoon and this has serious implications on public health.However, periodic monitoring of Epe Lagoon is essential considering the nutritional and socio-economic importance of the Lagoon to the inhabitants of the area and environs. The fishery organisms from this Lagoon are marketed in various parts of Nigeria. This study could be used to establish a baseline study on heavy metals, its environmental impact and health risks of consuming organisms from the lagoon (Fig. 1) and to test other organisms from this lagoon.

REFERENCES

1. Ita, E.O., 1993. Inland Fishery Resources of Nigeria, CIFA Occasional Paper, 20: 94-100
2. FAO, 2002. Ecosystem Issues. OAR/National Undersea Research Programme/ G. McFall.www.fao.org.
3. Odumuyiwa, O.F., 2010. Assessment of Heavy Metals in Two Common Species (*Soleasolea*and *Pseudolithus*spp) from Lagos and Cocoa Lagoons in Lagos and Delta States, 5: 31.

4. Arabatizis, G.D. and A.K. Kokkinakis, 2005. Typology of the Lagoons of Northern Greece according to their Environmental Characteristics and Fisheries Production. ORIJ Contents, 5(1): 114-118.
5. MacFarlane, G.B. and M.D. Burchettt, 2000. Cellular distribution of Cu, Pb and Zn in the Grey Mangrove Avicemnia Marina (Forsk.). Vierh Aquatic Botanic, 68: 45-59.
6. Adeniyi, A.A. and K.A. Yusuf, 2007. Determination of Heavy Metals in Fish Tissues, Water and Bottom Sediments from Epe and Badagry Lagoons, Lagos, Nigeria. Environmental Monitoring and Assessment, 37: 451-458.
7. Storelli, M.M., A. Storelli, R. D'ddabbo, C. Marano, R. Bruno and G.O. Marcotrigiano, 2005. Trace Elements in Loggerhead Turtles (*Carellacarella*) from the Eastern Mediterranean Sea: Overview and Evaluation. Environment and Pollution, 135: 63-170.
8. Adefemi, S.O., S.S. Asaolu and O. Olaofe, 2008. Determination of Heavy Metals in *Tilapia mossambicuis* Fish, Associated Water and Sediment from Ureje Dam in South-Western Nigeria. Research Journal of Environmental Sciences, 2: 151-155.
9. Oyewo, E.O. and K.N. Don-Pedro, 2003. Lethal and Sub lethal effects of copper to the African Catfish (Clariasgarienpnus). West Africa Journal of Applied Ecology, 4: 115-123.
10. Mokhtar, M.B., A.Z. Aris, V. Munusamy and S.M. Praveena, 2009. Assessment level of heavy metals in *Penaeusmonodon* and *Oreochromis*spp in selected aquaculture ponds of high densities development area. Eur. J. Sci. Res., 30: 348-360.
11. Zhou, H.Y., R.Y.H. Cheung, K.M. Chan and M.H. Wong, 1998. Metal concentrations in sediments and Tilapia collected from Inland waters of Hong Kong. Water Res., 32: 3331-3340.
12. Mansour, S.A. and M.M. Sidky, 2002. Ecotoxicological Studies 3: Heavy Metals Contaminating Water and Fish from Fayoum Governorate, Egypt Food Chemistry, 78: 15-22.
13. Newman, M.C. and M.A. Unger, 2003. Fundamentals of Ecotoxicology Sixth EditionBoca Raton, FL: Lewis Publishers, pp: 27.
14. Kalay, M. and M. Canli, 2000. Elimination of Essential (Cu, Zn) and Non-Essential (Cd, Pb) Metals from Tissues of a Freshwater Fish *Tilapia zillii*. Turkey Journal of Zoology, 24: 429-436.
15. Uysal, K., Y. Emre and E. Köse, 2008. The Determination of Heavy Metal Accumulation Ratios in Muscle, Skin and Gills of Some Migratory Fish Species by Inductively Coupled Plasma-Optical Emission Spectrometry (Icp-Oes) in Beymelek Lagoon (Antalya/Turkey). Microchemistry Journal, 90(1): 67-70.
16. Wayne, G. and L.M. Hoya, 1999. Introduction to Environmental Toxicology: Impacts of Chemicals upon Ecological Systems. Journal of Ecotoxicology, 9(3): 231-232.
17. Zyadah, M.A. and T.E. Abdel-Baky, 2000. Toxicity and Bioaccumulation of Copper, Zinc and Cadmium in Some Aquatic Organisms. Bulletin of Environment, Contamination and Toxicology, 64(5): 740-747.
18. Basha, P.S. and A.U. Rani, 2003. Cadmium-Induced Antioxidant Defence Mechanism in Freshwater Teleost *Oreochromismossambicus* (Tilapia). Ecotoxicology, Environment and Safety, 56(2): 218-221.
19. Etesin, M.U. and N.U. Benson, 2007. Cadmium, Copper, Lead and Zinc Tissue Levels in Bonga Shad (*Ethmalosafimbriata*) and Tilapia (*Tilapia guineensis*) caught from Imo River, Nigeria. American Journal of Food Technology, 2: 48-54.
20. Almeida, J.A., Y.S. Diniz, S.F.G. Marques, L.A. Faine, B.O. Ribas, R.C. Burneiko and E.L.B. Novelli, 2002. The Use of the Oxidative Stress Responses as Biomarkers in Nile Tilapia (*Oreochromisniloticus*) Exposed to InvivoCadmium Contamination. Environment International, 27(8): 673-679.
21. Taweel, A., M. Shuhaimi-Othman and A.K. Ahmad, 2013. In vivo Acute ToxicityTests of some Heavy Metals to Tilapia fish (*Oreochromisniloticus*). Journal of Biologocal Sciences, 13: 365-371.
22. Saeed, S.M. and I.M. Shaker, 2008. Assessment of Heavy Metals Pollution in Water and Sediments and their Effect on *Oreochromisniloticus* in the Northern Delta Lakes, Egypt. 8^{th} International Symposium on Tilapia in Aquaculture, pp: 475-490.
23. Edokpayi, C.A., R.E. Uwadiae, A.O. Asoro and A.E. Badru, 2008. Phytomacrofauna arthropod associated with the roots of water hyacinth (*Eichhorniacrassipes*) in Epe lagoon Southern Nigeria. Ecology Environment and Conservation, 14(2-3): 241-247.

24. Asegbeloyin, I.N., A.E. Onyimonyi, O.T. Ujaml, N.N. Ukwuezel and P.O. Ukohal, 2010. Assessment of Toxic Trace Metals in Selected Fish Species and Parts of Domestic Animals. Pakistan Journal of Nutrition, 9(3): 213-215.
25. Steel, R.G.D.and J.H. Torrie, 1980. Principles and procedures of statistics: a biometrical approach. McGraw-Hill. 2nd Edition, pp: 633.
26. Adedeji, O.B. and R.C. Okocha, 2011. Bioconcentration of Heavy Metals in Prawns and Water from Epe Lagoon and Asejire River in Southwest Nigeria. Journal of Applied Science, Environment and Sanitation, 6(3): 377-384.
27. Taiwo, I.O., O.A. Olopade and A.F. Gafar, 2014a. An Analysis of some Heavy Metals in the Water, Sediments and some Fishery Organisms from Yewa Lagoon, Nigeria. Nigerian Journal of Animal Production, 41(1): 183-188.
28. Taiwo, I.O., M.O. Ipinmoroti, O.A. Olopade and J.A. Olugbojo, 2014b. The Presence of some Heavy Metals in the Sediments, Water and *Sarotherodongalileaus* in Ilo-Idimu River, Ogun State, Nigeria. Nigerian Journal of Animal Production, 41(2): 219-225.
29. World Health Organisation (WHO), 2008. Guidelines for Drinking Water Quality. 3rd Edn., Health Criteria and Supporting Information. WHO, Geneva, pp: 668. Retrieved from: http://www.who.int/water_sanitation_health/dwq/fulltext.pdf.