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Heavy Metals in *Oreochromis niloticus* (Linnaeus, 1758) (Persiformes: Cichlidae), *Ictalurus punctanus* (Rafinesque, 1818) (Suliriformes: Ictaluridae) and Bottom Sediments from Lagos Lagoon Proximal to Egbin Power Plant, Ijede, Ikorodu, Lagos Nigeria

[1,2]R.A. Olowu, [2]C.T. Onwordi, [3]A.A. Denloye, [2]M.O Osundiya, [2]N.O. Adebayo, [2]M.S. Owolabi, [2]O.O. Tovide, [2]B.A. Moronkola, [1]O.A. Omoyeni and [4]O.R. Ajuwon
[1]Department of Chemistry, University of the Western Cape Private Bag X17 Bellville, South Africa
[2]Department of Chemistry,
[3]Department of Zoology, Lagos State University, P.O Box 001 LASU Post Office, Lagos, Nigeria
[4]Oxidative Stress Research Centre, Faculty of Health and Wellness Sciences, Cape Peninsula University of Technology, PMB 1906, Bellville, South Africa

Abstract: This study presents the level of the heavy metal concentration in sediment and two fish species from the Ijede end of the Lagos lagoon in order to ascertain the pollution level of the lagoon .The pollution status of sediment and two fish species namely the Nile Tilapia *Oreochromis niloticus* (Linnaeus, 1758) (Persiformes: Cichlidae) and Channel Catfish *Ictalurus punctanus* (Rafinesque, 1818) (Suliriformes: Ictaluridae) in the Ijede end of Lagos lagoon were investigated. Samples of the test fish species and bottom sediments of the Lagoon were analyzed quantitatively for the presence of the cadmium (Cd), cobalt (Co), lead (Pb), iron (Fe) and zinc (Zn) using atomic absorption spectrophotometer. The results showed that the sediment contained a higher concentration of the metals than the fish samples with Fe recording the highest value of 33.32 μg/g against 18.34 and19.55 μg/g in the two fish species sampled. The study on the two fish samples revealed a higher concentration of lead (2.88 μg/g) in the Tilapia compared to the Catfish species indicating the pollution trend of the two fish species investigated in the lagoon. The concentration of Cd, Fe and Zn in the fish species sampled was within limits permitted by the National Food, Drug adminstration and Control (NAFDAC) and the United State Food and Drug Agency (USFDA). However, the concentrations of lead (Pb) in the fish species was above the recommended standard which indicate that the fish species studied in the area are unsafe for consumption.

Key words: Anthropogenic source, effluents discharges, heavy metal, *Ictalunus punctanus*, *Oreochomis niloticus*, power generation, toxic substances

INTRODUCTION

The aquatic environment with its water quality is considered the major factor controlling the state of health and disease in both cultured and wild fishes. The pollution of the aquatic environment with heavy metals has turned out to be a worldwide problem in recent years, because these pollutants are resilient and often have toxic effects on organisms (Olowu *et al*., 2010a, MacFarlane and Burchett, 2000; Sam *et al*., 2010; Storelli *et al*., 2005).

Furthermore, factors such as high population growth accompanied by intensive urbanization, increase in industrial activities and higher exploitation of natural resources including cultivable land have caused pollution increase (Olowu *et al*., 2010a; Kamaruzzaman *et al*., 2011; Adefemi and Awokunmi, 2010). Among environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to bioaccumulate in aquatic organisms (Censi *et al*., 2006). Many African aquatic ecosystems are increasingly experiencing heavy metal pollution due to growing agricultural and industrial development (Kamaruzzaman *et al*., 2011). The level of these metals in the aquatic environment has increased immensely in the past decades as a result of human inputs and activities (Omoigberale and Ikponmwosa-Eweka, 2010; Feranandes *et al*., 2008). These inputs include various treated and untreated effluents, agricultural surface water run-off, as well atmosphericic particulates (Olowu *et al*., 2010b; Kamaruzzaman *et al*., 2011, Ololade *et al*., 2008; Adeniyi and Yusuf, 2007; Kosi-Siakpere *et al*., 2007; Alabasterus and Iloyd, 1980). The vulnerability of aquatic

Corresponding Author: R.A. Olowu, Department of Chemistry, University of the Western Cape Private Bag X17 Bellville, South Africa

habitats to inorganic element contamination has been established (Adeniyi and Yusuf, 2007) and pollution of the aquatic environment by inorganic chemicals is a potent threat to the aquatic organisms including fishes. Inorganic ions from these chemicals are inadvertently sourced from agricultural drainage water containing pesticides and fertilizers as well as effluents of industrial activities and runoffs (ECDG, 2002; Yoshiteru, 2002). (Olowu *et al*., 2010b) and Andrew *et al*. (1980) reported that fish living in polluted water, may accumulate pollutants from water via their food chains as well as fish feeding on small marine organisms, algae and bottom sediments that readily accumulate dangerous inorganic elements.

Sediments are the major repository of heavy metals in aquatic system while both allochthonous and autochthonous influences could make a concentration of heavy metals in the water high enough to be of ecological significance (Olowu *et al*., 2010a; Awofolu *et al*., 2005; Oyewo and Don-Pedro, 2003). It is very well establshed that the bottom sediment of many of Nigeria's aquatic ecosystem is highly inundated with heavy metal pollutants (Olowu *et al*., 2010a; Awofolu *et al*., 2005; Asaolu and Olaofe, 2005). It is also known that contaminated sediments can intimidate creatures in the benthic environment, exposing worms, crustaceans and insects to harmful concentrations of toxic chemicals (Olowu *et al*,., 2010a). In this regard some toxic sediments kill benthic organisms, reducing the food available to larger animals such as fish while others are taken up by benthic organisms and bioaccumulated when bigger animals feed on these contaminated organisms. This signals the taking up of the pollutants with their toxic effects and thus moves up the food chain in increasing concentrations in a process well-known as biomagnifications (Olowu *et al*., 2010b, Abida *et al*., 2009; Adefemi *et al*., 2008). It remains to be shown if these pollutants get to Man through his food and if so, which of his food serves as veritable sources of these pollutants.

Fish constitute one of such sources for the accumulation of heavy metals in Man. They are highly valued for their balanced level of amino acid, vitamin B_{12} cholesterol, high polysaturated fatty acid and therefore accounts for 40% of the animal protein in the diet of Nigerians (Olowu *et al*., 2010a). Fish species are notorious for their ability to concentrate heavy metals in their muscles, yet they play important role in human nutrition (Olowu *et al*., 2010a, Adeniyi and Yusuf, 2007). Consequently, there is need to carefully screen them in order to ensure that unnecessary high level of toxic trace metals are not being transferred to man through them. This provides a background for the anlysis of the candidate metals in fish species in the present study.

However, Lagos as a commercial hub and the industrial nerve center of Nigeria with an estimated population of more than 17 million people, environmental concerns are normally focused on Lagos State. Over 60% of Nigeria's industries are cited in the state, each discharging its characteristic range of effluents containing heavy metals into the terrestrial and aquatic ecosystems within the state. Typically, the lagoon system in Lagos State is made up of Badagry, Ologe, Lagos, Lekki, Epe and Ikorodu lagoons and which act as sink or reservoir receiving effluents of over 10,000 m^3 daily from drainages through different parts of the metropolis and hinterland (Olowu *et al*., 2010b, Oyewo and Don-Pedro, 2003). The Lagos lagoon at the Ijede end of Lagos state receives discharges from the Egbin thermal station of the Power Holding Company of Nigeria, the Nigeria National Petroleum Cooperation (NNPC) gas plant, runoffs from dump sites in the community, exhausts form automobile activities at the jetty and agricultural runoff from the farming communities along the river course couple with upsurge of population towards this area due to reformation taken place in the entire state arose the need to investigate the pollution status of the lagoon. The Lagos Lagoon forms a major transport channel from Ikorodu to Lekki-Ajah area of Lagos State and also serves as fishing sources, drinking water source and an asset for recreational activities like swimming for the people in Ijede area of Ikorodu Lagos State.

It becomes imperative to ascertain the safety of these fishes caught from this lagoon before they are consumed by man. The results obtained from this study should provide information on levels of metals in the water, sediments and samples of fish species from the lagoon, and overall environmetal quality of the lagoon.

MATERIALS AND METHODS

Sample site: The sample site is located at the Ijede end of the Lagos lagoon between Egbin thermal station discharge point and the Ijede ferry Jetty. The Ijede axis is not one of the deepest points of the lagoon with its depth ranging from 10-50 m. At Ijede, the lagoon receives discharges from the Egbin thermal station of the Power Holding Company of Nigeria, the Nigeria National Petroleum Cooperation (NNPC) gas plant, runoffs from dump sites in the community, exhausts from automobile activities at the jetty and agricultural runoff from the farming communities along the river course and the area overpopulation with the aim of assessing the influence of discharged into the water body. Samples of sediment and fish (*Oreochomis niloticus* and *Ictalunus punctanus*) were collected between the Egbin thermal station discharge point and Ijede Jetty (Fig. 1).

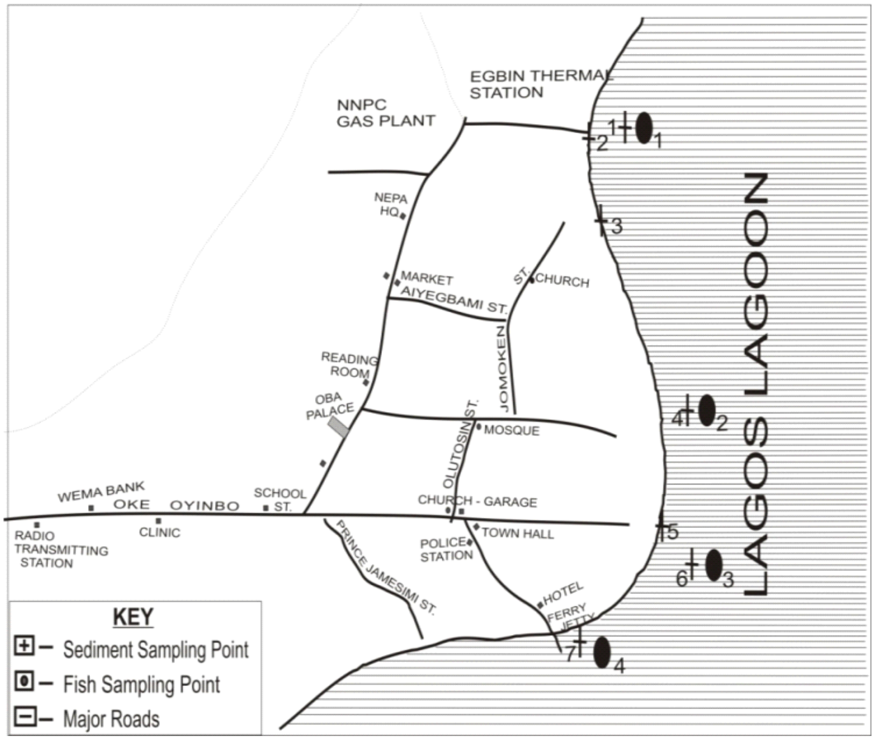

Fig. 1: Map showing the various sampling point in Ijede, Ikorodu Lagos State

Sampling and sampling method: Sampling was carried out in accordance with the recommendation of UNEP (2006) reference method for marine pollution studies previously used by Olowu *et al*. (2010a). Sediments and fish samples were collected between the period of December 2008 and March 2009 at the Ijede end of the Lagos lagoon fortnightly for analytical purposes. The species used for the study are Oreochomis niloticus and Ictalunus punctanus. Each fish species were caught in the lagoons using drag net, which were usually left over night in the lagoon by local fishermen. Each fish was properly cleaned by rinsing with distilled water to remove debris planktons and other external adherent. It was then drained under folds of filter, weighed, wrapped in aluminum foil and transported to the laboratory and then frozen at -10ºC prior to analysis. Samples were collected at varying distances of the lagoon, some as far as 200 m away from the bank of the lagoon. Bottom sediment from each study sites was collected in the same lagoon into pre-cleaned polythene bag using a stainless van-veen grab alongside the fish samples. Each batch of fish and sediments were collected at an interval of two weeks to each other

Sample preparation: For analysis the fish samples were defrosted for two hours. The scales were removed and the batches of fish samples were weighed before and after oven drying. Drying of the fish samples was done using Gallenkamp® hot box oven at a temperature of 110ºC for 2 h. After drying, the samples were pulverized in an acid cleaned electric Moulinex® blender. The pulverized fish samples were sieved with a 2 mm mesh and stored in clean polythene bags. The sediment samples were air dried for 14 days and then pulverized and it was then sieved with the 2 mm mesh and stored in a clean polythene bag.

The fish and sediment samples were prepared respectively for metal analysis using the wet digestion method. For the fish samples, 5 g of each of the dried pulverized samples was weighed into separate 250 mL conical flasks, the fish samples being homogenized with 50 mL of deionized water after 10 mL of concentrated HCl and 5ml of concentrated HNO_3 were added in succession. The mixture was heated on an electrical heater to a thick yellow solid but ensuring that the digest does not dry up. It was allowed to cool, filtered and the filtrate made up to 100mL with distilled water for the determination of Cd, Co, Pb, Fe and Zn. This was stored in acid washed plastic bottles. Blank samples were also carried out. The cadmium, cobalt, lead, iron and zinc levels of the digests were determined by a BUK scientific, VGP 210 model flame atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

The results of the analysis are presented in Table 1, 2, 3, 4, 5, 6, 7, 8 and 9, respectively. Table 1, 2, 3 and 4 showed the level of heavy metal concentration in Catfish

Table 1: Heavy metal concentration in fish sample at sampling point 1

Fish samples	Cd (µg/g)	Co (µg/g)	Pb (µg/g)	Fe (µg/g)	Zn (µg/g)
CF_A	0.44	4.00	3.60	5.40	18.00
CF_B	0.22	2.00	3.60	7.20	18.80
CF_C	0.26	1.80	2.00	0.00	14.80
Mean	0.31	2.60	3.10	4.20	17.20
TF_A	0.24	3.40	7.20	8.40	23.00
TF_B	0.36	2.00	2.80	8.00	19.00
TF_C	0.20	1.40	1.40	5.40	16.20
Mean	0.27	2.27	3.80	7.27	19.40

Table 2: Heavy metal concentration in fish sample at sampling point 2

Fish samples	Cd (µg/g)	Co (µg/g)	Pb (µg/g)	Fe (µg/g)	Zn (µg/g)
CF_A	0.46	3.80	3.20	4.60	21.20
CF_B	0.38	2.00	2.20	5.60	18.20
CF_C	0.28	1.40	1.60	6.20	15.80
Mean	0.37	2.40	2.33	5.47	18.40
TF_A	0.60	3.00	4.40	10.00	23.60
TF_B	0.38	1.80	2.20	8.00	19.60
TF_C	0.20	2.20	1.60	4.20	16.40
Mean	0.39	2.33	2.73	7.40	19.87

Table 3: Heavy metal concentration in fish sample at sampling point 3

Fish samples	Cd (µg/g)	Co (µg/g)	Pb (µg/g)	Fe (µg/g)	Zn (µg/g)
CF_A	0.46	3.60	3.00	4.20	23.00
CF_B	0.32	1.80	3.80	5.40	17.40
CF_C	0.20	1.60	1.80	5.20	15.80
Mean	0.33	2.33	2.87	5.27	18.73
TF_A	0.70	2.00	3.60	26.60	22.20
TF_B	0.30	2.40	2.60	8.60	19.40
TF_C	0.22	2.20	1.60	4.20	16.20
Mean	0.41	2.13	2.60	13.13	19.27

Table 4: Heavy metal concentration in fish sample at sampling point 4

Fish samples	Cd (µg/g)	Co (µg/g)	Pb (µg/g)	Fe (µg/g)	Zn (µg/g)
CF_A	0.50	3.40	3.00	5.40	22.20
CF_B	0.32	2.60	2.60	7.80	18.20
CF_C	0.24	1.60	1.60	5.00	15.80
Mean	0.35	2.53	2.40	5.93	18.73
TF_A	0.64	2.80	3.00	4.60	22.60
TF_B	0.34	2.80	2.60	7.80	20.20
TF_C	0.22	2.00	1.60	4.20	16.20
Mean	0.40	2.53	2.40	5.53	19.67

CF_A: Catfish Sampled in December, (Dry Season); CF_B: Catfish Sampled in February, (Rainy Season); CF_C: Catfish Sampled in March (Heavy Rainy Season); TF_A: Tilapia fish Sampled in December, (Dry Season); TF_B: Tilapia Fish Sampled in February, (Rainy Season); TF_C: Tilapia fish Sampled in March (Heavy Rainy Season)

Table 5: Mean concentration (µg/g) and Metal Pollution Index (MPI) of heavy metal [Cd, Co, Pb, Fe, Zn] from four sampling points in catfish (*Ictalurus punctatus*)

Sampling point	Cd	Co	Pb	Fe	Zn	MPI
1	0.31	2.60	3.07	4.20	17.20	2.82
2	0.37	2.40	2.33	5.47	18.40	2.91
3	0.31	2.33	2.67	5.27	18.73	2.86
4	0.35	2.53	2.40	5.93	18.73	2.98
Mean	0.34	2.47	2.62	5.22	18.34	
SD	±0.03	±0.11	±0.29	±0.63	±0.63	

(*Ictalurus punctatus*) and Tilapia (*Oreochromis niloticus*) species at different sampling points within the lagoon. The mean Concentration (µg/g) and Metal Pollution Index (MPI) of heavy metal [Cd, Co, Pb, Fe, and Zn] from Four

Table 6: Mean concentration (µg/g) and Metal Pollution Index (MPI) of heavy metal [Cd, Co, Pb, Fe, Zn] from four sampling points in tilapia (*Oreochromis niloticus*)

Sampling point	Cd	Co	Pb	Fe	Zn	MPI
1	0.27	2.27	3.80	7.27	19.40	3.19
2	0.39	2.33	2.73	7.40	19.87	3.25
3	0.41	2.13	2.60	13.13	19.27	3.56
4	0.40	2.53	2.40	5.53	19.67	3.05
Mean	0.37	2.32	2.88	8.33	19.55	
SD	±0.06	±0.14	±0.54	±2.92	±0.23	

Table 7: Mean concentration (µg/g) of heavy metals [Cd, Co, Pb, Fe, Zn] from locations in sediments

Sampling point	Cd	Co	Pb	Fe	Zn
1	3.06	0.33	2.16	27.32	18.67
2	2.65	0.15	1.57	34.33	23.05
3	2.81	0.88	2.85	33.32	29.15
4	3.11	0.16	2.29	27.15	22.11
5	3.27	0.58	2.31	31.31	24.77
6	3.06	0.28	2.87	32.94	25.56
7	2.24	0.23	2.27	3262	25.55
Mean	2.89	0.37	2.33	31.28	24.13
SD	±0.35	±0.27	±0.44	±2.91	±3.28

Table 8: Correlation coefficients between metal concentration in sediments and in Tilapia (*Oreochromis niloticus*) and catfish (*Ictalurus punctatus*) at p>0.05

	Metals				
Correlations	Cd	Co	Pb	Fe	Zn
Tilapia and sediment	- 0.30	- 0.41	- 0.45	0.39	- 0.02
Catfish and sediment	- 0.27	0.39	0.20	0.57	0.96
Catfish and tilapia	0.45	- 0.50	- 0.73	- 0.12	0.22

Table 9: Comparism of mean metal concentration values with maximum acceptable level of metal concentrations of certain organisms and agencies for fish samples

	Present study		Organizations			
Metals	Tilapia	Catfish	FAO	USFDA	WHO	NAFDAC
Cd	0.37	0.34	2.0	1.5	0.2	3.0
Co	2.32	2.47	-	-	-	-
Pb	2.88	2.62	0.5	-	1.5	0.01
Fe	8.33	5.22	-	-	-	-
Zn	19.55	18.34	30.0	-	-	-

Sampling Points in Catfish (*Ictalurus punctatus*) and Tilapia (*Oreochromis niloticus*) were summarized in Table 5 and 6 respectively. Table 7 present the mean concentration of heavy metal in the sediment at different sampling points. The mean comparison of the heavy metal concentration in the analyzed fish samples and the acceptable standards in fish and the correlation coefficients between the metal concentration in the fish samples and the sediment were presented in Table 8 and 9, respectively. Figure 2 shows the mean concentration (µg/g) of heavy metal in catfish from four locations, Fig. 3 mean concentration (µg/g) of heavy metal in sediment from seven locations while Fig. 4 shows mean concentration (µg/g) of heavy metal in cat fish from four locations The level of heavy metal concentration in both fish samples at the sampling point 1 of the Ijede end of the lagoon in Table 1 ranged from 0.27 µg/g Cd -19.40 µg/g Zn. The highest concentration of heavy metal investigated was recorded in the sediment which has been reported to

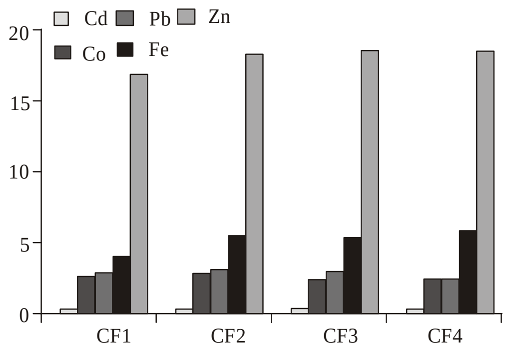

Fig. 2: Mean concentration (μg/g) of heavy metal in cat fish from four locations

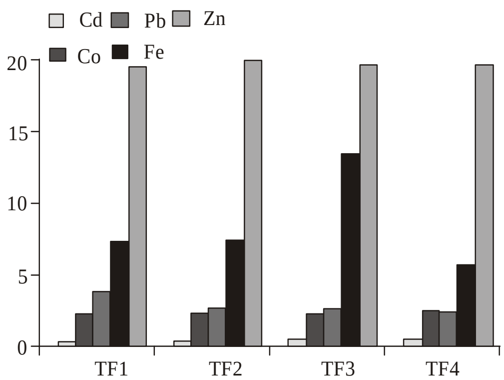

Fig. 3: Mean concentration (μg/g) of heavy metal in tilapia from four locations

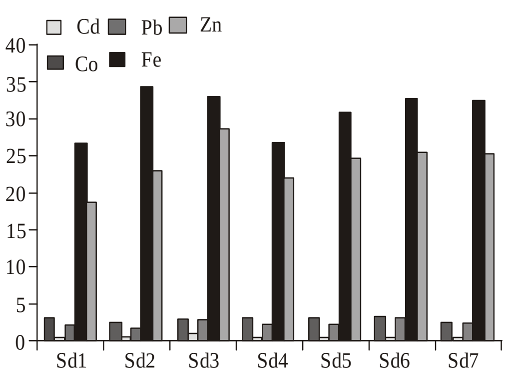

Fig. 4: Mean concentration (μg/g) of heavy metal in tilapia from seven locations

serve as major repository of heavy metal in aquatic system (Olowu *et al*., 2010a; Adeniyi and Yusuf, 2007; Maaboodi *et al*., 2011). The sediment at sampling point 1 was particularly enriched with Fe (27.32 μg/g) and Zn (18.7 μg/g) while cobalt had the least value of 0.33 μg/g. The high content of iron in the sediment may be because of the clayey material that forms the river bed in the area sampled. This may explain the high concentration recorded in the fish species sampled. The fish, being carnivores may have taken the iron from the iron rich bed material along with food which is in an agreement with earlier reports from Olowu *et al*. (2010a) and Adefemi *et al*. (2008).

Table 2 shows the metal distribution at the sampling points 2. Zn was consistently higher tha n other metals analyzed. It ranged between 15.80 -19.87 μg/g in the fish sample. The level of cadmium (Cd) and lead (Pb) in the fish samples studied revealed a higher concentration of the metals compared to the standard set value of 1.5 μg/g (Pb) and 0.20 μg/g (Cd) in fish. The high level of these metals may be ascribed to the closer proximity of the sample points to the effluent discharge point from Egbin power station of power holding of Nigeria (PHCN) as well as the discharges from the drainage point of the Nigeria National Petroleum Corporation (NNPC) gas plant depot situated in the studied area. Higher concentrations of the heavy metal were also recorded in the sediment at this sampling point. The level of metal concentration in the sediment at the sampling point 3 is presented in Table 3 which is closer to the residential area. The metal concentration ranged from 0.88 μg/g Co -33.32 μg/g Fe while that of the fish samples ranged from 0.2 μg/g Co-19.40 μg/g Zn. The values of lead and cadmium recorded at this sampling site were found to be higher than the standard which may be attributed to various discharges of petroleum and petroleum product from the residents as result of continuous use of generating sets powered with leaded gasoline due to incessant power failure as well as domestic wastes discharge into the lagoon.

Zinc (Zn), iron (Fe) and lead (Pb) were the chief metal found in fish samples analyzed at sampling point 4 as shown in Table 4. The most predominant metal recorded in the sediment at sampling point 4 of the Ijede end of the lagoon were Fe (27.15.32 μg/g) and Zn (22.11 μg/g) and Pb (2.29 μg/g). As shown in Table 5 other sampling points (5-7) investigated also revealed a higher load of heavy metal. Sampling point 4 is closer to town hall, church garage and a host of other relaxation centre hence various discharges from church as vehicular emission, from the church garage as well as domestic waste from the various activities from the relaxation spots may be responsible to high value of Pb. and Cd. The concentration of cadmium was low in the fish sample compared to Pb concentration but has a preference for the sediment being the major depositing agent for metal which is in agreement with earlier report (Olowu *et al*., 2010a; Adeniyi and Yusuf, 2007; Ali *et al*., 2010; Maaboodi *et al*., 2011).

The overall mean concentrations of heavy metal in the Ijede proximity are presented in Table 6 and 7. The tables revealed a higher concentration of heavy metal in tilapia fish with a higher load of Pb, Fe, Zn and Cd compared to catfish with highest metal pollution index at sampling point 3 and 4 which is situated close to the jetty where the fish species are likely to have to have greater roaming laxity. From these Tables it can be seen that tilapia fish species are more polluted than the catfish in the study however the fish species studied in the lagoon had lesser heavy metal concentration than what was reported for fish species studied from Lagdo Lake in Cameroun (Ali *et al*., 2010). The pollution of the fish species investigated may be attributed to indiscriminate discharge of untreated effluent from the Egbin power station as well as discharge from NNPC gas depot. The correlation coefficients between the tilapia, catfish and the sediment in Cd, Co, Pb are very weak but there exist a strong correlation in iron in tilapia as well strong correlation in Zn and Fe in catfish respectively which revealed that there is a common source of these metals in the study fishes as shown in Table 8. The strong correlation of Fe in both fish species may also be attributed to the high nutritive value of iron in living organisms (Olowu *et al*., 2010a). It is noteworthy that the coefficients obtained for Fe in Tilapia and Co, Pb, Fe and Zn in catfish were positive at $p<0.05$ level of confidence with the sediment. Coefficients close to zero or negative indicates that the amount of metals in the sediment is not directly reflected in the fish species which is an indication that concentration are probably lower than the threshold below which these organisms are able to regulate the accumulation of metal in the bodies (Ikem *et al*., 2003). The Comparison of the mean concentration of the metal in Table 9 in the fish species sampled revealed that Cd, Fe and Zn fall within the acceptable limits of various metal for fish sampled. However, high concentration of lead (Pb) was observed in the two fish species with tilapia species recording the highest value of 2.88 μg/g compared with the reference standards and this shows a high level of pollution of the lagoon. In addition it can also be inferred from this work that the tilapia fish are more polluted and that the two species from the lagoon in the studied area are unsafe for consumption hence proactive measure must be taking in ensuring treatment of the effluents from this power station before been discharge into the aquatic environment.

CONCLUSION

The present study showed that the impact of effluent discharge from the PHCN, the NNPC and that of the activities of automobiles at the Ijede jetty poses a great treat to the aquatic life and humans through the consumption of the *O. niloticus* and *I. punctanus* from the lagoon. There is therefore a great need for stiffer measures in ensuring that the two companies treat their wastes properly before discharging them into the lagoon. Also, a sustainable environmental pollution remediation program needs to be evolved in order to arrest the level of contamination of the Ijede axis of the Lagos lagoon. This study has provided data and information that may be useful for such studies and policy formulation. Lastly, there is need for regular monitoring of the level of heavy metals among the communities around Ijede

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