Dynamics of Heavy Metal Pollution in Tropical lagoon of Gulf of Guinea, West Africa

*[1]ABDUL, WO; [1]OGUNTUASE, KE; [1]OMONIYI, IT; [2]BADA; SB; [1]ADEKOYA, EO;
[1]BASHIR, AO; [1]IBEBUIKE, LC; [1]OPAJOBI, GA

[1]Department of Aquaculture and Fisheries Management, Federal University of Agriculture Abeokuta, Nigeria.
[2]Department of Environmental Management and Toxicology, Federal University of Agriculture Abeokuta, Nigeria.
*Corresponding Author Email: abdulwo@funaab.edu.ng; Tel: +2348183429107

ABSTRACT: In this study the accumulation of Iron (Fe), Zinc (Zn), Cobalt (Co), Chromium (Cr), Cadmium (Cd), Lead (Pb) and Nickel (Ni) in sediment, water, some fish samples (*Schilbe mystus*, *Mormyrus rume*, *Gymnarchus niloticus*, *Cynoglossus senegalensis*, and *Chrysichthys nigrodigitatus*) and an aquatic plant *Eichhornea crassipes* collected from Lekki lagoon, Lagos Nigeria were examined. Heavy metals in the water, sediment, some selected fish and an aquatic plant were determined seasonally across nine sampling Stations; in the gills, liver and muscles of the fish species and in the root stem and leaves of *Eichhornea crassipes* using an atomic absorption spectrometer (AAS). Heavy metals concentrations in the sediment and water varied significantly, both spatially and seasonally. Metal concentrations varied between species and body parts while Co, Cr and Pb were not detected. Ni was found in the liver and gills of *S. mystus* and *M. rume* and Cr in the gills of *G. niloticus* only. In *Eichhornea crassipes*, metals detected were in the order: root>leaves>stem for Fe, Zn, Cr, and Cd; root>stem>leaves for Pb and Ni while Co was not detected. Heavy metal presence in Lekki Lagoon calls for monitoring of activities within and around the lagoon and policy development towards the sustainable ecosystem health services.

Aquatic pollution has been an issue of concern over the last few decades as a result of the health hazards it poses to aquatic lives and the human population at large. Pollutants in aquatic ecosystems come from excessive nutrient inputs, eutrophication, acidification, heavy metal contamination, organic pollution, and obnoxious fishing practices (Emmanuel and Chukwu, 2010). Meanwhile, among these pollutants, heavy metal contamination is of particular interest and has attracted the attention of several investigators both in the developed and developing countries of the world (Arena *et al*., 2013; Kuton *et al*., 2014). However, the level of pollutants have been on increase through anthropogenic sources such as the increase in human population, urbanization, industrialization, agricultural practices, petroleum contamination and sewage disposal (Santos *et al*., 2005; Gupta *et al*., 2009). Heavy metals being a principal pollutant, bio-accumulates in the food chain and makes fish very sensitive to heavy metal pollution (Akan *et al*., 2012). Fish takes up these metals via food, intake of water through the gills, suspended particulate matter, and sediment, which are then absorbed into different organs or tissues in the body such as the gills, liver, kidney and muscles (Nussey,

2000) causing health hazards when intake is excessively elevated in humans. Sediments play a major role in determining the pattern of pollution in aquatic ecosystems as they serve as depositories and carriers of contaminants including heavy metals (Celo *et al*., 1999; Li, 2014). Most of these metals are absorbed into the sediment and subsequently released into the water via re-suspension processes such as currents, waves, dredging and other anthropogenic activities (Jonah *et al*., 2014). Heavy metals are also taken up directly from the sediment by benthic organisms and transferred up the food chain when they are fed upon. Also, aquatic plants have also been reported to accumulate pollutants such as heavy metals thus making them important indicators of heavy metal contamination (Samecka-Cymermanoz, 2005). Heavy metals have been reported to be well concentrated in the water, sediments and biota in lagoons exceeding permissible levels (Don-Pedro *et al*., 2004), thus representing an unsafe link between the aquatic resources and human health. Similar studies have been carried out by Chindah *et al.* (2004) and Davies *et al.* (2006) in Calabar River Estuary and Eleshi Creek with paucity of information on the dynamics of Lekki lagoon. Earlier studies on sediment, water and biota of

Corresponding Author Email: abdulwo@funaab.edu.ng; Tel: +2348183429107

Lake Victoria, Kenya reflected no significant heavy metal pollution [Onyari and Wandiga, 1989) while Ogoyi *et al.* (2011) reported a high concentration of heavy metals in the sediment compared to water and microalgae in the same lake. Also, Akhiromen and Ogbonne (2018) reported an evidence of heavy metal contamination in Epe axis of Lekki Lagoon in water, sediment and the biota, with a significantly high concentration of zinc, copper and iron in the sediment compared to water and the biota (*Macrobrachium vollenhovenii*). Ekpo *et al*. (2013) also reported that the concentrations of heavy metals in bottom sediment were significantly higher (p<0.05) than those recorded in water samples. Reports from these studies showed the utmost importance of periodically determining the levels of heavy metals in aquatic ecosystems. This will guide in ascertaining the health status of aquatic systems towards sustaining its integrity, thus this study, which focused on examination of bioaccumulation of Zinc, Lead, Cadmium, Chromium, Copper and Cobalt in the water, sediment, water hyacinth (*Eichhornia crassipes)* and selected fish species in Lekki Lagoon, Lagos Nigeria.

MATERIALS AND METHODS

Description of the Study Area: This study was carried out in Lekki lagoon a tropical lagoon in the Gulf of Guinea. The lagoon lies between $4° 00'$ - $4° 15'$ E and between $6° 25'$ - $6° 37'$ N, with a surface area of about 247 km^2 and it is mostly shallow (less than 3.0 m deep) with a maximum depth of 6.4m (Opadokun *et al*., 2015). It is fed by River Oni in the North-eastern part and Rivers Oshun and Saga in the North-western part (Kuton *et al.*, 2014).

Sampling Location and Sample Collection: Sediment and water samples were obtained in wet and dry seasons in triplicates in all the nine Stations in the study area as shown in Figure 1. Water samples were obtained at a depth of about 0.5m and stored in labeled polyethylene bottles. Sediment samples were collected using Van Veen grab and stored in labeled polyethylene bags. Forty samples each of adult *Schilbe mystus*, *Mormyrus rume*, *Gymnarchus niloticus*, *Cynoglossus senegalensis*, and *Chrysichthys nigrodigitatus* were collected randomly from fishermen in the study area and stored in sterile polyethylene bags. Samples of *Eichhornia crassipes* were selected randomly across the water body and transported in polyethylene bags. All samples were kept in ice box and transported to the laboratory.

Sample treatment: In the laboratory, sediment samples were dried at 105 ºC, ground and passed through a 2mm sieve and as described by Page *et al.* (1982). Water samples were treated by adding 10 ml concentrated nitric acid to 100ml of sample. The water samples were than digested as described by Olusola and Festus (2015). Prior to digestion, all the fish samples were washed with running water and dissected with sterile scissors to remove gills, liver and muscles. These were transferred into sterile sample bottles, labelled and kept for digestion. The samples were then digested following the procedure of Muritala *et al.* (2012). *Eichhornia crassipes* samples were separated into roots, leaves and stems, oven dried at 65 ºC and homogenized with mortar and pestle and digested using the procedure described by Nazir *et al*. (2015). Heavy metal concentrations in all the digested samples were determined using Atomic Absorption Spectrophotometer (AAS).
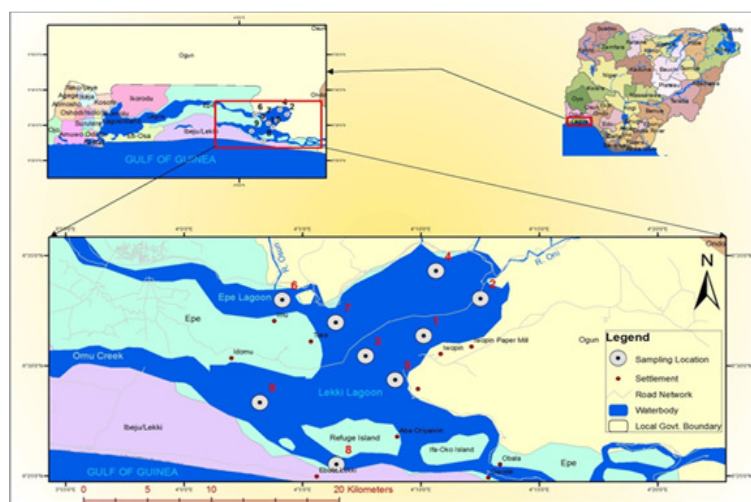

Fig 1. Map of Lekki lagoon showing the sampling Stations
Key: 1=Brushpark, 2=River Oni, 3= Open water, 4= River Mosafejo, 5= Imeki, 6= River Osun, 7=Emina, 8=EbuteLekki, 9=Yuboye.

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Statistical analysis: Data obtained were subjected to descriptive and inferential statistics using Statistical packages for Social Sciences (SPSS version 19.0).

RESULTS AND DISCUSSION

Sediment is very important tracer of metal in aquatic system (Abeh *et al.*, 2007). The highest concentration (291.62±18.16mg/kg) of Fe was recorded in Station 4 while the least (81.11±4.17mg.kg) was recorded in Station 7. The concentrations of Zn were 1.02±0.21mg/kg, 5.27±0.51 mg/kg, 1.98±0.33 mg/kg, 1.57±0.12mg/kg, 5.37±0.13 mg/kg, 1.06±0.03 mg/kg, 0.85±0.02 mg/kg, 1.52±0.21mg./kg and 5.67±0.35mg/kg in Stations 1-9 respectively as shown in Table 1. The concentrations of Co were 0.11±001mg/kg, 0.21±0.01 mg/kg and 0.22±0.01mg/kg in Stations 1-3 respectively and other values were below the detection limit in the remaining Stations. The highest and least concentrations of Cr in the sediment were 1.93±0.12 mg/kg and 0.42±0.02mg/kg in Stations 2 and 6 respectively. Also, highest concentrations of Cd and Ni were recorded in Station 2 (1.87±0.15 mg/kg, 1.74±0.04 mg/kg) while the least were recorded in Stations 8 (0.10±0.01mg/kg) and 7 (0.54±0.03mg/kg) respectively. Pb values

recorded in all Stations were below detection limit. The concentrations of Cr, Zn, Ni, Cd, Pb, Fe, and Co recorded in the sediment in this study were above DPR and WHO maximum permissible limits. Jonah *et al.* (2014) reported similar high concentrations of these metals in the sediment of Ohii Miri River, Abia State, Nigeria. Table 2 shows that the concentrations of metals were generally higher in the dry season compared to the wet season. Fe recorded the highest concentration of heavy metals in the dry (183.78±95.49 mg/kg) and wet (142.24±100.30 mg/kg) seasons while the least concentration were recorded in Co in the dry season and Cr (0.76±0.21 mg./kg) in the wet season. The highest concentration of Fe is similar to the findings of Aderionla *et al.* (2009), who reported that Fe was the most abundant metal in Lagos lagoon (one of the lagoons of the Gulf of Guinea) with a mean value of 482±8.66 mg/Kg in the sediment. The high level of Fe in the sediment was also similar in the sediments of the water bodies studied by Asaolu *et al.* (1997); Asaolu and Olaofe (2004); Nwajei and Gagophien, (2000). Pb was below detectable limit in both seasons in this study which was contrary to the findings of Eddy *et al.* (2004) who observed a considerable high Pb values in sediment of River Crossriver.

Table 1: Spatial concentrations heavy metal in the sediment of Lekki lagoon

Stations	Iron	Zinc	Cobalt	Chromium	Cadmium	Lead	Nickel
			Metals (mg/kg)				
1	146.41±13.15[b]	1.02±0.21[bc]	0.11±0.01[b]	1.87±0.16[a]	1.16±0.21[b]	BLD	0.78±0.03[bc]
2	129..81±1..20[c]	5.27±0.51[a]	0.21±0.01[a]	1.93±0.12[a]	1.87±0.15[a]	BLD	1.74±0.04[a]
3	143.51±21.22[b]	1.98±0.33[b]	0.22±0.01[a]	0.78±0.02[b]	0.78±0.02[b]	BLD	0.87±0.05[bc]
4	291.62±18.16[a]	1.57±0.12[b]	BLD	0.85±0.15[b]	BLD	BLD	1.08±0.01[b]
5	278.01±15.60[a]	5.37±0.13[a]	BLD	0.87±0.01[b]	0.68±0.04	BLD	0.81±0.04[bc]
6	87.21±9.81[d]	1.06±0.03[bc]	BLD	0.42±0.02[b]	BLD	BLD	0.71±0.07[bc]
7	81.11±4.17[d]	0.85±0.02[c]	BLD	0.78±0.12[b]	BLD	BLD	0.54±0.03[c]
8	167.18±4.11[b]	1.52±0.21[b]	BLD	0.81±0.01[b]	0.10±0.01	BLD	0.93±0.02[b]
9	132±8.15[bc]	5.67±0.35[a]	BLD	1.28±0.04[a]	BLD	BLD	1.72±0.12[a]

*Means with similar superscript across the column indicate there is no significant (p>0.05) difference between means
Detection limit for metals: Fe = 0.05mg/kg, Zn=0.005 mg/kg, Co =0.05 mg/kg, Cr= 0.04 mg/kg , Cd= 0. mg/kg, Pb= 0. mg/kg, Ni=0.10 mg/kg
BDL - Below detection limit
Key: 1=Brushpark, 2=River Oni, 3= Open water, 4= River Mosafejo, 5= Imeki, 6= River Osun, 7=Emina, 8=EbuteLekki, 9=Yuboye

Table 2: Seasonal concentrations heavy metal in the sediment of Lekki lagoon

Metals (mgl⁻¹)	Dry Season	Wet Season	F (value)	p(value)	DPR (2002)/FEPA (2003) standards for sediment (mgkg⁻¹)
Iron	183.78±95.49	142.24±100.30	203	0.658	20
Zinc	3.28±2.56	2.49±2.29	442	0.525	50–300
Cobalt	0.07±0.11	BLD	14.64	0.010	20
Chromium	1.05±0.46	0.76±0.21	2.33	0.145	0.5
Cadmium	0.53±0.07	BLD	11.806	0.030	0.03-0.3
Lead	00±00	00±00	0.00	0.00	2-20
Nickel	1.07±0.56	0.964±0.37	1.312	0.268	0.8

*Means with p>0.05 indicate there is no significant difference

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As observed in Table 3, Fe and Zn concentrations in water were compared with standards which revealed that they were within tolerable limits. Fe concentrations in water for the sampling Stations were found in the following order: 2>6>4 >3>8>7 >1 >5 >9 (in terms of stations), while that of Zn followed the order: 4>2>6>8>5>3>7>1>9. Cr was only detected in Station 9, while Co, Pb, Cd and Nickel all fell below the detection limit in all Stations.

Olusola and Festus (2015) recorded contrary results on the concentrations of Cr, but similar results of Zn within permissible limits in Ondo coastal waters. Fe, Zn and Cr were higher in the dry season (0.200±0.03 mg/l, 0.174±0.048 mg/l, 0.155±0.041 mg/l respectively) than during the wet season (0.153±0.02 mg/l, 0.155±0.041 mg/l, 0.022±0.00 mg/l respectively). However, Co, Cd, Pb and Ni all fell below the detection limit (Table 4), and there was no significant (p>0.05) difference in the concentrations of Fe, Zn and Cr in both seasons, while the concentrations of Fe was less than the acceptable standards. Iron had the highest concentration across Stations compared to other metals recorded in water. This has been previously reported that Fe is usually more abundant in freshwater environments than other metals as reported by Forstner and Wittman, (1979); Edokpayi *et al*. (2016).

The analysis of heavy metals in this study, as shown in Table 5, shows the presence of Zn and Fe in the liver, gills and muscles for all fish samples, with traces of Ni in the liver and gills of *S. mystus* and *M. rume* and Cr in the gills of *G. niloticus* only. Co, Cd and Pb were, however, not detected in all the samples. The highest concentrations of Iron and Zinc were recorded in the livers of *C. senegalensis* (0.633 mg/kg) and *M. rume* (1.119 mg/kg).

Fe concentrations varied in the order: Liver>Gill>Muscle for samples from *G. niloticus*, *C. senegalensis* and *M. rume*, and in the order: Gills>Muscle>Liver and Gills>Liver>Muscle for *S. mystus* and *C. nigrodigitatus.* Zn, on the other hand, was recorded in the order: Gills>Liver>Muscle in *S. mystus*, *G. niloticus* and *C. nigrodigitatus*, while that of *M. rume* followed the order: Liver>Muscle>Gill. Zinc concentrations in *C. senegalensis* were in the order of Gill>Muscle>Liver. The level of accumulation of metals in fish is of high interest because of the potential effects of pollutant on the fish and humans (Burger and Gochfield, 2005). The results showed the presence of varying concentrations of Fe, Zn, in all fish samples and Cr, and Ni only in some

samples while Co, Cd and Pb were below the detection limit in all fish samples. Variation of heavy metals in the fish samples may be a function of the food habits of the fish, tropic status and source of a particular metal and the distance of the fish from the contamination source (Adebayo, 2017).

Taweel *et al*. (2013) reported similar variation between the heavy metals in the analysed muscle, liver and spleen tissues in *Oreochromis niloticus* where Zn and Fe were higher in species sampled compared to other metals analysed. This could be traced to the presence of these metals as the most abundant of all metals analysed in the sediment and water samples in the study area. Olusola and Festus (2015) observed similar result for the species sampled from the coastal waters of Ondo state. Also, Murtala *et al*. (2012) observed that the accumulation of the metals (Cd, Ni, Cr, Co and Pb) were higher in the gills than muscle of *H. forskahlii* and *H. bebe occidentalis* from Ogun coastal water. (Shukla *et al*., 2007; Murtala *et al*., 2012).

The concentrations of heavy metals in *E. crassipes* is shown in Table 6. Fe, Zn, Cr, and Cd varied in the order; root>leaves>stem, Pb and Ni in the order root>stem>leaves while Co was not detected. Cd and Ni were not detected in the stem and leaves of the plant. Figure 2 and 3 also shows the bio-accumulation factors of *E. crassipes* relative to sediment and water respectively. In the root, the respective bio-accumulation factors of Fe, Zn, Cr, Cd, Pb, and Ni relative to the sediment were 0.01, 2.45, 4.43, 2.19, 0.62 and 1.19. In the stem the bio-accumulation factors were 1.66×10^{-3}, 0.42, 2.88, 1.51 for Fe, Zn, Cr, and Ni respectively while the bio-accumulation in leaves for Fe, Zn, Cr, and Cd, were 1.85×10^{-4}, 1.74, 4.21, and 0.85 respectively. The BAF in relation to water for Fe, Zn and Cr were: 11.44, 12.64, 110.27; 1.52, 2.16, 71.62; 5.80, 8.95, 10.46 for root, stem and leaves respectively. In this study heavy metal concentrations in *E. crassipes* were generally higher in the roots followed by the leaves and least in the stem except in the case of nickel which was higher in the stems than in the roots. The high concentration of Ni in the stem compared to the roots of *E. crassipes* might be because nickel showed low mobility ability in its transport from the root to green parts of the plant (Yabanlı *et al.,* 2014). The high concentration of heavy metals in *E. crassipes* as observed in this study confirms the capability of macrophytes in removing water soluble substances from solution and temporarily immobilizes them within the aquatic system (Materac and Sobiecka, 2017).

Table 3: Spatial concentrations heavy metal in the water of Lekki lagoon

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	Metals (mg/l)						
Stations	Iron	Zinc	Cobalt	Chromium	Cadmium	Lead	Nickel
1	0.101±0.03^c	0.057±0.0^c	BDL	BDL	BDL	BDL	BDL
2	0.312±0.11^a	0.215±0.02^b	BDL	BDL	BDL	BDL	BDL
3	0.198±0.02^{ab}	0.101±0.01^{bc}	BDL	BDL	BDL	BDL	BDL
4	0.126±0.12^b	0.421±0.03^a	BDL	BDL	BDL	BDL	BDL
5	0.131±0.02^b	0.133±0.01^b	BDL	BDL	BDL	BDL	BDL
6	0.212±0.02^a	0.170±0.0^b	BDL	BDL	BDL	BDL	BDL
7	0.178±0.17^{ab}	0.101±0.0^{bc}	BDL	BDL	BDL	BDL	BDL
8	0.185±0.02^{ab}	0.159±0.04^b	BDL	BDL	BDL	BDL	BDL
9	0.107±0.01^c	0.020±0.00^c	BDL	0.39±0.02	BDL	BDL	BDL

Means with similar superscript across the column indicate there is no significant (p>0.05) difference between means
Detection limit for metals:`Fe = 0.05mg/kg , Zn=0.005 mg/kg, Co =0.05 mg/kg, Cr= 0.04 mg/kg , Cd= 0. Mg/kg, Pb= 0. Mg/kg, Ni=0.10 mg/kg
BDL - Below detection limit
Key: 1=Brushpark, 2=River Oni, 3= Open water, 4= River Mosafejo, 5= Imeki, 6= River Osun, 7=Emina, 8=EbuteLekki, 9=Yuboye

Table 4: Seasonal concentrations heavy metal in the water of Lekki lagoon

Metals (mgl^{-1})	Dry Season	Wet Season	p(value)	WHO(2008) standards for water (mgl^{-1})
Iron	0.200±0.03	0.153±0.02	0.511	0.01
Zinc	0.174±0.048	0.155±0.041	0.572	3
Cobalt	BDL	BDL	-	-
Chromium	0.052±0.00	0.022±0.00	0.671	0.05
Cadmium	BDL	BDL	-	0.003
Lead	BDL	BDL	-	0.01
Nickel	BDL	BDL	-	0.02

Means with p>0.05 indicate there is no significant difference

The results of this study also suggest that aquatic plants may facilitate the transportation of metals from sediments up into leaves. These metals are thereby made available to grazing molluscs and, thus, reintroduced into the food web via fish to birds and humans (Sawidis *et al*., 1995).

However, subsequent accumulation along the food chain is a potential threat to human health. Swain *et al*. (2014) recorded a similar trend (root>leaves>stem) of bioaccumulation of Cd in an experiment on the phytoremediation of Cu and Cd from water using *E. crassipes.* Also, Soltan and Rashed (2003) concluded that water hyacinth accumulated higher concentrations of heavy metals in the roots than in the aerial parts when the plant was treated with several heavy metals (Cd, Co, Cr, Cu, Mn, Ni, Pb and Zn).

Lead (Pb) was recorded at a higher concentration compared to other metals analysed in the plant. The source of this metal could not be traced as the concentration was below detection limit in the water, sediment and fish. According to Ramachandra *et al*.

(2017), metal accumulation in aquatic plants depends on various factors including metal concentration in the environment, physical and chemical properties of sediments, contact time, condition of plant growth, absorption mechanisms and time of sampling. The findings of this study show that the sediment played an important role in accumulation of metals in plants. The higher accumulations of metals in sediments were directly responsible for the accumulation of heavy metals in *E. crassipes.*

The bioaccumulation factors (BAF) of heavy metals in fish in relation to water and sediment are presented in Figures 4 and 5. *M. rume* bioaccumulated Zn in relation to water at a higher concentration compared to other fish species. This was followed by *S. mystus. G. niloticus, C. senegalensis* and *C. nigrodigitatus.* High bioaccumulation of Nickel in *S. mystus* relative to sediment was observed in this study, while the bioaccumulation of Fe, Zn, and Cr in all fish species in relation to sediment was relatively low compared to that of fish to water.

Table 5: Concentrations of heavy metals in selected parts of some fish species in Lekki Lagoon

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Fish species/Metals	Organ	Iron	Zinc	Cobalt	Chromiu	Cadmium	Lead	Nickel
Schilbe mystus	Liver	0.303±0.15	0.565±1.43	BDL	BDL	BDL	BDL	0.12±0.01
	Gill	0.476±0.22	0.75±0.04	BDL	BDL	BDL	BDL	0.08±0.00
	Muscle	0.417±0.69	0.335±0.05	BDL	BDL	BDL	BDL	BDL
	Total	**1.196**	**1.65**	-	-	-	-	**0.2**
Mormyrus rume	Liver	0.426±0.28	1.119±0.08	BDL	BDL	BDL	BDL	0.13±0.00
	Gill	0.314±0.26	0.622±0.01	BDL	BDL	BDL	BDL	0.16±0.00
	Muscle	0.311±0.17	0.821±0.01	BDL	BDL	BDL	BDL	BDL
	Total	**1.051**	**2.562**					**0.29**
Gymnarchus niloticus	Liver	0.612±0.29	0.516±0.16	BDL	BDL	BDL	BDL	BDL
	Gill	0.601±0.91	0.653±0.38	BDL	0.08±0.01	BDL	BDL	BDL
	Muscle	0.195±0.36	0.131±0.02	BDL	BDL	BDL	BDL	BDL
	Total	**1.408**	**1.3**		**0.08**			
Cynoglossus senegalensis	Liver	0.633±0.35	0.223±0.21	BDL	BDL	BDL	BDL	BDL
	Gill	0.362±1.75	0.619±0.23	BDL	BDL	BDL	BDL	BDL
	Muscle	0.323±0.29	0.477±0.09	BDL	BDL	BDL	BDL	BDL
	Total	**1.318**	**1.319**					
Chrysichthys nigrodigitatus	Liver	0.362±0.48	0.140±0.02	BDL	BDL	BDL	BDL	BDL
	Gill	0.465±0.57	0.852±0.37	BDL	BDL	BDL	BDL	BDL
	Muscle	0.150±0.09	0.130±0.07	BDL	BDL	BDL	BDL	BDL
	Total	**0.977**	**1.122**					
PM		43	10-75		0.15-1.0			0.5-0.6

*BDL=Below Detection Limit, BDL= Not Detected.

Table 6: Heavy metal concentrations (mg/kg) in *Eichhornia crassipes* in lagoon of Lekki Lagoon

Metals (mg/Kg)	Root	Stem	Leaves
Fe	2.03	0.27	1.03
Zn	7.09	1.21	5.02
Co	ND	ND	ND
Cr	4.08	2.65	3.87
Cd	0.59	ND	0.23
Pb	8.54	5.46	0.088
Ni	0.632	0.8	ND

PM = Permissible limits (FAO, 1983; WHO, 1985, 1994; FEPA, 2003)

Fig 3: Bioaccumulation factor of heavy metals in *Eichhornia crassipes* in relation to water in Lekki Lagoon
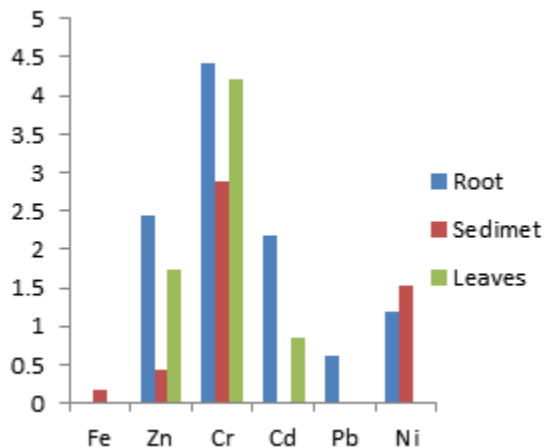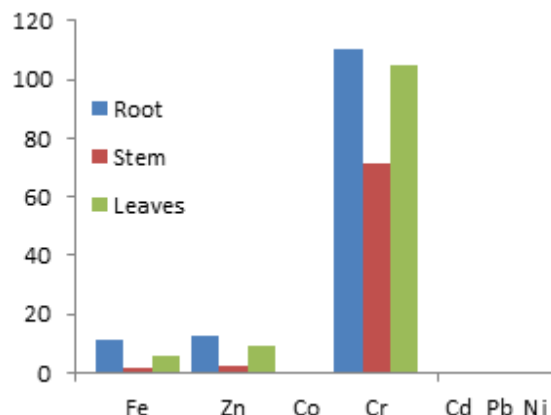

Fig. 2: Bioaccumulation factor of heavy metal in *Eichichia crassipes* in relation to sediment

Fig. 4: Bioaccumulation factor of heavy metal in in fish in relation to water

ABDUL, WO; OGUNTUASE, KE; OMONIYI, IT; BADA; SB; ADEKOYA, EO; BASHIR, AO; IBEBUIKE, LC; OPAJOBI, GA
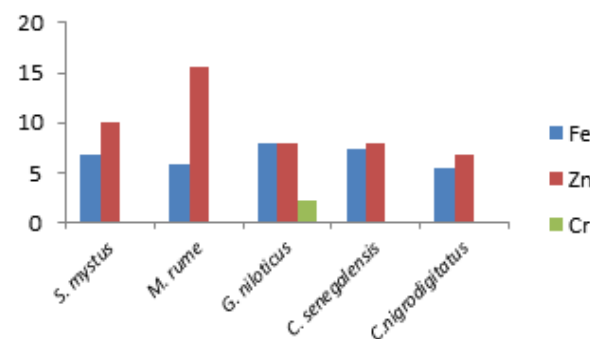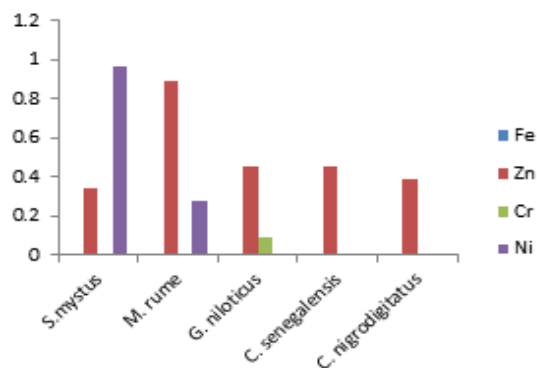
Fig. 5: Bioaccumulation factor of heavy metal in in fish in relation to sediment

Conclusion: Heavy metals are present in varying concentrations in the sediment, water, fish and aquatic macrophytes (*Eichhornea crassipes*) in Lekki lagoon, a Tropical lagoon in the Gulf of Guinea in West African coastline. The presence of these metals is, however, within the permissible limits in the fish species and water sampled but above permissible limits in the sediment and well accumulated in the plant.

In view of the importance of fish as food for man and the safety of human health, it is important to periodically monitor the concentrations of heavy metals in the Lagoon in order to prevent any health hazards and maintain ecological processes along the Gulf of Guinea of the Atlantic Ocean.

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