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Full Length Research Article

ASSESSMENT OF HEAVY METAL LEVELS IN FISH TISSUES, WATER AND SEDIMENT FROM EPE LAGOON, LAGOS, NIGERIA

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ABSTRACT
Pollution of heavy metal in water bodies is a threat to public water supplies and also to consumer of fishery sources. This study aimed at investigating the distribution of heavy metals in some fish species, water column and sediment of Epe Lagoon. Water samples, sediments and ten fish species (Synodontis schall, Chrysichthys nigrodigitatus, Megalaspis cordyla, Ulua mentalis, Caranx hippos, Tilapia guineensis, Marcusenius cyprinoides, Xenomystus nigri, Oreochromic niloticus, Clarias gariepinus) were sampled in 2019. Heavy metals (Zinc, Copper, Manganese, Iron, Lead and Cadmium) were detected in three matrices including fish tissues, water and sediment using Atomic Absorption Spectrophotometer (AAS). The heavy metal level ranges of the metals detected were: Zn: 1.128 to 4.875 mg/kg; Cu: ND to 0.488 mg/kg; Mn: 0.5 to 7.480 mg/kg; Fe: 0.125 to 9.125 mg/kg; Pb: ND to 0.875 mg/kg; and Cd: 1.750 to 2.750 mg/kg. The highest mean concentration of the heavy metal in all fish species is Zn, followed by Mn, Cd, Fe, Cu and Pb. The mean concentration of metals determined in the water samples ranged from 0.020 – 0.635 mg/L and for sediments the range was 0.669 – 17.453 mg/kg. The results obtained show high levels of Mn, Fe and Cd in some fish species which can pose danger to consumers of foods and water from this Lagoon. There is therefore the need for continual assessment of the level of pollution of this Lagoon with a view to reducing this level via sensitization and education.

Keywords: Bioaccumulation Factor, Water Pollution, Heavy Metal Toxicity, Aquatic Ecosystem.

INTRODUCTION
Intensive urbanization and increase in industrial activities have caused increasing heavy metal pollution resulting from industrial, agricultural and geochemical wastes. Pollution of heavy metal in water bodies is a threat to public water supplies and also to consumer of fishery sources (Sufiani and Ishak, 2015). These heavy metals bioaccumulate in food chain and consequently pose great risks to humans after consumption due to the persistent nature in the environment (Kazim *et al.,* 2008). Fish contains balance level of amino acid, cholesterol, high poly saturated fatty acid, vitamin B12, and it accounts for 40% of the animal protein in the diet of Nigerians (Atta *et al.,* 1997). Fish serve as compliment for meat, as the cost of the latter cannot be afforded by most Nigerians (Oladimeji *et al.,* 2013). The presence of pollutant such as metals in fresh water is known to disrupt the balance of the aquatic ecosystem and bioaccumulation and magnification is capable of leading to toxic level of these metals in fish, even when the exposure is low. Fishes and other aquatic foods are capable of concentrating heavy metals in their muscles and for the fact that they play vital role in human nutrition, they need to be screened properly to ensure that unnecessary high level of some organic and inorganic pollutants are not being transferred to human through consumption (Adeniyi and Yusuf, 2008; Aderinola *et al.,* 2009; Charis and Abbasi, 2015). Previous reports showed that industrial and domestic effluent constitute the largest sources of heavy metal which contribute to the increasing metallic pollutant in aquatic and terrestrial environment in most part of the world (Ayodele *et al.,* 1991; Jibiri and Adewuyi, 2008). Studies on bioaccumulation of pollutants in fish are important in determining different content of trace metal in fish species from bio-magnifications of food chains, metabolic capability and feeding habits (Asuquo *et al.,* 2004). This provides substantial information on the adverse effect of metal in aquatic ecosystem (Borgmann and Norwood, 1995). In Nigeria, surveys on heavy metals in fish have been reported by some researchers (Tawari-Fufeyin, 1998; Alinnor and Obiji, 2010; Olowu *et al.,* 2010; Edward *et al.,* 2013; Adeosun *et al.,* 2015).
The Epe Lagoon serves communities like Mejona, Erepoto, Marina, Ebute Afuye, Oko Orisan and Ere Ise, where fishing is as a major source of occupation for most inhabitants of these communities. Other activities like bathing, washing of clothes by the river, welding works and automobile repairing works are also a common feature of water pollution observed in Epe. Human settlements and industries are sited along the river course due to the importance of water to human (Adeniyi and Yusuf, 2007). Large amounts of water consumed by humans are mainly from surface waters, which include rivers, streams, lakes, wetlands and groundwater (Charis and Abbasi, 2005). In the recent times, Epe has been witnessing a lot of developmental programmes especially in terms of road construction which has resulted in massive landscape disturbance. These activities together with expanding human population and discharge of massive amount of wastewater into the lagoon may result into deterioration of the water quality. When the impact of these activities is so extensive, the water body may lose its self-purification capacity to a large extent. This study aimed at investigating the distribution of heavy metals in some selected fish species, water column and sediments of Epe lagoon in order to assess the impact of discharge into the water body from industries and homes with a view to establishing their suitability for human consumption and baseline data on the current pollution status of the lagoon environment.

MATERIALS AND METHODS

Study Area
Lagos is a commercial hub and the industrial nerve center of Nigeria with an estimated population of over 20 million people. About 60% of Nigeria's industries are situated in the state, each

discharging its effluents containing heavy metals into the terrestrial and aquatic ecosystems within the state. Typically, Lagos State is made up of five lagoons viz: Badagry, Ologe, Lagos, Lekki and Epe which act as sink receiving effluents daily from drainages (Adeniyi and Yusuf, 2007). Epe lagoon is an important source of fishery in Nigeria but has received little attention in heavy metal studies relative to the Lagos Lagoon widely known as a reservoir for these metals from various industries spread across Lagos State (Aderinola *et al.,* 2009). The study was carried out in Epe which is located in the eastern part of Lagos State, Nigeria and lies between latitude 6.59387°N and 3.98696°E of the equator. Epe is popular for the fishing activities attributed to the city and its lagoon is sandwiched between two other lagoons; the Lekki lagoon (freshwater) in the east and Lagos lagoon (brackish water) in the west. The study sites include Ebute Berger (6.575986°N and 3.94533°E), Ebute Erepoto (6.57718°N and 3.96854°E), Marina (6.57971°N and 3.98074°E) and Ebute Oluwo (6.58226°N and 3.98265°E) with an area of 965 km² (Figure.1).

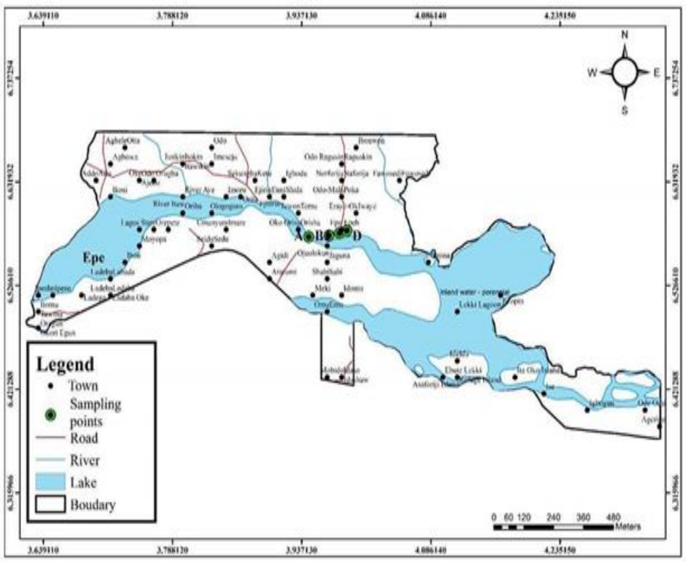

Figure. 1. The map of the study area showing the sampling locations.

Sample Collection, Preparation and Identification
Ten fish samples *Synodontis schall, Chrysichthys nigrodigitatus, Megalaspis cordyla, Ulua mentalis, Caranx hippos, Tilapia guineensis, Marcusenius cyprinoides, Xenomystus nigri, Oreochromic niloticus, Clarias gariepinus,* were caught using gill nets. The fishes were washed using deionized water and preserved in an ice box while been transported to the Department of Aquaculture and Fisheries Management, University of Ibadan for Identification. The samples were then taken to the Chemistry Laboratory and kept frozen at -20 °C until ready for analysis.

Water sampling was done by immersing sampling bottles at about 10 cm below the water surface. Two 500 ml of water samples were taken at each sampling point, and kept in ice while been transported to the laboratory. The samples were filtered through 0.45 µm micropore membrane filter and acidified with concentrated HNO_3 (65 %) to a pH less than 2. The samples were kept at 4 °C before treatment. Sediment from each study sites was collected using grab sampler into pre-cleaned polythene bag. Samplers were transported to the laboratory, air-dried at room temperature and then sieved with 200 mm mesh screen. The samples were packed in polyethylene bags and stored at -15 °C prior to analysis.

Sample Treatment
The fish samples were dried in an oven at 75 °C for 48 hours. The tissue was removed using a stainless steel knife and ground to fine powder using a porcelain mortar. 2 g of each homogenized fish samples were weighed into separate beakers. Conc. HNO_3 and H_2O_2 was added into the beakers in ratios 3:1 and allowed to digest on a hot plate in a fume chamber at 120 °C for 20 minutes (Tawari-Fufeyin, 1998). The digested samples were allowed to cool at room temperature, filtered through Whatman filter papers and each solution made up to 25 ml mark with deionized water and analyzed for trace metal concentration. Digestion of water samples was carried out by adding about 9 ml of concentrated HNO_3 to filtered water samples and gently heating at 80 °C until the solution become transparent (Taweel *et al.,* 2003). The solutions were allowed to cool and filtered using 0.45 µm membrane filter. The solutions were then adding up with deionized water to 50 ml and kept ready for AAS analysis. Sediment samples were weighed and placed into the digestion bombs with 10mL of HNO_3/HCl (1:3 v/v) and digested in a microwave digestion system. Sediment analysis was carried out according to the procedure described by (Binning and Baird, 2001). This was done in duplicate for all the samples analyzed.

Heavy metal analysis
Digested samples were analyzed for Zinc (Zn), Copper (Cu), Manganese (Mn), Iron (Fe), Lead (Pb), and Cadmium (Cd) by using atomic absorption spectrophotometer (Perkin Elmer, Analyst 100). Element standard solution from Perkin Elmer was prepared by diluting stock solutions of 100 mg/mL of each element. The concentrations of heavy metals were presented in mg/kg, wet weight (ww) for fish and sediment samples and µg/L for water.
Bio-Concentration Factors of Heavy Metals
The bio-concentration factors (BCF) of the heavy metals obtained in fish samples were calculated using equation:

$$BCF = \frac{C\ Organism}{C\ sediment\ or\ water}$$

Where, C organism = concentration of metals in the fish species and C sediment = concentration of metals in the sediment (Adeosun *et al.,* 2015).

Statistical Analysis
All data generated were analyzed statistically by calculating the mean and standard deviation of the measured parameters. The bioconcentration factors of the metals were also calculated. The software used was Microsoft Excel 2010 and Origin8.

RESULTS AND DISCUSSION
The present study determined the heavy metal levels in ten fish species (24 samples) (Table 1), water and sediment samples from Epe Lagoon. The result of heavy metals in fish, water and sediment samples are presented in Tables 2 and 3.

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Table 1: Fish Species list from Epe Lagoon

No.	Fish Species	Common Name	Number of Samples
S1	*Synodontis schall*	Akokoniko	3
S2	*Chrysichthys nigrodigitatus*	Igangan	3
S3	*Megalaspis cordyla*	Ayoo	2
S4	*Ulua mentalis*	Lele	2
S5	*Caranx hippos*	Owere	2
S6	*Tilapia guineensis*	Epiya	3
S7	*Marcusenius cyprinoides*	Lele	2
S8	*Xenomystus nigri*	Atoko	3
S9	*Oreochromic niloticus*	Abo	2
S10	*Clarias gariepinus*	Aro	2

Concentrations of heavy metals in fish

The fish species in Epe Lagoon bioaccumulated heavy metals at varying levels on a dry weight basis. Zn, Cu, Mn, Fe and Cd were detected by the AAS, although concentrations of Pb in seven species were below the detection limit. The concentrations of heavy metals (Zn, Cu, Mn, Fe, Pb and Cd) in fish are given in Table 2 and illustrated in figure 2.

Table 2: Heavy metal concentration in tissues of fish species (mg/kg)

Samples	Zn	Cu	Mn	Fe	Pb	Cd
S1	3.630±0.12	ND	4.270±0.01	0.249±0.01	ND	2.070±0.21
S2	1.625±0.01	0.100±0.01	1.250±0.01	0.125±0.01	ND	2.125±0.19
S3	1.128±0.01	0.113±0.01	0.625±0.00	0.251±0.01	0.122±0.01	2.001±0.01
S4	3.500±0.29	0.150±0.01	0.500±0.02	0.373±0.01	0.129±0.01	2.750±0.02
S5	3.875±0.38	0.063±0.01	0.500±0.01	0.510±0.03	ND	2.248±0.01
S6	4.875±0.64	0.488±0.01	2.241±0.02	3.130±0.02	ND	2.250±0.06
S7	1.869±0.02	0.300±0.01	7.480±0.05	9.125±0.18	ND	2.320±0.11
S8	1.901±0.07	0.325±0.01	3.874±0.01	1.625±0.01	ND	2.500±0.14
S9	2.014±0.15	0.238±0.01	2.375±0.01	1.000±0.01	0.875±0.01	2.375±0.10
S10	4.750±0.25	0.400±0.01	1.026±0.01	1.127±0.01	ND	2.240±0.09

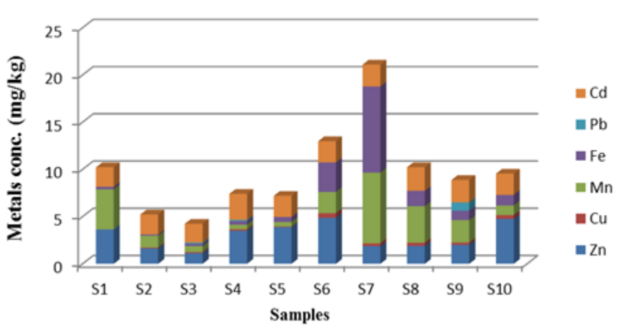

Figure 2: Level of heavy metals in fish species from Epe Lagoon

Apparently, the concentration ranges of the metals detected were: Zn: 1.128 to 4.875 mg/kg; Cu: ND to 0.488 mg/kg; Mn: 0.5 to 7.480 mg/kg; Fe: 0.125 to 9.125 mg/kg; Pb: ND to 0.875 mg/kg; and Cd: 1.750 to 2.750 mg/kg. The highest mean concentration of the heavy metal in all fish species is Zn, followed by Mn, Cd, Fe, Cu and Pb, as shown in Table 4 and Figure 2. The result indicated the extent of heavy metal pollution of the water body from where these fish are obtained. Also the presence of most of the metals determined in the fish parts agrees with the results of the report of the level of heavy metals in aquatic organism from different water bodies (Edward *et al.,* 2013; Tawari-Fufeyin, 1998; Adeosun *et al.,* 2015; Alinnor and Obiji, 2010; Olowu *et al.,* 2010), which showed that aquatic animals bioaccumulate heavy metals and due to non-bio-degradability of these metals, they tend to stay in the fish tissues for long which could lead to consequent bioaccumulation in human upon consumption of these fish. This could result in acute poisoning if present in higher concentrations (Underwood, 1977). Zinc was found in all the fish species and the pattern of accumulation follows the order: S6 > S10 > S5 > S1 > S4 > S9 > S8 > S7 > S2 > S3. *Tilapia guineensis* (S6) (4.875 mg/kg) and *Clarias gariepinus* (S10) (4.750 mg/kg) showed higher Zn concentrations than all other fishes. Some of the values obtained in this study were higher than those reported by Adeosun *et al.* (2015) from Ogun River and Alinnor and Obiji (2010) from Nworie River. The values in this study are below the WHO recommended limit of 60 mg/kg in food. Zinc is an essential element, however, at higher concentrations, it affects the growth and survival of fish by accumulating in the gills of fish and this adversely affect haematological and innate parameters (Çelik *et al.,* 2013). Exposure to little Zn can cause decrease in sense of taste and smell, loss of appetite, skin sores and slow wound healing (Ebrahimpour *et al.,* 2010). Copper was the least accumulated metal in the fish samples with *Tilapia guineensis* (S6) showing the highest concentration value of 0.488 mg/kg and *Caranx hippos* (S5) a value of 0.063 mg/kg. Cu was below detection limit in *Synodontis schall* (S1). The mean Cu concentration from fish in this study was similar to that reported by Adeosun *et al.* 2015 but lower than values obtained in other studies (Opaluwa *et al.,* 2012; Edward *et al.,* 2013). The results obtained were below the WHO/FEPA (3.0 mg/kg) recommended limit for human consumption. Copper is an essential metal which play a vital role in enzyme activity. However, a very high concentration of these metals leads to toxicity (Osakwe and Peretiemo-Clarke, 2008). The toxicity of Copper depends upon the pH and hardness of water, and therefore, it is more toxic in water with low alkalinity and in soft water (Ebrahimpour *et al.,* 2010). Manganese was detected in all the fish species with the highest concentration found in the flesh of *Marcusenius cyprinoides* (S7) amounting to 7.48 mg/kg and it is lowest in the flesh of both Ulua mentalis (S4) and *Caranx hippos* (S5) each containing 0.5 mg/kg. Edward *et al.* (2013) observed a Mn concentration of slightly lower than the results obtained from the present study. The results obtained in 80% of the samples were above the WHO/FEPA (0.5 mg/kg) permissible level of Mn in food. Manganese in trace amount is an essential element. It interferes with iron metabolism, especially haemoglobin formation (Underwood, 1977). Iron was found in all the fish species with the highest concentration found in the flesh of *Marcusenius cyprinoides* (S7) amounting to 9.125 mg/kg and it is lowest in the flesh of *Chrysichthys nigrodigitatus* (S2) containing 0.125 mg/kg. The mean concentration of Fe from fish species analyzed was similar to that reported by Edward *et al.* (2013) and lower than that reported by Opaluwa *et al.* (2012). The results obtained in 60% of the samples were above the WHO/FEPA (0.5 mg/kg) recommended limit of Fe in food. Iron is an essential element in haemoglobin formation, however in high concentrations, it increases the risk of liver disease (cirrhosis, cancer), heart failure, diabetes mellitus, osteoarthritis, osteoporosis and hypothyroidism (Underwood, 1977). Lead is absent in seven of the fish species analyzed, the highest concentration found in *Oreochromis niloticus* (S9) to be 0.875 mg/kg and the lowest in *Megalaspis cordyla* (S3)

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amounting to 0.122 mg/kg. The Pb level in fish of this study was lower than reported by Sani (2011) and higher than others (Edward *et al.* 2013; Adeosun *et al.,* 2015). The results obtained were below the WHO/FEPA (2.0 mg/kg) recommended limit of Pb in food. Cadmium was detected in all fish species analyzed with highest concentration found in *Ulua mentalis* (S4) to be 2.75 mg/kg and the lowest in *Megalaspis cordyla* (S3) to be 2.001 mg/kg. The results obtained in all of the samples were above the WHO/ FEPA (0.5 mg/kg) recommended limit of Cd in food. Lead and cadmium are non-essential and therefore have toxic effects on living organisms by accumulating in the tissues and body of aquatic organisms and biomagnified in food chain that cause physiological damages in human consumers. Health effects of lead and cadmium are cancer, damage to nervous, urinary, reproductive, cardiovascular and respiratory systems (Rahimzadeh *et al.,* 2017; Leon and Pacheco, 2020). The mean metal concentrations and standard deviation of water and sediment samples are shown in Table 3 and illustrated in Figures 3 and 4.

Table 3: Heavy metal concentration in sediment (mg/kg) and water (mg/L) samples from Epe Lagoon

Sampling	Zn		Cu		Mn		Fe		Pb		Cd	
Sites	Water	Sed	Water	Sed	Water	Sed	Water	Sed	Water	Sed	Water	Sed
1	0.510	17.750	0.008	0.900	0.130	25.010	0.070	2.745	0.130	2.427	1.000	2.752
2	0.650	18.500	0.019	0.450	0.270	12.475	0.110	4.258	ND	0.458	0.360	2.314
3	0.640	15.120	0.029	0.700	0.390	15.200	0.220	4.500	ND	ND	0.320	3.181
4	0.740	12.890	0.022	0.625	0.380	17.125	0.210	2.500	ND	ND	0.070	2.500
Mean	0.635	16.065	0.020	0.669	0.293	17.453	0.153	3.501	0.038	0.721	0.438	2.687
SD	0.08	2.22	0.01	0.16	0.10	4.67	0.06	0.89	0.05	1.00	0.34	0.32

The mean concentration of metals determined in the water samples ranged from 0.020 – 0.635 mg/L and for sediments the range was 0.669 – 17.453 mg/kg. The metals determined were Zn, Cu, Mn, Fe, Pb and Cd with mean concentrations of 0.635, 0.020, 0.293, 0.153, 0.038 and 0.438 (mg/l) in water and 16.063, 0.669, 17.453, 3.500, 2.063 and 2.630 (mg/kg) in sediment respectively with Pb not detected in two water and sediment samples.

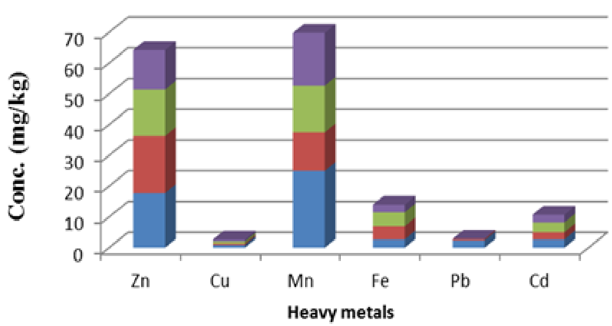

Figure 3: Level of heavy metals in the samples of water from various sample points

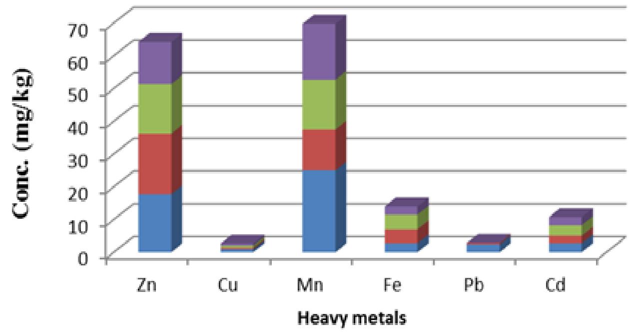

Figure 4: Level of heavy metals in the samples of sediments from various sample points

The concentration of all the metals analyzed in the water samples were lower than those reported by Edward *et al.* (2013) from Odo-Ayo River with exception of cadmium which is slightly higher. The levels of heavy metals in sediment samples were higher for Zn, Mn, Pb and Cd while lower for Cu and Fe in the same river. However, when the results were compared with earlier reports on Zn and Fe level in Epe Lagoon (Olowu *et al.,* 2010), and Pb, Cu, Cd and Zn level from Ogun River, Opeji (Adeosun *et al.,* 2015), the concentrations obtained were higher showing increase in metal contamination after many years. The levels of all the heavy metals analyzed were higher in the sediment than water. This shows that sediments are major repository of heavy metal in aquatic bodies. The concentrations of Mn, Pb and Cd in the water samples and all the metals analyzed in the sediment samples were beyond the permissible limits set by WHO and FEPA.
The high level of these metals in both the water and sediment samples are as a result of discharge of industrial effluents into the Lagoon and the runoffs during the rainy season from agricultural fields and the dumping of domestic wastes in the water body at different points along the Lagoon as they are known to contain heavy metals such as As, Cd, Co, Cu, Fe, Hg, Mn, Pb, Ni and Zn which will eventually end up in this aquatic ecosystem. The International guidelines for heavy metals in fish, sediment and water are show in table 4 below.

Table 4: International guidelines for heavy metals in fish, sediment and water

	Fish		Sediment		Water	
Heavy Metals	Means of total concentration in present study	Maximum limit WHO/ FEPA (mg/kg)	Means of total concentration in present study	Maximum Limit WHO/ FEPA(mg/kg)	Means of total concentration in present study	Maximum Limit WHO/ FEPA (mg/L)
Zn	2.917	30	16.063	0.0123	0.635	3.000
Cu	0.218	3.0	0.669	0.025	0.020	1.000
Mn	2.414	0.5	17.453	0.030	0.293	0.050
Fe	1.752	0.5	3.5	0.030	0.153	0.300
Pb	0.113	2.0	2.063	0.040	0.038	0.010
Cd	2.288	0.5	2.630	0.006	0.438	0.003

Table 5: BCF of heavy metals in fish species (water)

Metal	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Zn	5.72	2.56	1.78	5.51	6.10	7.68	2.94	2.99	3.17	7.48
Cu	0.00	0.16	0.18	0.24	0.10	0.77	0.47	0.51	0.37	0.63
Mn	6.72	1.97	0.98	0.79	0.79	3.53	11.78	6.10	3.74	1.62
Fe	0.39	0.20	0.40	0.59	0.80	4.93	14.37	2.56	1.57	1.77
Pb	0.00	0.00	0.19	0.20	0.00	0.00	0.00	0.00	1.38	0.00
Cd	3.26	3.35	3.15	4.33	3.54	3.54	3.65	3.94	3.74	3.53

Table 6: BCF of heavy metals in fish species (sediment)

Metal	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Zn	0.23	0.10	0.07	0.22	0.24	0.30	0.12	0.12	0.13	0.30
Cu	0.00	0.15	0.17	0.22	0.09	0.73	0.45	0.49	0.36	0.60
Mn	0.24	0.07	0.04	0.03	0.03	0.13	0.43	0.22	0.14	0.06
Fe	0.07	0.04	0.07	0.11	0.15	0.89	2.60	0.46	0.29	0.32
Pb	0.00	0.00	0.17	0.18	0.00	0.00	0.00	0.00	1.21	0.00
Cd	0.79	0.81	0.76	1.05	0.85	0.86	0.88	0.95	0.90	0.85

Table 5 and Table 6 shows the bioconcentration factors for all the ten fish species analyzed. The results showed that bioconcentration factor of water were greater than those of sediments. All the bioconcentration factor of water were greater than 1.00 except Cu in all samples, Mn in S3, S4 and S5, Fe in S1 – S5 and Pb in S1 – S8, S10. On the other hand, the BCF for sediment were relatively lower than the 1.00 recommended limits of WHO/FEPA except for iron in S7, lead in S9 and cadmium in S4. This indicates that the fishes undergo bioaccumulation of these metals from Epe Lagoon and hence the presence of metals in these fishes biochemically showed that fish is relatively dependent on the levels of metals available in aquatic ecosystem.

Conclusion

This research has presented data on the levels of heavy metals in sediments, water and tissues of various fish species from Epe Lagoon in Epe, Lagos State. The results obtained show high concentrations of Mn, Fe and Cd in some fish species which can pose danger to consumers of sea foods and water from this Lagoon and longtime exposures can lead to deleterious effects. This is as a result of the fact that this water body serves as the receptor for domestic wastes as well as runoff from agricultural lands where phosphate fertilizers and other agrochemicals are frequently used. There is therefore the need for continual assessment of the level of pollution of this Lagoon with metals from the mentioned sources with a view to reducing the level of pollution via sensitization and education.

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