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Research Article

Bioaccumulation of Potentially Toxic Metals in Water, Sediment, Silver Catfish (*Chrysichthys nigrodigitatus*) and Tilapia (*Tilapia zilli*) Acquired from Majidun and Igbede Rivers, Lagos State Nigeria

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Abstract

Potentially toxic metals in aquatic system are produced from natural and anthropogenic sources and the degree of contamination in fish is dependent on the sampling site, pollution types as well as mode of feeding. The concentration of PTMs such as manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), cobalt (Co), chromium (Cr), cadmium (Cd), lead (Pb) and nickel (Ni) were investigated in water, sediment Silver Catfish (*Chrysichthys Nigrodigitatus*), and Tilapia (*Tilapia Zilli*) collected from Majidun and Igbede river in Ikorodu using atomic absorption spectrophotometer (AAS). Iron (Fe) was abundant in the entire sample and had the highest level of mean concentration accumulated in the sediment with a value of 0.56mg/L against 0.20mg/L, 0.19mg/L 0.18mg/L recorded in Tilapia, water and Silver Catfish for Majidun river. The distribution of PTMs in the Majidun samples analyzed were in the order of magnitude Fe > Zn =Mn >Cu, Fe > Mn > Zn > Cu > Co >Ni, Fe > Mn > Zn > Cu and Fe > Zn > Mn > Cu for water, sediment, Tilapia and Silver Catfish respectively. The concentrations of PTMs in the samples obtained from Igbede River were found to be significantly higher in the order of Fe > Mn > Zn > Cu, in comparison to the samples obtained from Majidun river, which had an order of Fe > Zn > Mn > Cu, Fe > Mn > Zn > Cu > Co > Ni, Fe > Mn > Zn > Cu and Fe > Zn > Mn > Cu. Ni, Co and Cr were not detected in the analyzed samples except sediment that contain a very low concentration of Ni and Co. The study on the two fish samples from Majidun and Igbede revealed a higher concentration of nickel in the Igbede tilapia fish and sediment. Pb and Cd were not detected in all the samples analysed in the

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two rivers indicating the pollution status of the two fish species investigated in both rivers. The accumulation of iron and zinc by the fishes from both the surrounding water, sediments and their diet were relatively low and are below recommended value of Food and Agriculture Organization (FAO) and Lagos State Environmental Protection Agency (LASEPA) for daily intake which revealed that the aquatic life analyzed in Majidun and Igbede Rivers are safe for consumption but the need for continuous monitoring to prevent bioaccumulation is recommended.

Keywords

Tilapia, Silver Catfish, Bioaccumulation, Accumulation, Anthropogenic Source, Effluents Discharges

1. Introduction

Africa is blessed with numerous inland water bodies. This aquatic system could be lagoons, creeks, rivers, streams etc. which play important role in social economic lives of the riverine populace, the inhabitant of these areas depends on this water bodies as a source of a livelihood, recreation among other things [1]. Water is an essential component of life; it is used for domestic, agricultural, industrial purposes to mention a few. Water is managed poorly in many parts of the world despite it being important for life [2]. Contamination of water due to discharge from the industries in a particular area is always directly related to the degree of contamination of its environment [3]. This discharges comes with various toxic chemicals which are known as endocrine disrupting chemicals which includes Potential Toxic Metals (PTMs) and organic pollutants such as bisphenols, polychlorinated hydrocarbons chlorophenols. Phthalates etc). Endocrine disrupting chemicals are natural or man made chemicals that mimic, block or interfere with body hormones [4].

The presence of Potential Toxic Metals in aquatic environment in trace concentrations is important for normal development of organism [5]. They could be detected in the aqueous medium and in the bottom; some however, a completely deleterious and need to be monitored continuously in the bodies of organism as they are capable of bioaccumulation, resulting to morbidity and often mortality of organisms [5, 6]. Potentially toxic metals are of special interest as they have both health and environmental significance due to their persistence, high toxic and bio-accumulation characteristics in water [7]. Potentially toxic metals degrade the quality of water and affect human health. Excessive accumulation of Pb causes impaired kidney functions, encephalitis etc. [8]. They are non-biodegradable and as such lack natural elimination processes and this in turns makes them shift from one compartment of the ecosystem to another; from water to sediment to biota [9].

Fishes tend to accumulate Potential Toxic Metals (PTMs) in their body tissues. Fishes are known to be bio-indicators of the levels of trace metals in aquatic ecosystems [9]. Fishes are important source of human diet as they contain amino acids, cholesterol, vitamin B12 etc [10]. The level of accumulation could be driven by physiochemical and biological variables like pH, temperature, salinity, hardness etc [10]. Studies have shown that levels of PTMs in bottom sediments are usually higher than in water columns, this implies that sediments have become repositories for PTMs [11]. Once discharged, the PTMs either accumulate in the aquatic organisms or adsorb on the sediment particles. The PTMs discharged becomes enriched in sediments by adsorption, flocculation and sedimentation [12]. When metals enter aquatic environment, agreat portion settle and is absorbed by the bottom mud [5], they could be recycled by chemical, physical and biological processes such that some quantity remains dissolved in the water columns and some part is being absorbed by the inhabitants [3]. Fishes are at the apex of the food chain and can bio-accumulate some of these substances into their tissues [13]. According to one of the 17 Sustainable developmentgoals (SDGs) in which SDG 14 advocates live below water, there isgreat need to be conscious of the various activities that could affect live in water. (14) Potentially toxic metal is non-biodegradable and can continue to be accumulated in the tissue of organism until they reach intolerable level resulting in morbidity and motility [4], man being higher in the food chain stands the risk of higher bioaccumulation. The dangers of PTMs have been long noted, but the symptoms are poorly diagnosed and patient could be treated for some other illness thereby aggravating PTMs pollution problems of man [14].

There is an increasing concern regarding the roles and fates of trace metals in Nigerian environment. Much of this concern arises from the low level of available information on the concentrations of this metal within the environments the contamination of sea foods by trace metal is a potential problem to man. Aquatic organism accumulates metals to concentrations many times higher than present in water. The potentially toxic metals are lead, nickel, zinc, chromium, arsenic, selenium, vanadium, beryllium, and barium. Natural and anthropogenic activities result ingaseous emission and wastewater discharge into air, water and land. [13] When substances in the emissions and effluent discharge in the environment are in very minute amount or in low concentrations, they are not toxic to plant and animals and have short residences time and in the environment, they are described as contaminants [13]. Fish and bivalve molluscs are used in bioaccumulation tests because they are higher tropic level organism and are usually eaten by man tissues such as liver, kidney; muscles, viscera and whole organism are analyzed to determine the concentration of the metals [15].

Potentially toxic metals are commonly found in natural waters and some are essential to living organism, yet they may become highly toxic when present in highly concentrations. These metals alsogain access into ecosystem through anthropogenic sources and yet distributed in water body suspended solids and sediments during the course of their mobility. The rate of bioaccumulation of PTMs in aquatic organism depends on the ability of the organism to digest the metal and the concentration of such metals in the river. [16]. Aquatic organism (including fish) bioaccumlates trace metals at an inconsiderable amount and stay over a long period. Fishes have been recognized as agood accumulator of organic and inorganic pollutions. Age of fish, liquid content in tissue and mode of feeding are significant factors that affect the accumulations of PTMs in fishes. They are finally transferred to other animal including human during the food chain and high concentration of PTMs such as Cd, Pb, Cu, Ni, Zn, Mn, Mg and Co revealed in fishes in rivers within proximity of some industrial cities in Nigeria [17]. The discharge of industrial waste containing toxic metals into water body may have significant effect on fish and other aquatic organism which may endanger public health through consumption of contaminated sea foods [16-25] and zinc contamination has been reported to affects the hepatic distribution of other trace metals in fish [17-20]. Furthermore, factors such as high populationgrowth accompanied by intensive urbanization, increase in industrial activities and higher exploitation of natural resources including cultivable land have caused pollution increase [18, 24-25].

Majidun and Igbede rivers supports fishing, sand mining, domestic and recreational activities in communities around them. It can be contaminated by potentially toxic metals from the mining, domestic, industrial and farming activities carried out along the river as well as residual fertilizer in the soil can leach into the water through runoff from rain and become a source of toxic metals hence this research aimed at determining the status of the Potentially Toxic Metals in both rivers.

2. Materials and Methods

2.1. Brief Description of Study Site

Majidun river is located on latitude 6°36′N 3°30′E and longitude 6.600 °N 3.500 °E (Figure 1). Also, it was known as Majidun Ilaje creek because the major inhabitants are mainly from Ilaje, Ondo State with the time zone of Lagos/Africa. Igbede river is a freshwater body located in Ojo localgovernment area Lagos state, Nigeria. It drains areas like Ojo, Alaba, Shibiri, Etegbin connecting to the Lagos creek. It drains residential, commercial and agricultural areas.

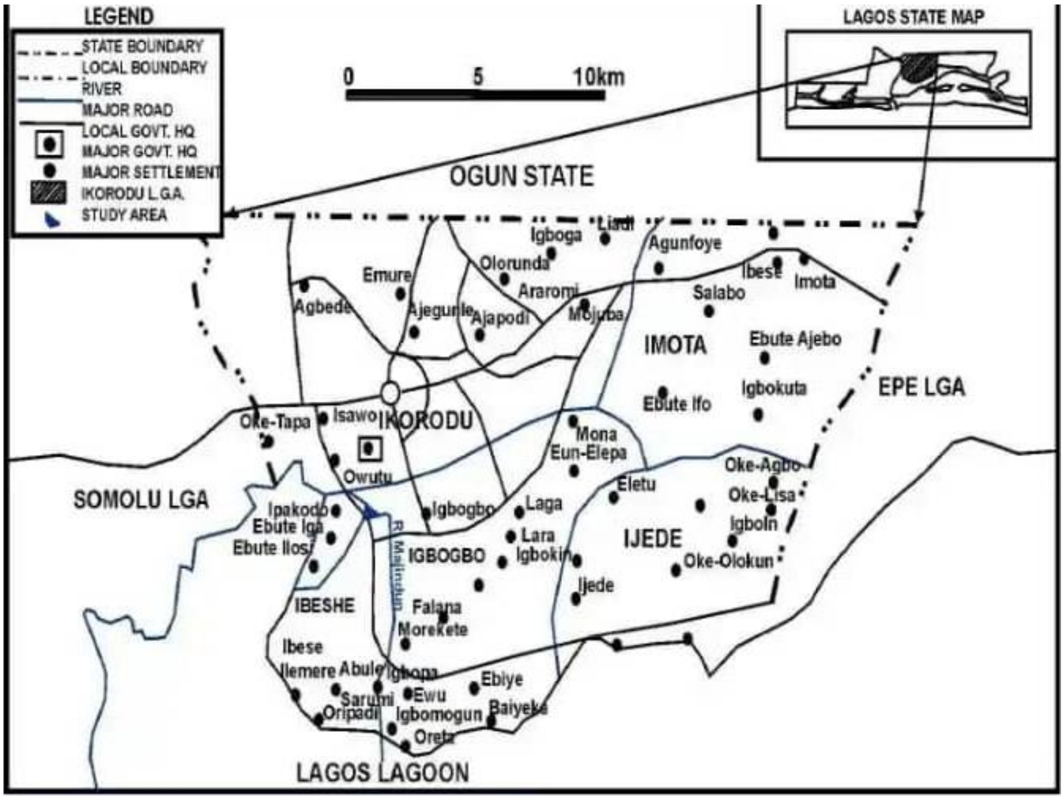

Figure 1. Map of Majidun and Igbede Rivers.

2.2. Sample Collection and Preparation

Water samples were collected from different locations of Majidun and Igbede Rivers using agrab sampler and all water samples were collected into a plastic bottle (750mL) which was pre-washed thoroughly with soap and ordinary water and soaked in an acid before rinsing with distilled water. At the site area plastic bottles were labeled and rinsed three times with the water sample before collection. About 3mL of nitric acid was introduced into to 750mL water sample to fix the metals before being transported to the laboratory. The water sample was placed in a refrigerator at 4°C prior to analysis.

2.3. Sediment Samples Collection

Bottom sediment from each study sites were collected with agrab sampler at different location with help of the local divers and were placed in pre-cleaned polythene bag. The collection was done between January to March of 2023. A composite sample was made by mixing equal amount of the sediments collected at different locations and was air dried for a week and then sieved with 200mm mesh screen.

2.4. Fish Samples Collection

Two different species of fish namely*:* Silver Catfish (*Chrysichthys nigrodigitatus*) and Tilapia (*Tilapia zilli*) were collected at the sampling sites using cast or throw fishing nets by fishermen. The fish samples were placed in an ice bag and transported to the chemistry laboratory in LASU. The fishes were then washed with distilled water to remove debris present on the fish and it was wrapped in aluminium foil and kept in the freezer at 0 ℃. Before digestion the fish was defrosted and oven dried at 100 °C and pulverized after drying using a mortar and pestle before blending in an electric blender.

2.5. Samples Digestion

2.5.1. Sediment Sample

Prior to digestion 5g of the sample was weighed using an analytical weighing balance and was placed in a conical flask and 50mL of aqua regia (HCl and HNO_3 in the ratio 3:1) was then added [11]. The solution was heated for about 20 minutes until a clear solution was obtained. All this was done in the fume cupboard to ensure that thegases are not inhaled. After cooling the solution was filtered into a 100mL volumetric flask and made up to mark with distilled water. The digested sample was labeled and ready for analysis using BUCK 201 Atomic Absorption Spectrophotometer.

2.5.2. Fish Samples

5g each of the fish sample were weighed into a conical flask and 50mL of aqua regia (HCl and HNO_3 in the ratio 3:1) was added. It was then heated for about 20 minutes till the solution was clear. All this was done in the fume cupboard to ensure that thegases are not inhaled. After cooling the solution was filtered into a 100mL volumetric flask and was made up to mark with distilled water. The digested sample was labeled and ready for analysis using BUCK 201 Atomic Absorption Spectrophotometer.

2.5.3. Water Sample

200mL of the composite water samples was placed into a conical flask and about 5mL of nitric acid was added. The solution was heated for about 40 minutes in a fume cupboard until the volume reduced to half of the flask. It was then cooled filtered into a 100mL volumetric flask and made up to mark with distilled water.

3. Result and Discussion

In the river, fish are frequently at the top of the food chain and have the desirability to concentrate potentially toxic metals from water. Therefore, bioaccumulation of metals in fish can be measured as an index of metal pollution in the aquatic bodies [11, 21-24]. Potentially toxic metal whether essential or not may be hazardous to living organism including fish and this can lead to various deleterious effect on fisheries and potentially public health [11]. In this work the analysis of the samples collected from Majidun and Igbede rivers revealed that iron (Fe) was the most abundant element, with the highest mean concentration recorded in the sediment samples (Table 1). Specifically, the sediment sample from Majidun river showed the highest concentration of iron, with a value of 0.56 µg/g, followed by Tilapia, water, and Silver Catfish (*Chrysichthys Nigrodigitatus*), which recorded concentrations of 0.20 µg/g, 0.192 µg/L, and 0.190 µg/g, respectively as shown in Table 1.

Table 1. *Concentrations of potentially toxic metals in the water, sediment and fishes from Majidun and Igbede river.*

TOXIC METALS	MACN (µg/g)	IGCN (µg/g)	MATZ (µg/g)	IGTZ (µg/g)	MAS (µg/g)	IGS (µg/g)	MAW (µg/L)	IGW (µg/L)
Mn	0.041±0.001	76.50±0.40	0.140 ±0.001	73.7 0±0.44	0.040 ±0.005	20.7 ±0.20	0.002±0.0005	0.70 ±0.03

TOXIC METALS	MACN (µg/g)	IGCN (µg/g)	MATZ (µg/g)	IGTZ (µg/g)	MAS (µg/g)	IGS (µg/g)	MAW (µg/L)	IGW (µg/L)
Fe	0.190±0.030	89.3 ±0.40	0.20 ±0.01	13.70 ±0.20	0.560±0.008	215.80±0.60	0.192 ±0.002	10.70 ±0.01
Cu	0.020 ±0.002	3.30 ±0.10	0.030±0.001	13.3 ±0.10	0.004 ±0.001	2.30±0.05	ND	1.70 ±0.02
Zn	0.080 ±0.001	63.7 ±0.1	0.080±0.001	52.30±0.10	0.030±0.001	7.00 ±0.02	0.001±0.0005	1.00 ±0.05
Co	ND	ND	ND	ND	0.001	ND	ND	ND
Cr	ND	ND	ND	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND	ND	ND	ND
Ni	ND	ND	ND	1.70 ±0.02	0.0030 ±0.0003	27.70±0.01	ND	ND

Legend: Majidun Chrysichthys nigrodigitatus ((MACN). Majidun Tilapia zili (MATZ) Igbede Chrysichthys nigrodigitatus ((IGCN). Igbede Tilapia zili (IGTZ), Majidun sediment (MAS), Igbede sediment (IGS), Majidun water (MAW), and Igbede water (IGW), ND (not detected).

The concentrations of potentially toxic metals were also found to be higher in the water, sediment, Tilapia, and Silver Catfish (*Chrysichthys nigrodigitatus*) samples obtained from Igbede River in comparison to those obtained from Majidun River as shown in figure 2 which may be attributed to the high human activities in Igbede study area due to the mining of sharp sand in the Igbede river which followed the same trend as obtained by Olowu et al 2010 [18]. The highest concentration in the sediment may be attributed to the nature of the sediment to act as sink for PTMs which in agreement with earlier report of Olowu and it coworker (18). A similar trend was observed for the samples collected from Igbede river, where the sediment sample showed the highest concentration of iron at 215.8 µg/g as shown in Table 1 compared to the concentration mean values of 13.3 µg/g, 3.30 µg/g and 10.70 µg/L for Tilapia, Silver Catfish (*Chrysichthys Nigrodigitatus*) and water respectively. The high value exhibited by the Igbede river sediment may attributed to the claying nature of the soil in the studied area.

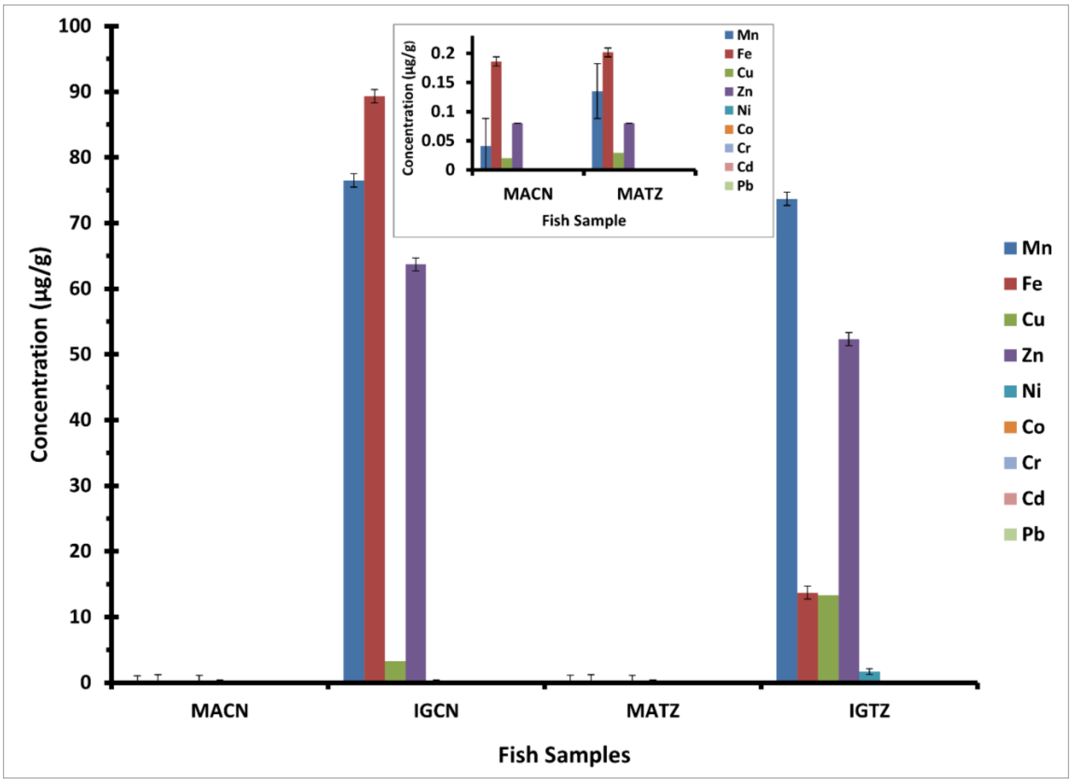

Figure 2. *Potential Toxic Metal (PTM) in fish samples from Majidun and Igbede Rivers Majidun Chrysichthys nigrodigitatus ((MACN). Majidun Tilapia zili (MATZ) and Igbede Chrysichthys nigrodigitatus ((IGCN). Igbede Tilapia zili (IGTZ).*

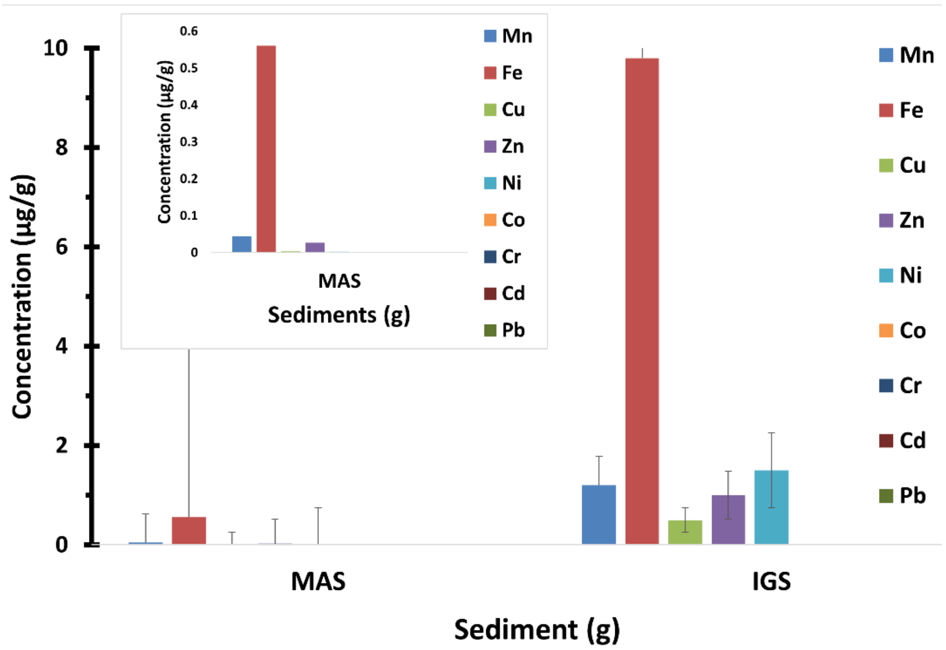

Figure 3. Chat showing Sediment samples from Majidun and Igbede Rivers.

The concentrations of heavy metals in the Igbede Silver Catfish fish samples obtained from Igbede River were found to be significantly higher in the order of Fe > Mn > Zn > Cu, in comparison to the samples obtained from Majidun river, which had an order of Fe > Mn > Zn > Cu, Fe > Mn > Zn > Cu > Co > Ni, Fe > Mn > Zn > Cu and Fe > Zn > Mn > Cu for catfish, sediment and water respectively. In addition, the levels of PTMs in both rivers were found to be lower in the water and sediment samples, in comparison to the levels in the Tilapia and Silver Catfish samples as shown in figures 2, 3, 4.

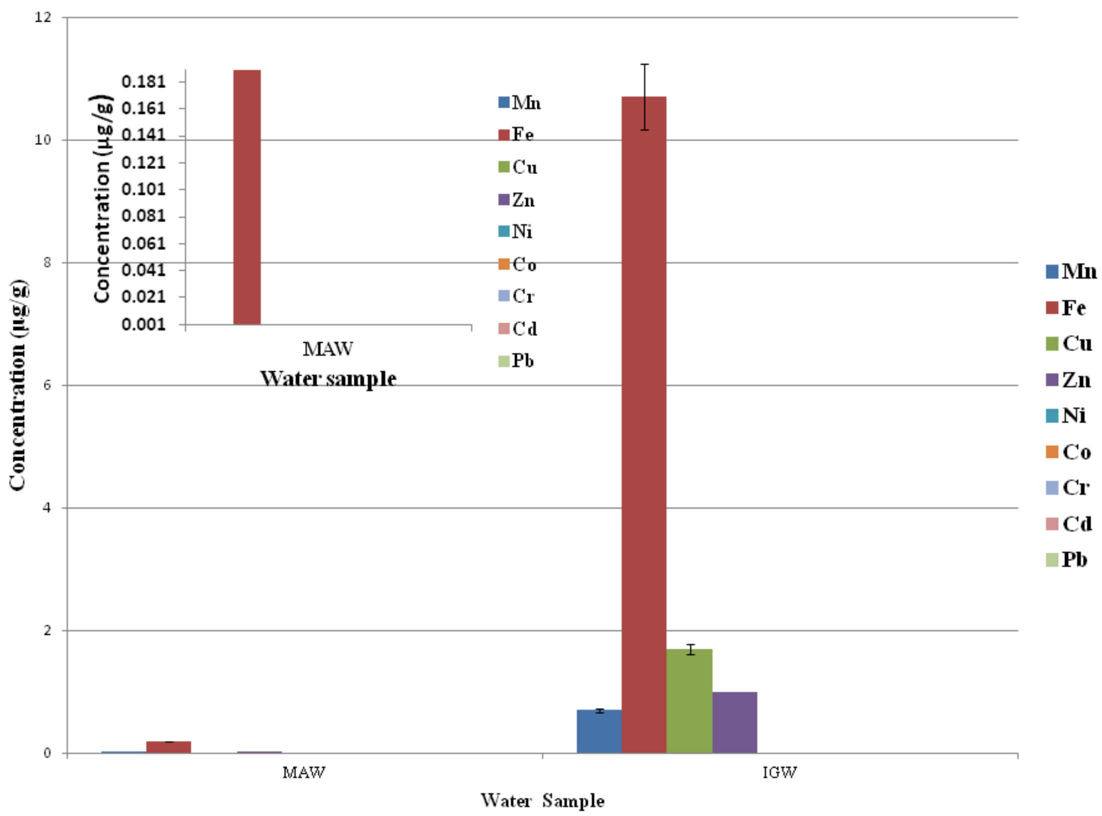

Figure 4. Chat showing the level of Potential Toxic Metal in water from Majidun and Igbede River.

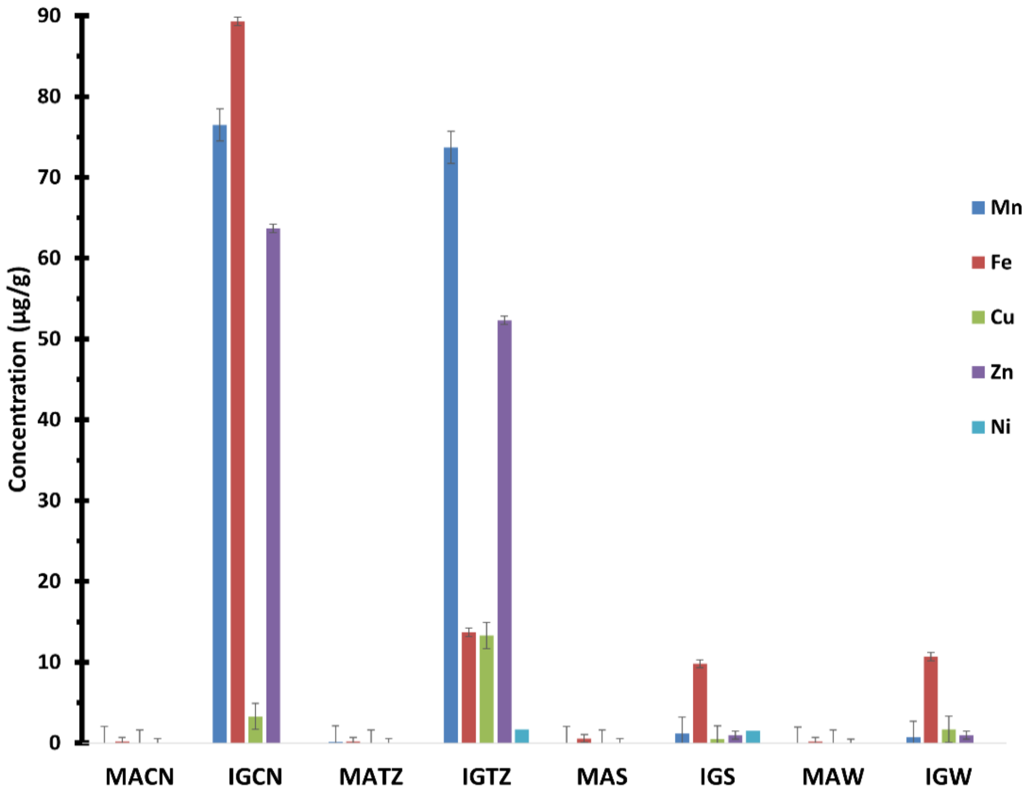

Figure 5. *Chat showing the level of Potential Toxic Metal in fish, sediment and water from Majidun and Igbede River.*

However, the concentrations of PTMs were also found to be higher in the Tilapia and Silver Catfish samples obtained from Igbede River as shown in figure 5, in comparison to those obtained from Majidun River. Nickel was not detected in almost all the samples except in Igbede tilapia fish and sediment with the lowest concentration value of 1.70µg/g and highest concentration value of 27.70µg/g of nickel recorded for Igbede tilapia fish and sediment respectively. The high concentration of nickel may be attributed to anthropogenic activities, high vehicular activities as well as increase in the discharge of liquid and solid fuel into the water body from engine powered canoes used for transportation on the Igbede river and domestic waste [22], but the values in the Igbede tilapia fish sample were more than what was reported by Olowu et al. [23].

The probable cause of the substantial iron levels detected in all samples can be attributed to the inherent abundance of iron in Nigerian soil, as well as its function as a significant storage site for potentially toxic metals which in agreement with earlier report [11, 19, 20]. The values of PTMs obtained in both fish from both locations are lower than the maximum permissible limits set furthermore Pb and Cd were not detected from both sampling locations. The implication of this finding is that the consumption of silver catfish (*chrysichthys nigrodigitatus*) and tilapia (*tilapia zilli*) from both Majidun and Igbede is still safe but regular monitoring (annual) should be done to promptly detect sudden increases in these metals, especially for Pb, which causes mental retardation in children [21]. Fish can accumulate zinc from both the surrounding water and from their diet. Even though zinc is an essential element, at high concentrations, it can be hazardous to fish, cause mortality, growth retardation, and reproductive impairment. Zinc is capable of interacting with other elements and producing antagonistic, additive or synergistic effects [24, 25]. Igbede River could be attributed to human activities, vehicular movement and waterway transportation via engine powered canoes that takes place around the sampling area. Human activities such as the use of chemicals, zinc-based fertilizer, and petrochemicals such as discarded engine oil as well as automobile mechanic workshops around the area could also enhance a high concentration of this metal in the soil and surrounding water [24]. Moreover, this work indicate that the levels of iron and zinc accumulated by the fish in both Majidun and Igbede Rivers from their diet, surrounding water, and sediments are within safe limits as established by the Food and Agriculture Organization (FAO) and Federal Environmental Protection Agency (FEPA) for daily consumption.

4. Conclusion

The study investigated the level of nine (9) potentially toxic metals in the environmental media such as water, sediment and fishes from Majidun and Igede rivers all situated in Lagos, Nigeria. The potentially toxic metals were determined with the aid of BUCK 201 Atomic Absorption Spectrophotometer after acid digestion of the various samples. This study has contributed significantly to the Sustainable developmentgoal (SDG 14) which advocates live below water. It is noteworthy that the level of iron was the highest among the nine metals analysed. This could be associated to the natural background level of iron in the soil in Lagos State because Lagosgeology lies in the Dahomey sedimentary basin, without outcrop, and with the upper sediments in the Basin underlain by coastal plain sands (CPS). Lead and cadmium were not detected in all the environmental media analysed, however, nickel was found only in Igbede tilapia fish and sediment. Igbede river had more levels of the metals analysed in all the environmental media compared with Majidun river. The accumulation of iron and zinc by the fishes from both the surrounding water, sediments and their diet were relatively low and are below recommended value of Food and Agriculture Organization (FAO) [8, 26] and Federal Environmental Protection Agency (FEPA) [27] for daily intake which revealed that the aquatic life analyzed in Majidun and Igbede Rivers are relatively safe for consumption but the need for regular monitoring of the environmental media is important to prevent bioaccumulation.

Abbreviations

AAS	Atomic Absorption Spectrophotometer
SDG	Sustainable Developmentgoal
FAO	Food and Agriculture Organization
LASEPA	Lagos State Environmental Protection Agency
CPS	Coastal Plain Sands
PTMs	Potential Toxic Metals

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Author Contributions

Olowu Rasaq Adewale: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology

Osundiya Medinat Olubunmi: Conceptualization, Methodology, Writing-review & editing

Oyewole Toyib Seun: Formal Analysis, Supervision

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Hammed Ayofe Mutalib: Formal Analysis, Investigation

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Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Kumolu-Johnson, C. A., and Ndimele, P. E. (2012). Some aspects of the Limnology and Heavy metal content of water, sediment and Oreochromis niloticus (Linnaeus, 1758) from Ologe Lagoon, Lagos, Nigeria, Research Journal of Environmental Toxicology 6(5), 210.-215.

[2] Lars, J. (2003). Hazards of Heavy Metals Contamination. British Med Bull, 68, 167-182.

[3] Peng, B. R., Hong, H. S. and Chen, W. Q. (2005). Ecological Damage Appraisal of Sea Reclamation: Theory, Method and Application. Journal of Natural Resources, 20, 714-726).

[4] Olowu, A. Rasaq. Arotiba, Omotayo, Mailu, N. Stephen Waryo, T. Tesfaye, Baker, Priscilla and Iwuoha Emmanuel, (2010), "Electrochemical Aptasensor For Endocrine Disrupting 17β-Estradiol Based On A Poly 3, 4-Ethylenedioxylthiopene –Gold Nanocomposite Platform, Sensors, Vol. 10, Issue, Pp. 9872-9890.

[5] Fidelis B. Ada, Ezekiel O. Ayotunde and Benedict O. Offem (2012) Surface andground Waters Concentrations of Metal Elements in Central Cross River State, Nigeria, and their Suitability for Fish Culture. International Journal of Environment and Sustainability 1(2), 9-20.

[6] Kori-Siakpere, O. and Ubogu, E. O. (2008) Sublethal Hematological Effects of Zinc on the Freshwater Fish, Heteroclarias sp. (Osteichthyes: Clariidae). Africa Journal of Biotechnology, 7, 2068-2073.

[7] Salem, N. A. and Salem, E. A. (2016) Protective Antioxidant Efficacy ofgarlic against Lead Induced Renal and Testicular Toxicity in Adult Male Rats. Journal of Heavy Metal Toxicity and Diseases, 1, 15-21.

[8] World Health Organisation (WHO),/FAO (1996). Water Quality Assessments. Aguide to Use of Biota, Sediments and Water in Environmental Monitoring, WHO, geneva.

[9] Plessl, C., Otachi, O. E., Korner, W., Avenant-Oldewage, A. and Jirsa, F. (2007). Fish as bioindicators for trace element pollution from two contrasting lakes in the Eastern Rift Valley, Kenya: spatial and temporal aspects. Environmental Science Pollution Resources International, 24(24), 19767-19776.

[10] Olowu, R. A., Ayejuyo, O. O., Adejoro, A. I., Adewuyi, O. g., Osundiya, M. O., Onwordi, C. T., Yusuf, A K. and Owolabi, M. S. (2010). Determination of heavy metals in crab and prawn in Ojo river, Lagos, Nigeria. E-journal of Chemistry, 7(2), 526-530.

[11] Olowu, R. A., Osundiya, M. O., Jimoh, A. A., Adeosun, F. I., Quadri, O. E., and Alegbe, M. J. (2019). Comparative Assessment of Potential Toxic Metal Concentrations in Water, Sediments and Fish (Clariasgariepinus) in Epe Lagoon, Earthen Pond and Concrete Pond in Epe Area of Lagos State. global Journal of Fisheries and Aquaculture, 7(3), 516-526.

[12] Zhang, Y., Zhang, H., Zhang, Z., Liu, C., Sun, C., Zhang. W and Marhaba, T. (2018). pH Effect on Heavy Metal Release from a Polluted Sediment. Journal of Chemistry, 2018. ID 7597640: 1-7.

[13] Olaifa, F. E., Olaifa, A. K., Adelaja, A. A., and Owolabi, A. g. (2004). Heavy metal contamination of Clariasgariepinus from a lake and fish farm in Ibadan, Nigeria, African Journal of Biomedical Research, Vol. 7(2004); 145-14.

[14] United Nations (2017) Resolution adopted by thegeneral Assembly on 6 July 2017, Work of the Statistical Commission pertaining to the 2030 Agenda for Sustainable Developmen.

[15] Sayyad, N. R., Khan, A. K., Ansari, N. T., Seema, H., And ShaikhI, M. A. J. (2007). Heavy metal concentrations in different body part of crab, Barytelphusaguerini fromgodavari River, Control Pollution 23(2), 363-368.

[16] Nwaedozie, J. M. (2000). Environmental pollution-A case study of wastewater effluent parameters of some industries in Kaduna. Afr. J. Environ. Stud 1 (1&2), 84-89.

[17] Hany M. Yehia and Elwoa Sh. Sebaee (2012) Bioaccumulation of heavy metals in water, sediment and fish (Oreochromis niloticus and Clarias anguillaris), in Rosetta branch of the River Nile, Egypt. African Journal of Biotechnology Vol. 11(77),. 14204-14216.

[18] Olowu. A. Rasaq.; Ayejuyo, O. Olusegun, Adewuyii, Ogregory.; Babatunde, A. O.; Adejoro, A. Isiaha Denloye, A. Abiodun, And Ogundajo, L. Adetayo, (2010), “Heavy Metals In Fish Tissue, Water, Sediment From Epe And Badagry Lagoons, Nigeria”, E-Journal Of Chemistry, Vol. 7, Issue 1, Pp. 215-221.

[19] Okorafor, K. A., Andem, A. B., and Arira, D. I. (2015). Concentrations of metals in the flesh musclesof five commercially important fishes obtained from thegreat Kwa River, Calabar, Nigeria, Journal of Basic and Applied Research International 3(2): 47-53.

[20] Olayinka-Olagunju, J. O., Ayo-Olalusi, C. I. and Adeyemi T. V. (2018). Bioaccumulation of Some Trace Elements in thegills and Tissues of Clariasganepines and Oreochromis nilocticus in Ogbese, Ondo River. Journal of Environmental Chemistry and Ecotoxicology, 9(3), 11-18.

[21] Rasaq A. Olowu, Abayomi A. Jimoh, Chionyedua T. Onwordi, Olumayowa J. Onipede, Babajide A. Ogunnaike, Albert O. Amosu (2015). Potential Toxic Metals Concentrations in Different Aquatic Lives Harvested from Lagos Island and Epe Lagoons, World Environment, 5(2): 80-89.

[22] Harasim P., Filipek T. (2015). Nickel in the environment. J. Elem., 20(2): 525-534.

[23] Osundiya Medinat Olubunmi, Olowu Rasaq Adewale, Alegbe Monday John, Igbasan Sam Odunayo, Abayomi Abdulazeez Jimoh, Olawoye Christiana Olawunmi, Emmanuel Jesuyon (2019). Bioaccumulation of Heavy Metals in Parts of the Silver Catfish (Chrysichthys nigrodigitatus) Harvested from Badagry Creek and Fish Ponds in Badagry, Lagos, Nigeria. American Journal of Chemistry 2019, 9(3): 95-102.

[24] Ezekiel Olatunji Ayotunde, Benedict Obeten Offem and Fidelis Bekeh Ada (2012). Heavy metal profile of water, sediment and freshwater catfish, Chrysichthysnigrodigitatus (Siluriformes: Bagridae), of Cross River, Nigeria. Int. J. Trop. Biol. Vol. 60(3): 1289-1301.

[25] Ayotunde, E. O. Offem B. O. and Ada, F. B. (2012), “Assessment of heavy water profile of water sediment and freshwater cat fish (chrysichthys nigrodigittus, siluriformes: bagridae) of Cross River State, Nigeria”, International Journal of Tropical Biology, Vol. 60 No. 3, pp. 1 -13.

[26] Food and Agriculture Organization (FAO). 1992. Report of the third Session of Working Party on Pollution and Fisheries, Accra, ghana, 25-29th Nov., 1991. FAO Fisheries Report. 471: 43.

[27] Federal Environmental Protection Agency (FEPA) (1999). guidelines and Standards for environmental pollution control in Nigeria. Decree 58 of 1988. p. 238.