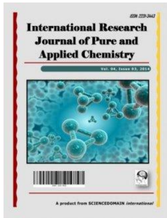

International Research Journal of Pure & Applied Chemistry

17(3): 1-7, 2018; Article no.IRJPAC.46146
ISSN: 2231-3443, NLM ID: 101647669

Analyses of Heavy Metal Pollution in a Tidal Polluted Creek in Lagos, Nigeria

Ogungbile Peter[1], Oyewale Morakinyo[2], O. Adepoju Adeyinka[1*] and Mynepalli K. C. Sridhar[2]

[1]Wesley University, Ondo, Nigeria.
[2]Department of Environmental Health Sciences, Faculty of Public Health, University of Ibadan, Ibadan, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IRJPAC/2018/46146
Editor(s):
(1) Dr. Dimitrios P. Nikolelis, Professor, Department of Chemistry, Athens University, Greece.
(2) Dr. Wolfgang Linert, Professor, Institute of Applied Synthetic Chemistry, Vienna University of Technology Getreidemarkt, Austria.
Reviewers:
(1) Muhammad Raziq Rahimi Kooh, Universiti Brunei Darussalam, Brunei Darussalam.
(2) Eniola Bolawa, University of Lagos, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/28082

Original Research Article

Received 11 October 2018
Accepted 27 December 2018
Published 02 January 2019

ABSTRACT

Concentrations of heavy metals in water, sediments, as well as littoral plants from two sampling sites A and B of ijora creek of Lagos metropolis were investigated using Atomic Absorption Spectrophotometer. Water and sediments from site A showed higher concentrations of the investigated metals in them than those in site B. Mean values of the selected heavy metals recorded in sediments generally exceeded those in water samples. Some concentrations of heavy metals in the two littoral plants included: Pb (0.013mg/kg for *Paspalum vaginatum*); Cu in *Philoxerus vermicularis* for sites A and B were 0.47 and 0.40 mg/kg respectively while in *Paspalum vaginatum*, they were 0.59 mg/kg and 0.39 mg/kg respectively. Variations in concentration of Mn in *Paspalum* and *Philoxerus* site A ranged between 0.01 mg/kg and 0.08mg/kg. In *Paspalum,* values ranged between 0.02 and 0.06mg/kg. Nickel was not detected in both plant species from the two sites. The results showed that water and sediments in Ijora creek were contaminated with Pb, Cu, Mn and Ni while the plants were shown to have absorbed Pb, Cu, and Mn. It is assumable that anthropogenic activities around the creek contributed increased levels of heavy metals in the creek.

**Corresponding author: E-mail: mryinkaadepoju@gmail.com;*

Keywords: Pollution; heavy metals; aquatic plants; creek.

1. BACKGROUND

Over the past century, heavy metals have been discharged into the aquatic systems as a result of the rapid industrial, agricultural and urban developments, thus, heavy metal contamination has become a serious problem in marine ecosystems throughout the world [1,2].

In Africa most industrial development occurs along the littoral zone of aquatic ecosystem. Numerous ecosystems are threatened with heavy metal pollution from mining and petrochemical industries [3]. Nigeria as a developing nation and Lagos metropolis which is located along the coastal region is experiencing rapid industrial growth. Rapid growth in population and massive industrial growth in recent years have resulted in pollution of the biosphere with toxic metals [4]. Heavy metal contamination of the biosphere has increased and possesses major hazard and human health problems worldwide.

Among environmental pollutants, metals are of particular concern, due to their potential toxic effect and ability to bioaccumulate in aquatic ecosystems [5]. The presence of heavy metals in aquatic ecosystems is the result of two main sources of contamination; natural processes or natural occurring deposits and anthropogenic activities. The main sources of heavy metal pollution to life forms are invariably the result of anthropogenic activities [6,7].

Some sources of heavy metals are industry, municipal wastewater, atmospheric pollution, urban runoff, river dumping, and shore erosion. Heavy metals in surface water systems can be from natural or anthropogenic sources. Currently, anthropogenic inputs of metals exceed natural inputs. High levels of Cd, Cu Pb and Fe can act as ecological toxins in aquatic and terrestrial ecosystems [8].

Aquatic plants are used in water quality studies to monitor heavy metals and other pollutants present in sediment and water. They are considered as important component of the aquatic ecosystem not only as food source for aquatic invertebrates, but also act as an efficient accumulator of heavy metals. They are unchangeable biological filters and play an important role in the maintenance of aquatic ecosystem [9,10,11].

1.1 *Philoxerus vermicularis*

*Philoxerus vermicularis*is, a species of grass known by many names, including Fowl's pepper, Sesuvium, etc. A fleshy herb with red creeping stems, rooting at nodes and attaining over 1 m in length with shortly erect nodal branches bearing terminal and lateral inflorescences. Common on all sandy beach-heads and in dry mangrove from Senegal to Cameroon, and on to Angola, and on the Atlantic Coast of the American Continent [12]. By its creeping habit it acts as a good sand-binder, a property recorded from all parts of West African Region Coast line.

1.2 *Paspalum vaginatum*

Paspalum vaginatum is a species of grass known by many names, including seashore paspalum, biscuit grass, saltwater couch, silt grass, etc. It is native to the Americas and also found throughout the other tropical areas of the world, where it is an introduced species and sometimes an invasive weed. This is a perennial grass with rhizomes and stolons. The stems grow 10 to 79 cm tall. The leaf blades are 10 to 19 cm long and may be hairless to slightly hairy. They are usually blue-green in colour [13,14].

Previous studies have reported that marine sediments have a large capacity to retain heavy metals from various sources, and marine sediments often act as sinks for heavy metals [10,11]. Therefore, sediment can be adopted as an efficient indicator for monitoring heavy metal pollution in coastal areas.

The aim of this study was to examine two plants (*Philoxerus vermicularis* and *Paspalum vaginatum*), sediment and water samples selected from two locations in the study area so as to detect the level of pollution caused by heavy metals in Ijora Creek, Lagos, Nigeria.

2. MATERIALS AND METHODS

2.1 Description of Sampling Site

The study was conducted in Ijora Creek located at the Central Business District of Lagos Metropolis. It is situated close to the National Theatre, Iganmu and surrounded by a number of industries which include the Nigerian Breweries, Apex Paper Mill, and Nigerian Flour Mills, Apapa. The effluent discharged from these sources are either treated or not treated. The Creek is also polluted through deposition of atmospheric particulates. Hence, the transfer of air borne particles to the water surfaces by dry deposition constitutes the first stage of accumulation of atmospheric heavy metals.

At high tide, water from the Atlantic Ocean flows through the canal into the Creek. The high tide that alternates with the low tide makes the Greek to be very dynamic in nature. However, the Creek cannot be navigated at both high and low tide periods. A map of the study area is shown in Fig. 1.

2.2 The Plant Samples Analyzed

The analysis of heavy metals (Pb, Cu, Mn and Ni) was carried on *Philoxerus vermicularis* and *Paspalum vaginatum* was done using the AAS ALPHA 4.

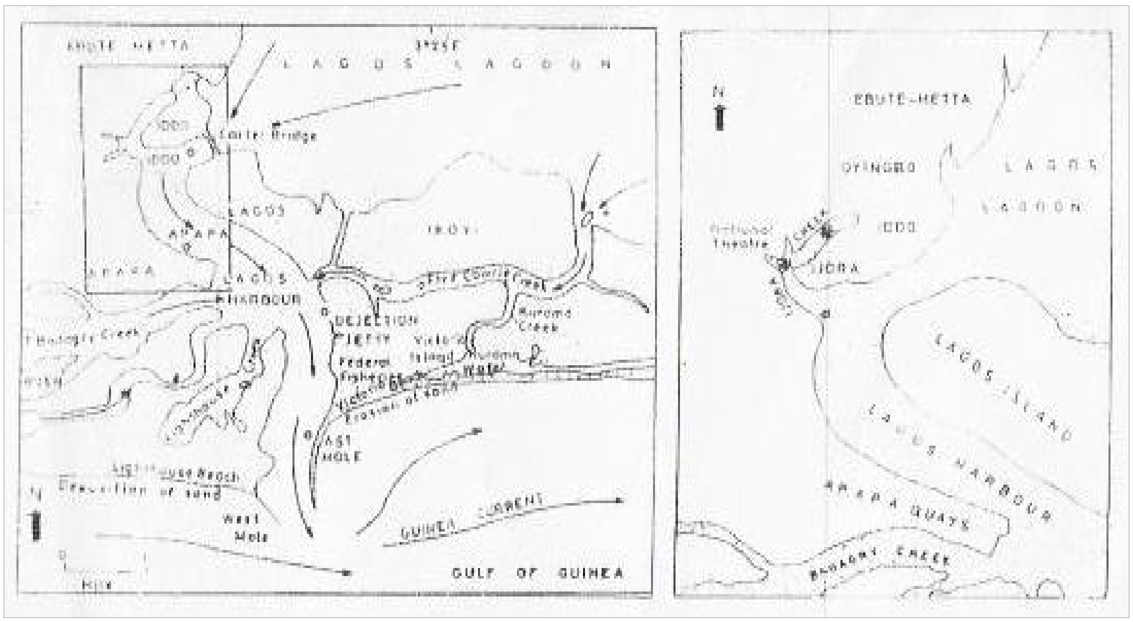

Fig. 1. Part of Lagos Lagoon showing Ijora creek and sampling sites

Fig. 2. A picture showing *Paspalum vaginatum*

2.3 Samples Collection, Preparation and Analysis

Samples of plants, sediments and water were collected between February and April, 2017.

2.3.1 Plant samples

The plant samples were collected using sterilized rubber gloves, and from the two stations, A and B which were about 4km apart. The plants were thoroughly cleaned with fresh water followed by distilled water, for quantitative removal of soil and other foreign particles.

Ashing procedure was used in the determination of the heavy metals (Pb, Cu, Mn, Ni) in plant samples (*Philoxerus vermicularis* and *Paspalum vaginatum*). The whole plant (i.e. root, shoot and leaf) was digested. Adequate amount of the sample was weighed inside a 100mls beaker; 5ml of concentrated HNO_3 and 10mls of freshly prepared 1:1 v/v H_2O_2/HNO_3were then added. The beaker was covered with a watch glass, allowed to stand for one hour and then placed on a hot plate. The temperature was carefully raised to 160ºC and thereafter boiled gently for about 2 hours to reduce the volume to 3-4 ml.

The solution was allowed to cool in a 250ml volumetric flask and made up to the mark using distilled water. The amount of the heavy metals in the sample was calculated using the formula:

$$X = \frac{C.V}{W}$$

Where;

X = Amount of element in sample
C = Concentration read from equipment
W = Weight of sample in grams
V = Volume of Solution.

2.3.2 Water samples

Water samples were collected at high tide biweekly for three consecutive months. Samples of water were collected from two stations using 250ml clean plastic containers. The samples were analysed for Pb, Cu, Mn and Ni using AAS ALPHA 4.

The water sample was aspirated into the flame through a nebulizer chamber. The solvent evaporates and the solute is dissociated into atoms by the heat of the flame. The atoms are excited and absorbs radiation cathode lamp specific of each concentration of metal in the water sample. Standard solutions of each metal were aspirated to determine their absorbance from which the concentration of the metals in the sample was determined.

2.3.3 Sediment samples

Sediment samples at a depth of about 15 cm from the surface at the two stations were collected into a clean polythene bags with a stainless steel crab. They were dried and passed through a 2 mm sieve. The samples were analysed for Pb, Cu, Mn and Ni. The AAS ALPHA 4 was used for the determination of the heavy metals. One gram of sediment was weighed accurately. The sediment was boiled to dryness with a mixture of 1:1 nitric acid and perchloric acid value v/v (each addition was 25ml).

The residue was dissolved in dilute HCl and then filtered into a 50ml volumetric flask and made to the mark. The amount of heavy metals in sample can be calculated using the following formula:

$$X = \frac{C.V}{W}$$

Where;

X = Amount of element in sample
C = Concentration read from equipment
W = Weight of sample in grams
V = Volume of Solution.

3. RESULTS

3.1 Pb in Plants, Water and Sediments

Pb levels ranged between 0.001 and 0.03mg/kg in *Paspalum vaginatum* in station A. Mean values of Pb in station A for *Philoxerus vermicularis* was 0.002±0.001 mg/kg and 0.019±0.015 mg/kg for *Paspalum vaginatum.* At Station B, *Philoxerus vermicularis* level of Pb ranged between 0.01 and 0.04 mg/kg. *Pasplaum vaginatum* showed a range between 0.03mg/kg and 0.02mg/kg. The mean values for *Philoxerus vermicularis* was 0.02 and 0.13mg/kg for *Paspalum vaginatum* (Table 1).

For water analysis as shown in Table 2, Pb estimates ranged between 0.38 and 7.20mg/L in station A while in B, the range was between 0.30 and 0.45 mg/L. Mean values for Pb in water were 3.09mg/L and 0.37 mg/L in both stations.

Variations in the levels of lead in station A ranged between 13.6 and 20.04 mg/kg. In station

B lead concentrations in the sediments ranged between 1.23mg/kg and 11.70 mg/kg. The mean values of Pb in sediment samples in station A was 18.37 and 8.10 in station B (Table 3).

3.2 Cu in Plants, Water and Sediments

Variations in Cu concentration in the plant species in station A showed that the level of Cu in *Philoxerus vermicularis* ranged between 0.26 and 0.68mg/kg. Mean value of Cu in *Philoxerus vermicularis* in station A was 0.46±0.13 mg/kg (Table 1).

Variations in the value of Cu in *Paspalum vaginatum* in station A showed a range of 0.27 and 0.74 mg/kg. From station B, the level of Cu in *Philoxerus vermicularis* showed a range of 0.26 mg/kg and 0.62 mg/kg. The level of Cu in *Paspalum vaginatum* showed a range of 0.22 mg/kg and 0.62 mg/kg. The mean values of Cu in *Philoxerus vermicularis* in stations A and B were 0.47and 0.40 mg/kg respectively. The mean values of Cu in *Paspalum vaginatumn* in both stations were 0.59 mg/kg in station A and 0.39 mg/kg in station B (Table 2).

In station A, copper levels ranged between 2.5 and 10.3mg/L. In station B the levels of Cu ranged between 1.07 and 1.99 mg/L. The mean value of 8.37 mg/L for station A and mean value of I.59 mg/L in station B. Mean values of Cu in station A was 8.39 and 1.59 in station B. Cu values ranged between 15.72 and 24.1 mg/kg. In station B Copper Concentration showed a range between 10.3 mg/kg and 15.9 mg/kg.

3.3 Mn in Plants, Water and Sediments

Levels of Mn in the plants were as follows: *Philoxerus vermicularis* recorded a range between 0.01 and 0.05 mg/kg. The mean value was 0.03 mg/kg. Variations in levels of Mn in *Paspalum vaginatum* and *Philoxerus vermicularis* in station A showed a range 0.01 mg/kg and 0.08 mg/kg. The mean value was 0.03 mg/kg. In *Paspalum vagmatum* values ranged between 0.02 and 0.06 mg/kg. The mean value was 0.04 mg/kg.

The Mn values in station A ranged between 0.14 and 4.1 mg/L. The Mn values in station B ranged between 0.40 and 0.65 mg/L. The Mn mean values in stations A and B were 2.05 and 0.51, respectively.

The presence of Mn in sediment from station A ranged between 2.86 to 6.20 mg/kg. Station A showed a mean value of 5.17 mg/kg. The lowest value of Mn in sediment in station B was 0.8 mg/kg and the highest value was 4.0 mg/kg.

3.4 Ni in Water and Sediments

Ni values ranged between 0.52 and 0.92 mg/L in station A. The highest value of 0.92mg/L was recorded in February while the lowest value of 0.52 mg/L was recorded in April Ni was not detected in station A in water sample in March. In station B, Ni was not detected in the samples of water. Mean values for Ni in water samples were 0.4383 station A and not detected in station B.

Ni concentration in sediments showed a range of 0.45 mg/kg in station B to 3.80mg/kg in station A. The mean Ni concentration in station A was 2.81 mg/kg which exceed concentration in station B which was 0.8 mg/kg. Mean values of Ni in sediment for both station A and B were 2.81 mg/kg and 0.80 mg/kg, respectively.

Table 1. Mean of levels of selected heavy metals in aquatic weeds of Ijora Creek

Parameters (mg/kg)	Station	(*Philoxerus vermicularis*)	(*Paspalum vaginatum*)	WHO limit
Pb	A	0.002±0.002	0.019±0.017	0.01
	B	0.002±0.001	0.134±0.006	
Cu	A	0.46±0.117	0.58±0.167	0.01
	B	0.39±0.212	0.39±0.107	
Mn	A	0.03±0.016	0.03±0.029	0.02
	B	0.03±0.081	0.04±0.018	
Ni	A	ND	ND	0.15
	B	ND	ND	

Table 2. Mean levels of selected heavy metals in water samples from Ijora Creek

Parameters (mg/l)	Station A	Station B	WHO limit
Pb	3.09	0.37	0.1
Cu	0.44	ND	0.2
Mn	8.37	1.59	0.2
Ni	2.05	0.51	0.2

Table 3. Mean of levels of selected heavy metals in sediment samples from Ijora Creek

Parameters (mg/kg)	Station A	Station B
Pb	18.37	10.03
Cu	2.81	0.80
Mn	20.62	13.05
Ni	5.17	2.64

4. DISCUSSION

This study shows that aquatic plants (*Philoxerus vermicularis* and *Paspalum vaginatum*) and sediments can provide sufficient information about the metal content of their aquatic environment. Our studies showed that accumulation is strongly dependent on numerous factors such as source of contaminant, contaminant concentration, season, rainfall, water temperature, water flow, plant species itself and the type of metal species [15]. The concentrations of heavy metals in the two plants were low, this may be due to the fact that they do not grow submerged in the ecosystem rather they are found growing along the bank of the creek (intertidal zone). In aquatic ecosystems, several studies have concluded that submerged plants tend to accumulate higher concentrations of metals than emergent or free-floating plants [16,17].

Heavy metals detected in the aerial portions of plants pose a serious health risk for herbivores [18]. Plants can take up metals from air, water, soil and sediments with variations in metal content dependent on several factors such as soil properties, seasonal changes, plant species, plant age, time interval of metallic soil input, nutrient availability and interaction among the metals [19,20,21].

Also, high levels of Pb, Cu and Mn were recorded in the sediment in the study area. This shows that the creek water and sediment is a store of heavy metals probably from overlying water. Plants and even animals are known to absorb dissolved nutrient and even bioaccumulate heavy metals from the sediment from which they inhabit [22]. This also shows that human activities around Ijora Creek in the Lagos metropolis has inevitably increased the levels of heavy industrial effluent discharge from the surrounding industries and the populated region have contributed to the heavy metal load of the creek.

Earlier studies carried out by Chukwu [23] have implicated coastal waters of Southwestern Nigeria. This study further confirms the investigation by Ansari et al. [24] who are of the view that concentrations of heavy metals in sediments usually exceed in the overlying water. This shows that anthropogenic inputs of pollutants such as heavy metals tend to accumulate in the bottom sediment.

5. CONCLUSION

In conclusion, the results of this study has shown that plant, water and sediments at the Ijora creek is mainly contaminated with Pb, Mn, Cu and Ni. Pollution in the area is noteworthy due to both industrial and anthropogenic activities such as dumping of industrial and household refuse. If the pollution is not prevented, it has the potential of endangering the lives of living organisms there based on bioaccumulation by reason of direct or indirect ingestion in future. Careful monitoring of the environment is hereby recommended so as to prevent further environmental pollution and its effects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Cundy AB, Croudace IW, Cearreta A, Irabien MJ. Reconstructing historical trends in metal input in heavily-disturbed, contaminated estuaries: Studies from Bilbao, Southampton Water and Sicily. Applied Geochemistry. 2003;18(2):311–325.
2. Pekey H. The distribution and sources of heavy metals in Izmit Bay surface sediments affected by a polluted stream. Marine Pollution Bulletin. 2006;52(10): 1197–1208.
3. Chukwu LO. Physico–Chemical characterization of pollutant load of treated industrial effluents in Lagos metropolis. Journal of

Industrial Pollution Control. 2006a;22(1): 147–153.
4. Rai UN, Amit P. Toxic metals and phytoremediaton. International Society of Environmental Botanist. 1999;5:4-7.
5. Censi P, Spoto SE, Saiano F, Sprovieri M, Mazzola S, Nardone G, Di Geronimo SI, Punturo R,d Ottonello D. Heavy metals in coastal water system. A case study from the north western Gulf of Thailand. Chemosphere. 2006;64:1167–1176.
6. Kennish MJ. Ecology of Estuaries: Anthropogenic effects. CRC Press Boca Raton Ann Arbor, London. 1992;494.
7. Francis BM. Toxic substances in the Environment, John Wiley and Sons, Inc, New York. 1994;363.
8. Guilizzoni P. The role of heavy metals and toxic materials in the physiological ecology of submersed macrophytes. Aquatic Botany. 1991;41:87-109.
9. Zurayk R, Sukkariah B, Baalbaki R. Common hydrophytes as Bioindicators of nickel, chromium and cadmium pollution. Water, Air and Soil Pollut. 2001;127:373–388.
10. Calmano W, Hong JH, Forstner U. Binding and mobilization of heavy metals in contaminated sediments affected by pH and redox potential. Water Science and Technology. 1993;28(8-9):223–235.
11. Menon MG, Gibbs RJ, Phillips A. Accumulation of muds and metals in the Hudson River estuary turbidity maximum. Environmental Geology. 1998;34(2-3): 214–222.
12. Burkill HM. The useful plants of west tropical Africa. 1985;1.
13. Bamidele JF, Igiri A. Growth of seashore *Paspalum vaginatum* in soil contaminated with crude petroleum oil. J. Appl. Sci. Environ. Manage. 2011;15(2):303-306.
14. Zulkaliph NA, et al. Use of saline water for weed control in seashore Paspalum (*Paspalum vaginatum*). Australian Journal of Crop Science. 2011;5:523-30.
15. Demirezen D. Investigation of heavy metal pollution at aquatic ecosystems in Sultan Sazlıgı and It's Environs', Ph.D. Thesis, University of Gazi, Institute of Science and Technology, Ankara; 2002.
16. Crowder A. Acidification metals and macrophytes. Environmental Pollution. 1991;71:171–203.
17. Outridge PM, Noller BN. Accumulation of toxic trace elements by freshwater vascular plants. Reviews of Environmental Communication and Toxicology. 1991;121: 1-63.
18. Gutiérrez-Ginés MJ, Pastor J, Hernández AJ. Effect of heavy metals from mine soils on *Avena sativa* l and education strategies. Fresenius Environ. Bull. 2010;19(9b):2083-2087.
19. Ekosse GE, Ngila JC, Forcheh N. Multivariable analyses of heavy metals in soils and *Colophosper mummopane* leaves around the Selebi Phikwe nickel-copper mine and smelter/concentrator plant area, Botswana. J. Appl. Sci. Environ. Mgt. 2005;9(1):177-185.
20. Zhou JD, Cai M, Liu C. Soil heavy metal pollution around the Dabaoshan mine, Guangdong province, China. Pedosphere. 2007;17(5):588-594.
21. Jung MC. Heavy metal contamination in soils and factors affecting metal uptake by plants in the vicinity of a Korean Cu-W mine. Sensors. 2008;8:2413-2423.
22. Oyewo EO, Don-Pedro KN. Lethal and Sub lethal effects of copper to the African Catfish (*Clarias garienpnus*). West Africa Journal of Applied Ecology. 2003;4:115–123.
23. Chukwu LO. The Impact of Industrial effluents on the water chemistry of Urban River in Southern Nigeria. Ekologia. 2006b;5(1):8–16.
24. Ansari TM, Marr IL, Tariq. Heavy metals in marine pollution – A mini review. Journal of Applied Sciences. 2004;4(1):1–20.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/28082