PHYTODIVERSITY AND TRACE METALS GEOCHEMISTRY OF A LACUSTRINE PLAIN IN AKWA IBOM STATE, NIGERIA

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ABSTRACT

Plant species occurrence and trace metal concentrations were assessed within a lacustrine plain in Uyo. Soil and water samples were collected at two instances (March 2013 and in March 2014). Also, vegetation community structure was characterized. Twenty one plants from sixteen plant families were recorded from the study area. Iron concentration was the greatest in both soil and water samples while cadmium was the least in terms of ions concentration in the habitat per sampling time. The concentration of Fe in soil and water at first instance was 113.02 ± 0.73mg/kg and 309.08 ± 0.72mg/l whereas this concentration at second instance was 143.04 ± 0.1mg/kg and 423.1 ± 0.96mg/l respectively. At instance 1, the concentration of cadmium in soil and water was 4.4 ± 0.03mg/kg and 0.85 ± 0.05mg/l but 3.7 ± 0.2mg/kg and 2.2 ± 0.1mg/l respectively as at the second sampling time. Also, the geochemical indices of the five metals (Pb, Cd, Fe, Zn and Ni) ranged between 0.106 – 2.08 and 0.197 – 3.958 at first and second instances respectively. This indicates temporal changes in the retention of trace metals across the plain. The high iron content in water is reflective of a point source contaminant, against the backdrop of the usage of surrounding water by tricycle operators for cleaning. However, we have stated in our conclusion that the high Iron content within the area needs more investigation. Furthermore, correlation analysis between heavy metals properties of soil and water samples yielded significant positive correlations in all cases (p>0.05). Results obtained from the study are relevant in the determination of environmental factors responsible for the occurrence and distribution of plant species within wetland areas, particularly in a fast growing urban city. Additionally, metal accumulation in plants may increase mortality rates in wetland plants and herperto-fauna population in and around this habitat.

INTRODUCTION

The concentration levels of heavy metals in the environment are continually changing due to man's activities. These changes have generated a lot of interest in pollution studies especially as human population density increases across urban and rural landscapes (Imperator *et al.*, 2003; Stevovic *et al.*, 2010). Anthropogenic sources of heavy metals include industrial and vehicular emissions, municipal wastes and agricultural wastes (Forsther, 1977 and Thornton, 1983). Heavy metals discharged into the environment become toxic to plants and aquatic organisms. They tend to bio-concentrate within these organisms, sometimes to levels greater than that within the physical environment. Additionally, during transportation, trace metals undergo numerous changes in their speciation which affect their behaviour and bioavailability (Howard *et al.*, 2009). Also, a large number of potentially harmful metals are implicated in certain human diseases (Chinweuba *et al*., 2007). For instance, lead causes cancer, damages the brain and kidneys (Sabine and Wendy 2009), while Cadmium damages the lungs and bones (Nriagu, 1980). Importantly, especially in the context of the current study, trace metals, are easily influenced by environmental factors such as surface runoff, erosion and sediment dissolution; thus, they may be sensitive indicators for monitoring changes in the environment (Papafilippaki *et al.,* 2008).

The Akwa Ibom capital like many urban cities within Sub-Saharan Africa has witnessed an increase in human population within the last decade (UN-Habitat, 2012). Vehicular movements and infrastructural development is a growing phenomenon that demands constant monitoring of metal pollution in the environment. Although, research efforts have been directed towards trace metals chemistry and plant distribution in different wetlands around the world, including Nigeria (Davis and Brock, 2008; Takarina, 2009; Awokunmi, 2010; Onwukeme *et al.*, 2013); yet, such information regarding different wetland typologies in Akwa Ibom State is scarce. Equally scarce is information on native aquatic flora within these wetlands. Thus, the main objective of this study was to assess trace metal occurrence in soil and water samples obtained from a sample area of floodplain within the urban area. Additionally, was the assessment of vegetation composition of this wetland over one-year period in congruence to the soil and water variables.

METHODOLOGY

Study Area

Study site (5.008˚N; 7.925˚E) is the vast floodplain zone surrounding Afaha Etok, Ibesikpo axis, adjacent to Udo Udoma Avenue within Uyo metropolis. Popular landmarks around this zone are the Tropicana Cinema and the Afaha market. Water and soil samples were collected from a seasonal pond, used by adjacent communities for planting Pineapple (*Annas comosus*).

Vegetation Water & Soil Sampling

Systematic sampling was adopted in sampling the vegetation and soil. Species were sampled in twenty 10m x 10m quadrants, spaced at regular intervals of 20m. In each quadrant, plants were enumerated and representative samples were identified to the species level. Voucher specimens of plant species have been deposited at the Herbarium of the Department of Botany and Ecological Studies, University of Uyo.

In each quadrant, a standardized soil auger was used to obtain two soil samples at opposite ends of the quadrant to a rooting depth of 40cm. The soil samples were air- dried and preserved for laboratory analysis. Water samples were collected from 8 different points within the floodplain between 10:00 and 11:00hours in each sampling year (i.e. March 2013 and 2014). The samples were digested and atomic absorption spectrophotometer was used to determine the metals concentration in both water and soil samples (Udo *et al.,* 2009).

RESULTS

The floristic composition of the pond as shown in Table 1 indicates a total of twenty one plant species from sixteen plant families. Seventeen plants from fourteen plant families were obtained in 2013; whereas twenty one were observed in 2014. The plant with the highest mean density (1143st/ha) was *Polygonum laginerum* while *Longocarpus griffoneonus* and *Sida acuta* were among the least common species found in the pond with a density value of 18.7 ± 2.19.

Table 2 shows the mean concentration of six heavy metals in the soils of the wetland. Iron was the most abundant of these metals assessed in this area. The mean concentration of this metal was about 113.02 ± 7.3mg/kg in 2013 and 143.04 ± 0.1 mg/kg in 2014. Magnesium ranked next with a mean concentration of 54.3 ± 1.4 and 52.9 ± 0.1 in 2013 and 2014 respectively. The concentration of lead in 2013 (16.1 ± 0.1 mg/kg) was very close to that of 2014 (17.8 ± 0.1 mg/kg). The least concentration of heavy metal found in the soil samples was cadmium. It had a mean value of 3.7 ± 0.2 mg/kg and 4.4 ± 003 mg/kg at the first and second sampling year respectively.

Table1. Showing the plants composition of the pond.

Family	Plant	Density[1](st/ha)	Sampling Year[2]	
			2013	2014
Arecaceae	*Elaeis guineensis*	112.5±19.4	+	+
Asteraceae	*Ageratum conizoides*	187±12.19	+	+
	Aspillia africana	75±10.7	+	+
Commelinaceae	*Commelina bengalensis*	150±7.4	+	+
	Commelina sp.	75±6.01	+	+
Convulvucaceae	*Ipomoea carnae*	225±12.4	+	+
Cyperaceae	*Cyperus iria*	90.48±11.59	_	+
	Mariscus esculentus	172±17.3	_	+
Fabaceae	*Calapogonum muconoides*	225±19.1	+	+
Graminae	*Khyllingia diffusa*	112.5±10.2	+	+
Leguminosae	*Longocarpus griffoneonus*	18.7±0.03	+	+
Malvaceae	*Sida acuta*	18.75±5.3	+	+
Mimosaceae	*Mimosa pudica*	56.25±12.4	+	+
Nymphaeceae	*Nymphaea lotus*	262.50±20.1	+	+
Onagraceae	*Ludwigia erecta*	18.7±0.15	+	+
Panicoideae	*Panicum maximum*	300±52.8	+	+
	Sacciolepsis africana	337.5±32.8	+	+
Poaceae	*Axonopus compressus*	79.45±2.41	_	+
	Eleusine indica	103±18.47	_	+
Polygonaceae	*Polygonum laginerum*	1143±175	+	+
Salviniaceae	*Azolla spp.*	337.7±16.4	+	+

Notes: [1]Values ±Standard error, st/ha- stand per hectare; [2]Absent in sampling year (_), Present in sampling year (+)

Table 2: Mean (±S.E) concentration (mg/kg) of heavy metals present in soil samples from the flood plain

Metals	Sampling Year	
	2013	2014
Cadmium (Cd)	4.4±0.03	3.7±0.2
Chromium (Cr)	13.9±2.6	15.8±0.75
Iron (Fe)	1013.02±7.3	143.04±0.1
Lead (Pb)	16.1±0.0	17.8±0.1
Manganese (Mn)	54.3±1.4	52.9±0.1
Zinc (Zn)	16.4±0.1	24.4±0.2

Comparatively, Table 3 shows the concentration of the heavy metals in the Water samples obtained from the study site. Iron was the most concentrated heavy metal in water in consonance with results obtained from soil samples. The mean concentration of Iron in 2013 was 309.8 ± 0.72mg/l but was 423.1 ± 0.96mg/l in 2014. Also, as in the case with the soil samples, the least absorbed metal was cadmium which had a mean concentration of 2.2±0.1 and 0.85±0.05 in 2013 and 2014 respectively.

Table 3: Mean (±S.E) concentration (mg/l) of heavy metals present in water from the flood plain

	2013	2014
Cadmium	0.85±0.05	2.2±0.1
Chromium	8.85±0.35	6.0±0.2
Iron	309.08±0.72	423.1±0.96
Lead	1.70±0.1	3.5±0.2
Manganese	21.35±0.25	37.9±0.7
Zinc	17.85±0.95	13.6±0.2

Geochemical factor (I_{geo}) for all heavy metals studied was determined and is presented in Table 4. The highest geochemical index (I_{geo}) was that of Iron (Fe). The geochemical factor of this element was 3.96 and 2.47 in the wetland respectively for first and second sampling. In 2013, only Zinc (Zn) had a factor value greater than 1. The Geochemical value for zinc as at the first sampling was 2.08. Aside from these few exceptions, the Geochemical factor in all cases was less than unity (<1).

Table 4: Geochemical index of Soil Present in the Flood plain

	Year 1	Year 2
Cadmium	0.193	0.595
Chromium	0.640	0.379
Iron	0.305	3.958*
Lead	0.106	0.197
manganese	0.393	0.717
Zinc	2.080*	0.557

* Indicates a Geochemical factor values greater than 1 and significant at p<0.05

Table 5 shows the correlation relationship between heavy metals found in water and soil. The matrix generated shows high positive correlation values for all the metals analysed.

Table 5**:** Soil-water heavy metal correlation matrix**.**

	Water Pb	Water. Cd	Water Zn	Water Cr	Water Mn	Water Fe
Soil Pb.	1					
Soil Cd	0.9957	1				
Soil Zn	0.9820	0.9752	1			
Soil Cr	0.9954	0.9999	0.9778	1		
Soil Mn	0.9937	0.9997	0.9734	0.9995	1	
Soil Fe	0.9772	0.9639	0.9923	0.9634	0.9606	1

DISCUSSION

The study shows that this ecosystem supports a good number of obligate and facultative aquatic plant species. The presence of families such as Nymphaceae, Polygonaceae, Commelinaceae and others is very typical for wetland ecosystems within this area (Awokunmi and Essaku, 2008). Also the existence of other facultative wetland plants is a line with similar works within the Niger Delta region (Adekambi and Ogundipe, 2009; Ubom *et al.*, 2012). The density values recorded in this study conforms to the general notion of the behavioural pattern of different plants in response to different gradient levels and nutrient availability. As a rule of thumb, plants with high density values reflect high preference for specific wetland types.

Trace metals are among the most common environmental pollutants and their occurrence in waters, soil and biota is indicative of certain sources of pollution. The existence of trace metals in aquatic environments has severe consequences on aquatic organisms (Davis and Brock, 2008). However, plants differ in their optimal tolerance range for metal concentration, but concentrations are generally narrow. Severe imbalances on metal proportions caused by exposure to elevated concentrations can induce death in aquatic organisms (Werner, 2010), including heperto-fauna populations that depend on aquatic ecosystems for their life-cycle processes. From the result of this study, it is apparent that cadmium was the least of all the metals in the site. These bear similarities with early reports of other researchers (Mohiuddin *et al.,* 2010; Olarinoye *et al.,* 2010). The ascending order of heavy metal content at both sampling years followed the pattern Cd < Pb < Cr < Zn < Mn < Fe. A comparison of the mean concentrations of Fe, Pb, Zn, Mn, Cd and Cr in Tables 2 and 3 with their proposed limits range in natural soil: Fe,100-7000mg/kg; Pb2-200 mg/kg; Zn, 10-300mg/kg; Cd, 2-200; and Cr, 2-

100 mg/kg (Vecera *et al.*, 1999), show that these concentrations are within WHO permissible limits. Generally the mean concentrations of Pb, Zn and Cr are higher for soil samples from year 2 than those from year 1 excluding Cd, Mn and Fe. The difference in metal concentration between the two sampling year could simply be attributed to the nature, quality and quantity of waste carried by the run-off to the studied environment. The refuse and waste materials observed from the relatively dry areas of the wetland are mostly cultural, domestic and agricultural in origin as there are no industries that could possibly deposit metallic wastes in the wetland.

Correlation analysis between metals in water and soil as shown in Table 5 revealed strong and positive correlations between the concentration of heavy metals in water and soil samples. It can therefore be inferred that with an increase in the amount of metals in water due to waste deposition, the accumulation of metals in soil also increases (Mohiuddin, *et al.*, 2010). Also, the positive relationships between water and soil content of metals might be a potential cause of metal toxicities to both plants and animals through edapho- accumulation and subsequent entry into the food chain (Ademoroti, 1990). This is a source of concern considering the fact that agricultural activities are ongoing going within this wetland. Muller and Ellenberg (1974), proposed seven grades or classes of the geo-accumulation index. Class 0 (practically uncontaminated): $Igeo < 0$ Class 1 (uncontaminated to moderately contaminated): $0 < Igeo < 1$; Class 2 (moderately contaminated): $0 < Igeo < 2$; Class 3 (moderately to heavily contaminated): $2 < Igeo < 3$; Class 4 (heavily contaminated): $3 < Igeo < 4$; Class 5 (heavily to extremely contaminated): $4 < Igeo < 5$; Class 6 (extremely contaminated): $5 < Igeo$. Class 6 is an open class and comprises all values of the index higher than Class 5. The elemental concentrations in Class 6 may be hundred fold greater than the geochemical background value. The agricultural activities going on in the terrain enforces the need for routine researches on metal speciation in this flood plain. Also the rich flora of the study area shows its ability to support a vast number of plant life forms. The additional species observed could be attributed to rainwater inflow from the surrounding drainage facility or wind dispersal borne from surrounding wetlands.

CONCLUSION AND RECOMMENDATION

The geochemical indices computed for this research highlights that there is no severe metal pollution as at the time of this research but the value for iron is a source of concern and should be further investigated.

REFERENCES

Adekanmbi, O. H. and Ogundipe, O. (2009). Mangrove biodiversity in the restoration and sustainability of the Nigerian natural environment. *Journal of Ecology and Natural Environment*, 1: 064-072.

Ademoroti, C.M.A., (1990). Bio-accumulation of Heavy Metal in some Mangrove Fauna and Flora. In: Environmental Chemistry and Toxicological Consultancy, Benin pp. 180 – 182.

Awokunmi, E. E. (2010). Determination of Physiochemical parameters and heavy metal in water. *African Journal of Environmental Science and Technology* 2: 065-098.

Awokunmi and Essaku (2008). Effect of beaching on heavy metals concentration of the soil in some dumpsite. *African Journal of Environmental Science and Technology* 8: 025-065.

Chinweuba A.J., Chendo M. N., Okoye P. A. C. and Okoye A. C. (2007). The metals in the blood of pregnant women in Anambra State. *Scientific Journal of Ecological Science* 1: 181-183.

Davis, J and Brock M. (2008). Detecting unacceptable change management and restoration. *International Journal of Ecological Management.* 9: 26-32.

Forsther U. (1977). Metal concentration in fresh water sediments, natural background and cultural effect: In intervention between sediments and fresh water. Junk Hague. Pp 94-103.

Howard I.C., Gabriel U.U. and Nduka, J.O. (2009). Bioaccumulation of heavy metals in Periophthalamus papillio and Tympanotanus fusscatus from the mangrove swamps of an oilfield in the Niger Delta, *Nigeria Journal of Chemical Society* 34:160-168.

Imperator, M., Adama P., Naimo D., Arienzo M., Stanzione D. and Violante P. (2003). Spatial distribution of heavy metals in urban soils of Naples city, Italy. *Environmental Pollution*.124: 247-256.

Mohiuddin, K.M., Zakir, H., Otomo, M.K., Sharmin, S and Shikazono, N. (2010). Geochemical distribution of trace metal pollutants in water and sediments of downstream of an urban river. *International Journal of Environmental Science and Technology*, 7: 17-28.

Muller, D., Ellenberg, H., (1974). *Aims and methods of Vegetation Ecology*. London. John Wiley, p.498.

Nriagu, J.O. (1980). *Cadmium in the Environment: Ecological Cycling*. Part 1, John Wiley. P682.

Onwukeme, V.I., Anarado, J.C. and Ajala, L.O. (2013). Partitioning Of Some Trace Metals In Floodplain Soil In Onitsha, Anambra State, Nigeria. *Journal of Science Innovations and Discoveries* 3: 109-116.

Papafilippaki, A.K., Kotti, M.E. and Stavroulakis, G.G. (2008). Seasonal variation in dissolved heavy metals in the Keritis river, Chania, Greece. *Global NEST Journal*. 10: 320-325.

Sabine, M. and Wendy, G. (2009). Science and Technology Briefs for Citizens. Environmental Science and Technology Briefs for Citizens. Issue 15:1-6.

Stevovic, S., Mikovilovic, V.S. and Calic-Dragosavac, D. (2010). Environmental impact of site location on macro- and micro-elements in Tansy. *African Journal of Biotechnology* 9: 2408-2412.

Takarina, N.D. (2009). Geochemical fractionation of toxic trace heavy metals (Cr, Cu, Pb, and Zn) from the estuarine sediments of 5 river mouths at Jakarta bay, Indonesia. *International J*ournal *Environ*ment *Sci*ence *Tech*nology, 7: 17-28.

Thornton, J. (1983). *Applied Environmental Geochemistry*. Academic Press, London. P501

Ubom, R.M., Ogbemudia, F.O. and Benson, K.O. (2012) Soil-vegetation relationship in fresh water swamp forest. *Scientific Journal of Biological Sciences* 1: 112-115.

Udo, E.J., Ibia, T.O., Ogunwale, J.A.,Ano, A.O and Esu, I.E. (2009). *Manual of Soil, Plant and Water Analyses*. Sibon Books Limited, Lagos, 183pp.

UN Habitat (2012).State of the world's cities 2012/2013: prosperity of cities. UN Habitat. Available at http://www.unhabitat.org/pmss/listitemDetails. aspx?publicationID=3387

Vecera, Z, Mikuska P, Zdrahal P, Docekal BM, Tynova Z, Parizek P,Mosna J, Marek J (1999). Soil heavy metal Trends. Environmental Analytical Chemistry Department, Institute of Analytical Chemistry, Academy of Sciences of the Czech Republic, Brno, Veveric. 97, 61-142

Werner, B. (2010). Prarie and Fenland complexes as landscape functional unit in a changing climate, *Bioscience* 60: 128-140.