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Bioavailability of Some Heavy Metals Associated With Municipal Solid Waste Dumpsites in Yenagoa Metropolis, Nigeria

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Abstract

The spatial and seasonal bioavailability of some heavy metals associated with vegetation of Municipal Solid Waste (MSWs) was evaluated in 7 stations, including control. Results on bioaccumulated cadmium was 0.001-0.093 and 0.001-0.083 mg/kg in dry and wet seasons respectively. In the same manner, other bioavailable heavy metals were: Chromium (0.001-0.055 and 0.001-0.032 mg/kg), Copper (0.001-3.991 and 0.001-3.013 mg/kg), Iron (43.97-164.20 and 37.45-117.34 mg/kg), Lead (1.81-5.51 and 0.001-5.07 mg/kg), and Nickel ranging from 0.001-0.38 and 0.001-0.168 mg/kg in dry and wet seasons respectively. While values of the control station was relatively lower in both season, the order of bioavailable heavy metals was; Iron>Copper>Lead>Chromium>Nickel. The results indicated that the dumpsites have trace amount of leachable heavy metals due to anthropogenic activities associated with MSWs.

Keywords

Bioaccumulation; Vegetation; Heavy Metals; Municipal Solid Waste

Introduction

The application of Landfills system as repositories for dumping of municipal solid wastes (MSW) has become a common practice in most developing countries. Unfortunately, landfilling with MSW in most of these countries are below safety standards as enshrined in best global practice as such most landfills are rather seen as dumpsites [1]. Consequent upon the fact that huge unsegregated and untreated MSW streams of are consistently discharged on daily basis, dumpsites are now threat to the environment and public health, as a result of release of toxic organo-metallic pollutants from MSWs leachates into fragile media like the soil and water bodies. It is already established in literature that all form as of biodiversity have the propensity to bio accumulate heavy metals with grave consequences when the tolerable limits are exceeded [2,3].

Sequel to the fact that the management of MSW developing country is challenged by insufficient funding of the sector, as well as poor planning on legislation and sensitization of the populace on the need to reduce, reuse and recycle waste. The exponential rise in population density as a result of urbanization and industrialization, which have impact on the levels of waste stream [4]. For instance, the persistent boost for socio-economic activities is linked to significant rise in volumes of MSW [3,5].

Yenagoa Metropolis is a wetland in Bayelsa State and forms part of the Niger Delta whose climate is humid tropical, with high levels of precipitation and temperatures that favour the transformation and mobility as well as the degradation and mobility of organo-metallic pollutant [1]. High levels of heavy metals in the soil can accelerate the enrichment of endemic vegetation by the process of translocation and can be further bioacummulated by biota in food chain complexes [6]. Intolerable accumulation of heavy metals is deleterious and associated with varying degrees of acute and chronic adverse effects.

For instance, Cadmium and Zinc, are implicated in acute gastrointestinal and respiratory impairment, as well as acute heart, brain, and kidney diseases [6]. Chronic side effects associated with accumulation of heavy metal includes but not limited to; impediment of the skin and mucous membranes as well as systemic effects on the intestines [7]. Also established is the adverse effects of heavy metal in plants bio accumulated from soil. Heavy metals have been found to inhibit plant growth and interfere with metabolic processes and even results to plant death in most cases [7]. Also, pollutant from dumpsites has adverse effects on the ascorbic acid and chlorophyll levels of most plants [8]. Based on the assertion, the bioaccumulation of vegetation associated with MSW is hereby evaluated.

Materials and Method

Study area

Yenagoa is the capital city of Bayelsa State which is located on the Southernmost (South-South) part of the Nigerian map. Bayelsa state is a wetland and Tropical rain forest and several networks of creeklets, creeks and Rivers that empties into a major Deltaic Tributary called River Nun. It is characterized by dry and dusty with higher temperature and ranges from November to March. The wet season which is relatively cooler with relative humidity of 80%-90% and temperature of 25°C-28°C has annual rainfall of 2000 mm and 4000 mm inland and coastward respectively.

Sampling

Aerial portion of the plants found in MSWs dumpsites were randomly collected from seven sampling stations, including control. The sampling was carried out bi-weekly (i.e 2^{nd} week of the month), in a post-monthly manner from November 2016 to March 2017 being dry season. The wet season sampling was similarly carried out from April to October 2017.

Sample preparation and digestion

Sand from the sampled plants were cleaned with tap water and allowed to shade-dry for two weeks prior to heavy metal analysis. The dried samples were powdered using electrical blender and sieved through a 1.5 mm mesh sieve and preserved in wrapped aluminium foil plates. Aqua regia (3:1 HCl/HNO3) was added to a weighed 5 g of the plant mixed in a 100 ml beaker. The mixture covered with watch glass and was heated in a fume cupboard for one hour and allow to cool [6]. The cool content of the beaker was filtered with into

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a volumetric flask with distilled water using Whatman filter paper, homogeneity of the mixture was achieved by inverting the flask [8].

Heavy metal analysis

The heavy metal analysis of the digested vegetation and soil samples were carried out using Perkin Elmer 5100 PC Flame Atomic Absorption Spectrophotometer (FAAS). The concentrations of heavy metals like Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Nickel (Ni), Lead (Pb) and Zinc (Zn) were measured. Results of the analysis were displayed on the screen after the samples were aspirated into the FAAS.

Result and Discussion

The spatial and seasonal levels of bioavailable cadmium in vegetation associated with the MSWs is presented in Figure 1. In dry season cadmium levels ranges from 0.001-0.093 mg/kg, meanwhile there was no detected levels (i.e <0.001 mg/kg) of cadmium in the control station. The stations of the central dumpsite indicated the highest level of cadmium, while the station in Kpansia market station indicated the lowest level of cadmium. On the other hand, values of the wet season showed that cadmium ranges from 0.001-0.083 mg/kg.

The station in the central dumpsite recorded the highest value as opposed to the station in Kpansia market that recorded the lowest value. Meanwhile the levels of cadmium for the control station in wet season was below detection limit. It was also observed that the levels of cadmium was slightly higher in dry season compared to wet season (Figure 1).

Figure 2 presents the spatial and seasonal levels of bioavailable Chromium. Values of dry season ranges from 0.001-0.055 mg/kg, with stations in the Central dumpsite and Kpansia market having the highest and lowest values respectively. Comparatively, values of the control station was lowest and below detection limit (<0.001 mg/kg) of the analyser (Figure 2). On the other hand, in wet season levels of chromium ranges from 0.001-0.032 mg/kg, and below detection limit in the control station. However, cadmium levels were similarly higher in the central dumpsite and lowest in Kpansia market (Figure 2).

As presented in Figure 3, bioavailable levels of copper in dry season ranges from 0.001-3.991 mg/kg with the lowest value in the control station. The highest level of copper was indicated in the central dumpsite, while lowest copper level was detected in sampling station located at Opolo market. Comparatively, the levels of copper

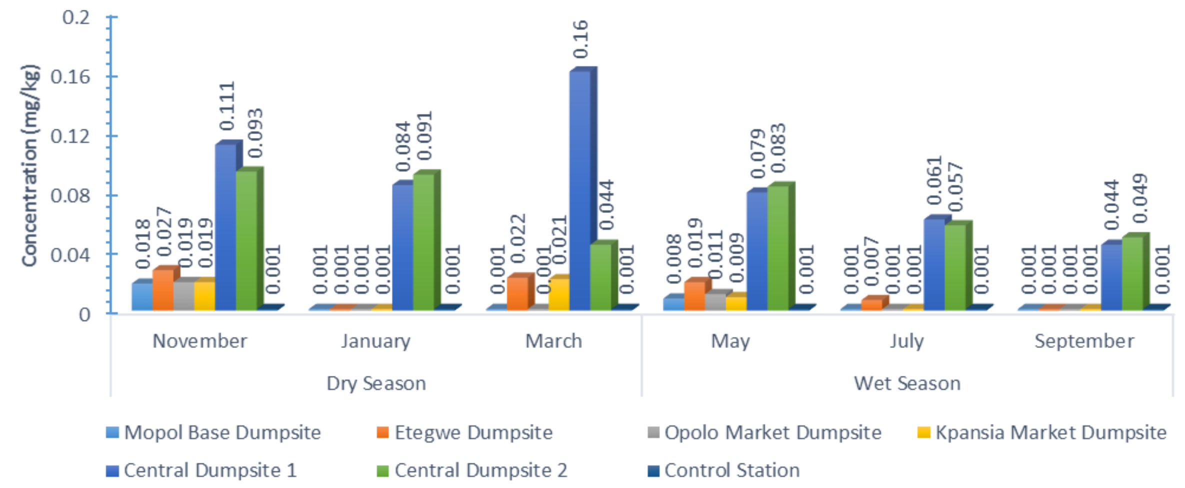

Figure 1: Bioavailable Spatial and Seasonal Level of Cadmium.

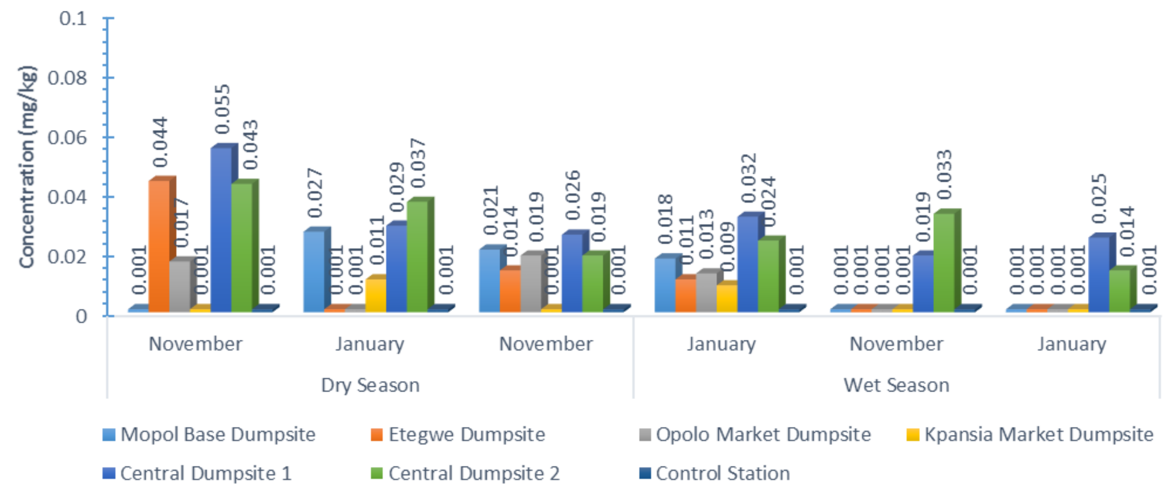

Figure 2: Bioavailable Spatial and Seasonal Level of Chromium.

in wet season ranges from 0.001-3.013 mg/kg, with the control station having the lowest value. Meanwhile levels of copper was similarly highest and lowest in the central dumpsite and Opolo market station as already established in dry season (Figure 3).

Bioaccumulated levels of iron in dry season ranged from 43.97-164.20 mg/kg with stations in the central dumpsite and Kpansia market having the highest and lowest values respectively (Figure 4). Also, values of iron in the control station was relatively lower in dry season. On the other hand, values of iron in wet season ranges from 37.35-117.34 mg/l. The control station similarly had the lowest value in wet season, while vegetation in the central dumpsite and Kpansia market indicated the highest and lowest levels of iron respectively (Figure 4). The spatial and seasonal levels of bioavailable lead are presented in Figure 5. Lead levels in dry season ranged from 1.81-5.51 mg/l, compared to values of 0.001-4.71 mg/l in wet season. The highest levels of lead in both seasons were recorded in the central dumpsite, with similarly corresponding lowest values in vegetation from dumpsite station located in Opolo market (Figure 5). Notwithstanding, lowest level of bioavailable lead were reported in the control station for both seasons.

Results on the spatial and seasonal evaluation of nickel levels bioaccumulated by the vegetation around the dumpsite is presented in Figure 6. In dry season nickel level varied from 0.001-0.38 mg/l, compared to values 0.001-0.168 mg/l. Notwithstanding, nickel levels were relatively lowest amongst all assayed stations for both seasons. In addition, values of the control station were lower compared to values of the study area (Figure 6).

The low level of chromium reported in our study is in tandem having values ranging from 0.005-0.25 mg/kg (9). Meanwhile, the levels of cadmium obtained in our study are comparable to values in Gombe state (4.41 ± 1.58 - 6.54 ± 2.81 for root and 5.44 ± 2.17-8.21 ± 3.16 mg/kg in the shoot [6]. Furthermore Akwa Ibom state had lower cadmium levels ranging from 0.05-0.35 mg/kg. Reported bioavailable copper levels in MSWs of Gombe state ranging from 32.05 ± 8.40-41.45 ± 16.21 mg/kg in the root and 21.30 ± 5.01-28.00 ± 5.87 mg/kg; in the same study, Iron levels ranges from 504.00 ± 92.18-565.00 ± 103.14 in the root and 473.10 ± 71.12-493.20 ± 88.42 mg/kg [6]. In Akwa Ibom state, Iron levels associated with vegetation around MSWs ranged from 51.04-53.45 mg/kg. In Akwa Ibom state level of bioavailable Nickel in plant ranges from 0.20 - 0.55 mg/kg [9].

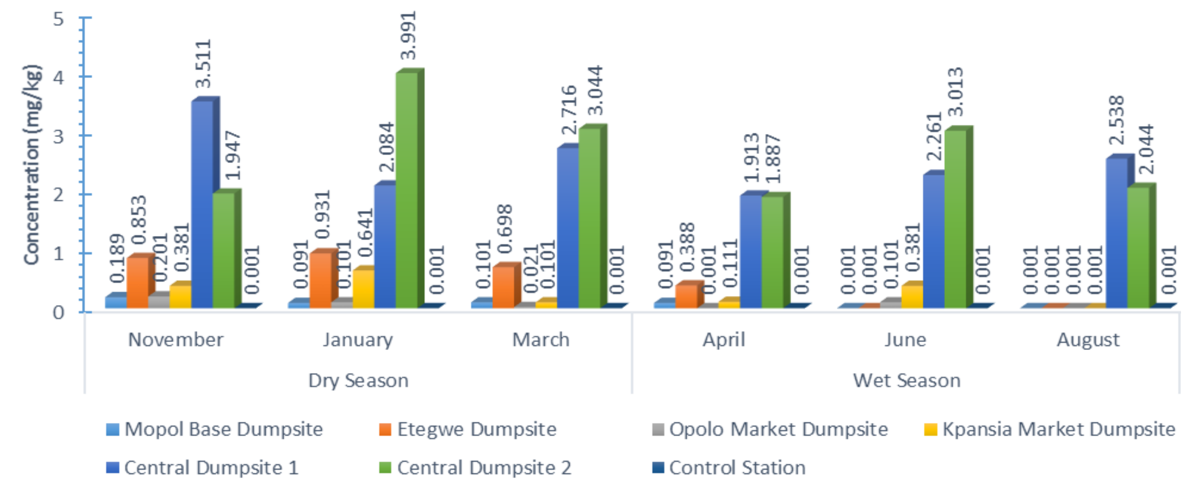

Figure 3: Bioavailable Spatial and Seasonal Level of Copper.

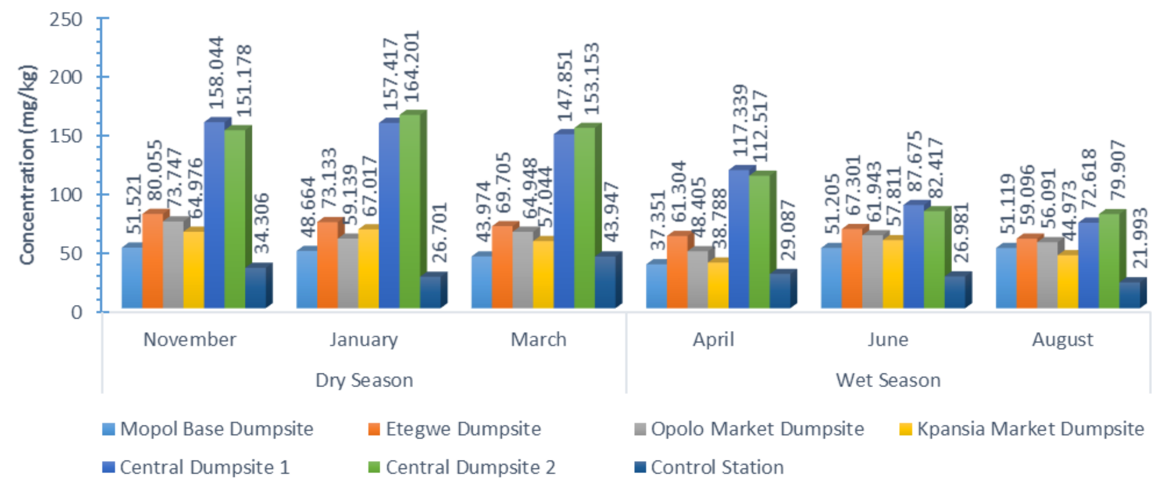

Figure 4: Bioavailable Spatial and Seasonal Level of Iron.

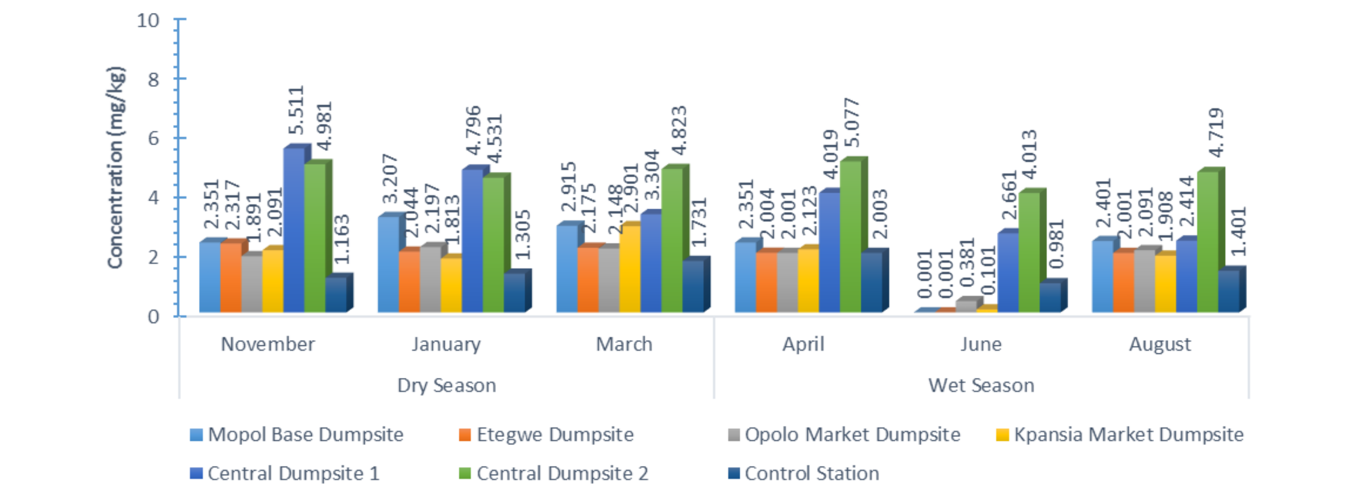

Figure 5: Bioavailable Spatial and Seasonal Level of Lead.

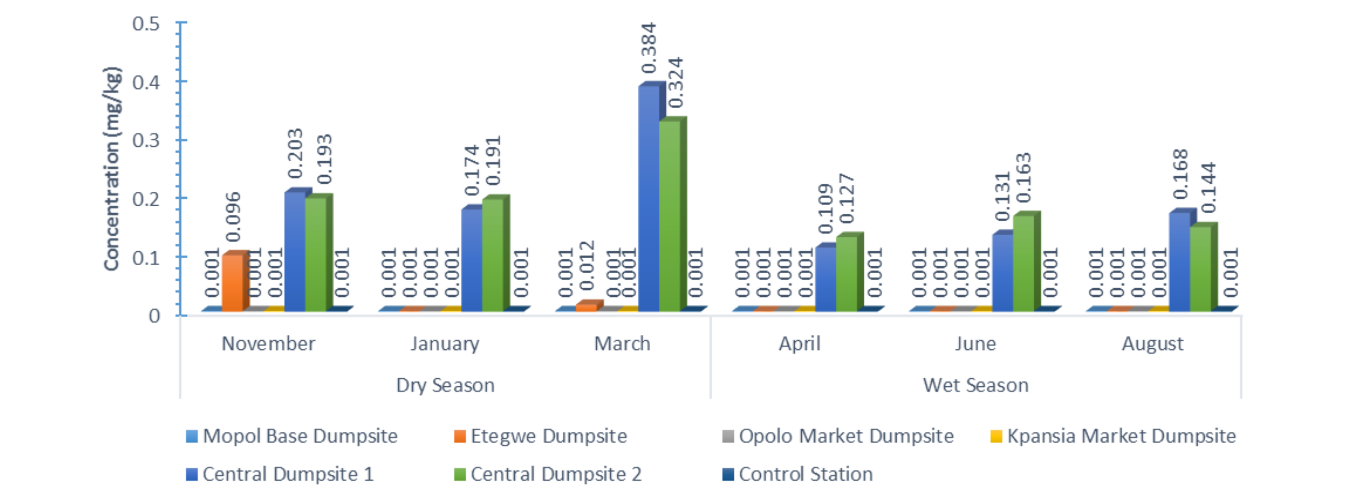

Figure 6: Bioavailable Spatial and Seasonal Level of Nickel.

Whereas in Gombe state, Nickel levels ranges from 8.07 ± 3.50-16.36 ± 5.05 mg/kg in the root and 6.46 ± 1.09-12.00 ± 4.01 in the shoot [6], in the same study, the levels of lead ranges from 20.64±4.91 - 25.10±2.08 mg/kg in the root and 20.26 ± 5.12-22.08 ± 5.11 mg/kg in the shoot.

It is established in literature that cadmium is highly mobile and absorbable in most parts of plant, especially in the leaves during the process of translocation [10]. Although, copper and Zinc tends to demonstrate lower mobility from root to shoot because the root tissues have the stronger holding capacity of copper or Zinc as opposed to shoots [6].

The high accumulation of Cd in the plant may be due to the fact that Cd can be readily absorbed by plant roots and easily translocated to other plant parts after absorption [11]. Copper, zinc and iron are relatively essential elements in plants [12], but when bioavailable in high concentration it could be toxic to the plant and bioavailable for other biota that consume such plant. It is also established in literature that cadmium is mostly bioaccumulated to plants, especially through the leaves after absorption [13].

Conclusion

The research investigated the bioavailability of some heavy metal from endemic vegetation in Municipal Solid Waste dumpsite. The results obtained revealed varying concentrations of heavy metals accumulated by the plant especially iron, copper and lead. The high levels of iron amongst all metals assayed is largely implicated by lithogenic factor rather than anthropogenic activities. Moreover, significant levels of metals enriching the vegetation is due to their leachability emanating from illicit dumping of unsegregated and untreated wastes streams. We therefore conclude that anthropogenicity of contaminants associated with MSWs should be checked, in order to avert adverse consequences.

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