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HEAVY METAL CONCENTRATIONS IN DUMPSITE SOIL AND ITS ASSOSIATED ENVIRONMENT IN RUMUOLUMENI, PORT HARCOURT, RIVERS STATE, NIGERIA

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ABSTRACT

A survey of some heavy metal concentrations (Zn, Cu, Cd, Pb, Cr and Fe) in soil of waste dumpsite and its associated environment was undertaken in this study. Soil samples were collected from the dumpsite (station 1), staff quarters of Ignatius Ajuru University of Education Port Harcourt (station 2) and Fence of Eagle Cement Company (station 3) for a period of four months (January- May 2012). Mean concentrations of heavy metal obtained were 3.761±1.525mg/kg, 1.223±0.828mg/kg, 0.160±0.293mg/kg, 0.126±0.085mg/kg, 3.481±0.133mg/kg and 248.548±13.800mg/kg for Zn, Cu, Cd, Pb, Cr and Fe respectively with Fe having the highest concentration of 248.548±13.800mg/kg and Pb having the lowest concentration of 0.160±0.293mg/kg. The order of heavy metal concentration is Fe > Zn > Cr > Cu > Cd>Pb. Highest concentration of heavy metals across the stations was obtained in dumpsite soil (station 1) followed by Eagle Cement Fence (station 3). This result shows that plants planted close to dumpsite, surface and groundwater of near-by environments will be contaminated with heavy metal and will not be usable for human consumption and other categories of water usage. Wastes from the dump site can be reduced, reused and recycled.

Keywords: dumpsite, heavy metals, accumulation, soil, rumuolumeni,

INTRODUCTION

Municipal wastes landfills are sources of ground water and soil pollution due to the production of leachates and its movement through refuse. Refuse waste will produce leachate if water is allowed to percolate through it (Shirdast, *et al*., 2010). The quality of leachate is determined primarily by the composition and solubility of the waste constituents. If waste is changing in composition, for example due to weathering or biodegradation, then leachate quality will change with time. This is particularly the case in municipal wastes. Heavy metals concentration in the environment cannot be attributed to geological factors alone, but human activities do modify considerably the mineral composition of soil, crop and water. Population and subsequent industrial growth has exacerbated the production of domestic, municipal and industrial wastes, which are indiscriminately dumped in landfill and water bodies without treatment. It has been revealed that municipal waste may increase heavy metals concentration in soil and water (Carison, 1976; Albores*et al*., 2000; Uba*et al.,* 2008), whichmay have adverse effects on the host soils, crops and human health (Smith *et* *al*., 1996; Nyle and Ray, 1999). Thus environmental impacts of municipal refuse are greatly influenced by their heavy metal contents.

However, while total metal contents is a critical measure in assessing risk of refuse dumpsites, total heavy metal contents alone does not provide predictive insight on the bioavailability, mobility and fate of the heavy metal contamination (Albores*et al*., 2000; Uba*et al*., 2009). Yahaya*et al*.,(2008), posit that municipal waste contains heavy metals which infiltrate and got in the sink when they are leached out from the dumpsites. According to Oloyemi*et al.,* (2008), municipal wastes often contain certain heavy metals in various forms and at different contamination levels. Some heavy metals like As, Cd, Hg, and Pb found in municipal wastes were identified to be hazardous to plants grown in soils around municipal waste dump (Alloway and Ayres, 1997). Most used and abandoned waste dumpsites in many towns in Nigeria attract people as fertile ground for cultivating varieties of crops. The cultivated plants take up the metals either as mobile ions presents in the soil solution through the root or through foliar adsorption. The uptake of the metals by crops results in the bioaccumulation of these elements in plant tissues. This is known to be influenced by the metal species, plant species and plant part (Juste and Mench, 2009) According to Grant, (1977), plants grown on soils possessing enhanced metal concentration due to pollution increased heavy metal ion content. If consumption of these metals through plant source by man and other animals is not checked, it may lead to accumulation in man with attendant health hazards.

Concern over the possible ecological effects of the increasing accumulation of metallic contamination in the soil and the environment at large is growing, for this reason, the need to investigate concentration of heavy metal in soil is pertinent since even slight changes in their concentration above acceptable limit, whether due to natural or anthropogenic factors can have adverse effects on the soil and the environment and subsequent health problems. Furthermore, soil is a vital resource for sustaining two human needs,of quality food supply and quality environment, accumulation of refuge waste and other waste in the soil as it is commonly done in most cities in Nigeria constitute a matter of environmental concern, hence this study which is designed to investigate the dynamics in the concentrations of Cd, Cu, Pb, Zn, Cr and Fein the soils within the dumpsites and soils in surrounding environment in Rumuolumeni, Port Harcourt, Rivers State, Nigeria.

Materials and Methods

Study Area. The study was carried out inRumuolumeni, a suburb of the city of Port Harcourt in Rivers State, NigerDelta, Nigeria. It lies between the latitude 4^{0} 48^{1} 25^{11} N and longitude 6^{0} 55^{1} 51^{11}E. Rumuolumeni play host to some companies such as Eagle Cement, Modant Marine, Saipem Nigeria Limited, Green Aker among others and some institutions such as Ignatius Ajuru University of Education Rumuolumeni, as well as the Nigeria Naval Base – NNS Okemini. These companies and institutions located in Rumuolumenihave led to the influx of humans. Due to the strategic location of Rumuolumeniin the out sketch of the city of Port Harcourt, and its proximity to New Calabar River, it is characterized by extensive mangrove swamps, tidal flats, influenced by semi-diurnal tidal regime (Bob-Manuel, 2012).Rumuolumeni was chosen by RiversState Waste Management Agency for the sitting of dumpsite/open landfill system for dumping of all manner ofwaste generated domestically and those generated by companies located within and outside Rumuolumenimetropolis.

Sampling Stations

Before the collection of soil samples for this study, a reconnaissance survey of the magnitude of the dumpsite and the surrounding environments was carried out, during which three sampling stations were selected. The dumpsite was chosen as station 1 for this study, this station was characterized by the presence of massive hips of waste dumped in open land fill system of waste management. The second sampling station is the farm land inside the staff quarters of Ignatius Ajuru University of Education Port Harcourt. This station is about one and half kilometer from station one and is littered by refuse /domestic and garden waste generated by residents of the staff quarters. Station three is by the fence of Eagle Cement Company, which is about two kilometers from the dumpsite. This station is characterized by high movement of heavy duty trucks and indiscriminate dumping ofwaste by residents as well as a significant level of economic activities.

Sample collection

Soil samples were collected from the three stations for a period of four months (February, March, April and May 2013). A total of 12 soil samples were collected from the designated stations and analyzed for the following heavy metals, Cd, Cu, Pb, Zn, Cr and Fe. At each sample collection point, all materials and organic debris were removed from the surface soil; the soil sampler (auger) was used to gather the soil samples to a depth of about 30cm. The soil samples collected were put in clean polythene bag, labeled appropriately and taken to the laboratory for pre-treatment and analysis.

Soil sample treatment and analysis

Soil samples were air dried at 30^0 C and mechanically grounded using mortar and pestle, after which it was sieved with a sieveof 2-mm mesh size. The soil samples (1.0_g) were weighed into Kjeldahl flasks. Aqua regia (15ml) was added, and swirled to wet the samples and kept overnight. The flasks were heated on a hot plate to 50^0 C for 30mins; temperature was later adjusted to 120^0 C and heated continuously for 2hrs. The samples were cooled, and 0.2m HNO_3 (10ml) added to the mixtures. The resulting mixtures were filtered through Whatman (no.541) filter paper. The flasks and liter papers were washed with small aliquots of 0.2m HNO_3. Filtrates were transferred into 50ml standard flask and made up to the max with 0.2m HNO_3. A blank sample was prepared using the same method for the sample. The concentrations of Zn, Cu, Cd, Pb, Fe and Cr were determined using flame atomic absorption spectrophotometer unicum 939 model.

Statistical analysis of the results

Results obtained from the laboratory analysis is presented using tables and averages, while analysis of variance (ANOVA) for significant variation in heavy metal concentrations among the sampled soils was determined using SPSS 17.0 for Windows (Njar, *et al*., 2012)

Results and discussion

The results of this study are presented across periods and sites of sampling in Tables 1 &2 and Figure 1&2 respectively.The mean concentration of Zn across sampling periods obtained in this investigation is 3.761±1.522 mg/.kg, with a range of 1.599-4.922mg/kg. Spatially, the highest concentration of Zn (7.02mg/kg) was obtained in Station 1 (Dumpsite) and least value (2.767±0.359) was observed in Station 2 (Staff quarters). The value of Zn obtained in this study is slightly above W.H.O permissible limit of 3.0. High level of Zn in the dumpsite station is because waste contributes significantly to high level of toxic metal to the environment, therefore sorting and recycling of wastes should be encouraged so as to ensure reduction in the quality of these toxic metals at dumpsite (Ebong*et al.,* 2008). However, the value of Zn obtained in this study is less than thatreported by Amadi and Nwakwaola, (2013) from Eyimba dumpsite in Aba.

The value of Cu across sampling periods fluctuated from 0.001-1.831mg/kg with a mean of 1.223±0.828 mg/kg,across stations the highest and lowest values of Cu were obtained fromstations 1(Dumpsite) and 2 (Staff quarters) respectively. The value of Cu obtained in this investigation is lower than the W. H.O permissible limit, as well as that observed by Tobias *et. al.,* (2013) in a dumpsite, in the commercial City of Aba.Copper's interaction in the environment is complex, when introduced it rapidly becomes stable and results in a form which does not pose a risk to the environment, unlike some man-made materials. Cu is not magnified in the body or bio-accumulated in the food chain and in the soil, Cu form strong complexes with organic matter implying that only a small fraction of copper will be found in solution as ionic copper, Cu(II). The solubility of Cu is drastically increased at pH 5.5, which is rather close to the ideal farmland pH of 6.0–6.5, (Ericksson*et al*., 1997), this could be the reason for the low concentration of Cu observed in the study.

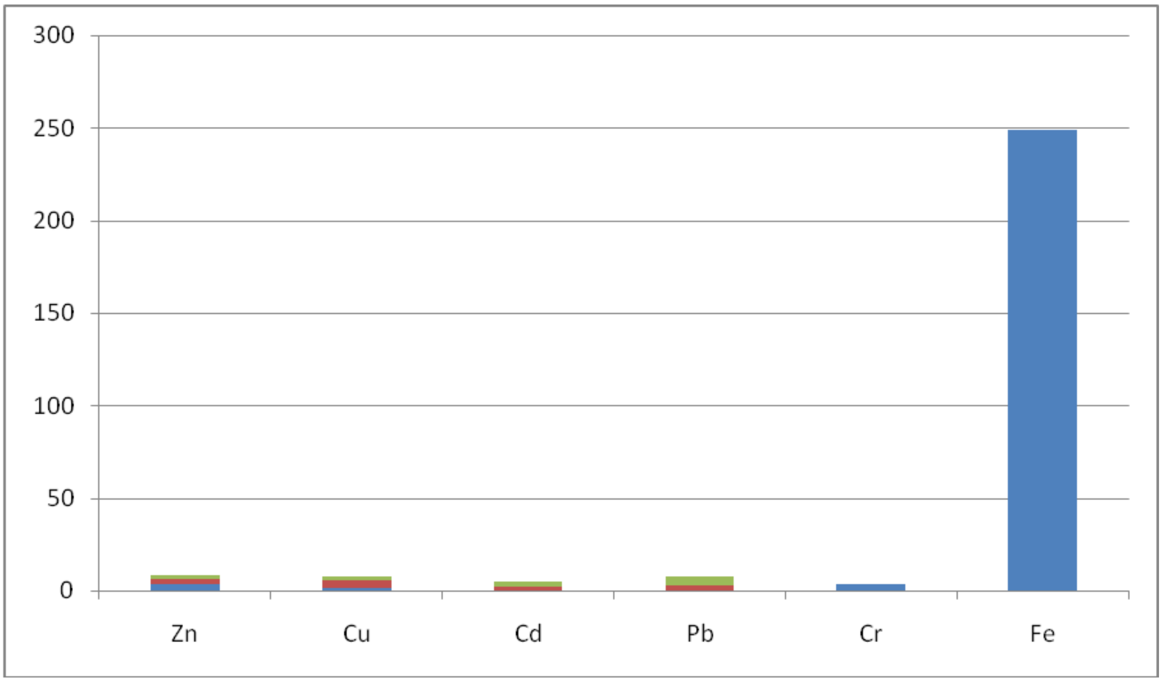
Table 1:Mean Concentration of Heavy metals in soil samples Across Periods of Sampling

Mg/Kg	***Mean***	***Range***	***W.H.O permissible limit***
Zn	***3.761±1.525***	***1.599-4.922***	***3.0***
Cu	***1.223±0.828***	***0.001-1.831***	***2.0***
Cd	***0.160±0.293***	***0.001-0.600***	***0.003***
Pb	***0.126±0.085***	***0.001-0.181***	***0.001***
Cr	***3.481±0.133***	***3.306-3.631***	
Fe	***248.548±13.800***	***230.915-259.915***	***0.005***

(W.H.O, 1998)

The mean concentration values of Cd, Pb, Cr and Fe are 0.160±0.293,0.126±0.085,3.481±0.133and 248.548±13.800 (mg/kg) respectively. The highest values ofPb, Cr and Fe were obtained in station 1 (Dumpsite), while the lowest values were obtained in station 2 (Staff quarters), while the concentration of Cd fluctuated from 0.001 – 0.600mg/kg. The values of Pb, Cd were slightly above W.H.O permissible limit, while the value of Fe was significantly above permissible limit. The highest concentration of iron as observed in this study agrees with the findings of Tobias *et al*., (2013). The high concentration of Fe relative to other metals in this study was expected, because Fe occurs at high levels in Nigerian soil (Adefani, 2009). The result of this study further indicated that the concentrations of heavy metals in stations two (Staff quarters) and station three (Eagle cement) were relatively lower than station 1 (Dumpsite), this suggest that metals in soil decreases with distance from source, which is mainly controlled by water movement and topography (Iwegbue, *et al*., 2006)

Fig.: 1. Mean concentrations of Heavy metals across sampling period

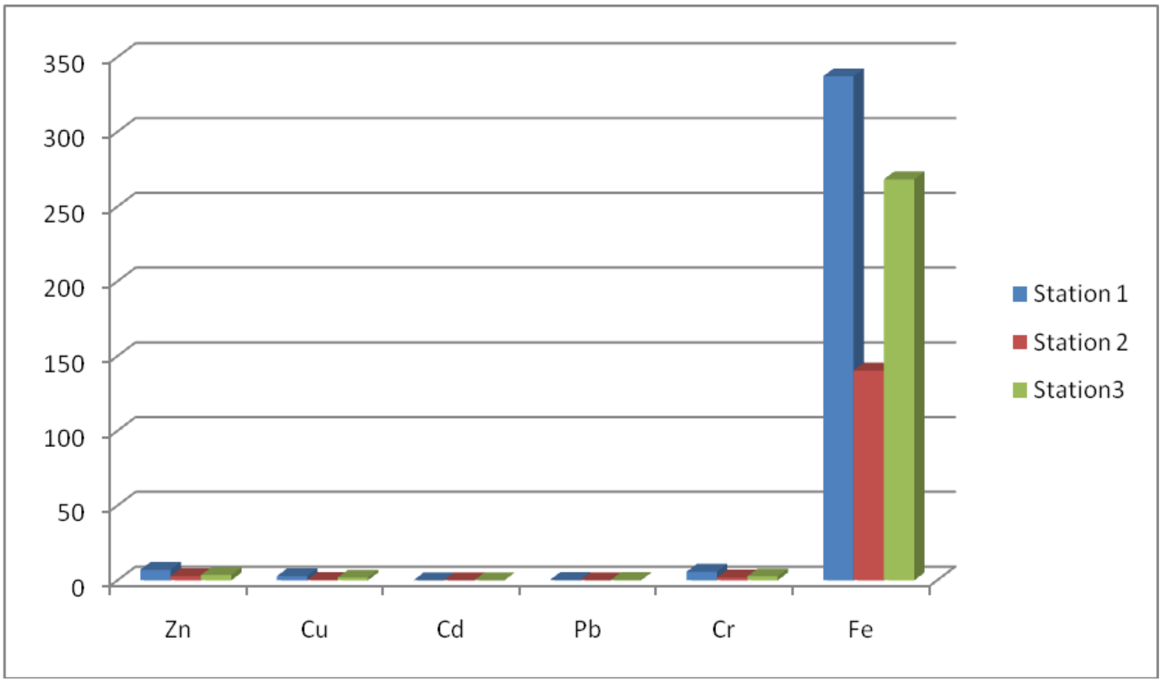


This result further shows that the soils were contaminated with heavy metals, with the dumpsite having the highest concentration, this shows that the refuse dumpsite was contaminated with zinc, lead, copper, cadmium, and iron which might be as a result of the nature of substances disposed in the site,as studies have shown that heavy metals with atomic density >6 g/cm^3- as these wastes can accumulate and persist in soils at levels with environmental impacts (Allowa 1993).

Table 2. Mean ± Standard Deviation of Heavy Metals across the stations

(Mg/Kg)	*Zn*	*Cu*	*Cd*	*Pb*	*Cr*	*Fe*
1	***7.025±0.539***	***2.787±0.197***	***0.001±0.000***	***0.274±0.034***	***5.778±0.420***	***337.140±39.445***
2	***2.767±0.359***	***0.276±0.621***	***0.001±0.000***	***0.015±0.009***	***1.873±0.230***	***140.294±7.138***
3	***3.508±0.343***	***1.810±0.237***	***0.001±0.000***	***0.202±0.032***	***2.602±0.237***	***268.256±46.554***

Fig.: 2. Mean concentrations of heavy metals across stations



The order of heavy metals concentration in this study in decreasing magnitude is Fe > Zn > Cr > Cu > Cd>Pb. The high level of Fe in this study suggests high deposition of wastes that have high Fe content coupled with the high content of Fe in Nigerian soil.

CONCLUSION

The result of this study showed that heavy metal concentration in dumpsite soil and soil from surrounding environment of the dumpsite is an issue of environmental concern, especially soil from the dumpsite as some plants were observed to be growing in the dumpsite. It is therefore expedient for the Government of Rivers State to initiate the process of remediation of these soils contaminated with heavy metal so as to reduce the associated risk of toxic metals, make land available for agricultural activities and other economic and recreational activities.Immobilization, soil washing, and phytoremediation are considered among the best available technologies for cleaning up heavy metal contaminated soils but have been mostly demonstrated in developed countries. These technologies are recommended for field applicability and commercialization in the developing countries also where agriculture, urbanization, and industrialization are leaving a legacy of environmental degradation

RECOMMENDATION

It is strongly recommended that this dumpsite be closed forthwith by the Rivers State Government, going by the findings of this investigation. This is to avert the potential health hazard the University Community and the high population density Rumuolumeni area will be exposed to if ground water which is the main source of portable water in the area is contaminated by heavy metals in dumpsite soil.

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