ASSESSMENT OF SELECTED HEAVY METAL PRESENCE IN SOME DUMPSITES IN NIGERIA: A REVIEW

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ABSTRACT

This study attempts to investigate the presence and vertical migrations of Copper (Cu), Manganese (Mn), Lead (Pb) and Zinc (Zn) in some dumpsite with the view to elucidate the risk of contamination to the environment, also to underscore the factorial effects of pH and organic matter on the migration of heavy metals in the dumpsite in relation to soils of selected metropolitan towns. The metal migrations were randomly checked at different depth profile. These heavy metals were determined by Atomic Absorption Spectrophotometer (AAS) other parameters determined includes pH and organic matter (OM) content. Results show contamination of the dumpsites and indicated downward migration of the heavy metals investigated. The relationship between metal concentration against pH and % OM respectively show antithetical relationships. The result of this study shows that there exists risk for the environment due to notable migration of heavy metals across depth profile and that the migrations were also observed to be highly correlated with organic matter content.

Keywords: *ASS, Health Risk, Metal Migration, Municipal Dumpsites, Soil Contamination*

INTRODUCTION

The proliferation of open and unsafe dumpsites containing multiple disposals of domestic, municipal, industrial and medical wastes is a common practice in most cities in Nigeria (Lawan *et al*., 2012). These dumpsites have become feeding ground for diseases breeding animals especially rats, birds, and stray animals; thereby contributing greatly to their nourishment and growth (Bellebaum, 2005; Adewuyi and Opasina, 2015). Another problem of these waste dumps is air pollution which sometimes results in temporary limitations on movement of people and consequently slowing economic activities in urban areas (Elaigwu, 2007).

Furthermore the random deposition of these wastes, consequently leads to adjacent lands getting enriched with heavy metals such as copper (Cu), manganese (Mn), lead (Pb), chromium (Cr), cadmium (Cd), Nickel (Ni), Zinc (Zn) and salts. Thus, dumpsite soils eventually become the repository for metals released from municipal waste sludge and several similar wastes deposited on it (Khairah *et al.*, 2004; Sharma *et al.*, 2007). The severe problems associated with these are the infiltration of leachate into the surrounding environment, subsequent contamination of the land and groundwater (Kumar *et al*., 2002; Lawan *et al*., 2012). Another environmental problem with heavy metals is that they are unaffected during degradation of organic waste and have toxic effects on living organisms when exceeding a certain concentration (Lawan *et al*., 2012). Untreated discharge or partially treated wastes are often discharged into the environment with these Dumpsite soils serving as reservoir for all the metals present in these wastes, this call for an urgent action (Olaitan *et al*., 2013)

Heavy metals occur naturally as chemical elements in the earth's crust and surface soils in varying concentrations (Iyaka and kakulu, 2012), but of concern is their emissions through industrial, man's agricultural and urban activities into the environment and consequently into soils that serve as ultimate sink. Furthermore, the persistent accumulation of heavy metals in soils is of great concern because they constitute health threat and toxicity problems to human life and environment (Ngoc *et al*., 2009).

The action of such metal pollution in relation to agricultural soils can result not only in decreased crop output and quality and hurt human health through the food chain, but also further deterioration of air and water environmental quality (Turkdogan *et al*., 2002, Su and Wong, 2003; Xia *et al.*, 2004). Studies of heavy metal uptake by plants have often revealed their accumulation at a level toxic to human health (USDA, 2000). Generally, uptake is increased in plants that are grown in areas with increased soil contamination. Among the metals, Cd and Zn are fairly mobile and readily absorbed by plants (Cobb *et al*., 2000). Since a survey of trace metal contents might provide some vital information for environmental planning. Vast investigations of agricultural soils have been carried out in some countries and regions in recent years (Onweremadu and Duruigbo 2007; Olatunde *et al*., 2013). Agricultural soil contamination with heavy metals through the use of untreated or poorly treated wastewater from water bodies and the application of organic and inorganic fertilizers and pesticides is part of the most severe ecological problems in Minna (Ahaneku and Sadiq, 2014).

AN OVERVIEW OF HEAVY METALS

Heavy Metals are defined as elements in the periodic table having atomic number more than 20 or densities more than 5 gcm^{-3} generally excluding alkali metals and alkaline earth metals (Sherene, 2010). The environmental problems with heavy metals are that they as elements are undestroyable and the most of them have toxic effects on living organisms when exceeding a certain concentration (Xilong *et al*., 2005). Furthermore, some heavy metals are being subjected to bioaccumulation and may pose a risk to human health when transferred to the food chain (Vijaya *et al*., 2010). Soils, whether in urban or agricultural areas represent a major sink for metals released into the environment from a wide variety of anthropogenic sources (Sherene, 2010).

Sources of Heavy Metals in Soil

According to Sherene, (2010), the sources of some heavy metals are briefly discussed below:

Arsenic (As). It is poisonous and is used in herbicides, cattle and sheep dips and insecticides. Also as a desiccant for cotton crop to facilitate the mechanical harvesting of the crop.

Cadmium (Cd). Soil contamination occurs by the addition of phosphatic fertilizers. (Containing 2-200 mg $Cdkg^{-1}$) domestic and sewage sludge, wear of automobile tyres, lubricants and mining and metallurgical activities.

Chromium (Cr). Wastewater and sludge from dyeing and tanning industries are the major sources of chromium pollution to the environment.

Lead (Pb). Major sources of Pb pollution are exhaust gases of petrol engines, which account for nearly 80% of the total Pb in the air. Soils located near Pb mines may contain as high as 0.5 % Pb content. Apart from minerals, sources of Pb are pesticides, fertilizer impurities, emissions from mining and smelting operations and atmospheric fallout from the combustion of fossil fuels.

Mercury (Hg). Major contaminating sources of Hg are: Hg based funcides, sewerge sludge and atmospheric fall out resulting from combustion of fossil fuels and industrial processes.

Nickel (Ni). Sources of Ni pollution are: metal refining, smelting, burning of coal, and industrial sewage sludge.

Potential Health Risk of Heavy Metals

The toxicity of heavy metals in living organisms is a phenomenon somewhat complex. Toxic effects of a metal depend on a number of factors that often include: rate, exposure time, tolerance of the organism and Environmental conditions. In recent years, the effect of the interaction between heavy metals on the expression of toxicity has been considered very intensely. As a result of the interaction, a given metal may increase or decrease the negative effects of other metal in the organism (Alloway, 2013).

The relative importance of heavy metals toxicity was addressed by Alloway (2013) in terms of food chain contamination. Alysson and Fabio, (2014) identified Cd as the metal with greatest potential to contaminate plants and subsequently to be transferred to animals and humans that eat these contaminated plants either in part or full. This statement is based on the fact that Cd possess health risks to animal and human when present in plant tissue in high concentrations which generally are not phytotoxic and the concentrations of Cd in agricultural soils are increasing in many parts of world due to its inadvertent additions through the use of fertilizers, sewage sludge and soil amendments (Rodríguez-Serrano *et al.*, 2009).

Due to the high risk of contaminating the food chain, the risk of Cd to cause toxicity is considered to be high as well. Despite increased concern with Cd, the toxicity risk of other heavy metals should not be neglected (Alysson and Fabio, 2014).

As a result of these complexities of toxic heavy metals in plants, animals and humans that eat such contaminated plants is primarily associated with environmental contamination. Soils may be contaminated with such hazardous elements by the use of sewage sludge. High concentrations of metals in the sludge increase the risks of contamination and therefore toxicity. Thus, it is important to know the chemical composition of sewage sludge

(Alysson and Fabio, 2014). Table 1 present the WHO safe limits as regards the minimum and maximum limits for drinking water and their adverse effect.

CONCENTRATION OF HEAVY METAL IN VARIOUS DUMPSITES

Copper (Cu)

Lawal *et al*., (2012) stated that, Cu concentrations across depth profile at the different dumpsites of Table 2; revealed a steady downward increase in Cu concentration in all the dumpsites. The highest concentration of Cu was observed at 100cm depth in dumpsite B (1.65 mg/kg) and the lowest concentration at M and Z sites (1.32 mg/Kg), the obtained average value for soils from these dumpsites in these study is lower than 2.44 and 4.21 mg/kg, respectively reported for farm and fertilizer blending companies by Harami *et al*. (2004) in their study of heavy metal levels in industrial estate of Bauchi, Nigeria. The higher organic matter at these points could also be a contributing factor to the enriched concentration of Cu at these points. Increase in soil organic matter content lead to elevation of soil adsorption capacity hence, enhancing the accumulation of trace metals (Inobeme *et al*., 2014). Organic matters can therefore be considered as an important medium through which heavy metals are incorporated into the soil (Afshin and Farid 2007).

Lead (Pb)

The result of Pb concentrations across depth profile and at the different sites showed the presence of Pb in samples from all the sites. Pb was highest at dumpsite A (502.12 mg/kg) and the lowest at site O1 (0.22 mg/kg). The concentration of Pb obtained in A for both depths is higher than the intervention (210 mg/kg) as stated by DPR-EGASPIN (2002). It is only concentration of site N at the depth of 0-15cm (45.20 mg/kg) that is higher than the target value (35 mg/kg) as stated by DPR-EGASPIN (2002). All other sites are below the target and intervention values for a standard soil. Environmental contamination by Pb can constitute health problems especially in young children, due to its tendency to accumulate in the body and magnify to a toxic level as a result of continuous exposure (David et al., 2008).

Manganese (Mn)

The results of Mn in Table 2 revealed that Mn was highest in concentration at dumpsite B (1.74 mg/kg) and the lowest at site Z (1.36 mg/kg). Similar to Cu and Pb, the concentration of Mn was also observed to be accumulated at 100cm depth level (Lawan *et al*., 2012). The concentration of Mn in the soil sample for the different depths of 0-5cm, 5-10cm and 10-15cm were 13.76mg/g, 15.56mg/g and 19.96 mg/g respectively (Herk, 2012), he further stated that, the concentrations of heavy metals in the soil samples obtained during the his study were higher than the FAO standard. Mn analysis gave mean values of 58.76 mg/kg at Apir Auto Mechanic Workshop Cluster (AP cluster) and 272.2 mg/kg at Adekaa suburb Gboko (GBK cluster) at a depth of (0-40cm) which shows a significant migration of these metals, although the levels found for Mn are above the control levels (Pam et al., 2013).

Zinc (Zn)

The results of Zn with the highest concentration at dumpsite A (66.90 mg/kg) at the depth of 0-15cm which is below soil concentration ranges and regulatory guidelines by Riley *et al*., 1992 and NJDEP 1996 and the lowest at O_2 (0.01 mg/kg). Lawan *et al*., (2012) in their study of vertical migration of heavy metals in dumpsites soil also observed that Zn shows almost constant concentrations in all the locations (surface and 50cm depth). Iyaka and Kakulu, (2012) revealed in their study of heavy metal concentrations in top agricultural soils around ceramic and pharmaceutical industrial sites in Niger State, Nigeria that only few sampling points had zinc contents of less than 10 mg/kg in the soils of the vicinity of the two industrial sites studied. However, higher Zn values were obtained from the pharmaceutical industrial site than in the ceramic industrial site, probably due to the observation that the whole surrounding environment of the pharmaceutical industrial site has been converted to cultivated farmlands. Several researchers such as Andreu and Gimeno (1996) as well as Alloway and Ayres (1997) had stated that agricultural chemicals or materials such as impurities in fertilizers, pesticides and wastes from intensive poultry production constitute the very essential non-point sources of metal pollutants such as Zn in soils. Furthermore, the mean Zn contents of 36±28 and 22±14 mg/kg obtained by Iyaka and Kakulu, (2012) from the soil samples of the pharmaceutical and ceramic industrial sites respectively are within the natural concentration range of Zn in surface soils of 17-125 mg/kg recommended by Ward (1995). However, the obtained mean values from the two industrial sites of their study are less than average value of 42.4 Zn mg/kg reported by Golia *et al*. (2009) in their study of Zn and Cu in surface soils of Central Greece. Nevertheless, higher range Zn content of 30-3782 mg/kg than 5.4-106 mg/kg obtained from this study has been reported by Asaah *et al*. (2006) in their study of surface soils of the Bassa Industrial Zone.

Soil pH and Organic Matter

Table 6, presents the results of soil pH and % OM at the different dumpsites and across the various depth levels of sampling by Lawan et al., (2012). The results revealed that pH levels varied only slightly from one dumpsite to another and the average pH range between 11.05±1.09 to 8.72±0.72. Despite the fact that pH level was generally higher at the REF dumpsite (10.4±0.54) and lowest at dumpsite M (9.66±0.31), there was generally a decreasing trend of pH across depth levels. Soil pH has been identified as a principal factor that affects the mobility and availability of metals in soil (Schulin *et al*., 2007). Inobeme *et al*., 2014 stated that, the pH of the soil ranging from 6.50±0.20 to 8.03±0.20, indicates a slightly acidic to slightly alkaline soil. Such pH values are characteristic of soils in areas were leaching is less pronounced due to low precipitation, resulting in the concentration of base forming cations in the place of acid contributing cations such as Al^{3+} and H^+ (Akoji, 2010).

Relationship of pH, % OM and Metal migration profile at dumpsites.

Figures 1 and 2 illustrate the relationships between metal concentrations and pH, and metal concentrations and % OM respectively by Lawan *et al*., (2012) in their study of vertical migration of heavy metals in dumpsites soil. The Figures illustrated antithetical relationships; while metal concentrations tend to increase as pH increases the reverse was the case between metal concentrations and % OM.

Lawan *et al*., 2012 stated that, the contamination of the dumpsites was obviously indicated by the high concentrations of heavy metals and the downward migration against the reference site. This shows the presence of metal containing wastes contributing enormously to heavy metal pollution. The result of accumulated metals in soil showed that zinc has the highest value. All the heavy metals (Cu, Pb, Mn and Zn) determined showed higher concentration at dumpsite B, which is due to the fact that this dumpsite is close to the high way and a mechanical workshop that is likely to contribute to the increased level of heavy metals (Abubakar *et al*., 2004 and Lawan *et al*., 2012). The appreciable level of Pb at the REF site is unclear, but may be due to proximity to unknown previous activities that are not palpable to the deduction in this study. However, it is unlikely to consider the geology of the area as a factor, but the varying concentrations of all metals studied in this work are within the common range (McLean and Bledsoe 1992).

The pH obtained in this study was generally alkaline; consequently the mobility of metal ions may not have been favored completely by the pH. However, there was correspondingly higher concentration of metals as the pH tends towards acidity. Heavy metal cations are said to be more mobile under acidic conditions (Alloway, 1990 and Lawan *et al*., 2012). Other factors, such as gravity, resulting from reoccurrences of heavy rainfall and constant leaching may be attributable. Acidic conditions in soil often enhance the solubility of heavy metals such as Cu, Zn and Pb. Also, the behavior of heavy metals in soil environments is dependent on the chemical speciation and the relative distribution of chemical forms of metals in soil solutions. These in turn influence the available and mobility of these metals in soils (McLean and Bledsoe 1992).

The concentrations of metals are observed to be favored by increase in % OM since it increases the rate of metal ion absorption. The decomposition of the organic components of waste by the action of microorganisms increases the level of organic matter in the dump soil. Organic matter acts as a major adsorbent for metals through the formation of chelates and renders them immobile (Alloway, 1990 and Lawan *et al*., 2012). Organic matter content of the dumpsites was also found to be higher than obtained from a farm land. This indicated that waste contaminated soils have relatively high organic matter content compared with that of non-waste contaminated soils (Shuman, 1991). The profiles of soil OM in this study are consistent with other studies (Dube *et al*., 2000 and Jobbagy and Jackson 2000). The antithetical relationships between pH and OM correspond to the results of other study (Dube *et al*., 2000 and Lawan *et al*., 2012).

CONCLUSION

The result of this study shows that there exists risk for the environment due to notable migration of heavy metals across depth profile. The migrations were also observed to be highly correlated with organic matter content than pH values. There where movement of heavy metals down the soil profile (leaching) to a depth of 15 cm due to application of sewage sludge and waste water from river Ngada were observed (Herk, 2012).

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Table 1: WHO Safe limits in PPM with Minimum and Maximum Acceptable limits for drinking Water and their adverse effects.

S/No.	Heavy Metals	Ground Water		Effect on lifting
		Maximum	Minimum	
1	Lead	0.05	NA	Toxic plumb solvency diseases, burning in mouth, several inflammations in gastro intestinal track, causes paralysis mental confusion, visual disturbance anemia etc.
2	Chromium	0.05	NA	Carcinogenic acuity (cancer), can produce coetaneous and nasal mucous membrane ulcer & Dermatitis, Hexavalent Cr causes lung tumors
3	Copper	1.5	0.05	Astringent taste but essential elements for metabolism, deficiency results is anemia in infants, excess may results in liver damage.
4	Mercury	0.001	NA	Causes minimata disease also causes blue baby disease in Infants the color of skin in baby is turn into blue. Paralysis.
5	Nickel	0.02	NA	May be carcinogenic, can react with DNA. Resulting in DNA damage.
6	Zinc	15	5	Causes Astringent taste & opalescence in water, Essential elements in human metabolism.
7	Iron	0.3	0.1	Promote Iron Bacteria in water, bad Taste, In trace is nutritional.
8	Manganese	0.5	0.05	Produces bad taste, essential as cofactor in enzyme system & metabolism process.
9	Selenium	0.01	NA	Toxic, leads to hair & finger loss, numbness in fingers or toes, causes circulatoryproblems.

10	Arsenic	0.05	NA	Beyond this limit water become toxic, causes skin damage circulatory problem increase risk of skin cancer, (found in ground water in Rajnandgaon district in M.P. also seen very much skin problems in slums area that are mainly depends on ground water source for drinking purpose.)

1 PPM = 1000 PPB, Source; (Akhilesh et al., 2009)

Table 2: Concentration of heavy metals across depth profiles in Maiduguri, Nigeria.

Parameters ($mgkg^{-1}$)	Meri M. (cm)			Zajeri Z. (cm)			Bulunkutu B. (cm)		
	0-5	5-50	50-100	0-5	5-50	50-100	0-5	5-50	50-100
Cu	1.32	1.35	1.36	1.32	1.36	1.57	1.41	1.62	1.65
Pb	1.20	1.17	1.32	0.91	0.86	1.29	1.69	1.69	1.74
Mn	1.49	1.51	1.72	1.38	1.36	1.40	1.47	1.49	1.74
Zn	1.67	1.70	1.81	1.52	1.52	1.70	1.77	1.79	1.80

Source: Lawal et al., 2012

Table 3: Concentration of heavy metals across depth profiles in Allahabad, India

Parameters ($mgkg^{-1}$)	Nianai N. (cm)			Buxi Badh B2 (cm)		
	0-15	15-30	30-45	0-15	15-30	30-45
Cd	6.86	5.45	3.65	4.24	3.24	2.20
Cr	3.20	2.80	1.40	3.00	2.60	1.20
Pb	45.2	33.24	20.45	24.42	20.12	16.24

Source: Dinesh Mani et al. 2015

Table 4: Concentration of heavy metals across depth profiles in Owerri, Nigeria

Parameters ($mgkg^{-1}$)	Otomiri Valley O1 (cm)			Otomiri Hilltop O2 (cm)		
	0-20	20-40	40-60	0-20	20-40	40-60
Zn	0.03	0.12	0.09	0.01	0.26	0.40
Fe	0.30	1.80	0.70	1.30	0.30	1.20
Pb	0.22	0.23	1.12	0.46	0.32	0.93

Source: Enejo and lemoha., 2012

Table 5: Concentrations of heavy metals in Alaba International Market Lagos, Nigeria

Parameters ($mgkg^{-1}$)	(A) 0-15 (cm)	(A) 15-30 (cm)
Cd	7.82	7.28
Zn	66.90	60.32
Pb	502.12	428.12
Cr	32.65	32.84

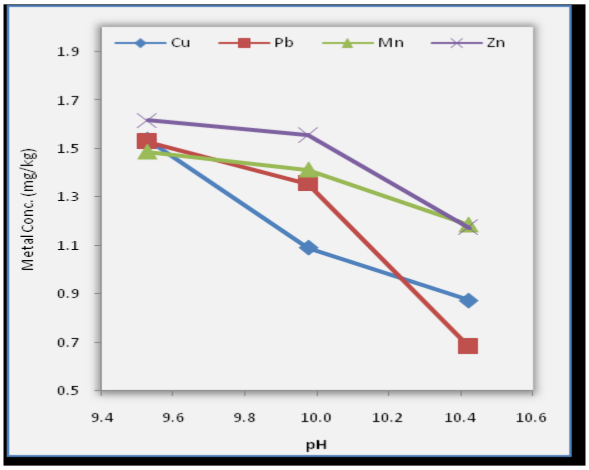
Source: Oladunni et al. 2013

Table 6: Mean pH and Organic Matter (% OM)

Dumpsites	DEPTH (cm)	pH	%OM
REF	0	11.05±1.09	4.15±0.76
	50	10.2±1.37	4.36±0.43
	100	9.96±0.83	4.42±0.92
B	0	10.34±1.33	21.68±4.88

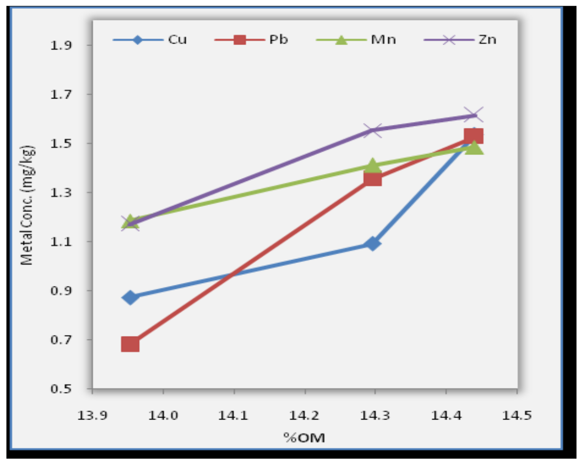
	50	10.17±1.45	21.87±5.11
	100	10.02±1.59	21.88±4.82
M	0	9.9±1.22	15.93±3.14
	50	9.66±0.91	16.65±2.56
	100	9.42±1.33	17.04±5.22
Z	0	10.41±1.00	14.05±2.38
	50	9.87±1.21	14.3±1.78
	100	8.72±0.72	14.42±2.54

Source: Lawan et al., 2012



Source: Lawan et al., 2012

Figure. 1. Relationship of pH and Metal migration profile at dumpsites.



Source: Lawan et al., 2012

Figure 2. Relationship of % OM and Metal profile at migration dumpsites.