COMPARATIVE STUDY OF THE VERTICAL DISTRIBUTION OF HEAVY METALS IN SOILS AROUND AUTOMOBILE AND DOMESTIC DUMPSITES IN ILARO, OGUN STATE NIGERIA

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ABSTRACT

This study attempts to investigate and compare the vertical migrations of pH, CEC and heavy metals (Pb, Cu, Fe, Cd, Mn,) in automobile and domestic dumpsites soils located in Ilaro, Ogun State Nigeria. Three soil samples each were collected from three different automobile dumpsite ($S_{A1,}S_{A2}$ S_{A3}) and domestic dumpsite (S_{D1}, $S_{D2,}$ S_{D3}) and the control soil. The pH of the soil samples were determined to evaluate the effect of pH on the metal concentration. The pH values for the automobile and domestic dumpsite ranged from 5.3 to 7.3 with the mean values of 6.46±0.71 and 6.1 to 8.1 with mean values of 7.06±0.69 respectively, indicating neutrality to slightly acidity of soil samples. The CEC ranged from 6.7 to 9.0meq/100g and 7.6 to 9.9meq/100g for both automobile and domestic dumpsite respectively. The vertical distribution of the heavy metals showed that the metals were higher at the top soils than the sub soils and bottom soils for both dumpsites. The mean concentration of the metals in the both sites were in the order>Mn>Pb>Cu>Cd. All the values obtained generally indicated that the soils in all the sites were contaminated with heavy metals. However the metal concentration levels found in this study do not pose any health risk, except for Mn which is above the WHO limit.

Key words: Heavy metals, soils, automobile dumpsite, Ilaro

INTRODUCTION

Soil is a natural body consisting of layers of mineral constituent of variable thickness which differ from the parent materials in their morphological, physical, chemical and mineralogical characteristics (Birwland, 1999). Soil is composed of particles of broken rocks that have been altered by chemical and environmental processes that militate weathering and erosion. The proliferation of open and unsafe dumpsites containing multiple disposal of domestic, municipal, industrial and medical waste is a common practice in most cities in Nigeria. These dumpsites have become feeding ground for diseases breeding animals especially rates, birds and stray animals, thereby, contributing greatly to their nourishment and growth (Adewuyi and Opasina, 2010).

Furthermore, the random deposition of these wastes, consequently leads to adjacent lands getting enriched in trace metal and salts, especially waste from automobile workshops and domestic dump activities has been on the increase. These waste dumps resulting from automobile business, ranging from servicing, repairs, and uses and dumping of automobile scraps are categorized as polluted sites. A typical automobile and machine part consists primarily of automobile and machine part and scraps at various stages of corrosion, discarded motor batteries and tyres, can etc. (Holderness *et al*, 1982). Over a long period of time these metals may reach harmful and toxic concentration levels and may spread and render the soil unsuitable for farming. There may be transfer of metals from soil to crops and grasses then to grazing animals and finally through food chain. This study would be useful in monitoring the pollution status of the dumpsites in Ilaro and its environs in Ogun state Nigeria.

MATERIALS AND METHODS.

Ilaro is a town situated in Yewa south Local Government Area of Ogun State. It lies on latitude 6^0 55'0" N and longitude $3^0$1'0" E. The mean annual rainfall in this area ranges between 2150-3300mm and the temperature varies between 27^0C-33^0C.The major occupation of the people are farming and commercial bike riders.

Sampling and analysis: Three soil samples each were collected from three different automobile and domestic ware dumpsites located in Ilaro. At depths of 0-15cm for top soil, 15-30cm for sub soils and 30-45cm for bottom soil.

Sample preparations: This soil samples were separately air-dried in a protected area, crushed to pass through 2mm sieve. The experimental test was performed on the aggregate samples prepared by mixing thoroughly equal amounts of the soil samples from the six different dumpsites based on the three different depths.

Sample digestion: 1 gram of air-dried soil sample was allowed to pass through a 2mm sieve, it was then transferred into a 50ml beaker and 40ml of 3:1 aqua regia (30ml of HCl and 10ml of HNO_3) was added, the solution was heated on a hot plate for 30mins and filtered into a 25ml volumetric flasks and made up to mark with distilled water.

Analysis of the samples: The digested soil samples were analysed for Pb, Cu, Fe, Cd, and Mn using Atomic Absorption Spectrophotometer with model buck 210 VGB.The pH values of the soil samples were determined on a 2:50 (air dried soil weight: volume of distilled water) soil suspension using digital pH meter(Mettler toledo).

Reagents: All reagents used in this study were of pure analytical grade. The glass wares were previously soaked in 15% nitric acid for 24hrs to remove entrained metals.

Cation Exchange Capacity: The CEC was done using ammonium saturated method. 5g of air-dried soil sample was soaked with about 125ml of 1M ammonium acetate extract and then filtered, about 15ml of 5% w/v of potassium chloride solution was used to replace absorbed NH_4^+N, 60ml of the leached sample was transferred into a quick fit round bottom flask with about 1gm of magnesium oxide salt in a distilling kit heated with a hot plate, the distillate condenses into a conical flask containing 100ml of boric acid. It was titrated against 1/40N of HCl until colour changed from green to dark green.

Calculate: CEC (meq/100g)= $\frac{T(ml) \times Aliquot\ (ml) \times 10}{Extractant\ Vol \times Sample\ weight}$

RESULTS

Table 1: pH, CEC Values and Vertical Distribution of Heavy Metals in Soils Profile of the Automobile Dumpsites.

SITES	Soil Depth(cm)	Soil pH	CEC	Pb	Cu	Fe	Cd	Mn
$S1_{AD}$	0-15	7.1	7.1	3.26	1.77	5625.0	0.04	15.02
	15-30	6.9	7.7	2.91	1.52	5395.0	0.01	14.73
	30-45	7.3	8.8	2.82	1.21	5020.0	ND	14.61
$S2_{AD}$	0-15	5.6	6.7	2.36	0.15	4111.0	1.02	17.00
	15-30	5.3	7.9	2.30	0.11	4012.0	0.08	17.05
	30-45	6.0	6.9	2.22	0.10	4001.0	0.02	16.90
$S3_{AD}$	0-15	6.3	8.3	2.08	3.01	2897.0	0.18	22.02
	15-30	7.1	8.1	2.34	2.17	2774.0	0.11	28.17
	30-45	6.5	9.0	2.05	2.01	874.0	ND	20.01
MEAN±S.D		6.46±0.7	7.83±0.81	2.48±0.42	1.34±1.04	3856.56±1497.74	0.16±0.33	18.39±4.42
CONTROL 1		6.70	11.70	0.12	0.14	142.0	ND	2.94
CONTROL 2		6.22	10.25	ND	0.02	103.0	ND	3.01
MEAN±S.D		6.46±0.34	14.98±6.68	0.06±0.08	0.08±0.085	122.5±27.58	ND	2.98±0.05

Table 2: pH, CEC Values and Vertical Distribution of Heavy Metals in Soils Profile of the domestic Dumpsite.

SITE	Soil Depth(cm)	Soil pH	CEC	Pb	Cu	Fe	Cd	Mn
S_{D1}	0-15	6.2	8.8	2.56	0.53	445.0	0.86	10.01
	15-30	7.2	9.1	2.12	0.41	350.0	0.17	9.93
	30-45	7.0	8.2	2.01	0.11	210.0	0.13	8.41
S_{D2}	0-15	8.1	9.1	3.33	0.73	301.0	0.05	12.11
	15-30	7.8	8.9	2.91	1.03	297.0	0.29	10.95
	30-45	7.2	7.6	2.09	0.14	205.0	0.14	10.41
S_{D3}	0-15	6.5	8.4	2.11	1.94	512.0	0.19	8.54
	15-30	6.1	9.1	2.03	1.11	335.0	1.03	8.11
	30-45	7.4	9.9	1.98	0.32	98.0	0.03	7.03
MEAN±S.D		7.06±0.69	8.79±0.66	2.35±0.48	0.70±0.59	306.89±126.15	0.32±0.37	9.5±1.59
CONTROL 1		6.20	10.70	0.10	0.11	112.0	ND	1.94
CONTROL 2		6.12	10.10	0.01	0.01	100.0	ND	2.00
		6.16±0.31	10.4±5.53	0.055±0.07	0.06±0.065	106.0±25.65	ND	1.97±0.03

DISCUSSION

The soil pH of the soils studied in the both sites ranged from 5.3 is 7.1 for the automobile dumpsite and 6.1 to 8.1 for the domestic dumpsite, with a mean value of 6.46±0.71 and7.06±0.69 respectively. The near neutrality to slightly alkalinity is common with reduced anaerobic soils and sediments in the Niger Delta area.(Odu,1985).The result was similar to the report obtained by (Ekpenyong,2012) and was lower than the values reported by (Sallau,2011a) whose values ranged from 8.11± 0.11 to 8.53±0.09. The pH values reported in this study are similar to those reported by (Osakwe, 2010) on the distribution of heavy metals in soils around automobile dumpsite in Agbor Delta State. Soil pH is an indication of the acidity and alkalinity of soil, it is considered a master variable in soil as it controls many chemical process that takes place in it.(Wikipedia,2010).The soil pH determines the availability of nutrients, potency of toxic substances and the physical properties of the soil pH (Gunderson and Elume,2002). Soil pH is important for most metals since metal availability is relatively low when the pH is between 6.5 – 7.0 (Bhattacharya, *et al.,* 2002). In this study the pH values indicates a decrease in the metal availability.

For the CEC, the values obtained for both the domestic and automobile dumpsites ranged from 6.7 – 9.0 and 7.6 -9.9meq/100g respectively. The mean values for the control of automobile and domestic dumps were 14.98±6.68 and10.4±5.53meq/100g respectively. This indicates that the values obtained at the domestic dumpsite were slightly higher than that of automobile dumpsite. As soil acidity increase, pH decreases, more H+ are attached to the colloids and push other cations from the colloid into the soil solution (CEC decreases).(Wikipedia, 2010). Inversely when soil become more basic (pH increases) the available cations in solution decreases because there are fewer H+ to push cations into the soil solution from the colloids (CEC increases). Ultimately, the values obtained in these study for domestic dumpsite was slightly greater than the automobile dumpsite, that also indicates greater capacity for the domestic dumpsite to retain nutrient in the soil and the control site would retain more nutrients. Hence, their values were within the range of cation exchange capacity for normal silt loamy soil which ranges between 8-15meq/100g (Frank et al, 2008).The values obtained for the both dumpsite were higher than the results obtained by Tripathi and Misra, 2012, which ranged between 3.12 to ±0.70meq/100g to 10.83± 0.55meq/100g). The increase in the CEC and organic matter results in plants taking up nutrients more easily and the changes in CEC and pH improves soil condition for crop growth (Aydinalp and Marinova, 2003).

The vertical distribution of the heavy metals showed that the heavy metal concentration were generally higher at the top soils than bottom soils. The high

level of metal on the top soil is due to the fact that the top soil is the point of contact. In this study the level of heavy metals for all the both sites was significantly higher than the control sites. This implies that the soils from the dumpsites (especially the automobile site) have some levels of heavy metal enrichments.

Iron had the highest concentration in the both sites, the concentration ranging from 874.0mg/kg-5625.0mg/kg for the automobile dumpsite with a mean value of 3856.56±1497.74mg/kg and 98.0mg/kg to 512.0mg/kg, with mean values of 306.89±126.15mg/kg for the domestic dumpsite, this values were similar to that reported by (Moses *et al.,* 2010 and Agbugui *et al.*, 2010). The high concentration seen in the values of the automobile dumpsite may be due to iron enriched products present in waste being dumped at these sites and may partly originate from natural sources-metal rich parent rock.(Siebielec, 2006).The values were higher than that reported by Ovasogie and Ofomaja (2007). The iron levels decreased with increasing depth in both sites. It has been confirmed that natural soils contains significant concentrations of iron and that pollution of the environment by iron cannot be conclusively linked to waste materials alone but to other natural sources as well. Eddy *et al.,* 2004. Iron is very important to almost all living things from organisms to humans. Iron can be found in vegetable, meat product, potatoes which are an essential parts of haemoglobin formation. Excessive concentration of iron oxide fumes or dust may result in development of a benign pneumoconiosis called siderosis which is an observable of an x-ray change. (Eddy *et al.*, 2004).

Lead (Pb) levels in the both sites ranged from 2.05mg/kg -3.26mg/kg for the automobile site with mean value of 2.48mg/kg±0.42mg/kg.The levels of Pb obtained in the domestic dumpsite ranged from 1.98mg/kg to 3.33mg/kg with mean value of 2.35mg/kg-0.48mg/kg.The high concentration of Pb in the automobile dumpsite may be attributed mainly to cell batteries waste, paint waste, lead solders, vehicle emission, diesel waste and application of waste water sludge to soil. The observations of high retention of lead in the top layer of the soil in the both sites corroborate the findings of Adelekan and Abegunde (2011), which Pb is especially prone to accumulation in surface horizons of the soil because of its low water solubility resulting in very low mobility. The level of lead in the both sites were lower than that reported by (Ekpenyong and Odoemelam,2012) and similar to the work reported by(Osakwe,2010). The levels of concentration of lead in both the automobile and domestic dumpsites were far below the maximum tolerable limit according to WHO Standard of 100mg/kg and USEPA Standard of 420mg/kg. Lead is a neurotoxin and a good example of multimedia pollutant. Toxic concentration can accumulate in the bone marrow where red blood corpusiles formation occurs (Murphy,1981).Lead has also been associated with a wide range of effects which includes anaemia, nervous system disorders, cardiovascular disease and disorders in renal function and reproduction.

The copper levels observed in this study ranged from 0.10mg/kg to 3.01mg/kg with the mean value of 1.34±1.04mg/kg for the automobile dumpsite and 0.11mg/kg to 1.94mg//kg with mean value of 0.70 ±0.59mg/kg for the domestic dumpsite. The values are in the same range with the levels reported in a similar study by (Iwegbue, 2006) and also similar to the study by (Osakwe, 2010). The values of Cu was lower than the levels reported in some other studies (Agbugui *et al.,* 2010, Oguntimilehin and Ipimoroti, 2007) and higher than the values reported by Butch *et al.* (2013). The high concentration of Cu in the automobile dumpsite could be attributed to the presence of electrical wiring cables, ornaments, automobile trims, electronic component (laggerwerf and Specht, 1970). Copper is an essential substance to human life but in high doses can cause anaemia, liver,kidney damage and stomach. In hesitant irritation, people with Wilson's diseases are at great risk for health effects from exposure to copper (Lenntech, 2009).

The result of the Manganese revealed that Mn had the next highest concentration in the dumpsites. It was highest in the automobile dumpsite than the domestic dumpsite. The values ranged from 14.61mg/kg – 22.02mg/kg for the automobile dumpsite with a mean value of 18.39±4.42mg/kg while the domestic dumpsite ranged from 7.03mg/kg to 12.11mg/kg with a mean value of 9.5±1.59mg/kg The values observed in this study was higher than that reported by (Lawan *et al.,* 2012) and lower than that reported by Moses *et al.* (2012). The presence of trace amount of Mn could be due to dumping of waste like batteries, discarded metals rails and machinery part. Though the level of Mn in this study were above the WHO Standard and Permissible limits for Mn (0.2mg/kg).In high concentration, Mn is known to have resulted to adverse effects on humans. Mn in the form of oxide is a component of subsoil materials (Levy et al., 1992), so its level of concentration could be as a result of these oxides.

The result of Cd in this study ranged from N.D- 1.02mg/kg for the automobile dumpsite and ranged from 0.03mg/kg to 1.03mg/kg for the domestic dumpsite. The values were in the same range with the study by (Butch *et al.,* 2013) and lower than the values reported by Osuji and Onojake (2010) and Moses et al. (2012). Though the values observed for the both study area were below the critical permissible concentration level of 3.0mg/kg as given by European communities, (1986).Cadmium is a bio persistent and once absorbed by an organism remains resident for many years. High exposure can lead to obstructive lung diseases and has been linked to lung cancer, kidney damage, bone deformities and cardiovascular problems. The major exposure path way is through food, soil from various sources (atmospheric deposition and fertilizer application). (Lenntech, 2011).

CONCLUSION

The problem of soil contamination by heavy metals may pose a serious effect on soil, plants, through grazing animals and to man. From the results, it can be concluded that the pH and the CEC of the automobile and domestic dumpsites were within the range of normal pH of a soil and CEC for normal silt loamy soil which is between 8-15meq/100g. The assessment of the heavy metal levels in this study indicated that soil investigated in the automobile and domestic dumpsite is contaminated with most of these metals. The vertical distributions of the metals were higher at the top soil than the sub soil and bottom soil. Evidence of contamination of this soil is in the order, Fe>Mn>Pb>Cu>Cd were obvious when compared to the control sites, though, the metals were within the USEPA and WHO standard for soil, this may not pose immediate toxic effect on man and the environment, but should be monitored, because the activities of the dumpsites can leach deeply into the soil after a period of time.

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