Analysis of Heavy Metals in Soil from Residential and Mechanic Dumpsites

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Abstract

Comparison was made between the bioavailability of heavy metals (Cu, Cd, Pb, Ni.) in a mechanic workshop and a residential dumpsites; samples were randomly collected and analyzed for physicochemical parameters, mobility, bioavailability and speciation of the heavy metals, using standard analytical methods, results show that the bioavailability of the Pb (0.81) and Ni (0.16) was higher in the residential dumpsite samples than the bioavailability of Pb (0.62) and Ni (0.04) in the mechanic workshop dumpsite sample, while the bioavailability of Cu (1.00) was higher in the mechanical workshop dumpsite sample than the bioavailability of Cu (0.91) in the residential dumpsite samples, except for Cd (1.00) which was equal in both dumpsite samples. The total metal concentration of Cu (14±1.39) and (22.86±8.19), Cd (0.62±0.05) and (1.1±0.22), Pb (15.6±2.08) and (11.08±0.89), Ni (14.07±8.79) and (13.37±0.13) in residential and mechanic dumpsite samples respectively, were lower than their target values in the soil. The heavy metal content of the soil samples from the dumpsite including the soil samples from the normal garden soil not subjected to the same conditions as the dumpsite were lower than the target value except for Cd at the mechanic workshop dumpsite, hence does not pose a threat.

1. Introduction

Pollution has been known to exist for a long time since the commencement of the use of fire, thousands of years ago; this has been more pronounced since the onset of industrial revolution in the 19th century which brought about technological process such as discovery and exploitation of oil. Increase in the population of developing countries, multiple and rampant basic industrial processes, and trends towards the western culture, has brought about the use of so many metallic and electronic devices which have the potential of introducing quite a number of heavy metals into the dumpsites when they are eventually dumped as waste after use, thus rendering the environment toxic for potential applications [1]. Since heavy metals are very useful, in that they have multiple applications in industries, domestic, agriculture, medicine and technology, their multiple applications have promoted their wide distribution in the environment. The presence of heavy metal in the environment at an amount higher than a particular acceptable level causes risk to human health, plants, animals and the ecosystem hence the concern over there potential effect on human health and the environment cannot be overemphasized. Dumpsite serves as a representative of everything man uses, since it contains domestic waste, industrial waste, hence will serve as a suitable sample to analyze the impact of human activities on the level of contamination of the environment. Some dumpsites are gradually turned into farmland thinking that they must have

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accumulated enough essential nutrients and manure required for plant growth thus, farmers use refuse dumpsite material for composting without the knowledge of the type of waste and what the waste are made up of. This is done so as to reduce the cost of fertilizer which is needed to improve crop production. In this process heavy metals are introduced into their crops. The plants take up these metals through the roots to the harvestable parts, since the metals comes in ionic forms making it easy for its uptake through plants root and easy translocation into the stem and aerial part of the plant [2]. These heavy metals released into the environment by aforementioned anthropogenic activities and unlike organic contaminants which are oxidized to carbon (IV) oxide by microbial action, are not biodegradable i.e. they do not undergo microbial or chemical degradation, and their total concentration in soils persists for a long time after their introduction [3]. Heavy metal contamination of soil may pose risks and hazards to humans and the ecosystem through: direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animal-human), drinking of contaminated ground water, reduction in food quality (safety and marketability) via phytotoxicity, reduction in land usability for agricultural production causing food insecurity, and land tenure problem. The build up of heavy metals in soil has been reported to be harmful to crops and human health [4].

In an attempt to remediate heavy metal contaminated soils and to know the urgency of the remedy on the environment, and make proper planning towards a cleaner and safer environment, there is a need to evaluate the source of contamination, basic chemistry, and environmental and associated health effects (risks) of these heavy metals. The mobility and bioavailability of heavy metals depend absolutely on their speciation or chemical forms [5]. These forms are determined by sequential extraction technique [6]. The soil texture (clay content), pH and organic matter have been found to be the most important soil properties and components influencing the ability and biological intake of heavy metals [5].

The aim of this research is to compare the level of pollution of a dumpsite at a residential area and a dumpsite at a mechanic workshop by determining the concentrations of Pb, Cd, Cu, Ni, in the selected dumpsites in Akure and investigate their environmental contamination risk between different chemical speciation forms.

2. Research Significance

It is very important and germane to access the speciation, mobility and bioavailability of Heavy metal contaminants in dumpsite soils so as to obtain a precise information and provide data on the level of risk or toxicity of the polluted soil, more so it shows the importance of speciation as a tool in curtailing the introduction of heavy metals to the environment. This report is a tool to create public awareness of the grave consequences of indiscriminate industrial and mechanical waste disposal. This report will also enlighten farmers to desist from planting on refuse dumpsite, in the same vein it will encourage analyzing for the physicochemical properties of dumpsite materials before being used for compost that will be applied to the soil to enhance fertility.

3. Materials and Methods

3.1. Description of Location and Study Site

The dumpsite at the mechanic workshop at Oluwafemi area was at longitude 7°16'30°N and latitude 5°9'35°E, while the dumpsite at the residential area at FUTA was at 7°17'29°N and latitude 5°9'7°E, the garden soil was at longitude 7°18'4°N and latitude 5°8'32°E.

3.2. Soil Sampling and Preparation

The samples collected were, two surface soils (0-20 cm) from dumpsites at a residential area and a mechanic workshop, two sub-surface soil samples (20-30 cm) from dumpsites at a residential area and a mechanic workshop, and a surface (0-20 cm) and subsurface soil sample (20-30 cm) of a garden soil which is not affected by waste disposal which was used as control were purposely selected at different location point using the composite sampling method, within Akure municipal area in the region of south Western Nigeria. The soil sample were collected randomly from twenty points on the dump sites then homogenized, air dried and sieved using a 2mm aperture after which they were stored in plastic containers to prevent them from further contamination.

3.3. Soil Analysis.

Glass wares used for the analysis were prewashed and rinsed with deionised water and the regents used, such as $K_2Cr_2O_7$, CH_2COONa were of analytical grade. The pH of the soil samples were determined according to Folsom et al 1987 [7] using a soil: water ratio of 1:2 with a pH meter. Particle size distribution was determined using Hydrometer by the method of Bouyoucos [8], Total organic carbon was determined by Walkley Black method [8], exchangeable cations was extracted with NH_4OAC and Cation Exchange Capacity (CEC) was determined by the Flame photometer [8].

3.4. Sequential Extraction Procedures

The metal fractions of the soils were determined using sequential extraction procedure and are named as follows;

F1. Water Soluble, the soil samples were extracted with 15 mL of deionised water for 2 h

F2. Exchangeable, the residue from water soluble were extracted at room temperature with 8 mL of 1M $MgCl_2$ at pH = 7.0 for 1h with continuous agitation.

F3. Metals Bound To Carbonate: The residue from analysis of metals bound to exchangeable fractions were leached with 8 mL of 1M Sodium Acetate solution adjusted to pH 5.0 with acetic acid for 5 h, with continuous agitation.

F4. Metals bound to Fe-Mn oxide: the residue from the analysis of metals bound to carbonate was extracted with 20 mL of 0.04 M hydroxylamine chloride ($NH_2OH.HCl$) in 25% (v/v) acetic acid at 96°C with occasional agitation for 6 h.

F5. Metals bound to organic matter: the residue from the analysis of metals bound to Fe-Mn was extracted with 3 mL of 0.02 M nitric acid (HNO_3) and 5 mL of 30% Hydrogen per oxide (H_2O_2) adjusted to pH 2 with nitric acid (HNO_3) and the mixture was heated to 86°C for 3H with occasional agitation. The mixture was cooled and 5 mL of 3.2 M ammonium acetate (NH_4OAc) in 20% (v/v) nitric acid (HNO_3) was added and the sample was diluted to 20 mL and agitated continuously for 30 minutes.

F6. Residual Metals: the residue from the analysis of metals bound to organic matter was digested with a mixture of nitric acid and perchloric acid. The supernatant from each extraction step was removed and analyzed for total metal concentration using acetylene flame Atomic Absorption Spectrophotometer, fitted with deuterium lamp for background correction.

The textural class of the soil sample was named as follows, soil sample A1 is sandy loam, A2 is sandy clay loam, B1 is sandy clay loam, and B2 is sandy clay loam, C1 sandy loam and C2 sandy loam

3.5. Statistical Analysis

The data obtained from the experiment were evaluated using Excel and T test in order to obtain the mean, standard deviation and coefficient of variance for each set of values. T test was also used to test for significant difference in the metal concentration.

4. Results

4.1. Physical and Chemical Properties of the Experimented Soils

4.1.1. Particle Size Distribution

The obtained soil samples were named as follows; A1 is top soil sample of dumpsite from residential area, A2 is depth soil sample of dumpsite from residential area, B1 is top soil sample of dumpsite at mechanic workshop, B2 is depth soil sample of dumpsite at mechanic workshop, C1 is top soil sample from unaffected garden soil. And C2 is depth soil sample from unaffected garden soil. From the particle size distribution as presented in Figure 1, it was discovered that the soils were sandy loam (A1), sandy clay loam (A2), sandy clay loam (B1), sandy loam (C1) and sandy loam (C2).
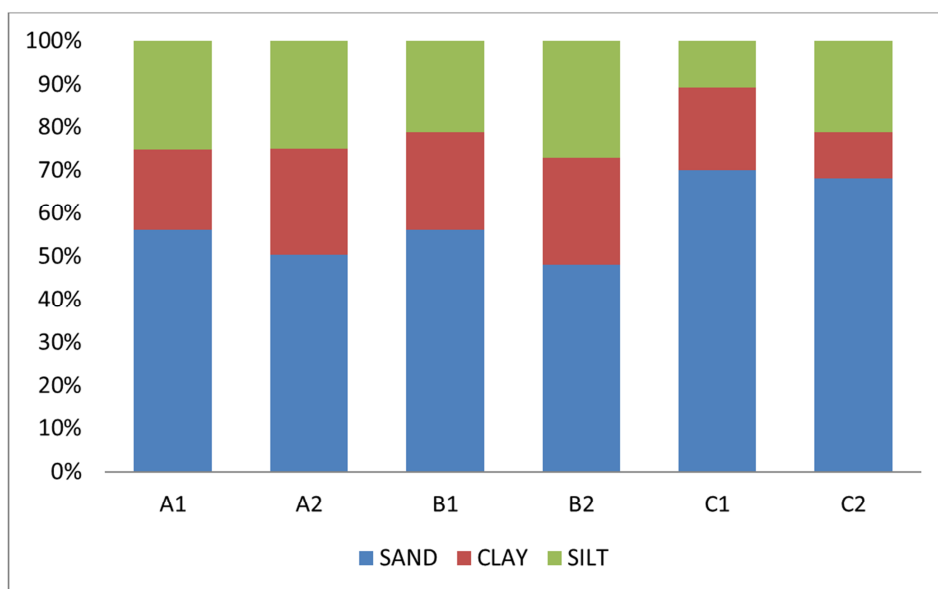

Figure 1. Particle Size Distribution of the soils.

4.1.2. pH Measurement

From the presentation in Figure 2 the pH of the dumpsites ranged from slight alkaline (7.34-7.84) to very weak acidic (6.01-6.44).
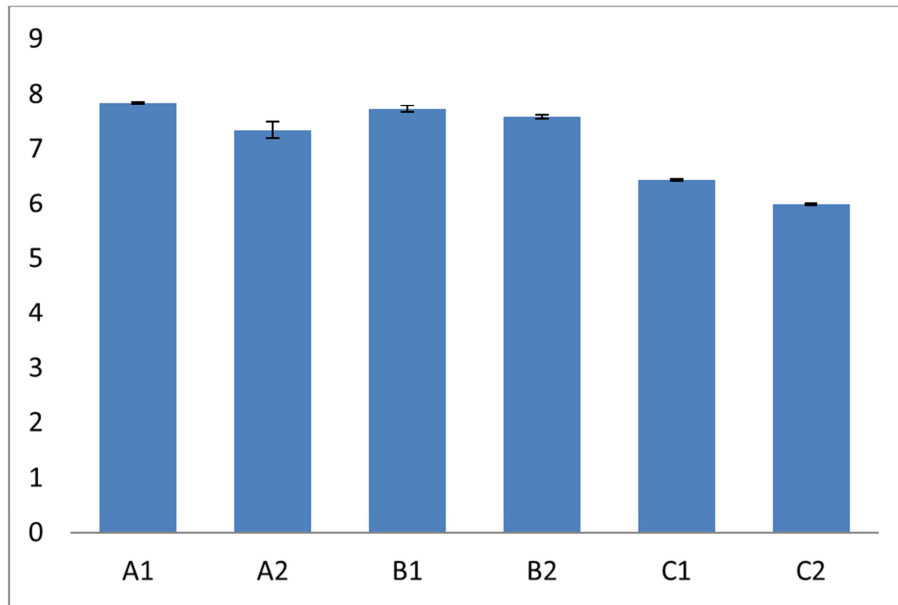
Figure 2. pH Values of the Soil Samples.

4.1.3. Cation Exchange Capacity

The total capacity of the soil to attract, exchange and release exchangeable cations (positively charged ions) is the Cation exchange capacity of the soil. CEC is an inherent soil characteristic and is difficult to alter significantly. It influences the soil's ability to hold onto essential nutrients.

Cation Exchange Capacity of the dumpsite was higher than that of the garden soil, while the Cation Exchange Capacity of the surface sample was higher than that that of the sub-surface sample in both the dumpsites and the garden soil samples.

4.1.4. Total Organic Carbon and Total Organic Matter

A high total Organic Carbon indicate a high Cation exchange Capacity which retains nutrient assimilated by plants [9]. The results show that the total organic carbon of the dumpsite soils which range from 1.62 ± 0.27 to 2.31 ± 0.46 was higher than that of the uncontaminated soils which ranged from 1.25 ± 0.15 to 1.37 ± 0.15. This correlates with report of Amos et al. (2014) [9]. Total organic matter is an indication of soil fertility. It controls the activity and supplies food for soil microbes [10], serves as a supplier of micronutrient to the soil and has an excellent water holding capacity. Total organic matter of dumpsite soil samples which ranged from 2.80 ± 0.47 to 3.99 ± 0.79 was higher than those of the uncontaminated soil samples which range from 2.16 ± 0.25 to 2.36 ± 0.26.
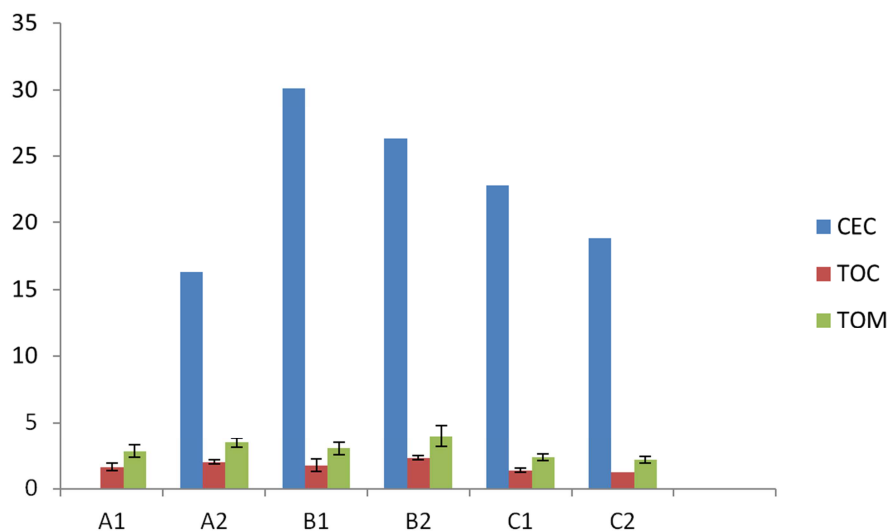

Figure 3. Cation Exchange capacity, Total Organic Matter amd Total organic Carbon of the Soil Samples (mg/kg).

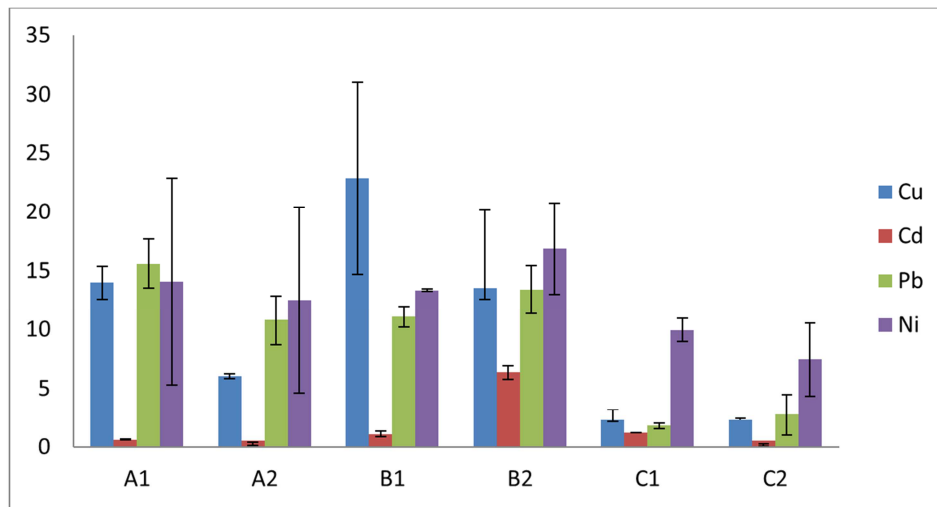## 4.2. Total Heavy Metal Concentrations in the Experimented Soil Sample

Figure 4. Total Heavy Metal Concentration in the Soil Samples.

Table 1. Target values for the Heavy Metals in the soil (mg/kg) (DPR, 2002) [1].

Heavy metal	Target value
Cu	36
Cd	0.8
Pb	85
Ni	35

The amount of heavy metals; Cu, Cd, Pb, Ni, found in the dumpsites soil samples were significantly higher than the amount found in the garden soil.

The analysis of the following metals: Cu, Cd, Pb, Ni in both dumpsite and control soil samples as shown in the Table 2 – 4 shows that their concentrations were lower than the DPR target values for heavy metals in the soil, except for cadmium. This agrees with reports of Amos et al. (2014) [9]

4.3. Sequential Extraction

Irrespective of sampling points the distribution of metals in the soil samples from the municipal waste dumpsites generally followed the order below for the various metal studied.

Cu: organic bound>carbon bound>reducible>residual>water soluble> exchangeable metal.

Cd: organic bound>exchangeable metal>carbon bound>reducible>water soluble>residue

Pb: reducible >organic bound>carbon bound>water soluble>residual>exchangeable metal

Ni: residual>organic bound>carbon bound>exchangeable metal>reducible>water soluble

For A1, A2, B1, B2, the highest amount of copper was found in the organic bound fraction, but the amount of copper in B1 was found to be higher than that in A1.

For the mechanic workshop dumpsite, cadmium exists in the Reducible and Exchangeable fractions with little or no traces of cadmium in the residential dumpsite. No traces of cadmium were found in the residual fraction of both dumpsites samples. The highest amount of cadmium was found in site B2 in the reducible fraction

Table 2. Concentrations of Cu, Cd, Pb and Ni in Water Soluble Fractions and Exchangeable Fractions of Four Contaminated Soils and Two Garden Soils.

HEAVY METAL	WATER SOLUBLE					
	A1	A2	B1	B2	C1	C2
Cu	0.00	0.00	0.00	0.00	0.00	0.19±0.05
Cd	0.00	0.00	0.00	0.09±0.03	0.00	0.08±0.04
Pb	0.00	0.00	3.07± 0.84	0.00	0.00	0.00
Ni	0.00	0.00	0.00	0.00	0.00	0.00
	EXCHANGEABLE					
Cu	0.00	0.00	0.13±0.10	0.00	0.00	0.00
Cd	0.00	0.09±0.03	0.38±0.20	0.08±0.04	0.00	0.00
Pb	2.41±0.67	0.00	0.00	0.00	0.00	0.00
Ni	0.00	0.00	0.00	0.91±0.21	0.09±0.04	0.2±0.09

Table 3. Concentrations of Cu, Cd, Pb and Ni in Carbon-bound Fractions and Reducible Fractions of Four Contaminated Soils and Two Garden Soils.

HEAVY METAL	CARBON-BOUND					
	A1	A2	B1	B2	C1	C2
Cu	5.07^a± 0.32	0.24^c±0.13	4.65^a±2.76	0.91^b±0.26	0.1±0.03	0.2±0.09
Cd	0.46^c±0.05	0.00	0.00	0.00	0.00	2.71±1.81
Pb	5.15^a±0.98	3.50^a±1.27	1.45^b±1.19	3.32^a±1.09	0.45±0.09	0.00
Ni	2.27^b±0.03	2.13^b±0.93	1.00^b±0.93	0.00	0.57±0.16	0.00
	REDUCIBLE					
Cu	0.79^b±0.20	0.79^b±0.20	0.00	25.90^a±4.64	0.00	0.00
Cd	0.13^b±0.01	0.00	0.13^b±0.01	6.10^b±0.71	1.25^a±0.00	0.00
Pb	4.58^a±1.93	3.19±0.36	0.13^b±0.01	6.10^b±0.71	2.59^a±2.32	0.00
Ni	0.00	0.00	0.00	0.00	0.00	0.00

Table 4. Concentrations of Cu, Cd, Pb And Ni in Organic bound and residual Fractions of Four Contaminated Soils And Two Garden Soils.

HEAVY METAL	ORGANIC BOUND					
	A1	A2	B1	B2	C1	C2
Cu	8.06^a±1.07	5.65^a±0.35	17.02^a±7.12	5.7±2.66	1.06±0.37	1.88±0.82
Cd	0.16^c±0.15	0.23^c±0.22	0.50^b±0.31	0.12±0.04	0.00	0.08±0.06
Pb	3.87^b±2.27	1.83^b±0.34	1.58^b±2.12	0.12±0.04	0.00	0.00
Ni	0.00	0.00	0.38^b±0.3	0.00	0.00	0.00
	RESIDUAL					
Cu	0.00	0.00	1.10^b± 0.00	0.00	1.17±0.70	0.00
Cd	0.00	0.00	0.00	0.00	0.00	0.00
Pb	0.00	0.00	0.00	0.56^c±0.49	0.00	0.00
Ni	11.8±8.78	8.55±5.55	12.9^a±0.00	16.88±3.90	8.70±1.49	7.45±3.16

Values are means of three replicates ± standard deviation

Column means followed by different letters are significantly different at p< 0.5

4.4. Mobility Factor and Bioavailability Factor

The mobility of metals in compost samples may be assessed on the basis of absolute and relative content of fractions weakly bound to components. The relative index of metal mobility was calculated as a "mobility factor" on the basis of the following equation:

$$MF = \left(\frac{F1 + F2 + F3}{F1 + F2 + F3 + F4 + F5 + F6}\right) \times 100$$

Where

MF is mobility factor

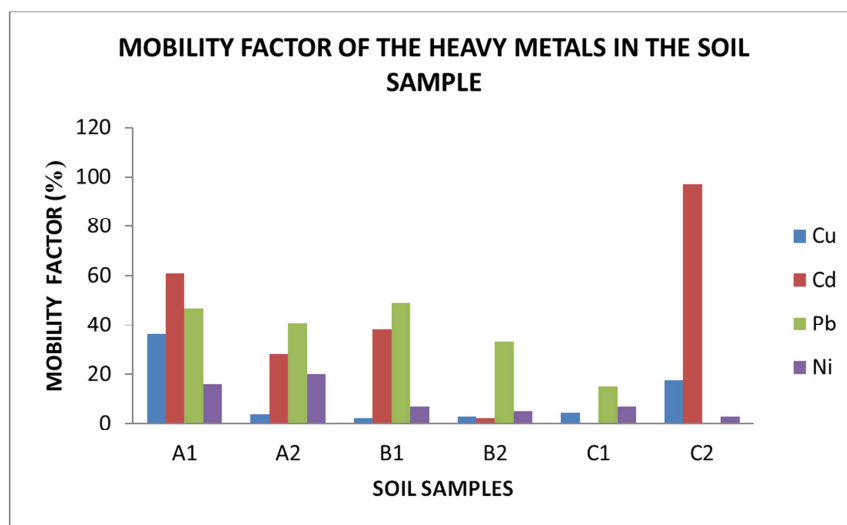F1 is Water soluble fraction

F2 is Exchangeable metal fraction

F3 is Carbon bound fraction

F4 is Reducible (Fe-Mn) bound fraction

F5 is Organic bound fraction

F6 is Residual fraction [11]

The sequence of Bioavailability factor in the experimented soil was Cd>Cu>Pb>Ni.

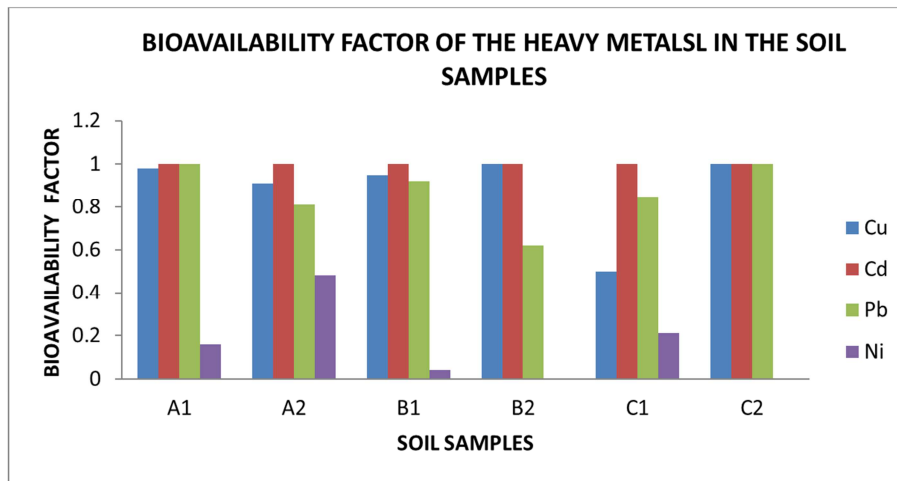**Figure 5.** Mobility Factor of Cu, Cd, Pb, Niin Dumpsite Samples and Garden Soil Samples.

Figure 6. Bioavailability factor of Cu, Cd, Pb, Ni in Dumpsite Composite Samples and Garden Soil Samples.

5. Discussion

5.1. Particle Size Distribution

The results shows that the soil samples from the various dumpsite has higher clay and silt content than the soil sample from the uncontaminated soil, this can be attributed to thefines emanating from the municipal solid waste deposited above the soil this correlates with reports from [8].

5.2. pH

The pHof the dumpsite oil samples were higher than pH of the uncontaminated soil sample, and this could be due to the effect of the waste on the soil, it might have contributed to the alkalinity of the soil [12]. The dumpsite soil contain higher soil organic matter content than the garden soil, the higher pH of the dumpsite soil might be a consequence of this. While that of the garden soil were slightly acidic. This observation was supported by Oyedele et al. (2008) [13]. This may favour nutrient solubility and availability to plant. The differences in the pH could be attributed to this report is in concordance with Amos et al. (2014) [9].

5.3. Cation Exchange Capacity

The higher CEC of the dumpsite soil samples might be attributed to the higher clay content and organic matter content of the dumpsite soil [9], and may lead to a ready uptake of heavy metal. This report correlates with that of Anikwe et al. (2002) [12].

5.4. Total Heavy Metal Concentration in Experimented Soil

The result of the total concentration of metal in both dumpsites soil and garden soil indicates the difference in parent material of the soil, properties of the soil and levels of contamination in each soil sample. High amount of Cu (32.51mg/kg), Cd (6.38mg/kg) and Ni 16.88(mg/Kg) were discovered at mechanic dumpsite, and this could be attributed to the anthropogenic activity in the area. For example, Cd could have been introduced from paint and coating used for vehicles corrosion resistance, might also come from Ni/Cd batteries, Cu may be as a result of inclusion of chalcopyrite in battery, but lead content is higher in residential dumpsite, this is because most of the source of lead pollution are domestic, such as jewellery, lead based pottery, lead based paints

The major use of Ni being an ingredient in steel and other metal product could have contributed to the amount of Ni found in the mechanic dumpsite [3].

All the soil samples showed high concentration of copper followed by lead, nickel and then cadmium. The low concentration of cadmium may be due to the weak absorption of cadmium in the soil this correlates with report of Jimoh et al. (2013) [11].

5.5. Total Organic Carbon and Total Organic Matter

The Total Organic Carbon value and the Total Organic Matter value of the soil samples from the dumpsite were higher than that of the uncontaminated soil sample; this may be due to presence of compostable waste in the dumpsite [14]. This report correlates with that of Amos et al. (2014) [9].

5.6. Sequential Extraction

The heavy metal fractions of Cu, Cd, and Pb were highly dominated in the carbon bound, reducible, organic bound, except for Nickel which was dominated in the residual fraction which is an implication that it is not readily available for plant uptake. A larger percentage of lead in the reducible form which correlates with reports by Jimoh et al. (2013) [11] could be attributed to ability of Fe/Mn oxides to scavenge metals from the soil solution that will normally not

precipitate [15]. Also the subsequent high lead content in the organic bound could be attributed to the fact that lead has a strong affinity for organic matter and the formation of its complex may greatly increase the mobility of lead in the soil [2]. Water soluble content of lead were found in a very small percentage hence the lead content of the soil sample may not be available to the plant through the soil solution.

5.6.1. Copper

The highest percentage of copper was found in organic fraction, this may be attributed to high formation constant of organic- Cu complex [16] and the obtained result is consistent with that of Jimoh et al. (2013) [11] who found significant amount of Cu associated with the organic bound fraction.

Under oxidizing conditions copper can be leached into the environment [17], becomes a mobile element which could be bioavailable for plant uptake.

5.6.2. Cadmium

For the residential dumpsite cadmium was found in the organic bound fraction with its surface sample of the mechanic workshop dumpsite higher than that of the residential dumpsite. This may be due to some variation in soil properties as B1 has a higher organic matter than A1, or due to the low solubility of cadmium carbonate and the low adsorption constant of the complex formed with the organic matter, Cd does not form stable organic complexes hence Cd is more concentrated in the carbonate fraction [18], this result correlates with that of Olajire et al. (2002) [19].

5.6.3. Lead

Higher percentage of lead was found in the non-residual fraction in all the sites this indicates that lead may be highly available for plant uptake, this may be a consequence of variation in some soil properties as some of the soil samples from the mechanic workshop dumpsite has a larger CEC than soil samples from the residential dumpsite, B2 has higher total organic matter and lesser alkaline pH value than B1, while A1 has a larger particle size than B1 (Amoo et al., 2014) [9]. A large percentage of lead in the reducible form correlates with reports by Jimoh, et al (2013). [11] could be attributed to ability of Fe/Mn oxides to scavenge metals from the soil solution that will normally not precipitate [16]. Also reported that the subsequent high lead content in the organic bound could be attributed to the fact that lead has a strong affinity for organic matter and the formation of its complex may greatly increase the mobility of lead in the soil as reported by Thomas et al (2015) [2].

5.6.4. Nickel

The larger percentage of Nickel in all the sites was found in the residual fraction hence it is going to be partially mobile and

bio available for plant uptake, while trace amount of Nickel was found in the carbon- bound, organic and exchangeable fractions of some of the soil samples, this implies that Nickel is strongly bound to minerals and resistant component and do not represent environmental risk. This result correlates with the observations of Olajire et al. (2002) [19]. Ni was not detected in the water soluble fraction in any of the soil sample. The high amount of cadmium in the non-residual fraction shows that it may be easily transported through the food chain through uptake by plants growing on this soil.

5.7. Mobility Factor and Bioavailability Factor

A high MF indicates a high a readily available heavy metal in the soil [20].

The indices of mobility of Cd and Ni were very low in B2 (subsurface sample of mechanic dumpsite soil sample), with Ni well below 50%, Ni is present majorly in the residual fraction, hence they are not readily available for plant uptake. This correlates with Olajire et al. (2002) [19] report, which may be due to high stability of heavy metals in these soil samples.

The Bf values of the heavy metals in the soil samples were found to be very high this may be linked to low organic matter content, hence less formation of insoluble compounds promoting the bioavailability of heavy metals.

6. Conclusion

The garden soil samples were slightly acidic while the soil samples from the two dumpsites were alkaline with a low organic matter content value. The heavy metal content of the soil samples from the dumpsite including the soil samples from the normal garden soil not subjected to the same conditions as the dumpsite were lower than the target value except for Cd at site B2. This may be due to nickel-cadmium batteries, phosphate fertilizers, detergents and refined petroleum products (Wuana et al., 2011) [3]. All the metals analyzed in this study has their higher concentration in the bioavailable fraction except Nickel, this poses a serious threat to the ecosystem, this also indicates their bioavailability to plant through plant uptake, to the water bodies through leaching and their bioavailability to man through the food chain. Among the contaminated soils, mechanic dumpsite had the highest heavy metal content and hence is the most contaminated soil when compared to the residential dumpsite. Hence it is important to desist from the habit of planting on refuse dumpsite. There is also a need to test for the physicochemical properties of dumpsite materials before using for compost that will be applied to the soil to enhance fertility. Policies which will prevent indiscriminate disposal of both industrial and municipal waste should be enacted.

Acknowledgements

Appendix

Appendix I

Preparation of 1.0 M Sodium Acetate Solution

136 g of sodium acetate was dissolved in 950 ml distilled water, proper mixing was done and the mixture was allowed to cool.

The pH of the mixture was adjusted to 8.2 by adding more acetic acid or sodium hydroxide

The mixture was topped up to 1 liter using distilled water.

Preparation of 1.0 M Ammonium Acetate Solution

57 ml of concentrated acetic acid was measured into a beaker containing 800 ml of distilled water using a measuring cylinder, 68 ml of ammonia was added to the beaker content and the mixture was properly mixed. The pH of the mixture was adjusted to 7.0 with dilute ammonium hydroxide or acetic ahead.

The mixture was made up to 1000ml with distilled water.

Appendix II

Preparation of 250 ml of $0.167 M K_2Cr_2O_7$

12.3 g of $K_2Cr_2O_7$ was dissolved in 250 ml of distilled water

Preparation of 0.5 M ferrous ammonium sulphate $Fe(NH_4)_2(SO4)_26H_2O$

198 g of ferrous ammonium sulphate was weighed and dissolved in 1000ml of distilled water.

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