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The Effects of pH On the Levels of Some Heavy Metals in Soil Samples of Five Dumpsites in Abeokuta and its Environs

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Abstract: ***The study shows the effect of pH levels of some heavy metals in soil samples collected from five dumpsites at Obada oko, Kobape, Idi-Aba, Osiele and Ijeun Titun, all within Abeokuta and its environs. Zinc, Cadmium and Lead in the soil samples of these locations were determined by digestion, then analysed using Atomic Absorption Spectrophotometer and the pH also analysed using calibrated digital pH meter. The data were subjected to statistical analysis using SPSS Version 20.0. The pH of the soil samples were inadequately and fairly acidic in nature with Zn higher concentrations observed in all the five dumpsites. However, the highest concentration of 107.20±0.8 µg/g was recorded in Zn at the pH of 6.45 but Cd had the lowest concentration of 3.32±0.0 µg/g, with Zn concentration of 75.75±0.2 µg/g at pH 6.10 respectively. Conclusively therefore, soil samples from dumpsites investigated could not be recommended for crop production due to the levels of Zn and Pb present which is high enough to cause toxicity of growing plants and grazing animals. Vegetables growing or grown on these soils could not be suitable for human consumption due to the likelihood of bioaccumulation of these toxic heavy metals.***

Keywords: pH, heavy metals, soil samples, dumpsites, bioaccumulation, toxicity

1. Introduction

Heavy metal, according to Alloways, 1990 can be defined as metals with density greater than $5gcm^{-3}$. It can also be referred to as metals discharged by industry, of which the metalloids such as Arsenic (As), Cadmium (Cd), Lead (Pb), Zinc (Zn), Copper (Cu), Chromium (Cr), Mercury (Hg) and Nickel (Ni) are listed by European Commission as greatest hazards to plants and animals. This is so because soil contamination due to waste materials used as fertilizers have been a matter of frequent concern to soil chemists. Since heavy metals in the composted product may be transferred from the soil to edible plants which invariably may be detrimental to both the plants and animals if they are present above certain limits (Thuy *et al*., 2007).

Soils from incinerator have the ability to accumulate trace elements from time to time and other contaminants that would have occurred in soil environment (Forstner and Withman, 1979). Incinerator such as remarkable for their ability to remove metal ions from aqueous solution by sorption reaction (Atmas, Salbu and Singh, 2000b). The major factors controlling the heavy metals exchange between the incinerator soil and other environmental bodies seem to be soil type, metal concentration, soil pH, solid solution mass ratio and contact time (Barrow, 1992). It has been shown that trace metals uptake is controlled not only by the soil types and soil conditions, but also by plant species around the incinerator (Barber, 1976). However, accumulation of heavy metals by plants grown in compost amended soil can be a serious problem that requires a continuous monitoring. Toxicity of heavy metals and their biological uptake by living organisms have shown to be best correlated with the free ions in soil solution which is in an agreement with the free metal ion hypothesis which states that the bioavailability of trace metals depends on the activity of free aquo ion (Lund, 1990). Soil pH has a great effect on the solubility or retention and lower solubility of metal cations occurring at high pH (Barrow, 1992). The soil pH has been defined as the parameter most widely accepted as exerting a controlling influence on the availability of micronutrients to plants (Sanders, 1982). Soil pH for instance is very important for most heavy metals since metal availability is relatively low when the pH is around 6.5 to 7. With the exception of molybdenum (Mo), Selenium (Se) and Arsenic (As), the mobility of trace elements is reduced with increasing soil pH because of the precipitation of these elements as insoluble hydroxides, carbonates and organic complexes. At high pH, ion hydrolysis (MOH) is favoured, and the energy barriers that must be overcome when these ions approach the surface of soil particles decreases (Yu *et al*., 1997).

Soil redox potential can also influence the solubility of heavy metals in the soil. For example, when oxidation reactions are involved, the solubility of heavy metals increases with decreasing pH whereas in reducing conditions, the solubility of heavy metals such as Zinc (Zn), Copper (Cu), Cadmium (Cd) and Lead (Pb) is higher in alkaline pH as a result of the formation of stable soluble organo-mineral complexes. On the other hand, if the pH ranges between 4 and 6, the solubility of these metals will be lower because of the formation of insoluble sulphides or insoluble organo-mineral complexes (Kiekens, 1983) and hence, the objective of this work is to investigate the effects of pH on the levels of some heavy metals in soils collected from five dumpsites at Abeokuta and its environs so as to ascertain the sustability of these soils therein for crop production and growing vegetables on these soils considered for human consumption particularly among the entire populace living in these areas.

2. Materials and Methods

Soil samples within 0-15cm depth collected in black polythene bags with soil auger from five different dumpsites namely (Obada-Oko, Kobape, Idi-Aba, Osiele and Ijeun-Titun) all within Abeokuta and its environs. The soil samples were air-dried and allowed to pass through a-2mm sieve in order to remove large debris and unwanted materials. They were thereafter labelled accordingly prior to analysis

pH of soil samples
pH 1:1 ratio of the soil samples in water was determined using a pH meter.

Wet digestion
The soil samples were digested in trioxonitrate (V) acid (HNO_3), perchloric ($HClO_4$) and after which the heavy metals namely Zinc (Zn), Cadmium (Cd), Lead (Pb) and copper (Cu) were determined by Atomic Absorption Spectrophotometer at wavelengths of 22.8nm, 324.7nm, 217nm and 324.7nm respectively.

3. Results and Discussion

The results of the pH and the effect on the concentrations of heavy metals studied are presented in the Table 1 below.

Table 1: pH and its effect on heavy metal concentrations in five different dumpsites

S/N	Location	pH	Zn	Cd	Pb	Cu
1.	Obada-Oko	6.30	98.90±0.5	9.45±0.1	48.70±0.3	9.10±0.2
2.	Kobape	6.45	107.20±0.8	4.95±0.2	38.95±0.1	6.90±0.3
3.	Idi-Aba	6.05	93.30±0.4	4.20±0.1	31.50±0.2	5.55±0.0
4.	Osiele	6.35	87.80±0.0	7.05±0.2	42.20±0.1	8.20±0.2
5.	Ijeun-Titun	6.10	75.75±0.2	3.32±0.0	29.45±0.0	5.25±0.1
	Mean					

The pH values were found to be slightly acidic in all the dumpsites investigated with the lowest value (6.05) observed for Idi-Aba and the highest value (6.45) obtained for Kobape. However, the pH values of the soil samples from five different dumpsites suggested the presence of heavy metals in these soils and thereby corroborating Barrow (1992) which stated that soil samples from dumpsite could retain heavy metals within a pH range of 2-8. This means to say that soil pH has been found to be the most widely accepted parameters which influences the availability of metals in the soils (Saunders, 1982). The concentrations of Zinc (Zn) were found to range between 75.75µg/g and 107.20 µg/g among the five different dumpsites investigated with the lowest concentration observed at Ijeun-Titun and the highest level found at kobape at pH 6.10 and 6.45 respectively. The increases in concentration of zinc (Zn) were observed at Obada-Oko and Idi-Aba at pH values of 6.30 and 6.05 respectively. However, zinc concentration at Osiele was 87.80 µg/g at pH 6.35. The highest value of Cadmium (Cd) (9.45 µg/g) was found at Obada-Oko and the lowest value of this element (3.30 µg/g) was found at Ijeun-Titun with the pH values of 6.30 and 6.10 respectively.

Lead concentrations on the other hand followed similar trends with cadmium but at much higher concentrations. For instance, at Obada-Oko, the concentration of lead was found to be found 48.70 µg/g at pH 6.30 whereas at Ijeun-Titun, the concentration of this heavy metal was found to be 29.45 µg/g at pH 6.10. Copper concentration was also found to be highest at Obada-Oko (9.10 µg/g) and lowest at Ijeun-Titun (5.25 µg/g) at corresponding pH values (6.30 and 6.10). The observed concentrations of heavy metals in soil samples of dumpsites investigated could probably due to the absolute concentrations of these metals within the soil samples taken which is strongly determined by the physio-chemical properties such as pH, organic matter and CEC (Ma *et al*., 1983) and (Morgan and Morgan, 1993). The observed higher concentrations of Zn and the observed lower concentrations of Cd in the five different dumpsites investigated followed similar trends reported by Sposite, 1992 for soils amended with sewage and this could be associated to the fact that dumpsites contain different wastes from different sources and the degree of decomposition cannot be adequately determined. Also, it could be assured to be associated with some chemical changes which occur in the soil samples as well as the forces of nature that could be attributed to different soil types and different levels of these metals in the soil.

4. Conclusion and Recommendation

Solubility of heavy metals is directly proportional to sorption capacity of residuals and soils. Soil pH and iron oxides are very important factors controlling metal solubility in these systems. The pH of the soil residual system is often the most important chemical property governing the sorption and precipitation of heavy metals in the soil. Application of residuals such as waste to the soil in the dumpsites affects phyto-availabiliity of heavy metals in the soils from dumpsites (Alloway and Jackson, 1991). In conclusion therefore, the soil samples taken from dumpsites investigated could not be used for crop production due to the levels of heavy metal present particularly Zinc (Zn) and Lead (Pb) whose concentrations were found to be toxic to the growing plants. Also, vegetables growing on these soils could not be suitable for human consumption and hence could not be recommended for the entire animal and human populace in these areas.

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