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Comparative Method of Acidic and Alkaline Digestion for Hexavalent Chromium in some Dumpsite soil of Lafia Metropolis

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ABSTRACT

The reduction of hexavalent chromium in soils of dumpsites in Lafia metropolis were determined by using digestion methods (alkaline and acidic digestion) and calorimetrically observed by Ultra Violet-Visible spectrophotometer at a wavelength of 540nm. Soil samples were collected from two dumpsites (Emir palace and Jos road) the concentrations of chromium in mg/kg in acidic (E_{A1-} E_{A3}) and alkaline (E_{B1}- E_{B3}) medium in sites E were E_{A1} 0.342, E_{A2} 0.364, E_{A3} 0.380, E_{B1} 0.374, EB_2 0.387, EB_3 0.400, while sites J were JA_1 0.388, JA_2 0.403, J_{A3} 0.453, J_{B1} 0.468, J_{B2} 0.474, J_{B3} 0.516 respectively. The concentration of chromium in soil of both sites is higher in alkaline medium than that of acidic medium which ranges from 0.342-0.380 (Acidic), 0.374 -0.400 (alkaline) dumpsite E (Emir palace dumpsite) and 0.388- 0.452 (Acidic), 0.468- 0.516 (Alkaline) dumpsite J (Jos Road dumpsite). The concentration of chromium in soil of both sites may have adverse effect on human health which may be attributed to dumping of refuse of household, structural components of condemned automobile parts and building materials into the dumpsite.

Keywords: Chromium, Dumpsite, Hexavalent, Lafia, Soil

INTRODUCTION

Dumpsite is a place where waste materials are disposed and is one of the oldest methods of waste disposal (Abdul-Sallam *et al.*, 2011). The disposal of waste to dumpsite is the most common methods of waste management and remains so in many places around the world. Most dumpsites are located within the vicinity of living communities (Ibrahim *et al.*, 2013). These wastes on dumpsite contain toxic metal, which are of great concern and pose dangers to the people in contact with the contaminated soil and plants. The chemical composition of the solid waste materials often leads to changes in soil physical and chemical characteristic due to contamination (Logan, 1992). The excessive input of un-separated municipal household waste may lead to changes in soil physicochemical properties that have serious impact on biophysical and chemical soil function functions, which may lead to accumulation of nitrates and heavy metals in soil (Anikwe and Nwobodo, 2002). Continuous disposal of municipal waste in soil may increase heavy metals concentration. However, heavy metals may have harmful effects on soil, crops, and human health (Smith *et al.*, 1996). No strong relationship between concentrations of heavy metals in soil and plant because it depends on many factors such as soil metal, bioavailability, and plant growth and metal distribution to plant part (Vousta *et al*, 1996). The dumpsites are not basement prepared for selective absorption of toxic substances hence it is susceptible to the discharge or pollutants to nearby water and to the air through leachates and dumpsite gases respectively (Abdul-Sallam, 2011). Industrialization population growth and unplanned urbanization have partially or completely turned our environment to dumpsites (Alimba *et al*, 2006). Poor urban planning, lack of enforcement of relevant laws, acts on waste disposal and lack of organized landfill sites add to the existence of dumpsite within living areas in developing nations, this results in discharge of domestic sewage and refuse into the environment untreated, (Abdul-Sallam, 2011). The surface runoff and leachates from dumpsite are sources of fresh water contamination. The general belief that wastes are sometimes hazardous to health cannot be over-emphasized un-control hazardous waste disposal leads to environmental pollution or contamination which consequently cause threat to health and may eventually leads to death. Exposure to multiple chemical combination in population living near waste dumpsite has led to series of human health disorder (Palmer *et al.*, 2005). Common problem emanating from abandoned dumpsite is the emergency of leachate caused by biochemical breakdown of organic or decomposable portion of the waste and the percolation of rain water through the waste (Adedara *et al.*, 2015). Leachates are liquids effluents produced by the decomposition of waste or by interaction of waste with rain water.

Heavy metals are natural component of the environment, they are present in rock soils, plant and animals, bond in organic and inorganic molecules or bound to particles in the air (Tan and Wong, 2000). Different definition has been used to explain heavy metals, some are based on density or atomic weight while some on chemical properties or toxicity. Recently, heavy metal is used as a general term for those metals and metalloids with potential human and environmental toxicity (Samar and Richard, 2009). Heavy metals are persistent in the environment because they are non-biodegradable and non-thermo degradable and readily accumulate to toxic levels. Heavy metals can accumulate in the soil at toxic levels due to long term application of waste water (Samara and Richard, 2009). Environmental pollution by heavy metal, even if it is at low concentrations and the long term cumulative effect health effects that go with it, is of major concerns all over the world for instance the bioaccumulation of lead (Pb) in the human body interferes with proper functioning of the mitochondria thereby impairing respiration as well as causing constipation, swelling of the brain, paralysis and cloud eventually lead to death (Oluyemi *et. al*., 2008). Heavy metals occur naturally in the ecosystem with large variations in concentration, in modern times, anthropogenic sources of heavy metals i.e. pollutions from the activities of humans, have introduced some of these heavy metals into the ecosystem. The presence of heavy metals in the environment is of great ecological significance due to their toxicity at certain concentrations, translocation through food chains and non- biodegradability which is responsible for their accumulation in the biosphere (Adekola *et al.,* 2008). Heavy metals like iron, copper, manganese and vanadium occur naturally in the environment and could serve as plant nutrient depending on their concentrations, arsenic (As), lead (Pb), Cadmium (Cd), Cobalt (Co), Chromium (Cr), and many others that are indirectly distributed as a result of human activities could be very toxic even at low concentrations. These metals are non- biodegradable and can undergo global ecological circles (Adekola *et al*., 2008). The use of dumpsite as farmland is a common practice in urban and sub-urban centres in Nigeria because of the fact that decayed and composted waters enhances soil fertility (Ogungbemi*et al.,* 2003). This waste often contains heavy metals like As, Cd, Hg, and Pb which are particularly hazardous to plant, animal and humans (Alloway *et al*., 1997). Municipal waste contains heavy metals such as As, Cd, Cr, Fe, Pb, Ni, and Zn which end up in the sink when they are leached out of the dumpsites, Soil is a vital resource for sustaining two human needs of quality food supply and quality environment. The present study is aimed at assessing the pollution status of the farm lands around the dumpsites in Lafia, the extent to which the crop plants grown on these farmlands were exposed to heavy metals, and hence, the safety levels of the plant leaves and the crop produced for human consumption.

MATERIALS AND METHODS

Study Area

Lafia is the capital of Nasarawa State as indicated in Figure 1. It lies between latitude of $8^{o}30^{'}$ $21^{'}$ north and longitude of 8^{o} 30' 20' East and Nasarawa state is located in the middle belt region and lies between latitude 7^{o} $45^{'}$ and 9^{o} $25^{'}$ N of the equator and between longitude 7^{o} and 9^{o} $37^{'}$ E of the Greenwich meridian, it shares boundary with Kaduna state in the North, Plateau State in the East, Taraba and Benue State in the South, while Kogi and Federal Capital territory flank it in the west (Marcus and Binbol, 2007).

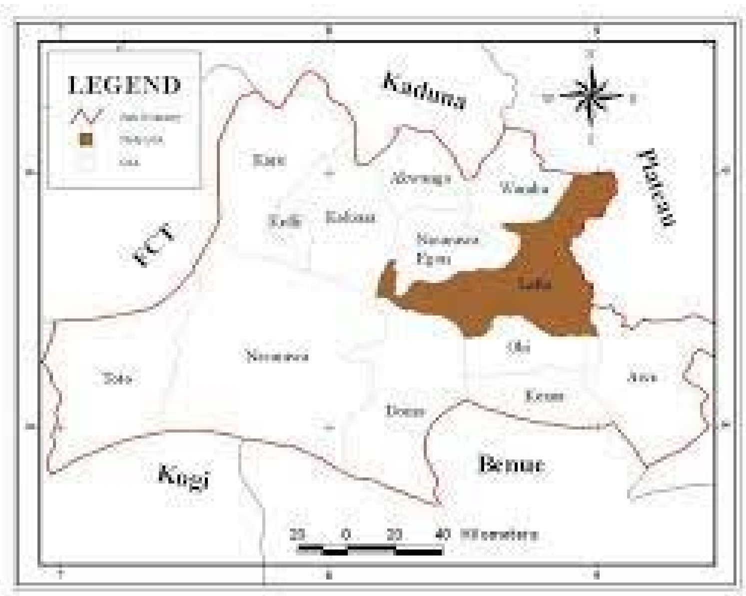

Figure 1: Map showing the study area

Samples collection and Preparation

Samples were collected from two different dumpsites, one location at a few kilometers from Emir's palace; the second at dumpsite along Jos road, soil samples were collected at the depth of 3 to 30 cm, from the surface as described by (Allen, 1974). From each dumpsite, the samples were placed in clean dried polythene bags, labelled and transported to the laboratory for analysis. The soil samples were air dried disaggregated with porcelain pestles and mortar through a 2mm mesh sieve for homogeneity, soil samples were analysed for the following parameters, pH, electrical conductivity, particles size, organic carbon, cation exchange and chromium.

DETERMINATION OF PHYSICOCHEMICAL PARAMETERS

pH

The pH of the soil samples were determined by measuring 10g of soil into a 250cm^3 conical flask where 100mL of deionized water was added and swirled for a little time and allowed to stand for 15 minutes, the pH of the soil was taken at the topmost layer of the solution using Suntex pH meter, standardized at pH 4.0, 7.0 respectively (Audu and Lawal, 2005).

Particle Size

Particle size analysis was done using capacity method described by (Black, 1965). A 100g of each of the air dried soil were weighed using a weighing balance, the weighed soil samples were transferred into an W.S. Tyler computerized Particle Analyzer which separates the soil into different segments according to the soil sizes, the biggest at top while the finest at the button end, the separate soil were weighed and taken for determination of water holding capacity. The particle sizes that did not allow easy passage of water through it were indicated as clay, while those that had moderate water holding capacity were recorded as the silt. The biggest particles, which did not hold water, were recognized as sand. The weights of the soil particles were used to calculate their percentage.

Cation Exchange Capacity (CEC).

The quantitative assessment of the ability of the soil to interact with cations is the cation Exchange Capacity (CEC) and is one of the most commonly measured properties of soil. The actual cations that occupy the exchange sites depend on the nature of the soil particles as well as other environmental circumstances, the Alkaline metal (N^+ and K^+) and the alkaline earth metal (Mg^{2+} and Ca^{2+}) are the most important exchange cations, and for many soils the quantitative order of their important is $ca^{2+}>Mg^{2+}>K^+>Na^+$. Only in specific circumstances do other metal cations contribute significantly to cation exchange capacity value (Walkey, 1934).

Determination of Organic Matter

The presence of the organic matter has a significant effect on the mobility and bioavailability of heavy metals (Weng *et. al.*, 2004). Soil organic matter is quite effective in retaining metals, Metal- Organic associations can occur both in solution and in the solid surface of native soil. Percentage organic matter was determined to Walkley Black Method (Walkley, 1934).

Determination of Heavy Metals

The digestion procedure used for determining heavy metals was described by Omojola, 1993.

RESULTS AND DISCUSSIONS

Table 1 shows the result of pH, electrical conductivity and organic matter from sampling sites; Emir Palace (E) and Jos Road respectively (J). The results of pH, EC and OM showed that the pH of a soil has a major effect on the metal dynamics, because it controls adsorption and precipitation, which are the main mechanisms of metal retention in soils. As pH increases the solubility of cationic forms of the metal in the soil solution decreases and therefore become more readily available to plants. The pH value for the normal soil is 5.5-7.5, pH of the soil below. This range can cause to the availability of some essential minerals needed by the soil. The pH value of all the soil samples ranged from 7.10 – 7.56, all the values range from neutral to basic. This is within the range of 5.5- 7.5 reported by Iyaka and Kakulu, (2009). Sample with a lowest pH value of 7.10 may have greater solubility for the metals. Therefore, becoming more readily available for plants. Conductivity measurements range from 70 - 130µs/cm. These values indicate the relative water-soluble salt content of the soil. Electrical conductivity depends on the amount of dissolved mineral and gives the ability of a substance to conduct an electric current at a specific temperature (25^{o}C). The results of soil organic matter range from 2.09 – 2.16 and 2.02 – 2.12 respectively soil organic matter has influence on soil structure, water holding capacity, nutrient contribution, biological activity, water and air in filtration rate and pesticide activity. A soil with a high level of organic matter is an indication of cation exchange capacity, holds more water and increases biological activities (Horwath, 2005). The presence of soil organic matter is regarded as being critical for soil function and soil quality, it increases soil fertility by providing cation exchange sites and acting as reserve of plant nutrients. The concentration of soil organic matter ranges from 1%- 6% of the total top soil mass for most upland soil whose upper horizons consist of less than 1% of the organic matter are mostly limited to desert area while the soil organic matter content of soil in low-lying, wet areas can be as high as 90%.Therefore, the soil organic matter for the samples analyzed ranged 2.02 – 2.16% which is within the range for the upland soils.

While Table 2, shows the variation of soil particle size and texture in same sampling sites where the textural classes of the soil samples varied from sandy to loamy. The particle size distribution of the soil showed that the soil contains higher composition of loamy than silt and clay in all the sampling sites. Determination of metals has preferential accumulation in clay and silt fraction of soil. Generally, the concentration of heavy metals in soil increases with decrease in the size of the soil particles (Ajayi *et al*., 2014).

Table 1: pH, electrical conductivity, organic matter of the soil samples from E and J sites

Sample code/ Soil	pH^- H_2O	pH^-CaCl_2	Electrical Conductivity (µs/ cm)	Organic matters (%)
E_1	7.45	7.02	70	2.09
E_2	7.50	7.20	85	2.14
E_3	7.56	7.37	90	2.16
J_1	7.10	6.50	110	2.02
J_2	7.14	6.65	120	2.06
J_3	7.54	7.01	130	2.12

Table 2: Particle size and texture of soil sample of E and J sites

Sample code/	Sand (%)	Silt (%)	Clay (%)	Texture
E_1	81.4	1.4	7.2	Sandy loamy
E_2	91.4	1.5	7.3	Sandy loamy
E_3	91.6	3.4	15.3	sandy loamy
J_1	81.6	1.4	9.1	loamy
J_2	89.3	1.5	9.2	loamy
J_3	89.6	3.4	14.7	loamy

Tables 3 – 6 shows the levels of exchangeable bases (EB), cation exchange capacity (CEC), heavy metal concentration, the concentrations of the digested extract in acidic and alkaline medium and the calibration curve values of the soil samples in both Emir Palace and Jos Road dumpsites samples.

The results of the effective cation exchange capacity were obtained by summing up the values of the exchangeable acidity, cation exchange capacity (CEC), which is the measure of the soil ability to hold positively charge ions. It is a very important soil property influencing soil structure stability nutrient availability, soil pH and soils reaction to fertilizers (Hazleton and Murphy, 2007). The CEC of soils varies according to the percentage of clay in the soil. The types of clay, soil pH and amount of organic matter. Organic has a very high (CEC) ranging from 250 to 400mg/ 100g (Moore, 1998). Soils with a low CEC are more likely to develop differences in potassium, Magnesium and other cations while high CEC soil is less susceptible to leaching of cations (CuCE, 2007). The results ranged from 3.33mol./kg to 4.04mol/Kg a higher CEC usually indicates more clay and organic matter present in the soil resulting in greater water holding capacity.

The concentration of heavy metal ranges from 0.351- 0.435, 0.037- 0.059, 0.827- 1.075, 4.688 – 9.329 mg/kg for Pb, Cr, Cu and Fe respectively. The presence of these metals might be a result of absorption of the metals from anthropogenic source, adsorption, and the natural occurrence of heavy metal in the soil. The mobility of heavy metals depends on the soil metal properties and the environmental factors (Fagbote *et al.*, 2010). All the values were below WHO (2004) and FAO (2011) standard. The order of occurrence is Fe > Cu > Pb > Cr. The high concentration of Fe recorded can be attributed to the burning of electronic gadgets containing iron at the Study area E and J

From the concentration of the soil samples in both acidic and alkaline medium, it was observed that the alkaline medium is higher than acidic medium in both sites E and J.

Table 3: Exchangeable ions and cation exchange capacity (CEC) of soil samples

Sample code (mol/Kg)	Na^+(ppm)	K^+(ppm)	Mg^+(ppm)	Ca^+(ppm)	CEC
E_1	0.08	0.23	0.32	2.11	3.33
E_2	0.09	0.24	0.36	2.28	3.48
E_3	0.10	0.30	0.40	2.32	3.54
J_1	0.09	0.32	0.26	2.08	3.40
J_2	0.14	0.34	0.28	2.36	3.90
J_3	0.16	0.35	0.30	2.45	4.04

Table 4: Heavy metal concentration of the soil samples (mg/kg)

Sample Code	Pb	Cr	Cu	Fe
E	0.351	0.059	1.075	4.688
J	0.435	0.037	0.827	9.329

Table 5: Concentration of digested extracts in acidic and alkaline Medium of Emir Palace

Acidic medium

S/N	Sample Code	Concentration
1	EA_1	0.342
2	EA_2	0.364
3	EA_3	0.380

Alkaline medium

S/N	Sample Code	Concentration
1	EB_1	0.372
2	EB_2	0.387
3	EB_3	0.400

Table 6: Concentration of the digested extracts in acidic and alkaline medium for Jos Road

Acidic medium

S/N	Sample Code	Concentration
1	JA_1	0.388
2	JA_2	0.403
3	JA_3	0.452

Alkaline medium

S/N	Sample Code	Concentration
1	JB_1	0.468
2	JB_2	0.474
3	JB_3	0.516

CONCLUSION

The study carried out successfully revealed that the concentration of chromium in dumpsite soil were higher in alkaline medium than the acidic. This concentration may have some adverse effect on human living in the neighborhood of the dumpsite and also plant growth in that location. Therefore, emerging technologies for cleaning up contaminated sites, which is cost effective and has aesthetic advantages and long-term applicability should be adopted on such sites.

Declaration of conflicting interests

The authors declared no potential conflicts of interest.

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