

## Assessment Of Heavy Metals Content In Soils And Plants Around Waste Dumpsites In Uyo Metropolis, Akwa Ibom State

By

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### -----ABSTRACT-----

The levels of heavy metals were assessed in five randomly chosen dump sites. Twenty soil samples were drawn at the depth of 0-15cm and 15-30cm on each of the two sampling points of the five randomly chosen locations and six samples from three locations away from the dumpsites. The result of the analysis carried out showed that the level of heavy metals were generally higher at surface soils than subsurface soils, with mean values of 1059.2mg/kg and 695.8mg/kg for Iron (Fe) surface and subsurface, respectively against control value of 665.3mg/kg. The mean value for lead (Pb) was 99.1mg/kg and 95.2mg/kg for surface and subsurface, respectively, against control soil of 15.8mg/kg and 13.6mg/kg for surface and subsurface soils, respectively. Nickel (Ni) was 308.5mg/kg and 5.9mg/kg for surface and subsurface, respectively, and a mean value of 1.13mg/kg (surface) and 0.9 (subsurface) for control. Chromium (Cr) was 2.2mg/kg and 2.1mg/kg for surface and subsurface, respectively. The level of Cr in the samples from control site was 0.3mg/kg for surface and subsurface soil. This indicates a higher concentration of heavy metals at the surface soils than subsurface and a high concentration at waste dumpsites than control sites. Assessments of some physicochemical properties of these metals were also carried out. The results show that the soils around the dumpsites were acidic with mean pH of 6.1. Organic matter had a mean value of 4.4%, available phosphorus was 23.3mg/kg, clay was 6.8% and effective cation exchange capacity (ECEC) was 10.6%.

**KEYWORDS:** Heavy metals, dumpsites, control sites, surface and subsurface soil

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## I. INTRODUCTION

### 1.1 Background to the Study

Heavy metals are metals and metalloids having atomic densities greater than 5g/cm<sup>3</sup> (Wild, 1993). They include mercury, zinc, copper, cadmium, lead and nickel among others. At some levels of exposure and absorption, they are harmful to most living things. Heavy metals are released into the environment through man's industrial, domestic and commercial activities, industrial effluents, pesticides and fungicides as well as manure from poultry farms. In Akwa Ibom State and in Nigeria as a whole leachates from dumpsite constitute a major source of heavy metal pollution. Due to the rapid increase in the population of Uyo and urbanisation, a high degree of generation of solid waste is taking place at a rate faster than they can be evacuated. Municipal solid waste usually contains paper, food waste, metal scraps, glass, ceramics, ashes, etc. Decomposition or oxidation process releases the heavy metal contained in these wastes to the soil of the waste dumpsite thereby contaminating the soil. Very often waste dumpsites around Uyo are sometimes utilised for cultivation of crops resulting in increased metal uptake by these crops. According to John, *et al.* (1972), the bio accumulation of these metals in plant tissue constitutes a hazard to man on consumption. The higher the concentration of these metals in soils, the higher the uptake by plant. Apart from uptake by plant, they can also be leached into underground water sources. Voogt, *et al.* (1980) noted that even slow movement of heavy metals in the soil profile may result in the deterioration of ground water quality. Other sources of heavy metals in the environment include: gas from automobile exhaust fumes, and chemical discharges from industries into the soil. Once these metals enter the soil, they are not static but are absorbed by plant, which is a source of nutrient to man.

Chemical agents such as heavy metals in human environment contribute to premature death of millions of people mostly infants and children. This environmental contaminant is a serious problem facing man in recent years. Since these metals constitute a hazard to man and other living things they require a more serious attention. One of the major sources of heavy metal in Nigeria is leachate from waste dumpsite. Collection and disposal of solid waste has therefore become one of the greatest problems facing Akwa Ibom State today. In Uyo metropolis the capital of Akwa Ibom State, waste dumpsites are still found in some streets despite government's effort to evacuate them. Since municipal wastes usually contain materials capable of releasing heavy metal on decomposition or oxidation process, they can be harmful to the environment and organism. These metals are non degradable in soil and gradually bio-accumulate until it reaches toxic level. Plants grown on such soils pick up these metals and transfer them to man, the ultimate consumer of such plants. This sometimes leads to death of these consumers.

According to Alloway (1996), toxicity sets in when the heavy metal content in the soil exceeds natural background level. This may cause ecological destruction and deterioration of environmental quality, influence yield and quality of crops as well as atmosphere, and health of animal through food chains. In most cases in Uyo, crops are cultivated on and around the waste dumpsites. These crops have the tendency to accumulate heavy metals in their edible parts and consumption by man may result in severe implication on health. The problem therefore is lack of awareness of the likely effect of cultivation and consumption of crops cultivated on such soils. The aim of this study is to investigate the total content of heavy metals in soil in selected refuse dumpsite in Uyo metropolis.

The objectives of this study are to:

- [1] determine the physicochemical properties of soil around dumpsites;
- [2] assess the levels of heavy metals in soils around the waste dumpsites; and
- [3] assess levels of heavy metals in plants around the waste dumpsites.

The significance of the study include:

- [1] The study will provide more information on the levels of heavy metals present in waste dumpsites and the potential uptake of these metals by crops growing on these sites.
- [2] The study will also help in estimation of ways to protect the health of people living in Uyo metropolis, the maintenance of environmental quality and to provide a basis for encouraging people to undertake proper care in the handling and disposal of solid waste.

## **II. COMPOSITION OF A TYPICAL WASTE DUMP**

The world is undergoing a silent epidemic of environmental metal poisoning from the ever increasing amount of metals being introduced into the biosphere (Alloway, 1990). Pollution by heavy metals occurs largely from industrial, domestic and agricultural wastes as well as from combination of fuel from automobile. In Nigeria and many third world countries, domestic waste and waste from small-scale industries are deposited in refuse dumps. The composition of these dumps varies from site to site and depends on the peculiarities of the neighbourhood. A typical waste dumpsite consist of leaves, plastics discarded cans, tins, pails, motor and machine parts of various stages of corrosion, rags and textile, dry cell and plants, etc (Holderness, Alonge, Ikeobi and Thompson, 1982). Many of the sites contain significant amount of ashes due to dumping of ash and the burning of refuse on the dumpsite from time to time. This burning gets rid of the organic materials and oxidises the metals leaving the ash richer in metal content. The process of oxidation and corrosion makes the metal soluble and leached into the soil from where they are picked up by plants, thereby entering the food chain. Some of these metals get washed into streams and rivers during rain thereby contaminating them. Since these metals can accumulate in fish and other aquatic organism. If fishes from the contaminated rivers and streams are consumed, it may cause health problems to the consumers (Vasques, *et al.*, 1993). Martins, *et al.* (1982) and Ibok, *et al.* (1989) discovered in their studies of effect of heavy metals on industrial wastes that industrial wastes are often contaminated with heavy metals such as Hg, Cd, Pb, Cr and Cu. Also heavy metals contained in pesticides, herbicides and fertilisers applied on agricultural lands are released on the soil. These percolate through the soil layer to contaminate underground water. Enwazor, *et al.* (1989) discovered that despite slow transport through the soil, these metals may eventually lead to the deterioration of ground water quality.

Hewitt (1990) in the study of soils and dust samples collected around the city of Cuera, discovered a high concentration of Pb, Cd and Zn in these soils. Carlson (1976), Purves (1973) and Alloway (1996) in studies of trace elements found out that municipal wastes may contain paper, food waste, metal, glass, ceramics, ashes and heavy metals from these wastes can accumulate and persist in soil at environmentally hazardous levels.

### 2.1. Heavy Metals in Soil of Waste Dumpsites

Alloway (1990) determined the concentrations of heavy metals (Zn, Cu, Cd and Fe) in the top soil of refuse dumpsite in Abeokuta and discovered a higher concentration of heavy metals in the refuse dumpsites than control. These show that dumpsites are major sources of environmental pollution. Oni (1987) found out that the effect of dumping industrial waste on land-fill sites has been found in shallow wells and in later years in deep wells.

### 2.2. Heavy Metal Bio-availability in Waste Dump and Plant Uptake

Amusan, *et al.* (2005) in their study of characteristics of soils and crop uptake of heavy metal in municipal waste dumpsite in Nigeria established that soil of municipal waste dumpsites are higher in heavy metal concentration and that crops growing on the dumpsites bio-accumulate considerably higher metal content than those on normal agricultural soils. They also observed that crops differ in their ability to uptake metals. Soils are able to biodegrade almost all organic compounds found in waste, converting them into harmless substances. However, inorganic products such as heavy metals are non biodegradable, thus they persist and accumulate in the soil Alloway (1996) observed that heavy metals can accumulate and persist in soils at environmental hazardous levels to crops and human health. Amusan, *et al.* (2005) observed that very often, dumpsites are used as fertile ground for cultivation of crops which result in increased uptake of heavy metals by the cultivated crops, either as mobile ions or through foliar absorption. Cadmium is a heavy metal with no biological roles. It is used for electroplating, paint pigment and plastic stabilisers. Cadmium input in the soils comes mainly from atmospheric deposition and animal feeds, industrial process and application of fertilisers containing cadmium. Voogt, Van, Fermstra and Copus (1980) maintained that cadmium can be taken up by plant such as maize, spinach, wheat and rice. It is capable of accumulating in food chains and its uptake is irreversible and its excretion is very slow, it is therefore very toxic in nature.

Uba, *et al.* (2008) in their assessment of heavy metals bioavailability in Zaria, Nigeria discovered that total extractable cadmium was found to be above the critical permissible concentration of 3.0 mg/kg. USEPA (1986), in all the dumpsite soils studied, concluded that cadmium batteries and scraps dumped from industrial and residential areas might have contributed to the high concentration of Cadmium in those sites. They also discovered an appreciable percentage of total extractable cadmium in the mobile phase which implied a potential bioavailability for plant uptake, cadmium is relatively easily taken up by plants and food intake of grains and vegetable products is the main source for human exposure except for smokers and those exposed through certain occupations. Crops uptake often increases with salt concentrations in the soil solution. Voogt, *et al.* (1980) maintained that cadmium uptake from soil to plant is influenced by a number of factors which are related to both site and soil properties, weather condition, plant species and cultivar. They also confirm that the interaction between soil and plant also plays a role. And further went on to say that the most important soil properties that affect uptake of cadmium in crops are probably cadmium level in soil and the soil pH. Uptake generally increases with increasing cadmium levels and decreasing pH. Other soil factors that are important in crop cadmium uptake are organic matter content, micro nutrient levels, and clay content. Over 80% of lands in Nigeria is cultivated with application of nitrate and phosphate fertilisers to increase nutrient in the soils, but becomes a problem when applied in excess and over a long period. Udosesien (2000) discovered that this process has resulted in the contamination of soils and plants with heavy metals.

### 2.3. Heavy Metals Pollution and Human Health

Heavy metals are common components of natural systems. Some are essential for living organism, but man's activities have increased the quantities and distribution of these metals in the site (water, rivers, lakes, streams and seas) and in the atmosphere. Heavy metals are highly toxic when present in these systems in high concentration and when they accumulate above maximum levels in any physiological system, they tend to be highly injurious to health.

Metals like mercury, silver and copper can attack sulphur. For example, mercury atom which is smaller has a stronger affinity for the large negative sulphur atom with its exposed electrons thereby causing a breakage of the disulphide bridge thus incapacitating the functioning of the proteins in the cell (Kabbe, 1975). Lead Pb, copper, and cadmium combine with the sulphur hydryl/group (-SH) and interfere with enzymes of other substances in the body as well as interfering with the passage of nutrients in and out of the cell (Kabbe, 1975). Copper intake in excessive doses leads to severe mucosal irritation, widespread capillary damage and central nervous system irritation followed by depression. Severe gastrointestinal irritation and possible necrotic changes in the liver and kidney could also occur (WHO, 1984). Lead (Pb) is known to present environmental problems worldwide because of its wide application in industries.

The result of toxicology studies on lead (Pb) have shown that this metal is not only a neurotoxin but has been linked up with several symptoms such as fatigue, loss of appetite, constipation, colic anemia, neuritis, seizure, general weakness, insomnia, hypertension and renal dysfunction, sperm count depression and death (Udosen, 2000). Lead (Pb) is known to be a cumulative metal and it is capable of inducing abdominal pains, vomiting, drowsiness and paralysis, convulsion, dysfunction in kidneys, reproductive system, liver, the brain and central nervous system (Goldsmith and Hildyard, 1988).

Oni (1987) in the book “Water quality surveillance and treatment”, pointed out that industrial manufacturers may endanger public health by discharging heavy metals into water which may cause taste and odour problems, contaminate irrigated food crops and kill fishes and other natural life in the rivers. According to Christman, Mar, Welch and Carlson (1974), an example of a disaster resulting from contamination of the environment by heavy metals was the outbreak of Minamata disease in Japan, which was caused by methyl mercury poisoning. Forty four people died between 1953 and 1961 from mercury poisoning as a result of eating fish caught from Japan’s Minamata bay. The authors observed that this mercury poisoning resulted from industrial waste containing mercury compound which was discharged into the bay. Fish in the bay accumulated mercury compounds through food chains and were in turn caught and eaten by people as well as cats that frequented the dock.

Chromium metals exist in 2+, 3+, 5+ and 6+ oxidation states. Of all these, 6+ state is the most toxic. Chromium is carcinogenic: its poisoning cause irritation to eyes, nose, and throat. Chronic exposure may lead to liver and kidney damage. In the cell, toxicity of chromium may result in chromosome abnormalities (Burrell, 1977). Copper and zinc are essential in human metabolism. However, high level of copper in man has been implicated in necrosis of hepatic parenchyma cell and in Wilson’s disease (Howel and Kumralilake, 1985). High concentration of Cu in water may affect aquatic lives, while intake of excess dose by man leads to severe mucosal irritation and convulsion, capillary damage, hepatic and renal damage (Duffus1980). Zinc is highly toxic to aquatic fauna and flora. Manganese occurs as insoluble oxides and exists in exchangeable forms associated with colloids and as organic complexes. It is absorbed in organic complexes in man, excessive amount of manganese causes cramp, tumours, hallucinations, magnetic pneumonia and renal degeneration (Duffus, 1980).

Nickel, although a micronutrient to most organisms, is known to be carcinogenic when consumed in excessive quantities (Duffus, 1980). It leads to respiratory disorder, lung cancer, dermatitis and inhibition of enzymatic activities in the body and inhibits photosynthesis and respiration in plants (Bazzaz, *et al.*, 1979). Vanadium is also a micronutrient but when accumulation reaches toxic levels it causes oxidation and synthesis of cholesterol in animal and interferes with synthesis of photosynthesis and amino acid (Duffus, 1980). Iron occurs in the water from rock sources such as iron pyrite (FeS), Ferrous carbonate (FeCO<sub>3</sub>). High concentration of iron in water is hazardous to health Voogt, et al. (1980). Umeweke (1995) reported that 0.12 mg/L of iron in water is injurious to health and can also cause turbidity and can add objectionable taste and odour in water.

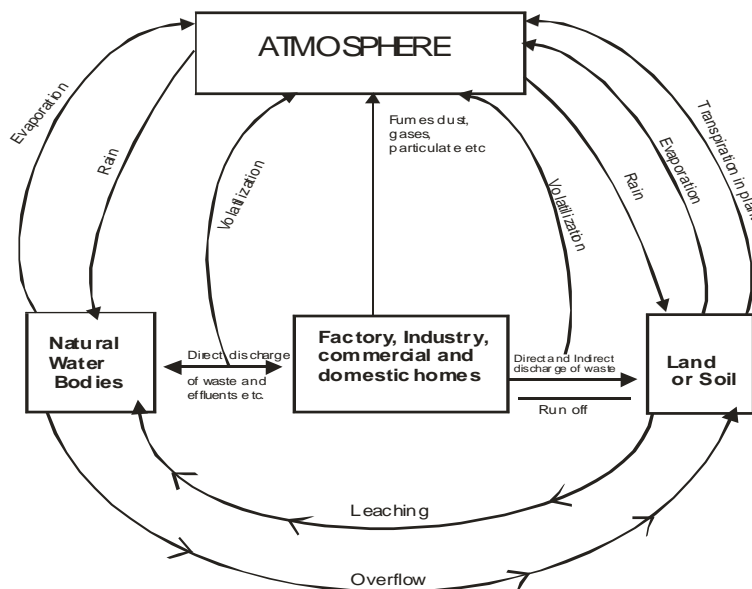


Fig. 1: Environmental pollution cycle

### III. MATERIALS AND METHODS

#### 3.1. Description of Study Area

Uyo, the capital city of Akwa Ibom State is located on the north west of the State. It extends from latitude  $7^{\circ} 47'$  to  $8^{\circ} 03'$  North and longitude  $4^{\circ} 52'$  to  $5^{\circ} 07'$  East. By 1991, the population of Uyo Urban was 118, 250. The mean annual temperature in Uyo Urban is  $27^{\circ}$  C. The relative humidity varies through the year from 70 – 80%. The mean annual rainfall is 2484mm. The city has two distinct seasons, namely; dry and rainy seasons. The dry season usually starts in November and ends in March. The rainy season starts usually in April and end in October. The prevailing wind blows from south west in the wet season and from north east in the dry season. Uyo is within the modified rainforest zone now called oil palm bush. This type of vegetation is however disappearing due to urban development. The topography of the area is generally undulating, except in the north eastern part that is occupied by Valley of Ikpa River which runs in a North West southwest direction. Parts of the valley are so steep that they are described as ravines. This topography poses a major limitation to physical development of the city; attention has been given to the stabilisation of the slope to protect the city from further encroachment by ravines. These areas have been turned into conservation areas and utilised for purposes that do not require buildings.

#### 3.2 Sample Collection and Sample Treatment

Twenty soil samples were collected from five waste dumpsites. In each dumpsite, four soil samples were collected at a depth of between 0-15cm and 15-30cm. Six samples were also collected from three locations away from the dumpsites, at depth of between 0-15cm, and 15-30cm plant samples: cocoa yam (*colocasia*) were also collected at dumpsites and some distances away from the dumpsites. Both plant and soil samples were packed in separate bags and taken to the laboratory for analysis.

- [1] **Soil Samples:** At the laboratory; the sample soils were air dried and ground to powdery form using a pestle and mortar. The sample was sieved with a 2mm sieve. The soil sample (1g) was weighed into a digestion flask. Concentrated nitric acid (20ml) was added and the mixture was digested using hot plate. After digestion it was allowed to cool and 30 ml of distilled water was added and filtered with Whatman filter paper. The digest was made up to 50 ml solution with distilled water. Then, the digest was sent to Aluminum smelting company of Nigeria (ALSCON) for the determination of heavy metals using Unicam 939 model of atomic absorption spectrometer (AAS).
- [2] **Physicochemical Properties Analysis**
- Soil Particle Analysis:** This was done according to the hydrometer method described by Bouyoucos (1951). The air-dried soil sample (50g) was used for the determination.
  - Hydrogen Ion Concentration (pH):** This was determined in 1:2:5 soil / water ratio using pH meter (Hanna instrument model 209).
  - Electrical Conductivity (Ec):** The electrical conductivity of the soil was measured with digital conductivity meter using the same soil solution that was used in determining pH.
  - Soil Organic Matter:** The soil organic matter was determined using the wet acid dichromate digestion and ferrous ammonium sulphate titration method.
  - Total Nitrogen:** The total Nitrogen was determined using the kjeldahl digestion method. The ammonia in the digest was absorbed into boric acid mixed indicator solution and then titrated with standard 0.01M  $H_2SO_4$ . The soil samples (2g) were digested into 50ml solution, and then 20ml of the digest were used for the determination of total nitrogen.
  - Available Phosphorous:** This was extracted using bray P1 and P2 extractant (Bray and Kurtz, 1945) and P in the extract was measured with spectrometer (model spectronic 20D) using the molybdenum blue colour method.
  - Exchangeable Bases:** This were extracted with 1M  $NH_4OAC$  (pH 7) solution. The concentrations of K and Na in the extract were determined using Flame analyser (Model FP640) while Mg was obtained by versenate titration.
  - Exchangeable Acidity:** ( $Al^{3+}$  and  $H^{+}$ ) were measured after extracting the soil samples with 1M KCL and titrating against 0.01M standard solution of NaOH.
  - Effective Cation exchange capacity (ECEC):** This was computed by the summation of exchangeable bases and exchangeable acidity.
  - Base saturation (BS):** BS was computed as the sum of basic cations expressed as percentage of ECEC.



(iii) **Plant Samples:** The plant samples were oven dried at 80°C for twenty four hours. The samples were ground to a powder. The same method as in soil sample was used to digest the plant sample and was sent to Aluminum Smelting Company of Nigeria (ALSCON) for the determination of heavy metals using Unicam 939 model of atomic absorption spectrometer (AAS).

## IV. RESULTS AND DISCUSSION

### 4.1 Physicochemical Properties of Study Area

Table 1 shows the physicochemical properties of the study area. The soil Hydrogen ion concentration (pH) ranged from 5.1 to 6.5, with mean values of 6.1 for both surface and subsurface soil. The result show that the pH of the study area ranged from strongly acidic to very strongly acidic (Enwezor, Udo, Chude and Usoro, 1989), while control soil has a pH of 5.5 and 5.1 for surface and subsurface, respectively. Electrical conductivity (Ec) ranged from 0.1ds/m to 0.5ds/m, with mean value of 0.2ds/m and 0.3ds/m for surface soil and subsurface soil, respectively, and 0.1ds/m for both control surface and subsurface soil. Organic matter (OM) ranged from 1.5% to 6.1% with mean values of 4.4% and 4.2% for surface and subsurface soil, respectively. The control soil has 0.4% and 0.04% organic matter in surface and subsurface soils, respectively. The organic matter in the study area was higher than the control.

This may be due to the poor drainage of these waste dumpsites which inhibits the activities of microorganisms that decomposes organic residues, leading to accumulation of organic matter. Total nitrogen (N) ranged from 0.04% to 0.4%, with mean of 0.1% for surface and 0.07% for subsurface. Available phosphorous (p) ranged from 11.3mg/kg to 57mg/kg with mean values of 23.3mg/kg for surface 22.3mg/kg for subsurface soils. Control soil is 57mg/kg and 52.33mg/kg, respectively. Calcium (C) ranged from 1.7 cmol/kg to 10.1 cmol/kg with mean values of 5.4 cmol/kg and 4.7 cmol/kg for surface and subsurface soils, respectively, and 2.0 cmol/kg and 1.7 cmol/kg for control surface and subsurface soils, respectively. Magnesium (Mg) ranged from 0.6 cmol/kg to 3.4 cmol/kg with mean values of 2.2 cmol/kg and 2.2 cmol/kg for surface and subsurface soils, respectively. Control soil has values of 1.0 cmol/kg and 0.6 cmol/kg for surface and subsurface, respectively. Sodium (Na) ranged from 0.04 cmol/kg to 0.01 cmol/kg, with mean values of 0.01 cmol/kg for both surface and subsurface and 0.07 cmol/kg for both control surface and subsurface soil, potassium (K) ranged from 0.07 cmol/kg-0.1 cmol/kg, with mean of 0.1 cmol/kg for surface and 0.10 cmol/kg for subsurface soils of waste dump, while K in control soil is 0.7 cmol/kg for both surface and subsurface. Exchangeable acidity (EA) ranged from 2.0 cmol/kg-3.3 cmol/kg with mean of 2.7 cmol/kg and 2.6 cmol/kg, and 2.1 cmol/kg and 2.0 cmol/kg for control surface and subsurface, respectively, Effective cation exchange capacity (ECEC) ranged from 4.4 cmol/kg-16.8 cmol/kg with mean of 10.6 cmol/kg and 10.0 cmol/kg for surface and subsurface, respectively, and 5.2 cmol/kg and 4.4 cmol/kg for control surface and subsurface, respectively. ECEC was higher in the dumpsite soil than the control; this shows that waste dumpsite has higher nutrient storage capacity. Hence, waste dumpsites soils are more fertile soils. Base saturation (BS) ranged from 54.8%-81.5% with mean value of 74.0% and 73.0% for surface and subsurface soil, and 59.71% and 54.8% for control surface and subsurface soils, respectively. Sand ranged from 62.8%-83.3% with mean of 74.0% and 73.0% for surface soil and sub surface soil, respectively. The control soil is 83.0% and 82.0% for surface and subsurface. Silt ranged from 5.7%-16.8% with mean of 12.4% and 12.1%, and 6.7% for both control surface and subsurface soils. Clay ranged from 10.3%-20.4% with mean of 6.8% and 17.5% for surface and subsurface soils, respectively, and 10.3% and 12.3% for control surface and subsurface soils, respectively.

**Source:** Author's Field work, 2010.

Table 1a: Physicochemical properties of the study area

Lab/No	Depth (cm)	pH	EC ds/m	Organic matter (%)	Total nitrogen (%)	A.V.P mg/kg-1	Exchangeable bases						Particle size analysis			
							Ca	Mg	Na Cmol/ kg	K	EA	ECEC	B.S (%)	Sand (%)	Silt (%)	Clay (%)
1	0-15	6.12	0.162	5.40	0.14	13.33	10.08	3.43	0.07	0.10	3.10	16.78	81.53	68.40	13.40	18.20
2	15-30	6.08	0.170	3.20	0.09	19.33	8.10	3.00	0.06	0.11	2.76	14.03	80.33	64.40	16.40	19.20
3	0-15	6.10	0.108	4.48	0.11	18.66	7.20	3.06	0.05	0.08	3.02	14.21	78.75	70.40	13.4	16.20
4	15-30	6.17	0.240	2.10	0.05	11.30	6.10	2.10	0.06	0.11	2.76	11.13	75.20	67.40	14.4	18.20
5	0-15	6.02	0.240	6.10	0.15	16.00	8.90	2.91	0.08	0.12	3.3	15.31	78.45	65.8	14.8	19.40
6	15-30	6.00	0.400	4.93	0.12	17.33	7.40	3.20	0.07	0.12	3.20	13.99	77.13	65.8	15.8	18.40
7	0-15	6.00	0.420	6.00	0.14	14.66	5.20	2.10	0.06	0.11	3.00	10.47	71.35	62.8	16.8	20.40
8	15-30	5.86	0.520	3.20	0.09	14.66	5.40	2.00	0.05	0.10	2.96	10.08	70.44	64.8	14.8	20.40
9	0-15	6.32	0.199	3.16	0.10	21.20	4.16	2.10	0.06	0.13	2.56	9.01	71.59	74.70	10.3	15.0
10	15-30	6.40	0.108	2.10	0.06	24.00	4.20	1.99	0.07	0.12	2.40	8.78	72.66	71.70	12.3	16.0
11	0-15	6.50	0.200	3.41	0.10	29.66	4.00	1.80	0.06	0.13	3.00	8.99	66.66	68.70	13.3	18.0
12	15-30	6.2	0.2010	2.40	0.07	23.33	4.10	2.00	0.05	0.14	2.53	8.82	71.32	71.70	9.3	19.0
13	0-15	5.52	0.210	5.13	0.13	20.66	4.00	1.66	0.04	0.09	2.30	8.09	71.56	73.2	11.4	15.4
14	15-30	5.40	0.220	3.16	0.08	22.66	4.20	2.00	0.04	0.10	2.40	8.74	72.79	75.2	9.4	15.4
15	0-15	5.78	0.107	4.11	0.10	24.66	3.10	1.70	0.05	0.10	2.48	7.43	66.62	76.2	10.4	13.4
16	15-30	6.20	0.200	2.80	0.07	20.46	3.20	1.70	0.05	0.11	2.65	7.71	65.62	75.2	9.4	15.4
17	0-15	6.40	0.203	3.00	0.08	31.33	3.48	2.10	0.05	0.09	2.33	8.05	71.06	76.4	8.8	14.8
18	15-30	6.44	0.204	2.11	0.05	30.00	3.00	2.00	0.06	0.09	2.16	7.31	70.45	75.4	9.8	14.8
19	0-15	6.30	0.200	3.17	0.08	42.40	3.40	1.91	0.06	0.08	2.30	7.75	70.32	71.4	11.8	16
20	15-30	6.18	0.210	2.00	0.06	40.33	4.80	2.10	0.05	0.10	2.44	9.49	74.29	69.4	12.8	17
21	0-15	5.51	0.080	2.10	0.4	56.99	2.00	1.00	0.05	0.07	2.10	5.22	59.71	83.0	6.7	10
22	15-30	5.07	0.061	1.50	0.04	52.33	1.70	0.60	0.05	0.07	2.00	4.42	54.75	82.0	5.7	12.3

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Table 1b: Physicochemical properties of study area (mean)

depth (cm)	pH	EC ds/m	Organic Matter (%)	Total (%)	A.V.P mg/kg-1	Ca	Mg	Na Cmol/ kg	K	EA	
Range	5.1-6.5	0.1-0.5	1.5-6.1	0.04-0.4	11.3-57	1.7-10.1	0.6-3.4	0.04-0.2	0.07-0.14	2.0-3.3	
X1	0-15cm	6.1	0.2	4.4	0.1	23.3	5.4	2.2	0.06	0.1	2.1
x2	15-30cm	6.1	0.2	4.2	0.1	22.3	4.7	2.2	0.06	0.1	2.1

BS: Base Saturation  
 EC: Electrical Conductivity  
 ECEC: Effective Cation Exchange Capacity  
 EA: Exchangeable Acidity

Source: Author's Field work, 2010

### 3.2 Mean Concentration of Heavy Metals in Soils of Waste Dumpsites in Uyo Metropolis

Generally, the iron (Fe) content of the soil ranged from 17.7 mg/kg to 563.3 mg/kg, with mean value of 920.1 mg/kg, lead (Pb), range from 3 mg/kg to 117.5 mg/kg with mean value of 81.9 mg/kg, Nickel (Ni) range from 1.5 mg/kg to 54.8 mg/kg with mean value of 7 mg/kg, cadmium (Cd) ranged from 0.91 mg/kg to 51.6 mg/kg with mean values of 4.6 mg/kg and chromium (Cr) range from 1.0 mg/kg to 4.5 mg/kg with mean value of 1.7 mg/kg (Table 2 and 3).

Table 2: Concentration of heavy metals in soils of waste dumpsites in Uyo metropolis

S/N	Depth (cm)	Heavy metals mg/kg				
		Fe	Pb	Ni	Cd	Cr
1	Surface (0-15)	1663.0	81.9	10.8	51.6	1.3
2	Subsurface (15-30)	1767.0	99.2	15.7	4.8	0.9
3	Surface (0-15)	1168.0	89.3	11.3	3.3	0.7
4	Subsurface (15-30)	563.0	111.4	11.0	1.7	0.5
5	Surface (0-15)	1571.0	117.8	9.1	2.9	1.8
6	Subsurface (15-30)	1081.0	110.8	5.9	3.1	1.6
7	Surface (0-15)	1129.0	105.2	54.8	2.3	1.4
8	Subsurface (15-30)	1057.0	84.6	2.4	1.7	1.0
9	Surface (0-15)	707.5	73.2	4.8	0.9	0.7
10	Subsurface (15-30)	692.0	86.8	2.4	0.7	1.6
11	Surface (0-15)	709.0	76.4	2.7	1.1	0.6
12	Subsurface (15-30)	618.0	77.7	1.6	0.9	0.4
13	Surface (0-15)	779.0	116.1	6	5.0	4.6
14	Subsurface (15-30)	808.0	127.5	5.5	7	4
15	Surface (0-15)	805.0	111	7	6.5	3.5
16	Subsurface (15-30)	760.0	124.5	5	6	3.1
17	Surface (0-15)	1155.0	106.1	5.0	5	3.8
18	Subsurface (15-30)	1001.0	112.8	4.5	4.5	3.9
19	Surface (0-15)	905.0	113.5	6	4.4	3.9
20	Subsurface (15-30)	903.5	117.5	5.5	4.5	4.5
21Control	Surface (0-15)	800.8	39.2	1.6	1	0.3
22Control	Subsurface (15-30)	910.9	34.65	1.2	1	0.15
23Control	Surface (0-15)	605.0	3.5	0.8	0.5	0.5
24Control	Subsurface (15-30)	570.0	3	0.6	0.4	0.4
25Control	Surface (0-15)	590.0	2.6	1	0.1	0.15
26Control	Subsurface (15-30)	603.0	3.05	1	0.3	0.3

Source: Author's Field work, 2010

Table 3: Mean concentration of heavy metals in soils of waste dumpsites in Uyo metropolis

	Heavy metals mg/kg				
	Fe	Pb	Ni	Cd	Cr
Range	17.7-563.3	3-117.5	1-54.8	0.85-51.6	0.95-4.5
Mean	920.1	81.9	7.0	4.6	1.7
SD	333.6098	41.32715	10.47958	9.816372	1.556263

Source: Author's Field work, 2010

The mean concentration of heavy metals in soils of waste dumpsites in Uyo metropolis is also illustrated with a bar chart (Fig. 2).



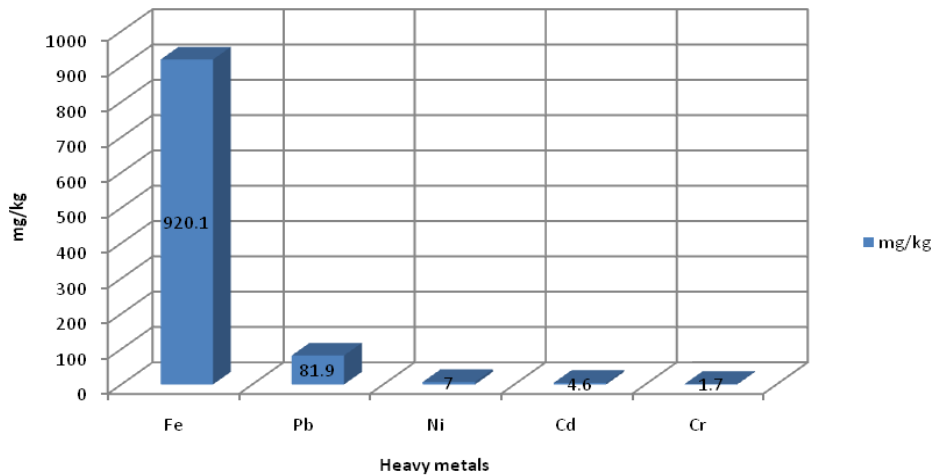


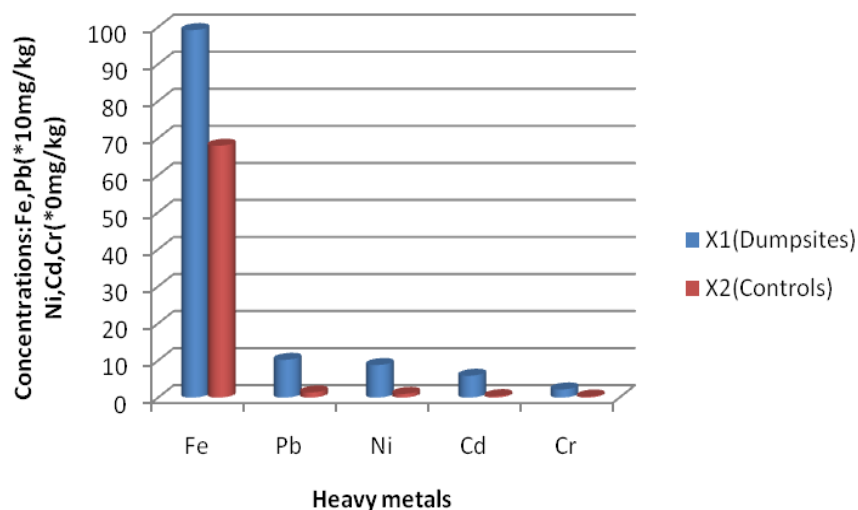
Fig. 2: Mean concentration of heavy metals in soils of waste dumpsites

### 3.3 Comparison between the Mean of Heavy Metal Concentrations in Soils of Waste Dumpsites and Control Sites

The mean value for (Fe) in the waste dumpsite is 992.1 mg/kg while that of the control is 680.0 mg/kg (Fig. 3). Fe is higher in the soil of the waste dumpsites than on that of the control. The high concentration of Fe in waste dump could have been due to the type of waste dumped there. If the waste dump contains more of metal scraps from mechanic shops and welder’s workshops than from household wastes which will have more of spoilt food, woods from broken furniture, ashes, broken glasses and plastics etc. definitely soil around such waste dumpsites will contain more Fe than control soil. Pb has a mean value of 102.2 mg/kg in the soil. Here there is also a big difference between Pb concentrations of the waste dump soil than on that of the control. It’s higher at the waste dump than the control. The mean value of Ni is 8.8 mg/kg for waste dump soil and 1.0 for the control soil. This is higher than the control. Cd has a mean value of 5.9 mg/kg in the waste dump soil while control has a mean value of 0.4 mg/kg/ indicating a higher content of Cd in the waste dump than that of the control. Cr has a mean value of 2.2 mg/kg at the waste dump soil as against 0.3 mg/kg at the control site.

Fig. 3: Comparison between mean of heavy metal concentrations in soils of waste dumpsites and control sites

### 3.4 Comparison between the Mean Concentrations of Heavy Metals in Surface, Subsurface Soils and the Soils of Control Sites



The mean concentration of Fe in surface soil is 1059.2 mg/kg, and 964.8 mg/kg for subsurface, indicating a high concentration of Fe at surface than subsurface soil. The control soil has a mean value of 665.3 mg/kg and 694.8 mg/kg in surface soil and subsurface, respectively. The mean value of iron in the subsurface is very

close to that of the control. This means that Fe concentration is higher at the surface soil and percolation is slow. The high concentration of Fe is probably due to the nature of waste dumped at that site. Pb at the surface soil has a mean value of 99.1 mg/kg and 95.2 mg/kg at the subsurface. This also shows a higher content of lead in surface soil than the subsurface soil, and a higher concentration at the dumpsite than the control whose mean value is 15.8 mg/kg and 13.6 mg/kg at the surface and subsurface, respectively. Ni content in the surface soil is high with a mean value of 308.5mg/kg as against mean value of 5.9 mg/kg in the subsurface and 1.13 mg/kg and 0.9 mg/kg in control soil. Cd is 8.2mg/kg and 3.5 mg/kg at the surface and subsurface, respectively. This also indicates a high content of Ni at the surface than at the subsurface and a lower concentration at the control site whose mean value are 0.5 mg/kg and 0.4 mg/kg for surface and subsurface soil, respectively. Cr is not very high in the dumpsite; the mean value for both surface and subsurface is 0.3 mg/kg and 2.1 mg/kg, respectively and 2.1 mg/kg. Probably the waste dumps here do not contain material made of Cr (Fig. 4).

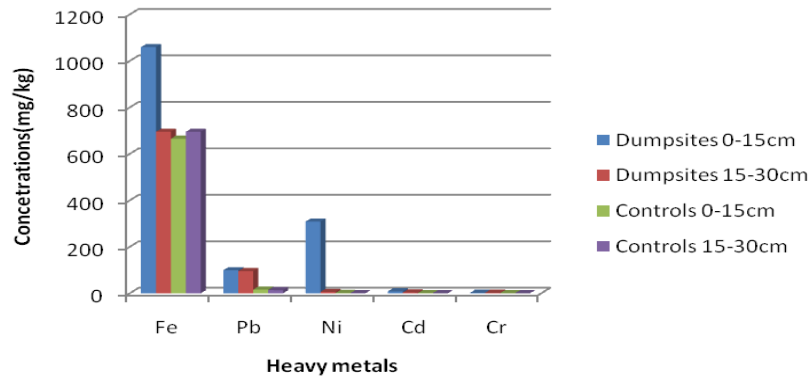


Fig. 4: Comparison between the mean concentrations of heavy metals in surface, subsurface soils and soils of control sites

In all, there is a clear indication that waste dumpsite has higher concentration of heavy metal than control site and the concentration is higher in surface soil than the subsurface soil. Therefore if a deep rooted crop is cultivated at dump site, the heavy metal uptake by plant may be slower than shallow rooted crop. According to Alloway (1996), plants pick up heavy metal that is found near the roots, and modify the chemical and physicochemical properties of the soil around them and thus influence the bioavailability of some chemical elements.

### 3.5 Heavy Metals Concentration in Plants from Waste Dumpsite

Generally, the mean iron content in cocoyam ranged from 40.9 mg/kg to 54 mg/kg, Pb from 1.9mg/kg to 23.1 mg/kg, Ni 0.2 mg/kg to 0.55mg/kg, Cd from 0.05 mg/kg to 0.4 mg/kg Cr 0.5. Fe content in cocoyam is 50.8 mg/kg, 10.6 mg/kg of Cd and 0.1 mg/kg of Cr. The mean Fe content in cocoyam is 50.8 mg/kg, 10.6mg/kg for Pb, 0.4mg/kg for Ni, 0.3 mg/kg for Cd and 0.1 mg/kg for Cr. As shown in Table 4 and 5.

Table 4: Heavy metal concentration in plants of waste dump sites and control sites

S/N	Heavy metals (mg/kg)				
	Fe	Pb	Ni	Cd	Cr
1	53.45	17.9	0.44	0.25	0.05
2	52.15	23.1	0.3	0.15	0.05
3	50.7	5.05	0.2	0.05	0.05
4	54	5.05	0.5	0.35	0.05
5	51.05	3.1	0.55	0.4	0.05
6 (control)	53.45	17.9	0.25	0.25	0.05
7 (control)	40.9	1.9	0.4	0.4	0.05

Source: Author's Field work, 2010

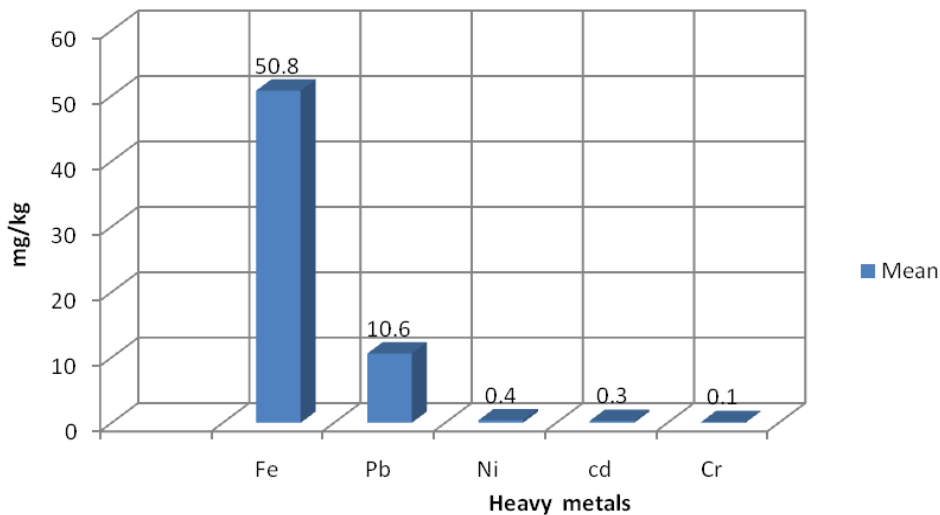
Table 5: Mean heavy metal concentration in plants of waste dump sites and control sites

	Heavy metals (mg/kg)				
	Fe	Pb	Ni	Cd	Cr
Range	40.9-54	1.9-23.1	0.2-0.55	0.05-0.4	0
$\bar{X}_1$ (Dumpsite)	50.81429	10.57143	0.377143	0.264286	0.04375

Source: Author's Field work, 2010

Generally, the mean concentration of iron in cocoyam ranged from 40.9 mg/kg to 54 mg/kg, Pb from 1.9mg/kg to 23.1 mg/kg, Ni 0.2 mg/kg to 0.55mg/kg, Cd from 0.05 mg/kg to 0.4 mg/kg Cr 0.5. Fe content of cocoyam is 50.8 mg/kg, 10.6 mg/kg for Cd and 0.1 mg/kg for Cr. The mean concentration of Fe content in cocoyam is 50.8

Mean heavy metal concentrations in plant (Colcasia) tissues



mg/kg, 10.6mg/kg for Pb, 0.4mg/kg for Ni, 0.3 mg/kg for Cd and 0.1 mg/kg for Cr (Fig. 5).

Fig. 5: Mean heavy metal concentration in plant

### 3.6 Comparison between the Mean Heavy Metals Content in Plant of Waste Dumpsites and that of Control

The mean concentration of heavy metals in cocoyam at the dumpsite is as follows; 52.3 mg/kg of Fe and 10.8 mg/kg of Pb, 0.4 mg/kg of Ni, 0.2 mg/kg of Cd and 0.05 of Cr. As against 47.2 mg/kg of Fe, 1.0 mg/kg of Pb, 0.3 mg/kg of Ni, 0.3 mg/kg of Cd and 0.05mg/kg of Cr in control cocoyam sample (Fig. 6).

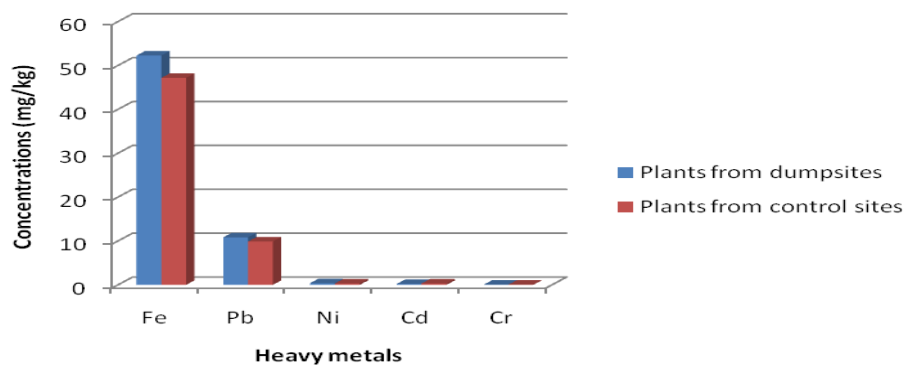


Fig. 6: Comparison between heavy metals in plants of waste dumpsite and control

The difference between the heavy metal content in Cocoyam cultivated at dumpsite and that of the control is not much. This shows that the uptake of heavy metals by this plant is slow. Cataldo and Wildung (1978, p.149) in their article “soil and plant factors influencing the accumulation of heavy metals by plants”,

mentioned that the major factor governing the availability of heavy metal to plants in soil is the solubility. In order for root uptake to occur, a soluble species must exist adjacent to the root membrane for some finite period. Once metal-containing materials are deposited, they are subjected to chemical and microbial modification with metal solubility ultimately approaching thermodynamic equilibrium with nature soil mineral and organic matter. The rate and extent of solubilisation are governed by the physicochemical properties of the deposited material, soil processes and soil properties, therefore solubility might be responsible for the slow uptake of heavy metal by plant. Although its uptake is very slow, it can accumulate to toxic level in some perennial plant. Some of the common ones found in waste dumpsite include pawpaw, and bitter leaf. According to Alloway (1996), toxicity sets in when heavy metal content exceed natural background level. If this is consumed it may result in some health problems such as severe gastro intestinal irritation, liver and kidney problems.

#### IV. CONCLUSIONS

Based on major findings, heavy metal concentration is generally higher at the surface than the subsurface soil. Therefore, if deep rooted crops are cultivated there, the rate at which the plants will take up these heavy metals may take place more slowly than shallow rooted crops. Also, the waste dumpsites and pl around it had higher concentrations of heavy metals than on the control sites.

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