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# Comparative study of heavy metals in the soil around waste dump sites within University of Uyo

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## ABSTRACT

*The high concentration of heavy metals in soils is reflected by higher concentrations of metals in plants consequently in animal and human bodies. Small amounts of many heavy metals are required by plants to remain healthy. Assessment of the levels of Fe, Pb, Cd, Zn and Ni in dumpsite soils and vegetation around solid waste dumpsites within university of uyo environment was carried out using Atomic Absorption spectrophotometric technique. This study focused on the investigation of soil contamination (Fe, Pb, Cd, Zn, Ni) in dumpsite soil and accumulation in plant growing in the environment within university of uyo. Total of six soil samples were collected three dumpsites in which three were control and nine plants samples were also collected at the three different dumpsite. Soil samples were randomly collected by depth profile (0-5cm). Both soil and plant samples were pretreated, digested by the wet method using microwave oven. Heavy metals in soil and plant samples were analyzed with atomic absorption spectrophotometer (AAS) equipped with Graphite Furnace. Concentrations of the metals in the dumpsite soil and plant were found to be in higher concentrations compared to control. However, continuous exposure to these metals might bring about bioaccumulation and thus harmfulhealth effects on the population.*

**Keywords:** Municipal waste, heavy metals, Dumpsites, Soil contamination, Plants samples

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## INTRODUCTION

The amount and variety of waste materials have increased with technological advancement, growing human population and industrial processes [18]. The growing rate of industrialization in Nigeria is gradually leading to contamination and deterioration of the environment, thus industrialization and heavy metal pollution are positively correlated. Heavy metals are described as those metals with specific gravity higher or more than 5 g/cm. Most common heavymetals are copper, nickel, chromium, lead, cadmium mercury and iron. Some heavy metals, such as iron and nickel are essential to the survival or all forms of life if they are low in concentrations[12].However, heavy metals like lead, cadmium and mercury are toxic to living organisms even in low concentrations, and they cause anomalies in metabolic functions of the organism especially in greater quantities [13]. The disposal of domestic, commercial and industrial garbage in the world is a problem that continues to grow with human civilization [1]. Toxicity sets in when the heavy metal content in the soil exceeds natural background level [4]. This may cause ecological destruction and deterioration of environmental quality, influence yield, quality of crops as well as atmosphere, and health of animal through food chains within university uyo where crops are cultivated on and around the waste dumpsites. Other activities that could contribute to excessive release of these metals into the environment include burning of fossil fuels, smelting, and discharges of industrial, agricultural, domestic wastes as well as deliberate application of pesticides [21]. The 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 [6]. The crops differ in their ability to uptake this metals. Soils are able to biodegrade almost all organic compounds found in waste, converting them into harmless substances. Since inorganic products such as heavy metals are non-biodegradable, thus they persist and accumulate in the soil. Heavy metals can accumulate and persist in soils at environmental hazardous levels to crops and human health[4]. Exposure to heavy metals may cause blood, bone disorders, kidney damage, decreased mental capacity and neurological damage [8, 9]. Heavy metal toxicity can result in damaged or reduced mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver, and other vital organs. One specific threat resulting from inadequate wastes disposal is the contamination by heavy metals that have significant toxic potential for the environment (soil, water and air), human's beings and the exposed biodiversity [22]. Population explosion and urbanization have increased the quantities and types of solid wastes produced [17]. Municipal solid waste usually contains paper, food waste, metal scraps, glass, ceramics, and ashes. Decomposition or oxidation process releases the heavy metal contained in these wastes to the soil of the waste dumpsite thereby contaminating the soil [24].Investigation of heavy metals is very essential since slight changes in their concentration above the acceptable levels, whether due to natural or anthropogenic factors, can result in serious environmental and subsequent health problems [25]. The concentrations of heavy metals in soil around waste dumps are influenced by types of wastes, topography, run-off and level of scavenging[11]. Solid waste dumped along roadsides are usually left over a long time to decompose naturally by micro-organisms, eaten by animals, picked by scavengers or washed away by the floods into the larger creek and rivers thus affecting the surface water quality of contamination and are stored faster than they are excreted [3, 17, 26]. Indeed, many heavy metals are found to accumulate in fishes causing human contamination and related health issues. Heavy metals also affect agricultural products and their consumers [7]. Toxic heavy metals can also be taken directly by man and other animals through inhalation of dusty soil. Heavy metal pollutants such as copper [15] lead and zinc [5]from additives used in gasoline and lubricating oils are also deposited on highway soils and vegetation. The aim of the present studyis to analyze the heavy metal concentrations of Fe, Pb, Cd, Zn and Ni in the three waste dump site and plants grown around the site.

## MATERIALS AND METHODS

### Study Area and Sample Collection

The sampling sites are three main dumpsites, one located along senior staff club, site A; the second location is the dumpsite behind bursary office, site B and third dumpsite located behind the saint peters catholic church, site C. The control samples were taken fewkilometers away from each of the site, where there was no dumpsite or any form of humanactivities that could generate wastes.Five sampling spots at a distance of 50 m from each other were mapped out forsoil samples within the sampling sites, using clean stainless steel shovel from 0-15 cm depth. In each location, representative composite samples obtained were air dried and pulverized using a porcelain mortar and pestle.A soilsample to serve as control was also collected.Three edible plant samples was collected from each of the site *Pawpaw, Mangifera indica, Neem, Mecuna beans, Water leaf, Plantain, Zea mays, Pawpaw, Bitter leaf* grown within the vicinity of the refuse dumpsites were randomly collected with a stainless steel trowel and knife.Both plant and soil samples were packed in separate bags and taken to the laboratory for analysis.

### Sample Pre-Treatment

The collected soil samples were thoroughly mixed in clean stainless steel bucket to obtain a representative sample.The samples were crushed, sieved with 2 mm mesh and stored in labeled polythene bags prior to analysis.Plant leaves were also collected, washed thrice with distilled water to remove dust particles.The leaves were air-driedto a constant weight in an oven at a temperature of $70^0$C. The dried samples were ground into a fine powder and stored in polyethylenebags, until used for acid digestion.

### Digestion of Sample

Two grammes (2.0 g) of prepared soil sample was digested with 15.0 ml nitric acid, 20.0 ml perchloric acid and 15.0 ml hydrofluoric acid and placed on a hot plate for 3hour. On cooling, the digest was filtered into a 100.0 ml volumetric flask and made up to the mark with distilled water [2]. The plant samples were washed, oven-dried at80°C, pulverized to fine powder. It was ashed in thefurnace for the three hours at 600ºC. 1g of the crushed plant material was weighed into a 50ml Kjeldahi flask.Concentrated $HNO_3$ 25ml (16N, 70%w/w)was introduce down the side of the flask and swirleduntil the plant material was thoroughly wetted. Perchloric acid 4ml and 2 ml of concentrated $H_2SO_4$(36N, 98%) were added and the flask swirled to mix the contents thoroughly. The sample was warmedgently on a digestion rack. Themixture was heated strongly for 1 minute after digestion, cooled anddeionized water 40ml was added and allowed to coolagain. The sample finally filtered throughWhatman N0. 42 filter paper into a 100ml volumetricflask and made up to the mark with deionized water.

**Metal Analysis**

The Atomic Absorption Spectrophotometric (AAS) methodwas used for the analysis and the British Pharmacopoeia calibrationplot method was adopted. The concentrations of heavy metals such as (Fe,Pb, Cd, Znand Ni) in all the sampleswere determined using the Perkin-Elmer model 403atomic absorption spectrophotometer.The digestedsample solutions were analyzed in triplicates.

## RESULTS AND DISCUSSION

**Table 1: Concentrations of heavy metals (mean ± SD) in mg/kg in the soil samples**

| Soil Metal | Fe | Pb | Cd | Zn | Ni |
|---|---|---|---|---|---|
| **Site A** | 595.57 ± 0.18 | 2.18 ± 0.08 | 1.80 ± 0.02 | 122.92 ± 0.06 | 15.70 ± 0.03 |
| **Control** | 150 ± 0.06 | 0.04±0.05 | 0.06±0.01 | 25.45±0.03 | 0.78± 0.04 |
| **Site B** | 624.21 ± 0.09 | 13.14 ± 0.10 | 9.25 ± 0.03 | 144.77 ± 0.03 | 49.49 ± 0.12 |
| **Control** | 205±0.50 | 2.41±0.06 | 2.04±0.01 | 30.19±0.04 | 7.71±0.02 |
| **Site C** | 901.89 ± 0.31 | 10.87 ± 0.04 | 2.12 ± 0.02 | 235.75 ± 0.04 | 46.08 ± 0.06 |
| **Control** | 116±0.04 | 2.58±0.04 | 0.23±0.07 | 46.98±0.08 | 3.34±0.06 |

The concentrations of heavy metals in the plantsanalyzed differ from one sampling location to another and vary from one species of plant to the other. This may be attributed to differential uptake capacity of plants for different heavy metals through roots and their further translocation within the plant parts [25, 28]. Soil characteristics namely acidity, organic matter contents and ability of the root type of the plants to penetrate where the heavy metals are deposited[19].The concentration of Fe in soil at the dumpsites ranged from 593.57 to 901.89 mg/kg.Higher concentration of Fe was recorded in dumpsite C with anaverage of 901.89 mg/kg, lower concentration was obtained at dumpsite A with an average of 593.57 mg/kg while dumpsite B has 624.21 mg/kg.The control sample recorded 150, 205, 116 for dumpsite A, B and C. There was a significantdifference / variation between the concentration of Fe in soil at the dumpsites andthe control with a positive correlation.

At the dumpsites, the concentration of Pb ranged from 2.18 to 13.14 mg/kg. Higherconcentrations was observed at dumpsite C with a mean of 13.14 mg/kg and lower concentrations was recorded in dumpsite A with a mean of 2.18 mg/kg while dumpsite B recorded 10.87 mg/kg against the control dumpsite with concentrations of 0.04, 2.14 and 2.58 mg/kg for dumpsite A, B, C respectively. These variations could be attributed to the nature,composition and amount of Pb containing wastes disposed off in these dumpsiteswhich may not be thesame.

There was a significant difference between the mean concentration of Cd in soil atdumpsites and the control. The concentration of Cd in the dumpsites ranged from1.80 to 9.25 mg/kg. The dumpsite B records the highest with means 9.25 mg/kg, dumpsites A has the lowest with concentration of 1.80 mg/kg while dumpsite C records 2.12 mg/kg. The control sample recorded 0.06, 2.04 and 0.23 mg/kg for dumpsite A, B and C respectively. The result obtained indicate that dumpsites contributed significant amount of Cd to the environment.

The concentration of Zn in the three dumpsites ranges from 122.92 to 235.75 mg/kg. Dumpsite C records the highest concentration with a mean of 235.75 mg/kg, dumpsite A has the lowest with mean of 122.92 mg/kg while dumpsite B has an average of 144.77 mg/kg against the control site with average of 25.45, 30.19 and 46.98 mg/kg respectively. The results obtained in this study were significantly higher than thenatural range. This indicate that waste releases significant amount of Zn to theenvironment.

There was a significant difference between the mean concentration of Ni in soil atdumpsites and the control. The control recorded 0.78, 7.71 and 3.34 mg/kg. While the mean concentration of Ni in dumpsites ranges from 15.70 to 46.08 mg/kg. Dumpsites sites B records the highest concentration of 49.49 mg/kg, dumpsite A has the lowest concentration of 15.70 mg/kg while dumpsite C records 46.08 mg/kg. The variation in the concentration might be due to similarities in the nature, compositions and amount of Ni containing wastes deposited in the dumpsites.It was further revealed that there was no significant differencein the concentration of Cd forall the plants collected at all the threedumpsites.

**Table 2: Concentrations of heavy metals (mean ± SD) in mg/kg in the plant samples**

| Plants/Site | Fe | Pb | Cd | Zn | Ni |
|---|---|---|---|---|---|
| **Site A** | | | | | |
| *Pawpaw* | 23.18 ± 0.01 | 0.21 ± 0.01 | 0.11 ± 0.79 | 16.21± 0.02 | 4.23 ± 0.23 |
| *M. indica* | 15.10 ± 0.14 | 0.46 ± 0.01 | 0.30 ± 0.01 | 12.13 ± 0.04 | 3.91 ± 0.12 |
| *Neem* | 12.23 ± 0.53 | 0.13 ± 0.01 | 0.12 ± 0.03 | 17.20 ± 0.01 | 5.60 ± 0.03 |
| **Site B** | | | | | |
| *Mecuna beans* | 43.59 ± 0.02 | 5.11 ± 0.02 | 0.10 ± 0.03 | 11.35 ± 0.04 | 0.98 ± 0.06 |
| *Water leaf* | 33.56 ± 0.01 | 3.45 ± 0.07 | 0.78 ± 0.13 | 20.00 ± 0.02 | 0.45 ± 0.01 |
| *Plantain* | 44.90 ± 0.03 | 4.33 ± 0.04 | 0.80 ± 0.02 | 15.16 ± 0.07 | 0.73 ± 0.08 |
| **Site C** | | | | | |
| *Zea mays* | 56.12 ± 0.06 | 0.97 ± 0.04 | 0.15 ± 0.06 | 21.52 ± 0.04 | 6.23 ± 0.05 |
| *Pawpaw* | 45.90 ± 0.01 | 2.11 ± 0.07 | 0.55 ± 0.01 | 22.31 ± 0.02 | 7.16 ± 0.02 |
| *Bitter leaf* | 41.34 ± 0.05 | 1.34 ± 0.02 | 0.12 ± 0.02 | 18.45 ± 0.01 | 5.45 ± 0.01 |

The heavy metal concentration of cadmium was generally low for all the plants. Dumpsite A records 0.11, 0.30, 0.12 for *pawpaw, M. indica, Neem,* dumpsite B records 0.10, 0.78, 0.80 for *Mecuna beans, water leaf, plantain* while dumpsite C has 0.15,0.55, 0.12 for *Zea mays, pawpaw and bitter leaf* respectively. The concentrations ofPb in plants at dumpsite A and C was withinthe limit of WHO/FAO (0.3mg/kg) with concentrations of 0.21, 0.46, 0.13 for *pawpaw, M. indica, Neem* while 0.97, 2.11, 1.34 mg/kg was recorded for *Zea mays, pawpaw* and *bitter leaf*respectively.

The concentration of Pb in plant at dumpsite B went beyond the allowable limit of WHO/FAO (0.3mg/kg), with concentrations 5.11, 3.45, 4.33 for *Mecuna beans, water leaf and plantain* mg/kg respectively. This result is alarming for those plant at dumpsite A and C since they are being consumed by human and the leaves are being fed to some farm animals. Bioaccumulation and toxicity of Pb must be taken into consideration. It can benoted that many metals act as biological poison even at milligram per kilogram levels. The presence of Pb in thecultivated plants in dumpsite soils further strengthens thepossible reason of increasing number of lead poisoningamong humans. It is believe known the Pb has adverse effecton neurological and haematological of children and evenadults [14].

It was found out that the concentration of Zn in the plants sample at dumpsite A, B and C are within the same range (16.21, 12.13, 17.20 for *pawpaw, M. indica and Neem*) for dumpsite A, (11.35, 20.00, 15.16 for *Mecuna beans, water leaf and plantain*) at dumpsite B while (21.52, 22.31 and 18.45 for *Zea mays, pawpaw and bitter leaf)* at dumpsite C. The small difference in the concentration of Zn in the plant can be explain by an intensive cumulating of the elements by biota.Generally, the concentrations of Ni was found to be very low in plants at dumpsite B (0.98, 0.45, 0.73) while plants at dumpsite A and C were high (4.23, 3.91, 5.60 and 6.23, 7.16, 5.45) respectively. When Zn is adequate in the soil Cd uptake of plant will not increase [10]. Thus, higher presence of Zn in the soil can also be related to the plant uptake of Cd. It can be noted thatCd has the least concentration among all metals observed.
The concentration of Fe in the examined in plants at dumpsite C records the highest with an average of 56.12, 45.90, 41.34 for *Zea mays, pawpaw, bitter leaf* and plants at dumpsite B records 43.59, 33.56, 44.90 for *Mecuna beans, water leaf and plantain*. Plants at dumpsiteArecords the lowest with a mean of 23.18, 15.10 and 12.23 for *pawpaw, M. indica and Neem*. This is the most abundant metal in this study found both in the soil and the plant. The concentration of Nickel records 0.21, 0.46, 0.13 mg/ kg for *pawpaw, M. indica, Neem* for plant at dumpsite A and 0.97, 2.11, 1.34 for *Zea ma, pawpaw, bitter leaf*for plants at dumpsite C while at dumpsite B was very high with an average concentration of 5.11, 3.45, 4.33 for *Mecuna beans, water leaf* and *plantain* respectively.

The bioaccumulation of these concentrations of heavy metals in the plant materials collected from thedumpsite are in the following trend for site A Fe > Zn > Ni > Pb > Cd while site B is Fe > Zn > Pb > Cd > Ni and site C is given as Fe > Zn > Ni > Pb > Cd. Metal uptake by plants can be affected by several factors including metal concentrations in soils, soil pH, cation exchange capacity, organic matter content, types and varieties of plants, and plant age. It is generally accepted that the metal concentration in soil is the dominant factor [4, 23]

## CONCLUSION

Municipal solid waste has been found to significantly increase the concentrations of the heavy metals studied in the environment.The results of heavy metals concentration measured in soils and plants at the three waste dumpsites is presented in table one and two respectively. The study revealed significant differences in the concentration of heavy metals such as, Fe, Pb, Cd, Zn and Ni in soil units at the dumpsitesand the control.All heavy metals investigated in the dumpsite have significantdifferences from those obtained in the control.Alsocontinuous usage of these farmlands for growing crops could lead to bioaccumulation of these metals and theireventual entry into the food chain with the associated health risks being manifested. There should be provision of a basement treatment for the dumpsites before use to provide sorption surfaces for pollutants and prevent groundwatercontamination. The dumpsites should be eradicated form the university of uyo environment and phytoremediation of soil should be established as a matter of urgency.

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