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# Heavy Metal Concentration and Bioaccumulation Potential of Plants Within Dumpsite Soil In Ozoro, South-South, Nigeria

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**ABSTRACT**

This study investigated the concentration and bioaccumulation of Heavy metals of plants within waste dumpsites in Ozoro, South-South Nigeria. The soil and plants parts (Root and shoot) were obtained from the dumpsite and at a farm land far away from the dumpsite (Control site). The soil and plant parts were digested using aqua regia and analysed for heavy metals using Atomic Absorption Spectrophotometer (Buck 200A model). *Musa paradisiacal (Plantain), Manihot esculenta* (Cassava), *Colocasia esculenta* (Cocoyam) *and Carica papaya* (Pawpaw) were studied. The heavy metals cadmium, copper, Iron, lead, manganese and zinc were analyzed. The metal concentration in mg/kg ranged thus; Cd (0.01 – 0.06); Cu (0.01 – 0.08); Fe (0.01 – 0.08); Pb (0.01 – 0.07); Mn (0.01 – 0.06) and Zn (0.01 – 0.05). The metal concentrations in the dumpsite soil and plants were relatively higher than those from the control site. *Musa paradisiacal* and *Manihot esculenta* had their heavy metals concentrations accumulated more in the roots than in the shoots while *Colocasia esculenta* and *Carica papaya* had heavy metal concentration more in the shoot than in the root. Bioaccumulation Factor of the studied plants showed that *Musa paradisiacal* is a bioaccumulator for Manganese, *Manihot esculenta* and *Colocasia esculenta* are bioaccumulators for cadmium while *Carica papaya* is a bioaccumulator for Cadmium, copper and Iron. Translocation Factor ($TF_{Root\ to\ Shoot}$) of the heavy metals in *Musa paradisiacal* and *Manihot esculenta* were all less than 1 while the ($TF_{Root\ to\ Shoot}$) for *Colocasia esculenta* and *Carica papaya* were all greater than 1 indicating easy translocation of the metals to the shoot by *Colocasia esculenta* and *Carica papaya*. The Translocation Factor ($TF_{Soil\ to\ Root}$) for cadmium was greater than 1 for all the plants except *Carica papaya*. Copper and Iron had $TF_{Soil\ to\ root}$ greater than 1 in *Manihot esculenta* while manganese had $TF_{Soil\ to\ root}$ greater than 1 in *Musa paradisiacal* implying easy translocation of the metals from soil to root. The Enrichment Factor of the heavy metals were all greater than 1 which implies that the metals are all readily available for absorption by the plants. The metal concentrations were less than FAO/WHO guidelines except lead. The ease at which cadmium and lead were translocated from the root to the shoot calls for concern. Therefore planting of crops around dumpsite soils should be discontinued with in order to safeguard our health.

**Keywords :** Bioaccumulation, Concentration, Dumpsites, Heavy Metal, Plants, Order, Translocation

## I. INTRODUCTION

Heavy metals are metals and metalloids with atomic density greater than 4 g/cm$^3$or 5 times or more greater than water (Nagajyoti et al., 2010). Most dumpsites have been largely utilized for the cultivation of a varieties of edible vegetables and plants not minding available data on the heavy metals phytoaccumulation potentials of plants in contaminated and polluted soils (Cobb et al.,2000; Benson and Ebong, 2015; Obasi et al., 2013, Ojebah and Uwague, 2015). This they do for consumption and profit making without taking cognizance of the absorption of toxic metals by the crops grown around these dumpsites (Cortez and

Ching, 2014). The consumption of plants grown in contaminated soils result in the transfer of the contaminants including heavy metals through the food chain (Ojebah and Uwague, 2015).

Bioaccumulation factor (BF), is defined as the ratio of chemical concentration in a plant to soil. It is used to measure the effectiveness of a plant in concentrating pollutant into aerial part (Fayiga et al., 2004), and translocation factor (TF) is the quotient of contaminant concentration in shoots to roots, which is used to measure the effectiveness of a plant in transferring a chemical from roots to shoots (Sun et al., 2009). BFs and TFs are usually calculated to evaluate plants for phytoextraction purposes and the effectiveness of the harvestable aerial parts of plants in metal accumulation and translocation (Zhang et al., 2002; Sun et al., 2008).

The present study was embarked upon to determine the concentration and bioaccumulation of some heavy metals by *Musa paradisiacal (Plantain), Manihot esculenta* (Cassava), *Colocasia esculenta* (Cocoyam) *and Carica papaya* (Pawpaw) commonly found in dumpsites to ascertain their bioaccumulation potentials.

## II. MATERIALS AND METHODS

### Study Area

The study was conducted in Ozoro, South-South Nigeria. Ozoro is located at longitude 6°12′58″E and latitude 5°32′18″N (www.wikipedia.org). Ozoro is one of fast developing Urban towns in Delta State, Nigeria with an increasing population due the State own Polytechnic.

### Sample Collection and Treatment

The method described by Zakka et al., (2014) was adopted. The whole plants (*Musa paradisiacal, Manihot esculenta*, *Colocasia esculenta and Carica papaya*) were harvested from the dumpsite soil along Owelogbo road, Ozoro on the 20th of April, 2018. Soil sample (150g) were collected from the root zone of each plant to a depth of 15cm with the aid of a hand trowel and mixed together thoroughly. Other plants were also collected from a control site. The collected soil samples were air-dried for 3 days at room temperature while the shoots and roots of the plants samples were washed separated and air–dried for 3 days at room temperature. The soil samples were ground into fine particles using an agate mortar and sieved. One gram (1g) of each of the soil and plants samples was digested separately with 10ml of aqua regia and the mixture was heated for 10minutes. Distilled water was added to avoid drying up the sample digest and then filtered through Whatman number 1 filter paper into 50cm$^3$ standard volumetric flask and made up to mark.

### Heavy Metals Analysis

The heavy metals Cadmium, Copper, Iron, Lead, Manganese and Zinc were analyzed in the soil and parts of the plants samples of dumpsite soil and controlled site soil using Atomic absorption spectrophotometer (Buck 200A model). The heavy metal determination was done in triplicates. All reagents used for the analysis were of analytical grade. Glass wares and plastics were soaked in 20% $HNO_3$ washed with detergent and copiously rinsed with distilled water.

### BIOACCUMULATION FACTOR (BF) AND TRANSLOCATION FACTOR (TF) AND ENRICHMENT FACTOR (EF) OF THE HEAVY METALS

The Bioaccumulation Factor (BF), Translocation Factor (TF) and Enrichment Factor (EF) were computed from the relations (Obasi et al., 2013; Setpathy et al., 2014; Zakka et al., 2014).

$$B.F = = \frac{concentration\ of\ metals\ in\ plants}{concentration\ of\ metal\ in\ soil}$$

$$T.F_{Root\ to\ Shoot} = \frac{concentration\ of\ metals\ in\ plant\ shoot}{concentration\ of\ metal\ in\ plant\ root}$$

$$T.F_{Soil\ to\ Root} = \frac{concentration\ of\ metals\ in\ plant\ root}{concentration\ of\ metal\ in\ soil}$$

$$E.F = \frac{concentration\ of\ metals\ in\ contaminated\ soil}{concentration\ of\ metal\ in\ uncontaminated\ soil}$$

## III. RESULTS AND DISCUSSION

The result of heavy metals concentration in the dumpsite, control site as well as the root and shoot of the plants in dumpsites and control sites are presented in table 1 – 3 and figure 1 and 2. The Bioaccumulation Factor (BF), Translocation Factor (TF) and Enrichment Factor of the Heavy metals are calculated and presented in Table 4 - 7 and Figure 3 – 6.

Table 1: Metal concentration in dumpsite soil and control site (Mean±SD)

| Sites | Metal concentration (mg/kg) | | | | | |
|---|---|---|---|---|---|---|
| | Cd | Cu | Fe | Pb | Mn | Zn |
| Dumpsite | 0.02±0.01 | 0.04±0.01 | 0.06±0.01 | 0.05±0.01 | 0.03±0.005 | 0.04±0.01 |
| Control site | 0.01±0.005 | 0.02±0.01 | 0.01±0.01 | 0.03±0.005 | 0.01±0.00 | 0.01±0.005 |

Table 2: Metal concentration in root and shoot of plants in dumpsite (Mean±SD)

| Samples | Metal concentration (mg/kg) | | | | | |
|---|---|---|---|---|---|---|
| | Cd | Cu | Fe | Pb | Mn | Zn |
| *Musa paradisiacal* root | 0.02±0.01 | 0.03±0.005 | 0.04±0.00 | 0.02±0.005 | 0.06±0.01 | 0.04±0.01 |
| *Musa paradisiacal* shoot | 0.01±0.005 | 0.02±0.01 | 0.02±0.005 | 0.01±0.00 | 0.01±0.005 | 0.01±0.00 |
| *Manihot esculenta* root | 0.04±0.01 | 0.06±0.01 | 0.07±0.01 | 0.04±0.01 | 0.03±0.010 | 0.04±0.01 |
| *Manihot esculenta* shoot | 0.01±0.005 | 0.02±0.01 | 0.03±0.01 | 0.02±0.00 | 0.01±0.00 | 0.02±0.005 |
| *Colocasia esculenta* root | 0.02±0.005 | 0.01±0.005 | 0.01±0.005 | 0.01±0.00 | 0.02±0.005 | 0.01±0.005 |
| *Colocasia esculenta* shoot | 0.05±0.01 | 0.07±0.01 | 0.08±0.01 | 0.07±0.01 | 0.04±0.01 | 0.05±0.01 |
| *Carica papaya* root | 0.01±0.00 | 0.02±0.005 | 0.03±0.01 | 0.01±0.005 | 0.01±0.005 | 0.02±0.01 |
| *Carica papaya* shoot | 0.06±0.005 | 0.08±0.01 | 0.1±0.00 | 0.07±0.01 | 0.04±0.01 | 0.04±0.01 |

ND - Not Detected

Table 3: Metal concentration in root and shoot of plants in control site (Mean±SD)

| Samples | Cd | Cu | Fe | Pb | Mn | Zn |
|---|---|---|---|---|---|---|
| *Musa paradisiacal* root | ND | 0.02± 0.01 | 0.02±0.005 | 0.01± .005 | ND | 0.01± 0.00 |
| *Musa paradisiacal* shoot | ND | ND | ND | ND | ND | ND |
| *Manihot esculenta* root | 0.02±0.005 | 0.04±0.005 | 0.04±0.01 | 0.03±0.01 | 0.02±0.005 | 0.03±0.01 |
| *Manihot esculenta* shoot | ND | 0.01±0.010 | ND | 0.01±0.010 | ND | ND |
| *Colocasia esculenta* root | ND | ND | ND | ND | ND | ND |
| *Colocasia esculenta* shoot | ND | 0.02±0.005 | 0.02±0.010 | ND | ND | 0.01±0.005 |
| *Carica papaya* root | ND | 0.01±0.00 | 0.01±0.005 | ND | ND | 0.01±0.010 |
| *Carica papaya* shoot | 0.01±0.005 | ND | ND | ND | ND | 0.01±0.005 |

ND - Not Detected

Table 4: Bioaccumulation factor (BF) of metals in the plant (Mean±SD)

| | Cd | Cu | Fe | Pb | Mn | Zn |
|---|---|---|---|---|---|---|
| *Musa paradisiacal* | 0.75 | 0.63 | 0.50 | 0.30 | 1.17 | 0.63 |
| *Manihot esculenta* | 1.25 | 1.00 | 0.83 | 0.60 | 0.67 | 0.75 |
| *Colocasia esculenta* | 1.75 | 1.00 | 0.75 | 0.80 | 1.00 | 0.75 |
| *Carica papaya* | 1.75 | 1.25 | 1.08 | 0.80 | 0.83 | 0.75 |

Table 5: Translocation factor ($TF_{Root\ to\ Shoot}$) of heavy metals in the plant

| | Cd | Cu | Fe | Pb | Mn | Zn |
|---|---|---|---|---|---|---|
| *Musa paradisiacal* | 0.50 | 0.67 | 0.50 | 0.50 | 0.17 | 0.25 |
| *Manihot esculenta* | 0.25 | 0.33 | 0.43 | 0.50 | 0.33 | 0.50 |
| *Colocasia esculenta* | 2.50 | 7.00 | 8.00 | 7.00 | 2.00 | 5.00 |
| *Carica papaya* | 6.0 | 4.00 | 3.33 | 7.00 | 4.00 | 2.00 |

Table 6: Translocation factor ($TF_{Soil\ to\ Root}$) of heavy metals in the plant

| | Cd | Cu | Fe | Pb | Mn | Zn |
|---|---|---|---|---|---|---|
| *Musa paradisiacal* | 2.00 | 0.75 | 0.67 | 0.40 | 2.00 | 1.00 |
| *Manihot esculenta* | 4.00 | 1.50 | 1.17 | 0.80 | 1.00 | 1.00 |
| *Colocasia esculenta* | 2.00 | 0.25 | 0.17 | 0.20 | 0.67 | 0.25 |
| *Carica papaya* | 1.00 | 0.50 | 0.50 | 0.50 | 0.33 | 0.50 |

Table 7. Enrichment factor of heavy metals

| Metal | Enrichment Factor |
|---|---|
| Cadmium | 2.00 |
| Copper | 2.00 |
| Iron | 6.00 |
| Lead | 1.67 |
| Manganese | 3.00 |
| Zinc | 4.00 |

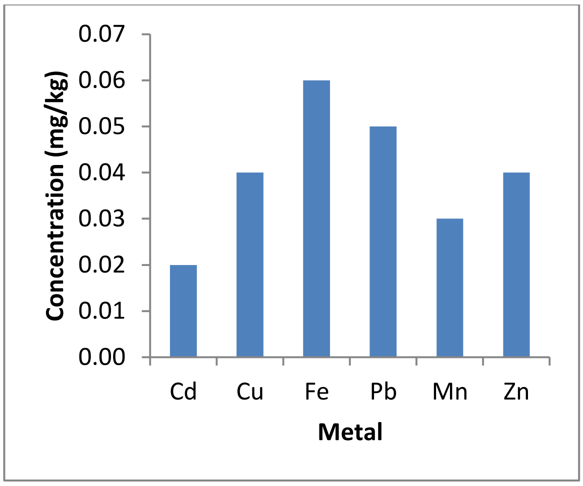


Figure 1: Distribution of heavy metals in the Dumpsites soil

Table 8: FAO/WHO Recommended limits for heavy metals

| Metal | (mg/kg) |
|---|---|
| Cadmium | 0.1 |
| Copper | 10 |
| Lead | 0.05 |
| Zinc | 5 – 15 |
| Manganese | 0.3 |
| Iron | 0.3 |

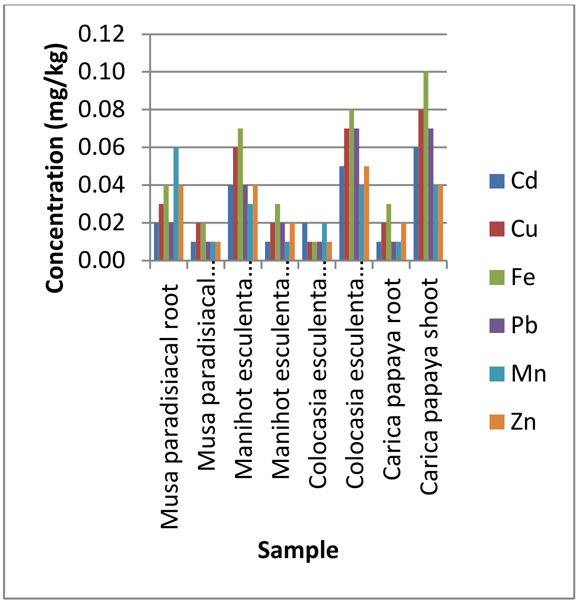


Figure 2: Concentration of metals in the roots and shoots of plants grown in dumpsites

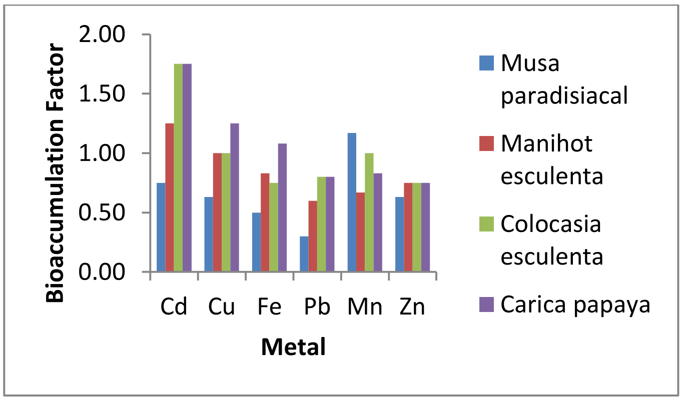


Figure 3: Bioaccumulation factor (BF) of plants grown in dumpsites

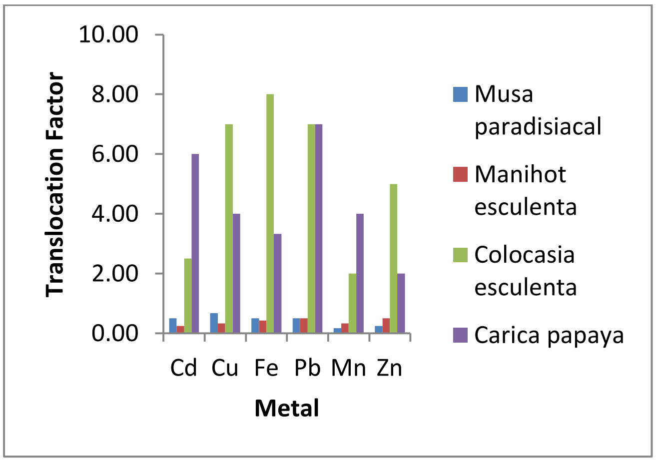


Figure 4: Translocation Factor ($TF_{Root\ to\ shoot}$) of heavy metals by plants grown in dumpsites

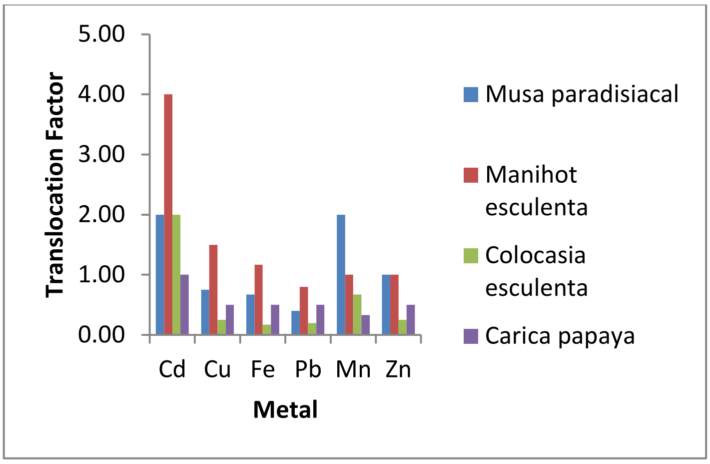


Figure 5: Translocation Factor ($TF_{Soil\ to\ Root}$) of heavy metals by plants grown in dumpsites

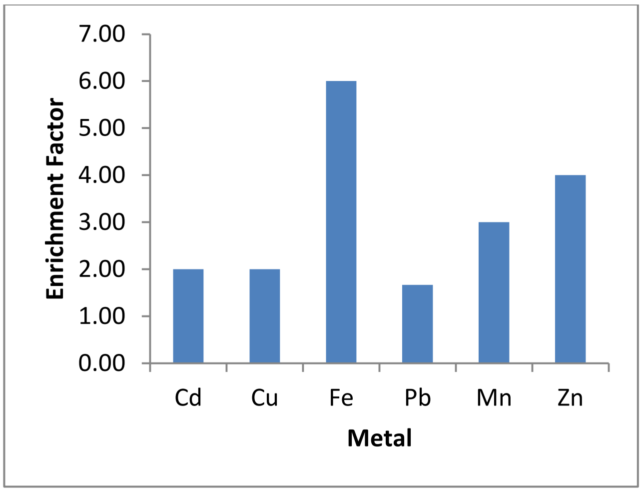


Figure 6: Enrichment Factor (EF) of heavy metals in the dumpsite soil

## Discussion

Iron was the most dominant metal in the dumpsite soil with a mean value of 0.06±0.005mg/kg. The next predominant metal was lead with a mean value of 0.05±0.010mg/kg. Copper and zinc result was 0.040±0.010mg/kg whereas manganese and cadmium had a mean metal concentration of 0.03±0.005mg/kg and 0.02±0.010mg/kg respectively (Table 1 and Figure 1). Cadmium and lead are toxic while Zinc, Manganese Iron and Copper are essential micronutrients (Brady and Weil, 2002). The heavy metals in the dumpsite soil follow the order: Fe>Pb>Cu=Zn>Mn>Cd. The heavy metals Concentrations of the dumpsite soil were higher compared to the control soils. The heavy metal concentration of control site follows in the order: Pb>Cu>Fe=Cd=Mn=Zn. The metal concentrations results were below recommended guidelines by FAO/WHO (1995) except lead (Table 8).

*Musa paradisiacal* and *Manihot esculenta,* had their heavy metals concentrations accumulated more in the roots than in the shoots while *Colocasia esculenta* and *Carica papaya* had the heavy metals concentrations more accumulated in the shoot than in the root (Table 2 and Figure 2). Higher concentration of the heavy metals in the root more than in the shoot had been reported by Satpathy et al., (2014) whereas Zakka et al., (2014) reported higher concentration of the metals in the shoot than in the root. The metal concentration in the root of *Musa paradisiacal* ranged from 0.02-0.06mg/kg while the shoot ranged from 0.01 – 0.02mg/kg (Table 2). The metal concentration follows in the order: Mn>Fe=Zn>Cu>Cd=Pb in the root and Cu=Fe>Cd=Pb=Mn=Zn in the shoot (Table 2 and Figure 2). The metal concentration in the root of *Manihot esculenta* ranged from 0.03 – 0.07mg/kg and 0.01 – 0.03mg/kg in the shoot. The metal concentration in the root and shoot of *Manihot esculenta* follows the ranking: Fe>Cu>Cd=Pb=Zn>Mn and Fe>Cu=Pb=Zn>Cd=Mn. The metal concentration in the root and shoot of *Colocasia esculenta* ranged from 0.01 – 0.02 mg/kg and 0.04 – 0.08 mg/kg respectively (Table 2 and Figure 2). The metal concentration follows the trend: Cd=Mn>Cu=Fe=Pb=Zn in the root of *Colocasia esculenta* and Fe>Cu=Pb>Cd=Zn>Mn in the shoot of *Colocasia esculenta*. The metal concentration in the root and shoot of *Carica papaya* ranged from 0.01 – 0.03mg/kg and 0.04 – 0.08mg/kg respectively. The metal concentrations are ranked in the order: Fe>Cu=Zn>Cd=Pb=Mn in the root of *Manihot esculenta* and Cu>Pb>Cd>Mn=Zn>Fe in the shoot of *Carica papaya* (Table 2 and Figure 2).

The Bioaccumulation factor (BF) is shown in table 4 and Figure 3. The BF factor ranged from 0.30 - 1.17 for *Musa paradisiacal*; 0.60 - 1.25 for *Manihot esculenta*; 0.75 – 1.75 for *Colocasia esculenta* and 0.75 – 1.75 for *Carica papaya*. The Bioaccumulation factor for the studied plants *Musa paradisiacal*, *Manihot esculenta*, *Colocasia esculenta* and *Carica papaya* follows in the order: Mn>Cd>Cu=Zn>Fe>Pb; Cd>Cu>Fe>Zn>Mn>Pb; Cd>Cu=Mn>Pb>Fe=Zn and Cd>Cu>Fe>Mn>Pb>Zn respectively (Table 4 and Figure 3). BF values less than or equal to 1 implies that the plant only absorbs the heavy metals but no accumulation of the metal while BF values greater than 1 indicates that the heavy metals are accumulated (Satpathy et al., 2014). The BF values for the heavy metals in *Musa paradisiacal* were all less than 1 except Manganese (1.17). This indicates that *Musa paradisiacal* is a good bioaccumulator for Manganese. BF values for the heavy metals in *Manihot esculenta* and *Colocasia esculenta* were all less than or equal to 1 except Cadmium (1.25 and 1.75 for *Manihot esculenta* and *Colocasia esculenta* respectively) showing that cadmium can readily bioaccumulate in *Manihot esculenta* and *Colocasia esculenta*. The BF values of the heavy metals in *Carica papaya* had values greater than 1 for Cadmium (1.75), copper (1.25) and Iron (1.08) while the rest were less than 1 which shows that *Carica papaya* is a good bioaccumulator for Cadmium, copper, and Iron.

The Translocation Factor ($TF_{Root\ to\ Shoot}$ and $TF_{Soil\ to\ Root}$) are shown in Table 5 and 6 and Figure 4 and 5. Transfer factor is a major component of human exposure to toxic heavy metals via the food chain (Satpathy et al., 2014). The Translocation Factor ($TF_{Root\ to\ Shoot}$) for *Musa paradisiacal*, *Manihot esculenta*, *Colocasia esculenta* and *Carica papaya* are ranged from 0.25 – 0.67; 0.25 – 0.50; 2.00 – 8.00 and 2.00 – 7.00 respectively. The Translocation factor ($TF_{Root\ to\ Shoot}$) for the metals in the plants as shown in Table 5 and Figure 4 follows in the order: Cu>Cd=Fe=Pb>Zn>Mn for *Musa paradisiacal*; Pb=Zn>Fe>Cu=Mn>Cd for

*Manihot esculenta*; Fe>Cu=Pb>Zn>Cd>Mn for *Colocasia esculenta* and Pb>Cd>Cu=Mn>Fe>Zn for *Carica papaya*. Translocation Factor ($TF_{Root\ to\ Shoot}$) was highest in lead, followed by copper and Iron and least in Manganese. Translocation Factor ($TF_{Root\ to\ Shoot}$) of the heavy metals for *Musa paradisiacal* and *Manihot esculenta* were all less than 1 showing that the translocation of the metals to the shoot by these plants is not easy. The ($TF_{Root\ to\ Shoot}$) for *Colocasia esculenta* and *Carica papaya* were all greater than 1. This indicates the easy translocation of the metals to the shoot by these plants (Obasi et al., 2013). Translocation Factor ($TF_{Root\ to\ Shoot}$) was highest in lead, followed by copper and Iron and least in Manganese (Table 5 and Figure 4)

The Translocation Factor ($TF_{Soil\ to\ Root}$) for *Musa paradisiacal, Manihot esculenta*, *Colocasia esculenta* and *Carica papaya* ranged from 0.40 – 2.00; 0.80 – 4.00; 0.17 – 2.00 and 0.33 – 1.00 respectively (Table 6 and Figure 5). The Translocation Factor ($TF_{Soil\ to\ Root}$) follows in the order Cd=Mn>Zn>Cu>Fe>Pb for *Musa paradisiacal*; Cd>Cu>Fe>Mn=Zn>Pb for *Manihot esculenta*; Cd>Mn>Cu=Zn>Pb>Fe for *Colocasia esculenta* and Cd>Cu=Fe=Pb=Zn>Mn for *Carica papaya*. The Translocation Factor ($TF_{Soil\ to\ Root}$) for cadmium was greater than 1 for all the plants except in *Carica papaya* (1.00). Copper and Iron had $TF_{Soil\ to\ root}$ greater than 1 in *Manihot esculenta* while manganese had $TF_{Soil\ to\ root}$ greater than 1 in *Musa paradisiacal*. This implies easy translocation of these metals from soil to root. The Translocation Factor ($TF_{Soil\ to\ Root}$) was highest for cadmium, followed by Manganese and least in lead (Table 6 and Figure 5). Translocation Factor (TF) is an important indicator that allows for the Assessment of the mobility of heavy metals in plants (Zakka et al., 2014; Zhao et al., 2001). The higher the values recorded for TF the more mobile or available the metals are (Satpathy, 2014). Metal transfer process is very necessary in ascertaining the distribution of the metals in different plant tissues (Xiong, 1998).

The Enrichment Factor (EF) of the dumpsite soils for the heavy metals ranged from 1.67 – 6.00 (Table 7 and Figure 6). The enrichment factor follows in the order: Fe>Zn>Mn>Cd=Cu>Pb. EF values greater than 1 implies higher availability and distribution of metals in the contaminated soil (Satpathy et al., 2014) thus increasing the metal accumulation in the plant species grown on the dumpsite. The EF of the heavy metals were all greater than 1 which implies that they are all readily available and distributed in the dumpsite soils. Iron had the highest EF and lead had the least (Table 7 and Figure 6).

## IV. CONCLUSION/RECOMMENDATION

The present study showed the metal concentration in the dumpsite soil and plant parts to be higher than those in the control site. The bioaccumulation and translocation Factors as well as the Enrichment Factors of the heavy metals were determined. The concentration of the heavy metals in the soil as well as the plant parts were all within the FAO/WHO (1995) except lead. The concentration of the heavy metals in the dumpsite soil follows in the order: Fe>Pb>Cu=Zn>Mn>Cd The accumulation of the heavy metals was higher in the root than in the shoot for *Musa paradisiacal* and *Manihot esculenta* while the metals were more accumulated in the shoot than in the root for *Colocasia esculenta* and *Carica papaya*. *Musa paradisiacal* is a good bioaccumulator for Manganese, *Manihot esculenta* and *Colocasia esculenta* are bioaccumulators for cadmium while *Carica papaya* is a bioaccumulator for Cadmium, copper and Iron. Translocation Factor ($TF_{Root\ to\ Shoot}$) was highest in lead, followed by copper and Iron and least in Manganese. Translocation Factor ($TF_{Root\ to\ Shoot}$) *Musa paradisiacal* and *Manihot esculenta* were all less than 1 while the ($TF_{Root\ to\ Shoot}$) for *Colocasia esculenta* and *Carica papaya* were all greater than 1 indicating easy translocation of the metals to the shoot by *Colocasia esculenta* and *Carica papaya* plants The Translocation Factor ($TF_{Soil\ to\ Root}$) for cadmium was greater than 1 for all the plants except *Carica papaya*. Copper and Iron had $TF_{Soil\ to\ root}$ greater than 1 in *Manihot esculenta* while manganese had $TF_{Soil\ to\ root}$ greater than 1 in *Musa paradisiacal*. This implies easy translocation of the metals from soil to root. The Enrichment Factor of the heavy metals were all greater than 1 which implies that they are all readily available and distributed in the dumpsite soils for absorption by the plants.

Although the metal concentrations were quite low in comparison with FAO/WHO (1995) recommended guidelines, the ease at which the non essential and toxic element cadmium and lead are translocated from root to shoot calls for serious concern. Therefore planting of crops around dumpsite soils should be discontinued with in order to safeguard our health.

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