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# EFFECTS OF URBAN WASTE ON HEAVY METALS CONCENTRATION IN CARICA PAPAYA LINN AND SOIL IN ENEKA DUMPSITE, PORT HARCOURT, RIVERS STATE, NIGERIA

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**Abstract:** The study examined the heavy metal concentrations in the tissues of Carica papaya (CP) tissues and soil in Eneka Dumpsite, Port Harcourt, Nigeria. A transect of 100 m x 300 m was laid from the center of the dumpsite. In the transect a 20 m x 20 m quadrat was established at 10 m, 20 m, 50 m, and 300 m (control) from the dumpsite whereby the soil samples and CP tissues (leaf, fruit and root) were collected. Standard laboratory techniques were used to determine the heavy metals in the soil samples and CP tissues. Results showed that heavy metals in CP and soil decreased with increasing distance from the dumpsite. Fe, Pb and Cu in CP tissues varied significantly with distance. In conclusion, there is accumulation of heavy metals in CP around dumpsite and human consumption of such CP should be reduced or totally avoided.

**Key words:** dumpsite, heavy metals, carica papaya, human health, medicinal

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## INTRODUCTION

Solid waste disposal releases toxic substances into the environment (Kouznetsova et al, 2007). Toxic substances which include heavy metals accumulate in the environment above their normal level and cause alterations in the air, plants, soil, water and micro-organisms. The heavy metals which have densities higher than $5 g/cm^3$, are non-biodegradable and persistently accumulate in the ecosystem; hence heavy metals are serious environmental pollutants (Nubi et al., 2009; Ukpong et al., 2013; Obasi et al., 2013; Aladesanmi et al., 2016; Romocea et al., 2018). The contamination of the soil and plants in the ecosystem may pose health hazards to humans by ingesting the contaminants directly and indirectly through the contaminated soil, food chain (soil-

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plant-human or soil-plant-animal-human), drinking of contaminated groundwater or surface water (Herman et al., 2019a,b,c). Subsequently, the solid waste dumpsite contaminates the soil through disintegration and oxidation processes which in the long run discharge leachate from dumpsites into the neighbouring soils and groundwater (Nagarajan et al., 2012).

The release of heavy metals to the ecosystem would have been reduced in the developing countries but the use of landfill as a way of waste disposal has been a major problem; however open dumps have been the most common method of solid waste disposal.

The threat of heavy metals to the ecosystem would have been reduced especially in the developing countries but the preparation of landfill is a major system of arranging waste in numerous under-developed nations including Nigeria (Adewole, 2009). Thus, open dumps have been the antiquated and commonest way for solid waste dumping. Subsequently, producing solid waste and inadequate dumping system is dangerous to the earth because it leads to ecological contamination particularly in the urban communities (Amadi et al., 2010). Perpetual movements from the provincial ranges to urban zones and population increase in sub-Saharan African nations have aggravated the rate of pollution increase (Awomeso et al., 2010; Najib et al., 2012). Furthermore, lack of extension services and terrible system execution are significant reasons for urban contamination from urban waste especially in Nigeria as this behaviour can result in exposure to heavy metals which exceed health standards.

Studies have shown that dumpsites are used for cultivating crops like cassava, maize and vegetables because of the perceived fertility of the soil in and around the dumpsite (Amadi and Nwankoala, 2013); but this attitude may be deadly if there is no proactive measure to intervene and enlighten the public. This is because the crops absorb heavy metals from the polluted soil and when consumed by man, it could constitute health challenges in the body system (Rotich et al., 2006; Njagi, 2013). It is already established that, the uptake of heavy metals in crops generates a threat to humans and may lead to death of man particularly children. World Health Organization (WHO) assessed that most of the diseases confronting mankind in the recent times came about due to continued contact to environmental contamination (Rotich et al., 2006; Pruss-Ustun and Corvalan, 2006).

Several studies had been carried out on the uptake of heavy metals by crops or plants. This included the study that examined the impacts of dumpsite on spinach, cowpea and potatoes in Mpape dumpsite, Abuja whereby the concentrations of mercury, copper, and cadmium in plants of the dumpsite were above FEPA limit, except spinach that contained Iron and zinc values within the safety limit (Magaji, 2012). Futhermore, the concentration of Cd was more than other heavy metals in all the vegetables investigated (Magaji, 2012). The impacts of dumpsite on the Amaranthus sp vegetable around the dumpsite in Anyigba, Kogi State showed that the concentration of Fe, Zn and Cu at the dumpsite was 7.27 ppm, 6.53 ppm and 6.53 ppm respectively and higher than that of the abandoned dumpsite; though the heavy metals were found to be within the acceptable limits (Musa and Ifatimehin, 2013). A study considered the ecological status of heavy metals in soil of waste dumpsite in Ido-Osun, Osogbo and it was observed that the concentration of Zn was the highest (1133±897 mg/kg) and Cr was the lowest (3.63±2.46 mg/kg) (Olayiwola and Onwordi, 2015). Also, a study investigated the heavy metals contents in both soils and plants in a non-functional waste dumpsites in Port Harcourt whereby the concentrations of Pb and Cd in the plants were higher at the dumpsite than the control site (Eshalomi-Mario and Taneel, 2015); while another study assessed various metals on edible leafy plants of Umuka and Ubahu dumpsites in Okigwe, Imo State, Nigeria whereby heavy metals (Cd, Fe, Pb, Mn, Zn, Cr, Ni and Cu) were significantly higher in different parts of Amaranthus hybridus, Talinum triangulare, Carica papaya, Ipomea batatas and Luffa aegyptica; and that the concentration of Cd among other heavy metals was found to be the highest in the leafy plants (Obasi et al., 2013). None of these studies considered the heavy metal absorption by Carica papaya tissue in a functional dumpsite. Besides, most of the dumpsites in Port Harcourt Metropolis are functional and lots of farming activities are going on around them to subsistently cultivate some crops especially vegetables (pumpkin, okro, pepper), yet some crops grow naturally and Carica papaya is inclusive. Against this background, the study examined the heavy metals uptake by Carica papaya tissues and soil in Eneka Dumpsite, Port Harcourt, Nigeria.

## MATERIAL AND METHODS

### Study Area

The study was carried out in Eneka Dumpsite, Port Harcourt Metropolis, Rivers State, Nigeria. The study area is located between latitude $4^{o}$ 47' 14'' and $5^{0}$ 06' 58'' North and longitudes $7^{o}$ 00' 14'' East and $7^{0}$ 02' 47'' East (figure 1). The criteria used in selecting the study area included proximity to the urban area, accessibility and availability of Carica papaya. Eneka Dumpsite is about 200 m in length and 425 m width tapering to about 130 m along Igwuruta/Eneka highway (Abah and Ohimain, 2010). The area is located in the sub-equatorial region and enjoys the tropical climate. The topography of the area ranges between 16 m and 40 m above the sea level (Mmom and Fred-Nwagwu, 2013) and has the vegetation type similar to tropical rainforest. Generally, the vegetation is consistently nourished with high rainfall and high temperature which provide favourable condition for the growth of varieties of tall and big trees like Swietenia macrophylla, Triplochiton scleroxylon, Terminalia superba, and Elaeis guineensis (Eludoyin et al., 2012). The soils of the area can be categorized as freshwater brown loams and sandy loams.

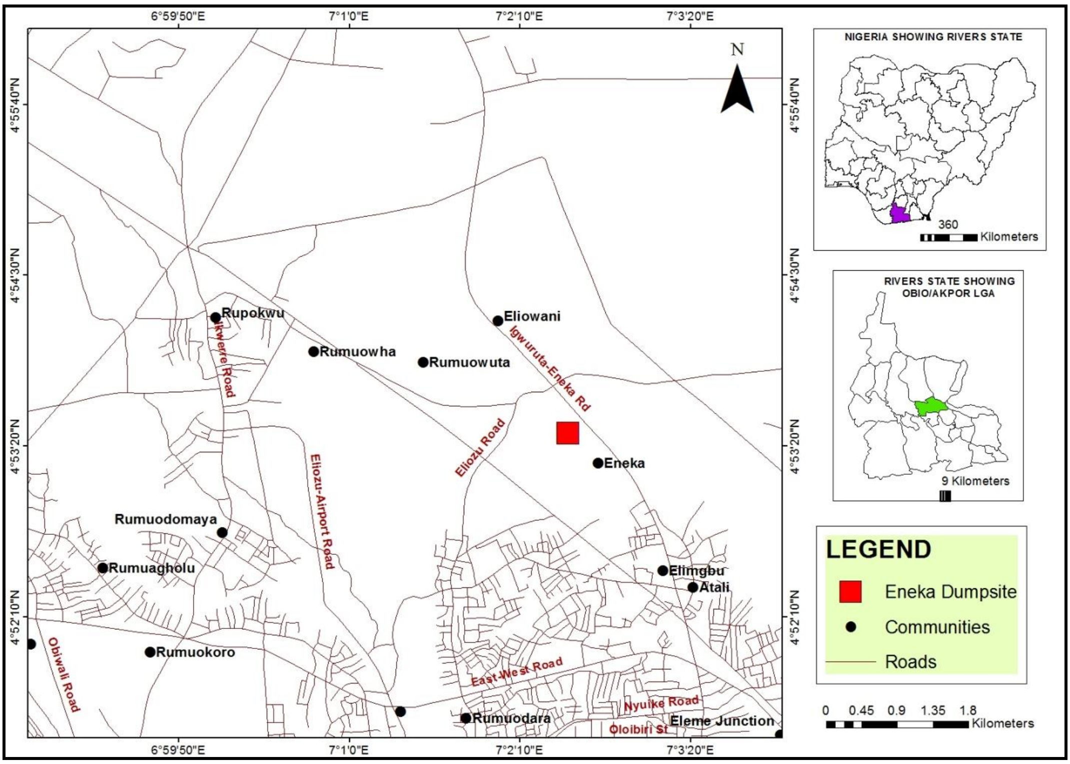


**Figure 1.** Port Harcourt Metropolis showing Eneka Dumpsite Location
Source: Rivers State Ministry of Lands and Survey, 2019

### Research Design and Site Description

The research design of this study was experimental design whereby the study made use of both experimental plot (Eneka Dumpsite) and the control plot. The experimental location of the study was Eneka Dumpsite while the control plot was a fallow land of about 5 years and about 300 m away from the dumpsite. Waste deposited at this site included plastic materials, bottles, cartons, textile materials, electrical wires, cans, leather materials, metal objects, used oil cans and commercial and domestic wastes of various compositions (Eludoyin et al., 2012; Abah and Ohimain, 2013; Mmom and Fred-Nwagwu, 2013; Avwiri and Olatubosun, 2014).

**Carica papaya Sampling Technique**

A transect of 100 m x 300 m was laid from the center of the dumpsite. In the transect, a 20 m x 20 m quadrat was established at 10 m, 20 m, 50 m and 300 m (control) from dumpsite whereby the tissues (leaf, fruit and root) of Carica papaya were collected on the identified papaya stand (figure 1). Three Carica papaya stands of at least 10 m apart were sampled in each 20 m x 20 m quadrat at each distance from the dumpsite. From each Carica papaya stand, 3 composite samples of each of fresh and mature leaves, mature fruits and roots were collected after being homogenized (Tigist et al., 2014). Each composite sample was properly labelled according to their stands and distance from the dumpsite. Thus, a total of 9 samples of each Carica papaya tissue were taken to the laboratory for further analysis.

**Laboratory Analysis for Carica papaya tissues**

The leaf, stem, fruit and root samples of Carica papaya were thoroughly washed with running tap water and rinsed with deionized water to remove any soil particles attached to the plant surfaces. The fruit samples were scrapped to separate the seed from the fruit and thereafter the fruit only were crushed. Similarly, the leaf and root was crushed. All the tissues were oven-dried at 70 °C for 24 hours. After cooling at ambient temperature, the dried tissues were weighed and ground into fine powder and thereafter were kept in pre-cleaned screw capped polyethylene container for further metal concentration analysis. The sample digests of the fruit, leaf, stem and root were analyzed in five replicates for Iron (Fe), Lead (Pb), Nickel (Ni), Cadmium (Cd), and Copper (Cu). These heavy metals were determined by Atomic Absorption Spectrophotometry (AAS) of the Association of Official Agricultural Chemists (AOAC) standard (Akinola and Adenuga, 2008). All the samples were quantified in quadruplicate. The analysis was carried out in the Agronomy Laboratory of the University of Ibadan, Ibadan, Nigeria.

**Soil Sampling Techniques**

A transect of 100 m x 300 m was laid from the center of the dumpsite. In the transect, a 20 m x 20 m quadrat was established at 10 m, 20 m, 50 m and 300 m (control) from dumpsite whereby soil samples were collected from the topsoil (0-15cm) (figure 1). Three soil samples were collected around every selected Carica papaya stand into the well-labelled polythene packs. Thus, nine soil samples were collected at each distance from the dumpsite. The soil specimens were air-dried and sieved with 2 mm mesh for laboratory examination.

**Laboratory Analysis for Soil Samples**

Extracts to be used for determining heavy metals were obtained by leaching soil samples using 0.1N EDTA and 5 g of each sample was weighed into a clean, dry silica dish, covered and ignited in a furnace for 6 h at 500 °C until a grey white ash was obtained (Nwaichi et al., 2014). The cover of the dish was opened to allow for escape of gases. To cool ash samples, 5 ml of 10 % HCl was added to enhance dissolution and 5 ml of 10 % $HNO_3$ was added thereafter and set on a water bath to dissolve completely. The solution was later relocated into a clean dry 50 ml standard volumetric flask and marked up with distilled water (Khan et al., 2008). Extracts used for determining heavy metals were obtained by leaching soil samples using 0.1N EDTA. The concentrations of extractable trace metals including Fe, Pb, Ni, Cd and Cu were determined using AAS of AOACs standard (Nazli et al., 2010; Naeem et al., 2012). The blank reagent and standard reference soil materials was included in each sample batch to verify the accuracy and precision of the digestion procedure and also for subsequent analyses. All the samples were quantified in quadruplicate. The analysis was carried out in the Agronomy Laboratory of the University of Ibadan, Ibadan, Nigeria.

**Method of Data Analysis**

Descriptive and inferential statistics were used to analyze the data obtained on soil samples and tissues of Carica papaya. Analysis of variance (ANOVA) was used to determine the significant differences at $p<0.05$ of heavy metals in soil and Carica papaya with respect to distances from the dumpsite. Relationships between heavy metals in the soil and tissues of Carica papaya were determined using Spearman's rank correlation statistics while scatter diagram was used to depict the correlation between the heavy metals in soil and tissues in Carica papaya. The mean values of the heavy metals in soil were compared with the permissible levels set by United States Environmental Protection Agency (USEPA), Department of Petroleum Resources (DPR) in Nigeria while that of C. papaya tissues were compared with the permissible levels of the World Health Organization (WHO). Pollution Load Index (PLI) for each study site was evaluated (Tomllinson et al., 1980). The PLI was obtained as a contamination factor (CF) of each metal with respect to the natural background value in the soil was computed using Equations (1) and (2) (Ogunmodede et al., 2016). CFs were the heavy metal loads at the baseline and CF>1 indicated heavy metal accumulation or pollution in soil from the test site (Agunbiade and Fawale, 2009). Translocation factors were computed for the heavy metals to quantify the efficiency of Carica papaya to accumulate in a given heavy metal and can be PLI>1 or PLI<1. When PLI>1, the location is being polluted and is of pollution concern (Uwah et al., 2012; Ololade, 2014).

Translocation factor (TF) was determined using the standard method (Ogunmodede et al., 2016).

$$CF = C_{sample} / C_{background} \quad \text{.......} (1)$$

$$PLI = [CF1 \times CF2 \times CF3 \times \ldots \times CFn]^{1/n} \quad \text{.......} (2)$$

where,
CF=contamination factor, n = number of metals = 5;
Csample= metal concentrate on in polluted soils;
Cbackground= mean natural background value of that metal.

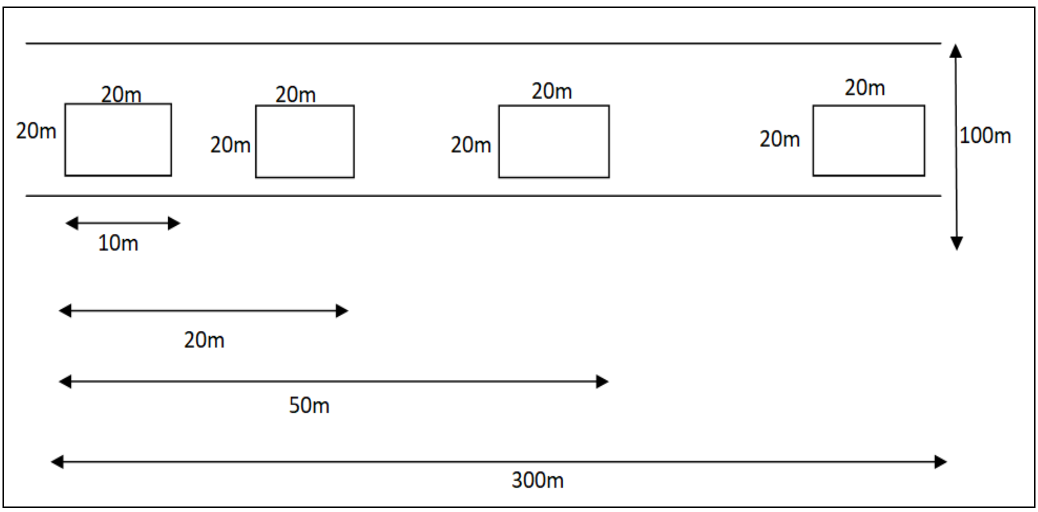


**Figure 2.** Layout of the sampling sites for Soil and Carica papaya sample collection
Source: Researchers' Fieldwork, 2019

## RESULTS

### Heavy metal uptake by Carica papaya with increasing distance from dumpsite

The findings revealed that the mean concentration of Fe decreased with increasing distance from the dumpsite. The mean concentration of Fe was lowest in the Carica papaya tissues in the control site (table 1). However, the concentration of Fe was the highest heavy metal at all the distances from the dumpsite considered for the study. The concentration of Fe was highest in the leaf at all distances from the dumpsite. More importantly, Fe concentrations at different distances from the dumpsite varied significantly among the tissues of Carica papaya ($F=7.18$, $p<0.05$). The mean Pb was highest in the root of Carica papaya at 10m (4.8±8.6 mg/kg); 20 m (3.5±0.3 mg/kg) and 50 m (2.7±0.3 mg/kg) of distance away from the dumpsite. In the root, leaf, and fruit; the concentrations of Pb decreased with increasing distance from the dumpsite. Furthermore, Ni and Cd were lower in concentrations compared to the level of availability of other heavy metals investigated. Their concentrations were slightly varied with increasing distance from the dumpsite. The concentration of Cu was highest in the root at all points of study from the dumpsite and the mean Cu significantly varied among the tissues in the study area ($F=1.27$, $p<0.05$). Summarily, majority of the heavy metals were concentrated in the root, followed by the leaf and lowest in the fruit. Generally, the mean concentrations of heavy metal contents in the tissues of Carica papaya in the dumpsite occurred in the decreasing order of Fe>Cu>Pb>Ni>Cd (table 1). Comparing the level of concentrations of heavy metals with the WHO permissible level, Fe, Ni and Pb concentrations were higher than the permissible level (table 1).

**Table 1.** Heavy metals in the tissues of Carica papaya at different distances from the dumpsite (Source: WHO permissible levels: Bigdeli and Selsepour, 2008; Ogunkunle et al., 2014; Hailemariam et al., 2015; Researchers' Analysis, 2019)

| Parameters (mg/kg) | Tissues | 10m | 20m | 50m | 300m (Control) | F value ($p<0.05$)$^{+}$ | F value ($p<0.05$)$^{++}$ | WHO |
|---|---|---|---|---|---|---|---|---|
| | | Mean±SD | Mean±SD | Mean±SD | Mean±SD | | | |
| Fe | Root | 134.2±21.6 | 127.1±12.3 | 108.3±10.1 | 98.2±6.2 | 4.81* | 7.18* | 425 |
| | Leaf | 189±20.2 | 156±11.2 | 121.3±5.5 | 98.0±7.3 | 5.27* | | |
| | Fruit | 143.0±19.5 | 106.1±15.4 | 97.3±5.6 | 80.0±9.3 | 12.95* | | |
| Pb | Root | 4.8±8.6 | 3.5±0.4 | 2.7±0.3 | 1.8±3.5 | 1.25* | 1.17* | 0.1 |
| | Leaf | 3.7±1.6 | 2.6±0.8 | 2.3±0.9 | 1.9±0.5 | 2.14* | | |
| | Fruit | 3.9±1.4 | 2.7±0.6 | 1.8±0.2 | 1.1±0.5 | 2.67* | | |
| Ni | Root | 0.8±0.1 | 0.6±0.1 | 0.3±0.2 | 0.2±0.1 | 0.07 | 0.29 | 67 |
| | Leaf | 0.7±0.2 | 0.6±0.1 | 0.3±0.1 | 0.2±0.1 | 0.35 | | |
| | Fruit | 0.5±0.1 | 0.4±0.1 | 0.3±0.1 | 0.2±0.1 | 0.27 | | |
| Cd | Root | 0.7±0.1 | 0.5±0.1 | 0.4±0.1 | 0.2±1.7 | 0.12 | 0.68 | 0.05 |
| | Leaf | 0.7±0.2 | 0.5±0.1 | 0.3±0.1 | 0.2±0.1 | 0.91 | | |
| | Fruit | 0.5±0.1 | 0.3±0.1 | 0.2±0.1 | 0.1±0.0 | 0.34 | | |
| Cu | Root | 7.6±1.8 | 7.5±1.1 | 7.3±0.9 | 7.2±0.8 | 0.74 | 1.27* | 73 |
| | Leaf | 6.1±3.8 | 5.4±2.4 | 5.1±2.3 | 5.0±1.9 | 0.75 | | |
| | Fruit | 6.0±1.5 | 5.3±0.3 | 4.9±0.6 | 4.7±1.9 | 1.32 | | |

*F value is significant; + F value of each tissue; ++F value of heavy metals for all tissues; SD-Standard Deviation; n=36;

### Effects of dumpsite on heavy metal concentrations in soil

The concentrations of heavy metals in soils at different distances from the dumpsite are shown in table 2. The result reveals that the concentration of Fe was 1663.0 mg/kg, 1571.0 mg/kg and 692 mg/kg at 10 m, 20 m and 50 m respectively while at the control plot, it was 605.0 mg/kg. The concentrations of Pb, Ni, Cd and Cu also decreased with increasing distance from the dumpsite. The concentrations of heavy metals investigated varied significantly with distance from the dumpsite. The result also revealed that the concentration of Fe was the highest while Ni was the lowest at all the distances considered for this study. The concentrations of heavy metals were significantly varied with distance from the dumpsite. The concentrations of

Ni, Cd and Cu (10 m and 20 m away only) were higher than the permissible limit of DPR while the concentration of Cd at 10 m away from the dumpsite only was higher than the permissible limit of USEPA (table 3). The mean concentrations of heavy metal contents in soils at different distances from the dumpsite occurred in the decreasing order of Fe>Pb>Cd>Cu>Ni (table 2).

**Table 2.** Heavy metal concentrations in soils at different distances from the dumpsite
(Sources: DPR, 2002; Chiroma et al., 2014; USEPA, 2016; Researchers' Analysis, 2019)

| Parameters (mg/kg) | 10 m | 20 m | 50 m | 300 m (Control) | F value (p<0.05) | USEPA | DPR |
|---|---|---|---|---|---|---|---|
| | Mean±SD | Mean±SD | Mean±SD | Mean±SD | | | |
| Fe | 1663±21.2 | 1571.0±18.4 | 692.0±7.8 | 605.0±9.2 | 13.06* | | 5000 |
| Pb | 220.0±8.6 | 175.0±6.4 | 105.0±5.2 | 102.0±3.5 | 5.41* | 300 | 85 |
| Ni | 23.0±3.1 | 16.0±2.6 | 12.5±1.5 | 9.7±1.2 | 2.91* | | 35 |
| Cd | 80.0±5.8 | 65.0±4.7 | 45.0±2.4 | 17.5±1.7 | 4.70* | 70 | 0.8 |
| Cu | 42.5±4.8 | 39.0±4.5 | 29.5±3.3 | 17.7±1.9 | 1.75* | 250 | 36 |

*F value is significant; SD-Standard Deviation

### Contamination Factor and Pollution Loading Index of Heavy Metals in Soil

Contamination factor (CF) and pollution load index (PLI) were used to assess heavy metal contaminations in soil located in and around Eneka Dumpsite (table 3). The CF for the five metals at different distances (10 m, 20 m, and 50 m) were relatively high ranging from 1.03 in Pb to 4.58 in Cd. The analysis has also shown that the CFs decreased with increasing distance from the dumpsite. Furthermore, the CF of Cd was the highest at all distances from the dumpsite considered in this study. Thus, CF at the distance of 10 m, 20 m and 50 m away from the dumpsite is arranged in the decreasing order of Cd>Fe>Cu>Ni>Pb; Cd>Fe>Cu>Pb>Ni and Cd>Cu>Ni>Fe>Pb respectively. The CF of all the heavy metals can be grouped into very severe contamination (table 4). Nevertheless, the PLI was highest at 10 m distance from the dumpsite while the least was observed at 50 m away from the dumpsite. All PLIs were greater than unity and the values fell within moderate pollution (table 4).

**Table 3.** Contamination Factors (CF) of Heavy Metals in Soils around the Mechanic Workshop
(Source: Researcher's Analysis, 2019)

| Heavy Metals | 10 m | 20 m | 50 m | Natural Background Concentration* |
|---|---|---|---|---|
| Fe | 2.75 | 2.60 | 1.14 | 605.0±9.2 |
| Pb | 2.16 | 1.72 | 1.03 | 102.0±3.5 |
| Ni | 2.37 | 1.65 | 1.29 | 9.7±1.2 |
| Cd | 4.58 | 3.71 | 2.57 | 17.5±1.7 |
| Cu | 2.40 | 2.20 | 1.67 | 17.7±1.9 |
| **PLI** | **2.74** | **2.27** | **1.45** | |

*Mean natural background concentration (±SD, n = 5)

**Table 4.** Significance of intervals of contamination/pollution index (C/P)
(Sources: Assuncao et al., 2003; Ogunmodede et al., 2016)

| **Class** | **Contamination factor index** |
|---|---|
| <1 | Very slight contamination |
| 0.10-0.25 | Slightly contamination |
| 0.26-0.5 | Moderate contamination |
| 0.51-0.75 | Severe contamination |
| 0.76-1.00 | Very severe contamination |
| 1.10-2.0 | Slight pollution |
| 2.1-4.0 | Moderate pollution |
| 4.1-9.0 | Severe pollution |
| 9.1-16.0 | Very severe pollution |
| >16.0 | Excessive pollution |

**Translocation Factor (TF)**

The transfer of the heavy metals from soil to Carica papaya tissues in Eneka Dumpsite is presented in table 5. TF is the ratio of the concentration of metal in the aerial portion of the plant to the total concentration in the part in the soil. The result showed that at 10 m away from the dumpsite, the heavy metals occurred in this decreasing order of Fe>Cd>Cu>Pb>Ni; at 20 m, they follow the decreasing order of Fe>Ni>Cd>Pb>Cu; at 50 m, the heavy metals also occurred in the decreasing order of Fe>Ni>Pb>Cu>Cd; while at the control plot (300 m), the TFs of heavy metals occurred in the decreasing order of Ni>Fe>Pb>Cd>Cu. Translocation factors of all the heavy metals in the Carica papaya parts were higher than 1 (table 5). Thus, it may be difficult to translocate metals from the roots to the shoots and as a result, the roots may contain more concentration of the metals.

**Table 5.** Translocation Factor (TF) of heavy metals from soil to Carica papaya tissues
(Source: Researchers' Analysis, 2019)

| Heavy Metals | Distance | | | |
|---|---|---|---|---|
| | 10 m | 20 m | 50 m | 300 m |
| Fe | 2.47 | 2.06 | 2.01 | 1.81 |
| Pb | 1.58 | 1.51 | 1.52 | 1.67 |
| Ni | 1.50 | 1.67 | 2.00 | 2.00 |
| Cd | 1.71 | 1.60 | 1.25 | 1.50 |
| Cu | 1.59 | 1.43 | 1.41 | 1.35 |

**Relationships between heavy metals in Carica papaya tissues and soil**

The correlations between heavy metals in soil and Carica papaya tissues were strong and positive except the relationship between Fe soil and Fe fruit; and Cu soil and Cu fruit (table 6). The coefficient of determination ($R^2$) of the correlations were above 0.90 except for the relationships in Fe soil and Fe fruit ($R^2$=0.691); Fe soil and Fe leaf ($R^2$=0.8919); Pb soil and Pb leaf ($R^2$=0.8734); Ni soil and Ni leaf ($R^2$=0.8809); and Cu soil and Cu fruit ($R^2$=0.6979); which were observed not to be significant at $p<0.05$ (table 6). The positive and strong correlations (≥0.90) showed that more than 90% of the heavy metals in the tissues of Carica papaya around Eneka Dumpsite were absorbed from the soil and through the root.

**Table 6.** Correlations between heavy metals in soil and Carica papaya tissues
(Source: Researchers' Analysis, 2019)

| | Fe Soil | Pb Soil | Ni Soil | Cd Soil | Cu Soil |
|---|---|---|---|---|---|
| Fe Root | 0.976* | 0.964* | 0.941 | 0.982* | 0.980* |
| Fe Leaf | 0.944 | 0.976* | 0.984* | 0.978* | 0.959* |
| Fe Fruit | 0.831 | 0.926 | 0.993* | 0.926 | 0.884 |
| Pb Root | 0.904 | 0.956* | 0.993* | 0.974* | 0.947 |
| Pb Leaf | 0.834 | 0.935 | 0.995* | 0.912 | 0.867 |
| Pb Fruit | 0.921 | 0.971* | 0.994* | 0.968* | 0.942 |
| Ni Root | 0.969* | 0.992* | 0.974* | 0.960* | 0.944 |
| Ni Leaf | 0.988* | 0.977* | 0.939 | 0.965* | 0.962* |
| Ni Fruit | 0.932 | 0.955* | 0.975* | 0.991* | 0.975* |
| Cd Root | 0.880 | 0.922 | 0.976* | 0.985* | 0.963* |
| Cd Leaf | 0.944 | 0.985* | 0.989* | 0.963* | 0.940 |
| Cd Fruit | 0.889 | 0.959* | 0.999* | 0.952* | 0.919 |
| Cu Root | 0.974* | 0.975* | 0.957* | 0.979* | 0.972* |
| Cu Leaf | 0.854 | 0.957* | 0.990* | 0.881 | 0.835 |
| Cu Fruit | 0.894 | 0.973* | 0.998* | 0.926 | 0.889 |

**DISCUSSION**

Findings reveal that only Cd and Pb were higher in the tissues of Carica papaya than the WHO permissible levels of 0.2 mg/kg and 0.3 mg/kg respectively. The high Cd concentration in the tissues of Carica papaya in the study area may be attributed to the inadvertent uptake and translocation (Asuncao et al., 2003; Obasi et al., 2013) and may lead to phytotoxicity in plant (Obasi et al., 2013). Cd in soil was higher than the permissible level of DPR (0.8 mg/kg) while it was only the Cd at 10 m away from the dumpsite that was higher than the permissible levels of USEPA (70 mg/kg). The high concentration of Cd in the entire study area is a great concern, though higher around the dumpsite. This can be attributed to the presence of waste like battery, engine oils, metal parts such as radiator which constitute part of the waste deposited in the dumpsite (Odoh et al., 2006).

The high levels of Cd and Pb may be dangerous to human health as there is tendency of injecting the toxic substance into the food chain thereby accumulating easily in the human body. Ang et al., (2003) reported that Pb is known to be toxic even at low concentration especially in young children and that the ingestion of Pb may result to kidney disorder, brain damage, sensory disturbances. High Cd in the human body can also lead to kidney problem, respiratory system malfunctions, bone damage and cancer (Godt et al., 2006). Translocation factors of all the heavy metals in the Carica papaya parts were higher than 1. Thus, it may be difficult to translocate metals from the roots to the shoots and as a result, the roots may contain more concentrations of the metals. Since the translocation factors of heavy metals in this study were greater than one, this indicated that there was high root to shoot translocation of metals in Carica papaya because translocation factors are always based on the root uptake of the heavy metals and not the foliar absorption of atmospheric metal deposits (Awode et al., 2006). This further proves that Carica papaya has the potentials to be used for phyto-extraction of the metals in the environment (Yoon et al., 2006; Cui et al., 2007). The higher contamination factor of Cd in the study area suggests that Cd was a major heavy metal being absorbed by plants especially Carica papaya and this confirms its high presence in the soil. The PLI of heavy metals in the study area is also found to be highest at the distance of 10 m from the dumpsite and reduced with the increase in distance from the dumpsite. This trend indicates that there is occurrence of dilution and dispersion of heavy metal contents through the soil with increasing distance from the source areas (Chakravarty and Patgiri, 2009). The higher values of PLI showed that anthropogenic sources contribute immensely as heavy metal sources in the study area. It was reported that lower values of PLI imply that there was no major input from anthropogenic sources (Chakravarty and Patgiri, 2009. The relationships between the heavy metals in Carica papaya and soil were positive and strong.

The results simply explained that the heavy metals accumulated in the soils are transported to the tissues of Carica papaya through their roots by the process of absorption (Uwah et al., 2012). Thus, the absorption of heavy metals in the tissues of C. papaya was greatly controlled by the content of heavy metals in the soil solution (Tigist et al., 2014).

## CONCLUSION

The study has demonstrated that heavy metals especially Pb and Cd were absorbed by the tissues of Carica papaya with most of the heavy metals being absorbed by the root and leaf. The concentrations of heavy metals varied significantly with distance from the dumpsite as their concentrations in the Carica papaya tissues decreased with increasing distance from the dumpsite. The heavy metal concentrations in the tissues of C. papaya and soil in the study area occurred in the decreasing order of Fe>Cu>Pb>Ni>Cd; and Cd had the highest contamination factor despite its lowest presence in the soil samples. Positive and strong correlations existed between the heavy metals in the tissues of C. papaya and heavy metal contents in soil except the correlations between Fe soil and Fe leaf; and Cu soil and Cu fruit. Thus, consuming any tissue or part of Carica papaya grown or surviving close to the dumpsite may lead to accumulation of the heavy metals in the body and can cause human ailments such as kidney disorder, brain damage, reductive system malfunction and disturbance of the respiratory organs. The study therefore recommended that the human consumption of C. papaya tissues especially the root and leaf for medicinal purposes around the dumpsite (≤ 50m away) should be discouraged.

Government and waste disposal agencies should prevent indiscriminate disposal of wastes especially those that may be the sources of heavy metals. In addition, government can intensify efforts to deliberately grow Carica papaya around the dumpsite not for human consumption but to be used for phyto-extraction because of its potentials to absorb heavy metals.

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