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Heavy metals loads in soil, farmlands and plant crop at open dumpsite

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ABSTRACT

This study aimed to evaluate concentrations of selected heavy metals in the soils of Ilokun dumpsite and adjourning farmlands, and to determine as well levels of heavy metals uptake in various parts of *Carica papaya* plant collected from the dumpsite. Twenty-two soil samples were collected within the dumpsites and farmlands at depths of 0-20 cm and 20-40 cm. Evaluations of heavy metals (Ni, Zn, Cd, Cr, Pb and Cu) in soil samples and in different parts of *Carica papaya* plants were carried out using atomic absorption spectrophotometer. The study revealed higher concentration of Pb in the dumpsite than the farmlands. Mean concentrations of Cd in the dumpsites; 2.98±1.93 (0-20 cm) and 3.22±2.14 (20-40 cm) were higher than their corresponding depth in farmlands (1.93±1.28 (0-20cm) and 1.94±1.59 (20 – 40 cm). The study established a strong correlation for Ni/Pb (0.948) at depth of 0.20cm; Cu/Cd (0.985) and Pb/Cd (0.918) at depth of 20-40cm. Heavy metal uptake was highest in the plant parts compared to the dumpsites and farmlands. The result showed that translocation factor arrangement is: Cu > Zn > Cd> Cr> Pb> Ni and Cu had the highest translocation factor of 4.698. Based on the results, the various heavy metal could be classified as slight contaminants (Pb, Cr and Ni), moderate contaminants (Cu and Cd) and severe contaminant (Zn). Although concentrations of heavy metals in the farmlands were below the Department of Petroleum Resources and World Health Organisation allowable limits, monitoring the concentration profile of these heavy metals concentrations in the area is recommended to prevent detrimental effects on the environment.

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INTRODUCTION

Soil is essential for human sustenance, sinking and recycling of liquid and solid wastes and production of quality food (Ogunmodede *et al*., 2015; Oyedele *et al*., 2008). Heavy metals are been introduced into the soil unabatedly through wastes generated from human activities. In most developing countries there are inadequate waste management regulations and disposal facilities, resulting in uncontrolled dumping of wastes near semi-urban communities, residential buildings, roadsides, farmlands and open spaces (Afolayan, 2018; Adefemi and Awokunmi, 2013; Dauda *et al*., 2011). Such waste heaps comprise of plastic, paper, metals, batteries, glass, ceramic, ashes, food wastes, which discharges metals and metalloids (with an atomic density >6g/cm^3) into the soil (Ioan *et al*., 2008; Amusa *et al*., 2005). Indiscriminate dumping of these wastes (domestic, industrial, hospital, agriculture etc.) on free and unoccupied land spaces create both long and short term environmental and health problems. Unfortunately, indiscriminate waste dumping and open dumpsite burning are the most prevalent forms of waste disposal practice in Nigeria. As wastes are continuously incinerated in open dumpsites in Nigeria, expectedly, heavy metal pollution in the environment is induced intensely. The presence of a high concentration of heavy metals deposit in the soil through animal manure, fertilisers, pesticides, industrial discharge and wastes can raise concern because the non-biodegradable metals are a threat to the assimilative and carrying capacity of the earth (Khairiah *et al*., 2009; Oyedele *et al*, 2008). Also, the high concentration levels hamper the physical, chemical and biological functionalities of the soil, causes toxicity in plants, animals and human beings (Shokr *et al*., 2016). The accumulation of heavy metals [lead (Pb), nickel (Ni), chromium (Cr), cadmium (Cd), mercury (Hg), aluminium (Al), zinc (Zn), copper (Cu), tin (Sn)] in the soil over a long period of time inadvertently becomes part of the biogeochemical cycle (Afolayan, 2018; Ayeni *et al*., 2017). Over time, the environmental hazardous metals accumulated in the soils and water sediments, resulting in high metals concentration level uptake in plants (Kyere *et al*., 2017; Ukpong *et al*., 2013). Besides, leachates from the dumpsites often contain heavy metals that could scale up soil pollution level (Ebong *et al*., 2018). And because metal depositions are caused by human activities, they tend to be more mobile in comparison with pedogenic or lithogenic forms (Shokr *et al*., 2016). The non-biodegradability of these heavy metals also results in their accumulation in the biosphere and translocation through food chains (Opaluwa *et al*., 2012). The cultivation of plants on contaminated soils can induce indirect or direct bioaccumulation of heavy metals along the food web (Afolayan, 2018). The contaminated farmlands used for the cultivation of crops and plants in some way negatively influence physiological activities of the plants (plant growth, dry matter accumulation and yield) (Oyeleke *et al*., 2016). Studies by Rattan *et al*. (2005), have shown that plant species and plants absorbing levels determine heavy metal accumulation, which has adverse effects on plants. According to Ioan *et al*. (2008), even the trace element of Pb and Cd are toxic to plants – inhibit growth, enzyme activation, photosynthesis and uptake of ion (Amos-Tautua *et al*., 2014; Asati *et al*., 2006). Although, Amos-Tautua *et al*. (2014), argued that at times, the dumpsites provide fertile soil for the cultivation of vegetables and feeder crops, however, excess Fe can result in dark green foliage, dark brown to purple leaves in plants and stunted growth (Afolayan, 2008). The consumption of crops contaminated by heavy metals contaminated agricultural lands have been identified to be the leading causes of health dysfunctional, which are but not limited to impaired psychosocial faculties, intrauterine growth retardation, low immunological defences, upper gastrointestinal cancer, bloody urine, icterus, kidney failure, stomatitis etc. (Duruibe *et al*., 2007). With the increasing health risks associated with the presence of these metals in the soil, exposure to contaminant type, exposure pathway and the vulnerable (Ogunkola and Fatoba, 2014; Adekola *et al*., 2012), it is, therefore, necessary to monitor the contamination level in soil constantly. In a study conducted by Ayeni *et al*., (2017) five selected heavy metals (Cd, Pb, Cu, Ni, Co) were only analysed in soil, plants and herbivorous insects within the vicinity of Ado Ekiti dumpsite. The results showed some contamination levels of copper, nickel and cobalt, while lead and cadmium were undetected in the area. Adefemi and Awokunmi (2013) study concluded that the presence of some selected heavy metals (Hg, Cr, Zn, Fe, Mn, Ni, Sn, Co, Cu, Pb) at the various dumpsites in Ado Ekiti could be attributed to the occurrence of metallic waste deposited from industrial and municipal wastes in the areas. Though, heavy metals levels have been identified in previous studies conducted in Ado Ekiti (Ayeni *et al*., 2017; Adefemi and Awokunmi, 2013; Adefemi *et al*., 2012; Awokunmi *et al*., 2010), however, there is limited analyses of heavy metals on farmlands adjourning dumpsites and fruits, the gap which this study seeks to fill. The aim of this study is to identify the concentration level of selected heavy metals within the dumpsite and adjourning farmlands, and to also determine levels of heavy metals uptake in various parts of *Carica papaya* collected from the dumpsite at Ilokun, Ado Ekiti, and carried out in Nigeria in 2018.

MATERIALS AND METHODS

Study area

The study area is an active open wastes dumpsite located on a vast land along Iworoko road, Ado Ekiti, Nigeria. The town lies on latitude 7° 40′ N and longitude 5° 16′ E with a land area of 265 km^2 (Fig. 1), an estimated population of about 427,700 people and an elevation of 400 metres above sea level (Akintan *et al*., 2018). The area is characterised with the underlain Precambrian basement complex of Southwestern Nigeria and migmatite rock type (Olagunju *et al*., 2018). Located in proximity of about 200 meters to the dumpsite, is a settlement called Ilokun. The monthly mean temperature for the area is 26.7^{0}C (Lawal, 2013), while precipitation is unequally distributed through the rainy season. The study site (~236,980.76 m^2) is a bare expanse of land with adjourning farmlands of about 20 meters away from the dumpsite (Olagunju *et al*., 2018). The site is a government approved dumpsite, where continuous open incineration of wastes, consisting of domestic, hospital, agricultural and industrial wastes takes place. The area surrounding the waste dumpsite is inhabited by people who are mostly farmers, residing in Ilokun.

Sample collection

In all 22 soil samples were collected of which 10 samples were within the dumpsites and 12 samples from the adjourning farmlands at depths of 0 – 20 cm and 20 – 40 cm in March 2018. At every sampling point the coordinates and elevations were taken with a hand-held Global Positioning System (GPS) (Garmin 20x). These soils samples and their corresponding coordinates are shown in Table 1. With the aid of a

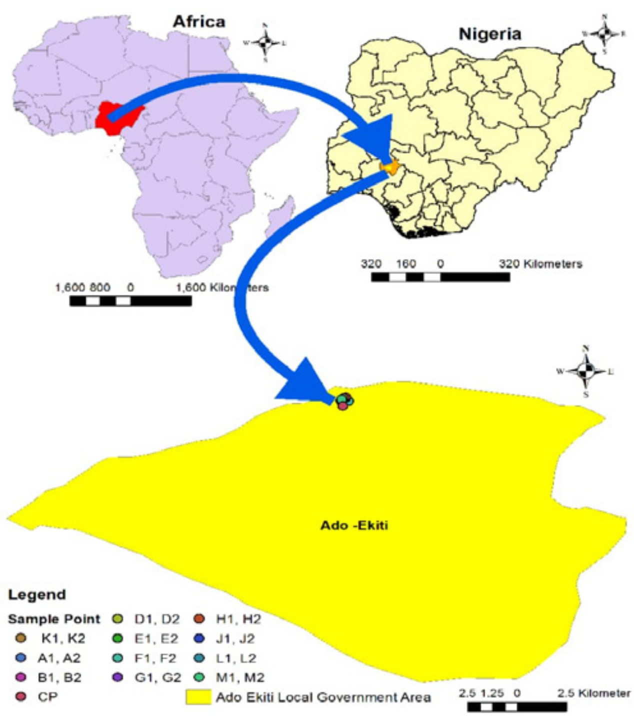


Fig. 1: Geographic location of the study area along with the sampling points in Ado Ekiti, Nigeria

Table 1: Global Positioning System location of sampling points

Sample code	GPS coordinates		
	North	East	Elevation (metres)
A_1, A_2	07°41.262'	005°15.593'	391
B_1, B_2	07°41.260'	005°15.640'	390
D_1, D_2	07°41.213'	005°15.638'	388
E_1, E_2	07°41.164'	005°15.639'	390
F_1, F_2	07°41.261'	005°15.794'	389
G_1, G_2	07°41.360'	005°15.729'	379
H_1, H_2	07°41.372'	005°15.722'	381
J_1, J_2	07°41.340'	005°15.666'	382
K_1, K_2	07°41.347'	005°15.659'	385
L_1, L_2	07°41.303'	005°15.619'	390
M_1, M_2	07°41.308'	005°15.612'	387
CP	07°41.100'	005°15.639'	385

*A_{1-2}–F_{1-2} (soil samples from dumpsite); G_{1-2}–M_{1-2} (soil samples from farmland)

soil auger, samples were collected from each point at depths of 0 – 20 cm and 20 – 40 cm and scooped inside well-labelled polythene sampling bags. The sampling bags were kept inside clean plastic containers to prevent contamination.

Soil Sample preparation

Soil samples were air dried and ground to pass through 0.15 mm sieve. 1g of the sieved samples was weighed into a digest tube and 10 mL of concentrated Trioxonitrate five acid ($HN0_3$) was added and allowed to soak for 30 minutes. The sample was placed on a block digester and heated at 25°C until frothing stopped and nitric acid almost evaporated. 5 mL of concentrated perchloric acid was added and heating continued until the sample turned light straw in colour. This was allowed to cool, distilled water was added and the sample filtered into 100 mL volumetric flask and made up to the mark with distilled water. Blank was prepared using the samples and were determined using a Buck scientific Atomic Absorption spectrometer (Model: 210VGP) at various wavelengths of the metal and detection limits. Quantification of metals was based upon calibration curves of standard solutions of metals. Blanks were included in each batch of analysis and certified reference standard were used to evaluate the accuracy of the analytical method. The blank determination was applied when the blank analysis gives results with a nonzero standard deviation. L_oD and detection limits of the various heavy metals using blank calibration method is shown in Table 2.

Plant Preparation

Stem, leaf and roots of *Carica papaya* plants from the study site were collected, washed with water several times to clean them of soil debris. The samples were air dried for several days and then sorted into its various parts i.e. root, stem and leaves. The various parts were grounded to powdery form and stored in polythene bags for heavy metal (Ni, Zn, Cd, Cr, Pb and Cu) uptake analysis.

Heavy metal analysis

Heavy metal analysis of the sampled soil and the plant (*Carica papaya*) parts were analysed using Atomic Absorption Spectrophotometer (AAS) (AAS BULK SCIENTIFIC MODEL 210 VGP) at the College of Science, Research and Extension Unit of Afe Babalola University (ABUAD), Ado Ekiti, Nigeria. Statistical Package for the Social Sciences (SPSS) 21 software was used in carrying out the descriptive statistical analyses (mean, standard deviation, range) and calculating the heavy metals correlation values of soil samples collected.

Table 2: Wavelengths and detection limit of the calibrated instrument used

Element	wavelength (m)	Detection limit (LoD)
Ni	232.0	0.05
Zn	213.9	0.005
Cd	228.9	0.01
Pb	283.3	0.08
Cr	357.9	0.04
Cu	324.8	0.005

Contamination Factor

The contamination factor of samples were calculated using the modified Ogunmodede *et al*., (2015) method as shown by Eq. 1.

$$CF = \frac{Concentration\ of\ metal\ in\ soil}{Target\ Value} \quad (1)$$

The target value was obtained by using the standard formulated by the Department of Petroleum Resources (DPR, 2002), for the maximum allowed concentration of heavy metals in soils.

Translocation Factor (TF)

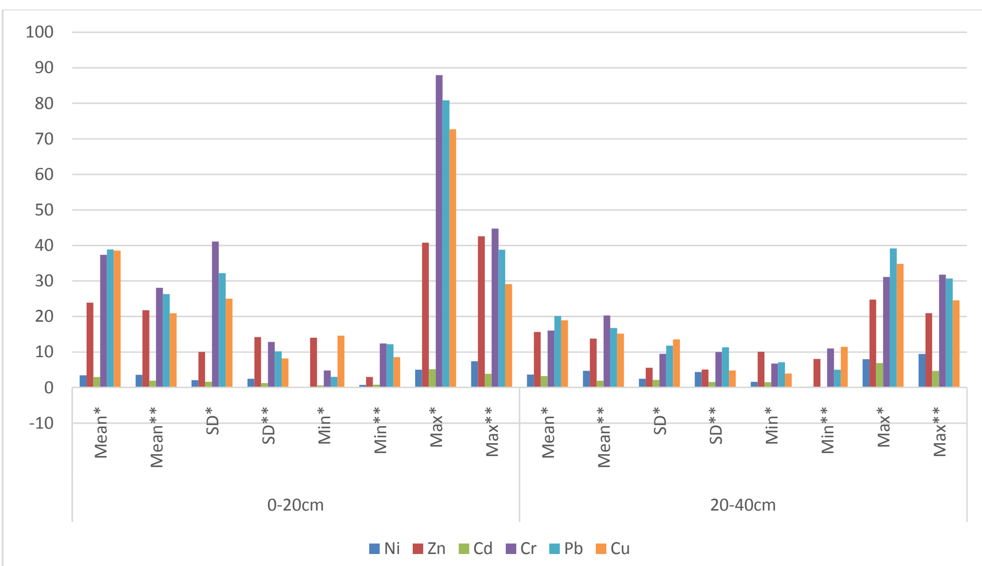
Using Onyedika (2015) approach, the translocation factor (TF) was calculated using Eq. 2.

$$TF = \frac{mean\ shoot\ concentration\left(\frac{mg}{Kg}\right)}{mean\ root\ concentration\left(\frac{mg}{Kg}\right)} \quad (2)$$

RESULTS AND DISCUSSION

Concentration of six heavy metals (Ni, Zn, Cd, Cr, Pb and Cu) were determined for in soils collected at various depths within dumpsite and farmland, and plant (*Carica papaya*) in the study area. The results presented in Fig. 2 indicated the concentrations of heavy metals at 0 – 20 cm and 20 – 40 cm depths in the study area.

From Fig. 2, it can be observed that the mean concentrations of Cr, Pb and Cu at 0 – 20 cm were considerably high in comparison to values at 20 – 40 cm depth. At the dumpsite and farmland, Ni ranges at 20 – 40 cm depth in Table 3 were found to be greater than values at the 0 – 20 cm depth values. The mean concentrations of Ni on the farmland (4.70 mg/kg) were found to be higher than the dumpsite values (3.36 mg/kg) at 20 – 40 cm depth. Cd concentration is relatively the same at both depths within the farmland. Zn, Cr, Pb and Cu decreased in concentration at the various locations. However, the mean concentration of Pb in the dumpsite was found to be higher than that of the farmlands regardless of the depth. This elevated level of Pb found in samples from the dumpsites could be due to ubiquitous presence of automobile wastes and other non-biodegradable metallic as well as hospital wastes that littered the site. Lead levels were also high in this study in comparison to other studies (Kpee and Adori, 2017; Opaluwa *et al*., 2012). This indicates a risk of possible bioaccumulation of the metal (Pb) in the roots, stems, fruits and leaves of plants in the environment thereby making them unfit for consumption since it would predispose humans to the attendant health impacts if consumed (Opaluwa



*Soil samples from dumpsite; **soil samples from farmland

Fig. 2: Comparing the concentration of heavy metals (mg/kg) within the dumpsite and farmland at different depths

et al., 2012; Sunday and Agbaji, 2012). Fig. 2 showed that the mean concentration level of Zn in the soil (dumpsites and dumpsite) was lower than the WHO permissible limit at various depths though higher than that of the farmlands. The mean concentration of Zn in this study (farmland or dumpsite) was above the value reported by Oluyemi and Awokunmi (2013) though lower than that of previous workers (Olayiwola and Onwordi, 2015; Eze, 2014; Cortez and Ching, 2014). The high level of Zn in the dumpsites compared to that of the farmlands could be attributed to the availability of metal-containing wastes at the dumpsites, which could have leached into the underlying soil (Hammed *et al*, 2017). The mean concentration of Cd [2.98±1.66 (0 – 20 cm), 3.22±2.14 (20 – 40 cm)] in the dumpsite were higher than the farmlands [1.93±1.28 (0 – 20 cm) and 1.94±1.59 (20 – 40 cm)]. This study differs from results of previous authors (Twinamatsiko *et al*., 2016; Amos-Tautua *et al*., 2014; Asawalam and Eke, 2006) who all recorded low cadmium levels in their various studies. However, this study agrees with findings of Oluyemi and Awokunmi (2013) who recorded higher level of cadmium in this study area. Possible routes of this metal into soil include batteries, plating, pigments and plastics from domestics' wastes and the application of phosphates in farmlands. The study also shows elevated level of Cu and Cr in the dumpsites compared to the farmlands. In general, levels of heavy metals concentrations in the dumpsites differ significantly from the farmlands. Tables 4 to 7 show the correlation analyses at various depths within the dumpsite and the farmland. There is a correlation between Pb/Cr (0.948) at 0 – 20 cm depth at the dumpsite; Cd/Ni (0.985), Cu/Pb (0.832) at depth of 0 – 20 cm on the farmland. At depth of 20 – 40 cm, the results indicated a correlation between Pb/Cd (-0.918) in the dumpsite, while on the farmland it follows thus: Cr/Ni (-0.931), Pb/Ni (-0.890), Pb/Cd (-0.830), Pb/Cr (0.873). These elemental pairs showed strong correlation significance, as the metal pairs were either positively or negatively correlated. The results indicated that the metals have common contamination source (Edori and Kpee, 2017).

Table 3: Ranges of heavy metals (mg/kg) concentration in the study area

Heavy metals	Range*,1	Range**,1	Range*,2	Range**,2
Ni	-0.05 – 5.05	0.75 – 7.40	0.30 – 9.45	1.60 – 8.00
Zn	14.05 – 40.80	2.99 – 42.60	8.05 – 20.95	10.05 – 24.75
Cd	0.60 – 5.20	0.80 – 3.90	0.10 – 4.65	1.50 – 6.90
Cr	4.80 – 87.95	12.40 – 44.75	11.00 – 31.75	6.75 – 31.15
Pb	3.00 – 80.85	12.20 – 38.80	5.00 – 30.70	7.10 – 39.15
Cu	14.60 – 72.75	8.55 – 29.10	11.50 – 24.55	3.95 – 34.85

*Soil samples from dumpsite; **soil samples from farmland; 1 (0-20cm); 2 (20-40cm)

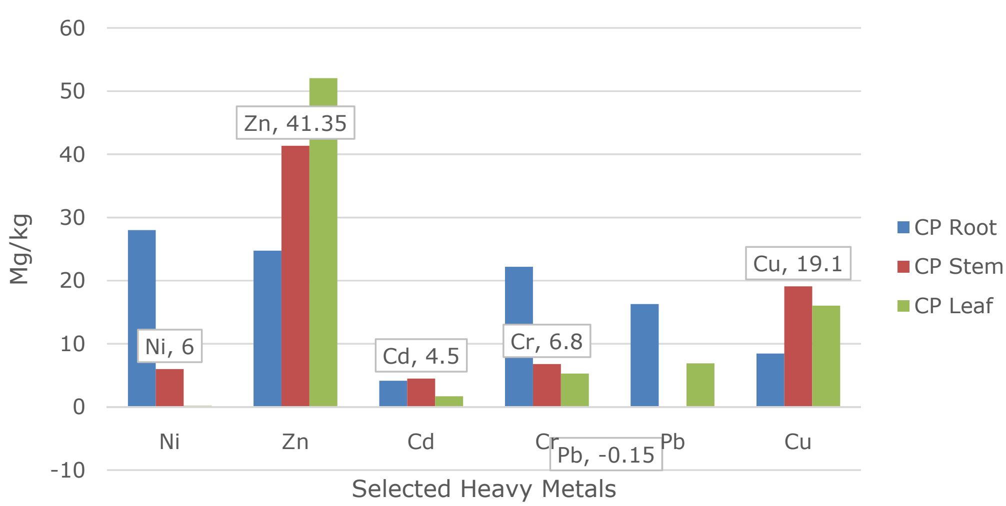


Fig. 3: Concentration of heavy metals in *Carica papaya*

Table 4: Correlation between the selected heavy metals and Dumpsite at 0 – 20 cm Depth

Heavy metals	Correlation of heavy metals (mg/kg)					
	Ni	Zn	Cd	Cr	Pb	Cu
Ni	1					
Zn	.339	1				
	.577					
Cd	-.410	-.243	1			
	.493	.694				
Cr	.614	.546	-.689	1		
	.270	.341	.199			
Pb	.698	.324	-.575	.948	1	
	.190	.595	.310	.014*		
Cu	.529	.530	.217	.532	.596	1
	.359	.358	.726	.356	.289	

*Correlation is significant at the 0.05 level (2-tailed)

Table 5: Correlation between the selected heavy metals and farmland at 0 – 20 cm Depth

Heavy Metals	Correlation of heavy metals (mg/kg)					
	Ni	Zn	Cd	Cr	Pb	Cu
Ni	1					
Zn	.189	1				
	719					
Cd	.985**	.253	1			
	.000	.629				
Cr	-.405	.186	-504 .308	1		
	.426	.725				
Pb	-409	.166	-372 .468	.465	1	
	.420	.754		.353		
Cu	-.375	.052	-357	.544	.832*	1
	.464	.922	487	.264	.040	

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed)

Table 6: Correlation between the selected heavy metals and Dumpsite at 20 – 40 cm Depth

Heavy metals	Correlation of heavy metals (mg/kg)					
	Ni	Zn	Cd	Cr	Pb	Cu
Ni	1					
Zn	-.489	1				
	.404					
Cd	.869	-117 .851	1			
	.056					
Cr	-.529	.779 .120	-.198	1		
	.360		.750			
Pb	.826	.081 .897	-.918*	-.162	1	
	.085		.028	.794		
Cu	.473	.473 .421	.842 .073	.216	.794	1
	.421			.727	.109	

*Correlation is significant at the 0.05 level (2-tailed)

Heavy metals uptake in plant

Fig. 3 shows the level of heavy metals uptake in the root, stem, and leaf of *Carica papaya*. Results of the analysis shows that cadmium uptake in the root is the highest. The concentration profile of heavy metals in the root, stem and leaf follow the order:

Root: Cd> Cu> Pb> Cr> Zn> Ni
Stem: Pb> Cd> Ni > Cr> Cu> Zn
Leaf: Ni >Cd > Cr> Pb> Cu >Zn

Table 7: Correlation between the selected heavy metals and farmland at 20 – 40cm Depth

Heavy Metals	Correlation of heavy metals (mg/kg)					
	Ni	Zn	Cd	Cr	Pb	Cu
Ni	1					
Zn	.786 .064	1				
Cd	.763 .078	-.764 .077	1			
Cr	-.931** .007	.744 .090	-.678 .139	1		
Pb	-.890* .018	.622 .188	-.830* .041	.873* .023	1	
Cu	-.332 .520	-.021 .969	-.132 .803	.595 .212	.500 .313	1

*Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed)

The highest concentration of cadmium in *Carica papaya* root could be due to the ease of absorption of cadmium by plant roots followed by its translocation to other parts (Alloway, 1996; Prasad and Strzalka, 1999).

Contamination factor (CF) and degree of contamination

From Fig. 3, Cd has the highest contamination factor value. The contamination factors in the various heavy metals in depths follow the order;

0 – 20 cm-- Cd> Zn> Cu> Pb> Cr >Ni
0 – 40 cm---Cd> Cu> Pb> Cr> Zn > Ni

Based on the allowed concentration of heavy metals by the DPR, the soil in the study area can be classified as being slightly contaminated (Pb, Cr and Ni) to moderately contaminated (Cu), severely contaminated (Zn) and moderately polluted (Cd) at depth 0 – 20 cm. Fig. 4 shows Cd has the highest contamination factor. The contamination at the depth of 0 – 40cm ranges from slight contamination (Zn and Ni), moderate contamination (Pb and Cr), and very severe contamination (Cu) to moderate pollution in Cd.

TF (Translocation factor)

Fig. 5 shows the translocation factor (TF) of heavy metals from the soil to plants, which is the ratio of the concentration of metals in plants to the total concentration in the soil. Results from this work shows that Cu (4.698) has the highest translocation

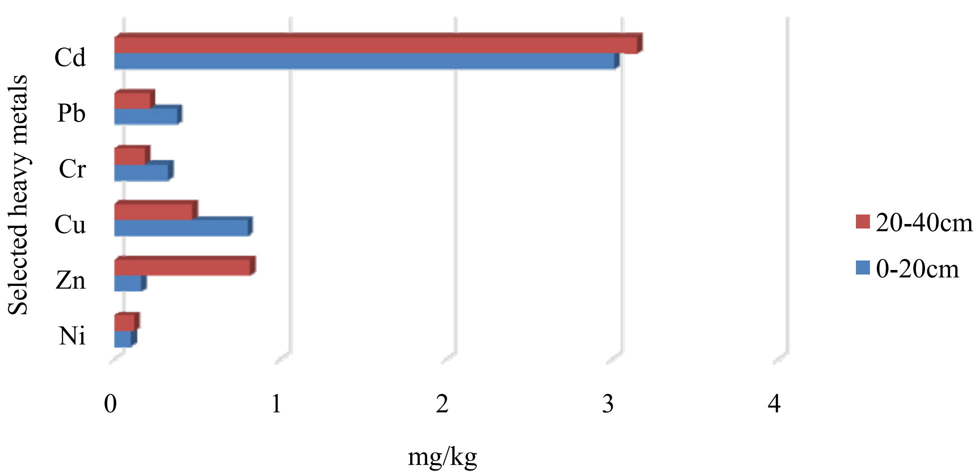


Fig. 4: Contamination factor (CF) for soil samples at various depths

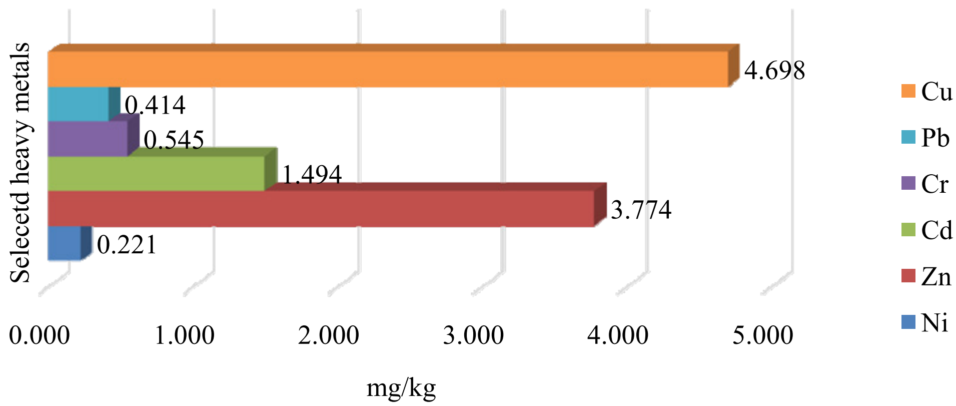


Fig. 5: Translocation Factor (TF) in *Carica papaya*

factor; this is closely followed by Zn (3.7774) while, Ni (0.221) is the least. In the plant, the rate of heavy metals uptake was generally in the order; Cu > Zn > Cd> Cr> Pb> Ni.

Fig. 5 also shows that the plant's parts (root, stem and leaf) have the highest concentration of heavy metals compared to the soil in the dumpsite and the farmlands. Olatunde and Onisoya (2017) reported a higher TF of *C. papaya* in their findings. Also, the result indicated that in the root of *C. papaya*, Ni has the highest load with a concentration mean of 28 mg/kg, while Cd (4.15mg/kg) has the lowest. In the stem, Zn (41.35 mg/kg) was found to be the highest uptake of heavy metals in *C. papaya* while P (0.15 mg/kg) has the lowest value. Zn (52.05 mg/kg) has the highest level of heavy metals uptake in the leaf. The difference in the variation in values obtained for these heavy metals in the soil and crop plant samples as against control site is an indication of their mobility from the dumpsites to the farmlands perhaps through leaching. This observation is in agreement with the study of Oluyemi *et al*., (2008).

TF and mobility

Translocation factors indicate whether heavy metal bio-magnification take place and TF greater than 1 indicates bioaccumulation. The translocation factor in the study area from root to the shoot of the plant shows mobility in the order: Cu> Zn> Cd > Pb > Ni >Cu. It shows that Cu, Zn and Cd exhibited the highest mobility evidenced by their TF>1. The high mobility of these heavy metals can be attributed to their ease of absorption by plants. Pb, N, Cr exhibited low mobility (TF<1) from their root to their stem (shoot system). The high concentration of heavy metals in the root of *Carica papaya* shows that the root tissue can hold more heavy metals through absorption than the shoot. This observation is in agreement with the conclusions in previous works (Prasad and Strzalka, 1999). The high root to shoot translocation is an indication that *Carica papaya* (from study area) could be used for phytoextraction and phytoremediation of heavy metals in contaminated soils, and so it is a good bio-indicator of pollution in some contaminated soils (Oluyemi *et al*., 2008). The findings show that there are positive correlations between Cu and Zn; Cu and Cd; Cu and Cr. There were positive correlations between Pb/Ni; P/Zn; Pb/ Cd; Pb/Cr. Positive correlation between the heavy metals could be attributed to the similarity in sources of these heavy metals in the dumpsites while the negative correlation between them could be attributed to difference in sources of contaminants in the environment (Olayiwola *et al*., 2017). *Carica papaya* has been shown to absorb and retain heavy metals in its various tissues (Ebong *et al*., 2018).

CONCLUSION

The study shows varying level of heavy metals concentrations in the dumpsites, farmlands and *Carica papaya*. Based on the findings, there is elevated level of Ni and Cd at various depths of the study site. At various depths within the farmland there is high concentration of lead in the area. Thus, predisposing crops and plants to risk of bioaccumulation of these heavy metals in their roots, stem, leaves and fruits.

In general, level of heavy metals concentrations in the dumpsites differ significantly from the farmlands. There was significant correlation between Pb/Cr and Pb/Cd at various depths in the locations. Cu, Zn and Cd exhibited the highest mobility evidenced by their TF and was in the order as follows; Cu>Zn>Cd> Cr> P> Ni. Contamination ranges from slightly-moderate-very severe-moderate contamination pollution. With a possibility of these metals leaching from batteries, pigments, plastics, plating and phosphates from fertilizers into the soil, humans and plants are at risk in the area. Though heavy metals accumulation in the farmlands was below DPR and WHO allowable limits, monitoring of heavy metals concentrations in the dumpsites and farmlands is recommended in order to keep under check the detrimental effects of these metals on humans and the environment.

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The authors would like to appreciate Mr Oso, the Laboratory Technologist, Faculty of Agricultural Sciences, Ekiti State University, Ado Ekiti, for his help with the laboratory analyses.

ABBREVIATIONS

°C	Celsius degree
AAS	Atomic absorption spectrophotometer
ABUAD	Afe Babalola University, Ado Ekiti
cm	Centimetre
Cd	Cadmium
Co	Cobalt
CF	Contamination Factor
Cr	Chromium
Cu	Copper
DPR	Department of Petroleum Resources
g	Gram
GPS	Global Positioning System
km	Kilometre
Pb	Lead
Mn	Manganese
Hg	Mercury
mL	Millilitre
mg/kg	Milligram/kilogram
mm	Millimetre
Ni	Nickel
SD	Standard deviation
SPSS	Statistical Package for the Social Sciences
TF	Translocation factor
Sn	Tin
WHO	World Health Organisation
Zn	Zinc

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