Original Research Article

Accumulation of Heavy Metals in Soil and Maize Plant (*Zeamay*) in the Vicinity of Two Government Approved Dumpsites in Benin City, Nigeria

Abstract

Soil contamination by heavy metals is of great concern with respect to human health risks, groundwater contamination, phytotoxicity to plants, adverse effects on microbial activity and diversity, long-term effects on soil fertility and depreciation of land. Soil samples were obtained with the aid of soil Augar within a depth of 0 – 20 cm from the vicinity of the two selected dumpsites in Benin City, Edo State Nigeria. The control samples were taken at 1.5 km away from each dumpsite. The soil samples were assessed for some physico-chemical properties and total heavy metal concentration using standard methods. *Zea mays* (corn) plant samples found growing in the dumpsite areas and their control sites were collected. The plants were sampled, partitioned into parts (leaves, stems, and roots) prior to analysis in the laboratory using atomic absorption spectrophotometer (AAS). The concentration of the metals spanned between 42.66-243.81 mg/kg for Zn, 2.16-21.41 mg/kg for Cu, 0.35-2.59 mg/kg for Cd, 1.11-7.76 mg/kg for Pb and 2.99-10.99 mg/kg for Cr. The mean metal concentrations were compared with Department of Petroleum Resources (DPR) standard values for soils in Nigeria, all the metals analysed are below the DPR target values and intervention values except Zn and Cd which were found above the DPR target values only. Pollution indices such as contamination factor, contamination degree and pollution load index of Zn, Pb, Cd, Cr, and Cu were calculated and their values varied among the heavy metals and between the dumpsites. Concentrations of the metals in the dumpsite soil and plant were found to be in higher concentrations compared to that of the control sites. Significant differences of heavy metals accumulations were observed per plant parts. Heavy metals were found in highest concentrations in the roots of the studied plant. Concentrations of the metals were lower in plant than in soil. The translocation factor, biological concentration factor and biological accumulation coefficient values of the plant species varied for all the metals. These results imply that dumpsites have associated human health and ecological risks.

Keywords: Dumpsites, Heavy Metals, translocation factor, Soil Maize (*Zea mays*).

Introduction

Dumpsites exist throughout developing countries. Most of these dumping sites are uncontrolled and years old, having grown over time from small dumps to large, unmanaged waste sites. This constitutes serious health and environmental concerns because of the effects on the host soils, crops, animal and human health. Many cities in Nigeria have developed without proper planning and it has led to the presence of open dumps within built-up areas inhabited by millions of people. Consequently, such waste dumps become point source for soil pollution as they serve as host for leachate from dumpsites. The composition of solid wastes in major cities in Nigeria comprises domestic garbage, wood, agricultural waste, industrial waste, hospital waste, polythene bags, plastics, broken glasses, abandoned automobiles, demolition waste, ash, dust, human and animal waste. The proper wastes disposal has been a serious problem in Benin City and most cities in Nigeria. Solid and fluid wastes generation and their poor disposal mechanism in the urban areas of most developing countries have become a threat to the environment (Amadi *et al.,* 2010). The contamination of soil with heavy metals is an environmental concern because accumulated metals may have adverse effects on soil ecology, agricultural production, animal and human health as well as groundwater quality (Okiemen *et al.,* 2011). While many heavy metals are essential elements at low levels of concentration, they can exert toxic effects at concentrations higher than permitted in the environment (Anegbe *et al.,* 2014; Mmolawa *et al.,*2011). They may be volatilized to the atmosphere, especially during dry seasons (Okuo and Okolo, 2011). In Benin City metropolis, most of the dumpsites are used as fertile soils for the cultivation of some fruits, food crops and vegetables due to the high cost of fertilizer. Some farmers collect the decomposed parts of the dumpsites and apply to their farms as manure. These cultivated plants take up these heavy metals either as mobile ion in the soil solution through their roots or through their leaves thereby making it unfit for human consumption (Ganesh *et al.,* 2010). Recent studies have also reviewed that waste dumpsite can transfer significant levels of these toxic and persistent metals into the soil environment. Eventually these metals are taken up by plant part and transfer same into the food chain. Consequently, higher soil heavy metals concentration can result in higher levels of uptake by plants. Although, the rate of metal uptake by crop plants could be influenced by factors such as metal species, plants species, plant age, plant part soil composition, geographic and atmospheric conditions (Dulama *et al.,* 2012). Transfer of heavy metal from soils to plants has been proved as an efficient way for removal of these heavy metals through harvestable plant parts such as roots, stems and leaves (Malik *et al*., 2010). However, the metal availability and toxicity to plant can be determined by the soluble and exchangeable fraction of metals in particular (OK *et al.,* 2011). Intake of heavy metals via the crop-soil system has been regarded as the predominant pathway of human exposure to toxic metals (Liu *et al*., 2007), and is normally chronic. This is because these metals are non-biodegradable and can undergo global ecological circles (Opaluwa *et al*., 2012). Thus, it become necessary to assess the uptake of heavy metals by maize plant (*zeamay*) in two government approved dumpsites in Benin City, Nigeria in order to determine their potential hazards to human beings and animals. The objective of this study was to determine and compare the content of heavy metals in various parts of the maize plant, namely the leaves, stems and roots compared to the levels in the soil around Oluku and Ikhueniro dumpsite zones.

Materials and Methods

Study Area

Ikhueniro dumpsite is the largest and the major open dumpsite site in Benin metropolis. It has been in operation as a disposal facility; permitted to receive commercial and municipal solid waste. However, the absence of waste management and sorting systems lead to the dumping of industrial waste into the dumpsite Ighodaro *et al.*, (2015). Ikhueniro and Oluku dumpsite comprises of household materials, hospitals disposables, metals scraps, polyethylene bags and papers, plants materials and debris among other substances. It also consists of scavengers that are involves in sorting some of these materials for re-use. Sites code and coordinates are shown in Table 1, while Figure 1 shows map of Benin City showing the sampling sites.

Table 1: Site Code, Coordinate and Site Description.

Sites	Site Code	Coordinate
Oluku Dumpsite	Site 1	Lat. 6.462425 ^{o} Long. 5.600356 ^{o}
Oluku Control	Site 2	Lat. 6.451132 ^{o} Long. 5.596863 ^{o}
Ikhueniro Dumpsite	Site 3	Lat. 6.326697 ^{o} Long. 5.746157 ^{o}
Ikhueniro Control	Site 4	Lat. 6.334061 ^{o} Long. 5.732361 ^{o}

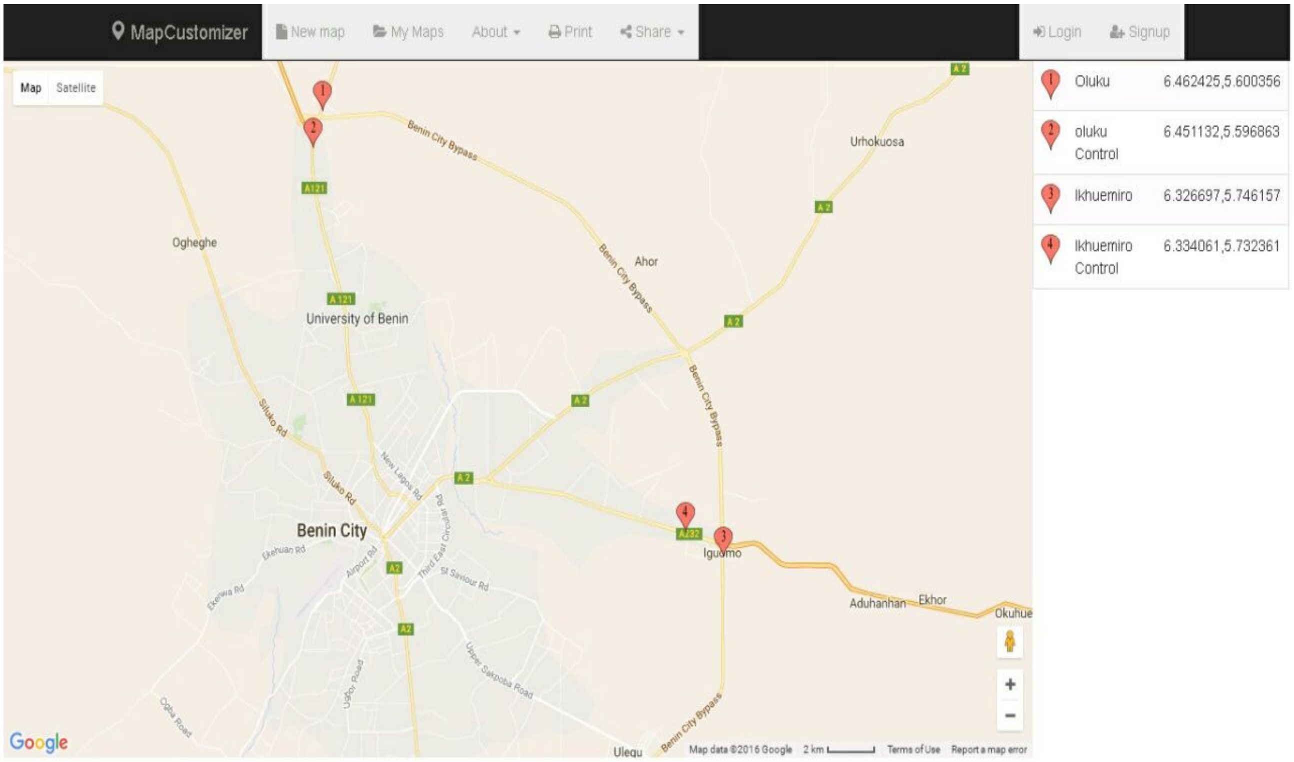

Fig 1: Map of Benin City Showing the Sampled Sites

Collection of Soil Samples

Soil and plant samples were collected from two government approved dumpsites and their control sites within Benin City, namely Oluku dumpsites (A), Oluku control site (B), Ikhueniro dumpsites (C) and Ikhueniro control site (D). In this research, Soil samples at 0- 20 cm depth from rhizosphere of the maize plant were taken from each site from where plant sample was rooted. The soil samples were obtained by the use of soil auger, and then blended (mixed) to obtain a representative sample. The samples were air dried and ground to pass through a 2 mm sieve and used for both physico-chemical analysis and total heavy metal experiment (Anegbe and Okuo, 2013). Prior to the analysis of plant material, leaf, stem and roots of plants were separated and carefully washed with tap and deionized water in order to remove soil or dust deposits. Then the plant samples were oven-dried at 70°C to constant weight, pulverized, passed through 2 mm steel sieve and weighed in order to determine the heavy metals concentrations by atomic absorption spectrometry (Tsvetomil *et al*., 2013). The control soil and plant samples were taken at about 1500 m away from each of the dumpsites.

Analysis of the Soil and Plant Samples

The pH and the CEC were determined as described by Anegbe and Okuo (2013). The hydrometer method described by Ugbune and Okuo (2011), were used in evaluating the particle size. The method described by Anegbe *et al*., (2017), were used to determine the organic carbon content, while the total heavy metals determination was carried out according to Okuo *et al*., (2016). All glasswares used were soaked and washed with chromic acid and rinsed with distilled water. Bulk scientific standard solution was used to calibrate the Atomic Absorption Spectrometer (Pg A500 model). Procedural blank samples were subjected to similar extraction method using the same amount of reagents.

Results and Discussion

The physico-chemical properties of the soil samples at various sites are shown in Table 2.

Soil pH plays a major function in the sorption of heavy metals as it directly controls the solubility and hydrolysis of metal hydroxides, carbonates and phosphates. It also influences ion-pair formation, solubility of organic matter, as well as surface charge of Fe, Mn and Al–oxides, organic matter and clay edges (Tokalioglu *et al.*, 2006). The pH of the studied areas ranged from 7.05 – 8.10 i.e. from neutral to moderately alkaline. It was observed that the pH of soil samples from the two dumpsites are higher than their corresponding control sites. Most mineral and nutrients are more soluble or available in acidic soils than in neutral or slightly alkaline soils. Soils tend to become acidic as a result of rain water leaching away basic ions (Ca^{2+}, Mg^{2+}, K^+ and Na^+) (Bickelhaupt, 2015). High pH might reduce the mobility of some metal species down the soil strata while low pH values usually enhance metal distribution and transport in soil.

Table 2: Physico-chemical Properties of the Soil Samples.

Parameters	Units	Dumpsite soil (Oluku)	Control soil (Oluku)	Dumpsite soil (Ikhueniro)	Control soil (Ikhueniro)
pH		8.10±0.01	7.14±0.02	7.40±0.00	7.05±0.02
CEC	meq/100g	12.82±1.22	5.22±0.15	11.21±0.30	5.20±0.22
TOC	%	1.90±0.26	1.56±0.14	1.74±0.15	1.23±0.30
OM	%	3.28±0.26	2.69 ±0.14	3.00±0.15	2.12±0.30
Clay	%	10.71±0.12	16.71±0.22	28.24±0.40	31.72±0.30
Silt	%	2.09±0.11	2.09±0.10	2.56±0.15	2.49±0.17
Sand	%	87.20 ±0.35	81.20±0.50	69.20±0.31	65.79±0.25

The CEC parameter particularly measures the ability of soils to allow for easy exchange of cations between its surface and solution. In this study the CEC values ranged from 5.20–12.82 meq/100g, which indicates the amount of metal cations such as Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} that are available in the soil, resulting from the porous nature and pH of the soil. The soil samples from the two dumpsites and their controls shows a low CEC which indicates that they are more likely to develop deficiencies in potassium (K^{+}), magnesium (Mg^{2+}) and other cations, while high CEC soils are less susceptible to leaching of these cations (CUCE, 2007). The low values of the CEC were attributed to high sandy nature of the soil samples. According to Wong *et al*. (2007), metals in Ikhueniro control soil will be most bioavailable to plant since the soil has the lowest pH and lowest cation exchange capacity while metals in Oluku dumpsite soil would be less bioavailable since it has the highest pH and highest cation exchange capacity. Textural analysis showed the preponderance of sand fraction (65.79 – 87.20 %), followed by clay (10.71 – 31.72 %) then silt (2.09 – 2.56 %), thus classifying the parent soil as loamy sand. Sandy soils are known to have a poor retention capacity for both water and metals (Wuana *et al.*, 2010). Low organic matter (2.12 – 3.28 %) was observed in all the soil samples. The low organic matter content of the dumpsite and the control soil samples is an indication that these soils will have low adsorption strength and an increased metal mobility and bioavailability (Udeigwe, 2010).

Table 3: Mean Concentrations of Heavy Metals in the Two Dumpsites and Their Control Sites

Heavy Metals	Unit	Dumpsite soil (Oluku)	Control soil (Oluku)	Dumpsite soil (Ikhueniro)	Control soil (Ikhueniro)
Zn	mg/kg	156.78±2.35	58.93±2.07	243.81±5.00	42.66±2.00
Cu	mg/kg	20.17±1.44	2.30±0.24	21.41±1.71	2.16±0.22
Cd	mg/kg	1.40±0.19	0.35±0.08	2.59±0.42	0.73±0.10
Pb	mg/kg	6.36±0.25	1.32±0.56	7.76±0.55	1.11±0.05
Cr	mg/kg	7.92±1.12	4.68±0.50	10.99±0.64	2.99±0.23

The soil samples showed Zn, Cu, Cd, Pb and Cr levels ranging from 42.66 – 243.81 mg/kg, 2.16 – 21.41 mg/kg, 0.35 – 2.59 mg/kg, 1.11 – 7.76 mg/kg and 2.99 – 10.99 mg/kg respectively. This could be attributed to the availability of metal-containing wastes at dumpsite which are eventually leached into the underlying soils. The concentrations of heavy metals are higher in each of the dumpsites than their respective control sites. Liu *et al.* (2007), observed that heavy metal concentration in soils is usually high near the sources, and decline with both distance and depth due to physical dilution and increasing limits in mobility. In overall terms, the results of the present study suggest that the five metals decline in the following order: Zn>Cu>Cr>Pb>Cd for each of the two sites. The results of heavy metals obtained from the analysis also indicate that the concentrations of the heavy metals were found to be higher in Ikhueniro dumpsite when compared with Oluku dumpsite. The higher concentration could be as a result of waste carrying more concentrations of these metals (Pb, Cu, Zn, Cd and Cr) in Ikhueniro dumpsite compared to that of Oluku dumpsite.

Table 4: Comparing of Mean Metal Concentrations of the Sites with the DPR Target and Intervention Values for Normal Soils (mg/kg)

Heavy Metals	Unit	Dumpsite soil (Oluku)	Control soil (Oluku)	Dumpsite soil (Ikhueniro)	Control soil (Ikhueniro)	Target value	Intervention value
Zn	mg/kg	156.78	58.93	243.81	42.66	140	720
Cu	mg/kg	20.17	2.30	21.41	2.16	36	190
Cd	mg/kg	1.40	0.35	2.59	0.73	0.8	12

Pb	mg/kg	6.36	1.32	7.76	1.11	85	530
Cr	mg/kg	7.92	4.68	10.99	2.99	100	380

Table 4 shows the comparism of the two dumpsites and their control sites soil with that of the Department of Petroleum Resources (DPR, 2002) target and intervention values. On comparing of the mean metal concentrations with the (DPR, 2002) standard values for soil, it was found that the concentrations of Zn and Cd were above the DPR target values while the concentrations of Cu, Pb and Cr were below the DPR target values in both Oluku and Ikhueniro dumpsites. All the individual metal concentrations in Oluku and Ikhueniro control sites were below the DPR target values (Table 4). It was also observed that all the individual metal analyzed in all the sites showed concentration that were below the DPR intervention values. The two heavy metals (Zn and Cd) having concentrations above the DPR target values must be monitored effectively and continuously before they attain the DPR intervention values, in order to prevent further soil pollution by these metals.

Assessment of Metal Contamination

Contamination factor (CF)

The level of contamination of soil by metal is expressed in terms of a contamination factor (CF) calculated as:

$$CF = \frac{\text{Cm Sample}}{\text{Cm Background}} \quad (1)$$

Cm Sample = metal concentration in Sample

Cm Background = metal concentration in background or control Sample. (Lin *et al.,* 2009)

Where the contamination factor CF < 1 refers to low contamination; 1 ≤ CF < 3 means moderate contamination; 3 ≤ CF ≤ 6 indicates considerable contamination and CF > 6 indicates very high contamination.

Table 5: Contamination Factor of Each Metal in the Two Dumpsites

Metals	Oluku Dumpsite	Oluku Classes	Ikhueniro Dumpsite	Ikhueniro Classes
Zn	2.66	Moderate contamination	5.72	Considerable contamination
Cu	8.77	Very high contamination	9.91	Very high contamination
Cd	4.00	Considerable contamination	3.55	Considerable contamination
Pb	4.82	Considerable contamination	6.99	Very high contamination
Cr	1.69	Moderate contamination	3.68	Considerable contamination

From the results of the contamination factors (Table 5) the soil samples may be classified as moderately contaminated with respect to Zn and Cr, considerably contaminated with respect to Cd and Pb, and very highly contaminated with respect to Cu in the vicinity of Oluku dumpsite. The soil in the vicinity of Ikhueniro dumpsite may be classified as considerably contaminated with respect to Zn, Cd and Cr, and very highly contaminated with respect to Cu and Pb. It was also observed that the contamination factor of each metal in the vicinity of Ikhueniro dumpsite is greater than the contamination factor of the same metal in Oluku dumpsite except for cadmium which proved otherwise. This is because contamination factor is directly proportional to the concentration of each metal in the sediment, and all the metals in the vicinity of Ikhueniro dumpsite except cadmium have higher sediment concentrations than their counterpart in Oluku dumpsite.

Degree of Contamination

The contamination factor described above is a single element index. The sum of contamination factors for all elements examined represents the contamination degree (Cdeg) of the environment. Using the sum of contamination factors obtained in Table 5 for all elements in each dumpsite.

Table 6: Contamination Degree of the Two Dumpsites.

Oluku Dumpsite	Ikhueniro Dumpsite
21.94	29.84

The contamination degree (Cdeg) values for the two dumpsites are less than 32 (Table 6). Therefore, the soils in the vicinity of the two dumpsites where the plant samples were gotten can be classified as having considerable degree of contamination according to Dasaram *et al.* (2011). However, it is worthy of note that the degree of contamination of soil in the vicinity of Ikhueniro dumpsite is greater than that of Oluku dumpsite; this might be attributed to the higher concentration, and hence higher contamination factor of each metal at the vicinity of Ikhueniro dumpsite than that of Oluku dumpsite.

The Pollution Load Index (PLI)

The pollution load index (PLI) is obtained as contamination factors (CF). The PLI of the place are calculated by obtaining the n-root from the n-CFs that was obtained for all the metals. Generally, pollution load index (PLI) as reported by Harikumar *et al.* (2009), is as follows:

$$PLI = \sqrt[n]{Cf1 \; x \; Cf2 \; x \; Cf3 \; x \; Cf4 \; \dots\dots\dots\dots\dots\dots Cfn} \qquad (2)$$

Where, CF = contamination factor, n = number of metals

The PLI value of > 1 is polluted, whereas <1 indicates no pollution (Harikumar *et al.,*2009).

Table 7: Pollution Load Index (PLI) for the Soil Samples in the Two Dumpsites

Oluku Dumpsite	Ikhueniro Dumpsite
3.77	5.53

The pollution load index values as calculated for both sites were greater than 1 (Table 7). This is strong signs of pollution deterioration by the five measured metals. The pollution load index value was higher in the vicinity of Ikhueniro dumpsite than that of Oluku dumpsite. Hence, the vicinity of Ikhueniro dumpsite may cause more pollution to the environment than Oluku dumpsite.

Uptake of Heavy Metals by Plants in the Vicinity of the Open Dumpsites in Benin City

Although certain trace elements are essential in plant physiology, plants growing in a polluted environment can bioaccumulate trace elements at very high concentration in their edible parts and can present public health concerns (Quierolo, *et al.,* 2000).

Table 8: Uptake of Zn, Cu, Cd, Pb and Cr by Different Parts of the Maize Plants Collected from Oluku Dumpsite and its Control

Metals	Collection Sites	Units	Roots	Stems	Leaves	Shoot
Zn	Dumpsite	mg/kg	62.30	25.14	7.37	32.51
	Control	mg/kg	17.64	7.36	3.11	10.47
Cu	Dumpsite	mg/kg	9.50	3.21	1.98	5.19
	Control	mg/kg	0.78	0.36	<0.05	0.36
Cd	Dumpsite	mg/kg	0.62	0.21	0.26	0.47
	Control	mg/kg	0.10	<0.05	0.09	0.09
Pb	Dumpsite	mg/kg	2.05	0.62	0.35	0.97
	Control	mg/kg	0.32	<0.05	<0.05	0.00
Cr	Dumpsite	mg/kg	3.08	2.15	1.07	3.22
	Control	mg/kg	0.90	0.72	0.54	1.26

Table 9: Uptake of Zn, Cu, Cd, Pb and Cr by Different Parts of the Maize Plants Collected from Ikhueniro Dumpsite and its Control.

Metals	Collection Sites	Units	Roots	Stems	Leaves	Shoot
Zn	Dumpsite	mg/kg	89.55	40.94	22.87	63.81
	Control	mg/kg	13.83	5.79	3.88	9.67
Cu	Dumpsite	mg/kg	10.30	4.98	1.08	6.06
	Control	mg/kg	0.44	0.26	<0.05	0.26
Cd	Dumpsite	mg/kg	0.96	0.54	0.60	1.14
	Control	mg/kg	0.19	0.09	0.15	0.24
Pb	Dumpsite	mg/kg	2.62	1.05	0.26	1.31
	Control	mg/kg	0.21	0.10	<0.05	0.10
Cr	Dumpsite	mg/kg	5.07	2.02	1.77	3.79
	Control	mg/kg	0.72	0.29	<0.05	0.29

Key: **Shoot** = Stem + Leaf

Among all plant parts, roots accumulated the highest metal contents in the two dumpsites (Tables 8 and 9). Whereas concentrations from highest to lowest were Zn 62.30 and 89.55 mg/kg, Cu 9.50 and 10.30 mg/kg, Cr 3.08 and 5.07 mg/kg, Pb 2.05 and 2.62 mg/kg, Cd 0.62 and 0.96 mg/kg, respectively for Oluku and Ikhueniro dumpsites. It was also found that roots from the dumpsite have higher metal concentrations than those found in the control site. This might be attributed to higher concentrations of metals in the dumpsite than the control site. This results compared favourably with those reported by others (Yusuf *et al.,* 2003; Amusan *et al.,* 2005; Li *et al.,* 2007) which all show that dumpsite plants have higher levels of heavy metals than plants grown in unpolluted sites. Highest uptake of metals in roots compared to other parts was also observed in similar studies (John *et al.,* 2009; Sekara *et al.,* 2005). The cited authors found that high accumulation of metals, specifically Zn, was found in the roots of corn and this might be attributed to the species ability to tolerate the metal toxicity. High concentration of metals might also be due to roots direct exposure to the contaminated soil. It was found that corn has a possibility of heavy metals accumulation (i.e. Cu and Zn) in roots, for the highest tolerable level of heavy metal contamination of soil (Sekara *et al.,* 2005). Heavy metals accumulation in leaves and stems of corn were also observed, wherein leaves and stems from the dumpsite have higher metal concentrations than those found in the control site. The results also indicated that the levels of metals in plants are dependent upon their concentrations in their habitual soil environment. Similar results have been reported by other researchers (Oyelola *et al.,* 2009; Ayari *et al.,* 2010; Malik *et al.,* 2010).

Transferability of Metals.

Biological Accumulation Coefficient (BAC) = $\frac{\text{[Metals] shoot}}{\text{[Metals]soil}}$ (3) (Li *et al.,* 2007).

Biological Concentration Factor (BCF) = $\frac{\text{[Metals] root}}{\text{[Metals]soil}}$ (4) (Yoon *et al.,* 2006).

Translocation Factor (TF) = $\frac{\text{[Metals] shoot}}{\text{[Metals]root}}$ (5) (Cui *et al.,* 2007).

Table 10: BAC, BCF and TF for Zn, Cu, Cd, Pb and Cr in the Maize Plant at Oluku Dumpsite

Metals	Biological Accumulation Coefficient (BAC)	Biological Concentration Factor (BCF)	Translocation Factor (TF)
Zn	0.21	0.40	0.52
Cu	0.26	0.47	0.55
Cd	0.34	0.44	0.76
Pb	0.15	0.32	0.47
Cr	0.41	0.39	1.05

Heavy metals accumulate in plant species with different intensity. From Table 10, our findings indicated that the biological accumulation coefficient (BAC) decreases in the following order Cr>Cd>Cu>Zn>Pb. This implies that Cr had the highest metals in shoot to soil ratio while Pb had the lowest ratio of metals in shoot to soil. The biological concentration factor (BCF) decreases as follows Cu>Cd> Zn>Cr>Pb. This implies that Cu had the highest metals in root to soil ratio while Pb had the lowest ratio of metals in root to soil. The translocation factor (TF) follows the order of Cr>Cd>Cu>Zn>Pb. This implies that Cr had the highest metals in shoot to root ratio while Pb had the lowest ratio of metals in shoot to root.

Table 11: BAC, BCF and TF for Zn, Cu, Cd, Pb and Cr in the Maize Plant at Oluku Control Site.

Metals	Biological Accumulation Coefficient (BAC)	Biological Concentration Factor (BCF)	Translocation Factor (TF)
Zn	0.18	0.30	0.59
Cu	0.16	0.34	0.46
Cd	0.26	0.29	0.90
Pb	0.00	0.24	0.00
Cr	0.27	0.19	1.40

From Table 11, our findings indicated that the biological accumulation coefficient (BAC) decreases in the following order Cr>Cd>Zn>Cu>Pb. This implies that Cr had the highest metals in shoot to soil ratio while Pb had the lowest ratio of metals in shoot to soil. The biological concentration factor (BCF) decreases as follows Cu > Zn >Cd >Pb>Cr. This implies that Cu had the highest metals in root to soil ratio while Cr had the lowest ratio of metals in root to soil. The translocation factor (TF) follows the order of Cr>Cd>Zn>Cu>Pb. This implies that Cr had the highest metals in shoot to root ratio while Pb had the lowest ratio of metals in shoot to root. Pb was not detected in the various plant parts but occurred in low concentrations in the roots of the maize plant. The translocation factor (TF) of the maize plant is greater than 1 with respect to chromium shows the special ability of the maize plant to absorb chromium from soils and transport and store it in its above-ground part (Wei *et al.*, 2002). BAC was categorised as: < 1 excluder, 1-10 accumulator and > 10 hyperaccumulator (Ma *et al.,* 2001). Using the results obtained for biological accumulation coefficient (BAC) above, it could be suggested that the maize plant is an excluder with respect to all the heavy metals analysed in Oluku dumpsite and its control site. This is because all the BAC values of the five heavy metals analysed are less than 1 for the two sites. TF > 1 signifies that the plant effectively translocates heavy metals from roots to the shoots (Baker and Brooks, 1989). Hence it can be seen from Tables 10 and 11 that the maize plant effectively translocate chromium from roots to the shoots since the TF of the maize with respect to chromium is greater than 1 both in Oluku dumpsite and its control site.

Table 12: BAC, BCF and TF for Zn, Cu, Cd, Pb and Cr in the Maize Plant at Ikhueniro Dumpsite.

Metals	Biological Accumulation Coefficient (BAC)	Biological Concentration Factor (BCF)	Translocation Factor (TF)
Zn	0.26	0.37	0.71
Cu	0.28	0.48	0.59
Cd	0.44	0.37	1.19
Pb	0.17	0.34	0.50
Cr	0.34	0.46	0.75

The biological accumulation coefficient (BAC) decreases in the following order Cd> Cr>Cu>Zn>Pb. This implies that Cd had the highest metals in shoot to soil ratio while Pb had the lowest ratio of metals in shoot to soil. The biological concentration factor (BCF) decreases as follows Cu> Cr>Cd= Zn> Pb. This implies that Cu had the highest metals in root to soil ratio while Pb had the lowest ratio of metals in root to soil. The translocation factor (TF) follows the order of Cd>Cr> Zn>Cu> Pb. This implies that Cd had the highest metals in shoot to root ratio while Pb had the lowest ratio of metals in shoot to root.

Table 13: BAC, BCF and TF for Zn, Cu, Cd, Pb and Cr in the Maize Plant at Ikhueniro Control Site

Metals	Biological Accumulation Coefficient (BAC)	Biological Concentration Factor (BCF)	Translocation Factor (TF)
Zn	0.23	0.32	0.70
Cu	0.12	0.20	0.59
Cd	0.33	0.26	1.26
Pb	0.09	0.19	0.48
Cr	0.10	0.24	0.40

From Table 13, our findings indicated that the transfer coefficient (TC) of maize in this site follows the order of Cd >Zn>Cr>Cu >Pb. This implies that Cd had the highest metals in plant to soil ratio while Pb had the lowest ratio of metals in plant to soil. The biological accumulation coefficient (BAC) decreases in the following order Cd>Zn>Cu> Cr>Pb. This implies that Cd had the highest metals in shoot to soil ratio while Pb had the lowest ratio of metals in shoot to soil. The biological concentration factor (BCF) decreases as follows Zn

>Cd > Cr >Cu>Pb. This implies that Zn had the highest metals in root to soil ratio while Pb had the lowest ratio of metals in root to soil. The translocation factor (TF) follows the order of Cd>Zn>Cu>Pb >Cr. This implies that Cd had the highest metals in shoot to root ratio while Cr had the lowest ratio of metals in shoot to root.

BAC was categorised as: < 1 excluder, 1-10 accumulator and > 10 hyperaccumulator (Ma et al., 2001). Using the results obtained for biological accumulation coefficient (BAC) above, it could be suggested that the maize plant is an excluder with respect to all the heavy metals analysed in Ikhueniro dumpsite and its control site. TF > 1 signifies that the plant effectively translocates heavy metals from roots to the shoots (Baker and Brooks, 1989). Hence it can be seen from tables 12 and 13 that the maize plant effectively translocate cadmium from roots to the shoots since the TF of the maize with respect to cadmium is greater than 1. High accumulation of heavy metals in roots and low translocation in shoots may indicate appropriateness of a plant species for phytostabilisation (Archer and Caiwell, 2004; Malik *et al.,* 2010). Phyto-stabilization process depends on roots' ability to limit the heavy metals' mobility and bioavailability in the soils and these occurs through sorption, precipitation, complexation or metal valance reduction (Ghosh and Singh, 2005). High root to shoot translocation of metals indicate that the plants have vital characteristics to be used in phytoextraction of the metals (Malik et al., 2010).

Conclusion

The two dumpsites studied in Benin City had revealed that indiscriminate disposal of wastes such as Municipal wastes, industrial wastes, agricultural wastes, etc are major sources of soil contamination and pollution by heavy metals. A knowledge of the total concentration of these heavy metals through soil analysis (as indicator) could be considered as a starting point for evaluating the degree of pollution as investigated in this study. The two heavy metals (Zn and Cd) whose concentrations are above the DPR target values must be monitored effectively and continuously before they attain the DPR intervention values. All of the heavy metals studied were found to accumulate mainly in the roots of the maize plant. It can be concluded that Ikhueniro dumpsite area is more polluted than Oluku dumpsite area and that the indiscriminate disposal of wastes on these land had contributed to the increment in concentrations of these metals in the land. All of the heavy metals studied were found to accumulate mainly in the roots of the maize plant. Linearity dependence was found between the total heavy metal content in the soil and in the plant for all the elements studied. This may suggest that, plant absorption is controlled by the content of heavy metals in the soil solution and also by the content that is bioavailable in the soil.

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