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Heavy metal accumulation in *Corchorus olitorius* L. and *Talinum fruticosurp* (Jacq) Wild grown on soil from abandoned battery dump site in Ile-Igbon, Oyo State, Nigeria

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Abstract

Plants are essential component of the natural ecosystems and terrestrial food chains. They have the potential to accumulate toxic metals when grown on such polluted soil, which could have negative health effects on man and livestock, if consumed. This study was conducted to evaluate the heavy metal accumulation in Corchorus olitorius and Talinum fruticosurp grown on soil from abandoned automobile battery dumpsite in Ile-Igbon, Lagelu Local Government Area, Oyo State, Nigeria. Heavy metals (Pb, Cd, Mn, Fe and Ni) concentrations in the soil, and root and shoot of Corchorus olitorius and Talinum fruticosurp were evaluated and the Transfer Factor (TF) of heavy metals in plants were determined. The experiment was laid out in a completely randomized design with four replicates. The treatments were battery polluted soil from Ile-Igbon and soil (control) from Teaching and Research Farm, University of Ibadan, Nigeria. Seeds and stem cuttings of C. olitorius and T. fruticosurp, respectively were planted into 5 kg pot of polluted and control soils. Heavy metal concentrations of the soil, shoot and root were analysed in the laboratory. Heavy metal concentrations of polluted soil were: Pb (2928 mg/kg), Cd (17.4 mg/kg), Mn (4482 mg/kg) and Fe (1877 mg/kg) as compared to the control: Pb (124 mg/kg), Cd (undetected), Mn (5368 mg/kg) and Fe (25.8 mg/kg). Heavy metals in the root and shoot samples of Corchorus olitorius and Talinum fruticosurp were Pb and Fe. Cadmium, Fe and Pb showed TF>1 for both vegetables. The study concluded that vegetables planted around Ile-Igbon have high concentrations of Pb and Fe. Even though Fe in the vegetables was below WHO permissible level of 425 mg/kg, Pb concentration (3.0 mg/kg) was beyond WHO/FAO permissible level.

Keywords: *Heavy metals, Corchorus olitorius, Talinum fruticosurp Battery dumpsite, Polluted, Non-polluted*

Introduction

Heavy metal had been reported to be non-biodegradable and persistent environmental contaminants (Rajesh *et al.*,2009; Kazemi *et al.*, 2012). They are of great importance in ecotoxicology because of their toxicity at small or large levels when released into the environment; they cannot be completely eliminated and usually accumulate in human organs (Viqar *et al.*, 1992). Accumulation of toxic heavy metals such as Cd, Zn, Cu, Cr, Hg and Pb remains a major concern due to their hazardous exposure and potential effects on human health, agriculture, natural ecosystems and food chain (Adefemi and Awokunmi, 2009).

Indiscriminate use of pesticides, crude oil pollution of agricultural lands, abandoned waste dumpsites, anthropogenic activities and chemical and metallurgical industries are sources of heavy metal pollution (Kuffner *et al.*, 2008). The usage of abandoned polluted factory site for agricultural purposes has resulted in the contamination of soil and exposure of human populations to environmental and health hazards. Report from Basel Convention (2004) revealed that metallic ores from metallurgical activities contain at least 6% of Pb. Also, Pb leachates had been observed from scrap battery dumpsites (Adie and Osibanjo, 2009). Unfortunately, there is no deliberate and systematic way of removing these pollutants from the environment (Idowu and Fayinminnu, 2015). Documentation on abandoned battery dumpsite showed that, the soil and plants contain high levels of heavy metals especially Pb (Ogundiran and Osibanjo, 2008; 2009) with devastative consequences.

Heavy metals accumulation in crops (especially vegetables) may pose a direct threat to human health as reported by Chaitali (2015). Earlier researchers (Moradmand and Harchegani, 2011; Noel and Kinunwe, 2015), revealed that, the toxic metals can be seriously responsible for decreasing immunological defenses, intrauterine growth retardation, impaired psycho-social faculties, disabilities associated with malnutrition and high prevalence of upper gastrointestinal cancer rates in humans. Toxicity of heavy metals such as Pb, Cd and Hg is causing kidney and lung damage, affecting the nervous system, liver, bones and the skeletal system, memory and concentration problems. Also infertility in men and miscarriage in women had been well reported (Nagajyoti *et al.*, 2010).

Vegetables are the edible parts of plant that are consumed wholly or in parts, raw or cooked as part of main dish or salad. They are rich sources of vitamins, minerals, fibers and trace elements (Aletor and Adeogun, 1995; Benti, 2014)) and also have beneficial oxidative effect which could be used to solve the problem of malnutrition (Emokaro and Ekunwe, 2007). Crops and vegetables grown in soils contaminated with heavy metals have greater accumulation of heavy metals than those grown in uncontaminated soil (Eriyamremu *et al.*, 2005) because heavy metals are rapidly taken up in soil (Fusconi *et al.*, 2006). Also, their absorption capacity is determined by the nature of the vegetables and some of them have a greater potential to accumulate higher concentrations of heavy metals than others (Akan *et al.*, 2009). Uptake of heavy metals by vegetables from polluted and contaminated soils causes toxic effects on the plants (Osuocha *et al.*,2013) and their consumption by humans (Odai, *et al.*,2008) might lead to serious health issues (Baker *et al.*, 2000; Duruibe *et al.*, 2007).

Corchorus olitorius is one of the popular edible vegetables in Nigeria. It is usually recommended for pregnant women and nursing mothers because it is believed to be rich in iron (Oyedele *et al.*, 2006). *Corchorus olitorius* is widely consumed with a variety of food particularly in South western Nigeria where it is locally referred to as ewedu, ooyo or obeeyo. The Hausa people and their Fulbe neighbors call it Ayoyo. Report from the study of Dosunmu *et al.* (2003) on trace element levels in local vegetable varieties showed that *C. olitorius* accumulated higher levels of heavy metals in almost all the gardens assessed.

Talinum fruticosurp Jacq. (Wild) (Water Leaf) an edible plant is a succulent herb that grows in shallow soil in rocky outcrops. Adeniyi, (1996) and Ebong *et al.* (2007) reported that *T. fruticosurp* grown on dumpsites in Lagos and Uyo accumulated high concentrations of heavy metals. A study carried out by Uwah *et al.* (2009) on *T. fruticosurp* grown on agricultural polluted soils in Maiduguri showed that, the concentration levels of heavy metals obtained in *T. fruticosurp* samples were higher than the control. Water leaf has been reported to accumulate more heavy metals in its root than in shoot which makes it a metal excluder.

Surprisingly, Nigerians are fond of collecting and farming vegetables from/on abandoned dump waste sites without any consideration for human exposure of such collections that could result in various health challenges after ingestion. Some studies have assessed the heavy metals in soil and plants in the vicinity or surrounding of abadoned battery dumpsites (Ogundiran and Osibanjo, 2008; 2009; Adie and Osibanjo, 2009; Oyeleke *et al.*, 2016). However, studies to asssess the heavy metals in soil and vegetables from such abadoned battery dumpsite are few. There is need to ascertain the quality of food available to our people, for safety concerns. This study was conducted to assess and determine the level of transfer and accumulation of heavy metals in two vegetables grown on soil from heavy metal polluted site in Ile-Igbon, Lagelu Local Government Area of Oyo state, Nigeria.

Materials and Methods

Description of the experimental site

The sample site was Ile-Igbon (7^0 29' 14.17'' N and 4^0 04' 03.03'' S; Elevation 204 m Above Sea Level) in Lagelu Local Government Area of Oyo State, Nigeria. The site consists of battery slag and scraps from automobile battery factory (Defunct Exide Battery), with a rural agricultural settlement (Ogundiran *et al.*, 2012). *Corchorus olitorius* (Ewedu) and *Talinum fruticosurp* (Water leaf) were chosen in this study on the basis that, the residents that lived at close distances from the abandoned automobile battery dumpsite planted vegetables such as *Amarantus cruentus* (Tete), *Abelmoschus esculentus* (Okra) *Corchorus olitorius* (Ewedu), *Talinum fruticosurp* (Water leaf) and *Celosia argentea* (Sokoyokoto). These vegetables are taken to the markets for sale and also for consumption.

Soil sample collection and analysis

Polluted soil sample was collected from Ile-Igbon, while the control soil was collected from Teaching and Research Farm, University of Ibadan Nigeria. Topsoil (0-15 cm) was collected with the aid of Dutchman auger, randomly, in different points at a location and pooled together to form composite samples for the polluted and control soils. The soil samples were collected in new clean polythene bags, sealed and properly labeled for easy identification. They were air-dried for 21days in the laboratory and ground using mortar and pestle, sieved with 2.00 mm wire mesh size, in order to remove stones, small sticks and to make the soil smooth and homogenized. The dried samples were taken to the laboratories for physico-chemical analysis and heavy metals determination.

The physico-chemical analysis for the polluted and control soil samples were determined at the the Departments of Crop Protection and Environmental Biology (CPEB) and Agronomy, University of Ibadan, Nigeria. Total nitrogen and available phosphorus in the soil (Anderson and Ingram, 1989), available potassium (Anderson and Ingram, 1993), pH (Rhoades, 1982), moisture content (Black, 1965) and organic carbon (Tu *et al.*, 2002) were carried out using standard procedures. Determination of heavy metals for the soil samples were done at Bio Tech Center, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun state, Nigeria.

Planting Materials

The vegetables used include *Corchorus olitorius* (Agbadu variety), *Talinum fruticosurp* Jacq. (Wild). *Corchorus olitorius* seeds were purchased from Eagle seeds shop, a renowned agricultural input store at Orogun area of Ibadan, Oyo State, Nigeria, while *Talinum fruticosurp* stem cuttings were obtained from the wild.

Experimental procedure

The experiment was carried out in the green house of the Department of Crop Protection and Environmental Biology. Five kilogrammes (5 kg) of undried polluted soil were measured into a pot (20cm x 60cm) for each of the vegetables. This procedure was repeated for the control soil. The experiment was laid out in a completely randomised design replicated four times. Ten (10) seeds of *C. olitorius* were sown by drilling into the pots for the polluted and control soil samples. This was also repeated for *T. fruticosurp*. Both vegetable stands were thinned to three per pot at two (2) weeks after sowing. There was no addition of fertilizer and the soil was irrigated to field capacity on daily basis using tap water for all experimental pots. Weeds were controlled manually by hand-weeding. Harvesting of plants at maturity was done at 6 and 10 weeks after germination (WAG), respectively for heavy metals analysis.

Heavy metal analysis for plant and soil samples

Whole vegetable plants of *Corchorus olitorius* and *Talinum fruticosurp* harvested at 6 and 10 WAG, respectively from polluted and control soils, were used for heavy metals analysis. Each vegetable plant sample was immersed in 0.01 M HCl solution to remove any external heavy metals and rinsed with deionised water for 1 min. Subsequently, the plants were separated into parts; root and shoot (stem + leaf). After which they were dried at 100 °C for 10 mins and then at 70 °C in an oven until constant weights were obtained. The dried plants and soil samples (5 g) each were digested with a conc. solution of 4:1 HNO_3:$HClO_4$ (v/v). Analysis for heavy metals Pb, Fe, Mn, Cd, Ni and Co in the plant and soil samples were determined using the method described by (AOAC, 2003) and Atomic Absorption Spectrophotometer (AAS).

Transfer Factor Determination

Translocation factor (TF) of heavy metals in plants grown on contaminated soil is the quotient of contaminant concentration in shoot to root (TF), which is used to measure the effectiveness of plant in transferring a chemical pollutant from roots to shoots (Sun *et al*., 2009). It is also the efficiency of different plants in absorbing metals which is evaluated by either plant uptake or soil-to-plant transfer factor (TF) of the metals (Rattan *et al*., 2005; Aktaruzzaman *et al*., 2013) which eventually leads to human exposure to heavy metals. The TF greater than 1 shows the ability of plant to translocate heavy metals from root to shoot. Translocation factor (TF) is a major indicator of human exposure to heavy metals through the food chain.

The Transfer factor for plant was determined using the ratio of the concentration of heavy metals in the soil (roots) and in the vegetables (shoots) (Awode *et al*., 2008; Sun *et al*., 2009):

$$TF = \frac{\text{Ps (mg/kg dry weight)}}{\text{St (mg/kg dry weight)}}$$

Ps is the metals content in plant tissues

St is the total heavy metals content in the soil.

The heavy metals content in the vegetable and soil samples were determined using

$$\text{Concentration (mg/kg)} = \frac{\text{Concentration (mg/L)} \times V}{M}$$

Where V is final volume of solution after digestion (25 mls), M initial weight of the sample (0.1g) (Uwah *et al*., 2012)

Quality Assurance Control

Analytical grade reagents were used for all analysis. All reagents were standardised against primary standards to confirm their actual concentrations. Glasswares and plastic containers used were soaked in detergent solution overnight, rinsed thoroughly under running tap, soaked in dilute nitric acid for 24 hrs and washed thoroughly with deionised water.

Statistical analysis

The data obtained from this study were analysed using Analysis of Variance (ANOVA) and means were separated using Least Significant Different LSD, $P \leq \pm 0.05$

Results

The results as presented in Table 1 summarises the physico-chemical parameters of the polluted and non-polluted (control) soils. The soil was neutral with pH 7.05 (polluted) and (control) 7.21. All soil components and nutrients were higher in the control than polluted soil, with the exception of potassium and phosphorus.

Table 1: Physico-chemical Parameters of the Soil from Polluted Soil from Ile-Igbon and Control

Soil	pH	%OC	%OM	Nitrogen	K	Mg	Ca	Na	P
Polluted	7.05	0.79	1.36	0.78	1.18	1.62	2.93	0.15	3.97
Control	7.21	5.60	9.57	0.82	0.30	0.53	3.25	0.79	2.97

%OC: Percentage Organic Carbon, %OM: Percentage Organic Matter, K: Potassium, Mg: Magnesium, Ca: Calcium, Na: Sodium, P: Phosphorus.

Analysis of heavy metal concentrations (Table 2) showed that Mn, Pb, Fe and Cd varied in the soil samples. High concentration of Mn (5368mg/kg) was found in the control soil, while the least (4482mg/kg) was in the polluted soil. The Cd concentrations in the polluted and control soils were 17.4 and 1.00mg/kg, respectively. For Fe, concentrations was 1879mg/kg for polluted soil and 25.80mg/kg for unpolluted soil. The soil sample from polluted site contained high Pb concentration (2978mg/kg) as against (124mg/kg) in the control. Among the heavy metal analytes, Mn was found to be the highest in concentration followed by Pb, Fe and Cd . The concentration of Cd was found to be the least in the soil samples from all the sampling sites, while Nickel (Ni) and Cobalt (Co) were not detected.

Table 2: Analysis of Heavy Metals from the Polluted Soil from Ile-Igbon

Soil	Pb(mg/kg)	Fe(mg/kg)	Mn(mg/kg)	Cd(mg/kg)	Ni	Co
Polluted	2978.00	1879.00	4482.00	17.40	ND	ND
Control	124.00	25.80	5368.00	1.00	ND	ND
EU (2001)	300	400	500	3	50.	-

Pb = Lead, Fe= Iron, Mn = Manganese, Cd = Cadmium, Ni = Nickel, Co = Cobalt ND; Not detected, EU(2001) = European Union Standard in soil, 2001

Heavy metals varied in the root and shoot samples of *Talinum fruticosurp* from the polluted and control soil samples at 6 and 10WAG. Highest concentrations of Fe (9.81mg/kg) compared to 6.21mg/kg were found in the root for polluted and control soil samples, respectively at 6 WAG. This was followed by Pb, with concentration of 5.47mg/kg (polluted soil) and 2.87mg/kg for the control. However, Cd contained the lowest concentrations (0.01mg/kg) in the root from both polluted and control soil samples. Shoot heavy metal analysis revealed higher concentration of Pb (6.01mg/kg) from the polluted soil and a lower value of 5.27mg/kg for the control. The concentrations of the Cd

(0.02 and 0.01mg/kg) in the shoot from the polluted and control soil, respectively were found to be lowest (Figure 1).

Concentration of Pb at 10WAG in the root of *Talinum fruticosurp* (4.46mg/kg) was higher for the polluted soil, while the control soil was 1.98mg/kg as presented in Fig. 1. The Fe concentration for both polluted and control soil was found to be highest; 8.83mg/kg for control soil and 3.12mg/kg for polluted soil. At 10 WAG, the Pb concentration in the shoot was highest (6.75mg/kg) compared to other heavy metals, for polluted soil and 3.83mg/kg for control. This was followed by Fe; 5.24mg/kg and 4.04mg/kg concentration for polluted and unpolluted soils, respectively. Interestingly, Cd was not detected in the shoot from the polluted soil, while its concentration (0.03mg/kg) from control soil was the lowest among the samples.

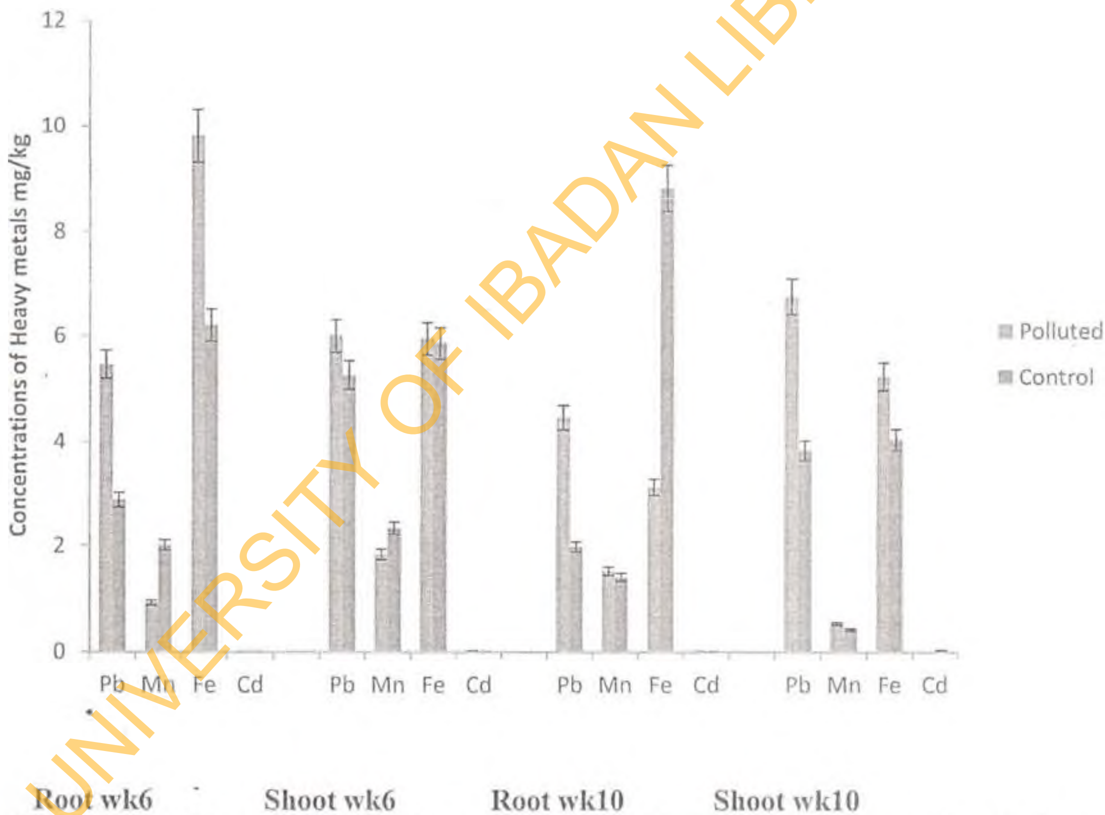

Figure 1: Analysis of Heavy Metals in Roots and Shoots of *Talinum fruticosurp* at Intervals FAO/WHO (2001) Standard in vegetables (mg/kg): Pb=0.3, Mn= , Fe= , Cd=0.2

The concentration of Fe was found to be highest (10.96mg/kg) in the root of *C. olitorius* from polluted soil with the control recording 7.35mg/kg at 6WAG (Fig. 2). High Pb concentration of 3.82mg/kg in the root was from polluted soil, while 1.02mg/kg was from the control. Cadmium was also not detected in the root from polluted soil but interestingly, it was present in the root from the control (0.01mg/kg); the lowest heavy metal concentration recorded. Heavy metal concentrations in the shoot from both polluted and control soil at 6 WAG, followed the same trend as in the root (Fig. 2). Concentration of Fe was highest (9.86mg/kg) in the root at 10 WAG from the polluted soil as against 4.01mg/kg for control. The highest Pb concentration (4.31mg/kg) in the root was also from the polluted soil, while 2.33mg/kg was recorded in the control. The Mn, however, was found to have the lowest concentrations (0.71 and 0.43mg/kg) in the root from both soil samples. Cadmium was still not detected. The shoot of *C.olitorius* from polluted soil at 10WAG had the highest concentration of Fe (10.32mg/kg), while it was 0.85mg/kg for the control. The Pb concentration was high (3.01mg/kg) in the shoot from polluted soil. For the control, it was 1.14mg/kg. The Cd concentration in the shoot sample compared to other heavy metals was the lowest (0.02mg/kg) from the polluted soil, while it was not detected in the control as shown in Fig. 2.

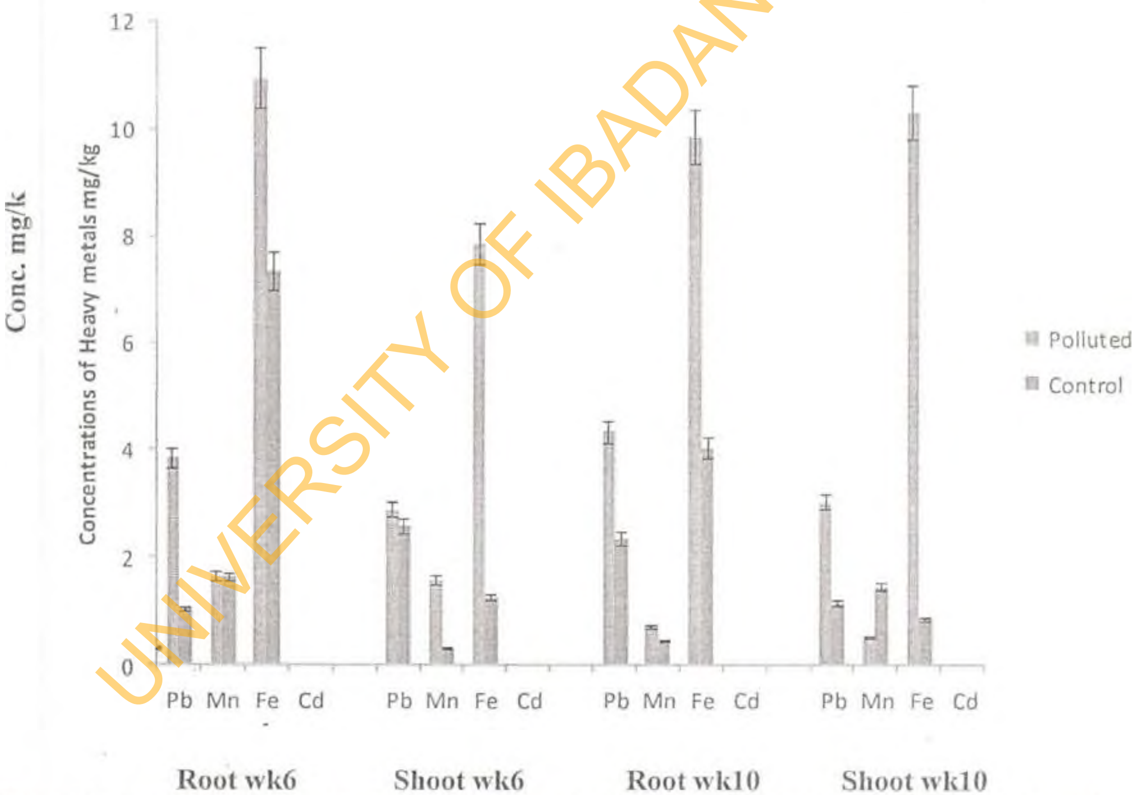

Figure 2: Analysis of heavy metals in Roots and Shoots of *Corchorus olitorius* at Intervals FAO/WHO (2001) Standard in vegetables (mg/kg) : Pb=0.3, Mn= , Fe= , Cd=0.2

High Transfer Factor (TF) values were obtained for Fe in the root and shoot samples of *Talinum fruticosurp* at 6 and 10 WAG for unpolluted soil (0.98-4.72). For polluted soil, TF values ranged from 0.08-0.42. The TF range for Pb was 0.32-1.29 (control soil) and

0.44-0.51 (polluted soil). However, TF values of Cd was constant ranging from 0.5-1.5 in both control and polluted soil samples (Table 3). In the case of *Corchorus olitorius* TF values obtained for Fe in root and shoot samples at 6 and 10 WAG were higher (0.46-2.47) for control soil when compared with 0.05-1.31 for polluted soil. This was followed by the Pb values ranging from 0.35-0.86 (control soil) and 0.60-1.01 (polluted soil). The TF for Cd was 0.00-0.50 (control soil) and 0.00-1.00 (polluted soil) (Table 4). However, the TF values for Mn in the root and shoot samples of both vegetables at 6 and 10 WAG from control and polluted soils were the lowest (0.00-0.01).

Table 3: Transfer Factor of Heavy Metals from Soil to *Talinum fruticosurp* Vegetable

T. fruitcosurp	Heavy metals							
	Pb cont	Pb Pol	Mn cont	Mn pol	Fe cont	Fe Pol	Cd Cont	Cd Pol
Root Wk6	0.32	0.48	0.00	0.01	0.98	0.08	0.50	0.50
Shoot Wk6	0.45	0.44	0.00	0.00	3.14	0.11	0.50	1.00
Root Wk10	0.66	0.51	0.01	0.01	4.72	0.41	0.50	0.50
Shoot Wk10	1.29	0.47	0.00	0.01	1.50	0.42	1.50	0.00

Table 4: Tranfer Factor of Heavy Metals from Soil to *Corchorus olitorius* Vegetable

C. olitorius	Heavy metals							
	Pb cont	Pb pol	Mn cont	Mn Pol	Fe cont	Fe Pol	Cd Cont	Cd Pol
Root Wk6	0.42	0.61	0.00	0.01	2.67	0.05	0.50	0.00
Shoot Wk6	0.86	0.96	0.00	0.00	0.66	0.14	0.00	0.00
Root Wk10	0.78	0.74	0.01	0.00	2.14	1.31	0.00	0.00
Shoot Wk10	0.35	1.01	0.01	0.01	0.46	1.15	0.00	1.00

If TF $\leq$ 0.1, crops from the soil are safe
If TF $\geq$ 0.5, crops from the soil need critical monitoring
Pb- Lead, Mn- Manganese, Fe- Iron and Cd- Cadmium
Cont= control, pol= polluted

Discussion

Organic Matter (OM) is one of the important physical properties of soil. However, its low value obtained in this study may be responsible for high levels of the heavy metals availability in soil, especially the polluted soil. This is in agreement with the study of Pan *et al*. (2007) that, the decrease in soil organic matter increases the accumulation of heavy metals. The high concentrations of heavy metals considered in the current study *viz*., Pb, Fe, Mn and Cd, while Ni and Co (not detected) were found to be within the safe limit set by European Union (EU, 2001) in control soil. However, they were highly above the safe limits in the polluted soil; Pb (300mg/kg), Fe (400mg/kg), Mn (500mg/kg) and Cd (3mg/kg). The high level of Pb and non-detectable status of Ni in the polluted soil sample conform to the report of Ogundiran and Osibanjo (2008) from abandoned battery dumpsite in Nigeria. This study is also in agreement with the reports of Olayinka *et al.* (2011) and Okoronkwo *et al.* (2005a, b) where the concentrations of heavy metals in soils were higher than safe limits in a contaminated soil and an abandoned waste dump soils in Lagos and Umuahia, respectively.

Talinum fruticosurp accumulated high concentrations of Pb in its roots and shoots in the polluted soils with values higher than the permissible levels of FAO/WHO (2001) ; (0.3mg/kg). This is in support of the work of Amusan *et al.* (1999) which reported increased Pb uptake by water leaf from dumpsites, in leaves and roots. Adeniyi (1996) found high levels of Pb in *T. fruticosurp* collected from dumpsite in Lagos. Also, this work is similar to the reports of many researchers that heavy metal such as Pb accumulates in leafy vegetables (Mensah *et al.*, 2008; De Nicola *et al.*, 2008; Odai *et al.*, 2008; Ghosh *et al.*, 2012; Fayinminnu and Adekunle-Jimoh, 2015). There was a decrease in the Pb levels from 6WAG to 10 WAG with Pb accumulating more in the shoots of water leaf than in the roots. Explanation for this may be attributed to differential uptake capacity of water leaf for different heavy metals through the root and their further translocation within the plant parts (Vousta *et al.*, 1996; Udosen *et al.*, 2006). The Fe concentrations in this study which ranged from 3.12-9.81mg/kg, were within the permissible levels. However, the levels of Fe were found to be higher in the roots and shoots of water leaf from polluted soil, which corroborates the report of Radwan and Salama (2006) that Fe is likely to accumulate in leafy vegetables at higher levels than other metals. Also high levels of Fe heavy metal uptake by *T. fruticosurp* in polluted soil had been reported by Obi-Iyeke (2014).

The Fe concentrations found in the roots and shoots of *Corchorus olitorius* from polluted soil in this study were within the permissible level of FAO/WHO (2001). However, the concentration levels 7.85-10.32mg/kg and 9.86-10.96mg/kg obtained in the shoots and roots, respectively were higher than the value recorded in *C. olitorius* (Tossa jute) (0.334mg/kg) as reported by Shuaibu *et al.* (2013). High levels of Fe accumulation in *C. olitorius* in this study is in agreement to the work of Rasaq *et al.* (2015) which found Fe to be highest in *C. olitorius* and other vegetables. This may be attributed to the nature of soil and the presence of some soil microorganisms (bacteria) sometimes which thrive on Fe. The concentrations of Pb in both roots and shoots of *C. olitorius* were highly above the safe limit of WHO/FAO (2001); (0.3mg/kg). This finding is in agreement with the study of Babatunde *et al.* (2014) that found high levels of Pb in stems and roots of *C. olitorius*. There were no increase in concentration of heavy metals from 6 WAG to 10 WAG. This is in sync with Whatmuff (2002) and McBride (2003) assertion that increasing concentrations of heavy metals in soil does not necessarily increase the crop heavy metal uptake. Manganese, however, recorded the lowest value in the shoot and root of *C. olitorius*.

The transfer factor values for the metals and the vegetable samples in this study varied. This may be due to the differences in the concentration of metals in the soils (polluted and control) and the extent of uptake of heavy metals by different vegetables (Singh *et al.*, 2010). The results from this present work showed general low transfer factor values. The explanation may be that, the metals were not very mobile in the soil, which led to reduction in availability.

Among all the different heavy metal analytes, Cd showed higher constant TF values >0.5 for the vegetables from the polluted and control soils, this conforms to the work of Deribachew *et al.*, (2015) that the TF for Cd was consistent for all vegetable samples from different sites studied. This indicated that Cd is more readily available in the soils than other heavy metals which made it to be retained by the soil and hence more mobile than other metals (Deribachew *et al*., 2015). One could, therefore, infer that the bioaccumulation of heavy metals in vegetables in this study, is very high and their consumption could lead to hypertension, arthritis, diabetes, anaemia, cancer, cardiovascular disease, cirrhosis, reduced fertility; hypoglycemia, headaches, osteoporosis, kidney disease and strokes as chronic toxicity (Lokeshappa *et al*., 2012) as a result of Cd poisoning.

The Pb heavy metal showed high TF values >0.5 in all the shoots and roots of both vegetables at 6 and 10 weeks after germination. The highest being 1.29 in the shoot of *Talinum fruticosurp* from the control soil, while *Corchorus olitorius* had a value of 1.01 from polluted soil. All these indicated that vegetables from the study areas had a high Pb contamination values with the possibility of development of Pb related diseases such as abnormal brain function, blindness, convulsions, deafness, dyslexia, encephalitis, epilepsy, insomnia, multiple sclerosis, muscular dystrophy, Parkinson's disease, vertigo, arteriosclerosis, atherosclerosis, colic, constipation, weight loss, spontaneous abortions, infertility, hypothyroidism, cancer, diabetes (Zander, 2012) among the inhabitants.

Iron (Fe) had highest TF values in this study with 4.72 and 2.68 in *T. fruticosurp* and *C. olitorius*, respectively. The consistently high load of iron recorded in vegetables from control and polluted soils could lead to iron toxicity/ poisoning (Iron overload) over time. This could cause anger, liver disease, cancer, iron deposits in organs, diabetes, arthritis, cirrhosis of the liver, schizophrenia, emotional problems, high blood pressure, myasthenia gravis, hemochromatosis and hemosiderosis (Zander, 2010) in the populace; especially the adults.

Conclusion

This present study revealed that, the shoots and roots of *Talinum fruticosurp* and *Corchorus olitorius* obtained in polluted soil from Ile-Igbon contained Pb and Fe concenterations that exceeded the acceptable limit for vegetables. This indicates a serious potential hazard to the people around the area. The Transfer Factor in this study does not present the risk associated with the metals in any form, because most of the metals might be affected by anthropogenic activities based on the transfer factor calculated in this present study. The degree of toxicity of heavy metals to human beings depends upon their daily intake. The transfer factor therefore, in this study showed a higher ease that can be attributed to differences in soils (polluted and control) and *Talinum fruticosurp* and *Corchorus olitorius* samples which revealed the anthropogenic activities in Ile -Igbon.

It therefore becomes imperative that vegetables grown and planted on polluted soil should be properly monitored, public campaign to create awareness to inhabitants of Ile-Igbon on ill health if continue to consume such vegetables. Waste disposal from private residences and industries are to be properly regulated by Environmental Protection Agency. Remediation and restoration activities should be carried out in this area to prevent possible negative consequences on the health and wellbeing of the local inhabitants.

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