International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Risk Assessment of Heavy Metals in Soil and Vegetables of Selected Dumpsites in Port-Harcourt Metropolis

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Abstract: ***The study to evaluate the concentration of heavy metals in soil and vegetables (Vernonia amygdalina and Telfairia occidentalis) was carried out in selected dumpsites in Port Harcourt Metropolis. Heavy metals were analyzed following standard methods using Perkin-Elmer model 403 Atomic Absorption Spectrophotometer. Data revealed that the levels of heavy metals in soil samples from Site I and II were below the safe limits with the exception of Fe, whereas in the vegetable (Vernonia amygdalina) the concentration of Mn was above Permissible limit in all sites while Cu was above safe limit in Site I. Telfairia occidentalis revealed that Mn was above safe limit in Site I and II, while Pb was above safe limit in Site I and Fe was above safe limit in Site I and III. Levels of the 6 metals in the soil ranged between 2.93 to 3247.91 mg/kg (site I), 1.03 to 206.69 mg/kg (site II) and 1.42 to 4189.70 mg/kg (site III). The levels of metals in the vegetable (Vernonia amygdalina) were in the range of 4.70 to 212.63 mg/kg at Site I, 0.71 to 263.41 mg/kg at Site II and 1.18 to 171.95 mg/kg at site III with Transfer Factor been highest for Cu and V in Site I, V and Mn in Site II and Cu, V and Pb in site III. The metals in Telfairia occidentalis were between 71 to 1929.9 mg/kg at Site I, 3.24 to 1735.03 mg/kg at site II and 4.55 to 250.74 mg/kg at Site III while Transfer Factor was highest for Pb and Cu in Site I, V and Fe in Site II and V, Cu, Pb in Site III. The daily intake of Fe was above the Oral reference dose, while the HQ for both Vegetables were above 1 with the exception for Zn in all sites and Cu in Site I in Vernonia amygdalina and in all Sites for Telfairia occidentalis which reflects that the consumption of vegetables from the dumpsites may pose a potential health risks to inhabitants.***

Keywords: heavy metals, health risk, *Vernonia amygdalina*, *Telfairia occidentalis*, Transfer Factor

1. Introduction

One of the greatest environmental problems that pose a grave challenge to the residents of Port Harcourt is waste disposal. Today, solid waste disposal constitutes a major urban environmental paralysis; a clog in the wheel of progress in terms of urban environmental, purity and sanitation (Adeniji, 1998). The deterioration of urban environment in terms of irresponsibly dumped and accumulated solid wastes is most apparent in our urban lives and blighted environments have often been cited and voted as contributing causes of the Nigerian urban decay (Adingbade, 1991). In Port Harcourt metropolis, solid waste problem has gained notoriety because of its visibility and general degradation of the environment. Port Harcourt was known as the “garden city of Nigeria” because of its neatness and the overwhelming presence of vegetation and flowers all over the metropolis. But today, the presence of piles of refuse dotting the entire city may have turned Port Harcourt rather to a “garbage city”. Indiscriminate dumping of wastes – industrial, commercial and household such as food wastes, paper, polyethene, textiles, scrap metals, glasses, wood, plastic, etc. at street corners and drainages/gutters, is still very common. The situation is so bad that traffic flow is often obstructed, while there is likelihood that leachates from such dumps, after mixing with rain water, have the potential to contaminate drinking water. The basic solid waste management processes of collection, transport, segregation and final disposal appear to be very inefficient (Ayotamuno and Gobo, 2004).

Rapid and relatively unorganized urban expansion, industrial developments coupled with inadequate waste management causes significant alterations in the physical environment and increases accumulation of municipal wastes. Indeed, one of the most pressing concerns of urbanization in the developing world, especially in Africa, has been the problem of solid, liquid and toxic waste management. Some cities lack proper solid waste regulations and proper disposal facilities, for harmful waste. Such waste may be toxic or radioactive (Onibokun and Kumuyi, 1996; Wong *et al.*, 2003; UNDP, 2006; Kimani, 2007).

Heavy metal pollution of the environment, even at low levels, and their resulting long-term cumulative health effects are among the leading health concerns all over the world (Oluyemi *et al.*, 2008). Open dumps are a source of various environmental and health hazards. The decomposition of organic materials produces methane, which may cause explosions and produce leachates that pollute surface and ground waters. It also ruins the aesthetic quality of the land (Cointreau –Levine, 1997; Oyelola *et al.*, 2009).

Added to these, dumpsites constitute health hazards even to a passers-by and those living near the dump sites. This is due to the obnoxious smell oozing from the activities of micro-organisms on the organic waste. Uncontrolled burning of solid waste constitutes serious environmental pollution, adversely affecting solid waste workers and pickers. Toxic and hazardous wastes when burnt with other solid waste like asbestos fibre may introduce potential carcinogenic fibre to the smoke plume (Woodward, 1997; Oyelola *et al.*, 2009).
Heavy metals from waste dumpsites can accumulate and persist in soils at an environmentally hazardous level (Alloway, 1996; Amusan *et al.*, 2005). This constitutes

serious health and environmental concerns because of their potential phytotoxicity effects and the health risk implications to humans and animals consuming such vegetables (Micieta and Murin, 1998; Ellias and Salt, 2003; Pillay *et al.*, 2003). Studies have shown that municipal refuse may increase heavy metal concentration in soil and ground water (Albores *et al.*, 2000; Okoronkwo *et al.*, 2005b; Okoronkwo *et al.*, 2006), which may have effects on the host soils, crops and human health (Smith *et al.*, 1996; Nyle and Ray, 1999). Thus, the environmental impacts of municipal refuse are greatly influenced by their heavy metal contents.

2. Description of the Study Area

The study area, Port Harcourt, is the capital of Rivers State and the most important city in the Niger Delta region of Nigeria (Fig 1). Port Harcourt is situated in the sub-equatorial region and lies on a peninsula approximately latitude $4^0$42' to 4^0 47' North and longitude and 6^0 55' east, 7^0 08' East. It is located on the eastern part of Rivers State and the metropolitan area which occupies about 180,000 hectares of land (Port Harcourt Master Plan, 1975). The area falls within the sub equatorial climate belt. Temperature and humidity are high throughout the year (Ayotamuno and Gobo, 2000). The area is marked by two distinct seasons the wet and the dry seasons, with 70 percent of the annual rainfall recorded between April and September, while 22 percent is spread in the three months of September to November. The driest months are from December to March (Ayotamuno and Gobo, 2000). The soil type consists mainly of poorly-drained silt clays mixed with sand, which is geologically classified under the Benin formation.

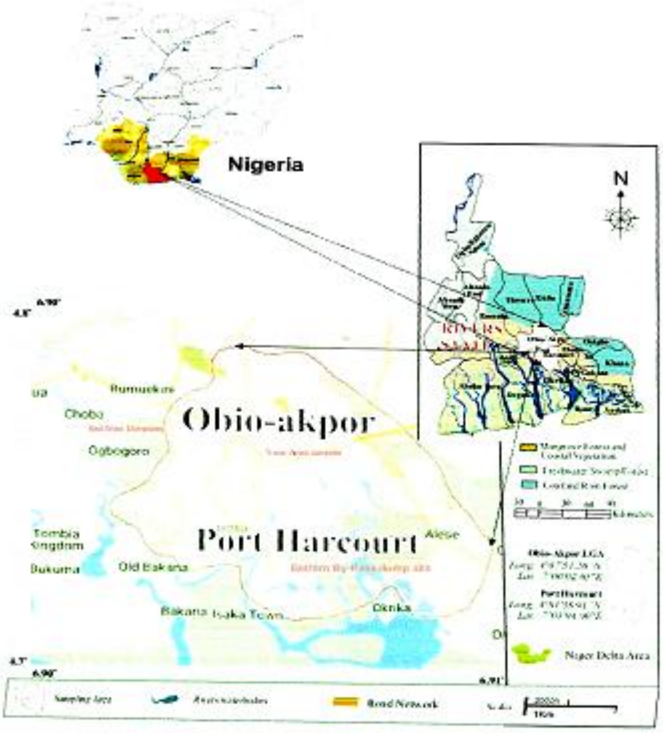

Fig. 1.1: Map of Rivers State showing Study Area

Sample Sites
Site I: Trans-Amadi Dumpsite
Site II: East-West Road Dumpsite
Site III: Eastern-by-Pass Dumpsite

Collection of Samples

Soil Sample Collection and Preparation

The soil samples were collected along transect lines following the methods of Melville and Welsh (2001). Soil samples were collected from Trans Amadi dumpsite, East West dumpsite, and Eastern By Pass with Dutch Auger at 0-10cm, 10- 20cm, 20 – 30cm and 30 – 40cm depths. Soil samples at each of the three sites were collected from the same locations where the vegetable plants were sampled. The 0-10 cm depth was considered to represent the plough layer and average root zone for nutrients uptake and heavy metals burden by plants (Nyangababo and Hamya, 1986; Eddy *et al.*, 2006; Odai *et al.*, 2008). The soil samples were then air dried, crushed, and sieved, then put in clean polythene bags and stored at room temperature for laboratory analysis.

Vegetable Sample Collection and Preparation

Vegetables were sampled along transect lines using standard procedures (Melville and Welsh, 2001). The samples were collected from East West Dumpsite, Eastern By-Pass Dumpsite and Trans Amadi Dumpsite. The following vegetables were collected: *Vernonia amygdalina* (Bitter Leaf) and *Telfairia occidentalis* (Fluted Pumpkin or Ugu). *The* leaves were collected by plucking three young leaves from each plant randomly from the plants. The leaves were thereafter packed in polythene bags and transported to the laboratory where they were rinsed with distilled water and air dried (Mapanda *et al*., 2005). They were then packed into clean polythene bags for laboratory preparation. The vegetables were placed under running tap water to wash off soil particles and other debris then rinsed with distilled water. The samples were then cut into small pieces and then air dried at room temperature in enclosed chambers for about two weeks and then pulverized to fine powder using a stainless grinder. Ground plant samples were then collected in labelled polythene bags and were placed in a desiccator awaiting laboratory analysis (Faithfull, 2002; Ebong *et al.*, 2008).

3. Laboratory Analysis

Analysis of Heavy Metals in Soil

Air-dried soil samples were, ground to fine dust, sieved through a 2mm sieve, then digested and heavy metal concentrations determined using the Perkin-Elmer model 403 Atomic Absorption Spectrophotometer according to the methods of Bates (1954). The Atomic Absorption Spectrophotometer calibrated using standard solution of the respective metals of interest (Pb, Fe, V, Cu, Zn and Mn). The concentrations were extrapolated from a calibrator graph of Absorbance and Concetration to obtain the concentration of the heavy metals.

Analysis of Heavy Metals in *Vernonia amygdalina* and *Telfairia occidentalis*

The vegetation samples were washed, oven-dried at 60°C into a 125ml Erlenmeyer flask which has been previously washed with acid and distilled water, Perchloric acid, 25bml concentration of HNO_3 and 2 ml of concentrated H_2SO_4 under a fume hood. The content was mixed and heat gently at low to medium on a hot plate under perchloric acid fume hood until dense white fumes appeared, pulverized to fine powder and ashed in the furnace for the three hours at 600ºC. Then 1g of the ground plant material was weighed into a 50ml Kjeldahi flask, 25ml of concentrated HNO_3 (16N, 70%w/w) was added down the side of the flask and swirled until the plant material was thoroughly wetted. The sample was filtered through Whatman N0. 42 filter paper into a 100ml volumetric flask and made up to the mark with deionized water. The concentrations of heavy metals in all the samples were determined using the Perkin-Elmer model 403 Atomic bsorption Spectrophotometer. The following metals were quantified; Mn, Fe, Zn,V,Cu and Pb and the results were expressed as milligrams per kilogram (mg/kg) of the dry matter.

Health Risk Index (HRI)

Ratio of HRI was calculated following Cui *et al.* (2004) in vegetable sample and oral reference dose. Values of RfD for Mn (0.041 mg/kg/day), Fe (0.70 mg/kg/day),Cu (0.04 mg/kg/day), Zn (0.3 mg/kg/day), were taken from the Integrated Risk Information System (USEPA, 2002). WHO (1996) recorded the value of RfD for Pb (0.0035 mg/kg/day). A value of health index more than 1 is not beneficial to human health (USEPA, 2002). For adult residents, the average daily metal intake was established to be 0.345 kg of vegetable, whereas average body weight was considered as 60 kg (Ge 1992; Wang *et al.*, 2005). Daily intake was calculated by the following equation:

Daily Intake of Metal (DIM) = $C_{Metal} \times D_{Food\ Intake}$ / $B_{average\ weight}$

Health Risk Index (HRI) = DIM / R_fD (USEPA 2002)

where C_{metal}, Baverage weight, and $D_{food\ intake}$, represented the metal content in vegetable (mg/kg), average body weight (kg) and daily intake of vegetable (kg/day/person), respectively.

Data Management and Analysis

The heavy metal data was analyzed using Microsoft excel to get the mean and standard Deviation of the mean. The mean concentrations of the heavy metals in the three sites for soil and vegetables were recorded. Transfer factors of heavy metals from the soil to the plant were also calculated. Statistical analysis for the cross sectional survey was carried out using Predictive Analytic Software for windows (SPSS version 16).

4. Results

Heavy Metals in soil

The results of heavy metals in soil are shown in Table 1. The mean levels of Mn revealed that Site I had the highest concentration followed by Site III and Site II with mean levels of 65.75±3.40 mg/kg, 66.11±8.21mg/kg and 63.07±5.83mg/kg respectively. Zn concentration in the dumpsite showed that Site I had the highest concentration followed by Eastern by-pass and Site II with mean concentration of 65.03±49.37mg/kg, 18.40±1.11mg/kg and 15.93±3.25mg/kg respectively. Pb levels in the dumpsite showed that Site II had the highest level followed by Sites I and II with mean levels of 206.69±15.30mg/kg, 82.64±118.94mg/kg, and 2.90±0.70mg/kg respectively. Fe levels in the sediment showed that Site III had the highest concentration followed by Sites I and III with mean concentration of 4189.70±244.9 mg/kg, 3247.91±2492 mg/kg and 348.39±49.91 mg/kg respectively. V levels in the soil showed that Site I had the highest level followed by Sites III and II with mean levels of 4.61±3.54mg/kg, 1.42±1.31mg/kg and 1.03±0.62mg/kg respectively. Cu levels in the soil were higher in Site II followed by Sites I and III with mean levels of 3.61±0.52mg/kg, 2.93±2.39 mg/kg and 2.49±2.47mg/kg respectively.

Table 1: Heavy Metal Concentration in Soil at the Sampled Sites

	Sites	Mn (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Fe (mg/kg)	V (mg/kg)	Cu mg/kg
Site I	Trans Amadi Dumpsite)	65.75±3.40[a]	65.03±49.37[ab]	82.64±118.94[ab]	3247.91±2492[ab]	4.61±3.54[a]	2.93±2.39[a]
Site II	(East west Dumpsite)	63.07±5.83[a]	15.93±3.25[a]	206.69±15.30[ab]	348.39±49.91[a]	1.03±0.62[a]	3.61±0.52[a]
Site III	(Eastern By- Pass)	66.11±8.21[a]	18.4±1.11[a]	2.9±0.70[a]	4189.70±244.9[ab]	1.42±1.31[a]	2.49±2.47[a]

Heavy Metal concentration in *Vernonia amygdalina* (Bitter Leaf)

The results of heavy metal concentration in *Vernonia amygdalina* are shown in Table 2. The mean levels of Mn revealed that Site II had the highest concentration with mean levels of 84.22±17.02 mg/kg followed by Sites III and I with mean levels of 73.72.75±6.92 mg/kg, and 61.71±33.4mg/kg respectively (Table 2). Zn concentration in the leaf of *Vernonia amygdalina* were not significantly different, the mean value showed that Site II had the highest concentration of 12.44±2.01mg/kg followed by Sites I and III with mean values of 10.79±3.69mg/kg and 1.18±0.21mg/kg respectively. Pb concentrated in the leaf showed that East-west dumpsite had the highest level with mean value of 4.84±0.93 followed by Sites I and III with mean levels of 4.70±1.89mg/kg, and 4.05±1.77mg/kg respectively. Fe concentration in the leaf of *Vernonia amygdalina* showed that Site II had the highest concentration of 263.41±115.54mg/kg followed by Sites I and II with mean concentration of 212.63±72.26mg/kg, and 171.95±31.09mg/kg respectively. Statistically ($P<0.05$) the values are not significantly different. V levels in the leaf showed that Site II had the highest level of 42.24±35.10mg/kg followed by Sites I and III with mean levels of 12.70±16.46mg/kg and 2.73±0.78mg/kg respectively. The concentration of Cu in the leaf of *Vernonia amygdalina* were statistically significant ($P<0.05$), the highest concentration was recorded in Site I with mean values of 26.33±18.63mg/kg followed by Site III and Site II with mean values of 17.64±15.57mg/kg and 0.71±0.17 mg/kg respectively.

Table 2: Heavy Metal Concentration in *Vernonia amygdalina* at the Sampled Sites

	Station	Mn (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Fe (mg/kg)	V (mg/kg)	Cu mg/kg
Site I	Trans Amadi Dumpsite)	61.71±33.42[a]	10.79±3.69[a]	4.7±1.89[a]	212.63±72.26[a]	12.70±16.46[a]	26.33±18.63[a]
Site II	(East west Dumpsite)	84.22±17.02[a]	12.44±2.01[a]	4.84±0.93[a]	263.41±115.54[ab]	42.24±35.10[a]	0.71±0.17[ab]
Site III	(Eastern By- Pass)	73.72±6.92[a]	1.18±0.21[a]	4.05±1.77[a]	171.95±31.09[a]	2.73±0.78[a]	17.64±15.57[a]

***Telfairia occidentalis* (Ugu)**

The results of heavy metal concentration in *Telfairia occidentalis* are shown in Table 3. The mean levels of Mn showed that Site III had the highest concentration with mean levels of 63.71±2.99mg/kg followed by and Sites I and II with mean levels of 41.06±26.24mg/kg, and 13.73±0.83mg/kg respectively. Zn concentration in the leaf of *Telfairia occidentalis* were not significantly different, the mean value showed that East west dumpsite had the highest concentration of 8.96±6.23mg/kg followed by Sites I and III with mean values of 5.99±1.96mg/kg and 5.19±0.63mg/kg respectively. Pb concentrated in the leaf showed that Site I had the highest level with mean value of 82.64±118.9mg/kg followed by Sites III and II with mean levels of 4.02±0.47mg/kg, and 3.34±1.23mg/kg respectively. Fe concentration in the leaf of *Telfairia occidentalis* showed that Site I had the highest concentration of 1929.9±2625.33mg/kg followed by and Sites II and III with mean values of 1735.03±1.23mg/kg, and 250.74±62.83mg/kg respectively. Statistically ($P<0.05$) the values were not significantly different. V levels in the leaf showed that Site III had the highest level of 13.08±16.06mg/kg followed by Sites II and I with mean levels of 10.35±11.41mg/kg and 3.73±0.63mg/kg respectively. The concentration of Cu in the leaf of *Telfairia occidentalis* were not statistically significant ($P<0.05$), the highest concentration was recorded in Site III with mean values of 4.55±1.60mg/kg followed by Sites II and I with mean values of 3.24±0.32mg/kg and 1.71±1.48 mg/kg respectively.

Table 3: Mean Heavy Metals Concentration in *Telfairia occidentalis* (Ugu)

	Sites	Mn (mg/kg)	Zn (mg/kg)	Pb (mg/kg)	Fe (mg/kg)	V (mg/kg)	Cu (mg/kg)
Site I	Trans Amadi Dumpsite	41.06±26.24[a]	5.99±1.96[a]	82.64±118.9[a]	1929.9±2625.33[ab]	3.73±0.63[a]	1.71±1.48[a]
Site II	East west Dumpsite	13.73±0.83[a]	8.96±6.23[a]	3.34±1.23[a]	1735.03±1.23[ab]	10.35±11.41[a]	3.24±0.32[a]
Site III	Eastern By- Pass	63.71±2.99[a]	5.19±0.63[a]	4.07±0.47[a]	250.74±62.83[ab]	13.08±16.06[a]	4.55±1.60[a]

Table 4: Permissible Maximum Limit for soil and edible vegetables

Permissible Maximum limit for Soil and edible vegetables (mg/kg)		
	Soil (USEPA, 1997)	Vegetables(WHO, 1996)
Mn	80	30
Zn	200	50
Pb	300	10
Fe	2100	1000
V	-	-
Cu	50	20

Table 5: Showing Daily intake and Hazard Risk Index for *Vernonia amygdalina* (Bitter Leaf)

Stations	Mn	Zn	Pb	Fe	Cu
Site I	0.35	0.06	0.02	1.22	0.15
HRI	8.53	0.2	5.71	1.74	3.75
Site II	0.48	0.07	0.02	1.51	0.004
HRI	11.70	0.2	5.71	2.15	0.1
Site III	0.42	0.01	0.02	1.0	0.10
HRI	10.24	0.02	5.71	1.40	2.5

Table 6: Showing Daily intake and Hazard Risk Index for *Telfairia occidentalis* (Ugu)

Stations	Mn	Zn	Pb	Fe	Cu
Site I	0.23	0.03	0.47	11.09	0.01
HRI	5.60	0.2	5.71	1.74	3.75
Site II	0.07	0.05	0.01	9.97	0.01
HRI	1.70	0.16	2.85	14.24	0.25
Site III	0.36	0.02	0.02	1.44	0.02
HRI	8.18	0.16	5.71	2.05	0.5

5. Discussion

Metal Concentration in Soil

The level of metals found in the soil of the dumpsites where the vegetable samples were collected was observed to be below the maximum safe limit (USEPA, 1997) except Fe in Site I and II. This finding is in line with the assertions of Awokunmi *et al.*, (2010), McGrath *et al.* (2001) and Kimani, (2007) who reported higher Fe but was in contradiction with the studies of Akubugwo *et al.* (2012) and Tsafe *et al.* (2012) who reported lower Fe values in soil respectively. The transfer factor of Fe between the soil and the vegetables was not significant ($P<0.05$) for the studied vegetables.

The metal concentrations of Cu in the dumpsites (Table 1) were below safe limits (USEPA,1997). This study was in contradiction with Awokunmi *et al.* (2010) who reported higher levels of Cu from soil collected from several dumpsites in Nigeria.

The transfer of Cu from the soil to the studied vegetables was almost zero. This could be because Cu do not mobilize in plants and remain stagnant in roots, which explained the lower content of the metal in leaves as compared to the soil (Bakere *et al.*, 1994). Yang *et al.* (2002) in their study revealed that Cu mainly accumulated in the roots while a small fraction (10%) of absorbed Cu was transfered to the shoots.

The natural range of Zn in soil is between 10 to 300 mg/kg (Eddy *et al.*, 2004). The soil concentration of Zn in this study was within these natural range (Table 1). This result was in line with studies done by different workers, Kabata-Pendias and Pendias (1992), Haluschak *et al.* (1998), McGrath *et al.* (2001), and Kimani (2007) for uncontaminated soil. The level of Zn in this study was in contradiction with that of Awokunmi *et al.*(2010) who reported higher values. Furthermore the results showed that the transfer of Zn from the soil to the vegetables was more significant than that of Cu. These findings agree with those of Barrg and Clark (1998) who reported that Zn is more actively mobilized than Cu from roots to shoots.

The values of Mn recorded in this study were below safe limit (USEPA, 1997) and also in agreement with that of Kabata-Pendias and Pendias (1992) and Haluschak *et al.* (1998) but in contradiction with the values recorded by McGrath *et al.* (2001), Kimani (2007) and Awokunmi *et al.* (2010) who reported lower levels than those of this study. The transfer factor for Mn between the soil and vegetables in this study shows that Mn in plants is highly mobile and is likely to accumulate in both leave and seed.

Farm soil contain approximately 3 to 1000 mg/kg of Mn, but the concentration can reach up to 24,000 to 53,000 mg/kg in soil near metal refineries and in dried sludge, respectively (Denkhaus and Salnikow, 2002; Sutherland and Costa, 2002).

Pb is one of the more persistent metals and is estimated to have a soil retention time of 150 to 5000 years (Sobolev and Begonia, 2008). This study reported a level ranging from 2.9 – 206.69mg/kg. This was in contradiction of the study of Aluko *et al.* (2003) who reported high values of Pb in soil at Ibadan, Nigeria ranging from 1340 - 1693 mg/kg and also that of Awokunmi *et al.*, (2010) who reported very high levels of Pb from soil collected from various dumpsites ranging between 3500-6860 mg/kg, but in agreement with the studies of Premarathna *et al.* (2011) Kabata-Pendias and Pendias (1992), Haluschak *et al.* (1998), McGrath *et al.* (2001) and Kimani (2007).

The Pb values were below the safe limit for agricultural soil (USEPA,1997), the transfer factor of this metal to the vegetables was 2.28 which indicated that there was a transfer from the soil to the vegetable. Indeed, Pb accumulation in many plants can exceed several hundred times the threshold of maximum level permissible for human (Wierzbicka, 1995).

V is widely distributed in the earth's crust at an average concentration of 100 mg/kg (Byerrum, 1991; ATSDR, 2009). In this study, the soil concentrations of V ranged from 1.03 to 4.61 mg/kg. Krishna and Govil (2007) reported V concentrations higher than those of this study with a range of 141.9 - 380.6 mg/kg in India. Kabata-Pendias and Pendias (1992), Haluschak *et al.* (1998) and McGrath *et al.*, (2001) reported values of 115 mg/kg, 455 mg/kg and 250 mg/kg, of V in an uncontaminated soils. On the other hand, Molatlhegi (2005) reported values as high as 5340mg/kg V in South Africa.

Metal Concentration in Vegetables

The accumulation of metals in vegetable is a major cause of public health risk (Cui *et al.*, 2005). The metal concentrations of Pb in *Vernonia amygdalina and Telfairia occidentalis* were below safe limit (WHO, 1996) (Table 4) except *Telfairia occidentalis* in site I.

The levels of Pb in both vegetables and soil may be attributed to the type of waste at the dumpsites and the busy Roads. Luilo and Othman (2006) found high levels of Pb in both soil and couch grass grown along the road in Dares Salaam. Pb is released into the air during burning of fossil fuel, or waste which is also removed from the air by rain into land or surface water.

Pb has no beneficial biological function and is known to accumulate in the body (Zurera-Cosano *et al.*, 1984; Ellen *et al.*, 1990; Yargholi and Azimi, 2008). Its exposure may have adverse health effects especially in young children and pregnant women, since Pb is a neurotoxin that permanently interrupts normal brain development.

The vegetables had Fe concentration below acceptable limit of (WHO, 1996)(Table 4) except *Telfairia occidentalis* in Site I and II which was above Permissible limit. This study recorded higher value of Fe concentration compared to the study reported by Aweng *et al.* (2011). An elevated dietary Fe intake enhances the incidence of carcinogen-induced mammary tumors in rats and estrogen-induced kidney tumors in Syrian hamsters. Estrogen administration increases Fe accumulation in hamsters and facilitates Fe uptake by cells in culture. In humans, increased body stores of Fe have been shown to increase the risk of several estrogen-induced cancers (Liehr and Jones, 2001).

Fe acts as a catalytic center for a broad spectrum of metabolic functions. Fe is also a component of various tissue enzymes, such as the cytochromes, that are critical for energy production, and enzymes necessary for immune system functioning (Michael *et al.*, 2009).

Cu levels were all below Permissible limit (WHO, 1996) except *Vernonia amygdalina*, in Site I. Cu is known to be strongly attached to organic matter and minerals in soil. As a result, it does not travel very far after released and consequently accumulate in soil (Slooff *et al.*, 1989; Alloway, 1990; Lenntech, 2009).

Exposure to excessive levels of Cu can result in a number of adverse health effects including liver and kidney damage, anaemia, immunotoxicity, and developmental toxicity. (ATSDR, 2004a).

The concentration of Zn in the vegetables (*Vernonia amygdalina and Telfairia occidentalis)* were below permissible limit (WHO, 1996) (Table 4). In this study, the metal concentrations of Mn in the vegetables were above permissible limit (WHO, 1996) of 30 mg/kg except in Site II of *Telfairia occidentalis*. This is higher than the studies carried out by Harmanescu *et al.* (2011) who reported Mn values of between 1.38 to 10.47 mg/kg in the vegetables studied.

The metal concentration of V in the two vegetables ranged from 2.73 – 42.24mg/kg. Molatlhegi (2005) reported lower V values in his study, V values between 31 to 35mg/kg in plants may be due to plants relatively high accumulation ability in respect to V, this metal is always present in food products (Sperling *et al.*, 2000).

Although V has not been shown to be essential for humans and has no nutritional value, its compounds have been shown to mimic the action of insulin in isolated cell systems, animal models and diabetic patients and therefore, their use in the therapy of diabetes mellitus has been considered (Shechter, 1990; Shamberger, 1996).

In order to know the human exposure to metals via food chain, transfer factor is considered an important indicator. Highest transfer factor for V showed that the soil did not retain much of their amount and they moved substantial to the vegetable.

The highest Transfer Factor are V and Cu in Site I, Mn and V in Site II, Pb, V, and Cu in Site III for *Vernonia amygdalina*, while that of *Telfairia occidentalis*, Pb and Cu in Site I, Fe, V in Site II, Pb, V and Cu in Site III. The metal accumulation from soil to plant depends on nature of soil, plant species and type of metal contamination of the vegetables by these metals (Albanese *et al.*, 2008).
The rate of metal uptake by the vegetables could have been affected by other factors such as plant age, plant species, soil pH, nature of soil and climate and this in turn would affect the content of heavy metals recorded (Alloway and Ayres, 1997; Uwah, *et al.,* 2009). Variations in transfer factor may also have contributed to the differences in the element uptake by different vegetables and the different metal contents (Cui *et al.,* 2004; Zheng, *et al.,* 2007).

Increased consumption of metal via diet results in development of disorders, so monitoring of these substances is necessary in human diet (Voiculescu *et al.*, 2010). It is suggested that inhabitants of the contaminated areas should not consume excessive amount of contaminated vegetable to avoid the abnormal buildup of metals in human body. The daily intake of Fe in the study was higher in all sampled Sites. However Health risk index due to Mn, Pb, Fe, and Cu were higher in the present research due to intake of *Vernonia amygdalina*, and *Telfairia occidentalis*

6. Conclusion

The daily ingestion of Fe was above the oral reference dose, thus the intake of *Vernonia amygdalina*, and *Telfairia occidentalis* from the studied dumpsites may pose significant threat to the health of the population. Therefore, farmers should be well informed and encouraged to decrease heavy metal concentrations by instituting control measures. It is further suggested that normal monitoring of the dumpsites should be encouraged and there should be an effective waste management system so as to evade potential utilization of unhygienic vegetables and food stuffs.

7. Acknowledgments

The authors thank all the supporters of this project and the referees for their constructive comments.

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