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HEAVY METAL LEVELS IN FLUTED PUMPKIN (*TELFAIRIA OCCIDENTALIS L.*) LEAF AND SOIL FROM SELECTED DUMPSITES IN PORT HARCOURT METROPOLIS, RIVERS STATE, NIGERIA

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Abstract
Composite samples were collected from three refuse dumpsites and a fourth one which served as control, and analyzed for heavy metals concentrations using Atomic Absorption Spectrometer (AAS VGB 210 system). The results of detectable concentrations of heavy metals in (mg/Kg dry weight) were as follows: Fe (11.308±0.034 - 9.479 ± 0.029), Pb (0.004±0.091 - 0.016 ± 0.017), Zn (1.084 ± 0.026 - 0.753±0.026), Ni (0.274±0.013 - 0.070 ± 0.013) in the leaf, while the soil recorded Fe (18.599±0.007 - 3.432±0.033), Pb (0.152±0.028 - 0.018±0.022), Zn (3.264±0.011 - 0.417±0.127), Ni (2.630±0.678 - 0.070±0.099). The levels in the soil were generally higher than those in the leaf. The trend which was attributable largely to anthropogenic inputs, and comparable with similar studies within and outside Nigeria, identified iron (Fe) to have a greater value of contaminant on both the soil and the leaf. The values of the heavy metals obtained at the different dumpsites were lower than their corresponding permissible limit. The values from the different dumpsites show some relationship between anthropogenic inputs and industrial activities. From each of the observed metals in the edible vegetable (Pumpkin leaf), and soil, the highest values were obtained in parts of Port Harcourt where there is the heavy presence of industrial discharge or activities. The transfer factor (tf) index revealed that Fe and Zn values from the dumpsites afforded greater than 1 value, while Pb indicated less than 1 value, Ni reported values within the normal range in the plant. It can therefore be argued that solid waste dumpsites in Port Harcourt Metropolis are laden with high concentrations of heavy metals which are later absorbed and assimilated by plants growing within such sites. The study, therefore, calls for regular monitoring to mitigate the dangers implicit in the continuous consumption of the leaf.

Keywords: Heavy metal; Concentration; *Telfairia occidentalis L.* (Pumpkin Leaf); Dumpsites; Pollution, soil.

Introduction

The distribution of the levels of uptake of heavy metal such as (Fe, Pb, Zn, and Ni) in pumpkin (*Telfairia occidentalis)* leaves has become imperative since it is the most cultivated and consumed vegetable in Port Harcourt metropolis. The indiscriminate cultivation of pumpkin vegetables in every available space especially within the Rumuolumeni area, domestic dumpsites, industrial dumpsites and the common uncontrolled urban dumpsites is of much concern. Demirezen and Ahmet (2006), reported that the levels of some heavy metals such as Cd, Pb, Ni, Cu, etc. in different vegetables from areas that play host to industries were higher than those in non-industrialized areas in parts of Turkey. Consumption of vegetables containing heavy metals is therefore one major way in which these elements enter the human body (Nwoko, 2002).

Wilson and Pyatt (2007), reported that heavy metal accumulation in vegetables could occur by various means but considered soil as the major one. Vegetables take up heavy metals and accumulate them in their edible and non-edible parts at quantities high enough to cause clinical problems for both animals and human beings. Steenland and Boffetta, (2000) and Jarup (2003), reported, however, that toxic metals are made available to human beings through food systems. Among such food systems, vegetables have been identified to be most potent for doing so due to their aerial burden concerning environmental pollution. Naturally heavy metals occur in the ecosystem with large variations in concentration (Oluyemi, et al., 2008). Some of the terrestrial pollutants of the environment are metals, and this is a result of human and industrial activities, being non-biodegradable substances. They usually persist for a long time in the ecosystem (Leah et al., 2014). The presence of heavy metals in the environment is of great ecological significance due to their toxicity at certain concentrations, translocation through food chains and non-biodegradability which is responsible for their accumulation in the biosphere (Awololu, 2005).

The use of dumpsites as farmlands is a common practice in urban and sub-urban centers in Nigeria because decayed and composited wastes enhance soil fertility (Ogunyemi, et al., 2003). Some of the wastes contained in dumpsites are rusted packing, the remnant of food, rusted packing paper, polythene, metal containers, and battery containers (Ademoronti, 1995). They are characterized by an irritating offensive odour. Humans are exposed to heavy metals through three basic routes, such as Inhalation, Ingestion, and Skin absorption, (Ogunyemi et al., 2003). Some trace metals like As, Cd, Hg and Pb are heavy metals that are particularly hazardous to plants, animals and humans (Alloway & Ayres, 1997). Exposure to these metals may cause some negative effects such as blood, and bone disorders, kidney damage, decreased mental capacity and neurological damage (Asuquo et al., 2004). It is unfortunate however that, heavy metals are not subject to chemical degradation. Heavy metal is normally chronic when it is exposed. (Exposure over a long period) due to food chain transfer (Zulikes, 1994). Heavy metal pollution tends to constitute serious environmental and health hazards, in communities within our country and localities (Keller et al., 2005).

Heavy metals are hazardous because they tend to bio-accumulate, which means, an increase in the concentration of the chemical in a biological organism over time, compared to the chemical concentration in the environment (Helmenstine, 2014). The transfer factor (tf) can be defined as the ratio of the concentration of metals in the plant to the total concentration in the soil (See Table 4.3). Therefore, the present study is to determine the heavy metal levels of Fluted Pumpkin (*Telfairia occidentalis L.)* leaf and soil from selected dumpsites within Port Harcourt metropolis.

Materials and Methods

Port Harcourt is the capital and largest city in Rivers State, Nigeria. Port Harcourt lies 40 km up the mouth of the Bonny River, in the Niger Delta. Originally known as “Igwu-Ocha’’ by the indigenous Ikwerre, was founded in 1913 by the British in an area traditionally inhabited by the Ikwerre and the Okrika Ijaws. It is the fifth most populous city in Nigeria after Lagos, Kano, Ibadan and Benin. The growth of Port Harcourt is tied to the social and economic history of the country. The city is a major educational, administrative, and industrial Centre, and is regarded as the capital of Nigeria since it hosts, most of the nation's multi-national oil and gas exploration and production companies, as well as a fast-expanding commercial sub-sector (Wokekoro & Owei, 2006). This study was conducted at three different locations, and a control site within Port Harcourt Metropolis.

This study was conducted at three different locations, within Port Harcourt and Obio/Akpor Local Government areas which include, Choba, Diobu, and Rumuolumeni, Rivers State, Nigeria. *Telfairia occidentalis*, (Fluted pumpkin) leaf were found growing on farmlands close to refuse dumps and were randomly collected by cutting at a height of 5 cm above the soil surface using a knife, the samples were then packed into plastic bags. Soil samples were collected at four (4) points (about 20 *m* apart and depending on the availability of the plant) through a stainless steel hand auger, within the areas Plants samples were also taken to achieve representative soil samples. A soil sample to serve as control was also collected from farmland. All samples were placed in polythene bags for onward transportation to the laboratory for storage. The leaves were thoroughly washed with tap water, and rinsed with distilled water to remove debris and insects, and it was then partitioned into parts (leaves, stems) and the leaves were oven-dried at 70 ^{0}C. The dried sample was pulverized into a fine powder using an agate pestle mortar and preserved in a desiccator. Soil samples were oven-dried at 60^{0}C for 3 days, pulverized and sieved through a 1 *mm* mesh screen to remove coarse materials.

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Sample Digestion
5 g of the dried sample of vegetables and soil were treated with 1:3:1 mixture of $HClO_4$, HNO_3, and H_2SO_4 and were digested on a hot plate until the volume reduces to near dryness. The solutions were filtered using Whatmann No.1 filter paper and the filtrate is made up to mark with distilled water in a 50 ml volumetric and kept for analysis.

The digested sample of the vegetables and soil was analyzed to determine the concentrations of heavy metals (Fe, Pb, Zn, and Ni). The determination of the heavy metals contents of the sample solutions was carried out following the producer of Allen et al. (1974), using Atomic Absorption Spectrophotometer (AAS VGB 210). To test the integrity of the results, reagent blanks, replicates, and standard reference materials (*SRM* 1515 for plants and *SRM* 2709 for soil) representing about 10 % of each of the total sample population were incorporated in the analysis to detect not only possible contamination but also assess precision and bias of the procedure and the recovery rates for the metals in the standard reference materials were between 89-97%.

Results
The levels of heavy metals in *Telfairia occidentalis* (Fluted Pumpkin) leaf and soil are listed in Table 4.1- 4.2

Table 4.1: Mean Levels (*mgkg^{-1}*, *dry weight*) of Heavy Metals in *Telfairia occidentalis* (Pumpkin Leafs) Samples Collected from Three Locations in Port Harcourt Metropolis

	Sample Locations			
HM	Choba	Diobu	Rumuolumeni	Control
Fe	9.479±0.029	11.308±0.034	2.230±0.030	0.936±0.030
Pb	0.004±0.091	0.005±0.011	0.016±0.017	0.003±0.028
Zn	0.249±0.030	1.084±0.026	0.753±0.026	0.097±0.035
Ni	0.091±0.036	0.070±0.013	0.274±0.013	0.249±0.026

HM = Heavy Metals

Table 4.2: Mean Levels (*mgkg^{-1}*, *dry weight*) of Heavy Metals in Soil Samples Collected from Three Locations in Port Harcourt Metropolis

	Sample Locations			
HM	Choba	Diobu	Rumuolumeni	Control
Fe	5.809±1.673	3.432±0.033	18.599±0.007	2.363±0.019
Pb	0.018±0.022	0.041±0.011	0.152±0.028	0.012±0.032
Zn	0.671±0.045	0.417±0.127	3.264±0.011	0.092±0.032
Ni	0.070±0.099	1.951±0.054	2.630±0.678	0.036±0.040

Table 4.3: Transfer Factor (tf) of Heavy Metals of some selected Dumpsite Pumpkin (*Telfairia occidentalis*) in Port-Harcourt Metropolis

Sample Locations	Fe	Pb	Zn	Ni
Choba	1.63	0.22	0.37	0.21
Diobu	3.29	0.09	2.59	0.036
Rumuolumeni	0.12	0.11	0.23	0.10

Discussion

Heavy Metal levels in *Telfairia occidentalis* (Fluted Pmpkin Leaf)
Table 4:1, shows the mean concentration of Iron (Fe) in *Telfairia occidentalis* ranges from (11.308 ± 0.034 - 9.479 ± 0.029) mg/kg. Diobu dumpsite afforded the highest value 11.308 ± 0.034 mg/kg, while Rumuolumeni recorded the least value of 2.230±0.030 mg/kg of iron in Pumpkin leaf. The control site recorded values of 0.936 ± 0.030 mg/Kg. All the values that were analyzed fell below the normal range of Fe in the plant which is 400-500 mg/kg (WHO/FAO, 2007). The mean concentration of Iron (Fe) in this study was greater than the concentration level of 3.14 µg/g reported by (Edem, 2004), for Cross River, and also higher than the values of 1.435 mg/kg reported at Benin metropolis (Ikhajiegbe et al., 2016). Iron (Fe) is very important for blood building but when in excess it

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becomes toxic and could cause Iron overload (Sabina, 2015), this results in the interaction of ferrous oxide with peroxide in the blood to produce highly reactive free radicals (Sabina, 2015). Oladebeye (2017), reported that Iron (Fe) acts as a catalytic centre for a broad spectrum of metabolic functions. It is a component of various tissue enzymes, such as the cytochromes, that are critical for energy production, and necessary for immune system functioning. Increased body stores of Iron in human has also been shown to increase the risk of several estrogen Induced cancers. In furtherance Iron (Fe) is reported to be capable of damaging cells in the heart, liver and elsewhere, which could result in coma, metabolic acidosis, shocks, liver failures, coagulopathy, adult respiratory distress syndrome, long-term organ damage, and even death. The pumpkin leaves have abundant iron that plays an essential role in strengthening the body's immune system. The leaves are always recommended for patients who suffer from a shortage of blood. The presence of iron and other important minerals in it contributes to the blood-boosting effect. Fluted pumpkin has haematinic properties with high levels of protein and iron. Fe, deficiency anaemia is a nutritional disorder afflicting large population groups in the world. It is prevalent amongst vulnerable infants, adolescent girls and pregnant women particularly in populations subsisting largely on plant food sources. (Bells, 1975).

From Table 4.3, It was observed that the (tf) of Iron (Fe) in pumpkin ranging from 3.29 - 0.12, Diobu revealed higher values which indicated that the transfer factor (tf) was greater than 1. This indicated that the locations can function as hyperaccumulators for iron (Fe). Location 3 respectively, recorded Transfer factor (tf) values less than 1. This could result that plants are not good bio-accumulators of Iron (Fe). The mean concentration of Lead (Pb) in *Telfairia occidentalis* ranges between (0.004±0.091 to 0.016 ± 0.017) mg/kg. Rumuolumeni recorded the recorded highest value of 0.030 ± 0.023, while, Choba recorded the lowest value of 0.004 ± 0.091. Akubugwo et al. (2012), reported lead (Pb) levels in vegetable reveals similar values to those of this study. Muhammad et al. (2008), also, reported higher lead metal levels in several vegetables. According to the allowable limit of lead in vegetables as used by (WHO 2011), all the vegetables apart from *Brassica Oleracea Acephala* grown at the control site were above this limit (0.5 mg/kg). The control site of this study recorded values of (0.003 ± 0.028) which were also within the normal range of lead in the plant (0.5 -30) mg/kg, compared to the control value reported by Muhammad et al. (2008). The high levels of lead in vegetables could be attributed to the dumpsite and the busy level of Rumuolumeni. This is because in the past lead (Pb) was used in gasoline and hence a major contributor of lead in soil, and eventually plants. Lead (Pb) is released into the air during the burning of oil or waste and is removed from the air by rain and by particles fallings to land or into surface water. Once lead (Pb) falls onto the soil, it sticks strongly to soil particles and remains in the upper layer of soil and can be accumulated by vegetables grown on such contaminated soils (ATSDR 2007). Lead (Pb) has no beneficial function and it is known to accumulate in the body to cause adverse health effects. It is a neurotoxin that permanently interrupts normal brain development and accumulates in the skeleton and its mobilization from bones during pregnancy and lactation causes exposure to fetuses and breast-freed infants (ATSDR 2007).

On a cellular and molecular level, lead may enhance carcinogenic events involved in DNA damage, DNA repair and regulation of tumour suppressor and promoter genes (Silbergeld 2003). Lead contaminates the soils and plants and then affects microorganisms and animals. Affected animals have a reduced ability to synthesize red blood cells which causes anaemia (Rich, 1994). Lead has been identified to have deleterious effects on human beings, and also a risk to human health through the consumption of vegetable crops. The level to which a system organ tissue or cell is affected by a heavy metal toxin depends not only on the toxin but also on its degree or level of exposure to the toxin (Forstner et al., 2015). The transfer factor (tf) of lead (Pb) ranges from 0.22 - 0.09. These indicated that the transfer factor (tf) was less than 1. This could mean that plants grown at the above locations are not good bio accumulators of Pb, (Table 4.3). The mean concentration of Zinc (Zn) ranges from (1.084 ± 0.026 to 0.753±0.026) mg/kg. The highest dumpsite value observed in Diobu was 1.084 ± 0.026 mg/kg, followed by Choba which recorded the lowest value of 0.249 ± 0.030 mg/kg. The control site recorded a value of 0.097l ± 0.035 mg/kg, these values fell within the (FAO/WHO, 2007), guideline for food and vegetable for Zinc normal range in plants 20-100 mg/kg. Zinc is an essential element for humans and animals but a high level of Zinc can reduce the Immune function level of high–density lip proteins (Surukete, et al., 2013). Oladebeye, (2017), also reported that Zinc is as capable of causing anaemia, nervous system disorders, damage to the pancreas and low levels of ‘’good’’ cholesterol. It was observed in table 4.3, the transfer factor of Zinc (Zn) in the dumpsites

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locations for the same metals was significantly different. The effects of Zinc in man include loss of appetite, decreases sense of taste, slows healing of wounds, and leads to excessive damage to the pancreas; Plant diversity is reduced because of the high presence of zinc in the soil (Bells 1975). Consuming vegetable plants in a contaminated environment could bring about a negative impact on both animals and human health.

The transfer factor (tf) of (Zn) varied between 2.59 - 0.37. Diobu revealed a higher value which indicated that the transfer factor (tf) of the metal is less available to the plant under alkaline conditions than under acid conditions. (Klock et al., 1984). This could also mean that the metal obtained in pumpkin is an indication that the metal uptake was controlled by variables such as pH, organic matter content and soil type. The mean metal concentration of Nickel (Ni) in *Telfairia occidentalis* ranges from 0.274±0.013 to 0.070 ± 0.013 mg/kg. This study reported a higher value in Rumuolumeni 0.274±0.013 mg/kg followed by Diobu which indicated the lowest value 0f 0.070 ± 0.013 mg/kg, and the control site 0.249 ± 0.026 mg/kg. The study reported similar findings to that of Premaranthna et al. (2011). On the other hand, Naser et al. (2009) in Bangladesh reported lower levels of Nickel than that of this study. Studies by Sirinivas et al. (2009), also reported that vegetables have more Nickel than animal products. Following the report of the study, it was observed that the vegetable grown at the control site were within the reported safe range of (3-7) mg/day daily intake of very large quantities of Nickel by humans from plants grown on Nickel rich soils has higher chances of inducing the development of cancers of the lung, nose, larynx and prostrate as well as inducing respiratory failures, birth defects and heart disorders (Duda et al., 2008). Studies have also shown that heavy metals such as Nickel can stimulate cell growth in estrogen receptor (ER) positive breast cancer cells, Martin et al. (2003). Ionescu et al. (2006), found highly significant Nickel accumulation in 20 breast cancer tissue biopsies in dumpsites compared to controls. However, although Nickel is a toxic metal, it plays a role as coenzyme in different enzymes Lyaka et al. (2005). The transfer factor for Nickel (Ni) varied between 0.21- 0.10. The transfer factor (tf) of Nickel (Ni) indicated high values in (location 1, Choba). Nickel plays important role in the biology of microorganisms and plants and is also associated with an increased risk of cancer (Sigel et al., 2011). The impact of these metals has also become apparent due to the long-term consumption of contaminated vegetables. Vegetables also uptake heavy metals in qualities that could result in a lot of clinical problems for consumers (Bahemuka & Mubofu, 1999). The transfer factor (tf) for the entire element was within the normal range in the plant for the three locations. (Table 4.3)

Heavy metal levels in the soil

Rumuolumeni dumpsite recorded the highest level of Iron (Fe) (18.599 ± 0.007) mg/kg while Diobu dumpsite recorded the least level of iron (3.432 ± 0.033) mg/kg. These values fall within the permissible limit of iron in the soil. The concentration in the control site ranges from (2.363±0.019 – 0.012± 0.032) mg/kg, which is below the permissible limit of iron in the soil. It was also noticed that the levels of iron recorded were higher than the values of other metals. This indicates the importance of iron to humans. This can also be a reflection that most dumpsites in Nigeria usually contain wastes containing iron metal (Ademoronti, 1995).

According to WHO (2011), the deficiency of iron in man can cause weak muscular coordination, vomiting, diarrhoea and other serious health defects, comparing this with the result obtained by Akaeze (2001), Elelenwo of (Rivers State) dumpsite had a concentration of iron ranged between (10, 300 to 31,000) ppm which fell within the accepted level. Eddy et al. (2004), suggested that any pollution of the environment by iron cannot be conclusively linked to waste materials alone but other natural sources of iron must be taken into consideration. From the author's point of view: even though iron is a micronutrient, it should be properly monitored to maintain its concentration in the accepted range to avoid health defects caused by the deficiency or excess amount of it. The standard and accepted level of iron in soil ranged between 100-700 mg/kg (Ebong et al., 2008). Echem et al. (2004) reported that a high concentration of Iron (Fe) in soil could be due to the presence of anthropogenic material sources of Iron (Fe). The concentration of Fe in the soil is high and tends to be toxic to plants.

The concentration of Lead (Pb) at the dumpsite ranges from Choba 0.018 ± 0.022 mg/kg, Diobu 0.041±0.011, Rumuolumeni 0.152 ± 0.028, while the control site afforded (0.012±0.032) mg/kg. These show that the dumpsites and the control sites have a normal range of iron (2.200) mg/kg (Ebong et al., 2008). The mean concentration of lead in soil at the Ibadan dumpsite also ranged from 34 mg/kg to 1.65mg/kg. Comparing the values at the

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dumpsites with that of the control sites, the higher concentration of lead at dumpsites could be attributed to the decomposition of lead-containing wastes, from similar work reported by Dara (1993). The main source of lead pollution could be traced to industrial. From the study locations, it is noticeable that Rumuolumeni and Diobu are the major areas where industrial activities are carried out because of the companies and other private firms' activities going on there. Also due to the industrial activities within this area, lead is been disposed of as one of its waste and this can also influence the concentration of lead in that environment according to Aluko et al. (2003). Lead (Pb) is a cumulative pollutant. Dara (1993), the pollution of soil by lead remains a very serious problem that should be given much attention by environmental chemists in collaboration with Government Agencies. It is also very important to educate the general public on the health effect of the metal when ingested in excess. These effects may include Damage to the brain, and kidney, Miscarriage in pregnant women and damage to sperm production organs in males. Lead is one of the more persistent metals and is estimated to have a soil retention time of 150 to 5000 years (Sabine & Wendy 2009).

The concentration of Zinc (Zn) mg/kg in soil occurred between (3.264 ± 0.011 - 0.417 ± 0.127) mg/kg. Rumuolumeni dumpsite reveal the highest level of Zinc (3.264 ±0.011) mg/kg while Diobu dumpsite recorded the lowest level (0.417±0.127) mg/kg. Choba afforded (0.671 ±0.045) mg/kg and the concentration for the control site recorded (0.092±0.032) mg/kg. It could be seen that the concentration for both the dumpsites and the control site fell within the accepted standard of zinc in soil (100 -700) mg/kg. According to Odukoya et al. (2008). The range of Zinc obtained from Abeokuta dumpsites was 100.80 to 226.00 mg/kg, While its control sample range was found to be (51.25 to 71.43) mg/kg which occurred within the accepted range. This variation could be attributed to the fact that categories of waste introduce to such dumpsites have less concentration of zinc. Zinc is required in human nutrients for the normal functioning of the body. The deficiency of zinc in man can lead to impaired growth, low energy balance and low protein intake (Udosen, 2000). The concentration of Nickel (Ni) in soil ranges between (2.630±0.678 - 0.070±0.099) mg/kg. Rumuolumeni recorded the highest value of (2.630 ± 0.067) mg/kg, while Choba recorded the lower value of (0.070±0.099) mg/kg. The control site afforded values of (0.249±0.026). This could be seen that the values that fell within the accepted standard for both the dumpsites and control site. Nickels were found to be below the critical permissible concentration of 50 mg/kg given by WHO, (2011) and within the range recorded by Bonnail (2016). Though most of the heavy metal concentrations fell below the critical permissible concentration level, their persistence in these soils of the dumpsites may lead to increase uptake by plants. (Klock et al., 1984), also reported that plants can accumulate relatively large amounts of these elements by foliar absorption.

Conclusion

The study on the leaf of *Telfairia occidentalis* (fluted pumpkin) leaf and soil of Port Harcourt Metropolis has shown that some of the dumpsites locations may have been contaminated by some heavy metals due to point source and diffuse factors that may be largely anthropogenic and Industrial. Iron (Fe) was noted to have the highest value of contaminant on both leaf and soil. The contamination level was well over 70% in the three dumpsite locations when compared with their safe limits, and this portends health implications for continuous consumption of the vegetable. The leaf appears to be worse hit because they suffer more of the aerial burden of these metals in the atmosphere due to their exposure. Hence, an effective waste management plan should be developed.

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