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CONCENTRATION OF HEAVY METALS IN FLUTED PUMPKIN (*TELFARIA OCCIDENTALIS* Hook F.) PLANTED AROUND UNICROSS DUMPSITE

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Abstract

This study examined analysis of Heavy Metals concentration on Fluted pumpkin (*Telfairia Occidentalis*) planted near a dumpsite in UNICROSS, Calabar. The leaves of fluted pumpkin (*Telfairia occidentali*s) were collected as randomly composite samples one dump site location for three consecutive months (June, July & August) representing dry, semi-dry and wet seasons of the cultivation of the vegetable. The samples were examined for heavy metal concentrations, using Atomic Absorption Spectrophotometer technique. Lead (Pb), Cadmium (Cd), and Nickel (Ni) of vegetable samples were detected at higher proportions than the permissible limits of WHO/FAO for plants. Exceptions were obtained for cobalt (Co), Chromium (Cr), Arsenic (As) and Mercury (Hg). Generally, the concentrations of the metals in the vegetable samples are in the decreasing order, Pb (2.762) > Ni (1.782) > Cd (0.837) > Cr (0.412) > Co (0.317) > As (0.067) > Hg (<0.001). The vegetable samples show the same trend of metal concentrations with slight difference in values for the June, July and August seasons. Generally, Pb concentrations were higher in the tissues of the vegetable samples followed by Nickel, then Cadmium, then chromium, then cobalt, then Arsenic, and finally mercury (Hg) which concentration was lower than the permissible limits. Heavy metals that exceeded the permissible limits were seen to cause health issues among consumers. The vegetable samples were recommended for possible application in phytoremediation of polluted soils.

1.0 Introduction

The quality of ecosystem becomes altered, when heavy metals find their way, somehow, into it through human and natural activities. These activities are one of the most pressing concerns of urbanization in developing countries like Nigeria, which result in the problem of solid, liquid and toxic waste management. Such waste may be toxic or radioactive (Onibokun and Kumuyi, 2012; UNDP, 2006). Such waste management problems include heaps of uncontrolled garbage, roadsides littered with refuse, streams blocked with rubbish, prevalence of automobile workshops and service stations, inappropriately disposed toxic waste and disposal sites that constitute a health hazard to residential areas (Adewole and Uchegbu, 2015).

Occurrence of uncontrolled urban sewage farming is a common site in African cities which exposes consumers of such produce to poisoning from heavy metals (Sam-Uket, 2024; Ebong, 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, which pollute surface and ground water. It ruins the aesthetic quality of the land (Oyelola et al., 2009). Automobile wastes include solvents, paints, hydraulic fluids, lubricants and stripped oil sludge; all results from activities such as battery charging, welding and soldering, automobile body works engine servicing and combustion processes (Adewole and Uchegbu, 2015; Utang et al., 2013).

Heavy metals are generally referred to as those metals which possess a specific density of more than 5 g/cm^3 and adversely affect the environment and living organisms (Sam-Uket, 2024; Järup, 2013). They, without doubt, are important constituents for plants and humans, when present only in small amount. Some micronutrient elements may also be toxic to both animals and plants at high concentrations. For instance, copper (Cu), chromium (Cr), fluorine (F), molybdenum (Mo), nickel (Ni), selenium (Se) or zinc (Zn). Other trace elements such as arsenic (As), cadmium (Cd), mercury (Hg) and lead (Pb) are toxic even at small concentrations (Divrikli et al., 2006).

Heavy metals, being persistent and non-biodegradable, can neither be removed by normal cropping nor easily leached by rain water (Khadeeja et al., 2013). They might be transported from soil to ground waters or may be taken up by plants, including agricultural crops. For this reason, the knowledge of metal plant interactions is also important for the safety of the environment (Divrikli et al., 2006). There has been increasing interest in determining heavy metal levels in public food supplied. However, their concentration in bio-available form is not necessarily proportional to the total concentration of the metal (Opaluwa et al., 2012; Nwachukwu et al., 2010).

Toxicity of ingested heavy metals has been an important health issue for decades (Jarup, 2013*)*. Some species of Brassica (cabbage) are high accumulators of heavy metals in the edible parts of the plants and this can be an important exposure pathway for people who consume vegetable grown in heavy metal contaminated soil (Idodo-Umeh and Ogbeibu, 2010). The level of heavy metals for examples lead, cadmium and copper where determined in cassava from different location of oil exploration areas of Delta State, Nigeria. The results of different heavy metals have higher values when compared with WHO standard. These metals have damaging effects on the plants themselves and may become hazardous to man and animals. Above certain concentrations and over a narrow range, the heavy metals turn toxic. Moreover, these metals adversely affect natural microbial population leading to disruption of vital ecological processes. Plants can accumulate heavy metals in their tissues and uptake increases generally in plants that are grown in areas with increased soil contamination with heavy metals and therefore, many people could be at risk of adverse health effects from consuming common garden vegetables cultivated in contaminated soil (Adah et al 2013).

Fluted pumpkin is a tropical vine plants. Its origin can be traced to the family of *Curcubitaceae* with botanical name known as *Telfairia Occidentalis* (Adah et al 2013). It is cultivated across the low-land areas rich in mineral elements. Fluted pumpkin is found in abundance between 6 – 10 months in areas with high rainfall such as West Africa. During the dry season, the plant is watered frequently for the production of good quality leaves and fruits. The two main varieties of *Telfairia Occidentalis* in Nigeria are male and female varieties. The female plant produces big leaves than the male plant (Abah et al 2012). It is commonly known as ubong in Efik/Ibibio, mfang ubre in Oron, Ugu in Igbo, iroko or aporoko in Yoruba, umee in Urhobo, and umeke in Edo (Abah et al 2012).

Fluted pumpkin as it is commonly known in southern Nigeria plays important role in human and livestock nutrition. It is a source of protein, oil, fats, minerals and vitamins (Benson and Ebong 2005). The leaves of this vegetable are used in the preparation of several delicacies in southern Nigeria, one of which is “Edikang Ikong Soup” (a popular delicacy of the Efiks/Ibibios in Cross River and Akwa Ibom States in Nigeria). It thrives better in the early part of the rainy season. It can also be planted between August and October which are the latter months of the rainy season. *Telfairia occidentalis* can be grown in garden and farmed as a vegetable. It can survive for 3-4 years if there is moisture in the soil (Adewole and Uchegbu, 2015).

Telfairia occidentalis is of high demand all over Nigeria perhaps because of its nutritional content. Heavy metals such as Copper (Cu), Cadmium (Cd), Zinc (Zn), Lead (Pb), Chromium (Cr) and Iron (Fe) are commonly found on contaminated sites. Heavy metals such as Cu, Zn and Fe are essential micronutrients for plant metabolism. Both essential and non-essential micronutrients when in excess in the human body pose adverse effect on health. Heavy metals can bio-accumulate in the human body via food chain transfer. These contaminated vegetables can have negative effects on human health. Heavy metals constitute an important contaminant of fluted pumpkin, because this pumpkin absorbs metals from the polluted soil and also from the deposit on vegetative part of the plant that comes in contact with polluted air. Fluted pumpkin cultivated on these types of environment can contain high level of heavy metals which have side effect on consumers (Khan, 2009). Roadside pumpkins are also exposed to disease causing micro-organisms, resulting in epidemics of disease such as cholera, dysentery, typhoid fever, etc. Therefore, this study is concerns itself with analysis of heavy metals concentration in fluted pumpkin (*Telfairia occidentalis*) planted near refuse dump in University of Cross River State, Calabar.

2.0 Materials and methods

2.1 Study Area

The study was carried out in University of Cross River State, Calabar. It is a state owned University with the acronym UNICROSS which was established in August 2002 by Cross River state Bill No.9, which was amended to Bill No. 6 of 2004. The Calabar campus of University of Cross River State is located at latitude 3˚18′ and 5˚21′ South and longitude 5˚13′ and 2˚14′ East of Calabar metropolis (Urban and Regional department report 2008, UNICROSS Calabar campus).

The university is the outcome of the merger of four former tertiary institutions. The polytechnic, Calabar, the College of Education, Awi, Akamkpa, and the Ibrahim Babangida college of Agriculture, Ovanum, Obubra, all owned by the Government of Cross River State of Nigeria. The university has four campuses located in Calabar, Obubra, Ogoja and Okuku dotted over a distance of well over 300 kilometers from one end to the other.

Within UNICROSS environment, there are various gardens/beds where fluted pumpkin is cultivated (see figure one). The locations are: staff quarter, behind new faculty of education, beside Hall three refuse dump, by Botany gardens and Pavilion extension.

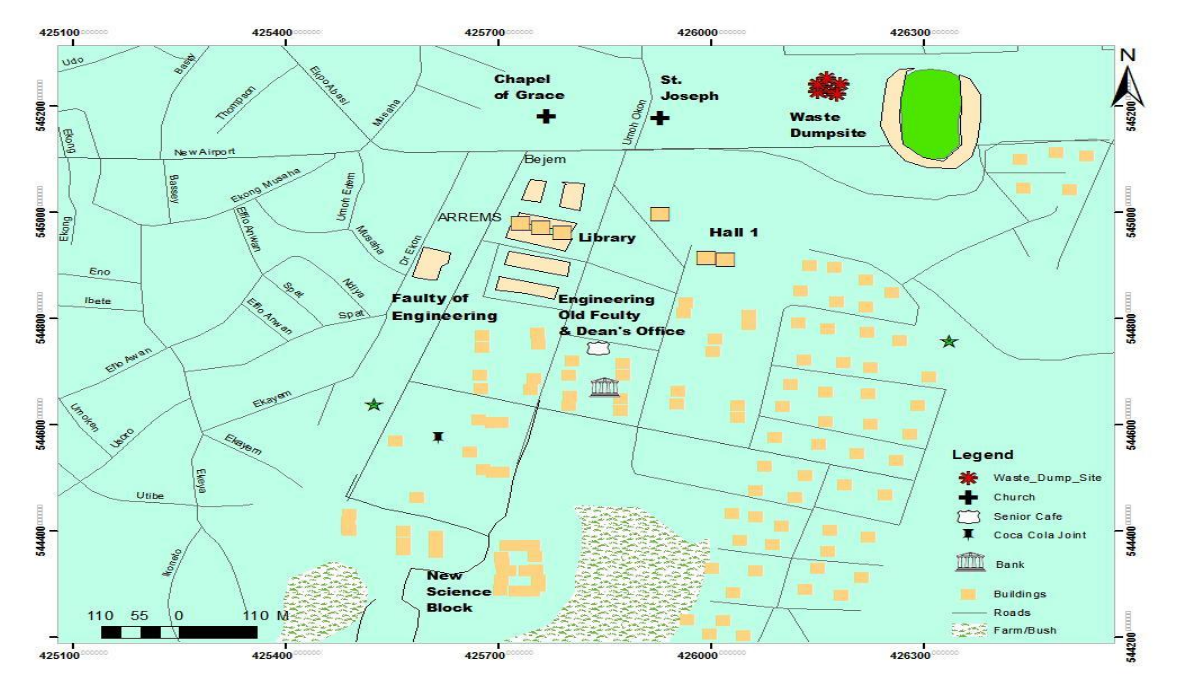

Figure 1: Map of *UNICROSS* Showing Dump Site

2.2 Materials

The materials used include pH meter, used to determine soil pH. Electronic balance used to weigh samples. Atomic Adsorption Spectrometer used to determine Hg, Cr, Cd, Ni, Co, Cu, As, and Pb concentrations in both vegetable sample.

2.2.1 Sample collection and preservation

2.2.2 Sample collection

Random sampling technique was employed to collect the vegetable samples of fluted pumpkin leaves (*Telfairia occidentalis*), Fluted pumpkin leaves were collected by plucking three young leaves from each plant randomly from each bed. The leaves were packed in polythene bags and transported to the laboratory where they were thoroughly rinsed with deionized water and cut into smaller sizes using a stainless steel knife which had been rinsed with distilled water and air dried. The leaves of vegetable samples were separated from the whole plants with the aid of a stainless steel knife and labelled.

2.2.3 Sample preservation

Fluted Pumpkin (*T. occidentalis*) were air-dried and blended to pass through 2mm sieve and was taken to the laboratory for analysis.

2.3 Preparation of Vegetable Samples

The vegetable samples (Fluted Pumpkin) were washed with tap water and de-ionized water to remove air pollutants, followed by oven drying at 105 ^{o}C 48 h to remove moisture. The dried samples were pulverized, using agate pestle and mortar, followed by sieving through a 0.5 mm mesh size sieve to obtain a uniform particle size. Each vegetable sample was labelled and stored in a dry plastic container that had been pre-cleaned with concentrated nitric acid to prevent heavy metal contamination prior to analysis with atomic absorption spectrophotometer

2.4 Procedure for the determination of Heavy Metal from vegetable samples

The air-dried vegetable samples were sieved using Whatman Filter Paper (2mm). One gram of each of the vegetable sample was weighed using Electronic balance into a 50ml beaker, 5ml of analytical grade acid $HN0_3$ and HCl were added. Mixture was allowed to stay for 5mins, and was heated at a temperature of about 80-90^{0}C for one hour thirty minutes using electric hot plate until a clear solution was obtained. After cooling, the solution was made up to a final volume (50ml) with distilled water in a volumetric flask. The metals (Cr, Cd, Ni, Co, Cu, As, and Pb) were determined on vegetable samples using Atomic Absorption Spectrophotometer (AAS) (model: Agilent Technology (Spectra 55B), Australia). Analysis of each sample was replicated and results reported in mg/kg.

2.5 Statistical analysis

Data generated will be subjected to statistical analysis using Minitab statistical package version 16. One way analysis of variance (ANOVA) was used to partition means and significant means were grouped by Tukey's multiple range tests at 5% significant probability level.

3.0 Results

The results for the various levels of metal concentrations (mg/kg) and months obtained for fluted pumpkin (*Telfairia Occidentalis*) is presented in Table 1. The laboratory analysis was carried out on Mercury (Hg), Lead (Pb), Chromium (Cr), Cadmium (Cd), Arsenic (As), Nickel (Ni), and Cobalt (Co).

The laboratory result of the analysis for the Fluted Pumpkin obtained behind UNICROSS refuse dump for the month of June, is detailed in Table 1.

The result of the concentration level of heavy metal obtained from refuse dump Behind UNICROSS in the month of July is given in table 2.

Table 1: Laboratory analysis of heavy metal in *Telfaria Occidentalis* obtained in June (Mg/Kg)

S/N	Heavy Metal	Result/concentration (Mg/Kg)
1	Hg	<0.001
2	Pb	2.765
3	Cr	0.413
4	Cd	0.842
5	As	0.070
6	Ni	1.813
7	Co	0.325

Table 2: Laboratory analysis of heavy metal in *Telfaria Occidentalis* obtained in July (Mg/Kg)

S/N	Heavy Metal	Result/concentration (Mg/Kg)
1	Hg	<0.001
2	Pb	2.654
3	Cr	0.411
4	Cd	0.830
5	As	0.065
6	Ni	1.724
7	Co	0.312

The result of the concentration level of heavy metal obtained from refuse dump Behind UNICROSS in the month of August is given in table 3 below.

Table 3: Laboratory analysis of heavy metal in *Telfaria Occidentalis* obtained in August (Mg/Kg)

S/N	Heavy Metal	Result/concentration (Mg/Kg)
1	Hg	<0.001
2	Pb	2.761
3	Cr	0.412
4	Cd	0.840
5	As	0.068
6	Ni	1.810
7	Co	0.315

The mean concentration values for all the heavy metal found in the fluted Pumpkin for the three months obtained in comparison with Food and Agricultural Organization of United Nation (FAO, 2011) and World Health Organization (WHO, 2011) permissible limits is shown in table 4.

The distribution of the heavy metals concentration in the fluted pumpkin according to the sample month obtained and concentration level is represented in the Figure 1. Also, the distribution of the heavy metal content of the Fluted pumpkin for the three months and the mean and computed standard deviation using Minitab statistical package version 16 is shown in table 5.

Table 4: Comparison of heavy metal concentrations in fluted pumpkin with FAO/WHO permissible limits

Sampled month	Hg	Pb	Cr	Cd	As	Ni	Co
June	<0.001	2.765	0.413	0.842	0.070	1.813	0.325
July	<0.001	2.654	0.411	0.830	0.065	1.724	0.312
August	<0.001	2.761	0.412	0.840	0.68	1.810	0.315
WHO/FAO limits (Mg/Kg)	**0.01**	**0.3**	**1.30**	**0.2**	**0.12**	**1.0**	**7.0**

Table 5: ANOVA significant heavy metal concentration of fluted pumpkin data for June, July and August, mean and standard deviation

Heavy Metal	June (Mg/Kg)	July (Mg/Kg)	August (Mg/Kg)	N	Mean	S.D	P-values
Hg	<0.001	<0.001	<0.001	3	0.001	0.0000	0.000
Pb	**2.765**	**2.654**	**2.761**	**3**	**2.726**	**0.0629**	**0.0002**
Cr	0.413	0.411	0.412	3	0.412	0.0010	0.000
Cd	0.842	0.830	0.840	3	0.837	0.0064	0.000
As	0.070	0.065	0.068	3	0.067	0.0025	0.0000
Ni	1.813	1.724	1.810	3	1.782	0.0505	0.000
Co	0.325	0.312	0.315	3	0.3173	0.0068	0.000

P<0.05 alpha level

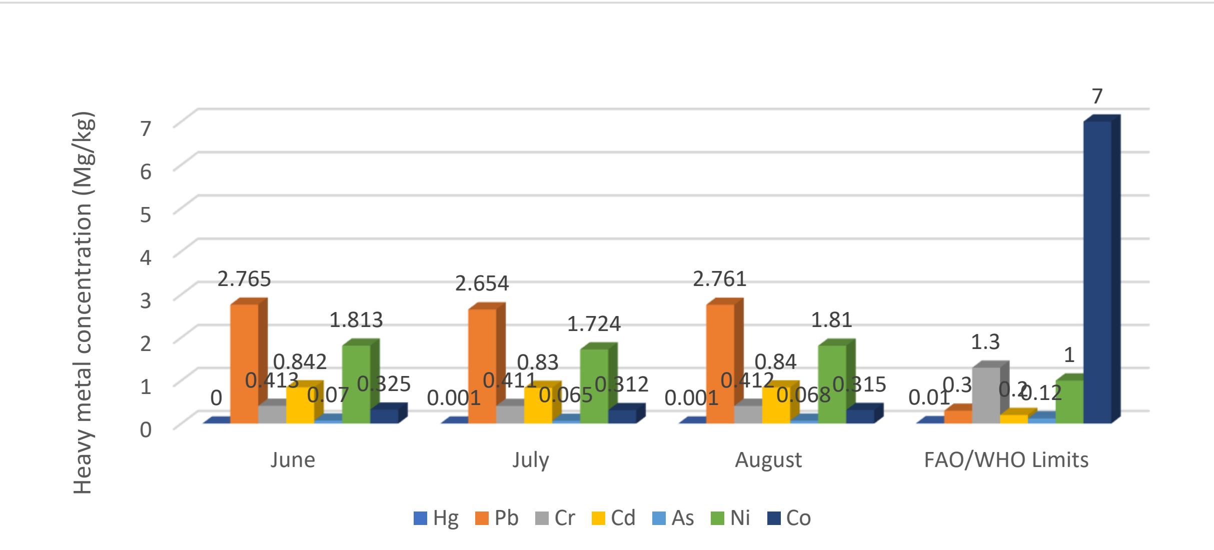

Figure 2: Heavy metal concentration of fluted pumpkin leaves for the month of June, July and August in comparison with FAO/WHO permissible limits

4.0 Discussion of result

Trends in the distribution of the concentrations in mg·kg-1 of the heavy metals in leaves of Telfairia occidentalis samples for June, July and August seasons were: **June;** Pb (2.765) > Ni (1.813) > Cd (0.842) > Cr(0.413) > Co (0.325) > As (0.070) > Hg(<0.001), and **July;** Pb (2.654) > Ni (1.724) > Cr(0.411) > Cd (0.830) > Co (0.312) > As (0.065) > Hg(<0.001). **August;** Pb (2.761) > Ni (1.810) > Cd (0.840) > Cr (0.412) > Co (0.315) > As (0.068) > Hg (<0.001) as seen in Tables 1, 2 and 3 respectively.

The analysis showed that the mean concentrations of some of the heavy metals analyzed were within the normal concentration range of heavy metals in vegetables as recorded by WHO/FAO permissible limits, Federal Ministry of Health for heavy metals in vegetables and foodstuffs (Table 4). Also the mean concentration of the heavy metals in the vegetables for the three periods obtained showed the following trend Pb (2.762) > Ni (1.782) > Cd (0.837) > Cr (0.412) > Co (0.317) > As (0.067) > Hg (<0.001).

The mean concentration of Lead (Pb) had the highest value of 2.762Mg/Kg followed by Nickel (Ni) with 1.782Mg/Kg, then Cadmiunm (Cd) with a value of 0.837Mg/Kg, and then Chromium (Cr) with 0.412Mg/Kg, and Cobalt (Co) with a value of 0.317Mg/Kg followed by Arsenic (As) with mean value of 0.067 Mg/Kg and finally Mercury (Hg) with a mean value < 0.001Mg/Kg respectively.

Lead (Pb)

Mean concentration of Pb in the plant samples ranged from 2.765 ± 2.654 ± 2.761mg/kg, June, July and August seasons. It was found to be highest in June, followed by August and July with mean values of 2.765mg/kg, 2.761mg/kg, and 2.654mg/kg respectively. These values exceeded the WHO/FAO allowable limit of 0.3mg/kg for edible plants (Schippers, 2000). The heavy metal significant value comparison from the analysis of variance (ANOVA) (Table 5) with a p-value less than significant value of 0.05 ($p<0.05$) affected the Telfairia occidentalis plant in the study area. Therefore, the high plant Pb value may be due to absorption of soil lead by plants. This result collaborates the work of Osma et al 2012 who reported that Telfairia occidentalis has the ability to absorb lead. Lead (Pb) is a non-essential toxic element which cause carcinogenic effects and teratogenic abnormalities in human, even at very low concentrations (Naser et al 2009). Pumpkin leaves have the capability to accumulate Pb from the soil as well as from the atmosphere through their leaves. Lead has been reported as a severe cumulative body toxin which enters the body through food, air and water and cannot be eliminated by washing the vegetables (Abbas *et al.*, 2010).

Nickel (Ni)

Mean concentration of Ni in the plant samples ranged from 1.813 ± 1.724 ± 1.810mg/kg, for the June, July and August seasons. It was found to be highest in June, followed by August and July with mean values of 1.813mg/kg, 1.810mg/kg, and 1.724mg/kg respectively. These values exceeded the WHO/FAO allowable limit of 1.0 mg/kg for edible plants (Schippers, 2000). The significant comparison of Ni in the vegetable from the analysis of variance (ANOVA) (Table 5) having a p-value less than significant value of 0.05 ($p<0.05$) of Ni affected the Telfairia occidentalis plant in the study area. Nickel toxicity in plants is characterized by chlorosis and necrosis of leaves. Also, stunting of the roots, deformation of various plant organs, and wilting are possible. Ni can cause various kinds of cancer on different organs within the bodies of animals. Nickel also plays some role in body functions including enzyme functions. It occurs naturally more in plants than in animal flesh. It activates some enzyme systems in trace amount but its toxicity at higher levels is more prominent (Divrikli et al., 2006).

Cadmium (Cd)

Mean concentration of Cd in the plant samples ranged from 0.842 ± 0.830 ± 0.810mg/kg, for the June, July and August seasons. It was found to be highest in June, followed by July and August with mean values of 0.842mg/kg, 0.830mg/kg, and 0.810mg/kg respectively. These values exceeded the WHO/FAO allowable limit of 0.2 mg/kg for edible plants (Schippers, 2000). The significantly comparison of Cd in the vegetable from the analysis of variance (ANOVA) (Table 5) having a p-value less than significant value of 0.05 ($p<0.05$) of Cd affected the Telfairia occidentalis plant and its users in the study area. This is disturbing considering the health implications this may have on the consumers. The high plant Cd may be due to atmospheric deposition on the plant by vehicular emissions and absorption by plant from soil Cd. The source of Cd in the study area may be due to fossil fuel and cement from construction sites. Cadmium is a metal of great environmental and occupational concern as it has been classified as a known human carcinogen. Also, excessive acute Cadmium exposure may lead to pneumonitis, bronchitis, pulmonary edema and gastrointestinal problem.

Chromium (Cr)

Mean concentration of Cr in the plant samples ranged from 0.413 ± 0.411 ± 0.412mg/kg, for the June, July and August seasons. It was found to be highest in June, followed by August and July with mean values of 0.413mg/kg, 0.412mg/kg, and 0.411mg/kg respectively. These values were below the WHO/FAO allowable limit of 0.1.3 mg/kg for edible plants (Schippers, 2000). The significantly comparison of Cr in the vegetable from the analysis of variance (ANOVA) (Table 5) having a p-value less than significant value of 0.05 ($p<0.05$) of Cr bioaccumulation affected the *Telfairia occidentalis* plant and its users in the study area. This result agrees with Salami (2013) who also detected Chromium in vegetable sample. The high plant Cr may be due to the absorption by plant. The source of Cr in the study area may be from welding and other anthropogenic activities. Although, Cr is an essential nutrient for humans, excessive intake can cause skin irritation, stomach ulcer, lung problem, kidney and liver damage, reproductive complication and weak immune system (Salami, 2013)

Cobalt (Co)

Mean concentration of Cobalt (Co) in the plant samples ranged from 0.325 ± 0.312 ± 0.315mg/kg, for the June, July and August seasons. It was found to be highest in June, followed by August and July with mean values of 0.325mg/kg, 0.315mg/kg, and 0.312mg/kg respectively. These values were below the WHO/FAO allowable limit of 7.0 mg/kg for edible plants (Schippers, 2000). The significantly comparison of Co in the vegetable from the analysis of variance (ANOVA) (Table 5) having a p-value less than significant value of 0.05 ($p<0.05$) of Co bioaccumulation affected the Telfairia Occidentalis plant and its users in the study area. This agrees with Alam et al 2003, who found the presence of Cobalt in Vegetables. Cobalt has little direct activity on its own in the body as it is an integral component of vitamin B_{12} and as such its effects, sources and uses are very similar to that of vitamin B_{12}. It is involved in preventing and treating pernicious anaemia and also helps in red blood cell production. Co also supports normal nervous system functions (Sobukola et al., 2010). Very little information has been reported on its concentrations in food materials.

Arsenic (As)

Mean concentration of Arsenic (As) metal in the plant samples ranged from 0.070 ± 0.065 ± 0.068mg/kg, for the June, July and August seasons. It was found to be highest in June, followed by August and July with mean values of 0.070mg/kg, 0.068mg/kg, and 0.065mg/kg respectively. These values were below the WHO/FAO allowable limit of 0.12 mg/kg for edible plants (Schippers, 2000). The significantly comparison of Arenic metal (As) in the vegetable from the analysis of variance (ANOVA) (Table 5) having a p-value less than significant value of 0.05 ($p<0.05$) of as bioaccumulation affected the Telfairia Occidentalis plant and those consuming it in the study area. This agrees with Alam 2003, who found Arenic metals in fluted pumpkin in their study. Plant exposure to arsenic metal occurs mostly near hazardous waste sites, or in areas with high natural levels. Chronic or lower levels of exposure can lead to progressive peripheral and central nervous changes, such as sensory changes, numbness and tingling, and muscle tenderness (Ebong 2008).

Mercury (Hg)

Mean concentration of Mercury (Hg) metal in the plant samples ranged from <0.001 ± <0.001 ± <0.001mg/kg, for the June, July and August seasons. It was found to be the same for the three seasons with mean values of 0.01mg/kg, 0.001mg/kg, and 0.001mg/kg respectively signifying the little presence of the metal in the vegetable. These values were the same with the WHO/FAO allowable limit of 0.001 mg/kg for edible plants (Schippers, 2000). The significantly comparison of Hg in the vegetable from the analysis of variance (ANOVA) (Table 5) having a p-value less than significant value of 0.05 ($p<0.05$) of Hg bioaccumulation affected the Telfairia Occidentalis plant and those consuming it in the study area. This also agrees with Adepoju, Okeke, Bamgbade and Oguntibeju (2013) who found 0.3500 ± 0.0000 mg/kg to 0.733 ± 0.0006 mg/kg concentration of Mercury metals in fluted pumpkin in their study. Although the level of Hg found in the present study is in accordance to WHO/FAO permissible limits, high concentration of mercury in leafy vegetables constitute health hazards to human health.

5.0 Summary

Bioaccumulation of heavy metals by edible vegetables poses a risk to human lives especially when the presence of some of these heavy metals exceed the WHO/FAO permissible limits/standards for Africa and its environs. The concentrations of heavy metals in the leaves of pumpkin (*Telfairia occidentalis*), from University of Cross River State refuse dump sites for the month of June, July and August have been studied in comparison with the WHO/FAO permissible limits, using Atomic Absorption Spectrophotometer (AAS) technique. The concentrations of Lead (Pb), Nickel (NI), and Cadmium (Cd), in the vegetable samples are quite higher than the permissible limits of WHO/FAO for edible plants, except for Chromium (Cr), Cobalt (Co), Arsenic (As) and Mercury (Hg) that were below the WHO/FAO permissible limits for the three samples of vegetables

6.0 Conclusion

Generally, the concentrations of the metals in the soil samples are in the decreasing order, Pb (2.762) > Ni (1.782) > Cd (0.837) > Cr (0.412) > Co (0.317) > As (0.067) > Hg (<0.001).The vegetable samples show the same trend of metal concentrations with slight difference in values for the June, July and August seasons. The nutritional implication of some of these high levels of Lead (Pb), Nickel (Ni) as well as Cadmium (Cd) in this vegetable is that consumers may be prone to heavy metals toxicity as a result of regular consumption. Hence, adequate care should be taken in the consumption of this vegetable so as to avoid bioaccumulation of these heavy metals and subsequently, its deleterious effects.

Based on the findings from this research work, it is recommended that:

1. Other methods of analysis of metals in vegetable should be

adopted for the same vegetable samples.
2. The eaters of these leafy vegetables should be screened for any incident of heavy metal contamination.
3. The vegetables studied in this research work could be applied for phytoremediation of polluted soils.

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