Evaluation of Heavy Metal (Zn, Cu, Pb, Cr, Cd and Ni) Concentrations in the Leaves, Stems and Roots of *Telfairia occidentalis* (*Fluted Pumpkin*) Harvested from the Egi Community, Rivers State

Ahiakwo, C.[1], Ekweozor I. K. E. [2], Onwuteaka, J. N. [3], Anaero-Nweke[4], G. N., Ugbomeh[5], A.P., Bobmanuel, K.N.O.[6]

Department of Applied and Environmental Biology, Rivers State University, Port Harcourt, Nigeria

Abstract: ***Heavy metal (Zn, Cu, Pb, Cr, Cd and Ni) concentrations were determined in the leaves, stems and roots of fluted pumpkin, harvested from Egi community, Rivers State. Samples were collected from four (4) different locations, namely: Location 1 (New Elf Road), Location 2 (Ugada Imeagi), Location 3 (Egita Land) and Control (Ohali-Elu). All samples were analysed using AA500 model Atomic Absorption Spectrophotometer. Results of heavy metal concentrations (mg/kg) in the leave, stem and root revealed that all metals were below permissible limits of food crops as specified by WHO/FAO/DPR (2012) in both seasons, with exception of Cd in the wet season which recorded 0.911(Control), 0.723 (Location 2) and 0.711 (Location 3) for leaf, 0.283 (Control), 0.511 (Location 2) and 0.521 (Location 3) for stem and 0.543 (Control), 0.35 (Location 2) and 0.39 (Location 3) for root which were above permissible limit of 0.02 mg/kg. The results above shows an evidence of oil and gas related activities, and other possible anthropogenic Cd contaminants in the study area. It is therefore recommended that more studies on other metals and constant monitoring of the environment should be carried out.***

Keywords: Heavy Metals, Pollution, Concentration, Contaminants

1. Introduction

Aggressive manner of crude oil exploration and exploitation by the International Oil Companies (Total E&P, Shell Petroleum Development Corporation, Exxon Mobil, Chevron Oil Company, Nigeria Agip Oil Company etc.) for over five decades in the oil rich Niger Delta has undoubtedly transformed the area into an arena of environmental degradation (UNEP, 2011). A day hardly passes without a report of one incidence of oil pollution. Most importantly, various publications on oil spillage containing relevant information and new understanding on its effect on specific environmental components have been made. This is exemplified by the earlier studies as seen in review of related literatures.

Chemical substances produced by industries through agricultural activities, mining of ores and minerals and burning of fossil fuels find their way into the various environmental medium thus impacting negatively on both terrestrial and aquatic lives (Akguc*et al.*,2010).

These chemicals especially the heavy metals get stored in the tissues and cells of plant with no noticeable effects, but exceeding human and animal permissible limits (Kovalchuk *et al.*, 2001., Frasad and Freitas, 2003). Kabatapendias and Pendias, 2001; Nameni*et al.*, 2008 reported both tolerable and lethal amount of chemical substances in tissues of different plants.

Heavy metal concentrations in the past few years have reached detectable toxic levels due to consequences of anthropogenic activities and urbanization (Ahlawat *et al.*, 2011). Nowadays, itisa well-established issue that cities suffer from considerable levels of pollution due to a wide array of substances that contaminate the air, water and soil (Rucandio *et al.*, 2010).

This is a specie of *Cucurbitaceace* family in the tropics largely consumed in Nigeria, Ghana and SierraLeone. The common names for fluted pumpkin include *Ubong* in Ibibio and *Ugu* in Igbo. It is a creeping vegetable that spiral low across the ground with lobed leaves and long twisting tendrils. It is a warm weather crop that grows well in low land and tolerates elevation of some few meters above the ground. It thrives best in soils rich inorganic matter (Uboh *et al.*, 2011). Fluted pumpkin plays important role in human and livestock nutrition. It is a source of protein, oil, minerals and vitamins. The leaves are low in crude fibre but rich in sourceof folic acid, Calcium, Zinc, Potassium, Cobalt, Copper, Iron and Vitamins A, C and K. It also has medicinal values as fluted pumpkin leaves and the seeds could be used to increase haematological indices, improve sperm quality and reduce blood glucose. It is rich in antioxidants, thiamine, riboflavin and ascorbic acid. The long shoots and leaves of this vegetable are used in preparation of several delicacies in Southern Nigeria, including *Edika Ikong* soup (a popular delicacy of the Efiks and Ibibios in Cross River and AkwaIbom States, Nigeria (Idodo-Umeh Ogbeibu, 2010).It thrives better in the early part of the rainy season, planted between August and October and can be grown in a garden.

The objective of the study is to assess the levels of Zn, Cu, Pb, Cr, Cd and Ni in the leaves, stems and roots of *Telfairia occidentalis* (fluted pumpkins) grown in the Egi community, Rivers State, over the wet and dry seasons.

Licensed Under Creative Commons Attribution CC BY

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

2. Materials and Methods

Description of the Study Area

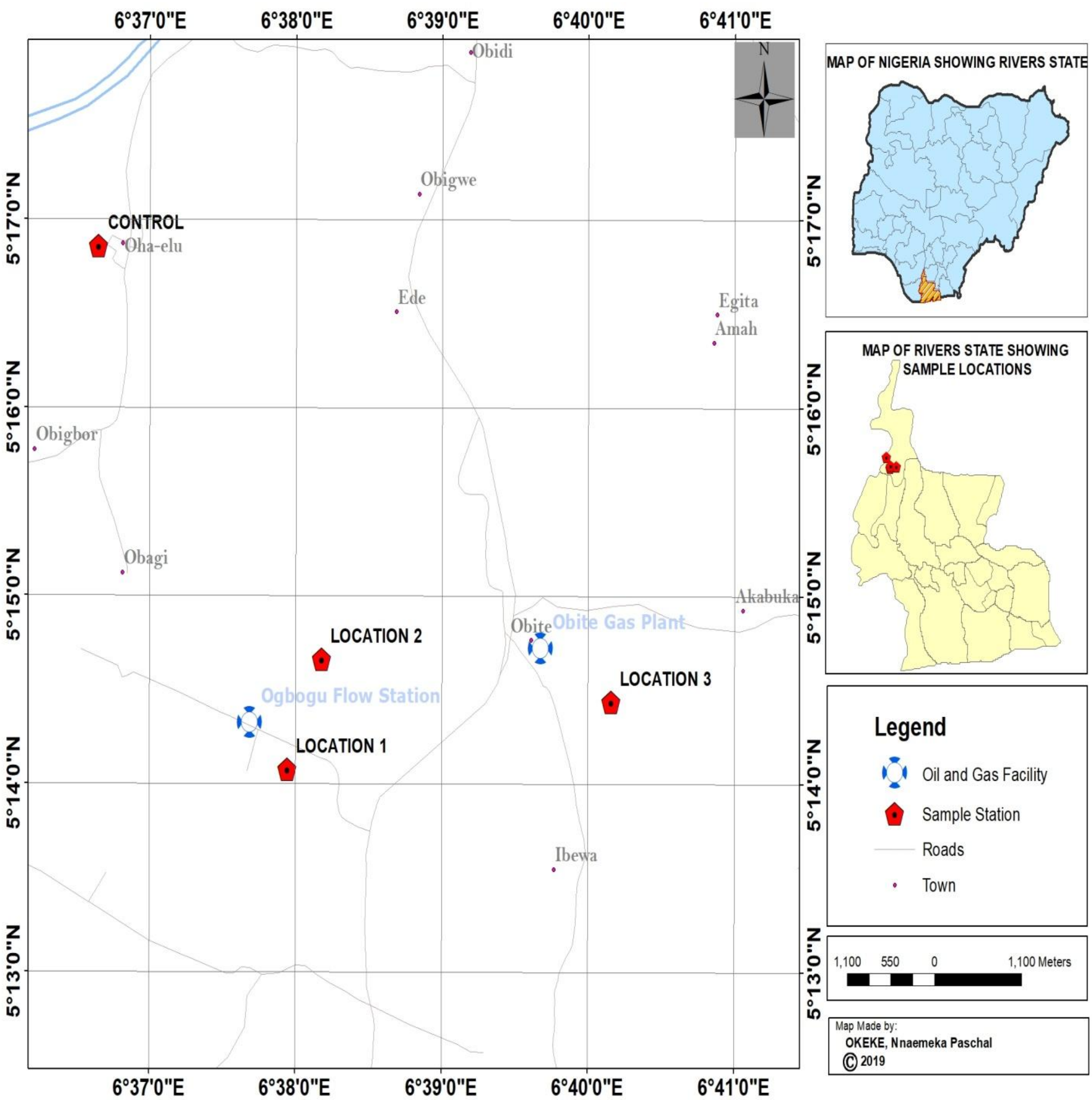

Figure1: Map of Study Area Showing Sampling Locations

This study was carried out in Egi Community in Ogba/Egbema/Ndoni Local Government Area. The area is located in the northern part of Rivers State sharing boundaries with Imo and Delta State respectively. It is a growing city with an estimated population of about 40,000 people EPNL (2005). The economy of the area relies mainly on agriculture and oil and gas, being one of the highest oil and gas producing communities in Rivers State. The climate is typically tropical with dry (November – March) and wet (June – October) seasons. Average temperature of the area ranges between $27^{O}C$ – $32^{O}C$, while average humidity is between 69% and 96%, EPNL (2005).

Description of Sample Location

Location 1 (New Elf Road) - Situated at latitude 05^0 16'51.3’’ and longitude $006^0$37’56.8’’, is 20 meters away from Total E&P Nigeria Ltd flare pit and flow station, and 50 meters to OB 29 Oil and Gas wells. The flare pit receives waste water from all injection wells around Ogbogu flow station. Members of the community farm annually on the land around the sample location for domestic and commercial purposes.

Location 2 (Ugada Imeagi) - Situated at latitude $05^0$14’39.5’’ and longitude $006^0$38’10.8’’. It is 10 meters away from OB 38 and OB 64 Oil and Gas wells belonging to Total E&P Nigeria Ltd. OB 38 has a waste pit that receives drill cuttings and other industrial waste from Total E&P Nigeria Limited facilities. The land also serves as community farm land.

Location 3 (Egita Land) - Situated at latitude $05^0$14’26.1’ and longitude $006^0$40’09.7’’. It is 50 meters away from the Ibewa gas cluster locations. This is where the gas eruption of

Licensed Under Creative Commons Attribution CC BY

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

2012 took place. The location is also 100 meters away from the Obite gas plant which witnessed an explosion in 1998.

Control Location (Ohali-Elu) - Situated at latitude $05^0 16'51.3''$ and longitude $006^0 36'39.0'$, 8km away from Location 3, 6.2km from Location 2 and 6km away from Location 1. The Control borders with the Orashi River from the North. The area is completely agrarian with no known records of Oil and Gas exploration and production activities. However, there is high vehicular and human activities in the area. Also, worthy of note is that the 2012 flood which submerged all the sample Locations including oil and gas facilities came from the Control.

Sampling Procedure

Plant Sample Collection

Samples of leaves, stem and roots of *Telfairia occidentalis* were collected randomly six months after planting using vinyl gloves and carefully packed into polyethylene bags (Alam *et al.,* 2003; Osma *et al.,* 2012) in both wet and dry season. Samples collected were properly labeled showing locations, sample types, plant species and date of sampling, before taken to the Department of Plant Science and Biotechnology, Rivers State University, Port Harcourt (RSU,PH) for proper botanical identification and thereafter to the Institute of Pollution Studies Laboratory RSU,PH for preparation and analysis.

Plant Sample Preparation

All samples were taken to the Institute of Pollution Studies Laboratory, Rivers State University, Port Harcourt. All plant samples (leaves, stems and roots) were washed in fresh running water to eliminate dust, dirt, possible parasites or eggs. The samples were then cut into small pieces and air dried for two weeks. The dried plant samples were homogenized by grinding using grinder and stored in polythene bags until used for acid digestion (Farooq *et al.,* 2009).

Analysis of Heavy Metals

1g of prepared dried plant material was added to 10ml of well mixed nitric, perchloric, and sulphoric acid. The mixture was heated using a heating mantle for 10-20 minutes. This was allowed to cool and thereafter, 20ml of distilled water was added. The mixture was then boiled to bring metals into solution. Thereafter, the solution was filtered after cooling through Whatmann filter paper into 100ml standard flask. It was then made up to the mark and content transferred into a plastic container. Each metal was thereafter ran using an AAS 500, calibrated daily with specific metallic standard.

3. Results

Heavy Metals Concentration in the Leaf (mg/kg) of *Telfairia occidentalis*

The concentration of heavy metals in the leaf of *Telfairia occidentalis* during the wet and dry season are shown in Table 1 and 2

Table 1: Showing the concentration of heavy metals in the leaf of *Telfaria occidentalis* sampled during the wet season

Heavy metals (mg/kg)	Loc 1	Loc 2	Loc 3	Control	WHO/FAO/ DPR (2017)
Cd	0.005	0.723	0.711	0.911	0.02
Cr	0.149	0.159	0.163	0.272	1.30
Pb	0.000	0.065	0.067	0.028	2
Cu	0.360	0.000	0.007	0.002	10
Zn	0.035	0.000	0.000	0.000	0.60
Ni	0.170	0.040	0.030	0.028	10

Table 2: Showing the concentration of heavy metals in the leaf of Telfaria occidentalis sampled during the Dry season

Heavy metals (mg/kg)	Loc 1	Loc 2	Loc 3	Control	WHO/ FAO/ DPR (2017)
Cd	0.002	0.002	0.002	0.001	0.02
Cr	0.015	0.006	0.026	0.011	1.30
Pb	0.006	0.002	0.004	0.004	2
Cu	0.104	0.014	0.051	0.049	10
Zn	0.298	0.238	0.181	0.200	0.60
Ni	0.000	0.020	0.000	0.000	10

The Trend in the concentrations of heavy metals in the leaf of *Telfairia occidentalis* sampled in the wet and dry seasons were:-

Wetseason:- Cu (0.360) > Ni (0.170) > Cr (0.149) > Zn (0.035) > Cd (0.005) >Pb (0) in Location 1 (Table 1)(Fig. 2). Cd (0.723) > Cr (0.159) >Pb (0.065) > Ni (0.040) > Zn (0) inLocation 2, andCd (0.711) > Cr (0.163) >Pb (0.067) > Ni (0.030) > Cu (0.007) > Zn (0) in Location 3 Cd (0.911) > Cr (0.272) Pb (0.028) > Ni (0.028) > Cu (0.002) > Zn (0) in the Control. Cd was recorded with the highest level of 0.911mg/kg at the Control (Table 1)(Fig. 2).. While that of Dry season followed a different pattern which reveals that Zn (0.298) > Cu (0.104) > Cr (0.015) >Pb (0.006) Cd (0.002) > Ni (0.00) in Location 1 (Table 2)(Fig. 3)., Zn (0.238) > Cu (0.014) > Ni (0.02) > Cr (0.006) > PbandCd (0.002) in Location 2, Zn (0.181) > Cu (0.051) > Cr (0.026)>Pb (0.004) > Cd (0.002) > Ni (0.00) in Location 3 and Zn (0.2) > Cu (0.049) > Cr (0.011) >Pb (0.004) > Cd (0.001) > Ni (0.00) in the Control. Zn was recorded with the highest level of 0.298mg/kg at Location 1 (Table 2) (Fig. 3).

Statistically the values were not significantly different ($P<0.05$).

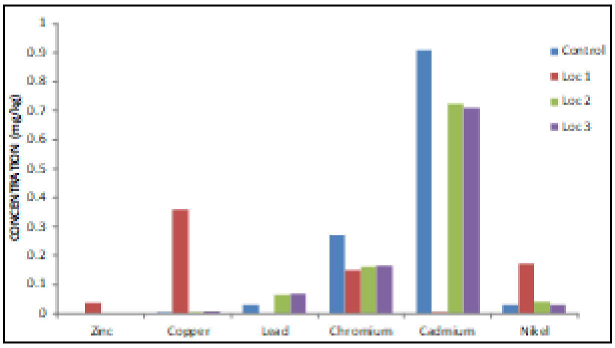

Figure 2: Concentration of heavy metals in the leaf of *Telfairiaoccidentalis* sampled during the Wet Season

Licensed Under Creative Commons Attribution CC BY

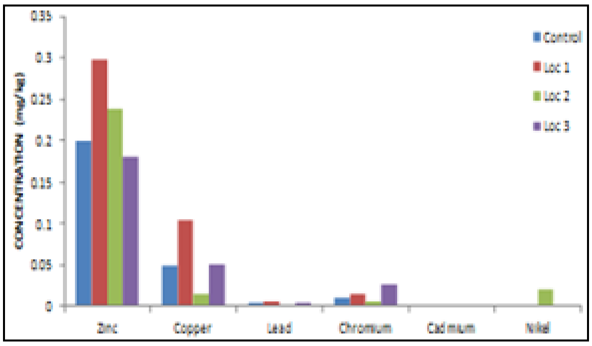

Figure 3: Concentration of heavy metals in the leaf of *Telfairiaoccidentalis* sampled during the Dry Season

Heavy Metal Concentration in the Stem (mg/kg) of *Telfairia occidentalis*

The concentration of heavy metals in the stem of *Telfairia occidentalis* are shown in Table 3 and 4

Table 3: Showing the concentration of heavy metals in the stem of Telfaria occidentalis sampled during the Wet season

Heavy metals (mg/kg)	Loc 1	Loc 2	Loc 3	Control	WHO/FAO/ DPR (2017)
Cd	0.005	0.511	0.521	0.283	0.02
Cr	0.000	0.215	0.226	0.178	1.30
Pb	0.000	0.042	0.047	0.016	2
Cu	0.093	0.035	0.040	0.052	10
Zn	0.032	0.000	0.000	0.000	0.60
Ni	0.000	0.021	0.035	0.017	10

Table 4: Showing the concentration of heavy metals in the stem of Telfariaoccidentalis sampled during the Dry season

Heavy metals (mg/kg)	Loc 1	Loc 2	Loc 3	Control	WHO/FAO/DPR (2017)
Cd	0.003	0.002	0.003	0.001	0.02
Cr	0.005	0.005	0.007	0.008	1.30
Pb	0.002	0.002	0.005	0.002	2
Cu	0.032	0.033	0.044	0.050	10
Zn	0.179	0.142	0.232	0.221	0.60
Ni	0.000	0.010	0.010	0.000	10

The values recorded during the wet season followed a trend which reveals. Cu (0.093) > Zn (0.032) > Cd (0.005) >Pb, Cr and Ni (0) respectively in Location 1 (Table 3, Fig.4). Cd (0.511) > Cr (0.215) >Pb (0.042) > Cu (0.035) > Ni (0.021) > Zn (0) in Location 2, Cd (0.521) > Cr (0.226) >Pb (0.047) > Cu (0.04) > Ni (0.035) > Zn (0) in Location 3 andCd (0.283) > Cr (0.178) > Cu (0.052) > Ni (0.017) >Pb (0.016) > Zn (0) in theControl (Table 3, Fig.4). Cd was recorded with the highest level of 0.521mg/kg at Location 2. The values were however not significantly different (P<0.05).

The values followed a different pattern during the dry season which reveals Zn (0.179) > Cu (0.032) >Cr(0.005) > Cd (0.003) >Pb (0.002) > Ni (0.00) in Location 1(Table 4, Fig.5). Zn (0.142) > Cu (0.033) > Cr (0.005) >Pb and Cd (0.002) > Ni (0.01) in Location 2, Zn (0.232) > Cu (0.044) > Cr (0.007) >Pb (0.005) > Cd (0.003) > Ni (0.01) in Location 3 and Zn (0.221) > Cu (0.05) > Cr (0.008) >Pb (0.002) > Cd (0.001) > Ni (0.00) in Control (Table 4, Fig.5).

Zn was recorded with the highest level of 0.232mg/kg in the stem of *Telfairiaoccidentalis*inLocation 3. Statistically the values were also not significantly different (P<0.05)

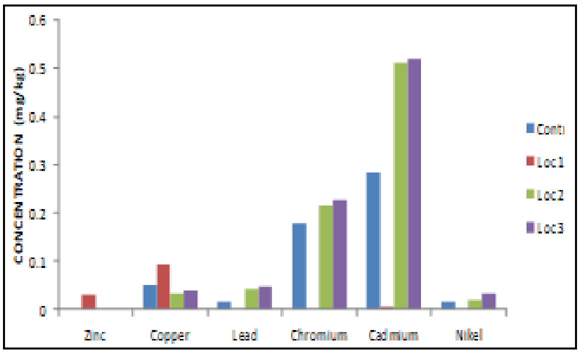

Figure 4: Concentration of HeavyMetals in the Stem of *Telfairiaoccidentalis* sampled during Wet Season.

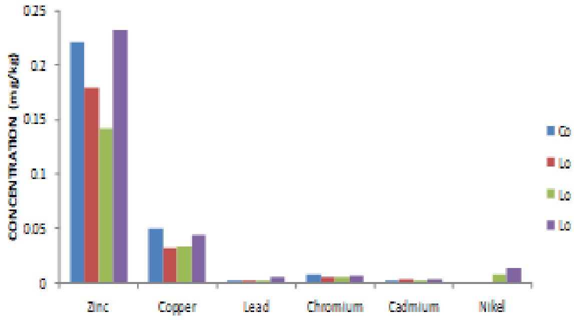

Figure 5: Concentration of Heavy Metals in the Stem of *Telfairiaoccidentalis* sampled during the Dry Season.

Heavy Metal Concentration in the Root(mg/kg)*Telfairiaoccidentalis*

The trend in the concentrations of heavy metals in the roots of *Telfairiaoccidentalis* sampled during the wet and dry season are shown in Table 5 and 6

Table 5: Showing the concentration of heavy metals in the Root of Telfariaoccidentalis sampled during the Wet season

Heavy metals (mg/kg)	Loc 1	Loc 2	Loc 3	Control	WHO/FAO/ DPR (2017)
Cd	0.005	0.350	0.390	0.543	0.02
Cr	0.000	0.118	0.115	0.083	1.30
Pb	0.000	0.123	0.150	0.019	2
Cu	0.493	0.250	0.390	0.048	10
Zn	0.044	0.000	0.000	0.000	0.60
Ni	0.000	0.012	0.015	0.017	10

Table 6: Showing the concentration of heavy metals in the root of *Telfariaoccidentalis* sampled during the Dry season

Heavy metals (mg/kg)	Loc 1	Loc 2	Loc 3	Control	WHO/FAO/ DPR (2017)
Cd	0.008	0.002	0.003	0.001	0.02
Cr	0.008	0.008	0.010	0.010	1.30
Pb	0.002	0.002	0.002	0.002	2
Cu	0.039	0.037	0.054	0.052	10
Zn	0.179	0.153	0.191	0.204	0.60
Ni	0.000	0.000	0.010	0.000	10

Wet season followed a trend which reveals that Cu (0.493) > Zn (0.044) > Cd (0.005) >Pb, Cr and Ni (0.00) in Location 1 (Table 5, Fig. 6). Cd (0.350) > Cu (0.250) >Pb (0.123) > Cr (0.118) > Ni (0.012) > Zn (0.000) in Location 2, Cd

Licensed Under Creative Commons Attribution CC BY

(0.390) > Cu (0.390) >Pb (0.150) > Cr (0.115) > Ni (0.015) > Zn (0.000) in Location 3 and Cd (0.543) > Cr (0.083) > Cu (0.048) >Pb (0.019) > Ni (0.017) > Zn (0.000)in the Control (Table 5, Fig. 6). Cd was recorded with the highest level of 0.543mg/kg at the Control Location. The values recorded, were not significantly different (P<0.05)

Dry season showed a different trend which further revealed that. Zn (0.179) > Cu (0.039) > Cr and Cd (0.008) >Pb (0.002) > Ni (0.00) in Location 1 (Table 6, Fig. 7). Zn(0.153) > Cu (0.037) > Cr (0.008) >PbandCd (0.002) > Ni (0.00) in Location 2, Zn (0.191) > Cu (0.054) > Crand Ni (0.01) > Cd (0.003) >Pb (0.002) in Location 3while Zn (0.204) > Cu (0.052) >Pb (0.002) > Cr (0.01) > Cd (0.001) > Ni (0.00) inthe Control. Zn was recorded with the highest level of 0.204mg/kg at the Control Location (Table 6, Fig 8), however the values were also not significantly different (P<0.05)

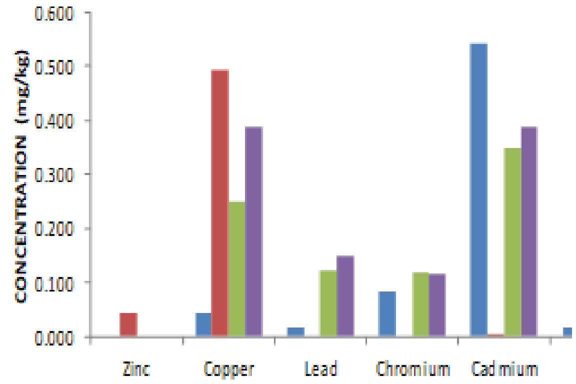

Figure 6: Concentration of Heavy Metals in the Root of *Telfairia occidentalis* sampled during the Wet Season

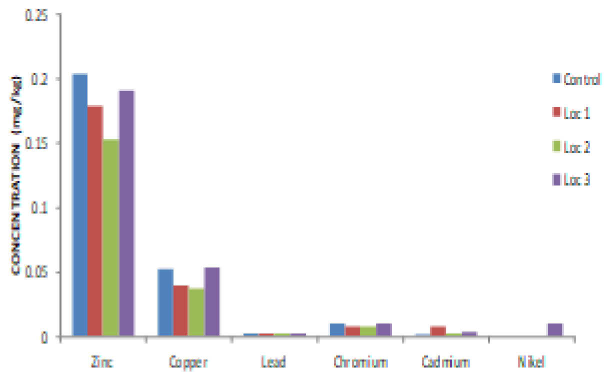

Figure 7: Concentrationof HeavyMetals intheRoot of *Telfairia occidentalis* sampled during the Dry Season

Discussion

Zinc (Zn)

The Concentrationof heavy metal in theroot, stem andleaf of*T. occidentalis*varied widely over wetand dry season withZn having the highest concentration which was recorded inthe dryseason as 0.298 in Location 1. Moreover, all values of Zn recorded in this study over the wet and dry season were below permissible limit as specified by WHO/FAO/DPR (2012). The result disagrees with that of Chukwuemeka *et al.*, (2014) who reported higher concentration of heavy metals in fluted pumpkin samples in the wet season when compared to dry season. The value of Zn obtained in this study showed statistical significant disparity in season at P<0.05. However, the result agrees with Oladunni *et al.*, (2013) who reported lower concentration of heavy metals inwet season compared to dry season. Edem *et al.*, (2009) recorded the same range of values as those reported in the present study for Zn in leaf, stem and root of *T. occidentalis.* Idoho-Umeh *et al.*, (2010) reported a concentration of 3.39mg/kg of Zn in epicarp of plantain fruit. Nwajei *et al.*, (2012) recorded amean concentration of 4.89±0.5mg/kg of Zn in tomato leaves and 3.33±0.5mg/kg of Zn in tomato fruits. Pande and Tewari (2013) reported 2.667 – 26.00mg/kg of Zn in Lady finger. The reason for low concentration of Zn in the wet season may be as a result of its strong affinity with Organic Matter which tends to accumulate more in wet season than dry season. Complexes of Zn with Organic Matter reduce its availability to plants. Furthermore, precipitation with oxides of Fe, Al and Mn in wet season could also be a factor responsible for the low concentration ofZn. Znis acomponent part of a numberof metalloenzymes and co-factors controlling the activities of specific dependent enzymes. Zn concentration can monitor metabolic processes through initiation and regulation of the activities of those enzymes (Ireland and Kuwabara, 1985).

Copper (Cu)

Cu was detected in the leaf, stem and root of *T. occidentalis* in all Locations and in all seasons. However, values of Cu recorded in the present study were recorded highest in the root as 0.493in Location2 compared to the dry season. However, all values of Cu obtained were below permissible limit of Cu for vegetables as recommended byWHO/F AO/DPR (2017). Cu is an essential heavy metal needed by plants and animals for their growth and development. However, high levels could inhibit plant growth and may present toxicity to animals. Okereke *et al.*, (2006) reported similar range of values for Cu concentration in leaves of vegetables consumed in Eleme and Alakahia communities in Rivers State, Nigeria. Edem *et al.*, (2001) reported higher levels of 0.88mg/kg of Cu in the leaf, stem and root of *T. occidentalis* than values recorded in the present study. Udo *et al.*, (2015) stated that *Telfairia occidentalis, Vernonia armydalina* and *Amarathus sps.* are good accumulators of heavy metals. The difference in wet and dry season concentration of Cu according to Chukwuemeka *et al.*, (2015) could be attributed to rise in soil water table which favoured assimilation and translocation of nutrients and heavy metals. The seasonal differences, he further stated could also be as a result of soil composition and pH.

Lead (Pb)

Pb was detected in all Locations in all plant tissues except for Location 1 in wet season where it was not detected in all plant tissues. Highest Pb values were recorded in the root during the wet season as against the dry season as 0.150 in Location 3. In addition, all values recorded for Pb were below the permissible limit of Pb for vegetable food crops. The high values of Pb recorded in the present study in the wet season could be attributed to increased pH of the soil which favoured its solubility and availability to the plant. Result of this study is in agreement with those reported by Okereke *et al.*, (2006) in Pb accumulation in vegetables consumed in Eleme and Alakahia communities in Rivers

Licensed Under Creative Commons Attribution CC BY

State. Sobunkola *et al.*, (2009) reported the same range of values for Pb in leaves of fluted pumpkin. Edem *et al.*, (2009) reported similar values of Pb in leaf, stem and root of *T. occidentalis.* Nkwocha and Duru (2010) also reported similar values of Pb in the leaves of fluted pumpkin. In another study, Essiet *et al.*, (2010) reported higher concentration of 0.36mg/kg of Pb. Udo *et al.*, (2015) revealed concentration of 0.07mg/kg, 0.06mg/kg and 0.07mg/kg of Pb in root, stem and leaf samples in leafy vegetables. Uboh *et al.*, (2011) reported higher values of heavy metals in fluted pumpkin. Chukwuemeka *et al.*, (2014) reported higher concentration in fluted pumpkin samples in wet season when compared to dry season. Kihampa *et al.*, (2011) reported range of higher values of 0.49 – 20.65mg/kg of Pb. Opujobi *et al.*, (2011) reported high mean concentration of 4.31±0.37mg/kg. Nwajei *et al.*, (2012) obtained higher values of 4.01mg/kg and 2.96mg/kg of Pb in tomato leaves and fruits samples. Anthropogenic sources of Pb contaminants including oil spill, use of fertilizers and fossil fuels can increase the metal load in the edible parts of the plant and as a result create a soil-plant-man pathway which may lead to accumulation for people who consume such plants. In children, Pb is most damaging at the age of six years and younger. At low levels, Pb can be harmful and is associated with learning disabilities resulting in decreased intelligence, attention deficit disorder, behavior issues, nervous system damage, speech and language impairment, decreased muscle growth, decreased bone growth and kidney damage (International Cadmium Association, 2013). Furthermore, WHO (2010)stated that chronic Pb toxicity is characterized by neurological defects, renaltubular dysfunctionand anaemia. In men, Pbalsoaffects themale gametesleading to insperm abnormalitiesanddecreasedsexual desires aswell assterility (Needleman*etal.*, 1981).Inwomen, Pb poisoningis associatedwith usual ovariancyclesand menstrualproblem inaddition to spontaneous abortion (Needleman *et al.*, (1984). Pb toxicity has also been linked with repressed hemesynthesis (Harmon *et al.*, 2004).

Chromium (Cr)

Cr levels in all plant tissues showed statistical significant differentbetween wetand dry seasons at $P < 0.05$. The highest concentration of Cr was recorded in theleaf in the wet season as 0.272 in the Control. While it was not detected in the stem in the wet season. The values of Cr when compared, revealed statistical disparity in season at $P < 0.05$. The variability observed in the concentration of Cr between wet and dry seasons could be due to the low pH of the soil in the wet season which influenced Cr solubility and bioaccessibility to *T. occidentalis* as against dry season. The result of Cr obtained in the present study is less than the permissible limit of Cr for vegetable crops. Edem *et al.*, (2009) reported similar range of value of 0.08mg/kg in are study titled, 'Distribution of heavy metals in leaves, stemsandroots offluted pumpkin'. Kihampa *et al.*, (2011)

Stated that the levels of Zn, Cr, Pb and Cd were above the permissible levels of heavy metals in food as outlined in WHO guidelines and Tanzania Bureau of Standards. Osakwe *et al.*, (2015) reported similar mean values of Fe, Zn, Cr, Pb and Ni in the leaves and tubers. Okereke *et al.*,(2006) also reported similar values of 0.00 – 0.46mg/kg Cr as those recorded in this study. Furthermore, Ano *et al.*, (2007) and Nabulo (2006) reported similar values as those recorded in this study for Cr. Nkwocha and Duru (2010) also reported similar values. Sources of Cr contamination to soil include materials used as anti-corrosion in pipeline. Also, materials used for vehicle parts plating are other sources of Cr to the soil. Al-Rhashman (2007) reported that Cr is used as an anticorrosive material for crude oil pipes and other industrial materials. Cr is carcinogenic, affecting respiratory organs of workers working in Cr contaminated sites (Langard, 1980).Furthermore, Cr^{2+} affects the urogenital and cardiovascular systems (Costa and Klein, 2006).

Cadmium (Cd)

Cd concentration varied statistically significant in all plant tissues in all Locations and between wet and dry seasons with the leaf recording the highest concentration in the wet season as 0.911 in the Control. Cd concentration obtained in this study were abovethe permissible limit of 0.02mg/kg for vegetable food crops intheleaf, stemand root in most of the Locations in the wet season. In addition, values of the dry season were below the permissible limit in all Locations.

Isirimah, (2004) reported that Zn and Cd have geochemical association, therefore any Zn contaminated soil will have Cd contaminated as well. Since Zn was present in the dry season in leaf, stem and root, it therefore indicates the possibility of Cd presence in the soil. High values of Cd in the wet season may have been influenced by low pH of the soil and rise in the water table of the soil which favours absorption of water, nutrients and heavy metals. Concentration values of Cd obtained in this study is consistent with those reportedby Okereke *et al.*, (2006), Essiet *et al.*, (2006), Nkwocha and Duru (2010),but lower than values reported by Howard *etal.*,(2006), Kihampa *et al.*, (2011), Ogboi (2012), Uboh*etal.*, (2011) and Chukwuemeka *et al.*, (2014). Cd concentrationin thesoil can be increased through phosphates fertilizers, detergents and refined petroleum products. In addition, acid rain and the resultant acidification of soils and surface water have increased the geochemical mobility of Cd (Campbell, 2006).Also, the application of pesticides and biosolids (sewage sludge) and the disposal of industrial waste or the atmospheric contaminants increases the total concentration of Cd in soils and the bioavailabilityof Cd determines whether the plant Cd uptake occurs to a significant degree (Weggler *et al.*, 2004).Cd inthe body is known to affect several enzymes. It is believed that the renal damage that resulted in Protein uria is the result of Cd adversely affecting enzymes responsible for re absorption of proteins in kidney tubules (Manahan, 2003). Cd toxicity induces tissue injury, epigenetic changes in DNA expression, in hibition nor control of transport pathways especially in proximal segment of the kidney tubule (Dufresme and Farnsworthy 2001).

Nickel (Ni)

The highest concentration was recorded in the wet season and in the leaf as 0.170 in Location 1. Furthermore, Ni was detected in some Locations in both the wet and dry season. All Ni values obtained in this study were below the permissible limit of 10mg/kg in vegetable food crops. Ni is an essential element needed by the plant for its growth and development, however it could be toxic at high

Licensed Under Creative Commons Attribution CC BY

concentration. Sources of Ni in the present study area could be from other anthropogenic input than crude oil. Onder *et al.*,(2017) reported. Air borne particles emitted by brakes and wears from vehicle tyres as possible sources of Ni. The absence of Ni in *T. occidentalis* in some Locations agrees with Akaniwor *et al.*, (2005) who reported the absence of Ni and Pb in fresh and treated Nigerian essential foods from oil producing communities of Rivers and Bayelsa States of Nigeria. Results obtained from the present study are lower than those reported by Okereke *et al.*, (2006), Edem *et al.*, (2009),but are in the same range with values reported by Nkwocha and Duru (2010). High values of Ni recorded in the wet season could be attributed to increased soil acidity and rise in water table of the soil which encourages uptake of water and nutrients and their translocation. Contact with large concentration of Ni from plants grown on Ni rich soils lead to greater chances of increasing case of cancer of the lungs, nose, larynx and prostate as well as respiratory failure, birth defects and heart disorders (Duda-Chodale and Blaszzyk, 2008; Lentech, 2009).

4. Conclusion

The determination of heavy metals contamination in farm lands around oil and gas production areas is very vital in checking the health risk of the populace. The results of the present study showed elevated amount of Cd in the leaves, stems and roots of *Telfairia occidentals* across all study locations except in location 1 where the concentration was found to be below permissible limit of 0.02mg/kg in all tissues. This suggests possible Cd pollution of the area which could be as a result of oil and gas activities or other anthropogenic sources. As a result, there should be a follow up monitoring to assess the level of metals in food crops around the study area as human and animals may be at risk of Cd contamination. Management measures should be put in place to reduce Cd contamination in agricultural soils to avoid possible transfer into the food chain.

5. Acknowledgments

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

References

[1] Ahlawat, S. P. (2011). Assessment of heavy metal tolerance in native plant species from soils contaminated with electroplating efficient. *Ecotoxicol Environmental Safety*.

[2] Akaniwor, J. O., Onyeke, S. N &Ifemeji, J. C. (2005). Trace Metal Levels in Raw and Heat Processed Nigerian Staple Foods from Soil Producing Areas of Rivers and Bayelsa States. *Journal of Applied Sciences and Environmental Management*,10(2), 23 – 27.

[3] Akgue, N., Ozyigit I. I.&Yarci, C. (2008). *PyracanthaCoccineaRoem (Rosaceae)* as a biomonitor for Cd, Pb and Zn in Mugla Province, Turkey.Publishers City.

[4] Al-Khashman, O. A. (2007). Assessment of heavy metal accumulation in urban soil around potash industrial site in the East of the Dead Sea and their environmental risks.*Soil and Sediment Contamination*, 21, 276 – 290.

[5] Ano, A. O., Odoemena, S. A.&Ekwueme, P. O. (2007). *Lead and cadmium levels in soil and cassava* (*Manihotesculenta*) along Enugu – Port Harcourt Expressway in Nigeria.

[6] Campbell, P.G.C. (2006). *Cadmium: A PriorityPollutant***.**Environmental Chemistry, 3(6), pp. 387 – 388.

[7] Chukwuemeka, A. N., Godwin, J. U &Alfreda, O. N. (2015).Investigations of heavy metals concentrations in leaves of *Telfairiaaccidentalis* Hook F. (fluted pumpkin) in Nigeria.*PollutionJournal Environmental Studies*,24 (4), 1733 – 1942.

[8] Costa, M.& Klein, C.B. (2006). *Toxicity and Carcinogenicity of Chromium Compound in Human*: *Critical Review Toxicolog***y**, 36,155 – 163.

[9] Dufresne, J. & Farnsworth, R. (2001).A review of latest research findings on the health promotion on the properties of tea.*Journal of Nutritional Biochemistry*, 12 (7), 404 – 421.

[10] Edem, N. E., Obadoni, B. O., Erhani, H &Osakwumi, G. E. (2009). Eco-phytochemical studies of plants in a crude oil polluted terrestrial habitat located at Iwhreken, Ughelli, North LGA, Delta. *Nature and Science*, 7 (9), 78.

[11] Essiet, U. A., Effiong, H. S., Ogbemudia, F. O & Bruno, E. J. (2010). Heavy metal concentrations in plants growing in crude oil contaminated soil in AkwaIbom State, Nigeria. *African Journal of Pharmacy and Pharmacology*, 4(7), 466.

[12] Farooq, M., Anwar, F & Rashid, U. (2009). Appraisal of heavy metal contents in different vegetables grown in the vicinity of an industrial area. *Pakistani Journal Botanical*, *40*(5), 2099 – 2106.

[13] Harmon, R. E. Holm, P. E., Lorenz, S. E., McGrath, S. P & Christensen, T. H. (2004). *Metal Uptake by Plants from Sludge Amended Soils, Plants and Soil*, 216 (1 – 2), 53 – 64.

[14] Howard, I. C., Horsfall, M., Spiff, I. A &Teme, S. C. (2006). Heavy metal levels in surface water and sediments in an oil field in the Niger Delta, Nigeria. *Global Journal of Pure and Applied Science*, 12(10), 79.

[15] Idoho-Umeh, H &Ogbueibu, E. (2010). Bioaccumulation of heavy metals in cassava tubers and plantain fruit grown in soils impacted with petroleum and non-petroleum activities. *Research Journal Environmental Science*, 4, 33.

[16] Ireland, H.V.&Kuwabara, J. S. (1985). ***Trace metals.*** In Fundamentals of Aquatic Toxicology, Rand, G.M. &Petrocelli, S.R. (Ed.), Washington: Hemisphere Publishing Corporation.

[17] Isirimah, N. O. (2004). *Soils and Environmental Pollution Management*.

[18] Kabata-Pendias, A.&Pendias, H., (2011). Trace element in soils and plants,(3rd Ed.). Boca Raton, Florida, USA:Crc.Press Inc.

[19] Kihampa, C., Mwegoha, W.J.S. &Shemdoe, R.S. (2011). Heavy metals concentrations in vegetables grown in the vicinity of the closed dumpsite. *International Journal of Environmental Sciences*, 2, 889.

Licensed Under Creative Commons Attribution CC BY

[20] Kovalchuk, I., Kovalchuk, O.&Hohn, B. (2001). *Biomonitoring the genotoxicity of environmental factors with transgenic plants*:Trends, plant, science, 6(7), 306 – 310.
[21] Lenntech, A. (2005). Lenntech water treatment and air purification. *Sewage*, pp. 402.Rottendam: Holding. B. U.
[22] Manahan, S. E. (2003). *Toxicological Chemistry and Biochemistry*. CRC Press, (3rd ed.).
[23] Nabulo, G., Oryem-Origa, H & Diamond, M. (2006).Assessment of Lead, Cadmium and Zinc contamination of roadside soils, surface films and vegetables in Kampala City, Uganda.*Environment Research*, 101, 43 – 52.
[24] Nameni, M., AlaviMoghadan, M. R.&Arami, M. (2008). Adsorption Hexavalent chromium from aqueous solutions by wheat Bran.*International Journal Environmental Science and Technology*,5 (2), 161 – 168.
[25] Needleman, H.&Landrigan, P. (1981). The health effects of low level exposure to Lead. *Ann Rev. Public Health*, 12, 111 – 140.
[26] Nkwocha, E. E.&Duru, P. O. (2010). Micro-analytic study in the effect of oil pollution on local plants species and food crops.*Advances in (2011 listed) Bioresearch*, 1 (1), 2010, 189 – 198.
[27] Nwajei, G. E., Okwagi, P., Nwajei, R. I & Obi-Iyeke, G. E. (2012). Analytical assessment of trace elements in soils, tomato leaves and fruits in the vicinity of paint industry, Nigeria. *Research Journal of Recent Sciences*, 1 (4), 22.
[28] Ogboi, E. (2012). Spread and bioavailability of heavy metals in topsoil and groundnut (*Arachishypogacl*) in crude oil polluted area of Delta State. *Journal of Agriculture and Veterinary Sciences*, 4, 85.
[29] Okereke, C. J., Eka, B. E. & Matthew, O. W. (2016).Human health risk assessment of heavy metals contamination for population via consumption of selected vegetables and tubers grown in farmlands in Rivers State, South-South Nigeria.*Journal of Analytical and Pharmaceutical Research.*
[30] Onder, S., Dursun, S., Gezgin, S. &Demirbas, A. (2017). Determination of heavy metals pollution in grass and soil of city centre green areas Konya, Turkey. *Polish Journal of Environmental Study*, 16 (1), 145 – 154.
[31] Opujobi, A.O., Esunu, C.O., Osasuyi, A. &Okehie, C.C. (2011).Determination of the Lead content of pumpkin leaf (*Telfairiaoccidentalis*) in selected towns of Delta State covering the three (3) Senatorial Districts of the State.*Curr.World Environments,* 6 (1), 39.
[32] Rucandio, M. I., Petit-Dominguez, M. D., Hijano, C. F &Gimenez, R. G. (2010).Biomonitoring of chemical elements in an urban environment using arboreal and bush plant species.*Environmental Science Research*, doi:10.1007/S11356-010-0350Y.
[33] Sobunkola, O. P., Adeniran, O. M., Odedairo, A. A.&Kajihausa, E. O. (2009). Heavy metal levels of some fruits and leafy vegetables from selected markets in Lagos, Nigeria. *African Journal of Food Science*, 4(2), 389.
[34] Uboh, E., Akpanabiatu, M.I., Edet, E.E. &Okon, I.E. (2011). Distribution of heavy metals in fluted pumpkin (*Telfairiaoccidentalis*) leaves planted at traffic congested highway. *International Journal of Advanced Biotechnology and Research*, 2(2), 250.
[35] Udo, G., Nwadinigwe, C.&Nwadinigwe, A.(2015).Investigations of HeavyMetals Concentrations in Leaves of *Telfairiaoccidentalis* in Nigeria. *Polish Journal of Environmental Studies.*
[36] Weggler, K. McLaughlin, M. J.& Graham, R. D. (2004). “Effect of chloride in soil solution on the plant availability of biosolid-borne cadmium”.*Journal of Environmental Quality*, 33(2), pp. 496 – 504.

Licensed Under Creative Commons Attribution CC BY