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ASSESSMENT OF TRACE METAL CONCENTRATION IN SOIL AND EDIBLE PLANT SPECIESIN INDUSTRIAL AREA OF ANAKPA, URUAN LOCAL GOVERNMENT AREA OF AKWA IBOM STATE, NIGERIA

Anthony Okon Etim*

Department of Environmental Management and Toxicology, Michael Okpara Univeristy of Agriculture, Umudike, AbiaState, Nigeria

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Translocation Factor (TF); Bioaccumulation Factor(BF); PI= *T. occidentalis* (Fluted pumpkin); P2=*T. triangulare* (Water leaf); P3=*V. amygdalina* (Bitter leaf); P4=*C. sativus*(Cucumber); P5=*A. esculentus*(Okro) and P6=*O. gratissimum* (Scent leaf); Anakpa.

ABSTRACT

Trace metal concentrations of six edible plant species:*Telferiaoccidentalis* (Fluted pumpkin); *Taliniumtriangulare* (Water leaf); *Vernonicaamygdalina* (Bitter leaf); *Cucumis sativus*(Cucumber); *Abelmosclus esculentus*(Okro) and *Occimiumgratissimum* (Scent leaf) was investigated in Anakpa crude oil bearing environment. This was done to assess the effect of trace metals pollution on the plant species. The study was undertaken between March-2016 and March -2018. Trace metals Iron(Fe), Lead(Pb), Zinc(Zn). Vanadium(V), Nickel(Ni), Chromium(Cr), Cadmium(Cd) were assessed in the roots, shoots and leaves of the edible plant species mentioned above. Standard approved procedure as recommended by AOAC was used to determine the trace metals in the plants parts mentioned above. Trace metals are non-biodegradable and can easily enters into the food chain and accumulate in humans causing irreversible health conditions. The ability of the edible plant species to extract these trace metals from the soil to the aerial part of the plants are expressed as Bioaccumulation Factor and Translocation Factor. In terms of trace metal accumulation in plant species, the mean concentration of trace metals accumulation in the studied plant species followed the order: *Occimiumgratissimu<Cucumussativis<Vernonia amagdalina <Teliniumtraingulare <Telferiaoccidentalis*. Also trace metal concentration in the studied soil samples followed the order: Ni<V<Cr<Cd<Pb<Zn<Fe. In terms of translocation and bioaccumulation factors, the study showed that values reported in the study were<1.00. Nevertheless, with this value, the plant species are effective in phytoextraction. As excluders they are only capable of extracting these trace metals from the soil toaccumulate intothe roots. However, the bioaccumulation and translocation factors of different plant parts followed the order: Leaf<Shoot<root. Therefore, consumptions of these plant species may not have any direct health effect on the people since the trace metal in the edible part was lower in all the plants tested at the polluted and control sites.

INTRODUCTION

As reported by Kofi and Dartey (2015) pollution due to trace metal load in the industrial areas ofNiger Delta oil producing communities had caused severe environmental risk in the region over the years. This is due to the direct and indirect adverse environmental consequences associated with trace metals enhancement in the environment (Malik *et al*.,2013).Apart from mineralization, crude oil pollution also enhances trace metal concentrations inbiotic and abiotic components of the environment due to crude oil spillages and gas flaring associated with production activities (Akan *et al*.,2013). Akan *et al*. (2013) further opined that trace metals such as lead(Pd) and Cadmium(Cd) found in crude oilare hazardousto human health and development.As potential hazardous inorganic substances, trace metals can enter the food chain and cause severe health risk in humans (Nematianand Kazemeirai, 2013). They are non-biodegradable inorganic substances and can remains in the environment over time without decay. The transportation of these trace metals from the plants to human is possible in situation where the non-edible part of the plant cannot accumulate these metals (Enenche and Abddulmumuni,2016). As reported by Nematianand Kazemeirai (2013) non-edible plant parts do not only accumulate these trace metalsinroots, but also translocate

Corresponding author:* **Anthony Okon Etim
Department of Environmental Management and Toxicology Michael Okpara Univeristy of Agriculture, Umudike, AbiaState, Nigeria

from roots to shoots and leaves. These has been a major problem in crude oil contaminated soil since most of the conventional remedial approaches do not provide any dependable solution (Nematianand Kazemeirai, 2013). Therefore, this study was undertaken to determine the trace metals concentrations of some vegetable plant species widely consumed in crude oil producing community of Anakpa, Uraun Local Government Area of Akwa Ibom State, Nigeria. The study specifically assessed the concentrations of the trace metals in roots, shoots and leaves of the plant species selected randomly at the study and control sites. This was done in order to determine phytotoxicity levels of these plant species taking into consideration their translocation and bioaccumulation factors of the selected vegetable plant species.

MATERIALS AND METHODS

Study Area

This study was carried out in Anakpa inUruan Local Government Area of Akwa Ibom State, Nigeria (**Figure1**). Anakpa is bound to the north by Itu and Ibiono Ibom Local Government Areas and to the East by the Cross-River State. The study site also shares the west boundary with Uyo and Ibesikpo Local Government Areas of Akwa Ibom State, Nigeria(**Figure1).** The area lies between latitudes and Longitudes 5^{0}10'N and 8^{0}3'E in the North and East respectively.

Crude oil exploration and exploitation activities in Anakpa was undertaken on shore by Shell Petroleum Development Company(SPDC). However, production and processing were abandoned after discovery of crude oil at the study site, because of low production volume from the crude oil wells. Currently the operational activities are undertaken by Monopolo Oil and gas production company on concessional arrangement with the Nigerian Nation Petroleum company(NNPC)and Shell Petroleum Development Company(SPDC).

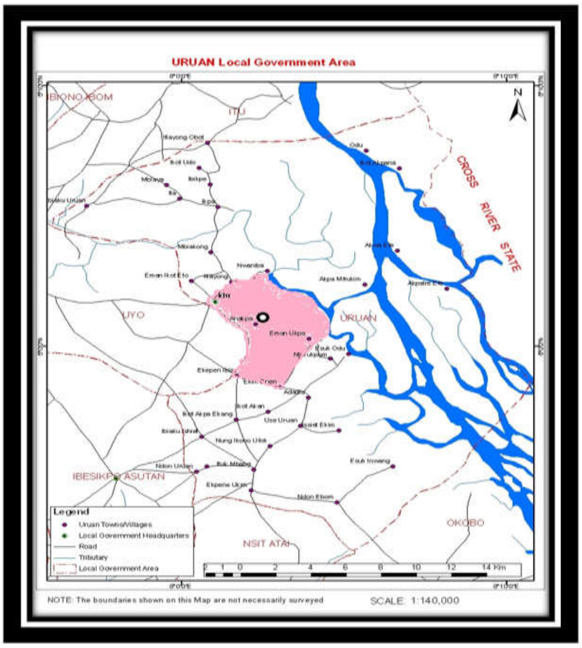

Figure 1 Map of Uruan Showing Specific Study Locations

Specific Study Locations

In terms of occupation, majority of people within the study location are peasant farmers. Rainfall in the study area is all year round, more severe in June and September. Due to intensive crude oil exploration, production and processing, Anakpa had recorded severe environmental degradation and other ecological problems due to soil erosion. Accidental spillages recorded over the years also contributed to pollution of soil used for agricultural activities in the area, thereby leading to decline in soil fertility and agricultural output.

Sample collection and Preparation

1× 6 factorial experiment in randomized complete block design was utilized to enhance sample collection at the study and control locations. The edible plant species at the study and control sites were collected in triplicate. Then stored in polyethylene bag and taken to the laboratory for analysis. The selected vegetable plant species were digested according to method described by Awofolu (2005). The six randomly selected plant species collected were washed gently under the running water in the laboratory to remove soil and other residues adhered to the plants. It was then rinsed with distilled water. Then separated into roots, Stems and leaves. The samples were then air dried to remove the residual moisture from the roots, Stems and leaves. It was then oven dried for 48 hrs. at temperature of 80.0^{O}C. The dried sample parts were then grounded using agate mortar and pestle. The different parts were sieved accordingly and stored in labelled and air tight containers for further laboratory analysis.

Laboratory Analysis of Trace Metals in Different Plants Parts

Roots, Stems and leaves of each of the selected plants species were analysed separately for trace metal concentrations according to Nematian. and Kazemeirai (2013). In this case Ig of <2mm fractions of each plant parts were appropriate weighed into the porcelaincrucibles. Then ignited with the furnace for 6hours at temperature between 45-500^{O}C until a grey white ash was obtained. The ash samples were allowed to cool.10ml of $2HNO_3$ was added to each labelled sample. Each solution then evaporated to near dryness on the hot plate and allowed to cool. The cooled residues were then re-dissolved in 30ml $2NHNO_3$ and filtered into 75ml certified graduated measuring cylinders. Both crucible and filter papers used properly washed into the flask; then make up to mark with deionized water and stored in polyethylene tubes for instrumental analysis. Hach 3900 model Spectrophotometer was used to analyse digested plant parts. In each test powder pillows relative to each trace metals of interest were used. Where applicable dilution factors were determined and applied on the actual machine reading so as to obtain the actual reading of the trace metal in the test sample solutions

Statistical Analysis

Data were descriptively analysed for mean, standard deviation, minimum and maximum values of the trace metals in the plant species tested. Bioaccumulation and translocation factors were calculated to determine the Phyto-toxicity values of the edible and non-edible plant parts in the study and at the control locations according to Rezvani and Zafarian(2011).

Translocation Factor =Con_{leaves}/Con_{roots}.

Where Con_{leaves}= Concentration of trace metal in leaves.
Con_{roots}=Concentration of trace metals in roots

Bioaccumulation Factor= Con_{roots}/Con_{soil}

Where $Con_{root=}$ Concentration of trace metal in roots
$Con_{soil=}$ Concentration of trace metal in soil

RESULTS AND DISCUSSIONS

Mean Concentration of Trace Metals by the Different Plant Species

Iron (Fe)

Results for the mean concentration of trace metals accumulated by the different plant species studied are shown in Table 1.0. Results in Table 1.0 indicate the mean level of iron (mg/kg) accumulated by the different plants species studied as follows: *T. occidentalis* (6.47); *T. triangulare* (5.20); *V. amygdalina* (2.81); *C. sativus* (1.76) and *A. esculentus* (1.65). The obtained results revealed that, *Telfairiaoccidentalis* had the highest potentials for accumulating iron in the study area while *Abelmoschus esculentus* showed the lowest capacity for accumulating iron. Thus, *Telfairiaoccidentalis* could be employed for the remediation of iron impacted soil. The mean iron concentrations in all the studied plants are within the recommended range of 40 - 500mg/kg by Radojevic and Bashkin (2006) for iron in plants.

Table 1 Mean Metal Concentration (mg/kg) in Different Plant Species.

Metals	Mean Trace Metalsconcentration of plant Species at study Location					OverallResults of Trace Metal Distribution Study Location				P6-Mean Trace Metal Concentration of Plant Specie at Control Location			
	P1	P2	P3	P4	P5	Min	Max	Mean	SD	Min	Max	Mean	SD
Iron	6.62	5.20	2.81	1.76	1.65	1.61	8.35	3.58	2.19	0.31	0.83	0.63	0.16
Zinc	4.76	4.00	3.22	2.54	2.14	1.57	6.60	3.33	1.44	0.20	0.56	0.37	0.14
Lead	26.92	25.00	20.95	13.59	11.13	8.37	32.03	19.52	6.91	0.31	1.04	0.61	0.26
Cadmium	2.57	1.92	1.22	0.46	0.46	0.17	3.12	1.33	0.90	0.17	0.55	0.36	0.13
Vanadium	0.59	0.47	0.27	0.17	0.04	0.01	1.02	0.31	0.26	0.00	0.01	0.003	0.01
Nickel	0.29	0.10	0.01	0.00	0.00	0.00	0.49	0.08	0.13	0.00	0.00	0.00	0.00
Chromium	0.04	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.00	0.00	0.00	0.00

P 1 = *Telfairiaoccidentalis* (Fluted pumpkin); P2 = *Talinum triangulare* (Water leaf); P3 = *Vernonia amygdalina* (Bitter leaf); P4 = *Cucumis sativus* (Cucumber); P5 = *Abelmoschusesculentus* (Okro); P6 = *Occimumgratissimum* (Scent leaf), Min = Minimum; Max = Maximum; SD = Standard deviation.

Thus, the consumption of these vegetable may not cause iron toxicity and associated health implications. However, the obtained levels may be suitable for normal plant growth and iron related processes in human. However, the general results in Table 1.0 indicate a range of 1.61 – 8.35mg/kg between *Abelmoschus esculentus* and *Telfairiaoccidentalis* respectively with a mean of 3.58±2.19mg/kg for iron. This range and mean level of iron is much higher than 0.31-0.83mg/kg and 0.63±0.16mg/kg obtained in *Occimumgratissimum* (Scent leaf) used as Control. Consequently, the activities by Oil Company within the marginal oil well area may have elevated iron concentration in studied plants. Hence, periodic assessment of iron concentration in vegetables grown in the oil well area is necessary to avoid health problems associated with consumption of high level of iron. The high value of standard deviation recorded for iron in studied plant species indicate high degree of variability in its distribution among studied plants.

Zinc (Zn)

Mean concentrations of zinc (mg/kg) accumulated by the different plants species studied in Table 1.0 are as follows: *T. occidentalis* (4.76); *T. triangulare* (4.00); *V. amygdalina* (3.22); *C. sativus* (2.54) and *A. esculentus* (2.14). Thus, *Telfairiaoccidentalis* accumulated the highest concentration of while Abelmoschus *esculentus* accumulated the lowest zinc level (Table 1.0). Zinc as one of the essential metals is needed by both plants and human for normal growth. The level of zinc obtained is within the range of 1.00 – 400mg/kg stipulated by Radojevic and Bashkin (2006) for plants. Thus, the consumption of these vegetables may not pose any health risks associated with high zinc to the consumers. Nevertheless, the general results indicate range and mean concentration of zinc in studied plant species as 1.57 – 6.60mg/kg (between *Vernonia amygdalina* and *Telfairiaoccidentalis)* and 3.33±1.44mg/kg respectively. The obtained range and mean are higher than 0.20 – 0.56mg/kg and 0.37±0.14mg/kg reported in the Control. Accordingly, human activities in the study area may have affected the level of zinc in plant species assessed and proper monitoring should bedone to avoid bioaccumulation with time. Variability in the distribution of zinc among the studied plant species is moderate as indicated by the standard deviation.

Lead (Pb)

The mean concentrations of lead (mg/kg) in the different plants species studied as indicated on table 1.0 are: *T. occidentalis* (26.92); *T. triangulare* (25.00); *V. amygdalina* (20.95); *C. sativus* (13.59) and *A. esculentus* (11.13).

Telfairiaoccidentalis also accumulated the highest concentration of lead. While *Abelmoschus esculentus (*Okro) accumulated least concentration. Lead is not known for any function in either plant or animal including human. Nevertheless, mean concentrations obtained in studied plant species except *Cucumis sativus* and *Abelmoschus esculentus* are higher than 0.2 – 20mg/kg recommended for plants by Radojevic and Bashkin (2006). Consequently, consumption of *Telfairiaoccidentalis* (Fluted pumpkin), *Talinum triangulare* (Water leaf) and *Vernonia amygdalina* (Bitter leaf) may pose serious health risks associated with lead toxicity to the consumers. This situation should be closely monitored and controlled as these are widely consumed vegetables in the State and Nigeria. The high lead concentrations in studied vegetables may be attributed to human activities within the study area. The general results obtained indicated a range and mean value for lead in studied vegetables as 8.37 – 32.03mg/kg (between *Abelmoschus esculentus* and *Telfairiaoccidentalis*) and 19.52±6.91mg/kg (Table 1.0). However, a lower range (0.31 – 1.04mg/kg) and mean (0.61±0.26mg/kg) were reported in *Occimumgratissimum* (Control). Thus, this confirms human activities in studied area as the reason for high lead level in studied vegetables. The relative moderate standard deviation reported is indicative of fair variability in the distribution of lead among studied vegetables.

Cadmium (Cd)

The distribution of mean (mg/kg) cadmium in studied vegetables followed the order: *T. occidentalis* (2.57); *T. triangulare* (1.92); *V. amygdalina* (1.22); *C. sativus* (0.46) and *A. esculentus* (0.46) (Table 1.0). The highest mean cadmium level was obtained in *Telfairiaoccidentalis* while the lowest mean concentration was reported in *Cucumis sativus* and *Abelmoschus esculentus.* Cadmium has no positive function in plants and animal systems. Hence, it is referred as a toxic metal even at a very low concentration. The obtained mean concentrations in different vegetables studied are within the recommended range of 0.1 – 2.4mg/kg by Radojevic and Bashkin (2006) except in *Telfairiaoccidentalis.* Consequently, the consumption of *Telfairiaoccidentalis* grown in area under investigation may result in serious health problems associated with cadmium toxicity. Thus, this menace should be properly checked and controlled to forestall devastating health problems in the area. This high cadmium level in *Telfairiaoccidentalis* may be attributed to its high tendency of accumulating metals from the soil and impact of human activities in the area. The general results in Table 1.0 indicate a range of 0.17 – 3.12mg/kg with mean value 1.33±0.90mg/kg for cadmium. These are higher than 0.17 – 0.55mg/kg and 0.36±0.13mg/kg respectively reported for cadmium in the Control. Thus, the oil activities within studied area may have increased the level of cadmium in soil environment thereby transferring same into vegetables grown on it. The high standard deviation relative to mean value shows high degree of variability in distribution of cadmium among studied vegetables.

Vanadium (V)

Mean concentrations of vanadium in studied vegetables as indicated in table 1.0 varied as follows: *T. occidentalis* (0.59); *T. triangulare* (0.47); *V. amygdalina* (0.27); *C. sativus* (0.17) and *A. esculentus* (0.04) (Table 1.0). This shows the high and low potentials of *Telfairiaoccidentalis* and *Abelmoschus esculentus* respectively for accumulating vanadium from the soil. The mean concentrations of vanadium reported in the different vegetables are far above 0.03mg//kg recommended limit for plants by WHO (2008). Thus, consumption of these vegetables may result in health problems associated with vanadium toxicity. The high vanadium concentration in studied vegetables may be attributed to the presence of crude oil in the area so cultivation of edible plants within the area in its present state should be minimized or stopped if possible. The general results also indicate a mean and range for vanadium in studied vegetables as 0.31±0.26mg/kg and 0.01 – 1.02mg/kg (between *Abelmoschus esculentus* and *Telfairiaoccidentalis*) respectively. The obtained mean and range are higher than 0.003±0.01mg/kg and 0.00 – 0.01mg/kg obtained in the Control. The higher vanadium concentrations in studied samples may be attributed to the activities by Oil Company operating in the area. The obtained standard deviation indicates high variability in the distribution of vanadium among studied vegetables.

Nickel (Ni)

Results in Table 1.0 show mean concentrations of nickel in the different studied plant species as follows: *T. occidentalis* (0.29); *T. triangulare* (0.10); *V. amygdalina* (0.01); *C. sativus* (0.00) and *A. esculentus* (0.00). This indicates that *Cucumis sativus* and *Abelmoschus esculentus* did not accumulate nickel from the soil to the level that could be detected by the equipment used. Nickel concentrations in other vegetable were detected were within acceptable range of 0.02 – 5.00mg/kg for plants by Radojevic and Bashkin (2006). Hence, the consumption of these vegetables may not pose any serious threat relating nickel toxicity to the consumers. The general results indicate a range and mean value of nickel in studied vegetables as 0.00 – 0.49mg/kg and 0.08±0.13mg/kg respectively. However, a lower range and mean of 0.00 – 0.00mg/kg and 0.00±0.00mg/kg were obtained in *Occimumgratissimum* (Control). Consequently, concentrations of nickel in Control were below detectable limit of the machine confirming impact of oil activities on the nickel levels in studied vegetables. The standard deviation obtained for studied vegetables indicates very high degree of variability in the distribution of nickel among the vegetables.

Chromium (Cr)

The mean concentration of chromium in studied vegetables varied as follows: *T. occidentalis* (0.004); *T. triangulare* (0.00); *V. amygdalina* (0.00); *C. sativus* (0.00) and *A. esculentus* (0.00). Mean concentration of chromium in all the studied vegetables except *Telfairiaoccidentalis* were below detectable limit. The mean concentration of chromium in all the studied plant species were far below 0.03 – 14.00mg/kg range recommended by Radojevic and Bashkin (2006). Thus, consumption of studied vegetables may not result in health problems associated with chromium toxicity. The general results in Table 1.0 show a range and general mean of chromium in studied vegetables as 0.00 – 0.01mg/kg and 0.01±0.03mg/kg respectively. Whereas, concentrations of chromium in Control were below detectable limit indicating the presence of anthropogenic source for the metal in studied vegetables. The general results have also shown very high degree of variability exhibited by chromium in the studied vegetables.

Table 2 Mean Translocation Factor mg/kg of trace metals in Different plant species

Metals	Mean Trace Metal concentration of plant Species at Study Locations					Mean Trace Metals concentration of plant specie at control location
	P1	P2	P3	P4	P5	P6
Iron	0.61	0.60	0.63	1.05	0.66	0.33
Zinc	0.48	0.59	0.53	0.61	0.62	0.24
Lead	0.91	0.92	0.89	0.82	0.82	0.67
Cadmium	0.97	0.89	0.84	0.68	0.80	0.74
Vanadium	0.74	0.58	0.59	0.26	0.36	0.25
Nickel	0.53	0.55	0.13	0.00	0.00	0.00
Chromium	0.38	0.00	0.00	0.00	0.00	0.00

P *1 = Telfairiaoccidentalis;* P2 = *Talinum triangulare;* P3 = *Vernonia amygdalina;* P4 = *Cucumis sativus;* P5 = *Abelmoschusesculentus;* P6 = *Occimumgratissimum,* Min = Minimum; Max = Maximum; SD = Standard

Mean Translocation factor (TF) of Trace Metals in the Different Plants Species.

Iron (Fe)

The mean translocation factors of iron in the different plant species studied are shown in Table 2.0. Translocation factors of iron in the different plants varied as follows: *T. occidentalis* (0.61); *T. triangulare* (0.60); *V. amygdalina* (0.63); *C. sativus* (1.05) and *A. esculentus* (0.66). Thus, as the TF of iron in *Cucumis sativus* is >1.00 it indicates that the translocation of iron was effectively from root to the shoot (Baker and Brooks, 1989; Fayiga and Ma, 2006). However, since the TF values for iron in other vegetables were less than<1.00 it implies that effective translocation of the metal may not been from their roots to the shoots. The TF values for iron in *Occimumgratissimum* (Control) showed a mean value of 0.33.

Zinc (Zn)

Mean translocation factors of zinc in studied vegetables in Table 2.0 are as follows: *T. occidentalis* (0.48); *T. triangulare* (0.59); *V. amygdalina* (0.53); *C. sativus* (0.61) and *A. esculentus* (0.62). Thus, indicating that zinc was not efficiently transferred from root to shoot in any of the studied vegetables. TF values in Control showed a mean of 0.24 indicating ineffective translocation of zinc from roots to the shots of *Occimumgratissimum*.

Lead (Pb)

The average TF values of lead in studied vegetables as indicated in Table 2.0 are: *T. occidentalis* (0.91); *T. triangulare* (0.92); *V. amygdalina* (0.89); *C. sativus* (0.82) and *A. esculentus* (0.82). Consequently, lead was not effectively transferred from roots to the shoots of these vegetables. The mean TF value for lead in Control is 0.67 which is indicative of ineffective translocation of lead from roots of *Occimumgratissimum* to the shoots.

Cadmium(Cd)

Mean translocation factors for cadmium in studied plants varied as follows: *T. occidentalis* (0.97); *T. triangulare* (0.89); *V. amygdalina* (0.84); *C. sativus* (0.68) and *A. esculentus* (0.80) (Table 2.0). Thus, translocation of cadmium was not effectively to the shoots from the roots of these vegetables. Translocation factors of cadmium in *Occimumgratissimum* indicated a mean value of 0.74 signifying that effective translocation to the shoot was not from the roots.

Vanadium (V)

Results in Table 2.0 indicate mean translocation factors of vanadium in different plant species studies as follows: *T. occidentalis* (0.74); *T. triangulare* (0.58); *V. amygdalina* (0.59); *C. sativus* (0.26) and *A. esculentus* (0.36). Thus, there was ineffective translocation of vanadium from root of these plants to the shoots. The mean translocation factor for vanadium in *Occimumgratissimum* is 0.25 indicating ineffective translocation of vanadium to the shoot from root.

Nickel (Ni)

The mean translocation factors for nickel in studied vegetables as indicated in Table 4.34 are as follows: *T. occidentalis* (0.53); *T. triangulare* (0.55); *V. amygdalina* (0.13); *C. sativus* (0.00) and *A. esculentus* (0.00). Hence, there was no effective translocation of nickel to the shoot of these plants from the root. The mean translocation factor for nickel in Control is 0.00 signifying minimal translocation of the metals from root to the shoot.

Chromium (Cr)

The average translocation factors for chromium in studied vegetables as indicated in Table 2.0 are as follows: *T. occidentalis* (0.38); *T. triangulare* (0.00); *V. amygdalina* (0.00);*C. sativus* (0.00) and *A. esculentus* (0.00). Consequently, the translocation of chromium from root to shoot of these plant species was ineffective. The mean translocation factor for vanadium in *Occimumgratissimum* (Control) is 0.00 indicating minimal translocation of vanadium to the shoot from root.

Mean Bioaccumulation of Trace Metal in Plant

Results in Table 3.0 indicate bioaccumulation factors of trace metals in studied plant species. Results obtained indicate that, all the studied plant species are poor accumulators of trace metals studied since their bioaccumulation factors are less <1.00 (Ma *et al.,* 2001; Cluis, 2004). The studied plant species could be referred to as excluders instead of accumulator plants. These plants may not effectively used for remediation of metal impacted soil as they are not good accumulator.

Trace Metals Concentration in Different Plants

Iron (Fe)

Results in Table 4.0 indicate that the leaves, stem and roots of *Telfairiaoccidentalis* accumulated the following mean iron concentration (mg/kg) 5.35, 6.45 and 8.06 respectively.

Table 3 Mean Bioaccumulation factors and Soil mg/kg of trace metals

Metal	Soil Study Locations	Mean trace metal concentration in plant species at Study Location Plant Species					Mean trace metal concentration of plant specie at Control location	Soil Control Location
	Mean Trace Metal in soil	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**Mean Trace Metal in Soil**
Iron	226.55	0.04	0.03	0.02	0.01	0.01	0.01	116.94
Zinc	157.80	0.04	0.03	0.02	0.02	0.02	0.01	109.89
Lead	80.29	0.35	0.32	0.28	0.19	0.15	0.10	49.36
Cadmium	12.14	0.22	0.17	0.11	0.04	0.04	0.43	0.98
Vanadium	2.37	0.28	0.25	0.14	0.13	0.03	0.00	0.00
Nickel	0.64	0.66	0.20	0.00	0.00	0.00	0.00	0.00
Chromium	3.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00

P 1 = *Telfairiaoccidentalis;* P2 = *Talinum triangulare;* P3 = *Vernonia amygdalina;* P4 = *Cucumis sativus;* P5 = *Abelmoschusesculentus;* P6 = *Occimumgratissimum*, Min = Minimum; Max = Maximum; SD = Standard deviation.

Thus, there was effective bioaccumulation of iron in the roots of *Telfairiaoccidentalis*. The different parts of *Talinum triangulare* accumulated iron concentration (mg/kg) in the following order: Leaf (3.87mg/kg), stem (5.33mg/kg) and root (6.40mg/kg). Iron concentrations in *Vernonia amygdalina* follow the trend: leaf (2.23), stem (2.62) and root (3.58) respectively. Mean concentrations of iron in the different parts of *Cucumis sativus* as shown in Table 4.0 is as follows: leaf (2.17), stem (1.03) and root (2.07). Different parts of *Abelmoschus esculentus* accumulated iron in the order: leaf (1.40), stem (1.41) and root (2.13). However, much lower concentrations of iron were accumulated by the different parts of *Occimumgratissimum* (Control) in the order: leaf (0.31), stem (0.63) and root 0.94). Generally, it has been observed that apart from *Cucumis sativus* concentrations of iron in other plant parts followed the order: Leaf < Stem < Root. This is consistent with the trend reported by Akan *et al*. (2013) for iron in vegetables. The obtained trend shows that higher concentrations of iron were obtained in the non-edible parts than in the edible parts. However, a different trend for the distribution of iron in the different parts of *Cucumis sativus* was obtained in the following order: Stem < Root < Leaf.

Zinc (Zn)

Results in Table 4 also indicate the mean concentration (mg/kg) of zinc in the different parts of *Telfairiaoccidentalis* as follows: leaf (3.38), stem (4.08) and root (6.82). This shows that, the edible part (leaf) accumulated less amounts of zinc than the other parts.

The different parts of *Talinum triangulare* accumulated mean amount of zinc in the order: leaf (2.98), stem (3.83) and root (5.19) respectively. This shows that higher amounts of zinc were accumulated in the non-edible part of the commonly consumed vegetable. Mean concentrations of zinc in the different parts of *Vernonia amygdalina* varied as follows: leaf (2.42), stem (2.18) and root (3.35) respectively. Thus, the highest level of zinc was accumulated in roots of *Vernonia amygdalina.* The different parts of *Cucumis sativus* accumulated mean zinc concentration as follows: leaf (2.10), stem (2.18) and root (3.35). Hence, the trend for the distribution of zinc among the three different parts is leaf < stem < root. A similar trend was observed for *Abelmoschus esculentus* with mean concentration in the different parts as follows: leaf (1.73), stem (1.92) and root (2.77). The control sample (*Occimumgratissimum*) accumulated lower mean concentrations of zinc in the different parts studied as follows: leaf (0.31, stem (0.21) and root (0.78) respectively. Generally, apart from *Vernonia amygdalina* with a trend of leaf > stem < root, all the other vegetables studied followed the trend leaf < stem < root.

Lead (Pb)

Table 4.0 indicates the distribution of mean concentration of lead (mg/kg) between three parts of *Telfairiaoccidentalis* studied as leaf (25.71), stem (26.56) and root (28.50). Mean lead concentration in *Talinum triangulare* varied as leaf (23.92), stem (24.99) and root (26.08). The distribution of mean lead concentration in different parts of *Vernonia amygdalina* are leaf (19.77), stem (20.83) and root (22.24) respectively. The leaf, stem and root of *Cucumis sativus* accumulated mean lead concentration of 12.31, 13.33 and 15.12 respectively. Mean concentrations (mg/kg) of lead accumulated by *Abelmoschus esculentus* varied between 9.91 in leaf, 11.22 in stem and 12.26 in roots. However, lower mean concentrations of lead were accumulated by the different parts of *Occimumgratissimum* (Control) as follows: leaf (0.52), stem (0.59) and root (0.72).

Table 4 Plant Parts and Trace Metal Concentration.

Plant Types	Plant parts	Trace Metal Concentration in Different plants part at study and control Locations (mg/kg)						
		Iron	Zinc	Lead	Cadmium	Vanadium	Nickel	Chromium
	Leaf	5.35	3.38	25.71	2.53	0.52	0.19	0.00
P1	Stem	6.45	4.08	26.56	2.57	0.58	0.25	0.00
	Root	8.06	6.82	28.50	2.62	0.66	0.42	0.00
	Leaf	3.87	2.98	23.92	1.83	0.37	0.08	0.00
P2	Stem	5.33	3.83	24.99	1.90	0.44	0.09	0.00
	Root	6.40	5.19	26.08	2.04	0.59	0.13	0.00
	Leaf	2.23	2.42	19.77	1.12	0.21	0.00	0.00
P3	Stem	2.62	2.18	20.83	1.20	0.25	0.00	0.00
	Root	3.58	3.35	22.24	1.36	0.36	0.00	0.00
	Leaf	2.17	2.10	12.31	0.37	0.09	0.00	0.00
P4	Stem	1.03	2.18	13.33	0.46	0.11	0.00	0.00
	Root	2.07	3.35	15.12	0.54	0.30	0.00	0.00
	Leaf	1.40	1.73	9.91	0.41	0.03	0.00	0.00
P5	Stem	1.41	1.92	11.22	0.46	0.03	0.00	0.00
	Root	2.13	2.77	12.26	0.51	0.07	0.00	0.00
	Leaf	0.31	0.20	0.52	0.31	0.00	0.00	0.00
P6	Stem	0.63	0.21	0.59	0.35	0.00	0.00	0.00
	Root	0.94	0.78	0.72	0.42	0.00	0.00	0.00

P 1 = *Telfairiaoccidentalis*; P2 = *Talinum triangulare*; P3 = *Vernonia amygdalina*; P4 = *Cucumis sativus*; P5 = *Abelmoschusesculentus;* P6 = *Occimumgratissimum*, Min = Minimum; Max = Maximum; SD = Standard deviation.

Thus, the accumulation of lead by studied vegetables and Control followed the order leaf < stem < root. Consequently, a greater proportion of this toxic metal in studied vegetables was in the non-edible part of the plants (roots).

Cadmium (Cd)

Results in Table 4.0 show mean concentrations (mg/kg) of cadmium in the different parts of *Telfairiaoccidentalis* as follows: leaf (2.53), stem (2.57) and root (2.62) respectively. However, there is no remarkable difference in the distribution of mean concentration of cadmium between the different parts of *Telfairiaoccidentalis.* Thus, both the edible and non-edible parts of *Telfairiaoccidentalis* accumulated high level of cadmium. Distribution of mean cadmium concentration (mg/kg) between the different parts of *Talinum triangulare* followed the order: leaf (1.83), stem (1.90) and root (2.04). The order for distribution of cadmium between different parts of *Vernonia amygdalina* is leaf (1.12), stem (1.20) and root (1.36). *Cucumis sativus* accumulated very low mean concentration (mg/kg) of cadmium in the different parts studied as follows: leaf (0.37), stem (0.46) and root (0.54). The different parts of *Abelmoschus esculentus* accumulated mean concentration (mg/kg) of cadmium in the following order: leaf (0.41), stem (0.46) and root (0.51) respectively. The Control sample (*Abelmoschus esculentus*) also accumulated cadmium in a similar order of leaf (0.31), stem (0.35) and root (0.42) respectively. Thus, the general order for distribution of cadmium between the different parts of studied vegetables and Control is leaf < stem < root. Consequently, roots of studied vegetables accumulated higher level of cadmium than the edible parts.

Vanadium (V)

The distribution of mean vanadium among different parts of *Telfairiaoccidentalis* as shown in Table 4.0 vary as follows: leaf (0.52), stem (0.58) and root (0.66) respectively. This shows that, the roots of *Telfairiaoccidentalis* have capacity of accumulating higher level of vanadium. The different parts of *Talinum triangulare* accumulated mean vanadium concentration as follows: leaf (0.37), stem (0.44) and root (0.59). Hence, the non-edible roots of *Talinum triangulare* have the potential of accumulating more vanadium than other parts. Distribution of vanadium between the different parts of *Vernonia amygdalina* followed the order leaf (0.21), stem (0.25) and root (0.36). Thus, the edible part of *Vernonia amygdalina* has a low capacity for accumulating vanadium relative to other parts. Results in Table 4.0 show mean concentration (mg/kg) of vanadium in different parts of *Cucumis sativus* as follows: leaf (0.09), stem (0.11) and root (0.30). The low concentrations of vanadium accumulated by the different parts of *Cucumis sativus* indicate the low potential of the plant for accumulating vanadium. The leaf, stem and roots of *Abelmoschus esculentus* accumulated mean concentration (mg/kg) of vanadium as follows: 0.03, 0.03 and 0.07 respectively. Thus, *Abelmoschus esculentus* has low potential for accumulating vanadium. The Control sample (*Occimumgratissimum*) accumulated very low mean concentrations (mg/kg) of vanadium in the different parts as shown by the following: leaf (0.003), stem (0.003) and root (0.004).

Nickel (Ni)

The distribution of mean nickel concentrations in different parts of studied vegetables are shown in Table 4.0. Mean concentrations in the different parts of *Telfairiaoccidentalis* indicated the following: leaf (0.19), stem (0.25) and root (0.42). This shows that the commonly consumed *Telfairiaoccidentalis* has a very low capacity of accumulating toxic nickel in the roots. The leaf, stem and root of *Talinum triangulare* accumulated the following mean concentrations of nickel: leaf (0.08), stem (0.09) and root (0.13). Thus, *Talinum triangulare* has very low potential for accumulating nickel especially in the edible parts (leaf and root). Different parts of *Vernonia amygdalina* accumulated very low level of nickel (mg/kg) as indicated by the following results: leaf (0.01), stem (0.01) and root (0.01). Hence, the different parts of *Vernonia amygdalina* have similar and low potential for accumulating nickel. Mean concentrations of nickel in the different parts of *Cucumis sativus*; *Abelmoschus esculentus* and *Occimumgratissimum* were below detectable limit. Consequently, these vegetables may have very low capacity for accumulating nickel in all the different parts.

Chromium (Cr)

The distribution of mean chromium concentration (mg/kg) in the different parts of *Telfairiaoccidentalis* indicated the following results: leaf (0.04), stem (0.04) and root (0.04) respectively. Results obtained for other vegetables studied as indicated in Table 4.0 indicate that, mean concentrations of chromium in these vegetables were below detectable limit. Hence, these vegetables may have very low potential for accumulating chromium in all the different parts of these plants.

CONCLUSION

The edible vegetable plants species have the potential to accumulate and extract the trace metals into roots, since the translocation and bioaccumulation factors were less than 1.00. They are regarded as phytoextractor(Excluders). It is therefore suitable for use in phytoextraction process only. They are however not indicators or bioaccumulators. Also the immobilization of these trace metals from the soil matrix to the shoots and leaves of the edible vegetable plant species was lower. This is due to the accumulation of the trace metals in the roots of the studied plant species (Tables2,3 and 4). This therefore is favourable conditions as these metals will not enter the food chain. Hence there is no health risk in consuming these plants in the study and control locations.

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