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Evaluation of the heavy metal levels from selected food cultivars, from coal mining communities of Enugu State, Nigeria

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ABSTRACT

Food cultivars from Akwuke, Ngwo and Udi were analyzed for their heavy metal content using the atomic absorption spectrometry (AAS). The mean concentrations of Manganese in leafy vegetable ranges from 1170±6.20µg/g and in chromium from 110±0.0 µg/g, in lead from 320±210, in cadmium from 30±10 µg/g and nickel from 10±0 µg/g all in Akwuke. The transfer factors results for the three communities shows that the pumpkin leafy have the highest transfer factor for manganese, 2.6 in Akwukeand chromium yam 2.465 in Udi, while Nickel has the least transfer factor in all the food cultivars in the three communities with 0 result. This study has revealed high concentration of manganese, lead, chromium cadmium and nickel in food cultivars in the three studied area Akwuke, Ngwo and Udi, all in Enugu State. Though the concentrations of these heavy metals were not high in any of the soil samples, but high concentration of these heavy metals, compared to WHO/FAO in food cultivars were observed, especially in Udi and Ngwo community.
Keywords: Heavy metal, levels, food cultivars, Enugu State and Nigeria.

INTRODUCTION

Diseases associated with the heavy metal toxicity include, pulmonary, abdominal pain, chronic bronchitis, kidney disease, pulmonary edema (accumulation of fluid in the lungs), cancer of the lungs and nasal sinus ulcers, convulsion, liver damage and even death [1].Heavy metals get into the environments: water, soil and food cultivars through activities like intense agriculture, power generation, industrial discharges seepages and municipal landfills, septic tank effluents etc. Many authors have reported high levels of heavy metals ions in the soil and groundwater in different areas of Nigeria [2]. Several studies have shown that heavy metals such as lead, cadmium, nickel, manganese and chromium amongst others are responsible for certain diseases [1]. In general heavy metals are systemic toxins with specific neutrotoxic, nephrotoxic, fetotoxic and tetratogenic effect [1]. Heavy metals can directly influence behaviour by impairing mental and neurological function, influencing neurotransmitter production and utilization and altering numerous metabolic processes. Systems in which toxic metal elements can induce impairment and dysfunction include the blood and cardiovascular, eliminative pathways (colon, liver, kidney, skin), endocrine (hormonal), energy production pathways, enzymatic, gastrointestinal,

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immune, nervous (central and peripheral), reproductive and urinary that have lethal effects on man and animals [1]. Heavy metal pollution poses a great potential threat to the environment and human health. Coal as source of fuel and one of natural endowment has constituted a repository of heavy metal to the environment. Heavy metal contaminate the soil, water and thus enter the food chain in these manner, humans are indirectly exposed to heavy metals through food chain.

Aim of the Study

This research work is aimed at evaluating the heavy metal levels from selected food cultivars of Enugu State, Nigeria.

Objective of the Study

To determine the heavy metal levels from selected food cultivars of Enugu State, Nigeria.

MATERIALS AND METHOD

Sample collection

Soil samples; these were collected from there different locations (Akwuke, Ngwo and Udi) in three different local Government area in Enugu state and the soil sample were collected from a depth of 15-30cm using a metal auger and transferred into prewashed polyethylene nylon bag to avoid contamination.

Water sample; well water sample were collected from three different locations (Akwuke, Ngwo and Udi), according to the method recommended by [3] and [4]. According to the method, two litres plastic container was rinsed with detergent and rinsed with the sample to be collected at least three times before samples are finally collected and stored in 1ml HCl to avoid microbial growth.

Food cultivars; leafy vegetables and tubers were collected from three different location (Akwuke, Udi and Ngwo) in three different Local Government Area in Enugu State, with the consent of the owners of the farm, and the tubers were also collected from their storage bans with the consent of the farmers .

Sample preparation

Preparation of soil samples: After collection, samples were brought to the laboratory and initial treatment was given for the preservation and further analysed according to the following methods. The soil samples collected from the selected areas were initially treated by adopting the method recommended by [5]. According to this method, samples were air dried in sun light for a day. Then the samples were finally dried in oven at 105^{oC} till a constant weight was acquired. Then about half of each sample was passed through 0.5mm nylon mesh sieve. Then soil samples were repacked with the complete labeling and preserved for further analysis. Preparation of plant samples: the sample preparation technique for plants involves steps like, washing, drying, grinding, and storage. The plant samples were prepared according to the method recommended by [6] and [7]. The plant sample were washed with water and air dried firstly and then in an oven at 70-80^{oC} until a constant dry weight was attained. The dried samples were ground in wooden mortar to make a fine powder. The finely ground samples were passed through 0.5mm nylon mesh sieve and packed in the air tight polythene bags to prevent the absorption of water from the humid environments

DIGESTION OF SAMPLES

Digestion of soil samples

Soil samples were dried at 105^{oC} and sieved with 100 mesh (152um Bs screen 410). 1g of the dried soil sample was weighed into a labeled 100ml conical flask and 20ml of mixture of concentrated HCL and concentrated HNO_3 (1:1) were added and well shaken. The solution was kept overnight after which it was filtered through with whatman N0.1 filter paper formerly leached by pouring cupious quantity of dilute HNO_3 on the filter paper while in the funnel. The clear solution obtained was made up to 100ml using a standard flask and transferred into a plastic bottle [8]. The sample solutions were analyzed at various wavelengths for each metal using Varian AA240 Atomic Absorption Spectrophotometer according to the method of APHA [9].

Digestion of food cultivars

Exactly 1g of the ground sample was weighed into a breaker. 10cm^3 of 1:1 dilution of the concentrated HNO_3 and water was mixed and then covered with a watch glass. The solution was placed on a hot plate to reflux for 10 to 15 minutes without boiling. The beaker was allowed to cool and then 2cm^3 of distilled water and 3cm^3 of 30% H_2O_2 were added, cover with watch glass and placed over a hot plate. After the effervescence had subsided, the solution was removed and cooled .HCl (5cm^3) and 10cm^3 of distilled water were added and then heated for another 15minutes without boiling. The solution was when transferred to 100cm^3 beaker and made up to mark using deionized water and taken for AAS determination of lead, chromium, Nickel, cadmium and manganese.

Principles of AAS: Atomic Absorption Spectrophotometer working principle is based on the sample being aspirated into the flame and atomized when the AAS light beam is directed through the flame into the monochrometor, and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Since metal have their own characteristic absorption wave length, a source lamp composed of that element is used in making the method relatively free from spectral or radiationalinterferences.The amount of energy of the characteristic wavelength absorbed is proportional to the concentration of the element in the sample.

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Phosphate Determination

Phosphate was measured using Standard Method 4500-P B.5 and 4500-PE [10].

Procedure: Exactly 100ml of the homogenized and filtered sample was pipetted into a conical flask. The same volume of distilled water (serving as control) was also pipetted into another conical flask. 1ml of 18M H_2S0_4 and 0.89g of ammonium persulphate were added to both conical flasks and gently boiled for 1½ hrs, keeping the volume of 25-50cm^3 with distilled water. It was then cooled; one drop of phenolpthelein indicator was added and after neutralized to a faint pink color with the 2M NaOH solution. The pink color was discharged by drop wise addition of 2M HC1, and the solution made up to 100ml with distilled water. For the colorimetric analysis, 20ml of the sample was pipetted into test tubes, 10ml of the combined reagent added, shaken and left to stand for 10mins before reading the absorbance at 690nm on a spectrophotometer, using 20ml of distilled water plus 1ml of the reagent as reference.

Methods for Calibration

Standard phosphate solution: 219.5 mg of dried AR potassium hydrogen phosphate was dissolved in distilled water and made up to 1000ml, where 1ml = 50.0µg. of phosphate. 10ml of the stock solution was made up to 1000ml to give 1ml - 0.05 mg. Standards of strength ranging from 0 (blank) to 0.05mg/L at intervals of 0.05mg is prepared by diluting the stock with distilled water.

$$\text{Conc. of sample} = \frac{\text{Abs of sample x conc of std}}{\text{Abs of Std}}$$

Chloride Determination

Chloride analyzed according to APHA standard method (APHA; 1998).

Procedure:

A 100ml of the clear sample was introduced using pipette into an Erlenmeyer flask and the pH adjusted to 7-10 with either H_2S0_4 or NaOH solution. Then 100ml of K_2Cr0_4 indicator solution was added with standard solution of $AgN0_3$ in a permanent reddish brown colouration. The $AgNo_3$ titrant was standardized and a reagent blank established. A blank of 0.2-0.3ml is usual for the method Calculation

Chloride cone = Titre value (x) x 10 =10xmg/l

Sulphate Determination

Sulphate analysed according to APHA standard method (APHA; 1998).

Procedure: A 250cm^3 of the water sample was evaporated to dryness on a dish. The residue was moisten with a few drop of concentrated. HC1 and 30cm^3 distilled water was added. This was boiled and men filtered.The dish was rinsed and the filter paper washed with several portions, of distilled water and both filterate and washings added together. This was heated to boiling and then 10cm^3 of 10% BaCb solution was added, drop by drop with constant stirring. The mixture was digested for about 30minutes, filtered and the filter paper washed with warm distilled water. It was then ignited, cooled and weighed in an already weighed crucible.

Calculation: Mg/$dm^3$$S0_4^{2-}$ = mg $BaS0_4$ x 411.5cm^3 of water sample

Nitrate Determination

Nitrate is determined using PD303 UV spectrophotometer (APHA, 1998)

Procedure

A known volume (50ml) of the sample was pipette into a poecelain dish and evaporated to dryness on a hot water bath. 2ml of phenol disulphonic acid was added to dissolve the residue by constant stirring with a glass rod. Concentrated solution of sodium hydroxide and distilled water was added with stirring to make it alkaline. This was filtered into a Nesslers tube and made up to 50ml with distilled water, the absorbance was read at 410nm using a spectrophotometric after the development of color. The standard graph was plotted by taking concentration along X - axis and the spectrophotometeric readings (absorbance) along Y-axis. The value of nitrate was found by comparing absorbance of sample with the standard curve and expressed in mg/1.

$$\text{Conc, of sample} = \frac{\text{Abs of sample x Conc, of std}}{\text{Abs of Std}}$$

RESULTS

HEAVY METAL CONCENTRATION IN CASSAVA FROM COAL MINING COMMUNITIES

Result of heavy metal levels in cassava from coal mining communities in Enugu State showed that Mn, Cr and Pb levels in cassava from Ngwo were significantly higher ($p<0.05$) when compared to Udi and Akwuke, while Cd level inUdi was significantly highest ($p<0.05$), followed by Ngwo and Akwuke. Ni level were below detectable level in cassava from all the communities (Table 1).

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Table 1: Heavy metal levels in cassava from coal mining communities

Trace Metals(µg/g)	Udi	Ngwo	Akwuke	WHO/FAO (µg/g)
Mn	110.00 ± 0.02^{C}	250 .00 ± 0.01^{a}	180.00± 0.01^{b}	5.00
Cr	0. 00 ± 0.01^{c}	40.00 ± 0.01a	20.00 ± 0.01^{b}	1.30
Pb	350.00 ± 0.01^{b}	420.00 ± 0.01^{a}	300.00 ± 0.01^{c}	2.00
Cd	90. 00 ± 0.10^{a}	20.00 ± 0.01b	20.00 ± 0.01^{b}	0.02
Ni	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}	0 .00 ±0.01^{a}	10.00

Values are mean ± standard deviation of triplicatedetermination
Values in the same row bearing the same superscript letters are not statistically significant at P<0.05

HEAVY METAL CONCENTRATION IN YAM FROM COAL MINING COMMUNITIES

The result of heavy metal levels in yam from coal mining communities in Enugu State showed that Cr, Pb and Cd levels in yam from Udi were significantly higher (p<0.05) when compared to Ngwo and Akwuke , while Mn level in Akwuke was significantly highes (p<0.05), followed by Ngwo and Udi. Ni level were below detectable level in yam from all the communities (Table 2).

Table 2: Heavy Metal Level of Yam from Coal mining Communities

Trace Metals(µg/g)	Udi	Ngwo	Akwuke	WHO/FAO (µg/g)
Mn	30.00 ± 0.01^{C}	140.00 ± 0.01^{b}	170.00 ± 0.01^{a}	5.00
Cr	320.00 ± 0.01^{a}	170.00 ± 0.01^{b}	70.00 ± 0.01^{c}	1.30
Pb	340.00 ± 0.01^{a}	200.00 ± 0.01^{c}	290.00 ± 0.01^{b}	2.00
Cd	60. 00 ± 0.10^{a}	10.00 ± 0.01^{b}	10.00 ± 0.01^{b}	0.02
Ni	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}	0. 00 ±0.01^{a}	10.00

Values are mean ± standard deviation of triplicate determination
Values in the same row bearing the same superscript letters are not statistically significant at P<0.05

HEAVY METAL CONCENTRATION OF PUMPKIN LEAF FROM COAL MINING COMMUNITIES

Result of heavy metal levels in pumpkin leaf from coal mining communities in Enugu State showed that Mn (1170±0.01) and Cr (110±0.01) levels in pumpkin leaf from Akwuke were significantly higher (p<0.05) when compared to Ngwo and Udi, while Pb and Cd level in Udi was significantly highest (p<0.05) followed by Ngwo and Akwuke. Ni level were below detectable level in pumpkin from all the communities (Table 3)

Table 3: Heavy Metal Level in Pumpkin leaf

Trace Metals(µg/g)	Udi	Ngwo	Akwuke	WHO/FAO (µg/g)
Mn	710.00 ± 0.01^{c}	850.00 ± 0.01^{b}	1170.00 ± 0.01^{a}	5.00
Cr	10. 00 ± 0.01^{c}	60.00 ± 0.01^{b}	110.00 ± 0.01^{a}	1.30.
Pb	340.00 ± 0.01^{a}	250.00 ± 0.01^{b}	210.00 ± 0.01^{c}	2.00
Cd	60. 00 ± 0.10^{a}	20.00 ± 0.01^{c}	30.00 ± 0.01^{b}	0.02
Ni	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}	0. 00 ±0.01^{a}	10.00

Values are mean ± standard deviation of triplicate determination
values in the same row bearing the same superscript letters are not statistically significant at P<0.05

HEAVY METAL CONCENTRATION OF SCENT LEAF FROM COAL MINING COMMUNITIES

Result of heavy metal levels in scent leaf from coal mining communities in Enugu State showed that Mn in Ngwo and Akwuke did not differ significantly (p<0.05), but significantly higher (p<0.05), when compared to that of Udi, while Cd level in the three communities showed no significantly difference (p<0.05). It was also revealed that Pb level in Akwuke scent leaf is significantly highest (p<0.05), followed by Ngwo and Udi, while Cr level (10.00±0.01µg) in Ngwo was significantly highest (p<0.05) followed by Akwuke and Udi which are below detectable level. Ni level were below detectable level in scent leaf of all the communities (Table 3).

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Table 4: Heavy Metal Level in Scent Leaf

Trace Metals(µg/g)	Udi	Ngwo	Akwuke	WHO/FAO (µg/g)
Mn	430.00 ± 0.01[b]	620.00 ± 0.01[a]	620.00 ± 0.01[a]	5.00
Cr	0.00 ± 0.01[b]	10.00 ± 0.01[a]	0.00 ± 0.01[b]	1.30
Pb	240.00 ± 0.01[c]	270.00 ± 0.01[b]	320.00 ± 0.01[a]	2.00
Cd	10.00 ± 0.10[a]	10.00 ± 0.01[a]	10.00 ± 0.01[a]	0.02
Ni	0.00 ± 0.01[a]	0.00 ± 0.01[a]	0.00 ±0.01[a]	10.00

Values are mean ± standard deviation of triplicate determination
Values in the same row bearing the same superscript letters are not statistically significant at P<0.05

COMPARISON OF TRANSFER FACTOR HEAVY METALS IN PUMPKINFROM THE STUDY SITES

The result of transfer factor in pumpkin from coal mining communities in Enugu State showed that transfer factor for Mn and Cr in pumpkin from Akwuke community were significantly higher (p<0.05) when compared to Udi and Ngwo, while the transfer factor for Pb and Cd in Udi were significantly highest (p<0.05) followed by Ngwo and Akwuke. Ni level were below detectable level in pumpkin from all the communities and as such, the transfer factor was not determined (Table 4)

Table 5: Comparison of transfer factor of heavy metals in pumpkin from the study sites

HEAVY METALS	UDI	NGWO	AKWUKWE
Mn	2.15±0.01[b]	1.97±0.01[c]	2.63±0.06[a]
Cr	0.08±0.01[a]	0.14±0.01[b]	0.33±0.01[a]
Pb	1.22±0.01[a]	1.14±0.01[b]	0.64±0.01[c]
Cd	5.67±0.58[a]	1.33±0.58[b]	0.25±0.01[c]
Ni	0.00±0.01[a]	0.00±0.01[a]	0.00±0.01[a]

Values are mean ± standard deviation of triplicate determination
Values in the same row bearing thesame superscript letters are not statistically significant at P<0.05

COMPARISON OF TRANSFER FACTOR OF HEAVY METALIN SCENT LEAF FROM THE STUDY SITES.

Result of transfer factor in scent leaf from coal mining communities in Enugu State showed that the transfer factor for Mn, Cr and Pb in scent leaf from Ngwo were significantly higher (p<0.05) when compared to Akwuke and Udi, while transfer factor for Cd in Udi was significantly highest (p<0.05) followed by Ngwo and Akwuke . Ni level were below detectable level in scent leaf from all the communities (Table 5)

Table 6:Comparison of transfer factor of heavy metals in scent leaf from the study sites.

HEAVY METALS	UDI	NGWO	AKWUKWE
Mn	1.30±0.01[c]	1.44±0.01[a]	1.38±0.01[b]
Cr	0.00±0.01[b]	0.02±0.01[a]	0.00±0.01[b]
Pb	0.08±0.01[c]	1.23±0.01[a]	0.97±0.01[b]
Cd	1.33±0.58[a]	0.53±0.06[a,b]	0.35±0.47[b]
Ni	0.00±0.01[a]	0.00±0.01[a]	0.00±0.01[a]

Values are mean ± standard deviation of triplicate determination
Values in the same row bearing the same superscript letters are not statistically significant at P<0.05

COMPARISON OF TRANSFER FACTOR OF HEAVY METAL IN CASSAVA FROM THE STUDY SITES

The result of transfer factor in cassava from coal mining communities in Enugu State revealed that the transfer factor for Mn, Cr and Pb in cassava from Ngwo were significantly higher (p<0.05) when compared to Akwuke and Udi, while that of Cd inUdi was significantly highest (p<0.05) followed by Ngwo and Akwuke. Ni level were below detectable level in cassava from all the communities (Table 6).

Table 7: Comparison of transfer factor of heavy metals in cassava from the study sites.

HEAVY METALS	UDI	NGWO	AKWUKWE
Mn	0.33±0.01[c]	0.58±0.01[a]	0.40±0.10[b]
Cr	0.00±0.01[b]	0.08±0.01[a]	0.07±0.02[a]
Pb	1.25±0.01[b]	1.91±0.01[a]	0.91±0.01[c]
Cd	8.67±0.58[a]	1.33±0.58[b]	0.17±0.01[c]
Ni	0.00±0.01[a]	0.00±0.01[a]	0.00±0.01[a]

Values are mean ± standard deviation of triplicate determination

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Values in the same row bearing the same superscript letters are not statistically significant at P<0.05

COMPARISON OF TRANSFER FACTOR OF HEAVY METALS IN YAM FROM THE STUDY SITES

Result of transfer factor in yam from coal mining communities in Enugu State showed that the transfer factor for Cr, Pb and Cd levels in yam from Udi were significantly higher ($p<0.05$) compared to Ngwo and Akwuke, while that of Mn in Akwuke was significantly highest ($p<0.05$) followed by Ngwo and Udi . Ni level were below detectable level in yam from all the communities (Table 8).

Table 8: Comparison of transfer factor of heavy metals in yam from the study sites

HEAVY METALS	UDI	NGWO	AKWUKWE
Mn	0.09 ± 0.01^{c}	0.33 ± 0.01^{b}	0.38 ± 0.01^{a}
Cr	2.46 ± 0.01^{a}	0.39 ± 0.01^{b}	0.21 ± 0.02^{c}
Pb	1.21 ± 0.01^{a}	0.90 ± 0.01^{b}	0.88 ± 0.01^{c}
Cd	10.00 ± 1.00^{a}	0.50 ± 0.10^{b}	0.08 ± 0.01^{b}
Ni	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}	0.00 ± 0.01^{a}

Values are mean ± standard deviation of triplicate determination

Values in the same row bearing the same superscript letters are not statistically significant at P<0.05

DISCUSSION

Concentrations of heavy metals in tuber cultivars from the study areas showed that the high metal levels in tuber cultivars from coal mining activities in these areas, may be attributed to decay of plant materials that are already contaminated, use of fertilizers and pesticides. Heavy metal concentrations in plant leaves from the study areas, as shown in tables 2 and 3 indicated that heavy metal contents of leafy vegetables from coal mining impacted areas were significantly higher at $p<0.05$, when compare to WHO/FAO standard. The high level of heavy metals in Akwuke followed by Ngwo and Udi vegetables could be attributed to coal mining activities which resulted to increase in heavy metal pollution of the farmland, and vehicular emission which may increase the atmospheric deposition of heavy metals on vegetables. This is similar to report by [11] that atmospheric deposition of heavy metals increases consistently on time scale. Other factors include the soil and water pH and organic mattercontent. Pollution reduces the soil and water pH and increases the organic matter content. The differences in heavy metal levels in the two leafy vegetable from same location could be attributed to differences in metal uptake by different plant species, atmospheric deposition of heavy metal on the shoot, size and shape, contact surfaces and heavy metal status on the soil and water. The transfer factor of heavy metals in soil and plant food cultivars from Akwuke, Ngwo and Udi was in the order pumpkin>scent leaf>cassava>yam and the preponderance of heavy metals in the environment were of the order Mn>Pb>Cr>Cd>Ni and were maximum in vegetable and least in tubers. The result is in consonance with that of [11] that the concentrations of heavy metals in plant food cultivars appears in the orderMn>Pb>Cr>Cd>Ni and were higher in leaves followed by tubers. The observation from this study showed that tubers (yam and cassava) had the lowest heavy metal concentrations compared to the vegetables and thus could be attributed to different plant having different uptake and sensitivity to heavy metals as well as such factors like contact surface, organic matter content, atmospheric deposition, textures and morphology [12] .

The level of lead (Pb) in the food cultivars from the three locations were in the order Cassava>scent leaf>pumpkin>yam, while lead (Pb) burden of the study areas were Ngwo>Akwuke>Udi. The levels of Pb in plant food cultivars exceeded the maximum Pb limit of (0.2mg/kg) for human health as has been established for edible plant parts. Elevated levels of lead or even low levels in human body reduce plasma copper concentration, which may lead to irreversible damage of the brain [13]. Lead absorption also increase deficiency and inhibits enzymatic activities which causes hemopeosis. More so, it can alter the flexibility of red blood cells (RBC). Environmental protection agency (EPA) has determined that lead is a probable human carcinogen. Lead can affect every organ and system in the body; long term exposure of adult can result in decreased performance functions of the nervous system, weakness in fingers, wrists or ankles, small increase in blood pressure, and anemia [14]. Exposure to high lead levels can severely damage the brain and kidney and ultimately cause death. Also in pregnant women, high level exposure to lead may cause miscarriage while high level exposure in men can damage organ responsible for sperm production [14].

The levels of transfer factor for Cd in these food cultivars from Udi is significantly higher ($p<0.05$) compared to those of Ngwo and Akwuke and were above the world health organization (WHO) safe standard of 1.50mg/day [15] and 0.03mg/kg limit of Cd concentration in vegetable for human. This may suggest that the population feeding on these food cultivars from Udi, Ngwo and Akwuke are at higher risk of cadmium toxicity. The accumulation of cadmium in the system may lead to acute cadmium poisoning which may cause high blood pressure, kidney damage, destruction of testicular tissues and destruction of red blood cells [16]. In pregnant women, normal dietary level exposure to cadmium may cause teratogenic and mutagenic effect to the fetus [17]. This is similar to the report of [14] that Cd and Pb are known human

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carcinogens and ingesting very high levels of cadmium severely irritates the stomach leading to vomiting and diarrhea. Also long term exposure of leads lowers the levels to build up in the kidneys and possible kidney disease, lung damage, and fragile bones [18].The levels of Cr in these food cultivars from Ngwo, Akwuke and Udi are within the allowable limit for food, though Cr in the food cultivars from Ngwo were significantly higher ($p<0.05$) compared to that of Akwuke and Udi. High concentrations of f chromium in the cell can lead to DNA damage [19].The transfer factor of nickel (Ni) in the food cultivars was not detectable both in leafy vegetable and tubers in the locations. Although excessive intake of nickel above recommended dietary allowance of 150µg/day causes allergy, bronchial asthma, dermatitis, larynx, prostate and stomach cancers [14].

CONCLUSION

This study revealed high concentrations of manganese, lead, chromium cadmium and nickel in food cultivars in the three studied areas of Akwuke, Ngwo and Udi, all in Enugu State. Though the concentrations of these heavy metals were not high in any of the soil samples.

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