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Influence of Municipal Wastes on the Mineral Contents of Food Crops Found at Selected Dump Sites in Abia State, Nigeria

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Abstract: The influence of municipal wastes from selected dump sites in Abia State on the mineral contents of some crops found at the dumps was studied. Water leaves at Osisioma dump had the highest chromium value (243.33 mg kg^{-1}) than the chromium values of other crops. The arsenic contents of the dump crops were low (2.63-12.01 mg kg^{-1}) when compared with that of the dump soil (173.51 mg kg^{-1}). Cadmium was only observed in a small quantity (1.85 mg kg^{-1}) at the dump. The cadmium content of the nearby normal farm was 0.11 mg kg^{-1}. None of the crops picked any significant amount as their cadmium contents all tended to zero. The nickel content of the dump soil (22.32 mg kg^{-1}) was almost 100% higher than that of the nearby normal soil (1.25 mg kg^{-1}). Maize at the dump seemed to have the highest affinity for nickel. The lead contents were not picked by any of the plants. Probably, there has not been degeneration of the lead containing components in the soil. All the crops at the Osisioma sample sites had a high affinity for iron. Hence, the consumption of crops from there needs to be watched in order to avoid iron overload.

Key words: Municipal wastes, dump, cadmium, water, chromium, cassava

INTRODUCTION

Solid wastes can be grouped as biodegradable and non-biodegradable. They can also be grouped as hazardous and non-hazardous. Wastes may be corrosive, reactive, ignitable or toxic as paints, lead batteries and some insecticide powders. The non-hazardous wastes are those which are harmless to the environment or human health such as fruit peels, paper and other plant materials. Many industrial solid waste materials irrespective of where they are grouped can be dangerous to human health and the environment depending on how they are managed (http://www.texasep.org/html/wst/industrial waste management.htm).

The mismanagement of waste has been implicated in the pollution of ground water, streams, lakes and rivers as well as damages to the wildlife and vegetation. Plants (edible crops inclusive) have been reported to pick up some elements or components of degenerating solid waste and these often end up in the edible portion constituting some health hazard due to the intake of harmful elements/compounds or undesirable high level of needed elements which may cause body imbalance of nutrients (Nwafor, 2006).

Different waste management options have been applied or reported such as recycling, composting, land filling, incineration and even reuse (http://en.wikipedia.org/wiki/wastemanagement).

Unfortunately, wastes are still being dumped untreated along the road sides and in old borrow pits in Nigeria. Food crops have been known to thrive on such sites. These crops are often harvested for consumption or sale by the scavengers of the dumps. The problem is that the presence and the levels of the elements of these wastes in the harvested crops, targeted for consumption (knowingly or unknowingly) are not known. But many of them may be harmful by being part of the food product or beyond certain levels in the food product.

The objectives of this study were to identify the type of solid wastes at designated dump sites in Umuahia (the capital city of Abia State) and Aba (an industrial city) to harvest and determine the mineral contents of selected common edible crops growing on such sites and nearby normal farms outside the dumps to compare the level of different mineral contents in each crop from normal and waste dump soils so as to detect the effect of the dumped wastes on the particular crops. A successful execution of this study will generate some information necessary to

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predict the intervention between the type of waste in the studied dumps and the crops studied. It will help in assessing the levels of the studied elements in normal farms, waste-dump soils and the crops harvested from them so as to predict if there is any risk to consumers of such crops. Such information will certainly be useful for convincing the human scavengers of waste-dump crops and those who patronize them in the market to stop consuming or trading waste-dump crops.

MATERIALS AND METHODS

The samples for this study were collected from three dump sites, in Abia State Nigeria. The dump sites were located at Ubakala (5°30'38"N, 7°29'13"E) and Umudike (5°28'43"N, 7°32'33"E) in Umuahia then Osisioma (5°15'25"N, 7°19'37"E) in Aba. The Umudike site is a specialized asbestos dump.

The crop samples growing in the dumps and collected for the study included pawpaw (*Carica papaya*) fruits, cocoyam (*Colocosia esculenta*) corms melon (*Colocynthis citrullus*) pods, cassava (*Manihot esculenta*) tubers, pumpkin (*Cucurbita pepo*) leaves, fluted pumpkin (*Telferia occidentalis*) leaves, sweet potato (*Ipomeoa batatas*) leaves, Ahihara (*Corchorius olitorius*) leaves and waterleaves (*Talinum triangulare*). Cassava tubers were only seen and collected at the specialized asbestos dump in Umudike. Soil samples were collected with a new shovel and a hand trowel from every dump site studied and then put in plastic bags. Matching soil and similar plant materials samples were collected from the normal (non-dump) farms adjacent to the dump site, to form the reference (control) sample. The analyses were carried out in duplicates. The soil samples were air dried by exposure to ambient dry air then later ground and sieved to homogenous samples which were used for analysis. The plant sample were dried in the oven and pulverized with a corona type milling machine and stored in plastic containers for analyses.

Laboratory facility: The pH determinations were carried out in the Food Science and Technology laboratories of Michael Okpara University of Agriculture, Umudike and Abia State. The bulk of the analytical work was done at the Laboratory of the Aluminum Smelting Company of Nigeria, Ikot-Abasi, Akwa-Ibom State.

Soil analyses

Determination of soil sample pH: The method described by Radojevic and Bashkin (1999) was employed. A 20 g sample of fresh soil which was free from stones, twigs and larger materials was placed in a beaker. About 40 mL of distilled water was added and it was vigorously stirred on a magnetic stirrer then allowed to stand for 30 min after which the pH was determined with the aid of a digital pH meter.

Determination of soil redox potential: The method described by Radojevic and Bashkin (1999) was adopted. Some 20 g sample of fresh soil sample free from stones, twigs and larger materials were placed in separate beakers. About 40 mL of distilled water was added to each with vigorous stirring on a magnetic stirrer. The samples were allowed to stand for 30 min. The redox potential was determined by measuring the potential difference between a platinum electrode and a reference electrode. The electrodes were immersed into the samples in the beaker. The potential was recorded in volts when the reading stabilized after a few minutes. The electrodes were rinsed with distilled water between each reading.

Determination of Hydrogen Cyanide (HCN) content: The Acid Titration Method described by Onwuka (2005) was employed. A 5 g sample was dispersed in 50 mL distilled water in a corked conical flask. The sample was allowed to stay overnight for the extraction of HCN. The extract was filtered and the filtrate used for the cyanide determination. An alkaline picrate solution was prepared by dissolving 1 g of picrate and 50 g of Sodium Carbonate in 20 mL warm water. The volume was made up to 200 mL with distilled water. To 1 mL of the sample filtrate, 4 mL of the alkaline picrate solution was added in a corked test-tube and incubated in a water bath for 5 min. After a redish brown colour developed, the absorbance of the mixed solution was read in a spectrophotometer at 490 nm. The absorbance of the blank containing only 1 mL distilled water and 4 mL alkaline picrate solution was read. The cyanide content was then extrapolated from a standard cyanide curve.

Mineral content determinations

Extraction of plant material for mineral determination: The wet ashing method described by Radojevic and Bashkin (1999) was employed. Here a 0.5 g of the oven dried ground and sieved samples ($\leq$1 mm) were weighed into a 50 mL kjedahl flask. About 1 mL of perchloric acid, 5 mL of nitric acid and 0.5 mL of the tetraoxosulphate (vi) acid were added. The mixture was gently swirled and digested at moderate heat first and then the heat was increased slowly. It was digested for 15 min after the appearance of white fumes. The flask was slowly cooled and then 10 mL of water added (for iron and manganese determination, it was boiled for 5 min before filtering). The mixture was filtered into a 50 mL volumetric flask and made up to the mark with distilled water. Blanks were prepared by repeating the same procedure but omitting the plant material. Calibration curves were prepared for each element using standard solutions. Lead, iron, magnesium, nickel, vanadium, manganese, calcium, arsenic, copper, potassium, sodium, sulphur, cadmium and zinc were the minerals determined using the method described by Vogel and Bassett (1978).

Soil digestion for mineral analysis: Here, the method described by Radojevic and Bashkin (1999) was employed for the digestion. The soil samples were crushed manually using mortar and pestle. Individual samples from the same location were bulked into one sample in order to give an average value. Further reduction was achieved by passing through a coarse 2 mm sieve.

Dissolution and extraction: The method of MAFF was employed. About 1 g of dried and homogenized soil was weighed into a beaker and 10 mL nitric acid was added. The resultant mixture was heated until dryness. There after 10 mL HNO_3 and 3 mL $HClO_4$ were added and the solution was heated till fuming. The sample solution was obtained by processing residue with hot Emol/Hec (4 mL) and then filtered and diluted with water to 50 mL.

Mineral contents of the soil: After the procedure enumerated in study 3.2.1 above was followed, the individual elements were determined using the same procedure for the plant elemental determinations.

Statistical analysis: The two-way ANOVA in randomized block was employed in analyzing the data using the SAS in 1999 Version. The mean was separated using LSD at 95% confidence interval.

RESULTS AND DICUSSION

The dump site visual components are shown Table 1.

Table 1: Components of wastes at the various dump sites

Dump components	Aba Osisioma, Dump Ubakala, and Dump Umudike Dump
Paper (pieces and cartons)	+++
	+
Plastics (scraps, cans and containers)	+++
	+
	+
Rubber (tyres and foot wears)	+++
	++
Cellophane	+++
	+++
Wood (chippings and pieces)	+
	+
Textiles	++
	+
Broken glasses	+++
	++
Bottles	+++
Metal (scraps and containers)	+++
	++
Faeces	
Yard (tree, bush and grass trimmings)	
Dead animals	+
Asbestos	+++
Charcoal and burnt materials	+++
	+++
	+
Constructed and demolition debris	+
	+++
Bone	++
	++
Food scraps/wastes	+++
	+
Electronics parts	+++
	+
Farm yard wastes	
Leather	++
	+
Unidentified material	+++
	+++
	+++

+ = Small amount observed; ++ = Moderate amount observed; +++ = Larger quantity observed

Soil pH, redox potential (mV) and salinity (g L^{-1}): The results of the soil pH, redox potential and soil salinity at the various sample sites are shows in Table 2. From the Table 2, it was observed that the pH of the various dump site soils were higher in values than the soil pH of normal farms near the dumps. That is the soils of the nearby farms tended to be more acidic than the soils of the dump. The pH which has been defined as the negative logarithm of the hydrogen ion activity is a measure of the free acidity that is the concentration of strong acids in dissociated form and not the total acidity present (Radojevic and Bashkin, 1999). Soil pH and associated properties strongly influence plant nutrient availability and soil productivity (Tisdale *et al.*, 2003).

Table 2: The pH, redox potential (mV) and salinity of the soil samples

Sample site	pH	Redox potential	Salinity (g L^{-1})
Osisioma farm	6.83	28	0
Osisioma dump	6.68	30	0
Umudike farm	4.95	133	0
Umudike asbestos dump	7.71	-1	0
Ubakala normal farm	5.47	106	0
Ubakala dump	7.45	1	0

Factors influencing soil acidity include organic matter, clay, minerals, iron and aluminum oxides, exchangeable Al^{3+}, soluble salts and carbon dioxide (Tisdale *et al.*, 2003). It may also depend on the parent material, climate, vegetation, fertilizer and lime application (Radojevic and Bashkin, 1999). The soil samples pH the normal farm near the Ubakala dump (5.47) and the normal farm near the Umudike dump (4.95) were all less than pH 5.5. Soils with pH <5.5 were feared to contain exchangeable aluminum ions leached from clay minerals at high levels and could be toxic to plants (Radojevic and Bashkin, 1999).

The redox potential values at the Ubakala dump soil (1 mV) and the Umudike asbestos dump (-1 mV) were very low. The negative value (-1 mV) obtained at the Umudike asbestos dump indicated that the environment was a reducing one and had oxygen shortage. The other low positive values indicated that the environments were oxidizing ones, though not very strong ones. Positive values indicated that the environments have enough oxygen for biodegradation while negative values are indications of pollution.

Most of the low values obtained were from dump soils which implied a sort of pollution. Redox potential determines the geochemical mobility of pollutants and nutrients (especially sulphur, nitrogen, phosphorus and heavy metals) in various compartments of the environment and consequently their influence on ecosystems (Radojevic and Bashkin, 1999). Oxidation and reduction reactions are especially important in soils.

Microbial respiration in soils provides electrons for which most redox reactions depend upon and these act to reduce available oxygen (Radojevic and Bashkin, 1999). However, if the rate of oxygen used up in respiration exceeds oxygen availability, reduction of other substances take place and this can affect the availability of nutrients either directly or indirectly. The salinity (g L^{-1}) of all the soil samples studied was 0.0 g L^{-1}. This might probably be attributed to the fact that the chosen sites were not in coastal areas.

The mineral components of the soil and crop samples

The mineral compositions (mg kg^{-1}) of samples at Osisioma Aba (Abia State): It was observed (Table 3) that for most of the minerals analysed, their amounts (mg kg^{-1}) in the dump site soil samples were significantly ($p<0.05$) higher than their levels in the normal farm soil. This finding was not surprising since most of the visual dump components (Table 1) on degradation would leach to the soil, thereby increasing the mineral contents of the dump soil. The exceptions were observed in only the levels of soil calcium and magnesium where their values at the normal sites 1480.25 and 436.23 mg kg^{-1} in the normal farm soil samples, respectively exceeded their values 1369.50 and 296.43 mg kg^{-1}, respectively in the dump soil samples. At the Osisioma sample sites, maize from the dump had the least quantity of aluminum (1.03 mg kg^{-1}).

This was followed by the pumpkin leaves at the dump with an aluminum level of 3.01 mg kg^{-1}. For pumpkin leaves this 3.01 mg kg^{-1} level implied a 1.03% of the level of aluminum in the dump soil. At this Osisioma sample sites also, most of the dump crops had their aluminum contents to be significantly higher than the aluminum contents at the normal sites. The only exception was maize that had its aluminum content at the normal site (4.52 mg kg^{-1}) to be higher than the aluminum content of maize (1.03 mg kg^{-1}) at the dump site. Apart from the fluted pumpkin leaves that had its percentage increase between the farm crop and dump crop to be <5% (4.43%, Table 3), all other crops had their dump values higher with at least 30% of increase in aluminum content between the farm and the dump crops (Table 3). Aluminum is reported to be the third most abundant element in the earth crust and also a major component of many minerals (Radojevic and Bashkin, 1999). It is on record that though aluminum is abundant in the soil, only a small portion is mobile (Massey and Taylor, 1988). This fact will account for the small quantity of crop aluminum at the sample sites when compared with that of the soil.

The arsenic content at the Osisioma sample sites all tended to zero. The arsenic content was lower than the values (0.2-40 mg kg^{-1}) reported to exist in soils (Radojevic and Bashkin, 1999). The low levels of arsenic obtained from the samples are advantageous as lots of claim surround the element. It is on record that arsenic is an essential nutrient at low dosages. This may be because of a large number of responses to arsenic deprivation by a variety of animal species (Nielson, 1998; Uthus, 1992, 1994). Symptoms include depressed growth and abnormal reproduction characterized by impaired fertility and increased prenatal mortality (Uthus, 1992, 1994). It has been argued that low intakes of arsenic cannot be carcinogenic (Dai *et al*., 1999; Bowman and Russell, 2001). Though toxicologists consider inorganic arsenic to be a human carcinogen and arsenic trioxide has been confirmed as an effective treatment for some cancers including acute promyelocytic leukemia (Dai *et al*., 1999). The plants at the Osisioma sites did not absorb any detectable cadmium. The values of the soil cadmium recorded at the Osisioma sample sites 0.11 mg kg^{-1} (farm soil) and 1.85 mg kg^{-1} (dump soil) fall within the range of cadmium values (<0.01-8 mg kg^{-1}) reported as the concentration of cadmium in typical soils (Radojevic and Bashkin, 1999). They were also lower than the values (16.50 mg kg^{-1}) recorded in landfill soils (Radojevic and Bashkin, 1999). It is possible that paints, plastics, batteries and metal plaited materials at the dumps which contain cadmium have not degenerated to the level where toxic components will be picked up by the soils and crops consequently. The cobalt contents of the dump crops

Table 3: Mineral composition (mg kg^{-1}) of samples and percentage (%) increase/decrease between them at Osisioma, Aba

Osisioma location	Al	As	Ca	Cd	Co	Cr	Cu	Fe	K
Normal farm soil	147.450^{b}	0^{a}	1480.25^{a}	0.11^{b}	3.560^{abc}	24.390^{b}	42.150^{c}	1572.250^{c}	119.000^{i}
Dump site soil	293.130^{a}	0^{a}	1369.50^{b}	1.85^{a}	4.930^{a}	48.840^{a}	107.130^{a}	1850.500^{a}	403.000^{h}
Percentage between farm soil and dump soil	98.800	0	7.84	1581.82	38.480	100.250	154.160	17.700	238.660
Pumpkin leaves									
Farm crops	2.030^{e}	0^{a}	1302.05^{d}	0^{c}	2.360^{bcd}	3.180^{i}	10.450^{j}	401.630^{g}	13400.000^{b}
Dump crops	3.010^{d}	0^{a}	1302.05^{d}	0^{c}	3.260^{bc}	3.480^{i}	24.730^{e}	1101.250^{e}	13100.000^{c}
Percentage between pumpkin leaves at the farm and the dump	48.280	0	0	0	38.140	9.430	136.650	174.200	2.240*
Fluted pumpkin leaves									
Farm crops	1.130^{f}	0^{a}	1281.25^{e}	0^{c}	1.730^{d}	4.170^{g}	14.530^{i}	1418.250^{d}	11800.000^{d}
Dump crops	1.080^{g}	0^{a}	1255.50^{g}	0^{c}	2.130^{cd}	4.350^{f}	18.130^{g}	1635.050^{b}	11700.000^{e}
Percentage between fluted pumpkin leaves at the farm and the dump	4.430	0	2.01*	0	23.120	4.320	24.780	15.290	0.850*
Maize									
Farm crops	4.520^{c}	0^{a}	305.23^{h}	0^{c}	2.980^{bc}	5.760^{e}	34.060^{d}	63.530^{j}	10900.000^{f}
Dump crops	4.030^{g}	0^{a}	150.23^{i}	0^{c}	3.330^{bc}	8.120^{d}	56.850^{b}	147.750^{i}	5350.000^{g}
Percentage between the maize at the farm and dump	77.210	0	50.78	0	11.740	40.970	66.910	132.580	50.920*
Waterleaves									
Farm crops	2.100^{e}	0^{a}	1303.25^{c}	0^{c}	1.430^{d}	3.980^{h}	14.930^{h}	395.950^{h}	13500.000^{a}
Dump crops	1.420^{f}	0^{a}	1267.50^{f}	0^{c}	3.730^{ab}	24.330^{c}	19.230^{f}	697.500^{f}	11800.000^{d}
Percentage between waterleaves at the farm and at the dump	32.380*	0	2.74*	0	160.840	511.390	28.800	76.160	12.590*
LSD	0.331	0	0.6565	0.0023	1.509	0.028	0.038	0.615	0.974

Osisioma location	Mg	Mn	Na	Ni	Pb	S	Se	Va	Zn
Normal farm soil	436.230^{a}	300.700^{b}	263.120^{c}	11.250^{b}	1.960^{b}	15.200^{a}	0^{a}	50.040^{b}	178.65^{d}
Dump site soil	296.430^{c}	314.880^{a}	297.930^{a}	22.320^{a}	111.430^{a}	15.530^{a}	0^{a}	54.480^{a}	331.25^{a}
Percentage between farm soil and dump soil	47.160*	4.720	13.230	98.400	5585.200	2.170	0	8.870	85.42
Pumpkin leaves									
Farm crops	277.850^{f}	24.240^{h}	70.930^{h}	0.260^{j}	0^{c}	9.900^{d}	0^{a}	0.110^{j}	92.53^{g}
Dump crops	295.630^{d}	138.830^{e}	107.130^{g}	0.550^{i}	0^{c}	14.270^{b}	0^{a}	0.400^{i}	184.43^{c}
Percentage between pumpkin leaves at the farm and the dump	6.400	472.730	51.040	111.540	0	44.140	0	263.640	99.32
Fluted pumpkin leaves									
Farm crops	256.930^{h}	97.430^{g}	107.230^{f}	5.430^{f}	0^{c}	9.630^{e}	0^{a}	4.000^{f}	86.15^{h}
Dump crops	290.500^{e}	127.130^{f}	192.830^{e}	6.300^{e}	0^{c}	8.840^{f}	0^{a}	10.140^{e}	97.45^{f}
Percentage between fluted pumpkin leaves at the farm and the dump	13.070	30.480	79.830	16.020	0	8.940*	0	153.500	13.12
Maize									
Farm crops	233.630^{i}	14.230^{j}	39.460^{i}	7.000^{d}	0^{c}	6.010^{h}	0^{a}	43.930^{d}	80.15^{j}
Dump crops	261.530^{g}	19.800^{i}	261.530^{d}	8.130^{c}	0^{c}	7.300^{g}	0^{a}	48.290^{c}	84.63^{i}
Percentage between the Maize at the farm and dump	11.940	39.140	562.770	16.140	0	21.460	0	9.920	5.59
Waterleaves									
Farm crops	314.730^{b}	239.440^{d}	29.330^{j}	1.560^{h}	0^{c}	10.130^{c}	0^{a}	0.750^{h}	149.83^{e}
Dump crops	273.330^{f}	245.450^{c}	281.330^{b}	2.530^{g}	0^{c}	0.100^{j}	0^{a}	1.960^{g}	255.43^{b}
Percentage between waterleaves at the farm and at the dump	15.150*	2.510	859.190	62.220	0	99.000*	0	161.300	70.47
LSD	0.037	0.536	0.029	0.241	0.024	0.103	0	0.021	0.24

$^{a-c}$Means with different superscripts along the same column are significantly different ($p<0.05$); *Percentage decrease

were also higher than those of the adjacent normal farm. The water leaf crops at the dump picked the highest cobalt content (3.73 mg kg^{-1}) in relation to the cobalt content (4.93 mg kg^{-1}) of the dump soil. Its cobalt percentage increase (160.84%) between the dump crop and farm crops was also the highest (Table 3) amongst all other crops.

For chromium, water leaves at the dump also had the highest value (24.33 mg kg^{-1}) than all other crops. It had a 49. 81% of chromium uptake in relation to the dump soil value. The percentage increase between the water leaf chromium values at the dump and at the farm was 511.39% (Table 3). The chromium values of other crops were low. Pumpkin leaves with the least chromium value (3.48 mg kg^{-1}) among the dump soils crops had a 7.12% of chromium uptake in relation to the soil. The chromium contents of the soils and vegetation were generally low. The copper content of Osisioma dump soil (107.13 mg kg^{-1}) was the highest value of copper recorded among the soil samples. Probably, the dump has lots of copper containing materials in it (Table 1) being located in an industrial town.

The percentage level of copper in the plants in relation to the soil copper was high. Maize at the dump with the highest copper value (56.85 mg kg^{-1}) had 53.07% copper level in relation to the soil copper while fluted pumpkin leaves with the least copper content (18.13 mg kg^{-1}) had 16.92% of copper level in relation to soil copper. At the nearby farms, maize that had the highest value of copper (34.06 mg kg^{-1}) gave 27.79% of copper in relation to the soil copper. The percentage increase between copper of the dump pumpkin leaves and that of the farm crop was the highest (136.65%, Table 3). It is reported that copper concentrations in soils range from 1-40 ppm and averages about 9 ppm while the total soil copper may be 1 or 2 ppm in deficient soils (Tisdale *et al*., 2003). The soil samples at the Osisioma sample sites exceeded the reported values. Its normal concentration in plant tissue ranges from 5-20 ppm (Tisdale *et al*., 2003). Most of the crops sampled had their copper values within this range. Copper availability and movement are influenced by soil texture, pH, organic matter content and hydrous oxides. Plant factors also affect availability as some crops are highly responsive to copper (Tisdale *et al*., 2003). Probably, a crop like maize that exceeded the reported range of copper at the Osisioma sample sites may have an affinity for copper. The genotypic differences in the copper nutrition of plants are related to the differences in the rate of copper absorption by roots, better exploration of soil through greater root length per plant or per unit area, better contact with soil through longer hair roots, modification of copper availability in soil adjacent to roots by roots exudation, acidification or change in redox potential, more efficient transport of copper from roots to shoots and/or lower tissue requirement for copper (Tisdale *et al*., 2003). Copper's most vital role in the body is to help form haemoglobin and collagen. It is also needed in many enzymes. It also assists in many of the reactions related to the release of energy (Sizer *et al*., 1994). Copper deficiency is rare but not unknown. It has been reported in children with protein deficiency and iron deficiency anaemia and can severely disturb growth and metabolism. Excess iron interferes with copper absorption and can cause deficiency (Sizer *et al*., 1994). Inadequate tissue levels of copper result from losses of endogenous copper. Copper toxicity from foods is unlikely but supplements can cause it (Sizer *et al*., 1994). Hence, the levels of copper in the crops are unlikely to have adverse effects on the consumers of such crops.

The iron uptake by plants at the Osisioma sample sites was high. At the dump, fluted pumpkin with the highest Iron content had 92.86% of iron content in relation to the dump soil iron. While maize with the least iron content had 4.04% of iron content in relation to the soil iron content. Pumpkin leaves also had the highest percentage increase of iron (174.2%) between the dump crops and the normal farm crops (Table 3). The sample sites at Osisioma may have some chelating compounds in the soil that accounted for the high iron compounds recorded in some of the crops. Tisdale *et al*. (2003) reported that numerous organic compounds in soil or synthetic compounds added to soil are able to complex or chelate Fe^{+3} and other micronutrients, these natural organic chelating compounds in the soil are products of microbial activity and degradation of soil organic matter and plant residues (Tisdale *et al*., 2003). Intake of 50 mg of iron per day or 25-75 mg day^{-1} by man has been cited as safe. Hence, it is possible to obtain this from the samples at Osisioma. Iron deficiency sets in when absorption cannot compensate for loses or low dietary intakes that cause iron stores to be used up (Sizer *et al*., 1994). Slightly lowered iron levels causes oxidation of pyruvate to be impaired thus reducing physical work capacity and productivity (Whitney *et al*., 1987). Iron is toxic in large amounts and once inside the body it is difficult to excrete. Iron overload can be caused by a hereditary defect or by the ingestion of too much iron. Ingestion or massive amounts can lead to sudden death (Sizer *et al*., 1994). Though the quantity that will lead to toxicity is not on record, the iron contents of the dump pumpkin leaves and the fluted pumpkin leaves may lead to iron toxicity based on the recommended daily intake of iron.

The potassium contents of crops exceeded the potassium contents of soils from which they were harvested. Though, it is on record that in tropical soils the total potassium content may be quite low because of origin of the soils, high rainfall and continued high temperature (Tisdale *et al*., 2003). Hence, the crops may have a quick capacity to obtain potassium and retain it. Most of the crops at the nearby normal farms had their potassium contents to be higher than those at the dump sites. Probably, the nearby normal farms had potassium fertilizers added to the soils. Since, one of the ways in which potassium is absorbed by plant is by diffusion, it may also be that potassium was transported from an area of high concentration (soil) to one of lower concentration (plants) thereby decreasing its quantity in the soils. Also the plants may have potassium as one of their major mineral components irrespective of the soils in which they are found/cultivated. Where multiple cropping is practiced, both total yield and potassium yield per unit of time are increased (Tisdale *et al*., 2003).

The high potassium values may not pose a threat to consumer of such foods because it is reported that people lives are not normally threatened by potassium overdoses as long as they are taken by mouth. This is because the excess of potassium in the stomach triggers a vomiting reflex that expels the unwanted substances. The Osisioma soil nickel content fell within the range of ≤50-100 mg kg^{-1} reported in soils. Nickel is introduced into the terrestrial environments as solid wastes from metallurgical industries or as deposition of atmosphere emissions (Radojevic and Bashkin, 1999). That may account for the higher nickel contents of soil at the Osisioma sample sites where many industries are sited.

The uptakes of nickel by the crops were also relatively low. The percentage increase between the nickel content of pumpkin leaves at the dump and that at the farm was 111.54% (Table 3). It is on record that in spite of the nickel accumulation in soils, uptake by plants is not sufficient enough to be of concern in the food chain (Radojevic and Bashkin, 1999). The lead content of the dump soil significantly ($p \leq 0.05$) exceeded the lead contents of soil of nearby normal farms. The Osisioma dump soil had the highest lead value but none of these were absorbed by the plants. Lead is a poisonous metal, the lower its content in foods the better.

Lead on entering the body is not metabolized or excreted rather it competes with calcium, iron and zinc and interferes with many of the body's system. It deranges the structure of the red blood cells making them leaky and fragile. It also interacts with white blood cells too impairing their ability to fight infections and binds to antibodies thereby reducing the body's resistance to disease (Whitney *et al*., 1987). Thus, the very low uptake of lead by crops at the sample sites is encouraging. Most especially the Osisioma dump whose soil recorded the highest lead quantity. The selenium contents of the soil and plant samples at the Osisioma sample sites tended to zero. These soil values are less than that reported as selenium concentration (between 0.1 and 2 ppm) in most soils. Insufficient plant uptake of selenium is usually caused by one of the following soil factors, low total selenium in the soil parent material or low availability of selenium in acid and poorly drained soil (Tisdale *et al*., 2003).

The dump soil vanadium exceeded the soil vanadium content of nearby normal farms. The vanadium contents at the Osisioma sample sites were the highest among all the sites analyzed. The pumpkin leaves had 263.64% increases between its farm and dump crops (Table 3). The fluted pumpkin leaves and the water leaves also have >50% increase between the farm crops and the dump crops. Maize had the highest vanadium contents. At the dump, maize had 87.83% level of vanadium in relation to the dump soil while at the nearby normal farm, maize had 87.78% level of vanadium in relation to the soil vanadium. Pumpkin leaves at the dump and nearby normal farm had the least vanadium contents. Vanadium is needed in the body in minute quantities. It is reported that <5% of vanadium ingested is normally absorbed (Nielsen, 1998). Hence, the vanadium contents of samples at Osisioma will not pose problems to consumers as only small amounts of the values eaten are absorbed.

The zinc content at the Osisioma dump soil significantly ($p \leq 0.05$) exceeded that of the nearby normal farm. The dump site crops also had higher zinc contents than crops from nearby farms. The percentages of absorption of zinc from the soil were also high. Zinc is a micronutrient whose normal concentration range is 25-150 ppm in plants (Tisdale *et al*., 2003). Most of the plants had their zinc contents within this range. Soluble zinc salts and zinc complexes can also enter the plant system directly through the leaves (Tisdale *et al*., 2003). This may account for the high contents of zinc contained in waterleaf from the three sample sites where it appeared.

Also waterleaf may have an affinity for zinc. Sizer *et al*. (1994) reported that though zinc is needed in very small quantity in the body, it works with proteins in every organ as a helper for more than hundred enzymes. The report further stated that zinc assists in immune functions and is essential to wound healing, sperm production, taste perception, fetal development and growth in children. Zinc is a relatively non toxic element but can be toxic if consumed in large enough quantities (Whitney *et al*., 1987). Hence, the waterleaves at the Osisioma dump sites may cause zinc toxicity if consumed in large quantities.

The mineral compositions (mg kg^{-1}) of samples at Umudike: The mineral composition of samples at Umudike (Abia State) and the percentage increase/decrease in the mineral compositions between the dump and farm samples are shown in Table 4. At the Umudike sample sites, all the mineral contents of the asbestos dump soil significantly ($p \leq 0.05$) exceeded those of the normal soil. The pH of the normal soil is acidic (4.95) when compared with the slightly basic pH (7.71) of the normal farm (Table 2). This may have affected the nutrient uptake by the crop at the normal site. The percentage increase between the dump and normal soil is 376.5% (Table 4 and 5).

Though aluminum is abundant in the soil, only a small portion is mobile (Massey and Taylor, 1988). This fact will account for the small quantity of crop aluminum at the sample sites. The arsenic values in the dump soil, normal soil, normal crops and dump crops tended to zero. The low or zero levels of arsenic obtained from the samples are advantageous as arsenic is a dangerous element. The calcium values of the dump crop

Table 4: Mineral composition (mg kg^{-1}) of samples and percentage (%) increase/decrease between them at Ubakala Umuahia

Ubakala location	Al	As	Ca	Cd	Co	Cr	Cu	Fe	K
Farm site soil	99.8200^{b}	0	1489.200^{d}	2.770^{bc}	5.340^{b}	46.850^{b}	23.350^{b}	1347.250^{b}	120.000^{c}
Dump site soil	138.9500^{a}	0	1835.950^{a}	3.270^{a}	6.670^{a}	59.000^{a}	55.680^{a}	1444.250^{a}	399.000^{f}
Percentage between farm soil and dump site soil	39.2000*	0	23.280	18.050	24.910	25.930	138.460	7.200	232.500
Cocoyam corms									
Farm crops	2.5500^{e}	0	131.550^{i}	2.370^{d}	0.140^{d}	3.200^{h}	1.180^{j}	597.250^{c}	4120.000^{d}
Dump crops	7.9600^{c}	0	1521.500^{c}	3.200^{a}	0.150^{d}	4.120^{f}	12.160^{d}	11.250^{j}	795.000^{e}
Percentage between cocoyam corms in farm and the dump	212.1600	0	1056.590	35.020	7.140	28.750	930.510	98.120*	80.700*
Sweet potato leaves									
Farm crops	2.0100^{g}	0	1218.350^{h}	1.920^{e}	0.140^{d}	3.970^{f}	5.520^{i}	388.500^{g}	10800.000^{b}
Dump crops	3.7200^{d}	0	1266.750^{g}	2.320^{d}	0.180^{c}	17.330^{c}	9.670^{f}	438.880^{d}	371.000^{g}
Percentage between sweet potato leaves in farm and dump	85.0700	0	3.970	20.830	28.570	336.920	75.180	12.970	96.560*
Unripe pawpaw									
Farm crops	0.9400^{i}	0	1311.300^{f}	1.730^{f}	0.120^{d}	2.070^{h}	6.630^{h}	398.650^{f}	8150.000^{c}
Dump crops	0.9900^{i}	0^{a}	1521.450^{c}	1.770^{ef}	0.180^{c}	3.500^{g}	12.440^{c}	403.750^{e}	0.990^{j}
Percentage between unripe pawpaw at the farm and at the dump	5.3200	0	16.030	2.310	50.000	69.080	87.630	1.530	99.990*
Water leaves									
Farm crops	1.9600^{h}	0	1480.250^{e}	0.010^{g}	0.130^{d}	7.040^{e}	10.400^{e}	111.900^{c}	11300.000^{a}
Dump crops	2.2500^{f}	0	1557.900^{b}	2.660^{c}	0.240^{c}	8.360^{d}	9.070^{g}	250.750^{h}	225.000^{h}
Percentage between waterleaves at the farm and the dump	14.8000	0	5.250	26500.000	84.620	18.750	12.790*	124.080	98.010*
LSD	0.0817	0	0.089	0.187	0.216	0.048	0.261	0.443	0.982

Ubakala location	Mg	Mn	Na	Ni	Pb	S	Se	Va	Zn
Farm site soil	473.350^{b}	89.080^{c}	255.260^{a}	4.110^{c}	41.000^{b}	13.980^{b}	0	0.600^{d}	295.9700^{b}
Dump site soil	480.750^{a}	230.550^{a}	254.550^{a}	9.330^{a}	84.140^{a}	20.700^{a}	0	5.130^{a}	329.5500^{a}
Percentage between farm soil and dump site soil	1.560	158.800	0.280*	127.000	105.220	48.070	0	755.000	11.3500
Cocoyam corms									
Farm crops	115.400^{i}	27.370^{h}	195.450^{e}	3.460^{d}	0.990^{i}	0.390^{i}	0	0.020	232.6500^{d}
Dump crops	319.900^{e}	41.650^{g}	217.750^{c}	9.110^{b}	1.850^{h}	7.120^{e}	0	2.970^{b}	295.7500^{b}
Percentage between cocoyam corms in farm and the dump	177.210	52.170	11.410	163.290	86.670	1725.600	0	14750.000	27.1200
Sweet potato leaves									
Farm crops	293.550^{f}	50.480^{f}	101.600^{i}	0.010^{h}	3.180^{d}	3.090^{h}	0	0.010^{e}	60.9700^{i}
Dump crops	375.600^{d}	58.330^{e}	138.800^{h}	1.750^{e}	4.040^{c}	6.040^{f}	0	0.960^{c}	69.9000^{h}
Percentage between sweet potato leaves in farm and dump	27.950	15.550	36.610	17400.000	27.040	95.470	0	9500.000	14.6500
Unripe pawpaw									
Farm crops	219.800^{h}	20.530^{i}	65.990^{j}	0.000^{j}	2.100^{f}	6.030^{f}	0	0.010^{e}	86.2500^{g}
Dump crops	319.900^{e}	26.810^{h}	150.950^{f}	1.180^{f}	2.200^{e}	10.060^{c}	0	0.010^{e}	87.7800^{f}
Percentage between unripe pawpaw at the farm and at the dump	45.540	30.590	128.750	0.000	4.760	66.830	0	0.000	1.7700
Water leaves									
Farm crops	317.750^{g}	87.530^{d}	147.950^{g}	0.010^{i}	1.910^{g}	5.350^{g}	0^{a}	0.010^{e}	206.7000^{e}
Dump crops	409.900^{c}	97.900^{c}	209.950^{d}	0.060^{g}	2.070^{f}	8.120^{d}	0	0.010^{e}	263.6500^{c}
Percentage between waterleaves at the farm and the dump	29.000	11.850	49.910	500.000	8.380	51.780	0	0.000	27.5500
LSD	0.716	1.074	0.653	0.025	0.042	0.037	0	0.019	0.2767

$^{a-c}$Means with different superscripts along the same column are significantly different ($p<0.05$); *Percentage decrease

significantly ($p\leq 0.05$) exceeded that of the farm crop. The percentage of calcium increase between the dump cassava tubers and the farm cassava tubers is 60.65% (Table 4). It is reported that calcium deficiency is rare but can occur in highly leached and unlimed acid soils (Tisdale *et al*., 2003). The plants appear to have high calcium contents and this may lead one to wonder why cassava is not included as a major source of calcium. Certain other foods like spinach, Swiss chard and rhubarb are reported to appear equal to milk in calcium content. But they contain certain binders that prevent calcium absorption (Sizer *et al*., 1994). The cadmium contents of the cassava samples were quite high compared to the cadmium contents of the soils. The dump soil cadmium had 94.75% of cadmium level in comparison with the dump soil cadmium while that of the nearby normal soil had a 96.49% of cadmium level in relation to the normal soil. The crops have a high affinity for the soil cadmium hence, the low cadmium contents of <3.0 mg kg^{-1} is okay as cadmium is a relatively toxic metal.

The cyanide content of the dump cassava was significantly lower than that at the normal farm. The percentage decrease between the cyanide content of the dump cassava and that at the normal farm was 58.71%.

Table 5: Mineral composition (mg kg^{-1}) of samples and percentage (%) increase/decrease between them at Umudike Umuahia

Umudike location	Al	As	Ca	Cd	CN	Co	Cr	Cu	Fe	K
Asbestos dump soil	218.750^{a}	0^{a}	283.550^{a}	2.77^{a}	-	8.560^{a}	1345.250^{a}	13.140^{a}	1296.750^{a}	254.5500^{a}
Normal farm soil	45.950^{b}	0^{a}	195.350^{b}	2.57^{c}	-	5.050^{b}	16.640^{c}	9.580^{b}	1273.750^{b}	90.1500^{c}
Percentage between the farm soil and dump soil	376.500	0	45.150	7.78	0.00	69.500	7984.440	37.160	1.810	182.2400
Cassava tubers										
Dump crops*	8.080^{i}	0^{a}	195.850^{b}	2.62^{b}	5.74^{b}	2.160^{c}	119.750^{b}	0.120^{d}	127.550^{c}	3167.2500^{a}
Farm crops*	7.020^{d}	0^{a}	121.950^{c}	2.48^{d}	13.90^{a}	0.120^{d}	1.790^{d}	0.430^{c}	62.450^{d}	39.9700^{d}
Percentage between the cassava at the farm and dump	15.100	0	60.600	5.65	58.71*	1700.000	6589.940	72.090*	104.240	7824.0700
LSD	0.571	0	4.446	0.02	0.59	0.045	0.446	0.022	1.299	0.5587

Umudike location	Mg	Mn	Na	Ni	Pb	S	Se	Va	Zn
Asbestos dump soil	183.150^{a}	89.980^{a}	61.17^{a}	7.580^{a}	75.040^{a}	1.880^{a}	0	7.270^{a}	37.620^{a}
Normal farm soil	170.960^{b}	25.480^{b}	59.91^{b}	0.100^{b}	23.090^{b}	1.530^{b}	0	0.010^{c}	29.510^{b}
Percentage between the farm soil and dump soil	7.130	253.140	2.10	7480.000	224.990	22.880	0	72600.000	27.220
Cassava tubers									
Dump crops*	14.590^{c}	6.630^{d}	28.74^{d}	0.080^{b}	3.080^{c}	0.630^{c}	0	0.160^{b}	20.080^{c}
Farm crops*	170.900^{b}	15.930^{c}	29.76^{c}	0.060^{b}	2.270^{d}	0.200^{d}	0	0.030^{c}	10.930^{d}
Percentage between the cassava at the farm and dump	91465.000*	58.380*	3.43*	33.330	35.680	215.000	0	433.330	83.710
LSD	0.161	0.129	0.41	0.052	0.069	0.004	0	0.042	0.106

$^{a-c}$Means with different superscripts along the same column are significantly different ($p<0.05$); *Percentage decrease

This high difference between them may be due to the variety of cassava planted at the sites. The dump site may have the low cyanide cassava planted on it. The chromium value of the dump soil at the Umudike asbestos dump was high (1345.25 mg kg^{-1}). This exceeds the range of <1-100 mg kg^{-1} reported at sites (Radojevic and Bashkin, 1999). This is not surprising as asbestos products are among the reported industrial sources of chromium in the environments (Radojevic and Bashkin, 1999). The uptakes of chromium by cassava at the Umudike sample sites were also low. The low concentrations of chromium obtained from the sample sites do not pose any harm to the individuals consuming the plants. Chromium toxicity is reported in animals and humans a lesser degree (Radojevic and Bashkin, 1999). The toxicological effects of chromium poisoning include lung and kidney damage, inactivation of various enzymes and skin disorders by the body. Thus, high oral intakes would be necessary to attain toxic levels. Toxic effects of industrial exposure have been primarily attributed to airborne Cr^{6} compounds (Katz and Salem, 1993; Barceloux and Barcelous, 1999).

The cassava at the dump site had a level of 0.91% of copper in relation to the soil copper while the cassava at the Umudike nearby normal farm had its copper level to be 4.44% in relation to the soil copper. Maybe there are some components of the dump that inhibit effective absorption of the soil copper. The iron contents at the dump site had 4.9% iron uptake in relation to the soil iron content. The percentage increase between the nickel content of the dump crop and that of the normal crop is 7480% (Table 4). The nickel content of the cassava crops was low compared to the dump soil nickel. The low Nickel values of the crops are advantageous as nickel is reported to be a toxic metal. The lead content of the dump site soil was significantly ($p\leq0.05$) higher than that of the normal farm. There existed a 224.99% increase between the normal soil lead and the dump site lead (Table 4). The dump cassava had a higher lead content than the farm cassava. Lead is a poisonous metal so the lower its content in food, the better. The selenium contents of the soils and crops tended to zero. The vanadium content uptakes by the crops were very low.

The percentages of absorption of zinc from the soils were high. The zinc values of the dump and normal crop cassava fall below the range of 25-150 ppm reported in plants (Tisdale *et al*., 2003). Though, Zinc is needed in very small quantities in the body and it works with protein in every organ as a helper for more than hundred enzymes. Zinc is a relatively non toxic element however, it can be toxic if consumed in large enough quantities (Whitney *et al*., 1987). Thus, the cassava at the dump might not contribute to zinc toxicity when consumed.

The mineral compositions (mg kg^{-1}) of samples at Ubakala: The mineral compositions of samples at Ubakala (Abia State) and the percentage increase/decrease in the mineral compositions between the dump and the farm samples are shown in Table 4. The aluminum content of the dump soil was significantly ($p\leq0.05$) greater than the aluminum content of the nearby normal soils. The dump crops also had most of their aluminum contents to be higher than those at the dump. The uptake of aluminum by the plants was not encouraging. Pawpaw had the least aluminum content (0.99 mg kg^{-1}) both at the dump and at the nearby normal farm (0.94 mg kg^{-1}). Also cocoyam had the highest aluminum content both at the dump (7. 96 mg kg^{-1}) and at the nearby normal farm (2.55 mg kg^{-1}). The low aluminum contents of the crop are not sufficient to cause aluminum toxicity. The arsenic contents of the soils and vegetation tended to zero. These values are lower than the value (0.2-40 mg kg^{-1}) reported to exist in soils (Radojevic and Bashkin, 1999). The calcium content of the dump soil also exceeded ($p \leq 0.05$) that of the nearby normal farm. The calcium uptake by the plants in relation to the soil calcium contents was also high. The percentage difference between the calcium contents of dump soil cocoyam and that of nearby normal farm was as high as 1056.59% (Table 4). It is reported that calcium concentration in the soil higher than necessary for plant growth will normally have little effect on Ca^{2+} uptake because calcium uptake is genetically controlled. Also calcium deficiencies are rare in agricultural crops as most acid soils usually contain sufficient calcium for plant growth (Tisdale *et al.*, 2003). The calcium contents of the dump soil was significantly ($p \leq 0.05$) higher than that of the nearby normal farm. The percentage difference between the cadmium content of the normal soil and that of the dump soil is 18.05% (Table 4). The difference in the cadmium contents between the water leaf at the normal site and the dump site is as high as 26500% (Table 4).

The crops seem to have a high affinity for the soil cadmium. Hence, the low cadmium contents recorded at the sample sites are encouraging as cadmium is a relatively toxic metal. The cobalt contents of the dump soil significantly ($p \leq 0.05$) differed from the cobalt contents of the crops of nearby normal farms. All the dump crops had higher cobalt contents than their counterparts in the nearby normal farm. The percentage of cobalt absorption by plants were low both at the dump and at the nearby normal farm. Waterleaf at the farm with the highest cobalt content (0.24 mg kg^{-1}) had a 3.52% of cobalt absorption in relation to the dump soil cobalt while sweet potato leaves with the highest cobalt value (0.14 mg kg^{-1}) at the nearby normal farm had a 2.58% level of cobalt in relation to cobalt level of the farm soil. There may be components at the Ubakala sample sites that affected the uptake of the soil cobalt by the crops. The cobalt levels of the soils fell within the range (0.2-30 mg kg^{-1}) reported in soils (Radojevic and Bashkin, 1999). The chromium content of the dump soil was significantly higher than the chromium content of the nearby normal farm.

The sweet potato leaves with the highest chromium content (17.33 mg kg^{-1}) had a 336.52% difference between its dump and the normal farm chromium values. Cocoyam corns had 28.75% difference between the normal soil and the dump soil chromium contents (Table 4). Sweet potato leaves had the highest chromium uptake (29.35%) in relation to the soil chromium. The chromium contents of all other crop was <4.5%. Thus, it is unlikely that chromium toxicity can be gotten from the consumption of the crops at these sample sites. The copper content of the dump soil was significantly ($p \leq 0.05$) higher than that of the normal soil. There was as much as 138.46% increase between the normal soil and the dump soil. The copper uptake by the plants was also high. The dump site sweet potato leaves with the highest copper content (9.67 mg kg^{-1}) had 23.3% level of copper in relation to the dump soil copper content while waterleaf with the least copper content (9.07 mg kg^{-1}) had 16.29% level of copper in relation to the dump soil copper. At the nearby normal farm waterleaf with the highest copper content (10.4 mg kg^{-1}) had a 41.03% of copper uptake in relation to the soil copper while cocoyam with the least copper content of 6.67 mg kg^{-1} had 26.3% of copper absorbed. It is likely that there are substances or components of the soils in these sites hindering effective uptake of copper by the crops. The copper of the soil samples exceeded the reported copper concentrations of 1-40 ppm (Tisdale *et al.*, 2003) in soils.

Copper toxicity from foods is reported to be unlikely but supplements can cause it (Sizer *et al.*, 1994). Hence, the copper contents of the crops are not likely to pose any contamination to the scavengers of the dump. The iron contents of the dump soil significantly ($p \leq 0.05$) exceeded that of the normal site soil. The percentage increase between the iron content of the normal soil and that of the dump soil is 7.20%. The iron content uptake by the crops was below average. At the dump, sweet potato leaves with the highest iron content had 30.18% of iron uptake while cocoyam with the least iron content had 0.78% iron uptake with respect to the soil iron content. At the nearby normal farm, cocoyam with the highest iron content had 44.33% iron uptake in relation to the soil iron content while water leaf with the least iron content had 8.31% of iron uptake. Though, the dump crops had higher iron contents than the crops of the nearby normal farm the iron uptake by the plants at the nearby normal farms were higher than those at the dump. There may be some substances at the dump that interfered with the iron uptake. But care still needs to be exercised while consuming crops from there as their iron contents are relatively high in order to avoid iron overload.

The potassium content of the dump soil significantly ($p \leq 0.05$) exceeded that of the nearby normal farms soil. The potassium contents of the crops exceeded the potassium content of the soils from which they were obtained. It is reported that in tropical soils, the total potassium content may be quite low because of the origin of the soils, high rainfall and continued high temperatures

(Tisdale *et al*., 2003). It was also observed that most of the crops at the nearby normal farms had their potassium contents to be higher than those at the dump sites. Probably, the nearby normal farms had potassium fertilizers added to their soils. Since, one of the ways in which potassium is absorbed by plants is by diffusion, it may be possible that potassium was transported from an area of high concentration (soil) to one of low concentration (plants) thereby decreasing its quantity in the soils. Also, the plants may have potassium as one of their major mineral components, irrespective of the soils in which they are found/cultivated. Where multiple cropping is practiced, both total yield and potassium yield per unit of plants is increased as plants need large quantities of potassium for growth. In the body, potassium is the principal, positively charged ion inside the body cells. It plays a major role in maintaining fluid and electrolyte balance and cell integrity. It is also critical in maintaining heart beat (Sizer *et al*., 1994). Dehydration leads to potassium loss from inside cells. It is especially dangerous because potassium loss from the brain cells makes the victim unaware for the need for water. A dietary deficiency of potassium is unlikely in healthy people although, low potassium intakes are possible with diets low in fruits ad vegetables. Hence, the crops at the sample sites will help to boost the potassium intake of the consumers. People's lives are not normally threatened by potassium overdoses as long as they are taken by the mouth because the presence of excess potassium in the stomach triggers a vomiting reflex that expels the unwanted substance. Hence, it is unlikely that potassium toxicity will be experienced from consuming crops from the sample sites.

The magnesium content of the dumps soil was significantly ($p \leq 0.05$) higher than that at the nearby normal farm. The magnesium uptake by plants in relation to the soil magnesium contents was quite high. The plants seem to have an affinity for magnesium. The cation exchange capacities of the sample soils must have been high for the magnesium uptake by the plants to have been quite high. Toxicity from the dump crops is unlikely as toxicity is reported to be seen only in individuals who consume supplements.

The manganese content of the dump soil was significantly ($p \leq 0.05$) higher than that of the nearby normal farm. The same trend was noticed between the farm crops and the dump crops. The percentage of increase between the manganese contents of the dumps ranged from 29-178% (Table 4). The manganese uptake by the dump crops in relation to the dump soil manganese was low while those of the nearby normal farms were high. Manganese exists as solution Mn^{2+}, exchangeable Mn^{2+}, organically bound Mn and as various manganese minerals. The equilibrium among the forms determines manganese availability to plants.

Factors that also influence the solubility of soil manganese include pH, redox potential and complexation. Manganese increase under low redox conditions (Tisdale *et al*., 2003). That may account for the high manganese contents of the dump soil with a low redox potential (Table 2). For the adult human, absorption of manganese from the diet has long been assumed to be no >5% (Bowman and Russel, 2001). Hence, the possibility of manganese toxicity from the sampled crops may not exist.

The sodium content of the nearby normal farms exceeded that of the dump soil though not significantly ($p \leq 0.05$). Tisdale *et al*. (2003) reported that low sodium in soil is an indication of weathering of sodium from sodium containing minerals. The sodium contents of the crops may have substances inhibiting their uptake by the body. The nickel content of the dump (9.33 mg kg^{-1}) soil significantly exceeded that of the (4.11 mg kg^{-1}) normal soil. The nickel contents of most crops of the nearby normal farms fell within the range of about 0.1-1.0 ppm reported in literature (Tisdale *et al*., 2003). Higher values were recorded from most of the dump crops. Cocoyam absorbed the highest quantity of nickel, both at the dump and at the normal site. Cocoyam may be responsive to the element nickel. This may call for caution while consuming cocoyam from dumps as it is on record that Nickel carbonyl $Ni(CO)_4$ is extremely toxic and any emission is especially hazardous to mammals and humans.

The lead content of the dump soil was also significantly ($p \leq 0.05$) higher than those of the nearby normal farms. There were as much as 102.89% increase between the dump site soil lead content and that of the normal soil. The crops here (mostly from the dumps) did pick some of the lead compounds that are in the soil. The dump crops lead contents were significantly ($p \leq 0.05$) higher than the lead contents of the crops of nearby normal farm. At the dump, sweet potato leaves had the highest lead uptake in comparison with the soil lead content while the cocoyam with the least lead content, at the dump had 2.19% of lead uptake in comparison with the soil lead content. At the nearby normal farm sweet potato leaves with the highest lead content had 7.66% of lead uptake in comparison with the soil lead content.

Cocoyam with the least lead content had 2.38% of lead uptake. Lead is a poisonous metal so the lower its content in foods the better. Lead on entering the body is not excreted or metabolized rather it competes with calcium, iron and, zinc and interferes with many of the body's systems (Whitney *et al*., 1987). The vanadium content of the soils and the crops at the dump was significantly ($p \leq 0.05$) greater than those of the normal farm soil. There was as much as 755% increase between the farm soil vanadium and the dump soil vanadium. The vanadium contents of the dump cocoyam corns and sweet potato leaves significantly ($p \leq 0.05$) exceeded those at the normal farms. The other crops picked little or no vanadium from the soil. At the sample sites in Ubakala, it was only cocoyam at the dump that picked up to half of the soil vanadium. It is reported that <5% of vanadium ingested is normally absorbed (Nielsen, 1998).

CONCLUSION

The farm crops also picked significant quantities of chromium. The nickel contents of crops should be watched as a substantial quantity was observed among the samples in relation to the soil nickel contents. There was also no substantial uptake of lead by the plants at this dump site. At the specialized dump in Umudike, the plants picked up cadmium, chromium, iron and zinc in high amounts. Lead was also recorded in the plants. The zinc contents of the cassava plant there (20.08 mg kg^{-1}) was >50% that of the dump soil (37.62 mg kg^{-1}). At the Ubakala dump site, sweet potato leaves at the dump seem to have the highest affinity for lead. The chromium contents of the sweet potato leaves at the dump (17.33 mg kg^{-1}) was also higher than those of other crops. Sweet potato leaves at these sample sites seemed to have an affinity for most of the elements. The potassium contents of the crops at all the sample sites had the mineral values of the normal farm crops being much higher than those at the dump.

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