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Trace Metals Distribution in Some Common Tuber Crops and Leafy Vegetables Grown in the Niger Delta Region of Nigeria

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Abstract: The main sources of trace metals to plants are the air and soil media from which trace elements are taken up by the root or foliage. Understanding the distribution of some trace metals in some common leafy vegetables and tuber cops is important for establishing baseline concentrations from which anthropometric effects can be measured. The trace metal distribution in some selected leafy vegetables and tuber crops in our study area were determined in samples that were dried, milled and digested. All the minerals investigated were found present in all the components of the selected vegetables and tuber crops. Iron was the most abundant mineral in the vegetables with concentrations ranging between 0.32mg/kg in *Ocimum gratissum* root to 9.7 mg/kg in *Telfaria occidentalis* roots. In the root tubers, zinc was the most abundant mineral ranging from 0.62 mg/kg in *Manihot esculenta* stem to 1.97 mg/kg in *Manihot esculenta* leaf. The bioconcentration factor indicates that the roots of the food crops concentrate most of the metals than the stems and leaves.

Key words: Trace metals, leafy vegetables, tuber crops, Niger Delta Region

INTRODUCTION

Trace metals analysis are an important part of environmental pollution studies (Loska *et al*., 2000; Chibowski, 2000; Solecki and Chibowski, 2000; Narin *et al*., 1998; Czarrnowska and Milewska, 2000). Some trace metals are essential in plant nutrition, but plants growing in a polluted environment can accumulate trace elements at high concentrations, causing a serious risk to human health (Vousta *et al*. 1996; Sharma *et al*., 2004). The main sources of trace metals to plants are the air and soil from which metals are taken up by the root or foliage. The uptake of metal concentration by roots depends on speciation of metal and soil characteristics and type of plant species etc. Consequently, metal mobility and plant availability are very important when assessing the effect of soil contamination on plant metal uptake, as well as translocation and toxicity or ultra structural alterations (Chandra Sekhar *et al*., 2001).

Atmospheric metals are deposited on plant surfaces by rain and dust. Several authors have shown a relationship between atmospheric element deposition and elevated element concentrations in plants and top soils, especially in cities and in the vicinity of emitting factories (Andersen *et al*., 1978; Pilegaard, 1978; Larsen *et al*., 1992; Sunchez *et al*., 1994; Srinivas *et al*., 2002). Airborne submicron particles are also filtered out on plant surfaces, constituting a substantial, but unknown contribution to the atmospheric supply. Indirect effects of air pollutants through the soil are also great interference, because of the large scale sustained exposure of soil to both wet and dry depositions of trace elements. Widespread interest in trace metal contamination in plant systems has emerged only over the last three decades and several research articles reported concentrations of a number of trace elements in the local crops and other plants as a consequence of anthropogenic emissions (Bernard *et al*., 2004a; Bernard *et al*., 2004b). The consequence of trace metals in foods such as vegetables and tubers have been a considerable interest because of their toxicity effect which are important in human beings (Asaolu, 1995). Also, information on the distribution of some of these metals in the various components of the vegetables and tubers contains the highest level of minerals and in assessing the nutritional and medicinal value of the various components for appropriate application. Equally, any component could serve as pollution indicators for some metals. The data will be useful for assessing trace metals contamination and determining the need for remediation. The results obtained from the study would also provide information for background levels of metals in the plants in the study area.

MATERIALS AND METHODS

Study area: Amai, a semi urban area in Delta State, Nigeria and the host community of a campus of Novena University was selected as the study area. Amai is surrounded by other urban and semi urban towns some of where human activities that introduce pollutants into the ecosystem takes place.

Sample collection: Four common and widely consumed Nigerian Leafy vegetable and two common and widely

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consumed tuber crops were selected for analysis. The varieties of the leafy vegetables are: *Telfaria occidentalis, Verona amygdalina, Ocimum gratissum* and *Talinum triangulare*. The varieties of the tuber crops are: *Discorea alata* and *Manihot esculenta*. The vegetables and tuber crops were obtained from local farmers at Amai, host community of Novena University. Soil sample was also collected from the farm.

Sample preparation: The roots, stems and leaves were separated in each case and the components were cut into pieces, washed, air dried for one week and then dried in the Oven (Gallen Kamp, England) at 80°C for 6 h. About 10 g of the dried materials of each component were powdered in a hammered mill. The powdered sample from each component was packaged in glass bottles and stored a 4°C in a refrigerator. About 1.0 g of dried and ground soil samples were placed inside a crucible and ignited in a muffle furnace at 500°C for 3 h. The ignited mass was cooled inside desiccators and transferred into a 100 ml Borosil beaker and kept in a desiccator until analysis.

Analysis of trace metal concentration: Trace metals concentrations were determined according to AOAC methods (AOAC, 1990). A quantity, 1.0 g of each powdered plant components were weighed and put in a Pyrex crucible and 10 ml of pure HNO_3 was added. This was incinerated in a GallenKamp Oven at 250°C for 18 h and then diluted to volume of 25 ml with water. Samples were filtered through a Filter paper. The digest were analyzed for Trace metals content by atomic absorption spectrophotometer (Buck Scientific Model-210). The soil inside the beaker was added 10ml of concentrated HCl and the suspension was swirled. The suspension was kept inside a thermostat controlled water bath in a temperature range of 70-80°C for 1 h. The supernatant was decanted and kept inside a 100 ml volumetric flask. This contains mostly alkaline earth metal. To the residue in the beaker, 10 ml each of the HCl (concentrated) and $HClO_4$ (concentrated 70% Pure) and few porous beads were added and were evaporated to complete dryness over a hot plate. This procedure was repeated when necessary. The dried residue was dissolved completely by using minimum amount of concentrated HCl. This solution was then transferred to the same volumetric flask where previous extract containing alkaline earth metal extract was stored. The flask were then made up to the mark by distilled water and stored inside a refrigerator. This extracts were analyzed for trace metals concentration by atomic absorption spectrophotometer (Buck Scientific Model-210).

Statistical analysis: Data were presented as mean of duplicate determinations.

Table 1: Concentrations of trace metal in (mg/kg) soil sample

	Elements				
Sample	Fe	Zn	Ni	Cd	Pb
Soil	20.0	3.20	0.40	0.10	1.20

Table 1 shows the trace metal concentration in soil sample from the study area. The result obtained showed that the trace metals concentration were decreased in the sequence Fe>Zn>Pb>Ni>Cd

RESULTS AND DISCUSSION

Trace metal contamination is of concern due to its effects as a carcinogen. Understanding the distribution of some trace metals in some common leafy vegetables and tuber crops is important for establishing baseline concentrations from which anthropogenic effects can be measured. All the trace metals analyzed were found present in the soil sample with Iron having the highest concentration. It has been reported that Iron occurs at high concentration in most Nigerian soils (Adefemi *et al*., 2008). The trace metals concentrations of lead, iron, zinc, cadmium and nickel in the present study are presented in Table 1 and are within the permissible limits for agricultural soils (Alloway, 1990; Aswatharayana, 1999). This indicates that, despite the close proximity of the cultivated land to high pollution sources, agricultural soils does not seem to have been contaminated by atmospheric deposition. This may be due to low deposition rate resulting from the dispersion of atmospheric pollutants and variations in soil physico-chemical characteristics (Srinivas *et al*., 2009).

All the minerals examined were found to be present in the various components of the selected vegetable and tuber crops. On the average, iron is the most abundant mineral; lead was the least in the various components of the vegetables and tuber crops. Analysis of the data in the present study showed that the leaves of *Ocimum gratissum* and *Verona amygdalina* accumulated more iron from the soil than the root and stem as presented in Table 2 and further confirmed by the data on the bioconcentration factor presented in Table 3. The high concentration of iron in *V. Amygdalina* leaves, followed by *O. Gratissum* leaves might be due to the participation of the green vegetables in the synthesis of ferrodoxin, an attribute which makes them useful sources of iron (Hart *et al*., 2005). This result are not totally consistent with literature reports which indicate that the highest concentration of heavy metals in food crops occur in lateral roots than main roots, rhizomes, leaves and the lowest in shoots (Romera *et al*., 2005). The environmental pollution of zinc greatly influences the concentrations of this metal in plants. In ecosystems where zinc is an airborne pollutant, the tops of plants are likely to concentrate more zinc; on the other hand, plants grown in zinc contaminated soils accumulate a great proportion of the metal in roots (Kabata-Pendias and Pendias, 1992). In this study, zinc concentration reported for the plant components were within the permissible

Table 2: Trace metal distribution in (mg/kg) vegetable dry matter

	Fe			Zn			Ni			Cd			Pb		
Sample	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf
V1	9.77	6.44	1.17	0.46	0.21	0.53	0.51	0.34	0.37	0.60	0.32	0.56	0.82	0.01	<0.01
V2	0.39	0.42	6.37	0.01	0.22	1.99	0.24	0.19	0.21	0.78	0.82	0.90	0.03	0.02	<0.01
V3	3.22	3.01	3.79	1.32	1.29	1.44	0.30	0.28	0.31	0.06	0.03	0.07	0.08	0.07	0.06
V4	0.65	0.55	0.50	2.63	2.10	1.92	0.41	0.29	0.20	0.60	0.52	0.46	0.02	<0.01	<0.01

V1 = *Telfaria occidentalis*, V2 = *Veronia amygdalina*, V3 = *Ocimum gratissum*, V4 = *Talinum triangulare*.

Table 2 shows the distribution of trace metals in the various parts of the leafy vegetables. The result obtained showed that the leaves of *Veronia amygdalina* and *Ocimum gratissum* accumulated more iron and zinc than the stem and root.

Table 3: Bioconcentration factor in vegetable samples

	Fe			Zn			Ni			Cd			Pb		
Sample	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf
V1	0.48	0.32	0.05	0.14	0.06	0.16	1.29	0.87	0.94	6.04	3.21	5.66	0.68	0.01	ND
V2	0.01	0.02	0.31	0.01	0.07	0.62	0.60	0.49	0.52	7.88	8.22	9.08	0.02	0.01	ND
V3	0.16	0.15	0.18	0.41	0.40	0.45	0.75	0.70	0.77	0.60	0.30	0.76	0.06	0.06	0.05
V4	0.03	0.02	0.02	0.82	0.65	0.60	1.04	0.74	0.50	6.06	5.20	4.62	0.01	ND	ND

V1 = *Telfaria occidentalis*, V2 = *Veronia amygdalina*, V3 = *Ocimum gratissum*, V4 = *Talinum triangulare*. ND = Not Determined.

$$\text{Bioconcentration factor} = \frac{\text{Concentration in plant tissue}}{\text{Concentration in soil sample}}$$

Table 3 shows the bioconcentration factor in the various parts of the leafy vegetables. The result obtained showed that the roots concentrated more of the trace metals than the stems and leaves.

Table 4: Trace metal distribution in (mg/kg) tuber crops dry matter

	Fe			Zn			Ni			Cd			Pb		
Sample	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf
T1	0.60	0.81	1.30	1.21	1.01	0.62	0.16	0.21	0.30	0.33	0.22	0.48	<0.01	<0.01	<0.01
T2	1.34	1.32	1.30	0.71	0.62	1.79	0.60	0.54	0.45	0.89	0.69	0.62	0.10	0.08	0.02

T1 = Discorea alata, T2= Manihot esculenta. Table 4 shows the distribution of trace metals in the various parts of the tuber crops. The result obtained showed that the leaves of *Discorea alata* concentrated more iron than the stem and root while the leaves of *Manihot esculenta* concentrated more zinc than the stem and root

Table 5: Bioconcentration factor in tuber crops

	Fe			Zn			Ni			Cd			Pb		
Sample	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf	Root	Stem	Leaf
T1	0.03	0.04	0.06	0.37	0.31	0.19	0.40	0.52	0.76	3.32	2.24	4.88	ND	ND	ND
T2	0.06	0.06	0.06	0.22	0.19	0.55	1.50	1.35	1.14	8.93	6.90	6.20	0.08	0.06	0.01

T1 = *Discorea alata*, T2 = *Manihot esculenta*

$$\text{Bioconcentration factor} = \frac{\text{Concentration in plant tissue}}{\text{Concentration in soil sample}}$$

Table 5 shows the bioconcentration factor in the parts of the tuber crops. The result obtained showed that the roots concentrated more of the trace metals than the stems and leaves

limits (10-50 mg/kg) for human consumption (Samara *et al.*, 1992). The leaves of *T. Occidentalis, T. gratissum and V. amygdalina* accumulated more zinc as indicated by the data on bioconcentration factors presented in Table 3. While the essential elements iron and zinc are desirable in the nutrition of man, animals and plants, their presence could reduce the bioavailability of lead; their undue presence in food could be harmful (Davidson *et al.*, 1979; Udosen *et al.*, 1990). The high storage of iron and zinc in the leafy part of some of the vegetables might be advantageous for their useful biochemical functions in human nutrition (Asaolu and Asaolu, 2010). Studies have shown that the excessive intake of zinc and iron results to vomiting, dehydration, electrolyte imbalance and lack of muscular co-ordination (WHO, 1984).

In general, lead concentration in food crops has increased in recent decades owing to human activities (Srinivas *et al.*, 2009). For all the trace elements analyzed and presented in Table 2 and 4, lead was the least abundant in vegetables and tuber crops. The permissible limit of lead in vegetables for human consumption is 2.0-2.5 mg/kg dry weight (Samara *et al.*, 1992). The concentration of lead in the vegetables and tuber crops were found to be below the permissible limits. Plants are known to have more nickel than animal products (Kabata-Pendias and Pendias, 1992). The concentration of nickel on plants generally ranges from 0.05-5.0 mg/kg dry weight. According to WHO (1984), the nickel concentration in vegetables and fruits should be within the range of 0.02-2.7 mg/kg. The concentration of nickel in vegetables and tuber crops are presented in Table 2 and Table 3 were found to be within the permissible limit. The concentration of cadmium in the various plant components in the present study is low and is below the FAO/WHO limit for cadmium toxicity (5-30 mg/kg) (Awofulu, 2005).

Conclusion: This study has revealed low concentration of heavy metal lead, with correspondingly high levels of iron and zinc in the various food crops harvested at the study areas. The high storage of iron and zinc as indicated by the bioconcentration factor in the leaf of some of the vegetables might be advantageous for their useful biochemical function in human system. Although the essential elements are beneficial to man and plants, when found in food can prove detrimental to health. This is more so when they exist in commonly consumed food crops, particularly the green vegetables which are generously consumed by all households especially during the season of abundance.

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