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Full Length Research Paper

Quantification of macro and micro elements in selected green vegetables and their soils from Aliero agricultural fields in Aliero, Kebbi State, Nigeria

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This study was undertaken to determine the concentrations of macro and micro elements in amaranth, roselle and kenaf as well as in their soils from six different agricultural fields in Aliero, Kebbi state, Nigeria. The highest values for the concentrations of P, Mg and Zn were observed in amaranth from site A; K, Fe and Mn from site D; Na from site E; Ca and Ni from site F; and Cu and Cd from site B. In roselle, the values for P was in samples from site C; K and Mn from site A; Na from site F; Ca, Mg and Fe from site D; and Cu, Ni and Pb from site E. Similarly, in kenaf, the values for P were in samples from site E; K, Fe, Zn and Pb from site D; Na and Ca from site F; Mg, Mn and Ni from site A; and Cu and Cd from site B. In soils of amaranth, the highest values for the concentrations of P, Na^+ and K^+ were in samples from site D; Mg^{2+}, Ca^{2+} and Fe from site A; Zn and Mn from site E; and Ni and Cd from site C. In roselle, the values for P, K^+, Mg^{2+}, Fe and Cd were in samples from site D, Ca^{2+} from site A; Zn and Mn from site E; Na^+ from site F; and Cu and Pb from site B. In kenaf, the values for P, Na^+, K^+, Mg^{2+} and Fe were in samples from site D; Ca^{2+}, Ni and Pb from site C; and Zn, Cu, Mn and Cd from site E. Significant differences at a level of $P<0.05$ were observed in the concentration of the elements within each species of the vegetables and also within their soils. Difference in environment (site of collection) had effect on the concentration of the elements in both the vegetables and their soils. The trends observed for the elements in each species of the vegetables were different from what was observed in their soils. From the transfer factor values, the concentrations of the micro elements (except Zn and Cu) in the vegetables do not necessarily depend on their concentrations in the soil.

Key words: Macro and micro elements, amaranth, roselle, kenaf, soils, transfer factor.

INTRODUCTION

Soil is not only a geochemical sink for contaminants, but also acts as a natural buffer controlling the transport of chemicals and ions to the atmosphere, hydrosphere and biota (Miroslav and Vladimir, 1999). It is the basic natural source of food production. Plants get most of their nutrients from the soil. In the process of absorbing these nutrients, some are absorbed in large amount depending on their concentration and available form in the soil. Similarly, unwanted materials are also absorbed in the process. High concentrations of nutrient elements occur only rarely in soils under natural conditions. The concentration of exchangeable cations in soils is one of the most important properties that influence its fertility and productivity. Soil contamination by heavy metals and other toxins is generally the result of human activity and this has a negative effect on the productivity, microbiological process of soils, plant growth and

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development, as well as the quality of agricultural products. Although, the content of heavy metals in soils is an important indicator of soil contamination, it is not sufficient to characterize this as environmental hazard as it depends on the forms available, pH, and moisture conditions of the soil. Similarly, translocation from root system to shoot is also another important factor as it differs from one plant to another and the type of element involved (Karezewska et al., 1998). Researchers have shown that Cd, Cu, Zn and Pb are more mobile in terms of movement from soil to the root of most plants (Anthony and Balwant, 2009; Kashif et al., 2009). Mobility rate differ from one part of a plant to another and from one plant to another (Nirmal et al., 2009).

In plants, phosphorus is a structural component of the membrane system of the cell, chloroplast, mitochondrum, nucleic acids (RNA and DNA), nucleoproteins, amino acids, phosphotides, phytin etc. (ICAR, 2006). Plants absorb and store potassium in large quantities than what is needed for optimum growth without causing toxicity which is termed as luxury consumption. Ca forms Ca-pectate which is an essential constituent of cell wall that maintains the integrity of membranes; in seeds, it is present as a Ca-phytate. Calcium is involved in cell division (mitosis) as well as in maintaining chromosome structure. It regulates the growth of meristems and functioning of the root tips and also protects the root cells against the ion imbalance, low pH and toxic effects of Al, Fe, etc. (ICAR, 2006). Magnesium is an essential component of the chlorophyll. It regulates the activities of several enzyme systems involved in the synthesis of nucleic acids and metabolism of carbohydrates (ICAR, 2006).

In plants, Cu plays an important role as a constituent of superoxide dismutate, plastocyanin which is the main component of the electron transport of photosystem, ascorbate oxidase that catalyses the oxidation of ascorbic acid to dehydroascorbic acid, polyphenol oxidase that catalyses the oxidation of phenolics as precursors of lignin, and diamine oxidase that provides the H_2O_2 required for oxidation by peroxidases in lignifications of cell walls (ICAR, 2006). Zinc is a constituent of carbonic anhydrase, alcoholic dehydrogenase, superoxide dismutate, etc. The carbonic anhydrase is localized in the cytoplasm and chloroplast where it causes reversible hydration of CO_2 to form HCO_3^- for transport and utilization of CO_2 in photosynthesis and resist pH changes in cytoplasm:

$$2H_2O + CO_2 \longrightarrow HCO_3^- + H_3O^+$$

Ni is essential for hydrogenase, methyl reductase and urease activities that regulate nitrogen metabolism. It is also needed for grain filling and seed vitality (ICAR, 2006). Fe is absorbed by plants in the form of Fe^{2+}. It is a constituent of heme and non-heme proteins. The heme protein contains Fe-porphyrin complex molecule, a prosthetic group of cytochrome, haemelin, ferrichrome, oxidase, catalase, peroxidase and leg hemoglobin enzymes. These are involved in redox reactions in respiration and photosynthesis. The non-heme contains stable Fe-S protein necessary for the synthesis and maintenance of chlorophyll in plants and also plays an important role in nucleic acid synthesis. Pb and Cd are non-essential elements in plant; Pb is not readily translocated from root to shoot (Anthony and Balwant, 2009).

Amaranth (*Amaranthus caudatus*) is a quick–growing green leafy vegetable which grows on a wide variety of soils. It is a C4 plant as it can efficiently use CO_2 and suppress its photosynthesis loss. Roselle (*Hibiscus sabdariffa*) is an annual herb of the Malvaceae family and genus Hibiscus with the green and red as the two common varieties. Kenaf (*Hibiscus canabinnus*) is a plant in the Malvaceae family and genus Hibiscus. It is a non-woody annual herbaceous plant with a 1 to 2 diameter stem which grows in varied types of soil - sandy loam to clay - and also tolerate moderate acidic and saline soils. Aliero is one of the 21 local governments of Kebbi State in Northwestern Nigeria, with its headquarters in the town of Aliero. It is located in the southeast of the state (12°16' 42'' N 4°27'6''E). The aim of this research was to investigate and compare the concentrations of selected macro and micro elements within each vegetable species and their soils from the six study areas as well as each vegetable's ability to absorb and retain the micro elements.

MATERIALS AND METHODS

Sample collection

About 1 kg of both the vegetables and their soils (0 to 30 cm depths) in triplicate from each of the following fadama areas - Rigiyan Marina, Kwadarko, Shaya, Tagango Chinbila and Allanka, were randomly collected and labeled as A to F respectively. The collections were made between the fifth and sixth week after sowing of each of the vegetables in the year 2008.

Vegetable sample treatment

Each set of the vegetables were washed before air drying and pulverised in a porcelain mortar, sieved through 20-mesh sieve (0.85 mm) and stored in plastic containers (Miroslav and Vladimir, 1999; Hassan et al., 2005).

Soil sample treatment

The soils were air-dried, crushed and sieved using 10-mesh sieve to separate the fine earth fractions (2 mm) from coarse materials and stored in clean polyethylene bags for pH and metal analysis (Aiboni, 2001).

Quality assurance

All reagents used in this work were of analytical grades and double distilled water was used throughout the analyses. The glass wares, plastic containers, crucibles, mortar and pestle were washed with liquid soap, rinsed with water and then soaked in 15% HNO_3 for 48 h before rinsing with distilled water and dried in an oven at 55℃ for 5 h (Uba and Uzairu, 2008).

Analysis of macro elements in the vegetables

The digestion processes in triplicates were carried out by weighing 1.0 g of each of the powdered sample into separate 100 cm^3 Kjeldahl flasks; 30 cm^3 of 69.5% (w/w) HNO_3 were added to each of the flasks and heated until about 10 cm^3 of each of the solution remained. This was followed with the addition of 2 cm^3 of 60% $HClO_4$ acid, 10 cm^3 of 69.5% (w/w) HNO_3 and 1 cm^3 of 98% (w/w) H_2SO_4 into each of the flasks. The mixtures were further heated in a fume cupboard until the appearance of white fumes. The resulting solutions after cooling were each filtered into separate 50 cm^3 volumetric flasks and diluted to the mark with distilled water (Miller and Baker, 2000; Daniel, 2003). Na and K were determined by flame emission spectroscopy (Corning 400 model), P was determined by colorimetric (phosphor-vanadomolybdate) method using spectrophotometer (6100, Jenway, UK). Mg and Ca were determined by AAS (S4 Atomic Absorption Spectrometer Thermo Electron, Cambridge, 2002).

Spiking experiment

The spiking experiment was carried out to test for the validity of the digestion procedure and analysis of the trace metals. The multi-element standard solution (30 cm^3) was pipetted to spike 1.0 g of the amaranth samples in a digestion flask. The same digestion procedure for the trace metals was adopted (Daniel, 2003; Uba and Uzairu, 2008).

Analysis of trace elements in the vegetables

The process was carried out in triplicates by weighing out 1.0 g of each of the dried and powdered samples into separate digestion tubes; 30 cm^3 of 69.5% (w/w) HNO_3 acid was added to each and heated until about 10 cm^3 was left. This was followed with addition of 10 cm^3 of 69.5% (w/w) HNO_3 acid and 2 cm^3 of 60% $HClO_4$ acid and the heating process continued until clear solutions were obtained. Each of the digests was diluted with about 20 cm^3 of distilled water, boiled for another 15 min, allowed to cool, filtered into separate 50 cm^3 volumetric flasks and made to the mark with distilled water. The solutions were stored in separate screw capped polyethylene bottles (Audu and Lawal, 2006; John, 2000). Blank solution was prepared in the same way but without any sample.

Analysis of soils

The soil pH was determined at a ratio of 1:1 with distilled water. Exchangeable cations (Ca^{2+}, Mg^{2+}, K^+ and Na^+) were extracted with 1 M NH_4-acetate at pH 7. The Na^+ and K^+ were determined with a flame photometer, while Ca^{2+} and Mg^{2+} were analysed with AAS (Fasina et al., 2005; Badora and Filipek, 1998; Wilcke et al., 1998). The soil samples were prepared for trace metal analysis by refluxing 1.0 g of air dried sample with 10 cm^3 of HNO_3 for 45 min. Heating was continued with 10 cm^3 of aqua-regia and finally with 10 cm^3 HNO_3. The filtrates were diluted to the marks of 50 cm^3 volumetric flasks and the determinations were carried out using AAS (Uba and Uzairu, 2008). The available phosphorus in the soils was determined using Bray 1 method (Ibitoye et al., 2005).

Statistical analysis

Except for moisture content, mean and standard deviation of results of 3 × 3 measurements obtained in this work were on dry weight basis either expressed in mg/100 g or μgg^{-1}. One way analysis of variance (ANOVA) was used to test for significant difference at a level of $P<0.05$ within means of each of the vegetable species (John, 2000; Daniel, 2003).

RESULTS

Tables 1 and 3 present the concentrations of macro and micro elements in the vegetables expressed in mg/100 g and μgg^{-1} (dry weight) respectively from the six study areas. The highest values for P concentration in amaranth, roselle and kenaf were observed in samples from sites A, C and E respectively. For Na concentration, the highest value in amaranth was in samples from site E and in both roselle and kenaf, the values were in samples from site F. The highest values for the concentrations of K were observed in both amaranth and kenaf from site D and in roselle from site A. The highest values for the concentrations of Ca in both amaranth and kenaf were in samples from site F and in roselle from site D, while for Mg concentration, the values in both amaranth and kenaf were observed in samples from site A and in roselle from site D.

The highest values for Fe concentrations in the vegetables were observed in samples from site D and for Cu concentration, the values in both amaranth and kenaf were in samples from site B and site E for roselle. The highest values for Zn concentrations in both roselle and kenaf were in samples from site D and site A for amaranth, while for Mn concentrations, the values in roselle and kenaf were in samples from site A and site D for amaranth. The highest values for Ni concentrations in amaranth, roselle and kenaf were in samples from sites F, E and A respectively. For Pb, the highest values in amaranth and roselle were in samples from site E and site D for kenaf and for Cd, the values in the vegetables were in samples from site B.

Table 2 presents the results of the application of the method of standard additions to the amaranth samples which serve as a final test of the adopted analytical method and provided estimates of the contents of trace metals. The results obtained showed that the method offered a satisfactory precision of the measurements and good sensitivity for each of the elements determined (Uba and Uzairu, 2008).

Tables 4 and 5 present the concentrations of the exchangeable cations and micro elements in soils where the vegetables were collected, expressed in μgg^{-1}. The highest values for P in the soils were in samples from site D and for Na^+ concentrations, the values in soils for amaranth and kenaf were in samples from site D and F for soils of roselle. Like what was observed for P, the highest values for K^+ in the soils were in samples from

Table 1. Macro element concentration (mg/100 g dry weight) in the vegetables.

Vegetable	Site	P	K	Na	Ca	Mg
Amaranth	A	663.07±27.82	1448.89±178.92	19.06±1.90	501.74±101 .92	1695.52±344.75
	B	374.81±39.15	967.69±67.36	24.17±3.93	343.47±59.75	1169.33±91.73
	C	357.79±24.14	1078.03±73.89	22.01±1.74	809.84±22.1 8	689.07±33.92
	D	327.36±110.27	1911.11±449.85	20.28±2.13	659.17±12 4.47	1598.68±677.12
	E	390.64±36.35	1022.06±70.07	33.02±3.13	997.06±283. 39	1247.86±48.14
	F	461.75±62.83	1350.56±159.29	28.50±3.04	1147.23±10 1.61	613.83±41.37
Roselle	A	267.08±17.41	2022.18±288.70	16.61±0.99	416.08±09. 87	867.82±211.17
	B	272.98±56.16	789.69±140.48	19.47±2.36	183.48±16.9 1	458.88±65.16
	C	308.12±26.82	1141.65±107.23	20.46±1.69	808.12±83. 23	638.39±39.67
	D	243.06±12.61	1011.11±296.63	10.14±1.27	860.03±108 .05	959.98±307.91
	E	261.63±28.85	948.49±69.67	25.41±2.43	689.67±206.4 5	475.78±79.95
	F	266.66±37.46	951.91±96.66	35.33±2.36	817.13±89.91	512.26±47.89
Kenaf	A	258.61±05.06	915.56±70.55	17.78±1.03	418.04±21.12	827.56±97.94
	B	351.98±27.52	945.02±71.58	18.03±2.10	245.98±71.42	386.38±29.26
	C	324.44±35.77	684.43±58.02	23.17±1.11	791.77±28.37	654.81±33.48
	D	214.03±7.12	1238.89±126.93	12.33±0.28	909.15±104. 83	789.02±174.70
	E	352.42±40.97	765.77±80.86	24.76±3.43	561.27±186.9 5	625.76±217.52
	F	249.66±29.78	856.54±64.08	35.07±1.55	924.29±45.68	414.03±50.81

A= Rigiyan Marina, B= Kwadarko, C= Shaya, D= Tagango, E= Chinbila and F= Allanka. Values are means and S.D of means. Means within columns for each vegetable species indicated significant difference at a level of P<0.05

Table 2. Mean percentage recoveries of trace metals from spiked amaranth samples.

Trace metal	Expected conc. in spiked sample digest in μgg^{-1}	Observed conc. in spiked sample digest in μgg^{-1}	% Recovery
Fe	5079.69	4931.27	97.08
Zn	5012.18	4755.56	94.88
Mn	5040.56	4842.47	96.07
Cu	5050.64	4874.88	96.52
Ni	5015.58	4709.63	93.90
Pb	5002.36	4629.18	92.54
Cd	5000.28	4645.27	92.90

Average of three observations of the spiked amaranth samples.

site D. For Ca^{2+}, the highest values for soils of amaranth and roselle were in samples from site A and site C in soils for kenaf, while for Mg^{2+}, the values in soils for roselle and kenaf were in samples from site D and site A in soils for amaranth. For Fe, the highest values in soils for roselle and kenaf were in samples from site D and site A in soils for amaranth. The highest values for Zn were in soil samples from site E, for Cu, the values in soils of amaranth and kenaf were in samples from site E and site B in soils for roselle. Like in Zn, the highest values for Mn concentrations in the soils were in samples from site E, while the values for Ni in the soils were in samples from site C. For Pb, the highest values in soils for amaranth and Kenaf were in samples from site C and site B in soils for roselle, while the values for Cd in soils for amaranth and kenaf were in samples from site E and site D in soils for roselle.

Table 6 presents the transfer factor (TF) values for the heavy metals from soils to the vegetables. Transfer factors quantify the relative differences in bioavailability of a metal to a plant; it identifies the efficiency of the plant species to accumulate a given heavy metal. The transfer factors considered only the root uptake of the metals and discount the folliar absorption of atmospheric metal

Table 3. Micro element concentration (µgg^{-1} dry weight) in the vegetables.

Vegetable	Site	Fe	Cu	Zn	Mn	Ni	Pb	Cd
Amaranth	A	1075.79±70.71	23.37±06.35	48.22±9.16	37.81±5.35	2.94±1.38	1.52±1.23	0.07±0.09
	B	158.79±74.41	90.07±12.52	20.44±1.84	38.39±10.15	7.46±1.12	2.88±1.21	1.47±0.48
	C	68.35±03.59	17.26±01.26	13.17±1.19	18.24±2.03	3.52±0.18	1.85±0.27	0.30±0.20
	D	1287.81±102.32	36.70±05.24	46.23±4.44	78.94±23.43	2.34±0.72	2.61±1.04	0.14±0.16
	E	94.73±49.73	81.75±26.14	18.77±2.33	43.38±3.89	12.65±2.38	5.35±2.65	0.26±0.14
	F	76.42±06.95	13.32±03.32	10.40±1.44	11.80±1.54	2.74±0.35	1.88±0.77	0.27±0.14
Roselle	A	861.01±186.85	23.77±05.02	32.92±3.54	104.39±15.12	5.94±2.19	2.60±1.62	0.12±0.09
	B	131.48±32.17	71.90±09.46	16.39±3.96	69.12±26.64	5.24±0.87	4.19±2.45	2.07±1.00
	C	75.26±09.43	17.06±02.45	11.83±1.13	16.57±2.09	4.58±1.40	2.27±0.94	0.22±0.11
	D	1195.32±57.17	32.78±06.15	42.64±6.69	88.87±23.46	3.01±1.08	3.58±0.77	0.18±0.09
	E	59.87±28.00	83.64±12.51	19.06±6.57	71.70±20.80	8.49±2.07	4.47±1.82	0.09±0.07
	F	83.51±09.45	22.27±02.16	13.99±1.09	21.42±2.80	5.15±0.95	1.17±0.21	0.25±0.16
Kenaf	A	715.24±215.04	16.07±05.86	29.04±7.38	95.80±17.03	8.57±2.97	0.98±1.09	0.03±0.05
	B	76.00±18.57	76.51±06.14	12.11±1.13	59.60±4.96	2.52±0.72	2.39±1.94	2.04±0.53
	C	85.83±03.71	16.73±01.02	15.06±1.03	18.13±1.67	4.06±1.06	2.06±0.21	0.37±0.14
	D	1174.21±26.66	24.17±07.62	35.78±5.96	41.19±8.16	1.84±0.36	5.56±2.93	0.11±0.04
	E	92.26±06.45	52.35±14.57	13.76±2.06	56.72±8.73	6.49±0.68	2.65±0.49	0.42±0.33
	F	116.65±17.43	13.72±02.18	19.05±1.06	13.17±1.82	4.31±0.92	1.13±0.28	0.59±0.52

A= Rigiyan Marina, B= Kwadarko, C= Shaya, D= Tagango, E= Chinbila and F= Allanka. Values are means and S.D of means. Means within columns for each of the vegetable species indicated significant difference at a level of P<0.05.

Table 4. pH, available phosphorus and cation concentration in soils of the vegetables.

Soil	Site	pH	P	Na^+	K^+	Mg^{2+}	Ca^{2+}
SAM	A	6.45±0.42	6.34±1.55	32.22±14.60	60.00±08.29	55.87±6.17	44.71±9.03
	B	6.38±0.46	6.32±1.48	28.00±1.96	72.77±15.32	38.78±3.19	38.33±2.99
	C	7.04±0.37	2.76±0.73	25.33±1.90	46.37±07.43	37.03±1.24	43.52±3.42
	D	7.14±0.16	11.76±0.75	42.78±11.21	238.89±21.18	46.39±14.51	29.79±6.72
	E	6.82±0.08	0.71±0.21	22.52±2.03	59.08±15.95	34.85±3.17	32.37±2.10
	F	7.36±0.16	3.50±0.53	27.86±4.68	30.28±03.50	33.46±2.16	41.59±4.76
SRO	A	6.57±0.22	4.62±0.48	25.00±3.54	47.22±09.72	24.31±4.16	52.27±8.24
	B	7.00±0.22	5.62±1.08	22.24±2.43	60.30±12.62	31.20±2.87	28.88±3.03
	C	6.70±0.40	2.73±0.71	25.92±4.10	34.51±06.05	35.14±3.59	40.58±4.82
	D	6.95±0.20	10.84±1.05	24.44±4.64	88.89±24.21	63.40±9.32í!	41.34±8.56
	E	7.37±0.31	0.93±0.21	23.45±1.49	56.41±23.23	23.69±2.45	37.70±2.48
	F	6.81±0.36	1.95±0.62	27.79±2.09	37.08±05.03	27.66±2.77	43.86±2.11
SKE	A	7.29±0.43	6.50±0.69	22.78±3.63	100.00±10.90	46.07±10.23	36.47±6.75
	B	7.13±0.50	5.95±1.58	35.05±4.59	80.36±19.45	32.72±2.57	36.41±4.04
	C	7.13±0.50	3.25±0.93	23.27±1.69	36.49±04.86	35.03±6.03	44.83±3.65
	D	6.58±0.47	10.47±0.17	67.22±4.41	403.89±61.33	48.95±11.14	30.50±12.55
	E	7.07±0.04	0.81±0.13	20.98±2.21	52.10±11.61	25.75±1.69	27.86±2.86
	F	7.04±0.22	2.34±0.65	27.82±3.90	25.75±01.94	33.68±4.36	41.94±4.18

SAM= soils of amaranths, SRO= soils of roselle and SKE= soils of kenaf.A= Rigiyan Marina, B= Kwadarko, C= Shaya, D= Tagango, E= Chinbila and F= Allanka. Values are means and S.D of means. Means within columns for soils of each of the vegetable species indicated significant difference at a level of P<0.05.

Table 5. Micro element concentration (µgg^{-1}) in the soil of the vegetables.

Soil	Site	Fe	Zn	Cu	Mn	Ni	Pb	Cd
SAM	A	11804.09±1801.62	03.59±1.08	23.02±02.38	42.80±15.54	0.17±0.14	1.48±0.61	0.58±0.05
	B	2718.87±305.00	17.90±4.71	69.34±14.69	151.75±14.18	5.20±1.54	8.25±3.71	1.24±0.70
	C	0624.27±044.38	17.26±1.10	17.26±01.89	38.03±02.18	6.82±1.47	9.02±2.81	0.73±0.32
	D	11754.09±1801.62	03.73±0.74	17.25±03.31	110.75±42.69	0.15±0.05	0.75±0.32	0.52±0.18
	E	2783.28±185.39	20.16±3.37	69.42±07.65	168.69±91.41	5.18±0.95	2.08±0.75	2.17±1.41
	F	0492.85±036.21	12.78±3.18	10.16±01.39	24.99±03.79	5.81±1.50	4.21±1.33	0.75±0.23
SRO	A	11184.09±1793.78	04.54±0.50	19.41±02.36	63.08±25.10	0.35±0.17	1.11±0.13	0.83±0.22
	B	1183.26±125.20	14.09±2.38	61.23±07.65	77.75±19.17	7.96±1.16	7.01±5.28	1.46±0.46
	C	0811.49±056.82	09.28±1.55	19.06±01.50	34.04±04.11	11.55±2.72	7.00±1.63	0.37±0.10
	D	11965.39±1196.78	02.73±0.33	15.07±03.78	75.04±32.38	0.22±0.04	0.70±0.15	2.39±2.66
	E	1372.82±265.75	14.43±1.52	53.61±09.59	81.56±22.73	6.09±0.85	3.54±1.92	1.29±0.59
	F	0636.91±051.16	13.81±2.00	14.76±01.09	26.30±02.77	8.30±2.71	4.64±1.66	0.67±0.35
SKE	A	11077.36±2512.21	03.60±0.45	16.19±01.54	93.88±28.37	0.24±0.17	1.93±1.30	0.61±0.08
	B	1267.97±489.33	12.79±3.42	54.06±21.81	158.73±24.80	6.17±2.40	5.42±2.95	1.31±0.98
	C	0713.65±039.95	11.44±2.50	17.93±01.62	34.63±03.26	11.31±2.07	7.88±1.60	0.80±0.30
	D	14134.00±1757.54	01.41±0.43	22.09±02.66	94.04±34.93	0.13±0.06	0.72±0.28	1.65±1.91
	E	3738.96±1613.63	34.47±21.75	71.75±03.22	175.14±54.87	5.26±1.32	3.11±1.79	2.90±0.77
	F	0554.21±051.75	12.18±2.18	13.26±01.59	25.52±02.20	6.02±2.09	3.37±0.77	0.88±0.41

SAM= soils of amaranths, SRO= soils of roselle and SKE= soils of kenaf. A= Rigiyan Marina, B= Kwadarko, C= Shaya, D= Tagango, E= Chinbila and F= Allanka. Values are means and S.D of means. Means within columns for soils of each of the vegetables species indicated significant difference at a level of P<0.05.

Table 6. Transfer factor (TF) for the micro elements from soil to individual vegetable.

Vegetable	Site	Fe	Zn	Cu	Mn	Ni	Pb	Cd
Amaranth	A	0.11	2.47*	1.59*	1.84*	0.72	0.93	0.24
	B	0.04	1.05*	1.18*	0.29	2.43*	0.65	0.21
	C	0.11	0.60	0.77	0.31	0.40	0.21	0.37
	D	0.09	2.02*	1.36*	0.34	0.99	0.63	0.14
	E	0.06	1.01*	1.50*	0.23	1.44*	1.39*	0.68
	F	0.14	1.08*	1.70*	0.73	0.61	0.44	0.40
Roselle	A	0.11	2.02*	1.69*	1.41*	0.69	0.95	0.22
	B	0.05	1.35*	1.37*	0.92	1.07*	0.64	0.06
	C	0.10	1.51*	1.17*	0.63	0.45	0.17	0.68
	D	0.07	1.54*	1.58*	1.39*	0.85	0.95	0.05
	E	0.10	1.14*	1.34*	0.85	0.86	1.18*	1.61*
	F	0.12	0.86	1.16*	0.63	0.55	0.49	0.33
Kenaf	A	0.11	1.87*	1.49*	0.44	0.57	0.95	0.18
	B	0.07	1.08*	0.97	0.36	1.05*	0.49	0.32
	C	0.16	1.67*	0.77	0.38	0.38	0.14	0.74
	D	0.05	1.39*	0.73	1.02*	1.06	0.58	0.02
	E	0.02	0.35	1.07*	0.34	0.48	0.77	0.70
	F	0.16	1.24*	1.26*	0.71	0.67	0.61	0.39

A= Rigiyan Marina, B= Kwadarko, C= Shaya, D= Tagango, E= Chinbila and F= Allanka. *The transfer factor value indicates that the concentration of the element in the vegetable depends on soil concentration.

deposits (Amusan et al., 2005; Uwah et al., 2009).

The transfer factors values for Fe, Pb (except in amaranth and roselle from site E) and Cd (except in roselle from site E) from soils to the vegetables were below 1, while the values for Zn and Cu were generally above 1. The transfer factor values for Mn were less than 1 except in amaranth and roselle from site A as well as in kenaf from site E. The values for Ni were also below 1 except in amaranths from sites B and E, roselle from site B, and kenaf from sites B and D.

DISCUSSION

Macro and micro element concentration in the vegetables

There was no consistency in the trend for the response of each of the vegetables to the concentrations of macro elements, but significant differences at a level of $P<0.05$ were observed within each of the vegetable species from the six study areas. The differences observed indicated that difference in environment (sites of collections) had effect on the concentrations of the elements in the vegetables. The mean values observed for Na in the vegetables were within the range of 2 to 150 mg/100 g reported by Lintas (1992). Except for roselle from site A, the values for K concentration were lower than 1970 mg/100 g reported by Sena et al. (1998). Only amaranths from site A indicated mean value for P concentration which compared well with 664 mg/100 g reported in roselle by Sena et al. (1998). The concentration of Mg in roselle from sites A and D were slightly higher than 786.50 mg/100 g reported by Sena et al. (1998). Like what was observed for the macro elements, the vegetables also showed different trends in their responses to the concentrations of the micro elements. Generally, site D and its vegetables were observed to be richer in the nutrients than others. Similarly, like what was observed for the macro elements, significant differences at a level of $P<0.05$ were observed in the concentrations of each of the micro elements within each of the vegetable species. Also, difference in environment (sites of sample collection) had effect on the concentrations of micro elements in the vegetables. Except for amaranths from sites A and D, and roselle and kenaf from site D, other vegetable samples had values that were within the range of 18 to 1000 μgg^{-1} as the natural content of Fe in folder plants (Adeyeye, 2005). Amaranth and rosellle from site B as well as kenaf from site F had values that were within the range of 100 to 500 μgg^{-1} reported as normal Fe concentration by ICAR (2006). Generally, all the vegetable samples had values that exceeded the maximum permissible level of 150 μgg^{-1} fresh weight recommended by WHO (Lone et al., 2003). Only amaranth from sites C and F, roselle from site C, and kenaf from sites A, C and D had values that were within the range of 5 to 20 μgg^{-1} recommended as normal Cu concentration in plants (ICAR, 2006). Similarly, the values for roselle samples were higher than 13.45 μgg^{-1} reported for roselle by Sena et al. (1998). Except for samples from sites B and E, the values for the vegetables were below the 40 μgg^{-1} fresh weight recommended as the critical level for Cu concentration in vegetables by WHO/FAO (Afshin and Masoud, 2008). For the concentration of Zn in the vegetables, the values observed were within the range of 5 to 300 μgg^{-1} reported by Audu and Lawal (2006) while most samples had values that were lower than the range of 20 to 150 μgg^{-1} reported as normal Zn concentration in plants (ICAR, 2006). The concentrations of Zn in the samples (except kenaf from site E) were within the 20 μgg^{-1} fresh weight established by Chinese Department of Preventive Medicine (Ejaz ul et al., 2006). Only roselle from site A had mean value that compared well with 114 μgg^{-1} reported for Mn concentration by Sena et al. (1998). Similarly, value as high as 832.83 μgg^{-1} was reported in amaranths by Uba and Uzairu (2008). The values generally exceeded the permissible limit of 6.61 μgg^{-1} fresh weight recommended for Mn by WHO (Lone et al., 2003). The values observed for Ni concentration in the roselle samples were slightly lower than 8.00 reported for roselle by Sena et al. (1998). Except the values for amaranth samples from E, the values for the vegetables were below the maximum limit of 10 μgg^{-1} fresh weight recommended for Ni by WHO (Lone et al., 2003). The values obtained for Pb were generally lower than the range of 11.23 to 16.99 μgg^{-1} reported in vegetables by Afshin and Masoud (2008), but higher than the range of 0.36 to 1.60 μgg^{-1} reported by Audu and Lawal (2006). Except for amaranth from site E, roselle from sites B and E, as well as kenaf from site D, the values for Pb in the samples were within the range of 1.70 to 3.95 μgg^{-1} reported by Uwah et al. (2009). Apart from amaranth from sites A, C and F, roselle from site F and kenaf from sites A and F, the vegetables indicated values that exceeded the maximum level of 2.00 μgg^{-1} fresh weight recommended for Pb in vegetables by WHO (Lone et al., 2003). Except for samples from site B, the values for Cd in the vegetables were either below or were within the ranges of 0.20 to 0.65 μgg^{-1} reported by Afshin and Masoud (2008). Generally, the values exceeded the 0.2 μgg^{-1} fresh weight recommended as the maximum permissible level of Cd in vegetables by FAO/WHO (Afshin and Masoud, 2008).

Macro and micro element concentration in the soils

The availability of elements to plants is influenced by various soil factors, among which, according to literature data, is soil reaction. Soil reactions are observed at pH <4.2 (Badora and Filipek, 1998). The pH range of 6.38 to 7.37 in the soils indicates that the soil reaction was almost neutral.

Generally, significant differences at a level of $P<0.05$ were observed for each of the macro elements within soils of each of the vegetable species. Like in the vegetables, the differences observed indicated that difference in environment (sites of sample collection) had effect on the concentrations of the elements in soils. The reasons for such differences may be attributed to both natural and anthropogenic activities on the soils. Except for soils of amaranth from site D and kenaf from sites B and D, the values of other samples were lower than the range of 33 to 41.30 μgg^{-1} reported for Na^+ in soils by Dauda (2008). Except for soils of amaranth and kenaf from site F, the values for other samples were higher than the range of 28.50 – 31.50 μgg^{-1} reported for K^+ by Dauda (2008), but all values were lower than the range 180 to 210 μgg^{-1} reported by Kashif et al. (2009). The values for Mg^{2+} and Ca^{2+} were generally within the ranges 9.30 to 694 μgg^{-1} (Ca^{2+}) and 5.00 to 134.37 μgg^{-1} (Mg^{2+}) reported by Buszewski et al. (2000).

Significant differences at a level of $P<0.05$ were also observed in the concentrations of the micro elements within soils of each of the vegetable species. The mean values for Fe were generally within the range of 2,000 to 50,000 μgg^{-1} reported for German soils by Kretzschmar et al. (1998). For Cu concentration, the values obtained were generally >0.50 to 3.60 μgg^{-1} reported by Tanko et al. (2009), while only values for soils of amaranth and kenaf from site B as well as soils of kenaf from site E were within the range of 36.5 to 72.99 μgg^{-1} reported by Amusan et al. (2005). Generally, the values were within the range of 1 to 40 μgg^{-1} reported as normal Cu concentration in German soils (Kretzschmar et al., 1998). Mean values that are as high as 63.20 μgg^{-1} and 102.11 μgg^{-1} were reported for Zn concentration in soils by Amusan et al. (2005). Except in few cases, the values observed were within the range of 10 – 300 μgg^{-1} reported by Alloway (1990) as normal Zn concentration in soils. All values for Mn concentration in the soils analysed were within the range of 20 to 800 μgg^{-1} reported as normal in German soils (Kretzschmar et al., 1998). The values for Ni concentration in the soils were either lower or within the range of 5 to 500 μgg^{-1} reported as normal in soils by USPHS (1997). For Pb concentration, the values observed in this work were much lower than the values reported by Amusan et al. (2005) and Uba and Uzairu (2008). Only soils of amaranth from site E, roselle from site D and kenaf from site C gave values that were slightly above the range of 0.01 to 2.00 μgg^{-1} reported as normal Cd concentration in soils by Alloway (1990).

Transfer factors for heavy metals from soils to vegetables

From the observed trend in the transfer factor values for all the micro elements in the vegetables, it was clear that the concentration of Fe in the vegetables, Pb in kenaf and Cd in amaranth do not depend on their concentrations in the soil. The trend was slightly different for the concentration of micro elements in other vegetables, generally the trend also indicated that the concentration of the elements (except Zn and Cu) are less affected by their concentrations.

Conclusion

The vegetables and soils from the six study areas have indicated the presence of all the elements in varying concentrations. Significant differences at a level of $P<0.05$ were observed in the concentrations of the elements within each species of the vegetables. Like in the vegetables, significant differences were also observed in the concentrations of the elements within soils of each species of the vegetables. The trends in the responses of the vegetables and soils to the concentrations of the elements were different. Such responses of the vegetables and their soils to the elements could be due to the difference in the soil composition and the concentrations of the elements, individual plant's level of growth and development, as well as its requirements and ability to absorb and retain an element. From the observed trend in the transfer factor values for all the micro elements in the vegetables, it was clear that the concentrations of the elements (except Zn and Cu) in the vegetables are less affected by their concentrations in the soil.

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