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Uptake and Bioaccumulation of Selected Heavy Metals in Selected Vegetables in Bokkos L.G.A, Plateau State

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ABSTRACT
The concentrations of some heavy metals (Cd, Cu, Fe, Mn, Pb, Cr and Zn) were investigated in selected vegetables (Carrots, Cabbage and Spinach) and the soil on which the vegetables were grown. Sample digestion was carried out in aqua regia and the analytes were quantified using Atomic Absorption Spectrophotometer, model 210 VGP (AAS). The concentrations of these heavy metals in vegetables is as follows: Cd ranges from 0.002- 0-019 mg/kg, Cu (0.082- 0.457 mg/kg), Cr (0.033- 0.138 mg/kg), Fe (1,215- 9.837 mg/kg), Mn (0.708- 7.822 mg/kg), Pb (0.015- 0.088 mg/kg) and Zn (2.293- 4.900mg/kg). while in the soil samples, the various concentrations ranges from 0.005-0.045 mg/kg for Cd, 0.277 - 1.287 mg/kg for Cu, 0.018- 0.620 mg/kg for Cr, 19.334-25.132 mg/kg for Fe, 1.196- 17.118 mg/kg for Mn, 0.089-0.471 mg/kg for Pb and 1.090- 5.275 mg/kg for Zn. The bioaccumulation studies show that cabbage has the highest absorption followed by carrot while the least absorption was observed in spinach. All the metals studied had concentrations within the WHO/FAO guidelines with the exception of Zn and Fe whose concentrations were slightly higher than the recommended values.

KEY WORDS: *vegetables, heavy metals, bioaccumulation, AAS, concentration*

INTRODUCTION
Contamination of environment by heavy metals is considered most serious environmental problem and has significant implication for human health. The vulnerability of vegetables plants to heavy metals ca

/not be under estimated-[\ / as continuous activities such as natural (geological) and anthropogenic (human) activities tempers with the environmental stability. This has given rise to the need for assessing the concentration of these toxic metals in vegetables to assess their toxicity in human. The contamination of these vegetables with heavy metals results from the contamination of soil and water thereby posing severe threat to its quality and consumption safety by human.

Vegetables plants forms the major component of most African dishes providing the most needed nutritional needs of the consumers such as minerals, vitamins, iron, protein and other nutritional requirement.

The demand for better quality vegetables by consumers is on the increase. Heavy metal rank high amongst the chief contaminants of leafy vegetable (Mapanda, Mangwayana, Nyamangera And Giller, 2007). Leafy vegetables have greater potential of accumulating heavy metals in their edible parts than grain or fruit crops.

Contamination of the human food chain by heavy metals is not directly affected by the plants total uptake but rather by the concentration in those parts that are directly consumed (Mapanda et al, 2007).

Since vegetables are major component of human diet their contamination by heavy metals cannot be under estimated; because they are rich sources of vitamins, minerals and fibres and also have beneficial antioxidative effects. However, taking of heavy metals contaminated vegetable may pose a great risk to human health.

The contamination of food items by heavy metals is one of the most important aspects of food quality assurance (Marshall, 2004, Radwan and Salama, 2006, Khan et al, 2008).

Heavy metals are non-biodegradable and persistent in the environment, can reach toxic level in vegetables, thus decreasing both yield and quality (Sharma et al, 2009). Heavy metals pollution is attributed to waste water irrigation, excessive agrochemical usage or atmospheric pollutant deposition.

MATERIALS AND METHOD

All chemicals and reagents used are of analytical grade obtained from BDH and used without further purification.

Study Area

Bokkos is one of the 17 Local Government Area of Plateau state with the population of 178, 454 (census 2006). Bokkos is situated at Latitude 9.168IN and Longitude 8.924^{o}E with the area of 1,682 Km^{2} and has a profound history of mining and farming activities.

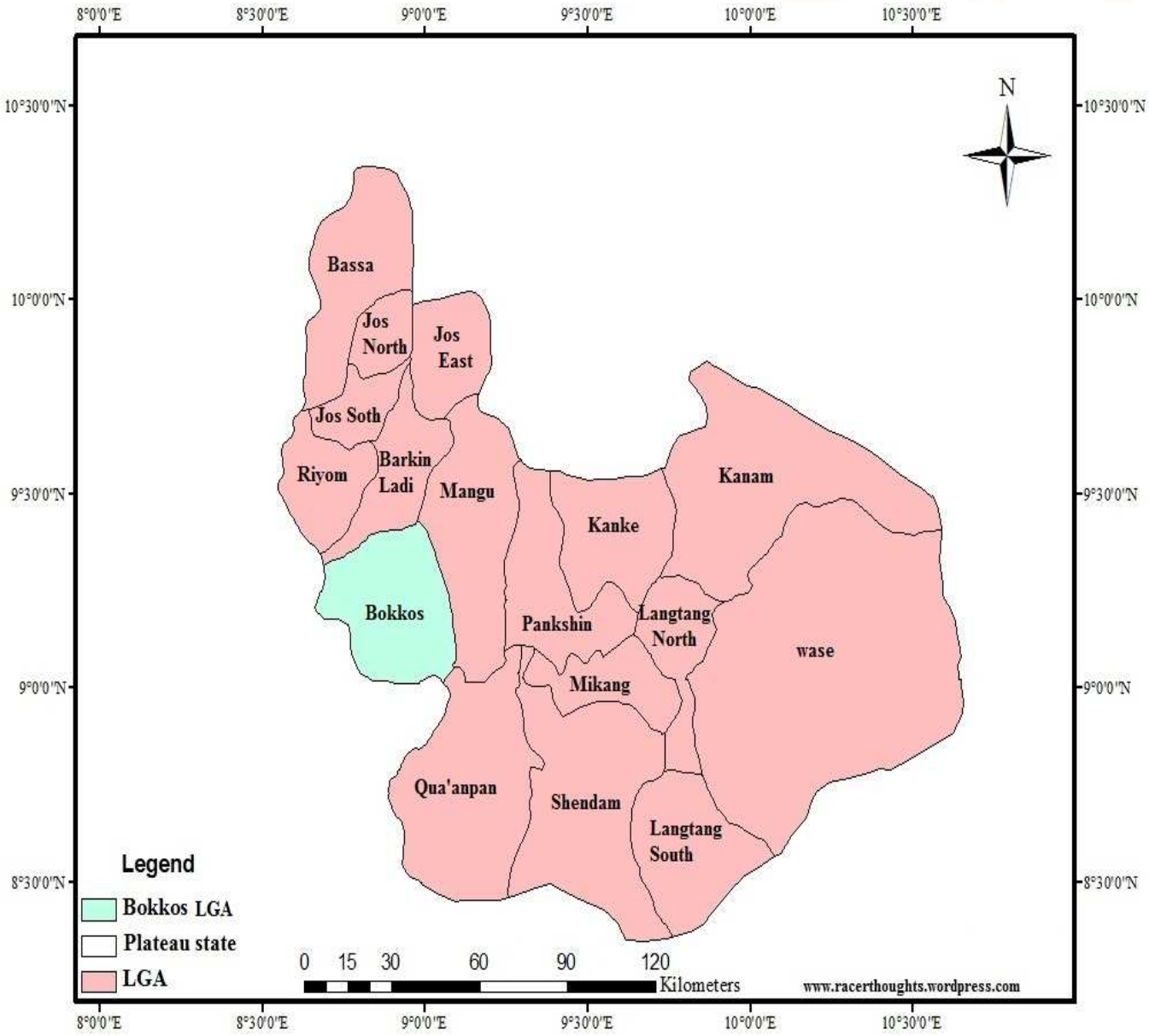

Figure 1 shows the map of plateau state with the area of concern highlighted

SAMPLE COLLECTION AND TREATMENT

Six samples of vegetable were collected in three different locations with soil samples taken at the same spot were the vegetables were taken into a clean Polyethylene bags, the vegetables samples were washed with distilled water to remove dust particles. The vegetables sample, were cut to small pieces using clean knife and dried is an oven at 100^{o}C.

After drying the samples were grinded into a fine powder using a commercial blender and stored in polyethylene bags, until used for acid digestion. The soil samples was collected using stainless steel spoonfrom the three different locations into a clean polyethylene bags and air dried in laboratory and grinded and sieved with 2mm sieve and stored for digestion.

The soil and vegetable samples were digested for heavy metal analysis using aqua regia (mixture of concentrated hydrochlorine acid (HCl) and nitric acids (HNO_3) in the ratio of (HCl: $HN0_3$) of 3:1 digestion method (Baker and Amacher, 1982) and refluxed. The digested mixture was centrifuged at 1500 rpm and the supernatant analyzed for cu, Zn, Cr, Cd, Pb, Fe, and Mn using AAS Model 210 VGP.

RESULTS AND DISCUSSION

Table1. Concentration of metals in Soil (mg/kg)

Sample	Cd	Cu	Cr	Fe	Mn	Pb	Zn
A	-0.0032± 0.0001	0.2765± 0.0491	0.0180± 0.0097	25.1320± 0.2500	17.1180± 0.1000	0.1667± 0.0232	4.0750± 0.0090
B	0.0049± 0.0007	0.9044± 0.0118	0.1811± 0.0321	20.2640± 0.0870	11.5420± 0.0760	0.4621± 0.0022	4.7780± 0.0020
C	0.0061± 0.0007	0.2917± 0.0075	0.1716± 0.0197	19.3340± 0.0920	1.5100± 0.0220	0.0925± 0.0034	1.0900± 0.0160
D	0.0448± 0.0006	1.2874± 0.0193	0.6198± 0.0448	21.6480± 0.1300	1.1960± 0.0030	0.4712± 0.0025	5.2750± 0.0450
E	0.0100± 0.0025	0.5021± 0.0319	0.2783± 0.0504	19.5400± 0.0700	2.3140± 0.0110	0.0896± 0.0003	2.4410± 0.0590
F	-0.0032± 0.0001	0.2765± 0.0491	0.0180± 0.0097	25.1320± 0.2500	17.1180± 0.1000	0.1667± 0.0232	4.0750± 0.0090

Table2. Concentration of metals in Vegetables (mg/kg)

Sample	Cd	Cu	Cr	Fe	Mn	Pb	Zn
A1	0.002± 0.0050	0.456± 0.1007	0.0653± 0.0083	2.5070± 0.0300	1.2150± 0.0040	0.0159± 0.0011	2.7880± 0.2990
B1	0.019± 0.0001	0.370± 0.0036	0.0427± 0.0017	9.2080± 0.0060	1.0650± 0.0180	0.0876± 0.0034	2.2930± 0.1220
C1	0.017± 0.0008	0.2586± 0.0131	0.0550± 0.0362	5.7650± 0.0510	1.7290± 0.0120	0.0347± 0.0010	3.0890± 0.0230
D1	0.017± 0.0015	0.0821± 0.0113	0.1260± 0.0133	9.8370± 0.0270	0.7080± 0.0060	0.0242± 0.0007	4.9000± 0.0010
E1	0.017± 0.0006	0.0890± 0.0192	0.1383± 0.0092	2.1330± 0.0190	1.6460± 0.0250	0.0153± 0.0017	4.2170± 0.0150
F1	0.009± 0.0004	0.3885± 0.0233	0.0333± 0.0184	1.2150± 0.0039	7.8220± 0.1130	0.0190± 0.0028	2.7290± 0.0260

Table3. Bioaccumulation Factor (Transfer Factor)

Sample	Cd	Cu	Cr	Fe	Mn	Pb	Zn
A1/A	0.002	1.650	3.611	0.099	0.071	0.096	0.684
B1/B	3.800	0.410	4.210	0.454	0.100	0.190	0.480
C1/C	3.000	0.886	0.320	0.300	1.145	0.380	2.833
D1/D	0.400	0.063	0.203	0.454	0.591	0.050	0.930
E1/E	1.700	0.180	0.490	0.110	0.711	0.168	0.730
F1/F	0.009	1.404	1.833	0.050	0.045	0.113	0.670

Foot note: A1 cabbage from Mushere, B1 Cabbage from Kuba, C1 carrot from Mushere, D1 Spinach from Kuba, E1 carrot from Kuba, F1 Spinach from Mushere,

Heavy metals accumulation in plants is particularly a cause for concern, since plants and vegetables are inevitable in food chain and are consumed by animals and humans in immeasurable quantity. Consuming vegetables contaminated with heavy metals has different detrimental effects on human health; therefore monitoring contamination of heavy metals is key in order to avoid unnecessary exposure (Kovalchuk, 2008).

The results of heavy metals in the soil samples studied is shown in Table1, cadmium was not detected in soil sample A and F probably because their concentration is below the instrument detection limit while other metals such as Cu, Cr, Fe, Mn, Pb and Zn were all detected in the soil sample studied, generally some of this metal such as Fe are useful to the body in the formation of the red component of the blood but other such as Pb and Cd have no history of usefulness to the body. The results shows higher value in Fe and Mn and generally these two metals form part of the component of the soil i.e they are generally found in the soil. Apart from Fe and Mn that shows higher concentration, the result of Zn is also high compared with others metals like Cd, Cu, Cr and Pb. Although Cd has the least concentration among the metals studied in the soils from these farms, nonetheless, the lower concentrations can accumulate over a long period of time and probably exceed the limit provided as guideline values if great care is not taken. From Table 2 the results showed all the metals studied were available in vegetables, including those from farm A and F where Cd was not detected in the soil samples. This can be attributed to absorption either from the air/wind deposition or water. The vegetables has highest value of iron (Fe) which ranges from 1.21mg/kg to 9.837mg/kg, followed by Zn with the highest concentration of 4.900mg/kg in Spinach and least with the concentration of 2.293mg/kg in cabbage. What account for the highest concentration of Fe, Mn and Zn in these vegetables might be due to the presence of these metals in the soil were these sample were taken. However, the presence of Cd and Pb can be attributed to mining activities commonly practice in this area, combustion from vehicle as well as car batteries and tyres contributing greatly to the availability of these metals. Pb which is reported to have deformation ability in human brain and also causes serious health challenges is found in both the soil and vegetables. This calls for care otherwise consumption of these vegetable without treatment over a long period of time could lead to accumulation and the resulting affects could be fatal. Other researchers like Nazemi (2010) reported higher value of Zn in their findings than the one reported here. The value of Cd and Cr of this finding compared with the WHO guideline limit, the result is within the maximum allowable limit.

Cu in samples A, C, E and F has the mean values of 0.276, 0.291, 0.502 and 0.276 mg/kg these are within the WHO guideline value of 0.55 mg/kg. For the concentration of iron in the vegetables shown in Table 2; the concentrations are higher than WHO guideline value of 0.8 mg/kg (JEIFA, 1983). Accumulation of heavy metals in plants is particularly dangerous since plants and vegetables are at the bottom of the food chain and are consumed by animals and humans. Consuming the vegetables contaminated with heavy metals has different detrimental effects on human health. The order of the concentrations of these metals in these vegetables is as follows.

Cabbages from Mushere Zn>Fe>Mn>Cu>Cr>Ph>Cd.

Cabbage from Kuba Fe>Zn>>Mn>Cu>Pb>Cr>Cd.

Carrots from Mushere Fe>Zn>Mn>Cu>Cr>Pb>Cd.

Carrots from Kuba Zn>Fe>Mn>Cr>Cu>Cd>Pb.

Spinach from Mushere Mn>Zn>Fe>Cu>Cr>Pb>Cd.

Spinach from Kuba Fe>Zn>Mn>Cr>Cu>Pb>Cd.

Table3 shows the bioaccumulation factors which is also known as transfer factor, from this results cabbages shows to absorbed more of these metals, followed by carrots and least in spinach, this call for caution due to accumulation over a long period could lead to chronic effect.

In conclusion there is need for carefulness, because the availability of these metals even though below the guidelines values but accumulation overtime could raise the concentrations and will pose a greater risk to the consumer of these vegetables.

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