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Research Article

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Analysis of Heavy Metals Composition in Some of the Vegetables from Waste Dump Soils in Selected Urban Areas of Benue State

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Abstract

Vegetables are highly consumed in all the states across Northern Nigeria where they constitute a major source of nutritious food. Some of the vegetables that grow fast and successfully are used as source of food by all categories of households. Soil being the natural source of for food production is often contaminated with heavy metals and other toxins as result of human activities. This study was conducted to determine the presence, concentration and bioaccumulation of selected heavy metals in some of the varieties of the vegetables grown on soils containing waste dumps. The selected heavy metals were analyzed using AAS. The levels of the heavy Metals in both vegetables and their soils were generally low with Fe and Co having the highest and lowest mean values respectively. The values were within the acceptable standards indicating that the vegetable is safe for consumption. Significant differences were observed at P<0.05 between the mean values of Cu and Cr in amaranth samples and Fe in the soil samples. The Transfer Factor values were generally less than 1.00 except for Cr in samples from sites Ma and Gb and for Co in samples from site OT. Except for Cr, the TF values obtained did not provide a clear trend on the movement of the selected heavy metals from soil to the study vegetable samples. Therefore the use of soils from waste dump site for cultivation of vegetables did not impact much on the heavy metal analyzed in the vegetable samples studied.

Keywords: Vegetables, Waste dump soil, Heavy metals, Transfer factor

Introduction

Vegetables are one of the world's greatest resources of nutritious food. Cultivation of vegetables is the most common practice may currently be the most economical source of income for the people of Benue State, Nigeria. Vegetables are rich in protein, minerals, and vitamins, and they contain an abundance of essential amino acids. Therefore, vegetables can be a good supplement to cereals [1]. However, many people are apprehensive about vegetables as a food and nutritional source. There is a very high incidence of malnutrition, especially of protein deficiency in developing countries. The situation is especially severe in sub-Saharan Africa especially in Northern Nigeria where crisis happen frequently leading to malnutrition, in the Northern part of Nigeria with the highest prevalence of under nourishment with one in three people deprived of access to sufficient food [2]. Protein malnutrition will become even more acute since the supply of protein for the diet has not kept in pace with population growth [3]. A detailed account of the compositional analyses of varieties species of vegetables has been reported elsewhere [4]. Vegetables have been used as human food for centuries, since human creation being valued particularly for the variety of flavors and textures they can provide [5]. However, they also have nutritional value and can be useful as food supplements, although species vary in their nutritional value [6]. Moreover, vegetable proteins contain all the essential amino acids needed in the human diet and are especially rich in lysine and leucine which are lacking in most staple cereal foods [7]. Vegetables are low in total fat content and have a high proportion of polyunsaturated fatty acids (72 to 85%) relative to total fat content, mainly due to linoleic acid [8]. The high content of linoleic acids is one of the reasons why vegetables are considered a healthy food [9, 10]. Furthermore, they contain significant amounts of carbohydrates and fibers as well as vitamins, especially B complex vitamins and some vitamin C, and they appear to be rich in inorganic mineral nutrients [11]. Vegetables, unlike many other supplements such as single cell protein algae, have been used as a food and food supplement throughout the world. Their broad acceptance and high consumption rate is an asset. In Africa's rural village communities vegetables are highly treasured and appreciated as a delicacy. Most people in Nigeria, especially Northern part of the Nigeria include vegetables in their diet and cultivated a lot in the gardens and their farms during the rainy and dry season through irrigation [12]. Their cheapness supply and distribution make them highly valued and therefore very valuable [13]. However, most villagers in Africa especially in Nigeria vegetables can be cultivated on home garden and other agricultural farmland, making them available year round. The utilization of vegetables is part of Africa's cultural heritage and they play important roles in the customs, traditions and food culture of the African household. Vegetable grows on a wide variety of soils. It is listed among the plants as it can efficiently use CO_2 and suppress its photosynthesis loss. The vegetable can photosynthesize at high rate even under high temperature. Soil 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 concentrations, soil pH, organic matter content, plant species, age and available form in the soil. 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 development as well as the quality of agricultural products [14]. 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, organic matter content, texture, cation exchange capacity (CEC) and moisture condition of the soil. Similarly, translocation of heavy metals from root system to shoot is also another important factor as it differs from one plant to another and the type of element involved [11, 15, 16]. Increase in pH, organic content and CEC has shown to reduce the availability of metals. Similarly, existence of carbonate, sulphate and phosphate in a soil creates an increase in a metal precipitation and consequently decreases the metal availability to the plant [17]. The rapid increase in the population of humans in urban areas of Northern Nigeria has made solid waste handling and disposal a major environmental challenge. Most solid wastes contain paper, food wastes, glasses, synthetic products, batteries, paints, pesticides and metallic containers which are good source of heavy metal accumulation to the soil [19]. As a result of high level of poverty, most farmers have resorted to the use of waste dump sites for cultivation of crops or transfer of such soils to farmlands as alternative to industrial fertilizer and manure [6]. The uptake of heavy metals by plants results in the bioaccumulation of metals in plant tissues. Bioaccumulation Factor (BAF) also called Transfer Factor (TF) which is the ratio of the metal concentration in plant to the metal concentration in the soil environment is used to quantify the relative differences in the bioavailability of metals to plants [6]. This research work aimed at evaluating the level of heavy metals in some vegetable species grown on soils from waste dump sites and their level of bioaccumulation, with the view to make appropriate recommendations on the safety of its consumption as well as growing vegetables on waste dump soils.

Materials and Methods

Collection of Samples and Sample Preparation

Four (4) common varieties of vegetable species were studied. The vegetables are African egg plant leaf (*Solanum macrocarpon*), African Spinach (*Amaranthus hybridus*), fluted pumpkin leaves (*Telfairia occidentalis*) and water leaf (*Talinum triangulare*). These vegetables were collected from the soil around waste dump sites in each of the study areas. Some the vegetable samples were uprooted, cut, destalked, washed and cleaned to remove extraneous substances, and sun-dried for some days. The vegetables were later milled to obtain vegetable meals using mortar and pestle and this was stored in a container for the analysis.

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 hours before rinsing with distilled water and dried in an oven at 55°C for 5 hours [6, 18].

Analysis of Heavy Metals in the Vegetable Samples

A procedure recommended by Environmental Protection Agency (EPA, Method 3050B) was used as the conventional acid extraction method. 1.00 g of sample was placed in 250 ml flask for digestion. The first step was to heat the sample to 95°C with 10 ml of 50% HNO_3 without boiling. After cooling the sample, it was refluxed with repeated additions of 65 % HNO_3 until no brown fumes were given off by the sample. Then the solution was allowed to evaporate until the volume was reduced to 5 cm3. After cooling, 10 ml of 30% H_2O_2 was added slowly without allowing any losses. The mixture was refluxed with 10 cm^3 of 37% HCl at 95°C for 15 minutes. The digestate obtained was filtered through a 0.45 µm membrane paper, diluted to 100 cm^3 with deionized water and stored at 4°C for analyses. The total extraction procedure lasted for 3–4 hours.

The resultant solution was cooled and filtered into 100cm^3 standard flasks and made to mark with distilled water. Atomic absorption spectrophotometer (Buck scientific model 200A) was used for heavy metal analysis.

Analysis Heavy Metals in Soil Samples

The soil samples were prepared in triplicate for heavy metal analysis by refluxing 1.0g of air dried sample with 10cm3 of HNO_3 for 45 minutes. Heating was continued with 10cm3 of aqua-regia and finally with 10cm^3 HNO_3. The filtrates were diluted to the marks of 50cm^3 volumetric flasks and the determinations were carried out using AAS [6]. The Transfer Factor (TF) for each metal was computed using the formula below [20].

$$TF = \frac{Concentration\ of\ Metal\ in\ plant\ Sampleexpressed\ in\ \mu gg^{-1}}{Concentration\ of\ Metal\ in\ Soil\ Sample\ expressed\ in\ \mu gg^{-1}}$$

Transfer Factor values >1 indicates that the plant has high chance of accumulation of a given heavy metal. For values around 1 indicate that the plant is not influence by the metal. Similarly, for values <1 indicates that the plant exclude the element from uptake. If the plant has higher TF values, it can be used for phytoremediation [9].

Statistical analysis

The mean and standard deviation of results of measurements obtained in this work were on dry weight basis and expressed in mg/g. One way analysis of variance (ANOVA) was used to test for significant difference at a confidence level of P<0.05 between the means of the vegetables as well as those of the soils [21, 22].

Results and Discussion

Results

Table 1: The average value of heavy metals concentration in vegetable samples from the study areas

Sites	Co	Cr	Cu	Fe	Mn	Pb	Zn
OT	0.052±0.042	0.07±0.05	0.019±0.004	2.017±0.032	0.192±0.025	0.047±0.020	0.957±0.315
MA	0.020±0.002	0.119±0.176	0.054±0,033	0.174±0.016	0.141±0.025	0.069±0.014	0.717±0.129
GB	0.144±0.263	0.144±0.263	0.024±0.006	0.188±0.098	0.186±0.071	0.041±0.004	0.695±0.108
KA	0.006±0.003	0.144±0.263	0.024±0.006	0.188±0.098	0.186±0.071	0.041±0.004	0.695±0.108

Table 2: The average value of heavy metals concentration in Soil samples from the study areas

Sites	Co	Cr	Cu	Fe	Mn	Pb	Zn
OT	0.052±0.042	0.07±0.05	0.019±0.004	2.017±0.032	0.192±0.025	0.047±0.020	0.957±0.315
MA	0.020±0.002	0.119±0.176	0.054±0,033	0.174±0.016	0.141±0.025	0.069±0.014	0.717±0.129
GB	0.144±0.263	0.144±0.263	0.024±0.006	0.188±0.098	0.186±0.071	0.041±0.004	0.695±0.108
KA	0.006±0.003	0.144±0.263	0.024±0.006	0.188±0.098	0.186±0.071	0.041±0.004	0.695±0.108

Table 3: The Transfer factor (TF) for the Heavy Metals in Vegetables from the study areas

Sites	Co	Cr	Cu	Fe	Mn	Pb	Zn
OT	2.670	0.200	0.790	0.830	0.270	0.200	0.720
MA	0.080	2.820	0.290	0.620	0.200	0.260	0.720
GB	0.560	0.210	0.280	0.810	0.200	0.200	0.730
KA	0.070	0.210	0.290	0.610	0.260	0.250	0.740

Discussion

Heavy Metal Composition in Soils

Table 2 present the heavy metal concentration in soil samples, the trend of Fe>Zn>Mn>Cr>Pb>Cu>Co was observed in samples from sites OT and GB, while the trend of Fe>Mn>Zn>Cr>Pb>Cu>Co was observed or samples from site MA and KA. Generally, the values for heavy metals in the soil samples were very low. Like in the vegetables, Fe had the highest mean values (39.741±1.824mg/g, 45.64±1.016, 45.610±1.098 and 45.188±1.980mg/g) which were much lower than 925.93 μgg^{-1} and 2527.34 μgg^{-1} reported for soils from dump sites [15]. Also, they were lower than the ranges of 63.75–663.12 μgg^{-1} but were within 1.28 – 488.75 μgg^{-1} Buszewski B. Significant difference was observed in the mean values for Fe in the soils. The values (28.957±3.150, 22.717±1.290, and 24.695±1.080 and 24.195±1.080 mg/g) for Zn were within the range of 1.60 – 120.87 μgg^{-1}, but lower than the ranges of 71.25 – 375.00 μgg^{-1} reported by Buszewski B, and 45 – 4014 μgg^{-1} by Anthony E. The values were also lower than the 63.20 μgg^{-1} and 102.11 μgg^{-1} reported by Anthony E, but were within the range of 3 – 100 μgg^{-1} normal Zn concentration in German soils [5]. No significant difference was observed at $P<0.05$ between the mean values for Zn in the vegetables. The values (22.192±0.025, 28.141±1.025, 24.86±4.071 and 24.16±0.071 mg/g) for Mn were lower when compared with those reported by Uba S and the range of 20 - 800 μgg^{-1} reported as normal Mn concentration in German soils by Krettzschmar S. Also no significant difference as Observed in the mean values for Mn in the soils. The values (0.824±0.153, 0.794±0.176, 0.644±0.163 and 0.624±0.26 mg/g) for Cr were much lower than the values of 65.50 μgg^{-1} and 76.18 μgg^{-1} [27]. No significant difference was observed at $P<0.05$ between the mean vales for Cr in the vegetables. The values for Cu were much lower than the range 30 – 330 μgg^{-1} in Costa Ricca soils but were within the range of 1 - 40 μgg^{-1} as normal Cu concentration in German soils [5]. The values compared well the values of 1.36 μgg^{-1} and 3.78 μgg^{-1} reported in soils [20]. There was no significant difference in the mean values for Cu in the soils. The values of 07.48±0.840, 0.640±0.020, 0.450±0.220 and 0.660±0.113mg/g observed for Co in soils from study areas OT, MA, GB and KA respectively were much lower than the values of 36.00 μgg^{-1} and 132.14 μgg^{-1} in soils from dump sites [15]. The values of 0.847±0.200, 0.691±0.141, 0.412±0.004 and 0.421±0.004mg/g for Pb observed in soils of sites OT, MA, GB and KA respectively were lower than the values of 63.58 μgg^{-1} and 418.58 μgg^{-1} [15], but were within the ranges of 4.80 – 60.25 μgg^{-1} and 0.50 – 15.45 μgg^{-1} [12]. They values were slightly higher than the values of 2.95 μgg^{-1} and 3.58 μgg^{-1} [20]. Like in the values for Zn, Cu, Mn, Co and Cr, there was no significant difference in the mean values for Pb in the soils. The low values observed in the soil samples were indication that the wastes did not contribute much to the quantities of the heavy metals determined.

Mobility of Heavy Metals from soil to Amaranths

The Transfer Factor (TF) values for the heavy metals presented in Table 3 are indicators of the bio-mobility and transportation of the metals to the vegetables from the soil. The factors were based on the root uptake of the metal and discount the foliar absorption of atmospheric metal deposits. High value indicates bioaccumulation of a given metal by the plant part. From the values obtained for TF in this work, Fe had values that were lower than 1 but slightly higher than 0.5 which indicated that the vegetables had less chance of Fe accumulation. According to Sajjad K if the transfer factor of a metal is greater than 0.5, the plant may have a greater chance of the metal contamination by anthropogenic activities. The TF values for Zn were also lower than 1 and slightly higher than 0.5. Values ranging from 0.4 – 1.2 were reported in selected vegetables [29]. In accordance with the observation made by Natasa et al., the values obtained in this work indicates that Zn may have the chance of accumulation in vegetables; and therefore these vegetables can be used as possible bio-indicator of Zn pollution [9]. All the TF values for Mn were lower than 0.5 an indication that its accumulation in vegetables is very low. Except for samples from Otukpo, the TF values for Cr were the highest. The significant difference observed could be related to the low concentration of Cr in the site as compared to sites MA, GB and KA. The values were much higher than the values reported by Kashif et al. unlike in the vegetables used by Kasif et al, the study vegetables had indicated high bio-accumulation of Cr and therefore can be used as possible bio-indicator of Cr pollution. Only samples from site OT indicated TF value less than 1, while samples from sites MA, GB and KA indicated values that were greater than 1 and 2 respectively. Only the TF value for Co in samples from site OT was greater 2. The TF values for Pb were much lower when compared with the values for other samples and were also lower than 1. This also is good indication that Pb accumulation in Vegetables is very low. The TF values for Pb supported the findings made by Kashif et al that, its accumulation in most plants is very low [29].

Conclusion

In the present analysis, heavy metal composition in study vegetables samples from soils in the vicinity of waste dumps in urban areas of Benue state revealed the presence of the analyzed metals in both the vegetable species and the soils samples. The levels of the metals in both the vegetable and their soils were generally low and were also within the acceptable standards. This is an indication that the vegetable safe for human consumption. Except for Cu and Cr where there was no significant difference at $P<0.05$ between the mean values of the metals. Similarly, with the exception of the values for Fe, there was no significant difference at $P<0.05$ between the mean values of the metals in their soils from the study areas. The TF values obtained for the samples from the four study areas did not provide a clear trend on movement of the metals to the study vegetable species. Therefore, the study vegetables did not indicate any pollution problems.

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