Heavy Metal Loads in Selected Vegetables Raised With Roadside Soils in South-Western Nigeria: Suitability for Consumption

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***Abstract*: - Heavy metal contamination of vegetables cannot be underestimated as these foodstuffs are important components of human diet. A study to investigate the heavy metal content in four selected vegetables (*Amaranthus virdis, Corchorus olitorus, Solanum melogena* and *Abelmoschus esculentus*) raised with Akure-Ilesa and Ife-Ibadan roadside soils was carried out. Soil samples were collected at two different locations each along Akure-Ilesa and Ife-Ibadan road. The samples were digested using Aqua regia method and heavy metals; Cd, Pb, Cr and Zn contents determined with Atomic Absorption Spectrophotometer (AAS). The study revealed that the vegetables varied in the amount of heavy metals absorbed from the soil. Of all the four raised vegetables *Abelmoschus esculentus* had the highest content of 0.391, 0.041, 0.042 and 0.516 mg/kg for Akure-Ilesa and 0.420, 0.037, 0.045 and 0.550 mg/kg for Ife-Ibadan of Pb, Cd, Cr and Zn respectively. It can be concluded that the selected vegetables accumulated high concentrations of Pb and Zn but low amount of Cd and Cr.**

I. INTRODUCTION

Vegetables are rich sources of vitamins, minerals and fibers, and also have beneficial antioxidative effects. However, intake of heavy metal-contaminated vegetables may pose a risk to human health. Heavy metal contamination of the food items is one of the most important aspects of food quality assurance (Marshall, 2004; Radwan and Salama, 2006).

Rapid and unorganized urban and industrial developments have contributed to the elevated levels of heavy metals in the urban environment of developing countries such as China (Wong *et al.,* 2003) and India (Khillare *et al.,* 2004). Heavy metals are non-biodegradable and persistent environmental contaminants, which may be deposited on the surfaces and then absorbed into the tissues of vegetables. Plants take up heavy metals by absorbing them from deposits on the parts of the plants exposed to the air from polluted environments as well as from contaminated soils (Jassir *et al.*, 2005). A number of studies have shown heavy metals as important contaminants of vegetables (Sinha *et al.*, 2006; Singh and Kumar, 2006). Heavy metal contamination of vegetables may also occur due to irrigation with contaminated water (Sharma *et al.*, 2007; Singh and Kumar, 2006).

Prolonged consumption of unsafe concentrations of heavy metals through foodstuffs may lead to the chronic accumulation of heavy metals in the kidney and liver of humans causing disruption of numerous biochemical processes, leading to cardiovascular, nervous, kidney and bone diseases (Jarup, 2003). Some heavy metals such as Cu, Zn, Mn, Co and Mo act as micronutrients for the growth of animals and human beings when present in trace quantities, whereas others such as Cd, As and Cr act as carcinogens (Feig *et al.*, 1994; Trichopoulos, 1997). Hg and Pb are associated with the development of abnormalities in children (Gibbes and Chen, 1989; Pilot and Dragan, 1996). Hartwig (1998) and Saplakog¢lu and Iscan (1997) have reported that long-term intake of Cd caused renal, prostate and ovarian cancers.

Even though vegetables are nutritious part of human diet, the type of soil used in raising them is very important in the safety health of animals and man when consumed. In order to ascertain the amount of some heavy metals in the selected vegetables when raised with different road side soils, there is the need to examine the concentrations of the heavy metals in the soil and the edible parts of the vegetables with which they were grown. This is aimed at ascertaining the safety level of the vegetables when consumed.

II. MATERIALS AND METHOD

Collection of Soil

Top soil samples were collected along Akure-Ilesa road and Ife-Ibadan road in March 2013 towards the end of the dry season. The soil samples were collected with soil auger and put in separate polyethylene bags.

Collection of Seeds

Seeds of four selected vegetables; *Amaranthus virdis* L., *Cochorus olitorius* L., *Solanum melongena* L. and *Abelmoschus esculentus* L. were obtained from the Ministry of Agriculture in Ilorin, Kwara State.

Filling of Pots with Soil Samples

The soil samples collected were mixed thoroughly to bring about homogeneity and it was filled into polytene pots used for planting the vegetables.

Planting of Vegetables

Planting of the vegetables was done in October, 2013. A pinch of finger of the seeds was planted into each pot. Tap water was used to irrigate the soil before planting to bring about hydration.

Collection and Analyses of the Vegetables

Harvesting of the vegetables was done in December, 2013. After harvesting of the vegetables, analyses of plant samples (*Amaranthus virdis* (leaf), *Corchorus olitorus* (leaf), *Solanum melogena* (fruit) and *Abelmoschus esculentus* (fruit)) for heavy metals present therein were carried out by weighing 2.5 g of each plant sample for digestion. Aqua-regia method of digestion was used. Three milliliter of HNO_3 and 1 ml of HCl were added to each sample. The digestion was carried out on hot plate inside fume cupboard. The digests were allowed to cool to room temperature, then filtered with filter paper and made up to 25 ml with distilled water. The samples were then subjected to Atomic Absorption Spectrophotometer (AAS) using GBC A Vanta PM Version 2.02 for metal analysis.

Data Analysis

The data generated from this study were analyzed statistically by using Statistical Package for Social Sciences (SPSS). Analysis of Variance was used to test for differences in the concentrations of the heavy metals.

Suitability for Consumption

The data generated from this study were compared with WHO standard for intake of heavy metals in order to ascertain the safety of the selected vegetables when consumed.

III. RESULTS

Table 1 shows the heavy metal concentrations in *Amaranthus virdis, Corchorus olitorus, Solanum melogena* and *Abelmoschus esculentus* raised with Akure-Ilesa roadside soil. *Abelmoschus esculentus* have the highest concentrations of heavy metals out of the four selected vegetables. When these metals in the vegetables were compared statistically, it was discovered that there were no significant differences among the Pb (F value – 3.228), Cd (F value – 1.851) and Cr (F value – 2.419) of the vegetables, but significant difference existed among the Zn (F value – 35.948) contents of the vegetables, such that Zn content of *Abelmoschus esculentus* was statistically greater than *Amaranthus virdis* and *Corchorus olitorus* which were also statistically greater than *Solanum melogena*, *Corchorus olitorus* was found to be statistically same in respect of Zn with *Solanum melogena* at $p<0.05$.

Table 1: Heavy metal concentrations (mg/kg) in selected vegetables raised with road side soil from Akure-Ilesa road, South-Western Nigeria

Heavy metal concentration (mg/kg)				
Soil / metal/ Vegetable	**Pb**	**Cd**	**Cr**	**Zn**
Amaranthus virdis	0.223 ± 0.012	0.056 ± 0.012	0.038 ± 0.008	0.335 ± 0.026
Corchorus olitorus	0.236 ± 0.069	0.038 ± 0.009	0.044 ± 0.002	0.266 ± 0.019
Solanum melogena	0.311 ± 0.080	0.036 ± 0.004	0.033 ± 0.004	0.223 ± 0.012
Abelmoschus esculentus	0.391 ± 0.061	0.041 ± 0.009	0.042 ± 0.001	0.516 ± 0.050
WHO standard	0.3	0.2	0.05	0.3

Table 2 shows the heavy metal concentrations in *Amaranthus virdis, Corchorus olitorus, Solanum melogena* and *Abelmoschus esculentus.* The heavy metal concentration of the vegetables were compared statistically, and it was discovered that there are no significant difference between the Pb (F value – 1.625), Cd (F value – 1.252) and Cr (F value – 0.898) of the vegetables but the Zn (F value – 18.702) content differ significantly such that the Zn content of *Amaranthus virdis*, *Corchorus olitorus* and *Solanum melogena* were statistically the same but statistically lower than the Zn content of *Abelmoschus esculentus* at $p<0.05$. The results showed that the four test plants (vegetables) are potential accumulators of Pb and Zn and excluders of Cd and Cr.

Table 2: Heavy metal concentrations (mg/kg) in selected vegetables raised with road side soil from Ife-Ibadan road, South-Western Nigeria

Heavy metal concentration (mg/kg)				
Soil / metals / Vegetable	**Pb**	**Cd**	**Cr**	**Zn**
Amaranthus virdis	0.257 ± 0.060	0.054 ± 0.007	0.040 ± 0.003	0.311 ± 0.042
Corchorus olitorus	0.269 ± 0.023	0.039 ± 0.001	0.041 ± 0.000	0.260 ± 0.019
Solanum melogena	0.289 ± 0.074	0.048 ± 0.001	0.034 ± 0.001	0.278 ± 0.081
Abelmoschus esculentus	0.420 ± 0.112	0.037 ± 0.004	0.045 ± 0.001	0.550 ± 0.012
WHO Standard	0.3	0.2	0.05	0.3

IV. DISCUSSION

The incredible increase in mobilization of human society has lead to exceptional rise in vehicular traffic on the major road ways. The vehicles release a substantial quantity of exhaust emissions which consist of poisonous gases like carbon monoxide, sulphurdioxide, oxides of nitrogen etc. with about 75 % of air pollution taking place through exhaust gases from automobiles (Chandan and Kumar, 2004) The emissions from the vehicles result into adverse effects on plants, animals, soil and other environmental components. Except for vehicle emissions, the concentrations of heavy metals in soil can be influenced by other local factors, like the use of agricultural fertilizers and pesticides, climate change and other anthropogenic activities.

The variation in the concentrations of the heavy metals in the investigated vegetables could be due to various factors such as contamination of soil by vehicle exhaust, geographical location and environmental pollution. The levels of the metals in the vegetables are of great interest from the toxicological and nutritional point of view, and it may be observed as an indication of pollution. A considerable amount of trace elements could have been absorbed directly via the foliages and roots, from deposition of particulate dust, and heavy metal profiles of the soil (Harrop *et al.*, 1990; Oyedele *et al.*, 1995). These sources may have contributed significantly to the concentrations of heavy metals in the vegetables analyzed. Cd and Pb are metals of public health concern because they are not needed, even in small quantities, by living organisms. Continuous consumption of plants containing 3.0 ppm Cd can poison man and animals since it meddles with the enzymes and other proteins (David *et al.*, 2008). In domestic animals, it accumulates in the kidney, spleen and liver, while in humans; Cd interferes with the metabolism of calcium and phosphorus, leading to a painful bone disease (David *et al.*, 2008).

Pb can result to health problems, predominantly in children. It accumulates in the body and can increase to toxic levels under constant exposure. On the other hand, McDowell (1997) has suggested that there is the confirmation that the elements B, Cd, Pb and La are in some way essential to animals. The toxic doses of Zn, Pb, Cu and As to plants are 60-400, 3-20, 0.5-8 and 10-200 mg/kg respectively (Bowen, 1979), while the toxic levels to man are 150-600, 250, 1 and 20 mg per day respectively (Bowen, 1979).

The concentrations of the heavy metals were higher in *Abelmoscus esculentus* than the other vegetables. This is an evidence of bioaccumulation of the heavy metals in the plants; this suggests variation among plants in accumulating a particular heavy metal. When soil is polluted with heavy metals, the metals are taken up by plants and accumulate them in their tissues (Trusby, 2003). This passes through the food chain as animals that eat these plants also accumulate the metals in their tissues and up to the top carnivores (Horsfall and Spiff, 1999).

The results of this study, when compared with the WHO standard lower limits of Pb and Zn (0.3 mg/kg), Cd (0.2 mg/kg) and Cr (0.05 mg/kg) it indicated that *Solanum melogena* (Pb – 0.311 mg/kg), *Abelmoschus esculentus* (Pb – 0.391 mg/kg and Zn – 0.516 mg/kg) and *Amaranthus virdis* (Zn – 0.335 mg/kg) raised with soil from Akure-Ilesa road (table 1) are not fit for consumption since they accumulate these metals above the WHO lower limit standards. *Abelmoschus esculentus* (Pb – 0.420 mg/kg and Zn – 0.550 mg/kg) and *Amaranthus virdis* (Zn – 0.311 mg/kg) raised with soil from Ife-Ibadan road (table 2) are also not fit for consumption because they accumulate the metals more than the required limit by WHO. Hence these vegetables can be used to monitor the state of agricultural soil in a specific environment.

The heavy metals can damage important biochemical processes posing a danger to human health (Akbar *et al.*, 2006; Ayodele and Oluyomi, 2011). It has been reported that lingering consumption of sub-lethal concentrations of heavy metals via food may lead to their chronic accumulation which delay accurate performance of the kidney and liver of humans thus causing disturbance of numerous biochemical processes, leading to cardiovascular, nervous, kidney and bone diseases (Jarup, 2003; Radwan and Salama, 2006).

The loss of calcium caused by cadmium's effects on the kidney can be stern enough to lead to deteriorating bones, "Itaitai" disease, an epidemic of bone fracture in Japan from gross cadmium contamination of rice stocks, has been revealed to take place in more subtle fashion among a general community living in area of fairly modest cadmium contamination (Staessen *et al.*, 1999). Chromium toxicity stems from its tendency to be corrosive and to cause allergic reactions. It is a carcinogen, principally of the lung through respiration (Howard, 2002).

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