



Concentrations of some Heavy Metals in *Lycopersicon esculentum* and *Allium cepa* Grown in Abarma River Bank, Gusau- Nigeria.

*Bawa, B.¹, Sharif, N.², Hashim, T.³, Ahmad, B. B.², Abbas, L. S.⁴, Shehu, I. S.¹, and Njinga, N. S.⁵

¹National Agency for Food and Drugs Administration and Control (NAFDAC), Nigeria.

²Department of Chemistry, Federal University Gusau, Nigeria

³National Biotechnology Development Agency, Nigeria

⁴Department of Medical Laboratory, Hospital Services Management Board, Gusau, Nigeria

⁵Department of Pharmaceutical and Medicinal Chemistry, University of Ilorin, Nigeria

*corresponding Author;chembash2001@yahoo.com

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Abstract

*This work evaluated the heavy metals (Cr, Cd, Ni, and Pb) uptake of *Lycopersicon esculentum* and *Allium cepa* grown in the river bank of Abarma area, Gusau-Nigeria and assessed the potential risks of such metals. The concentration of metals in this samples follows the; Cd > Cr > Pb > Ni, Tomato is Cr > Cd > Ni > Pb, onion leave as Cr > Cd > Ni > Pb, and onions bulb is Cr > Cd > Ni > Pb. The range concentration of Cd, Cr and Pb in *Lycopersicon esculentum* Samples Obtained in mg/kg; 10.3±1.7-6.9±1.8 for Cd, 12.6±3.0-8.0±0.6 for Cr and 4.3±1.0- 2.1±0.6 for Pb, are greater than FAO/WHO guidelines of 0.2mg/kg, 2.3mg/kg and 0.3mg/kg respectively. But the mean concentrations in mg/kg of Ni 5.5±0.8-2.8±0.8 is below 10mg/kg FAO/WHO guideline. However, the mean concentration in mg/kg of Cd, Cr and Pb and in *Allium cepa* samples obtained; 24.6±2.5-9.7±0.6(leaves), 10.9±1.2-6.8±2.7(bulbs) for Cd, 11.4±3.5-2.3±1.0(leaves), 15.4±3.6-5.1±1.7(bulbs) for Cr and 4.3±1.2-2.5±0.3(leaves), 3.9±0.3-2.8±0.3(bulbs) Pb are greater than the guideline for FAO/WHO. And mean concentrations of 8.8±3.2-5.5±2.1 (leaves), 8.3±2.4-5.1±1.2 (bulbs) for Ni are below 10mg/kg FAO/WHO guideline. The range mean concentration of 6.3±1.6-4.3±0.5mg/kg for Cd in soil samples is greater than the FAO/WHO guideline value of 3mg/kg. And the range mean concentration of Cr, Pb And Ni in the soil samples is below 10mg/kg FAO/WHO guideline values of 400, 100 and 75mg/kg. This confirmed that the soil and vegetables in the area were contaminated with the heavy metals. Thus, the results of this study revealed that the consumption of vegetables grown in the vicinity of sample areas pose a significant health risk to the inhabitants of the area.*

Keywords: heavy metals; tomato; onion; soil; Abarma.

1.0 INTRODUCTION

Although trace quantities of certain heavy metals, such as chromium, cobalt, copper, manganese, zinc, e.t.c are essential micronutrients for higher animals and plant growth, they are of considerable environmental concern due to their toxicity and accumulation behavior (Yusuf *et. al.*, 2002). Heavy metals are non- biodegradable and persistent environmental contaminants, which may be deposited on the surfaces and then absorbed into the tissues of vegetables (Alirzaveya *et. al.*, 2006). 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 (Kachenko and Singh, 2006). As a result of increasing anthropogenic activities, the heavy metals pollution of soil, water, and atmosphere represents a growing environmental problem affecting food quality and human health. Heavy metals may enter the food chain as a result of their uptake by edible plants, thus, the determination of heavy metals in environmental samples is very important (Kachenko and Singh, 2004; Alirzaveya *et. al.*, 2006).

The interactions between metals and solid phases of soil, soil water, and air within and above soil depend of a variety of chemical factors and determine the heavy metal transport and fate. Absorption of metals from soil water to soil particles is the most important chemical determinant that limits mobility in soils (Curtis and Smith 2002). Heavy metals from soil enter plants primarily through the root system. In general, plant roots are the most important site for uptake of chemicals from soil (Bell, 1992).

In soil, metals are found in one or more of several "pools" of the soil, as described by Shuman (1991);

- i) Dissolved in the soil solution;
- ii) Occupying exchange sites on inorganic soil constituents;
- iii) Specifically adsorbed on inorganic soil constituents;
- iv) Associated with insoluble soil organic matter;
- v) Precipitated as pure or mixed solids;
- vi) Present in the structure of secondary minerals; and/or
- vii) Present in the structure of primary minerals.

In situations where metals have been introduced into the environment through human activities, metals are associated with the first five pools. Native metals may be associated with any of the pools depending on the geological history of the area.

Heavy metals may have significantly toxic and hazardous effects on human health, especially cadmium and lead, as non-essential elements (Bakirdere and Yaman, 2008).

Cadmium tends to be very mobile in soil systems and therefore very available to plants.

Cd^{2+} is the main species in soil solution. Accumulation of cadmium in food crops at soil concentrations that are not phytotoxic is a significant concern. Plant species differ widely in their tendency to accumulate cadmium. Absorption/desorption of cadmium is about 10-fold more rapid than that of lead. Chronic cadmium exposures result in kidney damage, bone deformities, and cardiovascular problems (Curtis and Smith 2002; Fritioff and Greger, 2007).

Lead is especially accumulated in surface horizon of soil because its low water solubility within an environmentally relevant pH range results in very low mobility. Neurological problems, especially in children, are the principal concern for chronic lead exposure, along with other health-endangering effects, such as blood enzyme changes, anemia and hyperactivity (Curtis and Smith, 2002; Barkirdere and Yaman, 2008).

Chromium occurs in the environment primarily in two valence states, trivalent chromium (Cr III) and hexavalent chromium (Cr VI). Exposure may occur from natural or industrial sources of chromium. Chromium III is much less toxic than chromium (VI). The respiratory tract is also the major target organ for chromium (III) toxicity, similar to chromium (VI). Chromium (III) is an essential element in humans. The body can detoxify some amount of chromium (VI) to chromium (III) (USEPA, 2007). The respiratory tract is the major target organ for chromium (VI) toxicity, for acute (short-term) and chronic (long-term) inhalation exposures. Shortness of breath, coughing, and wheezing were reported from a case of acute

exposure to chromium (VI), while perforations and ulcerations of the septum, bronchitis, decreased pulmonary function, pneumonia, and other respiratory effects have been noted from chronic exposure. Human studies have clearly established that inhaled chromium (VI) is a human carcinogen, resulting in an increased risk of lung cancer. Animal studies have shown chromium (VI) to cause lung tumors via inhalation exposure (USEPA, 2007).

The adverse health effects of nickel depend on the route of exposure (inhalation, oral, or dermal) and can be classified according to systemic, immunologic, neurologic, reproductive, developmental, or carcinogenic effects following acute (1day), sub chronic (10-100 days), and chronic (100 days or more)

2.0 MATERIALS AND METHOD

Analytical (AnalaR) grade reagents and distilled water were used throughout the experiments. All glass wares and plastic containers used were washed with liquid soap, rinsed with distilled water, soaked in 10% nitric acid for 24h, cleaned thoroughly with distilled water and dried in such a manner to ensure that any contamination does not occur.

The samples were collected on 17 March, 2013 (i.e. during dry season) along the river bank from five different farms. Sample of soil, onion, and tomato were collected in triplicates in each farm.

2.1 Study Area

Abarma village in Gusau Local Government Area of Zamfara State is located in north-western part of Nigeria (Latitude 12.167° N and Longitude 06.250° E) and occupies an area of approximately 39,762km². In 2006 population census, Gusau was estimated to have approximately 3.83m peoples. Out of this, Abarma village as a district in Gusau Local Government had an estimated population of approximately 3,500 (NPC, 2006). Gusau is in the southern part of Zamfara State. The mean annual rainfall in the area is about 990 mm and the vegetation type is Northern guinea savannah. The Abarma village is a heterogeneous environment made of mainly Hausa community as their major tribe. Their major occupations are farming, trading as well as civil service. No

exposure periods. The most common harmful health effect of nickel in humans is an allergic skin reaction in those who are sensitive to nickel. Nickel is the most observed cause of immediate and delayed hypersensitivity noticed in occupationally exposed as well in the general population (Das *et. al.*, 2008).

The aim of this study was to determine the concentrations of the heavy metals (i.e. Pb, Cd, Ni and Cr) in soil and in the edible parts of onions and tomatoes of farms within river bank in Abarma village of Gusau Local Government Zamfara State Nigeria, and to evaluate the levels of bioaccumulation of the metals by these vegetables and their potential risks of pollution and human health effects.

health centre is located in the village. The inhabitants rely on and draw water from bore hole and a river, which is running water from Tsafe and drainages from Gusau Local Government. The drawn water from the river is usually used by the inhabitants of Abarma for cooking, drinking, washing, bathing, Irrigation among others.

2.2 Soil Samples: Soil samples were collected at 0-20 cm depth and stored in polyethylene bags for transportation to the laboratory. They were air-dried, mechanically grounded and sieved. To determine the heavy metals content, 1 g of the air-dried (<2mm) composite soil sample from each of the samples (in triplicates) were first moistened with a few drops of water (to prevent sputtering) followed by the addition of 10 cm³ concentrated nitric acid (HNO₃). The mixture was slowly evaporated over a period of 1 hour, on a hot plate. The solid residue obtained was digested with 20 cm³ of a 3:1 mixture of concentrated HNO₃ and HClO₄ for ten minutes at room temperature and then heated on a hot plate for 1 hour until the fumes of HClO₄ starts to escape, heating was continued until a clear solution was obtained. The mixture was allowed to cool to room temperature. The cooled mixture was then filtered using Whatman No. 1 filter paper into 100cm³ volumetric flask and made up to 50cm³ marks with distilled water. The digests

were stored in polythene bottles till analysis (John *et. al.*, 2012).

2.3 Vegetables Samples: Vegetable samples were collected with gloved hands to avoid contamination. Samples of onions (*Allium cepa*) were collected by randomly picking up some matured plants until a sizable bundle was collected. Ripe fruits of tomatoes (*Lycopersicon esculentum*) were collected by randomly plucking the fruits from the plants. On reaching the laboratory, for each type of vegetables, collections from each farm were washed with distilled water to remove dirt and other particulate matters. Each of the onion samples were divided in to onion bulk and onion leaves. Each collection or bundles were then subdivided to give triplicate samples weighing approximately 150g fresh weight. Prior to analysis, fresh vegetable samples were dried in the oven at 70°C until a constant weight was obtained. Samples were then pulverized using a porcelain mortar, sieved through 1 mm mesh sieve, and stored in polythene bags ready for digestion and analysis (John *et. al.*, 2012).

1 g of oven-dried and grounded sample of each type of vegetable and from each of the 5 farms

3.0 RESULTS AND DISCUSSION

Heavy metal average concentrations in edible vegetable samples are presented in Table 1 and 2. The concentrations of heavy metals in vegetables differ from one sampling location to the other and vary from one species of vegetables to the other. This may be due to differential uptake capacity of vegetables for different heavy metals through roots and their further translocation within the plant parts (Charles *et. al.*, 2011). It can also be due to soil characteristics such as acidity and organic matter contents and ability of the root type of the plants to penetrate where the heavy metals are found (Okoronkwo *et. al.*, 2006). The bulk of onion and tomatoes production in Nigeria is from the dry season cropping system particularly under irrigation in the Northern States. Repeated application of poor quality irrigation water and manure can strongly influence the speciation of heavy metals, especially if the metal input is anthropogenic and make it more available for plant utilization (Shridhara, *et. al.*, 2008). The

were weighed (in triplicates) into a 50 cm³ beaker. This was followed by the addition of 10 cm³ mixtures of analytical grade acids (HNO₃ and HClO₄) in the ratio of 3:1. The beakers were then covered with watch glasses and left overnight. Digestion was done on a hot plate at a temperature of about 90°C until about 4cm³ of the mixture was left in the beaker. A further 10 cm³ of the acid mixture was added and evaporated to a volume of about 4 cm³, while still on hot plate, giving a clear solution. The mixture was cooled to room temperature and the solution filtered using Whatman No. 1 filter paper, to remove small quantities of waxy solids and made up to a final volume of 50 cm³ with distilled water in a volumetric flask. These were stored in polythene bottles prior to analysis (John *et. al.*, 2012).

Metal concentrations in the digests were determined using Atomic Absorption Spectrometer. The instrumental settings and operating conditions were carried out according to the manufacturer's specifications. Blanks were also determined to ascertain the contribution of reagents to metal concentration.

varying amounts of heavy metals in the tomatoes, onion bulbs and leaves obtained from different parts of river bank is probably due to uptake of these metals from the water used for irrigation and inefficient farming techniques. For instance, large amounts of industrial wastes, batteries, medical waste, waste cloths, glass and bottles, newspapers, paints, ash, tires, metal cans, inks, plastics, used motor oils, ceramics, electronics, containers, and domestic waste water some of which are known to be sources of heavy metals and other toxic chemicals been reported to be discharged into city streams and used for irrigation.

Even though production of tomatoes and onion using irrigation practices has contributed significantly to poverty alleviation, food security, and improvement of the quality of life for rural populations, a study conducted by Ojo *et al.*, (2009) observed that, farmers were technically inefficient with the use of fertilizers

and agrochemicals due to their low level of education.

With the exception of chromium content of farm 3 which is equal to FAO/WHO limit, the lead, cadmium and chromium contents of the onions (leaves and bulbs) and tomatoes obtained from the different locations were substantially high when compare with the FAO/WHO guidelines. The concentrations of nickel in all onions and tomatoes samples are below FAO/WHO guidelines. The study conducted by Shemdoe

(2010) in soil and water that are used for vegetables production also reported high levels of heavy metals such as arsenic, cadmium, chromium, nickel and lead. Similar reports of high levels of heavy metals accumulation in vegetables in irrigated fields have been reported (Abdullahi *et al.*, 2008; Charles *et. al.*, 2011; Olorunfemi and Ogunsanwo, 2011; Tsafe *et. al.*, 2012).

TABLE 1: Concentration of Heavy Metals in Onions Samples Obtained. Data expressed as mean \pm standard error mean for replicate determinations.

Farms	Cadmium (mg/kg)		Chromium (mg/kg)		Nickel (mg/kg)		Lead (mg/kg)	
	Leaves	Bulbs	Leaves	Bulbs	Leaves	Bulbs	Leaves	Bulbs
Farm 1	12.6 \pm 2.1	10.3 \pm 2.0	4.6 \pm 1.5	9.9 \pm 4.2	7.4 \pm 2.8	6.9 \pm 0.8	2.5 \pm 0.3	2.8 \pm 0.3
Farm 2	19.4 \pm 5.2	7.4 \pm 1.2	2.3 \pm 1.0	5.1 \pm 1.7	5.5 \pm 2.1	5.5 \pm 0.8	2.8 \pm 0.3	3.2 \pm 0.6
Farm 3	24.6 \pm 2.5	10.9 \pm 1.2	10.3 \pm 4.2	15.4 \pm 3.6	8.8 \pm 3.2	8.3 \pm 2.4	3.9 \pm 0.9	3.9 \pm 0.3
Farm 4	9.7 \pm 5.0	10.9 \pm 3.2	4.6 \pm 1.5	9.9 \pm 4.2	7.4 \pm 2.8	6.9 \pm 0.8	2.5 \pm 0.3	2.8 \pm 0.3
Farm 5	9.7 \pm 0.6	6.8 \pm 2.7	11.4 \pm 3.5	9.1 \pm 2.1	6.9 \pm 1.4	5.1 \pm 1.2	4.3 \pm 1.2	3.9 \pm 1.3

TABLE 2: Concentration of Heavy Metals in Tomatoes Samples Obtained. Data expressed as mean \pm standard error mean for replicate determinations.

Farms	Cadmium (mg/kg)	Chromium (mg/kg)	Nickel (mg/kg)	Lead (mg/kg)
Farms 1	10.3 \pm 1.7	12.6 \pm 3.0	4.2 \pm 0.8	2.1 \pm 0.6
Farms 2	7.4 \pm 1.2	9.7 \pm 1.5	4.6 \pm 1.2	4.3 \pm 1.0
Farms 3	7.4 \pm 2.1	10.9 \pm 1.5	3.7 \pm 0.9	2.9 \pm 0.7
Farms 4	6.9 \pm 1.8	8.0 \pm 0.6	2.8 \pm 0.8	3.2 \pm 1.0
Farms 5	8.6 \pm 3.5	12.6 \pm 3.8	5.5 \pm 0.8	4.3 \pm 1.0
FAO/WHO guideline for Vegetables	0.2 ^a	2.3 ^b	10 ^b	0.3 ^a

a: FAO/WHO (2011) b: FAO/WHO (2001)

The obtained concentrations were compared to maximum levels of lead (0.30 mg/kg in vegetables), cadmium (0.20 mg/kg in vegetables), and chromium (2.3 mg/kg in vegetables) according to FAO/WHO, (2001) and (2011) guidelines. The highest mean concentration of nickel in the study area is 5.5mg/kg in tomato and 8.8mg/kg in onion, which is lower than the FAO/WHO guideline value of 10mg/kg.

The heavy metals (Tables 1 and 2) in vegetables in this work were compared with

similar works reported. It revealed that most of the results of this work were higher than the compared results and higher than the maximum permissible limits of WHO/FAO (2001 and 2011) except in the case of Nickel. A good example of this can be seen in Cd. This variation however, is a function of the availability and the uptake of a particular plant species to a given element referred to as the transfer factor of the metal.

TABLE 3: Concentration of Heavy Metals in Soil Samples Obtained. Data expressed as mean \pm standard error mean for replicate determinations.

Farms	Cadmium(mg/kg)	Chromium (mg/kg)	Nickel (mg/kg)	Lead (mg/kg)
Farms 1	4.3 \pm 0.5	3.7 \pm 0.6	3.2 \pm 0.6	1.6 \pm 0.3
Farms 2	5.4 \pm 0.3	4.9 \pm 2.0	2.5 \pm 0.4	1.6 \pm 0.6
Farms 3	6.3 \pm 1.6	2.2 \pm 0.4	1.0 \pm 0.3	2.3 \pm 1.2
Farms 4	5.4 \pm 1.3	3.9 \pm 0.6	1.6 \pm 0.6	3.4 \pm 0.8
Farms 5	5.1 \pm 0.5	3.7 \pm 1.8	2.8 \pm 0.4	1.6 \pm 0.5
FAO/WHO guideline for soil, 2001	3.0	400.0	75.0	100.0
Ewers, V., 1991	3	100	50	100
UK ^c	3	400	75	300
Germany ^c	1	60	50	70
France ^c	2	150	50	100
Netherlands ^c	0.5	30	15	40

c= European Commission Directorate General Environment, ECDGE (2010).

The results of heavy metals concentrations in soil obtained from this study shown that, in all the farms, the concentration of cadmium is higher than the 3mg/kg guideline given by FAO/WHO, (2001). However, the concentrations of chromium, nickel, and lead obtained are lower than 400mg/kg, 75mg/kg, and 100mg/kg guidelines given by FAO/WHO, (2001) respectively.

Experience has shown that most of the farmers do apply compost manure to improve soil fertility; it is apparently clear that, the application of industrial and municipal wastes as compost manure in the farms may contribute to the heavy metals content of the soil.

4.0 CONCLUSIONS

The paper evaluated and assessed the heavy metals composition of the vegetables grown in the river bank of Abarma, Northern Nigeria. Based on the results of this study, leafy vegetables grown at the Abarma river bank sites where water from the river is used for irrigating the vegetables were contaminated Cd, Cr, and Pb. Potential public health hazards, especially

The concentrations of Cd, Cr, and Pb in vegetables at the river bank site were above the FAO/WHO recommended limit, indicating that exposure to Cd, Cr, and Pb may be high. Based on the results of this study, vegetables grown at the river bank were contaminated with Cr, Cd, and Pb. Potential public health hazards, especially from Cd, are high at the sampling locations.

However, elucidation of the dietary intake of these metals through consumption of the onion, tomato, and other vegetables as well as other food items grown in the area and how it can be related to various ailments in the community await further investigations.

from Cd and Pb, are high at the sites. It is possible that other sites using water from the river for irrigation in Gusau and Bungudu have similarly been affected. There is need for an improved food quality assurance system and promotion of the production of vegetables that comply with existing standards on heavy metal concentrations

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