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Full Length Research Paper

Heavy metals in vegetables collected from selected farm and market sites in Lagos, Nigeria

Doherty V. F.[1], Sogbanmu T. O.[2*], Kanife U. C.[1] and Wright O.[1]

[1]Environmental Biology Unit, Department of Biological Sciences, Yaba College of Technology, Lagos, Nigeria.
[2]Ecotoxicology Unit, Department of Zoology, Faculty of Science, University of Lagos, Lagos, Nigeria.

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This study was conducted to determine the concentration of heavy metals (copper (Cu), zinc (Zn), lead (Pb) and cadmium (Cd)) in five vegetables viz; *Cochorus olitorus* (Jew's mallow), *Vernonia amygdalina* (Bitter-leaf), *Talimum triangulare* (Water-leaf), *Talifaria occidentalis* (Flutted pumpkin) and *Spinachcia oleracea* (Spinach) and soil collected from selected farm and market sites in industrial, residential and commercial areas of Lagos state. The heavy metals present in the vegetables and soil were analyzed using Atomic Absorption Spectrophotometer (AAS). The results reveal that all the heavy metals were detected in both soil and vegetables from the various sites but at concentrations below the World Health Organisation (WHO) and Food and Agriculture Organisation (FAO) safe limit of 40, 60, 5, and 0.2mg/kg for copper (Cu), zinc (Zn), lead (Pb) and cadmium (Cd) respectively in vegetables. Also, there was no significant difference ($p>0.05$) between the heavy metals found in vegetables collected from industrial, residential and commercial areas. The results hence shows that vegetables consumed in Lagos state are safe for consumption.

Keywords: Heavy metals, Vegetables, AAS, WHO, Markets, Farms

INTRODUCTION

The term "heavy metals" refers to any metallic element that has a relative density greater than 4g/cm^3 (Grant and Grant, 1987). Heavy metals include; Lead (Pb), Cadmium (Cd), Zinc (Zn), Mercury (Hg), Arsenic (As), Silver (Ag), Chromium (Cr), Copper (Cu), Iron (Fe) and the Platinum group elements. They are non-biodegradable and persistent environmental contaminants which may be deposited on the surface and then absorbed into the tissues of vegetables. They might accumulate in the food chain with risks to the health of animals and humans which are less sensitive to metal toxicity compared to plants but are capable of concentrating heavy metals. The uptake of metals from the soil depends on different factors such as their solubility, soil pH, plant growth stages, fertilizer and soil (Sharma et al., 2006; Ismail et al., 2005). Plant species have various ways of removing and accumulating heavy metals, hence there are reports indicating that some species may accumulate specific heavy metals, causing a serious risk to human health when plant-based food stuff are consumed (Wenzel and Jackwer, 1999).

Vegetables are edible plants which store up food reserves in their roots, stems, leaves and fruits. They play an important role in maintaining general good health due to the presence of mineral elements such as calcium, iron, sulphur, potassium and vitamins such as vitamins A, B, and C. These substances help to build bone, teeth and protect the body from diseases. They also regulate body

*Corresponding Author E-mail: topesho@gmail.com Tel: +2348033576361

Table 1. Classification of market and farm sites based on their location in industrial, residential and commercial areas of Lagos State

Commercial Areas	Industrial Areas	Residential Areas
Agboju	Iyana-iba	Bajulaye
Mushin	Oshodi	Ikeja G.R.A
Oyingbo		Iyana-ipaja
		Egbeda

processes on which vitality and good health depends. Leafy vegetables are widely used for culinary purposes. They are used to increase the quality of soup and for dietary purposes (Sobukola et al., 2007). They contain cellulose and form roughage which helps the bowel to function regularly in the elimination of unwanted matter from the body. They also contain 70-75% water which is essential to the body system. They are very important protective foods, useful for the maintenance of health, prevention and treatment of various diseases (D'Mello, 2003).

Waste water irrigation is known to contribute significantly to the heavy metal contents of soils (Mapanda et al., 2005). Although problems occur in waterways when pollutants are leached out of the soil, if the plants die and decay, heavy metals taken into the plants are redistributed, so the soil is enriched with pollutants. Long term wastewater irrigation may lead to the accumulation of heavy metals in agricultural soils and plants. Crop yields are reduced due to the inhibition of metabolic processes in plants by the metals. The sources of food contamination have often been traced to fumes from car exhausts (Fakayode, 2003). Potentially contaminated soils may occur at old landfill sites (particularly those that accept industrial wastes), old orchards that used insecticides containing arsenic as an active ingredient. Excessive content of lead and cadmium metals in food is associated with etiology of a number of diseases especially with cardiovascular, kidney, nervous as well as bone diseases (Jarup, 2003). They have also been implicated in causing carcinogenesis, mutagenesis and teratogenesis. Copper toxicity induces iron deficiency, lipid peroxidation and destruction of membranes (Zaidi et al., 2005). In humans and animals, heavy metals can produce bone defects. Also, they are linked to increased blood pressure and effects on the myocardium in animals. Periodic monitoring of concentrations of these heavy metals in food such are vegetables which are consumed by all and sundry is hence imperative to ensure that they are pollutant free. This study therefore aims to determine the levels of heavy metals such as cadmium (Cd), copper (Cu), Lead (Pb) and zinc (Zn) in some selected vegetables grown and sold in selected farm and markets respectively and soils in various industrial, residential and commercial areas of Lagos. The results obtained from this study will reveal if the vegetables consumed by the inhabitants of Lagos state and the soils in which they are grown are contaminated or not when compared with world health organization safe limits and standards.

MATERIALS AND METHODS

Collection of samples, sample preparation and treatment

Five types of leafy vegetables were randomly purchased from five markets and four farm sites located in industrial, residential and commercial areas in Lagos, Nigeria in July (wet season), 2011. The soil from each farm site was collected with a soil auger and packed in a nylon bag for analysis. The vegetables include jew's mallow (*Cochorus olitorus*), bitter-leaf (*Vernonia amygdalina*), water-leaf (*Talimum triangulare*), flutted pumpkin (*Talfaria occidentalis*) and spinach (*Spinachcia oleracea*). The markets are located at Agboju, Oyingbo, Bajulaye, Oshodi and Mushin while the farm sites are situated at Egbeda, Ikeja G.R.A, Iyana-ipaja and Iyana-iba (Table 1).

The vegetables were washed with distilled water to remove dust particles and then cut to separate the root, stems and leaves using a knife. The leaves and soil were air-dried and then oven-dried at 65^0C. Dried vegetable samples were ground into a fine powder using a commercial blender (TSK-WestPoint, France) and stored in polyethylene bags until they were used for digestion.

2g of each vegetable was weighed into a digestion flask and treated with 9ml of an acid mixture made up of concentrated nitric acid (HNO_3), hydrochloric acid (HCl) and sulphuric acid (H_2SO_4). A blank sample was prepared by applying 9ml of concentrated HNO_3, HCl and H_2S0_4 into an empty digestion flask. The samples were mixed and heated for 30 minutes on an electric hot plate at 80-90^0C at which they were brought to boil and a clean solution was obtained. After cooling, the solution was filtered with whatman No. 4 filter paper and then transferred quantitatively to a 100ml volumetric flask by adding 50ml of de-ionized water. The solution was then preserved in a universal bottle for further analysis. All reagents used were of analytical grade and the Atomic Absorption Spectrophotometer (AAS, Perkin Elmer model 2130) was used to determine the heavy metals (copper

Table 2A. Concentration (mg/kg) of heavy metals in combined leafy vegetables from selected markets in Lagos

Markets	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)
Agboju	0.279 ± 0.106	nd	0.061 ± 0.106	0.001 ± 0.106
Bajulaye	0.355 ± 0.106	nd	0.100 ± 0.106	0.001 ± 0.168
Oyingbo	0.312 ± 0.106	0.001 ± 0.168	0.064 ± 0.106	0.001 ± 0.119
Mushin	0.437 ± 0.106	nd	0.092 ± 0.106	0.001 ± 0.106
Oshodi	0.504 ± 0.106	0.001 ± 0.168	0.001 ± 0.106	0.001 ± 0.106
WHO/FAO	40.0	5.0	60.0	0.2

Table 2B. Concentration (mg/kg) of heavy metals in leafy vegetables from combined selected markets in Lagos

Vegetables	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)
Jew's mallow	0.306 ± 0.158	Nd	0.086 ± 0.003	0.001 ± 0.000
Water leaf	0.867 ± 0.058	Nd	0.091 ± 0.018	0.001 ± 0.001
Bitter leaf	0.295 ± 0.127	Nd	0.081 ± 0.030	0.001 ± 0.000
Flutted pumpkin	0.405 ± 0.018	0.001 ± 0.000	0.078 ± 0.024	0.003 ± 0.000
Soko	0.066 ± 0.034	0.001 ± 0.000	0.081 ± 0.025	0.001 ± 0.000
WHO/FAO	40.0	5.0	60.0	0.2

Nd – Not detected

Table 3A. Heavy metals concentration (mg/kg) in combined vegetables from selected farm sites

Farm Sites	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)
Egbeda	0.400	0.002	0.450	0.001
Ikeja GRA	1.961	nd	0.101	0.001
Iyana-iba	0.373	0.001	0.099	0.001
Iyana-ipaja	0.417	nd	0.416	0.002
WHO/FAO	40.0	5.0	60.0	0.2

(Cu), zinc (Zn), lead (Pb) and cadmium (Cd)) in the digested solution.

Statistical Analysis

Data were reported as mean ± standard deviation (SD). One way analysis of variance (ANOVA) was used to determine significant difference ($p<0.05$) between groups using SPSS version 19.0.

RESULTS

Table 2A reveals the concentration of heavy metals detected in all the vegetables selected from the various market sites. The concentrations of copper and zinc in the vegetables from the markets increased as follows; Agboju < Oyingbo < Bajulaye < Mushin < Oshodi and Oshodi < Agboju < Oyingbo < Mushin < Bajulaye respectively. Lead was detected at 0.001mg/kg in vegetables purchased from Oyingbo and Oshodi only. It was not detected in vegetables purchased from the other markets. Cadmium was detected at 0.001mg/kg in the vegetables purchased from all the markets.

Table 2B shows the concentration of heavy metals determined in selected leafy vegetables sampled from five markets in Lagos. The levels of copper and zinc detected in the vegetables from all the markets increased in this order: spinach < bitter leaf < jew's mallow < flutted pumpkin < water leaf and flutted pumpkin < bitter leaf and spinach < jew's mallow < water leaf respectively. Lead was detected at very low concentrations of 0.001mg/kg in flutted pumpkin and spinach and not detected at all in the other vegetables while Cadmium was detected at 0.001mg/kg in all the other vegetables except flutted pumpkin which recorded 0.003mg/kg.

Table 3A shows the concentration of heavy metals investigated in the vegetables sampled from four farm sites in Lagos. The order of increasing concentration of

Table 3B. Heavy metals concentration (mg/kg) in vegetables from combined selected farm sites

Vegetables	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)
Jew's mallow	0.412 ± 0.130	0.001 ± 0.130	0.103 ± 0.035	0.001 ± 0.000
Water leaf	0.893 ± 0.144	0.003 ± 0.003	0.086 ± 0.017	0.001 ± 0.005
Bitter leaf	0.329 ± 0.051	0.008 ± 0.000	0.089 ± 0.016	0.001 ± 0.001
Flutted pumpkin	0.273 ± 0.093	0.002 ± 0.001	0.199 ± 0.251	0.002 ± 0.001
Spinach	0.071 ± 0.082	0.002 ± 0.001	0.568 ± 0.960	0.001 ± 0.007
WHO/FAO	40.0	5.0	60.0	0.2

Table 4. Heavy metals concentration (mg/kg) in soil from selected farm sites

Farm Sites	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)
Egbeda	0.810 ± 0.033^{a}	0.021 ± 0.031^{a}	0.125 ± 0.031^{a}	0.013 ± 0.031^{a}
Ikeja GRA	0.781 ± 0.033^{b}	0.008 ± 0.031^{b}	0.096 ± 0.031^{c}	0.016 ± 0.031^{a}
Iyana-iba	0.794 ± 0.041^{b}	0.005 ± 0.033^{b}	0.109 ± 0.033^{b}	0.003 ± 0.033^{c}
Iyana-ipaja	0.811 ± 0.033^{a}	0.022 ± 0.031^{a}	0.125 ± 0.031^{a}	0.013 ± 0.031^{b}

Values are mean ± SD. Mean values with the same superscript are not significantly different ($p>0.05$) while those with different superscript are significantly different ($p<0.05$).

Table 5. Concentration (mg/kg) of heavy metals in each vegetable collected from industrial, commercial and residential areas of Lagos state

Vegetables	Areas	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Cadmium (Cd)
Jew's Mallow	Industrial	0.406 ± 0.233	0.001 ± 0.000	0.110 ± 0.043	0.001 ± 0.000
	Residential	0.401 ± 0.150	0.001 ± 0.000	0.095 ± 0.030	0.001 ± 0.000
	Commercial	0.254 ± 0.132	nd	0.081 ± 0.032	0.001 ± 0.000
Water leaf	Industrial	0.846 ± 0.106	0.001 ± 0	0.101 ± 0.006	0.008 ± 0.000
	Residential	0.916 ± 0.123	0.001 ± 0	0.088 ± 0.019	0.009 ± 0.008
	Commercial	0.779 ± 0.190	nd	0.077 ± 0.028	0.001 ± 0.000
Bitter leaf	Industrial	0.345 ± 0.001	0.001 ± 0	0.094 ± 0.007	0.006 ± 0.006
	Residential	0.344 ± 0	0.001 ± 0	0.092 ± 0.017	0.006 ± 0.005
	Commercial	0.242 ± 0	nd	0.069 ± 0.035	0.001 ± 0.000
Flutted Pumpkin	Industrial	0.484 ± 0.123	0.008 ± 0.000	0.085 ± 0.011	0.001 ± 0.000
	Residential	0.326 ± 0.078	0.002 ± 0.000	0.416 ± 0.439	0.002 ± 0.001
	Commercial	0.372 ± 0.192	0.001 ± 0.000	0.062 ± 0.063	0.001 ± 0.001
Spinach	Industrial	0.058 ± 0.022	0.001 ± 0.000	0.031 ± 0.031	0.002 ± 0.001
	Residential	0.125 ± 0.188	0.001 ± 0.002	0.564 ± 0.833	0.001 ± 0.001
	Commercial	0.068 ± 0.044	nd	0.072 ± 0.031	0.001 ± 0.001

copper and zinc in the vegetables from the various farm sites is as follows; Iyana-Iba < Egbeda < Iyana-Ipaja < Ikeja GRA and Iyana-Iba < Ikeja GRA < Iyana-Ipaja < Egbeda respectively. Lead was detected concentrations of 0.001mg/kg and 0.002mg/kg at Iyana-Iba and Egbeda respectively. It was however not detected at the other farm sites. Cadmium on the other hand was detected at 0.001mg/kg at all the farm sites.

Table 3B shows the concentration of heavy metals determined in selected leafy vegetables sampled from four farm sites in Lagos. The order of increasing concentrations of copper, lead and zinc in the vegetables from all the farm sites is as follows; Spinach < Flutted pumpkin < Bitter leaf < Jew's mallow < Water leaf; Jew's mallow < Flutted pumpkin and Spinach < Water leaf < Bitter leaf and Jew's mallow < Water leaf < Bitter leaf < Flutted pumpkin < Spinach respectively. Cadmium was detected at 0.001mg/kg in all the other vegetables except Flutted pumpkin detected at 0.002mg/kg.

Table 4 indicates the level of heavy metals detected in the soils from selected farm sites in Lagos. The concentration of copper, lead, zinc and cadmium increased as follows; Ikeja GRA < Iyana-iba < Egbeda < Iyana-ipaja; Iyana-iba < Ikeja GRA < Egbeda < Iyana-

ipaja; Ikeja GRA < Iyana-iba < Iyana-ipaja and Egbeda and Iyana-iba < Egbeda and Iyana-ipaja < Ikeja GRA respectively.

Table 5 shows the comparison of heavy metals detected in vegetables obtained from markets and farm sites in industrial, residential and commercial areas. The order of increasing concentration of copper, lead, zinc and cadmium in Jew's mallow is as follows: commercial < residential < industrial; residential and commercial; commercial < residential < industrial; same in the three areas. The order of increasing concentration of copper, lead, zinc and cadmium in Water leaf is as follows; commercial < industrial < residential; industrial and residential; commercial < residential < industrial; commercial < industrial < residential. The order of increasing concentration of copper, lead, zinc and cadmium in Bitter leaf is as follows; commercial < residential < industrial; industrial and residential; commercial < residential < industrial; commercial < industrial and residential. The order of increasing concentration of copper, lead, zinc and cadmium in flutted pumpkin is as follows; residential < commercial < industrial; commercial < residential < industrial; commercial < industrial < residential; commercial and industrial < residential. The order of increasing concentration of copper, lead, zinc and cadmium in Spinach is as follows: industrial < commercial < residential; industrial and residential; industrial < commercial < residential; commercial and residential < industrial.

There was no significant difference ($p>0.05$) between the level of heavy metals in vegetables purchased from markets when compared with those obtained from the farm sites.

There was also no significant difference ($p>0.05$) in the level of heavy metals found in industrial, residential, and commercial areas.

DISCUSSION

Copper is an essential micronutrient which functions as a biocatalyst required for body pigmentation in addition to iron, maintain a healthy central nervous system, prevents anaemia and interrelated with the functions of Zinc and Iron in the body (Akinyele and Osibanjo, 1982). However, most plants contain the amount of copper which is inadequate for normal growth which is usually ensured through artificial or organic fertilizers (Itanna, 2002). In this study, the concentrations of copper in all the vegetables from the various markets varied between 0.066 – 0.867mg/kg. This is higher than the findings of Divrikli et al. (2006) and Ozcan (2004) who reported Copper concentrations of 0.02mg/kg and 0.0081mg/kg, respectively for Indian Basil.

In this study, Lead was not detected in vegetables from most of the markets and where detected, it was at very low or almost negligible concentrations of 0.001mg/kg. This is consistent with the report of Ladipo and Doherty (2011) which stated that Lead was not detected in vegetable samples analyzed at the time of their study.

Cadmium is a non-essential element in foods and natural waters and it accumulates principally in the kidneys and liver (Divrikli et al. 2006.). Various sources of environmental contamination have been implicated for its presence in foods. Differing values have been previously reported in leafy vegetables which include 0.090mg/kg for flutted pumpkin by Sobukola et al. (2010) and 0.049mg/kg by Muhammad et al. (2008) for lettuce. In this study, Cadmium was detected at low concentrations of 0.001 – 0.003mg/kg in vegetables purchased from the markets. This is below the FAO/WHO safe limit of 0.02mg/kg for cadmium consumption in vegetables.

Zinc concentrations in vegetables from the markets ranged from 0.078 – 0.091mg/kg. This is lower than the value reported for cabbage (0.777mg/kg) by Muhammad et al. (2008). Also, Itanna (2002) analyzed three green leafy vegetables and reported a higher concentration of Zinc in spinach.

The levels of copper and zinc detected in vegetables from the farm sites was lowest in those from Iyana-iba compared to the other farm sites. Lead was also not detected at some sites and where detected, it was at very low concentrations, same as cadmium.

For soil collected from the four farm sites, copper, lead, zinc and cadmium were detected at all the sites. Their concentrations were however significantly different at each of the sites. The varying concentrations of heavy metals in all the farm sites may be due to their different uptake rate. The heavy metals were detected least in vegetables obtained from the commercial areas compared to the industrial and residential areas. Generally the level of heavy metals were higher in vegetables obtained from the farm sites compared to those purchased from the markets. These variations may be ascribed to the physical and chemical nature of the soil of the farm sites, absorption capacities of heavy metals by vegetables, atmospheric deposition of heavy metals, which may be influenced by innumerable environmental factors such as temperature, moisture and wind velocity, and the nature of the vegetables, i.e. leaf, root, fruit, exposed surface area.

The results indicate that the heavy metals in the vegetables were below the safe limits of 40, 60, 5, and 0.2mg/kg for copper (Cu), zinc (Zn), lead (Pb) and cadmium (Cd) respectively set by the WHO/FAO and lower than previous studies. As human health is directly affected by ingestion of vegetables, which is the main source of food for man, biomonitoring of trace elements in the vegetables should be continued to forestall possible consumption of contaminated vegetables or foodstuff. It is essential that the farmers be educated and encouraged to reduce such contamination by controlling

the use of pesticides, avoiding the use of waste water and cultivating in fields far away from highways and industrial areas. This study thus showed that leafy vegetables consumed in Lagos state are safe for consumption.

REFERENCES

Akinleye IO, Osibanjo O (1982). Levels of trace elements in hospital diet. Food Chem. 8: 247-251

D'Mello JPF (2003). Food safety: Contamination and Toxins. CABI Publishing, Wallingford, Oxon, UK, Cambridge, M.A. p. 480.

Divrikli U, Horzum N, Soylak M, Elci L (2006). Trace heavy metal contents of some spices and herbal plants from western Anatolia, Turkey. Int. J. Food Sci. Technol. 41: 712-716.

Fakayode SO, Olu-Owolabi BI (2003). Heavy metal contamination of roadside topsoil in Oshogbo, Nigeria. Its relationship to traffic density and proximity to highways. J .Environ. Geol. 44 (20): 150-157.

Grant R, Grant C (1987). Grant and Hackh's Chemical Dictionary, McGraw-Hill, New York.

Ismail BS, Farihah K, Khairiah J (2005). Bioaccumulation of heavy metals in vegetables from selected agricultural areas. B. Environ. Contam. Tox. 74:320-327.

Itanna F (2002). Metals in leafy vegetables grown in Addis Ababa and toxicology implementations. Ethiopia J. Health Develop. 16:295-302.

Jarup L (2003). Hazards of heavy metals contamination. Br. Med. Bull. 68:167-182.

Ladipo MK, Doherty VF (2011). Heavy metal levels in vegetables from selected markets in Lagos, Nigeria. Afr. J. Food Sci. Technol. Pp. 018-021.

Mapanda F, Mangwayana EN, Nyamangara J, Giller KE (2005). The effect of long term irrigation using wastewater on heavy metal contents of soils under vegetables in Harare, Zimbabwe. Agric. Ecosys. Environ. 107:151-165.

Muhammad F, Farooq A, Umer R (2008). Appraisal of heavy metal contents in different Vegetables grown in the vicinity of an industrial area. Pak. J. Bot., 40(5): 2099-2106

Ozcan M (2004). Mineral contents of some plants used as condiments In Turkey. Food Chem. 84:437-440.

Sharma RK, Agrawal MM (2006). Heavy metals contamination in vegetables grown in waste water irrigated areas of Varanasi, India. Ecotoxicology and Environmental Safety 66: 258-266 .

Sobukola OP, Adeniran OM, Odedairo AA, Kajihausa OE (2010). Heavy metal levels of some fruits and leafy vegetables from selected markets in Lagos, Nigeria. Afr. J. Food Sci. 4(2): 389 - 393

Sobukola OP, Dairo OU, Sanni LO, Odunewu AV, Fafiolu BO (2007). Thin layer drying process of some leafy vegetables under open sun. Food Sci .Technol. Int. 13(1): 35-40 .

Wenzel W, Jackwer F (1999). Accumulation of heavy metals in plants grown on mineralized solids of the Austrian Alps. Environ. Poll. 104: 145-155.

Zaidi MI, Asrar A, Mansor A, Farooqui MA (2005). The heavy metal concentrations along roadsides trees of Quetta and its effects on public health. J. Appl. Sci. 5(4):708-711.