Research Journal of Environmental and Earth Sciences 4(1): 55-59, 2012
ISSN: 2041-0492

Submitted: July 13, 2011 Accepted: August 27, 2011 Published: January 01, 2012

Assessment of Cadmium and Lead in Soil and Tomatoes Grown in Irrigated Farmland of the Kaduna Metropolis Nigeria

[1]W.L.O Jimoh and [2]Mahmud Imam Mohammed
[1]Department of Pure and Industrial Chemistry, Bayero University, Kano Nigeria
[2]Department of Applied Science, College of Science and Technology, Kaduna Polytechnic

Abstract: The objective of this study was to determine the level of cadmium and lead in soil and tomatoes grown in irrigated farmland of Kaduna metropolis. Twenty sampling sites were selected with one control site. Concentration of these metals was determined using atomic absorption spectrophotometer. In the soil analysis it was found that most of the concentrations were higher than obtained in the control site. The concentrations of tomatoes samples for cadmium were found to be in the range of 0.10±0.10 to 1.33±0.23 μg/g and lead ranged from 0.92±0.08 to 4.67±1.29 μg/g. This also shows that concentrations of cadmium and lead in tomatoes samples were above FAO/WHO Allimentarious standard. Pearson correlation shows positive correlation between soil and vegetable. Therefore, consumption of tomatoes from these study areas may constitute health hazard to human as at the time of this research work.

Key words: Atomic absorption spectrophotometer, heavy metals, Kaduna metropolis, Nigeria, soil, spinach, Tomatoes

INTRODUCTION

Heavy metals are general terms, which apply to the group of metals and metalloids with atomic density greater than 4 g/cm^3, (Huton and Symon, 1988; Nriagu, 1999; Garbarino *et al*., 1995; Hawkes, 1997). This classification includes transition metals and higher atomic weight metals of group III to V of the periodic table. Heavy metals include lead cadmium, zinc, copper, Iron etc (Duruibe *et al*., 2007).

Heavy metals are among the major contaminant of food supply and are considered as problem to the environment (Zaidi *et al*., 2005). Heavy metals contamination may occur due to irrigation with contaminated water, the addition of fertilizers, metal based pesticides, industrial emissions, transportation, harvesting process and storage. Advancement in technology has lead to high levels of industrialization leading to the discharge of effluent bearing heavy metals into our environment. The various activities by man in recent years have increased the quantity and distribution of these heavy metals in the atmosphere, land and water bodies (Gustar, 1974).

Human exposures to heavy metals occur primarily through inhalation of air and ingestion of food and water. The concentration of these metals in the environment varies considerably depending in the soil concentration and proximity to sources of emission (Kenneth and Harvey, 1979).

Excessive accumulation of heavy metals in agricultural soil through wastewater irrigation may not only result in soil contamination but also lead to elevated heavy metal up take by crops and thus affect food quality and safety (Muchuweti *et al*., 2006).

Heavy metal accumulation in soil and plants is of increasing concern because of the potential human health risk. This food chain contamination is one of the important pathways for the entry of these toxic pollutants into the human body. Heavy metal accumulation in plant depend upon plant species and the efficiency of different plants depends is evaluated by either plant uptake or soil-to plant transfer factors of the metal (Rattan *et al*., 2005).

Vegetables take up metals by absorbing them from contaminated soil as well as from deposits on different parts of the vegetables exposed to the air from polluted environments (Sobukola *et al*., 2003). Vegetable plants growing on heavy metal contaminated medium can accumulate high concentrations of trace elements to cause serious health risk to consumers (Long *et al*., 2010).

Vegetables are plants that are eaten or cooked. It is described as shrubs or herbaceous annualar perennial plants that are eaten by man (Longman, 2005). Soil is thin layer of organic and inorganic materials that covers the earth's rocky surface. The organic portion, which is derived from the decaying remains of plant and animals, is concentrated in the dark uppermost topsoil. The inorganic portion made up of rock fragments, was formed over thousand of years by physical and chemical

Corresponding Author: Mahmud Imam Mohammad, Department of Applied Science, College of Science and Technology, Kaduna Polytechnic

weathering of bedrock. Productive soils are necessary for agriculture to supply the world with sufficient food.

There are many sources of trace metals contaminants that can be accumulated in soils. The burning of fossils fuels, smelting and other processing techniques release into the atmosphere which can be carried for miles and later deposited on the vegetation and soil. Lead, nickel and boron are gasoline additives that are released into the atmosphere and carried to the soil through rain and snow (Holmgen *et al*., 1993; Igwe *et al*., 2005).

Farmlands were irrigated with water from Kaduna River and drainages within Kaduna metropolis. For the past decades, water from these rivers was clean, however, with the increase in urban population and industrialization it now becomes contaminated with various pollutants among which are heavy metals.

MATERIALS AND METHODS

Sample and sampling: Tomatoes samples were collected from October 2009 to February 2010 from twenty one (21) different irrigation sites of farmlands from Kaduna metropolis where they were irrigated with water from the river or pond which are sometimes contaminated. Soil samples were also randomly collected from the farm where these vegetables were grown and irrigated with water. These samples were then stored in polythene bags and taken to the laboratory and dried in an oven at 100^0C.

The dried samples were ground with mortar and pestle and sieved with 2 mm sieve.

Description of the sampling sites: Soil samples for heavy metal determination were collected from twenty one (21) irrigation sites of the Kaduna metropolis. These sites were Kabala (KBL), Danmani (DMN), Rigasa (RGS), Barnawa (BNW), Makera (MKR), Kakuri (KKR), Badiko (BDK) Nasarawa (NAS), Malali (MAL), Kudenda (KUD), Kinkinau (KKN), Kawo (KWO), Unguwan Rimi (URM), Unguwan Sanusi (UNS), Tudun Wada (TDW), Doka (DKA), Unguwan Dosa (UDS), Kabala Costain (CTA), Kurmin Mashi (KMS) and Abakpa (ABK). In this research work soil sample from Rigachikun (RCK) irrigation site was taken as control site.

Sample preparation:

Tomatoes samples: 5 g of the ground tomatoes samples were ashed in a muffle furnace at a temperature of 550^0C for 5 h and digested with 20 cm^3 of HNO_3/H_2O_2 (2:1). The digested residues were dissolved with 50 cm^3 of distilled water and filtered in 50 cm^3 volumetric flask.

Soil sample: 20 g of the finely ground soil samples was mixed with 60 cm^3 (5:5:1) $H_2SO_4/HNO_3/HCl$ acid mixtures and the content were refluxed for 12 h. The sample was washed with 1M HNO_3 and 100 cm^3 of deionized water was also added and centrifuged. The elements (Cd and Pb) were determined using bulk scientific model VPG 210 model atomic Absorption Spectrophotometer (AAS).

In order to investigate the ratio of the concentration of heavy metal in a plant to the concentration heavy metal in soil, the transfer factor was calculated based on the method described by Oyedele *et al*. (2005) and Harrison and Chirgawi, 1989).

$$TF = Ps\ (\mu g/g) / St\ (\mu g/g)$$

where; Ps is the plant metal content originating from the soil and St is the total content in the soil.

RESULTS AND DISCUSSION

The mean concentration of cadmium and lead in soil and tomatoes at various irrigation sites of the Kaduna metropolis are summarized in Table 1-2.

Analysis of cadmium and lead concentrations in soil: Table 1 shows Cadmium concentrations in soil from irrigation sites of Kaduna metropolis. The result shows that some sampling sites had more concentration of Cadmium than of the control site (1.32 µg/g). Sharma *et al*. (2009) reported concentration of cadmium as 2.3 µg/g in the soil which is higher than the concentration obtained in the present study.

Table 1 also shows lead concentrations in soil from irrigation sites of Kaduna metropolis. The concentrations obtained in the analyzed samples were more than that of

Table 1: Concentrations of cadmium and lead in soil samples from different irrigation sites of the kaduna metropolis

	Mean concentration	
Sampling sites	Cd (µg/g)	Pb (µg/g)
SL (KBL)	1.35±0.30	4.17±2.88
SL (DMN)	1.02±0.94	4.00±2.84
SL (RGS)	0.04±0.06	13.23±6.64
SL (BNW)	2.23±1.47	35.46±14.26
SL (MKR)	1.95±0.28	3.23±020
SL (KKR)	0.73±0.60	36.47±12.57
SL (BDK)	1.27±0.10	2.17±0.96
SL (NAS)	1.80±0.70	4.67±1.89
SL (MAL)	1.25±0.31	3.80±1.64
SL (KUD)	2.18±0.28	4.95±2.23
SL (KKN)	1.55±0.14	3.47±1-00
SL (KWO)	0.12±0.03	39.78±13.64
SL (URM)	ND	16.47±2.22
SL (UNS)	0.03±0.03	9.60±7.21
SL (TDW)	0.20±0.25	5.16±6.35
SL (DKA)	1.25±1.75	30.36±20.50
SL (UDS)	1.57±0.23	3.67±1.36
SL (CTA)	1.55±0.23	2.53±0.61
SL (KMS)	1.47±0.20	2.60±0.60
SL (ABK)	1.18±0.22	3.47±1.58
SL (RCK)	1.32±0.44	3.67±2.02

SL: Soil

Table 2: Concentrations of cadmium and lead in tomatoes from different irrigation sites of the kaduna metropolis

	Mean concentration	
Sampling sites	Cd (µg/g)	Zn (µg/g)
TM(KBL)	0.42±0.68	3.63±1.54
TM(DMN)	0.10±0.10	4.26±2.67
TM(RGS)	0.69±0.66	4.19±2.45
TM(BNW)	0.60±0.48	3.99±1.72
TM (MKR)	0.87±0.61	2.13±0.81
TM (KKR)	0.74±0.84	1.87±0.61
TM (BDK)	0.36±0.26	0.92±0.08
TM (NAS)	1.33±0.12	3.27±1.70
TM (MAL)	0.67±0.50	3.07±1.94
TM (KUD)	0.77±0.51	2.44±0.66
TM (KKN)	1.00±0.53	2.00±0.60
TM(KWO)	0.84±0.63	1.93±1.10
TM(URM)	0.93±0.31	1.87±0.81
TM (UNS)	0.09±0.10	1.93±0.50
TM(TDW)	0.32±0.21	3.53±3.25
TM (DKA)	1.33±0.23	2.32±0.30
TM (UDS)	0.93±0.46	4.60±2.42
TM (CTA)	0.60±0.58	3.40±1.56
TM (KMS)	0.87±0.58	4.67±1.29
TM (ABK)	0.93±0.23	2.40±0.53
TM (RCK)	1.00±0.35	3.27±1.70

TM: Tomatoes

the control sites (3.67 µg/g). Oyedele *et al*., (2008) reported 37.9-42 µg/g for lead in soil which were higher than the concentration obtained in this research study.

Lead concentration for all the soil samples analyzed in this research work were found to be lower than 2.95 and 3.58 µg/g for the soil from Alau dam and Gongulon (Maiduguri, Nigeria) as reported by Uwah *et al*. (2009), in contrast with Badiko, costain and Kurmin mashi samples with lower concentrations.

Cadmium concentration in tomatoes samples: Table 2, shows Cadmium concentration in tomatoes, the mean concentration of these samples were far above WHO/FAO (2007) standard of 0.2 µg/g. This implies that, the concentration of Cadmium in tomatoes were above the tolerable limit in most of the sampling sites. However, there is an isolated case in Danmani where the Cadmium concentration is within the WHO limit.

Sharma *et al*. (2009) recorded higher concentration of 1.96 µg/g of cadmium in tomatoes more than that obtained in the present study. High concentration of heavy metal such as cadmium in the vegetables like tomatoes may occur due to irrigation with contaminated water (Sharma *et al*., 2009; Singh and Kumar, 2006).

Lead concentration in tomatoes samples: Table 2, also shows lead concentration in tomatoes, the mean concentration of the sample analyzed was far above WHO standard, given as 0.3 µg/g. This implies that, the concentrations of lead in tomatoes are above the tolerable limit in most of the sampling sites. However, from the results obtained in this research work consumers of such vegetables are liable to lead toxicity.

Table 3 shows correlation coefficients for cadmium in soil and tomatoes samples. It was obtained that $p = 0.000<0.05$ for tomatoes. This shows that there is significant correlation between Cadmium concentrations in soil and Cadmium concentrations in the tomatoes. The correlation is strong positive with the value of $r = 0.771$. This implies that both Cadmium concentrations in soil and Cadmium concentrations in the tomatoes increase and decrease together in the same direction. As Cadmium concentrations in soil increases, the Cadmium concentrations in the tomatoes also increases and vice versa.

Table 4 shows correlation coefficients for cadmium in soil and tomatoes samples. It was obtained that, $p = 0.003<0.05$ for tomatoes. This shows that there is significant correlation between lead concentrations in soil and lead concentrations in the tomatoes. The correlation is strong positive with the value of $r = 0.576$. This implies that both lead concentrations in soil and lead concentrations in the tomatoes increase and decrease together in the same direction. As lead concentrations in soil increases, lead concentrations in the tomatoes also increases and vice versa.

Table 5 shows transfer factor for heavy metal from soil to tomatoes. All transfer factor are below 1 with the exception Rigasa, Kakuri, Kawo, Unguwan Sanusi, Tudunwada, Doka, Abakpa and Rigachikun (control site). Most of the values obtained in this research work had transfer factor lower then than that obtained from Rigachikun (control site).

The transfer factor reported by Oyedele *et al*. (2005) were 0.75, 0.86, 0.40, 1.42 for the Zn, Cd, Cu and Pb respectively. Infact most of these values were higher than that obtained in the present study.

Table 3: Correlation coefficients for cadmium

Vegetable type			Cadmium concentration in tomatoes sample (µg/g)
Tomatoes	Cadmium concentration in soil sample (ug/g)	Pearson correlation	0.771
		Sig. (2-tailed)	0.000

Table 4: Correlation coefficients for lead

Vegetable type			Lead concentration in tomatoes sample (g/g)
Tometoes	Lead concentration in soil sample (µg/g)	Pearson correlation	0.576
		Sig. (2-tailed)	0.003

Table 5: Trans Fer factor (TF) For each metal from soil to tomatoes

Sampling sites	Cd (µg/g)	pb (µg/g)
Kabala	0.31	0.87
Danmani	0.09	0.80
Rigasa1	7.25	0.12
Barnawa	0.26	0.05
Makera	0.47	0.50
Kakuri	1.01	0.14
Badiko	0.29	0.63
Nasarawa	0.74	ND
Malali	0.52	0.48
Kudenda	0.35	0.31
Kinkinau	0.65	0.56
Kawo	1.56	0.07
Unguwan Rimi	0.93	0.23
Unguwan Sanusi	3.00	0.23
Tudunwada	1.60	0.34
Doka	1.06	0.13
Unguwan Dosa	0.59	0.85
Costain	0.39	0.75
Kurmi mashi	0.56	0.97
Abakpa	0.78	1.00
Rigachikun	0.76	0.67

Table 6: Percentage ash in spinach sample

Samples	Mean percentage ash (%)	SD (%)
Kabala	25.60	9.07
Danmani	23.66	6.03
Barnawa	16.00	2.00
Makera	26.67	2.52
Badiko	29.67	2.52
Nasarawa	20.00	6.00
Malali	25.33	5.69
Kudende	32.33	2.08
Kinkinau	23.33	4.16
Kawo	2.082	8.33
Unguwan Rimi	34.33	4.04
Unguwan Sanusi	32.67	2.30
Tudun Wada	27.67	5.69
Doka	29.67	2.52
Unguwan Dosa	29.67	1.53
Costain	16.00	2.00
Kurmin Mashi	30.00	4.00
Abakpa	24.67	8.08
Kakuri	31.00	2.00
Rigasa	18.00	3.00
Rigachikun Control	31.00	1.78

SD: Standard Deviation

Table 6 shows percentage ash in tomatoes samples from Kaduna metropolis. Some of the percentage ash obtained in this analysis were lower than the percentage in the control site 31.00%. All percentage ash for tomatoes obtained in the present study were higher than 18.00% for Balsam Apple as reported by Hassan and Umar (2006) with the exception of samples from Barnawa and costain with each having 16.00%.

CONCLUSION

This research work successfully assessed the level of cadmium and lead in soil and tomatoes grown in the irrigated farmland of Kaduna Metropolis in Nigeria, using Atomic Absorption Spectrophotometry. The findings showed that the studied samples were polluted with the above mentioned heavy metals. This is because, the result revealed that the concentration of these metals were above the recommended limit stipulated by WHO/FAO (2007) allimentarius. Therefore consumption of tomatoes from the study areas might pose health hazards to human as at the time of this study.

REFERENCES

Duruibe, J.O., M.O.C. Ogwuegbu and J.N. Egwurugwu 2007. Heavy metal pollution and human biotoxic effects. Int. J. Physical Sci., 2(5): 112-118.

Garbarino, J.R., H. Hayes, D. Roth, R. Antweider, T.I.Briton and H. Taylor, 1995. Contaminants in the Mississippi River U.S. Geological survey circular 1133, Virginia U.S.A.

Gustar, R., 1974. Heavy Metals Hazardous Heavy Metal, WHO International Ref. Center for Waste Disposal (IRCWD News) pp: 6.

Harrison, R.M., Chirgawi, 1989. The assessment of air and soil as contributor of some trace metals to vegetable plant III-experiment with field grown plants. Sci. Total Environ., 83: 47-63.

Hassan L.G. and K.J. Umar, 2006. Nutritional values of Balsam Apple (*Momordica balsam mina* L.). J. Nurtr., 5: 77-82.

Hawkes, S.S., 1997. Heavy metals. J. Chem. Edu., 74(1): 1374-1377.

Holmgen, G.G., M.W. Meyer, R.L. Chaney, Daniel, 1993. Cadmium, Lead Copper and Nickel Agricultural soil. Agricultural Soil in the United States of American, 1st Edn., 22: 335-348.

Huton, M. and C. Symon, 1988. The quantities of Cd, Hg, and As entering the UK environment from Human Activities. Sci. Total Euron., 57: 129-150.

Igwe, J.C., D.N. Ogunewa and A.A Abia, 2005. Comparative adsorption of Zn (II), Cd(II) and Pb(II) ions from aqueous solutions and non-aqueous solution by maize cob and husk. Afr. J. Biotechnol., 4(10): 1113-1116.

Kenneth, B. and P.S. Harvey, 1979. Health Implication of Trace Metal in the Environment, Ultra Trace Metal Analysis in Biological Sciences and Environment. Advances in Chemistry Society, Washinton DC, pp:27-32.

Long, X.X., X.E. Yang, W.Z. Ni, Z.Q. Ye, Z.L. He, D.V. Calvert and J.P. Stoffella, 2010. Assessing zinc thresholds for phytotoxicity and potential dietary toxicity in selected vegetable crops. Commun Soil Sci. Plant Anal., 34(9-10): 1421-1434.

Longman, 2005. Dictionary of Contemporary English. Longman Nigeria PLC.

Muchuweti, M., J.W. Birkett, E. Chinyanga, R. Zvauya, M.D. Scrimshaw and J.N. Lester, 2006. Heavy metal content of vegetables irrigated with mixture of waste waterandsewage sludge inZimbabwe; the implication for human health. Ecosyst. Environ., 112: 41-48.

Nriagu, J.O., 1999. A global assessment of Natural sources of Atmosphere. Trace. Metals Nature, 338: 47-49.

Oyedele, D.J., I.B. Obioh, J.A. Adejumo, A.F. Oluwole, P.O. Aina and A.I. Asubiojo, 2005. Lead contamination of soils and vegetation in the vicinity of a lead smelter in Nigeria. Sci. Total Environ., 1732: 189-195.

Oyedele, D.J., M.B. Gasu and O.O. Awotoye, 2008. changes in soil properties and plant uptake of heavy metals on selected municipal solid waste dump sites in Ile-Ife Nigeria. J. Environ. Sci. Tech., 3(5): 107-115.

Rattan, R.K., S.P. Dattan, P.K. Chhonkar, K. Suribabu and A.K. Singh, 2005. Long-term impact of irrigation with sewage effluent on the heavy metal content in soil, crops and ground water. A case study. Agric. Ecosyst. Environ., 109: 310-322.

Sharma, R.K., M. Agrawal and F.M. Mashall, 2009. Heavy metals in vegetables collected from production and market site of a tropical urban area of India. J. food chem. Toxicol., 47: 583-591.

Singh, S. and M. Kumar, 2006. Heavy metal load of soil, water and vegetables in peri urban Delhi. Environ. Monitoring Asses., 120: 79-91.

Sobukola, O.P., O.M. Adeniran, A.A. Odedairo and O.E. Kajihausa, 2003. Heavy metal levels of some fruit and leavy vegetables from selected markets in Lagos Nigeria. Afri. J. food Sci., 4(2): 389-393.

Uwah, E.I., N.P. Ndah and Ogugbuaja, 2009. study of the levels of some agricultural pollutants in soil and water leaf (*Talinum triangulare*) obtained in Maiduguri, Nigeria. 4(2): 71-78.

WHO/FAO, 2007. Joint FAO/WHO Food Standard Programme Codex Alimentarius Commission 13 Session. Report of the thirty eight session of the codes committee on food hygiene. Houston, United State of America, ALNORM 07/03/13.

Zaidi, M.I., A. Asrar, A. Mansoor and M.A. Farooqu, 2005. The heavy metal concentration along roadside trees of Quetta and its effects on public health. J. Appl. Sci., 4: 708-711.