Adamawa State University Journal of Scientific Research
Volume 7 Number 1, April, 2019; Article no. ADSUJSR 0701019
ISSN:2705-1900(Online); ISSN: 2251-0702 (Print)
http://www.adsujsr.com

Assessment of the Level of Heavy Metals in Soil and Vegetables in some Irrigated Farmlands in Jos Metropolis, Nigeria

Dodo J. D*, Orachor I., Salami S. J. and Eseyin E. A
Department of Chemistry, University of Jos. Nigeria
Contact: dodojuliet1969@gmail.com

Abstract

In this study, the concentrations of Lead (Pb), Cadmium (Cd) and Chromium (Cr) in selected vegetables (tomato and cabbage) were determined in ten (10) different irrigated farmlands in Jos metropolis, Plateau State, Nigeria using Atomic Absorption Spectrophotometry (AAS). In order to establish the level of contamination and bioaccumulation in the vegetables, the soil samples from the same irrigated farmlands were also analyzed for the heavy metals. Unlike Cd which was found to be below the detection limit, about 0.388±0.171 mg/kg, 0.959±0.130 mg/kg, and 1.315±0.067 mg/kg concentrations of Pb were determined in the cabbage, tomato and the soil respectively. These values were found to be above the permissible limits (PL) of 0.300 mg/kg recommended by WHO/FAO for vegetables and below PL set for soil which is 10 – 50 mg/kg. From the result obtained it will suffice to say that the consumption of these vegetables cultivated in the farmlands irrigated with wastewater could increase the likelihood of Pb related toxicity.

Key words: Heavy metals; Soil; Vegetables; Irrigated Farmland; AAS

Introduction

The increasing demand for food safety has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by agrochemicals, heavy metals and/or toxins (D'Mello, 2003). Dietary intake of heavy metals pose a great risk to the entire biota, high concentration of these metals especially Cu, Cd, As and Pb in fruits and vegetables are implicated in a number of health-related complications such as gastrointestinal cancer (Turkdogan *et al*., 2002).Vegetables act as buffering agents for acidic substances obtained during the digestion process. However, these plants may contain both essential as well as toxic elements such as heavy metals at a diverse range of concentrations (Paul *et al*., 2012).The contamination of vegetables with heavy metals may be due to irrigation with contaminated water, addition of fertilizers and metal-based pesticides, industrial emissions, transportation, the harvesting process, storage or at the point of sale. It is a known fact that plants take up metals by absorbing them from contaminated soil as well as from deposits on parts of the plants exposed to the air from polluted environments (Chojnacka *et al*., 2005). Public awareness regarding the high level of heavy metals in the environment has created apprehension and fear in the public as to the presence of heavy metal residues in their daily food. Noting the potential toxicity and persistent nature of heavy metals and the frequent consumption of vegetables and fruits, it is necessary to investigate these essential part of our diet to ensure that their levels meet the agreed International requirements. .Lead and Cadmium are among the most abundant heavy metals and are particularly toxic. Excessive content of these metals in food is associated with a number of diseases, especially of the cardiovascular, renal, nervous and skeletal systems (WHO, 1995; Jarup, 2003). These heavy metals are also implicated in carcinogenesis, mutagenesis and teragenesis (Radwan and Salama, 2006).

Irrigation is the artificial addition of water to soils in order to meet plants needs to overcome drought limitations and improve the crops yields. However, other factors like soil management practices and water quality are also important. Waste water irrigation is known to contribute significantly to the heavy metal content of soils (Mapanda *et al*, 2005).

Tomato is a vegetable crop cultivated by peasant farmers in Nigeria, especially Jos, the Plateau state capital. The ripe fruit can be eaten raw, used for the preparation of different delicacies as well as making stew. Tomato requires a temperature of between 20^{o}C – 25^{o}C, high level of sunshine and a well-drained loamy soil rich in organic matter. Maturity period is between two to three months from planting which normally starts from September to October. Cabbage (*Brassica oleracea*) is a leafy garden plant with a short stem and a globular head of tightly overlapping green to purplish leaves. As the cabbage plant grows, its leaves increase in number forming a ball-shaped "head" at the centre of the plant. Its maturity period also is within two to three months. Tomato and cabbage are known to have high content of vitamins, such as vitamin A, vitamin C, vitamin B3, B6, B9 vitamin E, vitamin K. These vegetables have low levels of saturated fat and cholesterol and are good sources of thiamin, calcium, iron, magnesium phosphorus, potassium, manganese as well as dietary fibre (Hatfield, 2014). Heavy metals exist in soil in soluble form and also in combined form. The soluble exchangeable and chelated metal species in the soils are mobile and therefore are available to plants and can also be accumulated in them depending on vegetable species, growth stages, soil composition, geographic, atmospheric conditions and type of metal (Radulescu *et al*, 2013).

Nyamangra and Mzezewa (1999) reported that the disposal of sewage and industrial effluents on farmland soils is the chief source of heavy metal enrichment of pasture land and agricultural fields. Studies conducted by Kisku *et al*., (2000) further reported that the uptake of Cu, Pb, Ni and Cd by *Brassica Oleracea* from fields irrigated with industrial effluent indicated widespread contamination from heavy metals despite showing a healthy and gigantic external morphology. Therefore, heavy metal contamination of vegetables cannot be underestimated as these foodstuffs are important components of human diets. Rapid and unorganized industrialization and urbanization have contributed to the elevated levels of heavy metals in the urban environment of most developing countries (Wong *et al*, 2003; Batagarawa , 2000).

Lacatusu and Lacatusu (2008) assessed the quality of vegetables and fruits grown within heavy metals polluted environment. They found that unlike vegetables, the accumulation of heavy metals in fruits is low because a large proportion of heavy metals absorbed by trees are stored in other organs, especially in leaves. The medium value of total and mobile heavy metal content (Cd, Cu, Pb,Zn) in most samples exceeds the maximum allowable limits.

Al-Jassir *et al* (2005) assessed the deposition of heavy metals on green leafy vegetables sold on roads sides. In this study the levels of lead, cadmium, copper and zinc were determined in washed and unwashed green leafy vegetable samples.

Materials and Methods

Samples collection

About ten (10) samples each of tomato and cabbage were collected in the ten (10) different irrigation farmland at Farin Gada, Jos Metropolis. Ten (10) soil samples were also randomly collected from the farm where these vegetables were grown and irrigated with the contaminated water. These samples were then stored in polyethene bags and taken to laboratory.

Samples pre-treatment

Each sample (Tomato and Cabbage) was washed with tap water and thereafter with distilled water and dried in an oven at 80°C (Lary and Morgan, 1986). At the end of the drying, the oven was turned off and left overnight to enable the sample cool to room temperature. Each dried sample was powdered using a mortar and pestle and sieved with 2 mm sieve.

Digestion of vegetables samples (tomato and cabbage)

To 1g each of the samples in a beaker, 15cm^3 of aqua regia (3:1 of HCI and HNO_3) was added. These samples were heated on heating mantle until the solution boiled for 2 minutes. Then the samples were dropped from the heating mantle and were filtered into different 100 cm^3 volumetric flask using filter papers (Whatman R41) and funnel. These were diluted to 100 cm^3 using distilled water. The filtrate was then analyzed for the required heavy metals using Atomic Absorption Spectroscopy (AAS).

Digestion of soil sample

The soil samples were air-dried, grounded and sieved with 2 mm mesh sieve. About 2.00g of the soil samples were weighted and transferred into a 100 cm^3 beakers and then 3:1 of both concentrated HCI and HNO_3 were added to the soil samples. The samples were then shaken and the beaker covered with a watch glass and the solution gently heated under reflux for 2 hours on an electric hot plate adjustable and maintaining a temperature of 90° - 95°C. After cooling the samples, they were rinse with deionized water and filter through No. 42 Whatman filter paper to remove any undigested solid material. The filtrate were collected in a volumetric flask and the solutions were then made up to 100 cm^3 with deionized water and stored in a 100 cm^3 sample bottle for analysis. Atomic absorption spectrophotometer [AAS Machine Model 6800 Shimadzu] equipped with photomultiplier tube detector and hollow cathode lamp was used to determine the metal concentrations of both digested vegetables samples and soil samples.

Results and Discussion

The results of the analysis of the vegetable samples are presented in Tables 1 to 3

Table 1 presents the concentration levels of Pb, Cd and Cr in the cabbage sample. Pb ranged from 0.117 – 0.683mg/kg at farm 3 and farm 10 with an average of 0.388±0.171mg/kg, Cd was 0.000 – 0.023 at farms 2,4,5,7,9,10 and farm 3 with an average of 0.004±0.002mg/kg. Cr was below the detectable limit of the instrument.

Table 1: Concentration of Pb, Cd and Cr in cabbage (mg/kg)

Cabbage sample	Pb	Cd	Cr
Farm 1	0.345	0.001	B.D.L
Farm 2	0.366	0.000	B.D.L
Farm 3	0.117	0.023	B.D.L
Farm 4	0.200	0.000	B.D.L
Farm 5	0.293	0.000	B.D.L
Farm 6	0.371	0.013	B.D.L
Farm 7	0.422	0.000	B.D.L
Farm 8	0.495	0.000	B.D.L
Farm 9	0.592	0.000	B.D.L
Farm 10	0.683	0.000	B.D.L
Average (±SD)	**0.388 ± 0.171**	**0.004 ± 0.002**	
WHO/FAO STANDARD (1995)	0.300	0.200	2.300

Table 2 shows the concentration levels Pb, Cd and Cr in the tomato samples. Pb was in the range of 0.770 – 1.124mg/kg at farm 1 and farm 9 with an average of 0.959±0.130mg/kg, Cd was 0.000 – 0.075 at farms 1, 2, 3, 4, 7 and farm 6 with an average of 0.008±0.004mg/kg. Cr was below the detectable limit of the instrument.

Table 2: Concentration of Pb, Cd and Cr in Tomato Sample mg/Kg

Tomato samples	Pb	Cd	Cr
Farm 1	0.770	0.000	B.D.L
Farm 2	0.820	0.000	B.D.L
Farm 3	0.851	0.000	B.D.L
Farm 4	0.858	0.000	B.D.L
Farm 5	0.933	0.001	B.D.L
Farm 6	0.992	0.075	B.D.L
Farm 7	1.041	0.000	B.D.L
Farm 8	1.076	0.000	B.D.L
Farm 9	1.124	0.003	B.D.L
Farm 10	1.121	0.002	B.D.L
Average (±SD)	**0.959±0.130**	**0.008±0.004**	
WHO/FAO STANDARD (1995)	0.300	0.200	2.300

B.D.L: (below detection level)

Table 3 presents the concentration levels of Pb, Cd and Cr in the soil samples at the various farm sites. The concentration of Pb ranges from 1.211 – 1.410 mg/kg at farm 2 and farm 9 with an average of 1.315±0.067 mg/kg, Cd ranged from 0.005 – 0.034 mg/kg at farm 2 and farm 1 with an average of 0.019±0.008mg/kg respectively. Cr was below the detection limit of the instrument.

Table 3: Concentration of Pb, Cd and Cr in soil sample mg/kg

Soil sample	Pb	Cd	Cr
Farm 1	1.242	0.034	B.D.L
Farm 2	1.211	0.005	B.D.L
Farm 3	1.273	0.017	B.D.L
Farm 4	1.309	0.024	B.D.L
Farm 5	1.285	0.018	B.D.L
Farm 6	1.324	0.013	B.D.L
Farm 7	1.318	0.022	B.D.L
Farm 8	1.404	0.022	B.D.L
Farm 9	1.410	0.025	B.D.L
Farm 10	1.383	0.010	B.D.L
Average (±SD)	**1.315±0.067**	**0.019±0.008**	
WHO/FAO STANDARD (1995)	90.000	0.100	0.100

The source of water for the irrigated farmlands was obtained from Farin Gada stream in Jos Metropolis. From the results obtained in Table 1, the concentration of Pb in cabbage cultivated in Farm 3, 4 and 5 were all below the recommended limit set by the WHO/FAO. Similarly, the concentration of Cd as shown in the table are far below the WHO/FAO recommended limit in cabbage cultivated in farm 1, 3 and 6. For sample collected in farm 4, 5,7,8,9 and 10 all the concentrations were below the detection limit. The concentration of Pb in the vegetables might be due to pollution of River by waste car battery and runoff from polluted substances from vehicular activities (Orish *et al.*, 2017). Several study linked the level of Pb in community farmlands to emissions from automobiles (Li *et al.*, 2001). Industrial and domestic wastewaters for irrigation on vegetable farms at Sharada, Kwakwachi and Jakara in Kano metropolis were studied in comparison to samples from remote part of Kano (Thomas Dam) indicates that significant differences ($P<0.05$) of all the metals analyzed in the vegetable samples, however the levels were within the National Agency for food and Drug Administration and Control (NAFDAC) tolerable limits for metals in fresh vegetables (Abdulmojeed and Abdulrahman, 2011). For both vegetables (cabbage and tomato) as presented in Tables 1 and 2, the concentration of Pb were observed to follow the decreasing order in the farms 10>9>8>7>6>2 and farm 9>10>7>8>6>5>4>2>1 when compared with the recommended limit set by WHO/FAO respectively. These sequences indicate that the heavy metal content of vegetables is higher in areas treated with wastewater. This observation is in agreement with other studies conducted by (Sharma *et al.*, 2009). This also conform to an experiment performed by (Chiroma *et al*, 2012) which results shows that the mean concentrations of heavy metals in treated and untreated urban sewage waters used for irrigation are above maximum PL set by WHO, analysis of the farm soil where sewage water was used indicated high level contamination by heavy metals. The plants grown on the plot also show variations in concentrations of heavy metals in different parts of the vegetable plants irrigated with treated and untreated sewage waters exceeding the maximum PL. Which suggested that uptake of metals by plants is proportional to their concentrations and availabilities in soil. The experimental results showed that all the vegetables (cabbage and tomato) and soils samples analyzed were observed to contain concentrations of lead in (Tables 1, 2 and 3). The maximum values of Pb for various farms are (0.683 mg/kg) at farm 10, (1.124 mg/kg) at farm 9 for tomato and for soil (1.410 mg/kg) respectively. From these results, it infers that lead accumulated more in the soil. In the soils samples the mean concentrations (mg/kg) of Pb and Cd (Table 3) are 1.315±0.067 and 0.019±0.008 respectively. While the mean concentrations of Pb and Cd in vegetables (cabbage and tomato) samples (mg/kg) (Tables 1 and 2) are 0.3884±0.171 and 0.959±0.180 respectively. The result depicts low concentrations of Cd in vegetables (cabbage and tomato) compared to the soils samples. The soil sample exhibited relatively high levels of lead in all the mean concentrations in the vegetables samples (cabbage and tomato) and soils sample fall above the maximum permissible standard limit as suggested by WHO/FAO. Studies conducted by (Doherty *et al*, 2012) on five vegetables collected from selected farms and markets in Lagos reveals all the heavy metals studied (Cu, Zn, Pb and Cd), their concentrations were below the WHO and FAO safe limit of 40, 60,5 and 0.2mg/kg respectively in all five vegetables. However, from the result obtained in this research, consumers of these vegetables are liable to accumulate lead which can lead to lead toxicity. However, the concentrations of Cr were all below detection limits.

Table 4 shows the correlation of Pb to Cd concentration in the crops and soil samples respectively. There was a negative correlation in cabbage while a positive and significant correlation existed in tomato and the soil samples respectively ($P = 0.05$).

Table 4: Correlation of Pb to Cd in crops and soil samples

Samples:	**Cabbage**		**Pb**	**Cd**
		Pb	1	-0.537
		Cd	-0.537	1
	Tomato		**Pb**	**Cd**
		Pb	1	0.120
		Cd	0.120	1
	Soil		**Pb**	**Cd**
		Pb	1	0.125

Cd	0.125	1

The cabbage sample has Pb with negative correlation with Cd as -0.537 which indicates that when one variable increases in value, the second variable decreases in value. It shows that the Pb concentrations in the study area are higher than that of Cd. But in the soil and tomato, Pb and Cd are positively correlated to each other. This is because both may have common sources or may be influenced by similar factors. The common sources of such contamination could either be the farm sites irrigation water polluted with atmospheric deposition of these metals. Based on the analysis carried out, Pb showed a higher level in the vegetable while that of Cr and Cd were below the WHO/FAO standard in both the vegetable and soil respective

Conclusion

The concentration of lead (Pb) in the samples investigated in this study was found to be higher than the WHO/FAO permissible limits. This may be attributed to contaminated soil and water used for irrigation while that of Cadmium (Cd) was lower than the WHO/FAO permissible limits. Furthermore, the concentration of Pb is relatively higher in the soil than the vegetables (cabbage and tomato), this could be attributed to automobile emissions as a result of its proximity to the road side in addition to the possible high levels of metals in the contaminated water being used for irrigation. The trends in the concentration of Pb in soil and vegetables (cabbage and tomato) follow the following order; soil>tomato>cabbage. Moreover, the concentration of Cr was found to be below detection limits of the instrument used.

References

Abdulmojeed, O.L & Abdulrahman, A.A. (2011). Analysis of heavy metals found in vegetables from some cultivated irrigated gardens in the Kano metropolis. *Journal of Environmental Chemistry and Ecotoxicology* 3(6): 142 – 148. ISSN: 2141-2261.

Al-Jassir, M.S., Shaker A. & Khaliq M.A., (2005). Deposition of heavy metals on green leafy vegetables sold on roadsides of Riyadh city, Saudi Arabia. *Bulletin in Environment. Contamination. Toxicity*., 75: 1020-1027.

Chiroma, T.M.., Ebewele, R.O. &Hymore, F.K (2012). Levels of Heavy metals (Cu, Zn, Fe, and Cr) in Bushgreen and Roselle Irrigated with Treated and Untreated Urban Sewage water. *International Research Journal of Environment Sciences* 1(4): 50 - 55

Chojnacka, K., Chojnacki, A., Gorecka, H., Gorecki, H. (2005). Bioavailability of heavy metals from polluted soils to plants. *Science Total Environmental*. 337: 175-182.

Doherty, V.F., Sogbanmu, T.O., Kanife, U.C. &Wright, O. (2012). Heavy metals in Vegetables Collected from selected farm and markets sites in Lagos, Nigeria. *Advanced Research Journal of Environmental Science and Toxicology* 1(6):137 – 142. ISSN: 2315-5140.

D,Mello, J.P.F., (2003). Food Safety: Contaminants and toxins. Cambridge, *CABI Publishing, pp 32-65.*

Duffus, J.H., (2002): Heavy Metals – A meaningless term. Pure and Applied Chemistry. 74: 793-807.

Hatfield, G., (2004). Encyclopedia of Folk Medicine: Old World and New World Traditions, *ABC-CLIO*, pp. 59-60.

Jarup, L., (2003). Hazards of heavy metal contamination. *Br Med Bullet*. 68: 167-182.

Lacatusu, R. & Lacatusu, A.R., (2008). Vegetables and fruits quality within heavy metals polluted areas in Romania. Carpth. *Journal Earth Environment. Science*, 3: 115-129.

Larry, R.W.& Morgan, J.T., (1986). Determination of plant Iron, Manganese and Zinc by wet digestion procedures. *Journal Food Agriculture*, 37: 839-844.

Li, X., Poon, C. & Liu, P.S., (2001). Heavy metal contamination of urban soils and street dusts in kong. *Application. Geochem.* 16 (11-12): 1361-1369.

Orish, E.O., Emmanuel, A D., Herbert, O. C.M. & Nnaemeka, A. U. (2017). Lead levels in Vegetables from artisanal mining sites of Dilimi River, Bukuru and Barkin Ladi, North Central Nigeria. Cancer and Non Cancer Risk Assessment. *Asian Pacific Journal of Cancer Prevention* 18(3): 621 – 627. DOI: 1022034/APJCP.2017.18:3.621.

Paul, B.T., Clement, G. Y., Anita, K.P. & Dwayne, J.S. (2012). Heavy metals Toxicology and the Environment. *HHS Public Access. NCBI Resources.* US National Library of Medicine. National Institute of Health. EXS: 2012; 101:133-164. DOI- 101007/978-3-7643-8340-46.

Radulescu, C., Stihi, C., Popescu, I.V., Ionita, I., Dulama, I.D., Chilian, A., Bancuta, O.R., Chelarescu, E.D., & let, D., (2013). Assessment of Heavy metals level in some perennial medicinal plants by Flame Atomic Absorption Spectrometry, *Romanian Reports in Physics*, 65(1), 246-260.

Sharma, R.K., Agrawal, M. & Marshall, F.M., (2009). Heavy metals in vegetables collected from production and market sites of a tropical urban area of India. *Food Chemistry, Toxicology*. 47: 583-591.

Singh, S. & Kumar, M., (2006). Heavy metal load of soil, water and vegetables in peri-urban Delhi *Environment Monitor and Assessment*. 120: 79-91.

Tripathi, R.M., Raghunath, R. & Krishnamoorthy, T.M., (1997). Dietary intake of heavy metals in Bombay city, India. Science. *Total Environmental*. 208: 149-159.

Turkdogan, M.K., Kilicel, F., Kara, K., Tuncer, I. & Uygan, I., (2002). Heavy metals in soil, vegetables and fruits in the endemic upper gastrointestinal cancer region of Turkey. *Environmental. Toxicology. Pharmacology*. 13: 175-179.

World Health Organization, (1995). Lead environment health criteria. Geneva: *World Health Organization*.

Wong, C.S.C., Li, X.D., Zhang, G., Qi, S.H & Peng, X.Z., (2003). Atmospheric depositions of heavy metals in the Pearl River Delta, China. *Atmospheric Environment*. 37: 767-776.