ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 7 No. 1 March 2021*

Assessment of Heavy Metals Contamination in a Farmland near a Market Dumpsite in Zaria, Nigeria

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Abstract

This paper determined the levels of five different heavy metals (Pb, Cd, Ni, Cu and Zn) in various soils (topsoil and subsoil) and vegetables (spinach, cabbage and lettuce) cultivated at a farm land near Zaria city market dumpsite Tudun Wada, Nigeria. The heavy metals present in the vegetables and soil were analyzed using Atomic Absorption Spectrometer (AAS). The results revealed that all the heavy metals were found in both soil and vegetables at a concentration ranging for Pb (0.222-0.783) mg/kg in vegetables and 0.381mg/kg in soil, Cd (0.006-0.021) mg/kg in vegetables and 0.019 mg/kg in soil, Zn (0.195-0.251) mg/kg in vegetables and 0.674mg/kg in soil, Cu (0.039-0.157) mg/kg in vegetable and 0.150mg/kg in soil, Ni (0.093-0.159) mg/kg in vegetable and 0.222mg/kg in soil. The values in soil are all below the WHO/FAO safe limits: (84, 3.0, 75, 100 and 300mg/kg) for Pb, Cd, Ni, Cu and Zn respectively. In vegetables heavy metals concentrations gotten for cabbage and lettuce were all below WHO/FAO safe limits except for Pb given by 0.3, 0.2, 0.1-0.5, 99.4 and 50 (mg/Kg) for Pb, Cd, Ni, Zn and Cu respectively. Therefore, regular monitoring of waste at the dumpsite which can affect soils on which vegetables are grown is to be monitored to prevent excessive build-up of the toxic heavy metals in food.

Keywords: Heavy metals, Vegetables, AAS, WHO, Dumpsite, Soils, Farms

INTRODUCTION

Heavy metals are generally referred to as metals with relatively high density, a density more than 5gm/cm^3. Heavy metals are environmental pollutants (Ghosh *et al.*, 2012). Public concern regarding high level of heavy metals in the environment has brought anticipation and fear in the public as to the presence of heavy metal residues in their daily food. The potential toxicity and persistent nature of heavy metals and frequent consumption of vegetables has made it necessary to analyze these vegetables. Leafy vegetables accumulate much higher contents of heavy metals as compared to other plant (Zue *et al.*, 2012). Potentially harmful metal contents in soils may come not only from the bedrock itself, but also from anthropogenic sources such as solid or liquid waste deposits, agricultural inputs, and fallout of industrial and urban emissions (Wilson and Pyatt) 2010.The rise in human population has negative influence to availability of land for agricultural purposes especially

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in urban and developing settlement like Zaria city. To a large extent, farmers in Zaria city have complement rural agriculture as it produces food crops that rural agriculture cannot supply especially perishable food crops. Agriculture has served as a source of income and food that would have been otherwise scarce. This complementary strategy has reduced poverty, food shortage, increase urban development and productive use of urban waste. However, due to rapid population growth and pressure on land use, Zaria city farmers tend to use unapproved land including lands near dumpsites for agricultural purposes. Also wastes from dumpsites are used as a source of composite manure to support main land farming activities.

Research has shown that the soil in and around dumpsites is usually nutrient rich and as well as heavily contaminated with toxic heavy metals (Olayiwola *et al*., 2017). The use of lands near dumpsites for agricultural purposes could serve as a potential source of heavy metals which can be introduced into food chain mainly through cultivation of crops which would attract serious health issues on plant, animal and humans at large. Vegetables take up heavy metals and accumulate them in their edible and non-edible part at quantities high enough to cause clinical problems both in animals and humans. Research carried out on lands close to dumpsites at Zaria city showed that soil around dumpsites is as well contaminated with heavy metals (Olayiwola *et al*., 2017). In Ghana an experiment was carried out from three dumpsites and lands near them in Kumasi, where vegetables were cultivated, results showed that two most toxic heavy metals cadmium and lead is higher in vegetables than the World Health Organization (WHO) and Food and Agriculture Organization (FAO) recommended values (Odai *et al*., 2008). Although, dumpsites could be a source of the organic composite manure, dumpsites have many dangerous chemicals and heavy metals which pose a threat to human health when they are introduced into the food chain. Since these heavy metals and other inorganic chemicals are non-biodegradable, they continue to accumulate with time. Due to high population density at the market and surrounding area, large quantity of wastes are generated on a daily basis which has led to the formation of mountain of refuse dump at the dumpsites (Zurera *et al*., 1987).
This study was necessary as a large number of people consume vegetables grown on this farmland. Therefore, this paper aims to assess the level of heavy metals in soils and vegetables grown in a farmland near a market dumpsite in Zaria City and to assess the level of risks to humans in the area.

METHODOLOGY

Study area
Zaria is a major city in Kaduna state in Northern Nigeria and is located at latitude $11^0$4′N and longitude $7^0$42′E with a total land area of 563 kilometer square. Its population is over 1,408,198 and density 730 kilometer square. Zaria city is well known for agriculture as its major occupation. Zaria belongs to the Northern Guinea Savannah zone which is characterized by the presence of variety of trees scattered among the savannah grass land. The wet season occur between April and October, while the dry season occurs between November and April. Daily maximum temperature of Zaria shows a major peak in April and minor in October. Zaria is known to variety of crops such as millet, guinea corn, maize, rice, tiger nut, peanut, groundnut, beans, and so on (Suleiman, 2007).

Preparation of Vegetable Samples
Edible portions of spinach, lettuce, and cabbage were collected randomly from three different locations at the sites into clean new polythene bags and transported to Material Science Laboratory of the Physics Department, Ahmadu Bello University, Nigeria. The

vegetable samples were washed with tap water and distilled water to remove sand particles, dirt and other pollutants, also leaves of vegetable samples were separated from the whole plants with the aid of a stainless steel knife, then aired under the sun for 24 hours to remove moisture, followed by oven drying at 120^{o}C for 3-4 hours to dry it completely. The dried samples were pulverized, using pestle and mortar, followed by sieving through a 0.5 mm mesh size sieve to obtain a uniform particle size. Each vegetable sample was labeled and stored in a dry plastic container that had been pre-cleaned to avoid contamination during digestion and then taken to Chemistry Multi-User Laboratory, Department of Chemistry, Ahmadu Bello University, Nigeria for further analysis.

Preparation of Soil Samples

Soil (top soil TS, sub-soil SS) samples were collected from the sites at a point and depth of between 0-15 cm into clean new polythene bags, labeled and transported to the Material Science laboratory of the Physics Department, Ahmadu Bello University, Nigeria. The soil samples were air dried for 24 hours then oven dried at 120^{o}C for 3-4 hours, grounded and sieved using 0.5 mm mesh size sieve to have uniform particle size. Each sample was labeled and stored in a dry plastic container that had been pre-cleaned to avoid contamination during digestion and further analysis. The 0-15cm depth was considered to represent the plough layer and average root zone for nutrients uptake and heavy metal burden by plants and also considering the top soil (TS) and sub soil (SS) of the area for heavy metals analysis.(Chang *et al.*, 2014)

Digestion of Samples

Materials needed for the course of digestion were, 0.5g of each sample measured using the digital weighing balance, 100ml of concentrated nitric acid and 50ml of concentrated hydrochloric acid, distilled water, spatula, beakers, test-tubes, measuring cylinder, syringe (5ml and 2ml), face mask, fume cupboard, heating molten, and filter paper. (Odai *et al.*, 2008.)A volume of 7.5ml of concentrated nitric acid and 2.5ml of concentrated hydrochloric acid was added into a beaker containing 0.5g of each sample separately, mixed well then placed on a heating molten to heat at about 150^{o}C for few minutes, before drying completely it was brought down and allowed to cool for 3 minutes, 20ml of distilled water was added into the content in the beaker, then filtered using filter paper and distilled water was added to the content to 50ml, the solution was transferred into plastic bottles and taken for analysis at Ahmadu Bello University, Chemistry Multi User Lab.

Sample Analysis

The digested samples were analyzed for lead, cadmium, nickel, copper and zinc using Atomic Absorption Spectrometer (AAS) (Buck Model 210 VGP) at A.B.U, Zaria Multi User laboratory, Chemistry Department. The instrument setting and operational conditions were done by the staff in accordance with the manufacturer's specifications.

Statistical Analysis

Data results gotten from the samples analysis was subjected to analysis of variance (ANOVA) to determine the differences in heavy metal concentration of the soil and vegetable. Duncan Multiple Range Test was used to separate differences between means.

Transfer Factor

Metal transfer factor (TF) denoting transfer of metals from soil to plant and which is computed as the ratio of the concentration of metals in plants to the concentration in soil, on dry weight basis (Ghosh *et al.*, 2012). The accumulation of metals from soil to plants depends on, the species, soil type, and metal chemical form. The soil transfer coefficient was calculated as the ratio of heavy metal in vegetable to soil using equation (1).

$$\text{TF} = \frac{Concentration\ of\ vegetable\ (C_{vegetable})}{Concentration\ of\ soil\ (C_{soil})} \quad (1)$$

Where Cvegetable and Csoil represent the concentration of heavy metals in extracts of vegetables and soils on dry weight (DW) basis, respectively (Xue *et al.*, 2012).
Standard Deviation and Mean

$$S = \sqrt{\frac{\sum_{i=1}^{N}(x-\overline{x})^2}{N-1}} \quad (2)$$

S = standard deviation, N = number of observations, x = individual concentration,
$\bar{x}$ = mean concentration, M = Mean

$$M = \frac{Sum\ of\ Terms}{Number\ of\ Terms} \quad (3)$$

RESULTS
TS=top soil, SS=sub soil
*EU (2002), **WHO (2006)
Table 1 shows a total analysis of three soil (TS and SS) samples were analyzed and found to be within the limits. It is clear that the concentration of Pb and Cu in soil near the dumpsites is far lesser than the European Union (EU) and World Health Organization (WHO) permissible concentration in soil.

Table 1: Heavy metals concentration in soil sample

Area	Soil sample	Lead (mg/kg)	Cadmium (mg/kg)	Nickel (mg/kg)	Copper (mg/kg)	Zinc (mg/kg)
Zaria City	TS	0.764	-0.010	0.062	0.165	1.449
	SS	0.180	-0.019	-0.182	0.144	0.763
	SS	0.199	-0.027	0.034	0.141	1.058
	Safe Limits	*300	*3.0	*75	0.140	*300
		**84	**3.0	-	**100	-

ND=Not Detected
SP=Spinach, C=Cabbage, and LH=Lettuce
* WHO/FAO (2007), **EU (2006).

From the results of vegetable samples analysis (Table 2), it is observed that concentration of Lead in spinach and cabbage ranged from 0.036 – 1.250mg/kg which was above the safe limit (0.05-0.3mg/kg) of *WHO/FAO but was within the safe limit (1-5 mg/kg) of European standard (2006), the concentration of lead in lettuce was observed to be within the safe limit of WHO/FAO and European standards. Cadmium concentration in spinach, cabbage and lettuce ranged from -0.029 – 0.004 mg/kg and was far less than the permissible levels given by WHO/FAO and EU (0.5 mg/kg). Vegetables grown on soils around dumpsites showed lead concentration above the tolerable ranges.

Table 2: Heavy metals concentration in vegetables and their comparison with WHO/FAO standards

Area	Sample Number	Vegetables Sample	Lead	Cadmium	Nickel	Copper	Zinc
Zaria City	1	SP1	0.519	ND	-0.207	0.457	0.177
	2	SP2	1.250	-0.005	-0.213	0.713	0.262
	3	SP3	0.581	-0.018	-0.246	0.145	0.031
	4	C1	0.461	0.004	-0.182	0.248	0.052
	5	C2	0.036	-0.007	0.108	0.136	0.028
	6	C3	0.845	-0.008	-0.031	0.201	0.037
	7	LH1	-0.054	-0.029	-0.132	0.213	0.063
	8	LH2	0.268	-0.015	-0.075	0.395	0.090
	9	LH3	0.343	-0.019	-0.270	0.244	0.039
*WHO/FAO			*0.3	*0.200	-	*99.4	*50
**EU standards			**1-5	**0.500	*0.1-5	**< 50 – 60	**3-15

From the results of vegetable samples analysis (Table 3), it is observed that concentration of Lead ranged from (0.04 - 1.25) mg/kg with Mean ± SD value (0.4500 ± 0.400) mg/ kg which is above safe limit of WHO/FAO (2007) (0.05-0.3) mg/kg but was within the EU (2006) (1-5) mg/kg, for all vegetables samples. In soil the concentration of Lead was found to be within the safe limit of WHO/FAO (2007) 0.3 mg/kg and EU (2006) (1-5) mg/kg, Cadmium concentration for all vegetables ranged from (0.00 - 0.03) mg/kg with Mean±SD (0.0134±0.00922) which is within the safe limits given by WHO/FAO and EU (0.2-0.5) mg/kg. The concentration of nickel, copper and zinc in soil and vegetable samples were all found to be less than WHO/FAO and European Union safe limits.

Table 3. Heavy metal concentration in the vegetable and soil samples

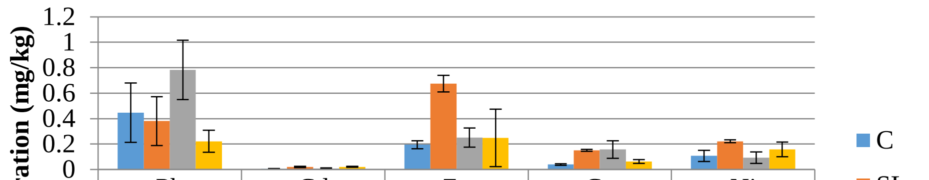
Heavy Metals	Vegetable Samples			Soil Samples		
	Minimum Value	Maximum Value	Mean$\pm SD$ $Value$	Minimum Value	Maximum Value	Mean$\pm SD$ $Value$
Lead	0.04	1.25	0.450±0.400	0.760	0.180	0.381±0.332
Cadmium	0.00	0.03	0.013±0.009	0.030	0.010	0.019±0.332
Nickel	0.14	0.40	0.251±0.127	0.760	0.550	0.667±0.113
Copper	0.03	0.26	0.157±0.117	0.170	0.140	0.150±0.013
Zinc	0.03	0.27	0.145±0.089	0.250	0.210	0.222±0.210

Transfer Factor

Table 4 shows the transfer factor (TF) of heavy metals from soil to plants, which is the ratio of the concentration of metals in plants to the total concentration in the soil.

Table 4: Soil-Vegetable Transfer Factor of Heavy Metals

SAMPLE	LEAD(mg/kg)	CADMIUM (mg/kg)	NICKEL (mg/kg)	COPPER(mg/kg)	ZINC(mg/kg)
SP	0.5420	0.0055	0.1535	0.1740	0.4700
C	0.3090	0.0042	0.0800	0.0270	0.1350
LH	0.1530	0.0145	0.1100	0.0443	0.0145



	Pb	Cd	Zn	Cu	Ni
C	0.447	0.006	0.195	0.039	0.107
SL	0.381	0.019	0.674	0.15	0.222
SP	0.783	0.008	0.251	0.157	0.093
LH	0.222	0.021	0.249	0.064	0.159

C=cabbage

SL=soil

SP=spinach

LH= lettuce

Fig 1. Graph showing the different level of heavy metals in all vegetable and soil samples

Fig 1 shows the bars that represent the concentration of heavy metals (Pb, Cd, Zn, Cu and Ni) in soil around dumpsite and vegetables (cabbage, spinach and lettuce) grown there. The results in Fig.1 shows that the concentration of lead was highest in spinach than the other vegetables followed by Zn, Ni, Cu and Cd, while in soil Zn has the highest value followed by Pb, Ni, Cu and Cd.

DISCUSSION OF RESULTS

The results in Table 1 gives the values for the concentration of heavy metals in soil samples (TS, SS and SS) and shows that the concentration of these metals in the soil are within safe limits when compared with the permissible levels given by EU, FAO and WHO. The WHO/FAO (2006) permissible limit of lead in soil is 300 mg/kg. The data in Table 1 shows that there is a good correlation with the levels of Pb, Cd and Cu when compared with previous data.This is within ranges of heavy metal in soil studied by (Premarathna *et al.*, 2011) who reported a range of 15 to 311 mg/kg. Additionally, lead concentration (1.36 mg/100g) was within the range of 0.05 to 6.70 mg/100g, and 0.13 to 2.27 mg/100 g, reported from Ireland and New York, respectively. However, (Awokunmi *et al.*, 2010) reported very high levels of lead in soils collected from various dumpsites located at Ikere and Ado Ekiti metropolis, South Western Nigeria ranging between 3500-6860 mg/kg.

The results in table 2 show a concentration of heavy metals in vegetables when compared with international standards and this comparison shows a level of agreement with some studies. For instance, Cd concentration in vegetables from Ireland was in the range of 0.005 to 0.06 mg/100g, whereas that from New York was in a range of 0.004 to 0.061 mg/100kg (Bahemuka and Mubofu, 1999), which are in agreement with the result of this study. However, Cd in this study, had a concentration below the range of 0.004 to 0.200 mg/100kg reported for vegetables grown in Metropolitan Boston and Washington DC (Hibber *et al.*, 1984). Furthermore, the Cd and Pb levels reported in this study were lower than those reported for vegetables in Nigeria (Ndiokwere, 1984) and Pakistan (Parveen *et al.*, 2003) and higher than those reported for vegetables in Tanzania (Bahemuka and Mubofu, 1999) and Egypt (Radwan and Salama., 2006). However, the concentration of Cd in this study was below the range of 0.09 to 0.26 mg/100 g reported for vegetables grown in Metropolitan Boston and Washington DC (Hibber *et al.*, 1984). Furthermore, the Cd and Pb levels reported in this study were lower than those reported for vegetables grown along river Niger and the Nigerian Atlantic coastal waters (Ndiokwere, 1984) and Pakistan (Parveen *et al.*, 2003) and higher than those reported for vegetables in Tanzania (Bahemuka and Mubofu, 1999) and Egypt (Radwan and Salama, 2006). The high contamination levels may be due to pollutants in irrigation water, farm soil or from other activities such as highway traffic around the area.

All vegetables had lower levels of nickel, copper and zinc than the permissible values for vegetables recommended by international standards WHO/FAO (2007) (0.05-0.3) mg/kg and also within the EU (2006) (1-5) mg/kg.

All the analyzed vegetable samples in Table 3 contained detectable concentrations of Zn, Cu, Ni, Cd and Pb. The average concentrations of heavy metals in all vegetable samples were in the order of Ni > Pb >Cu,Zn>Cd. The coefficients of variation for the five heavy metals in vegetables also followed the same order, suggesting that Ni is more susceptible to the interference of vegetable species, pollution and other external factors. According to FAO/WHO (2007), the concentration of Lead for this study which ranged from (0.04 - 1.25) mg/kg with Mean ± SD value (0.4500 ± 0.400) mg/kg which is above the standard safe limit of WHO/FAO (2007) (0.05-0.3) mg/kg but was within the EU (2006) standard limit for all vegetables samples. In a study carried out by (Halilu *et al*.,2019**),**the levels of Pb, Cd, Zn and Cu exceeded the standard levels in soils. Likewise, Pb, and Cd levels exceeded the recommended values in vegetable samples with concentrations ranging from 1.93–5.73, 3.63–7.56, 0.56–1.56, 1.49–4.63 and 3.43–4.23 mg/kg, respectively.

The levels of Pb obtained in the soil samples in this study were found to be more than 5 times higher than the limit value for Pb (10 mg/kg) as cited by (Sharma *et al*., 2007) but much lower than Indian standard (250–500 mg/kg) as provided by (Alghobar *et al*., 2015),in soil. Cadmium (Cd) on the other hand had values ranged from 4.76 mg/kg in soil samples under cabbage cultivation and 5.30 mg/kg under tomato cultivation. The Cd concentrations in this study were far lower (0.33-0.019mg/kg) than those reported by Sharma and his co-workers (2017) which was (0.79–1.73 mg/kg) and also much higher than the limit value reported by (Chang *et al.*, 2014) Zinc (Zn) and copper (Cu) were also found in higher concentration in both soil samples collected from sampling locations with concentration range of 93.66 to 98.86 mg/kg for Zn and 25.50 to 25.96 mg/kg for Cu. The levels of Zn obtained in this study were found to be much lower(0.25–0.21 mg/kg) than the reported and limit value (50 mg/kg) cited by (Sharma *et al*., 2007). Likewise, the level of Cu obtained in this study were also found to be lower (0.14mg/kg) than soil reference value (20 mg/kg) reported by Sharma and co-workers (2007).The levels of Ni obtained in soil samples considered in this study (0.55mg/kg) are found to be less than there commended value of 50 mg/kg for Ni as reported by Sharma and co-workers (2007).

The result of this study in general have revealed that, the soil and vegetables in the study area are clearly within the limits recommended by FAO/WHO. Thus, we conclude that a large daily intake of these vegetables grown on this farmland is not likely to be a health hazard to the consumer

CONCLUSION

The bioaccumulation of heavy metals showed varying concentrations among the analyzed vegetable samples which had a minimum and maximum values for Pb, Cd, Ni, Cu and Zn to be 0.04, 0.14, 0.03 and 0.03(minimum in mg/kg) and a maximum values of 1.25, 0.03, 0.40, 0.26 and 0.27 respectively with lead and zinc having higher values with different figures more than cadmium, nickel and copper and for soil minimum values (0.18, 0.01, 0.55, 0.14 and 0.21) mg/kg maximum values (0.76, 0.03, 0.76, 0.17 and 0.25) mg/kg respectively. The result revealed the concentration heavy metals in soil at the farm near the dumpsite in Zaria city follow the trend Zn>Pb>Ni>Cu>Cd while in vegetables grown at the farm around the dumpsite also follow the trend Pb>Zn>Ni>Cu>Cd.The contamination of the soils and vegetables with heavy metals pose hazard not only to humans but also animals. The informal recycling of waste also has the potential to pollute the environment and nearby communities and farmland. The need for periodic monitoring of toxic metals in this area is important to protect human health and the environment.

REFERENCES

Alghoba, M., Suresha, S. (2015). Evaluation of metal accumulation in soil and tomatoes irrigated with sewage water from Mysore cityKarnakata India. Journal of the Saudi Society of Agricultural Sciences 10.1016/j.jssas.2015.02.002

Aluko. O., Sridha, M. K. C., Oluwande, P.A., (2003). Characterization of leachates from a municipal solid waste landfill site in Ibadan, Nigeria. Journal of Environmental Health Research 2:32-37.

Awokunmi, E. E., Asaolu, S. S., Ipinmoroti, K. O. (2010). Effect of leaching on heavy metals concentration of soil in some dumpsites. African Journal of Environmental Science and Technology 4(8):495-49

Bahemuka, T. E., Mubofu, E. B. (1999). Heavy metals in edible green vegetables grown along the sites of the Sinza and Msimbazi rivers in Dar es Salaam, Tanzania. Food Chem;(1999) 66: 63-6

Chang, C.Y., Yu, H.Y., Chen, F.B., Li, H.H., Zhang. (2014) Accumulation of Heavy metals in leaf and Vegetables from agricultural soils and associated potential health risks in the pearl River Delta, South China Environ. Monit. Assess., 186 (2014), pp. 1547-156.

Ghosh, A.K., Bhatt, M. A. and Agrawal, H.P. (2012) Effect of Long Term Application of Treated Sewage Water on Heavy Metal Accumulation in Vegetables Grown in Northern India. *Journal of Environmental Monitoring and Assessment*, 184: (2012). pp6673-6682.

Haliru, N. N., Agusa, T., Ramu, K., Tu, N. P. C., Murata, S., Bulbule, K. A., Tanabe, S. (2009). Contamination by trace elements at e-waste recycling sites in Bangalore, India. Chemosphere, 76(1), 9–15. doi:10.1016/j. chemosphere.2019.02.056

Hibber, C.R., Hagar, S. S., Mazza, C.P., (1984) Comparison of cadmium and lead contents of vegetable crops grown in urban and suburban gardens. Environ Pollut (Ser B) 1984; 7: 71-80

Ndiokwere, C.L. (1984) A study of heavy metal pollution from motor vehicle emission and its effect on road soils, vegetation and crops in Nigeria. Environ Pollut (Ser B) 1984; 7: 35-42.

Odai, S.N., Mensah, E., Sipitey, D., Roy, S., and Awuah, E. (2008) Heavy Metals Uptake by Vegetables Cultivated on Urban Waste Dumpsites. *Journal of Environmental Toxicol*, 2(2): (2008) pp92-99.

Olayinka, K.O., Oyeyiola, A.O., Odeijebe, F.O., and Oboh, B. (2011) Uptake of Potentially Toxic Metal by Vegetable Plants Grown on Contaminated Soil Their Potential Bioavailability Using Sequential Extraction. *Journal of Soil Science and Environmental Management*, 2(8): (2011) pp220-227.

Parveen, Z., Khuhro, M. I., and Rafiq, N. (2003). Market basket survey for lead, cadmium, copper, chromium, nickel, and zinc in fruits and vegetables. *Bulletin of Environmental Contamination and Toxicology, 71*(6), 1260–1264.

Premarathna, H. M., Hettiarachchi, G.M., Indraratne, S. P. (2011). Trace metal concentration in crops and soils collected from intensively cultivated areas of Sri Lanka. Pedologist 54(3):230-240

Radwan, M.A., Salama, A.K. (2006) Market basket survey for some heavy metals in Egyptian fruits and vegetables. Food ChemToxicol 2006; 44: 1273-8.

Sharma, R. K., Agrawal, M., Marshall, F. (2007). Heavy metal contamination of soil and vegetables in suburban areas of Varansi, India. Ecotoxicol Environ Saf 2007; 66: 258-66

Singh, A., Sharma, R.K., Agrawal, M., and Marshal, F.M. (2010) 'Health risk assessment of heavy metals via dietary intake of foodstuffs from waste water irrigated site of a dry tropical area of india', Food and Chemical Toxicology, 48(2), doi: 10.1016/j.fct.2009.11.041. (2010) pp. 611-619.

Wilson, B., and Pyatt, F.B. (2007). Heavy Metal Bioaccumulation by the Important Food Plant, oleaeuropea L., in an ancient metalliferous polluted area of Cyprus, Bulletin of environmental contamination and toxicology, 78(5),. Doi:10.1007/s00128-007-9162-2 (2007) pp. 390-394

WHO/FAO (World Health Organization/Food and Agricultural Organization). (2007). *Joint WHO/FAO Food Standard Programmed Codex Alaimentarius Commission*.

World Health Organization/Food and Agriculture Organization (2004). Fruit and Vegetable for Health. Reports of a Joint FAO/WHO Workshop, Kope, Japan.

Xue, Z.J., Liu, S.Q., Liu, L.Y., and Yan, Y.L. (2012). Health Risk Assessment Of Heavy Metals for Edible Parts of Vegetables Grown in Sewage-Irrigated Soils in Shrubs of Baoding City, China. *Journal of Environmental Monitoring and Assessment*, 184: Pp3503-3513.

Zurera, G., Estrada, B., Rincon, F., and Pozo, R. (1987). Lead and Cadmium Contamination Levels in Edible Vegetables. *Journal of Bulletin of Environmental Toxicol*, 38: Pp805-812.