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Bioaccumulation of Potentially Toxic Elements and Risk Assessment in Edible Vegetables from Urban Farming Areas within Jos Metropolis, Plateau State. Nigeria

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ABSTRACT

For decades the presence of heavy metals in our environment (soil, water and air) and in food (vegetables, grains, beverages, drinks etc) is not a new phenomenon. The levels of some potentially toxic elements(Cd,Cu,Ni, Pb,Zn, Mn and Fe) were determined in 5(five)vegetables carrot*(Dantus carota H.)* , cabbage(*Brassica olercea L,)* , *cucumber(Cucumis satinus L.)* , *lettuce(Lactuca sativa L)* , *and* tomato(*Solanum lycopersicum* L.) The uptake of these metals by humans via consumption of such produce has been reported by many authors from different parts of the world. This study evaluated the heavy metal uptake of vegetables grown in Jos, Nigeria and assessed risks involved in consumption of such vegetables were assessed. The concentration(mgkg^{-1}) for the vegetables, soil and water samples otained from this study shows that it is lower than the established critical limits causing toxicity in plants and lower than the FAO/WHO maximum limits(ML) of heavy metals in vegetables.The result show transfer factor of metal from soil to plant to be Zn<Cd<Pb<Mn<Ni<Fe<Cu. For Daily intake of metal the pattern was Cu>Cd>Ni>Pb>Mn>Zn>Fe. Pattern for Health risk index Pb>Zn>Ni>Cu>Fe. Results for THQ shows high value of Pb but less than 1for the other metals. This indicates that consumption of the studied vegetable samples is free of risks.

Keywords: Heavy metals, Vegetables Potentially toxic elements Daily intake of metal (DIM), Target hazard quotient(THQ),Maximum limit(ML),Heavy metal uptake.

1.0 Introduction

High demand for food safety has necessitated research regarding the risk associated with consumption of food stuffs and vegetables contained by pesticides, heavy metals and other toxins (D'mello 2003). Vegetables are staple part of human diet taken as food in cooked or raw form. In recent years consumption of vegetable has increased due awareness of their food values (Sobukola et al 2007) as a result of exposure to other cultures and proper education. They constitute an important part of human diet since they contain carbohydrate , vitamins, minerals and trace elements.

However with the increase in urban population, industrialization, mining activities and indiscriminate dumping and discharge of domestic and industrial waste into the land and water ways , water for irrigation has become contaminated with various pollutants , among which are heavy metals. (Fisseha .I. 2002).

Research results has shown heavy metals to be potentially toxic to crops, animals and humans when contaminated soils and water are used for crop production (Yebpella et al. 2011). In a related study by Sigh et al 2006, they concluded that soil, irrigation water and some vegetables from peri- urban sites were significantly contaminated by Cu, Cd, Pb and Zn, although Cd and Pb were more concern thatcue Zn, in the last decade.

Wide spread of heavy metal contamination has raised public and scientific interest hence special attention is given to them throughout the world due to their toxic effects even at very low concentrations (Kumar A, 2004). Ground water, water from old mining ponds, rivers, streams are used to irrigate vegetable crops and for household and industrial uses. In Nigeria, the use of polluted water in the immediate surroundings of big cities for growing vegetables is a common practice. Although this water is considered to be rich source of organic matter and plant nutrients, it also contains sufficient amount of soluble salts and heavy metals like Fe, Mn, Cu, Zn, Pb, Ni, Sn, Hg, Cr, As, Al (Uwah et. al, 2009). When such water is used for cultivation of crops for a long time, these heavy metals may accumulate in soil and maybe toxic to the plants and also cause deterioration of soil (Kirkhan. 1983).

Heavy Metals are generally present at low level in agricultural soils. The input of heavy metals to soil from various sources maybe detrimental to plant through its uptake to toxic limit, thereby facilitating its entry into food chain, there is possibility of biomagnification of toxins as it travels up in the food web. The transfer factor of heavy metals from soil to plant maybe an indicator of the plant behaviour (Yebpelle et. al, 2011, Kabota- Pedias et. al. 1992) previous work (Lubpen, et al 2005) revealed large difference in the transfer of Cd , Zn, Ni, Co, Pb and Cr from soil to difference part of plants.

Similarly lowest transfer factors of Cd were found for grains of maize , peas , oats and wheat , whereas the highest values were reported for leaves of spinach and lettuce and roots of various plants. Low transfer factors for Zn were reported for carrot and grains of maize and pea , whereas, the highest were found for leaves of spinach and roots of radish and other plants.

The general health of consumers was given priority by researchers who conducted a number of studies to asses the health risk of the consumers of contaminated vegetables (Sajjad et al 2009, Xie et al 2008).

Numerous studies have also linked excessive accumulation of heavy metals to development of health abnormalities which include cardiovascular, kidney, nervous and bone diseases, spontaneous abortion and abnormal pregnancy , gastrointestinal morbidity etc.(Thakur et al 2007, Telisman et al 2000). Report from studies by (Anita et al 2010) shows that waste water irrigation led to the accumulation of heavy metals in soil and consequently into vegetables. With the increasing awareness of risk assessment of heavy metal in food crops, monitoring of heavy metals in vegetables is therefore critical as it gives information in nutritional planning and provides data for epidemiological studies (Bruce et al 1983).

This study is aimed at finding out the levels of contamination of 7 heavy metals (Cd, Cu, Fe, Mn, Ni, Pb and Zn) in some selected vegetables carrot*(Dantus carota H.*) , cabbage(*Brassica olercea L,) , cucumber(Cucumis satinus L.) , lettuce(Lactuca sativa L) , and* tomato(*Solanum lycopersicum* L.)) cultivated in Jos Metropolis. The study also aims at assessing the uptake of heavy metals from the soil to the vegetables and also conduct risk assessment of heavy metals.

2.0 Materials and Methods

2.1 Sampling – The method proposed by Prabu (2009) was adopted in this study.

Edible proportion of vegetable samples namely carrot, cucumber , lettuce , cabbage and tomatoes were picked randomly from the farm and stored in clean polythene bags. Soil sample at surface level of 0-15cm^3 in depth were collected from the same locations where the vegetable crops were grown. 5 water samples were collected in a pre-acid washed cans.

2.2 Sample Preparation

Vegetable samples were thoroughly washed to remove all soils that adhere to the plant. Samples were cut into tiny pieces and aired for 6 days. 1g each of well homogenized vegetable sample was digested with 10cm^3 nitric acid using proposed method by Awofolu 2005.

Soil samples were air dried and ground into fine powder and passed through 2mm sieve. Well homogenised soil sample (1g) each were weighed into 250cm^3 beakers, covered with watch glass and digested with a mixture of nitric acid and perctiloric acid in the ratio 3:1 on hotplate for 2hrs to ensure complete digestion, after evaporation to near dryness ; 5ml of deionized water was added to the digest and filtered while still hot into 50ml volumetric flask and made up mark with deionized water.

3.0 Analysis

Analyses of heavy metals (Cu , Zn, Pb, Ni, Fe, Mn and Cd) were carried out using atomic absorption spectrophotometer (AAS:210 system) (Shimadzu japan) at National research institute for chemical Technology (NARICT)Zaria Nigeria. The calibration curves were prepared separately for all the metals by running the concentration of standard solutions.

Average values of three replicate readings were taken for each determination. Transfer factor was calculated for each metal according to the formula proposed by Harrison and Chirgawi 1989.

TF=Ps (mg/kg) st (mg/kg) where p is the metal content originating from plant.

St is the metal content originating from soil.

This is however dependent on different factors such as the soil pH and the plant itself. This is as a result of the fact that different authors have reported different transfer factors for the same species of plant and across different parts of the plants , such as roots and leafy parts (Tsafe et. al, 2012). the transfer factor calculated in this study was based on the total metal con tent on the whole plant without taking into consideration the various parts of the plant.

3.1 Daily intake of Metal(DIM) (mg person -1 day-1)

The daily intake of metals (DIM) was calculated to averagely estimate the daily metal loading into the body system of a specified body weight of a consumer. This will inform the relative phyto-availaibility of metals. It does not however take into cognizance the possible metabolic ejection of metals but can easily tell the possible ingestion rate of a particular metal. The daily intake of metal in this study was determined by the formular proposed by sajjad et al (2009).

Daily intake of metals = C(metal concentration) x C(factor) x D(food intake)/BW(average body weight).

Whereas C= heavy metal concentration in plants (mg/kg)

C= conversion factor

D= daily intake of vegetables.

The conversion factor of 0.085 is to convert fresh vegetable weight to dry weight (Sajjad et al 2009) , while the average body weight was 67kg for this study. The average daily metal rate of vegetable was calculated by carrying out a survey in which 20 people having an average body weight of 67kg were asked for their daily intake of the studied vegetables from the study area for a period of 6(six) months. (Wang et al, 2015)

3.2 Health Risk Index (HRI)

In order to asses the health risk of any chemical pollutant, it is essential to estimate the level of exposure by qualifying the routes of exposure of a pollutant to the target organisms. There are various possible exposure pathways of pollutants to humans but the food chain is one of the most important pathways (Khan et al 2007).

By using Daily intake of metal (DIM) and Reference Oral dose, the health risk index is calculated.

RfD is an estimate of daily exposure to the human population. That is likely to be without an appreciable risk of deleterious effect during a lifetime (USEPA ,IR,IS).

The following formular is used for calculating Healyh risk inex

HRI= DIM/RfD (USEPA , 2012).

If the value of HRI is less than 1 the exposed population is said to be safe.

3.3 Target Hazard Quotient (THQ)

The assessment of health risks through consumption of vegetables THQ was calculated following the method described by USEPA(2009). This was developed for the estimation of potential health risks associated with long term exposure to chemical pollutants. This includes not only intake of metals but another significant data as exposure frequency and duration, body weight and the oral reference dose (RFD). The THQ is a ratio between the measured concentration and the oral reference dose (RFD) measured by length and frequency of exposure, amount infected and body weight.

THQ is calculated by the general formular established by EPA using the equation:

$$THQ = \frac{E_f \times F_D \times DIM}{RFD \times W \times T}$$

whereas E_f is exposure frequency= 182.5 days^{-1}(6months)

F_D= exposure duration (for 62years, based on the expectancy of 70years starting from 8years (Bannett et al 1999).
DIM= Daily intake of metal (kg person^{-1} day^{-1} x metal concentration (mg Kg^{-1})

RfD= Oral reference dose (mgkg^{-1} day^{-1}).
W= average body weight -67kg
T= average exposure tune (365 days^{-1} x number of exposure years)

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THQ< 1 means the exposed population is assumed to be safe and 1<THQ
<5 means the exposed population is in a level of concern interval. It must be noted that THQ is not a measure of risk but indicates a level of concern.

4.0 Results and Discussion

Table 1: Mean + SD concentration of individual vegetables, soil and water samples.

Elements (mg/kg	Lettuce	Cabbage	cucumber	tomatoes	carrot	Soil	Water	For vegetables WHO/FAO	NAFDAC	For water
Cu	0.02±0.001	0.09±0.001	0.04±0.001	0.63±0.001	0.03±0.001	0.39±0.001	0.029±0.001	30	20	2.0
Zn	1.86±0.001	0.27±0.002	0.18±0.001	0.91±0.002	0.29±0.003	1.79±0.009	1.024±0.005	60	50	3.0
Pb	0.34±0.001	1.59±0.022	1.02±0.002	1.54±0.002	0.06±0.001	0.909±0.001	0.739±0.001	2	2	0.01
Cd	0.02±0.001	0.02±0.001	0.02±0.001	0.02±0.001	0.03±0.001	0.03±0.001	0.03±0.001	1	------	----
Mn	0.65±0.001	0.58±0.001	0.38±0.001	0.24±0.013	0.27±0.001	1.59±0.002	0.668±0.003	----	-----	0.5
Ni	0.12+0.002	0.09±0.005	0.06±0.003	0.14±0.004	0.12±0.001	0.83±0.003	0.085±0.003	2.7	2.7	-----
Fe	3.72+0.003	0.66±0.002	0.29±0.002	1.77±0.003	0.09±0.005	26.6±0.014	3.15±0.002	48	-----	0.3

Table 2:. Transfer Factor of heavy Metals from soil to vegetables.

Sample	Cu	Zn	Pb	Cd	Mn	Ni	Fe
Lettuce	0.07	2.29	0.38	0.94	0.41	0.14	0.14
Cabbage	0.22	0.15	1.74	0.94	0.37	0.10	0.02
Cucumber	0.10	0.10	1.13	0.88	0.24	0.07	0.01
Carrot	0.67	0.16	0.06	1.15	0.17	0.13	0.01
Tomatoes	1.63	0.51	1.70	0.67	0.15	0.17	0.07

$$Tf = \frac{Ps(mg\ kg^{-1})}{St\ (mg\ kg)}$$

Table 3:. Daily intake of metals (DIM) (mg^-1 person ^-1 day^-1)

Sample	Cu	Zn	Pb	Cd	Ni	Mn	Fe
Lettuce	0.01	0.99	0.18	0.01	0.06	0.35	1.98
Cabbage	0.05	0.14	0.85	0.01	0.05	0.35	0.35
Cucumber	0.02	0.10	0.54	0.01	0.03	0.20	0.15
Carrot	0.02	0.15	0.03	0.02	0.06	0.14	0.48
Tomatoes	0.33	0.48	0.82	0.01	0.07	0.13	0.94

$$\text{DMI} = \frac{\text{Cm x C Factor x D food intake}}{\text{Bwt}}$$

where

C metal = Heavy metal concentration in plants (Mg Kg ^-1)

C factor = conversion factor

D food intake = Daily intake of vegetables

The conversion factor of 0.085 is to correct fresh vegetables wt. into dry wt.

Table 4:. Health Risk index (HRI)

Sample	Cu	Zn	Pb	Cd	Ni	Mn	Fe
Lettuce	0.25	3.3	45.00	10.00	3.00	2.50	2.80
Cabbage	1.25	0.47	212.50	10.00	2.50	2.50	0.50
Cucumber	0.50	0.33	135	10.00	1.50	14.29	0.21
Carrot	0.75	0.50	7.50	20.00	3.00	3.00	0.69
Tomato	8.25	1.60	205.00	10.00	3.50	9.30	1.34

$$\text{Health Risk Index} = \frac{\text{Daily intake of metal}}{\text{Oral reference dose}}$$

Table 5;. Target hazard quotient (THQ)

Sample	Cu	Zn	Pb	Cd	Ni	Mn	Fe
Lettuce	0.001	0.02	0.34	0.07	0.02	0.19	0.02
Cabbage	0.01	0.00	1.59	0.08	0.02	0.19	0.00
Cucumber	0.01	0.00	1.01	0.08	0.01	0.01	0.00
Carrot	0.01	0.003	0.06	0.15	0.02	0.09	0.01
Tomato	0.12	0.01	1.53	0.08	0.03	0.07	0.01

Table 6. Oral reference doses (RFD) Mg $Kg_{-}^{!}$ day^{-1} and upper lolerable daily intake (UI) for investigated metals (USEPA 1989).

Elements	RFD reference	UL reference
Fe	0.700	45
Mn	0.014	11
Zn	0.300	40
Cu	0.0400	10
Nl	0.020	1
Cd	0.001	0.064
Pb	0.0035	0.240

5.0 Discussion

In this study five(5) vegetable samples namely lettuce, cabbage , cucumber, Tomato and carrot , soil and water were collected from the irrigated land where the vegetables were grown and analysed for the presence of Cu, Zn, Pb, Cd, Mn, Ni, and Fe. The mean triplicate concentration of the total heavy metals, soil, water and vegetables are presented in Table 1.

In the vegetables, 3 out of 5 of out namely vegetable samples analysed (cabbage,cucumber,and tomato) had Pb concentration above 1.00mgkg^{-1}, the levels of the other metals were less than 1 except for Fe in tomato which was also above 1. For the soil sample, the level of Zn , Mn and Fe where above 1 and for water sample only the level of Zn was above 1.00 mgkg^{-1}.

The highest concentration of heavy metals in the vegetable, soil and water samples were found to be Zn 1.86, 1.79 and 1.024 mgkg^{-1} respectively. The lowest concentrate of metal in the 3 samples (vegetable soil and water) was found to be Cd. High concentration of Mn was also observed in the soil sample, with concentration of 1.59 + 0.002 . Mn normally acts as metal scavengers due to their tendency to form colloidal particular hydros oxides which has strong adsorption infirmities for certain metals like Pb and Cd (Mil 1980).

Mean concentration of Zn was also observed to be highest in the vegetables, soil and water sample, 1.86 + 0.001, 1.79 +0.001 and 1.024 +0.005 respectively. For all the metals determined in the study, high concentrations were observed in the soil than the vegetables and water , except for Zn and Pb which were high in the vegetable samples (Table 1). These identified metals are among the wide range of heavy metals found in fossil fuels. They are emitted into the environment as particles during combustion, accumulate in ash, transported in air and contaminated soils (Yahaya et. al, 2010). It was obserevd that the level of heavy metals in soil were higher in magnitude than those of water (Table1) this could be as a result of suggestions made that soil act as sink for heavy metals.

Vegetables take up metals by absorbing them from contaminated soils as well as deposits from on different parts of the vegetables exposed to air from polluted environments. (Dzoma et al 2010).

The results obtained from this study was compared with values recorded in the other literature , the values of Cd, Cu, Mn and Zn in vegetables were lower than studies from Alan Dam and Gongulon in Maiduguri (Uwah et. al, 2009) and River Challawa , Kano Nigeria (Awode et al 2008). The concentrations of metals in this study falls within the maximum limit for vegetables.

5.3 Transfer Factor

Transfer Factor (TF) is a function of different factors such as soil pH, soil organic matter , metal availability and soil particle size. Table 2 represents the result of TF of various metals from this study. From table 2 above Pb and Cd has the highest transfer factor of 1.74, 1.70, 1.13 and 1.15 respectively, this could be attributed to the low retention rate of metal in soil and therefore more mobile in soil.

Variation in transfer factor among different vegetables maybe attributed to differences in the concentration of metals in the soil and differences in metal uptake by different vegetables(Cui et al 2004 , Zheng et al 2007)

Based on the suggestion that the greater the transfer coefficient value than 0.50, the greater the chances of vegetables for metal contamination by anthropogenic activities(Tsafe et. al,2012) the elevated levels of the contaminated heavy metals observed in this study could be linked to emmision from anthropogenic activities

5.4 Daily intake of metals (DIM)

Exposure of consumers and related health risks are usually expressed as provisional tolerable daily intake (PTDI), a reference value established by joint FAO//WHO (1999) .

Table 3 represents the estimate of each heavy metal intake through consumption of the studied vegetables.

The result show that the daily intake for the studied vegetables did not exceed the upper tolerable daily intake level except for Fe (1.98) in lettuce.

From the result, the highest intake of metal was found in Fe (1.98) for lettuce, this exceeded the upper tolerable daily intake level for Fe (0.700).

5.1 Health Risk Index

Table 4 represents the health risk index of metals consumed through vegetable intake. The result showed high HRI values for Pb (45), (205), (212.50), (135.00) in lettuce, tomato, cabbage, and cucumber respectively. It also showed high values for Pb, Cd, Ni and Mn in all the vegetable samples; indicating that consumer of vegetable from the study area are at risk since the values are greater than 1.

The result from studies conducted by (Tsafe et al, 2012) showed high HRI values for Cd (65.38), Zn (11.48) and Cu (2.09) which agrees with the result obtained from this study.

5.2 Target Hazard Quotient (THQ)

The Target hazard quotient is a complex used for the estimate of potential health risks associated with long term exposure to chemical pollutant (USEPA 1995). The THQ results is shown in Table 5.

Results from this study show THQ was less than 1 for all the metals except for Pb in cabbage (1.59), (1.01), (1.53) cucumber and tomato which was more than1; this may pose health risk to consumers. Higher THQ for Cd and Pb were also reported by (Zheng et. al, 2007) in vegetable collected from Huludao. Zinc plant in Huludao city, China. (Anita et. al, 2010) reported high values of Cd (19.54) in cabbage and Ni (2.00) in tomato. High values of Cd (65.38), Zn (1.48) and Cu (2.09) was also reported by (Tsafe et al 2012).

Conclusion

The paper assessed and evaluated the heavy metal composition of the vegetables grown in industrial area of Jos metropolis, Nigeria. The vegetables, soil and water samples assessed showed significant contamination of heavy metals and their risk assessment for DIM,THQ and HRI were determined, the results showed serious health risk for such metals as Pb,Cb,Mn,Ni,Cu.

Considering the health risks encountered in diet as a result of high levels of heavy metals in vegetables, the maximum allowable levels of these metals in vegetables should not exceed levels that reflect good agricultural practices/ food security.

There is therefore every need to educate the farmers on the problems associated with excessive usage of fertilizers and other chemicals well as irrigating the crops with water and all sort of polluted water. The concentrations of the heavy metals (Cd, Cu, Mn, Ni, Pb, Fe, and Zn) investigated in this study in all the vegetables samples were below the WHO/FAO and NAFDAC standards recommended safe limits of heavy metals.

The results obtained in this study were compared with concentrations of heavy metal concentrations in a typical soil in Yauri , Nigeria (Yahaya et al 2010).

REFERENCES

Bruce, A. and L. Bergstrom, (1983). User requirement or data bases and applications in nutritional research. Food Nutr. Bull., 5: 24-29

Prabu, P.C. (2009). Impact of heavy metals contamination of Akaki River of Ethiopia on soil and metal toxicity on cultivated vegetable crops. *EJEAFChe, 8 (9), (*818-827)

Awode, U.A., A. Uzairu, M.L. Balarabe, G.F.S. Harrison and O.J. Okunola (2008). Assessement of peppers and soil for some heavy metals from irrigated farmlands on the bank of River Challawa, Northern Nigeria. Pakistant Journal of Nutrition.. 7(2): 244-248.

Lokeshwari, H., and Chandrappa, G.T. (2006) Imapct of heavy metal contamination of Bellandur Lake on soil and cultivated vegetation. Current Science, 91(5), pp.622-27

Uwah, E.I., N. P. Ndahi and V. O. Ogugbuaja, 2009. Study of the Levels of Some Agricultural Pollutants in Soils, and Water Leaf (Talinum triangulare) Obtained in Maiduguri, Nigeria. Journal of Applied Sciences in Environmental Sanitation, 4 (2): 71-78.

Kirkhan, M. B, 1983. Study on accumulation of Heavy Metals in Soil receiving sewage and Effluent water. Agric. Ecosystem. Environment, 9: 251.

Kabata-Pendias A., Pendias H. (1992): Trace elements in soils and plants. 2nd ed. CRC Press, Boca Raton.

Awofolu, O.R., 2005. A survey of Trace metals in vegetation, soil and lower animals along some selected major and Roads in metropolitan city of Lagos. Environmental monitoring and Assessment, 105: 431-447.

Mill AJ (1980). Colloidal and macromolecular forms of iron in natural waters. A review. Environ. Technol. Lett. 1:97-108.

Yahaya, M. I. G. C. Ezeh, Y. F Musa and S. Y. Mohammad (2010). Analysis of heavy metals concentration in road sides soil in Yauri, Nigeria African Journal of Pure and Applied Chemistry Vol. 4(3), pp. 022-030, March 2010

Dzoma, B.M., R.A. Moralo, L.E. Motsei, R.V. Ndou and F.R. Bakunzi (2010). Preliminary findings on the levels of five heavy metals in water, sediment, grass and various specimens from cattle grazing adn watering in potentially heavy metal polluted are of the North west province of South Africa. J.Anim.Vet.Adv. 9 (24): 3026-3033.

D,Mello, J.P.F., 2003. Food safety: Contaminants and Toxins. CABI Publishing, Wallingford, Oxon, UK, Cambridge, MA. pp: 480.

Khan, S., Q.Y.Z. Cao, Y.Z. Huang and Y.G. Zhu., 2008. Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. Environ. Poll., 125(3): 686-692

Cui, Y.L., R.H. Zhu, R.H. Zhi, D.Y. Chen, Y.Z. Huang and Y. Qiu, 2004. Transfer of metals from soils to vegetables in an area near a smelter in Nanning, China, Environ. Intl., 30: 785-791.

Anita Singh, Rajesh Kumar Sharma, Madhoolika Agrawal and Fiona M. Marshall (2010); Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Varanasi, India; *Tropical Ecology* 51(2S): *International Society for Tropical Ecology*; pp 375-387;

Sajjad Khan, Robina Farooq, Shagufta Shahbaz, Mohammad Aziz Khan and Maria Sadique (2009); Health Risk Assessment of Heavy Metals for Population via Consumption of Vegetables, *World Applied Sciences Journal* Vol. 6 (12): pp 1602-1606

Zhuang P, Murray B.M, Hanping X, Li N and Li Z (2009); Health risk from heavy metals via consumption of food crops in the vicinity of Dabaoshan mine, South China. *Elsevier: science of the total environment* 407: pp 1551-15616714

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

Fisseha, I., 2002. Metals in leafy vegetables grown in Addis Ababa and toxicological implications. Ethiop J. Health Dev., 16: 295-302.

Yebpella G.G., A..M. Magomya, U.U. Udiba, I. Gandu, S.M Amana, V.C Ugboaja, N.L Usman (2011) Assessment of Cd, Cu, Mn and Zn Levels in Soil, Water and Vegetable Grown in Irrigated Farm along River Kubani, Zaria, Nigeria. *Journal of Applied Environmental and Biological Sciences* 1(5)84-89, 2011

Tsafe A. I, 1Hassan L G, Sahabi D.M, Alhassan Y, Bala B M,(2012) Evaluation of Heavy Metals Uptake and Risk Assessment of Vegetables Grown in Yargalma of Northern Nigeria. *J. Basic. Appl. Sci. Res.*, 2(7)6708-6714

USEPA. 2000. *Risk-based Concentration Table*. United State Environmental Protection Agency, Washington, DC.