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Heavy Metals in Soils and Tomatoes Grown in Urban Fringe Environment in Asaba, Delta State, Nigeria

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ABSTRACT: Pb, Cu, Ni, Zn, Cr, Mn and Fe in soils and tomato leaves and fruits from peri-urban environments in Asaba, Delta State were determined after acid digestion by using atomic absorption spectrophotometry (AAS). The concentrations of metals in the soil samples were 10.14, 2.28, 3.96, 7.88, 0.15, 14.53 and 66.00 mg/kg site A; 7.01, 2.01, 2.03, 5.53, 0.16, 12.15, and 70.12 mg/kg site B, and 9.12, 2.24, 3.01, 4.35, 0.01, 11.52, and 61.22 mg/kg site C for Pb, Cu, Ni, Zn, Cr, Mn and Fe respectively. The concentrations of metals in the tomato leaves samples were 4.01, 1.91, 1.83, 4.89, 0.16, 4.51 and 7.13 mg/kg in site A; 3.84, 1.56, 2.07, 4.00, 0.41, 4.48 and 8.15mg/kg in site B, and 4.03, 1.75, 2.01, 4.52, 0.01, 4.42 and 8.11 mg/kg in site C for Pb, Cu, Ni, Zn, Cr, Mn and Fe respectively while in the tomato fruits, the concentrations of metals in mg/kg were 2.96, 0.41, 1.35, 3.33, 0.01, 3.83 and 6.38 mg/kg in site A; 3.01, 1.35, 1.88, 2.98, 0.15, 3.01 and 5.09 mg/kg in site B, and 3.92, 1.44, 1.82, 3.73, 0.01, 3.05 and 6.00 mg/kg in site C for Pb, Cu, Ni, Zn, Cr, Mn and Fe respectively. These values obtained in the soils for all sites were below the given values for naturally occurring metals in soil and Department of Petroleum Resources target and intervention values for metals in soil while the values recorded for tomatoes leaves and fruit are below the levels recommended by WHO/FAO and NAFDAC for metals in foods and vegetables but are within the normal range of metals in plants. There was positive correlation among metals except Pb/Cr, Cr/Mn and Cr/Fe. The values of transfer factor (tf) obtained for all the metals except Fe in leaves and fruits for all the sites were above 0.2 indicating anthropogenic contamination of the sites and also high take up and accumulation of the metals from the soil by the tomatoes thus the need for environmental monitoring of the area.
Key words: Heavy metals, tomato, anthropogenic, contamination, pollution

INTRODUCTION

Heavy metals are ubiquitous in the environment, as a result of both natural and anthropogenic activities, and humans are exposed to them through various pathways (Wilson and Pyatt, 2007). Heavy metals like iron, tin, copper, manganese and vanadium occur naturally in the environment and could serve as plant nutrients depending on their concentrations. Mercury, lead, cadmium, silver, chromium and many others that are indirectly distributed as a result of human activities could be very toxic even at low concentrations. These metals are non-biodegradable and can undergo global ecological circles (Opaluwa *et al*., 2012).

Contamination of soils by heavy metals is the most serious environmental problem and has significant implications for human health (Moore *et al*., 2009). Soil is a vital environmental, ecological and agricultural resource that has to be protected from further degradation as an adequate supply of healthy food needed for the world's increasing population. Heavy metal accumulation in soils is of concern in agricultural production due to the adverse effects on food quality (safety and marketability), crop growth (due to phytotoxicity) (Islam *et al*., 2007) and environmental health (soil flora/fauna and terrestrial animals). The mobilization of heavy metals into the biosphere by human activity has become an important process in the geochemical cycling of these metals. This is acutely evident in urban areas where various stationary and mobile sources release large quantities of heavy metals into the atmosphere and soil, exceeding the natural emission rates (Bilos *et al*., 2001).

Vegetables constitute essential diet components by contributing protein, vitamins, iron, calcium and other nutrients, which are usually in short supply (Thompson and Kelly, 1990). They also act as buffering agents for acidic substances produced during the digestion process. However, they contain both essential and toxic elements over a wide range of concentrations. Metal accumulation in vegetables may pose a direct threat to human health (Damek-Poprawa and Sawicka-Kapusta, 2003; Türkdogan *et al*., 2003). Commercial and residential vegetable growing areas are often located in urban areas, and are subject to anthropogenic contamination. Studies of vegetables grown in locations close to industry and roadsides have reported elevated levels of heavy metals (Kachenko and Singh, 2006; Okunola *et al*., 2008).

Vegetables take up metals by absorbing them from contaminated soils, as well as from deposits on different parts of the vegetables exposed to the air from polluted environments (Kachenko and Singh, 2006; Islam *et al*., 2007). It has been reported that nearly half of the mean ingestion of lead, cadmium and mercury through food is due to plant origin (fruit, vegetables and cereals). Moreover, some population groups seem to be more exposed, especially vegetarians, since they absorb more frequently 'tolerable daily doses' (Islam *et al*., 2007.

The consumption of vegetables produced in contaminated areas, in addition to ingestion or inhalation of contaminated particles (Zhuang *et al*., 2008) from vehicular emissions, are two principal factors contributing to human exposure to metals (Ogbonna and Okezie, 2011).

Consequently, serious systemic health problems such as belly ache, renal dysfunction, pulmonary emphysema (Yeung and Hsu, 2005; Kirkham, 2006) can develop from excessive dietary accumulation of toxic metals in human body. Thus determination of metal in environmental samples such as soils and vegetables is very necessary for monitoring environmental pollution (Tuzen, 2003; Al-Khashman, 2007). Therefore, in this study, we assessed the concentration of heavy metals in soil and tomatoes grown in urban fringe environment.

MATERIALS AND METHOD

Description of study area

Asaba is the capital of Delta State. It is an urban town with increased population due to it being a capital city. Asaba has an estimated area of 200 square kilometers. As at 1991 census, Asaba has an estimated population of 149,603 by the 2006 census figure. Asaba is located at longitude 6° 42' 19" E and latitude 6° 11' 04" N of the equator it is situated along the bank of River Niger which washed the Eastern and southern boundaries of the town. Asaba has a rich deposit of alluvial soil which is very good for cultivation. Before it was made a capital city, the main occupation was farming and trading. But since 1991, there has been a shift from agriculture to commercial and administrative activities.

Sample collection

Soil samples were collected from three sites located in the urban fringe area of Asaba town, Delta State. The soil samples were collected using a stainless steel soil auger at a depth of 0 – 15 cm. Tomato leaves and fruits cultivated in the three sampling sites were also collected using a stainless steel knife. All samples were kept in clean polythene bags after which they were labeled according to the sites from which they were collected. The samples were transported to the laboratory for analysis. Soil samples were air dried while the plant samples were thoroughly washed with distilled water to remove dust and other particles, air dried in a dust free room then in an oven at 70 °C for 48 hrs to a constant weight. The dried soil and plant samples were gently crushed in an agate mortar with a pestle and passed through a 2 mm sieve and stored in polyethylene bags for analysis while the dried plant samples were ground into fine powder using a stainless steel blender.

Sample treatment

Two grammes (2.0 g) of prepared soil sample were digested with 15.0 mL nitric acid, 20.0 mL perchloric acid and 15.0 ml hydrofluoric acid and placed on a hot plate for 3 hrs. On cooling, the digest was filtered into a 100.0 ml volumetric flask and made up to the mark with distilled water. Similarly, dry powdered tomatoes leaves and fruit samples were digested with 60% $HClO_4$, concentrated HNO_3 and H_2SO_4. Blanks were prepared too. The digest samples were analyzed for the various heavy metals using atomic absorption spectrophotometer (GBC scientific equipment SENS AA, Melbourne, Australia).

RESULT AND DISCUSSION

Table1 shows the heavy metal concentrations in soil and tomato grown in urban fringe environments. These values obtained for all sites were far below the given values for naturally occurring metals in soil and Department of Petroleum Resources (DPR, 2002) target and intervention values for metals in soil (Table 2).

Table 1 also shows the levels of heavy metals in the tomato leaves and fruits. For the tomato leaves, the concentration ranged from 3.84 to 4.03 mg/kg for Pb, 1.56 to 1.91 mg/kg for Cu, 1.83 to 2.07 mg/kg for Ni, 4.00 to 4.89 mg/kg for Zn, 0.01 to 0.41 mg/kg for Cr, 4.42 to 4.51 mg/kg for Mn and 7.13 to 8.15 mg/kg for Fe. For the tomato fruits, the concentration ranged from 2.96 to 3.92 mg/kg for Pb, 0.41 to 1.44 mg/kg for Cu, 1.35 to 1.88 mg/kg for Ni, 2.98 to 3.73 mg/kg for Zn, 0.01 to 0.15 mg/kg for Cr, 3.01 to 3.83 mg/kg for Mn and 5.09 to 6.38 mg/kg for Fe. The concentrations of the metals in the soil were higher than in the tomato leaves and fruits while the metal concentrations in tomato leaves were higher than in the fruits. The values recorded for tomatoes leaves and fruit were below the levels recommended by WHO/FAO and NAFDAC for metals in foods and vegetables but were within the normal range of metals in plants (Table 3).

Table 1: Heavy Metal Concentrations (mg/kg) in Soil and Tomato Leaves and Tomatoes Fruits

Location	Sample	Pb	Cu	Ni	Zn	Cr	Mn	Fe
SITE A	SOIL	10.14	2.28	3.96	7.88	0.15	14.53	66.00
	LEAVES	4.01	1.91	1.83	4.89	0.16	4.51	7.13
	FRUITS	2.96	0.41	1.35	3.33	0.01	3.83	6.38
SITE B	SOIL	7.01	2.01	2.03	5.53	0.16	12.15	70.12
	LEAVES	3.84	1.56	2.07	4.00	0.41	4.48	8.15
	FRUITS	3.01	1.35	1.88	2.98	0.15	3.01	5.09
SITE C	SOIL	9.12	2.24	3.01	4.35	0.01	11.52	61.22
	LEAVES	4.03	1.75	2.01	4.52	0.01	4.42	8.11
	FRUITS	3.92	1.44	1.82	3.73	0.01	3.05	6.00

Table 2: Naturally occurring and Department of Petroleum Resources (DPR, 2002) Target and Intervention Values for Metals in Soil

METALS	Cd	Cr	Cu	Pb	Zn	Mn	Fe
DPR Target value	0.8	100	36	85	140	437	5000
DPR Intervention value	17	380	190	530	720	-	-
Naturally occurring values (Bowen, 1979)	0.3	-	8	20	900	9000*	5000

*Eddy *et al*. (2004).

Table 3: FAO/WHO guidelines for metals in foods and vegetables

Metals mg/kg)	WHO/FAO	NAFDAC	EC/CODEX	Normal Range In Plants
Cd	1	-	0.2	<2.4
Cu	30	20	0.3	2.5
Pb	2	2	0.3	0.50-30
Zn	60	50	<50	20-100
Fe	48	-	-	400-500
Ni	-	-	-	0.02-50

The non-parametric Analysis of Variance (ANOVA) revealed that the differences observed in the levels of the metals among the different samples is not statistically significant ($P>0.05$). Table 4, gives the correlation coefficient of metal concentration in all the soil and tomatoes samples analyzed at all the sites. The result shows poor positive correlation between Ni/Cr and Zn/Cr, fairly positive correlation between Cu/Cr, and shows strong negative correlation between Pb/Cr, Cr/Mn and Cr/Fe. There was however very strong positive correlation among the other metals. The significant positive correlations observed among the other metals possibly suggest a strong association between these metals as they could come from a common geogenic input.

Soil-Plant Transfer Coefficients (tf)

The transfer coefficient quantifies the relative differences in bioavailability of metals to plants and is a function of both soil and plant properties. The coefficient was calculated by dividing the concentration of a metal in the tomato leaves or fruit by the total metal concentration in the soil. Higher transfer coefficients reflect relatively poor retention in soils or greater efficiency of plants to absorb metals. Low coefficients reflect the strong sorption of metals to the soil colloids (Khan *et al*., 2009). Table 5 shows the transfer factor (tf) of heavy metals calculated for each site.

In all the sites, the tf values obtained for both leaves and fruits for Pb and Cu were far greater than the suggested range of 0.01 to 0.1 reported by Kloke *et al*. (1984). However, the tf values obtained for Zn were lower than the suggested range of 1 to 10 reported by Kloke *et al*. (1984). Transfer quotient of 0.1 indicates that plant is excluding the element from its tissues while the transfer coefficient of 0.2 for vegetables indicate the chances of metal contamination by anthropogenic activities (Khan *et al*., 2009) and so the need for environmental monitoring of the area will be required (Sponza and Karaoglu, 2002). Generally, the values obtained for all the metals except Fe in all sites and in leaves and fruits were above 0.2 thus indicating anthropogenic contamination and also high metal uptake from soil by the tomato. Since vegetables are known to take up and accumulate trace metals from contaminated soil (Khan *et al*., 2009), detection in tomato leaves and fruit samples were not surprising. Soil properties such as lower pH and low organic carbon contents of the soil may have influenced the soil-plant transfer of Cu and Pb.

Table 4: Correlation Coefficient for Association Among Metals

	Pb	Cu	Ni	Zn	Cr	Mn	Fe
Pb	1.000						
Cu	0.861	1.000					
Ni	0.995	0.906	1.000				
Zn	0.943	0.981	0.971	1.000			
Cr	-0.042	0.473	0.055	0.292	1.000		
Mn	1.000	0.862	0.996	0.944	-0.039	1.000	
Fe	0.997	0.816	0.984	0.912	-0.124	0.996	1.000

Table 5: Transfer Coefficients of Metals in Tomato Leaves and Fruits

Location	Sample	Pb	Cu	Ni	Zn	Cr	Mn	Fe
SITE A	LEAVES	0.40	0.84	0.46	0.62	1.07	0.31	0.11
	FRUITS	0.29	0.18	0.34	0.42	0.07	0.26	0.10
SITE B	LEAVES	0.55	0.78	1.02	0.72	2.56	0.37	0.12
	FRUITS	0.43	0.67	0.93	0.54	0.94	0.25	0.07
SITE C	LEAVES	0.44	0.78	0.67	1.04	1.00	0.38	0.13
	FRUITS	0.43	0.64	0.60	0.86	1.00	0.26	0.10

CONCLUSION

The concentration of heavy metals determined were in sequence Fe > Mn > Pb > Zn >Ni > Cu > Cr for soil from all sites and they were all found in tomatoes grown in the sites studied. There was high metal transference from soil to tomatoes which is a concern particularly for urban vegetables in which the roots, stems, stalks, leaves or fruits are consumed.

REFERENCES

Al-Khashman, O.A. (2007). The investigation of metal concentrations in street dust samples in Aqaba city, Jordan. *Environmental Geochemistry and Health*, **29:** 197-207.

Bilos, C., Colombo, J.C., Skorupka, C.N. and Rodriguez-Presa, M.J. (2001). Source, distribution and variability of air-borne trace metals in La Plata City area, Argentina. *Environmental Pollution*, **111(1):** 149-158.

Damek-Poprawa, M. and Sawicka-Kapusta, K. (2003). Damage to liver, kidney, and teatis with reference to burden of heavy metals in yellow-necked mice from areas around steel works and zinc smelters in Poland. *Toxicology*, **186(1-2):** 1-10.

Department of Petroleum Resources (DPR) (2002). Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (Revised Edition). Department of Petroleum Resources, Ministry of Petroleum and Natural Resources, Abuja, Nigeria.

Islam, E., Yang, X., He, Z. and Mahmood, Q. (2007). Assessing potential dietary toxicity of heavy metals in selected vegetables and food crops. *Journal of Zhejiang University Science B*, **8(1):** 1-13.

Kachenko, A.G. and Singh, B. (2006). Heavy metals contamination in vegetables grown in urban and metal smelter contaminated sites in Australia. *Water, Air, and Soil Pollution*, **169:** 101–123.

Khan, S., Farooq, R., Shahbaz, S., Khan, M.A. and Sadique, M. (2009). Health risk assessment of heavy metals for population via consumption of vegetables. *World Applied Sciences Journal*, **6(12):** 1602-1606.

Kirkham,M.B., (2006). Cadmium in plants on polluted soils, effects of soil factors, hyperaccumulation and amendments. *Geoderma,* **137:** 19-32.

Kloke, A., Sauerbeck, D.R. and Vetter, H. (1984).The contamination of plants and soils with heavy metals and the transport of metals in terrestrial food chains. In: J. O. Nriagu (Ed.). Changing Metal Cycles and HumanHealth: Report of the Dahlem Workshop on Changing Metal Cycles and Human Health. Germany: Springer, pp: 113-141.

Moore, F., A. Shakeri and S. Modabberi, (2009). Heavy metal contamination and distribution in the Shiraz industrial complex zone soil, South Shiraz, Iran. *World Applied Science Journal*, **6:** 413-425.

Ogbonna, P.C. and Okezie, N. (2011). Heavy metal level and macronutrient contents of roadside soil and vegetation in Umuahia, Nigeria. *Terrestrial and Aquatic Environmental Toxicology*, **5:** 35-39.

Okunola, O.J., Uzairu, A., Ndukwe, G.I. and Adewusi, S.G. (2008). Assessment of Cd and Zn in roadside surface soils and vegetations along some roads of Kaduna metropolis, Nigeria. *Research Journal of Environmental Sciences*, **2(4):** 266-274.

Opaluwa, O.D., Aremu, M.O., Ogbo, L.O., Abiola, K.A., Odiba, I.E., Abubakar, M.M. and Nweze, N.O. (2012). Heavy metal concentrations in soil, plant leaves and crops grown around dumpsites in Lafia metropolis, Nasarawa State, Nigeria. *Advances in Applied Science Research*, **3(2):** 780-784.

Sponza, D. and Karaoglu, N. (2002). Environmental geochemistry and pollution studies of Aliaga metal industry district. *Environment International*, **27:** 541-553.

Thompson, H.C., Kelly, W.C., (1990). Vegetable Crops, 5th Ed. MacGraw Hill Publishing Company Ltd., New Delhi.

Thornton, M. and Farago, E. (1997). Geochemistry of arsenic. In: C. O. Abernathy, R. L. Calderon and W. R. Chappell (Eds). Arsenic, Exposure and Health Effects, Chapman & Hall, London, pp: 27.

Türkdogan, M.K., Kilicel, F., Kara, K., Tuncer, I., Uygan, I., (2003). Heavy metals in soil, vegetables and fruit in the endemic upper gastrointestinal cancer region of Turkey. *Environmental Toxicology and Pharmacology.* **13(3):** 175-179.

Tuzen, M. (2003). Determination of heavy metals in soil, mushroom and plant samples by atomic absorption spectrometry. *Microchem Journal*, **74:** 289-297.

Wilson, B., and Pyatt, F.B. (2007). Heavy metal dispersion, persistence, and bioaccumulation around an ancient copper mine situated in Anglesey. UK. *Ecotoxicology and Environmental Safety*, **66:** 224-231.

Yeung, A.T. and Hsu, C.N. (2005). Electrokinetic remediation of cadmium contaminated clay. *Journal of Environmental Engineering*, **131:** 298-304.

Zhuang, P., M.B. McBride, H. Xia, N. Li and Z. Li, (2008). Health risk from heavy metals via consumption of food crops in the vicinity of Dabaoshan mine, South China. *Science of Total Environment*, **407:** 1551-1561.