academicJournals

Vol. 7(6), pp. 540-545, June 2013
DOI: 10.5897/AJEST2013.1511
ISSN 1996-0786 © 2013 Academic Journals
http://www.academicjournals.org/AJEST

African Journal of Environmental Science and Technology

Full Length Research Paper

Impact analysis of lead, copper and zinc content in selected African indigenous and exotic vegetables from Nairobi markets, Kenya

Mutune, A. N.*, Makobe, M. A. and Abukutsa-Onyango, M. O. O.

Jomo Kenyatta University of Agriculture and Technology. P.O. Box 62000, 00200. Nairobi, Kenya.

Accepted 4 June, 2013

Vegetables consumed in urban sites can be contaminated with harmful metal levels absorbed from planting sources because metals are commonly present in soil. The present study was carried out to evaluate Pb, Cu and Zn concentration in ten of the commonest vegetables in Nairobi markets. Vegetables were collected from 15 markets in urban and peri-urban Nairobi and analyzed for metal content using an Atomic Absorption Spectrophotometer (AAS). The concentrations were in the order Zn > Cu > Pb with values of 15.6 to 120, 0 to 19 and Pb 0 to 1.37 mg/kg, respectively. There were significant differences in markets and within vegetables ($p<0.05$). Sources were not consistent in the levels of metals indicating that they were supplied from different planting sites. Cu and Zn were within permissible consumer limits while Pb in many vegetables exceeded the limit. Continuous control of pollution and evaluation of metal content in vegetables is recommended in monitoring environmental contamination and food safety.

Key words: African indigenous vegetables, heavy metals, pollution, urban and peri - urban markets.

INTRODUCTION

The impact of industrial development on the environment in Kenyan agricultural sites cannot be underestimated. Environmental problems range from water, soil and atmospheric contamination. The pollution has a negative impact on the safety of food produced. Many studies have shown that food crops accumulate trace metals in their tissues when grown on contaminated soil or when watered with contaminated water (Ghosh et al., 2012; Sinha et al., 2010). It is recognized that land used for food production can be contaminated with Pb, Cu and Zn from natural and anthropogenic sources such as metal smelting, irrigation with wastewater, disposal of solid wastes, vehicular exhaust and adjacent industrial activity (Nabulo et al., 2012). Heavy metals are of considerable environmental concern due to their toxicity and cumulative behavior in human tissues (Sinha et al., 2010). Since they are not degradable (Ghosh and Singh, 2005; Salt et al., 1995), they last for long in the environment and thus readily accumulated at toxic levels (Tiwari et al., 2011). Copper and Zinc are essential trace elements (Olowoyo et al., 2012; Audu and Lawal, 2006); however, at high levels, they are known to cause oxidative stress (Sinha et al., 2010). Intake of these metals in low quantities is harmful because they are not easily eliminated from the body and cause cumulative poisoning (Islam et al., 2007). Excess zinc causes copper deficiency, anaemia, neutropenia, pancreatitictis, damage of hepatic parenchyma and vascular shock (Islam et

*Corresponding author. E-mail: nadelaide@yahoo.com.

Table 1. Codes of the vegetables and markets.

Vegetable name	Code	Market	Code	Market	Code
African Nightshade	V1	Githurai 45	M1	Gikomba	M11
Swiss chard	V2	Mutindwa	M2	Kenyatta university KM	M12
African kale	V3	Kangemi	M3	Juja	M13
Spider plant	V4	Kawangware	M4	Ruiru	M14
Amaranth	V5	Dandora	M5	Buruburu	M15
Pumpkin	V6	Lunga Lunga	M6		
Cowpea	V7	Kibera	M7		
Jute mallow	V8	Kayole	M8		
Crotalaria	V9	Kenyatta market	M9		
Kale	V10	Mathare	M10		

al., 2007; Fosmire, 1990). Excess Cu is transported to the liver, and causes liver and kidney damage, anaemia, immunotoxicity, gastrointestinal distress, and genetic disorders such as Wilson's disease and idiopathic copper tocixity (ATSDR, 2004).

Despite the efforts to eliminate lead from sources such as gasoline, paints, batteries and household items, high levels are still reported in soils and vegetables (Nabulo et al., 2012). Harzadous effects of lead depend on dosage but the general effects include increased risk of hypertension, anaemia, reduced lifespan of erythrocytes, impairment of heme synthesis, neurological disorders, impaired cognitive skills in children, in rats, it disrupts normal bone growth and density and causes caries in children (ATSDR, 2007). Consumption of african indigenous vegetables (AIVs) in Kenya is high (Habwe et al., 2008; Shiundu and Oniang'o, 2007; Abukutsa-Onyango, 2005) because they are rich in essential minerals and vitamins, and are medicinal (Shackleton et al., 2009; Smith and Eyzaguirre, 2007; Orech et al., 2005). They are rich in antioxidants, ß-carotene, Fe, Ca and Zn (Smith and Eyzaguirre, 2007). Work on nutrient content of AIVs has gained momentum only in recent years. One study has shown that Amaranth is rich in ß-carotene and vitamin A (Faber et al., 2010), and traditionally, *Cochorus olitorius* is a blood purifier, Amaranth is a tapeworm expeller and *Vigna unguiculata* treats dermatitis and swellings (Ayodele, 2005). Spider plant is used to alleviate migraine, diphtheria, headache, pneumonia, septic ears and stomach ailments (Drissa, 2009). AIVs are easy to grow, many times sprouting on their own in undisturbed sites and are agronomically less-demanding (Abukutsa-Onyango et al., 2005). Vegetables consumed in Nairobi are either supplied from upcountry sources or farmed within the city in all available spaces especially in close proximity to water sources.

Urban and Peri-urban agriculture is an old and common practice in African towns (MOA, 2010; Shackleton et al., 2009). There is need to establish whether there is significant heavy metal accumulation in common AIVs that could poison consumers.

MATERIALS AND METHODS

Collection of samples

A purposive survey and collection was carried out in 15 markets namely, Githurai 45, Kibera, Kangemi, Kawangware, Kenyatta M-arket, Lunga Lunga, Mutindwa, Kayole, Dandora, Mathare, Gikomba, Kenyatta University KM, Juja, Ruiru and Buruburu (Table 1). The choice of sites was purposive taking care to include only markets whose vegetables were likely to have been sourced from contaminated sites. These sites were close to river banks and roadsides where vegetables are often planted. In each market, 3 traders were chosen randomly. The vegetables analysed were African Nightshade (*Solanum villosum*), Swiss chard (*Beta vulgaris*), African kale (*Brassica carinata)*, Spider plant, Amaranth (*Amaranthus)*, Pumpkin (*Curcubita moschata),* Cowpea (*Vigna unguiculata)*, Jute mallow (*Cochorus clitorius)*, Slenderleaf (*Crotalaria*) and Kale (*Brassica oleracea*). These are some of the commonest vegetables consumed in Kenya (Abukutsa-Onyango, 2007; Shackleton et al., 2009). Two kilograms of each vegetable were bought from each trader from all the markets. Not all vegetables; however, were available from the markets. Vegetable samples were composited, one vegetable type from three retailers to make one sample, then taken to the laboratory immediately for analysis. Samples were carried in cooler boxes to avoid undesirable physiological changes. They were dried for three days at 70°C then powdered using a miller.

Digestion of samples for analysis

Samples were digested in two replicates each. Five grams of fine powder was weighed into silica crucibles and charred to remove carbon in a block digester at 200°C until all smoke had gone. Material that is not charred may ignite at high temperatures causing self-combustion (Okalebo et al., 2002). The sample was dry-ashed at 550°C in a muffle furnace for 14 h. To the ash, 15 ml of 6 NHCl was added and the mixture heated for about 10 min at 250°C on a hot plate. This was meant to digest the minerals in the ash. The resulting digest was filtered using Whatmans No. 42 filter paper. The filtrate was topped up to 50 ml using distilled water and stored in plastic bottles in a cold room up to analysis.

Table 2. Pb content of vegetables collected from Nairobi markets.

Market	Vegetable										
	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	Mean
M1	*	0^{***a}		0.34^{ab}	0.14^{a}	0.224^{a}	0.22^{a}	0.24^{ab}	0.25^{a}	0.27^{ab}	0.21
M2	0.95^{a**}	1.37c	0.43^{a}	0.80^{b}	0.96^{b}		0.36^{a}				0.81
M3	0.65^{a}	0.10^{ab}	0.33^{a}	0.12^{a}	0.67^{ab}					0.18^{ab}	0.34
M4	0.66^{a}	0.27^{ab}		0.23^{ab}	0.38^{ab}	0.087^{a}	0.27^{a}	0.064^{a}	0.26^{a}	0.31^{ab}	0.28
M5	0.76^{a}			0.15^{a}	0.28^{ab}	0.26^{a}	0.22^{a}	0.96^{b}		0.92d	0.51
M6	0.14^{a}			0.07^{a}	0.11^{a}	0.16^{a}	0.27^{a}	0.28^{ab}		0.31^{ab}	0.19
M7	0.33^{a}	0.08^{ab}	0.16^{a}	0.22^{ab}	0.19^{a}	0^{a}	0.24^{a}			0.06^{a}	0.16
M8	0.23^{a}		0.38^{a}	0.41^{ab}	0.48^{ab}	0.06^{a}	0.18^{a}	0.27^{ab}		0.27^{ab}	0.29
M9		0.49^{b}	0.17^{a}	0.41^{ab}	0.71^{ab}	0.37^{a}	0.33^{a}	0.72^{ab}	0.32^{a}	0.03^{a}	0.39
M10	0.33^{a}	0.27^{ab}		0.61^{ab}	0.32^{ab}						0.38
M11	0.42^{a}	0.12^{ab}	0.11^{a}	0.20^{a}	0.22^{ab}	0.25^{a}	0.24^{a}		0.17^{a}	0.70cd	0.27
M12	0.57^{a}	0.53^{b}		0.39^{ab}	0.55^{ab}		0.68^{a}	0.50^{a}		0.49^{b}c	0.53
M13	0.10^{a}			0.3^{ab}	0.13^{a}	0.42^{a}	0.11^{a}				0.21
M14	0.17^{a}			0.08^{a}	0.33^{ab}	0.32^{a}	0.44^{a}			0.27^{ab}	0.27
M15	0.10^{a}		0.15^{a}	0.17^{a}	0.12^{a}	0.22^{a}	0.17^{a}			0.19^{ab}	0.16
Mean	0.42	0.36	0.25	0.30	0.37	0.22	0.29	0.43	0.25	0.33	0.21
SE	0.136	0.07	0.0814	0.156	0.119	0.1^{a}	0.10	0.1246	0.13	0.06	
P	0.008	<.001	0.144	0.003	0.003	0.197	<.001	0.014	0.85	<.001	

*Blanks indicate that the vegetable was missing in a market.
**Alphabetical letters indicate significance of variation within each vegetable among markets.
***Below detection limit.

Heavy metal analysis

Analysis was done using an Atomic Absorption Spectrophotometer (Shimadzu AAS-6200). The AAS was calibrated for all the metals by running standard solutions at concentrations of 0, 1, 1.5, 2 and 2.5 mg/kg. The sensitive wavelength for each metal was specified on the respective cathode lamps.

Data analysis

All data analysis was done using GENSTAT 14. Data obtained from the AAS was analyzed for variance (ANOVA) at $p<0.05$ to determine statistical variation in the concentration of Pb, Cu and Zn in the vegetables. Probabilities less than 0.05 ($p<0.05$) were considered statistically significant. Means were separated using Benferroni test.

RESULTS AND DISCUSSION

African Kale, Crotalaria and Jute mallow were found in fewer markets compared to other vegetables. Tables 2, 3 and 4 show the results of the concentrations of Pb, Cu and Zn, respectively; of the vegetables obtained using the AAS. Differences within vegetables and within markets were significant ($p<0.05$). Metal concentration of this study were in some cases higher while in others were lower than those obtained in other studies. Some vegetables analyzed here were not seen in other recorded studies for comparison purposes. Concentration of lead ranged from 0 (undetectable) to 1.37 mg/kg. The highest Pb content (1.37 mg/kg) was found in Swiss chard from Mutindwa followed by Amaranth (0.96 mg/kg, Mutindwa). Mutindwa had the highest mean Pb content (0.81 mg/kg) followed by Dandora (0.62 mg/kg). Mutindwa market is located along a very busy road while Dandora is surrounded by many sources of urban-planted vegetables and is close to the main Nairobi dumpsite. Othman (2001) doing similar work on various leafy vegetables collected from Dar es Salaam reported Pb concentration of 0 to 7.7 mg/kg in pumpkin and 0.2 to 6.6 mg/kg in cowpea, but in this study, Pb content was lower. There has been a worldwide elimination of Pb in fuel which may account for this discrepancy.

C. olitorius and *Amaranthus hybridus* from Nigeria had Pb 0.05 to 0.33 mg/kg (Dosumu et al., 2003), while Pb in leafy and non-leafy was 0.1 to 15.8 mg/kg (Salariya et al., 2003), which were much higher than values in these study. Compared to other metals, Pb is low because it is not actively absorbed by plants (Alloway, 1995) and there are no known genes for its accumulation (Ghosh and Singh, 2005). Copper content in vegetables also varied significantly within vegetables and within sites. Values were between 0 and 19.15 mg/kg. The highest copper

Table 3. Cu content of vegetables collected from Nairobi markets.

Market	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	Mean
M1		6.32^{d}		7.48^{bcd}	13.57^{g}	2.35^{d}	8.67^{f}	6.37^{d}	9.41^{d}	10.88^{bc}	8.36
M2	8.81^{f}	18.00^{f}	8.66^{e}	11.6^{d}	2.24^{bcd}		12.28g				9.01
M3	9.15^{f}	3.31^{b}	7.77^{d}	12.24^{d}	7.78^{f}					13.35^{c}	10.01
M4	7.13^{e}	19.15^{g}		9.11^{cd}	0^{a}	14.88^{a}	0^{a}	0^{a}	0^{a}	3.66^{a}	4.21
M5	8.16^{ef}			9.4^{cd}	6.79^{f}	7.74^{bc}	9.21^{f}	9.81^{e}		5.11^{a}	8.01
M6	2.36^{bc}			4.37^{abc}	2.92^{de}	7.86^{bc}	2.50^{de}	1.91^{e}		1.97^{a}	3.56
M7	1.47^{ab}	1.08^{a}	0.5^{ab}	0.804^{a}	2.84^{de}	1.66^{d}	1.35^{bcd}			0.88^{a}	1.34
M8	4.74^{d}		1.17^{b}	1.754^{a}	2.22^{bcd}	1.91^{d}	0.76^{abc}	6.48^{d}		2.97^{a}	2.50
M9		4.37^{c}	3.84^{c}	4.9^{abc}	0.98^{ab}	6.78^{c}	1.40^{bcd}	3.92^{c}	1.6^{b}	1.22^{a}	3.10
M10	4.93^{d}	1.22^{a}		11.27^{d}	1.26^{abc}						5.73
M11	2.45^{bc}	1.88^{a}	0^{a}	2.07^{ab}	2.38^{bcde}	1.72^{d}	1.88^{cd}		3.37^{c}	5.57^{ab}	2.42
M12	0.75^{a}	11.27^{e}		1.07^{a}	1.24^{abc}		0.00^{a}	3.79^{c}		0.00^{a}	1.45
M13	0.79^{a}			0^{a}	0^{a}	9.13^{b}	3.58^{e}				3.08
M14	3.45^{c}			2.83^{ab}	3.99^{e}	5.88^{c}	0.63^{ab}			1.96^{a}	3.07
M15	1.82^{ab}		4.4^{c}	1.32^{a}	3.09^{de}	7.31^{bc}	0.77^{abc}			3.67^{a}	3.39
Mean	3.96	6.21	3.06	4.75	2.78	6.45	2.12	4.36	2.14	3.72	
SE	0.19	0.15	0.1271	0.896	0.26	0.345	0.19	0.1501	0.209	0.89	
P	<.001	<.001	<.001	<0.001	<.001	<0.001	<.001	<.001	<.001	<.001	

*Blanks indicate that the vegetable was missing in a market.
**Alphabetical letters indicate significance of variation within each vegetable among markets.
***Below detection limit.

Table 4. Zn content of vegetables collected from Nairobi markets.

Market	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	Mean
M1		51.46^{ef}		46.01^{cd}	47.31^{e}	26.55^{ef}	44.44^{fg}	22.32^{a}	26.82^{a}	54.48^{gh}	39.16
M2	59.29^{g}	110.19^{h}	9.74^{a}	59.33^{f}	81.01^{i}		69.85^{h}				67.14
M3	83.79^{i}	105.3^{h}	77.12^{e}	42.63^{b}	88.78^{j}					76.88^{i}	85.43
M4	21.76^{b}	120.16^{i}		34.56^{a}	37.47^{c}	25.05^{f}	40.99^{ef}	31.82^{c}	32.91^{c}	63.28^{h}	49.63
M5	47.24^{ef}			47.32^{d}	37.66^{c}	29.24^{d}	50.24^{g}	50.24^{e}		33.47^{b}	41.48
M6	42.6^{de}			48de	50.2^{f}	35.24^{c}	37.71^{cde}	42.69^{d}		41.23^{e}	42.51
M7	80.67^{i}	39.19^{bc}	68.55^{d}	44.76^{bc}	57.38^{g}	38.73^{b}	48.03^{g}			52.96^{g}	51.23
M8	45.44^{e}		35.74^{b}	60.75^{g}	26.22^{b}	28.19^{de}	27.89^{ab}	27.02^{b}		24.02^{a}	33.03
M9		27.81^{a}	55.76^{c}	50.6^{f}	60.17^{h}	15.61^{g}	35.96^{cde}	21.25^{a}	31.27^{b}	38.11^{d}	35.93
M10	39.87^{cd}	43.61^{cd}		104.01^{h}	79.71^{i}						63.37
M11	50.24^{f}	31.98^{ab}	77.48	49.63^{e}	51.39^{f}	54.35^{a}	38.96^{def}		39^{d}	50.38^{f}	49.10
M12	24.15^{b}	58.42^{fg}		36.19^{ab}	25.18^{b}		36.95^{cde}	32.3^{c}		35.51^{c}	37.31
M13	15.88^{a}			45.68^{c}	21.31^{a}	33.08^{c}	31.74^{bc}			25.51^{a}	31.03
M14	65.86^{h}			41.16^{b}	45.23^{d}	35.05^{c}	32.65^{bcd}			32.84^{b}	38.18
M15	37.4^{c}		68.41^{d}	48.46^{de}	19.8^{a}	35.14^{c}	22.05^{a}			0.28	32.46
Mean	47.25	66.21	56.11	49.88	48.67	32.91	39.45	33.98	33.92	39.63	
SE	0.0761	0.404	0.422	1.205	0.3067	0.384	1.00	0.205	0.136	<.001	
P	<.001	<.001	<.001	<0.001	<.001	<0.001	<.001	<.001	<.001	11	

*Blanks indicate that the vegetable was missing in a market.
**Alphabetical letters indicate significance of variation within each vegetable among markets.
***Below detection limit.

content was in spider plant from Kawangware, followed by 18 mg/kg from Mutindwa. Kawangware had the highest mean Cu content (10.3 mg/kg) followed by Mutindwa at 9 mg/kg. Othman (2001) reported that copper levels were 0.22 to 1.47 mg/kg in pumpkin and 0.25 to 1.42 mg/kg in cowpea while for this study copper was much higher at 19.3 mg/kg in spider plant. Other studies of leafy vegetables from markets, contaminated sites or vegetables watered with contaminated water recorded up to 2.2 mg/kg (Iyaka, 2007), 0.1 to 1.5 mg/kg (Gogoasai et al., 2005) and 7.8 mg/kg (Yebpella et al., 2010). Besides the variation in conditions, the vegetables were exposed to these differences, may be due to the different capabilities of different vegetables to absorb minerals and ions.

Zinc was also significantly different in vegetables and sites had values of 15.6 to 120.2 mg/kg. The highest level of Zn was found in Swiss chard from Kawangware (120.2 mg/kg). The market with the highest Zn content for all the vegetables was Kangemi (85 mg/kg). Zn was higher in this study (120.2 mg/kg) than Othman (2001) whose highest level was 56.7 mg/kg in pumpkin. Zn in leafy vegetables from contaminated sites or markets in various studies were recorded as 7 mg/kg (Iyaka, 2007), Zn 1.2 to 21 mg/kg (Gogosai et al., 2005), 0.41 to 1.06 mg/kg (Dosumu et al., 2003), 26.7 mg/kg (Yebpella et al., 2010) and 10.5 to 80.92 mg/kg (Salariya et al., 2003) which were below and within range, but all lower than the highest value in this study.

According to Taber (2009), normal Cu content in plants should range from 2 to 20 mg/kg while for Zn it is 25 to 300 mg/kg. The amount found in this study was therefore within acceptable range. Below 2 mg/kg, Cu is deficient; none of the vegetables was deficient. Although, Zn is sometimes deficient in vegetables (Yebpella et al., 2010) from poor soils, none of the vegetables had deficient content. Pb content was 0.3 mg/kg which was above the allowable limit.

Conclusion

Earlier studies of Mutuku (2005) working on kale reported high levels of Pb (300 mg/kg); however, the current study recorded that most sites are within safe limits for consumption. This may be due to efforts to reduce Pb in fuel. Metal contents were higher in some sites compared to others. There is need for relevant authorities to delineate safe planting sites. Although, only Pb in some sites was above the permissible limits, long-term metal exposure by regular consumption of locally grown vegetables poses potential health problems to humans and animals. There is need for more environmental monitoring to ensure Pb sources to water, soil and plants are contained. Urban Agriculture in Kenya is associated with sewage usage for watering vegetables and is perceived illegal, albeit being accepted in MOA (2010). In all the markets; however, some vegetables are from upcountry sources.

REFERENCES

Abukutsa-Onyango M (2007). Seed production and support systems for African leafy vegetables in three communities in Western Kenya. Afr. J. Food Agric. Nutr. Dev. 7:3.

Abukutsa-Onyango MO, Muriithi AN, Ngamau K, Anjichi V, Angong SG, Fricke A, Hau B, Stutzel H (2005). Proceedings of the 3rd Horticultural Workshop on Sustainable Horticultural production in the Tropics. 23rd to 29th Nov. 2003. Maseno University, MSU. Maseno, Kenya.

Alloway BJ (1995). Heavy metals in Soils. 2nd edn. Blackie Academic and Professional. London, England.

ATSDR (2004). Toxicological profile for copper. U.S. Department of Health and Human Services.

ATSDR (2007). Toxicological profile for lead. U.S. Department of Health and Human Services.

Audu AA, Lawal AO (2006). Variation in Metal Contents of Plants in Vegetable Garden Sites in Kano Metropolis. J. Appl. Sci. Environ. Manage. 10 (2):105 - 109.

Ayodele AE (2005). The medicinally important leafy vegetables of south western Nigeria. Available from: http://www.siu.edu/~ebl/leaflets/ayodele.htm. Accessed 8th February 2013.

Dosumu OO, Salami N, Adekola FA (2003). Comparative study of trace element levels in some local vegetable varieties and irrigation waters from different locations. Bull. Chem. Soc. Ethiop.17(1):107-112.

Drissa S (2009). Spider plant: An indigenous species with many uses. AVRDC; The World Vegetable Center.

Faber M, Oelofse A, Van-Jaarsveld PJ, Wenhold FAM, Jansen RWS (2010). African leafy vegetables consumed by households in the Limpopo and KwaZulu-Natal provinces in South Africa. South Afr. J. Clin. Nutr. 23:1.

Fosmire GJ (1990). Zinc Toxicity. Am. Soc. Clin. Nutr. 51(2): 225-227.

Ghosh AK, Bhatt MA, Agrawal HP (2012). Effect of long-term application of treated sewage water on heavy metal accumulation in vegetables grown in Northern India. Environ. Monit. Assess. 184:1025-1036.

Ghosh M, Singh SP (2005). A review of phytoremediation of heavy metals and utilization of its by-products. Appl. Ecol. Environ. Res. 3(1):1-18.

Gogosai I, Jianu I, Rivis A, Parvu D, Gergen I, Jianu C (2005). Heavy metal distribution in soil-water-vegetable system of Banat area. Annals of the Faculty of Engineering Hunedoara 3:1.

Habwe FO, Walingo MK,Abukutsa-Onyango M (2008). Food Processing and preparation Technologies for utilization of African Indigenous Vegetables for nutrition security and wealth creation in Kenya. In: Robertson, G.L. and Lupien J.R. (eds). Using food and technology to improve nutrition and promote national development. International Union of Food Science and Technology.

Islam EU, Yang XE, He ZL, Mahmood Q (2007). Assessing potential dietary toxicity of heavy metals in selected vegetables and food crops. J. Zhejiang Univ. Sci. B. 8(1):1-13.

Iyaka YA (2007). Concentration of Cu and Zn in some fruits and vegetables commonly available in North-Central zone of Nigeria. Electron. J. Environ. Agric. Food Chem. 6(6):2150-2154.

MOA (Ministry of Agriculture) (2010). National urban and Peri-urban agriculture and Livestock policy. May 2010. Ministry of Agriculture, Kenya.

Mutuku J (2005). Lead levels in Nairobi, Kenya. www.unep.org/pcfv. 10th April 2010

Nabulo G, Black CR, Craigon J, Young SJ (2012). Does consumption of leafy vegetables grown in peri-urban agriculture pose a risk to human health? Environ. Pollut. 162:389-398.

Okalebo RJ, Gathua KW, Woomer PL (2002). Laboratory methods of soil and plant analysis. A working manual. TSBF-CIAT ans SACRED

Africa, Nairobi, Kenya.
Olowoyo JO, Okedeyi OO, Mkolo NM, Lion GN, Mdakane ST R (2011). Uptake and translocation of heavy metals by medicinal plants around a waste dump site in Pretoria, South Africa. South Afr. J. Bot. 78:116-121.
Orech FO, Akenga T, Ochora J, Friis H, AagardHansen J (2005). Potential Toxicity of Some Traditional Leafy Vegetables Consumed in Nyang'oma Division, western Kenya. Afr. J. Food Nutr. Sci. 5:1.
Othman OC (2001). Heavy Metals in green vegetables and soils from vegetable gardens in Dar es Salaam, Tanzania. Tanzan. J. Sci. 27:37-48
Salariya AM, Rehman ZU, Ashraf M (2002). Effect of polluted water on accumulation of heavy metals in commonly consumed vegetables. J. Chem. Soc. Pak. 25:3.
Salt DE, Blaylock M, Nanda PBAK, Dushenkov V, Ensley BD, Chet I, Raskin I (1995). Phytoremediation: a novel strategy for the removal of toxic metals from the environment using plants.Biotechnology 13:468-474
Shackleton CM, Pasquini MW, Drescher AW (2009). African indigenous vegetables in urban agriculture. Earthscan. London, England.
Shiundu KM, Oniang'o RK (2007). Marketing African Leafy Vegetables: Challenges and Opportunities in the Kenyan Context. Afr. J. Food Agric. Nutr. Dev. 7:4.
Sinha S, Sinam G, Mishra K, Mallick S. (2010). Metal accumulation, growth, antioxidants and oil yield of *Brassica juncea* L. exposed to different metals. Exoticol. Environ. Safe. 73:1352-1361.
Smith IF, Eyzaguirre P (2007). African leafy vegetables: their role in the World Health Organization's global fruit and vegetables initiative. Afr. J. Food Agric. Nutr. Dev. 7:3.
Taber HG (2009). Plant Analysis Sampling Procedures and Micronutrient Characteristics with Emphasis on Vegetable Crops. Commercial Vegetables, Horticulture. Iowa State University of Science and Technology.
Tiwari KK, Singh NK, Patel MP, Tiwari MR, Rai UN (2011). Metal contamination of soil and translocation in vegetables growing under industrial waste water irrigated agricultural field of Vadodara, Gujarat, India. Ecotoxicol. Environ. Safe.74:1670-1677.
Yebpella GG, Magomya AM, Udiba UU, Gandu I, Amana SM, Ugboaja VC, Usman NL (2010). Assessment of Cd, Cu, Mn and Zn Levels in Soil, Water and vegetable Grown in Irrigated Farm along River Kubani, Zaria, Nigeria. J. Appl. Environ. Biol. Sci. 1(5):84-89.