INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCES Volume 2, No 2, 2011

Research article ISSN 0976 – 4402

Heavy metals concentrations in vegetables grown in the vicinity of the closed dumpsite

Charles Kihampa[1], William J.S. Mwegoha[1], Riziki S. Shemdoe[2]
1- Department of Environmental Science and Management, Ardhi University, P. O. Box 35176, Dar es Salaam, Tanzania
2- Institute of Human Services and Settlements, Ardhi University, P. O. Box 35176, Dar es Salaam, Tanzania.
kihampa@yahoo.com

ABSTRACT

Levels of heavy metals cadmium, lead, chromium, zinc and copper in five different edible vegetables, *Amaranthus blitum*, *Vigna unguiculata*, *Ipomea batata, Solanum nigrum* and *Cucurbita maxima* grown along the slopes of the closed dumpsite were determined using atomic absorption spectrophotometry. The extraction of heavy metals from the vegetables was done by dry ashing methods and data were analysed using Statistical Programme for Social Sciences (SPSS) and Excel computer packages. Results obtained for five heavy metals in vegetables ranged between 0.28 and 1.50 mg/kg dw for cadmium; 0.49 and 20.65 mg/kg dw for lead; 1.15 and 29.39 mg/kg dw for chromium; 18.61 and 122.88 mg/kg dw for zinc and 3.96 and 22.47 mg/kg dw for copper. The levels of Zn, Cr, Pb and Cd were above the permissible levels of heavy metals in food as per FAO/WHO guidelines and Tanzania Bureau of Standards (TBS) standards. This implies that vegetables grown along the closed Mtoni dumpsite are not suitable for human consumption. This study highlights the potential risks involved in the cultivation and consumption of vegetables on plots along the dumpsites and irrigated with water contaminated with leachates effluents, a practice which may place at risk the health of the urban population who consume these vegetables.

Keywords: Dar es Salaam, Dumpsite, Heavy metals, Vegetables

1. Introduction

Urban agriculture comprises production, processing and distribution of a diversity of foods, including vegetables and animal products within urban areas. It has recently gained increasing recognition as a survival strategy for the urban poor to cope with the declining standard of living in the developing countries. The diversity of activities that have been described as urban agriculture over time has evolved with changing social realities and contemporary efforts to integrate the act of growing food into the urban environment (Wooley, 2007; Salkin, 2008). Nevertheless, rapid and unorganized urban and industrial developments together with improper waste management have contributed to the elevated levels of heavy metals in the urban environment of developing countries, especially in soils and surface waters (Wong et al., 2003), which happen to be the major water source for irrigation. The urban soils and waters receive large pollution loads of trace metals from different anthropogenic sources especially municipal waste, industrial effluents, garages and automobile emissions (Yusuf et al., 2003). These toxic ions may be retained in soil or leach out through the soil and may contaminate ground and surface water along with the soil itself. FAO estimates that approximately 800 million people around the world are engaged in agricultural activities in urban areas (Wikipedia 2010). Waters used for irrigation is normally

Received on September 2011 Published on November 2011

obtained from urban streams, wells and rivers which have often been reported to be polluted by heavy metals that can as well be the source of heavy metals accumulations in agriculture products (Othman, 2001; Bilos et al., 2001; Islami et al., 2007). In Dar es Salaam city for instance, urban agriculture has emerged as an unplanned activity as a result of rapid rates of urbanization. The poor urban farmers are practicing vegetable cultivation within the municipal area, many of them do not have access to land resources and most likely they use high-risk sites such as road verges, river valleys, waste dumping sites, abandoned areas and wetlands whose pollution history is not well articulated (Kitilla and Mlambo 2001; Kihampa and Mwegoha 2010).

As it is in most cases, soils in municipal waste dumpsites commonly serve as fertile ground for the cultivation of a variety of fruit and leafy vegetables, with little regard to the probable health hazards the heavy metal content of such soils may pose (Amusan et al, 2005). A similar activity exists at the closed dumpsite at Mtoni, which is located centrally within Dar es Salaam City boundaries where a ten years worth of refuse is left to produce streams of poisonous leachates (Shemdoe, 2010). The water used for irrigation of vegetables and cultivated soil from the edge of the dumpsite up to 200 m away have been reported to be heavily polluted by heavy metals arsenic, cadmium, chromium, nickel and lead above the limit of Tanzania Bureau of Standard (TBS) (Shemdoe, 2010). The production of vegetables using wastewater for irrigation raises concerns about the safety of such vegetables with respect to their heavy metal content. Heavy metals are kept under environmental pollutant category due to their toxic effect to plant, animals and human beings (Sharma et al., 2006).

Toxic metals may be absorbed by vegetables through several processes and finally enter the food chain at high concentrations capable of causing a serious health risk to consumers. Their toxicity can damage or reduce mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver and other vital organs. Long term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that cause muscular dystrophy, and multiple sclerosis. This study was therefore aimed at assessing the concentrations of heavy metals in vegetables grown in the closed Mtoni dumpsite. Of particular interest were the leaves of *Amaranthus blitum*, *Vigna unguiculata*, *Ipomea batata, Solanum nigrum* and *Cucurbita maxima* which are grown in all season and frequently used fresh vegetables in Dar es Salaam.

2. Materials and Method

2.1 Study area

The present study was carried out in the cultivation sites in the vicinity of the closed Mtoni dumpsite (4 km from the city centre) Dar es Salaam, Tanzania, during February 2011 to July 2011. Mtoni dumpsite officially started in October 2001, as part of the response to the request made by Mtoni residents to the Dar es Salaam City Council to reclaim their land by using solid waste materials. The land at Mtoni area was serious damaged due to land erosion that occurred during the *Eli nino* in 1997, several houses were drown and the land was connected to ocean gulf. The dumpsite was receiving waste from the three Municipalities of Ilala, Temeke and Kinondoni, and an average of 800-1200 tones of different waste materials were disposed off at the site daily. The dumpsite was untimely closed in January 2007 due to the manifested serious environmental implications like fire explosion, health problems and unpleasant odors, originally it was supposed to close at the end of 2016 where the final amount of waste was expected to be about 5,000,000 tons (DCC, 2007). Based on the survey, it was found that the current soil used for cultivation is the land reclaimed from the ocean gulf through crude dumping of waste materials. The green vegetables *Amaranthus blitum*, *Cucurbita maxima* (pumpkin leaves), *Ipomea batata*, *Vigna unguiculata* (cowpea leaves) and *Solanum nigram* are the most grown vegetables in the site (Figure 1; Table 1).

2.2 Sample collection

A reconnaissance survey was conducted to identify locally grown vegetables, site history and marketing areas. Nine sampling locations were established along the cultivated slopes of closed Mtoni dumpsite (Figure 1 and Table 1). Twenty seven samples (500 g each) of leaves vegetable from five different types of vegetables namely *A. blitum*, *V. unguiculata*, *I. batata, S. nigrum* and *C. maxima* were collected. The collected samples were wrapped in aluminium foils and stored in polythene bags according to their type and brought to the laboratory for preparation and analysis. The vegetable species were authenticated at the Herbarium of the Department of Botany at the University of Dar es Salaam, Tanzania where voucher specimens are preserved.

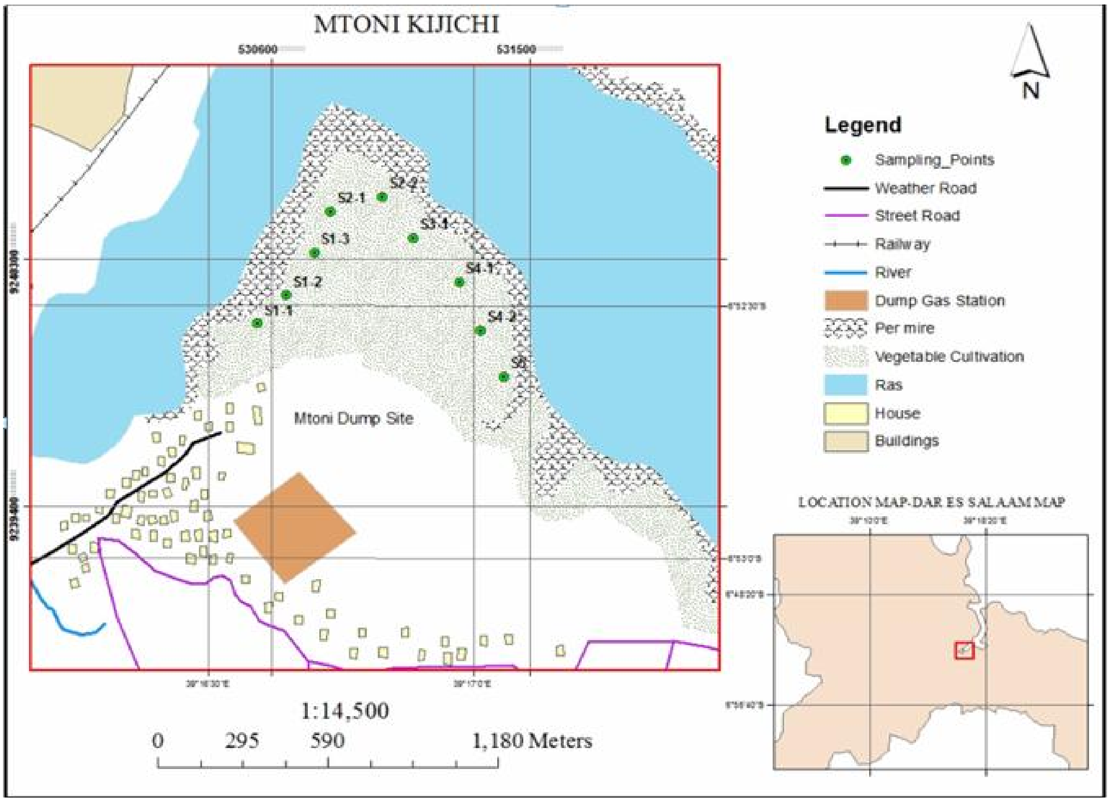

Figure 1: Location of closed Mtoni Dumpsite and sampling sites

2.3 Sample preparation and treatment

Samples were washed with distilled water to eliminate air-borne pollutants. The leafy stalks were removed from all samples and these were sliced and dried to eliminate excess moisture. These samples were weighed and oven-dried at 60°C to constant weight. Each oven-dried sample was ground in a mortar until it could pass through a 0.18 mm sieve. The samples were then stored in a clean, dry, stoppered glass container before analysis.

2.4 Determination of heavy metals

2.4.1 Reagents

All standard reagents used were analytical grade obtained from Romil limited, England.

2.4.2 Extraction of the vegetable samples

The dry ashing method was used followed by atomic absorption spectrophotometric analysis as stipulated in the Perkin Elmer manual for atomic absorption spectrophotometry. Each determination was carried out by accurately measuring a sample of 1 g of a ground sample in a crucible. The crucible with its content was placed in a muffle furnace and ashed at 450 ºC for 12 h. The ash was digested with 5 ml of 20% (v/v) AnalaR HCl solution. The residue was filtered into a 50 ml volumetric flask using Whatman filter paper No. 41, and the solution was made to the mark with deionised water.

2.4.3 The atomic absorption spectrophotometer (AAS) determination

The extracted solution was aspirated into the instrument after all necessary set-up and standardization procedures. Heavy metals were determined using Perking Elmer AAnalyst 100 AAS with Perking Elmer HGA 850 Graphite Furnace and Perking Elmer and AS 800 Auto-sampler made in Germany. For analytical quality assurance, after every five sample readings, standards were run to make sure that the margin of error is within 5%. A 10 cm long slot-burner head, a lamp and a standard air-acetylene flame were used. The detection limit was 0.01 ppm, slit width 0.70 nm and elements wavelength were 228.8, 357.9, 324.8 and 283.3 nm for Cd, Cr, Cu and Pb, respectively.

2.5 Analytical quality

Quality control measures in analyzing procedure were taken to confirm the accuracy of the analytical data. Two reference plant materials were digested in a similar manner to the vegetable samples for quality control and to monitor any instrument variability. The reference vegetables were grown in the experimental hut at Ardhi University. In every analytical batch, 10% samples of all were analyzed repeatedly to ensure the precision and accuracy of analysis. Standard reagents and blanks were also used in the process of analysis to ensure the precision.

2.6 Statistical analysis

Mean concentrations of heavy metals in vegetable were analysed using Statistical Programme for Social Sciences (SPSS) and Excel computer packages.

3 Results and Discussion

Heavy metal average concentrations in edible vegetable samples of *A. blitum*, *C. maxima*, *I. batata, V. unguiculata* and *S. nigram* are presented in Table 1. The concentrations of heavy metals in vegetables differ from one sampling location to the other and vary from one species of vegetable to the other. This may be attributed to differential uptake capacity of vegetables for different heavy metals through roots and their further translocation within the plant parts (Vousta *et al.,* 1996, Zurera *et al*., 1989). It can also be due to soil characteristics such as acidity and organic matter contents and ability of the root type of the plants to penetrate where the heavy metals are found (Okoronkwo et al., 2006). Among all heavy metals analyzed, the concentration of Zn (122.88 mg/kg dw) detected in *V. unguiculata* was the highest and that of Cd (0.28 mg/kg dw) detected in *A. blitum* was the lowest in all vegetables analyzed. Similar results were reported by Radwan and Salama (2006), in which highest concentration of Zn and lowest concentration of Cd were detected in vegetables collected from Egyptian markets. With exception to Cu and Zn, the levels of Cr, Pb and Cd detected in most of the vegetables analyzed in this study, were higher than the stipulated permissible levels in food by FAO/WHO guidelines. The values of concentration in Table 1 also indicate that there is no significant difference for Zn in *A. blitum* and *C. maxima* vegetables collected in all the sampling sites. It was further revealed that there was no significant difference for Pb in *C. maxima* collected in all sampling sites. On the other hand Cu detected in *I. batata* and *C. maxima* had no significant difference within the same plant species. The established high levels of heavy metals bioaccumulation in the vegetable are in the following trend *Vigna unguiculata* > *Cucurbita maxima* > *Ipomea batata* > *Amaranthus blitum* > *Solanum nigram* and the heavy metal concentrations is as Zn > Cr > Cu> Pb >Cd. Cadmium was observed to be in lower amount in all sampling point and this is due to the characteristics of cadmium to leach easily than heavy metals.

The sources of heavy metals accumulated in the investigated vegetables are envisaged to be soil used for cultivation and water used for irrigation. These were conceived to be the sources due to the fact that during its operation the dumpsite was receiving wastes of different compositions such as batteries, medical waste, waste cloths, glass and bottles, newspapers, paints, industrial dust, ash, tyres, metal cans, inks, plastics, used motor oils, ceramics, electronics and containers, some of which are known to be sources of heavy metals and other toxic chemicals (Zhang *et al.,* 2002 and Woodbury 2005). The study conducted by Shemdoe, 2010 in soil and water that are used for vegetables production also reported high levels of heavy metals such as arsenic, cadmium, chromium, nickel and lead. During sampling some wastes were visible as results of cultivation and soil erosion due to rain runoff, while leachetes from unlined closed dumpsite were found spilling in the water used for irrigation and the ocean gulf.

Table 1: Heavy Metal Concentrations in Vegetables

Sampling point / Vegetable	**Average heavy metal concentration $\pm$ SD (mg/kg dw), n = 3**				
	Zn	**Pb**	**Cu**	**Cr**	**Cd**
S1-1 / *A. blitum*	28.09±1.04^{a}	0.56±0.56^{a}	18.21±0.99	15.06±0.39	0.28±0.28
S1-2 / *I. batata*	53.51±0.06^{b}	0.49±0.01^{a}	13.88±1.57^{a}	25.19±0.91	0.32±0.32
S1-3 / *C. maxima*	39.34±0.06	20.65±1.99	14.52±0.05^{a}	1.78±0.22^{a}	0.62±0.13
S2-1/*V. unguiculata*	122.88±0.62	6.86±0.19	12.57±0.17^{a}	29.39±0.31	0.54±0.54
S2-2 / *I. batata*	18.61±0.36	1.38±1.38^{a}	22.47±0.96	13.02±0.67^{b}	0.74±0.16
S3-1 / *C. maxima*	54.55±1.07^{b}	12.06±0.12^{b}	13.54±0.04^{a}	13.59±0.5^{b}	1.50±0.85
S4-1 / *A. blitum*	45.28±1.96	11.56±0.89^{b}	7.99±0.00	6.13±0.45	1.00±0.45
S4-2 / *C. maxima*	49.16±0.53	1.15±1.15^{a}	14.89±0.46^{a}	1.15±0.15^{a}	1±0.68
S5 / *S. nigrum*	28.39±1.59^{a}	0.95±0.6^{a}	3.96±0.27	9.45±0.09	1.48±0.97
Permissible levels in food as per WHO&FAO	60	0.3	40	2.3	0.2
TBS Permissible levels in food	60	0.3	40	2.3	0.2

bdl – below detection limit, $p < 0.05$, $^{a,\, b}$mean values in the same column are not significant different.

4. Conclusions

Although attempts to reclaim the eroded land by crude dumping were physically successful, the soil in the dumpsite is highly contaminated as indicated in the literature. This study shows that it is highly risks to human health when consuming vegetables grown in the dumpsite, it is necessary to take measures both to stop cultivating vegetables and to conduct community awareness on the risks associated with dumpsite. The presence of heavy metals Zn, Pb, Cu, Cr and Cd in the edible vegetables *A. blitum*, *C. maxima*, *I. batata, V. unguiculata* and *S. nigram* indicate that the area is not suitable for vegetables production and animal keeping. Dealing with the problem is very difficult because the nearby area is open to the public. This case stresses the responsibility of the authorities in the country to make sure that foods are processed in relevant areas and of good quality. Based on the data obtained from the present study, it is very important to conduct a subsequent study to assess the levels of the toxic elements for the vegetables that are sold in different markets in Dar es Salaam. Findings from such study in conjunction to the findings that are reported in these papers will help to persuade policy makers on the need to identify suitable and non-suitable areas for vegetable production in the city.

Acknowledgements

We are gratefully acknowledging the work done by Ms. Beatrice Range during data collection, organisation and analysis. Mr Stalin Mkumbo and Mr. Addo Ndimbo from the School of Environmental Sciences and Technology, Ardhi University are appreciated for their invaluable technical assistance during the field sampling, laboratory extraction and heavy metals analysis in the laboratory.

5. References

1. Amusan, A.A., Ige, D.V., Olawale, R (2005), characteristics of Soil and Crop uptake of metals in municipal waste dumpsites in Nigeria. Journal of Human Ecology, 1(2), pp 167-171.

2. Bilos, C., Colombo, J.C., Skorupka, C.N., Rodriguez Presa, M.J (2001), source, distribution and variability of airborne trace metals in La Plata City area, Argentina. Environmental Pollution, 111(1), pp 149-58.

3. DCC (Dar es Salaam City Council) (2007), landfill gas recovery and electricity generation at Mtoni Dumpsite Dar es Salaam Tanzania. CDM Project Report.

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

5. Kihampa, C., Mwegoha, W.J.S (2010), heavy metals accumulation in vegetables grown along the Msimbazi River in Dar es Salaam, Tanzania, International Journal of Biological and Chemical Sciences, 4(6), pp 1932-1938.

6. Kitilla, M.D., Mlambo, A (2001), integration of agriculture in city development in Dar Es Salaam. Urban Agriculture Magazine, 4, pp 22-24.

7. Mapanda, F., Mangwayana, E.N., Nyamangara, J., Giller, K.E (2007), uptake of heavy metals by vegetables irrigated using wastewater and the subsequent risks in Harare, Zimbabwe, Physics and Chemistry of the Earth, 32, pp 1399–1405.

8. Muchuweti, M., Birkett, J.W., Chinyanga, E., Zvauya, R., Scrimshaw, M. D., Lester, J.N (2006), heavy metal content of vegetables irrigated with mixture of wastewater and sewage sludge in Zimbabwe: implications for human health. Agriculture, Ecosystem and Environment, 112, pp 41–48.

9. Othman, O.C (2001), heavy metals in green vegetables and soils from vegetable gardens in Dar es Salaam, Tanzania. Tanzania Journal of Science, 27, pp 37-48.

10. Okoronkwo, N.E., Odemelam, S.A., Ano, O.A (2006), levels of toxic elements in soils of abandoned waste dumpsite. African Journal of Biotechnology, 5(13), pp 1241-1244.

11. Radwan, M.A., Salama, A.K (2006), market basket survey for some heavy metals in Egyptian fruits and vegetables. Food and Chemical Toxicology, 44, pp 1273-1278.

12. Salkin, A (2008), leaving behind the trucker hat. *New York Times*, March 16, 2008.

13. Shemdoe, R.S (2010), heavy metal concentrations in soils and leachetes of Mtoni dumpsite bordering the Indian Ocean in Dar es Salaam, Tanzania. Scientific Research and Essays, 5(16), pp 2143-2147.

14. Wikipedia (2010), urban agriculture. Retrieved Augudt 18, 2011 from http://en.wikipedia.org/wiki/Urban_agriculture.

15. Woodbury, P.B (2005), municipal solid waste composting: potential effects of heavy metals in municipal solid waste composts on plants and the environment.

16. Wooley, H (2007), farming goes vertical. *Business 2.0 Magazine*, September 11, 2007.

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

18. Yusuf, A.A., Arowolo, T.A., Bamgbose, O (2003), cadmium, Copper and Nickel levels in vegetables from industrial and residential areas of Lagos City, Nigeria. Food and Chemical Toxicology, 41, pp 375-378.