Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.6, No.8, 2016

Heavy Metals in Edible Vegetables Grown Around Sewage Ponds and Damp Site in Eldoret Town, Kenya

Francis Ongachi Olal
Department of Physical Sciences, Rongo University College, P.O. Box 103 -40404, Rongo, Kenya

Abstract
Exposure to heavy metals including Ni, Cd, Cr, Co, Pb, As, Hg, Zn and Cu, has been recognized as a risk to human health through the consumption of vegetables. This study investigates the source and magnitude of heavy metal contamination in various kinds of vegetables including kales, spinach, carrot, cabbage and tomato in Eldoret town. In the study the concentrations of Pb, Cd, Ni, Mn, Co, Cu, Fe and Zn in vegetable crops around the municipal damp site and near the sewage ponds were investigated; and their contamination status with respect to international food standard guidelines evaluated. The lead in vegetables in all tested areas had higher level than that of the permissible limits of international standards. Except lead, it is concluded that nearly all the samples did not exceed the Intentional Food Standards maximum level (ML) in vegetables in Eldoret. Contaminated soil and vegetables may contribute to a progressive gathering of these metals in food chain that might affect ecosystem with possible noxious effect on human health. The study shows that vegetables growing soil containing higher amount of metals could be transferred into edible parts of the plant, so study area should be monitored regularly to avoid health risk of human being due to exposure of toxic level.
Keywords: Heavy metals, Spectroscopy, Vegetables, Contamination, Eldoret.

1.0 Introduction

Heavy metals are hazardous contaminants in food and the environment and they are non-biodegradable (Heidarieh *et al*., 2013). The effects associated with metal contamination are of great concern due to their increasing trends in human foods and environment (Kachenko and Singh, 2006). Cd and Pb are the metals most often found as contaminants in vegetables. These metals can pose as a significant health risk to humans in elevated concentrations above the body requirements (Gupta *et al*., 2008). In order to assure public health safety, the metals must be controlled in food sources (WHO, 1995). Excessive amount of heavy metals in food cause a number of diseases, especially cardiovascular, renal, neurological, and bone diseases (Olal, 2015; Chailapakul *et al*., 2007). These metals could reach food chain through various biochemical process and ultimately biomagnified in high levels and eventually threaten the health of human. The contamination of vegetables by heavy metals is also a global environmental issue. They are everywhere in the environment through various pathways, due to natural and anthropogenic activities (Wilson and Pyatt, 2007). Under certain environmental conditions metals may accumulate to toxic concentration and they cause ecological damages (Jofferies, 1984; Freedman, 1989).

There is an inherent tendency of plants to take up toxic substances including heavy metals that are subsequently transferred along the food chain (Singh *et al*., 2010). And as such, heavy metal contamination in vegetables cannot be underestimated as food stuffs are important components of human diet. Leafy vegetables grown on heavy metal contaminated soils accumulate higher amounts of metals than those grown in uncontaminated soils because of the fact that they absorb these metals through their roots (Bahemuka and Mubofu, 1991; Al-Jassir *et al*., 2005; Sharma *et al*., 2006; Sharma *et al*., 2007; Marshall *et al*., 2007). Heavy metals are persistent in the environment and are subject to bioaccumulation in food-chains. They are easily accumulated in the edible parts of leafy vegetables, as compared to grain or fruit crops (Mapanda *et al*., 2005).

Some of the sources of anthropogenic contamination include the addition of manures, sewage sludge, fertilizers and pesticides to soils. Studies have identified the risks in relation to increased soil metal concentration and consequent plant uptake (Whatmuff, 2002; McBride, 2003). Commercial and residential areas are also vulnerable to atmospheric pollution as a result of metal-containing aerosols. These aerosols can penetrate the soil and be either absorbed by vegetables, or be deposited on leaves and adsorbed. Analysis of vegetables grown in locations close to industry has shown elevated levels of heavy metals contamination (Kachenko and Singh, 2006; Voutsa *et al*., 1996). However, the major sources of vegetable contamination with heavy metals might be due to the waste water irrigation, solid waste disposal, sludge applications, vehicular exhaust and agrochemicals. Excessive accumulation of heavy metals in agricultural soils through the use of agrochemicals and by other sources may lead to elevated heavy metal up-take by vegetables and thus affect food quality and safety (Muchaweti *et al*., 2006). Heavy metals are easily accumulated in the edible parts of leafy vegetables, as compared to grain or fruit crops (Mapanda *et al*., 2005). Vegetables take up heavy metals and accumulate them in their edible and inedible parts (Bahemuka and Mubofu, 1991), in quantities high enough to cause problems both to animals and human beings when they consume these metal-rich plants (Alam *et al*., 2003). Intake of toxic metals in a chronic level through soil and vegetables has adverse impacts on human, plants and the associated harmful impacts become apparent only after several years of exposure (Bahemuka and Mubofu, 1991; Ikeda *et al*., 2000). However, the consumption of heavy metal-contaminated food can seriously deplete some essential nutrients in the body that are further responsible for decreasing immunological defenses, such as intrauterine growth retardation, impaired psycho-social facilities, disabilities associated with malnutrition and high prevalence of upper gastrointestinal cancer rates (Iyengar and Nair, 2000; Turkdogan, 2003).

2.0 Materials and Methods

2.1.1 Sampling site

Plant samples were collected from six sites within Huruma and Mwenderi in Eldoret town. The following vegetables were considered for heavy metals investigation: kales, spinach, cabbage, carrot and tomato, which are mostly grown in the study area. The sites were residential vegetable gardens but with surplus being sold to consumers.

2.1.2 Vegetable Sampling

The collected vegetable samples (200 g) were thoroughly washed with fresh water in order to remove the adhering dirt and finally with distilled water. Then 10 g of each sample were placed in a mortar for grinding to obtain a homogenous mass for subsequent analysis.

2.1.3 Chemicals and equipment used

Standard solutions of relevant elements were bought locally from Laborama laboratory supplies. The standards were of high purity levels; pure nitric acid, potassium iodide and hydrochloric acid. The analytical instrument used in this study was Atomic Absorption Spectrometer (AAS). A microwave accelerator reaction system was used for the digestion of the samples.

2.2 Experimental procedure

2.2.1 Digestion of vegetable samples

To determine the concentration of heavy metals in vegetable samples, aliquot (about 0.3 g) amount of the ground dried samples were taken in a vessel of the microwave oven where 4 ml of concentrated HNO_3 was poured. After the digestion, the samples were filtered and leveled up to the mark with distilled water in a 10 ml volumetric flask. Finally the samples were analyzed for heavy metals using AAS.

2.2.2 Metals determination

The working standard solutions were prepared for heavy metal determination by diluting a stock solution containing 100 ppm of single element AAS grade standard with distilled water. The standard solutions for the heavy metals were used to construct the calibration curves with the help of AAS. Quality assurance measures included the calculation of method detection limit and analysis of standard reference material. A blank reading was also taken and necessary correlation was made during the calculation of concentration of different elements.

3.0 Results and discussion

Table 1: Heavy metals concentration in vegetables, mg/kg

	kales	spinach	carrot	Cabbage	Tomato
Pb	1.41	1.50	1.23	0.12	1.10
Cd	ND	ND	ND	ND	ND
Ni	ND	ND	ND	ND	ND
Mn	0.07	0.08	0.05	0.03	0.03
Cr	0.04	0.06	0.05	0.03	0.02
Cu	ND	ND	ND	ND	ND
Fe	0.53	0.80	0.60	0.58	0.71
Zn	0.60	1.20	0.95	0.89	0.50

The results of heavy metals concentration in the vegetable samples are presented in Table 1. The contamination of heavy metals in vegetables indicate that the concentration of Ni, Cd, and Cu were below the detection limits; the concentrations of Fe, Mn, Zn and Cr were below the permissible limit recommended by WHO (WHO, 2000; WHO, 2004). But only the concentration of lead (Pb) in vegetables was found in toxic level, which varied from 0.12 mg/kg to 1.50 mg/kg. The highest lead content was found in spinach (1.50 mg/kg) while in cabbage it was lowest in concentration (0.12 mg/kg). According to WHO food hygiene standard, the standard limit of lead for vegetables and fruit is 0.3 mg/kg (Codex Alimentarius Commission, 2001). In the study area, lead concentration that was found in the vegetables may be as a result of human activities such as waste water irrigation, solid waste disposal and sludge applications.

Lead is a toxic element that can be harmful to plants, although plants usually show ability to accumulate large amounts of lead without visible change in their appearance or yield. In many plants lead accumulation can exceed several hundred times the threshold of maximum level permissible for human (Codex

Alimentarius Commission, 2001). The introduction of lead into the food chain may affect human health and may cause disruption of the biosynthesis of hemoglobin and anemia, rise in blood pressure, kidney damage, miscarriages, disruption of nervous systems and brain damage.

4.0 Conclusion and Recommendation

The results of the study clearly indicate that some heavy metals like Mn, Cr, Zn, Fe, and Pb have been built up in vegetables and could be responsible for contamination. Apart from the above four heavy metals contamination, the vegetables in the study area were found to be free from other heavy metal contamination. So, the vegetables are safe for consumption. But dietary intake of these vegetables result in long term low level body accumulation of heavy metals and the detrimental impact becomes apparent only after several years of exposure. So regular monitoring of these toxic heavy metals in vegetables and other food materials is essential to prevent excessive build-up in the food chain.

From the overall study of the heavy metals in vegetables it has been found that the results obtained for different parameters investigated in each category of vegetable samples were at normal levels except lead, which is harmful to human. Thus immediate actions are necessary to keep it within the permissible limit.

References

Alam, M.G., Snow, E.T., Tanaka, A. (2003). Arsenic and heavy metal contamination of vegetables grown in Samta village, Bangladesh. Sci Total Environ 308: 83-96.

AL-jassir, M. S., Shaker, A. & Khaliq, M. A. 2005. Deposition of heavy metals on green leafy vegetables sold on roadsides of Riyadh city, Saudi Arabia. *Bulletin of Environmental Contamination and Toxicology*, 75, 1020-1027.

Bahemuka, T.E., Mubofu, E.B. (1991). Heavy metals in edible green vegetables grown along the sites of the Sinza and Msimbazi Rivers in Dar es Salaam,Tanzania. Food Chemistry 66: 63-66.

Chailapakul. O., Korsrisakul, S., Siangproh, W., Grudpan, K. (2007). Fast and simultaneous detection of heavy metals using a simple and reliable microchip-electrochemistry route: An alternative approach to food analysis. Talanta 74: 683-689.

Codex Alimentarius Commission. Joint FAO/WHO (2001) Food additives and contaminants. Joint FAO/WHO food Standards program; ALINORM 01/12A: 1-289.

Freedman, B. (1989). Environmental Ecology: The impacts of pollution and other stresses on ecosystem structure and function. New York: Academic Press Inc.

Gupta, U.C., Subhas, C., Gupta, M.D. (2008). Selenium in soils and crops, its deficiencies in livestock and humans: Implications for management. Commun Soil Sci Plant Anal 29: 1791-1807.

Heidarieh, M., Maragheh, M.G., Shamami, M.A., Behgar, M., Ziaei, F., et al. (2013). Evaluate of heavy metal concentration in shrimp (Penaeus semisulcatus) and crab (Portunus pelagicus) with INAA method. Springerplus 2: 72.

Ikeda, M., Zhang, Z.W., Shimbo, S., Watanabe, T., Nakatsuka, (2000). Urban population exposure to lead and cadmium in east and south-east Asia. Sci Total Environ 249: 373-384.

Iyengar, G.V., Nair, P.P. (2000). Global outlook on nutrition and the environment: meeting the challenges of the next millennium. Sci Total Environ 249: 331-346.

Jofferies, D.J. (1984). Chemical analysis some coarse fish from a sufflok River carried out part of the preperation for the first release of captive-bred otters. J Otter Trust 1: 17-22.

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

Mapanda, F., Mangwayana, E.N., Nyamangara, J., Giller, K.E. (2005). Impacts of sewage irrigation on heavy metals distribution and contamination. Environ Intern 31: 05-812.

Marshall, F.M., Holden, J., Ghose, C., Chisala, B., Kapungwe, E., Volk, J., Agrawal, M., Agrawal, R., Sharma, R.K. & Singh, R.P. (2007). contaminated irrigation water and food safety for the Urban and Peri-urban Poor. *Appropriate M easures for Monitoring and Control from Field Research in India and Zambia.* University of Sussex.

McBride, M.B. (2003). Toxic metals in sewage sludge-amended soils: has promotion of beneficial use discounted the risks? Adv Environ Res 8: 5-19.

Muchuweti, M., Birkett, J.W., Chinyanga, E., Zvauya, R., Scrimshaw, M.D. (2006). Heavy metals content of vegetables irrigated with mixture of waste water and sewage sludge in Zimbabwe: Implication for human health. Agricul Ecos Environ 112: 41-48.

Olal, F.O. (2015). Assessment of the Impact of Urban Runoff from Migori Town on the Concentration Levels of Selected Heavy Metals in Migori River, Kenya. *Journal of Environment and Earth Science.* Vol. 5, No. 20, pp 24-30.

Sharma, R.K., Agrawal, M. & Marshall, F.M. (2006). Heavy metal contamination in vegetables grown in wastewater irrigated areas of varanasi, India. *Bulletin of Environmental Contamination and Toxicology,* 77, 312-318.

Sharma, R.K., Agrawal, M. & Marshall, F.M. (2007). Heavy metals contamination of soil and vegetables in suburban areas of Varanasi, India. *Ecotoxicology and Environmental Safety*, 66, 258-266.

Singh, A., Sharma, R.K., Agrawal, M. & Marshall, F.M. (2010). Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Varanasi, India. *International Society for Tropical Ecology ,* 51, 375-387.

Türkdoğan, M.K., Kilicel, F., Kara, K., Tuncer, I., Uygan, I. (2003). Heavy metals in soil, vegetables and fruits in the endemic upper gastrointestinal cancer region of Turkey. Environ Toxicol Pharmacol 13: 175-179.

Voutsa, D., Grimanis, A., Samara, C. (1996). Trace elements in vegetables grown in an industrial area in relation to soil and air particulate matter. Environ Pollut 94: 325-335.

Whatmuff, M.S. (2002). Applying biosolids to acid soil in New South Wales: Are guideline soil metal limits from other countries appropriate? Aust J Soil Res 40: 1041-1056.

WHO (2000). Safety evaluation of certain food additives and contaminants. International Programme on Chemical Safety. WHO Food Additive Series 52.

WHO (2004). Task group on environmental health criteria for arsenic and Arsenic Compounds 18, World Health Organization, Geneva, Switzerland 1-174.

WHO (1995). Inorganic lead. Geneva, World Health Organization, International Programme on Chemical Safety. Environmental Health Criteria 165.

Wilson, B., Pyatt, F.B. (2007). Heavy metal dispersion, persistance, and bioccumulation around an ancient copper mine situated in Anglesey, UK. Ecotoxicol Environ Saf 66: 224-231.