Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol. 4, No.3, 2014 www.iiste.org

Assessment of Selected Heavy Metal Concentrations in Selected Fresh Fruits in Eldoret Town, Kenya

Mr. Grey Mausi[1] Dr. Gelas Simiyu[2] Dr. Samuel Lutta[3,*]

1. School of Natural Resources and Environmental Studies, Karatina University, PO box 1957-10101, Karatina, Kenya
2. School of Environmental Studies, University of Eldoret, PO box 1125-30100, Eldoret, Kenya
3. School of Science, University of Eldoret, PO box 1125-30100, Eldoret, Kenya

*E-mail of the corresponding author: stlutta@yahoo.com

Abstract

This study assessed levels of selected heavy metals (Lead, Chromium and Cadmium) in oranges and mangoes sold in Eldoret town and their health implications to consumers. A total of one hundred and eighty (180) samples were collected for analysis from randomly selected market sites within Eldoret town. Samples were wet digested using a mixture of 1:3 (65% HCl: HNO_3) and analyzed using Atomic Absorption Spectrophotometer version 200. One Way Analysis of Variance (ANOVA) was used to test the significance of selected heavy metal levels in consideration of market sites at 5% significance level. There was insignificant variance in mean chromium levels in mango fruits among market sites (f=2.1, f=3, p=0.10) with the highest mean level occurring at 2.43±0.24 mg/kg. Lead levels in orange fruits were significant (f=13.3, df=3, p=0.00) with the highest mean level occurring at 0.65±0.03 mg/kg. Cadmium levels were significant in mango fruits among market sites (f=6.5, df =3, p=0.00) with the highest level at 0.09±0.05 mg/kg. Risk Assessment in terms of values of Daily Intake of Metal (D.I.M) had chromium levels in mango fruits with the highest at 0.05mg/day, lead in orange fruits was at 0.02mg/day with the least D.I.M occurring in cadmium levels in mango fruits at 0.002mg/day. Mango and orange fruits sold in Eldoret town posed no health risks to consumers based on their D.I.M levels, as the values were within Provisional Daily Tolerable Intake standards of World Health Organization (WHO). The elevated chromium D.I.M levels in mango fruits in this study meant that environment in which mango fruits are grown were high in chromium content. There is need to initiate and sustain continued monitoring of heavy metals in fruits and food sold to consumers due to their different sources where contamination of heavy metals varies to ascertain food safety.

Keywords: Daily Intake of Metal, Hazard Quotient and Heavy metal.

1. Introduction

Consumption of fruits on a regular basis is critical in providing health promoting nutrients to the human body. Protective antioxidants and phytonutrients in fresh fruits including: flavonols, anthocyanins and phenyl propanoids are critical to best functioning of human immune system, protecting against communicable and non-communicable diseases such as cancer and other degenerative diseases (Dauchet *et al*., 2010). Additionally, other vital components in fresh fruits such as vitamin C, carotenoids, minerals and dietary fiber are vital requisites to body's optimum immunity functions. These protective functions derived from fresh fruits necessitates that every human meal serving be accompanied with fresh fruit intake in providing a balanced diet and boosting of the body's immune system (Maggini *et al*., 2010). Inadequate intake of fruits is increasingly becoming recognized as one of the key risk factors for cardiovascular diseases and some form of cancers, the two leading causes of death in the world today (WHO/FAO, 2012). Compared to vegetables and their nutrient contribution to the human body, fresh fruits are usually taken in large quantities whereas vegetables are usually consumed in relatively small amounts as side dishes or relished with staple foods (Stewart *et al*., 2011).

Despite extensive documentation on the importance of consumption of fresh fruits, fresh fruit consumption can be associated with some health risks arising from elevated levels of heavy metals emanating from various environmental sources (Sobukola *et al*., 2010). These sources include: use of synthetic fertilizers in fruit farming, use of pesticides and waste water in food crop farming and contaminated transport modes involved in transporting fresh fruit products from farms to markets (Sudhakar *et al*., 2012). Heavy metals may be of particular concern in fruit tree production because of the importance of foliar spray which deposits fertilizer directly on fruits, some foliar fertilizers used in fruit production could be laden with heavy metals (Thomas *et al*., 2012). Low but measurable amounts of heavy metals occur in agricultural commodities because of uptake by plants from trace amounts in the soil and these levels can be of health risk to consumers (Heshmat *et al*., 2012). Other sources of heavy metal contamination in fruits are from rapid unorganized urban and industrial developments (Doherty *et al.*, 2012). Food safety is a major public concern worldwide. During the last decades, increasing demand for food safety has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by pesticides, heavy metals and toxins (WHO/FAO, 2012).

High lead level in human food chain is associated with development of abnormalities in children including: teratogenesis and mutagenesis (Carlisle *et al.,* 2009). Exposure of lead to young children, generally of the age below 5 yrs has been linked to low Intelligence Quotients and increased levels of blood pressure (Carlisle *et al.,* 2009). Lead is also linked to condition of anemia in humans (Kavita *et al*., 2010). Uptake of Cadmium levels exceeding recommended level is associated with renal, prostrate and ovarian cancers (Satarug *et al*., 2010). Cadmium is known to be a bioaccumulator heavy metal whose target body organs includes: reproductive system and bones. Cadmium has been classified as a probable carcinogen and as an endocrine disruptor (Shimphei *et al.,* 2012). The consequences of ingesting hexavalent chromium are damages to nose lining and irritation of lungs and gastrointestinal tract. When swallowed, chromium inflicts damages to stomach, liver and kidneys. Environmental Protection Agency in United States classifies hexavalent chromium as a human carcinogen (Ashraff *et al*., 2011).

International and national regulations on food quality have lowered the maximum permissible levels of toxic metals in food items due to an increased awareness of risks these metals pose to food chain contamination (WHO/FAO, 2012). Presently research on fresh fruit contamination by heavy metals has been extensively reported on temperate fruits such as: strawberries, raspberries, blackcurrant and food crops namely asparagus, peanuts and tomatoes have been reported. There is need to also investigate the levels of heavy metals in tropical fruits that are consumed in developing countries. Safety in consumption of fresh fruits due to their trace elements has to be guaranteed as fruits are significant sources of critical vitamins to human health and are relatively affordable to large proportion of the population (Fernando *et al.*, 2012).

2. Materials and Methods

This study was carried out in Eldoret town, Kenya. The town is located at Longitude 35^oN 12^oE and Latitude 0^o 35^oN (**Figure 1**). Eldoret town serves as a regional commercial centre where fresh fruits are sold to consumers. 180 replicates of Mangos and Oranges were sampled on monthly basis for 3 months from **four** (**4)** market sampling sites located in Eldoret town. The fruits upon collection from sampling sites were packaged in clean, dry, high density clear plastic bags immediately after purchase and then stored in refrigerator at 4^oC awaiting further analysis for heavy metals (Cui *et al*., 2010).

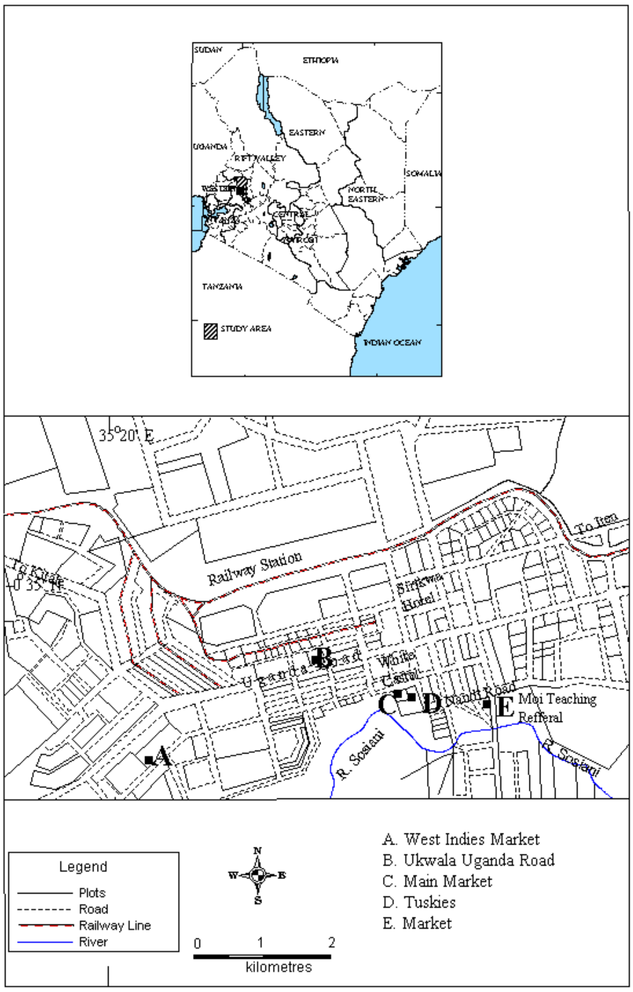

Figure 1. Map showing study area

2.1 Heavy Metal Analysis

Fresh fruit samples were extracted using acid digestion method (Cui *et al*., 2010). Three aliquots of 30mls each representing three replicates for each fruit were accurately measured and placed in a 200 ml flask beaker to which 30 mls of 10% concentrated HNO_3 was added and left to settle for 15 minutes. Wet acid digestion followed in 10mls of 1:3 mixture of concentrated 65% HCl: HNO_3 (Merck) using a hotplate, till clear solution was obtained. Digested samples were allowed to cool off at room temperature. Digested samples were then acidified with 10mls of 1:1 mixture of HCl: H_2O and filtered through 0.45 micron filter paper and the final volume made up to 50ml with distilled water. The resultant filtrate was then transferred to cleaned dried plastic bottles awaiting heavy metal level analysis (Cui *et al*., 2010).

2.2 Quality Control

All glass and non-glassware (with no metal liners) used in this study were washed with deionized distilled water and immersed in 2% Nitric acid (HNO_3) for 24 hours prior to use to avoid heavy metal contamination (Wang *et al*., 2012). Fruit samples were cleaned with distilled water and peeled with stainless steel knife, sliced to get edible parts and homogenized to juice for analysis using an electric blender with stainless steel rotor knives (Cui *et al*., 2010). Glasswares were properly cleaned and reagents used for heavy metal analysis were of analytical grade (MERCK sourced from Darmstadt, Germany). De-ionised water was used throughout sample preparation and analysis. Reagent blank determinations were used to correct analysis readings. All samples were analyzed in triplicates and three quality control samples consisting of: reagent blank, sample duplicate and spiked sample were run for every batch of 5 samples. Mean fractional recoveries were satisfactory being in excess of 90% for the analyzed metals (Lead, Cadmium and Chromium).

2.3 Statistical Analysis

The statistical significance in mean concentrations of heavy metals in the fruits vis a vis Market sites was tested using SPSS version 16, One Way analysis of variance (ANOVA). A probability level of P<0.05 was considered significant.

3. Results and Discussion

3.1 Lead levels in Oranges and Mangos

Lead levels in Oranges and Mangos had significant variance in mean concentration levels between market sites in Eldoret Town; Oranges (f=13.33, df=3, p=0.00) and Mangos (f=21.87, df=3, p=0.000) respectively. Mean lead levels were significant in oranges and mangos sampled in market A in comparison to Market C; Oranges (q=4.14, p=0.00) and Mangos (q=7.84, p=0.00) respectively. Significant mean variance in lead levels were also noted in oranges sampled between market sites B and C (q=6.18, p= 0.00); Markets C and D (q=2.99, p=0.02). Mango fruit samples had significant lead concentrations between market sites: A and B (q=5.25, p=0.00) and A and D (q=5.43, p=0.02) respectively. Oranges sourced from Market site B (Open Market) had the highest mean concentrations of lead at 0.651±0.032mg/kg while Mangos sourced from market site A had highest mean concentrations of lead at 0.606±0.039mg/kg **(figure 2).** Lead levels were highly reported in Orange than in Mango fruits. High lead levels above the recommended limit of 0.3 mg/kg (WHO/FAO, 2012) found in sampled fresh fruits in this study may be related to their environmental points of production.

Another possible explanation to high levels of lead in fresh fruits in this study could be the use of pesticides, fertilizer and wastewater in farming of fruit crops. Orange fruit plants could be having a greater affinity of lead uptake from the soil compared to mangos (Anju *et al*., 2011). Works of Krejpcio *et al*., (2005) agrees to this finding by reporting that lead contents of fruits grown in non-polluted areas of Poland were generally low and did not exceed maximum permissible level (0.3 mg/kg fresh weight). The highest content of lead was detected in black current fruits at 0.073 mg/kg and lowest in pears at 0.044 mg/kg. Most significant was that lead content of strawberries was regionally dependent to places within Poland with lowest lead level in strawberries reported at 0.03 mg/kg in central part of the country, higher in Northern Eastern Poland at 0.06 mg/kg with the highest level of lead in southern region of Poland at 0.20 mg/kg Krejpcio *et al*., (2005).

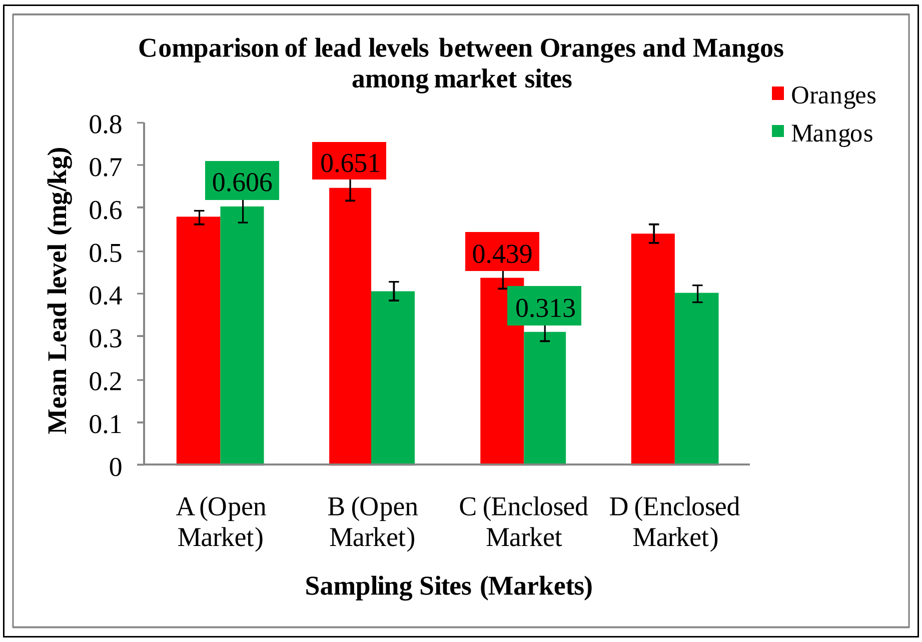

Figure 2. Comparison of lead contents in Oranges and Mangos among market sites

3.2 Cadmium levels in Oranges and Mangos

Cadmium concentrations in oranges had no significant variance in mean concentrations between market sites in Eldoret Town (f=1.85, df=3, p=0.14) whereas Mangos sampled in different market sites had significant variance in mean concentrations (f=6.50, df=3, p=0.00). Mean Cadmium concentrations were significant in Mangos sampled between markets A and C (q=4.09, p=0.00), Markets A and D (q=2.70, p=0.00) and Markets B and C (q=3.05, p=0.02). Oranges sourced from market site B had highest mean concentration of Cadmium at

0.057±0.004mg/kg whereas Mangos sourced from site C had the highest concentration at 0.052±0.004mg/kg. The least Cadmium Concentration in Oranges was found in samples sourced from market site D at 0.046±0.003mg/kg as the least level of cadmium in mangos occurred from samples sourced in market site A 0.066±0.005mg/kg **(Figure 3).** Cadmium levels were reported to occur in high concentration in Mangos compared to Orange fruits.

Low levels of Cadmium analyzed in the fruits sampled occurred within recommended level of 0.2mg/kg (WHO/FAO, 2012) posed insignificant health risk to consumers. Cadmium levels in fresh fruits sold in Eldoret town could be multiple sources of environmental pollution exposed to fruit trees during growth period. In agreement to this, Sobukola *et al*., (2010) reported a mean value of 0.090mg/kg of Cadmium in fluted pumpkin in a study conducted on some fruits and leafy vegetables from selected markets in Lagos, Nigeria. Krejpcio *et al*., (2005) reported a mean level of Cadmium contents in fruits in Poland being similar in all the three regions of Poland ranging from 0.018 to 0.023 mg/kg with the lowest in apples within a range of 0.003 to 0.005 mg/kg. Cadmium levels in fruits are dependent on plant fruit type and its affinity to uptake cadmium from the environment in which the fruits are grown. Environment is rich in cadmium content correlates with elevated uptake of the same by fruit plants (Tuan *et al.*, 2012). Seyed *et al*., (2008) reported concentrations of 1.8 mg/kg of cadmium in oranges and 2.14 mg/kg in mangos fruits collected in India city market with high concentrations of 15.39 mg/kg of cadmium in oranges and 16.9 mg/kg in mangos collected at Yeshwantur market. Fruits sourced from Yeshantupur market had high concentration of heavy metals due to a combination of several environmental factors including uptake from soil due to use of fertilizers, use of waste water and pesticides in fruit farming.

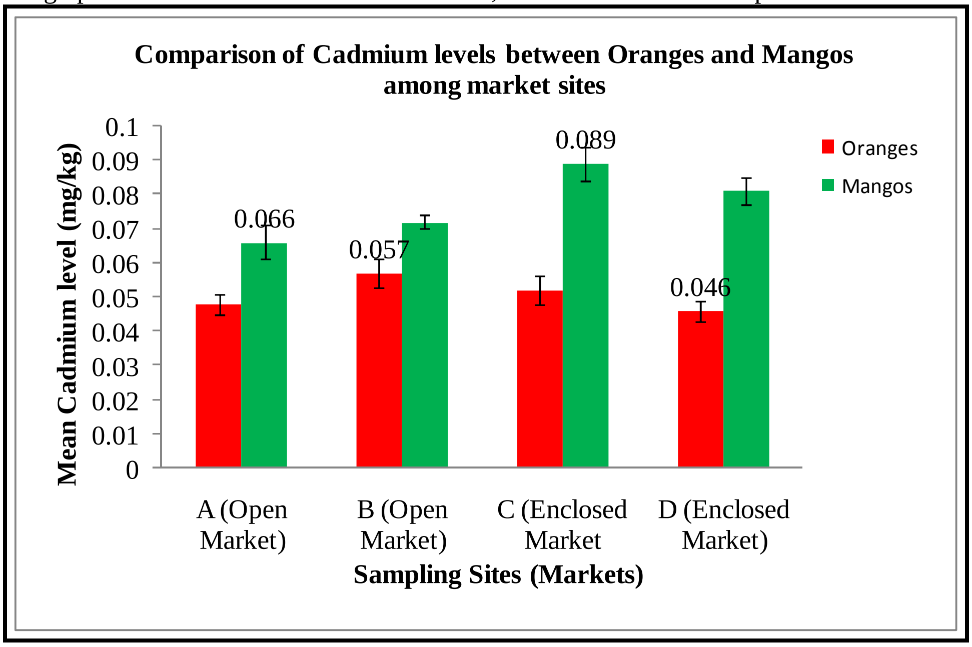

Figure 3. Mean Cadmium levels in Oranges and Mangos at different Market sites

3.3 Chromium levels in Oranges and Mangos

Chromium concentrations in oranges had significant variance in mean concentrations between market sites in Eldoret Town (f=3.5, df=3, P=0.02). Mean Chromium concentrations were significant in oranges sampled between markets A and B (q= 2.62, p=0.048), Markets A and D (q=2.69, p= 0.040). Mangos samples sourced in different market sites had no significant variance in mean concentrations (f=2.14, df=3, p=0.10). Orange sourced from market site A had the highest mean levels of chromium at 1.741±0.060mg/kg whereas mangos sourced from market site D had highest mean level of chromium at 2.429±0.243mg/kg. The least level of chromium in sampled oranges occurred at market site D at 1.393±0.115mg/kg respectively while in mangos chromium concentrations in mangos, followed by market site C level at 2.283±0.149mg/kg, market site B had a mean concentration of 2.014±0.145mg/kg, with market site A at 1.915±0.054mg/kg respectively **(Figure 4).**

High concentration of Chromium levels in oranges sampled in market sites could be hypothesized to the fact that oranges sold in these market sites may have originated from different growing regions. This could have impacted on uptake of heavy metals from the soil to deposition in the orange fruit. In contrast to this study, Erum *et al*., (2009) in a study of market basket survey of selected metals in fruits from Karachi city in Pakistan found out that chromium metal exhibited high concentrations in mango fruits at an average value of 4.09 mg/kg whereas this present study had the highest chromium concentration in mangos at 2.428 mg/kg. The probable explanation to this is the different environments where the fruits are grown (Krepjcio *et al.*, 2005). Chromium as a heavy metal is the most bioavailable heavy metals in fresh fruits signifying that the uptake of chromium from soils by plants is at a more magnified level than other heavy metals (Fernando *et al*., 2012). Depending on the richness of the environment in terms of heavy metal concentration, chromium can be a health concern especially to fresh food products. Prolonged consumption of unsafe concentrations of chromium through foodstuffs may lead to the chronic accumulation of heavy metals in kidney and liver of humans causing disruption of numerous biochemical processes, leading to cardiovascular, nervous, kidney and bone diseases (Satarug *et al*., 2010).

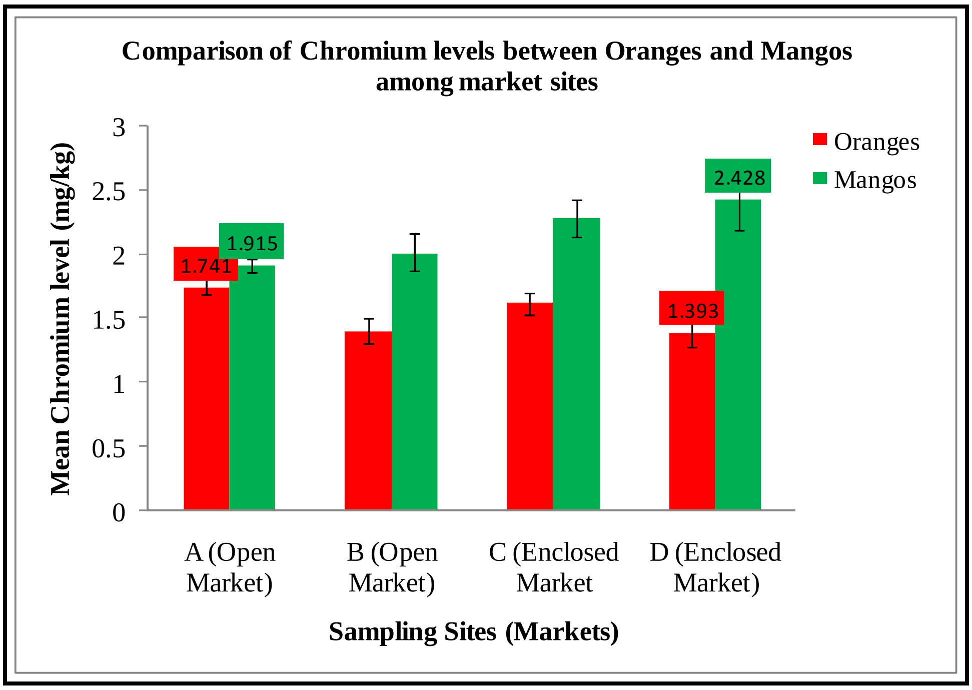

Figure 4. Chromium Mean levels in Oranges and Mangos within market sites

4. Conclusion and Recommendations

Fresh fruits are known to contain levels of metals that are essential to well-being of human health but these levels of metals can be toxic when they exceed the recommended health levels (Orish et *al.*, 2012). Elevated levels of these heavy metals arise from many sources in the environment; Uptake by plants from soils and subsequent deposition in fruits and application of fertilizers and pesticides laden with heavy metals. Heavy metal occurrence in fresh fruit sampled in markets in Eldoret Town had the following order: Cr>Pb>Cd. Elevated chromium levels in fresh fruits sampled were of concern. Sources correlating strongly to high levels of chromium in fruit samples include: use of pesticides, use of wastewater for irrigation farming and use of fertilizers that are of industrial manufactured in nature (Karanja *et al*., 2012). High levels of lead above the recommended limits (WHO/FAO, 2012) as assessed in the fresh fruits was a health concern due to the potential risks it might pose to consumers.

In assurance of safety to consumers against health risk of heavy metal uptake it would be in the interest that regular assessment of sources of heavy metals from areas that can impact on food safety. This study has brought forth baseline data on heavy metal contamination of fresh fruit sold in Eldoret Town. The hypothesis that consumers of fresh fruits in Eldoret town were at no health risk of heavy metal contamination has been proved through this study with the exception of elevated levels of lead in the fruits which could pose health risks. Contamination of fresh fruits in Eldoret town is thought to be enhanced by environment in which fresh fruits are grown There is a need to ascertain soil content for presence of the analyzed metals in the environment under which these fruit plants are grown. This information is vital especially to specialists in crop production who will device best crop farming practices, disseminate to relevant stakeholders so that safety of fresh fruits and food is guaranteed. There is need also to ascertain levels of other toxicants in fresh and processed food products currently flooding markets based on the dynamic lifestyles. There is concern that process in manufacturing can impact levels of these toxicants in the final products; of concern are soft drinks and beverages being sold in markets.

5. Acknowledgement

The authors acknowledge the assistance from the staff in the department of Environmental Biology and Health, department of Biochemistry of Eldoret University and department of Chemistry from Maseno University for their technical assistance. In particular authors wish to appreciate the assistance given by Mr. Taratiso Ndwiga and Mr. Thomas Bowa whose inputs were incredible.

References

Anju, D., Arun, N. and Sayeed, A. (2011). Metal analysis in *Citrus Sinensis* fruit peel and *Psidiun Guajava* leaf. *Toxicology International*. **18**(2), 163-167.

Ashraf, M., Maah, M.J. and Yuseff, I. (2011). Heavy metal accumulation in plants growing in ex-mining catchment. *International Journal on Environmental Public Health*. **8**(2), 401- 416.

Carlisle, J.C., Dowling, K.C., Siegel, D.M. and Alexeeff, G.V. (2009). Blood Lead benchmark for assessing risks from childhood lead exposure. *Journal of Environmental Science Health*. **15**(44), 1200-1208.

Cui, Y.J., Zhu, Y.G., Zhai, R.H., Chen, D.Y., Huang, Y.Z., Qiu, Y. and Liang, J.Z. (2010). Transfer of metals from soil to vegetables in an area near a smelter in Nanning, China. *International Journal of Environment.* **30**, 785–791.

Dauchet,L., Montaye, M., Ruidavets, J., Arveiler, D., Kee, F., Bingham, A., Ferriere, J., Haas, B., Evans, A., Ducimetiere, P., Amouyel, P. and Dallongeville, J. (2010). Association between the frequency of fruit and vegetable consumption and cardiovascular disease in male smokers and non-smokers. *European Journal of Clinical Nutrition.* **64**, 578-586.

Doherty, V.F., Sogbarimu, T.O., Karifa, U.G. and Wright, O. (2012). Heavy metals in vegetables collected from selected farm and market sites in Lagos, Nigeria. *Journal of Environmental Science and Toxicology*. **1**(6), 137-142.

Erum, Z., Iftikhar, M. and Sheikh, M. (2009). Market basket survey of selected metals in fruits from Karachi city, *Pakistan Journal of Basic and Applied Sciences*. **5**, 47-52.

Fernando, G., Anderson, R.T., Takashi, M., Nericlerus, C.M. and Solange, G.C. (2012). Heavy metals in Vegetables and potential risk for human health. *Journal of Agricultural Science*. **69**, 54- 60.

Heshmat, S., Aldesunguy, S., Abo, H., Mohamed, A. and Abeer, E. (2012). Role of glycne, betaine and salicyclic acid in improving growth vigor and physiological aspects of droughted wheat cultivars. *Journal of Stress Physiology and Biochemistry*. **8**(1), 151-171.

Karanja, N.N., Njenga, M., Mutua, G.K., Largerkrist, G.J., Kutto, E. and Okello, J.J. (2012). Concentration of heavy metals and pesticides in leavy vegetables and implications for Peri-urban farming in Nairobi, Kenya. *Journal of Agriculture, Food Systems and Community development*. **2**(1), 255- 267.

Kavita, G., Basudeb, B., Slyum, B.L. and Arunabha, R. (2010). Effects of diesel exhaust, heavy metals and pesticides on various organ systems: Possible mechanisms and strategies for prevention and treatment. *Indian Journal of Experimental Biology.* **3**, 710-721.

Krejpcio, Z., Sionkowski, S. and Bartela, J. (2005). Safety of Fresh Fruits and Juices available on the Polish market as determined by heavy metal residues. *Polish Journal of Environmental Studies*. **14**(6), 877- 881.

Maggini, S., Wenzlaff, S. and Horing, D. (2010). Essential Role of Vitamin C and Zinc in Child Immunity and Health. *Journal of International Medical Research.* **38**, 386- 414.

Orish, E.O., John, K.N., Cecilia, N.A., Daniel, O.D. and Onyinyechi, B. (2012). Heavy metals health risk assessment for population via consumption of food crops and fruits in Oweri, South Eastern Nigeria. *Chemistry Central Journal.* **6**, 1-7.

Satarug, S., Scoh, H.G., Mary, A.S. and Donald, A. (2010). Cadmium. *Environmental exposure and Health Outcomes*. **118**(2), 182-190.

Seyed, E.M. and Somashekar, R.K. (2008). Heavy metals and safety of fresh fruits in Bangalore city, India. *Kathmandu University Journal of Science, Engineering and Technology*. **1**(5), 17- 27.

Shimpei, U. and Toru, F. (2012**).** Cadmium transport and tolerance in rice: perspectives for reducing grain Cadmium accumulation. *Rice Journal*. **5**(5), 8433- 8435.

Sobukola, O.P., Adroniran, O.M., Odedairo, A.A. and Kalihausa, O.E. (2010). Heavy metals levels of some fruits and leafy vegetables from selected markets in Lagos, Nigeria. *Africa Journal of Food Science.* **4**(2), 389-393.

Stewart, H., Hyman, J., Buzby, J.C., Frazao, E. and Carbo, A. (2011). How much dofruits and vegetables cost? Washington DC: USDA: Economic Research Service.

Sudhakar, G.K., Verma, R., Kurba, V.B. and Kumar, L. (2012). Heavy metals in Environment, Living system and herbal preparations: An overview. *International Research Journal of Pharmacy*. **3**(7), 128-130.

Thomas, E.Y., Omueti, J.A. and Ogundayomi, O. (2012). Effect of Phosphate fertilizers on heavy metals in soils and *Amaranthus caudatus*. Agriculture and Biology *Journal of North America*. **3**(4), 145-149.

Tuan, A.T. and Losanka, P.P. (2012). Functions and toxicity in Cadmium in plants: Recent advances and future prospects. *Turkish Journal of Botany*. **37**, 1-13.

Wang, X., Sato, T., Xing, B. and Tao, S. (2012). Health risk of Heavy metals to the general public in Tianjin, China via consumption of Vegetables and Fish. *Science of Total Environment*. **350**: 28–37.

World Health Organization (2012). Global Health Observatory (GHO) 2012. World Health Organization, Geneva. www.http://www.who.int/gho/mortality_burden_diseases/countries/ben/index.html