Selected Heavy Metals Concentration in Maize Grains and Leaves in Homahills, Homabay County

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Abstract

A single basis of heavy pollution may have severe impact on the health of human beings. Heavy metals go into the body system through air, food along with water and some bio-accumulate over a time period. The uptake of heavy metals by plants such as maize (Zea mays) is a path of their way into the human food chain. Pollution of animal feedstuffs with heavy metals can cause negative impacts to animal health and can cause harmful effects to humans through food chain such as consumption of meat and milk products. For that reason, monitoring uptake of excess heavy metals in Zea mays grains and leaves is paramount in avoiding unnecessary exposure. Therefore, this study sorts to determine heavy metal uptake in Zea mays grains as well as leaves in diverse agro-ecological regions farms in Homa Bay County. The average concentrations of Zn, Cd, Cu, Co and Pb in Zea mays grains were 0.113, 0.225, 0.122, 0.042 and 0.324 mg/kg respectively and that of maize leaves were 0.119, 0.041, 0.115, 0.041 and 0.321 mg/kg, respectively. The average concentration levels of Zn, Co and Cu were within the acceptable FAO/WHO standards for both Zea mays grains and leaves except Cd and Pb which were slightly above. The maize grains of the research area are quite secure for consumption. Regular monitoring for these metals in food is vital in ensuring consumption of safe food and avoids bioaccumulation in the food chain.

Key words: Heavy metals; *Zea mays* grains, Agro-ecological zones and *Zea mays* leaves

INTRODUCTION

Increased growth of industrialization as well as the intense use of, pesticides, herbicides and chemical fertilizer in agricultural lands, heavy metal pollutants have been regarded as part of the major severe environmental concern worldwide today (Pan *et al.*, 2010). Heavy metals phyto-accumulation research is vital because food comprise a major source of human exposure to heavy metals (Koopmans *et al.*, 2008). On top of certain concentrations and above a slight range, the heavy metals change into poisons (Athar & Ahmad, 2002). Hamid *et al.*, (2010) and Appenroth, (2010) defined heavy metals as a group of elements having density higher than representative of soil minerals, plants, organic matter, about 5 g/cm.

A single basis of heavy pollution may have severe impact on the health of human beings. Heavy metals go into the body system through air, food along with water and some bio-accumulate over a period of time (Duruibe *et al.*, 2007; UNEP/GPA, 2004). Heavy metals uptake by plants such as maize is a pathway into the food chain of human beings (Sharma *et al*., 2006; Kachenko and Singh, 2006; John *et al.*, 2010). The speed of metal being taken up by a plant might be manipulated by aspects including types of metal, species of plants, age of the plant and part of the plant (Amusan *et al.,* 2005; Beesley *et al.,* 2010; Singh *et al.,* 2010). Oluyemi *et al.,* (2008) stated that at stumpy levels, heavy metal could result to lasting mounting effects on human and animal health.

Maize (*Zea mays L.)* is a flowering plant in the family Gramineae and belongs to the grass family *Poaceae* (Agyei *et al.,* 2018). Maize is recognized to be one of the major sources of food for people from prehistoric times. It is a cultivated plant with numerous valuable uses for human and animal (Lee *et al.,* 2009; Ibrahim *et al.,* 2015). It has an elevated composition of proteins, fats, carbohydrates, as well as vitamins and minerals (Guria, 2006). Additionally, maize can be utilized as animal feed and feedstock resource (Jompuk *et al.,* 2011).

To achieve it's ever rising demand for home consumption as well as demand for the market to sell abroad, farmers currently employ varying ways of farming including application of pesticides, compost manure, fertilizers and irrigating to increase yield at the same time take care of the maize (Ibrahim *et al.,* 2015). Nevertheless, agricultural practices comprising of application of pesticides, phosphate fertilizers as well as refuse obtained composts may form significant cause of heavy metals from the soil (Li *et al.,* 2009; Nagajyoti *et al.,* 2010; Sarwar *et al.,* 2017).

Feed materials as well as animal feed can be spoiled with unwanted materials, which may initiate from the production process and/or surrounding environment (Fink-Gremmels, 2012; Streit *et al.,* 2012; Adamse *et al.,* 2017). A group of appropriate contaminants in feed material and animal feeds are such heavy metals along with elements (Dai *et al.,* 2016; Adamse *et al.,* 2017). Animals take in those contaminated feed and the contaminants can relocate to food originated from animal, which comprise of meat, milk and liver (Lopez-Alonso, 2012).

Health effect caused by consumption of heavy metals in humans include; respiratory diseases, cancers, kidney disease, brain damage, heart attack, anemia, chronic nephritis, encephalopathy and disease in digestive system among others (Mishra *et al.,* 2010; Liu *et al.,* 2013; Mahmood & Malik, 2014).

A study done by Sulyman *et al.,* (2015) found heavy metal concentration to be higher in maize grain (level of Copper (Cu) in the maize grain samples analyzed was 0.98mg/Kg and that of Zn was 2.01 mg/Kg). Khan *et al.* (2013) while assessing heavy metals found that agricultural soils and crops also form Cd level of 0.12 mg/kg which was higher than the limit (0.05 mg/kg) set by WHO/FAO in fruits and vegetables. In Kenya, a study done by Owiti, (2015) on chosen plants grown beside Nairobi River for taking up of copper, cadmium and zinc demonstrated that the level of the heavy metals in the leafy vegetables had fairly elevated levels along with elevated transfer factors of the heavy metals. Omambia & Simiyu (2014) while studying indigenous green vegetables contamination in Eldoret Town, Kenya on reported high levels Pb in vegetable species *Solanum nigrum*, *Cleome gynandra* and *Amaranthus blitum* was 630 µg/L, 600 µg/L and 640 µg/L which was above the WHO standards of 100 µg/L. Also the levels of Cd in *S. nigrum*, *C. gynandra* and *A. blitum* were 280µg/L, 190µg/L and 250µg/L which were above the WHO standards of 30µg/L.

Our previous study on heavy metal concentrations in agricultural farms in Homa Hills Homa Bay County, Kenya revealed that the mean concentrations of Pb, Cd and Zn in soil sample surpassed WHO limits (Akenga *et al.*, 2016). Monitoring uptake of excess heavy metals in maize grains as well as leaves is paramount in avoiding unnecessary exposure. Therefore, this study sort out to determine total heavy metal uptake in leaves and grains in varying agro-ecological zones in farms in Homa Bay County.

METHODOLOGY

Study area

Homabay County is located between latitude of 0^o 15' South along with 0^o 52' South, and between longitudes of 34^o East as well as 35^o East (Homa Bay County Integrated Development Plan, 2013 – 2017). The study was conducted in Homahills which is situated around 50 km north of Kendu Bay. The area lying on the Nyanza Rift encloses an area of roughly 150 km^2 (Lagat, 2010; Antony, 2012). Saggerson, (1952) stated that the Homa Mountain crest gets to an altitude of around 1571 m above sea level or of 610 m above the level of Lake Victoria. Homa hills area is characterized by black cotton soils and dark loam soils, which are derivatives of basalts, tuff, rhyolites and andesite. The Bala hot spring also dominates the irrigated farms in some parts of Kauma and Kakdhimu location. The greater Lake Victoria is situated on the eastern parts next to Kendu-Bay all the way to Kakdhimu location (Lagat, 2010). The main economic activity include, fishing, rain fed agriculture, keeping of livestock and trade. Main crops planted include maize, millet and beans for home utilization as well as trade.

Experimental Procedures

Plant material

The species chosen for gathering plant samples are very common grains used in human nourishment for they are rich in carbohydrates. Maize plant was chosen specifically because, among other cereals, it is frequently taken by residents as a stable food and they can accumulate heavy metals, especially without illustrating noticeable phytotoxicity signs, a reality that increases the danger to human health.

Sample collection and preparation

Two agro-ecological zones were purposively sampled and where intense maize farming is carried out. The two zones were Lower Midland 3 where Kanam B location falls and Lower Midland 4 Kokoth Katang location falls. Six farms in each sub-location were purposely sampled. A line transect was used to identify the sites where maize and maize leaves samples were collected.

The maize grains samples were dehusked into grains and two leaves were picked in five plants in each selected sites randomly. The leaves and grains were stored in clean khaki bags. From every location, 5g of the sample was measured and put into various containers. The samples were dried from every container in a burning air circulating oven at 70^{o}C (Gallenkemp DV 330) for 18-24 hours. The samples from the various containers were then mixed up jointly after which they were standardized with a mixer crushed to powder. Plant samples on the ground were subsequently gathered into marked plastic bags after which they were put in a desiccator waiting for analysis in the laboratory.

Sample Analysis

A 0.3 g of finely ground dried grain samples were weighed and placed into separate pre cleaned digestion tubes. A 4.4mL of the digestion mixture and reagent blanks were put into every tube. At 350 ^{0}C the tubes were heated in a block digestion at for 2 hours until it became colourless. Then the tubes were detached from the digester and it was left to cool at the normal room temperature. Distilled water of 25 mL was then added, thoroughly mixed and topped up to 50 millilitres with distilled water. The contents were finally relocated into a 50 millilitres volumetric flask after which they were left to settle. The clean solution was finally decanted and Pb, Cd, Co Zn and Cu concentrations was determined using Inductive couple plasma (Perkin-Elmer OPTIMA-2000, USA).

Statistical analysis

Data collected was statistically analyzed using SPSS and results presented as charts and percentages. One-Way ANOVA and T-test was employed to judge levels of heavy metals from maize grains as well as leaves, also from diverse agro ecological zones.

RESULTS

Mean heavy metal concentrations in maize grains and leaves collected from Homabay County Agro-ecological zones

The mean heavy metal concentrations of Pb, Cd, Zn, Cu and Co in maize grains and leaves collected from Homabay County Agro-ecological zones are shown in figure 1 below.

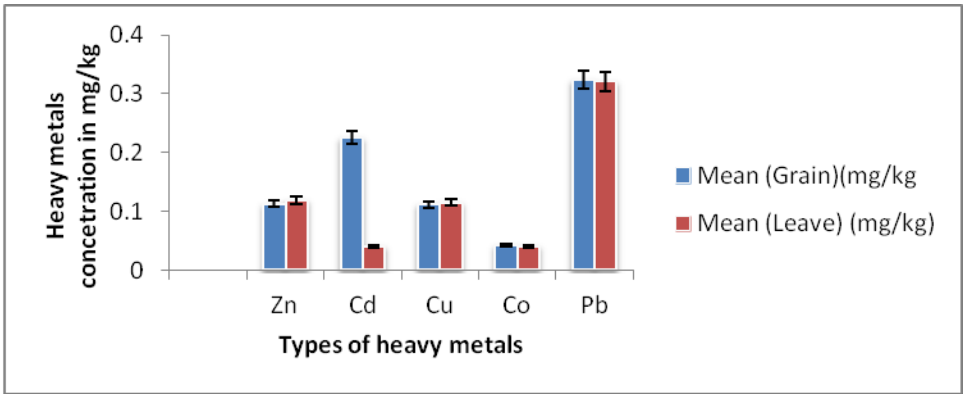

Figure 1: Mean levels of heavy metal ion concentrations in different region found in grains and leaves

The mean concentration of Zn, Cd, Cu, Co and Pb, in maize grains were 0.113, 0.225, 0.122, 0.04224 and 0.324 mg/kg correspondingly and that of maize leaves were 0119, 0.041, 0.115, 0.041 and 0.321 mg/kg respectively.

Comparisons of metal ion concentrations between grains, leaves and agro-ecological zones

To determine if there existed significant differences in the concentration of heavy metals in maize grain in the two sampled sites in Homabay Agro-ecological zones, T-test was performed. The outcomes are presented below.

Table 1: T- test results comparing heavy metal concentrations in the grains from two sites in Homa Bay County

Types of heavy metals	**Mean Kanam B**	**Mean Kokoth Kata**	**T**	**DF**	**Significance (2-tailed)**	**Mean Difference**
Zn	0.120	0.122	0.158	10	0.878	0.333
Cd	0.040	0.050	1.587	10	0.896	0.003
Cu	0.120	0.119	0.307	10	0.765	0.167
Co	0.045	0.044	1.0	10	0.341	0.167
Pb	0.353	0.342	2.004	10	0.073	2.333

According to T- test results above, the p-values of Zinc, Copper, Cobalt and lead were 0.878, 0.765, 0.341 and 0.073, correspondingly. They were above 0.05 significance level indicating there was no significance at 95 % in the content of heavy metals in grains.

To determine if there existed significant differences in the concentration of heavy metals in maize leaves in two sampling sites in Homabay Agro ecological zones, a T-test was done. The products are presented below.

Table 2: T- test results comparing heavy metal concentration in maize leaves from two sites in Homa Bay

	Mean Kanam B	Mean Kokoth Kata	t	DF	Significance (2-tailed)	Mean Difference
Zn	0.129	0.125	0.374	10	0.716	0.833
Cd	0.036	0.042	1.754	10	0.110	0. 667
Cu	0.123	0.123	0.200	10	0.845	0.167
Co	0.045	0.043	1.581	10	0.145	0.333
Pb	0.347	0.340	0.877	10	0.401	1.333

According to the t-test results above, the p-values of Zn, Cd, Cu, Co and Pb were 0.716, 0.110, 0.845, 0.145 and 0.401, respectively. They were above 0.05 significance level indicating there was no significance at 95 % in the level of the heavy metals ions in the leaves.

To determine whether there was significant difference in the concentration of heavy metals in grain and leaves in two sampling sites in Homabay Agro ecological zones, a t-test was performed. The products are as shown in table 3 below.

Table 3: T- test results of heavy metal ion concentrations in maize leaves and grains in Homa Bay County

	Grains Mean value	Leaves Mean value	T	DF	Significance (2-tailed)	Mean Difference
Zn	0.113	0.119	0. 851	22	0. 404	1.250
Cd	0.225	0.041	4.022	22	0. 001	0.833
Cu	0.112	0.115	1.402	22	0.175	0.667
Co	0.042	0.041	0.596	22	0.557	0.083
Pb	0.324	0.321	0.834	22	0.413	0.833

According to t -test results above, the p- values of Cd was 0.001 below the 0.05 significance level indication significance at 95 %. The p values of Zn, Cu, Co, and Pb were 0.404, 0.175, 0.557and 0.413 respectively. They were above 0.05 significance level indicating there was no significance at 95% in the content of heavy metals in grains in Uasin Gishu County.

Comparison of Heavy metals in Grains and leaves with WHO/FAO standards
The obtained heavy metal ion concentrations from the maize grains and leaves from various sampling sites were compared to the recommended WHO/FAO standards and presented in Table 4.

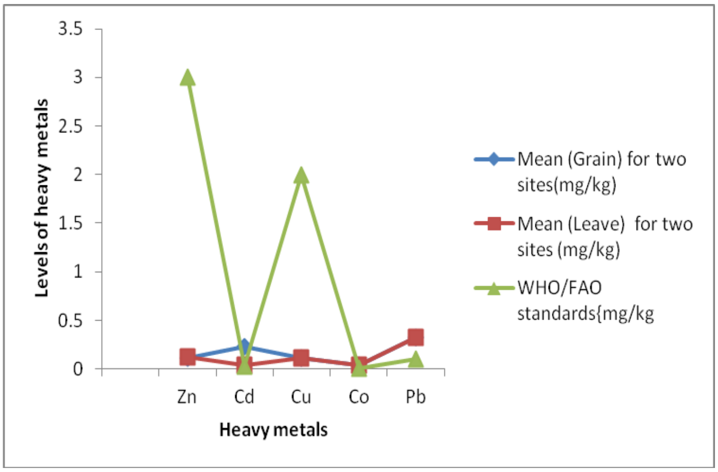

Figure 2: Mean heavy metals in grains and leaves in Homa Bay County and the maximum recommended concentration in food crops (FAO/WHO, 2001).

The mean concentrations of Zn, Cu and Co were less than the acceptable limits laid down by (FAO/WHO, 2001**;** Maleki *et al.*, 2014) while that of Cadmium and lead were barely beyond the standards.

DISCUSSION

Heavy Metal content in maize grains in Homa hills Homabay County

In this research, the average concentration levels of Zinc, Cadmium, Copper, Cobalt and Lead in maize grains from Homabay agro-ecological zones were 0.113, 0.225, 0.122, 0.042 and 0.324 mg/kg correspondingly. The average concentration of lead was the highest while Cobalt was the lowest and the order of concentrations were Pb>Cd>Cu>Zn>Co. This is almost similar to those reported by Tegegne, (2015) in Ambo City, Ethiopia where the recorded Zn mean level in Maize grains was 0.66 mg/kg. Kibet *et al.*, (2019) while assessing heavy metal in maize corn recorded similar levels of 0.04 mg/kg in Pb. Kibet *et al.*, (2019) also recorded low levels of cadmium of 0.05 which was lower than our study. Tegegne, (2015) could not detect any concentration of cadmium in maize grains form Nigeria. Cupper levels were same as those reported by Tegegne, (2015), where 0.13 mg/kg was recorded in maize grains. Shobha, & Kalshetty, (2017) reported a higher levels of cupper in wheat grains from Bagalkot, India to range from 3.15 mg/kg to 4.15 mg/kg. Lastly, cobalt levels were the lowest in our study, Tegegne, (2015) reported slightly high concentrations of 0.24 mg/kg which was below FAO/WHO standards in both studies. Shobha, & Kalshetty, (2017) reported a higher levels of cobalt in wheat grains from Bagalkot, India to range from 0.13 mg/kg to 0.49 mg/kg.

There was no significant difference in the levels of Zinc, Cadmium, Cobalt, Copper and lead in maize grains recorded from Kanam B and Kokoth Kata Location this could be attributed to same parent rock and agricultural practices.

Heavy Metal content in maize leaves in Homa hills Homabay County

The mean concentration of heavy metals inside maize leaves in Homabay County agro-ecological zones were 0119, 0.041, 0.115, 0.041 and 0.321 mg/kg for Zn, Cd, Cu, Co and Pb, in maize leaves were respectively. Concentrations of heavy metals of Zinc, Copper, Cadmium and Cobalt in maize leaves were below the permissible limits recommended by FAO/WHO except Pb.

A study done by Ibrahim *et al.*, (2015) while assessing Heavy metal concentration (Pb, Cu, Fe, Zn, Ni) in plant parts of *Zea mays* L. cultivated in agricultural area near Alor Gajah, Melaka, Malaysia recorded accumulation levels of Pb and Fe in maize plants which were above the maximum levels as stipulated by the Malaysian Food Act (1983) and Food Regulations (1985). Kibet *et al.*, (2019) recored concentration of Pb, Cd and Zn in leaves to be 0.01, 0.02 and 026 mg/kg around Fluorspar mining Plant, Kenya. The concentration was similar to our study.

There was no significant difference in the concentration of Zinc, Cadmium, Cobalt, Copper and lead in maize leaves recorded from Kanam B and Kokoth Kata Location this could be attributed to same parent rock and agricultural practices.

The p-value of Cd was significant in grain and leaves from Kanam B and Kokoth Kata Location. This could be attributed to the different parts of the plant.

CONCLUSION AND RECOMMENDATION

Maize grain and leaves samples from the five regions were found to contain lead, cadmium, zinc, copper and cobalt. The levels of zinc, copper and cobalt were above the acceptable limits recommended by FAO/WHO except Cd and Pb which were slightly above the recommended level. Frequent examination of heavy metals in vegetables along with other foodstuffs must be done so as to control excessive assemblage of the heavy metals in the food chain of human beings.

REFERENCE

Adamse, P., Van der Fels-Klerx, H. J., & de Jong, J. (2017). Cadmium, lead, mercury and arsenic in animal feed and feed materials–trend analysis of monitoring results. *Food Additives & Contaminants: Part A*, *34*(8), 1298-1311.

Agyei, G. D., Liping, L., Wang, J., & Gao, J. (2018). Occurrence Fusarium species, mycotoxins on cereal crops and their health implication.

Akenga, T., Sudoi, V., Machuka, W., & Kerich, E. (2016). Heavy Metal Concentrations in Agricultural Farms in Homa Hills Homa Bay County, Kenya. *International Journal of Science and Research*. 5(10). Pp 1664-1669.

Amusan, A. A., Ige, D. V., & Olawale, R. (2005). Characteristics of soils and crops' uptake of metals in municipal waste dump sites in Nigeria. *Journal of Human Ecology*, *17*(3), 167-171.

Appenroth, K. J. (2010). Definition of "heavy metals" and their role in biological systems. In *Soil heavy metals* (pp. 19-29). Springer Berlin Heidelberg.

Athar, R., & Ahmad, M. (2002). Heavy metal toxicity: effect on plant growth and metal uptake by wheat, and on free living Azotobacter. *Water, Air, & Soil Pollution*, *138*(1), 165-180.

Beesley, L., Moreno-Jiménez, E., & Gomez-Eyles, J. L. (2010). Effects of biochar and greenwaste compost amendments on mobility, bioavailability and toxicity of inorganic and organic contaminants in a multi-element polluted soil. *Environmental pollution*, *158*(6), 2282-2287.

Dai, S. Y., Jones, B., Lee, K. M., Li, W., Post, L., & Herrman, T. J. (2016). Heavy metal contamination of animal feed in Texas. *Journal of Regulatory Science*, *4*(1), 21-32.

Duruibe, J. O., Ogwuegbu, M. O. C., & Egwurugwu, J. N. (2007). Heavy metal pollution and human biotoxic effects. *International Journal of physical sciences*, *2*(5), 112-118.

Fink-Gremmels, J. (2012). Introduction to animal feed contamination. In *Animal Feed Contamination* (pp. 1-10). Woodhead Publishing.

Guria, P. (2006). *Physico-chemical properties, nutritional quality and value addition to quality protein maize (Zea mays L.)* (Doctoral dissertation, UAS, Dharwad).

Hamid, N., Bukhari, N., & Jawaid, F. (2010). Physiological responses of Phaseolus vulgaris to different lead concentrations. *Pak J Bot*, *42*(1), 239-246.

Hu, W., Huang, B., Tian, K., Holm, P. E., & Zhang, Y. (2017). Heavy metals in intensive greenhouse vegetable production systems along Yellow Sea of China: Levels, transfer and health risk. *Chemosphere*, *167*, 82-90.

Ibrahim, K. N., Yet, Z. R., Som, A. M., Razali, N., Rahaizah, N. A. M., Othman, E. N., ... & Yahya, T. F. T. (2015). Theavy Metal Concentration (Pb, Cu, Fe, Zn, Ni) in Plant Parts of Zea Mays L. Cultivated in Agricultural Area Near Alor Gajah, Melaka, Malaysia. *American Journal of Environmental Engineering*, *5*(3A), 8-12.

Ibrahim, M. M., El-Baroudy, A. A., & Taha, A. M. (2016). Irrigation and fertigation scheduling under drip irrigation for maize crop in sandy soil. *International agrophysics*, *30*(1), 47-55.

John, Y. A. B. E., Ishizuka, M., & Umemura, T. (2010). Current levels of heavy metal pollution in Africa. *Journal of Veterinary Medical Science*, *72*(10), 1257-1263.

Jompuk, C., Cheuchart, P., Jompuk, P., & Apisitwanich, S. (2011). Improved tryptophan content in maize with opaque-2 gene using marker assisted selection (MAS) in backcross and selfing generations. *Kasetsart J. Nat. Sci*, *45*, 666-674.

Kachenko, A. G., & Singh, B. (2006). Heavy metals contamination in vegetables grown in urban and metal smelter contaminated sites in Australia. *Water, Air, and Soil Pollution*, *169*(1-4), 101-123.

Khan, K., Lu, Y., Khan, H., Ishtiaq, M., Khan, S., Waqas, M., ... & Wang, T. (2013). Heavy metals in agricultural soils and crops and their health risks in Swat District, northern Pakistan. *Food and chemical toxicology*, *58*, 449-458.

Kibet, B. J., Jackson, C. K., Cheruiyot, M. Y., Munyendo, W. L., Ambrose, K., & Achieng'G, O. (2019). Assessment of Fluoride and selected heavy metals in food chain around Fluorspar mining Plant, Kenya.

Kibet, N., Lagat, J., Obare, G., 2011. Identifying efficient and profitable farm enterpise in Uasin Gishu County in Kenya. Asian J Agric Sci 37, 378-384.

Koopmans G.F., Romkens P.F.A.M., Fokkema M.J., Song J., Luo Y.M., Japenga J., Zhao F.J. (2008). Feasibility Of Phytoextraction To Remediate Cadmium And Zinc Contaminated Soils. Environ. Pollut. 156, 905.

Korir, L.K., 2011. Risk management among agricultural households and the role of off-farm investments in Uasin Gishu County, Kenya. Egerton University,

Lagat, C. K., Okemwa, P., Dimo, H., Kipkurui, L., & Korir, J. K. (2007). The state of agricultural mechanisation in Uasin Gishu District, Kenya, and its impact on agricultural output.

Lee, B., Kim, C. G., Park, J. Y., Park, K. W., Kim, H. J., Yi, H., & Kim, H. M. (2009). Monitoring the occurrence of genetically modified soybean and maize in cultivated fields and along the transportation routes of the Incheon Port in South Korea. *Food Control*, *20*(3), 250-254.

Li, J., Lu, Y., Yin, W., Gan, H., Zhang, C., Deng, X., & Lian, J. (2009). Distribution of heavy metals in agricultural soils near a petrochemical complex in Guangzhou, China. *Environmental monitoring and assessment*, *153*(1-4), 365.

Liu, X., Song, Q., Tang, Y., Li, W., Xu, J., Wu, J., & Brookes, P. C. (2013). Human health risk assessment of heavy metals in soil–vegetable system: a multi-medium analysis. *Science of the Total Environment*, *463*, 530-540.

López-Alonso, M. (2012). Animal feed contamination by toxic metals. In *Animal Feed Contamination* (pp. 183-204). Woodhead Publishing.

Mahmood, A., & Malik, R. N. (2014). Human health risk assessment of heavy metals via consumption of contaminated vegetables collected from different irrigation sources in Lahore, Pakistan. *Arabian Journal of Chemistry*, *7*(1), 91-99.

Mishra, S., Dwivedi, S. P., & Singh, R. B. (2010). A review on epigenetic effect of heavy metal carcinogens on human health. *Open Nutraceuticals J*, *3*, 188-193.

Nagajyoti, P. C., Lee, K. D., & Sreekanth, T. V. M. (2010). Heavy metals, occurrence and toxicity for plants: a review. *Environmental chemistry letters*, *8*(3), 199-216.

Oluyemi, E. A., Feuyit, G., Oyekunle, J. A. O., & Ogunfowokan, A. O. (2008). Seasonal variations in heavy metal concentrations in soil and some selected crops at a landfill in Nigeria. *African Journal of Environmental Science and Technology*, *2*(5), 089-096.

Omambia, B. M., & Simiyu, G. M. (2014). Heavy Metal (Cu, Zn, Cd And Pb) Contamination Of Indigenous Green Vegeta-Bles In Eldoret Town And Their Health Implications To Consumers.

Owiti, O. T. (2015). Assessment of selected plants growing along Nairobi River for uptake of copper, zinc and cadmium, Nairobi County, Kenya (Doctoral dissertation).

Pan J., Plant J., Voulvoulis N., Oates C., Ihlenfeld C. (2010). Cadmium Levels In Europe: Implications For Human Health. Environ. Geochem. Health 32, 1.

Peterson, P. M. (2001). Poaceae (Gramineae). *eLS*.

Sarwar, N., Imran, M., Shaheen, M. R., Ishaque, W., Kamran, M. A., Matloob, A., ... & Hussain, S. (2017). Phytoremediation strategies for soils contaminated with heavy metals: modifications and future perspectives. *Chemosphere*, *171*, 710-721.

Sharma, R. K., Agrawal, M., & Marshall, F. (2006). Heavy metal contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. *Bulletin of environmental contamination and toxicology*, *77*(2), 312-318.

Shobha, N., & Kalshetty, B. M. (2017). Assessment Of Heavy Metals In Green Vegetables And Cereals Collected From Jamkhandi Local Market, Bagalkot, India. *Rasayan Journal Of Chemistry*, *10*(1), 124-135.

Singh, A., Sharma, R. K., Agrawal, M., & Marshall, F. M. (2010). Health risk assessment of heavy metals via dietary intake of foodstuffs from the wastewater irrigated site of a dry tropical area of India. *Food and Chemical Toxicology*, *48*(2), 611-619.

Streit, E., Schatzmayr, G., Tassis, P., Tzika, E., Marin, D., Taranu, I., & Oswald, I. P. (2012). Current situation of mycotoxin contamination and co-occurrence in animal feed—Focus on Europe. *Toxins*, *4*(10), 788-809.

Sulyman, Y. I., Abdulrazak, S., Oniwapele, Y. A., & Amad, A. (2015). Concentration of heavy metals in some selected cereals sourced within Kaduna state, Nigeria. *J Environ Sci Toxicol Food Technol*, *9*(10), 17-19.

Tegegne, W. A. (2015). Assessment of some heavy metals concentration in selected cereals collected from local markets of Ambo City, Ethiopia. *Journal of cereals and oilseeds*, *6*(2), 8-13.

United Nations Environmental Protection/Global Program of Action (2004). Why The Marine Environment Needs Protection From Heavy Metals, Heavy Metals 2004, UNEP/GPA Coordination Office (http://www.oceansatlas.org/unatlas/uses/uneptextsph/wastesph/260 2gpa.)