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Risk of Environmental Chemical Contaminants Associated with Animal Feeding in Peri Urban Areas of Kisumu Town

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A B S T R A C T

The objective of this study was to determine, quantify and disseminate the level of environmental chemical contaminants in the topsoil, water, pasture, milk, blood, feaces, kidney, and adipose tissues from cattle reared in peri-urban slum of Kisumu County. Various samples were collected from Mamboleo, Nyalenda and Otonglo in Kisumu County in the months of April and August 2019 respectively to determine possible seasonal or environmental variability of contaminants. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was used to identify and quantify the level of toxic heavy metals and the results were compared to WHO food safety limits.Flotation method was used to determine Helminth's infections. Viable bacterial cell counts were determined using the Spread-Plate method. The heavy metals analyzed were: Lead (Pb), Mercury (Hg), Cadmium (Cd), Arsenic (As) and Copper (Cu). One-way ANOVA (Analysis of Variance) test was used to determine significant difference in the mean level of heavy metals. There were variations in mean heavy concentration levels between the two visits ($p<0.05$). Helminthosis was prevalent (59.5%) and total Fecal Egg Count (FEC) varied across samples. Study findings show varying heavy metal concentration levels which exceed WHO/FAO food safety limits implying livestock kept in peri-urban setting of Kisumu town are at a risk of ingest contaminated pasture, threatening food safety among consumers. This study recommends policies aimed at mitigating pollution from chemical contaminants and other anthropogenic activities and farmer sensitization on better farming system with limited risks on food safety and animal-human food chain.

Introduction

Food safety is a growing concern in the peri-urban areas dependent on food chains (Shimshoni, 2017). Safe, good quality food is key to food security, public health and economic development since it promotes trade (FAO, 2008). The production of safe food of animal origin is a responsibility of livestock farmers, animal feed suppliers, and public health and extension officers, who are the stakeholders. Majority of those keeping livestock in peri-urban slums are vulnerable groups of female-headed

households, children, retired people, widows and the less educated who often access polluted water for livestock due to scarcity. The wastewater and fertilizer residue released locally are of ecological concerns (FAO, 2007).

The associated pollutants of public health concern include surplus nutrients (nitrogen, phosphorus and potassium), bacterial and parasitic pathogens, heavy metals and drug residues.

A variety of parasites and bacterial pathogens have natural reservoirs among components of the farm ecosystem, which could be a potential entry point into the food chain through contamination of animal products. This may lead to a continually maintained depository of foodborne pathogens that reach humans by direct contact, ingestion of contaminated animal products or tainting during process. Accordingly, recognition of parasites' expected impact on public health as well as sensitivity to economic consequences, such as worker productivity and agricultural losses need to be well understood (Laranjo-González *et al.,* 2018).

Heavy metals (Copper (Cu), Zinc (Zn), Selenium (Se), Cobalt (Co), Iron(Fe), Manganese (Mn) and Cadmium (Cd), are incorporated in animal feeds and water for health and growth enhancement, however, not all are metabolized, ending up in the environment via wastewater and manure. Heavy metals (Lead and Copper) cause toxicity in animals and human beings due to their wide spread environmental pollution e.g., paints, pipes, batteries, soldering rods, gunpowder, pesticides, fungicides, gasoline, engine oils, anthelmintics, chemical fertilizers or when they occur in high amounts in air, soil, water, plants and other compounded animal feeds (Elliott *et al.,* 2017).

High levels of these metals in blood and animal tissues suggest an exposure either from the air, soil, water or feeds (Muleke *et al.,* 2013; Yasotha, 2014). Lead and copper poisoning alter hematological parameters which are of diagnostic value in animals suspected of heavy metal toxicity (Javed and Usmani, 2019). Human beings are at risk of exposure by eating food and drinking fluids contaminated with heavy metals, inhaling air contaminated by heavy metals, or direct contact with the metals in people working in industries/factories dealing with heavy metals and their derivatives (Zahra and Kalim, 2017). Some areas of Kisumu town are characterized by small enterprises dealing with metal works, car garages (Jua Kali sheds) and construction sites that pose a risk of contamination to the environment with hazardous substances including heavy metals. Kisumu County government collects and disposes solid wastes at a Nyalenda - Kachok dumpsite. Lorry-loads from the city's supermarkets, industrial set-ups, petrol stations, residences and markets dump their solid wastes at this site (Kanyari *et al.,* 2010).

Sinceperi-urban livestock farmers may not get adequate animal feeds and water, they either graze livestock or harvest grass around this dumpsite, along roadsides and near polluted water puddles (Lupindu *et al.,* 2015). This presents high risk of food contamination along the food chain from heavy metals and microbial pathogens of public health importance to consumers. The objective of this study was to determine, quantify and disseminate the level of environmental chemical contaminants in soil, pasture, water, blood, milk and animal tissues in peri-urban slums of Kisumu town, and the implications on food safety as well as general well-being of livestock. This study contributes to the body of knowledge on developing and maintaining a food safety system from farm to table involving all the stakeholders along the food chain for enhanced food safety and reduced environmental pollution from heavy metals in the peri-urban slums of Kisumu town, Kenya.

Materials and Methods

Study area

The study was undertaken at the shores of Lake Victoria, Kisumu County and its environs within the area limits of 00° 51' South and Longitude 00°41'

North and longitudes 33° 20'- 35°20' East and an altitude of 528 meters above the sea level. Location of the study sites within peri-urban areas of Kisumu city were as follows: Sites 1: Nyalenda Obunga, Manyatta - Kachok: whose animals feed and graze at the dumping site in urban slums - suspected to be polluted with the metals. Sites 2: Nyamasaria, Mamboleo lie in a peri-urban area: 8 km – north eastern outskirts of the city with relative high animal husbandry. Site 3: Otonglo located in Chiga: 8 km-eastern outskirts of the city slums with subsistence with light animal husbandry. The choice of the sites 2 and 3 was based on the fact that cows graze freely in their areas but cannot reach the dumping site where only those from site 1 (Nyalenda, Obunga, Manyatta, Kochak) access for forage.

Field visits were undertaken to purposely select study sites 1, 2 and 3(see Fig.1)in collaboration with the county animal health extension workers and administration officers. Study sites headed by a village/ward chairperson were demarcated on the basis of having a higher concentration of livestock keeping in urban and peri-urban areas.

At each study site, samples were obtained, packed appropriately, and labelled according to time, date, location and replicate as follows: Pasture was cut at approximately1cm height from the ground in an area of 1 x 1 meter (m) squared, within five randomly selected cattle grazing grounds per location. At the center of the area where pasture was taken, the topsoil was dug to a depth of 12cm at an area of $24x24cm^2$ and put in clean polythene bags. About 50ml of water samples from swamps and damsinsites 1 and 3,and five equidistant spots along the stream that passes through the grazing area of location 2were obtained and placed in clean unused plastic bottles with screw caps.

About 50ml fresh milk samples were taken by self-milking into sterilized polyethylene bottles from fifty lactating cows in randomly selected homes in each location proportionate to size on a three-day milking interval in the morning and packed into ice-bags. Five milliliters (5ml) of blood were collected from bleeding the jugular vein of randomly selected adult free ranging cattle into sterile plain universal bottles and kept at 4^0C overnight to clot. The supernatant was centrifuged at 10,000rpm for 20min, and separated serum stored at -20ºC until used for determination of toxic heavy metal levels.Kidney and adipose tissue samples were collected and divided into three equal parts from cattle kept in urban slums at slaughter in the abattoirs and preserved in ice packed boxes. At least 10grams of faeces was collected directly from the rectum (or freshly voided ones into screw top containers and stored in cool boxes.

Dry matter content of pasture, soil, fecal samples was determined in accordance with theAssociation of Official Analytical Chemists (AOAC) (1990). Toxic heavy metals in feeds, kidney, adipose tissue pasture, soil, milk and water samples was determined using Inductively Coupled Plasma Mass Spectrometry (ICP-MS),from microwave assisted acid digestion. Levels of lead and copper in plasma harvested from blood samples after being centrifuged were determined using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). Hemoglobin concentration (Hb) was measured using the cyanomethaemoglobin method recommended by (Karakochuk *et al.,* 2019). The packed cell volume (PCV) percentage of blood samples was determined from the height of the column of red cells in a PCV reader. White and red blood cell counts were determined according to a standard procedure by Mlay and Mgumia (2008). Laboratory culturing of bacterial and parasites species was done on pasture, soil, faeces, blood and water targeting species of public health importance.

The helminth identification was performed using the egg floatation technique (Amuzie *et al.,* 2018). Approximately 2grams of the sample was mixed with 28milliliters of saturated sodium chloride and passed through the sieve. About 10mls of the mixture was put in a test tube, inverted several times to mix and left to stand for ten minutes. The top liquid was drawn using Pasteur pipette, and both sides of a McMaster counting chamber filled and

examined under a microscope using *10 eyepieces and *10 objective lens.

Spread-plate method was used to establish the viable bacterial cell counts for the following: aerobic total counts on Bio-Rad plate count agar, fecal coliform counts on Bio-Rad violet red bile lactose agar, Escherichia coli counts, Bio-Rad RAPID' *E. coli* agar incubated at 37°C for 18-24 hours, *Staphylococcus aureus* and Bio-Rad Baird-Parker agar, *Clostridium perfringens*.

In addition to these cell counts, 25gm samples were analyzed for the presence or absence of Salmonella species according to protocol described by Cohen *et al.*, (2007).

Statistical analysis

Data generated was subjected to analyses such as mean, standard error and One-way Analysis of Variance (ANOVA) to determine statistical difference in means levels of the elements in the three locations ($p<0.05$). Statistical package for social sciences (SPSS 13.0) was used for statistical analysis. Egg flotation method was used to determine Helminths infections while viable bacterial cell counts were analyzed using the Spread-Plate method.

Results and Discussion

The elements analyzed were: Lead (Pb), Mercury (Hg), Cadmium (Cd), Arsenic (As) and Copper (Cu). Three isotopes of Lead (Pb 206, Pb 207 and Pb 208) and two isotopes of Mercury (Hg 199 and Hg 202)were detected. Table 1 shows a summary of the total number of samples collected in the month of April 2019 and Table 2 shows a summary of the total number of samples collected in the month of August 2019.

Cadmium (Cd) and Arsenic (As) were either not detected or detected at levels below 1 part per billion (ppb). Tables 3-8 show the mean values of levels of the elements detected in all the tested samples.

Analysis of Variance (ANOVA) test results

Table 9 shows the p-values for each of the elements detected. The results show that there is a significant difference in the mean levels of Hg199 and Cu between the groups ($p<0.05$).

Bacteria and parasite determination

Fifty-six (56) fecal samples were collected from Otonglo, Nyalenda and Mamboleo and 37 samples from Otonglo and Mamboleo were analyzed at the site. Out of these 29(78%) were infested with helminths. Five types of helminths were found in cattle sampled from these two sites namely: Strongyles (54.1%), Trichostrongylus (13.5%), Fasciola hepatica (2.7%), Moneizia (5.4%) and *Bunostomum phlebotomum* (56.8%). Total Fecal Egg Count (FEC) in helminth infested animals varied from 50 eggs/g to 1250eggs/g with a mean of 472 ± 81.1 eggs/g of faeces. Seventeen (58.6%) of the helminth infested cattle had mixed helminths infestation.

In Otonglo, 88.9% of the cattle sampled were infested with helminths. Five types of helminths were observed in cattle sampled as follows: Strongyles (61.1%), Trichostrongylus (16.7%), *Bunostomum phlebotomum* (61.1%), Moneizia (11.1%) and Fasciola hepatica (5.6%). Total FEC in helminth infested animals varied from a minimum of 100 eggs/g to a maximum of 1850eggs/g with a mean of 659 ± 121eggs/g of faeces. Eleven (68.7%) of the helminth infested cattle had mixed helminths infestation and four (25%) of the helminth infested cattle had FEC greater than 100eggs per gram of faeces.

In Mamboleo, 68.4% of the cattle sampled were infested with helminths. Three types of helminths were observed in cattle sampled: strongyles (42.1%), Trichostrongylus (10.5%) and *Bunostomum phlebotomum* (52.6%). Total FEC in helminth infested animals varied from a minimum of 50 eggs/g to a maximum of 800 eggs/g with a mean of 242 ± 60 eggs/g of faeces. Six (46.2%) of the

helminth infested cattle had mixed helminths infestation and none had FEC greater than 1000eggs per gram of faeces.

Environmental pollution is a global concern for human beings and animals. Various anthropogenic activities release toxicants into the ecosystem. Ecological contaminants can enter and accumulate in livestock body organs through ingestion of contaminated feeds and water. These toxins can be transmitted through the food chain by consuming contaminated food products or through contamination from livestock effluent causing serious public health concerns. Livestock feeding practices among peri-urban farmers could also contribute to food safety risks. Smallholder peri-urban farmers face various challenges, including inadequate animal feeds and inability to purchase commercial supplements. Subsequently, they practice free-range farming system as a means to perpetuate animal husbandry (Barnes *et al.,* 2018). According to Kanyari *et al.,* (2010), prevalence of free-range farming system among smallholder farmers in low-income and high-density peri-urban neighbourhoods such as Kisumu city, may encourage transmission of zoonotic diseases as animals are at a risk of ingesting feeds polluted by various environmental chemical contaminants.

Permissible heavy metal levels in food and plants according to WHO/FAO are shown in Table 10. Findings from this study were compared to these limits to determine whether they were above or below tolerable food safety limits. High standard deviation values indicate variation in the distribution of different toxic metals in various samples. This could be attributed to factors such as: solubility, rate of metal uptake, soil PH, temperature, redox potential, organic content and time.

Three Lead (Pb) (Pb 206, Pb 207, Pb 208) and two Mercury (Hg) isotopes (Hg 199, Hg 202) were identified in samples from all three sites. This could be attributed to direct pollution from atmosphere, indirectly through contamination of animal feeds during processing and storage, animals grazing on forage growing on soils or drinking water polluted by heavy toxic metals. According to Miranda *et al.*, (2005), accumulation of heavy metals such as Mercury, Lead and Zinc in soils leads to contamination and uptake by food crops. This could lead to potential health risks to humans and animals from consumption of these crops as well as direct deposition of contaminants from the atmosphere onto plant surfaces.

Minimal levels (below 1 part per billion) of Cadmium (Cd) and Arsenic (As) were detected indicating no pollution from these metals. Perhaps, this is because these are generally globaltrace elements that naturally occur in limited quantities. According to Tchounwou *et al.,* (2012), metals such as arsenic (As), barium (Ba) and cadmium (Cd)sometimes occur in the soil, vegetables, cereals, starchy roots at natural background levels and are sometimes considered “non-essential” metals.

In the first visit to Mamboleo location in April 2019, Lead (Pb), Mercury (Hg) and Copper (Cu) mean concentration ranged from non-detectable to 9565.1mg/kg, 291.39mg/kg and 9604.33mg/kg respectively (Table3). In the second visit (August 2019), Lead (Pb) and Copper (Cu) mean concentration ranged from non-detectable to 137164.5mg/kg and 2639.69mg/kg correspondingly. Mercury (Hg) ranged from 1.25 – 349.99gm/kg (Table 4). These exceed the World Health Organization (WHO) tolerable food safety limits of 0.1gm/kg, 2mg/kg and 30mg/kg for Mercury, Lead and Copper respectively implying seasonal variability of the toxicants.

Varying concentrations of these heavy toxic metals could be as a result of automobile exhaust fumes, dry cell batteries and sewage effluents causing bio-accumulation in plants via uptake from the soil and eventual entry into the food chain. This corroborates findings by Ogundele *et al.*, (2015), who reported varying higher than normal values of Lead, Copper Mercury and Zinc in plant, soil and animal samples analyzed in peri-urban farming communities in Nigeria.

Fig.1 Map of Kenya (Inset), bolded the study sites 1, 2 and 3 in the peri-urban precincts of Kisumu City (courtesy: Maoulidi, M., 2012).

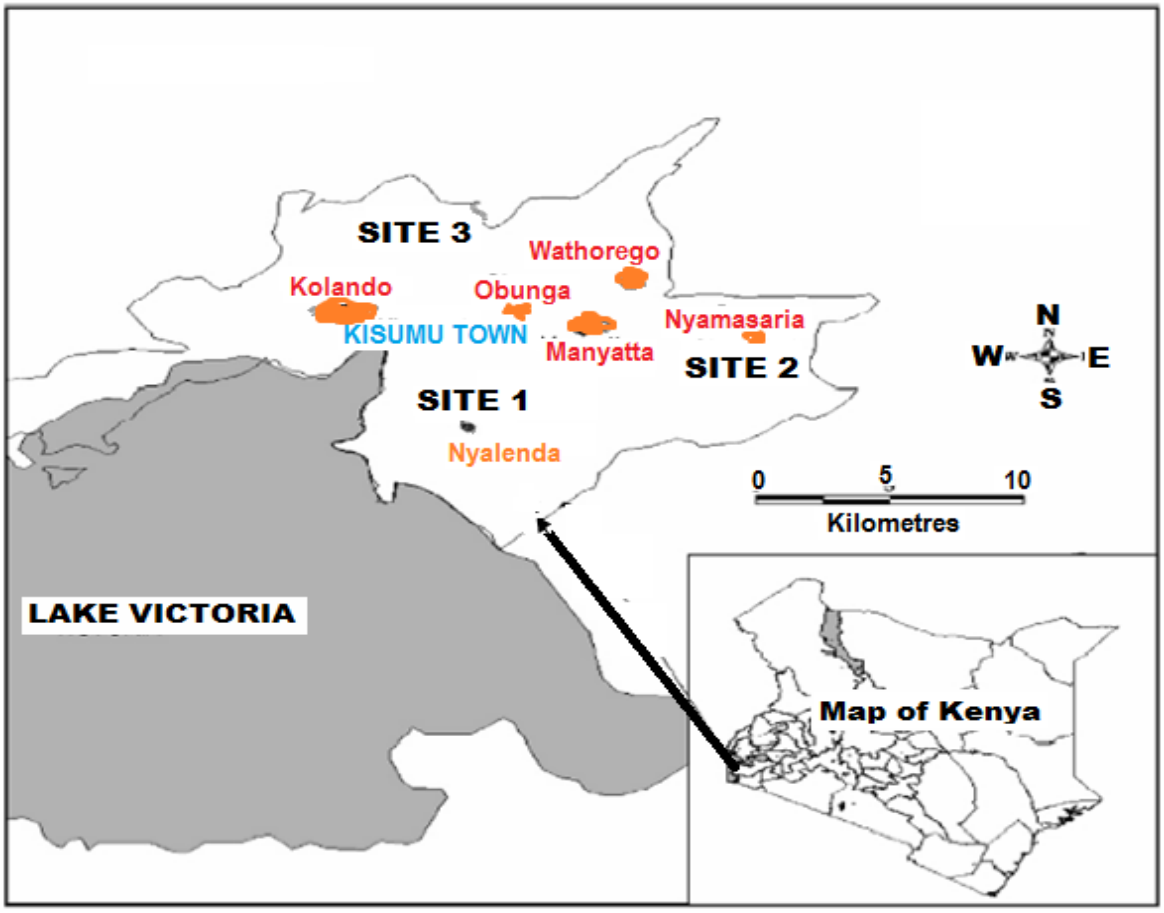

Table.1 Total number of samples collected in April 2019

1st Visit	Soil	Water	Pasture	Milk	Blood	Tissue
Mamboleo	13	20	22	20	20	20
Nyalenda	20	26	26	20	18	0
Otonglo	15	31	14	20	21	20

Table.2 Total number of samples collected in August 2019

2nd Visit	Soil	Water	Pasture	Milk	Blood	Tissue
Mamboleo	24	13	21	11	18	12
Nyalenda	14	12	16	10	15	0
Otonglo	11	12	10	8	19	10

Table.3 Mean and Standard Deviation (SD) of elements detected in samples from Mamboleo during the 1st mission

Mamboleo	Pb 206		Pb 207		Pb 208		Hg 199		Hg 202		Cu	
Issue 1	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Soil	9565.1	4255.05	7979.95	3878.63	8625.86	3707.16	106.68	1.8	120.17	2.06	4995.69	2665.9
Water	ND	0	ND	0	ND	0	0	0	0	0	0	0
Pasture	ND	0	ND	0	ND	0	0	0	0	0	617.31	706.64
Milk	ND	0	ND	0	ND	0	246.16	123.31	255.32	120.77	0	0
Blood	ND	0	ND	0	ND	0	291.39	264.09	262.89	254.81	244.05	1091.41
Tissue	ND	0	ND	0	ND	0	119.47	12.81	133.09	13.51	9604.33	8453.46

Table.4 Mean and Standard Deviation (SD)of elements detected in samples from Mamboleo during the 2nd mission

Mamboleo	Pb 206		Pb 207		Pb 208		Hg 199		Hg 202		Cu	
Issue 2	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Soil	128243.7	478987.1	137164.5	520089.3	115083.4	420193.8	349.99	49.98	342.91	50.41	2639.89	3291.78
Water	3.97	4.1	2.96	4.74	6.75	7.61	1.28	0.01	1.25	0.01	9.22	9.87
Pasture	1472.27	4520.9	1558.35	4845.92	1709.28	4730.65	237.13	78.22	228.68	69.93	810.13	1585.63
Milk	ND	0	0	0	0	0	97.37	0.36	110.87	0.34	0	0
Blood	6.81	28.9	15.68	15.68	64.76	274.77	97.13	0.16	110.73	0.24	0	0
Tissue	2133.34	6574.34	2373.35	7220.93	2561.49	7125.66	97.31	0.2	110.8	0.24	0	0

Table.5 Mean and Standard Deviation (SD) of elements detected in samples from Nyalenda during the 1st mission

Nyalenda	Pb 206		Pb 207		Pb 208		Hg 199		Hg 202		Cu	
Issue 1	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Soil	17000.83	12650.99	15016.93	12343.13	15669.6	12585.35	91.56	55.52	101.43	61.21	5494.99	2891.49
Water	ND	0	ND	0	ND	0	0	0	0	0	0	0
Pasture	ND	0	ND	0	ND	0	0	0	0	0	604.94	944.52
Milk	ND	0	ND	0	ND	0	185.51	106.89	198.27	107.16	0	0
Blood	ND	0	ND	0	ND	0	260.03	59.87	290.24	67.56	557.41	831.8
Tissue	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table.6 Mean and Standard Deviation (SD)of elements detected in samples from Nyalenda during the 2nd mission

Nyalenda	Pb 206		Pb 207		Pb 208		Hg 199		Hg 202		Cu	
Issue 2	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Soil	42805	93749.8	42522.47	97388.53	37862.38	79669.95	336.3	13.76	328.35	12.6	6639.39	5643.66
Water	23.46	43.79	23.24	44.29	24.88	39.16	1.28	0.02	1.25	0.01	22.73	26.51
Pasture	7070.02	23021.26	7655.31	24914.95	7761.99	25264.96	196.69	4.29	189.49	5.39	51.61	194.05
Milk	ND	0	0	0	0	0	98.59	0.7	112.11	0.53	0	0
Blood	ND	0	0	0	0	0	97.17	0.34	110.57	0.26	0	0
Tissue	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table.7 Mean and Standard Deviation (SD) of elements detected in samples from Otonglo during the 1st mission

Otongolo	Pb 206		Pb 207		Pb 208		Hg 199		Hg 202		Cu	
Issue 1	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Soil	11699.61	3736.62	10113.9	3422.72	10696.05	3542.09	109.74	2.79	123.31	2.94	2650.14	1468.92
Water	ND	0	ND	0	ND	0	0	0	0	0	0	0
Pasture	ND	0	ND	0	ND	0	103.41	1.38	116.42	1.23	971.78	1084.82
Milk	ND	0	ND	0	ND	0	121.78	27.72	135.3	26.58	0	0
Blood	ND	0	ND	0	ND	0	271.68	54.86	299.37	59.28	0	0
Tissue	ND	0	ND	0	ND	0	134.5	43.07	148.7	44.63	4597.81	5713.21

Table.8 Mean and Standard Deviation (SD)of elements detected in samples from Otonglo during the 2nd mission

Otongolo	Pb 206		Pb 207		Pb 208		Hg 199		Hg 202		Cu	
Issue 2	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Soil	4700.76	2302.76	3607.7	2262.48	5590.89	1926.46	325.18	2.03	317.81	3.67	103.48	333.28
Water	ND	0	0	0	2.73	4.71	1.27	0.01	1.22	0.01	3.42	4.65
Pasture	14153.96	30191.05	15376.81	32800.5	15791.95	33625.64	183.73	33.22	184.64	2.97	199.89	392.71
Milk	148.39	419.71	174.65	493.98	200.86	568.12	97.7	0.29	111.29	0.48	0	0
Blood	46.55	202.94	60.07	261.83	119.6	521.34	97.13	0.27	110.64	0.23	0	0
Tissue	2985.2	6178.5	3226.97	6634.03	3295.58	6529.65	98.13	2.33	110.75	0.27	0	0

Table.9 Summary of results from test of significance using one-way Analysis of Variance (ANOVA)

No	Element	Degree of freedom (df)	ANOVA Value (F)	Significance (p)
1	Pb 206	2	0.929	0.395
2	Pb 207	2	0.936	0.393
3	Pb 208	2	0.938	0.392
4	Hg 199	2	4.137	0.016**
5	Hg 202	2	2.670	0.070
6	Cu	2	3.961	0.020**

NB: (**) significantly different at ($p<0.05$).

Table.10 FAO/WHO guideline for metals in food and vegetables

Metals(mg/kg)	WHO/FAO	NAFDAC	EC/CODEX	Normal range in plants
Cadmium(Cd)	1	-	0.2	<2.4
Copper (Cu)	30	20	0.3	2.5
Lead (Pb)	2	2	0.3	0.50-30
Mercury (Hg)	0.1			
Zinc (Zn)	60	50	<5.0	20-100
Iron (Fe)	48	-	-	400-500
Nickel (Ni)	-	-	-	0.02-50
Cobalt (Co)	-	-	-	-
Arsenic (As)	30	20	0.5	0.5-20

Source: FAO/ WHO

Lead, Mercury and Copper mean concentration in Nyalenda location ranged from non-detectable to 17000.83mg/kg, 290.24mg/kg and 5494.99mg/kg respectively (Table 5) in the first visit (April 2019). Leadand Copper mean concentration ranged from non-detectable to 42522.47 mg/kg and 6639.39 mg/kg correspondingly in the second visit (August 2019) while Mercury ranged from 1.25 – 336.30 gm/kg (Table 5). These levels are above the permissible WHO/FAO food safety limits of 0.1gm/kg, 2mg/kg and 30mg/kg for Mercury, Lead and Copper respectively. Furthermore, Lead, Mercury and Copper mean concentration levels were higher in the second visit (August 2019) which is the month with most precipitation compared to the first visit(April 2019). This may be ascribed to heavy rainfall, dilution and other run-off effects during the wet season hence metals and other environmental toxicants are washed away to some extent. This corroborates findings by Rahman *et al.*, (2012) who reported seasonal variability in average toxic metal concentrations in plant and animal samples during wet and dry seasons, with particularly higher concentrations in the dry season or periods with low precipitation levels.

Lead, Mercury and Copper mean concentration in Otonglo location ranged between0.00 to 11699.61mg/kg, 299.37mg/kg and 4597.61mg/kg respectively (Table 6) in the first visit (April 2019). Lead and Copper mean concentration ranged from non-detectable to 15891.95mg/kg and 199.89mg/kg correspondinglyin the second visit (August 2019) while Mercury ranged between 1.22 – 325.18gm/kg (Table 7). These levels are above the permissible WHO/FAO food safety limits of 0.1gm/kg, 2mg/kg and 30mg/kg for Mercury, Lead and Copper respectively. This may be due to contamination by anthropogenic inputs associated with industrialization, urbanization and agricultural

deposition leading to accumulation of heavy metals in soil and crops. Latif *et al.,* (2018) noted that, accumulation and bio-magnification of heavy metals in peri-urban ecosystems can be attributed to waste incineration, urban effluent, traffic missions, fertilizer application, and long-term application of wastewater in agricultural land.

There was significant difference in the mean levels of Mercury (Hg 199) and Copper (Cu) and none in Lead (Pb 206, Pb 207, Pb 208) and Mercury (Hg 202) in the three sites ($p<0.05$).This could be as result of the dumpsite in site 1 which is absent in sites 2 and three and the varying economic activities in the three sites leading to different levels of heavy metal accumulation. This is in line with findings by Hammed *et al.,* (2017) who reported varying heavy metal concentration and ion contents in plants grown in waste dumpsites compared to those from other peri-urban agricultural lands. Similarly, Anikwe *et al.*, (2002) reported variations in heavy metal concentrations in vegetables grown in waste dumpsite soils and those in agricultural soils.

There was an increase in the prevalence of helminths infections in cattle by 31% and increase in the mean FEC in infected animals by 51% from the previous sampling. In Otonglo, prevalence of infection increased by 28.8% and mean FEC in infected animals increased by 136%. In Mamboleo, infection prevalence increased by 42% while mean FEC in infected animals decreased by 45%. This can be attributed to pathogens and bacterial parasites such as parasitic nematodes, protozoa and other micro-organisms from dumpsites, contaminated animal effluent and untreated waste whose infective stages can embryonate in the soil leading to soil transmitted Helminths (STH).According to Adesewa (2017), accumulation of heavy metals can encourage the existence of pathogens that consume harmful toxicants, accumulate and transfer to host animals when ingested causing infections and mortality.
However, in Mamboleo despite area wide deworming of cattle two weeks prior to this sampling, there was a significant increase in the prevalence of helminth infestation but a significant decrease in the worm load. This implies that the treatment reduced the worm load but did not prevent the animals from being infested with worms. This could be due to the high prevalence and diversity of helminth species especially in Sub-Saharan counties such as Kenya, making it difficult to successfully manage or eradicate helminth infections. Also, climatic conditions may have contributed to persistence of parasites despite initial deworming. According to Alcaraz *et al.*, (2004), climatic conditions and seasons are key factors that determine the development of parasites. Similarly, Karshima *et al.,* (2018) reported that, failure to observe adequate preventive measures such as control of intermediate hosts and strategic deworming may lead to higher prevalence and re-emergence of helminth species in areas with favourable climate.

This study sought to determine the risk of environmental chemical contaminants associated with animal feeding in peri urban areas of Kisumu town. From study findings it can be concluded that there were season variations of heavy metal concentrations with higher concentrations during the wet season (April 2019 – first visit). Average Lead (Pb), Mercury (Hg), and Copper (Cu) levels surpassed theWHO/FAO food safety limits whileCadmium (Cd) and Arsenic (As) were below WHO/FAO food safety levels. Environmental pollution from anthropogenic activities such as dumpsites, heavy metal contaminants and animal feeding practices such as free-range farming system positively influence the prevalence of helminth infections. Furthermore, there was an increase in prevalence of helminth infection between April and August 2019 while the total Fecal Egg Count (FEC) varied across sites and samples. This study therefore recommends policies aimed at mitigating pollution from chemical contaminants and other anthropogenic activities in an effort to reduce heavy metal concentration levels and resulting negative impacts to human beings and animals. There's also need for farmer sensitization on better farming system with limited risks on food safety and animal-human food chain.

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