Lead and Copper Levels in the Soil, Water, Serum and Tissues of Livestock Feeding on Dumpsite Waste in Urban Slums of Industrial Towns in Western Kenya

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Submitted 5th Feb. 2012; Reviewed 22nd Jan. 2013; Accepted 7th April 2013

Abstract

Knowledge of toxic metal levels in livestock feeding on dumpsite waste is important for assessing the effects of pollutants in animals and contaminant intakes by human. A study was conducted in western Kenya to determine the lead and copper levels in the soil, water, serum and tissues of livestock feeding on refuse dumpsite waste in Webuye and Mumias urban towns suspected to be polluted with these metals. Indigenous free ranging cattle, sheep, goats and chicken were investigated. The samples: soil (5), water (5), dumpsite wastes (7), serum (76) and 17 kidney/liver were analyzed. Lead and copper levels were determined by the conventional aqua regia digestion protocol and read using the atomic absorption spectrophotometer. The mean lead and copper levels in the soil and water of 1.16 – 2.86mg/kg and 0.001mg/L were below acceptable risk limits of 5 – 25mg/kg and 0.015mg/L, respectively. The mean lead levels in serum of cattle, sheep, goats and chicken were 0.86, 0.82, 0.54mg/L and 0.76, 0.46, 0.21mg/L in Bungoma and Mumias towns respectively, and they exceeded acceptable risk limit levels of 0.01mg/L. The lead levels in kidney/livers of cattle, shoats and chicken were 1.2; 1.5; 1.0mg/kg respectively, and exceeded the acceptable risk limits of 0.5 mg/kg. Based on this study, the lead and copper levels in the soil, water and dumpsite wastes in Bungoma and Mumias towns are below the acceptable risk limits. However due to bio-accumulation process observed in animal tissues, there is need to continuously monitor the status of these heavy metals and create public awareness on good animal feeding practices in the urban slums to avoid mineral toxicity in animals and man through the food chain.
Key words: Heavy metals, urban slums; dumpsite wastes, livestock feeding, human.

Introduction

Food safety is a growing concern in the urban areas dependent on food chains and where food scares are increasingly frequent (Bellaiche, 2007). The Food and Agricultural Organisation (F.A.O) emphasises that safe, good quality food is essential to food security, public health and economic development (FAO, 2007). The livestock population in urban slums in Kenya is expanding and the livelihood opportunities linked to livestock are increasingly in competition with domestic, industrial and other service uses for fresh water (FAO, 1995 and 1997; Waters-Bayer, 1995). Majority of livestock keepers in urban slums are the vulnerable groups of female headed households, children, retired people, widows and the less educated who lack access to inputs. It is estimated that drinking and service water needs vary from 30 to 148 litres for a lactating cow, 65 to 95 litres for a lactating sow and 25 to 65 litres for every 100 layer birds daily (Rosegrant et al., 2002; Chapagain et al., 2003). This additional demand is largely unaccounted for by the urban authorities whose water supply is unable to match the increasing demand hence livestock accessed contaminated water sources. Presently, urban authorities and policy makers lack relevant information to inform their decisions on regulating framework in the design of water-use efficiency and mitigation of pollution associated with livestock production in the urban slums.

The wastewater and manure discharged locally are of major environmental concerns. The associated pollutants of public health concern include surplus nutrients (N, P and K), bacterial and parasitic pathogens, heavy metals and drug residues. Heavy metals are incorporated in animal feeds and water in low concentration for health and growth enhancement, but not all are metabolised, ending up in the environment via wastewater and manure. The commonly used heavy metals are Cu, Zn, Se, Co, Ar, Fe, Mn and Cd. Lead and copper are among the heavy metals implicated to cause toxicity in animals and man. They are found in paints, pipes, batteries, soldering rods, gunpowder, pesticides, fungicides, gasoline, engine oils, some anthelmintics, chemical fertilizers or soil, water, plants and other compounded animal feeds (Farr, 2004). While copper is a trace element required in small amounts in various metabolic functions, lead and other heavy metals can be highly toxic due to interference directly in the metabolic pathways or indirectly by causing deficiencies of other trace metals (Farr 2004). Excessively higher levels of these metals in blood and tissues of animals suggest an exposure
either from the air, soil, water or feeds or all of these sources (Dupler 2001; Farr 2004). Man is exposed to the risk by eating food and drinking fluids contaminated with heavy metals, through air, or direct contact with the metals for people working in industries/factories dealing with heavy metals and their derivatives (Farr 2004).

The industrial towns of Webuye and Mumias in western Kenya are densely populated urban slums with prominent livestock keeping and large volumes of waste discharges from industrial, domestic and livestock units. However the disposal practices of waste discharges are poor and indiscriminate. There is a paper mill factory in Webuye and sugar milling factory in Mumias. Closely linked to these industries are numerous small to large factories dealing with metal works, car maintenance and repair, construction works and backyard farming that use agro-chemicals (pesticides, herbicides, fungicides, anthelmintics), soap and leather factories that use a lot of chemicals. These activities pose a risk of contaminating the environment with hazardous substances including heavy metals. The broad objective of this study was to assess the food safety risks associated with livestock feeding on dump site waste feeds and drinking polluted waters in the urban industrial towns in Western Kenya. The specific objectives were to determine the levels of lead and copper in the soils, refuse dumpsite waste, drinking water, serum and kidney/liver tissues of livestock feeding on dumpsite wastes in urban slums of Webuye and Mumias towns. This was to create awareness on the safety of consuming drinking water and livestock products (blood, liver and kidney) sourced from Mumias and Webuye urban areas. Appropriate interventions to protect the consumers from the health risks from the heavy metals will be devised.

Materials and Methods

Study Area
The study was carried out in Bungoma and Mumias urban towns of Western Kenya. The two towns were chosen since they suggested evidence of food safety concerns linked to livestock feeding practices in urban slums. Bungoma Town: The town lies between latitude 0°25.3’ and 0° 53.2’ North and longitude 34° 21.4’ and 35° 04’ East. It covers an area of 2,068.5km2, which is about 25 per cent of the total area of Western Province. Major industries found here include sugarcane processing factory (Nzoia sugar Company, 10km from Bungoma town), Pan African Paper Mills at Webuye (processing paper from wood) and several coffee pulping factories located in the district. Other people are involved in off-farm businesses such as retail trading (own small shops, food kiosks, butcheries, small hotels). Others trade
in food commodities (buying and selling), grains, pulses, vegetables, fruits, and even second hand clothes.

**Mumias Town:** The town is 1258 m above sea level and lies between latitude 0°20'11.000" North and longitude 34°34°29'21.120" East. Mumias sugar factory is the major source of employment.

**Livestock**
Samples were taken from free ranging mature cattle, sheep, goats and chicken owned by smallholder urban town farmers who readily availed their animals in the study.

**Inventory of Unconventional Refuse Dumpsite Feeds**
A reconnaissance survey was undertaken to identify major dump sites within the urban slums. A careful examination of what scavenging livestock ingested at urban dumpsites was undertaken and inventory of unconventional refuse dumpsite materials recorded. The species of ruminant livestock were also recorded and numbers obtained from local government livestock records.

**Soil, refuse dump site feeds and water sampling**
Soil and refuse dumpsite feeds were collected in different dumpsites from urban slums where cattle, sheep, goats forage and where poultry scavenge. Collected dump site feed materials were put in a clean polythene bags and divided into two portions. One half was used for DM determination while the remaining was rinsed with de-ionized water several times and dried for lead and copper determination.

At the centre of the 1.5x1.5m² area where refuse dump site samples were taken, the topsoil was dug to 12 cm depth in an area of 24 x 24cm square. The soil was carefully mixed and put in clean polythene bags, in the laboratory, it was ground in a mortar to obtain small particles of uniform particle size, and then DM, lead and copper levels were determined.

About 50ml of water samples were collected in clean unused 50ml plastic bottles from each dump site areas where livestock drink. Each sample was filtered through Whatman® filter paper grade 40 to remove debris before analysis for lead and copper using atomic absorption spectrophotometer.

**Serum Sampling**
A random sample of adult free ranging cattle, sheep and goats were bled from the jugular vein. At each bleeding, 5ml of whole blood was collected.
from each animal into sterile plain universal bottles and kept at 4°C overnight to clot. The supernatant was centrifuged at 10,000rpm for 20min. Separated serum was stored at -20°C until used for determination of lead and copper levels.

Liver and Kidney Samples
Liver and kidney samples were collected in the abattoirs from cattle, sheep and goats kept in urban slums from and preserved in ice packed cold boxes until used for heavy metal analysis. A few scavenging chicken raised around the urban dump sites were sacrificed to obtain liver, kidney and whole blood specimens for determination of lead and copper levels.

Laboratory Analysis
Proximate analysis of dump site feeds
The proximate composition of refuse dump site feeds were determined using the AOAC (1990) procedure.

Determination of lead and Copper Levels
Conventional aqua regia digestion was performed in 250-mL glass beakers covered with watch glasses. A well-mixed sample of 0.5 g soil, ground dump site feeds, kidney and liver was digested in 12 mL of aqua regia on a hotplate for 3h at 110°C. After evaporation to near dryness, the sample was diluted with 20 mL of 2% (v/v with H2O) nitric acid and transferred into a 100-mL volumetric flask after filtering through Whatman® filter paper grade 40 and diluted to 100 mL with dionized distilled water then analyzed for levels of lead and copper using the atomic absorption spectrophotometer.

Statistical Analysis
The data were analyzed using SPSS version 11.5 statistical package to obtain the mean, standard deviation, standard error of the mean, range and student’s test on the measured parameters.

Results
Unconventional Feed Resources at Refuse Dumpsites
The most common unconventional feed resources at refuse dumpsites were peels from potatoes, cassava, maize stalk residues, maize cob, sugarcane tops, baggage, residues from groundnuts and cowpea haulm. Other dumpsite materials were papers, rags, rope and jute bags; house hold waste polythene bags that are either degradable or non-biodegradable; remains of fruits and vegetables such as orange, pineapple melon; pumpkin, lettuce, cabbage and
carrots. The species of ruminant livestock recorded and numbers obtained from local government livestock records are shown in Table 1.

Table 1: The population of free ranging ruminant livestock in Mumias and Bungoma urban slums

<table>
<thead>
<tr>
<th>Species</th>
<th>Mumias town</th>
<th>Bungoma town</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Cattle</td>
<td>150</td>
<td>250</td>
</tr>
<tr>
<td>Sheep</td>
<td>250</td>
<td>415</td>
</tr>
<tr>
<td>Goats</td>
<td>204</td>
<td>589</td>
</tr>
</tbody>
</table>

Table 2: Proximate composition of feed resources at refuse dumpsites

<table>
<thead>
<tr>
<th>Dumpsite location</th>
<th>% DM</th>
<th>% CP</th>
<th>% Ash</th>
<th>% CF</th>
<th>% Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bungoma-1</td>
<td>23.5</td>
<td>10.9</td>
<td>11.1</td>
<td>52.7</td>
<td>0.48</td>
</tr>
<tr>
<td>Bungoma-2</td>
<td>22.7</td>
<td>9.07</td>
<td>12.5</td>
<td>54.8</td>
<td>0.46</td>
</tr>
<tr>
<td>Bungoma-3</td>
<td>24.1</td>
<td>8.87</td>
<td>12.3</td>
<td>54.2</td>
<td>0.26</td>
</tr>
<tr>
<td>Mumias-1</td>
<td>23.0</td>
<td>11.31</td>
<td>11.2</td>
<td>53.8</td>
<td>0.38</td>
</tr>
<tr>
<td>Mumias-2</td>
<td>22.5</td>
<td>10.9</td>
<td>10.7</td>
<td>55.3</td>
<td>0.35</td>
</tr>
</tbody>
</table>

The nutrient composition of unconventional ruminant feeds sampled from five different dump sites in Bungoma and Mumias urban slums had a mean % DM of 22.5, % CP of 9.5, % Ash 11.0, % CF 53.5, % Fat 0.35 respectively. Dumpsite feeds obtained from Bungoma and Mumias had high % DM and % CF levels as indicated in Table 2.

Lead and Copper Levels
The mean lead and copper levels in ascending order of the food chain from soil, dump site feeds, water, serum and kidney/liver in Bungoma and Mumias urban slums are shown in Figures 1 and 2, respectively. The highest lead and copper levels were recorded in soil and kidney/liver samples that ranged between 0.4mg/kg – 3.5mg/kg. Of all the samples analyzed, water, serum and refuse dump feeds had negligible quantities of lead and copper that ranged between 0 - 0.001mg/L.
Figure 1: Lead concentration [Pb] in ascending order of the food chain from soil, water, dump site feeds, serum and kidney/liver in Bungoma and Mumias urban slums.

Figure 2: Copper concentration [Cu] in ascending order of the food chain from soil, water, dump site feeds, serum and kidney/liver in Bungoma and Mumias urban slums.

Discussion
This study shows that livestock in urban slums feeding on refuse dumpsite material and drinking waste water are likely to ingest heavy metals implicated to cause toxicity through the human food chain. The free ranging livestock (cattle, sheep and goats) in the urban slums were mainly indigenous to the environment in the study area, thus adapted to the vagaries of climatic
and feed scarcity. This perhaps explains their ability to subsist on materials obtainable at the refuse dumpsites in these urban centres.

Proximate composition of dumpsite wastes was 22.5 and 53.5% DM and CF, respectively. The degradable or non-biodegradable open refuse dumps not only make the environment filthy, but also provide unconventional feed resources for livestock roving in urban centres. The repercussion for consuming indigestible polythene materials is rumen impaction (Mohammed et al., 2007) and poor performance that is a drawback to scavenging livestock in the urban metropolis.

The soil lead levels in the range (1.16 – 2.86mg/kg), were higher than those reported in uncontaminated urban soils of 0.50mg/kg (Mlay et al, 2008), suggesting there was heavy lead contamination in the study area. The soils in the proximity of Mumias sugar factory and Pan African Paper Mills at Webuye (processing paper from timber) had higher lead and copper levels that were almost three times the level from other sites. Elevated mineral levels in Mumias and Bungoma soils were expected due to pollution from the factories in the localities.

The water lead and copper levels of 0.001mg/L were lower than minimum acceptable risk levels of 0.015mg/l (ILO 1983; Fitzgerald 1998). Drinking water from unknown sources predispose animals to ingestion of parasite eggs and heavy metals (Na, Cu, Pb, Cu, etc) that would accumulate leading to parasitosis and mineral toxicosis, consequently affecting humans through the food chain. Although the results here indicate refuse water could be safe for use by animals in as far as the levels of lead and copper are concerned, it is recommend that animals raised in urban centres be provided with clean drinking water and mineral supplements to enhance performance.

The lead levels in serum of cattle, sheep and chicken were 0.86, 0.82, 0.54mg/L and 0.76, 0.46, 0.21mg/L in Bungoma and Mumias, respectively. The elevated lead levels in Bungoma urban slums were probably due pollution through numerous small factories dealing with metal works, garages within Webuye township, exhaust fumes from motor vehicles that use leaded gasoline. The possibility of cattle, sheep and even chicken to obtain extra lead through ingestion of dump site refuse feeds, soil and water cannot be ruled out since these metals tend to bio-accumulate in animal kidney and liver tissues as evidenced in this study pausing danger to the human food chain. The serum lead levels in this study, exceeded those reported by Lopez et al (2000) of (0.01mg/L) suggesting that animals in the urban slums were at risk of exposure to this metal contaminant.
The mean serum copper concentration in the animals was 0.0001mg/L. This was less than 0.955 mg/L level reported by Mlay et al., 2008, and much less than the lower risk level of 0.6mg/L (range 0.6 – 1.47mg/L) recommended by the environmental Protection Agency. The unexpectedly low copper levels could have been due to the assay failing to detect the mineral below a certain threshold in the serum. Based on this study and inconsistent findings elsewhere (Fitzgerald, 1998, Mlay et al., 2008), one should interpret the lead and copper levels in serum and water with caution and where applicable utilize soil, grass, kidney, liver and adipose tissue in assessing heavy metals risks associated with livestock feeding on refuse dumpsite material in urban slums instead of serum and water.

**Conclusions**

Despite presence of lead and copper in soil, water, dump site feeds, serum and kidney/liver of livestock in Bungoma and Mumias urban slums they have not reached the high risk level. However, there is need to continuously monitor the status of these heavy Metals in the urban slums to avoid toxicity in animals and man through the food chain.

**Acknowledgements**

The research work was funded by a grant from the Division of Research and Extension, Egerton University. The authors are grateful to Mr. Kamiti Ndegwa for his assistance in data analysis.

**References**


