# ENVIRONMENTAL HAZARDS IN PERI-URBAN POULTRY FARMING IN WESTERN KENYA

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## ABSTRACT

Poultry keeping is popular in peri-urban centres of Kenya. Poultry wastes arising from intensive poultry units may become too large to be absorbed in the immediate areas of production as crop plots and gardens decrease in size in urban centres leading to potential for environmental hazards. This study was conducted in four urban centres of Bungoma, Eldoret, Kakamega and Kisumu to evaluate the contribution of poultry wastes to environmental hazards. Manure samples were collected from 40 randomly selected intensive poultry farms and taken to the Kenya Bureau of Standards laboratory for microbial and heavy metal content analysis. There was no significant variation in *E.coli* levels between the four municipalities (p-value > 0.353) as well as between the poultry manure types (p-value > 0.823). There was a statistically significant interaction between manure condition and municipalities and the *Salmonella* levels, $F$ (2, 33) = 6.266, $p < 0.005$. There was lack of evidence to dispute the claim that the means concentration (mg $kg^{-1}$) of mercury [$F$ (3, 33) = 1.035, $p < 0.390$] as well as copper [$F$ (3, 35) = 0.084, $p > 0.968$] in poultry manures was similar across the four municipalities. This means that the heavy metal contents in the manure in the study area was below levels that could be considered hazardous in the manure if handled as waste. Strict hygiene and bio-security was recommended. It was recommended that Bio-security and hygiene should be included in the poultry extension programmes and training curricula.

**Keywords:** Environment, Hazards, Poultry, Peri-Urban, Kenya.

## INTRODUCTION

Hazards arising from poultry manure are enormous depending on quantities produced and the way those wastes are disposed of. Besides the desired plant nutrients in manure, undesired pollutants, including pathogenic organisms, antibiotic resistant bacteria and organic pollutants such as pharmaceutical residues and hormones may be present in manure in varied proportions (Petersen *et al*., 2007). Manure which is a resource and sometimes can be a nuisance will become enormous as more intensive commercial systems are applied to meet increasing demand for human food (Cliver, 2009). The United Nations(2015) Sendai Framework for Disaster Risk Reduction 2015-2030 had given first priority to understanding of disaster risk contending that "... in order to reduce disaster risk, there is a need to address existing challenges and prepare for future ones by focusing on monitoring, assessing and understanding disaster risk and sharing such information on how it is created". This would address the disaster risk drivers such as unplanned and rapid urbanization, poor land management, non-risk-informed policies, declining ecosystems, pandemics and epidemics among others (UN, 2015). Most intensive poultry keepers in Kenya are located in urban and sub-urban areas with inadequate space to utilize all the manures for soil amendment; necessitating its long storage and/or transportation to distant farmlands for use as fertilizer, cattle feed and bio-fuel (FAO, 2008). There is increasing production of poultry in peri-urban areas with increased production of manure and accompanying potential pollutants without any documented strategy to control hazardous consequences that arise. Furthermore these hazards have not been quantified. This study was conducted in four municipalities in Western Kenya namely, Kisumu, Kakamega, Eldoret and Bungoma with the following objectives:

i) To determine the levels of zoonotic pathogens in poultry manure;
ii) To determine the concentration of toxic heavy metals in poultry manure;

## LITERATURE REVIEW

### Hazards in Poultry Manure

Environmental pollution is the addition of any substance or form of energy (e.g.. Heat, sound) to the environment at a rate faster than at which the environment can accommodate it by absorbing, dispersing or breaking it down, and that would harm humans, flora and fauna or abiotic systems (Narayanan, 2009). Livestock production is likely to be increasingly affected by carbon constraints and environmental and animal welfare legislation, although demand for livestock products in the future could be heavily moderated by socio-economic factors such as human health concerns and changing socio-cultural values (Thornton, 2010). Manure condition and handling affects its hazard level. Wet litter greatly increases pathogen load, and therefore, chances of disease outbreak (Tabler and Wells, 2012). The intensive nature of poultry production leads to the generation of large amounts of waste in the form of poultry litter which often exceeds the limits that can be safely applied to the land area locally available for litter application (Kelley *et al*. 1994). In the long term, when these application limits for litter are exceeded, environmental degradation often results (Kelley *et al*. 1994)**.** Contribution of poultry to environmental degradation violates the concerns of the United Nations' Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR, 2004) which defines environmental degradation as the reduction of the capacity of the environment to meet social and ecological objectives and needs. Poultry litter contains a diverse population of microorganisms, some of them potentially pathogenic to humans, poultry, or both (Venglovsky *et al*. 2006; Kelley *et al*. 1994). Manure contains the four primary contaminants of water (nitrogen, phosphorous, organic matter and pathogens) in varied amounts (Cliver, 2009).

These contents contaminate water through runoff, leaching and deposition from atmosphere. Excess nitrogen may cause eutrophication of surface water resources while excess ammonia (> 2 ppm.) can lead to fish deaths, while nitrate (>10 ppm.) in drinking water causes blue baby syndrome in infants (Ogejo, 2010). Pathogens present in manure could cause infection to persons consuming crops grown on fields supplied with untreated manure. Stored manure gives airborne emissions including hazardous gases (Ammonia and Hydrogen sulphide), odours, and dust and greenhouse gases (Methane, Nitrous oxide, and Carbon dioxide) (Vu *et al*. 2007). The airborne emissions affect atmospheric visibility and cause respiratory health problems. Odours have negative social effect by causing strained relationship with neighbors who will have emotional and health concerns with bad odours emanating from poultry manures (Ogejo, 2010). Greenhouse gases mentioned above are responsible for global warming that leads to changes in the ecosystems and food production patterns and opportunities. Other potential pollutants in the environment are heavy metals (Sparks, 2005). The term "heavy metals" refers to elements with densities greater than 5.0 g $cm^{-3}$ and usually indicates metals and metalloids associated with pollution and toxicity (Sparks, 2005). Heavy metals can be derived from both natural and anthropogenic sources. According to Sparks (2005), animal manures and pesticides is one of the anthropogenic sources of heavy metals. Copper (Cu), Mercury (Hg), Lead (Pb) and Zinc (Zn) can be spread to the environment through animal manure (Sparks, 2005). Manure is a significant source of heavy metals in soil, and in Europe the permitted levels of Cu and Zn in livestock diets have been lowered to reduce their environmental impact (Petersen *et al*. 2007).

## Strategies for Reduction of Manure Hazards

Manure management involves setting up an effective system to handle and utilize manure produced by livestock. According to the United States Department of Environmental Protection (DEP, 2001) the reasons for developing a sound manure management program include: environmental benefits, economic benefits to the farmer, compliance with laws and regulations concerning environmental quality, limited liability protection, and better neighbor relations. Good manure management starts with recognizing and understanding the value of manure as a resource that contains nutrients for crop production as well as the potential negative impacts manure can have on air, water, and soil (Ogejo, 2010). Manure can be beneficial as a rich source of soil nutrients (Nitrogen and Phosphorous); it can be used in fuel (biogas, char, oils, dry burning) as well as animal and fish feed production. In the future, livestock production will increasingly be affected by competition for natural resources, particularly land and water, competition between food and feed and by the need to operate in a carbon-constrained economy (Thornton, 2010). According to Thru field (2008), biosecurity is the application of management practices that reduce the opportunities for infectious agents to gain access to, or spread within, a food animal production unit. Biosecurity encompasses cleanliness, disinfection, reduction of exposure (e.g., maintenance of perimeter fencing, testing of animals before inclusion into a herd, isolation of new additions and diseased animals, and waste management), management of personnel (limiting visitors, adequate training of staff), and ensuring that animals can be traced(Thrusfield, 2008).

There are several ways of poultry manure management including but not exclusively: lagoon storage; deep stacking; composting; sieving and re-utilization; fuel; feed; and special soil incorporation etc. (Petersen *at.al*, 2007; Kelley *et.al*, 1995; Kirk, 1998). Keeping litter or manure dry has been recommended as a best practice to control ammonia levels, provide a healthy flock environment, and reduce condemnation due to hock and footpad sores (Tabler and Wells, 2012). Tabler and Wells (2012) recommended improved ventilation, manure raking, and use of chemical amendments as strategies to keep litter dry. The numbers of pathogens found in manure is usually reduced by most storage methods such as lagoon storage (slurry), deep stacking and composting (Kirk, 1998). However, manure storage could be complicated further by other environmental issues such as smell and build up of pathogens and even emission of greenhouse gasses (Vu *et al*., 2007). Covered pits used for temporary storage of manure could spread pathogens into ground water. It should be noted also that stored manure will still be affected by losses of ammonia ($NH_3$) via volatilization and contributing to the greenhouse gas load in the atmosphere.

## METHODOLOGY
### Study Site

This study was conducted among poultry farms in four purposively selected urban centers of Bungoma, Eldoret, Kakamega, and Kisumu all in western Kenya (Figure 3.1). These towns were selected for study due to their strategic location on the major trade route to neighboring land locked countries; the existing large numbers of chickens.

Western Kenya is the region bordering Uganda to the West and Tanzania to the South, comprising of former Nyanza and Western provinces as well as the Western highlands extending to Kericho, Nandi hills, Eldoret and Kitale in the North Rift (ICRAF, 2003). The region lies between latitude $1^0$ $8^'$ N and $1^0$ $24^'$ S and between longitude $34^0$ and $35^0$ E. The altitude ranges between 1000 to 1600 metres. Rainfall varies from less than 1000 mm near the shores of Lake Victoria to 2000 mm in the highlands away from the lake shore.

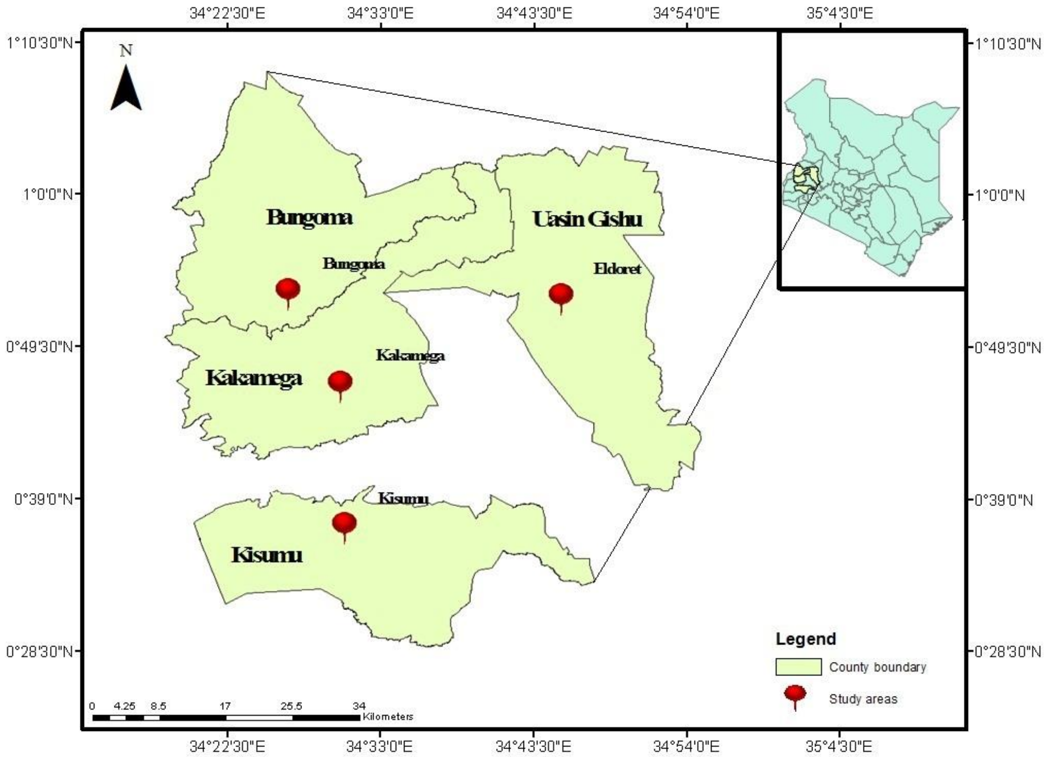


**Figure 3.1: Map of Kenya showing the Study areas in Western Kenya**
Source: Researcher (2014)

## Research Design and Sampling

Reconnaissance survey was conducted to identify poultry farmers in the four municipalities. According to Babbie and Mouton (2001), Survey design is especially appropriate for making descriptive studies of large populations and may be used for explanatory purposes as well. Cross-sectional Survey Design using questionnaires was used to gather data on poultry manure and management practices amongst farmers. In addition, consent of the farmers was sought to take samples of manure for laboratory analysis. Out of the 475 poultry farmers visited, a sample of 40 was randomly selected for manure sample collection. This sample considered to give descriptive and correlation observations as recommended sample size by Kasomo (2008). A total of 40 manure samples were collected from the study area. To ensure representativeness, subsamples of manure were picked from ten different sites at full depth of litter in each poultry house then thoroughly mixed to form a composite sample before packaging about 500 grams of the mixed manure from each poultry house. The samples were packaged securely in plastic bags, sealed, and labeled to indicate the farm, flock type, flock age, and county. The manure samples were then taken to the Kenya Bureau of Standards (KEBS) laboratories for microbial and chemical analysis. For increased reliability, the analysis per sample was done in duplicate.

## Data Analysis

Descriptive statistics were used to analyze levels of zoonotic pathogens and heavy metals in manure samples. Cross-tabulation, Chi square test and ANOVA were used to test differences that existed between the variables across municipalities (Singh, 2008). These were summarized in tables, graphs and charts, means and standard deviation.

## RESULTS

### Levels of Salmonella and E. coli in Poultry

It was found that all the chicken manure from intensive poultry units contained *Salmonella* and *E. coli* in levels that were hazardous (Table 4.1). ). A two-way ANOVA was conducted that examined the effect poultry manures types across the four (Kakamega, Bungoma, Kisumu, and Eldoret) municipalities on the Escherichia coli levels. There was no statistically significant interaction between the effects of poultry manure types and municipalities on the Escherichia coli levels, $F$ (2, 33) = 0.560, $p$ > 0.577.

**Table 4.1: A Summary of the Average Levels of Zoonotic Pathogens Observed In Poultry Manures (the number of positive isolation used i.e., n)**

| | | Poultry manure types | |
|---|---|---|---|
| **Municipality** | **Zoonotic pathogen** | **Dry** | **Wet** |
| Kakamega | Escherichia coli | 2.083 (4) | 18.424 (7) |
| | Salmonella | 1.123 (4) | 0.109 (7) |
| Bungoma | Escherichia coli | 5.949 (7) | ND |
| | Salmonella | 0.094 (7) | ND |
| Kisumu | Escherichia coli | 27.213 (9) | 17.962 (3) |
| | Salmonella | 0.122 (9) | 0.150 (3) |
| Eldoret | Escherichia coli | 0.347 (3) | 0.200 (7) |
| | Salmonella | ND | 0.024 (7) |

Units used were Million Colony forming units per gram
ND = Not determined.

Further tests were carried out concerning the presence of the main effects. However, there was no significant difference in Escherichia coli levels between the four municipalities (p > 0.353) as well as between the poultry manure types (p > 0.823). Another two-way ANOVA was employed that examined the effect of poultry manure types across the four (Kakamega, Bungoma, Kisumu, and Eldoret) municipalities on the salmonella levels. There was a statistically significant interaction between the effects of poultry manure types and municipalities on the salmonella levels, $F$ (2, 33) = 6.266, $p$ < 0.005. Further multiple comparisons for each combination of poultry manure type and municipality were examined to determine the differences in average salmonella levels. It was observed that only Kakamega had significantly greater levels of Salmonella than Bungoma, Kisumu, or Eldoret municipality in dry poultry manures.

**Concentration of Heavy Metals in Poultry Manure**

A one-way ANOVA was conducted that examined the average chemical composition of Lead **(Pb)** in poultry manures across the four municipalities (Kakamega, Bungoma, Kisumu, and Eldoret). There was enough evidence to support the claim that at least one of the means concentration (mg $g^{-1}$) of lead in poultry manures among the four municipalities differed from the others, $F$ (3, 34) = 2.905, $p < 0.049$. Next, the Least Significant Difference (LSD) post hoc test was carried out to establish how the means concentration (mg $kg^{-1}$) of lead in poultry manures differ among the four municipalities and the results for the different municipalities presented in the Multiple Comparisons table, as shown below:

**Table 4.2: Multiple Comparisons of Lead Concentration LSD among Municipalities**

| (I) Municipality | (J) Municipality | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Kakamega | Bungoma | 0.53 | 4.50 | 0.91 | -8.62 | 9.69 |
| | Kisumu | 10.35* | 3.99 | 0.01 | 2.23 | 18.46 |
| | Eldoret | 6.58 | 4.09 | 0.12 | -1.73 | 14.89 |
| Bungoma | Kakamega | -0.53 | 4.50 | 0.906 | -9.69 | 8.62 |
| | Kisumu | 9.81* | 4.42 | 0.033 | 0.83 | 18.79 |
| | Eldoret | 6.05 | 4.50 | 0.188 | -3.11 | 15.20 |
| Kisumu | Kakamega | -10.35* | 3.99 | 0.014 | -18.46 | -2.23 |
| | Bungoma | -9.81* | 4.42 | 0.033 | -18.79 | -0.83 |
| | Eldoret | -3.77 | 3.99 | 0.35 | -11.88 | 4.35 |
| Eldoret | Kakamega | -6.58 | 4.09 | 0.12 | -14.89 | 1.73 |
| | Bungoma | -6.05 | 4.50 | 0.19 | -15.20 | 3.11 |
| | Kisumu | 3.77 | 3.99 | 0.35 | -4.35 | 11.88 |

*. The mean difference is significant at the 0.05 level.

From the multiple pair wise comparisons, the pairing of municipalities of Kakamega and Bungoma, Kakamega and Eldoret, Bungoma and Eldoret, as well as Eldoret and Kisumu were not significantly different from each other; both had similar chemical composition of lead in poultry manures. However, Kisumu had significantly lower average chemical composition of lead in poultry manures than both Kakamega ($p < 0.014$) and Bungoma ($p > 0.033$). Irshad *et al*. (2013) established that chicken manure had higher content of lead than ostrich, cow and goats. Also, one-way ANOVA was conducted that examined the chemical compositions of **mercury (Hg)** and **copper (Cu)** in poultry manures across the four (Kakamega, Bungoma, Kisumu, and Eldoret) municipalities. But, there was lack of evidence to dispute the claim that the means concentration (mg $kg^{-1}$) of mercury [$F$ (3, 33) = 1.035, $p < 0.390$] as well as copper [$F$ (3, 35) = 0.084, $p > 0.968$] in poultry manures was similar across the four municipalities. This means that the heavy metal contents in the manure in the study area was below levels that could be considered hazardous in the manure if handled as waste.

## DISCUSSION

According to the requirements of Kenya Bureau of Standards, these pathogens must be absent in all foodstuffs. Results of microbial content and comparison with critical levels are summarized in Table 5.1. It appears that the levels of Salmonella in poultry manure were high compared to studies from other parts of the world. Salmonella levels of between 100 to 1000 cells have been shown to be infectious to man causing a variety of ailments including Salmonella enteritis, Typhoid Fever, Paratyphoid fever (diarrhea, dysentery, systemic infections that spread from the intestinal tract to other parts of the body, abdominal pain, vomiting, dehydration, septicemia arthritis and other rheumatologic syndromes) (USEPA, 2013).

**Table 5.1: Summary of Microbial Contents of Poultry Manure Samples from Peri-Urban Poultry Farms in Western Kenya**

| Hazard | Findings in Study area | Critical levels | Hazard status |
|---|---|---|---|
| Escherichia coli | **12 million cfu per gram** | Must be absent in food. | Hazard |
| Salmonella spp. | **0.19 million cfu per gram** | Must be absent in food. | Hazard |
| E. coli | **12 million cfu per gram** | **3 – 50,000 cfu/gram** of feces is the range of amount normally shed by animals.<br>**10 cfu/gram in feces is** the minimum that causes infection in man. | High.<br><br>Hazard |
| Salmonella spp. | **0.19 million cfu per gram or 1.9 x $10^5$ cfu per gram** | 2.2 X $10^4$ **for wet manure** | High |

In a study on levels of zoonotic agents in British livestock manures, the reported highest levels (CFU $g^{-1}$ ) observed for Salmonella from poultry manure were 2.2 X $10^4$ for wet manure and 8.0 X $10^3$ for wet manure respectively (Hutchison *et al.* 2004). The levels of *E. coli* detected in western Kenya were higher than levels reported to be shed by livestock (Table 5.2). These results indicated that poultry manure were vector to both Salmonella and E. coli. These pathogens would contaminate objects with which the poultry manure came in contact including foodstuffs such as leafy vegetables, water bodies and roadside facilities. Spread of the manure was reported to be through spillage on transit to farms, application on gardens and through dust emitted from the units as a result of scratching and wing flapping by the birds. It was however not clear why Kisumu registered much higher levels of E. coli than the rest of the municipalities. Kakamega municipality also showed higher counts of Salmonella than the others. The study also determined the average concentration of toxic heavy metals in poultry manures across the four municipalities. Poultry manure is classified as a hazard in itself since it may cause serious eye irritation, may cause respiratory irritation and may be harmful if swallowed (Ogejo 2010).

**Table 5.2: Summary Of Manure And Heavy Metal Contents Of Poultry Manure From Peri- Urban Poultry Farms In Western Kenya**

| Hazard | Findings in Study area | Critical levels | **Hazard status** |
|---|---|---|---|
| Copper | **Mean of 68.1 ppm** | **20-100** mg/kg intake toxic to young sheep and calves.<br>**200-800** mg/kg intake toxic to adult cattle.<br>**>25** ppm in any feed potentially toxic to sheep. | Hazard on ingestion. |
| Lead | **Mean of 15.7 ppm** | **500** mg/kg. Wastes containing concentrations greater than this are considered hazardous.<br>**ML** in salt food grade is 1 mg/kg | Waste Not Hazardous |
| Mercury | **Mean of 29.7 ppm** | **10,000 mg/kg.** Wastes containing concentrations greater than this are considered hazardous.<br>**ML** in salt(food grade) is 0.1 mg/kg | Waste Not Hazardous Hazard on ingestion |

ML = maximum limit.

## CONCLUSIONS

It was found that levels of Salmonella and *E coli* in the manure from the survey area were higher than those reported elsewhere. This suggests that the poultry manure from the study area was vector of these two zoonotic pathogens. Use of the manure would require necessary precautions to avoid spread of these diseases in the environment. Concentration of copper in the manure samples were comparable to those found elsewhere. They were probably safe if disposed of in soils except if ingested by sheep and cattle. Levels of Lead and mercury were far below what would be considered hazardous in wastes. The mercury levels however were above the minimum limit in salt (food grade). This means that the poultry manure was relatively safe to use on land with respect to heavy metal pollution. However, these results show that ingestion of the manure would probably be harmful to health of animals, especially sheep. Sustainable poultry manure management must address the entire manure chain from its production point at the poultry house through the storage and transport process and end use points whether as fertilizer, cattle feed or fuel. Recommendations given in view of this survey study would address three main areas namely: biosecurity and hygiene in manure management, formulation of laws and by-laws and inclusion of biosecurity in extension programmes.

Adherence to strict hygiene and biosecurity is recommended to avoid the danger associated with poultry in the peri-urban areas. There should be restricted use of poultry manure or application of measures to reduce its pathogen and heavy metal content before being used as soil amendment. Minimum distances between poultry facilities and sensitive areas such as residential houses and water bodies should be defined by law.It is also recommended that biosecurity and hygiene be included in the poultry extension programmes and training curricula. There is a need to improve the knowledge of local authorities and farmers about sustainable manure management to keep a balance between livestock, land and environment.

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