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ENVIRONMENTAL AND PUBLIC HEALTH RISKS OF URBAN AGRICULTURE IN KISUMU CITY, KENYA

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ABSTRACT

Kenya's blueprint on national development (Vision 2030) is based on the principles of sustainable development and it has prioritized agriculture to drive economic development. The current Kenya's Constitution (2010) provides for the right to a clean and healthy environment as well as to food of good quality. The aim of this study was to determine the environmental and public health risks of crops grown in the privately-owned land within Kisumu City, Kenya. This study was premised on the assumption that farm produce from privately – owned land is relatively safe as they are less predisposed to municipal wastes, waste water and exhaust fumes. Therefore, the study was carried out in privately-owned land away from road reserves and storm water from rivers, roads and built up urban areas. This study assessed concentrations of Lead, Zinc, Copper, Cadmium, Iron, and Chromium in 5 leafy vegetables; 2 root crops; and 1 fruit crop. The study involved a sample of 24 edible tissues of crops (5 leafy vegetables - *vigna sinensis, chlorophytum comosum, crotolariabrevidens, amaranthus and kales;* 2 root crops (*dioscorea and Manihot esculenta*), and 1 fruit crop (*Carica papaya*) and 24 soil samples. The results of this study show that there are low traces of heavy metals in the crops and those found in the soils, vegetables and fruits are within the WHO/FAO permissible standards. The highest concentrations of Pb, Zn, Cu, and Fe were found in *carica papaya (*0.303ppm) *crotolariabrevidens (*8.167ppm)*, crotolariabrevidens (*13.6ppm)*,* and *amarantus* (6.637ppm) respectively. The concentrations of Pb, Zn, CU, Fe, and Cr in the soils were, respectively, 0.313ppm, 0.359ppm, 0.054ppm, 123.093ppm and 0.049ppm, while the WHO/FAO standards for Pb, Zn, Cu, Fe, and Cr in soil are 100ppm, 300ppm, 100ppm, 50,000ppm, and 100ppm respectively. WHO/FAO limits for Pb, Cd, Cr, Zn, and Cu in vegetables and fruits are 0.5, 0.2, 1.2, 1.5, and 2.0 respectively. No traces of cadmium and chromium were found in the sampled crops. So, farm produce from such parcels of land are safe for human consumption. The results of the study indicate that it is possible to undertake safe urban farming on privately – owned land in the City for the benefit of the residents. So, necessary measures should be taken by the City authority to promote urban farming, including land use zoning and control of waste disposal into the farms. Other measures include regular monitoring of urban farming for quality and safety concerns.

Key words: Urban, agriculture, Kisumu, City, Kenya, environmental, public, health, risk

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INTRODUCTION

Kenya has during the last decade instituted major institutional reforms geared towards improving the quality of life in the country. This begun in earnest with the blueprint on national development in 2008, which embraced the principles of sustainable development. Further, in 2010, the country passed the Constitution that created a framework for transformation of governance and management in the Country. For example, the Constitution (Article 42) creates the bills of rights, including the right to a clean and healthy environment; and the right to goods and services of good quality (Article 46) [1]. In addition, in 2009, Parliament approved a policy on land creating structures for the development of urban agriculture [2], a land use that was hitherto excluded from urban land use classification. Following the passage of the policy, agriculture is now a legitimate urban land use. Therefore, city authorities are expected to take necessary measures to develop the sector.

Kenya has registered rapid rate of urbanization (approximately 5 percent per year) during the last five decades, but the development of basic infrastructure and services has not occurred at comparable rates. About 35% of the country's population lives in the urban areas. Kisumu City is the third largest urban centre in Kenya with a population of about 721,000 people. Its annual population growth rate is 2.8% [3]. The rapid rate of urbanization has exerted pressure on the existing infrastructure and services evidenced by a large proportion of the urban population (over 50 percent) living in the informal settlements. Just 10% of Kisumu City is served by sewerage system which often dysfunctions because of poor systems of maintenance and repair. In the absence of basic infrastructure and services, uncollected and poorly disposed of solid and liquid wastes find their way in the environment increasing environmental and public health risks.

Unlike unsecured public land, privately-owned land is less predisposed to pollution from illegal dumping of waste and pollution-laden storm – water discharges from different parts of the City. Therefore, it is possible to expect low pollution levels in the private land making it possible to engage in safe urban agriculture. Idle private land in the urban and peri – urban areas can be harnessed for productive and safe urban agriculture before they are converted into other urban development. By tapping ready market within the City, urban agriculture can contribute to food supply, employment creation and income.

Kisumu is emerging from 'an agricultural City' where the City has developed from and encroached into rural farmlands. A substantial area of the City is still used and fertile for urban agriculture. The two main wetlands of Nyamasaria and Obunga have deep alluvial soils, black cotton soil with farming activities in the Nam Thowe area which supply the City with vegetables [4].

Despite the important role played by urban agriculture in meeting food security needs as well as income and employment creation, serious environmental and public health concerns have been raised because of poor management of wastes. One of the major safety concerns relates to pollution from municipal waste including exhaust fumes,

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waste water, and solid waste. Also, poorly managed urban agriculture predisposes urban residents to environmental and public health safety risks such as infectious diseases, rodents, odour spell, noise pollution, and insecurity. Bushes of urban farms and poorly managed waste create conditions for the spread of diseases such as malaria. Some animals generate unpleasant smell including noise pollution, for example pigs, poultry, and livestock. Further, urban farms create bushes that can be used as hideouts by criminals. Therefore, poorly managed urban agriculture can compromise the well – being of the farmers, consumers and the overall environmental quality. This paper sought to investigate the safety of farming in the privately – owned land in Kisumu City.

Constitutional, policy and legislative context of urban agriculture
A decade ago, the Country passed a new Constitution whose full implementation is still underway. The new Constitution created robust governance and management regime including elaborate bills of rights, and devolution of governance and management. For the first time in the history of the country, the right to a clean and healthy environment found its way into the Constitution. Article 42 of the Constitution states that every person has the right to a clean and healthy environment, which includes the right (*a*) to have the environment protected for the benefit of present and future generations. The same Constitution obliges state and citizens to contribute to the realization of a clean and healthy environment. Article 69(1) of the Constitution states that the State shall (*a*) ensure sustainable exploitation, utilization, management and conservation of the environment and natural resources, and ensure the equitable sharing of the accruing benefits; (*d*) encourage public participation in the management, protection and conservation of the environment; (*f*) establish systems of environmental impact assessment, environmental audit and monitoring of the environment; (*g*) eliminate processes and activities that are likely to endanger the environment; and (*h*) utilize the environment and natural resources for the benefit of the people of Kenya. Further, article 69(2) states that every person has a duty to cooperate with State organs and other persons to protect and conserve the environment and ensure ecologically sustainable development and use of natural resources [1].

The Constitution seeks to protect the consumers from unsafe produce. Article 46 states that consumers have the right (*a*) to goods and services of reasonable quality; (*b*) to the information necessary for them to gain full benefit from goods and services; *c*) to the protection of their health, safety, and economic interests; (*d*) to compensation for loss or injury arising from defects in goods or services [1]. So, in the case of urban agriculture, farm produce should meet the consumers' right to food of reasonable quality. The Constitution creates structures for performance of functions by the different levels of Governments, namely National and County. As per the constitutional requirement, agriculture is a devolved function, but the national government is responsible for policy and legislations as well as technical support to the devolved units. The fourth schedule, part two of the Constitution states that agriculture, including crop and animal husbandry is a County Government function. Therefore, the responsibility to ensure that urban agriculture in Kisumu City is undertaken in conformity with the Constitution rests with the County Government.

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Although prior to the year 2009 agriculture was not designated as an urban land use, but it was permissible under strict conditions. The policy on land created opportunities for the development of agriculture in the urban areas by including it as an urban land use. Since it was not included in the land use classification, it was impossible to harness its full potential in addition to monitoring the quality of the produce. Furthermore, most parts of cities and urban areas in Kenya are largely rural where agriculture remains an integral part of socio – economic activities. So, the land policy can be seen as a major response to the reality of urban agriculture in the Country. Section 110 of the policy notes that urban agriculture has not been properly regulated and facilitated in the country. The policy (section 111) calls for promotion of multi-functional urban land use; and putting in place an appropriate legal framework to facilitate and regulate urban agriculture and forestry [2].

In an effort to cascade national policy position on urban agriculture to the county level, County Government Act [5] has provided specific objective of planning to facilitate the development of a well-balanced system of settlements and ensure productive use of scarce land, water and other resources for economic, social, ecological and other functions across a county. The County Government of Kisumu has not taken necessary measures to institutionalize urban agriculture in compliance with national policies and legislations. The Kisumu County Integrated Development Plan (2013/2017) maintains the traditional approach to agricultural development, which has treated agriculture as a rural land use [6]. The plan has prioritized development of agriculture and rural development with no mention of urban agriculture. So, the development of urban agriculture in Kisumu city is likely to suffer with attendant environmental and public health risks to the unsuspecting consumers.

Theoretical underpinning

The theory of political ecology has been deployed to structure this study. This theory is relevant to this study as environmental quality in Kisumu City is attributed to the socio – economic processes in the face of environmental governance and management regimes in the county. Pollution of land and water bodies in cities originate from residential, industrial, commercial and institutional sources as well as traffic. Environmental quality in a city is related to the level of resources (financial, personnel and technology, and regulations) that the political leadership mobilizes for that purpose. Therefore, environmental and public health risks caused by urban agriculture produce is explained by the prevailing governance and management regime in the city.

Urban Political Ecology takes interest in cities as dynamic hybrids, constantly (re-) produced by humans and non-humans alike. These processes are socially embedded and historically specific. This implies that they are influenced by power relations which mediate between humans as well as between humans and non-humans. Special attention is paid to the dynamics in practices, discourses and social relations as well as societal relationships with ‘nature’. Neo-Marxist approaches became popular for their simultaneous attention to political and economic factors in clarifying how material power (for example capital, wealth, military power) mediates human/society/nature relations [7].

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MATERIALS AND METHODS

Location and extent of the study area

This study was undertaken in Kisumu City. The City is located at the shores of Lake Victoria, the second largest freshwater lake in the world. Kisumu City is situated about $00^{0}06'$ South of the Equator and $34^{0}45'$ East of Greenwich. It lies between Lake Victoria at an elevation of approximately 1140m above sea level and the Nyando Escarpment to the North, which rises to over 1800m above sea level. The City covers an area of approximately 417 km^2, of which 297 km^2 is dry land and approximately 120km^2 under water. The City receives mean annual rainfall of 1245 mm occurring in two seasons, the long and short rainy seasons occur during March-June and October-November periods respectively. The mean annual minimum and maximum temperatures are $17.3^{0}c$ and $28.9^{0}c$ respectively [8]. Figure 1 shows the location of Kisumu City in the regional context, while Figure 2 shows the location where farms were sampled for this study within Kisumu City.

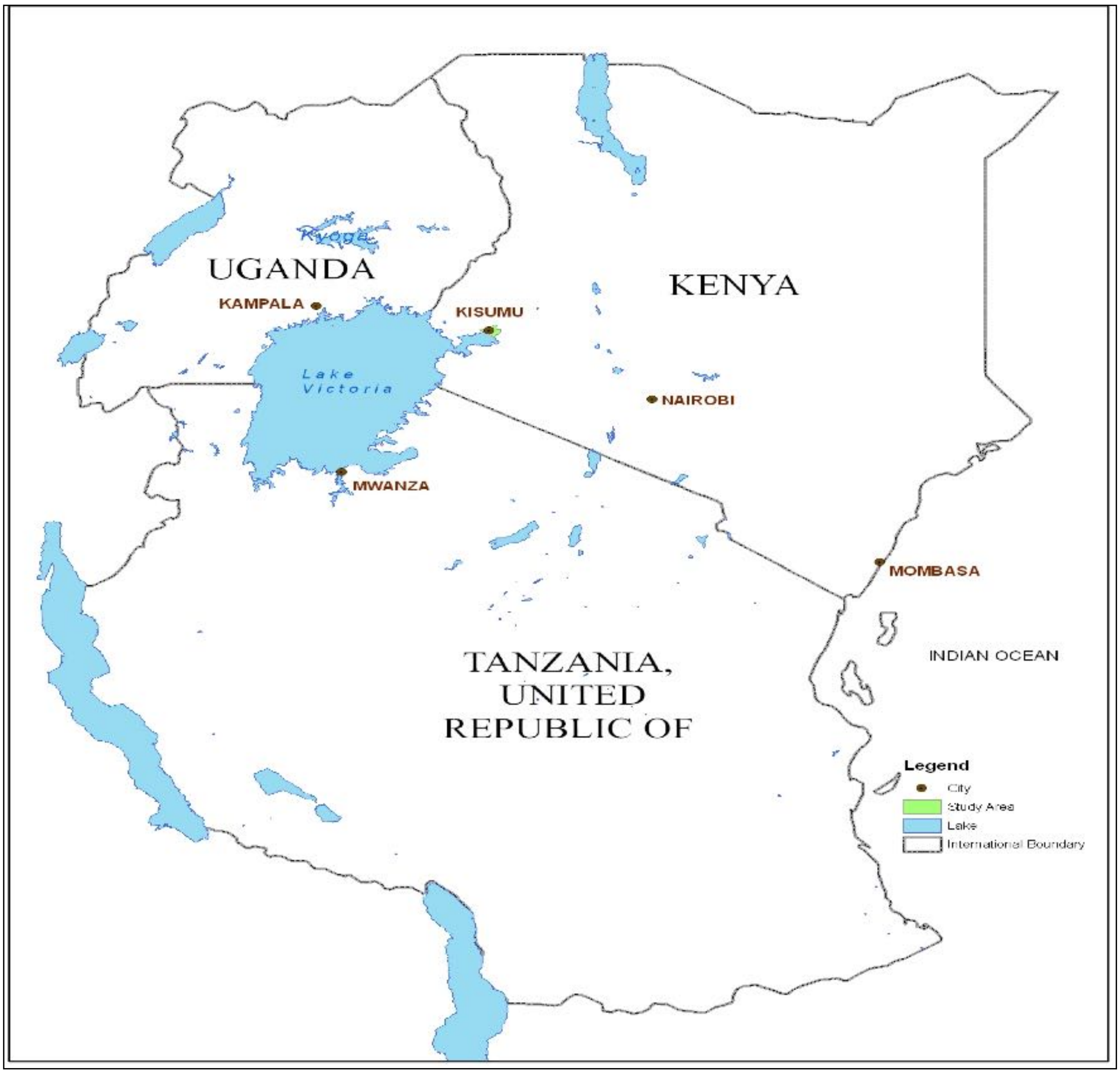

Figure 1: The Location of Kisumu City in the Regional Context

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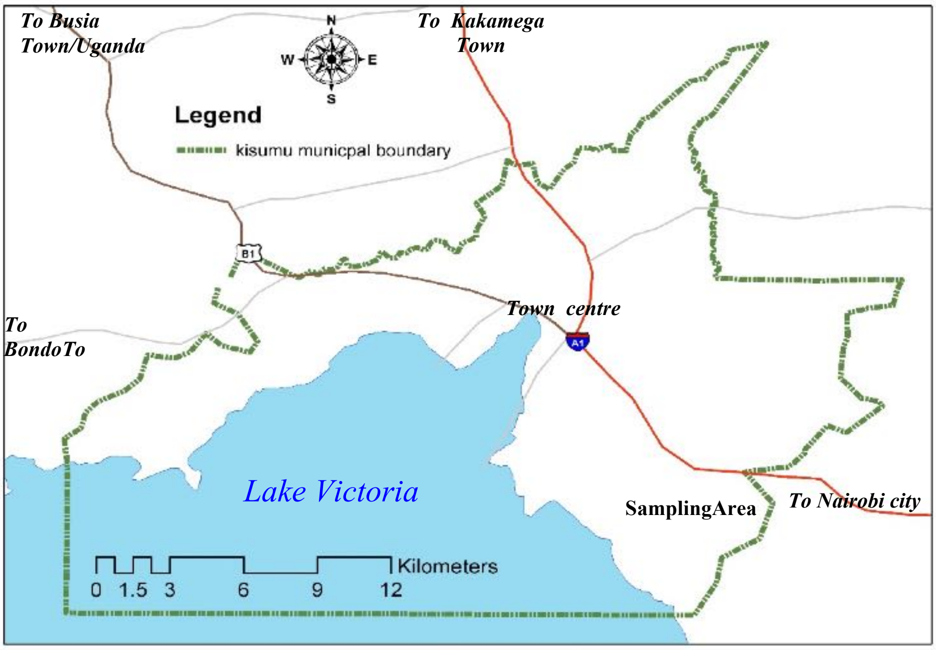

Figure 2: Kisumu City and the sampling area

Kisumu City has developed from terminus of Kenya – Uganda Railway line at Port Florence that was founded in 1901 at the shores of Lake Victoria. According to National Population Census, the City of Kisumu has grown rapidly during the last five decades rising from 32,431 in 1969 to 500,000 in 2009 to 721,000 in 2019 [9, 10, 11]. Kisumu City is the third largest urban centre in Kenya and urban agriculture remains a major feature in the City contributing towards livelihoods of the residents. Further, a significant proportion of the City remains rural in character where agriculture can be promoted in transition to other urban land uses. The city experiences one of the highest incidences of food poverty with 48 per cent of the population falling below food poverty [4].

The choice of the sampling area was informed by the main objective of the study – to determine the safety of farm produce from private farms in the City. Sampling of the farms was informed by the following factors: First, it is the area where intensive horticultural crop farming is taking place within the municipality. Second, the area is not drained by storm water from the built up areas of the municipality. Third, it is not exposed to municipal waste disposal. Fourth, the area is located 2km away from major roads, which can cause pollution from exhaust fumes. Fifth, different types of crops are grown in the area: leafy vegetables, root crops, and fruit trees.

The sampling area is basically a wetland with high water table so farmers dig shallow wells to obtain water for irrigation. The crops sampled are grown using both rainfall and irrigation (during the dry season). During the dry season, water used for irrigation is obtained either by hand from shallow wells in the farms or from Nyamasaria River

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draining along the border of the farms. Nyamasaria River drains from farmlands away from the built up area of the City. Sampling of crops and soil was taken during the month of October, just before the onset of the short rainy season.

Sampling of soils and crops

The study aimed at determining the concentrations of heavy metal in the soils, root crops, leafy vegetables and fruits and the environmental and public health implications. This study involved analysis of heavy metals in 5 leafy vegetables (*vigna sinensis, chlorophytum comosum, crotolariabrevidens, amaranthus and kales*), 2 root crops (*dioscorea and Manihot esculenta*), and 1 fruit crop (*Carica papaya*) as well as soils. These are the crops most commonly grown in the area. Further, apart from kales, all the other leafy vegetables are indigenous. These indigenous vegetables are very popular among urban residents. The samples were tested for the concentrations of Lead (Pb), Zinc (Zn), Copper (Cu), Iron (Fe), Cadmium (Cd) and Chromium (Cr).

Apart from *Carica papaya* that is grown at the edges of individual farming units, each of the crops are grown in separate spatial units dedicated to them measuring approximately 16m^2. In order to assess pollution levels in the 8 crops sampled, one transect in the middle of each of the 7 sub plots for each of the crops was set up. Along each of the 7 transects, 3 samples of the edible tissues of the 7 crops were taken. In addition, a sample of 3 *Carica papaya* trees was taken from 12 *Carica papaya* trees using simple random sampling. From each of the 3 sampled *Carica papaya* trees, a sample of 1 *Carica papaya* fruit was taken for the study using simple random sampling. In order to determine the relationship between pollution levels in the edible tissues and soils, 24 soil samples were taken around the roots of each of the crops sampled. The soils were sampled from the top 20cm after removing surface vegetation.

Materials treatment and testing

In order to investigate the concentrations of heavy metals in both edible tissues of the crops and soils, the samples were cleaned and dried in open air. For the purpose of analysis the dried samples were pulverized in a mortar to convenient sizes, so the samples were passed through 2 mm sieve. The 24 soil samples taken were oven-dried at 60^{0}c and homogenized, namely coarse material > 2 mm were removed using 2 mm stainless steel sieve because coarser grains always have less affinity with heavy metals. The finer fraction (<2 mm) of the samples was finely powdered using a pestle and mortar. For the analysis of edible tissues of the crops and soil, dried material (0.1 g) was digested in 10 ml of aqua-regia. They were heated to near dryness and the digest made up to 50ml in volumetric flasks.

Analysis of Pb, Zn, Cu, Cd, Fe, and Cr

A Buck scientific AA spectrometer was used for analysis of Pb, Zn, Cu, Cd, Fe, and Cr. The conventional parameters of acetylene–air FAAS analyses were applied. The standards were prepared by diluting the Merck AAS standard solutions of the nitrates of elements, analytical grade, and acidifying to 1% (v/v) with nitric acid.

As shown in Table 1, the permissible WHO/FAO standards of Pb, Zn, Cu, Cd, Fe, and Cr in the soils are 100ppm, 300ppm, 100ppm, 50,000ppm, 3ppm and 100ppm, respectively. Also, heavy metals in vegetables and fruits are within the permissible WHO/FAO limits: Pb, Cd, Cr, Zn, and Cu are 0.5, 0.2, 1.2, 1.5, and 2.0ppm, respectively.

RESULTS AND DISCUSSIONS

Lead

The levels of lead found in the crops tested were in the range of 0.08 – 0.303ppm, which were within WHO/FAO limits on vegetables and fruits of 0.5ppm. The two root crops tested *(dioscorea and Manihot esculenta*) similarly had comparable levels of lead, 0.182ppm and 0.13ppm, respectively. The concentration of lead in *crotolariabrevidens* was lowest (0.08ppm), while *Carica papaya* (0.303ppm) had the highest concentrations of lead. In addition, this study found the concentration of lead in the vegetables to be much lower than the levels found in the soil (0.313ppm). The concentration of lead in the soil was similar to that found in *Carica papaya* (0.303ppm) suggesting efficient uptake of lead from the soil. The concentration of lead in the soil was much lower than the WHO/FAO permissible standards of 100ppm. A study on the concentrations of lead in fruits (local guava and mango) in Kisumu municipality was found to be 0.3ppm levels [12], which was very similar to this study that found lead in *Carica papaya* to be 0.303ppm. Similarly, the study sampled the fruits from 7 sub-plots in private farms, about 2km away from the highway, which was less predisposed to pollution.

This study found the concentration of lead in *amaranthus* to be 0.25ppm levels, which was significantly different from another study [12] conducted in Kisumu municipality that found the concentration of lead in *amaranthus* was 2.5ppm as they took their samples along the road reserve. The concentration of lead along the road reserve was bound to be much higher because of exhaust fumes from vehicles and storm water pollution. Land held by individuals and is located away from pollution – prone areas (such as road reserves) and flood – prone areas are likely to be safe for urban farming.

The findings of this study showed that the traces of lead in *Brassica oleracea* (0.107ppm) and *dioscorea* (0.182ppm) were much lower than the findings of a similar study within Kisumu municipality [8], which was undertaken in an area that was predisposed to pollution from municipal solid waste. The study found that the concentrations of lead in *Brassica oleracea* and *dioscorea* were 1.44ppm and 1.3ppm respectively. The major differences in the concentrations of lead could be explained by higher exposure to pollution in the latter case, which was in proximity to the municipal solid waste disposal site.

Zinc, Copper and Iron

The levels of zinc in the crops tested were in the range of 0.164 – 8.167ppm. Zinc concentrations in vegetables and fruits are within the permissible WHO/FAO standards of 1.5ppm except in *Vigna sinensis* (5.447ppm) and *Crotolariabrevidens* (8.167ppm). The concentration of zinc in the soil (0.359ppm) was much lower than that found in *vigna sinensis* and *crotolariabrevidens.* The crops with the lowest concentrations of zinc were *amarantus* (0.164ppm) and *Manihot esculenta* (0.216ppm). A study [14] in

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Nigeria found the concentrations of zinc in *Manihot esculenta* tuber and soil to be 28.8ppm and 17.7ppm, respectively. The results of the study in Nigeria were much higher than the findings of this study, which found the concentrations of Zinc in *Manihot esculenta* tuber and soil to be 0.216ppm and 0.359ppm, respectively. The concentration of zinc in the soil was much lower than WHO/FAO permissible standards of 300ppm, which was important for both farmers and unsuspecting consumers of farm produce from the area.

The concentrations of copper in the crops grown were in the range of 0.041 – 13.6ppm. The concentration of copper in the vegetables and fruits was within the permissible WHO/FAO standards of 2.0ppm except in *crotolariabrevidens* (13.6ppm) and *Vigna sinensis* (2.193ppm). Copper was very low in *Carica papaya* (0.041ppm) and *amaranthus* (0.042ppm). The concentration of copper in the soil (0.054ppm) was far below the WHO/FAO permissible standards of 100ppm. The traces of copper in *Brassica oleracea* (0.26ppm) and *dioscorea* (0.144ppm) were relatively higher than those found in a study [8] that found traces of copper in the said crops to be 0.045ppm and 0.042ppm, respectively. The differences in the concentrations of copper in *Brassica oleracea* and *dioscorea* could be explained by differences in exposure to pollution sources in the City. In the latter case, the farms were in proximity to the municipal solid waste disposal site with high risks of pollution.

Test results showed that most crops were rich in iron, except *Carica papaya*. *Carica papaya* had the lowest concentrations of iron, but *vigna sinensis, chlorophytum comosum,* and *amaranthus* had 3.34ppm, 5.873ppm and 6.637ppm iron concentrations, respectively. The soils were rich in iron (123.093ppm), which explained the high iron concentrations in the crops tested. The traces of iron in the crops grown were in the range of 0.895 – 6.637ppm. The concentration of iron in the soils (123.093ppm) and *Manihot esculenta* (2.167ppm) was significantly different from those found in another study [14], which found the concentrations of iron in the soils and *Manihot esculenta* to be 15.5 and 30.3ppm, respectively. The concentration of iron in the soil was within WHO/FAO permissible standards dispelling health risks of farm produce from such farms.

Cadmium and Chromium
Traces of cadmium and chromium were not found in all the crops tested, although traces of chromium (0.049ppm) were found in the soils. WHO/FAO limits for cadmium and chromium in vegetables and fruits is, respectively, 0.2ppm and 1.2ppm, while the permissible concentrations in soils are 3ppm and 100ppm, respectively. The absence of cadmium and chromium in all the crops surveyed was a good indication of safety of farm produce in the private farms. The findings of this study were much better than the findings of a study [8] that found the concentrations of cadmium in both *Brassica oleracea* and *dioscorea* to be 0.243ppm and *dioscorea* 0.327ppm, respectively and traces of chromium in *Brassica oleracea* and *dioscorea* to be 0.211ppm and 0.043ppm, respectively.

CONCLUSION

This was a study of pollution in crops on private land in Kisumu City, Kenya. The crops covered in the study were: *vigna sinensis, chlorophytum comosum, crotolariabrevidens, amaranthus, Brassica oleracea, Manihot esculenta, Carica papaya, and dioscorea.* Soil samples in the farm were also taken to relate pollution levels in both crops and soils. The study was undertaken on land located 2km away from the major roads. The heavy metals tested were: lead, zinc, copper, iron, cadmium and chromium. The farms covered are relatively less predisposed to pollution from storm water and municipal solid waste, with the exception of occasional flooding by the nearby Nyamasaria River that does not drain the built up areas of the City. Therefore, the farms are not predisposed to contamination from urban settlements. The findings of the study showed that crops and soils tested had low concentrations of the heavy metals. The concentrations of heavy metals in the soils tested were well within WHO/FAO permissible standards suggesting that crops grown in land held by individuals were relatively safe.

The findings of this study showed variations in the concentrations of heavy metals in root crops, fruits and leafy vegetables. The study found varying amounts of the heavy metals tested (lead, zinc, copper, and iron) in the crops and soils tested. Test results showed no traces of cadmium and chromium in the crops, which was good news for the consumers of urban agriculture produce in the City. Traces of cadmium and chromium in edible tissues represent serious health risks as the two heavy metals are highly toxic. The root crops (*dioscorea and Manihot esculenta*) and fruit (*Carica papaya*) tested had relatively lower concentrations of heavy metals compared with leafy vegetables, especially indigenous ones (*vigna sinensis, chlorophytum comosum and crotolariabrevidens*).

In compliance with the constitutional requirement and land policy, the County Government of Kisumu should take necessary measures to institutionalize the development of urban agriculture in the City. Urban agriculture in the City should be regulated through mapping and zoning of land less predisposed to urban pollution, thus suitable for the development of urban agriculture. Urban agriculture, especially of high value crops can contribute to meeting the growing demand for food in the City as well as create employment opportunities. Further, this will be a better way of using idle land before they are converted to other urban land uses. Urban agriculture should be regularly monitored to safeguard the public from environmental and health risks that are likely to increase with conversion of land into other urban development.

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Table 1: Concentrations of heavy metals in some selected crops and soils and WHO/FAO standards

Types crops	Lead (Pb)	Zinc (Zn)	Copper (Cu)	Iron (Fe)	Cadmium (Cd)	Chromium (Cr)
Vigna sinensis	0.123	5.447	2.193	3.34	0.000	0.000
Chlorophytum comosum	0.163	1.147	0.553	5.873	0.000	0.000
Crotolariabrevidens	0.08	8.167	13.6	2.83	0.000	0.000
Amarantus	0.25	0.164	0.042	6.637	0.000	0.000
Brassicaoleracea	0.107	0.57	0.26	2.287	0.000	0.000
Carica papaya	0.303	0.291	0.041	0.895	0.000	0.000
Manihot esculenta	0.13	0.216	0.212	2.167	0.000	0.000
Dioscorea	0.182	0.681	0.144	2.045	0.000	0.000
Carica papaya	0.303	0.291	0.041	0.895	0.000	0.000
Soil	0.313	0.359	0.054	123.093	0.000	0.049
WHO/FAO in soils	100	300	100	50,000	3	100
WHO/FAO in vegetables / fruits	0.5	1.5	2.0	-	0.2	1.2

Source: Field Survey, October 2009 and WHO/FAO heavy metals limits in the soils [15]; WHO/FAO heavy metals limits in vegetables and fruits [13]

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