# The Effects of Environmental Lead Pollution in Kisumu, Mwanza and Kampala

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**Abstract:** In this paper, a study was conducted to determine lead contamination levels in the environment (soil and water) and foods. The foods targeted were maize, beans and fish which are among the major staple foods common to Kenya, Tanzania and Uganda. Water, food and soil samples were taken in 2007 and 2009. The study sites were located in Kisumu (Kenya), Mwanza (Tanzania), and Kampala (Uganda). From the results of 2009, the mean lead content in tap water, was within the WHO maximum safe limits of 1.0 μg/100 ml for all the samples from the three cities. For all water samples obtained from similar sources from the three cities, the lead content during 2007 was significantly higher than that of 2009. For the soil samples from Kisumu and Kampala the lead content in the 2009 samples was significantly lower ($p< 0.05$) than that of samples from similar sources during 2007, indicating a decreasing trend of lead pollution in soil in the two cities. In 2009 in all the three cities, the mean lead content in all the maize and bean samples was below the WHO maximum limits of 20.0 μg/100 g. For the maize the lead content in 2009 was significantly lower ($p< 0.05$) than that of 2007. The mean lead content in all the fish samples was below the WHO maximum limits of 20.0 μg/100 g in 2009. For all similar fish samples from the three cities, the lead content in the samples of 2009 was significantly lower than that of the samples of 2007. The results indicate that for all the samples of food, tap water and soil from the three cities, the lead content was within the WHO maximum levels in 2009, and showed a decreasing trend from 2007 to 2009.

**Keywords:** Lead, pollution, environment.

## INTRODUCTION

Environmental pollution of lead is a worldwide public health problem. Lead poisoning has severe adverse health impacts, which particularly affect children [1]. It has been linked to neuro-behavioural and developmental problems of children which may be irreversible [2-4]. Lead pollution generally elevates blood lead levels among subjects living in the polluted areas [5]. Lead pollution also exacerbates the malnutrition situation. It has also been reported to particularly exacerbate iron deficiency anaemia, whose prevalence among pregnant women and children in East Africa is very high [1, 6, 7]

Lead may be ingested through food or water, or it may be inhaled through contaminated air [8]. Worldwide, it had been reported that leaded petrol causes more exposure to lead pollution in human beings than any other single source [9-11]. As a consequence, the USA, all European, and many developing countries have outlawed the use of leaded petrol [12]. They have put in place strict regulations controlling the use of lead. In such countries, levels of lead are closely monitored in food and drinking water [13]. The United Nations World Health Organization (WHO) has also given recommendations for maximum lead content in foods and water [1, 14]. However, African countries, including Kenya, Tanzania and Uganda were relatively slow in putting in place regulatory structures on leaded products.

Despite the well-established severity of the consequences of lead poisoning, there has been very little data on the magnitude of the contamination levels of lead in the environment and in foods in the region. There has also been a weak policy and regulatory frame work for the control of lead pollution in the region.

The main objective of this study is to determine the extent of lead contamination in soil, water and foods around the project area in the Lake Victoria region in East Africa, and assess the implication of such contamination on human health. Among the specific objectives were to determine the lead content in soil, water and foods and to compare these levels with the WHO maximum lead levels in these substances. Further, the lead levels during 2007 were compared to those of 2009.

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1874-8295/11 

## MATERIALS AND METHODOLOGY

### Study Area and Sampling Sites

The study was carried out in the Lake Victoria basin, in three specific sites around Kisumu in Kenya, around Mwanza in Tanzania and around Kampala in Uganda. These cities were selected because they are all situated on the shore of Lake Victoria. Samples were taken within a radius of 20 km from the Lake in these areas, including the lake itself. The sampling sites at Kisumu, Kampala and Mwanza were the same sites for the two years, 2007 and 2009. The interval of the two years were expected to reveal a trend of environmental lead pollution after banning of the use of leaded petroleum in all the three countries by 2006. The sampling sites were as shown below:

Sites in Mwanza, Tanzania:

- Igogo Landing Site: Fish, water, soil and food samples.
- Mwanza City Market: Food samples.
- Along main Mwanza- Shinyanga highway : soil samples.

Kisumu sampling sites:

- Dunga site: Fish and water samples.
- Tilapia beach : Soil, water and food samples.
- Kisumu-Nakuru highway: Soil sample.
- Kisumu fish market: Fish and food samples.

Kampala sampling sites:

- Ggaba landing site: fish and water sample.
- Entebbe – Kampala highway: Soil and food samples.
- Kampala – Jinja Highway: Soil samples.
- Nakasero market: Fish and food samples.

### Study Design

The research design was a longitudinal study. The lead levels in soil, water and staple food samples were taken from the research sites once after very two years, in April 2007 and 2009, to track the changes in the lead levels in relation to the changing policy environment. All the three governments proclaimed that they had phased out the use of leaded petrol by 2006. Lead was determined in the physical environment (soil and water), and food for the lead levels.

### Samples

Water samples: Water samples were obtained from the Lake itself, onshore at purposively selected beach landing sites, and at points which were 2 km inshore from this points. Onshore, the sampling sites for the water samples were purposively chosen based on anthropological activities likely to result in pollution such as vehicle washing points, and fish landing points. The sampling was at the depth of 30 cm, and three 500 ml of water was collected in a plastic bottle per each sample.

Drinking water samples were obtained from taps. The tap was opened, and water allowed to run for one minute before filling three 500 ml sample bottles with the water for each sample.

Soil samples: Soil samples were obtained from purposively selected sites in the research area. These included those which are next to the highways, where motor vehicle pollution rate is relatively high, and likely pollution hotspots on the shore of the lake, including fish landing sites at Kisumu, Mwanza and Kampala. Control soil samples were taken from at least 2 km from the highway where there was comparatively low exposure to motor vehicle exposure and other forms of pollution. Three soil samples, each 500 g, were taken from each purposively selected sampling point. The samples were scooped at a depth of 0-15 cm. Soil sampling was done according to the International Atomic Energy Agency (IAEA) protocols [15].

Food samples: Maize and bean grain, which are key staple foods in all the three countries of Kenya, Uganda and Tanzania, were purchased from the open air markets in the study area. The sampling sites were purposively selected to include those next to the highway, where exposure to lead pollution from motor vehicles is high. For maize (Zea mays L.) three 500 g portions of dry maize were purchased for each sample from randomly selected vendors in the open air markets of Kisumu, Mwanza and Kampala. Similarly for beans (Phaseolus spp) three 500 g portions of dry beans were purchased for each sample from randomly selected vendors in the open air markets of Kisumu, Mwanza and Kampala. Sampling and sample preparation for foods were done according to the (IAEA) protocols [15].

### Sample Handling and Preparation

After collection, the soil samples were transported in the sample bottles to the laboratory where they were air-dried, ground, and screened to pass through a 0.5 mm sieve and then stored in plastic sample bottles awaiting determination of lead.

The maize and bean samples were transported in the sample bottles and stored under refrigeration until analysis. The samples were ground and dried at 65 $^{0}$C for 10 hours prior to determination of lead. The fish samples were kept under refrigeration in cool boxes and transported to the laboratory where they were kept under refrigeration till the time of lead determination.

For the water samples, immediately after collecting the samples 5 ml of concentrated HCl was added to the water samples to stabilize them. The water samples were then kept under refrigeration conditions till the time of lead determination. After collection in the field they were placed in cool ice boxes and transported to the laboratory where they were transfered to the refrigerator.

### Lead Determination

The lead in the soil, water, and staple food samples were determined using a Shimadzu Atomic Absorption Flame Emission Spectrophotometer model AA-6200 [16, 17]. The

**Table 1. Lead Content in Water from Kisumu, Kenya**

| Sample Source (n=3, All Samples) | Mean Lead Content in µg/100 ml, 2009 | Mean Lead Content in µg/100 ml, 2007 |
|---|---|---|
| Dunga Beach 2 km inshore | 1.2 ± 0.11bc | 2.6±0.5$^{bc}$ |
| Dunga Beach onshore | 1.5 ± 0.03b | 4.7±0.3$^{ab}$ |
| Tilapia Beach 2 km inshore | 0.3 ± 0.03d | 1.5±0.4$^{c}$ |
| Tilapia Beach onshore | 2.0 ± 0.26a | 4.5±0.9$^{ab}$ |
| Tap water | 0.0 ±0.00d | 0.2±0.6$^{c}$ |
| **WHO maximum limit, drinking water** | **1.0c** | **1.0dc** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p< 0.05$) from each other.

**Table 2. Lead Content in Water Samples from Kampala, Uganda**

| Sample Source | Mean Lead Content in µg/100 ml, 2009 | Mean Lead Content in µg/100 ml, 2007 |
|---|---|---|
| Ggaba Beach, Onshore | 0.0 ± 0.0c | 12.3±0.61$^{a}$ |
| 2 km inshore (n=9) | 2.2 ± 0.25a | 4.6±0.89$^{b}$ |
| Tap water (n=12) | 0.7 ± 0.0.70b | 1.4±0.25$^{c}$ |
| **WHO maximum limit, drinking water** | **1.0b** | **1.0$^{c}$** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p< 0.05$) from each other.

detection limit of the spectrophotometer was 0.01 µg/ 100 g/ml. For the soil and food samples, three replicate samples of one gram each were analyzed as per the AOAC method (AOAC, 1984). The lead extraction was through treatment of the samples with 5 ml of a mixture of nitric acid, sulphuric acid and hypochloric acid in the ratio of 6:3:1. They were then allowed to stand for five minutes after shaking thoroughly. The samples were digested on a hot plate starting at 70 $^{0}$C through to 120 $^{0}$C until the volume reduced to approximately 1 ml, and the suspended white fumes of $SO_3$ were clearly observed. The samples were then allowed to cool to room temperature after which approximately 20 ml of 5% hydrochloric acid solution was added. The samples were heated on a hot plate at approximately 75 $^{0}$C for 15 minutes and then cooled. They were filtered through Whatman Filter Paper number 42 into a 100 ml volumetric flask, and filled to the mark using 5% HCl. A blank sample was also prepared in the same way.

The water samples were put into a 250 ml beaker and placed on a hot plate. The water was heated and while about to boil, 2 ml of nitric acid-water mixture (50:50) and 10 ml hydrochloric acid-water mixture (50:50) were added. The samples were evaporated until the mixture reduced to approximately 25 ml. The 25 ml residues were transferred into 100 ml volumetric flasks and filled to the mark with distilled water.

### Data Analysis

Statistical analysis of data was done using analysis of variance (ANOVA) of the lead levels in soil, water and staple foods from the study areas. Comparison was made between the lead levels in the samples and the maximum safe limits set by WHO. Analysis was also done to compare lead levels at the same sites between the two years of 2007 and 2009.

### Data Quality Assurance

Three samples (triplicate), each 500 mg/500 ml, were obtained to represent each one sample of water, food or soil (IAEA, 1997). These samples were analyzed separately. Each analysis was performed in triplicate. Commercial lead standards were used for quality assurance of the data on lead determination (Wako Pure Chemical Industries Ltd., Japan).

## RESULTS AND DISCUSSION

### Lead Content in Water

Lead content in most of the water samples from different sources in Kisumu, Kampala and Mwanza were within the World Health Organization (WHO) maximum safe limits for drinking water of less than 1 µg/100 ml (Tables **1-3**) in the 2009 samples. The mean lead content in tap water, commonly used for drinking, was within the WHO maximum safe limits for all the samples from the three cities. In Ki-

**Table 3. Lead Content in Water Samples from Mwanza, Tanzania**

| Sample Source | Mean Lead Content (µg/100 ml), 2009 | Mean Lead Content in µg/100 ml, 2007 |
|---|---|---|
| | **Mean** | **Mean** |
| Igogo Beach, Onshore (n=12) | 0.4 ± 0.61c | 3.6±0.70[b] |
| 2 km inshore (n=9) | 1.9 ± 0.29a | 4.3±0.55[a] |
| Tap water (n=12) | 1.4 ± 1.39ab | 4.3±0.5[a] |
| **WHO maximum limit, drinking water** | **1.0bc** | **1.0[c]** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.

**Table 4. Lead Content in Soil from Kisumu in Kenya**

| Sample Source | Mean Lead Content in (µg/100 g), 2009 | Mean Lead Content (µg/100 g), 2007 |
|---|---|---|
| Dunga Beach (n=3) | 14.2 ± 16.8bc | 42.1±0. 4[a] |
| Tilapia beach (n=3) | 12.5 ±0.21c | 9.2±0.4[c] |
| 2 km off roadside (n=6) | 15.2 ± 2.0b | 10.4 ±0.8[c] |
| Roadside (Kisumu Nairobi) (n=6) | 13.5 ± 0.25bc | 33.0±0.6[b] |
| **Maximum safe limits, soil** | **40.0a** | **40.0[a]** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.

sumu, the exceptions where the lead content was significantly higher ($p < 0.05$) than the maximum WHO limits were the onshore water samples (from Dunga Beach and Tilapia Beach). On the other hand around Kampala, it is the samples from the inshore water (about 2 km inshore) that had significantly higher lead levels than the WHO limits in the 2009 samples. Similarly around Mwanza, it was the water samples obtained inshore that had significantly higher ($p < 0.05$) lead content than the WHO limits and the water samples from onshore in the 2009 samples.

In Kisumu, the trend of onshore water samples having a higher lead content than inshore samples was observed in the samples of 2007 and 2009. This is an indication of lead pollution onshore. Natural unpolluted water systems usually have low lead levels [18]. One probable source of lead pollution in the lake is the leaching of lead from soils into the water system [19]. Once lead falls onto the soil, it usually attaches to the soil, from where small amounts may leach into rivers and lakes as the soil particles are moved by rainwater [20]. However, generally for all water samples obtained from similar sources from Kisumu, the lead content during 2007 was significantly higher than that observed during 2009. There is a trend towards decreasing lead content from 2007 to 2009. For the Kampala samples, the inshore samples had a significantly higher ($p < 0.05$) lead content than the offshore samples. The higher lead levels in the inshore water may be due to a gradual diffusion of lead deposited earlier into the interior of the lake [21]. Similar to the Kisumu situation, the lead content in the water samples during 2009 was significantly lower ($p < 0.05$) than what was observed in 2007. In Mwanza, similarly the water samples from inshore had a significantly higher lead content than the onshore water samples. As in the other two cities, the lead content during 2009 from samples from similar sources was significantly lower ($p < 0.05$) during 2009 in comparison to 2007. The trend towards decreasing lead content in water may be due to the decreasing soil lead levels, since a significant amount of water lead levels is leached from the soil particles [20].

## Lead Content in Soil

The lead content in soil samples of 2009 from all the sites in Kisumu, Kampala and Mwanza were within the WHO maximum limits for soil samples (Tables **4-6**). Around Kisumu, there was no significant difference ($p < 0.05$) among soil samples obtained from the roadside, and those from at least 2 km from the road side. This is an indication that motor vehicle pollution may not be a significant source of lead pollution around Kisumu. Similarly, around Kampala, there was also no significant difference ($p < 0.05$) in the lead content of samples obtained from the roadside in comparison to those obtained at least 2km away from the road. A similar observation was made for the samples from Mwanza, where there was no significant difference in the lead content in the soil samples from the roadside and those from at least 2km away from the road, or those on the lake shore.

For the Kisumu soil samples, the samples from the roadside and those from onshore for 2007 had a significantly higher ($p < 0.05$) lead content than those of 2009. This indicates a decreasing trend of lead pollution in these specific

**Table 5. Lead Content in Soil from Kampala, Uganda**

| Sample Source | Mean Lead Content in µg/100 g, 2009 | Mean Lead Content in µg/100 g, 2007 |
|---|---|---|
| | **Mean** | **Mean** |
| Kampala Entebbe road (n=18) | 5.8 ± 4.28b | 50.9±0.11[a] |
| Kampala Jinja road (n=15) | 1.9 ± 1.6b | 52.9±0.13[a] |
| 2 km off Kampala Entebbe road (n=3) | 7.7 ± 5.00b | 18.6±0.01[c] |
| 2 km off Kampala Jinja road (n=3) | 2.4 ± 1.70b | 15.5±0.05[c] |
| **Maximum safe limits, soil** | **40.0a** | **40.0[b]** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.

**Table 6. Lead Content in Soil from Different Points in Mwanza, 2009 and 2007**

| Sample Source | Lead Content in µg/100 g, 2009 | Mean Lead content in µg/100 g, 2007 |
|---|---|---|
| | **Mean** | |
| Highway (n=30) | 12.6 ± 3.94b | 10.8±0.67[b] |
| 2 km off highway (n=12) | 15.6± 4.17b | 17.7±0.32[b] |
| Lake onshore (n=6) | 7.8 ± 0.85b | 19.2±0.68[b] |
| **Maximum safe limits, soil** | **40.0a** | **40.0[a]** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within c7olumns followed by different letters are significantly different ($p < 0.05$)

areas. However, there was no significant difference in the lead content in samples obtained at least 2 km from the roadside. For all the soil samples from Kampala, the lead content during 2009 from samples from similar sources is significantly lower ($p < 0.05$) during 2009 in comparison to 2007. This again points to a decreasing trend in lead content. The lead content in soil samples of 2009 from all the sites in Kisumu, Kampala and Mwanza were within the WHO maximum limits for soil samples (40 µg/100 g). Within such limits, children can play within such soils without a high risk of lead poisoning. The observations for Mwanza are different, where there is no significant difference ($p < 0.05$) in the lead content of soil samples of 2009 from the highway, and from 2 km from the highway, in comparison to similar samples of 2007. However, the lead content in the onshore soil samples of 2009 is also significantly lower ($p < 0.05$) than that of 2007. Generally, the mean lead content in the soil samples lies within typical concentrations of lead in soil. This has been reported to be between 5-100 µg/ 100g [1]. Variation in lead soil content may also be due to historical factors such as past traffic congestions, industry and the type of soil. Of these, traffic, and its associated use of leaded petrol, has played the most important role in determining where lead is found in soils [11]. Leaded petroleum has been in use in the East African countries of Kenya, Uganda and Tanzania till 2006, when it was banned in all the three countries [19, 22]. The trend of decreasing soil lead levels from 2007 to 2009 may reflect the gradual depletion of soil lead levels since there were no further deposits from motor vehicle pollution.

### Lead Content in Dry Maize and Bean Grain

Lead content in dry maize and bean grain for 2007 and 2009 in Kisumu, Kampala and Mwanza are shown in Tables **7-9**, respectively. For the samples of 2009, in all the three cities, the lead content in the legume and cereal grain was below the WHO maximum limits of 20 µg/100 g. For the Kisumu samples, there was no significant difference ($p < 0.05$) in the mean lead content among the maize, bean and peanut samples for the 2009 samples. For the Kampala samples, the mean lead content in the pea samples was significantly higher ($p < 0.05$) than that of maize and bean samples. For the samples from Mwanza in 2009, the mean lead content in maize and beans was significantly higher ($p < 0.05$) than that of rice and peanuts.

Lead content in maize and beans is of particular interest as these are staple foods for many communities in Kenya, Uganda and Tanzania [19]. The results of the lead content in these grain may not reflect the lead content in the immediate environment since the grain may be purchased from far off places then transported for sale in the cities [22].In all the samples across the three cities, lead levels were below the maximum WHO limits, and comparable to those observed in other studies [19, 21, 22].

### Lead Content in Fish

In Kisumu, the lead content in the tilapia (fresh), was significantly lower ($P \leq 0.05$) than the WHO maximum limits, while it was higher in the dry dagaa samples (Table **10**).

**Table 7. Lead Content in Dry Maize, Beans and Peanuts, Kisumu, Kenya, 2009 and 2007**

| Sample (n=3 All Samples) | Lead Content in µg/100 g, 2009 | Lead Content in µg/100 g, 2007 |
|---|---|---|
| | Mean | Mean |
| Maize | 2.4 ± 0.23b | 10.9±0.2[b] |
| Beans | 2.7 ± 0.26b | 20.2±0.3[a] |
| **WHO maximum limits (maize, beans)** | **20a** | **20[a]** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.

**Table 8. Lead Content in Dry Maize and Bean Samples from Around Kampala, Uganda, 2009 and 2007**

| Sample | Lead Content in µg/100 g, 2009 | Lead Content in µg/100 g, 2007 |
|---|---|---|
| | Mean | Mean |
| Maize (n=12) | 2.0 ± 1.50b | 15.3±0. 3[b] |
| Beans (n =6) | 3.7 ± 5.18b | 15.6±0.1[b] |
| **WHO maximum limits (maize, beans)** | **20.0a** | **20.0[a]** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.

**Table 9. Lead Content in Dry Maize and Bean Grain Mwanza, Tanzania**

| Sample (N=3, All Samples) | Lead Content in µg/100 g, 2009 | Lead Content in µg/100 g, 2007 |
|---|---|---|
| | Mean | Mean |
| Beans | 5.2 ± 0.1b | 12.3±0.0[b] |
| Maize | 4.8 ± 0.2b | 10.9±0.0[c] |
| **WHO maximum limits (maize, beans)** | **20.0a** | **20.0[a]** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.

**Table 10. Lead Content in Fish from Kisumu Kenya**

| Sample | Lead Content in µg/100 g, 2009 | Lead Content in µg/100 g, 2007 |
|---|---|---|
| | Mean | Mean |
| Tilapia) (n =9) | 3.3 ± 0.59b | 14.1±0.2[a] |
| Dry Dagaa (dagaa) (n=9) | 3.0 ± 0.40b | 30.5±0.3[b] |
| **WHO maximum limits** | **20.0a** | **20.0[c]** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.

The higher content in the dry samples may reflect a concentration of the lead content due to reduction in moisture. Similarly lead content in tilapia obtained from Kampala and Mwanza in 2009 was within the WHO maximum safe limits of 20 µg/100 g (Tables **11** and **12**). It was only the 2007 tilapia sample from Kampala that For the Dagaa samples from both sites, the lead content was significantly lower than the WHO maximum limits.

The two types of fish in which lead was determined, tilapia and dagaa, are commonly consumed in all the three countries of Kenya, Uganda and Tanzania. The 2009 results indicate that in all the samples analysed the lead content was below the maximum safe limits of 20.0 µg/100 g. This is perhaps a reflection of the relatively low to moderate amount of lead content that was observed in the water from the lake. However, in the 2007 results, the lead levels in the tilapia

**Table 11. Lead Content in Fish from Kampala, Uganda**

| Sample Source | Lead Content in µg/100 g, 2009 | Lead Content in µg/100 g, 2007 |
|---|---|---|
| | Mean | |
| Tilapia (fresh) (n=12) | 2.4 ± 0.82c | 63.3 ±0.0a |
| Dry Dagaa (n=12) | 10.6 ± 3.86b | 14.7±0.6[c] |
| **WHO maximum limits** | **20.0a** | **20.0[b]** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.

**Table 12. Lead Content in Fish from Mwanza, Tanzania**

| Sample | Lead Content in µg/100 g, 2009 | Lead Content in µg/100 g, 2007 |
|---|---|---|
| | Mean | |
| Tilapia (2km inshore) n=3 | 1.5 ± 0.05b | nd |
| Dry Dagaa (n=3) | 0.0 ± 0.00c | 21.8±0.3 |
| **WHO maximum limits** | **20.0a** | **20.0** |

Each value is a mean ±SE of three analyses done in triplicate.
Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.
Nd – not determined

from Kampala and dagaa from Kisumu had significantly higher lead levels than the maximum safe limits. Further monitoring of these levels may be required to give a conclusive trend. Generally the results of lead levels in the fish are in agreement with those reported by other researchers [23].

## CONCLUSIONS

In conclusion, for the 2009 samples, lead content in all the food, tap water, and soil samples from all the three sites of Kisumu, Kampala and Mwanza was below ($p < 0.05$) the WHO maximum limits and therefore does not pose a significant risk for lead poisoning to the consumers. In the soil samples from all the three cities, there was also no significant difference ($p < 0.05$) between the soil samples obtained from the roadside and those from at least 2 km from the roadside. This is an indication that motor vehicle pollution may not be a significant source of pollution in the 2009 samples. The soils are also safe for children to play in without risk of lead poisoning. The results also indicate a decreasing trend of lead levels in the environment and foods from 2007 to 2009.

## ACKNOWLEDGEMENT

We acknowledge with gratitude the financial support for this study that was received from the Lake Victoria Research Initiative (VicRES), Kampala, Uganda.

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Received: December 06, 2010 Revised: January 27, 2011 Accepted: January 29, 2011