# Lead Metal Exposure to Residents Residing in Informal Settlement: A Case Study of Residents in Nakuru Municipality, Kenya

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## Abstract
The study was conducted with the aim of determining the level of lead exposure to residents living in slum areas, close to sewerage and waste dumpsites of Nakuru Municipality using a sample of 120 individuals. Cross sectional study design, was adopted where a representative proportion of the population at different age groups was included in the three sites, viz: dump site, slum areas and sewage prone areas. The level of lead exposure was determined by subjecting human hair samples to Atomic Absorption Spectroscopy tests after wet acid digestion using Nitric acid analytical grade. Result indicate that the incidence of presence of lead in samples were 0.45±0.106; 0.17±0.064 and 0.29±0.057 of 0-6, 6-17 and >17 years of age respectively. There was a significant difference ($P \leq 0.05$) among sites with majority of those sampled from dump site having 5 µg/ $g^{-1}$ and above. This study therefore concludes that, Nakuru being one of the fastest growing towns in East Africa faces a high level of Lead heavy metal contamination among residents, a fact that has not been documented as a necessity in accommodating the growing population, industrial, and commercial activity.

Keywords: Lead, AAS, Heavy metal, Toxicity, Nitric acid, Hair, Slum, Dumpsites, Sewer prone.

## Introduction
In a report by IUPAC, the term "heavy metal" has never been defined by any authoritative body such as IUPAC and its use is confusing (Duffus 2002). According to Järup (2003), he states that although there is no clear definition of what a heavy metal is, density is in most cases taken to be the defining factor. Heavy metals are thus commonly defined as those having a specific density of more than 5 g/$cm^3$. According to Hossn et al. (2001), although adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues and is even increasing in some areas. For example, mercury is still used in gold mining in many parts of Latin America. Järup (2003) states that emissions of heavy metals to the environment occur via a wide range of processes and pathways, including to the air (e.g. during combustion, extraction and processing), to surface waters (via runoff and releases from storage and transport) and to the soil (and hence into ground waters and crops). Atmospheric emissions tend to be of greatest concern in terms of human health, both because of the quantities involved and the widespread dispersion and potential for exposure that often ensues.

These sources can contribute an additional daily intake of 5 µg for a toddler engaging in normal hand-to-mouth activity (Lanphear 1998). The most common route of occupational exposure to lead is contact with lead containing products (Ahlgren et al. 1980), inhalation of lead fumes or lead-laden dusts in air and absorption of lead through the respiratory system. Lead may also be ingested and absorbed via the gastrointestinal tract (Vaglenov et al. 2001; Njoroge et al. 2008 and Report on carcinogens 2011). According to Järup (2003), the main threats to human health from heavy metals are associated with exposure to Lead. These threats are diverse and results from toxicity of lead, e.g. exposure to Lead has

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been shown to lead to proneness to Neurobehavioral changes (Williamson and Teo 1986). Lately, lead is known to be carcinogenic and genotoxic (Vaglenov et al. 2003). Järup (2003) continues to note that, even though several adverse health effects of heavy metals have been known for a long time, exposure to heavy metals continues, and is even increasing in some parts of the world, in particular in less developed countries, though emissions have declined in most developed countries over the last 100 years. The routes of environmental exposure to lead resulting in its absorption into the body are inhalation (with 30 - 50% of the inhaled dose absorbed into the bloodstream), ingestion (with 8- 15% of the ingested dose absorbed into the bloodstream) and, to a limited extent, dermal contact. Inorganic lead absorption takes place throughout the respiratory and gastrointestinal tracts. For adults with occupational exposure, the most significant route for absorption is through the respiratory tract. Respiratory lead absorption is primarily dependent on particle size; the smaller the particle, the more completely the lead is absorbed. The percentage of inhaled lead reaching the bloodstream is estimated to be 30–40%. Rates of absorption through the gastrointestinal tract depend on the nutritional status and the age of the individual exposed. Therefore, while adults absorb an average of 10 to 15% of the ingested quantity, this amount can increase to 50% in infants, young children and pregnant women. Absorption through the gut is the predominant route for children and increases when dietary intakes of iron, calcium, phosphorus, or zinc are low. There is little transcutaneous absorption of lead when inorganic lead compounds, such as those found in paint, are applied to the skin. In contrast, organic (tetraethyl) lead, which is that found in gasoline, can be absorbed via the skin (Staudinger and Roth 1998; Papanikolaou et al. 2005; Committee on Environmental Health 2005)

Sources of Lead emissions to the environment are mainly related to road transport and thus most uniformly distributed over space (Järup 2003). Lead exists in various inorganic and organic forms, which affect its environmental fate, transport, and bioavailability. The metal is not degraded and remains available for exposure. Combustion of leaded gasoline contributes about 90% of all anthropogenic lead emissions (ATSDR 1999). Over 90% of the lead released from the combustion of leaded gasoline was in the form of inorganic lead halides (e.g., lead bromochloride), while less than 10% was in the form of organic lead alkyls (e.g., tetraethyl lead). Tetraalkyl lead compounds once accounted for 5- 10% of the total particulate lead present in the atmosphere but are no longer present in significant quantities. For young children, the most common source of environmental lead exposure is direct ingestion of paint chips and lead-laden dust and soil released from aging painted surfaces. In a report by Sniffer research group (2008), sewerage sludge was shown to contain a significant amount of cadmium, lead and to a lesser extent mercury and arsenic. This is in addition of harboring a number of organisms, some of which are drug resistant and these organisms include *Salmonella spp, E.coli, Campylobacter, Giardia, Ascaris* and Hepatitis viruses. These organisms were found to be present in unrecommendable amount of the sewerage affluents in Nakuru even after treatment by a study done by Ngari, Kotut and Okemo (2011). Escalated levels of heavy metals in Lake Nakuru were observed by Ndetei and Muhandiki (2005) due to the heavy industrialization of the lake catchment basin (Jackson and Kuleto 2008). These industries in Nakuru process a wide range of products such as agrochemicals, textiles, paints, tanned leather, detergents, welded metal panes, human and animal foodstuffs and batteries that are known to increase amount of lead and other heavy metals in the environment (Jackson and Kuleto 2008). Working with, or improper handling of with potential lead containing products and waste could make people living in or in neighborhoods of slums and next to landfill dumpsites prone to lead pollution (Hengstler et al 2003). Despite these known potential levels of could be heavy metal exposures to Nakuru residents, data is still scant on the real absorbed levels of lead by the residents. The main objective of this study was to determine the presence/absence of lead exposure to residents living in slum areas, dump sites and sewage prone areas of Nakuru Town Municipality.

**Materials and Methods**

This study used cross-sectional study design, where a representative sample was obtained from the residents of Nakuru. The samples were collected as the clients shaved their hair at various barber shops, put in individual specimen envelop and labeled with the clients details.

The study was conducted within Nakuru municipality, in Nakuru County, Kenya. Nakuru Municipality covers an area of 290 $km^2$ and has four locations and five sub locations. It has about 700,000 inhabitants (Owuor 2006). Most of the municipality's income comes from wholesale and retail businesses, banking services, educational services, tourism and even the informal sectors.

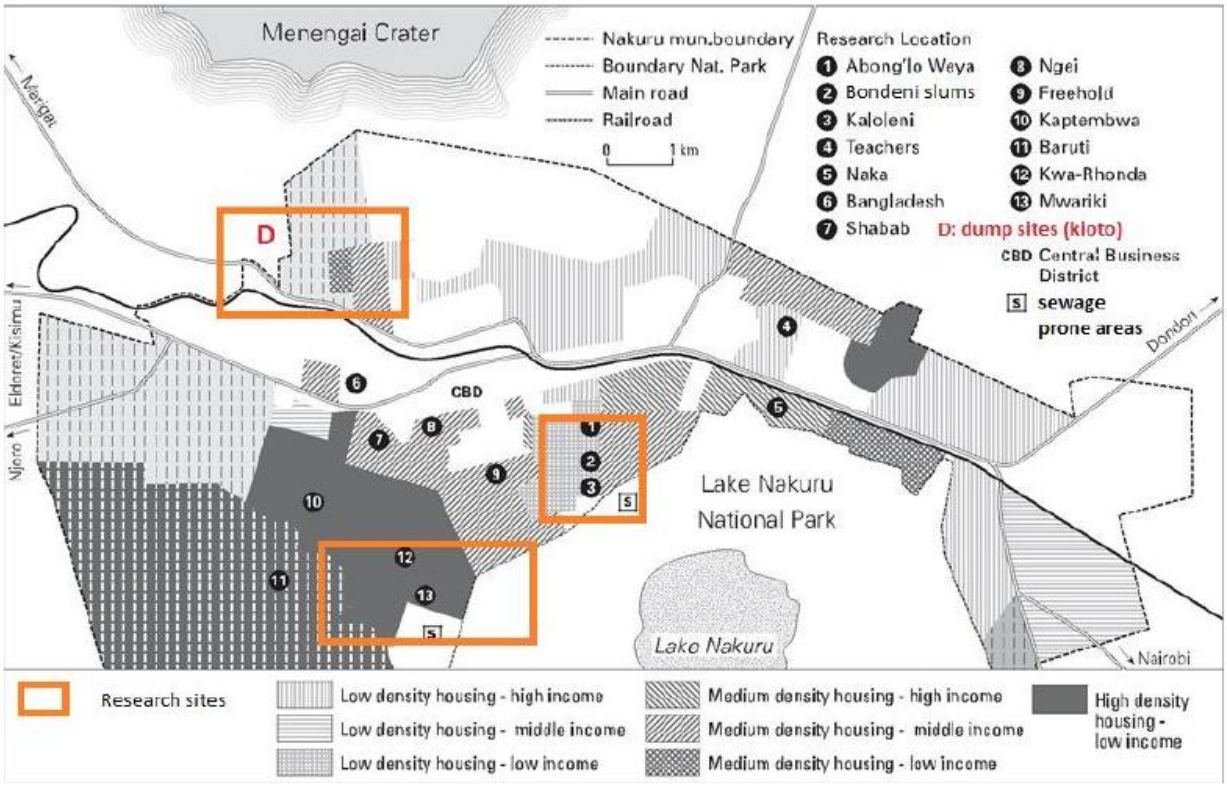


Figure 1: Map of Nakuru municipality showing the research target sites.

For the purpose of this study, the target population was made up of residents of Nakuru Town municipality, living in assumed areas of heavy metal exposure areas. These included, residents living within the proximity to the major Nakuru dumpsite (Kyoto), residents drawn from slums in Nakuru specifically in Bondeni, Rhonda and school children within the sewer prone areas. Target population comprised of 300 000 who are residents of Nakuru (Owuor 2006).

The high cost of conducting the AAS tests forced the researcher to consider only a small representative portion of the target population. Therefore a sample size of 120 respondents was considered. This sample was equally distributed to the three categories of population; Kyoto dumpsite, Slums, and sewage areas as shown in the map (Figure 1). The study used stratified sampling method form. Forty 40 participants were chosen from each of the three clusters. Participants from the target sites were selected randomly from barber shops as they shaved. Samples of 40 were selected for each category. Convenience sampling was used in that participants were approached, as they shaved and were briefed on the proposed research therefore at the end of the shaving exercise, they would allow for hair samples to be taken in for analysis. And in cases of minors the permission were sought from their guardian's as a pre-requisite for the research that involve the minors. Samples obtained from the study sample were taken for analysis using

the absorption spectrometer (AAS-Spectr-AA-10 SOLAAR AA). Distilled–deionized water was used. The reagents for analysis were of high quality analytical grade. Nitric acid AR (Aqua regia), acetone, hydrogen peroxide and the glassware (conical flask, falcon tubes) were supplied by the local registered laboratory supplier, on order basis. All the glassware used in this study were decontaminated by soaking overnight in 5% $HNO_3$ and rinsed thoroughly in deionized water. The metal standards from the stock solution (1000 mg/L) were freshly prepared and checked for constancy of absorption before taking the readings.

The hair samples in the plastic falcon tube containers were soaked in acetone for 2 hr in a labeled glass beaker to free them from metallic debris. They were then again subsequently soaked in acetone for 1 hr before rinsing them five times with distilled–deionized water. The samples were then kept in labeled petri dishes, oven dried at 60 °C to a constant weight of 0.5 g. The samples were then analytically transferred to a 50 ml conical flask and a volume of 10 ml Nitric acid was added. It was then put on a hot plate with a pre-set temperature of 40 °C to accelerate the digestion of the hair samples. Nitric acid was added as the mixture continued to digest until a final volume of around 8 ml remained. A fume chamber was used since the reaction is exothermic and leads to production of poisonous manganese oxide gas. They were allowed to completely digest and to cool to room temperature before adding hydrogen peroxide 2 ml to clear the brown color from the final analyte. All the prepared solutions were stored under refrigeration to avoid deterioration while awaiting analysis.

The data collected was coded and entered in the computer for analysis using the Statistical Package for Social Sciences (SPSS). Statistical inferences were then drawn. Incidence of presence of or absence of lead in the samples was estimated using binomial distribution using the following formula;

$\hat{p} = \frac{x}{n}$ Where x = number of positive incidence and n = number of total sample by age group; $\hat{q} = 1 - \hat{p}$; $se = \sqrt{\frac{\hat{p}\hat{q}}{n}}$ and 95% confident interval $\hat{p} \pm 1.96.se$. The chemical levels of lead were analyzed using general linear model of SAS. The means were separated by least square probabilities of differences.

**Results and Discussion**

Table 1: The proportion of incidence of lead over different age groups

| Age group (years) | Sample p | Sample Se | Sample (n) | 95% confidence level Lower 95 | 95% confidence level Upper 95 |
|---|---|---|---|---|---|
| 0-6 | 0.45 | 0.106 | 22 | 0.246 | 0.663 |
| 6-17 | 0.17 | 0.064 | 35 | 0.047 | 0.296 |
| 17-70 | 0.29 | 0.057 | 63 | 0.174 | 0.397 |

Table 2: Least square means over age group for chemical levels

| Sources | DF | Typye III SS | Mean Square | F value | Pr>F |
|---|---|---|---|---|---|
| Site | 2 | 8528.848450 | 4264.424225 | 4.85 | 0.0095** |
| Age group | 2 | 1920.895170 | 960.447585 | 1.09 | 0.3389ns |
| Site*Age group | 4 | 5929.536107 | 1482.384027 | 1.69 | 0.1581ns |

NB: ns = no significantly different (P>0.05)

** Significantly different at both (p=0.05 and p=0.01).

Table 3: Mean lead distribution

| Site | Lead levels (µ/l) | Standard Error |
|---|---|---|
| Dump site | 26.556 | 5.5610A |
| Slum area | 6.540 | 4.8773B |
| Sewage prone | 4.261 | 6.0990B |

The results of incidence of lead are presented on (Table 1). There was a high incidence on the 0-6 year groups followed by the 17-70 year old and least by 6-17 years. The data shows that smaller children have higher exposure to lead compared to other group a fact that is supported by other findings probably due to their eating and playing habit and their high gastrointestinal uptake of lead. Older population also is exposed due to the fact that exposure might be from the occupational since majority falls into the working class category. Age group 6-17 years had the least exposure probably due to the fact that they are in school and do not engage in activities that predisposes them to lead. The ANOVA table indicated that there is no correlation between sites and age (Table 2). The samples picked from people residing close to the Dump sites had a significantly ($p \leq 0.05$) higher levels of lead in their bodies than other sites as seen from the values of the mean lead obtained as shown in (Table 3).

The study found that indeed there is a high level of exposure of lead among those living close to the dumpsite with the majority of the most affected being children below 6 years perhaps due to their playing and feeding habits. For young children, the most common source of environmental lead exposure is direct ingestion of paint chips and lead-laden dust and soil released from aging painted surfaces. These sources can contribute an additional daily intake of 5 µg for a toddler engaging in normal hand-to-mouth activity and also their gastrointestinal activity is quite high (Lanphear 1998). Another group that had significantly high lead levels is of 17-70 years old, perhaps due to occupational exposure since majority are either working or from the fact that they have been residing along the dumpsite for long. The study also found that there is correlation between the site and age when dealing with lead exposure since it found that the samples picked from people residing close to the dumpsite had significantly higher lead in their bodies than other sites.

The Centers for Disease Control and Prevention states that a blood level of 5 µg/L or above is a cause for concern. In this study, the use of atomic absorption spectrophotometry after wet acid digestion of hair samples provided an indicator of Lead levels in the body since hair is a sequestered site and it's not affected by metabolism. Lead can impair development even at blood lead level below 5 µg/L. Adults that are exposed to dangerous amount of lead may experience anemia, nervous system dysfunction, weakness, hypertension, kidney problems, decreased fertility, and increased level of miscarriages, low birth weight and premature deliveries. Children exposed to high levels of lead show similar symptoms, including anemia, kidney damage, colic, neurological impairment, and impaired vitamin D metabolism. However children are susceptible to damage from lead exposure at lower levels than adults, and neurological

impairment can occur in children with blood lead levels <10 µg/L. Neurological impairment or growth retardation, and delayed sexual maturation as a result of lead exposure may even affect children as they mature to adulthood (Cecil and Lindquist 2011).

**Conclusion**

Result indicate that the incidence of presence of lead in samples were 0.45±0.106; 0.17±0.064 and 0.29±0.057 for 0-6, 6-17 and >17 years of age respectively. There was a significant difference (P≤0.05) among sites with majority of those sampled from dump site having 5 µg/L. This study therefore concludes that, Nakuru being one of the fastest growing towns in East Africa faces a high level of Lead heavy metal contamination among residents, a fact that has not been documented as a necessity in accommodating the growing population, industrial, and commercial activity.

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