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Lead pollution in the environment and contamination in food around Mwanza, Tanzania

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ABSTRACT

Objective: To determine the extent of lead contamination in soil, water and food around Mwanza, Tanzania and assess the implication of such contamination on food safety and human health.

Methodology and results: Samples of water, soil and food were taken from around Mwanza town in Tanzania. Lead content as determined by spectrophotometry was correlated with the level of pollution in soils and in Lake Victoria water, and also compared to the maximum limits recommended by WHO for the different samples. Lead content in tap water and other surface water ranged from 0.03 to 0.05, and 0.02 to 0.08 mg/100 ml, respectively which is above the 0.001 mg/100 ml WHO maximum limit. The lead content in vegetables and dry cereal and legume grains ranged between 0.21 to 1.18, and 0.02 to 0.12 mg/100 g, respectively. Soils contained between 0.01 to 0.48 mg / 100 g lead.

Conclusion and application of results: The results indicate that there is considerable risk of lead poisoning from drinking water and eating vegetables obtained from the sampling sites. The data are useful in raising awareness about the risk of lead contamination to human health and in the enactment of policies and regulatory measures to limit lead pollution and contamination in foods and the environment in Tanzania.

Key words: Lead, pollution, environment, food safety

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INTRODUCTION

Lead poisoning is an environmental and public health hazard globally. Children and adults in virtually every region of the world are exposed to unsafe levels of lead in the environment and children are particularly vulnerable (WHO, 1987; Richard *et al*., 1993; Needleman *et al*., 1996). In addition to renal disease, cardiovascular effects, and reproductive toxicity, lead may cause irreversible neurological damage (Beattie *et al*. 1972). Increased death rates have been reported after occupational exposure to lead resulting in concentrations in the blood in excess of 50 µg/dL. The causes of death most often associated with such exposure are cardiovascular disease, renal disease and cancer (Cooper, 1988; ATSDR, 1997).

To the general non-smoking adult population, the main exposure to lead pollution is from food and water. Airborne lead may contribute significantly to exposure, depending on several factors, e.g. use of tobacco, occupation, proximity to motorways, etc. Food, air, water, and dust or soils are the main potential sources of exposure to infants and young children (WHO, 1995). Worldwide, leaded petrol previously caused more exposure to lead pollution in human beings than any other single source (Ellen, 1996). As a consequence, the USA, all European, and many developing countries have outlawed the use of leaded petrol and have also put in place strict regulations for lead in food and drinking water Magda, 1996). The United Nations World Health Organization (WHO) has issued recommendations on the maximum lead content in foods and water (WHO, 1995; CAC/FAO, 1999).

However, many African countries including Tanzania have generally been slow in adopting policies and regulatory structures to reduce lead pollution. There is also little awareness about lead pollution and lead levels in foods and their adverse impacts on human health (Makokha, 2004). Despite the well known severe consequences of lead poisoning, there is very little data on the magnitude of contamination of lead in the environment and in foods in Tanzania. The objective of this study was to determine the extent of lead contamination in soil, water and foods around Mwanza town in Tanzania and assess the implication of such contamination on food safety and human health.

MATERIALS AND METHODS

Study area: The study was carried out around Mwanza town on the shores of Lake Victoria in Tanzania. The potential sources of lead pollution in this area include fish processing enterprises, motor vehicle emissions and agricultural activity. Samples were taken within a radius of 10 km from the lake shores.

Sample collection: Key staple foods samples were purchased from the fields and the market places in the study area (Table 1). The sampling sites were purposively selected to include those next to the highway, where exposure to lead pollution from motor vehicles is highest. The food samples included maize, beans, and vegetables (amaranthus and onions). A 500 g sample of each type of food was obtained. Cereals, legume grains and onions were obtained from the main food market in Mwanza, while amaranthus leaves were obtained from a field next to the highway. Two types of fish samples, Tilapia and Dagaa were also obtained, each 500 g from each sampling site. Five drinking water samples, each 500ml, were obtained from taps and an equal number of samples were also obtained from Lake Victoria and River Milongo. For the lake water, some samples were taken onshore at the beach, and others at least 2 km inshore in order to establish the effect of pollution onshore. Food and water samples were collected and prepared according to IAEA protocols (IAEA, 1997).

Soil samples were also obtained from purposively selected sites in the research area. Some sampling sites were next to the highway, where motor vehicle pollution is high, and others were at least 2 km away from the highway. Five 500g samples of soil were taken at each site, as per the IAEA protocols (IAEA, 1997).

Table 1: Sampling sites for lead content analysis in food, soil and water in Mwanza, Tanzania.

Site	Type of sample
River Milongo	Water
Kamanga Landing Site (Onshore & 2 km inshore	Water, soil (onshore) and fish
Igogo Landing Site (Onshore & 2 km inshore)	Water, soil onshore) and fish
Heavy Truck Packing Site	Soil
Along Mwanza – Shinyanga Highway (next to highway, and 2km from Highway)	Soil and amaranthus leaves
Mwanza City Market	Foods

Lead content determination: The lead content in the soil, water and food samples was determined by spectrophotometry using a Shimadzu Atomic Absorption Flame Emission Spectrophotometer model AA-6200 (AOAC, 1996; Osborne & Voogt, 1978). Each analysis was done in triplicate. Commercial lead standards and reference samples were used for quality assurance of the data.

Data analysis: Data was subjected to analysis of variance (ANOVA) and checked for correlations between lead levels in the environment and in food and water. Comparison was also made between the lead levels in the samples and the maximum safe limits set by WHO.

RESULTS AND DISCUSSION

Lead content in all the water samples from different sources in Mwanza were above the World Health Organization (WHO) maximum safe limits for drinking water of 0.001 mg/100 ml ($P \leq 0.05$) (Table 2). The lead content in the onshore water did not significantly differ ($P \leq 0.05$) from that of the water obtained at least 2 km inshore. The lead content of tap water did not differ significantly from that of the lake water. However, water from River Milongo had significantly higher lead content than the lake water ($P \leq 0.05$), indicating that the river had other sources of lead pollution.

Table 2: Lead content in water sampled around Mwanza town, Tanzania (mg/100 ml).

Sample source (n = 5)	Mean Lead content	Range
2 km inshore	0.04 ± 0.006^{b}	0.03 – 0.06
Onshore (Kamanga, Igogo)	0.04 ± 0.007^{b}	0.02 – 0.04
River Milongo	0.08 ± 0.002^{a}	0.08 – 0.08
Tap water	0.04 ± 0.005^{b}	0.03– 0.05
WHO maximum limit, drinking water	0.001^{c}	

Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.

Levels of lead contamination in natural raw waters, treatment plants or in distribution mains are typically low and rarely exceed drinking water regulations (Chow, 1968). However, lead contamination in water for drinking may occur as the water moves through the water distribution system. Tap water can be contaminated by lead pipes, copper pipes with lead solder or bronze and brass faucets contaminating lead. Lead contamination has also been found to be high in water from plastic pipes, probably from lead stearate which is used as a stabilizer in the manufacture of polyvinly plastics.

One probable source of lead pollution in Lake Victoria is the leaching from soils that are found next to busy highways into the water system (USEPA, 2003). Contamination of lead in groundwater may result from the dissolution of lead from soil and earth crust, where it is usually present in a form of carbonate and hydroxide complex, with varying degree of solubility. Once lead falls onto the soil, it usually sticks to the soil, depending on the particulate matter size, from where small amounts may enter rivers and lakes and streams as the soil particles are moved by rainwater (Mahaffey, *et al.,* 1982). Lead may remain stuck to the soil particles for many years. In this study the lead content in soils ranged from a minimum of 0.01 to a maximum of 0.48 mg / 100 g (Table 3). However, there was no significant difference between lead levels in soils sampled from the roadside when compared to those obtained 2km away or from the lake shore.

Table 3: Lead content in soil around Mwanza town in Tanzania (mg/100 g).

Sample source	Mean Lead content	Range
Highway	0.11 ± 0.067^{a}	0.01 – 0.34
2 km off highway	0.18 ± 0.032^{a}	0.07 – 0.48
Lake onshore	0.19 ± 0.068^{a}	0.10 – 0.32
Maximum safe limits, soil	0.04^{b}	

Means within columns followed by different letters are significantly different ($p < 0.05$)

Though the mean lead content in the soil samples are within typical concentrations of lead in soil (0.5-10 mg/ 100 g), all the samples had lead content above the maximum safe limits of 0.04 mg/ 100 g (WHO, 1995). Such soils are not safe for children to play on as there is a risk of contamination. Though the results do not reveal significant difference in the soil samples obtained adjacent to the highway in comparison to those obtained at least 2 km away, other studies have shown that an important source of soil lead is from dust particles on the side of roads that is released from burning of leaded petroleum (USEPA, 2003). In the USA, mean blood lead concentration in the general population dropped from 13 µg/100 ml to 2.8 µg/100 ml between 1980 and 1991 (Pirkle *et al*., 1994). The decrease was attributed to the drastic reduction in the use of lead in petroleum products. Between 1976 and 1990, lead used in petroleum fuel declined by 99.8% in the USA. (NAPE, 1993). Considering that the lead content in all the soil samples in Mwanza was above the recommended maximum WHO limits, such soil may result in lead poisoning either by direct ingestion, deposition of soil on the hands, or contamination of food (WHO, 1995).

Past traffic of motor vehicle volume, and its associated use of leaded petrol, has played the most important role in determining where lead is found in city and rural soils (Xintaras, 1992; UNEP, 2000). Hence, areas with historically high traffic volume are susceptible to lead pollution from leaded petrol that settle out into the soil or cling to buildings and is consequently washed into the surrounding soil. Use of leaded petroleum fuel has only been recently stopped in Tanzania. Pollution from this fuel may have contributed to accumulation of lead in soils around Mwanza.

Proximity to roads with high traffic density may contribute substantially to high soil lead levels. In addition, high levels of lead content may be found in dust settling in such areas, which may result in direct contamination of food and water (UNEP, 2000). High soil-lead levels mean that residents and their children in such areas face a health threat of lead poisoning from soil (UNEP, 2000). In a study in the USA, where 78 % of homes had soil-lead levels higher than 50 µg/100 g, it was estimated that a child eating only half a gram of such soil would ingest 250 µg of lead, almost twice the maximum safe intake limit per day.

Both types of vegetables sampled, amaranthus and onions, had lead content above the WHO maximum limits of 0.03 mg / 100 g (Table 4). The vegetable obtained from the roadside (amaranthus) had significantly higher ($p < 0.05$) lead content than that in the onions, which was obtained from the market. This is an indication that motor vehicle pollution is a likely source of lead contamination of vegetables on roadsides. Other investigations have also reported high levels of lead content in vegetables sampled near major highways (Tyroller, 1988).

These results are consistent with those reported by Leelhaphunt *et al.* (1994), of lead levels of 210 µg/100g in tomatoes purchased from Thailand markets. However, the lead levels in vegetables in this study are much higher than those reported by Denmark National Food Agency (Benko *et al*., 1995), probably due to the successful phasing out of leaded gasoline in European countries. When leaded fuel is burnt, it emits very fine particles of lead into the air, where they may settle on vegetables as they are vended along the streets and next to busy highways. Some of the particles settle on soil where they later contaminate the food when the dust is blown by wind (UNEP, 2000). Not surprisingly, there is good correlation between average traffic counts and average soil and plant lead content at sites close to the roadside. An inverse relationship between distance from the road and lead content has also been observed in various soils and vegetables (Wheeler & Rolfe, 1979; Tyroller,1988; Muramatsu *et al.,* 1994).

Table 4: Lead content in amaranthus and onions in Mwanza town, Tanzania (mg / 100 g).

Sample	Mean Lead content	Range
Amaranthus (Roadside)	0.88±0.136[a]	0.63– 1.18
Onions	0.22±0.005[b]	0.21 – 0.23
WHO Maximum limits, fruits and vegetables	0.03[c]	

Means within columns followed by different letters are significantly different ($p < 0.05$) from each other.

Table 5: Lead content in dry cereal and legume grain in Mwanza town, Tanzania (mg/100 g).

Sample	Lead content in mg/100g	Range
Pea nuts	0.04±0.010[b]	0.03 – 0.05
Peas	0.10±0.009[a]	0.10- 0.11
Rice	0.03±0.006[b]	0.03-0.03
Wheat	0.21±0.004[a]	0.02 – 0.03
Beans	0.12±0.0030[a]	0.11 – 0.12
Maize	0.11±0.010[a]	0.10 – 0.11
WHO maximum limits (maize, beans)	0.02[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.

Lead content in the dry cereal and legume grains in Mwanza did not differ significantly from that of peas and wheat grain ($P \leq 0.05$) (Table 5). However, these levels were significantly higher ($P \leq 0.05$) than the WHO maximum limits of 0.02 mg/ 100 g. The lead content in peanuts and rice did not differ significantly from the WHO maximum limit.

Lead content in cereal and legume grain, particularly maize and beans, is of particular interest as these are staple foods for many communities in Tanzania. In this study the lead levels in maize, beans, wheat and peas grain exceeded the maximum WHO limits. However, the lead content of rice and peanut samples was within the WHO limits. The difference in the lead content in the different grain samples may reflect the fact that the grain is obtained from different sources. Some of the grain may have been obtained from rural areas. The results are comparable to those obtained by Yang *et al.* (1994) in which cereals in China had lead levels of 6.3 µg/100 g. In Denmark, the National Food Agency established lead levels of 3.3 µg/100 g in cereals (National Food Agency of Denmark, 1992; Andersen *et al*., 1996). Another study (Urieta *et al.*, 1996) found mean lead levels of 2.0 µg/100 g in cereals from Spain. In the United Kingdom, Ysart (1994) reported mean lead levels of 2.0 µg/100 g in cereal products. In Poland, Krelowska-Kula (1991) found lead levels of 6.7 µg/100 g in cereals. In Japan, Muramatsu *et al.* (1994) established lead concentrations of 0.05 µg/g in wheat and rice.

CONCLUSION

Lead levels in tap water, soil and some foods in Mwanza town was above the WHO maximum limits and may pose a health risk to the inhabitants. The lead content was higher in vegetables grown near the roadside in comparison to that obtained from the market, indicating that motor vehicle pollution is an important source of lead contamination. Enforcement of regulations concerning lead pollution, including strict use of non leaded petroleum fuel needs to be applied. Routine monitoring of lead levels in the environment and food samples should also be established in Tanzania since these levels are likely to change with time.

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