ASSESSMENT OF LEAD RISK EXPOSURE FACTORS IN ADULT MALES IN KENYA

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Abstract

The study dealt with assessment of demographic and risk factors of lead exposure by people living in Nairobi and Mathira in Kenya by use of a standard questionnaire. The study subjects were the public vehicle drivers/conductors, people working in petrol stations, street hawkers, traffic policemen, artisans, those people who spend most of their time travelling and clerks. Farmers and students from Mathira were selected as the study subjects since they were expected to be least exposed while the rest were more exposed to Pb. Two hundred informed and consented subjects (n=200) of 18-50 years filled a self-administered questionnaire. From the questionnaire, most of the male subjects were at a greater risk of exposure to Pb from various sources for example having residences near busy roads or near industries, consumption of canned foods as well as exposed foods, smoking, use of glazed ceramics among other risk factors considered in this study. The data from the questionnaire was handled using descriptive statistics. The SPSS program version 17 was used and significance level was chosen at α=0.05.

Key words: Males, Lead, Risk factors, Questionnaire, Assessment, Kenya.

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Introduction

Lead is a non-essential element with no known biological function in the body. It has raised concern among heavy metals, due to relatively high toxicity and elevated quantity in the environment as a result of its widespread use (Cambra *et al.*, 1999). Further, Pb does not have any known biological use but is widely used in the industries (Mielke *et al.*, 1999; Gaw *et al.*, 2006). It is well documented that human beings may be exposed to lead through contamination of food, water, house, leaded dust, soil and through industrial activities such as metal recycling, battery industry and flaking paints (Park and Palk, 2002; Nabulo *et al.*, 2006). Nabulo *et al*. (2006; Ndiritu *et al.*, 2012) found that when Pb is released into the air, it stays there for ten days and most of it in the soil comes from particles falling from the air. Risk factors have been reported to exacerbate the absorption of Pb into the bodies of human beings (Albert and Badillo, 1991; ATSDR, 2000; Were *et al.*, 2008). There are many risks factors which may increase the exposure of human males to Pb. The social demographic risk factors include; age, race/ethnicity, income, education, housing vintage, poverty status among others (Sukumar and Subramanian, 2003; Ndiritu *et al.*, 2012). The environmental risk factors includes; living near heavy traffic road, eating exposed foods, source of water, use of glazed ceramics, living near a Pb based industry, smoking, duration of stay near an industry, influence of early child hood diseases, among other life style changes (Ndiritu *et al*., 2012). The occupational risk factors include; working in industries (where adult males predominate) dealing with lead based products for example, paints, car batteries and radiators, drivers/conductors, petrol station attendants, traffic policemen, artisans, among others factors (Oyaro, 2000; Park and Palk, 2002; Were *et al.*, 2008; Mogwasi, 2009). These may greatly contribute to elevated Pb levels in the body (Ndiritu *et al.*, 2012). Lead is of a particular concern as there is increasing evidence that relatively low levels of exposure affects mental development of the child whose toxicity increases even in adulthood and may cause permanent mental and behavior disorders (Lanphear *et al.*, 2005). In general Pb poisoning results in adverse health effects associated with hematological, gastrointestinal; and neurological system. Lead also affects the CNS and causes neurological symptoms that have been reported with BPb of 40-60 µg/dL (Cambra *et al.*, 1999). Slowed nerve condition in peripheral nerve of adult has also been observed at BPd of 30-40 µg/dL (Carnifield *et al.*, 2003). Studies have found that first exposure to neurotoxicants such as Pb might lead to decreased reserve capacity of the brain, detrimental effects on neuropsychological factor which may become apparent in old age

(Tang *et al.*, 2003). Toxicity of Pb is also manifested in male reproductive system by deposition of lead in testes, epididymis, vas deferens, seminal vesicle and seminal ejaculate (Roy *et al.*, 1986). Deficiencies of essential elements exacerbates Pb uptake in the body (Nowak and Chmielnicka, 2000). Human males are the heads and bread winners of most families in Kenya (Fapohunda and Rutenberg, 1999). In addition they work in areas that expose them to heavy metal pollution such as lead and because of their busy schedule they are unable to eat foods which may help their bodies to have the required levels of essential elements (Fapohunda and Rutenberg, 1999; Oakes and Slotterback, 2005). These males are found many times taking very poor diets for example tea, mandazi, roasted maize and other fast foods mostly prepared in roadside kiosks which further increases their risk of Pb ingestion. These poor diets often lead to deficiency of important essential elements in the bodies of males (Ndiritu *et al.*, 2012). Several researchers have reported that deficiency of essential minerals Zn, Ca and Fe exacerbates the absorption of lead (Wilhem and Hafner, 1993; Satarug *et al.*, 2000; Nowak and Chmielnicka, 2000; Imran *et al.*, 2003). It is important to note that human males are not exempted from diseases and ailments that are brought about by essential trace element deficiencies, it is therefore imperative that human males are advised accordingly on proper eating habits. This will go a long way in reducing the effects of Pb pollution besides reducing its absorption in the body. Studies on Pb have been reported by Were *et al.* (2008) among school age children and in women Owago (1999). However, no study has reported Pb assessment in the male population. The purpose of this study therefore was to set to assess the exposure to lead in human males from Nairobi and Mathira rural. The results of this study will therefore aid in coming up with data that can be harmonized with earlier data from studies on children and women. This will then aid in development of fresh policies and programs to curb Pb pollution as well as sensitizing the public.

Area description:

Nairobi is the capital city of Kenya and covers an area of 697 Km^2 with a population of over 3.1 million as recorded by CBS (2010). Nationally, Nairobi has been established to have the greatest concentrations of industrial and vehicular air pollution sources. It is reputed to be the fastest growing city in the world after Guadeloupe in Mexico City and Maputo in Mozambique. Interestingly, Mulaku and Kariuki (2001) reported that Nairobi does not have any air quality

management system. Indeed out of 20 mainly developing countries cities that were sampled for the study on air quality management capabilities Nairobi was rated as the worst (UNEP/WHO, 1996). It has high pollution intensity due to increasing population, industries, deforestation on the fringes of city, constriction and vehicular traffic density. The city is now regarded as "hot zones" with highest concentration of pollutants and industrial activity (Mulaku and Kariuki, 2001). The CBS (2010) reported that Mathira is situated in central Kenya with a population of 152,000 and covers an area of 434 Km^2. It is a rural setting with few vehicles and industries. The study sites included schools and homes situated in this agricultural region, in which coffee, tea and horticultural crops are predominant. These crops requires substantial amount of fertilizers and pesticides for their production (Ndiritu *et al.*, 2012). These chemicals have heavy metals in-put. Therefore it was the aim of this study to assess lead exposure in adult males over the age of 18 years in different environmental settings.

Experimental:

Participation of all the subjects in this study was voluntary and relevant permits were obtained prior to the study. Confidentiality of the data collected and subsequent findings were assured by using only code numbers for each participant. Participants were free to terminate participation at their convenience. Field visits and sampling began in June 2010 and ended in September 2010. A pilot questionnaire was given to a few subjects who were not part of the experimental group for filling. Some subjects could not understand some of the questions and hence adjustments were done to such questions to make them easily understood. The questionnaires were reissued to the subjects and this time the subjects were able to fill the questionnaire without problems. After successful piloting, the questionnaires were now issued to the experimental group. For the subjects who did not understand English the questionnaire was translated to Kiswahili orally by the interviewer.

Two hundred (n=200) males over the age of 18 years were randomly recruited. Consent was sought from parents/guardians in case the subject was still under their care. The informed and consented subjects (n=200) filled a self-administered questionnaire. This took into account the previous findings and the WHO (1996) recommendations. The questionnaire elicited information on demographic characteristics, health conditions, socio-economic background, environmental

risk exposure factors and diet habits of the subjects. The diet habits considered factors such as consuming processed food, canned with high fat content and marginal proteins. The environmental risk factors included; working in industries, petrol stations, drivers and conductors, those people who spend most of their time traveling, living near the road, living in a house painted with leaded paint or use of glazed ceramics utensils frequently, consuming exposed food from open air market or streets and taking water from leaded piping or borehole water frequently. Purposive sampling strategy was used to select males in both urban and rural settings. The major criterion for selection of males in urban areas was influenced by the intensity of pollution, one hundred and twenty (n=120) subjects were recruited under this category. In Mathira rural, the criterion for selection was that it is in the interior far from urban influence. Therefore, eighty (n=80) subjects were recruited under this category. Each recruited subject gave his paired sample of finger nails and scalp hair.

Data analysis:

Statistical calculations were done using statistical SPSS program (Statistical Package for Social Sciences Version 17). The data from the questionnaire was handled using descriptive statistics.

Results and discussions

Age

The age distribution of the respondents from rural and urban areas is presented in Figure 1.

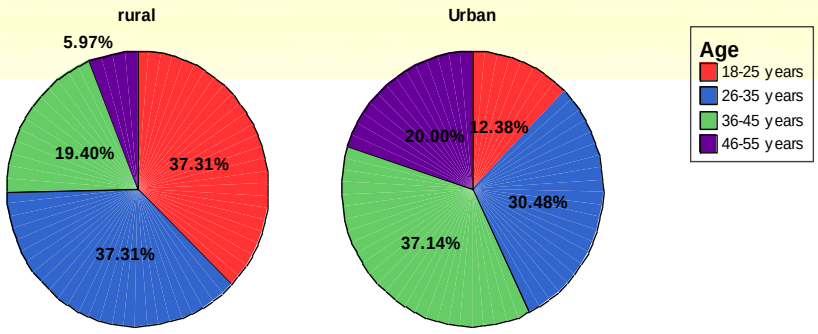


Figure 1: Age distribution of the respondents from rural and urban areas

As can be seen from Figure 1, subjects aged 18-25 and 26-35 years were each 37.31 % from rural area and 12.38 % and 30.48 % respectively from urban area. On the other hand, those aged 36-45 and 46-55 years were 37.14 % and 20.00 % respectively from urban and 19.40 % and 5.97 % from rural areas. It was established that 63.37 % of the respondents from both urban and rural were aged from 26-45 years. These people are energetic and hence active in their respective occupations. These findings agree with those of other researchers (Owago, 1999; Mogwasi, 2009). It is also evident that after people go to urban areas while young, they are reluctant to go back to their rural homes since in the rural areas there were fewer people aged 36-55 years.

Respondents socio-economic background

The results for socio-economic background are presented in Figure 2.

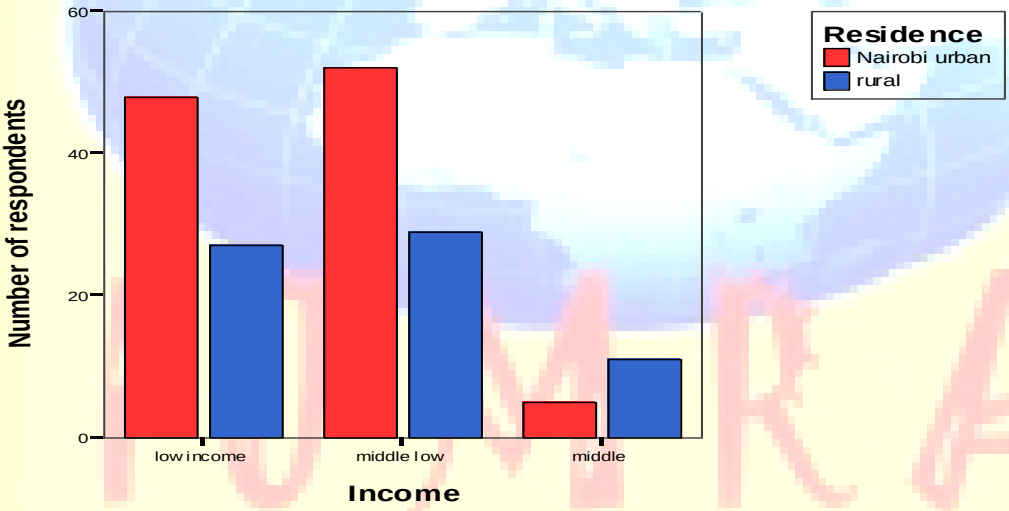


Figure 2: Socio-economic background of the respondents

Subjects from low social economic background were 43.60 % and reported a gross income of below Ksh 5,000, 47.10 % were from a low middle status with a gross income of Ksh 5,001-20,000. Subjects from a middle background were 9.30 % with a gross income of Ksh 20,001-50,000. However, no subject was found from high socio-economic background. The results agree with the findings of other researchers (Owago, 1999; Were *et al*., 2008) who reported that majority of the Kenyan population are low income earners.

Medical history

In regard to possibility of influence of early childhood deficiencies such as rickets pyorrhea, anemia or pica on the levels of Pb, 66.90 % of the subjects stated that they had never been afflicted and 28.00 % stated that they had been afflicted by the deficiencies. Of those who had been afflicted, 7.00 % were from the rural areas and 26.00 % from the urban areas. Further, it was established that 0.90 % of the subjects exclusively from the rural areas had kidney problems and 0.90 % had brain disorders. Subjects from urban area that reported they had hyperactivity were 8.30 %. This study established that most of the respondents were not willing to disclose information regarding their past health condition despite assuring them confidentiality and as such most of them did not give their responses in this part. Sukumar and Subramanian (2005) and Ayodele and Bayero (2009) reported that subjects were unwilling to disclose their medical history even where confidentiality was assured.

Respondents place of residence

This study established that 61.00 % (n=105) of the subjects had lived in urban area. Of those who lived in urban area, 50.00 % (n=52), 21.00 % (n=22) and 29.00 % (n=32) had lived there for 6-7, 4-5 and 2-3years respectively. On the other hand, those that had lived in rural area composed 39.00 % (n=67) of the study subjects, with 67.00 % (n=45), 25.00 % (n=17) and 6.00 % (n=4) having lived there for 4-5, 6-7 and 2-3 years respectively (Appendix I).

Respondents residence location

The results for the location of the residence of the respondents are presented in Figure 3.

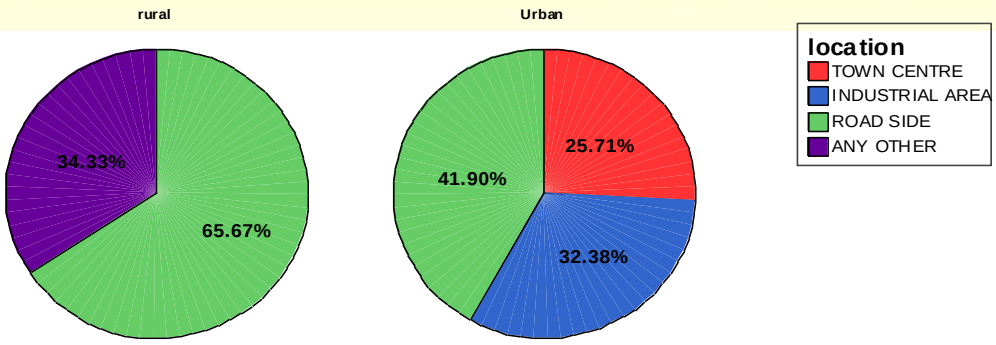


Figure 3: Location of residence for the hair and nail donors

From Figure 3, 25.71 % of the urban subjects had their residence in the city centre, 32.38 % in industrial area and 41.90 % had their residences by the road side (a distance not more than 100 m from the road). This is in agreement with results from another study (Were *et al.*, 2008). Of the rural subjects, 65.67 % stated that they lived by the roadside while 34.33 % lived far away from the road. Roads in the Mathira (rural area) are not busy to cause a serious environmental pollution; some of the roads could hardly record two vehicles in one day. Results that show the distance of the residence from the road are shown in Figure 4.

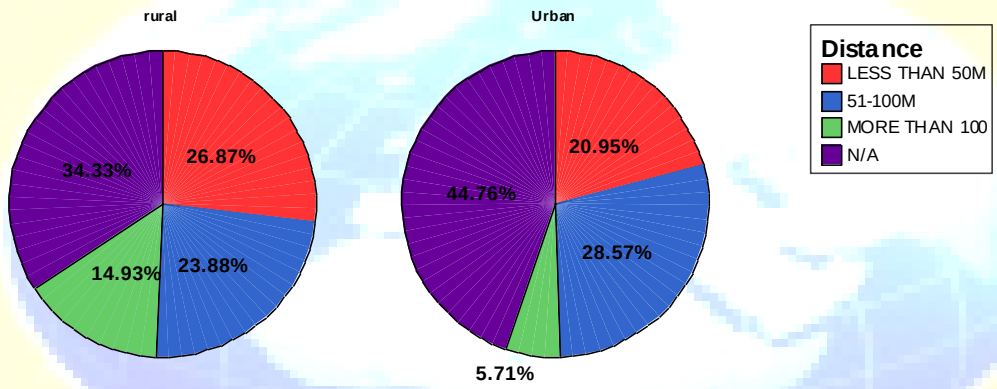
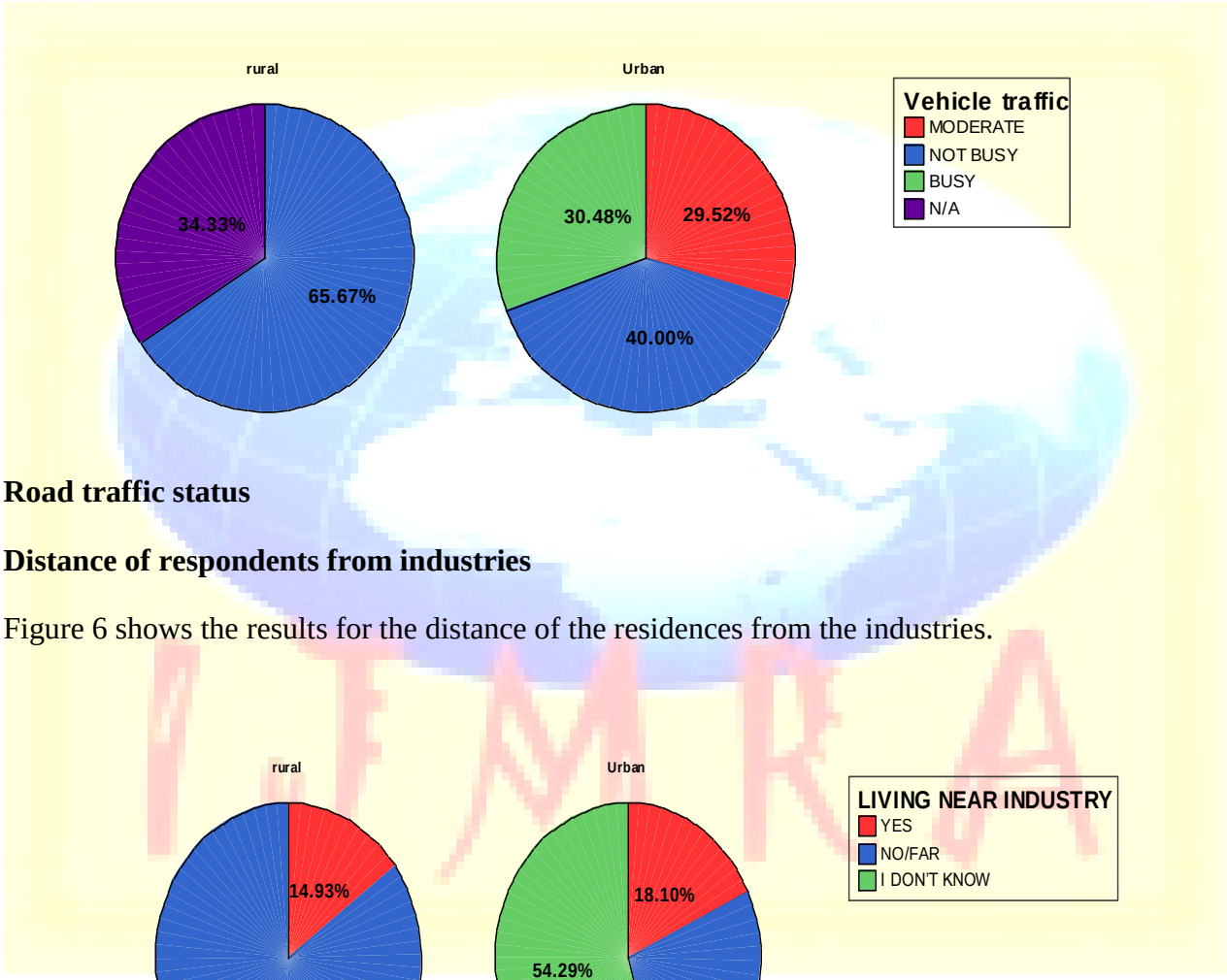


Figure 4: Distance of the residence from the road

This study established that of the subjects who lived by the roadside, 26.87 % and 20.95 % respectively were from rural and urban settings and lived less than 50 m from the road. Subjects who lived 51-100 m from the road in Mathira rural and Nairobi urban settings were 23.88 % and 28.57 % respectively, while 14.93 % and 5.71 % from rural and urban settings respectively, lived more than 100 m from the road (Figure 4).

It was found out that 30.48 % of the urban subjects (n=32) lived near a very busy road recording more than 50 vehicles per minute, while 29.52 % (n=31) lived near a moderately busy road recording not more than 20 vehicles per minute. Those who lived near a road which was not busy recording less than 5 vehicles per minute were 40.00 % (n=42). Rural subjects who lived near a road which was not very busy were 65.67 % (n=44) while 34.33 % lived far away from busy roads abbreviated as N/A (Figure 5). Distance of the residence from the road is highly associated

with elevated levels of Pb. Were *et al.* (2008) and Mogwasi (2009) reported that subjects who lived near busy roads had higher Pb levels in their finger nails and blood respectively than those who lived far away from the busy roads or those who lived in rural areas where vehicular density was lower. This study then seeks to establish whether the same findings will be obtained with human males since children and women were used in the reported studies Were *et al.* (2008) and Mogwasi (2009).



Road traffic status

Distance of respondents from industries

Figure 6 shows the results for the distance of the residences from the industries.

Figure 6: Percentage of the residences near an industry

Subjects from Mathira rural who lived far from the industry were 85.07 % while 27.62 % of the urban subjects lived far from the industry. Those who lived within 1 Km radius from the industry were 14.93 % and 18.10 % from rural and urban settings respectively, while 54.29 % of the urban subjects stated that they did not know (Figure 6). (Owago, 1999; Oyaro, 2000; Mehra and Juneja, 2005; Were *et al*., 2008; Ayodele and Bayero, 2009) reported that having residences near industries that emitted dangerous fumes or worked in industries that dealt with Pb for example paints, batteries, car radiators and others was related to high levels of Pb in human tissues such as finger nails, hair and blood. Oyaro (2000) reported higher Pb levels in vegetables grown in the industrial area than those grown far from industrial proximity.

Lead exposure from painted residence

The results of those respondents who lived in painted or unpainted houses are presented in Figure 7.

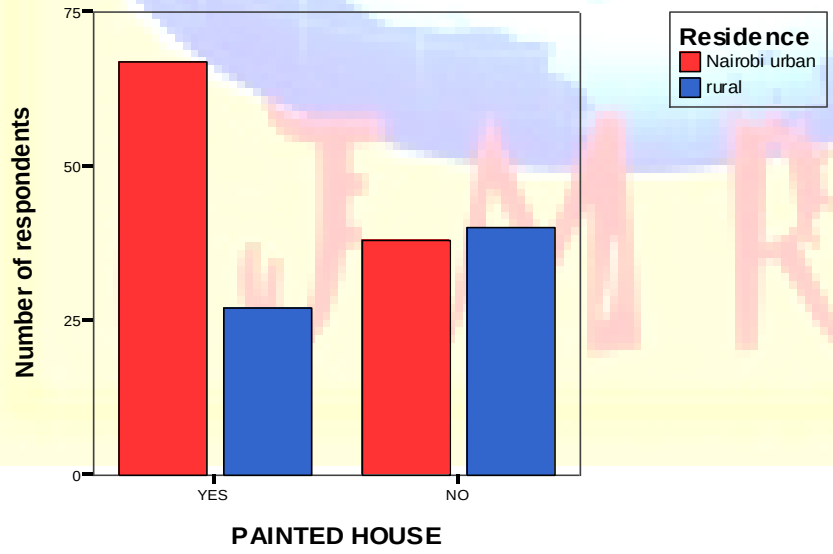


Figure 7: Painted house status

Figure 7 shows that subjects who lived in painted houses were 94 (54.70 %) while 78 subjects (45.30 %) lived in unpainted houses. Most of those who lived in painted houses came from the

Nairobi (urban) settings where most of the houses are permanent rented houses. The condition of the paint for those living in painted houses.

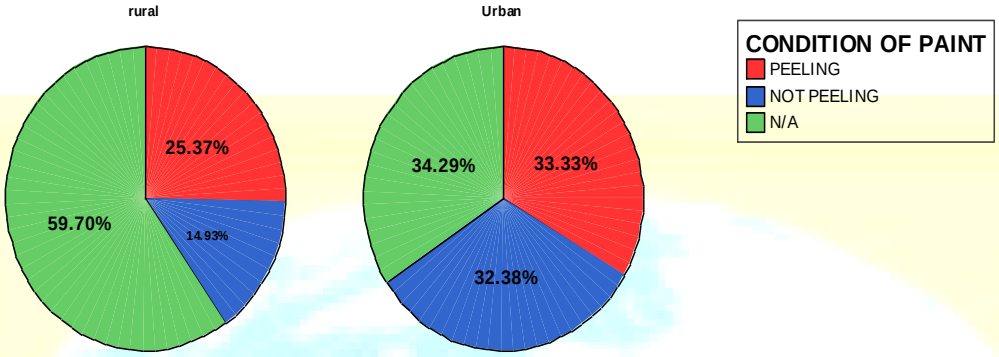


Figure 8: Condition of the paint in the painted houses

Further, this study found that 25.37 % of the painted houses in the rural area had their paints peeling off while in the urban area 33.33 % of the painted houses had their paint peeling off. Of those who lived in painted houses, 14.88 % and 32.36 % from Mathira (rural) and Nairobi (urban) respectively stated that the paint was not peeling while 59.70 % and 34.28 % subjects from rural and urban area respectively had never lived in a painted house abbreviated as N/A (Figure 8**)**. Living in a painted house or in a house where the paint was peeling was highly associated with increased levels of Pb (Owago, 1999; Samatha *et al*., 2004; Mehra and Juneja, 2005; Were *et al.*, 2008). This therefore means that the subjects who lived in painted houses in this study were expected to have higher levels of Pb than those who did not live in painted houses. Therefore there is need to sensitize the males and the general public about painted houses as well as the condition of the paint in the houses.

Respondents occupational exposure

The results for occupational exposure of Mathira (rural) and Nairobi (urban) respondents are presented in Figure 9.

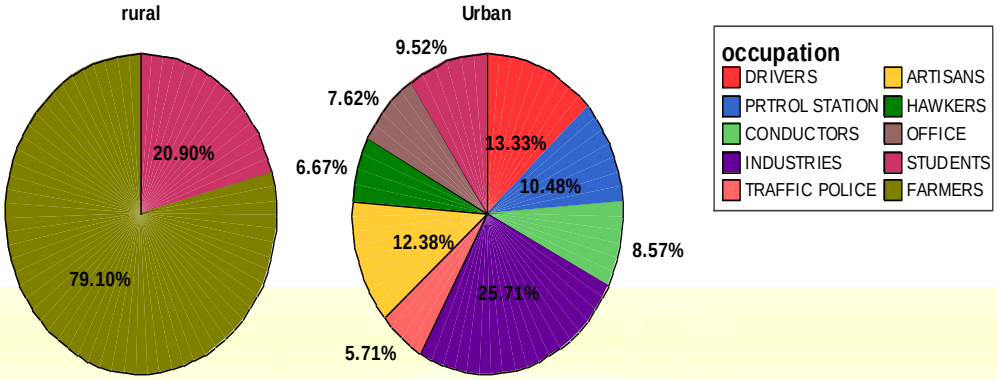


Figure 9: Occupations of the urban and rural respondents

As can be seen from Figure 9, 25.71 % of the urban respondents worked in the industries. Of those, 47.00 % worked in battery industry, 19.00 % worked with paint and 20.00 % worked in car radiator industry. Drivers were 13.33 %, 8.57 % were conductors, 10.48 % worked as petrol station attendants, 5.71 % were traffic policemen, 12.38 % worked as artisans in the garages, 6.67 % were hawkers, 7.62 % worked in offices, 9.52 % of the urban respondents were students while 20.90 % were students from the rural area, while 79.10 % of the rural respondents were farmers (Figure 9). The type of occupation is associated with high levels of Pb (Wilhelm and Hafner, 1993; Owago, 1999; Nowak and Chmielnicka, 2000; Sukumar and Subramanian, 2003; Samatha *et al.*, 2004; Mehra and Juneja, 2005; Nnorom *et al.*, 2005; Sanna *et al.*, 2007; Ayodele and Bayero, 2009; Mogwasi, 2009). This is so because subjects in certain occupations are more exposed to Pb than others for example subjects who work in industries that are Pb based or those who work with lead acid batteries are more exposed to Pb than those who work in offices.

Use of glazed ceramics by respondents

The results for use of glazed ceramics by the respondents are presented in Figure 10.

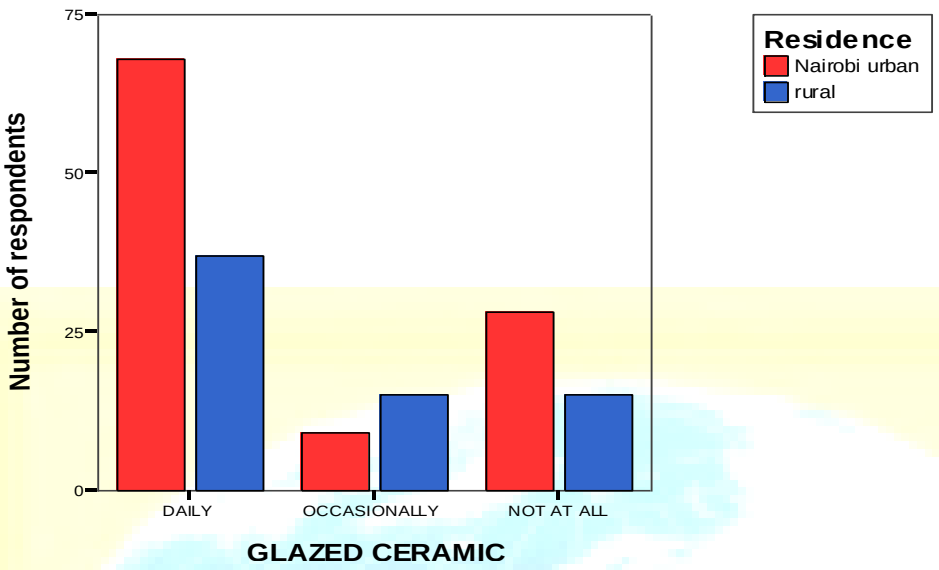


Figure 10: Use of glazed ceramics by the respondents

From Figure 10, subjects who used glazed ceramics frequently were 105 (61. 00 %), while 24 subjects (14.00 %) used glazed ceramics occasionally and 43 subjects (25.00 %) were non users. Glazed ceramics are common utensils in most homes nowadays and have replaced the metallic utensils that rust easily. Were *et al.* (2008) and Mogwasi (2009) reported that frequent use of glazed ceramics was related to higher levels of Pb in finger nails and blood respectively. Lead (II) oxide is typically present in concentration ranging from a few percent up to nearly 50 % (Lehman, 2002). The Lead (II) oxide is chemically combined in the ceramics structure and the Pb is easily extracted by food substance (ATSDR, 1993). Generally the tendency of Pb to migrate from the glaze is greatest under acidic conditions (ATSDR, 1993; Rahman, 2001; Lehman, 2002). This study found that 61.00 % of the males were at risk of lead exposure emanating from frequent use of glazed ceramic as opposed to those who used them occasionally or those who did not use them at all, which calls for the need to sensitize the public.

Consumption of highly processed foods

The results for consumption of highly processed and canned foods by the respondents are presented in Figure 11.

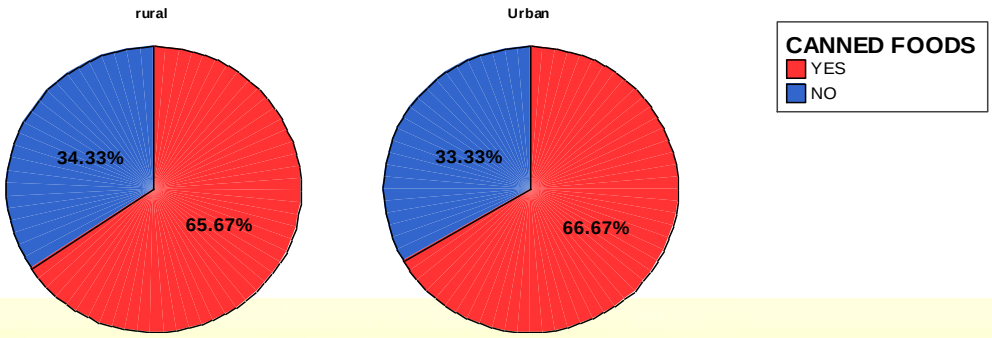


Figure 11: Use of canned foods by the respondents

As can be seen from Figure 11, subjects from Mathira (rural) who frequently consumed highly processed and canned foods were 65.67 % (n=44) while 66.67 % (n=70) were from Nairobi (urban). Non consumers of highly processed and canned foods were 34.33 % and 33.33 % from Mathira (rural) and Nairobi (urban) respectively. In general the subjects exclusively from the urban areas were from low middle and middle socio-economic background and they were found to consume highly processed and canned foods frequently since they were able to afford them. When natural foods are taken through a series of refining that changes the original form of the natural foods then these foods are said to be processed. For example removing the outer cover of maize or wheat grains before grinding into flour. Consumption of highly processed and canned food was associated with high levels of Pb as reported by Were *et al. (*2008) and Mogwasi (2009) in finger nails and blood respectively. The processed foods are deficient of some essential elements in addition they may accumulate Pb in the process of refining/processing. The study seeks to establish whether the same findings will be obtained with human males. This therefore, calls for the need to sensitize the males and the general public on the importance of eating natural foods which are not highly processed.

The results that show the use of exposed foods by the respondents are presented in Figure 12.

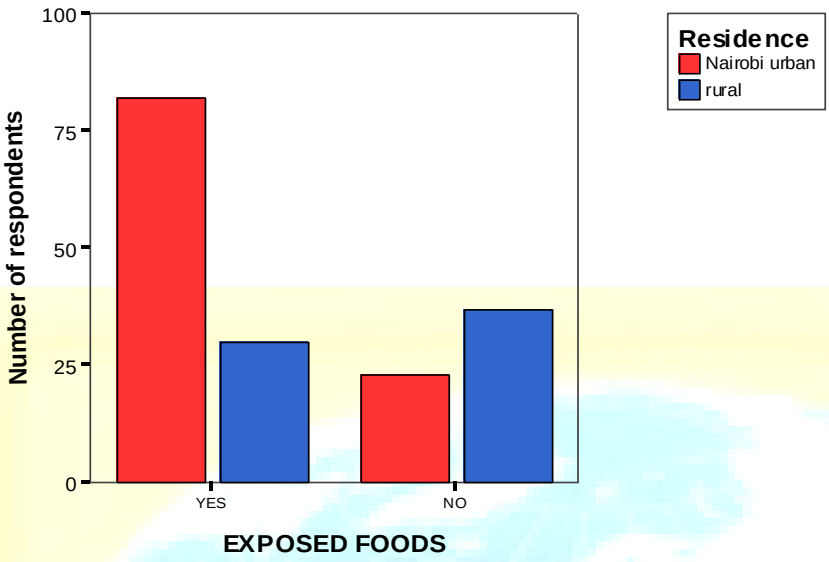


Figure 12: Use of exposed foods by the respondents

As can be seen from Figure 12, 30 subjects (44.78 %) from Mathira (rural) frequently consumed exposed foods while 82 subjects (78.10 %) from Nairobi (urban) were also consumers. Those from Mathira and Nairobi who stated that they had never consumed exposed foods were 37 subjects (55.22 %) and 23 subjects (21.90 %) respectively. Exposed foods are the foods prepared, sold or even consumed in open places for example, along the roads or streets. Exposed foods especially along dusty and busy roads and streets accumulate high levels of Pb and other metals emanating from the dust as well as from the car exhaust. Consumption of exposed foods is associated with high levels of Pb as reported by (Oostdam *et al.*, 1999; Oyaro, 2000; Dickson *et al*., 2005; Nabulo *et al.*, 2006; Were *et al*., 2008; Mogwasi, 2009). In most of Nairobi (urban) estates, food is cooked and sold along the dusty streets some of which are very busy with traffic and hence increasing the risk of exposure to lead present in the smoke from the exhaust pipes of the vehicles. The public should therefore be sensitized on the dangers of eating exposed foods. The policy makers should on the other hand ensure that human food sold in open places for example along the streets is covered.

Sources of water

The results that show the source of water used as given by respondents are presented in Figure 13.

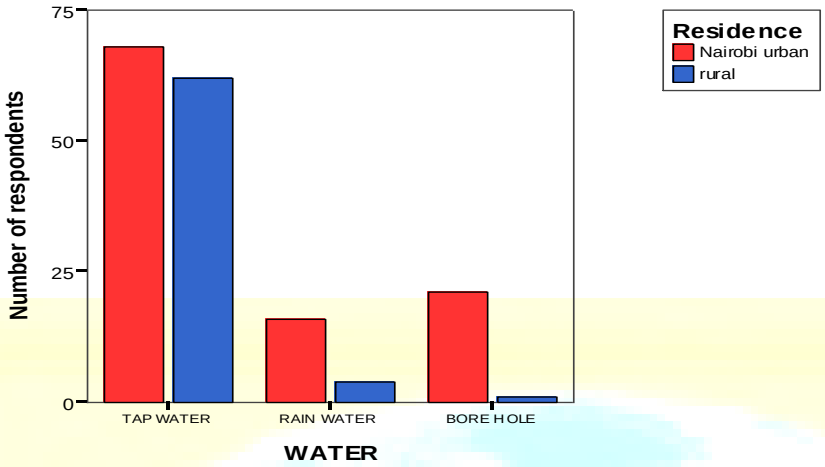


Figure 13: Source of water consumed by the respondents

The study established that 62 (92.54 %) and 68 (64.76 %) of the subjects from Mathira (rural) and Nairobi (urban) respectively depended on tap water. Those who depended on borehole water were 1 (1.49 %) and 34 subjects (20.00 %) from rural and urban settings respectively. Those who depended on harvested rain water were 4 (5.97 %) and 16 subjects (15.24 %) from rural and urban settings respectively (Figure 13). Results of this study are in agreement with the findings of Were *et al*. (2008) who reported increased use of tap water in most homes. The study reported that subjects who depended on tap water had higher levels of Pb in finger nails than those who used rain water. High Pb levels originate from the plumbing system which were reported by UNEP (2001) and agrees with results of CDC (2005) which reported that use of galvanized pipes increased the levels of Pb in drinking water while Segura-Munoz *et al*. (2006) reported that high levels of Pb was as a result of weathering of rocks.

Smoking and use of cosmetics by the respondents

The results that show the number of smokers and non-smokers in the study areas are presented in Figure 14.

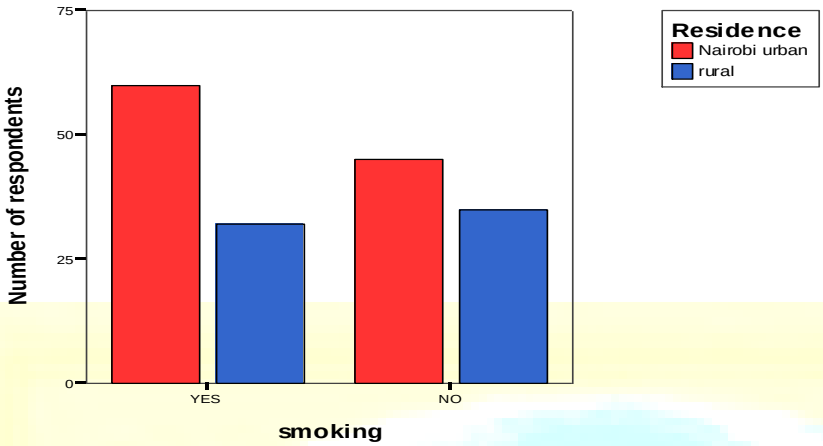


Figure 14: **Smoking habits of the respondents**

As can be seen from Figure 14, 32 subjects (47.76 %) and 60 subjects (57.14 %) from rural and urban settings respectively were smokers while 35 (52.24 %) and 45 subjects (42.86 %) from rural and urban settings respectively stated that they had never smoked (Figure 14). Tobacco smoking is associated with high levels of Pb as well as other metals since Pb accumulates during the processing of tobacco or the tobacco leaves absorbs the lead from soil containing lead metal as reported by (Kyle, 1992; O'Neill, 1993; Chakrabati *et al.*, 1996; Owago, 1999; Sukumar and Subramanian, 2003; Mehra and Juneja, 2005). Owago (1999) reported elevated levels of Pb in pregnant women who smoked than in those who did not smoke.

The percentage of the subjects applying nail/hair vanish by the male respondents are presented in Figure 15.

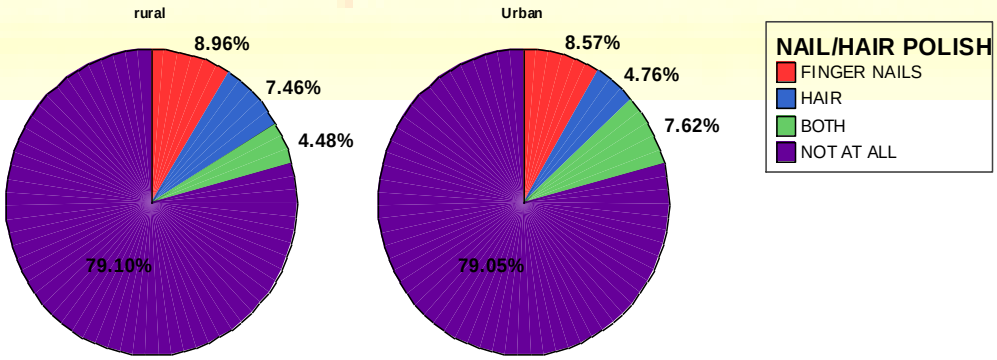


Figure 15: Application of cosmetics by the respondents

The study established that 8.70 % of the respondents applied nail polish, 5.80 % applied hair chemical and 6.40 % stated that they had applied both the nail vanish and hair chemical. Those that had never applied nail vanish or hair chemical were 79.10 % (Figure 15). Application of nail vanish, hair chemicals and other types of cosmetic are associated with high levels of heavy metals especially Pb as reported by (Samatha *et al*., 2004; Mehra and Juneja, 2005; Nnorom *et al.*, 2005). Were *et al.* (2008) reported that application of nail vanish did not influence the levels of Pb.

Conclusions

Most of the male subjects were at a greater risk of exposure to Pb from various sources for example having residences near busy roads or near industries, consumption of canned foods as well as exposed foods, smoking, use of glazed ceramics among other risk factors considered in this study.

Acknowledgements:

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REFERENCES

1. Agency for toxic substances and disease registry (ATSDR), (1993). Toxicology profile for lead (draft). U.S. public health services, U.S. department of health and human services, Atlanta, G.A.
2. Agency for toxic substances and disease registry (ATSDR), Case study in environmental medicine, lead toxicity, U.S department of health and human services. Atlanta, G.A., 2000.
3. Albert, L. and Badillo, F. (1991). Environmental lead in Mexico. *Reviews of Environmental Contamination and Toxicology* **117:** 1-4.
4. Ayodele, J. and Bayero, A. (2009). Lead and zinc concentrations in hair and nail of some Kano inhabitants. *African Journal of Environmental Science and Technology* **3:** 164-170.
5. Cambra, K., Martinez, T., Urzelai, A. and Alanzo, E. (1999). Risk analysis of a farm area near lead and cadmium contaminated industrial site. *Journal of Soil Contamination* **8:** 527-540.
6. Carnified, R., Henderson, C., Cory-Slechta, D., Cox, C., Jusko, T. and Lanphear, B. (2003). Intellectual impairment in children with blood lead concentration below ten micrograms per deciliter, New England. *Journal of Medicine* **348:** 1517-1526.
7. Central Bureau of Statistics (CBS), Kenya population census 2010, Ministry of Planning and National Development, Nairobi Kenya, 2010.
8. Centre for Disease Control (CDC), (2005). Second report on human exposure to environmental chemicals, centre for disease and prevention, National Chemical Environmental Health publisher number 02-0716, Atlanta, GA.
9. Chakrabati, C., Cheng, J., Lee, F., Back, H. and Schroeder, H. (1996). Lead exposure in children. *Environmental Science and Technology* **304:** 1245-1252.
10. Dickson, N., Lepp, W. and Lepp, S. (2005). Lead and potential health risks from subsistence food crops in urban Kenya. *Environmental Geochemistry and Health* **9:** 37-42.
11. Fapohunda, B. and Rutenberg, N. (1999). Expanding men's participation in reproductive health in Kenya. African population policy research centre, Nairobi, Kenya pp 1-2.
12. Gaw, K., Wilkins, A., Kim, N., Palmer, G. and Robinson, P. (2006). Trace element and DDT concentrations in horticultural trial soils from the Tasman Waikato and Auckland regions of New Zealand. *Science of the Total Environment* **355:** 31-47.

13. Imran, H., Gul, K., Jamali, M., Hassan, K. and Shar, Q. (2003). The status of trace and toxic elements in biolgical samples (scalp hair) of skin disease patients and normal subjects. *Analytical Chemitry* **3:** 24-29.
14. K. and Chatterjee, B. (1986). Effect of lead on human semen. *Contraceptive Delivery System* **2:** 208-210.
15. Kyle, S. (1992). *Journal of the American Medical Association* **271 (1):** 94-99.
16. Lanphear, B., Horming, R., Khoury, J., Yolton, K. and Bellinger, D. (2005). Low levels environmental lead exposure and children's intellectual functions, an internal pooled analysis. *Environmental Health Perspective* **113:** 894-899.
17. Lehman, L. (2002). Lead glazes for ceramic foodware. The international lead management centre, Research triangle park, NC USA 1st ed pp
18. Mbaria, J. (2007). False start in the battle against lead. In: DailyNation; Nairobi Kenya; 28-33.
19. Mehra, R. and Juneja, M. (2005). Finger nails as biological indices of metal exposure, Department of Pure and Applied Chemistry, Mallershi, Dayanand Saraswati University. *Journal of Bioscience* **30:** 253-257.
20. Mielke, H., Gonzales, C., Smith, M. and Mielke P. (1999). The urban environment and children's health, soil as an integrator of lead, zinc and cadmium in New Orleans, Louisiana United States of America. *Environmental Research Centre* **81:** 117-129.
21. Mogwasi, R. (2009). Use of human blood as bio-indicator of heavy metal overload, M.Sc Thesis, Department of Chemistry, Kenyatta University, Nairobi, Kenya.
22. Mulaku, G. and Kariuki, L. (2001). Mapping and analysis of air pollution in Nairobi, Kenya, International conference on spatial information for sustainable development. Nairobi, Kenya 2nd -5th October.
23. Nabulo, G., Oryem-Origa, H. and Diamond, M. (2006). Assessment of lead, cadmium and zinc contamination of roadside soil surface films and vegetables in Kampala city Uganda. *Environmental Review* **101:** 42-52.
24. Ndiritu, J., Wanjau, R and Murungi, J. (2012). Lead in finger nails and scalp hair of adult males in Kenya. *International Journal of Physical and Social Sciences* **2 (10):** 211-224.

25. Nnorom, I., Igwe, J. and Ejimne, J. (2005). Multielement analyses of human scalp hair samples from three distant towns in south eastern Nigeria. *African Journal of Biotechnology* **4:** 1124-1127.
26. Nowak, B. and Chmielnicka, J. (2007). Contents and relationship of elements in human hair for a non-indu. population in Poland. *Science of the Total Environment* **209:** 59-68.
27. O'Neill, P. (1993). Environmental chemistry. Chapman and Hall, London; Second Edition, 202-208.
28. Oakes, E and Slotterback, S. (2005). Prejudgement of those who eat a healthy versus an unhealthy food for breakfast. *Current Psychology* **23 (4):** 267-278.
29. Oostdam, J., Gilman, A., Dewailly, P., Usher, B., Wheatley, H., Neve S., Walker, J., Tracy, B., Feeley, M., Terome, V. and Kwavnik B. (1999). Human health implication of environmental contaminants in Artic Canada. *Science of the Total Environment* **230:** 1-8.
30. Owago, J. (1999). Determinants of blood Pb levels in pregnant women living in Nairobi. M.Sc Thesis, Department of Chemistry, Kenyatta University, Nairobi, Kenya.
31. Oyaro. N. (2000). Heavy metals in amaranthus as a determinant of pollution in the City of Nairobi and its environs. M.Sc Thesis, Department of Chemistry, Kenyatta University, Nairobi, Kenya.
32. Park, D. and Palk, N. (2002). Effects of Pb of air-borne lead particles characterized by size. *Annals of Occupational Hygiene* **46:** 237-243.
33. Rahman, I. (2001). Preparation of low melting temperature, lead-free glaze by the sol-gel method. *Ceramic International* **27:** 681-687.
34. Roy, A., Chinoy, N., Gautam, A., Rao, R., Parikh, D., Shah, G., Highland, H., Patel,
35. K. and Chatterjee, B. (1986). Effect of lead on human semen. *Contraceptive Delivery System* **2:** 208-210.
36. Samatha, G., Sharma, R., Roychowdury, T. and Charkraborti, D. (2004). Arsenic and other elements in the hair, nails and skin scales of arsenic victims in west Bengal India. *Science of the Total Environment* **326:** 30-45
37. Sanna, E., Liguori, A., Palmas, L., Soro, M. and Floris, G. (2003). Blood and hair lead levels in boys and girls living in two Sardinian towns at different risk of lead pollution. *Ecotoxicological Environmental Safe* **55:** 293-299.

38. Satarug, S., Elkins, R. and Moore, R. (2000). Safe levels of cadmium intake to prevent renal toxicity in human subjects. *British Journal of Nutrition* **84:** 30-45.
39. Segura-Muñoz, S., da Silva Oliveira, A., Nikaido, M., Trevilato, T., Bocio, A., Takayanagui, and Domingo, J. (2006). *Environmental. International* **32:** 52-59.
40. Sukumar, A. and Subramanian, R. (2003). Relative element levels in paired samples of scalp hair and fingernails of patients from New Delphi. *Science of the Total Environment* **372:** 474-479.
41. Tang, R., Zhang, S., Xiong, Y., Zhao, Y., Fu, H., Zhang, H. and Xiong, K. (2003). Studies of the microelement content in human serum, hair and fingernails correlated with aged hypertensive and coronary heart disease. *Biological Trace Element Review* **92:** 97-104.
42. United Nations Environmental Programme (UNEP), (2001). Environmental data report, Blackwell publishers Massachusetts **1987:** 951-952.
43. United Nations Environmental Programme (UNEP)/World Health Organization (WHO), (1996). Air quality management and assessment capabilities in major cities, 245.
44. Were, F., Njue, W., Murungi, J. and Wanjau, R. (2008**)**. Use of finger nails as biomarkers of heavy metal pollution. *Science of the Total Environment* **8:** 376-393.
45. Wilhem, M. and Hafner, D. (1993). Monitoring of Cd, Cu, Pb and Zn status in young children using toenails, comparison with scalp hair. *Science of the Total Environment* **103:** 1999-2007.
46. World health organization (WHO), (1996). Sampling methods in mobility survey and public health investigation, Geneva. technical report series volume 36.