International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:8, No:10, 2014

Use of Hair as an Indicator of Environmental Lead Pollution: Characteristics and Seasonal Variation of Lead Pollution in Egypt

A. A. K. Abou-Arab, M. A. Abou Donia, Nevin E. Sharaf, Sherif R. Mohamed, A. K. Enab

***Abstract*—**Lead being a toxic heavy metal that mankind is exposed to the highest levels of this metal from environmental pollutants. A total of 180 Male scalp hair samples were collected from different environments in Greater Cairo (GC), i.e. industrial, heavy traffic and rural areas (60 samples from each) having different activities during the period of, 1/5/2010 to 1/11/2012. Hair samples were collected during five stages. Data proved that the concentration of lead in male industrial areas of Cairo ranged between 6.2847 to 19.0432 µg/g, with mean value of 12.3288 µg/g. On the other hand, lead content of hair samples of residential-traffic areas ranged between 2.8634 to 16.3311 µg/g with mean value of 9.7552 µg/g. While lead concentration on the hair of the male residents living in rural area ranged between 1.0499-9.0402µg/g with mean value of 4.7327 µg/g. The Pb concentration in scalp hair of Cairo residents of residential-traffic and rural traffic areas was observed to follow the same pattern. The pattern was that of decrease concentration of summer and its increase in winter. Then, there was a marked increase in Pb concentration of summer 2012, and this increase was significant. These were obviously seen for the residential-traffic and rural areas residents. Pb pollution in residents of industrial areas showed the same seasonal pattern, but there was marked to decrease in Pb concentration of summer 2012, and this decrease was significant. Lead pollution in residents of GC was serious. It is worth noting that the atmosphere is still contaminated by lead despite a decade of using unleaded gasoline. Strong seasonal variation in higher Pb concentration on winter than in summer was found. Major contributions to the pollution with Pb could include industry emissions, motor vehicle emissions and long transported dust from outside Cairo. More attention should be paid to the reduction of Pb content of the urban aerosol and to the Pb pollution health.

***Keywords*—**Hair, lead, environmental exposure, seasonal variations, Egypt.

I. Introduction

GREATER Cairo (GC) in Egypt is one of the 15 largest cities in the world. Urbanization and industrialization have caused increased levels of air pollutants and environmental hazards [1]. The severe air pollution combined with the meteorological conditions and seasonal variations are known to cause many health problems. Lead is a common environmental and air pollutant [2]. Environmental contamination includes industrial use of lead, such as lead-acid batteries, lead to wire or pipes, and metal recycling and foundries [3]. Lead in the atmosphere can be deposited in urban soils [4], and may then be re-suspended to re-enter the atmosphere [5]**.** This could increase human exposure to Pb and cause long-term potential health effects. Thus, monitoring Pb pollution has been one of the major tasks in controlling air pollution worldwide.

Lead contributes more than 20% of the total mass of those fine particles emitted from burning of leaded gasoline, of which approximately 75% is emitted directly to the atmosphere [6]. Residual lead in the air and soil contributes to lead exposure in urban areas [7]. It has been thought that the more polluted an area is with various contaminants; the more likely it is to contain lead. However, as there are several other reasons for lead contamination in soil [8], it may be caused by broken-down lead paint, residues from lead-containing gasoline, used engine oil, or pesticides used in the past, contaminated landfills, or from nearby industries such as foundries or smelters [9]. Routes of exposure to lead include contaminated air, water, soil, food, and consumer products.

Lead (Pb) has attracted public attention to several decades of its adverse effects on human health, especially on children's growth and intelligence [2]. Although lead poisoning is one of the oldest known occupational and environmental hazards, the modern understanding of the small amount of lead necessary to cause harm did not come about until the latter half of the 20th century. No safe threshold for lead exposure has been discovered that is, there is no known amount of lead that is too small to cause the body harm.

In the GC area, particulate matter (PM) and its lead content are the major pollutants. The distribution of PM concentrations and its lead content is characterized as large-scale spatial and temporal variations, which are probably created, in part, by meteorological conditions. Due to the arid climate, there is a persistent high background PM level in the GC area that will probably always prevent reducing daily PM10 levels below the 24h limit of 70 lg/m^3. The GC area is considered to being one of the megacities which have the highest concentrations of PM10 in the atmosphere [10]. Lead levels in Cairo are among the highest in the world: for example, the annual average concentration of lead in the

Assem A.K. Abou-Arab is with the Dept. of Food Toxicology and Contaminants, National Research Centre, Dokki, Cairo Egypt, P.O.Box 12622 (Corresponding author to provide fax: (+202) 33370931; e-mail: aak_abouarab2007@yahoo.com).

M.A. Abou Donia and Sherif R. Mohamed are with the Dept. of Food Toxicology and Contaminants, National Research Centre, Dokki, Cairo, Egypt, P.O.Box 12622 (e-mail: maboudonia1@yahoo.com, sheriframzy4@gmail.com).

Nevin E. Sharaf is with the Dept. of Environmental and Occupational Medicine, National Research Centre, Dokki, Cairo, Egypt, P.O.Box 12622 (e-mail: nevinecharafe@yahoo.com).

A.K. Enab is with the Dept. of Dairy, National Research Centre, Dokki, Cairo, Egypt, P.O.Box 12622.

Shoubra El-Kheima area (an industrialized environment containing several lead smelters) is 23.09 on 1999 lg/m^3 and is estimated to cause 15–20,000 deaths a year, according to a 1996 report by the Egyptian environmental affairs agency.PM lead concentrations ranged from 0.5 lg/m^3 in a residential area to 3 lg/m^3 at the city center [11]. Lead pollution is concentrated on two industrial areas Shoubra El-Kheima and Tebbin. The lead concentrations decreased dramatically from these two industrial areas after closing the lead smelter activities in Tebbin and moving the lead smelters from Shoubra El-Kheima to another industrial area [10]**.** This decrease in lead concentrations is due to the [12] initiatives, represented in cleaning up of lead contaminating sources from the industrial areas by their relocation outside the residential blocks, as well as switching to the natural gas instead of mazout in the industrial areas and power generation sectors.

The aim at this work is to evaluate the levels of environmental contamination by Pb as indicated by measuring the Pb concentrations of human hair at different locations and seasons in Egypt**.**

II. Materials and Methods

A. Materials

1. Chemicals and Reagents

Stock standard solution (1000 mg/L) of lead (pb), acetone, absolute alcohol, H_2O_2, perchloric acid and redistilled concentrated nitric acid at high grade (BDH chemical LTD) were purchased from Merck (Merck, Darmstadt, Germany). De-ionized water from Milli Q water purification was used.

2. Scalp Hair Samples

Male scalp hair samples (180) were collected from different districts in Cairo having different activities. These districts are industrial residential areas of Shoubra El-Kheima and Helwan, heavy traffic residential area of Faysal and rural area away from any industrial pollution sources areas (near cultivated lands), during the period of 1/5/2010 to 1/11/2012. Sixty hair samples were collected from each area. The collected hair samples were stored in clean polyethylene bags of 4°C during transportation. Once received, they had been frozen at -20°C until time for analysis.

The number of hair samples was collected during five stages. The first stage included 60 samples collected from the three localities (20 sample from each) during the period of 1/5/2010 to 26/10/2010 (St-I). The second, third, fourth and fifth stages of collected samples were during the period of 1/11/2010 to 30/4/2011 (St-2), 1/5/2011 to 20/10/2011(St-3), 1/11/2011 to 30/4/2012 (St-4) and 1/5/2012 to 1/11/2012(St-5), respectively, in which 10 samples from each activity and from each stage were collected.

B. Methods and Procedures

1. Test Principle

Samples of male scalp hair are digested by a mixture of HNO_3 and H_2O_2 according to the method of [13]. The content of lead in digestion vessels is determined by atomic absorption spectrophotometer at maximum absorbance lamp.

2. Sample Preparation

One hundred milligrams of hair samples are weighed and placed in Teflon beakers and washed successively with magnetic stirring for 10 min in 125 mL portions of acetone, deionized water, acetone and finally in absolute alcohol [13]**.** The washed samples were allowed to dry at 50°C for one hour. After this time, the samples were weighed into digestion vessels and treated with 3 mL of acid mixture made from 5 parts concentrated nitric acid (65%) and 1 part of concentrated perchloric acid (70%). The digestion vessels were closed and placed in an oven maintained at 150°C for one hour. Then the contents of digestion vessels was transferred to polypropylene volumetric flasks and diluted to 10 mL with high purity distilled water [14], [15].

3. Determination (Instrumentation)

Prepared samples are measured for lead by PG-990 atomic absorption spectrophotometer (PG Instruments LTd) with flame atomization (air-acetylene), equipped with a 10 cm burner and a deuterium lamp for back ground correction. Maximum absorbance was obtained by adjusting the cathode lamp at a wavelength (217.0 nm). The other analytical parameters were; bandwidth, 0.4 nm; filter factor, 1.0; lamp current, 5.0 ma; integration time, 3.0 sec; background, D2/SR and flame setting, oxidizing blue.

4. Method's Validity

Quality assurance procedures and precautions were carried out to ensure reliability of the results. All processing to work are performed under clean conditions, including laminar flow hoods. The materials used for collecting and processing screened for possible lead contamination. Acidic-clean volumetric flasks and other glassware is soaked in a soapy solution (2% solution detergent) for 24 h., then rinsed and soaked in 10-15 % nitric acid solution for 48 h., then rinsed with ultrapure water and dried under clean conditions. De-ionized water was used throughout the study. The samples generally carefully handled to avoid any contamination.

The detection limit was determined according o the method of [16]. The baseline noise may be statistically quantities by making 10 or more replicate measurements of the baseline absorbance signal observed for an analytical blank, and determining the standard deviation of the measurements.

5. Questionnaire

A questionnaire was completed for all subjects in this research for identifying the non-occupational confounding factors, which contained the following points: age, cigarette-smoking habit (smoker, nonsmoker), hair color, using the gas vehicle or not and working life. Occupational exposure to lead was determined according to the description of the actual job. Regions were determined according to the official distribution of Egyptian Governorates.

C. Statistical Analysis

The data obtained from this study was statistically subjected to analysis of variance (ANOVA) and means separation was by [17]**.** The least significant difference (L.S.D) value was used to determine significant differences between means and to separate means at p≤0.05 using SPSS package version 15.0.

III. Results

Scalp hair samples of 180 males are collected from urban sites: residential-industrial, residential-traffic and rural sites during years 2010-2012. The concentration of lead in scalp hair was determined and data was reported in Table I and illustrated in Fig. 1. Results shows that lead concentration in the hair of male residents of residential-industrial areas of Cairo, was the highest, it ranged between, 6.2847 to 19.0432 µg/g, with mean value of 12.3288 µg/g. On the other hand, lead content of hair samples of residents of heavy traffic areas (residential-traffic areas) ranged between 2.8634 -16.3311 µg/g with mean value of 9.7552 µg/g. While lead concentration of the hair of male residents living in rural areas ranged between 1.0499-9.0402 µg/g with mean value of 4.7367 µg/g. Data proved that lead level in the samples are quite variable among the three areas. Analysis of variance revealed that difference was highly significant (p≤ 0.05).

TABLE I
LEAD LEVELS IN SCALP HAIR SAMPLES OF ENVIRONMENTALLY EXPOSED MEN (INDUSTRIAL, TRAFFIC AND RURAL AREAS) DURING THE PERIOD OF 1/5/2010 TO 1/11/2012

Area of the samples collection	Concentrations (µg/g)±SD	
	Mean± SD	Range
Residential-Industrial	12.3288[a]±1.13 (60)*	6.2847-19.0432
Residential-Traffic	9.7552[b]±0.71 (60)	2.8634 -16.3311
Rural	4.7327[c]±0.67 (60)	1.0499 - 9.0402
LSD at 5%	0.99	

-All values are means of samples number determinations in each area ± standard deviation (SD).
-Means within rows with different letters are significantly different -(p≤0.05).
-( )* Samples number in each area.

The concentration of Pb in scalp hair samples of residential traffic areas residents during the period (stages/intervals) of 2010-2012 is listed in Table II and illustrated in Fig. 2. The lowest concentration of Pb could be seen clearly in summer 2010-St1 (8.0315 µg/g ± 3.62), then increased significantly in the next winter 2011-St 2 (10.3174 µg/g ± 0.99). The pattern of decrease concentration of summer and its increase in winter has been repeated in the next year (summer 2011- winter 2012), and finally the lead concentration showed marked to increase to the summer period 0f 2012 (St 5, last measured stage) and this increases was statistically significant. The same seasonal pattern was observed in the samples collected from both rural and industrial residential areas (Table II and Fig. 2).

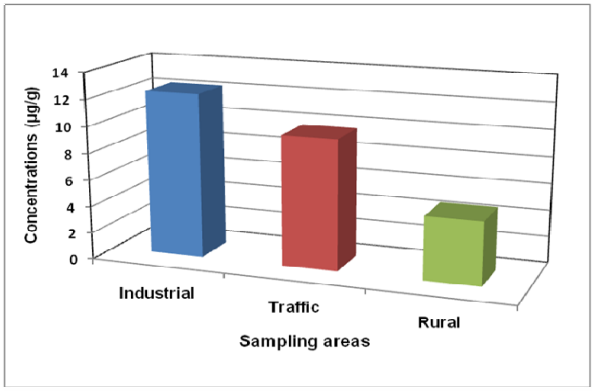
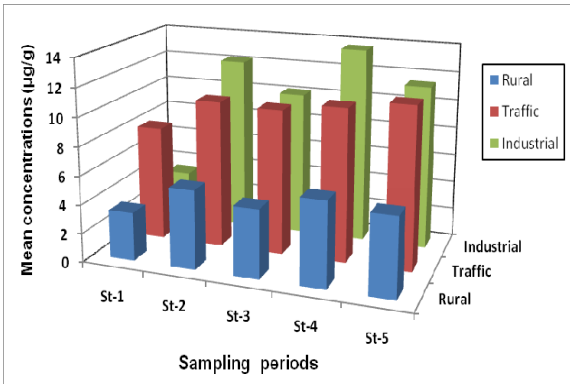


Fig. 1 Lead levels in scalp hair samples of environmentally exposed men (industrial, traffic and rural areas) during the period of 1/5/2010 to 1/11/2012



St-1: 1/5/2010 to 26/10/2010 **St-2:** 1/11/2010 to 30/4/2011 **St-3:** 1/5/2011 to 20/10/2011 **St-4:**1/11/2011 to 30/4/2012 **St-5:** 1/5/2012 to 1/11/2012

Fig. 2 Mean lead levels (µg/g) in scalp hair samples collected from industrial, traffic and rural areas during the period (stages/intervals) of 1/5/2010 to 1/11/2012

TABLE II
MEAN LEAD LEVELS (µG/G) IN SCALP HAIR SAMPLES COLLECTED FROM INDUSTRIAL, TRAFFIC AND RURAL AREAS DURING THE PERIOD (STAGES/INTERVALS) OF 1/5/2010 TO 1/11/2012

Areas	Mean concentrations (µg/g) ± SD					LSD at 5%
	St-1	St-2	St-3	St-4	St-5	
Residential-Industrial	12.2333[a]±3.78 (20)*	14.2245[b]±2.48(10)	10.1598[b]±2.45 (10)	13.6793[b]±2.60 (10)	11.4430[b]±1.75 (10)	3.97
Residential-Traffic	8.0315[a]±3.62 (20)	10.3174[b]±0.99(10)	10.1559[b]±1.59 (10)	10.7059 [b]±1.50 (10)	11.2887[b]±2.01 (10)	3.60
Rural	3.3812[a]±2.47 (20)	5.4944[b]±1.43(10)	4.7695[b]±1.24 (10)	5.9113[b]±1.54 (10)	5.4822[b]±1.46 (10)	1.98

-All values are means of samples number determinations in each period from each area ± standard deviation (SD).
-Means within columns with different letters are significantly different (p≤0.05).
-( )* Samples number in each period.
St-1:1/5/2010 to 26/10/2010 **St-2:** 1/11/2010 to 30/4/2011 **St-3:** 1/5/2011 to 20/10/2011
St-4:1/11/2011 to 30/4/2012 **St-5:** 1/5/2012 to 1/11/2012

Comparing the Pb concentrations of the two seasons (summer and winter) in the three residential areas (Table III and Fig. 3), data showed its highest concentration during the winter seasons, especially for those who are living in the residential-industrial followed by residential-traffic.

TABLE III
LEAD LEVELS (µG/G) IN SCALP HAIR SAMPLES COLLECTED FROM INDUSTRIAL, TRAFFIC AND RURAL AREAS DURING SUMMER AND WINTER THROUGH THE PERIOD OF 1/5/2010 TO 1/11/2012.

Areas	Mean concentrations (µg/g) ±SD		LSD at 5%
	Summer	Winter	
Residential-Industrial	11.4923[b] ±1.16 (40)*	13.9519[a] ±2.54 (20)*	2.52
Residential-Traffic	8.0276[b]±0.62 (40)	10.5117[a] ±1.25 (20)	2.09
Rural	4.2954[b]±0.37 (40)	5.7029[a] ±1.48 (20)	1.24

-All values are means of samples number determinations in each season from each area ± standard deviation (SD).
-Means within columns with different letters are significantly different ($p \leq 0.05$).
-( )* Samples number in each season.

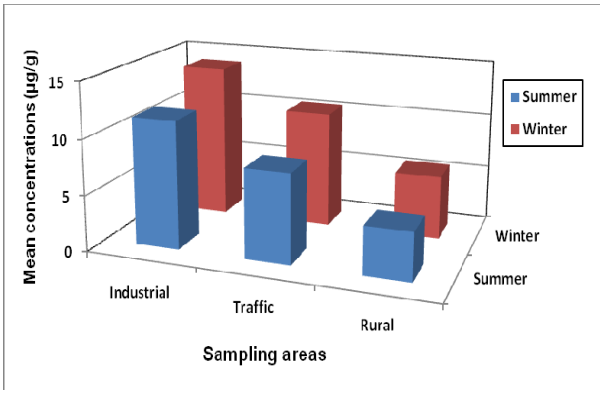


Fig. 3 Lead levels (µg/g) in hair samples collected from industrial, traffic and rural areas during summer and winter through the period of 1/5/2010 to 1/11/2012

IV. DISCUSSION

Results presented in Table I shows that lead concentration on the hair of the male residents living in Cairo (industrial and traffic areas) during years 2010-2012 has a mean value of 11.0420 µg/g ± 3.19. While lead concentration on the hair of the male residents living in rural areas during the same period has a mean value of only 4.7323 ± 0.67 µg/g. This indicates that the level of Pb in the hair of Cairo residents was higher than that of rural residents and this difference was statistically highly significant ($p \leq 0.05$). This in agreement with that of [18], who found that the concentrations of Pb in hair of Cairo population were significantly higher than those found in rural areas, which is attributed to the difference in the concentrations of that metal in the atmosphere of a megacity like Cairo, which is facing increased urbanization and industrialization [1], causing more increase in the level of pollutants than in the rural areas. Also, [19], [20] concluded that residents of urban/industrialized areas suffer more from increased Pb concentration in scalp hair than those of rural areas. The later study indicated that women living in the city of Karachi have approximately 600% higher Pb levels in their hair than their age-matched counter parts living in rural environment in Bangladesh [20].

The highest concentrations of Pb were recorded in the hair of those living in the residential-industrial areas (12.3288 ± 1.13 µg/g), followed by those living in the residential-traffic areas (9.7552 ± 0.71µg/g). This difference is highly significant ($p \leq 0.05$).

In 1998, EGL/94 specifies maximum limits of pollutants in ambient air (outdoors), workplace atmosphere, and source emissions, and the values of PM concentrations and its Pb content were exceeding the limits established by EGL/94 for them in these places, especially at the industrial sites [21]. Safar and Labib [10] proved that the annual mean of lead concentrations in air had decreased dramatically since 2002 in all the monitoring sites of GC after closure of all operating lead smelters. The concentrations are still higher for the industrial sites than the traffic sites. In comparison to other megacities [22], [11], GC had the maximum values; this is due to its arid climate, and the very low rain fall, in addition to the existence of more than 15,000 industrial establishments in the GC area [10], as the monthly average concentrations of lead particulate (Pb_{10}) recorded at two residential industrial sites were the highest levels of lead concentrations from 1998 till 2007.

In addition, Pb was more enriched in fine particles [21]. Fine particles can enter the human body more easily than coarse particles and deposit in the tracheobronchial and alveolar regions of the lung, and Pb would be accumulated continuously and have more harmful effect on the human being. Moreover, the study of [23], found that the mean concentration of Pb in the entry way, stairs and household dust of urban areas (residential-traffic areas) exceeded the maximum permissible limit 100 µg/gm^{-1} for Pb in soil, and the small particle size of dust had more Pb, in addition the study indicated that in urban household dust the presence of indoor sources of Pb beside outdoor sources was certain. Also Khodeir et al. [24] reported that high concentrations of Pb were found in settled dust in the urban area of Giza, Egypt despite decades of using unleaded gasoline.

Zakey et al. [21] mentioned in their study that Greater Cairo (GC) was subjected to high concentrations of particulate matter (PM) and their Pb content most of the years in different environments, and the average concentration of particulates was lower in summer of dust storm episodes and waste burning in combination with good dispersion. The periods of dust storms were counted according to [25] and waste burning using data from the Terra satellite according to [26] could be linked to the seasonal variation of particulate matter (PM) and their Pb content [21]. In addition to these two seasonal effects, low winter time temperatures often result in stable weather conditions that aggravate the effects of particle emission from urban (traffic) and industrial activities.

Table II and Fig. 2 show the concentrations of Pb in scalp hair samples of traffic areas residents for the period 2010 to 2012. The data onto Table II indicates significant increases in Pb pollution from 8.0315 ± 3.62 µg/g in summer 2010 (St-1) to 11.2887 ± 2.01 µg/g in summer 2012 (St-5).This increase

takes a seasonal pattern, as the Pb concentration shows its lowest concentration in summer 2010 (St-1), followed by an increase in its concentration in the next winter (St-2). This seasonal pattern has been repeated in the next year of the study. Generally, the Pb concentrations of rural and residential areas residents also follow the same pattern of that of residential-traffic areas residents. This could be explained by the effect of seasonal meteorological variations, as in summer, the wind speed calms, while in winter GC faces an almost constant northern wind forced by Saharan cyclones [27]. Second the presence of temperature inversions during winter seasons and the arid climate led to low dispersion of particulate and the increase in Pb concentration in the air and the particulate matter. This is in agreement with [21].

The stage 5 of residential-traffic areas, and rural areas shows relative increase in the pb concentrations (statistically significant), while that of residential–industrial areas shows relative decreases. These two phenomena could be explained by the chaotic conditions that Egypt facing it since the revolution. During this stage, residential-traffic and rural areas begun to suffer from huge amount of street dust, lack of regularity in cleaning, removing of dust from streets and pavement of rural streets, with re-suspension of dust and pollutants again in the atmosphere. During this period, most of the commercial and industrial activities were lowered till closure for many of them. This embarrassing situation has decreased the emissions of the industrial areas and the residential areas around it, causing low ambient concentration of Pb and other pollutants, and in-turn decrease its concentration in the hair of those residents during this stage.

V. Conclusion

It could be concluded that the pollution of GC by lead was very serious. The Cairo environment is still contaminated by lead. Seasonal variation plays an important role on the levels of Pb in the atmosphere, which was higher in winter than in summer. Major contributions to the pollution with Pb could include industry emissions, motor vehicle emissions and long transported dust from outside Cairo. Re-suspended soil that contained deposition from previously emitted leaded gasoline vehicle exhaust could be an important source of pollution of Cairo residents with lead. More attention should be paid to the reduction of Pb content of the urban aerosol and to the Pb pollution health problems by implementation of environmental actions such as regular removing for the main and side street dust, paving the side streets, abatement of the major Pb polluting industrial activities.

Acknowledgement

The team work of the project wishes to express his deepest appreciation of Science and Technology Development Fund team for funding and the continuous guidance and supporting of this work.

References

[1] S. M. Robaa, “Urban –Suburban/rural differences over greater Cairo, Egypt,” Atmosfera, vol. 16, pp.157-171, 2003.
[2] P. Ragan, and T. Turner, "Working to prevent lead poisoning in children: getting the lead out," JAAPA: Official Journal of the American Academy of Physician Assistants, vol. 22, no. 7, pp. 40–45, 2009.
[3] N. Mañay, A.Z. Cousillas, C. Alvarez, and T. Heller, "Lead contamination in Uruguay: the "La Teja" neighborhood case," Reviews of Environmental Contamination and Toxicology, vol.195, pp.93–115, 2008.
[4] C.S.C. Wong, and X.D. Li, “Pb contamination and isotopic composition of urban soils in Hong Kong,” The Science of the Total Environment, vol. 319, pp.185–195, 2004.
[5] T.M. Young, D.A. Heeraman, G. Sirin, .and L.L. Ashbaugh, “Re-suspension of soil as a source of airborne lead near industrial facilities and highways,” Environmental Science and Technology, vol. 36, pp. 2484–2490, 2002.
[6] J.M. Pacyna, “Source inventories for atmospheric trace metals,” In: Harrison, R.M., Van Grieken, R. (Eds.), Atmospheric Particles, IUPAC Series on Analytical and Physical Chemistry of Environmental Systems, vol. 5. Wiley, Chichester, UK, pp. 385–423, 1998.
[7] T.L. Guidotti, and L. Ragan, "Protecting children from toxic exposure: three strategies," Pediatric clinics of North America, vol. 54, no.2, pp. 227– 235, 2007.
[8] D. Barltrop, C.D. Strehlow, I. Thornton, and J.S. Webb, "Absorption of lead from dust and soil,” Postgrad Med J., vol. 51, no.601, pp. 801– 804, 1975.
[9] A.D. Woolf, R. Goldman, and D.C. Bellinger, "Update on the clinical management of childhood lead poisoning," Pediatric Clinics of North America, vol.54, no. 2, pp. 271–294, 2007.
[10] Z. Safar, and M.W. Labib, “Assessment of particulate matter and lead levels in the Greater Cairo area for the period 1998–2007,” J. of Advanced Research, vol.1, pp.53–63, 2010.
[11] N. Sturchio, M. Sultan, M.E. Sharkaway A.E. Maghraby, and A. Taher, “Concentration and isotopic composition of lead in Urban particulate air, Cairo, Egypt: Argonne National Laboratory, Argonne, IL and Centre for Environmental Hazard Mitigation, Cairo, University, Cairo, Egypt, 1996.
[12] E.E.A.A, “Egyptian Environment Affair Agency. Report – 1999 Baseline lead emissions inventory for the Greater Cairo Area; Cairo Air Improvement project (CAIP),” Chemonic International, Inc. USAID/Egypt, Office of Environment USAID Contract No. 263-C-00-97-00090-00, 2002.
[13] J. Popko, S. Olszewski, K. Hukalowicz, R. Markiewicz, M.H. Borawska, and P. Szeparowicz, “Lead, cadmium, copper, and zinc concentrations in blood and hair of mothers of children with locomotor system malformations,” Polish J. of Environmental Studies, vol.12, no.3, pp. 375-379, 2003.
[14] B.A. Revich, “Lead in hair and urine of children and adults from industrialized areas,” Arch. Environ. Health, vol.49, pp. 59 – 62, 1994.
[15] A. Chatt, and S.A. Katz, “Hair analysis. Applications in the Biomedical and Environmental Sciences,” VCH publishers Inc: New York, pp.1-134, 1998.
[16] R.D. Beaty, and J.D. Kerber, “Concepts, instrumentation and Techniques in Atomic Absorption Spectrophotometery,” Copyrighted by The Perkin-Elmer, Norwalk, CT, USA, 1993.
[17] G.W. Snedecor, and W.G. Cochran, “Statistical Methods”, 7th Ed. Oxford and IBIT public. Co. New York, 1980.
[18] E. Ali, and M. Nasralla, “Using hair as bioindicator for exposure to heavy metals in the Egyptian environment,” Egyptian J. of Occupational Medicine, vol.14, no. 2, pp. 287-292, 1990.
[19] J. Sen, “Human scalp hair as an indicator of environmental lead pollution and human exposure,” J. Hum. Ecol, vol.7, no.2, pp.133-141, 1996.
[20] D.S. Jamall, and P.V. Allen, “Use of hair as an indicator of environmental lead pollution in women of child bearing age in Karachi, Pakistan and Bangladesh,” Bull. Environ. Contam. Toxicol, vol.44, pp. 350-356, 1990.
[21] A.S. Zakey, M.M Abdel-Wahab, J.B.C. Pettersson, M. J. Gatari, and M. Hallquist, “Seasonal and spatial variation of atmospheric particulate matter in a developing mega city, the Greater Cairo, Egypt,” Atmosphera, vol. 21, no. 2, pp.171-189, 2008.

[22] M. J. Molina, and L. T. Molina, "Megacities and atmospheric pollution," J. of the Air and Waste Management Association, vol. 54, no. 6, pp. 644–680, 2004.
[23] S.K.M. Hassan, "Metal concentrations and distribution in the household, stairs and entryway dust of some Egyptian homes," Atmospheric Environment, vol. 54, pp.207-215, 2012.
[24] M.I. Khodeir, S.K. Hassan, and A.A. El-Abssawy, "An Evaluation of Loading Rate of dust, Pb, CD, and NI and metals Mass Concentration in the settled Surface Dust in Domestic Houses and Factors Affecting Them," Indoor and Built Enviroment, vol.19, no.3, pp.391-399, 2010.
[25] A.S. Zakey, and M. A. Omran, "1st LAS/WMO International Symposium on Sand and Dust Storms," WMO Programme on Weather prediction Research Report Series Project No. 10, World Meteorological Organization (WMO), Technical Document No. 864, 1997.
[26] D.P. Roy, J.S. Borak, S. Devadiga, D.E. Wolfe, M. Zheng, and J. Descloitres, "The MODIS land product quality assessment approach," Remote Sensing Environ, vol. 83, pp.62-76, 2002.
[27] Y. Abo el Fetouh, H. El Askary, M .El Raey, M. Allali, W.A. Sprigg, and M. Kafat, "Annual Patterns of Atmospheric Pollutions and Episodes over Cairo Egypt," Hindawi Publishing Corporation Advances in Meteorology Volume , Article ID 984853, pp.11 – 22, 2013.