ECRONICON OPEN ACCESS

EC PHARMACOLOGY AND TOXICOLOGY

Research Article

Lead Levels in the Urine of Males and Females from Different Age-groups in an Agricultural Village and Sugar-producing Town in the Gezira State, Central Sudan

Eltohami MME[1], Bashir NHH[1]* and Mohamedani AA[2]

[1]Department of Pesticides and Toxicology, Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan

[2]Faculty of Medical Laboratories, University of Gezira, Wad Medani, Sudan

***Corresponding Author**: Nabil H H Bashir, Department of Medical Entomology and Vector Control; Blue Nile National Institute for Communicable Diseases (BNNICD), University of Gezira, Wad Medani, Gezira State, Sudan.

Received: October 17, 2017; **Published:** November 06, 2017

Abstract

Lead (Pb) is one of the most serious environmental poisons all-over the world. Exposure to Pb results in health hazards. This study aimed to determine the levels of Pb in urine among adult males, females and children ≤ 5, in Rigwa village (agricultural) and Wadelsayed village (neighboring the Genaid Sugar Factory; established 1963), Gezira State, central Sudan, and compare them with the international and regional limits. The study age groups were 15 - 20, 25 - 35, 40 - 50 and 55 - 65 yr-old. Urine samples collected from these groups were analyzed using AAS. Results revealed presence of Pb in all collected samples. Pb levels in urine of females in Rigwa were 0.343, 0.099, 0.092, 0.138 and 0.2 mg/L, for age groups ≤ 5, 15 - 20, 25 - 35, 40 - 50 and 55 - 65 yr-old, respectively. The respective levels in males were 0.162, 0.11, 0.103, 0.19 and 0.298 mg/L. On the other hand, for Wadelsayed, the levels in the urine of females were 0.336, 0.117, 0.211, 0.317 and 0.148 mg/L, respectively, for same five age categories. However, following the same order of age, Pb levels in urine of males were 0.101, 0.049, 0.089, 0.4 and 0.198 mg/L. In most cases females urine showed higher levels than males. Wadelsayed showed higher levels than the agricultural village.

Keywords: *Heavy Metals; Lead; Urine; Professions; Gezira State; Genaid Sugar Factory, Sudan*

Introduction

Pollution is described as "The deliberate or accidental contamination of the environment with man's waste", and has been expressed as "matter in the wrong place", or "anything released into the environment, which degrades it", or "the presence of matter or energy in an unusual or unintended place" [1]. A pollutant is a substance or effect, which adversely alters the environment by changing the growth rate of species, interferes with the food chain/web, is toxic, or interferes with health [2].

Virtually all metals can produce toxicity when ingested in sufficient quantities, but there are several which are especially important, because either they are so pervasive, or produce toxicity at such low concentrations. When we talk about heavy metals (HMs), we generally mean, Pb, Hg, Fe, Cu, Mg, Cd, As, Ni, Al, Ag, and Be [3].

Generally, HMs produce their toxicity by forming complexes or "ligands" with organic compounds. These modified biological molecules lose their ability to function properly, and result in malfunction or death of the affected cells. The most common atoms involved in ligand formation are O, S and N. When metals bind to these atoms, they may inactivate important enzyme systems, or affect protein structure. There is a considerable cross-over in many of the toxic manifestations of the different metals, and in the agents used to treat the toxicity [4].

Pb is a soft, silvery grey metal, with an atomic number of 82, atomic weight 207.2, and melting point 327.5^{0}C. Pb is highly resistant to corrosion, but is soluble in nitric and not sulfuric acids. The usual valence state in inorganic lead compounds is +2. Solubilities in water vary; lead sulfide and lead oxides being poorly soluble and the nitrate, chlorate and chloride salts are reasonably soluble in cold water. Pb also forms salts with such organic acids as lactic and acetic acids, and stable organic compounds, e.g. tetraethyl lead and tetramethyl lead [5].

Pb has been widely used in many countries, and in many places some contamination of the environment has occurred as a result of the mining and smelting process used or from the use of products made from it. Consequently, it is present in air, food, water, soil, dust and snow [5].

Pb in the environment exists almost entirely in the inorganic form. However, small amounts of organic Pb result from the use of leaded gasoline. Pb is widely used for a variety of purposes including the manufacture of acid accumulators, alky lead compounds for gasoline, solder, pigments, ammunition, calking and cable sheeting. Its use as roofing material and piping material, including pipes used for potable water, is currently being discontinued and discouraged [6].

Pulmonary absorption depends on the size of Pb particles and on the depth and rate of breathing. Some large particles are deposited in the mucous lining of the respiratory tract and, some are ultimately swallowed. Pulmonary retention is typically 40%. Absorbed Pb enters the body and is distributed to soft tissues and bone. After prolonged exposure equilibrium is reached between the blood and soft tissues. In contrast, bone has the ability to accumulate Pb with time and the skeletal burden of Pb increases with age. In fact, about 90% of the total body burden lies in the bone. The respective half-life of Pb in blood soft tissues and bone has been estimated to be 2 - 4 wk. Pb passes through the placenta easily and fetal blood has almost [5].

However, in infants and young children as much as 50% of dietary Pb is absorbed, although absorption rates for Pb from dusts/soils and paints chips can be lower, depending upon the bioavailability. Diets that are deficient in calcium, phosphate, selenium or zinc may result in increased Pb absorption. Iron and vitamin D also affect absorption of Pb [5].

Several organs and systems are adversely affected by Pb. Pb is now recognized as a heHM- poison; it acts by complexing with oxo-groups in enzymes and affects virtually all steps in the process of heme synthesis and porphyrin metabolism. It also inhibits acetyl choline esterase, acid phosphatase, ATPase, carbonic anhydrase, etc. and inhibits protein synthesis, probably by modifying tRNA. In addition to oxygen complexation, lead (II) also inhibits SH enzymes, especially by interaction with cysteine residues in proteins. Typical symptoms of Pb poisoning are colic, constipation, anemia, headaches, convulsions, chronic nephritis the kidneys, brain damage and CNS disorders [6].

In adults and children, the most specific therapeutic objective is removal of Pb from the body using chelating agents such as EDTA. In adults, the most widely accepted procedure is I.V. infusion of the CaEDTA, for 4 to 5 consecutive days. The Pb chelate formed by exchange of Ca for Pb is excreted promptly in the urine. In children, the treatment of Pb poisoning also entails a course of CaEDTA therapy, either alone or in combination with dimercaptopropanol. Combined therapy has been found to be more effective [7].

Materials and Methods

Study area

The present study was carried out in two villages in two localities out of the eight localities of the Gezira State, Central Sudan (Longitudes: 32 25' 13' 36 N and 34'18 E, Latitude: 15' 29). These localities are Um Al Goura and East Gezira and Eastern Gezira localities. The population of the Gezira State is ca.4.5million. Each locality is divided administratively into seven administrative units (total 38 units in the state). From Um Al Goura locality, Rigwa village (population of 1,700) was selected, because it is small and isolated agricultural village and far from pollution activities. The other village was from Eastern Gezira locality, namely Wadelsayed village, near Elgenaid Sugar Factory (GSF), established 1963; population of 2,100. This factory is accused of being one of the major polluting sources in the state [8].

Study Design

Complete Randomized Designed (CRD) with four replications was adopted. A questionnaire was used to relate the detected concentrations of these HMs to their sources or some anthropogenic activities in the village or the locality. Health condition information of the villagers were and nearby hospitals.

Study population (groups)

Studied population was divided into five age-groups in each village; each group included four individuals (males or females) as replicates, including a group of children (5 yr and less)/village. The age groups were 5 yr or less, 15 - 20, 25 - 35, 40 - 50 and 55 - 65 yr-old.

Urine samples collection

Following the approval of the ethical committees of the university and the state, samples were collected from Um Al Goura locality (population > 227,000, three administrative units), viz. Rigwa village, and from the Eastern Gezira locality (> 500,000; five administrative units), viz. Wadelsayed village. The study was conducted to determine levels of Pb in the human urine (males, females and children population) with the abovementioned age groups. Urine samples (80) were taken on the morning (8 -11 am) to a void dilution of HMs in the subsequent urination. Standard urine sample sterile containers were provided for the individuals (capacity 65 ml), labeled and kept in cold box (ca. 4°C). Samples were kept in a freezer until being transported inside the cold box to the laboratory for analysis using 20 ml from each sample for AAS (model AA-6800, Shimadzu, Kyoto, Japan, 2005).

Instruments, glassware and reagents

The instruments and glassware used in this study were sterile urine containers, measuring cylinders of different sizes, pipettes, test tubes, plastic volumetric flasks and atomic absorption spectrometry (AAS). The reagents required for this work were Glacial acetic acid and 0.5N hydrochloric acid, and strontium (Sr^{++}).

Determination of Pb in urine

Pb levels were determined in the collected urine using a method described by Zinterrhoger., *et al* [9]. The details of this method are explained under the titles standards preparation (2.7) and samples preparation (2.8) below.

Standards preparation

Standard solutions of Pb were prepared as follows

250 μl was taken from stock standard solution (1000 mg/L) in a plastic volumetric flask (25 ml) and made up to the mark with 0.5 N of HCl solution, to yield the intermediate standard solution (10 mg/L). Working standard solutions were left to stabilize and then a series of 20, 60, 200, 600 and 800 μl from Pb stock solution (1000 ppm) were taken in a series of 10 ml of plastic volumetric flask and were made up to the marks using 0.5 N HCl solution. These correspond to 2, 6, 20, 60 and 80 ppm. A concentration of 0.4% (Sr^{++}) was prepared from strontium chloride (as a matrix modifier). Each standard was diluted with this solution to get 0.08% strontium corresponding to 1, 3, 10, 30 and 40 ppm of the Pb [9].

Sample preparations

The same procedure was followed to prepare the urine samples [9].

Chemical Analysis

Chemical analysis of urine samples was conducted at Shambat Central Laboratory, Faculty of Agriculture, University of Khartoum, using AAS. The AAS was adjusted as follows: after turning the power supplier on, the valves of acetylene gas cylinder were opened, the pressure was adjusted at 0.09 and 0.35m.p., for acetylene and air, respectively. The PC was turned on; the analysis of Pb in urine was setup on the control program. The nebulizer capillary tube was transferred to the standard one solution flask and the reading of the absorption was taken, then the tube was returned to the deionized water cup and waited till the digital reading reach zero value. Before the reading of the standard or samples solution, the absorption value of the plank solution was taken (all added reagents except sample). The absorbance values were taken for sample solutions and subtracted the plank value from the sample value.

Data analysis

Data collected was subjected to analysis using SPSS (version 11.5, 2002) statistical package software was used to perform the statistical analysis.

Results

Rigwa village

Females

The Pb concentration in the urine samples collected from the females in Rigwa village showed a mean of 0.343 ppm (range: 0.308 - 0.369 ppm) in age < 5yr, while that collected from age 15 - 20 yr gave a mean of 0.044 ppm (range: 0.003 - 0.096 ppm). The mean for age 25 - 35 yr was 0.092 ppm (range: 0.016 - 0.064 ppm), while that collected from age 40 - 50 yr resulted in a mean of 0.0138 ppm (range: 0.053 - 0.168 ppm) and the concentration for age 55 - 65 yr reflected a mean of 0.2 ppm (range: 0.199 - 0.229 ppm; Figure 1).

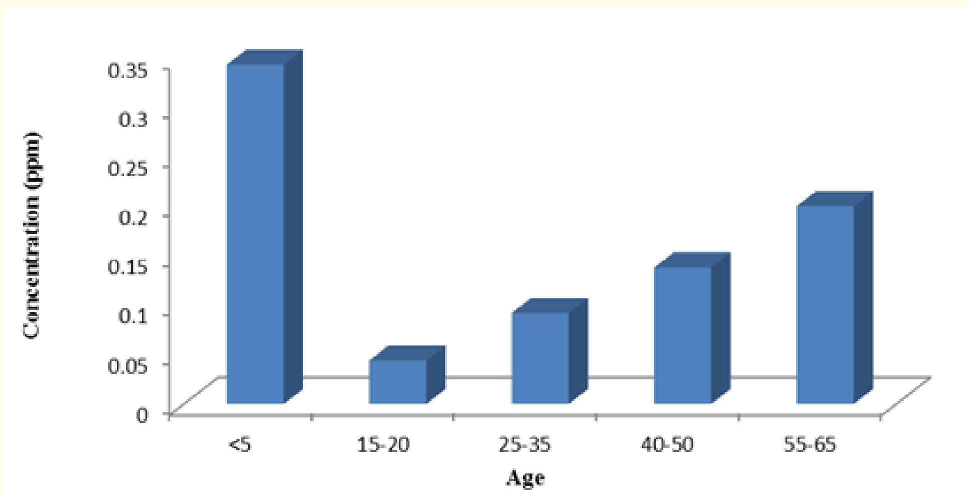

Figure 1: *Means of lead concentration (ppm) in females in Umelgura (Rigwa).*

Males

The males reflected a mean of 0. 162 ppm (range: 0. 101 - 0.259 ppm) in age ≤ 5 yr, while the age 15 - 20 yr resulted in a mean of 0.11 ppm (range: 0.101 - 0.241 ppm). However, the mean for age 25 - 35 yr was 0.103 ppm (range: 0.010 - 0.089 ppm), while that collected from age 40 - 50 yr was of 0.190 ppm (range: 0.077 - 0.223 ppm). Finally, the concentration of in age 55 - 65 yr reflected a mean of 0.298 ppm (range: 0.302 - 0.327 ppm; Figure 2).

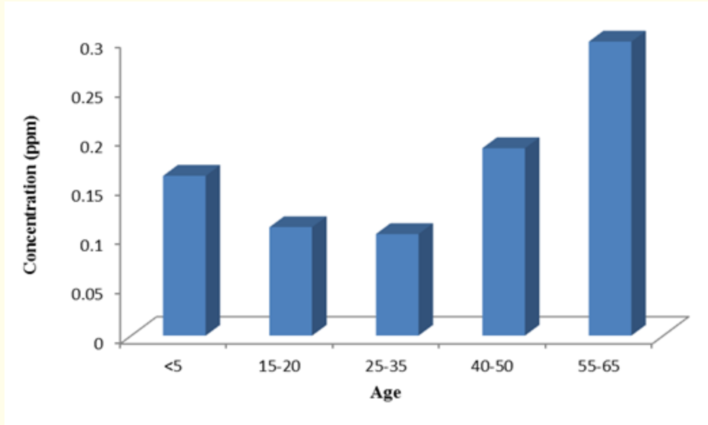

Figure 2: *Means of lead concentration (ppm) in males in Umelgura (Rigwa).*

Wadelsayed

Females

The females in Wadelsayed reflected a mean of 0.336 ppm (range: 0.119 - 0.862 ppm) in the urine of age ≤ 5 yr, while that collected from age 15 - 20 yr was 0.117 ppm (range: 0.003 - 0.370ppm). The mean for 25 - 35 yr was 0.211 ppm (range: 0.0941 - 0.384ppm), while that collected from age 40 - 50 yr resulted in a mean of 0.317 ppm (range: 0.418 - 0.090ppm). However, the oldest group, 55 - 65 yr, reflected a mean of 0.198 ppm (range: 0.09 - 0.176 ppm; Figure 3).

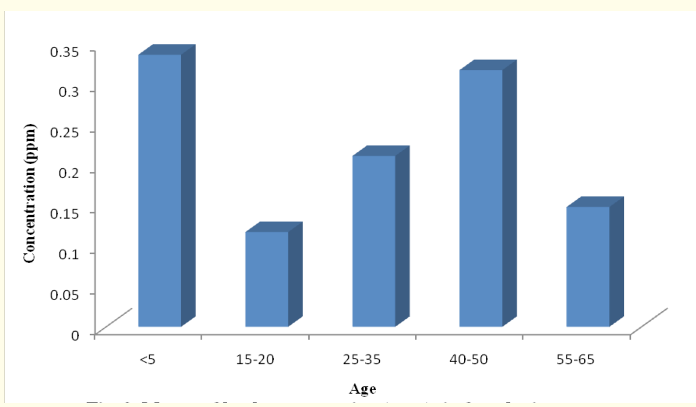

Figure 3: *Means of lead concentration (ppm) in females in Wadelsaid (East Gezira).*

Males

In this population, the Pb concentration in the urine samples collected from children (5 yr or less) reflected a mean of 0.101 ppm (range: 0.064 - 0.077 ppm), while that collected from age 15 - 20 yr gave a mean of 0.099 ppm (range: 0.010 - 0.064 ppm). The respective values for age-group 25 - 35 yr were 0.084 ppm (range: 0.039 - 0.064 ppm), whereas those of the age-group 40 - 50 yr resulted in 0.4 ppm and range: 0.443 - 0.577 ppm, respectively. For the oldest group (55 - 65 yr), the mean was 0.298 ppm and the range was 0.155 - 0.351 ppm (Figure 4).

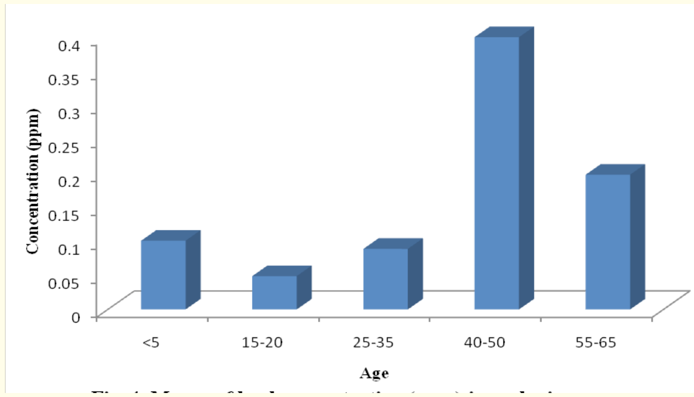

Figure 4: *Means of lead concentration (ppm) in males in Wadelsaid (East Gezira).*

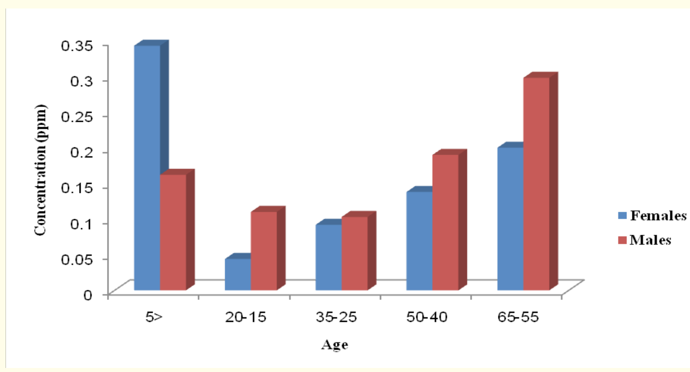

Figure 5: *Means of lead concentration (ppm) in males and females in Rigwa village.*

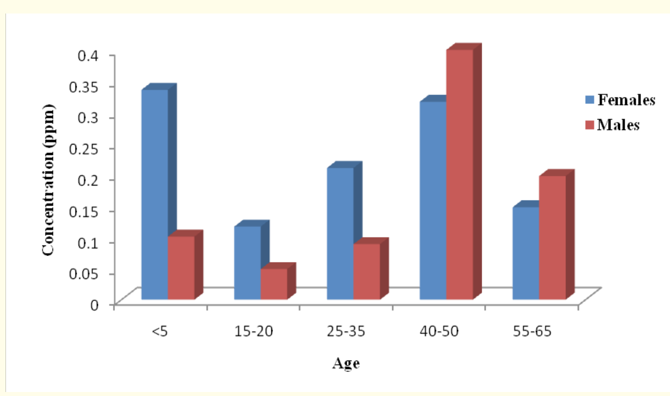

Figure 6: *Means of lead concentration (ppm) in males and females in East Gezira (Wadelsaid).*

Discussion

The analysis of urine samples of all investigated groups from Rigwa village revealed that the concentration of Pb varied between and within each population (age-group). For instance, taking the females in this village as an example for the variations between the age-groups in this population, the age group of ≤ 5 yr, which is supposed to be the group that represents the lowest exposure of all groups in the study, because of being most of the time staying in their homes under close supervision of the mothers, showed an average of 0.343 ppm of Pb in their urine. Surprisingly, this was the highest level of Pb concentrations among all tested age-groups in the females population in this village. This was followed by the oldest group, 55 - 65 yr-old (0.2 ppm). The age- group 40 - 50 yr- old reflected an average concentration of 0.138 ppm, followed by the age group 25 - 35 yr-old (0.092 ppm). However, the least concentration was reported in the supposedly the most active age group (15 - 20 yr-old) with an average of 0.044 ppm.

Regarding the males of Rigwa village population, the picture was completely different. The highest concentration was detected in the oldest group (0.298 ppm), followed by the second oldest group (40 - 50 yr-old) with an average of (0.190 ppm). The children (5 yr and less) ranked third with an average of (0.162 ppm), whereas the group which ranked fourth was group 15 - 20 yr- old (average 0.110 ppm). The group which was expected to be the most exposed (25 - 35 yr-old; 0.103 ppm) ranked the fifth. No justification can be found regarding the differences between the children groups of males and females. Can this be attributed to metabolism, absorption or excretion. More detailed studies are required.

Rodriguez-Flores and Rodriguez-Castellon [10] reported that Pb can be transported to soil and vegetation through atmospheric transport. Exhausts from gasoline-engine motor vehicles that use leaded gasoline have been identified as one of the sources of Pb in the environment. Both areas are agricultural areas where agricultural machineries are available in addition to Lorries, trucks and means of transportation. It is reported by several authors that Pb in the urban environment is strongly related to the vehicles.

The analysis of urine samples of all investigated groups from Wadelsaid village revealed that the concentration of Pb, also as in Rigwa, varied between groups and within the population. Regarding the females/girls in Wadelsaid village, the age group of ≤ 5 yr-old (children), which, as mentioned earlier, is supposed to be the group that represents the lowest exposure of all groups, showed an average of 0.336 ppm of Pb in their urine. Again, this was the highest level of Pb concentrations among all tested age groups in the females population in Wadelsaid village. This was followed by the age group 40 - 50 yr-old, with an average concentration of 0.317 ppm, then the age group 25 - 35 yr old (0.211 ppm), followed by the oldest group; 55 - 65 yr-old (0.148 ppm) and the least concentration was detected in the supposedly one of the most active age group (15 - 20 yr-old), with an average of 0.117 ppm.

Regarding the males there was completely different picture. The highest concentration was detected in second oldest group (40 - 50 yr-old), with an average of 0.4 ppm, followed by far by the oldest group (55-65 yr-old), with an average of 0.198 ppm. The children ≤ 5 yr and less ranked third with an average of 0.101 ppm, whereas the group which ranked fourth was group 25-35 yr- old (average 0.089 ppm). Similar to the female's population, the group which was expected to be the most exposed (15 - 20 yr-old) ranked the fifth among the five examined groups (0.049 ppm).

Idris [11] in the Sudan, in his study on children, found that 84% of street children (locally known as Shamsha) has unacceptable blood lead levels it is a fact that a considerable number of them are addict to inhalation of benzene or glue or both.

Pb may enter the atmosphere during mining, smelting, refining, manufacturing processes and by the use of Pb containing products. All these activities are not available in these villages. Pb intake occurs also from the consumption of fruit juices, food stored in Pb lined containers, cosmetics, cigarettes and exhaust of motor vehicles [12]. The atmospheric exposure is expected as a result of the existence of Elgenaid Sugar Factory since 1963 [8].

Conclusions

1. All collected urine samples of the tested groups showed the presence of Pb (from 0.044 to 0.343 ppm). This indicates that the populations in Wadelsaid and Rigwa villages were exposed to these HMs from their food, water, air, working places and/ or other sources.

2. The concentrations varied within and between age groups and sexes of the same village, and between the two villages.

3. The Pb concentration in the urine of Wadelsaid village females (from 0.117 to 0.336 ppm) was higher than that detected in the urine of Rigwa village females (from 0.044 to 0.343 ppm).

4. All results obtained from the study revealed that Pb levels are still within the limits of the accepted values by regulatory bodies (acceptable levels are 10 ppm and 60 ppm for Cd and Pb respectively).

Bibliography

1. Anonymous. "Dangers of Lead Still Linger". US Food and Drug Administration, (FDA) Consumer (1998): 56-59.
2. Holister G and Porteous A. "The Environment: A Dictionary of the World Around US, Arrow" (1976).
3. UNEP. Pollutants (2002).
4. UNEP. "Heavy metals toxicity, Toxic materials (2003).
5. IPCS. "Inorganic lead". Geneva, WHO Organization international programme on chemical safety (Environmental Heath Criteria 165) (1995).
6. Greenwood NN and Porteous A. 'The environment : A dictionary of the World Around US, Arrow" (1976).
7. Doull JCD and Amdur MD. "Air pollution in Casarett and Doull's Toxicology: The basic Science of poisons, 5th edition". New York (Klaassen, C.D; ed) Macgraw–Hill (1980): 857 - 882.
8. Ahmed MEH. "Sugar Industry as a source of pollution – case study – Elgunaid Sugar Factory (1963 – 2010), Gezira– Sudan". M.Sc. Thesis, University of Gezira, Sudan (2010).
9. Zinterhofer LJM., *et al*. "Atomic Absorption Determination of Lead in Blood and Urine in the Presence of EDTA". *Journal of Laboratory and Clinical Medicine* 78.4 (1971): 664-674.
10. Rodriguez-Flores M and Rodriguez-Castellon E. "Lead and cadmium levels in soil and plants near highways and their correlation with traffic density". *Environmental Pollution* 4.4 (1982): 281-290.
11. Idris MEA. "Blood lead levels and lead toxicity in high-risk groups of Sudanese children in Khartoum, Sudan". M.Sc. Thesis, University of Khartoum, Sudan (2001).
12. Benneth BG. "Exposure Commitment Assessment of Environmental Pollution". Volume 1, London, Monitoring and Assessment Research Center (1981).

Volume 5 Issue 1 November 2017