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Research Article

Effect of Some Professions on the Lead Levels of Male Urine in Wad-Medani, Sudan

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Abstract

Amongst toxic heavy metals, lead (Pb) is one of the most serious environmental poisons all-over the world. Exposure to Pb in the home and workplace results in health hazards to adults and children. The objectives of the present study were to determine the Pb levels in urine in Wad Medani (capital of Gezira State, Central Sudan) male population represented by the following professions: University of Gezira (U of G) staff (supposedly unexposed population), traffic police (exposed to car exhaust fumes), car painters (exposed to Pb-based paints), gas stations workers (exposed to leaded fuel and its fumes) and car battery-repair workers (exposed to Pb and its fumes), in addition to investigating the correlation between Pb level and. duration of exposure. Urine samples were collected from these groups, analyzed by using atomic absorption spectrophotometry (AAS). The design adopted was completely randomized design. All tested sample revealed to presence of Pb in the urine. The means in all tested samples ranged from 22.89 - 42.0 μg/100 ml urine. significant differences were detected between groups at ($p < 0.05$). The detailed results, based on profession, were as follows: a) The U of G staff mean 22.8 (range: 20 - 28 μg/100 ml); b) Traffic police mean 31.11 (27 - 34 μg/100 ml); c) Gas/fuel stations workers mean 29.7 (27 - 33 μg/100 ml); d) Car -painting worker, mean 31.44 (28 - 35 μg/100 ml), and e) Battery repair workers, mean 36.2 (30 - 42 μg/100 ml). A strong positive correlation was found between Pb level and working duration (yr) in battery-repair workers (R^2= 0.772), fuel stations workers (0.682), painters (0.771). and a weak negative correlation in traffic police (R^2= 0.006).

Keywords: *Lead Concentration; Heavy Metals; Pollution; Contamination; Urine; Males; Sudan Gezira*

Introduction

Pollution is the deliberate or accidental contamination of the environment with man's waste", or "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]. Pollution is also defined as the introduction by man of waste matter or surplus energy into the environment, which directly or indirectly cause damage to man and his environment other than himself, his household, those in his employment, and those with whom he has a direct trading relationship [2]. 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, comfort, amenities, or property values of peoples [3]. Generally, pollutants are introduced into the environment in significant amounts in the form of sewage, waste accidental discharge, or as a by-product of a manufacturing process or other human activity [1]. The first exposure to metallic hazards might have been due to abnormally high natural concentrations in the food and/or water [4]. The use of metallic cookware increased the risk of adverse effects. With the coming of the industrial age, occupational diseases became more frequent. Later, diseases related to pollution of the environment from industrial contamination were recognized. Of > 100 elements, 77 are metals. Of the elemental metals 55 can be considered of industrial or economic importance. Some metals are essential nutrients; they also serve as industrial and environmental hazards, if the homeostatic mechanism maintaining them within the physiologic limits is unbalanced. In this context, it recognized the heavy metal (HM) is a member of an ill-defined subset of elements that exhibit metallic properties, which would mainly include the transition metals, some metalloids, lanthanides and actinides. Many different definitions have been proposed. The term HM has been called “meaningless and misleading” in an IUPAC technical report, there is an alternative term “toxic metal” for which no consensus of exact definition exists either [5]. The elements having the greatest disease potential are those that tend to accumulate in the body. HMs is a group of elements between Cu and Bi on the periodic table of elements having specific gravities > 4. These chemicals are Pb, Hg, Ni, Al, Ag, and Be [6]. In general, HMs produce their toxicity by forming complexes or ligands with organic compounds, which lose their ability to function properly, and result in malfunction or death of the affected cells. When these HMs bind to these atoms, they may inactivate important enzyme systems, or affect protein structure. These metals are a cause of environmental pollution (i.e. HM pollution) from a number of sources, including Pb in petrol, industrial effluents, and leaching of metal ions from the soil into lakes and rivers by acid rain [7].

Amongst toxic HMs, Pb ranks as one of the most serious environmental poisons all over the world. Solubilities in water vary; lead sulfate and lead oxides being poorly soluble, and the nitrate, chlorate and chloride salts are reasonably soluble in cold water [8]. Pb is a natural constituent of the earth’s crust at an average concentration of about 16 mg/kg [9]. This metal has been widely used in many countries, and in many places some contamination of the environment has occurred as a result of mining and smelting processes used or from the use of products made from it. Consequently, Pb is present in air, food, feed, water, soil, dust and snow. Pb in the environment exists almost entirely in the inorganic form. However, small amounts of organic Pb result from the use of leaded gasoline [9]. Exposure to Pb in the home and workplace results in health hazards to many adults and children. People have been at risk of absorbing toxic amounts in their drinking water, in their food, and in the air. Several organs and systems are adversely affected by Pb. The latter acts by complexing with oxo-groups in enzymes and affects virtually all steps in the process of heme-synthesis and porphyrin metabolism. Pb also inhibits acetyl cholinesterase, acid phosphatase, ATPase, carbonic anhydrase, etc., and inhibits protein synthesis, probably by modifying tRNA. Pb also inhibits –SH containing enzymes, especially by interaction with cysteine residues in proteins.

The typical symptoms of Pb poisoning are colic, anemia, headaches, convulsions, chronic nephritis of the kidneys, brain damage and central nervous system (CNS) disorders. Also, gastrointestinal tract (GIT) disorders, diarrhea, stomatitis, tremor, hemoglobinuria causing a rust-red color to stool, ataxia, paralysis, vomiting and convulsion, depression, and pneumonia, when volatile vapors and fumes are inhaled [10]. The nature of effects could be toxic (acute, chronic or sub-chronic), neurotoxic, carcinogenic, mutagenic or teratogenic.

The Objectives of the present work was to measure the Pb levels in the urine of males from five different professions living in Wad Medani Town, the capital of the Gezira State, Central Sudan. The profession were University of Gezira teaching staff, traffic police, car painters, gas/fuel stations workers and car battery-repair workers. The second objective was to investigating the correlation between Pb level in the urine and the working age/exposure period/duration.

Materials and Methods

Site of experiment

The study was carried out in Wad Medani, Gezira State (Central Sudan; population 4 million). Samples were prepared in National Health Laboratories (Occupational Health), Khartoum, and the analysis was carried out in the laboratories of the Geological Research Authority of the Sudan, Khartoum State, the capital of Sudan.

Samples collection

Samples were collected from different areas in Wad Medani Town (7 administrative units, population 500 thousand). Study population was divided into five professional groups (9 individuals each). These groups were: Traffic policemen, gas/fuel station workers, car painters, battery-repair men, and the control, i.e. supposedly unexposed population, was represented by U of G staff. The urine volume collected/ sample was 40 ml of in a 70 ml dark bottles. All samples were collected within 2 days, and were stored at 4°C or lower before preparation.

Reagents

The reagents required for this work were as follows: Glacial acetic acid, HNO_3, NaOH, Tritone, ammonium pyrrolidine dithiocarbamate (APDC), methylisobutylketone (MIBK), lead nitrate, and deionized water.

Instruments and Glassware

Electric shaker, centrifuge, Atomic Absorption spectrophotometer (AAS), dark bottles, measuring cylinders of different sizes, pipettes, test tubes, etc. were used.

Sample Preparation

The pH of the urine sample was adjusted to 5.5 (+ 0.1 pH unit) using 3N HNO_3 and 3N NaOH. The urine was transferred (40 ml) to a centrifuge tube and to it 1 ml of 10% tritone 100 (TX) and 1 ml of 2% APDC were added. The sample was agitated thoroughly following each step. MIBK (water-saturated, 3 ml) was added; shaken for 20 min at about 3500 rpm after the addition of deionized water (20 ml) to the last step.

Preparation of Standard

Lead nitrate (1.598g) was dissolved in 10 ml of HNO_3 and the volume was completed to 1L as a stock solution. From this 20, 40, and 80 μg/100 ml were prepared for the standard curve.

Chemical Analysis

The prepared urine samples were placed in the bottles, connected with a tube, which takes the samples into the AAS that reads the spectra automatically and shows the amount/concentration of Pb in the screen.

Results and Discussion

People are exposed to a variety of potentially harmful agents in the air they breathe, the liquids they drink, the food they eat, the surfaces they touch and the products they use. An important aspect of public health protection is the prevention or reduction of exposures to environmental agents that contribute, either directly or indirectly, to increased rates of premature death, disease, discomfort or disability [11]. Trace metals may enter the human body through inhalation of dust, consumption of contaminated drinking water, direct ingestion of soil and consumption of food plants grown in metal-contaminated soil [12,13]. Pb may enter the atmosphere during mining, smelting, refining, manufacturing processes and by the use of Pb-containing products. The natural concentration of Pb in soils had a range of 2 to 200 ppm, with an approximate average of 16 ppm [4]. The same source reported that plants can translocate Pb through their roots to leaves and fruits.

Pb intake occurs from the consumption of fruit juices, food stored in Pb-lined containers, cosmetics, cigarettes and exhaust of motor vehicles [14]. Pb and Cd levels in vegetation increased linearly with traffic density and proximity to roadways [15]. Their levels in soil and vegetation decrease with increasing distance from the roadside [16].

The effects of Pb are the same, whether it enters the body through breathing or swallow-wing. The main target for Pb toxicity is the nervous system, both in adults and children. Long-term exposure of adults to Pb at work has resulted in decreased performance in some tests that measure functions of the nervous system. Pb exposure may also cause weakness in fingers, wrists, or ankles. The exposure also causes small increases in blood pressure, particularly in middle-aged and older people, and may also cause anemia. At high levels of exposure, Pb can severely damage the brain and kidneys in adults or children and ultimately Pb and Pb- compounds are reasonably anticipated to be human carcinogens, based on limited evidence from studies in humans and sufficient evidence from animal studies, and the EPA has determined that lead is a probable human carcinogen [4,7,17].

The world-wide averages of Pb were 35 and 17 μg/ml for urine and blood, respectively. The urinary and blood levels of 150 and 80 μg/ml, respectively, are indicative of hazardous exposure [24]. Casarett and Doull [18] reported that approx. 60% of the absorbed Pb is retained by body and 40% is excreted.

The present work results revealed that the concentrations of Pb vary from one profession to another. The five groups/ professions can be classified into three categories according to the level of significance (Figure 1). The means of Pb levels in all samples ranged from 22.89 - 36.22 µg/100 ml urine. These results revealed that there are significant differences between groups at ($p < 0.05$). The University of Gezira teaching staff population (i.e. the low-risk population) Pb levels in urine ranged from 20 to 28 µg/100 ml, with a mean of 22.8 µg/100 ml. This can be justified by the presence of Pb in air, food, feed, water, soil, dust and snow [4,9]. Moreover, the natural levels of metals normally increased through various anthropogenic processes. Currently, anthropogenic inputs of metals are higher than the natural input, and this may pose a great threat to aquatic life in particular, and to the whole ecosystems in general [19]. The global mean Pb concentration in lakes and rivers is estimated to be between 1.0 to 10.0 µg/L [19]. Pb enters the aquatic environment through erosion and leaching from soil, leads dust fallout, combustion of gasoline, municipal and industrial waste discharges, runoff of fallout deposit from streets and other surfaces, as well as precipitation [4,20]. Most Pb used by industry comes from mined ores ("primary") or from recycled scrap metal or batteries ("secondary" [21]).

The second category includes three professions (i.e. medium exposure professions). Their combined mean is 30.6 µg/ml. These professions are traffic police (range: 27 to 34; mean = 31.11 µg/100 ml); gas/fuel stations workers (range: 27 to 33; a mean = 29.7 µg/100 ml); car painters (range: 28 to 35, mean = 31.44 µg/100 ml. Finally, the battery repair workers (range: 30 to 42; mean of 36.2 µg/100 ml (Figure 1).

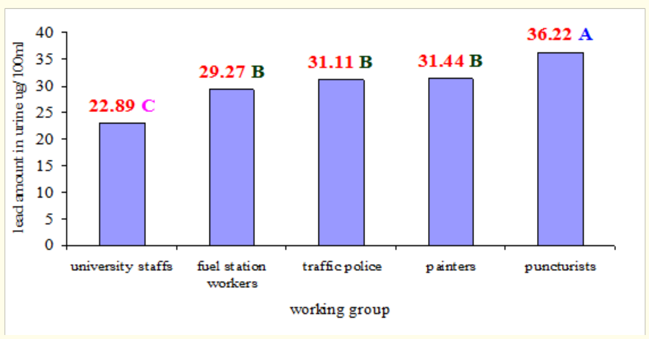

Figure 1: *Means of lead amount in urine (µg/100 ml) in different working groups.*

SE + 0.77 C.V. % 7.65

Eltigani [22] found that urine samples collected from workers at University of Khartoum Press had a mean Pb concentration of 23.94 µg/ml. surprisingly, it is lower than University of Gezira teaching Staff value. Al Sudan Al-Hadith Printing Press workers urine samples showed a mean of 39.56 µg/ml, which is closer to the highest limit detected in the present work for battery repair workers. Idris [23], in the Sudan, found that 84% of the street children (locally known as shamasa) had unacceptable blood Pb levels. This is attributed to their addiction to benzene and/ or glue. Mohamed., *et al*. [24] studied five types of fresh vegetables, viz. carrots, sweet pepper, snake melon, garden rocket and tomato (salad components), collected from three different sites in Khartoum State: viz. road-side farm, road-side market and open market, before and after washing. For all sites, Pb concentration was very high in all vegetables and exceeded the maximum level recommended by FAO/WHO, even after washing (0.3 mg/kg). Moreover, John and Van Laerhoven [25] reported that cereal grains accumulate substantial amounts of Pb through the air.

WHO [26] reported that normal populations are exposed to Pb from water, air and food. This explains where the university staff got these levels. The same source stated that the food and water absorption was estimated to be ca.10% of the intake, whereas that retained in the lungs from the Pb inhaled is about 40%, which is completely absorbed. The same source also estimated that adults weekly intake of Pb from the three sources ranges from 1.12 to 3.64 mg, depending on the concentration in the source. It can be concluded that the concentrations obtained in the five professions are lower than the world average (35 µg/ml) and the hazardous exposure (150 µg/ml).

From these results, all urine samples of the five tested groups (professions) showed the presence of Pb. The Pb concentration varied from tested profession to another and within the same profession. Also there was correlation between working duration and the concentration detected in the urine. The university staff, as expected, showed the lowest level. This could be attributed to the minimum exposure, especially in the work-place. They could be representing the rest of the population in town other than the tested four tested professions. Gas stations workers ranked second, but higher than the university staff. They are exposed to leaded fuel and other activities within the service station generating Pb fumes, in addition to car-exhaust, at least 8 hr/day. It is worth mentioning that almost all these workers are not using any personal protective measures/ equipment (PPE). Moreover, their awareness about the hazards in work is very weak. No especial training is available for them before or during their service. Traffic police is exposed to car exhaust on daily basis, especially in the cross-roads. They are not using nose-masks, thus inhalation could be the major route of exposure. Again, no training in such issues is provided to the traffic police before or during the service. Car painters and battery- repair workers, need special attention. The former still use material for coating and painting that contain high concentration of Pb. Moreover, PPE is not available or even offered to them. The small droplets of the sprayed paint can easily be inhaled, and their bodies, viz. hand, arms and face are the areas liable to deposition of droplets (dermal exposure). The solvents used to dilute the paint can even enhance the absorption process. Regarding the battery-repair worker, mostly very young worker, are heavily exposed to Pb-fumes for at least 3 - 4 hr /day. Melting the Pb is a major activity in such workshops. No PPE is available to them. Even if available, they do not care to use them for one reason or another. The lack of safe workplace, the very limited awareness among the workers of these two professions has resulted in high urine Pb levels. Moreover, both were observed to have poor personal hygiene during and after work, e.g. they go to restaurants wearing work clothes that are heavily contaminated and they continue using these clothes without washing them as long as they can persist. No bathrooms are available in the workshops or cabinets for keeping their street clothing. The employers failed in providing proper facilities for the workers.

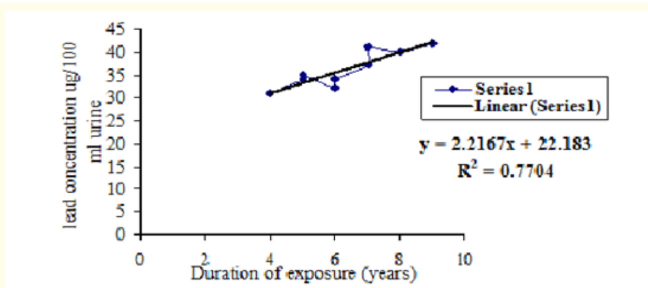

Figure 2: *Correlation of battery repair workers duration of exposure (years) and lead concentration in urine (µg/100 ml).*

R^2= 77% It means there was strong (+) correlation.

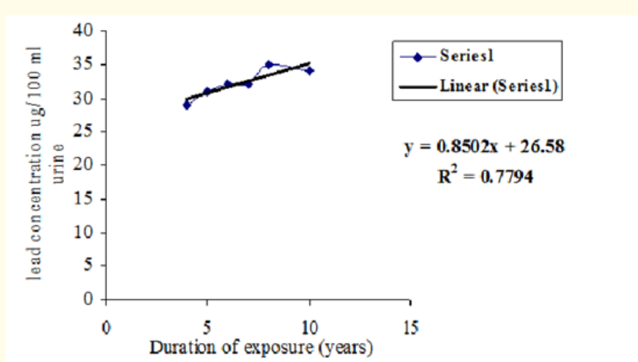

Figure 3: *Correlation of painters duration of exposure (years) and lead concentration in urine (µg/100 ml).*

R^2 = 77% it means there was strong (+) correlation.

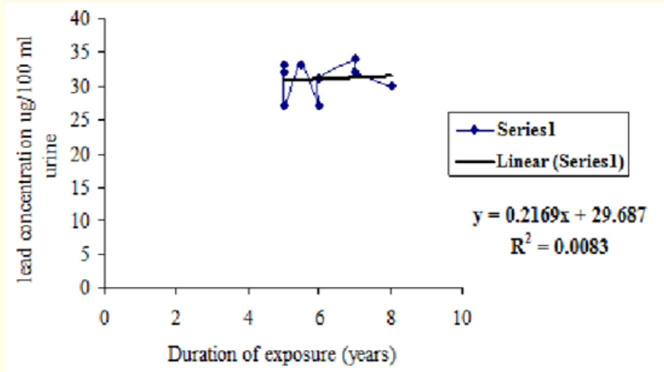

Figure 4: *Correlation of traffic police duration of exposure (years) and lead concentration in urine (µg/100 ml).*

R^2 = 0.8% It means there was a weak (-) correlation.

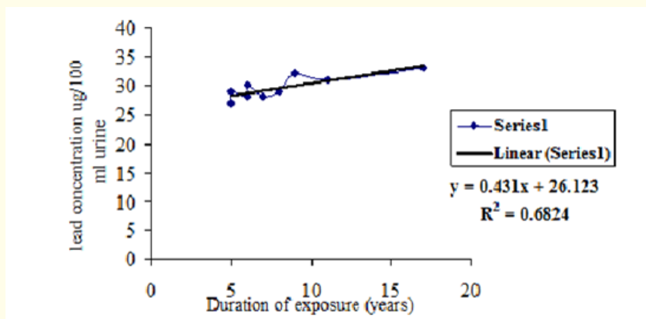

Figure 5: *Correlation of fuel station workers duration of exposure (years) and lead concentration in urine (µg/100 ml).*

The correlation between the working duration in car-painters and the battery-repair workers was strong (R^2 =0.77). However, for the traffic police, the correlation was weak (R^2 =0.0083) (Figures 2-5).

It is, therefore, recommended that the regulatory authorities should make it mandatory to train and raise the awareness in the workers who are dealing with materials containing Pb, about its ill-effects and should insist on regular health check up to prevent or avoid adverse health effects. The workers must be forced to wear proper PPE, otherwise will be subjected to punishment. The employer must providing proper facilities and PPE for the workers, including showers and cabinets for keeping their clean belongings. Based on the medical checkups and measuring the Pb level in the urine or blood, workers might be allowed to continue in the job or transferred to another job far from exposure to Pb. The leaded fuel and lead-based paints must be banned. The authorities must avail all types of protective clothing in the local markets with affordable or even subsidized prices for the private sector and small business. Battery repair workers must understand that repair is unjustifiable economically. Finally, Occupational Health and Safety Units (OHSU) must be established in all sectors, e.g. corporations, factories, industrial areas, etc.

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