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Evaluation of Airborne Lead Pollution and Its Association with Children's Urinary Lead Levels

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ABSTRACT: Despite the measures taken by most countries, lead pollution still poses an environmental and health risk to humans, especially children. Therefore, the current study aims to evaluate lead in the air and its impact on children's health. Lead samples from the air and children's urine were collected from three different areas within Kerbala Governorate: the urban city center residential areas, and rural areas as a reference area for comparison. A suspended dust collector was used to collect lead samples, and then the lead concentration was measured using an atomic spectrometer after digesting them with acids. The results of the study showed that the highest concentration of lead was in the center of the urban area (3.150 μg/m³) and its mean concentration in the air was 1.703 (μg/m³), which is higher than the US Environmental Protection Agency limits, with statistically significant differences between the study areas $p < 0.01$. The mean concentration of lead in children's urine was 0.622 (μg/dL) with statistically significant differences between the areas $p < 0.01$. Pearson's correlation coefficient indicated a significant positive correlation between the concentration of lead in the air and children's urine ($r = 0.651$; $p < 0.05$). This means that high lead concentrations in children's urine are due to lead air pollution and are an indicator of lead pollution in the environment and warn of potential risks to children's health. Therefore, the study recommends reducing lead emission sources and conducting periodic examinations.

Key words: Lead, air pollution, urine, kerbala

1. INTRODUCTION

Air pollution in many urban areas is a public health problem and a critical environmental issue due to the emission of many pollutants such as hydrocarbons and heavy metals, especially lead [1] . Many studies indicate an increase in the concentration of these pollutants in the air due to vehicle emissions, rapid industries, and other sources [2, 3]. Heavy metals such as mercury, nickel, lead, arsenic, and cadmium are the most prominent environmental pollutants in the air and the most dangerous due to their high toxicity and long-term environmental persistence [4]. Lead is among the most important heavy metals and a source of concern for most urban environments due to its multiple health effects as well as its widespread use. Paints, batteries, pesticides, device and vehicle waste, and leaded gasoline (in countries that still use it) are the most important sources of airborne lead in the atmosphere [5]. Despite international and local legislation in many countries to limit its use, lead pollution remains a source of concern for many people concerned with public health in urban areas [6]. Children are the most affected age group by lead due to their high absorption mean and body growth. High levels of lead in the environment may have negative effects on children's growth, and cognitive and behavioral awareness [7]. Several studies have indicated the effect of lead, even at low concentration levels, on children's intellectual performance and learning [8]. There is no safe level of lead exposure [9]. Lead causes several functional problems in the body, including disruption or disturbance of calcium-dependent metabolic processes, the release of neurotransmitters, induction of oxidative stress, cyanosis, and permanent nerve damage [10, 11]. Lead generates free radicals that damage vital compounds such as proteins, lipids, DNA, and enzymes, disrupting biochemical processes [12, 13]. Kerbala Governorate suffers from a large increase in population due to migration from other governorates, in addition to the large numbers of tourists, as the number of tourists on some religious occasions reaches more than 22 million tourists, which constitutes a large burden on the environment due to traffic, the increase in the number of vehicles, the abundance of waste, and the consumption of various types of fuel [14, 15]. Some local studies have indicated that lead concentrations exceed the limits permitted by the World Health Organization and the US Environmental Protection Agency (EPA) and warned that increasing its concentrations

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Table 1 Mean concentration of lead in the air within the study areas

Area	N	Mean (μg/m³)	SD	Min.	Max.
Rural	20	0.5561 a	0.493	0.030	1.570
Residential	20	1.4035 b	0.832	0.380	3.120
Urban city center	20	3.1502 c	1.054	0.890	4.690
Average	60	1.703	1.358	0.030	4.690
EPA		0.15 μg/m³			
ANOVA Test		0.000			

*Different letters indicate differences between study areas using Duncan's test.

beyond the permissible limits has serious effects on health and the environment [14, 16, 17]. Many researchers have indicated that the presence of lead in the blood or urine of children is evidence of air pollution with lead [18, 19], but without evaluating the level of lead concentration in the air and explaining its effect on children. Despite the importance of these results, they need to be proven and supported. Therefore, the current study aims to evaluate the concentration of lead in the air of different environments within Kerbala Governorate, as well as its concentration in children's urine. The results of this research will help us to know the environmental and health effects of lead, as well as clarify the relationship between air pollution with lead and its high levels in children.

2. MATERIALS AND METHODS

2.1 Study Area

Kerbala Governorate (100 km from the capital, Baghdad) is one of the most important Iraqi Governorates due to religious tourism, as the number of tourists to the shrine of Imam Hussein, peace be upon him, exceeds 25 million tourists annually. In addition, the city is witnessing an increase in population as a result of immigration from the rest of the Governorates and the increase in urban projects and commercial activity. Three different areas were chosen to collect samples from air and children's urine: the rural area (Al-Husseiniyah district) as a low-pollution reference area, the residential area (Al-Ghadir neighborhood), and the urban city center as shown in Figure 1.

2.2 Measuring Lead Concentration in the Air μg/m³

To measure the concentration of lead in the air, a dust collection device (Type L60 240V) was used at a height of 1.5 meters during January and February of the year 2023 (20 samples for each area) at eight in the morning. Lead was extracted from filter papers using a mixture of nitric and perchloric acid in a ratio of 1:4. The lead concentration was calculated in μg/m3 following the method described by Central Pollution Control Board (CPCB) [20].

2.3 Measurement of Lead Concentration in Urine μg/dL

Urine samples were collected from children under the age of 6 from the study areas (20 samples per area), kept in opaque and refrigerant containers, and then transported directly to the laboratory. The samples were filtered and examined using an atomic absorption spectrometer to measure lead concentrations.

2.4 Statistical Analysis

SPSS (version 24) is an advanced statistical analysis software package developed by IBM. It is a powerful data analysis tool widely used in social research and healthcare. It was used to extract descriptive statistics (mean, standard deviation) and one-way analysis of variance at level ($p < 0.01$) to find differences between the study areas, followed by Duncan's multiple range analysis. The Pearson correlation coefficient was calculated to find the relationship between the concentration of lead in the air and the urine of children at a level ($p < 0.05$).

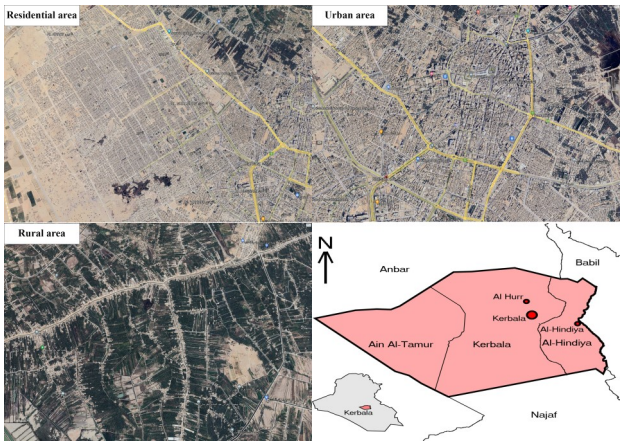

Fig. 1. Kerbala Governorate, the three areas are: Rural, Residential, and Urban.

3. RESULT AND DISCUSSION

Table 1 shows the means of lead concentrations in the air. The lowest mean was in the rural area (0.5561) μg/m³, followed by the residential area (1.4035) μg/m³, while the highest mean of lead was in the urban city center (3.1502) μg/m³. ANOVA analysis showed that there were significant differences between the study areas ($p < 0.01$), and this reflects the impact of human activity on each area, especially the presence of factories, vehicle emissions, commercial activities, and others. All lead concentrations (0.556, 1.403 and 3.150 μg/m³) exceeded the US Environmental Protection Agency's limits of 0.15 μg/m³ [16]. High

Table 2 Mean concentration of lead in the urine within the study areas

Area	N	Mean (µg/dL)	SD	Min.	Max.
Rural	20	0.3938 a	0.563	0.000	2.060
Residential	20	0.5089 a	0.556	0.000	1.540
Urban city center	20	0.9621 b	0.526	0.180	1.950
Average	60	0.622	0.593	0.000	2.060
ANOVA Test		0.004			

*Different letters indicate differences between study areas, and similar letters indicate the opposite using Duncan's test.

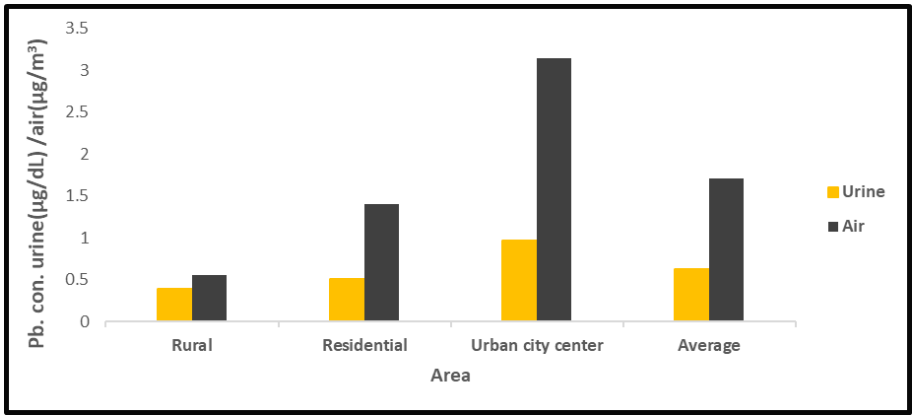

Fig. 2. The mean concentration of lead in the (air/urine) within the study areas.

concentrations of lead in the air have serious effects on human health, as it is transmitted directly, through inhalation or ingestion[21], and indirectly through the accumulation of lead after it is deposited from the air and enters the food chain, which results in what is known as biological magnification [22].

It is clear from the results of the study the effect of lead concentrations in the air on its concentration in children's urine (Figure 2). The lowest mean lead concentration was in the rural area (0.3938) µg/dL, followed by the residential area at a mean of 0.5089 µg/dL, while the highest concentration was in the urban city center at a mean (0.9621) µg/dL, with significant differences between the study areas ($p < 0.01$) (Table 2).

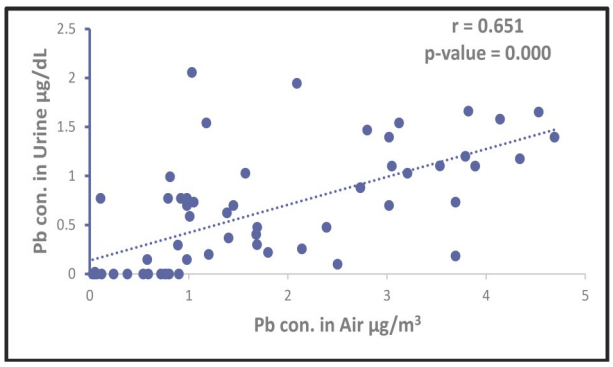

Fig. 3. Correlation coefficient between the concentration of lead in the air and its concentration in children's urine

This means that high concentrations of lead in the air of the area lead to a high concentration in the tissues of the human body, thus exposing him to the risks of lead accumulation. This conclusion is reinforced by the correlation coefficient analysis, as a positive significant correlation was found ($r = 0.651$; p-value < 0.05) between the high lead concentration in the atmosphere and the lead concentrations in children's urine (Figure 3). This clearly proves that the main reason for the high lead concentration is Lead in children's urine is the result of high concentration of lead in the air. This study was consistent with what was indicated by some studies that showed that high concentrations of lead in the air led to an increase in the tissues of plants and birds[14, 23]. Although the human body excretes lead with urine as one of the physiological ways to get rid of toxins and harmful elements [24], some concentrations accumulate in the body's tissues due to the ability of lead to bind and replace other elements in the tissues of the human body, thus causing functional disorders and various diseases[24] .Some studies have reported the effect of heavy metals, especially lead, on the health and development of children, as well as their behavior and the incidence of autism spectrum disorder [25, 26]. Comparing the results of the current study with other studies shows that the level of urinary lead concentration was somewhat close to the study conducted in Bangladesh [27] and Malaysia [28] (Table 3). In contrast, the results of the study were higher than the study conducted in Spain [29], where lead

Table 3 Comparison of the results of the current study with international studies

	(Con. of lead μg/dL)				Country of study	Reference
	Mean	Urban Area	Residential Area	Rural area		
1	0.62	0.39	0.51	0.96	Iraq	The current study
2	0.4			0.4	Bangladesh	[27]
3	0.58	0.58			Malaysia	[28]
4	NC*				Spain	[29]
5	0.03	0.022		0.040	Swaziland	[34]
6	4.19				Pakistan	[30]

*Below the level of measurement

levels were very low and could not be measured. The commitment to monitoring and working according to international health regulations, as well as reducing the sources of lead pollution, and the difference in the level of income and education per capita, maybe the most important factors that led to its decrease in Spain and its increase in the study country. Several studies have indicated an increase in lead concentration in Karbala due to the rise in various industrial activities and the huge increase in cars and electricity generators [14, 17]. The urinary lead concentrations in the study conducted in the city of Hyderabad in Pakistan [30] were approximately four times higher than the results of the current study. This may be due to the increase in various industrial activities and the increase in the concentrations of heavy elements in the environment. This is reinforced by the results of some studies conducted in Pakistan, which warned of a multi-fold increase in the concentrations of heavy elements and their impact on human health [31-33].

4. CONCLUSION

The results of the study indicated that lead concentration in the air of Kerbala Governorate increased and exceeded the US Environmental Protection Agency's limits several times as a result of increasing human activity and urban expansion. There is also a higher concentration of lead in the urine of children living in the city center compared to the rural area, with a significant correlation between the concentration of lead in the air and the urine of children. The increased concentration of lead in the air and its presence in the urine of children is a dangerous indicator of their health. Based on the results of the current study, the rise in lead concentration in the air of any country will negatively affect human health, especially children. Therefore, the study recommends periodically assessing the concentration of other heavy metals in the air, and blood of children and reducing potential sources of pollution.

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