RESEARCH ARTICLE

The Effect of Living Place and Smoking on Blood Level of Lead, Cadmium and Mercury: As a Model of Pollutants in Human Blood

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ABSTRACT

It is known that heavy metals (as lead, cadmium and mercury) are naturally occurring elements that have a high atomic weight and a density 5 times greater than that of water. Their different industrial, domestic, agricultural, medical and technological applications may led to distribution widely in the environment, raising their harmful effects on human health and the environment. Their effects and degree of toxicity depend on several factors, including the level of these metals in the blood and the age, gender, genetics, smoking, living place, and nutritional status of exposed individuals. Accordingly and in fact is needed to estimate heavy metals levels in the blood of living people in different areas in Iraq from time to time. The present study was designed to search the relation between heavy metal (lead, cadmium, and mercury) levels in the blood of people and smoking, and living place (rural, and city center), gender, as factors that may aggravate heavy metal toxicity in Diyala Province. Total 72 patients were considered in this study. Group (A) of 21 males (A1, A2, A3, A4, A5, A6, A7) each sub group compose of three males, A1, A2, A3, from rural areas, while A4, A5, A6, A7,were from the center of the city, and group (B) of 51 females (B1. B2. B3, B4) each sub group of 12, 13, 8, 18 in number respectively according to availability, at age (≤ 29), and at age (≥30). The results showed that in comparison 1 the level of lead and cadmium in the blood of individuals living in the center of the city was significantly higher in comparison to those living in the village in both mail and females at age (≤ 29), While in comparison 2, it was noted that the level of lead and cadmium together in the villagers was more than its level in the blood of city resident individuals, but statistically was not significant. The city's residents than those in rural areas had more levels of mercury in their blood in all comparisons but statistically was not significant between the studied groups. The smoking factor had an effect on the levels of heavy metals in the blood, as the level of lead in smokers was higher compared to its level in non-smokers (control group) in comparisons 3 and 1, while the opposite was in comparison 2, the level of lead increased in non-smokers but statistically was not significant. The level of cadmium in the blood of smokers was higher compared to its level in non-smokers in all comparisons, as well as with mercury, its level increased in smokers in comparisons 3 and 1, except for comparison 2, where its level increased in non-smokers. The concentration of lead and mercury did not exceed the internationally permissible limits in individuals' blood, while the cadmium level exceeded the internationally permissible limits.

Keywords: Lead, Mercury, Cadmium, Environmental pollution.

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INTRODUCTION

Pollution with heavy metals represents a serious and acute problem for the tendency of these compounds to collect and accumulate within living ecosystems. The wasteful use of these metals has accompanied tremendous technological development and has reached a high level of danger, leaving great effort on the environment, and man considers himself one of the victims of the environment.[1] Despite several years of studies, we are inactive away from the actual treatment of long toxicity of heavy metals such as mercury, lead, cadmium, etc.[2] Heavy metals at definite levels is a poisonous substance to all living subjects. Different communities are exposed to lead from air and food in roughly equal proportions, lead can reach humans via the food chain because airborne lead can be deposited on soil and water.[3]

The toxicity of heavy metals has been shown to be a major threat and there are many associated health risks with the toxic effects of these metals even if they do not have any biological role, remain harmfully present to the human body and function properly. Heavy metals may sometimes act as a false element in

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the body, while at certain times may interfere with metabolism, little minerals can be removed through removal activities while some minerals accumulate in the body and the food chain showing the chronic nature.[4]

Iraq also faces other very serious environmental problems, including poor water quality, air pollution, waste management, polluting sites, degradation of major ecosystems, largely neglected environmental problems before the war as well during war and conflicts, and the economic sanctions resulted in exacerbated environmental conditions,[5] and the Iraq weak environmental management structure has exacerbated the problems. This causes a large number of serious diseases across Iraq, including a rise in birth defects, abortion, premature births, infertility, leukemia, gland problems and other.[6]

The term "heavy metals" refers to any relatively high-density metal element.[7] Which is considered toxic or toxic even in low concentrations of them and which have a qualitative weight at least 5 times higher or greater than the qualitative weight of water.[8]

Heavy metals include lead, cadmium, zinc, mercury, arsenic, silver, copper and iron chromium.[9] There are about 20 metals that are heavy metals, but four of them are harmful to humans and their environment: lead, cadmium, mercury and arsenic.[10]

Some of these minerals are micronutrients necessary for plant growth, such as zinc, manganese, nickel and cobalt, while others have an unknown biological function, such as lead, cadmium and mercury,[11,12] Heavy metals have the ability to enter the human body through inhalation and ingestion or through skin contact as they accumulate in soil, plants and aquatic organisms,[13]

Lead is a natural blue-gray metal found in small quantities in the Earth's crust, and lead can be found in all parts of the environment that surround us, many of which result from humanitarian activities, including burning fossil fuels and mining, industries are the sources of lead exposure, industrial processes of food, smoking, drinking water and household sources.[14]

Lead is naturally present in the environment, yet most of the lead to which people are exposed is the result of human activity, especially smoke resulted from the combustion of leaded gasoline, mining, factories and pesticides. Inhalation is often the biggest cause of lead entry into the body, specifically by people working in metal production plants such as iron and steel, the manufacture of acid lead batteries, paint, non-ferrous foundries (copper), exposure to hazardous waste sites, contaminated food or water, or old houses containing lead-based coatings, and in water pesticides because of the pipes that carry it.[15]

Lead is associated with red blood cells when it enters the body, then blood forms 3% of the lead in the body and 5% is stored in soft tissues. Most of the lead amount (95–90%) is stored in the bones, and the biological half-life has 3 to 6 weeks in the blood.[16]

Occupational exposure limits guidelines in the United States have shown that high blood lead levels (40 μg/dL) cause systolic and diastolic blood pressure among women aged 40–59.[17]

It also leads to protein clotting by forming complexities with auxiliary enzymes, thereby inhibiting adenosine triphosphate (ATP) production during breathing.[18] Lead poisoning also inhibits hemoglobin synthesis, causes dysfunction of the kidneys, joints, reproductive system and cardiovascular system and leads to severe and chronic damage to the central and peripheral nervous systems.[19] There is evidence that children with low calcium content in their bodies have a high lead in blood.[20] Chronic exposure to lead can result in mental retardation, birth defects, psychosis, autism, allergies, dyslexia, weight loss, hyperactivity, paralysis, muscle weakness, brain damage, kidney damage, and may cause death.[21]

Lead adversely affects the secretion, production and biological activities of thyroid hormones, stress hormones and metabolism, which may be associated with the duration and level of lead intake.[22]

Cadmium is of major concern, mainly due to its presence at relatively high concentrations in drinking water, among the heavy metal, and has extensively been studied for their public health effects.[23]

Cadmium is a mineral with known endocrine disorder activities. This toxic metal into the environment as a pollutant emitted from industrial, agricultural and other sources.[24] Cadmium is a bright, blue-inclined white metal element that is a natural element in the Earth's crust, usually forth's a metal integrated with other elements such as oxygen (cadmium oxide), chloride (cadmium chloride) or sulfur (cadmium sulfate and cadmium sulfide).[25]

Sources of human exposure to cadmium are iron and steel production, cement production of non-ferrous metals, waste incineration, use of phosphate fertilizers, absorb cadmium plants from the soil and form the main source of cadmium consumption in the non-smoking and non-occupationally exposed population. There is a great use of this toxic heavy metal in batteries, paint and alloys in industries. While household wastewater, smelting and refining of minerals, and the manufacture of chemicals and minerals are other major sources of cadmium in water.[26] In a study conducted[27] was found that another major source of exposure to cadmium was cigarette smoke. When cadmium was measured in smokers' blood samples, it was shown that they had 4 to 5 times higher blood cadmium levels than non-smokers.

Cadmium is a toxic mineral even at low rates, as it accumulates in the liver and kidneys of the human being and causes hypertension, and emphysema damages the kidneys and can turn into a carcinogen of the breasts.[28]

According to a study conducted[29,] cadmium can affect the structure of the skeleton, where it can interact directly with bone cells, inhibit protein production and collagen production, and cadmium may interfere with calcium metabolism, vitamin D3 and collagen so bone softening or osteoporosis can be observed in the late stages of acute poisoning with this element. The U.S. Environmental Protection Agency (USEPA) has identified cadmium as a potential human carcinogen in

Table 1: Shows grouping details

Groups	*Details*				
	Number	*Gender*	*Living places*	*Smoking*	*Age*
A1	3	♂	Village	No	≤29
A2	3	♂	Village	No	≥30
A3	3	♂	City	No	≤29
A4	3	♂	City	No	≥30
A5	3	♂	Village	Yes	≥30
A6	3	♂	City	No	≥30
A7	3	♂	City	Yes	≤29
B1	12	♀	Village	No	≤29
B2	13	♀	Village	No	≥30
B3	8	♀	City	No	≤29
B4	18	♀	City	No	≥30

recent years and affects pregnant women, and cadmium can cross the placenta and may disrupt the gene expression of the fetus's body and interfere with the normal process of fetal development. During breastfeeding, cadmium can be excreted in milk, accumulating in the baby's body and destroying the child's learning and memory ability.[30]

Environmental sources of mercury include contaminant paints in freshwater fish industries, paper, oil refining, rubber processing, fertilizer, batteries, dental fillings adhesive, fabric softeners, drugs, electroplating, steel, agriculture, thermometers industries, and other sources.[31] Mercury is one of the most toxic minerals in the environment and poses a major threat to human health and the environment.

Mercury is found mainly in three forms: mineral elements, inorganic salts and organic compounds, each with different toxicity and biological availability, and these forms of mercury are widely found in water resources such as lakes, rivers and oceans, where they are picked up by microorganisms and converted into methylmercury within them. This eventually leads to biological hypertrophy that causes significant disruption to aquatic life and the consumption of this contaminated water animal is the main way to human exposure to methylmercury.[32]

Methylmercury is a worldwide pollutant originating largely from burning fossil fuels, primarily in generating electrical power. Methyl mercury is a potent neurotoxin that can cause birth defects, learning disabilities, blindness, paralysis, loss of muscular control and death, and bio-accumulates through the food chain with the primary source of and risk to human health, being the consumption of fish.[33]

MATERIALS AND METHODS

Blood samples 72 were collected during six months (1 November 2020 to 1 April 2021) at ages 7 to 85 years from different areas in Diyala Governorate after obtaining administrative approvals and taking verbal approval from each individual. They were provided a questionnaire form to obtain information regarding gender, age, address, and smoking and chronic diseases. Patients with chronic diseases were excluded from the study.

Samples grouped into; (A) of 21 male samples, and group B of 51 female samples. The male samples were sub-divided into seven sub-groups (A1, A2, A3, A4, A5, A6, A7) each of three individuals, while female samples, were divided into four sub-groups (B1, B2, B3, B4), each of 12,13, 8, 18, individuals respectively. All ages ranged between ≤29 and ≥30 (Table 1). Five mL of venous blood was drawn from each individual, and the samples were placed in sterile plastic tubes, to check the levels of, lead, cadmium and mercury using a flame absorption atomic spectrometer at Ibn Sina Center, Ministry of Industry and minerals.[34] The factors considered in the study were: age, gender, smoking and living place.

RESULTS AND DISCUSSION

Effect of Place Factor on Heavy Metals Levels

The level of lead in the blood samples taken from the village and the city

The results of the study found that levels of lead in blood samples taken from the non-smoker individuals in village (A1) were higher than that of females (B1) at age ≤ 29, as well as the lead level were higher in non-smoker males A2 in the village at age ≥30 than non-smoker females of the same age. This may be due to several reasons, including the exposure of males to lead contamination more than females due to their contact with the outside world and inhalation of car smoke resulting from the burning of gasoline, which is added to the fourth instance of lead or fourth methyl lead to improve the performance of the car engine, add to that the nature of the eastern society, especially in the village community requires that man be responsible for work and maintain living requirements to the family, which makes him in direct contact with the factors of lead contamination. Some men may also be exposed in the workplace within the village (agricultural machines repair workshops, construction etc) to these factors. Either females and without the distinction between the two age groups are mostly housewives with little contact with the outside world, so the level of lead in males was higher than in females. The results of lead in this study recorded higher levels than that recorded[35] in a study to estimate the concentration of lead and cadmium in the blood of the population of Baquba, the mean level of lead in males was (34 µg/l) While in females was (24 µg/l), this may be ascribed to the time period between the previous study and the current study (4 years) in which increased numbers of cars in the city and increased population density. This means that lead contamination is continuously increasing and will exceed the maximum limit restricted by WHO (100 µg/l)). In another study done[36], blood lead levels were examined in a Basra population; the mean lead level in males was (132.5 µg/l) and in females was (101.1 µg/l). This increase in lead level may be due to the fact that Basra is a large port with many ships and naval vehicles, so it remains a city with wells and factories producing and refining crude oil, which is considered source of gas emission.

Comparison no. 3, (Table 2) between groups A3 non-smokers males in the city at age ≤ 29 (lead level at (51.7337 µg/l)

Table 2: The mean of the levels of lead and its standard error of the totals of the village and city for different age groups in males and females who are not smokers

Comparisons	*Groups*	*No.S*	*Gender*	*Living*	*Age.G*	*Pb µg/l Mean ± SE*	*The upper limit of lead in the blood according to WHO*
1	A1	3	♂	Village	29≥	41.5890 ± 3.69002	100 µg/l
	B1	12	♀			39.1042 ± 1.43880	
2	A2	3	♂		30≤	49.9343 ± 2.59220	
	B2	13	♀			43.5585 ± 1.44432	
3	A3	3	♂	City	29≥	51.7337 ± 3.34882	
	B3	8	♀			50.5994 ± 2.69744	
4	A4	3	♂		30≤	46.6199 ± 1.91401	
	B4	18	♀			57.4144 ± 3.14243	

*Vertically different letters mean that there are statistically significant differences, p≤ 0.05

was higher than the level in non-smoker female in the city B3 (lead level was 50.5994 µg/l). In contrast, the opposite has appeared in comparison no. 4, among the group of non-smokers male in the city A4 at age ≥ 30 with lead level (46.6199 µg/l). In contrast, non-smoker females B4 showed higher percentage in the level of lead at the same age as it was (57.4144 µg/l), In the third and fourth comparisons, differences in lead level existed as described. Still, there were no moral differences when comparing males and females at the probability level of $p \leq 0.05$. However, this disparity may be due to the fact that males have a higher lead level than females at age ≤ 29, and females with the highest lead level at age ≥ 30, is that in the city's streets have become crowded with cars, and housing is not far from the busy street as well. Therefore, it may be found at one time and area that males have higher lead level than females, while at another time and area in females is higher than males, because they both may be exposed to the same factors, men and women working outside of houses and inhale the smoke of cars and other means of transport, or by working in occupations where lead is used more than women have been kept from working in kitchens and close to the gases emitted in them, as well as the phenomenon of smoking, which has become common in recent years in both men and women. The other factor may be the use of lead cosmetics at ages 30 and higher for females is more common because these ages are the most commonly used for these products, such as certain types of eyeliner which is less commonly used at lower age.[37] Lead level in all groups has not exceeded the global maximum allowed, but this does not mean that it is not dangerous because lead is a toxic heavy metal and cumulative even at very low exposure levels.[38] No moral differences were observed between males and females in both cases at the p-probability level of ≤ 0.05.

The reason for the high level of lead in the males in the city compared to its level in the males in the village may be due to the high percentage of pollution in the city due to the spread of pollutants in water, air and soil and their transmission to the food chain, in addition to the difference in their lifestyle, where the city environment is more polluted due to the large number of the presence of factories, large number of cars and motorcycles, the congestion. High levels of lead are likely to be found in the general population that lives in areas of heavy traffic and high emissions of lead into the atmosphere and in crowded areas where exposure to lead is higher due to the greater number of gasoline generators and vehicles,[39] more than that, the high level of these metals in canned and imported food, administered by humans in the cities as was found by a study done[40] to the determination of the levels of lead and cadmium in canned fish and meat, imported to the local markets of Diyala Province, Iraq, they found high concentration of lead and cadmium in such foods more than that permitted by (WHO), which may results in increases in people blood levels of such heavy metals, living in city centers.

In comparison 2, the reason for the high levels of lead in male villagers may be, because some male persons may be exposed in workplaces within the village (car repair workshops, pipe installation, paint, mining, food packaging, construction and some other fields) to these factors. Or working in a job where lead is used, in addition to those who work in agricultural places, lead exposure also causes specific elevations in blood pressure, especially in middle-aged and elderly people[39]

The results of the present study recorded lower levels than what was found[41] in an analytical study of lead of blood samples in Diyala Governorate during (2020), found that the lead mean level in the village samples was (54.7 µg/l) mg/L, while in the city samples was (83.1 µg/l). Despite the short period of time between the two studies, only a year, but during this period, the level of lead decreased in the city and village as obtained by the current study in Diyala governorate, and this may be due to the outbreak of the COVID-19 virus in the country, which led to a reduction in population transports, industrial activities and other activities, which in turn led to a decrease in lead levels in the environment, but this does not mean that there is no danger to humanity, because any level of lead in the body, even if it is little, is considered dangerous. while our

Table 3: Average and standard error of cadmium levels among male and female groups for different age groups in the village and city for non-smokers

Comparisons	*Groups*	*No*	*Gender*	*Living*	*Age.G*	*Cd µg/l Mean ± SE*	*The upper limit of cadmium in the blood according to WHO*
1	A1	3	♂	Village	29≥	25.6081 ± 2.18645	0.3–1.2 µg/l
	B1	12	♀			25.5336 ± 1.08099	
2	A2	3	♂		30≤	32.6722 ± 2.99172 A	
	B2	13	♀			27.6705 ± 1.15148 B	
3	A4	3	♂	City	29≥	37.0308 ± 2.85382 A	
	B3	8	♀			28.2153 ± 1.14656 B	
4	A5	3	♂		30≤	31.8978 ± 1.64617	
	B4	18	♀			24.9241 ± 2.54803	

*Vertically different characters (A, B)mean statistically significant differences $p \leq 0.05$

results were higher than what[35] found in a study to estimate the concentration of lead and cadmium levels in the blood of the population of Diyala Governorate, where the average lead in blood samples of males was (3.4 µg/l). As we mentioned earlier, the reason for the rise in the level of lead may be due to the four-year period between the two studies, and during this period, the number of cars increased, and population density increased, in addition to factories and other factors that enhanced the increase of lead levels.

The results of the current study are in agreement with another study but conducted in Administrative Capital Baghdad; on the effect of some heavy metals on thyroid function[42], where the lead level in blood samples in Karada city was (52.41 µg/l), while in Jadiriyah was (42.73 µg/L). Despite the difference in the time period between the current study and the previous study and the increase in lead levels during these years and to the present time, but the results were close and this means that the pollution in the Diyala city is less than that in the Baghdad, and this may be due to the fact that the Administrative Capital atmosphere is more polluted because it is a central area, where the population density, industrial and commercial activities and other human activities that results day after day to an increase in lead levels and their impact on the pollution. The results of the study differs from what was found[43] in a study of lead exposure among the general population in Dohuk Governorate, level in blood samples among urban population was (27 µg/l) and in the rural population was (16 µg/l), and in another study[44] the concentration of some air pollutants in the blood of roadside workers in Erbil, as the level of lead in urban residents reached (20.3 µg/l) while rural residents (Surann) reached (18.2 µg/l), this may be due to the less density of population and rural lifestyle and less environment pollution which is differs between north of Iraq from other Iraq governorates.

It was obtained in this study (Table 2) that the level of lead (39.1042 µg/l) in group (B1) non-smoker females in the village at age ≥29 was less than the level 50.5994 of (B3) non-smoker females in the city at the same age. In the same way at age ≥30 the level (43.5585 µg/l) of lead of the non-smoker females in the village (B2) was less than the level (57.4144 µg/l) of lead of non-smoker females in the city (B4), in the two comparisons, significant differences were observed between lead levels of the non-smoker females in the village and that of the city females at $p \leq 0.05$. The higher level of lead obtained in the blood of females in the city at different ages may be due to inhalation of dust contaminated with lead, inhalation of car smoke, eating caned and preserved foods, or drinking polluted water transported by pipes containing lead, containers welded by lead or due to some cosmetics and traditional medicines enhances exposure to lead.[45]

The Level of Cadmium in the Blood Samples Taken from the Village and the City

Table 3 shows the comparison 3 between the groups A4, B3 in cadmium levels, it shows that the level of cadmium in males is (37.0308 µg/l), is higher than that in the females (28.2153 µg/l), as well as in the comparison no. 4 among the A5 (31.8978 µg/l) and B4 group (24.9241 µg/l) of non-smoking mails in the city of males and females at age ≤30 respectively is higher in males. There are moral differences between males and females in comparison 3, but no moral differences are observed between the sexes in comparison 4 at the probability level of $p \leq 0.05$.

Table 4: Average and standard error of mercury levels among male and female groups for different age groups in the village and city for non-smokers

Comparisons	*Groups*	*No. Sampls*	*Gender*	*Living*	*Age.G*	*Hg µg/l Mean ± SE*	*The upper limit of mercury in the blood according to WHO*
1	A1	3	♂	Village	29≥	13.1404 ± 1.17725	2-24 µg/l
	B1	12	♀			13.2876 ± 0.43123	
2	A2	3	♂		30≤	16.7492 ± 0.70631	
	B2	13	♀			13.3700 ± 0.4027	
3	A4	3	♂		29≥	13.3700 ± 0.40277	
	B3	8	♀			17.2710 ± 0.47814	
4	A5	3	♂	City	30≤	17.7849 ± 0.50458 A	
	B4	18	♀			14.6969 ± 0.37939 B	

However, the reason for the high level of cadmium in the blood of males in the city's, may be due to the atmosphere of their workplaces due to industrial activities in the city, including mining, smelting, battery manufacturing, dyes, stabilizers, alloys and many other works in which the in which cadmium is introduced and which in nature require males who have strong physical structure.[46]

In comparison with other studies the results recorded much lower levels of cadmium than that estimated by others[41] in his study in Baquba province, where the level of cadmium in village blood samples for both males and females was 0.1312 mg/l (131.2 µg/l), and also found to be lower than that of[35] who recorded cadmium in the blood samples in Baquba with average of males was about 0.0066 mg/dl (66 µg/l) while In females 0.0044 mg/dl (44 µg/l). in another study, it was obtained[47] in there biomonitoring study of lead, cadmium and mercury in adult blood in the city of New York, in that Cadmium blood level in males was 0.76 mg/dl (76 µg/l) while in females 0.79 mg/dl) (79 µg/l). The reason that the cadmium level is lower in the blood of both males and females in the current study in comparison to other studies mentioned above may be due to factory interruptions and the various actions due to the corona pandemic during the period of the present study, and this is a good indicator of the restoration of the land's natural resources to some of its health and this reflects positively on human health by reducing the toxins that enter its body in various ways.

The Level of Mercury in the Blood Samples Taken from the Village and the City

This study is one of the few studies in Diyala Province that has been estimated the blood level of mercury in the population and compared to global levels. Table 4 shows mercury levels in the blood of males and females for different age groups in the village and city of non-smokers. Comparison no. 1 between group A1 (village males) aged ≥29 their mercury levels was (13.1404 µg/l) which is not so much differs from that of the females in group B1 (13.2876 µg/l). Comparison no. 2 between A2 groups, where the mercury level (16.7492 µg/l) at age ≤30 years was higher than that of the village female B2 for the same (13.3700 µg/l). Comparison 3 represents group A4, which includes non-smoking city males aged ≥29, the mercury level was 16.32. 14 µg/l, which was lower than that of females B4 (17.2710 µg/l), but the opposite was shown in comparison no. 4 between the A5 group of non-smoking city males aged ≤30 and group B4 female city at the same age, with the mercury level in males was (17.7849 µg/l) while in females was less (14.6969 µg/l), no moral differences between males and females were observed in the first three comparisons, but there were moral differences between the sexes in comparison 4 at the probability level of $p \leq 0.05$.

The mercury level was found (0.2-2.4 mg/dl), which not exceeded the allowable limit[48] in all samples. However, this does not mean that this level is not considered normal in the blood, any level of mercury in the blood, even if it is not high considered to be harmful because exposure to mercury causes serious health problems.[49] High levels of mercury in females in comparisons 1 and 3 may be due to it's presence in cosmeticit'sd skin lightening creams used by women. Mercury can be found in beauty products for the eye surrounding area, such as mascara, and in cosmetic eye cleaning products where they are used as a preservative.[50] The elevated mercury level in blood samples among males in comparisons 2 and 4, may be due to exposure to mercury in the workplace and its presence in the environment due to the burning of coal (in working power plants, industrial boilers and household stoves) in order to obtain energy and heat in addition to its presence in toothpaste, fungicides, and agricultural pesticides. It is also present in the diet of both sexes, like meat and fish meat, and wheat.[49] In addition to imported foods such as canned goods threaten human health because they contain high proportions of heavy metals such as mercury.[41]

The results of the current study recorded higher levels of mercury in the blood samples taken from Baquba than that obtained by[42] in Baghdad in a study on the effect of some heavy metals on thyroid functions, where the level of mercury for

Table 5: Average and standard error of lead levels among male smoking and non-smoking groups for different age groups in the village and city.

Comparisons	*Groups*	*No.S*	*Smoking*	*Living*	*Gender*	*Age.G*	*Pb µg/l Mean ± SE*	*The upper limit of lead in the blood according to WHO*
1	A2	3	No	Village	♂	30≤	49.9343 ± 2.59220	100 µg/l
	A3	3	Yes				53.1431 ± 4.22459	
2	A4	3	No			29≥	51.7337 ± 3.34882	
	A6	3	Yes				51.1343 ± 3.11401	
3	A5	3	No	City		30≤	46.6199 ± 1.91401 A	
	A7	3	Yes				63.1334 ± 8.75840 B	

** Letters with different numbers in comparison fields 1, 2 and 3 vertically mean that there are statistically significant differences p ≤ 0.05*

males and females in the city of Karrada was 2.82 µg/l. While in the city of Al-Jadriya was (2.09 µg/l), but less than that obtained by[47] in the study of biomonitoring of lead, cadmium and mercury in adult blood in New York city, where there was no moral difference between the two genders in that the level of mercury was (26.7 µg/l) in males, while in females was (27.8 µg/l).

Level of Lead among Smoker and Non-smoker Males

In comparisons 1.3, in Table 5, the level of lead in smokers increased, which may be due to the containment of tobacco with a quantity of lead, when smoking, the amount of lead in tobacco is transmitted to cigarette smoke, which leads to elevation of lead level in smokers blood, in this respect[51] have shown that cigarette smoking or secondary exposure to cigarette smoke leads to high blood lead levels.

By comparison 2, lead levels in male smokers and non-smokers were close but rose slightly in non-smokers, possibly due to its high presence in large quantities in the atmosphere, in water and soil through which it was absorbed by plants that are the main source of lead transmission to non-smokers and not professionally exposed. Food is the main source of lead for non-smokers as well as drinking water.[45]

The results of the current study recorded lower levels of lead in the blood of cigarette smokers in Diyala province than that obtained by[52] in his study conducted in Baghdad 20.0 µg/dl (200 µg/l), but in non-smokers was 12.9 µg/dl (129 µg/l).

Level of Cadmium Among Smoker and Non-smoker Males

Table 6 shows cadmium levels in the 1st comparison, the level is lower (32.6722 µg/l) in group A2, which includes non-smoking village males, at age ≤30 than (38.4978 µg/l) in group A3, which includes smoker males in the village for the same age. Also in comparison 2, the cadmium level in the group (A4) non-smokers males at age 29 and younger, in the center of Diyala city (43.2376 µg/l) was less than that (43.2376 µg/l) in a group (A6) male smokers for the same age group in the center of Diyala city, in the same way the comparison 3 between the group A5 male non-smokers of the city age 30 and older, the level (31,897 µg/l) is lower than that of smokers (34.0982 µg/l), for the same age groupbut but there are no moral differences between the male city and the village smokers and non-smokers in the comparison, 1 and 2. However, there were moral differences in the comparison3 between the city smokers and non-smokers at the probability level of p ≤ 0.05.

In all comparisons 1,2.3 cadmium level increased in male smokers in the village and city for different age groups, cause cigarette smoke may contain a quantity of cadmium, where tobacco in all its forms contains noticeable amounts of metal. Because cadmium is absorbed from the lungs much more than the digestive system, smoking contributes significantly to the body pack.[53]

In all comparisons, 1.2.3 the level of cadmium in smoker males in the village and city increased for different age groups due to the containment of tobacco and cigarette smoke with the amount of cadmium, where tobacco in all its forms contains noticeable amounts of the metal. Because cadmium is absorbed from the lungs much greater than from the digestive system, smoking contributes significantly to its rise in the body.[53]

The results of the current study showed lower levels of cadmium than[35] in a study done to estimate the concentration of cadmium level in the blood of the population of Diyala city with an average of cadmium in males 0.0066 mg/dl (66 µg/l). The level of cadmium measured by the present study was also lower than that obtained by[54] in a study to estimate the level of cadmium in the blood among adults who smoke compared to non-smokers in Mosul, where the level in smokers was 0.9967 mg/l (996.7 µg/l) while in non-smokers 0.2673 mg/L (267.3 µg/l).

Level of Mercury in the Blood of Smoker and Non-smoker Males

Table 7 shows in comparison 1, a decrease in the mercury level for (group A2) non-smokers (16.7492 µg/l) compared to its

Table 6: Average and standard error of cadmium levels among smoker and non-smoker males at different age in the village and center of the city

Comparisons	*Groups*	*No.S*	*Smoking*	*Living*	*Gender*	*Age.G*	*Cd µg/l Mean ± SE*	*The upper limit of cadmium in the blood according to WHO*
1	A2	3	No	Village	♂	30≤	32.6722 ± 2.99172	0.3-1.2 µg/l
	A3	3	Yes				38.4978 ± 3.79660	
2	A4	3	No			29≥	37.0308 ± 2.85382	
	A6	3	Yes				43.2376 ± 6.34738	
3	A5	3	No	City		30≤	31.897 ± 1.64617	
	A7	3	Yes				34.0982 ± 2.75840	

Table 7: Average and standard error of mercury component levels among smoker and non-smoker males at different ages in the village and city

Comparisons	*Groups*	*No.S*	*Smoking*	*Living*	*Gender*	*Age.G*	*Hg µg/l Mean ± SE*	*The upper limit of mercury in the blood according to WHO*
1	A2	3	No	Village		30≤	16.7492 ± 0.70631	
	A3	3	Yes				18.3844 ± 0.78768	
	A4	3	No				16.3214 ± 0.68540	
2	A6	3	Yes	City	♂	29≥	15.6592 ± 0.39353 15.6592 ± 0.39353 15.6592 ± 0.39353	2–24 µg/l
3	A5	3	No			30≤	17.7849 ± 0.50458	
	A7	3	Yes				15.3381 ± 0.63733	

level (18.3844) of smokers (group A3). While in comparison 2, the mercury level (16.3214 µg/l) in group A4, non-smoking city males aged 29 and younger, was higher than in group A6 (15.3381 µg/l), which includes male city smokers for the same age group.

In comparison 3; the level of mercury in non-smokers males in the city (group A5) was 15.6592 µg/l in comparison to the highest level (17.7849 µg/l) in smokers (group A7). No moral differences were observed between male city and village smokers and non-smokers in comparison 1.2, but there were moral differences in comparison 3 between the city smokers and non-smokers at the level of ($p \leq 0.05$).

The high mercury level in comparison 1, for male smokers in the village, may be due to cigarette smoke from tobacco containing mercury, but in comparisons 2 and 3, if the mercury level rises in non-smokers males in the city, for the two different age groups, is due to the diet, which is the main source of mercury exposure for non-smokers people who mainly exposed to methyl mercury when they eat mercury-containing fish, and can also be exposed to mercury fumes, or in dental amallomers (filling) and other sources of exposure.[49]

The level of mercury obtained by this study is higher than that obtained[42] in a study conducted in Baghdad, in that the level of mercury in the city of Karrada reached 2.82 µg/l while in Al-Jadriya 2.09 µg/L. The results of the study are consistent with a study conducted[55] to estimate mercury levels in the blood sample taken at that time. There was no moral difference between daily smokers and non-smokers, with the highest level among smokers reaching (5.6 µg/l), while the in non-smokers was (4.3 µg/l).

CONCLUSIONS

Through the study of the three heavy metals level in blood taken from people in Diyala, the following conclusions can be drawn:

- Lead did not exceed the global maximum allowed level (10 µg/dl) according to the (WHO) in all blood samples, with the highest level in male samples (63.1334 µg/l).
- Cadmium exceeded the global maximum allowed level (0.03–0.12 µg/dl) according to the (WHO) in in all samples, with the highest level in male samples) at (43.2376 µg/l).
- mercury did not exceed the global maximum allowed level (0.2–2.4 µg/dl) according to (WHO) in all samples, with the highest level in male samples being (18.3844 µg/l).
- Sex, place, age, and smoking are factors affecting heavy metal levels in the blood.

RECOMMENDATION

Depending on the literature review and from the results of the present study it is recommended to continuously estimation of the level of the three main heavy metals mentioned in this study in the blood of people from time to time in any city in Iraq or anywhere in the world, and find the relation between

the level of these metals and the health problems in the blood of patients admitted to health centers, hospitals, and private or governmental medical clinics.

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