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Evaluation of Heavy Metal Pollution (Lead, Cadmium, Copper) in Some Areas of the Tigris River in Baghdad Governorate

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Abstract

This study was conducted to assess the possible state of contamination in the waters of the Tigris River and the soil of the beaches adjacent to it with some heavy elements as a result of the direct release of sewage water and industrial wastes of all kinds therein without resorting to treating them with modern scientific methods and its impact on increasing the problem of environmental pollution. Three soil and water sampling sites were selected, the first located under Al-Jumhuriya Bridge, the second located under Bab Al-Muadham Bridge, and the third under Al-Ahrar Bridge in the center of Baghdad Governorate, with three replicates for each sample. However, extraction of heavy metal ions (Cd^{2+}, pb^{2+}, Fe^{2+}, Cu^{2+}, Mn^{2+}) was carried out using the chelating agent Diethylene triamine penta acetic acid (DTPA). The models were measured with an atomic absorption device, and the following pollution indices were used: enrichment factor (EF), contamination factor (CF), Index of Geochemical Load (lgeo), and Pollution load index (PLI). That can give a clear and correct assessment of the degree of pollution occurring as a result of various human activities, which has directly contributed to the pollution of the waters of the Tigris River and the surrounding soil. The results showed a significant increase in the values of (EF) for the lead element in the soil adjacent to the Ahrar Bridge, reaching 32.25. While the copper element recorded a slight increase in the percentage of (EF), reaching 4.78 in the same location. However, the (CF) recorded a significant increase in the values for the two elements lead and copper for all sites, with a clear increase in the lead values in the soil adjacent to the Ahrar Bridge, reaching 98.97 and 15.54 for the two elements, respectively. These percentages are considered an extremely dangerous indicator of the presence of a very high state of pollution. The highest value of the (PLI) was shown in the soil adjacent to the Ahrar Bridge, followed by the Bab al-Muadham Bridge soil, then the Jumhouriya Bridge soil. The lgeo index also showed a variation in values from one place to another. The highest value of lead appeared in the soil adjacent to the Ahrar Bridge, reaching 7.00. It is classified as extremely contaminated and dangerous to public health. Moreover, water tests showed the presence of high concentrations of lead, reaching (294.2, 300.7, 292.5) mg/L in the course of the Tigris River under the Al-Jumhuriya Bridge, Bab Al-Muadham and Al-Ahrar, respectively, are naturally considerably higher based on international standards adopted to measure the extent of water contamination by heavy elements. This increase may be attributed to the continuous release of sewage water and factory waste into the river stream without proper treatment.

Keywords: Tigris River water, Heavy elements, Chelating agent DTPA, Enrichment factor EF.

Introduction

Water is the most important economic resource for all the countries of the world and the most in need of sustaining human life on the Earth's surface, which depends almost primarily on water and soil as the basic resources. Therefore, this resource must be invested effectively to achieve the maximum benefit. As a result of the rapid and sustained increase in the world's population as a whole and the accompanying need to expand by establishing major residential and industrial cities with a direct focus on agricultural and industrial development to accommodate this excessive increase in population numbers and the accompanying mismanagement and use of soil and water resources. The acute water shortage and pollution increase have emerged, which caused a real problem in terms of its scarcity and the change in its characteristics for most countries of the world, including Iraq. The quality of water used in irrigation plays an important role in directly affecting the properties of most agricultural soils and thus the growth and productivity of various crops and then affecting consumers such as humans and animals [1,2]. However, [2] and [3] explained that the majority of countries in the world are threatened by water shortages and pollution, especially Third World countries. Developing countries work to throw their waste into the water stream without carrying out any treatment on it, whether physical, chemical, or biological [4,5,6]. The process of releasing sewage waste and liquid industrial facility waste into the course of the Tigris River is a real danger of causing an undesirable change to the components of nature and a direct threat to the chemical and physical properties of water and the various types of life in it. As [7,8,9] explained the most important pollutants of water and soil are industrial waste, city waste, sewage, pesticides, and agricultural waste of various kinds. Water pollution can be defined as the amount of damage or qualitative corruption that occurs to water due to a defect in its ecosystem in one way or another, which reduces the ability of the system to perform its natural role in sustaining the various types of life on Earth [10, 11,12]. Heavy elements are called trace elements because they exist in nature at concentrations of less than 100 mg/kg. They are also called toxic and dangerous elements. They are also termed toxic and dangerous elements and the most acceptable, and more commonly recognized term is heavy metals, as they have a specific density higher than 6 g/cm^3 as [13, 14, 15, 16, 17] mentioned. Pollution of the environment with heavy metals is a problem of the modern era due to the increase in industrial development and urbanization, which poses a real threat to the state of the ecosystem as a whole, especially soil, water, and air, which is directly related to food security and humans [18]. Pollution of soil, water, and air with heavy elements such as lead and cadmium is considered one of the most serious problems in the environment, as they remain in place for long periods without any chemical change occurring to them [19, 20, 21]. The process of throwing city liquid waste and sewage directly into the course of the Tigris River without resorting to treating it in various ways is a serious violation and a real threat to the environment with its various components [9]. Heavy elements are among the oldest toxic substances known to man and history, as man began using lead at the beginning of 2000 BC. Moreover, lead appeared as a by-product of smelting and purification of silver [22,23,24,25]. The average concentration of lead in nature is about 16 g/kg in the earth's crust and has a large ionic radius. It is a heavy element with a bluish-gray color. Furthermore, it has a low melting point and a high Malleability. This is the main reason for its use in various industries and the formation of alloys from it over the past thousands of years, which gives it the property of merging with the rest of the elements and has the characteristic of accumulation in living bodies [15, 26, 21]. As for the element cadmium, it was discovered at the beginning of the eighteenth century in 1817 as one of the elements found in nature by the German scientist Friedrich Strohmer in the German city of Goettingen within the impurities of zinc carbonate, but it was not used in any industry at that time until the end of the nineteenth century. Germany remained the only producer country this element for nearly 100 years. Its Greek name is Calamine and the Latin name is Cadmia, and its poisoning was not classified as an occupational disease for people working in industry until after the middle of the twentieth century. It is toxic and very dangerous to life of all kinds, it entered human life after the development of the Industrial Revolution in the world as a whole. It carries more harm than benefits, as it is a transitional metal element and it is within the twelfth group in the periodic table of chemical elements. It is an unwanted and unnecessary element for plant, animal, and human life, it is a dangerous pollutant that enters the organism's body through the food chain and accumulates in vital tissues, causing serious functional dysfunction, which causes various types of cancer [22,27,28,29].

Pollution indices

- Enrichment factor EF means the ratio of the abundance of the contaminated element in the studied sample to its clear percentage in the comparison sample. This factor is used as a basic standard in evaluating the levels of soil contamination with heavy elements and determines whether their inputs are natural or human-made. It is considered one of the easy and simple ways to measure the extent of Pollution in various sites [30].
- Contamination factor CF. This factor is used to express the extent of soil contamination with the element and is calculated according to the method of [31] modified in 1979.
- Pollution Load Index (PLI). This index is often used to estimate the extent of potential pollution by creating a special index called the Pollution Load Index developed by [32].
- Index of Geochemical Load (Igeo) By applying this indicator, it is possible to calculate the percentages of the pollutant element for seven enrichment categories from (0-6) according to the method of [31], who developed an equation for the calculation known by his name, and it is generally used to indicate the extent of the human factor's contribution to Pollution in the environment [33].

Characteristics of polluted water

It is rare to note the presence of water completely free of pollutants. Therefore, specialists and scientists have established and developed specialized research centers in water and soil pollution. They have developed internationally applied standards to determine the extent of pollution, which has been increasing in recent decades with the development taking place in the industrial, agricultural, and commercial sectors, which had a direct impact on the extent of the deterioration in the quality of water and its unsuitability for various human uses, and the threat it poses to all kinds of organisms and fish resources, and thus to providing and protecting food security and the economy of countries.

Table (1) represents some of the international standards that have been developed in this field and that can be adapted to determine the extent of pollution occurring, taking into account the overall environmental conditions surrounding the system and the characteristics of the soil in different regions to determine the appropriate standard for it.

Table (1) Some approved international standards for the total concentrations of some heavy elements in the soil ($mg.kg^{-1}$)

Elements	A	B	C	D
Cd^{2+}	3	1	5	20
Pb^{2+}	300	50	150	600
Cu^{2+}	200	50	100	500

Since: -

A: represents the upper limit for the internationally permissible concentration of the element in agricultural soil at pH>7 according to the Scottish Standard (SEPA, 2001).

B: represents the upper limit of the contaminant element concentration allowed to be present in the soil, at which it is considered not contaminated with that element.

C: represents in this that the concentration of the element becomes a negative influence on the life of living organisms as a whole, including humans.

D: represents in these concentrations of the element that the soil is considered contaminated with the element and needs to be rehabilitated to reconstruct it according to the Dutch standard [34].

Research materials and methods

Water and soil samples were collected from areas adjacent to and near the Tigris River in the capital, Baghdad, for the period from 20/10/2023 to 30/12/2023, and are planned for study in three locations: the first is located under Al-Jumhuriya Bridge, the second is under Bab Al-Muadham Bridge, and the third is under Al-Ahrar Bridge, at a depth of 0- 30 cm, by three replicates per sample.

After obtaining the soil samples, they were air-dried and placed in plastic bags, and the information was written on them in an accurate and detailed manner. As for the water samples, they were collected in plastic bottles with a capacity of 1 liter, washed with diluted HCL acid to store them correctly, in 3 replicates per sample, and sent to the specialized laboratories to conduct the required physical and chemical analyses on them.

- **Physical analyses**

- Particle size distribution

The relative distribution of different soil separates was estimated using the hydrometer method mentioned in [35].

- **Chemical analysis**

- Soil reaction number (pH) and electrical conductivity (EC)

It was estimated in the soil extract (1:1) using a pH meter and EC-meter according to method [36].

- Cation exchange capacity (CEC)

It was estimated using the Simplified Methylene Blue Method, according to [37].

- Organic matter OM

It was estimated by wet oxidation according to the Walkley and Black method mentioned in [38].

- Calcium carbonate $CaCO_3$

It was estimated with a Calciometer device using 3N HCl acid according to the method [39].

- **Determination of negative and positive dissolved ions**

- Soluble Ca^{+2} and Mg^{+2}

It was determined using an atomic spectrometer according to [40].

- Soluble sodium and potassium, Na^{+} and K^{+}

It was determined using a flame photometer according to [41].

- Carbonate and Bicarbonate

It was determined by titration with dilute sulfuric acid (0.01 N) according to the method of [41].

- Soluble Cl^{-}

It was determined volumetrically by titration with silver nitrate (0.01N) using the potassium chromate index according to the method of [41].

- Soluble SO_4^{-2}

It was determined by Turbidity using barium chloride and measured with a spectrophotometer according to what was mentioned in [35].

- Determination of element ions (Fe) and heavy metals in water and soil

Minor element ions (Fe^{2+}, Mn^{2+}, Cu^{2+}) and heavy element ions (Pb^{2+}, Cd^{2+}) were extracted from soil and water using the chelating compound (DTPA) (diethylene triamine penta acetic acid) according to [42] and measured with an atomic absorption spectrometer

- **Calculating environmental pollution indicators: -**

The enrichment factor is calculated by applying the following equation:

$$EF = \frac{(\frac{Cm}{Fe})Sample}{(\frac{Cm}{Fe})background}$$

Since: -

Cm = concentration of the element to be entered in the application of the equation in $mg.kg^{-1}$.

Background = the element concentration in the reference sample in $mg.kg^{-1}$ [30].

- **The CF factor is calculated by applying the following equation:**

$$CF = \frac{Cm\ Sample}{Cm\ background}$$

CF= Cm Sample
Cm background
[37]

- **Pollution Load Index (PLI). This index is calculated by applying the following equation: -**

$$PLI = (CF1 \times CF2 \times CF3 \times ------------ \times CFn)1/n$$

[32]

- (**Igeo) factor is calculated through the following equation: -**

$$Igeo = Igeo\ \frac{cm\ Sample}{1.5 \times cm\ Background}$$ [31]

The number 1.5 represents a factor used to reduce the percentage of possible variations in the background values, which may be somewhat affected by the original geological materials that generate the soil.

Results and discussion

- Chemical and physical properties of the studied soils

The results in Tables 2, 3, and 4 show some of the chemical and physical characteristics of the soils subject to study for the three sites. The concentrations of element ions were within internationally permissible limits in the soils adjacent to the shores of the Tigris River under the Al-Jumhuriya Bridge. While these concentrations increased slightly in the soils adjacent to the Al-Ahrar Bridge at the time that the concentrations of some element ions, such as lead, exceeded the internationally permissible limits in the soil adjacent to the Bab al-Muadham Bridge, as the concentration of lead ions reached 339.84 $mg.kg^{-1}$. This increase in the ion concentration of this element in the soil is due to the river water containing high quantities of it, which affected the increase in its concentration in the soil as a result of throwing all kinds of waste on the banks of the river. As well as the drainage of wastewater pipes resulting from various civil activities into the riverbed. It should also be noted here that the difference in the concentrations of element ions in the river water, whether increasing or decreasing during the different seasons of the year with the rise and fall of water levels in it and the speed of its flow, which affects the processes of washing and sedimentation during the different seasons.

Table (2) Chemical and physical properties of the soil model adjacent to Al-Jumhuriya Bridge in central Baghdad

Characteristic	Units	Results	
EC	dSm^{-1}	4.34	
pH		7.80	
SAR	Meq/L	1.71	
CEC	$Cmol.kg^{-1}$	17.98	
Organic matter	Meq/L	30.0	
Carbonate minerals	Meq/L	365.50	
Soluble calcium	Meq/L	14.71	
Soluble magnesium	Meq/L	18.63	
Soluble sodium	Meq/L	6.98	
Soluble potassium	Meq/L	3.01	
Soluble bicarbonate	Meq/L	3.49	
Soluble chlorine	Meq/L	31.16	
Soluble sulfates	Meq/L	7.18	
Soluble carbonate	Meq/L	Nil	
Lead	$Mg.kg^{-1}$	248	
Cadmium	$Mg.kg^{-1}$	Nil	
Copper	$Mg.kg^{-1}$	68.87	
Manganese	$Mg.kg^{-1}$	584.38	
Iron	Mg.kg	546.36	
Textue	**$g.kg^{-1}$**		
	Clay	**silt**	**Sand**
Sandy loam	120	230	650

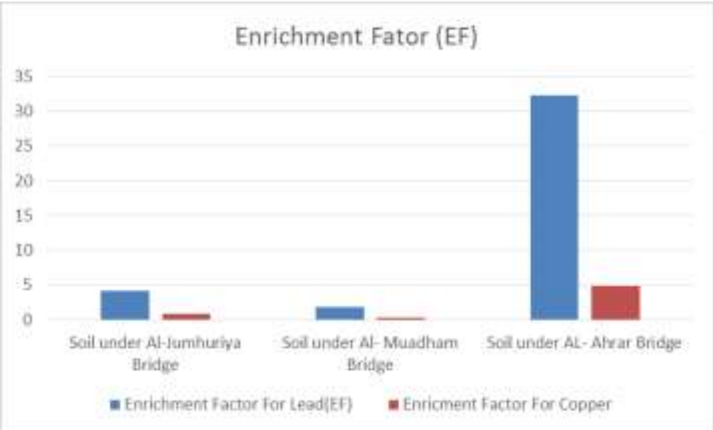
Table (3) Chemical and physical properties of the soil sample adjacent to Bab al-Muadham Bridge in central Baghdad

Characteristic	Units	Results	
EC	dSm^{-1}	3.99	
pH		7.68	
SAR	Meq/L	1.23	
CEC	$Cmol.kg^{-1}$	16.77	
Organic matter	Meq/L	51.0	
Carbonate minerals	Meq/L	283.0	
Soluble calcium	Meq/L	18.80	
Soluble magnesium	Meq/L	13.00	
Soluble sodium	Meq/L	4.91	
Soluble potassium	Meq/L	3.12	
Soluble bicarbonate	Meq/L	13.73	
Soluble chlorine	Meq/L	22.10	
Soluble sulfates	Meq/L	3.87	
Soluble carbonate	Meq/L	Nil	
Lead	$Mg.kg^{-1}$	279.18	
Cadmium	$Mg.kg^{-1}$	Nil	
Copper	$Mg.kg^{-1}$	74.21	
Manganese	$Mg.kg^{-1}$	718.35	
Iron	$Mg.kg^{-1}$	2579.87	
Textue	**$g.kg^{-1}$**		
	Clay	**silt**	**Sand**
Sandy loam	119	295	586

Table (4) Chemical and physical properties of the soil sample adjacent to the Ahrar Bridge in central Baghdad

Characteristic	Units	Results
EC	dSm^{-1}	3.31
pH		7.68
SAR	Meq/L	1.35
CEC	$Cmol.kg^{-1}$	14.36
Organic matter	Meq/L	27.0
Carbonate minerals	Meq/L	237.60
Soluble calcium	Meq/L	16.86
Soluble magnesium	Meq/L	9.33
Soluble sodium	Meq/L	4.90
Soluble potassium	Meq/L	2.01
Soluble bicarbonate	Meq/L	3.13
Soluble chlorine	Meq/L	23.74
Soluble sulfates	Meq/L	6.23
Soluble carbonate	Meq/L	Nil
Lead	$Mg.kg^{-1}$	339.84
Cadmium	$Mg.kg^{-1}$	Nil
Copper	$Mg.kg^{-1}$	127.36
Manganese	$Mg.kg^{-1}$	189.31
Iron	$Mg.kg^{-}$	691.35
Textue	**$g.kg^{-1}$**	
	Clay / **silt** / **Sand**	
Sandy loam	150 / 303	586

- **Enrichment Factor (EF) for the soil on the banks of the Tigris River in Baghdad for the studied sites.**
The results of Figure 1 showed a significant increase in the EF for lead in the soil of the beaches adjacent to the Ahrar Bridge, reaching 32.25, which is considered a dangerous percentage for the environment in general and life of all kinds in particular, according to the adoption of international standards 20 < EF < 40 Very high enrichment. Lead is considered one of the most dangerous elements because it can accumulate in living bodies for long periods without decomposing and does not cause any change chemically. The reason for the increase in the EF for the lead element in the soil of this study area may also be attributed to its proximity to Al-Mutanabbi Street, which contains printing presses that use inks extensively in their daily routine work and then throw their waste directly into the river water without treating it. As the lead element enters directly into the manufacture of printing inks, in addition to the river water that originally contains this element from other sources as it passes through the different regions. Table 5 shows the comparison to the rest of the soil samples of the study, in which the EF percentage reached moderate values. The results in the figure also indicated the convergence in the values of the EF for the copper element in the soil adjacent to the Al-Jumhuriya Bridge and the Bab al-Muadham Bridge, which amounted to 0.88 and 0.23, respectively. It represents less than the first standard level for global measurements of pollution limits for this element, which amounts to EF < 2. The soil adjacent to Al-Ahrar Bridge recorded a slight increase in the percentage of this factor, reaching 4.78, which is considered a moderate percentage according to international standards adopted in determining the percentage of pollution in soil.

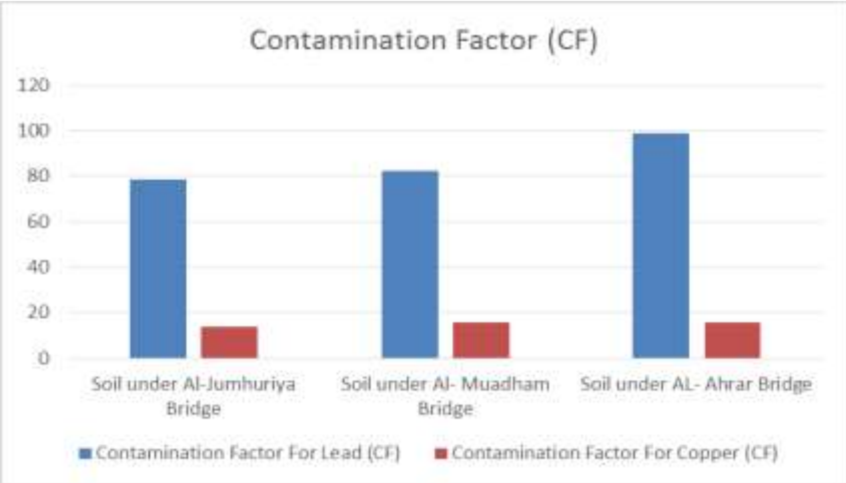


Soils adjacent to Al-Ahrar Bridge	Soils adjacent to Bab al-Muadham Bridge	Soils adjacent to the Al-Jumhuriya Bridge	
32.2 5	**1.85**	**4.12**	**EF for lead**
4.78	**0.23**	**0.88**	**EF for copper**

Figure (1) EF for lead and copper in the soil of the Tigris River shores (under Al-Jumhuriya Bridge, Bab Al-Muadham Bridge, and Al-Ahrar Bridge)

- **Contamination Factor (CF) for the soil on the banks of the Tigris River in Baghdad for the studied sites**

The results of Figure 2 indicated a significant increase in the CF values for lead for the soil adjacent to the Al-Jumhuriya Bridge, Bab al-Muadham Bridge, and the Ahrar Bridge, reaching (78.51, 82.17, and 98.67), respectively. These percentages are considered an extremely dangerous indicator of the presence of very high lead contamination in the three studied sites. They are within extremely dangerous levels for all forms of life, and they are considered a definite result of the progress of civilization that has relied on the introduction of lead into most of its industrial cycles, starting from manufacturing water pipes to paints and pesticides. This is in addition to its involvement in the industry of installing printing letters on signs, the manufacture of glassware, pottery and all its details, batteries, electricity cables, military industries, and cosmetics such as hair dye and eyeliner...etc. This element is also the basis of automobile fuel, and the reason for the increase in these areas lead may have resulted from throwing industrial waste, and sewage into them. The results in the figure above also indicate a significant increase in the CF values for copper for the three studied sites, which reached (13.58, 15.77, and 15.54) in each of the soils adjacent to the Al-Jumhuriya Bridge, Bab al-Muadham Bridge, and the Ahrar Bridge, respectively. These are very high values that may be due to the throwing of copper waste used in the gold industry by goldsmiths into the riverbed and the soil near them because the areas close to it are famous for the manufacture and trade of gold in Baghdad, and according to global international standards, these values indicate the presence of a very large case of contamination with the element copper [43].

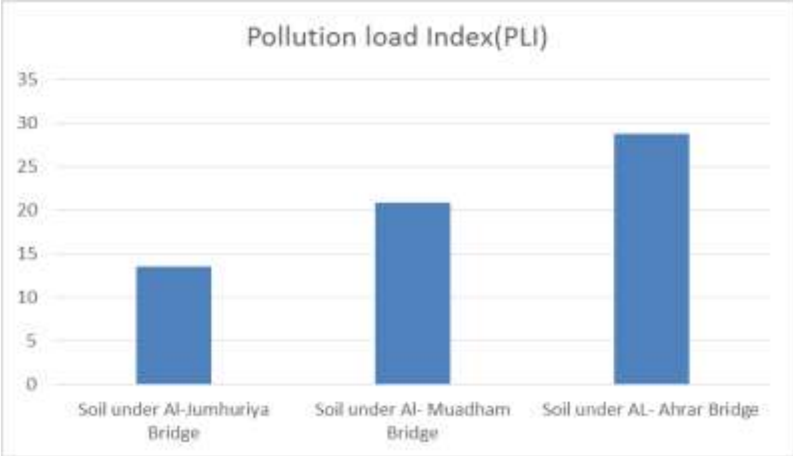


Soils adjacent to Al-Ahrar Bridge	Soils adjacent to Bab al-Muadham Bridge	Soils adjacent to the Al-Jumhuriya Bridge	
98.67	82.17	78.51	EF for lead
15.54	15.77	13.58	EF for copper

Figure (2) CF for lead and copper in the soil of the Tigris River shores (under Al-Jumhuriya Bridge, Bab Al-Muadham Bridge, and Al-Ahrar Bridge)

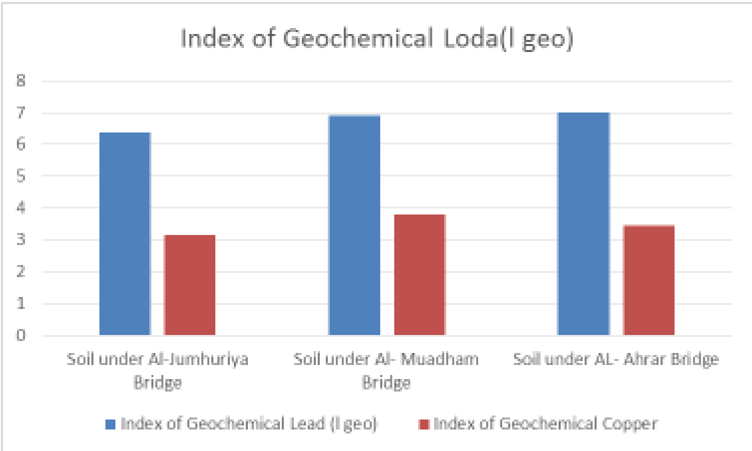
- **The pollution load index PLI**

is considered a standard that expresses the total amount of soil pollution with the heavy elements it contains. The results in Figure 3 indicated the presence of a high level of pollution, as the lowest value of this index was 13.57 in the soil adjacent to the Al-Jumhuriya Bridge. Its highest value was recorded in the soil adjacent to Al-Ahrar Bridge, reaching 28.81, and recorded a value of 20.87 in the soil adjacent to Bab Al-Muadham Bridge. All values are considered very high due to the presence of various sources of pollution resulting from various civil activities in Bab Al-Muadham and the waste of the Medical City Hospital, Al-Mutanabbi Street, and the printing presses. In addition to this, waste and industrial waste on the banks of rivers due to the absence of a sanitary control role.



Soils adjacent to Al-Ahrar Bridge	Soils adjacent to Bab al-Muadham Bridge	Soils adjacent to the Al-Jumhuriya Bridge	
28.81	20.87	13.57	PLI

Figure (3) PLI for lead and copper in the soil of the Tigris River shores (under Al-Jumhuriya Bridge, Bab Al-Muadham Bridge, and Al-Ahrar Bridge)



oils adjacent to Al-Ahrar Bridge	Soils adjacent to Bab al-Muadham Bridge	Soils adjacent to the Al-Jumhuriya Bridge	
7.00	6.89	6.37	Igeo for lead
3.44	3.78	3.15	Igeo for copper

Figure (4) Igeo for lead and copper in the soil of the Tigris River shores (under Al-Jumhuriya Bridge, Bab Al-Muadham Bridge, and Al-Ahrar Bridge)

- **Index of Geochemical Load (Igeo) for soils on the banks of the Tigris River in Baghdad for the studied sites**

The results in Figure 4 indicate the values of Igeo for the element lead in the soils of the three study areas, as its lowest value reached 6.37 in the soils adjacent to the Al-Jumhuriya Bridge and the highest value reached 7.00 in the soils adjacent to the Al-Ahrar Bridge, while the value was recorded at 6.89 in the soils adjacent to the Bab Al-Muadham Bridge. According to international standards, these values are very high and very polluting, which explains how dangerous they are to human life. The results in the figure also showed that the values of Igeo for the element copper reached 3.15 in the first site of the study, represented by the soil adjacent to the Al-Jumhuriya Bridge, and reached 3.78 in the second site of the study, represented in the soil adjacent to the Bab al-Muadham Bridge, while it reached 3.44 in the third site, represented by the soil adjacent to the Al-Ahrar Bridge, which is, of course, considered soil heavily contaminated with copper, as this evidence was based on what was mentioned by [31].

- **Ionic composition of water in the Tigris River for study sites**

The results in Tables 5, 6, and 7 showed the content of positive and negative ions in the soils under study, which appeared relatively high in the soils adjacent to the Bab al-Muadham Bridge compared to the rest of the sites. Then, a reduction in these concentrations occurred due to the continuous flow of river water. A convergence of the values of ion concentrations was recorded in each of the soils adjacent to the Bab Al-Muadham and Al-Ahrar Bridge. The concentrations of calcium ions reached (5.12, 8.13, 4.96) Meq/L, magnesium ions (3.73, 4.63, 4.37) Meq/L, sodium ions (2.19, 3.87, 2.19) Meq/L, and potassium ions (0.60, 0.59, 0.36) Meq/L. As for the concentrations of chlorine ions, they reached (8.91, 12.70, 8.33) Meq/L and bicarbonate reached (1.01, 1.36, 0.93) Meq/L. Whereas, for sulfates, they reached (1.74, 3.07, 2.32) Meq/L in each of the soils adjacent to the Al-Jumhuriya Bridge, Bab Al-Muadham Bridge, and Al-Ahrar Bridge, respectively.

Table (5) Chemical characteristics of the water of the Tigris River (under Al-Jumhuriya Bridge) on 10/10/2023

Characteristic	Units	Results
EC	dSm^{-1}	1.16
pH		7.32
Soluble calcium	Meq/L	5.12
Soluble magnesium	Meq/L	3.73
Soluble sodium	Meq/L	2.19
Soluble potassium	Meq/L	0.60
Soluble chlorine	Meq/L	8.91
Bicarbonate	Meq/L	1.01
Sulfates	Meq/L	1.74

Table (6) Chemical characteristics of the water of the Tigris River (under Bab Al-Muadham Bridge) on 10/10/2023

Characteristic	Units	Results
EC	dSm^{-1}	1.71
pH		7.21
Soluble calcium	Meq/L	8.13
Soluble magnesium	Meq/L	4.63
Soluble sodium	Meq/L	3.78
Soluble potassium	Meq/L	0.59
Soluble chlorine	Meq/L	12.70
Bicarbonate	Meq/L	1.36
Sulfates	Meq/L	3.07

Table (7) Chemical characteristics of the water of the Tigris River (under Al-Ahrar Bridge) on 10/10/2023

Characteristic	Units	Results
EC	dSm^{-1}	1.16
pH		7.28
Soluble calcium	Meq/L	4.96
Soluble magnesium	Meq/L	4.37
Soluble sodium	Meq/L	1.89
Soluble potassium	Meq/L	0.36
Soluble chlorine	Meq/L	8.33
Bicarbonate	Meq/L	0.93
Sulfates	Meq/L	2.32

- **Concentration of heavy metals in the water of the Tigris River at the study sites**

The results of Tables 8, 9, and 10 indicate the values of lead ion concentrations, which amounted to (294.2, 300.7, and 292.5) $mg.L^{-1}$ in the studied water samples obtained from the site of the Tigris River under the Al-Jumhuriya Bridge and Bab Al-Muadham and Al-Ahrar, respectively, it is considered very high based on the international standards adopted to measure the extent of water pollution with heavy metals shown in Table 11, which reflects the extent of their danger to the environment in general and on the various types life in particular. This increase in lead concentrations may be attributed to the continuous release of sewage and factory waste into the riverbed, as lead constitutes a large percentage of sewage waste and is used in many industries. It is also considered an essential element used in manufacturing and preparing automobile fuel and is therefore excreted with fumes and exhausts from automobile engines. Furthermore, falling rain washes this element from the atmosphere into the riverbed, as well as the waste of the Medical City Hospital and printing presses on Al-Mutanabbi Street, while the concentrations of the ions of the remaining elements recorded low values, relatively close and far from the level of toxicity, as the ions of the copper element recorded values that reached (0.50, 0.56,0.53) $mg.L^{-1}$, manganese ions (0.06, 0.09, 0.04) $mg.L^{-1}$, iron ions (0.17, 0.16, 0.18) $mg.L^{-1}$, and Cadmium ions (0.005, 0.007, 0.005) $mg.L^{-1}$ in the water of the Tigris River under Al-Jumhuriya Bridge, Bab Al-Muadham and Al-Ahrar, respectively.

Table (8) Concentrations of ions of micro and heavy elements for water samples of the Tigris River under Al-Jumhuriya Bridge on 12/10/2023

Element	Concentration specified in $mg.L^{-1}$
Fe^{2+}	0.17
Cu^{2+}	0.50
Mn^{2+}	0.06
Pb^{2+}	294.2
Cd^{2+}	0.005

Table (9) Concentrations of ions of micro and heavy elements for water samples of the Tigris River under Bab Al-Muadham Bridge on 12/10/2023

Element	Concentration specified in $mg.L^{-1}$
Fe^{2+}	0.16
Cu^{2+}	0.56
Mn^{2+}	0.09

Pb^{2+}	300.7
Cd^{2+}	0.007

Table (10) Concentrations of ions of micro and heavy elements for water samples of the Tigris River under Al-Ahrar Bridge on 12/10/2023

Element	Concentration specified in $mg.L^{-1}$
Fe^{2+}	0.18
Cu^{2+}	0.53
Mn^{2+}	0.04
Pb^{2+}	292.5
Cd^{2+}	0.005

Table (11) Iraqi specifications and standards No. (417) in 2000 for disposing of waste into river water issued by the Standardization and Quality Control Authority

Element	Maximum water content in $mg.L^{-1}$	Wastewater Content
Iron	0.3	1
Lead	0.05	0.3
Copper	1	0.2
Cadmium	0.01	0.5

Conclusions

The existence of a noticeable discrepancy in the values of environmental pollution standards, which are naturally high in all soils, and their highest value was recorded in the soils adjacent to Al-Ahrar Bridge, which indicates an increase in the problem of pollution in the region as a result of the various sources associated with various civil activities. This indicates that insufficient attention has been paid to preserving the environment from possible pollution and the lack of control in the application of international standards for the permissible percentages of heavy elements in soil and water.

Recommendations

- It is necessary to pay serious attention to the environmental aspect and preserve the environment from pollutants resulting from various civil activities by requiring all industrial facilities to submit to laws in applying international standards and environmental requirements and evaluating and monitoring industrial sites to reduce the negative repercussions of these facilities in the health, environmental and economic aspects.
- Periodically control over liquid wastes resulting from the activities of industrial facilities and not allowing them to be thrown into rivers and adjacent lands without being treated according to the international standards permitted for those wastes.

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