Agriculture College – Wasit University

Dijlah Journal of Agricultural Sciences

ISSN 2790 – 5985
eISSN 2790 – 5993

Dijlah J. Agric. Sci.، 5(1):34-51, 2026

Assessment of soil pollution in Wasit Governorate by brick factories in Al-Hay District

Zainab Saad Ahmed[1] **Mahdi wasmi Saheeb[2]**

University of Wasit - College of Agricultural Engineering Sciences - Department of Soil Sciences and Water Resources

Corresponding author:

Abstract:

This study aimed to evaluate the extent of soil pollution with selected heavy metals lead (Pb), cadmium (Cd), cobalt (Co), chromium (Cr), and nickel (Ni) and to assess the impact of gases and volatile emissions from brick factories in Al-Hay District, Wasit Governorate. Soil pollution was quantified using the Contamination Factor (CF) and the Degree of Contamination (Cdeg), while measured concentrations were compared to international standards (WHO, 2007), which classify soils as polluted when Pb, Cr, Cd, Co, and Ni exceed 100, 200, 3, 10, and 50 mg kg^{-1} soil, respectively four sampling sites were established at distances of 500, 1000, 1500, and 2000 m from the pollution source, with an additional reference site at 3000 m. Soil samples were collected from two depths (0–30 cm and 30–60 cm) in both southeastern and northwestern directions. The data were analyzed statistically using analysis of variance (ANOVA), followed by Least Significant Difference (LSD) tests to identify significant differences between sites and depths.Results indicated that soils in the southeastern direction, particularly at 500 m and the surface layer (0–30 cm), recorded the highest concentrations of all studied heavy metals. Concentrations at the first depth consistently exceeded those in the deeper layer (30–60 cm), reflecting accumulation of airborne pollutants in the topsoil. The CF values for Pb, Cd, Co, Cr, and Ni at the southeastern site (500 m, 0–30 cm) were 8.66, 10.55, 14.40, 21.22, and 11.90, respectively, indicating very high pollution, while the northwestern sites exhibited significantly lower CF values. Similarly, the Cdeg values reached 66.73 and 60.37 at the two depths of the southeastern site, confirming a very high degree of contamination These findings demonstrate that brick factory emissions have a substantial spatial impact on soil quality, with the southeastern downwind direction being the most affected. The study highlights the importance of monitoring industrial emissions, providing critical insights for environmental management and soil protection in regions affected by brick manufacturing.

Keywords: *Soil pollution; Heavy metals (Lead, Cadmium, Cobalt, Chromium, Nickel); Brick factories; Pollution Factor (CF); Contamination Degree (Cdeg).*

Received:1/11/2025 **Accepted:14/12/2025** **Published:11/1/2026**

تقييم تلوث التربة في محافظة واسط بفعل معامل الطابوق في قضاء الحي

زينب سعد أحمد[1] مهدي وسمي صاحب[2]

جامعة واسط – كلية علوم الهندسة الزراعية – قسم علوم التربة وموارد المياه

الخلاصة

هدفت هذه الدراسة إلى تقييم مدى تلوّث التربة ببعض المعادن الثقيلة المختارة، وهي الرصاص (Pb) والكادميوم (Cd) والكوبالت (Co) والكروم (Cr) والنيكل(Ni) ، فضلاً عن تقييم تأثير الغازات والانبعاثات المتطايرة الصادرة من معامل الطابوق في قضاء الحي بمحافظة واسط. تم تحديد تلوّث التربة باستخدام عامل التلوّث (CF) ودرجة التلوّث(Cdeg) ، كما تمت مقارنة التراكيز المقاسة بالمعايير الدولية (منظمة الصحة العالمية، 2007)، والتي تُصنّف التربة على أنها ملوَّثة عند تجاوز تراكيز الرصاص والكروم والكادميوم والكوبالت والنيكل قيم 100 و200 و3 و10 و50 ملغم كغم$^{-1}$ تربة على التوالي. أُنشئت أربعة مواقع لأخذ العينات على مسافات 500 و1000 و1500 و2000 م من مصدر التلوّث، مع موقع مرجعي إضافي على بعد 3000 م. جُمعت عينات التربة من عمقين (0–30 سم و30–60 سم) وفي اتجاهين هما الجنوبي الشرقي والشمالي الغربي. جرى تحليل البيانات إحصائياً باستخدام تحليل التباين(ANOVA) ، تلاه اختبار أقل فرق معنوي (LSD) لتحديد الفروق المعنوية بين المواقع والأعماق.

أشارت النتائج إلى أن الترب الواقعة في الاتجاه الجنوبي الشرقي، ولا سيما على مسافة 500 م وفي الطبقة السطحية (0–30 سم)، سجلت أعلى التراكيز لجميع المعادن الثقيلة المدروسة. كما تفوقت التراكيز في العمق الأول باستمرار على تلك المسجلة في العمق الأعمق (30–60 سم)، مما يعكس تراكم الملوّثات المحمولة جواً في التربة السطحية. بلغت قيم عامل التلوّث (CF)للرصاص والكادميوم والكوبالت والكروم والنيكل في الموقع الجنوبي الشرقي (500 م، 0–30 سم) 8.66 و10.55 و14.40 و21.22 و11.90 على التوالي، مما يشير إلى تلوّث عالٍ جداً، في حين أظهرت المواقع في الاتجاه الشمالي الغربي قيماً أقل بكثير لعامل التلوّث. وبالمثل، بلغت قيم درجة التلوّث 66.73 (Cdeg) و60.37 عند العمقين في الموقع الجنوبي الشرقي، مؤكدةً درجة تلوّث عالية جداً. تُبيّن هذه النتائج أن انبعاثات معامل الطابوق تُحدث تأثيراً مكانياً كبيراً في نوعية التربة، وأن الاتجاه الجنوبي الشرقي الواقع مع اتجاه الرياح هو الأكثر تأثراً. وتسلّط الدراسة الضوء على أهمية مراقبة الانبعاثات الصناعية، وتوفّر رؤى مهمة لإدارة البيئة وحماية التربة في المناطق المتأثرة بصناعة الطابوق.

الكلمات المفتاحية :تلوّث التربة؛ المعادن الثقيلة (الرصاص، الكادميوم، الكوبالت، الكروم، النيكل)؛ معامل الطابوق؛ عامل التلوّث(CF) ؛ درجة التلوّث.(Cdeg)

1. Introduction:

The world is currently facing serious environmental problems resulting from human impacts on the surrounding environment. The severity of these problems has increased over the past decades due to the industrial development witnessed globally, population explosion, and natural factors such as volcanic eruptions, earthquakes, and floods, in addition to other cosmic phenomena and human-induced activities such as wars, nuclear explosions, accidents involving the sinking of large fuel-carrying tankers, oil-refining companies, and brick manufacturing plants (Al-Umar, 2009).
The tremendous development and industrial revolution that the world has experienced have caused substantial damage by introducing some of the most dangerous pollutants into the environment. Their risk increases when they persist in the soil or undergo chemical transformations, eventually contaminating plants, fruits, and vegetables consumed by humans, which in turn negatively affects human health (Zaalan et al., 2006).Environmental pollution by heavy metals is a specific type of pollution that occurs as a result of the accumulation of heavy elements such as lead (Pb), cadmium (Cd), mercury (Hg), nickel (Ni), and chromium (Cr) in various environmental components—including soil, water, and plants—at levels exceeding the environment's natural capacity for processing or eliminating them (Abbas et al., 2023). Sources of heavy metal pollution originate from industrial and agricultural activities, including brick factories, metallurgical industries, power plants, and the use of fertilizers and pesticides containing heavy metals. This pollution leads to the deterioration of soil fertility, contamination of surface and groundwater, and negative impacts on plant growth and agricultural productivity, making its monitoring and assessment an

environmental and public health necessity (Hamid et al., 2022).Brick factories are considered one of the major traditional industrial sources that significantly contribute to environmental pollution, especially in developing countries that rely on coal and firewood as primary energy sources for firing operations. These operations release large quantities of polluted gases and particulate matter, including fine particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen oxides (NO_x), sulfur dioxide (SO_2), as well as heavy metals such as lead (Pb), cadmium (Cd), nickel (Ni), and chromium (Cr) (Maqsood et al., 2022).Environmental pollution by heavy metals has received considerable attention from specialists, especially after noticing the significant degradation of environmental resources such as soil, water, and air. This degradation has led to an increase in environmental diseases, particularly among humans, due to the emissions released from brick factories that cause substantial environmental contamination. The brick production process passes through several stages, beginning with the preparation of raw materials (clay and other mineral components), followed by shaping the bricks using manual or mechanical molds. This is then followed by a drying stage to remove moisture, and finally firing in kilns using high-intensity fuels such as coal or diesel. During the firing stage, gases and fine particulate matter are emitted, in addition to the release of heavy metals such as lead (Pb), cadmium (Cd), nickel (Ni), and chromium (Cr). The waste generated from these operations, including dust and ash, also contains high concentrations of heavy metals, which may be directly disposed of onto the soil or transported by runoff into nearby water sources, thereby increasing the risk of environmental contamination (Khan et al., 2015).

Achakzai et al. (2017) indicated that the amount and magnitude of pollution released from brick factories vary depending on several key factors, including:The size of the factory. The age of the factory. The maintenance system. The production capacity. The presence of effective pollution-control technologies.Most pollutants consist of smoke in which carbon particles form a major component, in addition to carbon oxides, nitrogen oxides, sulfur oxides, unburned hydrocarbons, and fluorine gas released from fluoride salts naturally present in the clay used as a raw material. Moreover, most of these factories do not adhere to operating mechanical firing systems and rely on traditional methods, leading to incomplete fuel combustion and increased environmental pollution. Based on the above, the importance of the current study in Al-Hay City emerges through its use of an integrated methodology that combines chemical analysis of soil with internationally recognized pollution assessment tools to achieve the following objectives:Determining the impact of emissions from brick factories in Al-Hay District on the accumulation of heavy metals (Cr, Co, Pb, Cd, Ni) in the soil, water, and plants of areas surrounding the factories at different distances.Evaluating the level of contamination of soil, water, and plants with heavy metals (Cr, Co, Pb, Cd, Ni) resulting from brick factory emissions in two different directions and comparing them with global standards.Using selected pollution indices to assess the state of soil degradation affected by the brick factories.

2. Materials and Methods

2.1. Study area

The study area from which the samples were collected is located in the Al-Hay District, south of Wasit Governorate. Al-Hay City is situated at the coordinates 32.1712° N and 46.0475° E. The district lies approximately 45 kilometers south of Al-Kut, the provincial capital. The area is characterized by diverse industrial and agricultural activities, with brick production considered one of the most important industrial activities in the region.The area contains numerous brick factories, with an estimated total of about 15 factories. It is surrounded by abandoned lands and agricultural fields. The study area was divided into two parts: the southeast and the northwest, as illustrated in Figures (1) and (2), and according to the coordinates listed in Table (1).

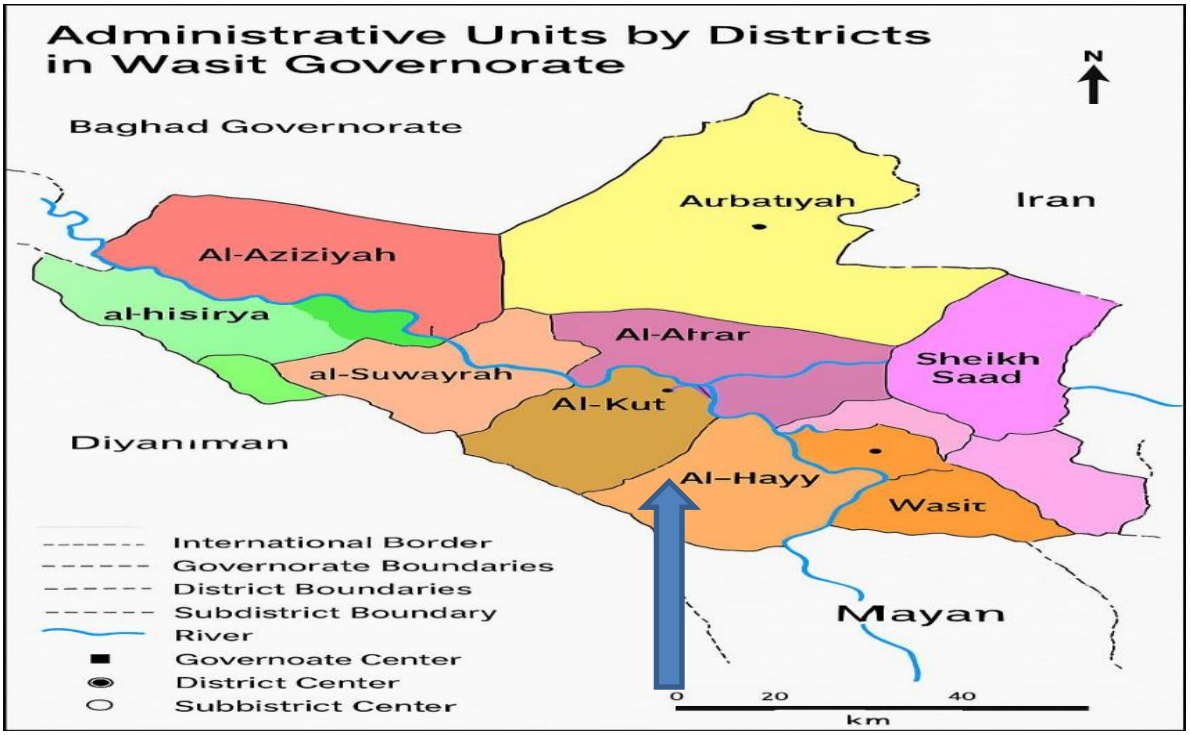

Figure 1: Map of the study area within Wasit Governorate

Table 1: Coordinate for the study area

Northeast		Northwest		Southeast	
Coordinates	**the site**	**Coordinates**	**the site**	**Coordinates**	**the site**
32°15'39.71" N 46° 2'5.04" E	**3000 Control**	**32°14'27.08"N 46° 0'44.43"E**	**500**	**32°14'7.83"N 46° 1'15.95"E**	**500**
		32°14'33.83"N 46° 0'44.45"E	**1000**	**32°13'59.99"N 46° 1'32.92"E**	**1000**
		32°14'39.02"N 46° 0'13.59"E	**1500**	**32°13'54.81"N 46° 1'51.58"E**	**1500**
		32°14'46.71"N 45°59'51.30"E	**2000**	**32°13'38.84"N 46° 2'1.33"E**	**2000**

2.2. Field work

Soil samples were collected from the southeastern and northwestern parts at four distances from the pollution source, where the dimensions were 500 - 1000 - 1500 - 2000 m respectively for each direction and were represented byA1, B1, C1 and D1 for the southeastern part and A2, B2, C2 and D2 for the northwestern part, respectively. The comparison sample was taken at a distance of 3000 m and represented E. Soil samples were taken at two depths for each site, the first from (0-30) cm and the second from (30-60) cm, with three replications for each depth, distance and direction.

3. Laboratory work:

3.1. Soil sample analysis

Soil sample models were prepared after being collected from the sites specified in the fieldwork for the purpose of this study. The samples were air-dried, gently crushed using a wooden hammer, and then passed through a sieve with a 2 mm mesh size. Subsequently, the samples were stored in plastic containers for the purpose of conducting the chemical and physical analyses listed in Table (2), according to the following analytical methods used in the analysis.

Table 2: Some Chemical and physical properties of the study soil

Unity	value	The adjective
$ds.cm^{-1}$	**3.56**	**EC**
----------	**7.54**	**pH**
$gm.kg^{-1}$	**5.4**	**O.M**
$cmol.kg^{-1}$ soil	**12.31**	**CEC**
$gm.kg^{-1}$ soil	**184.6**	**CaCo3**
dissolved ions		
$mmol/L^{-1}$	**20.30**	**Ca^{2+}**
	10.28	**Mg^{2+}**
	4.21	**Na^{+}**
	0.87	**K^{+}**
	13.55	**$SO4^{2-}$**
	20.45	**Cl^{-1}**
	1.66	**$HCO3^{-}$**
	0.0	**$CO3^{2-}$**
Soil particle sizes		
%	**46.0**	**Sand**
	25.0	**Silt**
	29.0	**Clay**
Sandy Clay Loam		**Texture**

3.2. Estimation of heavy elements in soil

Heavy elements in soil (cadmium, lead, nickel, iron, chromium, cobalt) were determined by wet digestion method and acid mixture. ($HCLO_4$: HNO_3) After extraction, the elements were measured using an Atomic Absorption Spectrometer (AAS) according to the method (Daives, 1992).

3.3. Calculating environmental pollution indicators

3.3.1: Contamination Factor(CF)

The pollution factor is calculated by the equation:(Hakanson,1980):

Cf=cm sample/cm background

Cf Pollution factor.
=Cm Total concentration of heavy metal in soil sample (mg. kg^{-1} soil).
Cm background=Total concentration of heavy metal in the control soil sample mg kg-1.

3.3.2. Pollution level Contamination Degree (Cdeg)

The pollution index is calculated using the equation (Hakanson, 1980) the following:
Cdeg= ∑CF1+CF2+CF3+……
Since:
Cdeg:Pollution degree.
CF1: Pollution factor for the first element.
CF2: Contamination factor for the second element and so on.

3.4. Statistical Analysis

The Statistical Analysis System (SAS, 2018) was used to analyze the data in order to evaluate the effects of the different factors (locations, depths, and distances) on the studied soil parameters, specifically the concentrations of heavy metals in the soil A Completely Randomized Design (CRD) in a factorial arrangement was employed The significant differences among the means were compared using the Least Significant Difference (LSD) test, as described by(Al-Rawi ,1981).

4. Results and discussion

4.1. Total concentration of heavy elements in the soil

4.1.1: Total lead concentration (Pb) mg. Pb kg^{-1} soil

The results presented in Table (3) indicated that the total lead (Pb) concentrations in the southeastern direction were 365.00, 253.00, and 150.00 mg Pb kg^{-1} soil at distances of 500, 1000, and 1500 m, respectively, compared with the fourth distance (2000 m) and the control sample (3000 m), which recorded values of 94.50 and 44.00 mg Pb kg^{-1} soil, respectively. The results of the present study shown in Table (6) also revealed that the values of total lead concentration in the soil at the first depth (0–30 cm) were higher than those at the second depth (30–60 cm) for the same direction and distances. The recorded values were 204.40 and 158.20 mg Pb kg^{-1} soil for the first and second depths, respectively. This may be attributed to the absence of leaching processes and the lack of suitable environmental conditions. Regarding the interaction between distance and depth, the highest value was recorded at a distance of 500 m and a depth of 0–30 cm in the southeastern direction, reaching 390.00 mg Pb kg^{-1} soil, whereas the lowest value was observed at a distance of 2000 m and a depth of 30–60 cm, amounting to 66.00 mg Pb kg^{-1} soil. Statistical analysis indicated the presence of significant differences for distance, depth, and their interaction. The results of the current study further demonstrated that total lead concentrations in the soil in the northwestern direction, across all studied distances and depths, were lower than those in the southeastern direction. The mean values reached 112.00, 98.00, 85.50, and 69.00 mg Pb kg^{-1} soil at distances of 500, 1000, 1500, and 2000 m, respectively, compared with the control treatment, which recorded 44.00 mg Pb kg^{-1} soil. The first depth (0–30 cm) also showed higher values than the second depth (30–60 cm). Statistical analysis revealed significant differences at a probability level of 0.05 for distance, depth, and their interaction. The results of the present study showed elevated concentrations of lead in the soil, particularly at sites close to brick factories, in both the southeastern and northwestern directions, exceeding the permissible global limits (WHO, 2007), which are set at 100 mg Pb kg^{-1} soil. This increase may be attributed to several factors, including the impact of heavy elements and gases emitted by brick factories into the atmosphere, which subsequently settle in nearby areas, contributing significantly to soil contamination by increasing the concentration of heavy metals. In addition, lead levels in the

surface soil layer are influenced by the rate of accumulation and deposition of heavy metals from atmospheric emissions originating from brick factories, with this accumulation gradually decreasing with increasing distance from the factories. Moreover, the prevailing northwesterly winds in the region play a role in transporting pollutants from the source to nearby sites and depositing them on the soil surface. The findings of the present study are consistent with those reported by (Al-Qarghouli ,2019) and Al-(Humaidi ,2023), whose studies indicated that lead concentrations in soil increase in areas close to pollution sources.

Table 3 The total lead concentration in the soil (Pb mg. kg^{-1} soil)

Average	Depth (cm)		Distance from the source of pollution (m)	the site
	30-60	0-30		
365.00	340.00	390.00	500	Southeast
253.00	238.00	268.00	1000	
150.00	104.00	196.00	1500	
94.50	66.00	123.00	2000	
44.00	43.00	45.00	3000	control
Dimension x Depth	158.20	204.40	Average	
	Depth	Dimension	LSD (0.05)	
4.91*	2.19*	3.47*		
112.00	104.00	120.00	500	Northwest
98.00	92.00	104.00	1000	
85.50	76.00	95.00	1500	
69.00	62.00	76.00	2000	
44.00	43.00	45.00	3000	Control
Dimension x Depth	75.50	88.00	Average	
	Depth	Dimension	LSD (0.05)	
4.37*	1.95*	3.09*		
100 pb mg.kg-1 soil			2007,WHO	Global determinants
300 pb mg.kg-1 soil			2011,Kabata-Pendias	

4.1.2. Total cadmium concentration (Cd) in the study soils

The results presented in Table (4) showed the soil cadmium (Cd) content at distances of 500, 1000, 1500, and 2000 m, as well as the effect of distance, proximity, and depth from brick factories on total cadmium content in the soil. The results indicated the presence of significant differences, particularly in the southeastern direction, where the highest cadmium concentration reached 14.00 mg Cd kg^{-1} soil at the first distance (500 m), compared with the fourth distance (2000 m) and the control sample (3000 m), which recorded the lowest concentrations of 7.50 and 1.43 mg Cd kg^{-1} soil, respectively. This increase is attributed to emissions from nearby brick factories and the associated release of heavy metals, which lead to soil contamination, especially at sites close to the pollution source.The results shown in Table (7) also revealed significant differences between soil depths in total cadmium concentration. The highest cadmium concentration was recorded at the first depth (0–30 cm), reaching 11.56 mg Cd kg^{-1} soil, compared with the second depth (30–60 cm), which recorded the lowest value of 5.81 mg Cd kg^{-1} soil. This may be due to the inefficiency of leaching processes in the region as a result of arid conditions, in addition to the relatively low mobility of heavy metals in soil. The findings of the present study are consistent with those reported by Al-Duraisawi (2024).Regarding the interaction between distance and depth, the highest value was recorded at a distance of 500 m and a depth of 0–30 cm in the southeastern direction, reaching 19.00 mg Cd kg^{-1} soil, whereas

the lowest value was observed in the control sample at a distance of 3000 m and a depth of 30–60 cm, amounting to 1.06 mg Cd kg^{-1} soil. Statistical analysis indicated significant differences for distance, depth, and their interaction. Furthermore, the results of the current study showed that total cadmium concentrations in the soil in the northwestern direction, across all studied distances and depths, were lower than those in the southeastern direction. The mean values were 7.50, 6.50, 4.50, and 3.50 mg Cd kg^{-1} soil at distances of 500, 1000, 1500, and 2000 m, respectively, compared with the control treatment, which recorded 1.43 mg Cd kg^{-1} soil. The first depth (0–30 cm) also exhibited higher values than the second depth (30–60 cm). Statistical analysis revealed significant differences for distance, depth, and their interaction. This pattern can be attributed to the increase in cadmium concentrations in areas close to brick factories due to gaseous emissions resulting from brick manufacturing operations. These findings are in agreement with those reported by (Al-Qarghouli ,2019). The results of Table (4) indicated that there was a significant effect of the total cadmium concentration for the studied sites, as the first depth (0-30) cm recorded the highest value of (6.36) mg. Cd kg^{-1} soil compared to the second depth (30-60) cm, as it reached (3.01 mg Cd. kg^{-1} soil, which is the lowest value recorded during the study. The results of the study agreed with what (Farhan ,2020) reached in the study of heavy elements in sites close to brick factories, as he found that the cadmium element recorded the highest concentration in the first depth. He attributed this to the combustion processes of fuel used in the factories, which release gases that contribute to the increase of heavy elements in the soil. The results of the statistical analysis showed that the interaction between dimension and depth had a significant effect on the concentration of the total cadmium element in the soil. The first dimension with the first depth (0-30) cm gave the highest value, reaching (10.00) mg Cd. kg^{-1} soil compared to the second depth sample (30-60) cm and the comparison sample which amounted to (2.00 and 1.06) mg Cd. kg^{-1} soil respectively and in general the study showed that the studied soils for all dimensions and depths and for the southeast and northwest directions were contaminated with cadmium as they exceeded the globally permissible limits (WHO,2007) which are (3 mg Cd. kg^{-1} soil).

Table 4: The total Cadmium concentration in the soil (mg Cd .kg^{-1} soil)

Average	Depth (cm)		Distance from the source of pollution (m)	the site	
	30-60	**0**-30			
14.00	**9.00**	**19.00**	**500**	**Southeast**	
12.00	**8.00**	**16.00**	**1000**		
8.50	**6.00**	**11.00**	**1500**		
7.50	**5.00**	**10.00**	**2000**		
1.43	**1.06**	**1.80**	**3000**	**Control**	
Dimension x Depth	**5.81**	**11.56**	**Average**		
	Depth	**Dimension**	**LSD (0.05)**		
3.90*	**1.74***	**2.75***			
7.50	**5.00**	**10.00**	**500**	**Northwest**	
6.50	**4.00**	**9.00**	**1000**		
4.50	**3.00**	**6.00**	**1500**		
3.50	**2.00**	**5.00**	**2000**		
1.43	**1.06**	**1.80**	**3000**	**Control**	
Dimension x Depth	**3.01**	**6.36**	**Average**		
	Depth	**Dimension**	**LSD (0.05)**		
3.00*	**1.34***	**2.12***			
3 mgCd .kg-1 soil			**2007, WHO**	**Global determinants**	
5 mgCd .kg-1 soil			**2011, Kabata-Pendias**		

4.1.3. Total cobalt concentration (Co) in the study soil

The results in Table (5) indicate the presence of significant differences in the total cobalt concentration in the soil. In the southeastern part, the results of the studied sites in the first and second sites recorded the highest value in cobalt concentration, reaching (63.00 and 39.00).mg Co. kg^{-1} soil, respectively, compared to the control sample that recorded the lowest value (4.50) mgCo. kg^{-1} soil.

Table 5: The total Cobalt concentration in the soil (mg Co. kg^{-1} soil)

Average	Depth (cm)		Distance from the source of pollution (m)	the site	
	30-60	0-30			
63.00	54.00	72.00	500	Southeast	
39.00	33.00	45.00	1000		
28.50	24.00	33.00	1500		
17.00	14.00	20.00	2000		
4.50	4.00	5.00	3000	Control	
Dimension x Depth	25.80	35.00	Average		
	Depth	Dimension	LSD (0.05)		
3.78*	1.69*	2.67*			
31.50	20.00	43.00	500	Northwest	
22.00	18.00	26.00	1000		
14.50	12.00	17.00	1500		
10.00	6.00	14.00	2000		
4.50	4.00	5.00	3000	control	
Dimension x Depth	12.00	21.00	Average		
	Depth	Dimension	LSD (0.05)		
*3.00	1.34*	2.12*			
10 mgCo. kg-1 soil			2007, WHO	Global determinants	
50 mgCo. kg-1 soil			2011,Kabata-Pendias		

The results in Table (5) showed significant differences in the sampling depth. The first depth (0-30) cm recorded the highest value of cobalt, reaching (35.00) mg Co. kg^{-1} soil compared to the second depth (30-60) cm which recorded the lowest value of (25.80) mg Co. kg^{-1} soil and this is consistent with the results of the study of (Taama ,2024) as it was found that the concentration of the element increases in the surface layer of the soil and decreases as the depth increases and he attributed the reason for this to the gaseous emissions resulting from the brick factory which is deposited on the surface layer of the soil which contributes to increasing the concentration of the cobalt element in the soil and the results also showed that the interaction between the distance and depth from the brick factory had a significant effect, as the highest value of the element concentration was for the first depth (0-30) cm with the first dimension (500) m reaching (72.00) mgCo. kg^{-1} soil, while the lowest value was for the comparison sample at a distance of (3000) m for the second depth (30-60) cm, reaching (4.00) mg. Co kg-1 soil. These results agreed with (Al-Ghalbi ,2016) and (Al-Omar ,2017). As for the northwestern part, the results in Table (5) showed significant differences in the concentration of cobalt, with respect to the effect of distance and proximity to the pollution source. The first dimension recorded the highest value of (31.50) mgCo. kg^{-1} soil compared to the fourth dimension and the comparison sample, which reached (10.00, 4.50) mg. Co kg^{-1} soil, respectively. As for the depth level, the concentration of the element increased in the first depth, as the highest value for the first depth (0-30) cm reached (21.00) mg Co. kg^{-1} soil measured at the second depth (30-60) cm, which recorded a value of (12.00) mgCo .kg^{-1} soil.

As for the overlap between dimension and depth, the first dimension (500) m, overlapping with the first depth (0-30) cm, recorded the highest concentration of the total cobalt element in the soil, as it reached (43.00) mg Co. kg^{-1} soil and the second depth (30-60) cm recorded the lowest value of the element concentration reached (6.00) mg Co. kg^{-1} soil, and the results of the statistical analysis indicated the presence of significant differences for each of the dimension and depth and the overlap between them. In general, we find that the concentration of the total cobalt element in the soil and the studied sites has increased clearly in the southeastern part of the brick factory compared to the samples studied in the northwestern part. When comparing the study values with the global determinants according to (WHO,2007), we find that the concentration of the total cobalt element in the soil has exceeded the permissible limit in the sites close to the brick factory for the southeastern and northwestern parts of the brick factory.

The results of the current study agreed with what (Al-Baydani et al,2015) reached, as they found in their study that the concentration of the cobalt element in the studied soils from the site of the Southern Gas Company in Basra increases significantly and they attributed this to the remains of pollutants that result from volatile vapors that accumulate in the soil, which contributes to increasing the concentration of the cobalt element.

4.1.4 Total chromium concentration (Cr) in the study soil

The results of Table (6) showed the effect of distance and proximity to the brick factory. The total chromium concentration recorded its highest value within the first dimension (500) m, as it reached (92.00) mg Cr. kg^{-1} soil compared to the comparison treatment which recorded the lowest value of (4.46) mg Cr. kg^{-1} soil The reason for this may be attributed to the gases rising from the brick factories and the heavy elements they carry which contribute to increasing the concentration of heavy elements in the soils near the brick factories. The results in Table (6) showed significant differences in depth in the total concentration of the total chromium element in the soil samples studied within the southeastern part of the brick factories, as the first depth (0-30) cm gave the highest value for the chromium element, amounting to (47.98) mgCr. kg^{-1} soil compared to the second depth (30-60) cm, which recorded a value of (35.20) mg Cr. kg $^{1-}$ Soil The reason for the decrease in the concentration of the element in the second depth and the accumulation of the element in the surface layer may be attributed to the absence of rain during the sampling period. Consequently, the elements accumulate in the surface layer and are not washed away or transferred to the lower soil horizons.

As for the interaction between dimension and depth, it had a significant effect on the concentration of the total chromium element in the soil, as the first depth (0-30) cm with the first dimension (500) m had the highest value of the chromium element reaching (104.00) mgCr. kg^{-1} soil, measured at the second depth (30-60) cm with the comparison sample, recorded a value of (4.03) mgCr. kg^{-1} soil, with a clear significant decrease compared to the rest of the values.

Table 6: The total chromium concentration in the soil (mg Cr. kg^{-1} soil)

Average	Depth (cm)		Distance from the source of pollution (m)	the site
	30-60	**0**-30		
92.00	**80.00**	**104.00**	**500**	**Southeast**
65.50	**55.00**	**76.00**	**1000**	
28.00	**23.00**	**33.00**	**1500**	
18.00	**14.00**	**22.00**	**2000**	
4.465	**4.03**	**4.90**	**3000**	**control**
Dimension x Depth	**35.20**	**47.98**	**Average**	
	Depth	**Dimension**	**LSD (0.05)**	
3.33*	**1.49***	**2.35***		

36.00	**30.00**	**42.00**	**500**	**Northwest**
24.00	**20.00**	**28.00**	**1000**	
13.50	**11.00**	**16.00**	**1500**	
10.00	**8.00**	**12.00**	**2000**	
4.465	**4.03**	**4.90**	**3000**	**Control**
Dimension x Depth	**14.60**	**20.58**	**Average**	
	Depth	**Dimension**	**LSD (0.05)**	
2.99*	**1.34***	**2.12***		
200 mgCr .kg-1 soil			**2011, Kabata-**Pendias	**Global determinants**

The results of the current study and statistical analysis in Table (6) showed the presence of significant differences in the northwestern part of the dimension and depth and their bilateral interactions in the concentration of the total chromium element in the soil. The chromium element in the first site recorded a value of (36.00 mg. Cr kg^{-1} soil compared to the comparison treatment which recorded the lowest value of (4.46) mg. Cr kg^{-1} soil, and the results of the current study agreed with what was reached by (Al-Hamidi, 2023) and it was found that the effect of depth in sampling had a significant effect on the concentration of the total chromium element, as the first depth (0-30) cm gave the highest value of the chromium element, amounting to (20.58) mg. Cr kg^{-1} soil compared to the second depth (30-60) cm which recorded a value of (14.60) mg. Cr kg^{-1} soil. As for the binary interaction between dimension and depth, the first depth (0-30) cm with the first dimension (500) m gave the highest values, amounting to (42.00) mg. Cr kg-1 soil compared to the second depth (30-60) cm for the fourth dimension (2000) m and the comparison treatment recorded the lowest value of (8.00 and 4.03) mg. Cr kg^{-1} soil The results of our current study are consistent with what was reached by (Khwaidem et al., 2009). Through the results of our current study, we find that the concentration of the total chromium element in the soil has increased in the southeastern part compared to the northwestern part. This is due to the nature of the prevailing winds in the region (northwesterly). When comparing these results with the permissible limits according to (Kabata-Pendias, 2011), we find that the concentration of the total chromium element in the soil was below the permissible limits in all studied sites and for both the southeastern and northwestern parts.

4.1.5. Total Nickel concentration (Ni) in the study soil

The results and statistical analysis in Table (7) indicate that there is a variation in the concentration of total nickel in the soil from one site to another as a result of proximity and distance from the pollution source and the overlap between them. The results showed that the distance from the pollution source affected the content of the total nickel element. There were significant differences in the southeastern part of the brick factory, as the first site recorded the highest value of nickel concentration, reaching (102.00) mg Ni. kg^{-1} soil compared to the fourth site (2000) m and the comparison treatment that achieved the lowest value reached (77.00 and 9.00) mg Ni. kg^{-1} soil, respectively. The results of our current study agreed with the study of Al-Omar (2017), as it was found through the results, he reached that the concentration of the nickel element increases in sites close to the brick factories and decreases in sites far from the factories. The reason for this was attributed to the fact that the gases emitted from the brick factories settle in sites close to the factories, which increases the concentration of the total element in the soil. The concentration of the total nickel element in the soil is also affected by the distance and wind direction. The results of the two-way interaction between dimension and depth had a significant effect on the concentration of the total nickel element in the soil, as the first depth (0-30) cm with the first dimension (500) m recorded the highest value of the element concentration, which

amounted to (119.00) mg. Ni kg-1 soil and the lowest value at the fourth site (2000) m for the second depth (30-60) cm, as it reached (64.00 mg Ni. kg^{-1} soil).

The results in Table (7) showed significant differences between the depths in the concentration of the total nickel element in the soil samples studied. The first depth (0-30) cm recorded the highest value of the nickel element, amounting to (56.60) mg Ni. kg^{-1} soil compared to the second depth (30-60) cm, which recorded the lowest value of (35.60) mg Ni. kg^{-1} soil These results are consistent with what Farhan (2020) conducted on soil pollution with heavy elements from industrial waste in Wasit Governorate, as he concluded in his study that the concentration of the element is higher in the first depth compared to the concentration of the element in the second depth.

Table 7: The total nickel concentration in the soil (mg Ni. kg^{-1} soil)

Average	Depth (cm)		Distance from the source of pollution (m)	the site
	30-60	0-30		
102.00	85.00	119.00	500	Southeast
93.00	82.00	104.00	1000	
84.00	72.00	96.00	1500	
77.00	64.00	90.00	2000	
9.00	8.00	10.00	3000	Control
Dimension x Depth	62.20	83.80	Average	
	Depth	Dimension	LSD (0.05)	
3.40*	1.52*	2.40*		
67.00	54.00	80.00	500	Northwest
62.00	49.00	75.00	1000	
48.50	35.00	62.00	1500	
44.00	32.00	56.00	2000	
9.00	8.00	10.00	3000	Comparison
Dimension x Depth	35.60	56.60	Average	
	Depth	Dimension	LSD (0.05)	
4.45*	1.59*	3.14*		
50 mgNi .kg-1 soil			2007, WHO	Global determinants
60 mgNi .kg-1 soil			2011,Kabata-Pendias	

The results of the current study in Table (7) showed that the values of total nickel in the soil in the northwest direction and for all dimensions and depths were lower compared to the southeast direction, as the highest value reached (67.00) mg in the first location (500) mgNi. kg^{-1} soil and the lowest value for the fourth site (2000) m and the comparison sample as it reached (44.00 and 9.00) mgNi. kg^{-1}, respectively. As for the effect of the interaction between distance and depth on the concentration of the total nickel element in the soil, we note from the results of the table that the nickel element recorded the highest value in the first site (500) m close to the pollution source and for the first depth (0-30) cm, as its value reached (80.00 mgNi. kg^{-1} compared to the second depth (30-60) cm for the fourth site (2000) m and the comparison sample (3000) m as its value reached (32.00 and 8.00) mgNi. kg^{-1}, respectively. When comparing these results with the permissible global limits (WHO,2007), we find that the concentration of nickel in the southeastern and northwestern parts has exceeded the permissible limits in some locations.

4.2. Criteria Heavy metal contamination in the studied soils

4.2.1. Pollution factor (CF) Contamination Factor

The contamination factor (CF) is one of the most important indices used to assess the degree of soil contamination with heavy metals. It is defined as the ratio of the concentration of a given

element in a contaminated soil sample to its natural concentration in an uncontaminated (background) soil sample. The contamination factor is considered a simple yet highly sensitive indicator for identifying increases in heavy metal concentrations above their natural levels. It is widely applied to determine which heavy metal has contributed most to soil contamination resulting from anthropogenic or industrial activities, as it reflects the extent to which the concentration of a heavy metal exceeds its natural background level, thereby providing an accurate indication of contamination severity. According to (Hakanson ,1980), the contamination factor is classified as follows: $CF < 1$ indicates low contamination; $1 \leq CF < 3$ indicates moderate contamination; $3 \leq CF < 6$ indicates considerable contamination; and $CF \geq 6$ indicates very high contamination.

Table 8: Pollution factor values (CF) for the studied elements

Ni	Cr	Co	CD	Pb	Depth (poison)	Distance from the source of pollution (m)	the site
11.90	**21.22**	**14.40**	**10.55**	**8.66**		**500**	
10.40	**15.51**	**9.00**	**8.33**	**5.96**		**1000**	**Southeast**
9.60	**6.73**	**6.60**	**6.11**	**4.36**		**1500**	
9.00	**4.48**	**4.00**	**5.55**	**2.73**		**2000**	
8.00	**8.57**	**8.60**	**5.55**	**2.67**	**0**-30	**500**	
7.50	**5.71**	**5.20**	**5.00**	**2.31**		**1000**	**Northwest**
6.20	**3.26**	**3.40**	**3.33**	**2.11**		**1500**	
5.60	**2.44**	**2.80**	**2.77**	**1.68**		**2000**	
10.63	**19.85**	**13.50**	**8.49**	**7.90**		**500**	
10.25	**13.64**	**8.25**	**7.54**	**5.53**		**1000**	**Southeast**
9.00	**5.70**	**6.00**	**5.66**	**2.41**		**1500**	
8.00	**3.47**	**3.50**	**4.71**	**1.53**		**2000**	
6.75	**7.44**	**5.00**	**4.71**	**2.41**	**30**-60	**500**	
6.13	**4.96**	**4.50**	**3.77**	**2.13**		**1000**	**Northwest**
4.38	**2.72**	**3.00**	**2.83**	**1.76**		**1500**	
4.00	**1.98**	**1.50**	**1.88**	**1.44**		**2000**	
very severe pollution CF>6		**severe pollution 6>CF>3**	**Moderate pollution 3>CF>1**		**low pollution CF > 1**		**value CF**

4.2.2. Lead pollution factor (pb)

Showed The results in Table (8) show the values of the pollution factor for lead in the soils of the sites included in the study in the southeastern and northwestern parts of the brick factories. In the southeastern part, the first site (500) m and for the first depth (0-30) cm recorded the highest value of the pollution factor, which amounted to (8.66) compared to the fourth site (2000) m and for the same first depth, which recorded the lowest value, which amounted to (2.73). Through the results obtained, we find that the values of the pollution factor in the first site indicate the occurrence of very severe pollution of the lead element, while the values of the pollution factor in the fourth site indicated the occurrence of medium pollution, according to the

classification of (Tomlinson et al., 1980). When comparing the depths, we find that the pollution factor has decreased significantly at the second depth (30-60) cm compared to the first depth (0-30) cm. But in the northwestern part of the brick factories, the results of the study (Table 8) showed a decrease in the pollution index values compared to the southeastern part. It is noted that the value of the pollution factor index for the first, second, third and fourth dimensions was (2.67, 2.31, 2.11 and 1.68) respectively, and this indicates the occurrence of moderate lead pollution according to the classification of (Tomlinson et al. (1980). The results of the study agreed with what (Abdul Latif ,2020) reached regarding an increase in the value of the pollution factor for lead in sites close to the Dora refinery, as well as with what (Al-Omar ,2017) reached, attributing the reason to the effect of the brick factory on soil pollution. The results of the study showed an increase in the pollution factor values in the southeastern part compared to the northwestern part of the brick factory, and this is attributed to the nature of the prevailing winds (northwesterly) in the region, which work to carry pollutants resulting from industrial activities to the southeastern part of the brick factory.

4.2.3. Cadmium pollution factor (Cd)

Showed The results in Table (8) show the values of the pollution factor index for the cadmium element in the soils of the studied sites. In the southeastern part of the brick factory, the highest value was in the first site (500) m, reaching (10.55), and the lowest value was in the fourth site (2000 m). A value of (5.55) was recorded at the first depth (0-30) cm, compared to the second depth (30-60) cm, which gave lower values. We note that the value of the pollution factor index in the first site (500) m indicates the occurrence of very severe pollution, and in the fourth site it indicates the occurrence of severe pollution, according to the classification of (Tomlinson et al. 1980). As for the northwestern part of the brick factory, the pollution factor recorded lower values compared to the southeastern part, as the first dimension (500) m and the first depth (0-30) cm recorded the highest value of the pollution factor, reaching (5.55), compared to the fourth site (2000) m and the second depth (30-60) cm, which recorded the lowest value, reaching (1.88) According to the classification of (Tomlinson et al. 1980), this indicates the occurrence of severe pollution in sites close to pollution sources and moderate pollution in sites far from brick factories. Through the results of the study, we note that the values of the pollution factor for the sites close and far and for the southeastern and northwestern parts are classified between moderate pollution to very severe pollution, and the reason for this is attributed to the activity of brick factories. This is consistent with what (Islam et al. 2017) and (Al-Omar 2017) found, as they found that the highest value of the cadmium pollution factor was in the soils adjacent to power plants and brick factories.

4.2.4. Pollution factor of cobalt element (Co)

Showed Results in Table (8) There is a variation in the values of the pollution factor for the cobalt element. In the southeastern part of the brick factory, it was found that the value of the pollution factor for cobalt in the first site (500) m, close to the pollution source, reached (14.40), and for the fourth site (4.00), and for the first depth (0-30) cm. According to the value of the pollution factor for the cobalt of the soils of the studied sites, the soil is classified as very heavily polluted. According to the classification of (Tomlinson et al., 1980), the results of the study agreed with what (Al-Baydani et al. 2015) reached, regarding the high values of the pollution factor for the cobalt element in the studied soils west of Basra Governorate and close to the Southern Gas Company. As for the northwestern part, the values of the pollution factor decreased compared to the southeastern part and for both depths, as the pollution factor in the first site (500) m recorded a value of (8.60), and in the fourth site (2000) m, it recorded a value of (2.80), and for the first depth (0-30) cm. The soil is classified as very polluted in the first location and severely polluted in the fourth location. The results of the study were consistent with what was

reached by (Al-Rikabi, 2022), as he found an increase in the value of the pollution factor in the soils near the Gharraf oil field and attributed the reason to the industrial activity in the region. It is noted from the results of the study that the value of the pollution factor for cobalt increased in the sites close to the pollution source. This was consistent with what was reached by (Farhan, 2020) regarding the increase in the pollution factor in the sites close to the Dora refinery and the power generation station, and he attributed the reason to the type of fuel used in these facilities, which leads to pollution with some heavy elements, including cobalt.

4.2.5. Pollution factor Chromium (Cr) in the studied soils

The results of the study in Table (8) show that there is a variation in the values of the pollution factor for the chromium element in the soil of the studied sites. In the southeastern part of the brick factories and in the first site (500) m, the highest value of the pollution factor was recorded, reaching (21.22), and the lowest value was recorded in the fourth site (2000) m, as it reached (4.48) and for the first depth (0-30 cm). Through the values of the pollution factor, the soil of the studied sites is classified, according to the classification of Tomlinson and others (1980), as very highly polluted. The reason for this is attributed to the high concentration of total chromium in the soil of the sites near the brick factories as a result of gaseous emissions containing heavy elements that are transported by the air and fall on the soil near the source of pollution. This is consistent with what was indicated by (Al-Ghalbi, 2016) regarding the high values of the pollution factor for heavy elements in the soil of the sites near the industrial facilities. As for the northwestern part of the brick factories, the pollution factor recorded low values compared to the southeastern part of the brick factories, as the first site recorded a value of (8.57) The fourth site recorded a value of (2.44) for the first depth (0-30) cm. According to the classification of (Tomlinson et al., 1980), the soil was classified from moderately polluted to very heavily polluted soil. We note from the results of the study that the values of the pollution factor recorded a decrease at the second depth (30-60) cm compared to the first depth (0-30) cm for both directions. From the results obtained, we note an increase in the values of the pollution factor in the southeastern part compared to the northwestern part. The reason for this is attributed to the nature of the prevailing north-westerly winds in the region, which carry pollutants from pollution sources to the southeastern side of the brick factories, which leads to an increase in pollutants in it compared to the regions located opposite to the direction of the prevailing winds.

4.2.6. Pollution factor of Nickel element (Ni) in the studied soils

showed the results of the study in Table (8) Variation in the value of the pollution factor for the nickel element according to proximity and distance from the pollution source, as well as according to the location and depth of taking soil samples in the southeastern and northwestern parts of the brick factories. In the southeastern part of the brick factories, the highest value of the pollution factor was recorded in the first site (500) m and the first depth (0-30) cm, as it reached (11.90) compared to the fourth site (2000) m and the second depth (30-60) cm, which recorded the lowest value of (8.00). We note that the value of the pollution factor in the two sites indicates the occurrence of very severe pollution, according to the classification of (Tomlinson et al., 1980). As for the northwestern part, the values of the pollution factor decreased compared to the southeastern part, as the first site (500) m and the first depth (0-30) cm recorded a value of (8.00), while the value of the pollution factor decreased in the fourth site (2000) m and the second depth (30-60) cm, which gave the lowest value of (8.00). (4.00) The results indicate that there was very severe pollution in the first site and severe pollution in the fourth site with nickel in the northwestern part of the brick factories, according to the classification of (Tomlinson and others, 1980). And during the study results, we find that the values of the pollution factor have increased in locations close to the pollution source, and this is attributed to the activity of brick factories in the region and the accompanying accumulation of heavy elements in locations close to the

pollution source as a result of gases and vapors emitted from brick factories, and that these results are consistent with a number of studies (Al-Jabouri, 2016, Al-Omar, 2017, Abdul Latif, 2020, and Taama, 2024) which found that the value of the pollution factor for the nickel element increases in places close to the pollution source and with different types of pollution sources. In general, we find that the values of the pollution factor have increased at the first depth (0-30) cm compared to the second depth (30-60) cm for all dimensions and both directions.

4.3. Pollution level index Contamination Degree (Cdeg)

The contamination degree (Cdeg) is an integrated index used to evaluate the overall level of soil contamination by multiple heavy metals. It is calculated as the sum of the contamination factors (CF) of the studied metals, reflecting the cumulative impact of heavy metals on soil quality. This index provides a comprehensive assessment of pollution intensity and allows classification of soil contamination as low (Cdeg < 8), moderate (8 ≤ Cdeg < 16), considerable (16 ≤ Cdeg < 32), or very high (Cdeg ≥ 32) according to (Hakanson ,1980). The results in Table (9) indicated that there was a variation in the values of the pollution index for the studied heavy elements of lead, cadmium, cobalt, chromium and nickel. In the southeastern part of the brick factory, the highest value of the pollution index was in the first location (500) m and for the first depth (0-30) cm, it reached (66.73) compared to the fourth location (2000) m and the second depth (30-60) cm in the northwest direction, which recorded the lowest value of the pollution index, which reached (10.80). Through the results of the study, we note that the pollution degree index in the southeastern and northwestern parts of the studied soil was greater than 32 in most of the studied sites. This indicates the degree of pollution of the studied soil. The reason for this is attributed to the gases and vapors emitted from the brick factories as a result of their work, which contain large quantities of heavy elements that contribute to the pollution of the soil surrounding the brick factories. The results of our study agreed with what was reached by (Mansour et al., 2017).

Table 9: Pollution Index Values (Cdeg) for the studie elements

Northwest	**Southeast**	**Depth (cm)**	**Distance from the source of pollution (m)**
33.39	**66.73**	**0**-30	**500**
25.72	**49.2**		**1000**
18.3	**33.4**		**1500**
15.29	**25.76**		**2000**
26.31	**60.37**	**30**-60	**500**
21.49	**45.21**		**1000**
14.69	**28.77**		**1500**
10.8	**21.21**		**2000**
Cdeg ≥ 32 very high degree of pollution	**Cdeg < 32 ≥ 16 high degree of pollution**	**Cdeg <16 ≥ 8 Moderate pollution**	**Cdeg < 8 low level of pollution**

5. Conclusions:

The soil analysis revealed that heavy metal concentrations were highest at sites closest to the brick factories, particularly at 500 m and in the surface layer (0–30 cm), with lower values observed at greater distances and deeper layers (30–60 cm). The southeastern direction showed the highest contamination, reflecting the effect of prevailing winds and industrial dust dispersion. Environmental pollution indices, including the contamination factor (CF) and contamination degree (Cdeg), confirmed moderate to high contamination levels in surface soils near the factories. These results highlight the direct impact of industrial emissions on soil quality

and demonstrate the effectiveness of these indices in assessing pollution severity and identifying the most affected sites.

References:

Abbas, M. T., Wadaan, M. A., Ullah, H., Farooq, M., Fozia, F., Ahmad, I., Khan, M. F., Baabbad, A., & Ullah, Z. (2023). Bioaccumulation and mobility of heavy metals in the soil–plant system and health risk assessment of vegetables irrigated by wastewater. *Sustainability, 15*(21), 15321. https://doi.org/10.3390/su152115321

Achakzai, K., Khalid, S., Adrees, M., Bibi, A., Ali, S., Nawaz, R., & Rizwan, M. (2017). Air pollution tolerance index of plants around brick kilns in Rawalpindi, Pakistan. *Journal of Environmental Management, 190,* 252–258.

Abdul Latif, A. A. (2020). *Heavy and radioactive element pollution of soil and plants of Baghdad city* (PhD thesis). College of Agricultural Engineering Sciences, University of Baghdad, Iraq.

Al-Baydani, A. H., Hawra, R. Y., & Al-Saad, H. T. (2015). Evaluation of geochemical contamination of some heavy elements in the soils of Basra Governorate. *Journal of Dhi Qar Sciences, 5*(2), 41–34.

Al-Drisawi, H. K. (2024). *The effect of gases emitted from asphalt plants on soil, water and plant pollution with some heavy elements in Wasit Governorate* (Master's thesis). College of Agriculture, University of Wasit, Iraq.

Al-Ghalbi, D. M. S. (2016). *The role of some industrial facilities in the city of Baghdad on the pollution of soil, water and plants by some heavy elements* (Master's thesis). College of Agriculture, University of Baghdad, Iraq.

Al-Hamidi, N. H. (2023). *Study of the impact of Al-Waha Oil Company on soil, water and plant pollution with heavy elements (Hg, Pb, Cr, Cd, Co)* (Master's thesis). College of Agriculture, University of Wasit, Iraq.

Al-Jubouri, D. A. R. (2016). *A study of different quantitative criteria for cadmium, lead, zinc and nickel pollution in soils and roadside plants in Baghdad Governorate* (PhD thesis). College of Agriculture, University of Baghdad, Iraq.

Al-Omar, H. J. O. N. (2017). *The effect of Nasiriyah brick factory on soil, water and plant pollution with some heavy elements* (Higher Diploma). College of Agriculture, University of Baghdad, Iraq.

Al-Omari, M. A. R. (2009). *Environmental pollution* (1st ed.). Wael Publishing House.

Al-Rawi, K. M., & Khalafallah, A. A. (1981). *Design and analysis of agricultural experiments*. Mosul University, Dar Al-Kutub for Printing and Publishing.

Al-Rikabi, M. S. A. (2023). *Case study of soil and plant pollution (Cd, Pb, Co, Cr, Ni) and surrounding waters of the Garraf oil field* (Master's thesis). College of Agriculture, University of Wasit, Iraq.

Al-Qarghouli, Z. M. S. (2019). *The effect of oil field waste on soil properties of Wasit and Maysan Governorates: An environmental geography study* (PhD thesis). Department of Geography, College of Arts, University of Al-Qadisiyah, Iraq.

Davies, B. E. (1992). Inter-relationships between soil properties and the uptake of cadmium, copper, lead and zinc from contaminated soils by radish (*Raphanus sativus* L.). *Water, Air, and Soil Pollution, 63*(3–4), 331–342.

Farhan, B. H. (2020). *Study of soil, water and plant pollution by some heavy industrial waste in Wasit Governorate* (PhD thesis). College of Agricultural Engineering Sciences, University of Baghdad, Iraq.

Hamid, E., Payandeh, K., Karimi Nezhad, M. T., & Saadati, N. (2022). Potential ecological risk assessment of heavy metals (trace elements) in coastal soils of southwest Iran. *Frontiers in Public Health, 10*, 889130.

Hakanson, L. (1980). An ecological risk index for aquatic pollution control: A sedimentological approach. *Water Research, 14*, 975–1001. https://doi.org/10.1016/0043-1354(80)90143-8

Islam, S., Ahmed, K., Al-Mamun, H., & Islam, S. A. (2017). Sources and ecological risk of heavy metals in soils of different land uses in Bangladesh. *Pedosphere, 27*(2), 239–253. https://doi.org/10.1016/S1002-0160(17)63941-0

Kabata-Pendias, A., & Szteke, B. (2011). *Trace elements in abiotic and biotic environments*. Taylor & Francis Group.

Khan, A., Khan, S., Khan, M. A., Qamar, Z., & Waqas, M. (2015). The uptake and bioaccumulation of heavy metals by food plants and associated health risks: A review. *Environmental Science and Pollution Research, 22*(18), 13772–13799.

Khwaidem, K. H., Al-Ansari, H. R., & Al-Bassam, K. S. (2009). Distribution of heavy metals in the soil of Basra city, southern Iraq. *Iraqi Journal of Science, 50*(4), 533–542.

Maqsood Ur Rehman, N., Ullah, B. A., Ahmad, I., Ali, I., Younas, M., Aslam, M. S., Rahman, A., Taheri, E., Fatehizadeh, A., & Rezakazemi, M. (2022). Assessment of heavy metals accumulation in agricultural soil, vegetables and associated health risks. *PLoS ONE, 17*(6), e0267719.

Tomlinson, D. C., Wilson, J. G., Harris, C. R., & Jeffrey, D. W. (1980). Problems in the assessment of heavy metals in estuaries and the formation of a pollution index. *Helgoländer Meeresuntersuchungen, 33*, 566–575.

WHO (World Health Organization). (2007). *Health risks of heavy metals from long-range transboundary air pollution*. http://www.euro.who.int/pubrequest

Zalan, L. S. A., Abdel Nabi, S. F., & Alwan, E. (2006). Assessment of pollution rates of some heavy elements in vegetable samples in southern Basra region. *Basra Journal of Agricultural Sciences, 19*(2), 1–10.

Taama, W. A. (2024). *Emission impact produced from brick factories in Kut city on some physical and chemical properties and soil, water and plant pollution with heavy elements* (Master's thesis). College of Agriculture, University of Wasit, Iraq