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Geochemical Evaluation of Heavy Metals Soil Pollution in Al-Hayy District Affected by Agriculture Activities: a case study

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Abstract

This research aims to assess trace elements of contamination by agricultural soils in the Al-Haye district. Soil samples were collected from a selected agricultural area near the banks of the Tigris River, and trace elements (Ag, As, Ba, Cd, Co, CR, Cu, Fe, Hg, Mn, Ni, Pb, Se, V, Zn, Zr, Pb, Se, V, Zn, Zr), pH, electrical conductivity, and organic matter were identified in soil samples. The pH of the soil sample ranged between 7.7 and 7.6, which is equivalent to the pH of the sub-alkalis (7.3). The organic matter content is 1.8433%; this range of organic matter is between 1.56 and 1.98. The average soil conductivity was 995.37 ug/cm. The level of trace contamination was found in soil samples as follows: Fe> Mn> Ba> Cr> Ni> Zr > V > Zn > Cu> Pb> Co> Ag >Cd> Hg> Se. Soil samples contained concentrations of Cd, Cr, Cu, Mn, and Ni much higher than the global average of unpolluted soil concentrations. In contrast, only half of the zinc samples exceeded the calculated average global average of the unpolluted soil, and lead had values within the international level of the unpolluted soil. The study area needs an environmental management system to manage and treat soil pollution in urban areas.

Keywords: Heavy metals; Agriculture soil; Pollution Index; E.F.; CF; I-geo; P.L.I ; E.R.I

التقييم الجيوكيميائي لتلوث التربة بالمعادن الثقيلة في قضاء الحي المتأثرة بالأنشطة الزراعية

رند ضياء النجار [1] , طارق عبد حسين [2] , عبد الحميد محمد جواد العبيدي [3]
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الخلاصه

ويهدف هذا البحث إلى تقييم العناصر النزرة للتلوث بالتربة الزراعية في قضاء الحي . وقد أخذت عينات التربة من منطقة زراعية مختارة بالقرب من ضفاف نهر دجلة، وحددت في عينات التربة العناصر النزرة (Ag, As, Ba, Cd, Co, CR, Cu, Fe, Hg, Mn, Ni, Pb, Se, V, Zn, and Zr) و Pb, Se, V, V, Zn, and Zr) و pH, والموصلية الكهربائية, والمادة العضوية. وكان متوسط الأس الهيدروجيني في عينة التربة يتراوح بين (7,7 و7,6) وهو ما يعادل درجة الأس الهيدروجيني للقلويات الفرعية. (7.3). ومحتوى المادة العضوية هو (1.8433٪)؛ وهذا النطاق من المادة العضوية هو بين (1.56 –1.98). وكان متوسط موصلية التربة (995.37 ميكروغرام/سم). وقد وجد مستوى التلوث النزر في عينات التربة على النحو التالي: Fe> Mn> Ba> Cr> Ni> Zr > V > Zn > Cu> Pb> Co> > Ag >Cd> Hg> Se.

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وكانت عينات التربة تحتوي على تركيزات من Cd وCr وCu وMn وNi أعلى بكثير من المتوسط العالمي لتركيزات التربة غير الملوثة. وعلى النقيض من ذلك، فإن نصف عينات الزنك فقط تجاوزت المتوسط المحسوب للمتوسط العالمي للتربة غير الملوثة، وكان للرصاص قيم ضمن المستوى العالمي للتربة غير الملوثة.ان منطقة الدراسة تحتاج إلى نظام للإدارة البيئية لإدارة ومعالجة تلوث التربة في المناطق الحضرية.

1. Introduction

Soil pollution is the buildup of known harmful compounds, chemicals, salts, radioactive materials, or disease-causing agents in soils, which affects plant growth [1]. As the primary component of the environment, agricultural and urban soil serve as the primary reservoir or sink for contaminants, including heavy metals [2]. Heavy metal pollution occurs in many parts of the world, especially in developing countries. Rapid industrialization and urbanization over the last few decades have resulted in significant and widespread soil pollution by heavy metals[3]. Researchers have observed that the concentration and shape of heavy metals are directly related to their movement and transformation in the soil-plant system and their ecological toxicity [3]. The bioavailability of metals varies depending on their chemical structure [4]. The accumulation of heavy metals in the soil over time and long-term toxicity can directly affect the soil's physical and chemical properties since these metals do not migrate or degrade easily through natural degradation processes[5]. Although heavy metals can be found in trace amounts in the Earth's crust, their concentrations in naturally occurring soils are often quite low. However, anthropogenic inputs of numerous heavy metals to soils far outnumber natural inputs from the parent material[6]. Fertilization, metal and smelting operations, sewage and sludge applications, urban effluent, and atmospheric deposition mostly cause heavy metals in the soil [7][6]. It can potentially transfer contaminants to groundwater, the food chain, and the human body so that it may be seen as both a sink and a source of pollution[8]. Heavy metals in soils and dust can build up in the human body when breathed in, eaten, or absorbed through the skin [9]. Heavy metals in the soil are one of the main sources of heavy metal contamination in crops. When crops are grown on arable land with polluted heavy metals, their physiological, biochemical, and developmental processes will be hurt [4]. Most polluted soils are full of harmful metal elements, impairing crop yields and threatening human health once they enter the food chain[4]. Given that agricultural soil is a crucial part of the study area, it is important to study heavy metal pollution in soil in general and in agricultural soil in particular. Al-Hayy district is defined by its agricultural activities and provision of food baskets for most of the area's people and the surrounding areas. Thus, the research aimed to assess the level of heavy metal contamination in soil affected by agricultural activity. The objectives of this study is to determine the heavy metal level in agricultural soils, and evaluate the research area's heavy metal distribution, using pollution indicators.

2. Materials and Methods

2.1.Study area

Al-Hayy District is one of the Waist Governorate's districts on the Al-Gharraf River banks. It was about 220 km southeast of Baghdad, the capital of Iraq. It is between 32° 10′ 33'' N and 46° 2` 9.5'' E. The Tigris River enters the district of Al-Hayy. It is estimated that about 280,000 people live in the district, which is 2000 km2 in size[10]. Al-Hayy is known for its distinguished agricultural season, when barley, wheat, yellow and white corn, sesame, and sunflowers are grown, surrounded by palm groves. The location was chosen to investigate the potential environmental effects of agricultural activity. Because the area is located in a vital part that contains agricultural activity and since pumps are used to get water for farms, much fuel gets into the area (Figure 1).

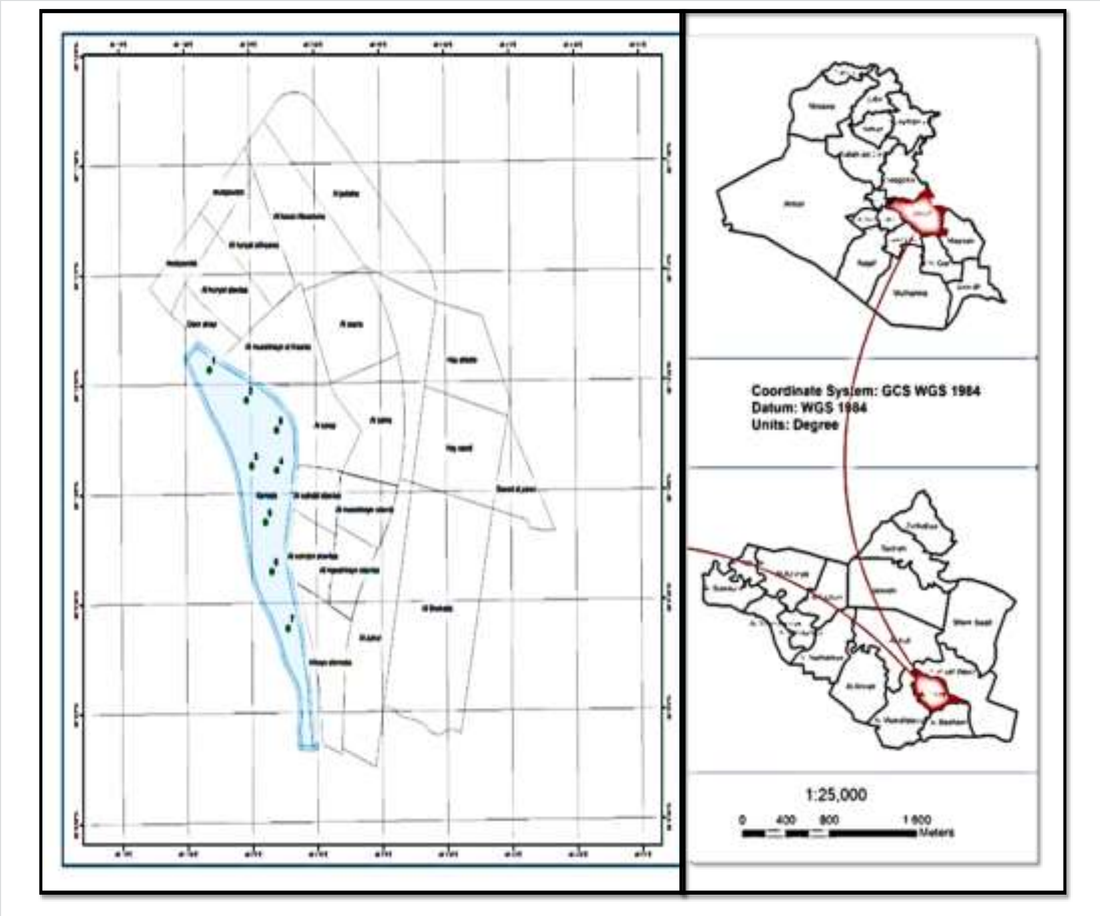

Figure 1: Map of AL-Hayy district –Wasit governorate and distribution of sampling

2.2.Sample Collection, Preparation, and Analyses

Composite soil samples were made for each site. There are numerous randomly placed sampling sites all over the study area. The locations of each sample were noted using a Garmin G receiver. The coordinates were listed in Table 2. From September to December 2022, 1 kg of topsoil (0–20 cm) is collected and stored in a cool, dry place for later use as a bulk sample. Soil samples were sieved to remove anything larger than gravel, any remaining roots, and anything else that would not be useful in the final product. After air drying, pulverization, and homogenization, the materials were sieved through a 2 mm mesh. Then, the samples are placed in new, airtight plastic bags [3], and all samples are stored at room temperature for further analysis. Details are in Table 1.

Table 1: The parameter Selected and procedure followed for analyzing soil samples

Parameters	Methods of analysis	Name of laboratory
Heavy metals and major elements(Ag,As, Ba, Cd Co, Cr,Cu,Hg, Mn, Ni, Pb,Se Sn, V, Zn, Zr)	X-ray fluorescence spectrometry (XRF)analyses. Model: spectra Xepos	University of Baghdad-College of Science, Iraq German Lab, spectra Germany 2010
X-ray powder diffraction (XRD)	Shimadzu X-Ray 6000. method identify clay and other minerals in surface soils	The Ministry of Science and Technology (Department of Materials Sciences)
Hydrogen number (pH)	PH-Meter, pH Values were determined using the suspension of 1:5 soil to water. A Cyberscan digital pH meter is then used to measure the solution's pH	
organic matter	Dry Combustion method (F.A.O.,1974) the weight of 1 gram of the sample is taken and placed in a carefully weighed ceramic lid. Then the sample is burned at a temperature of 300 °C for two hours, after which the lid and sample are weighed accurately. The weight difference represents the weight of the organic materials	Baghdad University College of Sciences, Iraq German Lab
electrical conductivity (E.C)	was measured with a conductivity meter. A suspension of 1:5 or 1:10 soil-to-water was made and spun for 30 minutes. The clear extract from the centrifuged mixture was then used to test conductivity	University of Baghdad-College of Science, Iraq German Lab

3. Results and Discussion

3.1.Physico-chemical analysis

3.1.1. Effect of pH

These findings indicate that most urban soil has a neutral to sub-alkaline pH range of 7.0 to 7.6, with a mean of 7.3.

3.1.2. Effect of electrical conductivity

The average soil conductivity in the study area was 995.37 µs/cm, ranging from 1136 to 638µs/cm.

3.1.3. Effect of organic matter

Organic matter values varied from 1.56 to 1.98%, with a mean of 1.843%.

Table 2: Data of soil sampling sites in the Al-Hayy District

Sample N	coordinates(Long)	Coordinates (Lat)
S1	46.02255534	32.17881496
S2	46.02939629	32.17536474
S3	46.03593981	32.17280682
S4	46.03207319	32.16911865
S5	46.03671314	32.16465717
S6	46.03314395	32.16239668
S7	46.03707006	32.15882749
S8	46.03956849	32.15135598

3.1.4.Heavy metals concentrations in soil

The average amounts of heavy metals found in soil samples were in the following order: Fe> Mn> Ba> Cr> Ni> Zr > V > Zn > Cu> Pb> Co> As > Ag >Cd> Hg >Se. It was clear that Fe was the most common. The Se is found in the lowest content in the agricultural land. The background concentration of heavy metals (Ag, As, Ba, Cd, Co, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Se, V, Zn, and Zr) in Kabata-Pendias [11], and Fe in [13] Here are short descriptions of each metal, compared to the results in Table 3.

Table 3: Heavy metals in concentration and some physical properties of soil samples

Parameters	**Min**	**Max**	**Mean**	**SD**	**[14]Al-Bassam**	**Parameters**	**Min**	**Max**	**Mean**	**S.D**	**[14]Al-Bassam**
pH	*7*	*7.6*	*7.3*	*0.106*		*Fe*	*41268*	*48720*	*45258.1*	*2665*	*22890.9*
EC	*638*	*1134*	*995*	*169.14*		*Hg*	*1.1*	*1.5*	*1.22*	*0.119*	-----
OM	*1.56*	*1.98*	*1.84*	*0.139*		*Mn*	*101.39*	*869.8*	*705.47*	*231.4*	-----
Ag	*2*	*5*	*3.08*	*1.02*	-----	*Ni*	*160.925*	*211.9*	*183.6*	*17.7*	*20.9*
As	*7.5*	*11.25*	*9*	*1.11*	-----	*Pb*	*13.92*	*21.344*	*15.79*	*2.22*	*39.4*
Ba	*321*	*417*	*356.12*	*31.06*	-----	*Se*	*0.2*	*0.6*	*0.533*	*0.125*	-----
Cd	*0.6*	*3*	*1.91*	*0.86*	*5.5*	*V*	*114.8*	*142.8*	*126.63*	*9.26*	-----
Co	*8.58*	*18.72*	*15.08*	*3.86*	*18.8*	*Zn*	*85.14*	*129.34*	*103.93*	*15.26*	-----
Cr	*210*	*461.2*	*302.26*	*74.2*	*161.9*	*Zr*	*153.92*	*184.26*	*167.05*	*11.42*	-----
Cu	*39.9*	*53.466*	*45.35*	*4.91*	*16.9*						

SD= standard deviation. To find out how much of a difference between the samples and to provide a greater depth of analysis

silver Ag: In the current study, the Ag range was 2–5 ppm, and the average was 3 ppm. The study's average Ag concentration in agricultural soils was greater than the world's average concentration of unpolluted soil (0.01 and 1 mg/kg) [11]. The details are in Table 3.
Arsenic As: In the current study, arsenic levels ranged from 7.5 to 11.25 ppm, with an average of 9 ppm. All samples were above the safe level [11] for 4.7 ppm.
Barium Ba: Ba concentration values in the present study varied from 321 to 417 ppm, averaging 356 ppm; some of these values are considered safe according to [11]at 360 ppm. The details are in Table 3.

Cadmium Cd: The concentration of cadmium in the current study ranges from 0.6 to 3 ppm, with an average of 1.91 ppm and the average concentration of cadmium in agricultural soils in the study was greater than the global average concentration of uncontaminated soil (0.53 mg/kg) [12]. The details are in Table 3.

Cobalt Co: The range of cobalt concentrations in this study was 8.58 to 18.72 ppm, with an average of 15.08 ppm; all of these values were higher than the global average concentration of uncontaminated soil (6.9 ppm) [11]. The details are in Table 3.

Chromium Cr: The amount of Cr can range from 461.2 to 210 ppm in the study area, with an average of 302.26 ppm. The values found were higher than the world scale for unpolluted soils (42 mg/kg) [11]; the details are in Table 3.

Copper Cu: The observed copper values ranged from 39.9 to 53.1 ppm, with an average of 45.35 ppm, higher than the normal global scale for uncontaminated soil (24 ppm) [12]. The details are in Table 3.

Iron Fe: The observed Fe values ranged from 41268 to 48720 ppm, with an average of 45258 ppm, higher than the normal in Riley & Chester of 29264 ppm. Most of the soil samples had significantly high iron levels.

Mercury Hg: In the study area, the average amount of Hg is (1.22 ppm), with values ranging from (1.11- 1.5 ppm). All the soil samples had Hg levels higher than the world average [11] (0.1 ppm).

Manganese Mn: The Mn content varies from 101.39 to 869.8 ppm in soil samples in the study area. Values were also observed to be above the typical level for uncontaminated soil (418 ppm) [11].

Nickel Ni: Ni content in the study area ranges from (160.9 to 211.9 ppm). The measured results exceed the world mean of unpolluted soil (34 ppm) [12].

Lead Pb: Lead concentrations in agricultural soil samples were found to be low compared to concentrations in unpolluted soil (44 ppm) [12], which ranged from (13.9 to 21.34ppm),

Selenium Se: selenium concentrations in soil typically range from(0.2 to 0.6 ppm). The results of the measurements fall within the range of the global mean (0.7 ppm) [11].

Vanadium V: The average V concentration in this study was 126.63 ppm, with a range of 114.8–142.8 ppm. All the soil samples had V levels higher than the world soil average (60 ppm) [11].

Zinc Zn: Zn can range from (85.14 to 129.34 ppm). All the soil samples had levels of Zn that were higher than the world soil average (62 ppm) [11].

Zirconium Zr: Zr concentrations in the examined soil ranged from (153.92 to 184.26 ppm), with a mean concentration of 167 ppm. This indicates all samples were below the [11]safe threshold for Zr (300 ppm).

3.2. Assessment of pollution sources

In the current study, heavy metal pollution in agricultural soil was estimated using the contamination factor (C.F.), the enrichment factor (E.F.), the Geo-accumulation index (I-Geo), Pollution Load Index (PLI .), Ecological risk index (RI) and Potential ecological risk index (Er^i).

3.2.1. **Contamination factor (CF)**

The contamination factor (C.F.) was utilized as an evaluation tool to identify contamination factors that led to higher toxicity of such metals and is a simple and well-known assessment index. (C.F.) is determined by the following formula:

$$\mathbf{CF} = \frac{C\ i\ (heavy\ metal)}{C\ b\ (heavy\ metal)} \qquad \mathbf{(1)}$$

Ci= metal concentration; Cb= the background value of that metal in the soil.
The tolerable levels for soil suggested by [11] were used as permissible levels.

The Contamination Factor was classified, according to [15]Hakanson, 1980 into:

CF≤ 0 uncontaminated ; 0 < CF ≤ 1.1Slight ; 1 < CF ≤ 3Moderate
3 < CF ≤ 5Considerable; 5 < CF ≤6strong C.F ; CF > 6Very strong

The average surface soil CF values for the elements were given in the following order: Ag > Hg > Ni > Cr > Cu > Cd > Co > V > As > Mn > Zn > Ba > Se > Pb > Zr > Zr. Ag, Hg, Ni, and Cr are all found in high amounts in CF soil samples, and Cu is also present. Copper, cadmium, cobalt, vanadium, Manganese, arsenic, and zinc are found in moderate amounts in soil samples from the study area (Table 4). On the other hand, the other metals are found in low amounts. In comparison to other studies (such as Al-Quraishi 2019)[16,17], the Nikl and Tantalum concentrations in CF soil samples are quite high, while the concentrations of Cd, Cr, Br, Sr, Cu, Pb, Zn, Co, M, and V are relatively low to moderate.

Table 4: CF values of heavy elements in the study area for sub-surface soil sample

Elements	CF	MIN	MAX	CFclass
Ag	30.3	20	46	Verystrong
As	1.912	1.59	2.39	moderate
Ba	0.981	0.88	1.15	Slight
Cd	2.18	0.54	4.54	Moderate
Co	2.18	1.24	2.71	Moderate
Cr	7.18	5	10.9	Very strong
Cu	3.241	2.85	3.819	Considerable
Hg	12.25	11	15	Very strong
Mn	1.68	0.242	2.08	Moderate
Ni	10.208	8.94	11.77	Very strong
Pb	0.632	0.55	0.813	Slight
Se	0.761	0.28	0.857	Slight
V	2.109	1.913	2.38	Moderate
Zn	1.672	1.373	2.08	Moderate
Zr	0.55	0.513	0.614	Slight

3.2.2. The pollution load index (PLI)

It is made by using contamination factors (CF). This PLI is used to classify the amount of metal contamination in soil samples.[18] The PLI . is found by taking the n-root of the n-CFs found for all metals. The PLI . can evaluate the level of metal contamination and suggest what to do next[17]. Generally, the pollution load index (PLI) developed by Hakanson in 1980 [15]is as follows:

PLI =n$\sqrt{(CF1xCF2xCF3x \ldots\ xCFn)}$(2)

n = Number of metals

The PLI . value was classified according to Hakanson [15]

0 Perfection ; <1 Baseline Level ; >1 Polluted

The PLI . value of urban soils shows that all soil samples in the study area are contaminated (Table 5)

Table 5: PLI values of heavy elements in the study area for soil sample

PLI	Class
2.57	Polluted
2.26	Polluted
2.48	Polluted

1.88	Polluted
2.29	Polluted
2.38	Polluted
2.55	Polluted
2.217	Polluted

3.2.3.Enrichment factor (EF)

EF is an excellent tool for tracing the origins of heavy metal contamination in agricultural soil samples that will allow us to estimate the level of metal contamination [8]. The EF values of metals in soil samples were determined using the following equation [19].

$$\boldsymbol{EF} = \frac{(C/_{Cfe})\ \boldsymbol{sample}}{(C/_{Cfe})\ \boldsymbol{reference}} \quad (3)$$

C/Fe (sample) is the ratio of the concentrations of metals and Fe in the sample; C/Fe (Earth's crust) is the ratio of the metal concentrations and Fe in the Earth's crust. The Fe was used as a reference element to compare background concentrations in the Earth's crust. This was done assuming that Fe's content in the crust has not been changed by human activity, and Fe was chosen as the normalization element because natural sources make up 98% of its input [12] [8].

Contamination can be seen at a range of levels in the results. When the value is between 0.5 and 1.5, it suggests that natural weathering processes could have only caused the concentration of heavy metals. However, if the EF is greater than 1.5, it indicates that a significant amount of the heavy metals came from sources other than the crust, such as point and non-point pollution)[19].

The EF index can be used to categorize soil quality.[23] Five categories based on the enrichment factor: EF < 2 states deficiency to minimal enrichment, EF= 2 - 5 moderate enrichment, EF= 5 - 20 significant enrichment, EF= 20 - 40 very high enrichment and E.F.> 40 extremely high enrichment.

Table 6: EFvalues of heavy elements in the study area for sub-surface sample

Elements	EF	Max	Min	EFclass
Ag	19.4	27.6	12.3	Significant
As	1.23	1.47	0.98	Deficiency to minimal
Ba	0.63	0.76	0.55	Deficiency to minimal
Cd	1.1	1.68	0.38	Deficiency to minimal
Co	1.41	1.92	0.76	Deficiency to minimal
Cr	4.65	6.76	3.3	Moderate
Cu	2.09	2.5	1.78	Moderate
Hg	7.9	9	7.39	Significant
Mn	1.09	1.29	0.145	Deficiency to minimal
Ni	6.58	7.56	6.12	Significant
Pb	0.4	0.48	0.35	Deficiency to minimal
Se	0.48	0.6	0.2	Deficiency to minimal
V	1.36	1.27	1.55	Deficiency minimal
Zn	1.07	1.29	0.92	Deficiency to minimal

Zr	0.35	0.43	0.31	Deficiency to minimal

Note that the Enrichment factor values in Table 6 are greater than expected for heavy metals from the local soil background. Instead, they may come from other natural and/or human-made sources in urbanized areas, such as vehicle emissions and other activities [8]. Based on the EF, the urban soils were significantly enriched with metals (Ag, Hg, and Ni) and moderately enriched with Cr and Cu. At the same time, minimal enrichment was recorded for As, Ba, Cd, Co, Mn, Pb, Se, V, Zn, and Zr. The pattern of heavy metal contamination in decreasing order by the EF method.Ag>Hg>Ni>Zn>Cr>Cu>As>Ba>Cd>CoMn>Pb>Se> and V>Zr. Anthropogenic activities like using phosphoric fertilizers and herbicides in agricultural soil and their overuse increase heavy metals in the study area [20].

3.2.4.Geo-accumulation index (I-Geo)

The index was used to determine how contaminated the soil was based on how much it was in the background. In this study, the background values are from [12]. Muller's method has been used to study several trace metals. It is calculated using the following equation:

I-geo = log2 (Cn\1:5Bn) (4)

Cn=Where is the amount of heavy metal in the soil; Bn is the geochemical background in the shale; Factor 1.5 is added to the relationship to account for possible differences in background data due to lithological effects [20]

He categorized the geo-accumulation index into Seven pollution grades: I-geo ≤0 (not polluted), 0<I-geo ≤1 (slightly to moderately polluted),1<I-geo ≤2 (moderately polluted), 2<I-geo ≤3 (moderately to strongly polluted),3<I-geo ≤4,(strongly polluted), 4<I-geo≤5 (strongly to extremely polluted), and I-geo>5 (extremely polluted)[21].

Table 7: I-geo values of heavy elements in the study area for sub-surface samples

Elements	Average	Max	Min	class
Ag	2.93	3.42	2.59	moderately
As	0.23	0.46	0.06	slightly
Ba	-0.42	-0.26	-0.52	no polluted
Cd	0.033	0.59	-1.01	no polluted
Co	0.33	0.59	-0.18	slightly
Cr	1.53	1.99	1.2	moderately
Cu	0.757	0.93	0.64	slightly
Hg	2.08	2.3	1.99	moderately
Mn	-0.027	0.32	-1.82	no polluted
Ni	1.9	2.06	1.78	moderately
Pb	-0.87	-0.61	-0.99	no polluted
Se	-5.75	-0.55	-1.65	no polluted
V	0.33	0.46	0.24	slightly
Zn	0.098	0.32	-0.088	no polluted
Zr	-0.988	-0.89	-1.07	no polluted

The measured heavy metals in the examined soil are presented in Table 7 as I-geo values. The soil samples in the study area were moderate to strongly polluted with Ag, and Hg and moderately polluted with Cr and Ni, as measured by the accumulation index. Most of the soil samples tested were found to be in the slightly unpolluted category, as shown by the acquired

I-geo, and the I-geo values for Ba, Mn, Pb, Se, and Zr were predominantly negative, indicating the absence of contamination.

3.2.5.Ecological risk index (RI) and potential ecological risk index (Er^i).

To evaluate the possible ecological risk of heavy metals in soil, the Er^i was developed by [15]. This technique evaluates the soil's contamination level and integrates toxicology with ecology and Environment considerations to give a complete picture of any possible dangers [22].
The environmental impact indicator (Er^i) of metal is described as follows:

$$Er^i = Tr^i \times (Ci/C0) \quad (5)$$

Use the following formula to determine a site's overall RI:

$$RI = \sum Er^i \quad (6)$$

Ci =is the amount of metal I in the soil; C0= is the background concentration; Tr^i is the element's biological toxicity factor (Ti values are: As=10, Cd = 30, Co = 5, Cr = 2, Cu=5, Hg=40, Mn =1 Ni=5, Pb= 5, V =2 and Zn = 1); Er^i =is the potential ecological risk factor for metal I; and RI. is the total potential ecological risk index for metals i–n. Heavy metals were put into five groups based on how long they stayed in the environment [22]. The RI. is divided into five groups:

Table 8: Classification of potential ecological risk index (Eri) [15]

Assessment Criterion PERI	Low	Moderate	Considerable	High	High Very
Er^i	<40	40-80	80-160	160-320	≥320
RI	<150	150-300	300-600	≥600	

Table 9: Ecological risk factors for metals in the study area

Elements	Average	Max	Min	Class (Er^i)	RI.	Class (RI)
As	37	159	17.39	Low	296	Moderate
Cd	65.3	135	16	Moderate	522.9	Considerable
Co	10.9	13.55	6.2	Low	87.25	Low
Cr	14.3	21.8	10	Low	114.76	Low
Cu	16.19	19.05	14.25	Low	129.5	Low
Hg	490	600	440	Very High	3920	very high
Mn	1.68	2.08	0.242	Low	13.5	Low
Ni	51	58.8	44.7	Moderate	408	Considerable
Pb	3.09	4	2.7	Low	24.8	Low
V	4.2	4.76	3.8	Low	33.7	Low
Zn	1.67	2.08	1.37	Low	13.3	Low

Ecological risk index (Er^i): It can be said that except for Hg, Cd, and Ni, the soil is lightly polluted with metals in the following order: Hg > Cd > Ni > As > Cu > Cr > Co > V > Pb > Mn > Zn. The values of ecology risk factors for most heavy metals are less than the critical value of 40. This means that accumulated heavy metals pose a low risk to the soil, except for mercury, which poses a large ecological risk.

3.3.Mineral analysis: XRD Technology

One soil sample is looked at with the XRD method to tell the difference between clay and other minerals in surface soils. In general, the Al-Hayy District has a significant amount of calcite and quartz, as well as other minerals that are not clay, like dolomite, vermiculite, and albite. The clay minerals are kaolinite, illite, and chlorite [16].

Quartz is the most important mineral; 23.4% of the total soils comprise it, which is weather-resistant for long-distance transportation (Figure 2).
Calcite contributes 20.8%, generated in diverse geological conditions. In various calcite-related chemical and physical processes, albite contributes 19.4%, vermiculite 0.7%, and dolomite 7.4%.
Clay minerals are kaolinite (7.7%) and illite (12.4%), formed through chemical weathering. The types of clay minerals depend on the climate and the quality of the source rocks [17].

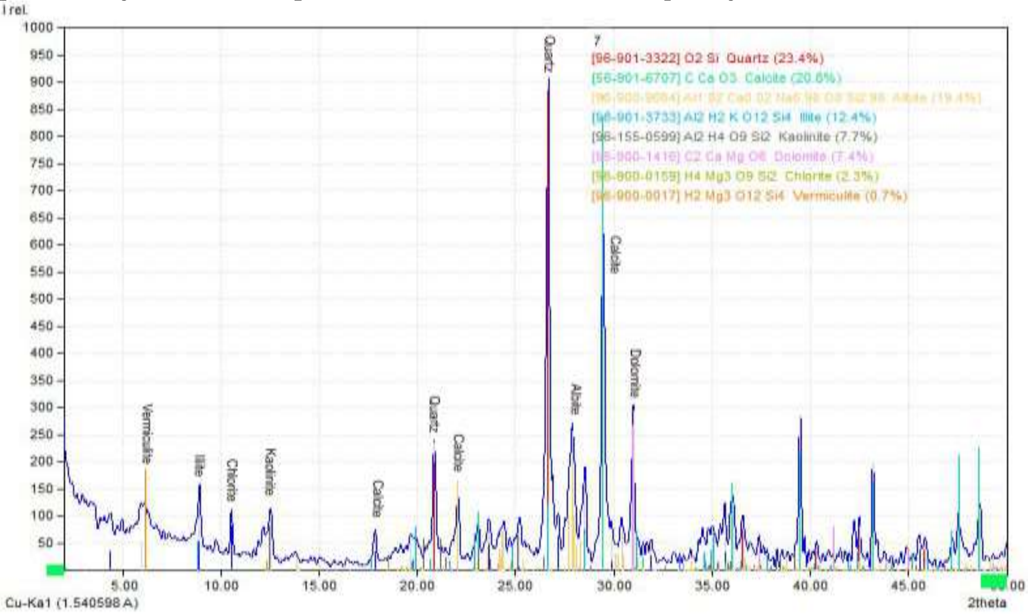

Figure 2: X-ray diffraction graph of Al-Hayy District soil; samples Number 7K

Sources of Contaminations with Heavy Metals
Toxic substances have accumulated in the environment due to the accelerated growth of industry and the increased use of pesticides and fertilizers in agricultural areas [24]. The main sources of anthropogenic emissions in the study area are as follows:

1. Mobile sources, such as vehicles and their fuel, produce linear emissions.
2. Emissions sources include factories in the region, such as bricks and cashiers.
3. The irrigated soil containing heavy metals was the subject of several recent publications.

According to research [25], wastewater irrigation can significantly alter the physical and chemical composition of the soil, leading to higher levels of mineral absorption by plants, particularly vegetables.

4. A major cause of exposure to heavy metals is atmospheric pollution. Heavy metals extracted from air deposits in surface soil can accumulate through precipitation, trapping and interception [8].
5. The soil could be a source of heavy metals that are discharged into the surrounding water through natural and anthropogenic processes [26].

Natural sources: Soil pollution is caused in part by the increased use of heavy metals and by natural events such as dust storms and deposition from the air [20].
Anthropogenic sources: The main causes are burning fuels, industrial waste, watering crops with sewage, and using chemical fertilizers and pesticides.

4. Conclusions

Based on the results of the current study.

1. Most heavy metal concentrations are higher than their background levels. Different locations had varying heavy metal pollution levels and concentrations, demonstrating the uneven distribution of human activity. Iron formed the highest concentration of the trace elements examined as being naturally present in the Iraqi soil, followed by magnesium and chrome. Manganese has the lowest content in the study area.
2. The CF contains significant contamination concentrations in Ag, Cr, Hg, Cu, and Ni. As shown by PLI analysis, all samples are contaminated and have significantly enrichment factors (Ag, Hg, and Ni), while I-Geo for Ag, Hg, Ni, and Cr is moderately contaminated. Class Eri, Very High in Hg, and RI.
3. XRD test shows that the soil contains the highest quantity of quartz, followed by calcite, while vermiculite has the lowest in the region.

References

[1] G. Li, N. Lu, Y. Wei, and D. Zhu, "Relationship between Heavy Metal Content in Polluted Soil and Soil Organic Matter and pH in Mining Areas," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 394, no. 5, 2018.

[2] A. Mahmood, A. H. Mahmoud, A. I. Z. El-Abedein, A. Ashraf, and B. M. A. Almunqedhi, "A comparative study of metals concentration in agricultural soil and vegetables irrigated by wastewater and tube well water," *J. King Saud Univ. - Sci.*, vol. 32, no. 3, pp. 1861–1864, 2020.

[3] T. Karak, P. Bhattacharyya, R. Kumar Paul, and D. K. Das, "Metal accumulation, biochemical response and yield of Indian mustard grown in soil amended with rural roadside pond sediment," *Ecotoxicol. Environ. Saf.*, vol. 92, pp. 161–173, 2013.

[4] R. Chen *et al.*, "Assessment of Potential Heavy Metal Contamination in the Agricultural Soils Based on Various Improved Evaluation Methods in Beijing, China," 2021.

[5] L. bo Pan, J. Ma, X. liang Wang, and H. Hou, "Heavy metals in soils from a typical county in Shanxi Province, China: Levels, sources and spatial distribution," *Chemosphere*, vol. 148, no. December, pp. 248–254, 2016.

[6] I. M. Al-sudani, M. H. Al Lami, A. Hameed, M. J. Al, and S. M. J. Al-rubaye, "Spatial Distribution of Some Heavy Metals in Urban Soil of Western Iraq," vol. 25, no. 4, pp. 10550–10558, 2021.

[7] M. S.Mohammed, E. J. Abdullah,. Heavy metals pollution assessment of the soil in the northern site of east Baghdad oil field, Iraq. *Iraqi Journal of Science*, *vol.57* .no.1A, pp.175-183, 2016.

[8] A. H. M. J. Al Obaidy and A. A. M. Al Mashhadi, "Heavy Metal Contaminations in Urban Soil within Baghdad City, Iraq," *J. Environ. Prot. (Irvine,. Calif).*, vol. 04, no. 01, pp. 72–82, 2013.

[9] A. Hameed, M. J. Al Obaidy, and F. H. A. Ali, "Assessment of Heavy Metals Pollution in Soil Affected by Industrial Activities," *Eng. &Tech.Journal*, vol. 33, no. 3, pp. 526–534, 2015.

[10] A. Z. Abass, D.Pavlyuchenko, H. T. AlRikabi, F. T. Abed, and J. Gaidukov, "Economic Feasibility Study of a Hybrid Power Station Between Solar Panels and Wind Turbine with The National Grid in Al-Hayy City in the Central of Iraq," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1184, no. 1, p. 012001, 2021.

[11] Mukherjee, A. B., & Kabata Pendias," A. Trace elements from soil to human ," 2007.

[12] A. Kabata-Pendias ," *Trace elements in soils and plants: Fourth edition*," 2010.

[13] Riley, J. P., & Chester, R," Introduction to marine chemistry," 1971.

[14] K. H. Khwedim, H. R. A.- Anssari, and K. S. A.- Bassam, "Study of Distribution of Some Heavy Metals in the Soil of Basra City- South of Iraq," *Iraqi J. Sci.*, vol. 4, no. 50, pp. 533–542, 2009.

[15] Hakanson, "An ecological risk index for aquatic pollution control. a sedimentological approach," *Water Res.*, vol. 14, pp. 975–1001, 1980.

[16] R. I. Muslim, M. J. Issa, and B. S. Al-Obaidi, "Environmental assessment of heavy metals concentration and distribution in surface soils of wasit governorate/ Iraq," *Iraqi J. Sci.*, vol. 60, no. 4, pp. 803–818, 2019.

[17] R. I. M. Al-quraishi, "Environmental Geochemistry of Wasit Governorate , Iraq," 2019

[18] E. H. Shaker, "Environmental Impact Assessment of Brick Industry at Abu Smeache Area ,

Southwest Babylon Governorate - Iraq," 2019.
[19] J. Rani and S. Chaudhary, "Evaluation of Heavy Metals Contamination in Agricultural Soils," pp. 1–14, 2021, [Online]. Available.
[20] E. Shifaw, "Review of heavy metals pollution in China in agricultural and urban soils," *J. Heal. Pollut.*, vol. 8, no. 18, 2018.
[21] Kamil, H. M., & Abdulhussein, F. M.. Evaluation of Vanadium Contamination in Some Soils of the East Baghdad Oil Field. *Iraqi Journal of Science*, pp.2959-2972, 2023.
[22] R. Mirzaei, S. Teymourzade, M. Sakizadeh, and H. Ghorbani, "Comparative study of heavy metals concentration in topsoil of urban green space and agricultural land uses," *Environ. Monit. Assess.*, vol. 187, no. 12, 2015.
[23] M. Barbieri, A. Nigro, and G. Sappa, "Soil contamination evaluation by Enrichment Factor (EF) and Geoaccumulation Index (Igeo) Messinian stratigraphy in Southern Apennines foreland basins View project Cost Action 620 View project," vol. 2, no. 3, pp. 94–97, 2015.
[24] A. Zwolak, M. Sarzyńska, E. Szpyrka, and K. Stawarczyk, "Sources of Soil Pollution by Heavy Metals and Their Accumulation in Vegetables: a Review," *Water. Air. Soil Pollut.*, vol. 230, no. 7, 2019.
[25] A. Mahmood and R. N. Malik, "Human health risk assessment of heavy metals via consumption of contaminated vegetables collected from different irrigation sources in Lahore, Pakistan," *Arab. J. Chem.*, vol. 7, no. 1, pp. 91–99, 2014.
[26] S. A. Ibrahim, M. F. Abed, &, B. S. Al-Tawash., "Calculation of pollution indicators and health hazards of heavy elements in surface soils in Samarra City," *Iraqi Journal of Science*,pp. 1419-1429,2018.