Ali and Abdullah *Iraqi Journal of Science, 2024, Vol. xx, No. x, pp: xx*
DOI: 10.24996/ijs.2024.65.12.18

ISSN: 0067-2904

Distribution Of Some Heavy Metals in Soils of Abu-Ghraib Land, Baghdad, Iraq

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Received: 13/9/2023 Accepted: 28/11/2023 Published: xx

Abstract

Heavy metals and metalloids can accumulate in the soil, cause severe risks to human health and the ecosystem, and threaten the sustainable use and management of soil resources. This study investigated the Distribution and levels of heavy metals in soils of different lands in Abu-Ghraib (AGP), Baghdad, Iraq. Twenty-seven samples from cultivated soil and two uncultivated soil samples were collected during February 2023 from the surface layer (0–30 cm depth) and analyzed for major oxides and heavy metals. Different parameters were utilized to investigate the naturality of studied soils, including grain size analysis, pH, total dissolved solids (TDS), electrical conductivity (EC), and trace elements (TEs) concentration. Analysis of grain size indicated that all soil samples were silty clay. The mean pH of the collected soils was 7.9, indicating its alkaline nature. Also, the mean of EC and the TDS of the studied soils was 801.55 µS/cm and 0.80155dS/m, respectively, referring to their non-salinity. Mineralogical analysis by XRD indicated the presence of non-clay minerals, such as calcite, quartz, feldspar, and dolomite, and clay minerals, such as illite, kaolinite, and palygorskite. Levels of Al_2O_3, CaO, Fe_2O_3, K_2O, MgO, P_2O_5, and SiO_2 were interchangeably found high in both types of soils, with CaO (19.84ppm), MgO (7.18ppm), and TiO_2 (0.78ppm) being slightly higher in the uncultivated soils. TE concentrations followed a descending order of Mn> Cr> Ni> V> Zn> Cu> Pb> Co> Mo> As> Th> Cd> U> Se in the cultivated soils and Mn> Cr> Ni> V> Zn> Co> Cu> Pb> Mo> Th> As> Cd> U> Se in the uncultivated soils. The results also showed that the concentrations of Cr (262.36> 200ppm), Mo (10.87> 10ppm), Ni (190.24> 150ppm), and V (157.68> 150ppm) acceded the maximum allowable concentrations. Such elevated concentrations of TEs in Abu-Ghraib soils are concerning and may lead to abnormal plant growth, reduced biodiversity, and increased risk of human health problems.

Keywords: Abu-Ghraib cultivated soil, heavy metal concentrations, soil contamination, soil evaluation, environmental concerns.

توزيع بعض المعادن الثقيلة في تربة منطقة أبو غريب، بغداد، العراق

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الخلاصة

تراكم المعادن الثقيلة والمعادن نصفية الثقل في التربة يؤدي الى عوائد خطيرة لصحة الإنسان والنظام البيئي، ويهدد الاستخدام المستدام وإدارة موارد التربة. قامت هذه الدراسة بفحص توزيع ومستويات الفلزات الثقيلة في تربة أراضي مختلفة في مدينة أبو غريب (AGB)، بغداد، العراق. تم جمع 27 عينة من التربة المزروعة وعينتين من التربة غير المزروعة خلال فبراير 2023 من الطبقة السطحية للتربة (عمق 0–30 سم) وتحليلها للكشف عن وجود الاكاسيد والمعادن الثقيلة. استخدمت معلمات مختلفة لفحص طبيعة التربة المدروسة، بما في ذلك تحليل حجم الحبيبات، درجة الحموضة (pH)، المواد الصلبة الذائبة الكلية (TDS)، التوصيل الكهربائي (EC)، وحيود الأشعة السينية (XRD). أظهر تحليل حجم الحبيبات أن جميع عينات التربة كانت غرينية طينية ذات حبيبات دقيقة. كان متوسط درجة الحموضة (pH) للتربة المجمعة 7.9، مشيراً إلى طبيعتها القلوية. أيضًا، كان متوسط التوصيل الكهربائي (EC) ومواد الصلبة الذائبة الكلية (TDS) للتربة المدروسة هو 801.55 ميكروسيمنتز/سم و 0.80155 ديسيسيمنز/م، على التوالي، مشيرة إلى عدم وجود الملوحة. أظهر تحليل المعادن بواسطة التفاوت الأشعة السينية (XRD) وجود معادن غير طينية مثل الكالسيت والكوارتز والفلدسبار والدولوميت، ومعادن طينية مثل الإيليت والكاولينايت والباليغورسكايت. كانت مستويات Al_2O_3 و CaO و Fe_2O_3 و K_2O و MgO و P_2O_5 و SiO_2 مرتفعة بشكل متبادل في كلا أنواع التربة، مع ارتفاع طفيف في CaO (19.84 ppm) و MgO (7.18 ppm) و TiO_2 (0.78 ppm) في التربة غير المزروعة. اتبعت تراكيز العناصر النادرة ترتيبًا تنازليًا لـ Mn > Cr > Ni > V > Zn > Cu > Pb > Co > Mo > As > Th > Cd > U > Se في التربة المزروعة و Mn > Cr > Ni > V > Zn > Co > Cu > Pb > Mo > Th > As > Cd > U > Se في التربة غير المزروعة. أظهرت النتائج أيضًا أن تركيزات Cr (262.36>200ppm) و Mo (10.87>10ppm) و Ni (190.24>150ppm) و V (157.68>150 ppm) تجاوزت التركيز الأقصى المسموح به في التربة. قد تؤدي تراكيز العناصر النادرة هذه في تربة أبو غريب إلى نمو نباتي غير طبيعي وتقليل التنوع البيولوجي وزيادة مخاطر المشاكل الصحية للانسان.

1. Introduction

Abu-Ghraib agricultural land is located within the lower Mesopotamian plain, characterized by Holocene deposits predominantly belonging to the floodplain of the Euphrates River. Additionally, a narrow eastern strip of the area is composed of sediments from the Tigris River [1]. Soil is rich with compositional values of minerals and oxides, and it is challenging to understand its natural resources because of their high heterogeneity. Different laboratory analyses are used to learn about the soil systems and evaluate their quality and content [2].

Soils polluted with TEs, such as Arsenic (As), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Manganese (Mn), Molybdenum (Mo), Nickel (Ni), Lead (Pb), Selenium (Se), Thorium (Th), Uranium (U), Vanadium (V), and Zinc (Zn) must be treated to lessen the dangers involved and adjusted to make it suitable for agricultural use. Understanding the chemistry and mechanism of action of TEs can help measure their impact on the environment and the threats they pose to human health. TE contamination is mitigated by the soil's ability to filter, buffer, store, and alter the elements. The soil can only perform such activities if its biological activity and cation exchange capability are monitored and maintained. Soil polluted with TEs is often cleaned using overarching strategies, such as extraction, physical separation, toxicity reduction, immobilization, or isolation [3], [4].

Plants are more likely to absorb metals from the soil, especially when metals are found in high concentrations [5]. Reduced soil fertility is a significant barrier to raising crop yields [6]. Improved soil fertility may be achieved using fertilizers; however, excessive use of inorganic fertilizers to treat lands used for agricultural purposes leads to severe health risks and irreversible environmental damage. Thus, organic farming, also known as sustainable farming or ecological farming, was established in response to concerns about synthetic fertilizers' potential health and environmental impacts [7].

Abu-Ghraib land is known for its poor soil quality, high salinity, and outdated irrigation systems. Thus, evaluating the chemical properties of the land and measuring the levels of TEs and oxides may help find solutions to increase the land's suitability for agriculture. In this study, the grain size, pH, electrical conductivity, oxides, and heavy metals levels of different cultivated and uncultivated soils from Abu-Ghraib land, Baghdad, Iraq, are extensively investigated.

2. Materials and Methods

2.1 Collection and preparation of samples

Twenty-seven samples (S1-S27) from cultivated soils and two uncultivated soils (S28 and S29) were collected during February 2023 from the surface layer (0–30 cm depth) using a hand auger and a plastic bag. The collected soils for testing are annotated on the map of Abu-Ghraib (Figure 1 and Figure 2). Samples were tested at the Iraqi-German Laboratory, Department of Geology, University of Baghdad.

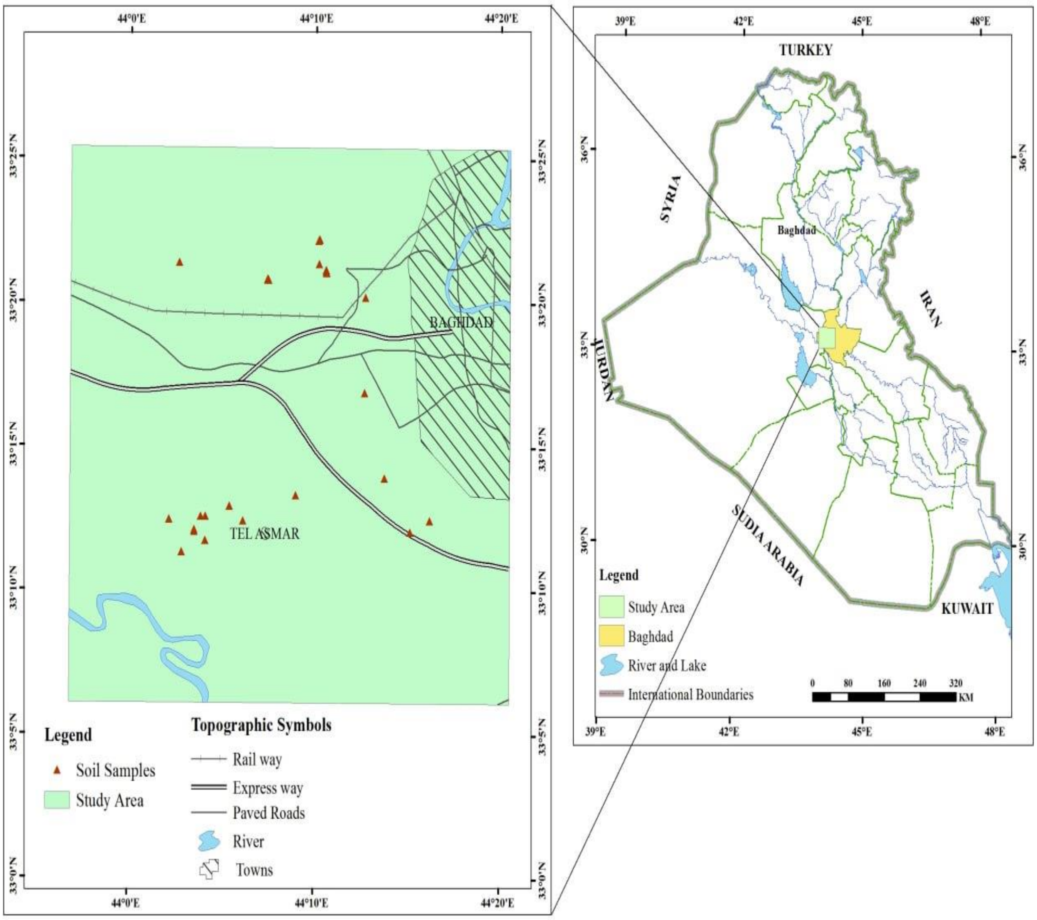

Figure 1: Location map of plant samples (ARC GIS map). (Source: Iraq Geological Survey).

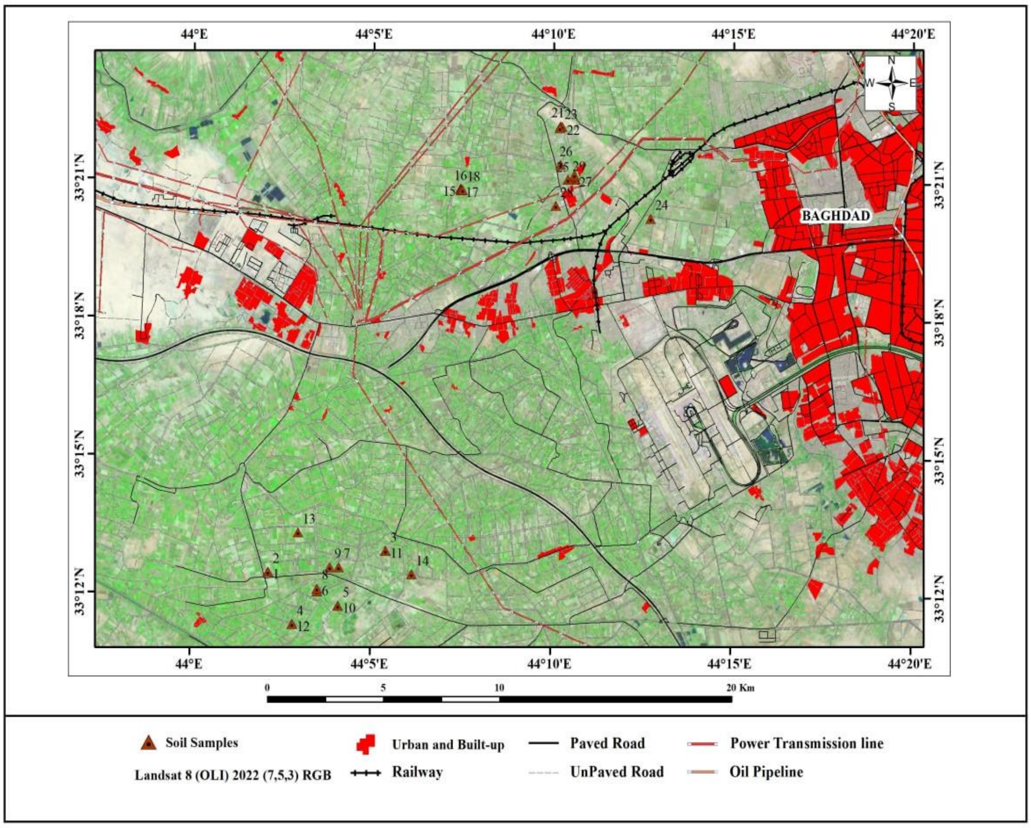

Figure 2: Landsat 8 (OLI) 2022 (7, 3, 5) RGB Abu-Ghraib site (source: Iraq Geological Survey).

2.2 Accuracy and Precision

The TEs of the international standard sample were measured, and then the results were compared with the recommended standard**.** Precision is expressed as the coefficient of variation calculated by [8], [9]:

$$P = \left(2 \times \frac{Std.\ Deviation}{Mean}\right) \times 100\% \qquad (1)$$

Where: P is the precision at a confidence interval of 95% with a permissible limit of ≥ 25.

2.3 Physical parameters

Different parameters were utilized to investigate the naturality of studied soils, including grain size analysis, pH value, total dissolved solids (TDS), and Electrical conductivity (EC).

2.4 Mineralogical Composition

Mineralogical analysis by X-ray diffraction (XRD) was performed to measure and compare the compositions between clay and non-clay minerals, where four soil samples were randomly selected for evaluation.

2.5 Chemical Parameters

Atomic Absorption Spectrometer (AAS) was used to measure the major oxides (potassium oxide (K2O), magnesium oxide (MgO), iron oxide (Fe_2O_3), aluminum oxide (Al_2O_3), calcium oxide (CaO), silicon dioxide (SiO_2), titanium dioxide (TiO2), and phosphorus pentoxide (P2O5), as well as the trace elements (Mn, Cr, Ni, V, Zn, Cu, Pb, Co, Mo, As, Th, Cd, U, and Se) in soil samples.

Results and Discussion

Two uncultivated and 27 cultivated soil samples were examined to determine the geochemistry of the soil in the study area. The results of detected TEs, as represented in Figure 3, indicated that the precision of U was 22.22%, which was the highest precision value, while the lowest precision value was 0.00% for both Cd and Se, which may indicate the difficulty of detecting them; therefore, the precision results were accepted.

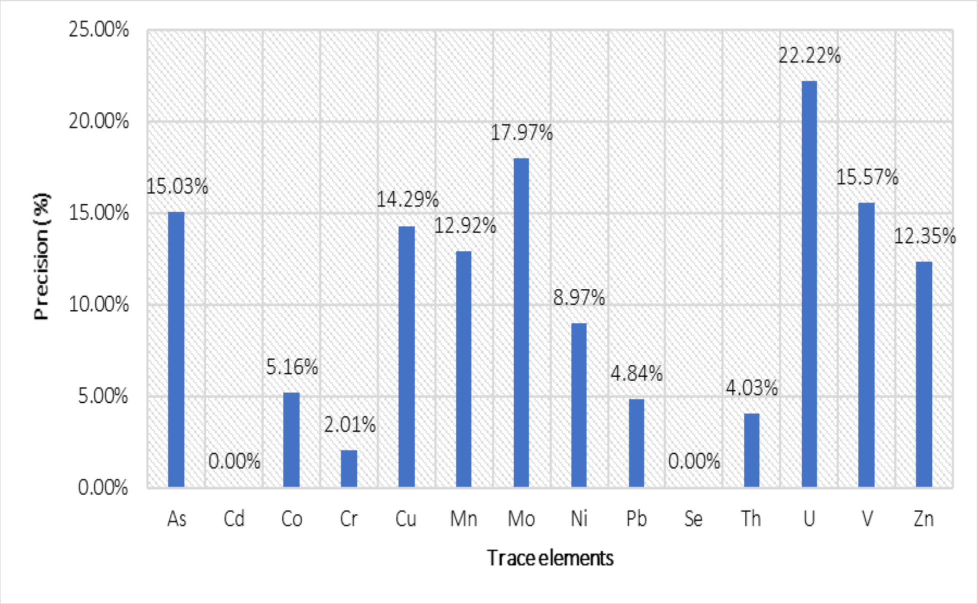

Figure 3: Precision values of trace elements in the soils at a 95% confidence interval.

Soil has a variety of minerals, oxides, and organic substances, as well as a physical texture that includes particle size distribution [10]. The capacity to interchange and retain chemicals delivered to the soil by solutions is influenced by the texture of the soil [11]. In general, soil grain size can affect the behaviour and Distribution of trace elements in the soil. The smaller the soil particle size, the more surface area for contaminants to bind to. Contamination affects texture class because fine soil, such as clay, absorbs more cations than coarse fractions [12]. This study analyzed twenty-nine soil samples (27 cultivated and 2 uncultivated) and presented the grain size assessments (Table 1). Also, the grain size analysis result indicated that all soil samples fall within the silty clay nature, as shown in Figure 4, using the triangular diagram of soil textural classes according to the USDA particle sizes.

Table 1: Grain size assessment of the soil samples used in the study.

Samples	Sand %	Silt %	Clay %	Class
S1	12.4	53.7	33.9	Silty Clay Loam
S2	8.6	49.9	42. 5	Silty Clay
S3	11.3	40.2	48.5	Silty Clay
S4	9.1	49.5	41.4	Silty Clay
S5	7.7	46.2	46.1	Silty Clay
S6	8.5	51.2	39.3	Silty Clay Loam
S7	13.4	49.1	37.5	Silty Clay Loam
S8	11.7	48.9	40.4	Silty Clay
S9	6.8	56.5	36.7	Silty Clay Loam
S10	8.6	51.9	39.5	Silty Clay Loam

S11	8.6	45.4	46.1	Silty Clay Loam
S12	7.1	42.1	50.8	Silty Clay Loam
S13	12.7	39.2	48.1	Clay
S14	9.5	40.1	49.4	Silty Clay Loam
S15	8.3	54.9	36.8	Silty Clay
S16	9.5	45.8	45.7	Silty Clay Loam
S17	12.2	39.3	48.5	Clay
S18	7.7	47.1	44.2	Silty Clay Loam
S19	5.8	53.7	40.5	Silty Clay Loam
S20	7.1	52.5	40.4	Silty Clay Loam
S21	6.6	42.2	51.2	Silty Clay Loam
S22	11.9	52	36.1	Silty Clay
S23	10.9	49.6	39.5	Silty Clay
S24	9.7	55.5	34.8	Silty Clay
S25	7.5	52.8	39.7	Silty Clay
S26	8.9	55.5	35.6	Silty Clay
S27	6.4	39.8	53.8	Clay
S28	9.7	48.8	41.5	Silty Clay Loam
S29	11.4	42.9	46. 7	Silty Clay Loam
Mean ± SD	9.3 ± 2.12	48.15 ± 5.5	42.59 ± 5.49	
Range	13.4 - 5.8	39.2 - 56.5	33.9 - 53.8	

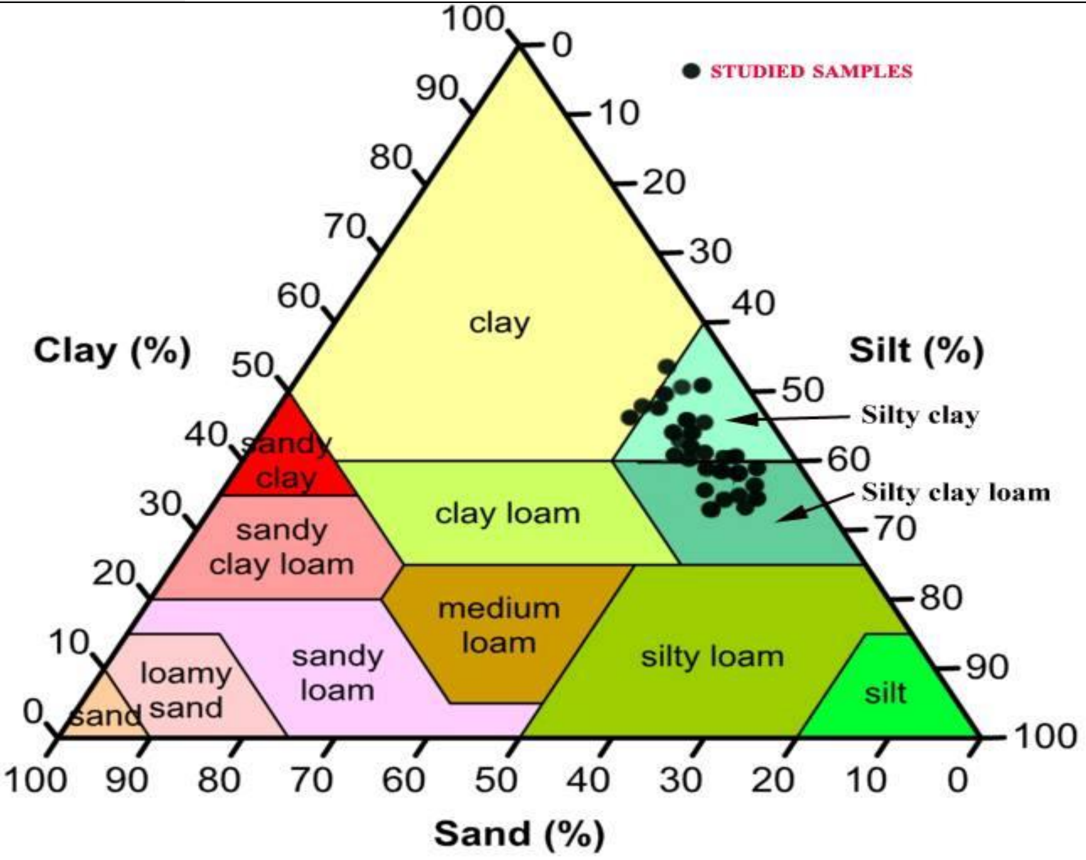

Figure 4: USDA diagram of soils collected from the study area samples (S1-S27).

The pH of the soil is an essential factor in the mobility and bioavailability of toxic heavy metals in the soil; its value demonstrates the acidity or alkalinity of the soil [30]. Elements become increasingly rare under higher alkaline situations [13]. The pH levels for the most natural soils are varied from 4.5 to 8.5. Alkaline soils (pH>7) contain solid phase carbonate, while bicarbonate is the dominating anion in solution. In this study, the mean pH of the soil was 7.9, so it was moderately alkaline (Figure 5). Also, the mean EC of soil was 801.55$\mu S.cm^{-1,}$ and it was non-saline (0.80155$dS.m^{-1}$) (Figure 6). This is in agreement with previous findings [14]. The pH of the Iraqi soil is mainly alkaline, with a pH ranging between 8 and 9. Al-Dahar et al. [15] reported that the pH of AGP was between 7.6 and 7.8, suggesting that it is attributed to the high content of cinders, ash, and carbonate coming from the soil's anthropogenic origin. The reported mean pH of the soil in AGP was 7.74, and the mean EC was 2.55 $dS.m^{-1}$.

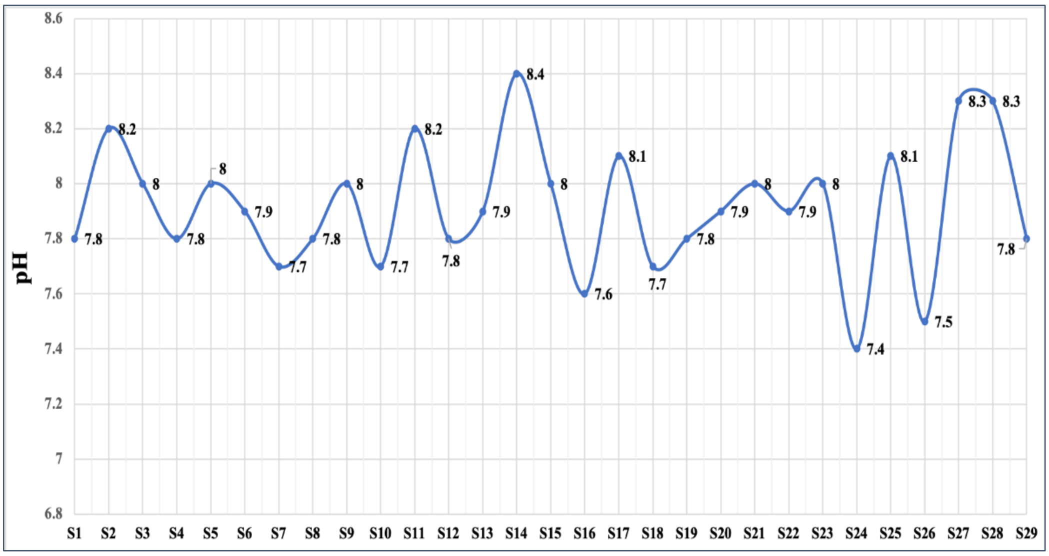

Figure 5: pH values of the soil samples (S1-S29) used in the study.

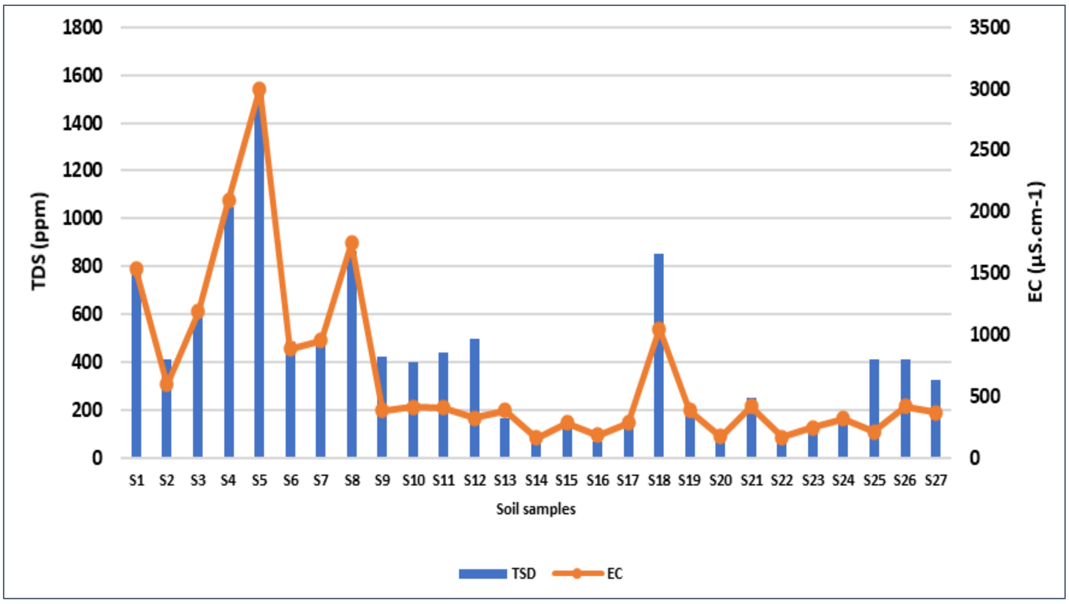

Figure 6: Physical parameters of soil samples. S1-S29: soil samples.

The results of the mineralogical analysis by XRD showed the presence of non-clay minerals of calcite (>20%), quartz (>40%), feldspar, and dolomite, and clay minerals that illite, kaolinite, and palygorskite represented, and only (56%) of the samples have albite (Figure 7). Similar reports showed that the soil of Baghdad city is composed of non-clay minerals, such as quartz, calcite, gypsum, albite, and halite, and clay minerals, such as illite, kaolinite, and chlorite, which are widespread in the Iraqi soil [7].

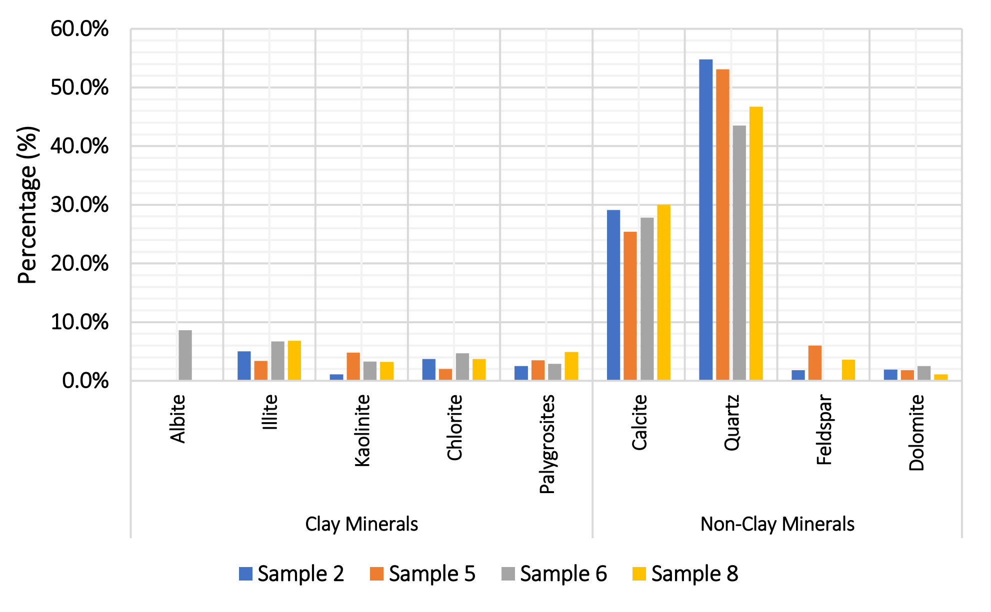

Figure 7: The mineralogical composition of the study soil.

Major oxides and trace elements in the cultivated and uncultivated soils were also measured. Based on the results, the mean concentration of Al_2O_3, CaO, Fe_2O_3, K_2O, MgO, P_2O_5, and SiO_2 in cultivated soil was 8.67, 17.51, 5.94, 1.45, 5.32, 0.28, 35.9, and 0.77 ppm, higher than that in uncultivated soils, which was at 7.99, 19.84, 5.43, 1.16, 7.18, 0.19, and 34.24 ppm, respectively (Figure 7). SiO_2 concentrations were the highest, followed by CaO, Al_2O_3, Fe_2O_3, MgO, K2O, TiO_2, and, last, P_2O_5 in both soil types. However, CaO (19.84 ppm), MgO (7.18 ppm), and TiO_2(0.78 ppm) were slightly higher in the uncultivated soils.

Table 2: Concentrations of major oxides (ppm) compared to reported from local and international studies.

Major Oxides	Cultivated Soil		Uncultivated Soil		S1	S2	S3	*Local soil	*International soil
	Mean ± SD	Range	Mean ± SD	Range					
Al_2O_3	8.67 ± 2.17	10.62 – 0.02	7.99 ± 0.17	8.11 – 7.88	4.59	13.11	12.64	5.94	15
CaO	17.51 ± 4.21	25.27 – 0.3	19.84 ± 2.4	21.53 – 18.14	11	14.24	18.91	ND	2
Fe_2O_3	5.94 ± 1.49	7.21 – 0.04	5.43 ± 0.51	5.79 – 5.07	5.014	6.68	7.3	3.08	5
K_2O	1.45 ± 0.57	3.69 – 0.95	1.16 ± 0.19	1.3 – 1.03	0.314	ND	1.89	0.98	1.6
MgO	5.32 ± 1.12	7.28 – 0.54	7.18 ± 1.23	8.05 – 6.31	4.17	4.57	6.88	ND	1.5
P_2O_5	0.28 ± 0.17	1.1 – 0.17	0.19 ± 0.09	0.25 – 0.13	0.126	5.6	0.33	0.16	0.19
SiO_2	35.9 ± 7.99	42.77 – 0.44	34.24 ± 0.95	34.91 – 33.57	9.629	ND	48.66	ND	6
TiO_2	0.77 ± 0.18	0.93 – 0.01	0.78 ± 0.07	0.83 – 0.74	0.166	0.79	0.79	0.44	0.67

S1: A local study at Al-Najaf, Iraq by Hussein, R. F., (2018) [9].

S2: A local study at Al-Najaf and AL-Diwaniya, Iraq by Abokhahella et al., (2015) [16].
S3: A local study at Abu-Ghraib by Mena F., (2018) [17].
* Local reference, AL-Bassam and Yousif (2014) [14].
** International reference, Reimann and Caritat (2012) [18].
ND: No Data.

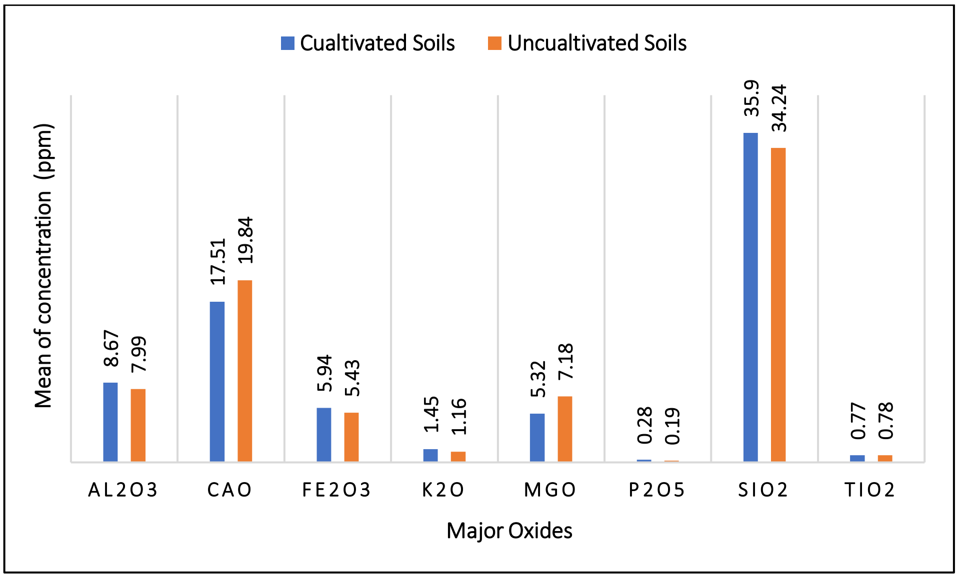

Figure 8: Concentrations of major oxides (ppm) of soil samples in this study.

However, cultivated soils of nearby provinces Najaf and Qadisiyah, Iraq, had much higher concentrations of Al_2O_3 (13.11 ppm), Fe_2O_3 (6.68 ppm), and P_2O_5 (5.6 ppm), and slightly lower concentrations of CaO (14.24 ppm) and MgO (4.57 ppm), indicating that the study area has lower levels of major oxides than these provinces [16]. A study in AGP found that the major oxides were SiO_2, CaO, Fe_2O_3, Al_2O_3, MgO, K_2O, TiO_2, and P_2O_5, which were at concentrations of 48.66, 18.91, 12.64, 7.3, 6.88, 1.89, 0.79, and 0.33 ppm, respectively [17], where SiO_2 and Fe_2O_3 were slightly higher than the concentrations reported in this study.

The iron oxide (Fe_2O_3) of the soil is not only important, along with the clay content, for the phosphate-fixation capacity of the soil but is also crucial in poising the oxidation-reduction of the soil (on being waterlogged) with organic matter, making the iron available to the crop, and developing under suitable conditions the characteristics of the soil profile [16].
Magnesium helps activate several plant enzymes critical for development and is a component of the chlorophyll found in all green plants, making it essential for photosynthesis. Magnesium is a vital nutrient for plant growth and can be obtained from various places [19]. By their very geological and mineralogical character, phosphate rocks contain different chemical components that harm the environment. Fertilizer containing superphosphates is a major source of contamination for agricultural soils since it is rich in these potentially harmful substances [20]. Thus, evaluating the soil compositions before using it for plant cultivation is important.

The results in Table 1 indicated that the mean levels of TEs in cultivated soil of the study area followed a descending order of Mn>Cr>Ni>V>Zn>Cu>Pb>Co>Mo>As>Th>Cd>U>Se. For uncultivated soil, the highest concentrations of TEs were Mn>Cr>Ni>V>Zn>Co>Cu>Pb>Mo>Th>As>Cd>U>Se.

Table 3: Concentrations of trace elements (ppm) of soil samples in this study.

TEs	**Cultivated Soil**		**Uncultivated Soil**		**S1***	**B***	**MAC***
	Mean	**Range**	**Mean**	**Range**			
As	8.52	0.37-73.04	9.12	5.13-5.45	1.8	1.8	15-20
Cd	2.83	2-20	0.2635	2.0 - 2.0	0.1	0.1	1.0-5
Co	17.63	3.07-31.14	23.17	8.65-74.72	10	10	20-50
Cr	262.36	217.78-319.52	109.95	185.42-295.64	100	100	50-200
Cu	62.6	21.25-432.19	49.22	37.15-37.71	55	55	60-150
Mn	821.79	12.55-1019.96	646.65	583.71-819.38	900	900	-
Mo	10.87	1-16.8	0.728	15.2 - 15.2	1.5	1.5	4-10.0
Ni	190.24	14.22-246.76	193.35	135.32-189.47	20	20-60	75-150
Pb	19.45	97.75-4.64	13.335	14.95-15.78	14	14	20-300
Se	0.49	0.2-0.5	0.68	0.5 - 0.5	0.05	0.05	-
Th	5.22	0.5-6.9	5.5	4.4-6.6	7.2	-	-
U	0.88	0.4-1.6	1.147	0.6-1	2	2	-
V	157.68	4.48-1336.81	74.35	114.27-136.68	135	135	150
Zn	142.64	23.46-937.56	73.85	91.19-101.79	70	70	100-300

*S1 is a reference value from a local study conducted by Hussein [9]. B is a background value compiled from Reimann and Caritat (2012) [18]. The mean values for various soils in different countries and the maximum allowable concentration (MAC) [9].

It is widely known that As is ubiquitous in nature and a pervasive pollutant found in water, sediment, and soil across nations, which arises from both natural occurrences and human activities. The three primary anthropogenic sources of As are pesticide manufacture, mining and smelting, and the combustion of coal and its byproducts [21]. The mining and metal processing sectors are a significant source of As in the environment, primarily due to copper smelting, which accounts for 40% of the total contribution. Other mining operations contribute 16% to the overall As input [22]. The concentration of As in soils depends on the parent rock from which the soil is derived. The present study examined the average concentration of As in cultivated soil, which was 8.52 ppm, lower than its levels in uncultivated soil (9.12 ppm) and lower than the maximum allowable concentration.

Several studies implicated that Cd was present in soils contaminated by anthropogenic activities such as mining and smelting, and it is more bioavailable than Cd from impacted soils [23]. The concentration of Cd in the soil has been observed to grow as a result of multiple factors, including the rise in organic matter content, the presence of cadmium in the rock base, industrial activities, the utilization of conditioners and pesticides, and the influence of water drainage [24]. Two factors work together to influence the process of soil enrichment, which increases the amount of Cd in the soil. The relative mobility of Cd is the first factor, and its affinity for binding to organic matter is the second [25]. In the soil solution, most of the Cd is present as free Cd^{+2} and CdHCO^{+3}, while most of the Cd added to calcareous soils was rapidly adsorbed or precipitated in the solid phase, and organic Cd complexes were minimal [26]. Our result showed that the mean concentration of Cd in cultivated soil was 3.53 ± 2.83 ppm and much lower in the uncultivated soils, falling within the MAC. These values are lower than those reported by Sultan (2010) [24], who documented a concentration of 5 ppm in soils from Abu Ghraib and a higher concentration of 25 ppm in Yarmouk district, Baghdad.

Phosphate fertilizers are one of the leading causes of the increase in the Cd concentration in soil solutions. On the other hand, Cd desorption from the soil matrix, which happens at low soil pH, may also be the cause of the rise in Cd [27]. A significant proportion, potentially reaching

90% of Cd contamination from different sources, remains inside the uppermost 15 cm of soil at the initial site. The emission of Cd from industrial sources is widely recognized as a significant factor in the prevalence of diseases in agricultural regions spanning multiple countries [28].

The elevation of Co concentrations in soil can be attributed to various variables, encompassing the soil's origin and composition, processes of weathering, human activities, and the influence of irrigation water [24]. In this study, the mean of Co concentration in soil was determined to be 17.63 ± 8.04 ppm. The concentrations found in the soil samples varied from 3.07 to 31.14 ppm. These results were less than what Sultan (2010) [24] had previously reported, who found 51 ppm of CO in the Abu Ghraib region and 53 ppm in Waziriyah, Baghdad. Co concentrations, on the other hand, are within the MAC and are not alarming. The immobile residual fractions of soils are where chromium is primarily found [29]. The present investigation revealed that the average concentration of Cr in the cultivated soil was determined to be 262.36 ± 29.26 ppm, with a range spanning from 217.78 to 319.52 ppm, which exceeds the MAC of 50-200 ppm.

The elevated levels of Cu in urban soil can be attributed to several factors. Firstly, the adsorption of Cu by clay minerals plays a significant role in its accumulation. Additionally, the transportation of Cu over long distances occurs through river sediment deposition. Furthermore, the presence of organic materials in the soil contributes to the increased copper concentrations. Industrial activities, including workshops, foundries, and smelting operations, also introduce Cu into the soil. Lastly, the impact of irrigation water and drainage further exacerbates the presence of Cu in the soil [24]. The mean concentration of Cu in the cultivated soil was 62.6 ± 76.53 ppm, with a range spanning from 21.25 to 432.19 ppm. Notably, these values exceeded previously reported concentrations by Sultan (2010) [24], who documented a high concentration of Cu in the Abu Ghraib soil. However, the concentrations of Cu in this study still fall within the MAC, as shown in Table 3.

Mn is mainly used in the metallurgical industry and is an essential ingredient of steel to improve strength, toughness, and hardness. It is also used to produce steel, aluminium, and copper alloys. Mn is necessary to produce alkaline batteries, electrical coils, ceramics, welding rods, glass, dyes, paints, and as a catalyst [9]. As presented in Table 3, the mean concentration of Mn in cultivated soil was 821.79 ± 213.7 ppm, ranging between 12.55 to 1019.96 ppm. However, the high concentrations of Mn are attributed to different plant diseases, such as magnesium deficiency.

The primary sources of Mo in the environment are using Mo fertilizers in cultivation, sewage sludges, coal combustion, and mining and smelting. The fertilizers sodium molybdate are soluble and frequently used in cultivation to reduce Mo deficiency in plants [9]. The mean concentration of Mo in cultivated soil was 10.87 ± 4.05 ppm, ranging from 1 to 16.8 ppm. Mo fertilizers used in coal combustion, sludges, sewage, agriculture, smelting, and mining are the primary contributors to environmental problems. Sodium molybdate fertilizers are widely used in uncultivated soils to remedy Mo deficiency because of their high solubility [9]. The mean concentration of Mo in cultivated soil was 10.87 ± 4.05 ppm, ranging between 1 to 16.8 ppm, slightly higher than the permissible limits.

Some sewage sludges and phosphate fertilizers may be important sources of Ni in agricultural soils, and some municipal sledges are enriched in Ni, which has recently become a serious pollutant that is released from metal processing operations and the increased combustion of coal and oil [30], [31]. In this study, the average concentration of Ni in cultivated soil was determined to be 190.24 ± 64.64 ppm, with a range of concentrations varied from 14.22 to 246.76 ppm. These findings indicate that the mean concentration of Ni in the soil is lower than previous findings [24], which reported a high Ni concentration in the Abu Ghraib area (220 ppm). It is important to note that Ni concentrations exceeded the permissible limits of 75-150 ppm in both studies, suggesting that the soil in these areas is contaminated with nickel and serious soil treatment is required.

Sediment types with higher clay fraction contents, such as argillaceous sediments, have higher Pb concentrations than those with lower clay fraction contents, including sands, sandstones, and limestone [1]. The study revealed that the average concentration of Pb was 19.45 ± 20.69 ppm, with a range of 4.64–97.75 ppm. These values were lower compared to the findings of Sultan (2010) [24], who reported that the lead concentration in the soil of Baghdad exceeded the permissible limits (20-300 ppm), particularly in specific regions such as Abu Ghraib and Achammaai Kadhimiya, wherein the Abu Ghraib area displayed a high concentration of lead (410 ppm). Such elevated concentrations are concerning and may cause serious human health risks in the Abu Ghraib area, especially when the soil is used for agriculture. Industrial operations like the smelter and battery facility in Abu Ghraib and Waziriya and brick factories that contribute to air and soil pollution in the Achammaai district have all been linked to lead poisoning in some areas of Baghdad [32].

The mean concentration of Se in cultivated soil was 0.49 ± 0.06 ppm, with a range between 0.2 to 0.5 ppm. In cultivated soil, Se is used as an addition to insecticides, fertilizers, and foliar sprays [33]. Also, the mean concentration of Th in cultivated soil was 5.22 ± 1.45 ppm, with a range of 0.5 to 6.9 ppm.

Soil supplemented with chemical fertilizers and compost often has the most significant water-soluble percentage of U, which ranges from around 0.05 to below 0.2 µg/l in surface soils [9]. The mean concentration of U in the cultivated soil was 0.88 ± 0.24 ppm, with a range between 0.4 to 1.6 ppm. However, U concentrations fall within the permissible limits.

The presence of V in rocks is typically found in higher concentrations in argillaceous sedimentary rocks and mafic igneous rocks [34]. The present study reveals that the average intensity of V in the cultivated soil was 157.68 ± 243.33 ppm, with a range spanning from 4.48 to 1366.81 ppm, slightly higher than the permissible limit of 150 ppm.

Agricultural methods and the absence of a ferrous metal sector are the key contributors to the region's high zinc content. Soil zinc levels may be significantly influenced by certain fertilizers, especially superphosphate [35]. The mean concentration of Zn in soil was determined to be 142.64 ± 170.43 ppm. These findings indicate that the levels of Zn in the soil were lower than those reported by Sultan (2010) [24], who found an average level of 100 ppm in the Abu Ghraib area. Furthermore, the observed concentrations did not exceed the permissible limits of 300 ppm, suggesting the absence of zinc pollution in the city's soil, except for the Rashid Hospital, where the zinc concentration exceeded the permissible limits. Therefore, elevated concentrations of these elements in soils are commonly due to anthropogenic inputs [36].

3. Conclusion

The examination of Abu-Ghraib agricultural land in Baghdad, Iraq, has provided valuable insights into soil composition and the Distribution of heavy metals. This region grapples with significant challenges, including poor soil quality, high salinity, and outdated irrigation systems, adversely affecting agricultural productivity. The soil in the area was identified as silty clay, with physical parameters indicating moderately alkaline conditions. Mineralogical analysis further unveiled a diverse composition, encompassing non-clay minerals like calcite, quartz, feldspar, and dolomite, alongside clay minerals such as illite, kaolinite, and palygorskite. Major oxides, including Al_2O_3, CaO, Fe_2O_3, K_2O, MgO, P_2O_5, and SiO_2, as well as trace elements such as As, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Se, Th, U, V, and Zn, were precisely measured. The results displayed variations in concentrations, with certain elements surpassing permissible limits. Chromium levels exceeded the maximum allowed concentrations, signifying potential environmental risks.

Moreover, the study underscored the profound impact of agricultural practices, fertilizer usage, and industrial activities on the alteration of soil composition. To address these concerning trends in oxides and trace elements, implementing soil management practices is urgent. Adopting sustainable organic farming methods and updating irrigation systems are crucial to enhance soil fertility and mitigate environmental risks. Ongoing monitoring, remediation initiatives, and public awareness campaigns are essential for ensuring sustainable agricultural practices and safeguarding ecological health in the region.

4. Conflict of Interest

The authors declare that they have no conflicts of interest.

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