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Study of the Controlling Factors of the Trace Elements in the Soil of East Baghdad Oil Field

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Abstract

Study of controlling factors that governing the distribution of trace elements in the soil of east Baghdad oil field was conducted through collecting and analyzing 6 surface soil samples from six sites (EB19, EB83, EB86, EB95, EB96, EB104). Soil samples were analyzed for trace elements, the mean values of (Cd, Co, Cr, Cu, Mn, Ni, Pb, Sr, V, Zn) were over the standard limits except Fe which was within standard limits. The Controlling factors are (Organic matters, Fe-Mn, pH, and clay minerals). The average of organic matter for highest three soil samples in their content of trace elements was (1.41) and the lowest three samples was (1.81), while the average of Fe- Mn in the highest samples was (51671, 1025 ppm) and the lowest samples was (17879, 402 ppm) respectively. The average of pH for high and low samples in the concentrations of trace elements (8.1, 8.2), respectively. Whereas the average of clay minerals in the highest samples was (9.16 %) and the lowest samples was (11.6 %) . The results revealed that the factors mentioned above didn't influence the trace element concentration in the soil samples, indicating that anthropogenic activities role were responsible for the increase of the concentration of trace elements, in addition to the parent rocks.

Keyword: Controlling factors, organic matters, Clay minerals, East- Baghdad oil field.

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دراسة العوامل المتحكمة بتوزيع العناصر النزرة في حقل شرق بغداد النفطي.

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الخلاصة

تمت دراسة العوامل المتحكمة بتوزيع العناصر النزرة في الترب المحيطة بالإبار النفطية في حقل شرق بغداد من خلال نمذجة وتحليل (6) عينات سطحية من ست مواقع من حقل شرق بغداد النفطي (EB19-S1، EB83-S3 ، EB86-S1، EB95-S1 ، EB96-S1 ، EB104-S4). اجري تحليل العناصر النزرة (Zn، Sr، V، Pb، Mn ،Ni، Fe، Cr، Cd، Co، Cu)، كان تركيز جميع العناصر النزرة المدروسة اعلى من المحددات العالمية في التربة ما عدا عنصر Fe الذي كان ضمن تلك الحدود. العوامل التي تتحكم بتوزيع العناصر النادرة في التربة والتي تمت دراستها هي (المواد العضوية، الحديد- المنغنيز، الدالة الهيدروجينية والمعادن الطينية) لأعلى واقل ثلاث عينات بتركيز العناصر النادرة، تم تحديد مستويات بعض العناصر النزرة في تربة حقل شرق بغداد النفطي. بلغ متوسط تركيز المادة العضوية لأعلى ثلاث عينات (1.41) وأدنى ثلاث عينات بتركيز العناصر النزرة (1.81)، بينما كان متوسط Fe- Mn في أعلى العينات (51671، 1025 ج.ج.م) وأدنى العينات (17879، 402 ج.ج.م) على التوالي، في حين كان متوسط الأس الهيدروجيني للعينات العالية والمنخفضة بتراكيز العناصر النزرة (8.1، 8.2) على التوالي، بينما بلغ معدل نسبة المعادن الطينية في أعلى العينات (9.16٪) وأقل العينات (11.6٪). أظهرت النتائج أن العوامل المتحكمة بتوزيع العناصر النزرة التي تمت اعتمادها في الدراسة الحالية لم تؤثر على تركيز العناصر النزرة في تربة المناطق المجاورة لحقل شرقي بغداد، مما يدل على دور العمليات الصناعية المتمثلة بالصناعات النفطية والأنشطة البشرية في زيادة تركيز العناصر النزرة في تلك الترب فضلا عن العناصر الموروثة من الصخور الام.

الكلمات المفتاحية: العوامل المتحكمة، المواد العضوية، المعادن الطينية، حقل شرق بغداد النفطي.

Introduction

Soil pollution is the build-up of toxic chemicals in soil, that occurs when the concentration of an element were three times high than the normal level [1]. Trace elements are one example of hazardous chemical substances that can form in the soil [1]. Trace element contamination in soil may spread be wind, water, and absorption plants[2]. Trace elements enter soils at relatively low concentrations as a result of natural and anthropogenic [3]. Soil pollution occurs with trace elements due to industrial waste, effects of oil wells drilling, application of fertilizers, and spill of hydrocarbons [4]. Trace elements that can pollute soil are classified as highly toxic include Ni, Cd, Pb, Zn, and Cu [5].

Oil pollution is one of the most hazardous contamination that caused problems for the ecosystem [1]. Oil is a type of an important energy, and consumption of that oil resulting an increasing of oil exploitation and storage, because of the limitation of the technological level, waste residue containing petroleum matter is discharged into the soil, causing an environmental contamination [6].

The drilling processes in the East Baghdad oil field can affect the surrounding soils, trace elements are moved from the soil to the tissues of plants, animals, hence affects the human health. Many factors governing the behavior of trace elements in soils in different ways. Controlling factors are (organic matter, Fe-Mn, pH, clay minerals) [7]. Organic and trace elements in the soil can bind minerals to different degrees. The solution pH plays a major role in determining the sorption behavior of trace elements. Soil components in terms of their content of (organic matter, Fe- Mn, clay minerals) are the most important soil properties that affect the sorption reaction [8]. The current study aims to study the controlling factors that governing the distribution of trace elements in soil of East Baghdad oil field.

Location of the study area

The studied area is lies in the East Baghdad oil field to the north of Baghdad City. Study area lies within the unstable shelf Mesopotamian basin **[9]**. The area of study is located between latitude (44˚20'46.73") to longitude (33˚ 29'26.60"). It is comprise 1201.00 km2. East Baghdad oil field contains reservoir rocks belong to the Cretaceous period, which form the basic and significant reservoirs in this field **[9]**. The samples were taken for six wells (EB-19, EB83, EB86, EB95, EB96, EB104), (Figure 1).

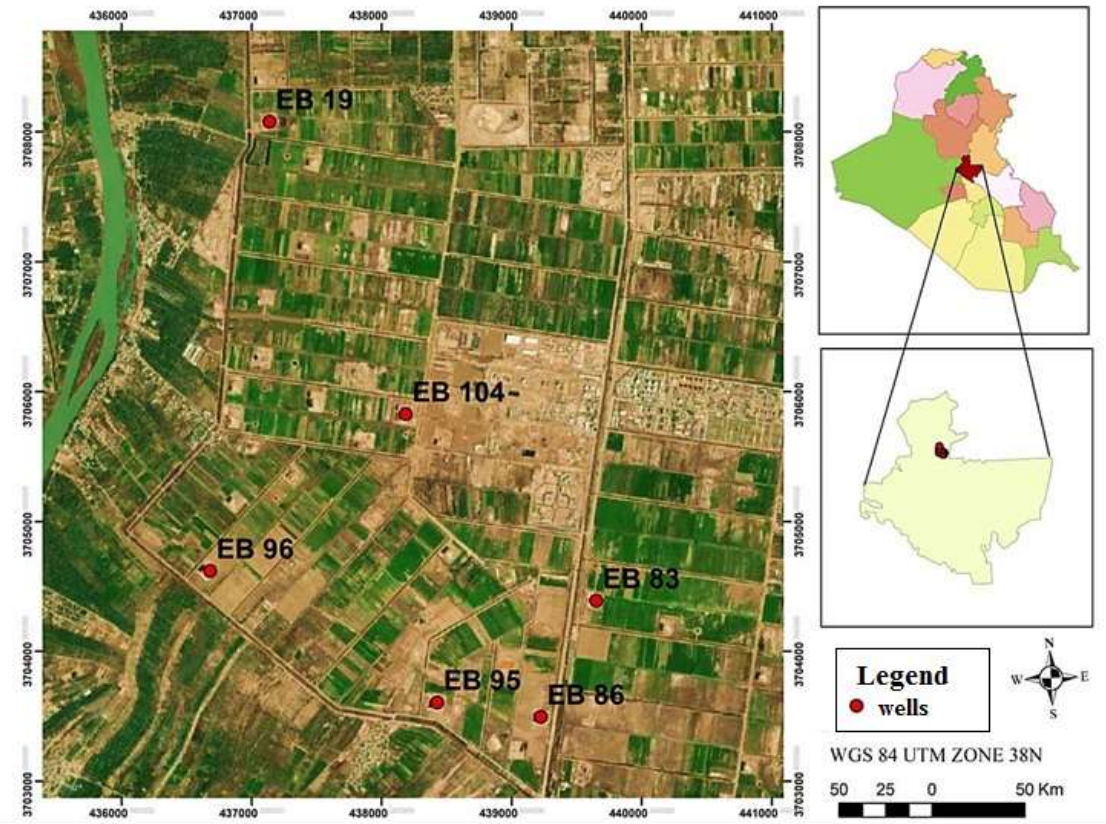

Figure 1: Location map of soil samples

Materials and Methods

Six soil samples are collected of East Baghdad oil field with a depth of (5-30 cm), soil samples are collected by plastic bags and was given a number for each samples to facilitate classification.

X-ray fluorescence:

Six soil samples from six oil wells in East Baghdad oil field (EB-19, EB-83, EB-86, EB-95, EB-96, and EB-104) were selected to be sampled. Soil samples were analyzed by (XRF) in German-Iraqi Laboratory at the University Baghdad, Department of Geology.

XRD analysis:

The mineralogical study focused on identifying clay minerals and non clay minerals using XRD (type Shiamatzu XRD-6000) at the German-Iraqi Laboratory at the University Baghdad, Department of Geology. The preparation of oriented samples were used according to **[10],[11],[12],]13].**

Grain size analysis:

Grain size analysis was carried out in Scandinavian Quick Solutions AB company to separate the clay and silt from the sand. This procedure is typical on a standard temperature of 20 C and uses ASTM 152H-Type hydrometer [14] and was conducted at the labs of the University Baghdad, Department of Geology.

Organic Matter:

To measure the content of organic matter 1g of soil sample was taken and reacted with hydrogen peroxide (H_2O_2) at a concentration of 30%. Left the reaction for one day with moved continuously and sample washed with distilled water and dried in the oven and the sample weighed accurately. The weight difference represents the quantity of organic materials, according (**Carver, 1971**).

pH:

To measure the degree of acidity in soil samples according to (**Rayment and Higginson, 1992**):

1) pH was estimated using pH standard solutions, to make a standardization of pH device
2) A suspension solution was created by combining 5g of the soil with 250 ml of distilled water.
3) 50 ml of pH granules were added to 100 ml of the suspended solution, which caused the color of the mixture to shift in accordance with the pH, and it is also confirmed using a manual device that is placed in the solution to measure pH.

Results

Trace elements in soil:

Trace elements contamination can spread in soil be wind, water, and plant absorption. The content of some trace elements in the soil samples were analyzed, as showed Table -1. The mean concentration of Cd was (2.3 ppm), while the mean concentration of Co is (14.8 ppm), the increase in Co concentration is due to the origin and composition of soils, human activities, and weathering processes **[15]**. Whereas the mean concentration of Mn, Ni, and Sr was (714, 152, 599 ppm) respectively, Table -1. The average concentration of Cr in this study was (189 ppm) generally Cr levels are rising in Iraqi soils as a result of transported clastics sediments that formed the stratigraphic column of the Mesopotamian plain **[11]**. Cu concentration in the study soil was (41 ppm). While Fe average was (34775 ppm) in soil samples. The mean of Pb was (170 ppm), the increased Pb content in soil is due to the most probable source which is fuel combustion in automobiles that added to the fuel as tetraethyl lead **[15]**. V average as (55 ppm). While Zn average was (124 ppm) in all soil samples.

Table 1: Trace elements concentrations (ppm) in the soil East-Baghdad oil field and elements distribution limits in world soil according (Kabata-Pendi and Pendias, 2001) and Iraqi soil according (Al-Bassam and Yousif, 2014).

Sample No.	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Sr	V	Zn
EB19-S1	2	22	288	60	46880	943	228	26	434	96	144
EB83-S3	2	29	237	61	53754	1087	259	67	353	131	114
EB86-S1	2	27	210	61	54380	1046	257	362	454	97	119
EB95-S1	3	4	89	22	17425	347	75	95	1069	1.3	77
EB96-S1	2	3	12	19	12486	461	27	82	775	1.2	50
EB104-S4	3	4	296	21	23727	399	64	390	509	1.4	238
Mean	2.3	14.8	189	41	34775	714	152	170	599	55	124
Al-Bassam and Yousif, 2014	-	-	282	18	-	-	99	6.8	-	76	56
Khwedim,2016	-	7.7	179	27	8012	-	52.6	173.9	-	159	44
Kabata-Pendi andPendias, 2001	1.1	6.9	42	14	-	418	18	25	147	60	62

Controlling factors that governing the distribution of trace elements in the soil:

1- Organic matter:

Organic matter is an important sorbent of metals and quite effective in retaining trace elements in soil and sediments. Other organic components can bind with elements to form organometal complexes **[16]**. Organic matter is a large group of carbon compounds, originally produced by plants and other organisms **[17]**.

Organic matters analysis was conducted for the highest three soil samples with in trace elements content (EB19-S1, EB83-S3, EB86-S1) and the lowest three soil samples (EB95-S1, EB96-S1, EB104-S4), Table- 1. Organic matter value in the highest samples was (1.41%), and the lowest samples (1.81 %). The percentage of organic matter in the highest samples was less than the percentage of organic matter in the lowest samples, so the organic matter in the present work couldn't be a controlling factor of trace elements in the soil of the study area.

2- Iron- Manganese:

Iron and Manganese (Fe- Mn) in the soil samples that have a low concentration of trace elements ranged between (12486- 23727, 347- 461 ppm) respectively, while its contents in the soil samples with high concentration ranges between (46880- 54380, 943- 1087 ppm) respectively. That means, its Fe concentration is slightly higher than the international limits for Fe (38000 ppm), its Mn concentration is slightly higher than the international limits for Mn (600 ppm) according to [18].

3- pH:

pH is one of the important soil variables that influence the availability of elements. Soil pH is a measure of acidic and alkaline [19]. The pH affects the solubility of organic materials on the surfaces of iron and aluminum oxides, and highing the pH of the soil leads to an increase in the ability of the soil to hold the elements on the surface of the soil through the adsorption process

[20]. pH in acidic soil increases with the reduction process, and the decreases in pH happen with oxidation [21].

Table 2: Organic matter, pH and Fe-Mn values for the selected soil samples

Sample	pH	O.M %	Fe	Mn
EB19-S1	8	1.25	46880	943
EB83-S3	8.4	1.90	53754	1087
EB86-S1	8	1.08	54380	1046
Mean	8.1	1.41	51671	1025
EB95-S1	8.2	2	17425	347
EB96-S1	8.1	2.08	12486	461
EB104-S4	8.3	1.35	23727	399
Mean	8.2	1.81	17879	402

pH analysis was conducted for the highest three soil samples in trace elements content (EB19-S1, EB83-S3, EB86-S1) and the lowest concentrations of trace elements (EB95-S1, EB96-S1, EB104-S4), Table- 2. Average of pH values in the 3 highest samples in trace elements content was (8.1), and the average pH in the lowest concentrations of trace elements was (8.2). Therefore, the pH rate is convergent for all samples, hence, pH in the present work is not considered a controlling factor that governing the trace elements behavior in the soil of the study area.

4- Clay minerals:

Clay minerals refer to group hydrous alumino-silicates that make up the majority of clay sized <2 µm fraction of soil. The majority of clay particles have a negative charge, which has a significant impact on the sorption characteristics of the soil. There are two main possibilities for how formed of these charges. First, the hydrogen that is possible covalently bound with oxygen (O_2) but is not securely bonded can be disposed of by the hydroxyl group on the that is found on the borders of minerals and outer layers of minerals. This is a pH-dependent mechanism, so when pH drops, the capacity to spill hydrogen atoms decreases **[22]**.

Grain size analysis was conducted for the highest three soil samples in the trace elements content (EB19-S1, EB83-S3, EB86-S1) and the lowest three soil samples (EB95-S1, EB96-S1, EB104-S4) to find the percentages sand, silt, clay, Table- 3. Soil texture of the study area is silty loam, Figure -2.

Through grain size analysis results, it could be find the average clay minerals in the highest samples were 9.16% clay (chlorite, illite, kaolinite, palygorskite, montmorillonite, mica), Figure (3), (4), (5). The average clay mineral in the lowest samples with concentrations of trace elements was 11.66% clay (Illite and Kaolinite), Figure (8), except for two samples (EB95-S1, EB96- S1) which did not contain clay minerals, Table 3. The percentage of clay minerals in the highest samples was less than the percentage of clay minerals in the lowest samples, hence it couldn't consider as controlling factor for the trace elements in the soil **[23]**.

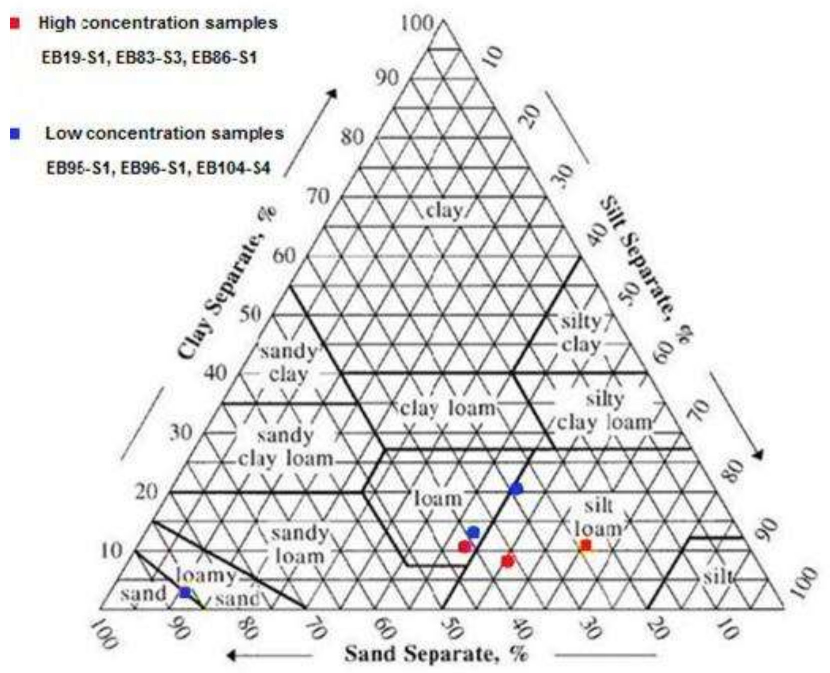

Figure 2: Classification of soil texture in the study area according to (Folk, 1980)

Table 3: The Grain size analysis results

Sample	Clay %	Silt %	Sand %	Soil texture	Clay minerals types
EB19-S1	7.5	55	37.5	Silt Loam	Chlorite, Palygorskite, mica, Montmorillonite.
EB83-S3	10	65	25	Silt Loam	Chlorite, Palygorskite, Illite, Montmorillonite.
EB86-S1	10	47.5	42.5	Loam	Chlorite, Illite, Kaolinite.
Mean	9.16	55.83	35		
EB95-S1	12.5	47.5	40	Loam	
EB96-S1	20	50	30	Silt Loam	
EB104-S4	2.5	10	87.5	Sand	Illite, Kaolinite.
Mean	11.6	35.83	52.5		

X-ray Diffraction for the same soil samples was achieved to distinguish clay and non-clay minerals. The results showed the presence of non-clay minerals of *Calcite* with a mean of 40%, *Dolomite* with a mean of 7.82, *Albite* with a mean of 7.77, *Barite* with an average of 6.75, *Gypsum* with a mean of 5.15%, *Quartz* with a mean of 3.1%, and *Sulfur* (only in sample EB96-S1) with a rate of 3%. Clay minerals represented by *Chlorite* and Illite with a mean of 7.2%, *Kaolinite* with a mean of 4.8%, *Palygorskite* with a mean of 2.95%, *Montmorillonite* with a mean of 0.4, and *mica* (only in sample EB19-S1) with a rate of 1.6%. It shows the mineral content of selected soil samples, Figures (3), (4), (5), (6), (7), (8).

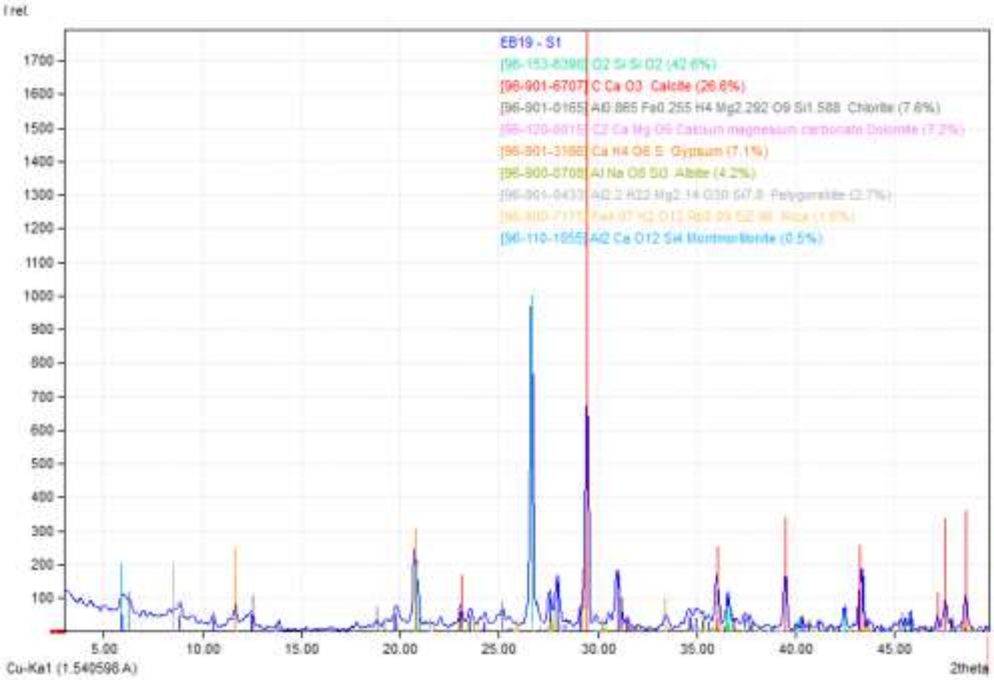

Figure 3: Bulk sample of EB19-S1 sample by X-ray diffraction analysis

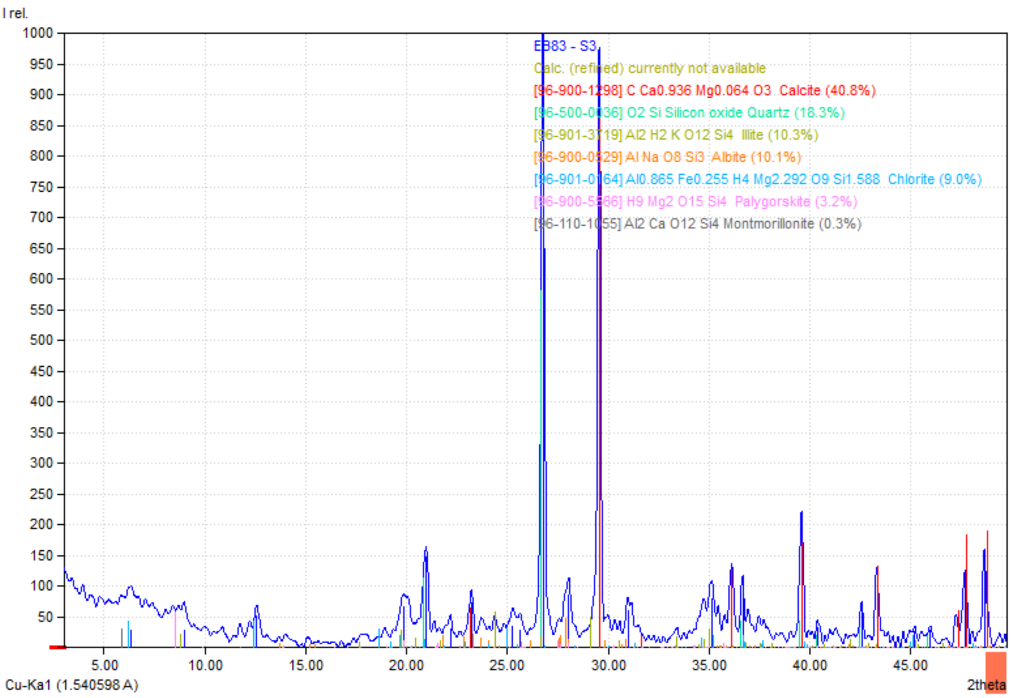

Figure 4: Bulk sample of EB83-S3 sample by X-ray diffraction analysis

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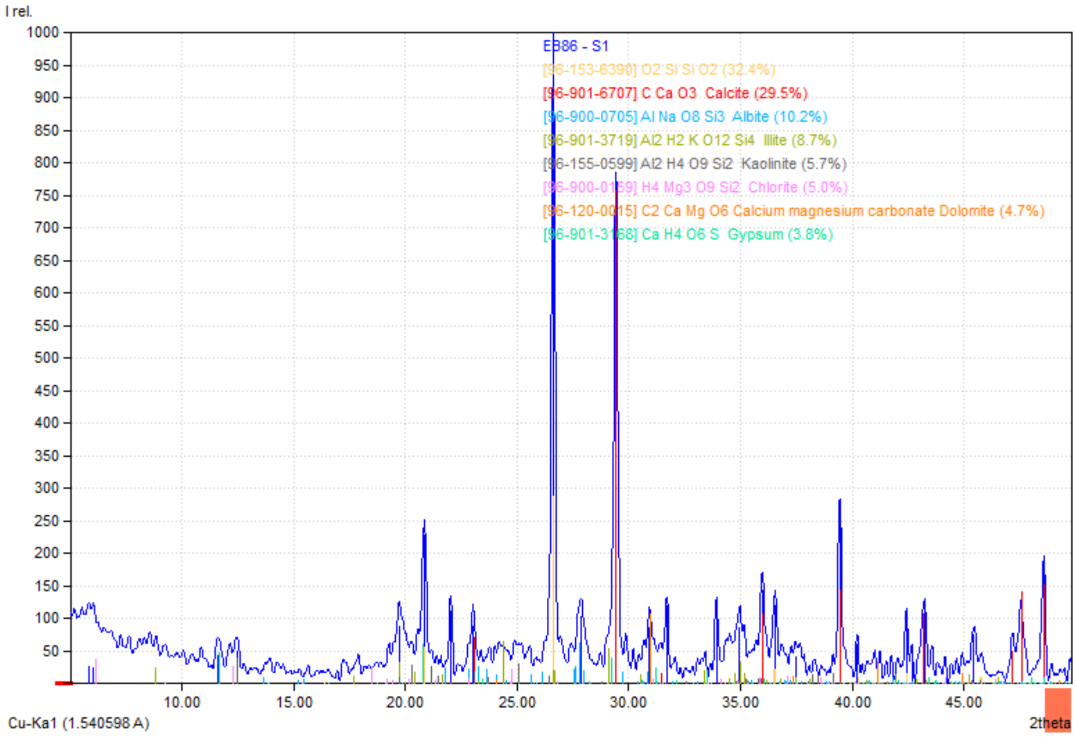

Figure 5: Bulk sample of EB86-S1 sample by X-ray diffraction analysis

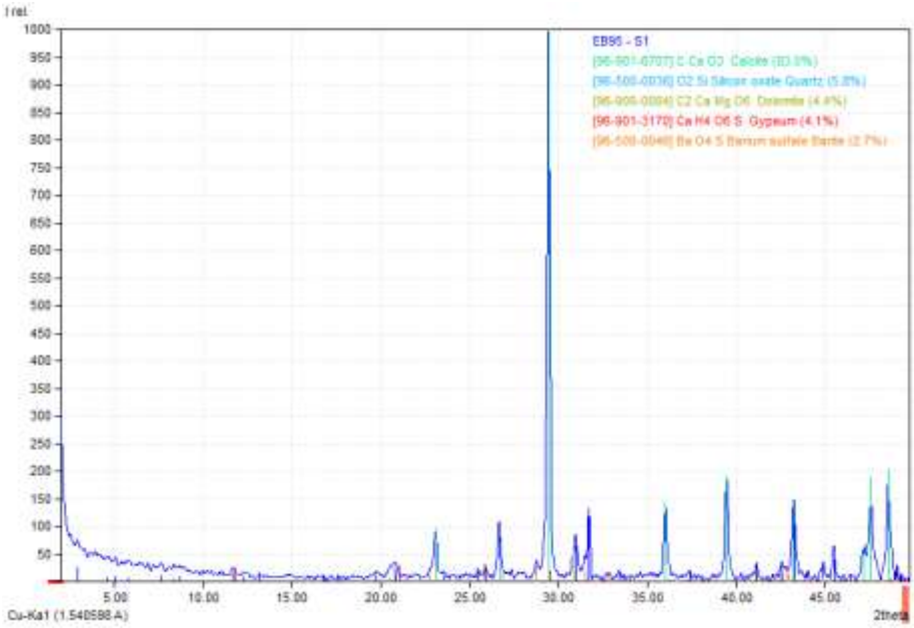

Figure 6: Bulk sample of EB95-S1 sample by X-ray diffraction analysis

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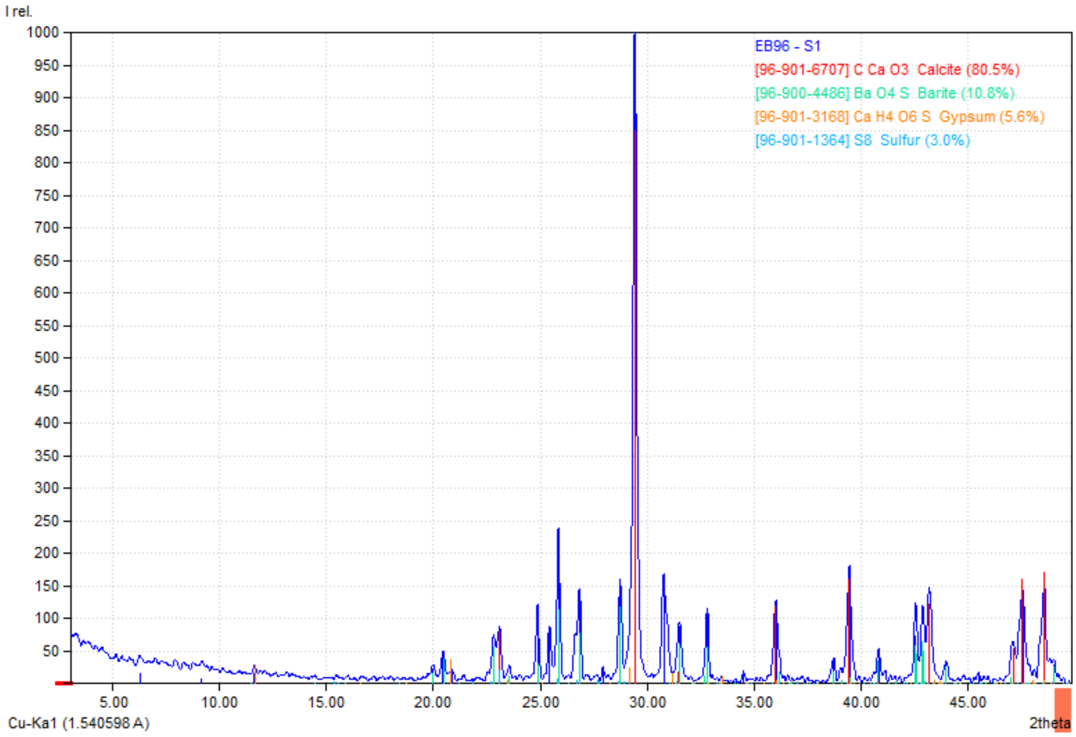

Figure 7: Bulk sample of EB96-S1 sample by X-ray diffraction analysis

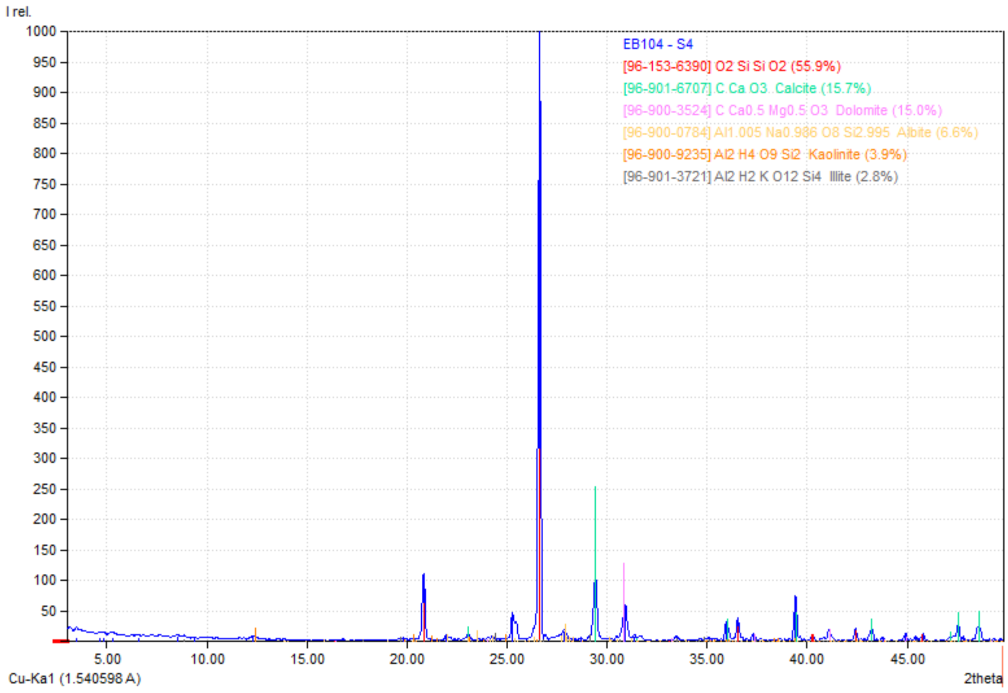

Figure 8: Bulk sample of EB104-S4 sample by X-ray diffraction analysis

Conclusions

The obtained results from geochemical and mineralogical analysis showed that the average concentrations of trace elements are above their normal rates when compared to the standard limits except for iron which was within the limits in soil. Therefore, East Baghdad oil field soil was contaminated with trace elements, which indicates the role of drilling processes near the study area in the increasing of the soil content of these elements.

The study of factors (organic matter, PH, Fe- Mn, clay minerals) revealed that these factors don't influence or governing the level concentration of trace elements in the soil samples, indicating that anthropogenic activities play a role in raising the level of trace elements in the soil of the study area in addition, the type of mother rocks. The results of mineralogical analysis revealed that the clay minerals are represented by chlorite, *Illite*, *Palygorskite*, kaolinite and *Montmorillonite*. *Chlorite* and *Illite* minerals are the most abundant in the study area. *Calcite* and quartz minerals were the most common non-clay minerals, followed by *Dolomite*, Albite, *Barite*, *Gypsum*, and Sulfur minerals with lower percentages.

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