Geochemical and Environmental Assessment of Some Minor and Trace Elements in Soils of Najaf Province, Southwest Iraq

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Abstract

125 Soil samples were collected from Najaf province which located within the southern deserts and Mesopotamia plain to determine the geogenic geochemical background range values for some chemical elements in the province. Some minor and trace elements (Al_2O_3, Fe_2O_3, SO_3, Cu, Zn, U, Cr and Ni) were analyzed by Titration and Atomic Absorption Spectrophotometry (AAS) and chemical properties of soil such as PH and the presence of salt (TDS, SO3), are statistically treated in this study to extract natural background values for these terrains. Natural (geogenic) background range values are presented in two ways: the first involved all analytical results including natural anomalous values and the second after removing values above the statistically calculated threshold. The concentration range values for the studied area are comparable to those reported for world soil with some exceptions. Higher upper range values are noticed for Cr, but the median values are within the world range. The distribution of minor elements (Al_2O_3, Fe_2O_3 and SO_3) is largely controlled by parent rocks. Some trace elements are also related to source rocks, especially U, Cr and Ni. Sulfate is enriched by authigenic processes. This study clearly emphasizes the impact of various soil – forming processes, parent rocks, physiography and climate on the geogenic background range of the analysed elements. It also suggests that local environmental studies to demonstrate pollution cases should consider comparison with backgrounds of the uncontaminated soil related to the same physiographic terrain instead of making conclusions based on comparison with world averages for soil.

Key words: Geochemical background, Environmental study, Soil, Najaf, southwest of Iraq

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التقييم الجيوكيميائي والبيئي لبعض العناصر الثانوية والعناصر النادرة لترب محافظة النجف جنوب غرب العراق

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الخلاصة

تم أختيار 125 نموذجاً من محافظة النجف وبالتحديد من الصحراء الجنوبية و سهل وادي الرافدين لتحديد قيم مديات الخلفية الكيميائية لصخور المصدرية لنماذج المدروسة من المحافظة. حيث حللت بعض العناصر الثانوية والنادرة وهي (Al_2O_3, Fe_2O_3, SO_3, Cu, Zn, U, Cr, Ni) بأستخدام طريقة التسحيح وجهاز مطيافية الامتصاص الذري و وتم تحديد الخواص الكيميائية للتربة مثل الدالة الحامضية PH وتواجد الاملاح (TDS, SO_3)، حيث تم معالجتها احصائياً للحصول على القيم الطبيعية الممثلة لهذه لترب في هذه المناطق. تم عرض مديات الخلفيات الطبيعية لقيم الدراسة من خلال طرقتين : الاولى اشتملت على جميع النتائج المحللة بما في ذلك القيم الطبيعية الشاذة، والثانية بعد ازالة القيم الاعلى من حد العتبة الاحصائي. ان قيم مديات التراكيز في المنطقة المدروسة كانت مماثلة للقيم المسجلة عالمياً مع بعض الاستثناءات ، حيث لوحظت ارتفاع في نسبة عنصر (Cr) ولكن قيم المتوسط كانت ضمن المدى العالمي.ان تراكيز العناصر الثانوية (Al_2O_3, Fe_2O_3, SO_3) كانت متأثرة بصخور الام المصدرية وكذلك العناصرة النادرة تأثرت بها وخصوصاً (U, Cr, Ni) ، أما الكبريتات فحصل بها اغناء نتيجة العمليات تكون الصخور الاولية. ان هذه دراسة ركزت بصورة جلية على التأثير الحاصل على مختلف الترب والتي منها عمليات التكوين والصخور المصدرية وفيزيوغرافية المنطقة والمناخ المؤثر في المديات السابقة الاصلية للعناصر المحللة . وتقترح الدراسة بان الدراسات البيئية المحلية التي تحاول اظهار حالات التلوث يجب ان تأخذ بنظر الاعتبار مقارنة نتائجها مع الخلفيات للترب الغير الملوثة التي تكون لها نفس التضاريس الفيزيوجرافية بدلا من جعل الاستنتاجات تستند لمقارنة مع المتوسط العالمي للتربة.

الكلمات المفتاحية: الخلفية الجيوكيميائية، دراسة بيئية، تربة ، النجف ، جنوب غرب العراق

Geochemical and Environmental Assessment of Some Minor and Trace Elements Najaf Province, Southwest Iraq

Ali M. Awad **Mutadhid M. Al-Obaidi**

Introduction

Samples were collected from top soil at a depth of 30 cm, covering an area of 28545.54 km^2 in Najaf province of Iraq (Fig. 1.1) . Comparing local results of soil analysis with global averages of Turekian and Wedepohl (1961), or "soil" of Hawkes and Webb (1962) or those of Aubert and Pinta (1977), (Table, 1.1) among other global averages reported for soil, may be misleading when dealing with local surveys. In addition, almost all soil analysis reported in the literature on geochemistry, report total (or nearly so) element concentrations in the samples, including structurally bound, exchangeable, adsorbed and other types of bonded elements to soil components. What is important for the environment is the concentrations of these elements in the soil water that may be available to plants under various pH and Eh conditions or can be mobilized to surface or groundwater resource. In this work, two major physiographic of Najaf province in Iraq are considered: the desert plateau and the Mesopotamia plain. For comparison to show the influence of parent rocks, physiography, climate and natural geogenic contamination on the background values.

The Desert terrain was dealt with collectively as one physiographic province as well as sub provinces divided according to dominating bedrock lithology, to show the influence of parent rocks on the elements concentration in the overlying soil.

The Mesopotamia plain was dealt with as one entity since it is the product of the collective sedimentation of Euphrates and Tigris river and their tributers in one flood plain basin. Since flooding of these rivers was stopped more than half a century ago, the upper horizon of these sediments has undergone salinization.

The main aim of this work is to present geogenic geochemical background range values for the above chemical elements in the province and comparison with other localities in Iraq, soil conditions and parent rocks, in order to show the influence of physiography, source rocks and natural contamination by mineralization on the geochemical distribution and background concentration of elements in soil and sediments.

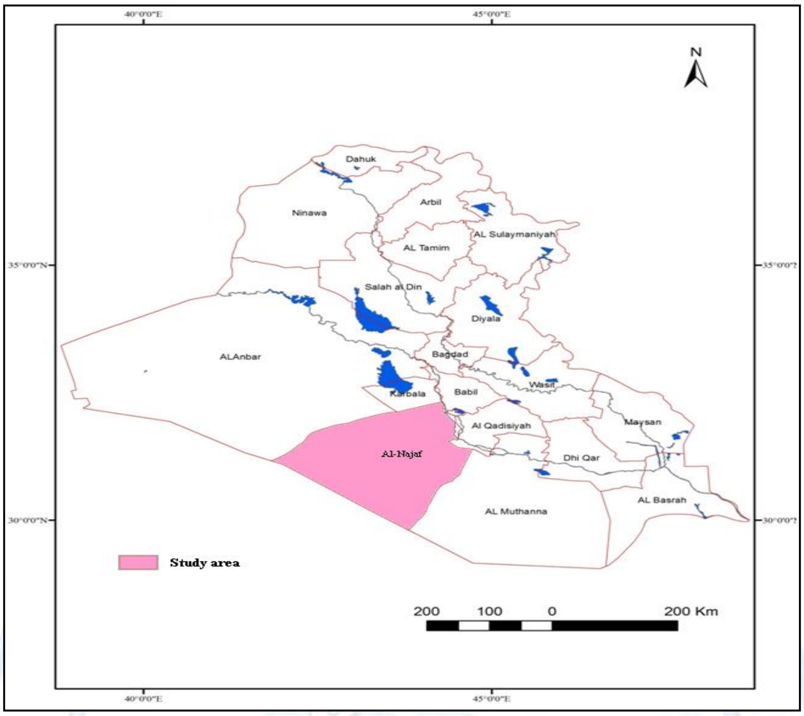

Fig. 1.1: Location map of the studied area.

Materials and Methods

1. Sampling and Analysis Methods

Soil and Recent sediments samples were collected from the upper 30 cm section by digging a shallow pit using soil auger. All samples were sieved using a nylon cloth and the (-80) mesh fraction was collected, air dried and kept in polyethylene bags for analysis. The average sampling density was as follow:- Desert terrain: about one sample per 10 km^2, Mesopotamia: about one sample per 15 km^2. Minor and trace elements were analyzed by Titration and Atomic Absorption Spectrophotometry (AAS) Type/PYE UNICON, SP 2900, in labs of The State Company of Geological Survey and Mining, Baghdad.

2. Spatial Analysis

-The applied GIS software for the spatial analysis of the geochemical elements involved the following steps:

-Exploratory spatial data analysis (ESDA) using ArcGIS 9.3 software for the geochemical elements to study.

-Geostatistical Analyst extension for advanced surface modeling using deterministic and geostatistical methods in ArcGIS 9.3 software and calculates summary statistics (Mean, Median, Std. Dev. and Threshold).

-Spatial interpolation for geochemical elements data using ArcGIS 9.3 software, while ordinary kriging is applied based on statistical models

-Semivariogram and covariance modeling, Model validation using cross validation and Surfaces generation of the geochemical elements.

3. Statistical Analysis

The statistical analysis of elemental contents in soil samples included (Table, 2.1):

Calculate the descriptive statistics; Mean, Median, Minimum, Maximum, Standard Deviation and determining the distribution of elements.

Establishing the values of background and threshold of elements to satisfy the main objective of exploration geochemistry; obtaining of geochemical anomalies.

4. Estimation of Background, Threshold and Anomaly.

The detection of spatially continuous zones of elevated values of a strategic element that exceed a specified threshold value is considered as an important goal of the investigation of geochemical data. Various estimates of background values exist including the arithmetic mean (Hawkes and Webb, 1962), the Median (Levinson, 1980) as well as the 50th percentile on the cumulative frequents curve (Lepiltier,1969).In this investigation, Median was valid to estimate the background values because the normality of the most elements distribution. Garrent (1983) defined the threshold as the outer limit of background variation. The classical estimation of threshold values proposed by Hawkes and Webb (1962) of the (mean + 2standard deviation) seems to be abandoned now (Siegel, 1974; Howarth and Martin, 1979; Govett, 1983).

Results and Discussion

1. Grain Size and Mineralogy (XRD)

41 Selected samples Were analyzed according to (Folk 1974) for grain size in studied area. Grain size distribution show that the soil in the Province is dominated by sand, followed by silt and minor clay, as shown in figure (Fig. 2-1).

The mineral constituents of non clay minerals (XRD results) are (Calcite, Quartz, Feldspar, Dolomite, Gypsum and Halite), the clay mineralogy consists mainly of: Palygorskite followed by Smectite with subordinate amounts of kaolinite (Fig.3-1). Mostly of these minerals are transported by surface water for each of Tigris and Euphrates rivers rock source in northern Iraq, Turkey and Syria, or transported by the wind blowing from the territory of Western.

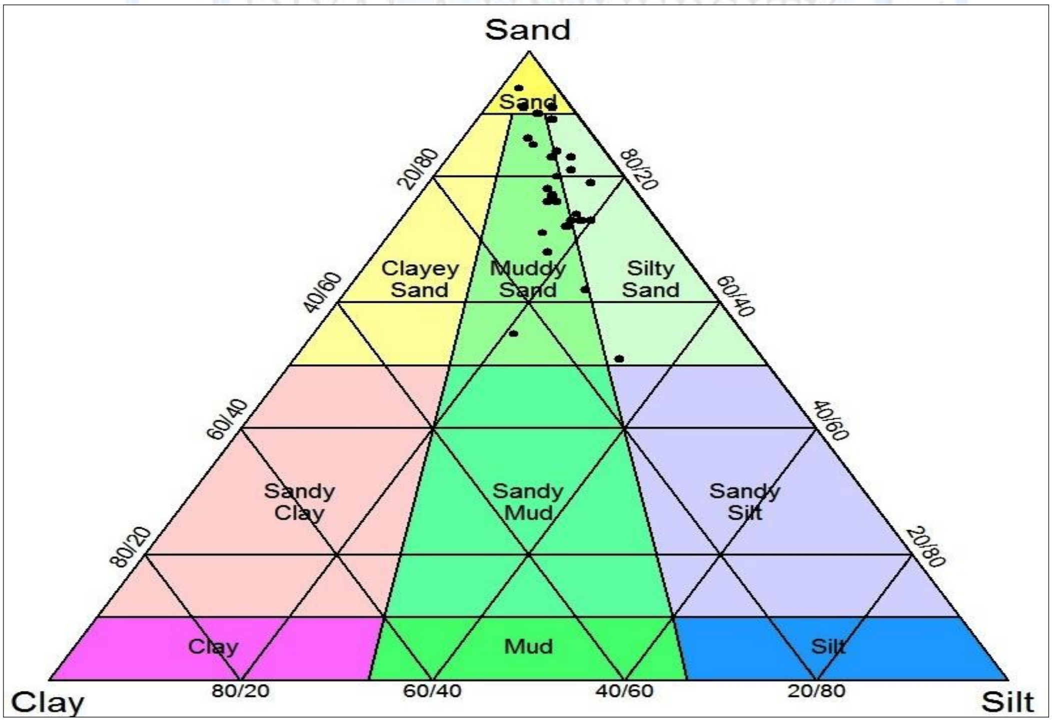

Fig. 2-1: Grain size distribution of topsoil according to Folk,1974 Classification in Najaf province

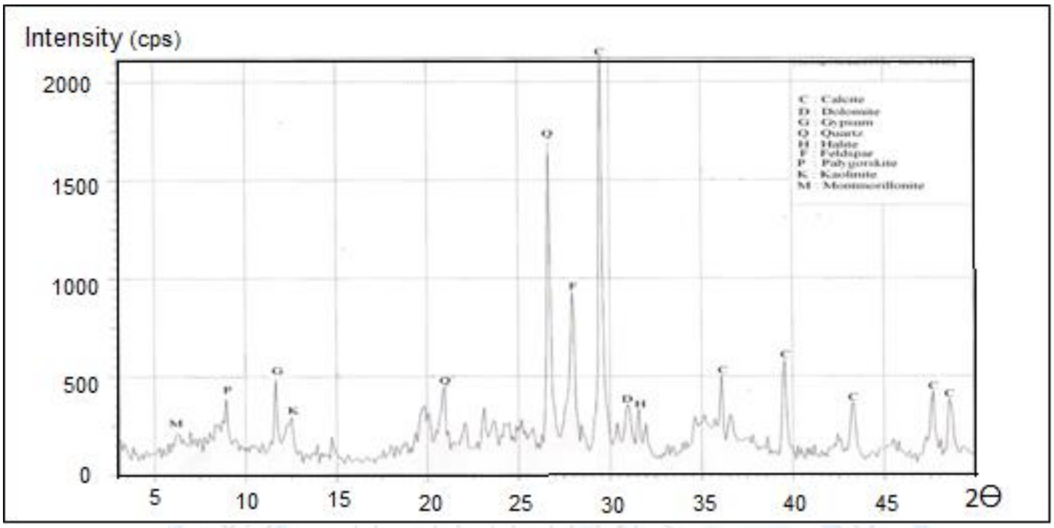

Fig. 3-1: X-ray diffractgram of clay and non clay minerals of topsoil in Najaf province.

Table 1.1: World soil range and average concentrations of the analysed trace elements (ppm).

	Hawkes and Webb (1962)	Kapata – Pendias and Pendias (2001)	Aubert and Pinta (1977).	UNSCEAR (1993)
Cu	20	13 – 24	15 – 40	
Zn	50	17 – 125	tr. – 900	
Cr	200	7 – 221	200 – 540	
Ni	40	0.2 – 450	50 – 500	
U	1.0	-----	-----	0.79 – 11

2. Minor and Trace elements

In this work, natural geochemical background ranges for the trace elements:- Cu, Zn, Cr, Ni and U are presented for Najaf province in Iraq with negligible anthropogenic activity. The results are compared to soil analysis in world (Table 1.1) and with other localities in Iraq soil range of trace elements (Table 2.1).. Significant differences occurred, which emphasize the role of source rocks, climatic conditions and soil – forming processes on the natural geogenic concentration of these elements and their spatial distribution (Aubert and Pinta, 1977). Moreover, minor element (oxides), directly related to parent rocks and their concentration in soil is geogenic, were also analysed and their spatial distribution in the Southern desert and Mesopotamia terrains was demonstrated together with statistical treatment of the analytical data. These are Al_2O_3 and Fe_2O_3. The affinity of the analysed trace elements to these minor geogenic elements was also studied to illustrate the role of parent rocks on trace elements concentration and distribution in the studied terrains. Sulfate (SO_3) was analysed in the Mesopotamia samples to show the influence of soil salinization on the concentration and background values of the trace elements analysed. It was also analysed in selected parts of the Desert terrain for comparison.

3. Soil Salinity

Saline soils normally have a PH value below 8.5, are relatively low in sodium and contain principally calcium and magnesium chlorides and sulfates. These compounds cause the white crust which forms on the soil surface and the salt streaks along the furrows. The compounds which cause saline soils are very soluble in water, therefore, leaching is usually quite effective in reclaiming these soils (Fipps, 1994). Salt-affected soils develop from a wide range of factors including: soil type, field slope and drainage, irrigation system type and management, fertilizer, and other soil and water management practices. To detect soil salinity in the surface soil in the studied area, (81) soil samples have been analyzed for sulfate (SO3), Total Dissolved Solids (TDS) and PH.

Table 2.1: Descriptive statistics of different variables concentration in the study area

Ser. No.	Element	Unit	No. of Analysis Samples	Range		Mean	Median (Background)	Std.Dev.	Transformation	Threshold (Mean+2St.Dev.)	Sampling ensity	
				Min	Max							
1	Fe2O3	%	125	0.2	4.25	1.57	1.24	0.96	Log	3.49	228.36 Kilometer per Sample	Al Najaf (28545.54) Sq. Km
2	Al2O3		125	0.97	7.79	4.23	3.98	1.68	None	7.59		
3	SO3		81	0.08	32.7	6.04	3.18	7.38	None	20.8		
4	Cr	ppm	124	13	298	76.10	65.5	49.8	None	175.70		
5	Cu		110	6	81	15.36	12	12.65	Log	40.66		
6	Ni		125	0.59	137	46.83	39	29.581	None	105.99		
7	Zn		125	6	133	26.62	23	15.96	Log	58.55		
8	U		8	0.35	1.1	0.60	0.65	0.235	None	1.07		
9	TDS	%	81	0.36	13.1	3.12	-	-	Log	-		
10	PH		10	8.5	8.98	8.12	-	-	None	-		
Total			125									

Table 3.1: Comparison between analytical results of the study area and other Iraqi soils

Element (ppm)	This study	W. part of w. Desert. Buday &Hack 1980	Hit-Nassiriya Al-Bassam 1981	W.&S.Desert Shehata et.al., 1984	Mesopotamian Plain Hana&Al-Hilali1986	Sediments of the Euphrates RiverAl-Basam and Al-Mukhtar,2007	Al-Nasiriya, Mesopotamia, Benni,2012
Cr	76.1	120	240	110	497	119.4	116.3
Ni	46.83	66	103	74	238	182.9	147.1
Zn	26.62	57	70	64	54	91.2	57.3
Pb	-	13	7	-	9	19.5	16.84
Cu	15.36	23	17	25	26	35.8	27.3
Co	-	-	8	-	21	48.7	27.5

4. Total Dissolved Salt (TDS)

The salinity of soils is sometimes reported as the total salt concentration or total dissolved salt solids (TDS), it is usually expressed in milligrams of salt per liter (mg/l) of water (also reported as ppm). Specific conductance, also called electrical conductivity (EC). Units of EC are reported usually as decisiemens per meter (ds/m). The conversions between EC and TDS can be made by the equation:

TDS (mg/l) = 640 * EC (ds/m)

The concentration of TDS in the study area ranges from (0.36 –3.1) with a mean of (3.12) mg/l (Table 2.1), when using equation we get the ranges ranging from (5.6-204.6) Ec (ds/m) When comparing these values and apply, according to Mohammad and Hussien, (1993) the soil type in the study area is slightly saline to extremely saline (Table 4.1).

Table 4.1: Different degree of soil salinity (Mohammad and Hussien, 1993).

Salinity class	Description	EC (ds/m)
S0	V. Slightly saline	0-4
S1	Slightly saline	4-8
S2	Moderately saline	8-16
S3	Strongly saline	16-25
S4	V. Strongly saline	25-50
S5	Extremely saline	>50

5. Sulfate (SO_3)

Under arid and semi arid conditions, the sulfate is retained for the most part in the soil and often separated as spots and nests of gypsum and may even form a marked horizon (Goldschmidt ,1954). The mean concentration of sulfate (SO3) in the studied soil samples is (6.04) % ranging from (0.08 – 32.7), median 3.18% and threshold is 20. 8% (Table 2.1). The sulfate in the studied soil is not related to parent rocks, it is enriched in the soil due to authigenic salinization by poor drainage, hot and arid climate, where evaporation rate is 200 – 300 times the rainfall rate in these terrains. It shows a log – normal distribution in both terrains

6. PH

In the natural soil conditions, PH ranges most often between (5 and 7). The most mobile fractions of ions occur at a lower range of PH, and it can be anticipated that with increasing pH of the soil substrate, then the solubility of most trace cations will decrease Kapata – Pendias and Pendias (2001). The values range of pH in the surface soil of the study area is (8.5- 8.9) with a mean of (8.3) (Table 2.1), therefore the nature of the almost soil of the study area is alkaline.

Minor Components (Al_2O_3 and Fe_2O_3)

1. Alumina

Alumina is usually a residual component in soil and closely connected with parent rocks composition. It shows normal distribution in the Desert and Mesopotamia samples, where the proportion of alumina in the global soils ranging from (0.45 -10%) in all types of rocks. The ranges of alumina concentration in the topsoil of the study area is (0.97 - 7.79%) and the mean is (4.23%), while the median (Background) is (3.98%), the threshold reached to (7.59%) (Table 2-1). When comparing the concentration average of alumina in different regions of the soils of Iraq, with the current study area is less than what is recorded in those soils (Table 3-1). Figure (8-1) shows that geochemical distribution of alumina in topsoil of the Najaf province is high concentrations it lies within the same iron distribution areas because of the intensity of geochemical familiarity for two elements together, not noticed any geochemistry abnormalities in the area, where no contamination of this element in the current soil in the province. The histogram (Figure 8-1) shows the bimodal pattern which indicates that there are two sources of supplying it in the soil, the clays one of the basic elements in the forming of clays and components of aluminum in depositions of study area from supplied rocks in the north and northeast of Iraq, which transported erosion products of these rocks by rivers and wind to the current study area in general, the other source are the rocks of the Arabian Shield region, transported erosion results of these rocks by valleys and wind that have moved into the southern desert area and the Mesopotamian plain in the current study.

2. Iron oxide

Iron ratio in the global soils ranging from (0.5-5%). The ranges of iron concentration in the topsoil of the study area is (0.2 - 4.25%) and the mean is (1.57%), while the median (Background) is (1.24%), the threshold reached to (3.49%) (Table 2-1). When comparing the iron concentration in the topsoil of the Najaf province, with concentrations soils in world, find that is located within normal ranges in soils. When comparing the iron concentration with its rates in different areas of the soils of Iraq, the iron concentration in the current study is somewhat less than what is recorded in those soils and there is no abnormal concentrations within the current study area. Figure (9-1) shows that geochemical distribution of iron in topsoil of the Najaf province is high concentrations, it lies within the normal ranges for the presence of iron in the soil, where no contamination of this element in the current soil in the province. Frequency distribution of iron (Figure 9-1) shows that unimodal distribution pattern which indicates that there is a single source of iron in the sediment of topsoil in the province, and this source of iron is the presence of natural in sedimentary and igneous rocks in the north and northeast Iraq and transporting products of erosion and weathering of these rocks by the Tigris and Euphrates to the Mesopotamian plain.

Trace elements (Cu, Zn, Cr, Ni and U).

1. Copper.

General world soil content of Cu ranges from traces to 250 ppm with an average range of (15 – 40) ppm (Aubert & Pinta, 1977) and 13 – 24 ppm (Kapata – Pendias and Pendias, 2001).. It is highly depended on parent rocks and generally high in soils of arid regions. The concentration range of Cu in soil surface samples is (6 – 81) ppm with a mean of 15.36 ppm. The background is 12 ppm and the threshold is 40.66 ppm (Table 2.1). Copper concentration exhibits a normal and bimodal distribution (Fig.4.1). The mean value of copper in surface soils of the study area is within the reported values of different parts of Iraqi soils (Table 3.1).Copper in the Earth's crust is most abundant in mafic and intermediate rocks and has a tendency to be excluded from carbonate rocks. Cu forms several minerals of which the common primary minerals are simple and complex sulfides. These minerals are quite easily soluble in weathering processes and release Cu ions, especially in acid environments (Pendias and Pendias, 2001). Total Cu distribution in surface soils in the study area is within the reported average of the world. (Hawaks and Webb, 1962; Rosler and Lang, 1972 and Aubert and Pinta, 1977) reported that the concentration of Cu in surface soil is 20 ppm. Quite similar Cu background values were calculated for the surface soils of the U.S.A. from data given by Shacklette and Boerngen (1984). The common characteristic of Cu distribution in soil profiles is its accumulation in the top horizons. This phenomenon is an effect of various factors, but above all, Cu concentration in surface soils reflects the bioaccumulation of the metal and also recent anthropogenic sources of the element (Pendias and Pendias, 2001).

2. Zinc

The grand range of Zn in world soil is reported as (trace – 900 ppm) and is believed to be dependent on parent rocks more than pedogenic processes (Aubert and Pinta, 1977). It is high in the soils of arid regions and saline alkaline soils. An average value of Zn in world soil was reported as (50) ppm (Hawkes and Webb, 1962). Zinc substitutes for Mg^{2+} in silicate minerals and is mobile in acid oxidizing environment. Kapata – Pendias and Pendias (2001) reported world soil background range of (17 – 125) ppm. The concentration range of Zn in soil samples is (6-133) ppm with mean of (26.62) ppm. The background is (23) ppm and the threshold is (58.55) ppm (Table 2.1). Zinc concentration exhibits a normal and unimodal distribution (Fig.5.1). The mean value of zinc in surface soils of the project area is within the reported values of different parts of Iraqi soils (Table 3.1). The mean concentration of Zn in soil surface of the area is close to the mean total of Zn content in surface soils of different countries. The grand mean of Zn for worldwide soils is 64 ppm (Pendias and Pendias, 2001). In arid regions, Aubert and Pinta (1977) reported that the range of Zn between (50 – 100) ppm. However Zinc does not migrate very far in arid climate and alkaline media (Aubert and Pinta, 1977). It has been found that the highest selective adsorption of Zn by Fe oxides, halloysite, allophane, and imogolite and the lowest by montmorillonite. Thus, clay minerals, hydrous oxides, and pH are likely to be the most important factors controlling Zn solubility in soils, while organic complexing and precipitation of Zn as hydroxide, carbonate, and sulfide compounds appear to be of much lesser importance. Zn can also enter some layer lattice silicate structures (e.g., montmorillonite) and become very immobile, (Abd- Elfattah and Wada, 1981).

3. Chromium

Chromium was reported to be rich and very rich in the soils of arid and semi arid regions; up to 2400 ppm Cr was reported in soils of such regions (Aubert and Pinta, 1977). A grand average for world soil was reported as (200) ppm (Hawkes and Webb, 1962) and a world background range was reported as (7 – 221) ppm by Kapata – Pendias and Pendias (2001). The range of chromium content in the analyzed soil is (13 – 298) ppm with a mean of 76.10 ppm. Chromium distribution is normal and unimodal (Fig.6.1), with a background of 65.5 ppm and threshold of 75.70, (Table 2.1). The mean value of chromium in surface soils of the study area is less than to the reported values of other Iraqi soils (Table 3.1). The grand mean Cr content is calculated to be 54 ppm for worldwide surface soils (Pendias and Pendias, 2001). In arid regions Aubert and Pinta (1977) reported the range of Cr between (100 – 300) ppm. The terrestrial abundance of Cr indicates that it is associated mainly with ultramafic and mafic rocks (Pendias and Pendias, 2001). The Cr content of surface soil is known to increase due to pollution from various sources, of which the main ones are several industrial wastes (e.g., electroplating sludge, Cr pigment and tannery wastes, leather manufacturing wastes) and municipal sewage sludge. The Cr added to soils is usually accumulated at the thin top layer, (Beckett *et al*., 1979 and, Uminska, 1988).

4. Nickel

Nickel is easily mobilized during weathering and coprecipitated with Fe – Mn oxides or organically bound in soil (Kapata – Pendias and Pendias, 2001). Nickel content in soil is highly dependent on climate and parent rock composition. It is higher in soil of arid regions than temperate and boreal regions. World range for soil is (tr. – 5000) ppm, reported range for Ni in soil of arid regions is (50 – 300) ppm and in saline alkaline soils (40 – 100) ppm (Aubert and Pinta, 1977). In recent literature, Kapata – Pendias and Pendias (2001), reported world range for Ni in soil as (0.2 – 450) ppm.

The range of nickel content in the studied surface soil is (0.59 – 137) ppm with a mean 46.83 ppm. Nickel distribution is a normal and bimodal (Fig.7.1) with a background of 39 ppm and threshold of 105.99 (Table 2.1). The mean value of nickel in surface soils of the study area is almost less than the reported values of some parts of Iraqi soils (Table 3.1). Soils throughout the world contain Ni within the broad range of from 0.2 to 450 ppm, while the range for soils of the U.S. is from < 5 to 150 ppm (Pendias and Pendias, 2001). In arid region Aubert and Pinta, (1977) reported that the average concentration of Ni is 46 ppm. The nickel status in soils is highly dependent on the Ni content of parent rocks. However, the concentration of Ni in surface soils also reflects soil-forming processes and pollution.

5. Uranium

Uranium, if not introduced to the soil environment by anthropogenic activities, is strongly related to parent rocks, and its concentration in soil shows a wide range. A world average of U in soil was reported as (1) ppm (Hawkes and Webb, 1962). In more recent literature a background range was reported as (0.3 – 11.7) ppm (UNSCEAR, 1993). Uranium is found in various concentrations in all rock types; among which are marine phosphorites, sandstones and black shale. Uranium may be introduced geogenically to soil by the weathering of and mobilization from Uraniferrous parent rocks or by uranium – bearing groundwater. Uranium is present in two valencies, U^{4+} , which is less mobile, and U^{6+} which is very mobile in the secondary environment, and may be found in secondary uranium minerals in soil or in association with Fe – Mn oxides, or with organic matter.

The range of Uranium content in the studied surface soil is (0.35 – 1.1) ppm with a mean 0.60 ppm. Uranium distribution is a normal with a background of 0.65 ppm and threshold of 1.07 (Table 2.1). The Uranium ranges are well within world range values, which exhibit no population of uranium in study area.

Conclusions

1. The Salinization of the upper part of the soils and surface sediments of the Southern desert and Mesopotamia is induced by poor drainage, little rainfall and very high evaporation rates.
2. The trace elements analysed in the soils of the study area show normal variations in their background range and median values controlled by parent or source rocks, pedogenic processes and drainage.

3. The distribution and concentration of minor elements (Al and Fe) in the samples analysed from the Southern desert are largely controlled by the underlying lithology, whereas in the Mesopotamia samples, their concentration in the sediments appear to have been mainly influenced by the type of source rocks of the rivers Euphrates, Tigris and tributaries.
4. The achieved background and median values of the elements analysed in the soil and sediments of the Southern desert and Mesopotamia terrains fall within the values reported for uncontaminated soil of the world.

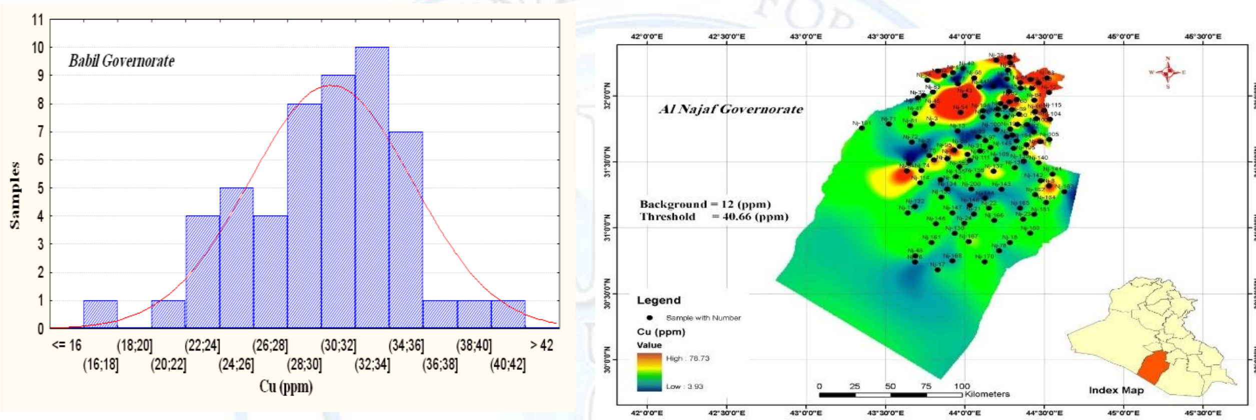

Fig.4.1: Geochemical distribution and frequency histogram of Cu within the study area

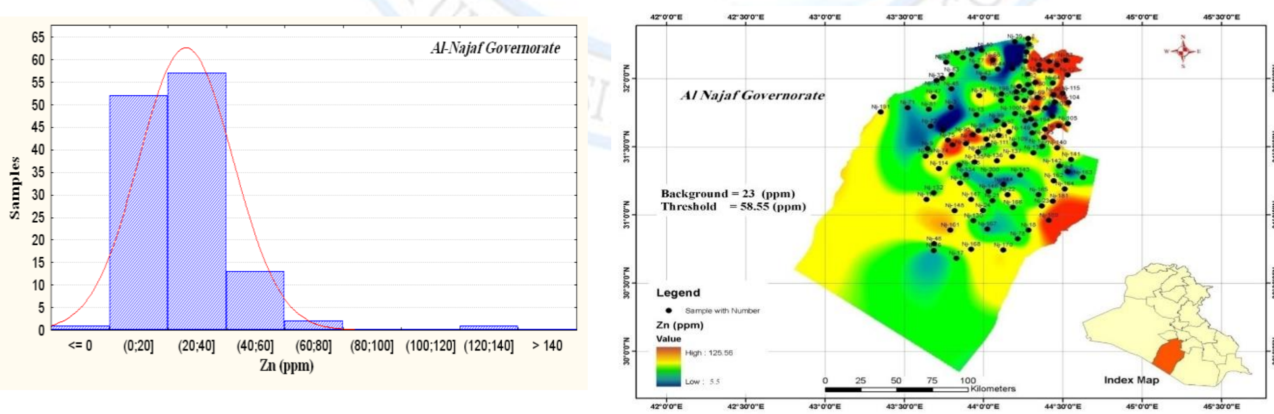

Fig.5.1: Geochemical distribution and frequency histogram of Zn within the study area

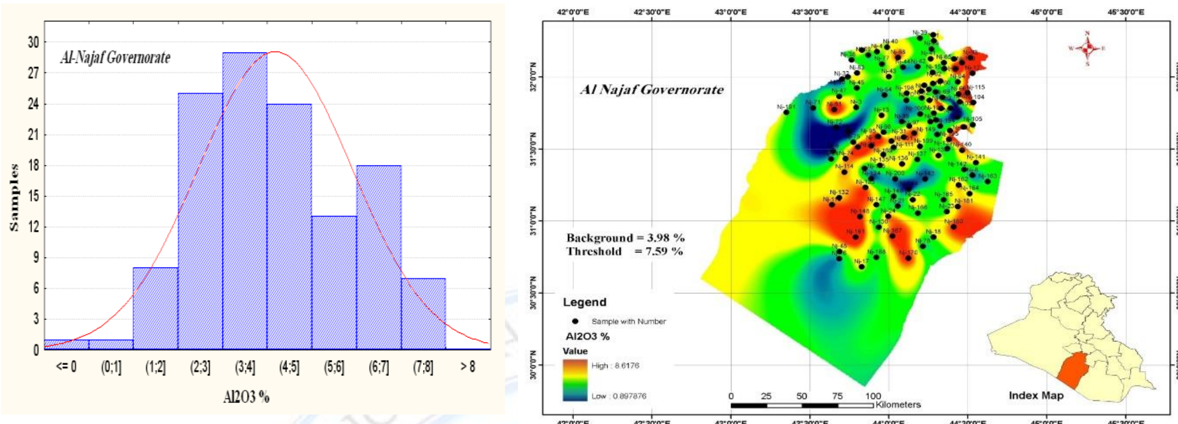

Fig.8.1: Geochemical distribution and frequency histogram of Al_2O_3 within the study area

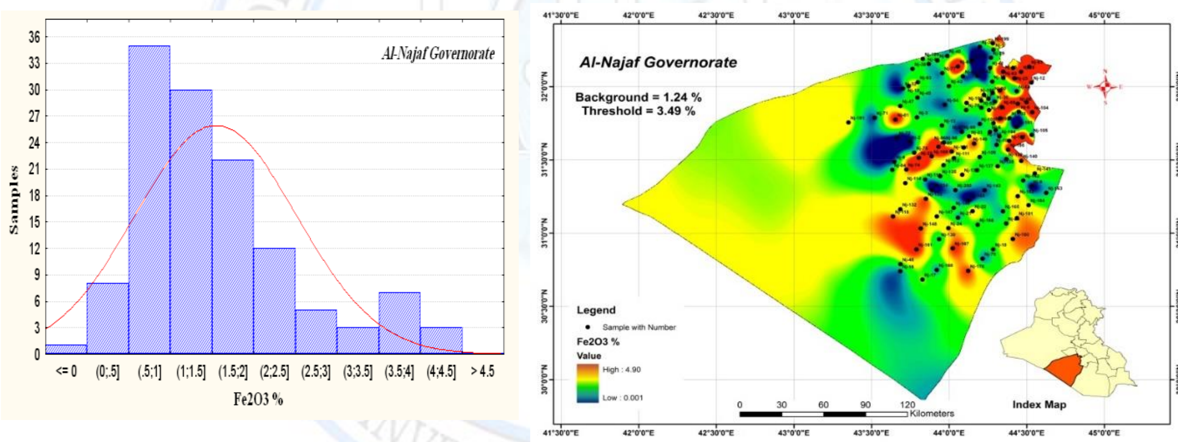

Fig.9.1: Geochemical distribution and frequency histogram of Fe_2O_3 within the study area

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