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Mineralogical Composition of Some Iraqi Soil Samples

Taha Al-Nuaimi[1], Khaldoun AL-Bassam[2], Sawsan Al-Haza a[3] and Nawal Al-Saadi[4]

1 Department of Earth and Environmental Sciences / Faculty of Science / Sana'a University , Yemen, taha_alnuaimi@yahoo.com.
2 State Company of Geological Survey and Mining / Ministry of Manufacturing and Mining / Iraq
3 Department of Applied Geology / Faculty of Science / Tikrit University/ Iraq .
4 State Company of Geology Survey and Mining / Ministry of Manufacturing and Mining/ Iraq

ABSTRACT

Twenty five soil samples were collected from various parts of uncultivated areas in Iraq including Rabe'a, Mosul, Hatra, Beygee, Balad, Radhwnaia, Abu Graib, Wasit, Anbar and Basrah. These samples were examined by XRD to determine the mineral constituents. Clay fractions were separated for clay mineralogy.
The results showed that the clay minerals represent about 40% of the mineral constituents of the samples, dominated by montmorillonite, illite, palygorskite and chlorite having various proportions. The non-clay minerals are represented by calcite and dolomite which present as detrital grains and representing about 32% of the mineral constituents. Quartz comes with about 22% and feldspars with about 5%. The water-soluble salts in the soil samples varied according to the sampling location and represented about 0.3% on average, increasing from north to south.
The study showed the relation of the soil mineralogy with source rocks, and the most of the Iraqi soils are the results of erosion, weathering and transported by rivers. The authigenic minerals are locally precipitated from near-surface saline ground waters.

INTRODUCTION

Quaternary sediments cover most of Iraq and represent most of its soils. It includes recent flood plain sediments (Holocene) of Tigris and Euphrates and their tributaries, in addition to sediments transported by wind mainly sand dunes which spread over the north and north – western parts of the sedimentary plain (Yacoub,1983). Most of these deposits consist of clays and mud with sand, together with chemical deposits of carbonates and evaporates formed as a result of evaporation. These recent alluvial deposits are different from the ancient alluvial deposits of Pliestocene age. The latter consists of alluvial terraces and widespread over the north and northwestern parts of the sedimentary plane forming relative highs and showing gradation from pebbles to sands, clays and mud (Domas, 1983).

In this study, the term soil is not used in its strict scientific meaning, which is, a weathering product. Instead, it is used as a cohesion less friable product, a weathering product in situ or a transported material by different erosional agents or a mix of both, which represent, most Iraqi soils form in situ. These soils are different in their constituents and stages of development from one area to another depending on conditions of weathering, transportation and deposition as well as the sort of diagenesis soils undergo.

Consequently, the mineralogical study of Iraqi soils gained importance and concern of several researchers. Al-Rawi, et. al., 1969, studied the mineralogy of Iraqi soils in northern and central parts of Iraq. They emphasized the mineralogical nature of soils and minerals of flood sediments and river terraces in addition to the mineral variability with soil depth. They found that montmrillonite is dominate in addition to other minerals in different proportions. Al-Rawi, 1977 studied recent sediments of Diwania region which were transported by Euphrates and its tributaries. He found that these sediments are sand, clay, mud and the grains of the latter are dominant. Banat and Al-Rawi, 1986; and Abdullah, 1982 studied the mineralogy of flood sediments of Diwania and Al- Hammar marshland as well as the clays along Euphrates is outlines. Al– Hassani, 1984, studied the mineralogical and chemical aspects of sabkha and shura soils in some regions of Iraq and found them alike.

Al–Ani, 1986 studied the geochemistry and sedimentology of sabkha in central and southern Iraq. He showed that montmorillonite is the major constituent of plain deposits and that these clays are detrital in origin transported by rivers and wind. He considered the igneous and metamorphic rocks in the upstream are the main source for these deposits in addition to some other sedimentary formations within the country.

A new outlook to the mineralogical nature of the Iraqi soils is adopted in this paper. It emphasises the influence of salinity, climate and source rocks on the type of minerals found in soils. The work is conducted on 25 samples selected from different areas of Iraq from north to south covered the provinces of Mosul, Salah – Al Din, Baghdad, Wasit, Al – Anbar , and Basrah (Fig.1).

MATERIALS AND METHODOLOGY

Twenty five non-cultivated agricultural soil samples were collected from different areas of Iraq (Table-1). After removing the upper layer, these samples were taken out by a shovel or auger from a depth of 30cm from the cleaned earth surface, and from areas cut by small wadis. Each sample was divided into two parts for grain size and mineral composition analysis.

Size gradation

100 grams of soil are taken after drying in an oven of 60C for a period of 24 hours. The sample is then washed in a 63 micron size sieve. The coarser part is dried in an oven of 60 C. The dried coarser part is placed into a sieve of 2 mm. The weights of sand (size 0.063 – 2.0 mm) and of pebbles (more than 2 mm) are determined. The rest of the sample (less than 63 microns) is left to settle for 24 hours and then dried.

Table (1): The distribution of sample localities and serial numbers.

City	area	Serial No.
Mosul	Mosul Rabea Hatra	4 1 -2 – 3 5
Salah Al-Deen	Bayjee Balad	6 7
Anbar	Kilo-160 Rutba Akashat	8 9 10
Baghdad	Abu Gharib Radhwania	13- 14-15 -16 -17 18 -19-20- 21 -22
Wasit	Wasit	11 – 12
Basrah	Basrah	23 – 24 – 25

To determine the clays proportions forty grams of Kalcon were taken and dissolved in a 100 milliliter with continuous stirring for half an hour. The sample now is left for another 24 hours, which is then put into a graduated cylinder (holds 1000 ml) and distilled water is added up to 1000 ml with continuous stirring. A hydrometer is put inside the cylinder. Readings are taken from a quarter of a minute to 24 hours. Then some arithmetic is executed to determine the proportions of mud and clays in the samples (Tamar–Agha and Mahdi, 1992).

Analysis of minerals

Samples were analyzed by X-ray diffraction to determine their mineral contents. Samples are grinded by agate mill and slides are made for testing.

Particles of clays were separated according to Jackson, 1958 and Al–Janabi et al, 1992and then determined and examined by X-ray diffraction. Clay minerals are determined and calculated sub- quantitatively as in Al–Janabi et al., 1992.

RESULTS AND DISCUSSION

Size gradation

Size analysis was performed on samples (Table-2) for the purpose of their classification depending on textural properties according to (Wentworth1922). Results show that 68 % of the samples is clayey mud soils (silty clay). Silt ranged from 29 – 48.4 % (table-2) while the clayey part showed a range of 17 – 50.5 % which reflects a transporting agent of low energy in the depositional plain region. 24 % of samples fall within the sandy soil type with a sand range of 26 – 48.2%. Clayey soils comprised 8 % of the studied samples.

Rabea is characterized by silty clayey soils with a sand percent not more than 5%. Southward of Mosul and Hatra sand percent increases and clay percent decreases, with silt percent remains almost constant (table-3). Some pebbles also appear but no more than 1.5%. The soils of Bayjee are characterized by a higher sand percent reach to 48%, and are classified as sandy clay loam. The reason for this is the presence of sand dunes in the region which influences the type of soil in these regions. Sands decrease in the southern direction in soils fringing Tigris river where clays and silt increase in Baghdad. The soil is classified as silty clay where it constitutes around 7.6% while silt content is 45.5 % (table-4) and clay contents 46.4 %, such as the soil samples of Wasit and Basrah which are classified as silty clay. In Wasit, sands reach to 2.5 % and clays to 50.5 % which is the highest value in studied samples.

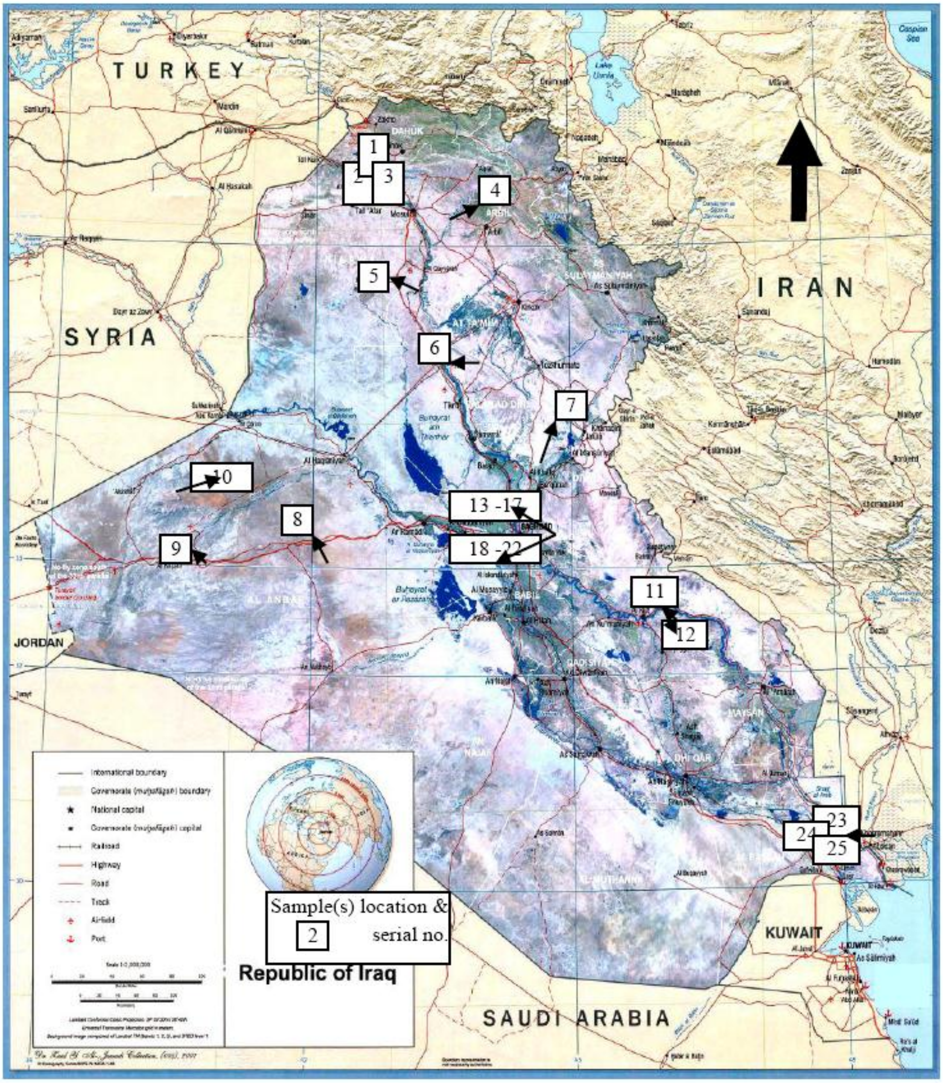

Figure (1) : Location map of the collected samples (Modified from Iraq Satellite Photomap,2003).

Table (2): Sieve analysis and classification of soil samples.

Serial No .	Samples	% *Gravel	% Sand	% Silt	% Clay	Texture Us Dep. Of Agriculture	Classification After Al-Taei,1968
1	Rabea-1	-	5	42	53	Clay Silty	Mollie Calciorthids (CM)
2	Rabe a-2	-	4	43	53	Clay Silty	Mollie Calciorthids (CM)
3	Rabe a-3	-	6	47	47	Clay Silty	Mollie Calciorthids (CM
4	Mosul	-	16	48	36	Silty Clay	Torrifluvents (TF)
5	Hatra	3	36	34	27	Sandy Silty Clay	Calciorthids and Lithic
6	Bayjee	-	48	23	29	Sandy Silty Clay	Calciorthids (CI)
7	Balad	-	4	53	43	Silty Clay	Torrifluvents (TF)
8	AL-Kilo-160	3	50	24	23	Sandy Silty Clay	Calciorthids (CL3)
9	Rutba	9	65	13	13	Sandy Silty Clay	Lithic Paleargids and Lithic Calciorthids (PL)
10	Akashat	5	30	50	15	Silty Sand	Paleargids and Lithic paleargids (PL)
11	Wasit - 1	-	2	41	57	Clay Silty	Salorthids Torrifluvents and Torrets (SI)
12	Wasit - 2	-	3	53	44	Silty Clay	Torrifluvent(TF)
13	Abu Garib-1	-	7	52	41	Silty Clay	Torrifluvent(TF)
14	Abu Garib-2	-	3	46	51	Clay Silty	Torrifluvent(TF)
15	Abu Garib-3	-	5	50	45	Silty Clay	Torrifluvent(TF)
16	Abu Garib-4	-	5	46	49	Clay Silty	Torrifluvent(TF)
17	Abu Garib-5	-	4	48	48	Clay Silty	Torrifluvent(TF)
18	Radhwania-1	-	13	38	49	Clay	Torrifluvent(TF)
19	Radhwania-2	-	5	49	46	Silty Clay	Torrifluvent(TF)
20	Radhwania-3	-	13	46	41	Silty Clay	Torrifluvent(TF)
21	Radhwania-4	-	15	37	48	Clay	Torrifluvent(TF)
22	Radhwania-5	-	6	43	51	Clay Silty	Torrifluvent(TF)
23	Basrah-1	-	2	50	48	Silty Clay	Salorthids(SI)
24	Basrah -2	-	1	54	45	Silty Clay	Salorthids(SI)
25	Basrah-3	-	13	41	41	Silty Clay	Salorthids(SI)

Gravel: >2.0mm Sand : 2.0 – 0.063 mm Silt : 0.063- 0.002 mm Clay:<0.002 mm

Table (3): The soil mean grain size according to geographical distribution.

Area	Gravel %	Sand %	Silt %	Clay %
Rabea	-------	5	44	51
Mosul + Hatra	1.5	26	41	31.5
Bayjee + Balad	-------	26	38	36
Anbar(Kilo-160+ Rutba + Akashat)	5.7	48.3	29	17
Wasit	------	2.5	47	50.5
Baghdad(Abu-Gharib +Radhwania)	------	7.5	45.5	46.9
Basrah	-------	5.3	48.4	46.3

Results also have shown a pebble highest content of 5.7 % in samples of Al-Anbar, in addition to the presence of high content of sands which reaches around 17%, classified as sand clay loam (Table-3). This is because of in situ origin of these soils and are influenced by wadi deposits that occurred by seasonal flash floods which carry clastics of different sizes of pebbles and sands.

Mineralogy of soil samples

In the light of X-RD investigation (Fig.2) it is possible to quantitatively estimate minerals present in the studied samples (Table-4 and Fig.2). Results show clays are predominant among soil minerals under study. Clays are present in about 40% with a range of 55 – 20 % (Table-5 and Fig.3A). Montmorillonite dominates in most samples (Fig.2) except Rabea and Mosul where mica (illite) or palygorskite comes first and montmorllonite remains the principal mineral in the samples of these regions. Also, palygorskite and montmorillonite dominate in the samples of Al-Anbar. Chlorite is the second in the samples next to montmorillonite inAl- Anbar and most samples of Basrah region. Illite is second in the samples of Abu-Gharib.

Kaolinite is the least distributed clay mineral in the studied samples except with individual samples in Basrah and Radhwania (Table-4). The main source of these minerals is the transported sediments by rivers and tributaries during flood seasons which carry along weathering products of different types of igneous and metamorphic rocks exposed within Tigris and Euphrates headwaters, in addition to sedimentary rocks which enrich Iraqi soils with extra clastics rich in clays derived from Injana and Muqdadia Formations. Also, few percentages of these minerals are a product of in situ weathering particularly in the soils of Al-Anbar. For weathering, chemical and mechanical, is a primary role in delineating the produced clay minerals (Degens, 1965),(sadiq,1985). For climate and topography, as well, have a long influence on the type of clay minerals produced. All of these lead us to believe that quite adverse mixture of these minerals is present in Iraqi soils.

Montmorillonite is the primary mineral in all samples which develops as a result of weathering of basic igneous and metamorphic rocks rich in iron, magnesium and calcium. These rocks are typical in Iraqi rivers headwaters, where they are eroded and transported by rivers to where their sediments accumulate. Here, it is noteworthy to mention that the three minerals (mica, illite, montmorillonite) do represent a chain of successive weathering stages. Micas frequently are a product of igneous and metamorphic rocks; they alter to illite by weathering, where part of potassium is replaced by hydrogen and form montmorillonite during successive stages of weathering by replacing potassium within the crystalline lattice with other ions such as calcium, which causes its increase in water. This reflects content of montmorillonite in most Iraqi soils. Climate has also a noticeable role in the formation of these minerals which are formed in arid and semiarid climate. In addition, this large proportion of montmorillonite is due to diagenesis which initiated weathering of chlorite as a result of sodium concentration particularly in samples of central and southern Iraq, which possibly was the major cause of chlorite decrease in these regions. The increasing of the concentration of mica (illite) in soil of Rabea and Mosul, north of Iraq, caused by nearness to regions of source rocks in northern and northeastern Iraq, igneous and metamorphic rocks rich in mica and may also be due to rock weathering of marl for example.

It is also noticed that palygorskite existence in the studied samples, considered in situ clay mineral, represent the major mineral in samples of western desert. But what explains its presence in most samples is the transportation and deposition of clastics derived from ancient formations, transported by rivers and wind. Kukal and Saadallah, 1978, Al – Khattab, 1972, and Buringh, 1960, have pointed out that dust storms, taken place in southern and western Iraq most of the year, which transport large quantities of sediments for long distances reaching up to hundreds of kilometers. Beside that is the possible diagenesis such as the transformation of montmorillonite to palygorskite as a result of uptaking magnesium from soils (Weaver and Pollard, 1975). Climate of arid and semiarid dominant in the country is required for the formation of such minerals (Aqrawi, 1993).

Table (4): Mineral percentages and clay minerals in studied samples.

Serial No .	Samples	Carbonates %	Quartz %	Clays %	Feldspar %	Clay minerals
1	Rabea-1	27.5	22.0	47.5	3.0	Mica, Palygorskite, Montmorillonite, Chlorite
2	Rabea-2	28.0	0.27	45.0	-------	Palygorskite, Montmorillonite, Kaolinite, Mica
3	Rabea-3	27.5	20.0	52.2	-------	Mica, Palygorskite, Montmorillonite, Kaolinite
4	Mosul	43.5	12.0	44.5	-------	Mica, Palygorskite, Montmorillonite, Chlorite, Kaolinite
5	Hatra	24.5	25.0	45.5	5.0	Palygorskite, Montmorillonite, Kaolinite
6	Bayjee	30.0	18.0	47.0	5.0	Montmorillonite, Chlorite, Mica, Kaolinite
7	Balad	35.0	24.0	36.0	-------	Palygorrskite, Mica, Montmorillonite, Chlorite
8	AL-Kilo-160	35.0	30.0	35.0	-------	Palygorskite, Montmorillonite, Chlorite ,Kaolinite
9	Rutba	26.0	33.0	41.0	-------	Montmorillonite, Palygorskite,
10	Akashat	42.0	18.0	40.0	-------	Montmorillonite, Chlorite, Mica, Kaolinite
11	Wasit – 1	30.0	26.0	44.0	-------	Montmorillonite, Chlorite, Mica, Palygorskite, Kaolinite
12	Wasit – 2	32.0	25.0	39.0	4.0	Montmorillonite, Mica, Palygorskite, Kaolinite
13	Abu Gharib-1	26.5	21.0	43.5	9.0	Montmorillonite, Mixed Plated, Mica, Palygorskite,
14	Abu Gharib-2	26.0	30.0	36.0	8.0	Montmorillonite, Mica, Palygorskite, Kaolinite
15	Abu Gharib-3	30.5	18.0	43.5	8.0	Montmorillonite, Chlorite, Palygorskite, Kaolinite
16	Abu Gharib-4	27.0	18.0	37.0	18.0	Montmorillonite, Mixed Plated, Mica, Palygorskite
17	Abu Gharib-5	26.0	20.0	41.0	13.0	Montmorillonite, Mica, Palygorskite, Kaolinite
18	Radhwania-1	27.0	18.0	47.0	8.0	Montmorillonite, Chlorite, Mica, Palygorskite, Kaolinite
19	Radhwania-2	29.0	26.0	38.5	6.0	Montmorillonite, Chlorite, Palygorskite,
20	Radhwania-3	26.0	19.0	44.5	10.0	Montmorillonite, Kaolinite, Palygorskite, Mica,
21	Radhwania-4	25.0	15.0	40.0	20.0	Palygorskite, Montmorillonite, Kaolinite
22	Radhwania-5	28.0	25.0	32.0	15.0	Montmorillonite, Chlorite, Mica, Kaolinite
23	Basrah-1	48.0	20.0	30.0	2.0	Montmorillonite, Chlorite, Kaolinite
24	Basrah -2	45.0	20.0	35.0	Trace	Montmorillonite, Chlorite, Kaolinite
25	Basrah-3	55.0	25.0	20.0	Trace	Kaolinite, Montmorillonite

On the other hand, Kaolinite is the least present mineral in the studied samples. This reflects a weak chemical weathering upon the source rocks (Wollast, 1967, in Banat, 1980), because formation of kaolinite requires a humid equatorial climate, contrary to the existed semiarid climate. Moreover, the presence of salt and alkali concentration in some Iraqi soils within the depositional plain offers the wrong environment for the formation of kaolinite (Grim, et al., 1960). Also, its presence indicates strong heavy rainfall and efficient water drainage and high soil permeability. Therefore, the presence of a little proportion of kaolinite supports a detrital source carried by rivers from sediments occurring within the northern parts of the depositional plain.

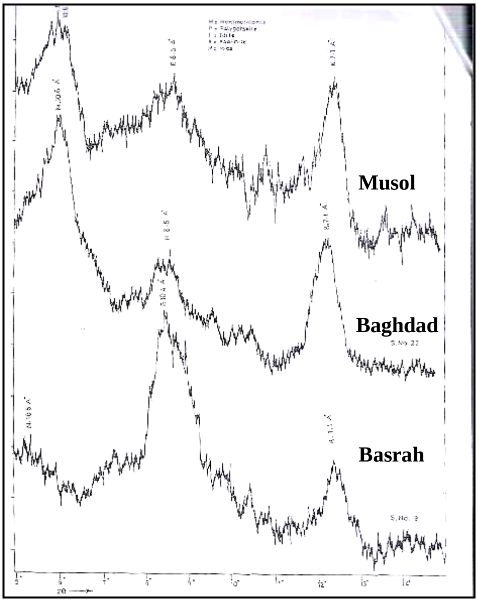

Figure (2): X-Ray diffractograms for clays separated from some soil samples.

Table (5): Results of mineral percentages and clay grain size individual studied geographic of encountered minerals in areas and their means and ranges.

Area	Number of samples	Carbonates %	Quartz %	Feldspar %	Clays XRD %	Clays grain size
Rabea	3	27.7	23.0	1.0	48.2	51
Mosul(Mosul – Hatra)	2	34.0	18.5	2.5	45.0	32
Salah Al-Deen(Bayjee–Balad)	2	32.5	21.0	2.5	41.5	36
Anbar (Kelo160 +Rutba +Akashat	3	34.3	27.0	-----	38.7	17
Baghdad (Abu- Gharib + Radhwania)	10	27.2	21.0	11.5	40.3	47
Wasit	2	31.0	35.5	2.0	41.5	51
Basrah	3	49.3	21.7	0.7	28.3	47
Percentage ranges Mean percentages		24.5-55.0 32.0	12-33 22.2	20-0 5.4	20-47.5 40.2	17-51

Carbonate minerals (calcite and dolomite) come next in abundance where their average in the studied samples is 33% with a range of 24.5 – 55.0 % (table-4). Samples of Basrah are characterized by the higher concentration of carbonate minerals where they reach an average of 49%, while samples of Rabea and Baghdad are characterized by the least percent (~ 27%). In general, and as shown in fig. 3-B, there is an inverse relationship between carbonate mineral content and clay mineral content in the studied samples. These minerals are present as rock fragments transported by rivers and wind from nearby rocks particularly

Euphrates and Dammam formations widespread in southwestern Iraq. This reflects the large proportion of carbonate minerals in the Basra samples, in addition to the possibility of their deposition from groundwater of low water table caused by evaporation. As of quartz, it represents the third mineral achieving an average of 22% and a range of 13 – 23 % .

The western desert samples are characterized by the highest quartz content accounting for 27 % (table-5), while it occurs with lowest concentration in Mosul samples of 18.5 % (fig . 3-C).

Results show little concentration of feldspar in the studied samples and none in most samples of Rabea, Mosul, Bayjee and Anbar, while feldspar is present in all Baghdad samples with an average of 5% and a range of 0 – 20%, and show highest concentration (table 5 and Fig. 3-D).

Quartz is present in the studied samples as grains transported by water and wind with high percent in the Anbar. The little occurrence of feldspar is due to absence of source rock or its little occurrence which is present in acidic igneous rocks such as granite. This little proportion of feldspar in Wasit and Baghdad samples is due to the effect of some formations such as Injana and Dibdiba which contain relatively high percentage, of clastics transported by rivers.

It is inevitable to indicate presence of different concentrations of evaporate minerals especially in the samples of central and southern Iraq (Fig. 2-E). The origin of these minerals is due to evaporation of irrigation water and near surface groundwater in areas of poor drainage and to type of groundwater (Al-Hazaa,et al., 2009).

CONCLUSIONS

The study shows that the studied soil samples consist of clay minerals (montmorillonit, illite, palygorskite and chlorite with little kaolinite) and carbonate minerals, in addition to quartz and feldspar. Clay minerals represent about 40% with their concentrations decrease in the samples of Anbar and increase in the samples of Baghdad and southern Baghdad soils. Carbonate minerals form about 33% with an increase in soils of Basrah. Quartz makes around 22% with a relative increase in the samples of western desert. Feldspar form around 5% of the soil mineral constituents. It increases in the samples of Baghdad. The study shows that the mineral constituents in most samples are transported detritus from eroded regions in the upper Euphrates, Tigris and their tributaries except samples of western desert which represent in situ soils.

As of the evaporate constituent, it has a secondary origin developed within the soil through evaporation from ground water and irrigation waters.

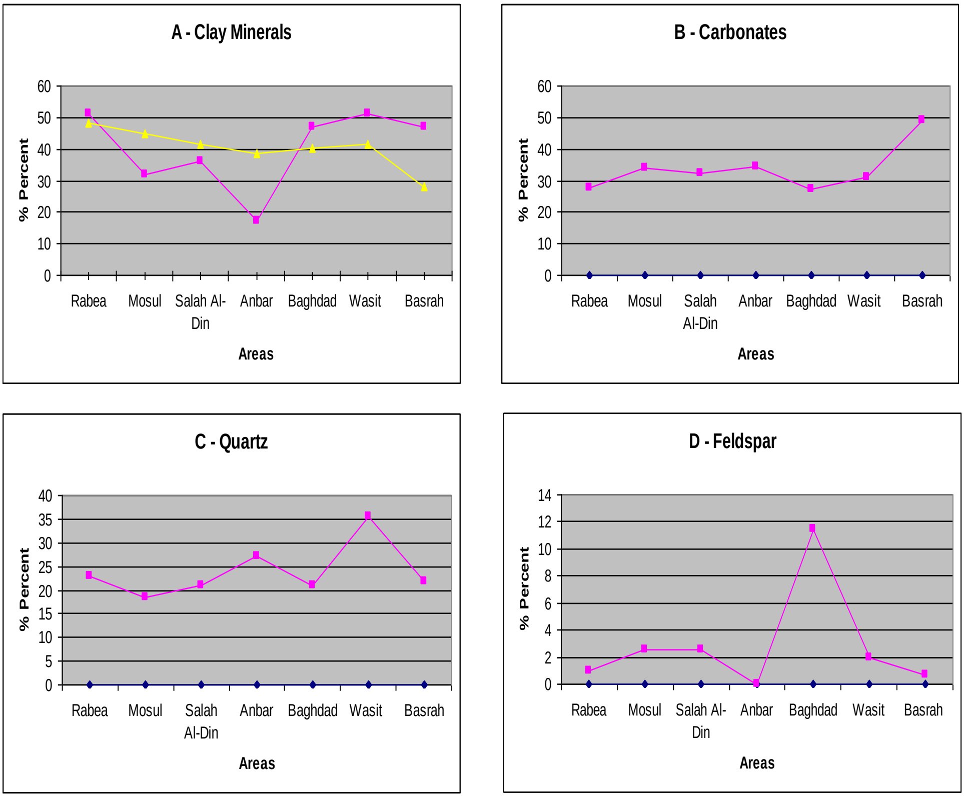

Figure (3): Mineral percentages of Iraqi soil samples according to geographical distribution

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التركيب المعدسني لعينات من الترب العراقية

طه النعيمي[1]، خلدون البصام[2]، سوسن الهزاع[3] ونوال السعدي[4]

1 جامعة صنعاء/ كلية العلوم./ قسم علوم الأرض والبيئة ./ صنعاء / اليمن
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4 الشركة العامة للمسح الجيولوجي والتعدين/ بغداد / العراق

ملخص

أجريت نمذجة للتربة من مناطق غير مزروعة في أنحاء مختلفة من القطر هي ربيعة، الموصل، الحضر، بيجي، بلد، الرضوانية، أبو غريب، واسط، الأنبار والبصرة وبلغ عدد العينات(25) عينة. تم فحص العينات معدنياً بواسطة حيود الأشعة السينية لتحديد التركيب المعدني للتربة وفصل الجزء الطيني لتشخيص المعادن الطينية.

بينت النتائج أن المعادن الطينية تمثل حوالي 40% من المكونات المعدنية للعينات وتسود فيها معادن المونتمورلونايت والآلايت والباليغورسكايت والكلورايت بنسب مختلفة وحسب المواقع الجغرافية لعينات الدراسة.

المعادن غير الطينية تمثلت بالكالسايت والدولومايت الموجودة بشكل فتات صخري منقول. وبلغ مجموع المعادن الكاربونيتية حوالي 32% كمعدل في عينات الدراسة. يأتي الكوارتز بالمرتبة الثانية من بين المعادن غير الطينية وبلغ معدله حوالي 22% والفلدسبار كان معدله حوالي 5%. تباينت معادن الأملاح الذائبة في الماء في عينات الدراسة حسب المواقع الجغرافية وبلغ معدلها حوالي 0.3% ولوحظ زيادة تراكيزها من الشمال إلى الجنوب.

بينت الدراسة علاقة الصخور المصدرية مع المكونات المعدنية للتربة حيث أن معظم العينات تمثل رواسب منقولة ومترسبة في بيئات نهرية وقسم آخر متكون موقعياً بسبب عوامل التجوية. وتمثل الأملاح معادن متكونة موقعياً ضمن العمليات التحويرية ومصدرها المياه الجوفية القريبة من السطح وتعتمد نوعيتها على التركيب الكيميائي لتلك المياه