Ann. For. Res. 65(1): 9038-9049, 2022
ISSN: 18448135, 20652445

ANNALS OF FOREST RESEARCH
https://www.e-afr.org/

WEATHERING INDEX OF GADWAL AL-GARBI SOIL PROJECT IN KARBALA PROVINCE

Hameed K. Abdul-Ameer* and Alaa H. A. Hussain

Al-Furat Al-Awset Technical University, Technical College Al-Mussiab, Iraq
*Email: Hameed.abass@atu.edu.iq

Abstract: A field study was carried out in the year 2021 to find out some soil properties and mineral distribution of clay separated as well as the elemental oxides and weathering index in the soil deposits of the Gadwal Al-Garbi Project for Karbala Governorate, within the coordinates: longitude (44.106° and 44.217° E) and latitudes (32.480° and 32,620°N) , 50 sites were selected covering the surface layer of the project soil, the locations of the points were revealed as pits, with a depth of 0-30 cm. The result show that the average value of pH was 7.6, electrical conductivity was 4.78 dSm^{-1}, cation exchange capacity was 22.83 Cmole charge. kg^{-1}, carbonate mineral was 23.75%, gypsum was 0.198%, and the average values of the organic matter was 0.97%. As for the results of the clay mineral analyses , it showed the predominance of Illite , followed by vermiculite, palygoriskite, chlorite, montmorillonite, and finally kaolinite. The elementary oxide analyses show the predominance of SiO_2 then CaO , Al2O3 , Fe2O3 , MgO , K2O , and Na2O respectively , while the weathering index value was low.

Keywords: Weathering index, Soil project, rock

1. Introduction

Soil particles consist of primary minerals resulting from the disintegration of rock components by physical weathering , and secondary minerals resulting from the decomposition of rock by chemical weathering. As the main product of primary minerals is the crystallization of magma at a low temperature on the surface of the earth, it includes silicate minerals such as plagioclase feldspar and iron and magnesium (ferromagnesian) minerals ,while the primary source of secondary minerals is the decomposition of primary minerals, including silicate minerals, such as clay minerals [1]. [2] studied the sediments of river levee in the Shatt al-Arab region and their composition of clay minerals. He found the predominance of montmorillonite clay minerals with a percentage of 37%, followed by Illite clay minerals with 20%, then chlorite by 18%, kaolinite by 14% and palygorskite by 11%, as well as the presence of mixed clay minerals such as montmorillonite-chlorite of a spatial origin, whose presence is due to the severity of the modulatory processes that the sediments were exposed during the deposition process especially in arid and semi-arid environments. [3] show that clay minerals are the most effective component among the mineral soil components, which effect on its chemical and physical properties due to clay having a surface charge, it enters into electrochemical reactions such as ion exchange and ion stabilization and this characteristic is important great in determining the chemical properties of soil, clay particles has a large and effective surface area and has the ability to retain water as well as the ability to swell and shrink due to the presence of expanding minerals such as the montmorillonite group. [4] indicated that the X-ray examinations of clay particles of some gypsic soils showed the predominance of montmorillonite , followed by chlorite, palygorskite, mica, and finally kaolinite . In addition, there was of polarized clay minerals at two types regular and irregular. [5] study the clay minerals types and element oxide of the desert and alluvial soil of Al-muthanna governorate, at two depths (0-15, 15-30 cm). the results show predominance of kaolinite mineral , palygoriskite followed by chlorite . and they found a decrease in the content of elemental oxides, as the values of iron oxides ranged between (1.42-1.48%), aluminum oxides between (2.11-2.29%) and silicon oxide between (20.93-21.23%) for desert soils, while it was (1.61. - 3.12%), (3.02-5.10%) and (29.95-32.33%) respectively for alluvial soils (%). The aims of study to identify clay minerals , oxide minerals and chemical weathering index in the soils of the Gadwal Al-Garbi Project in Karbala Governorate.

Material and Methods

The study area is located in the Karbala governorate within the geographical coordinates between longitudes (44.22° and 44.54° east) and latitudes (33.32° and 32.44° north) (Fig. 1) and it is part of the sedimentation of the floodplain which is known as the Iraqi alluvial plain (Abdul-Amir , 2016).

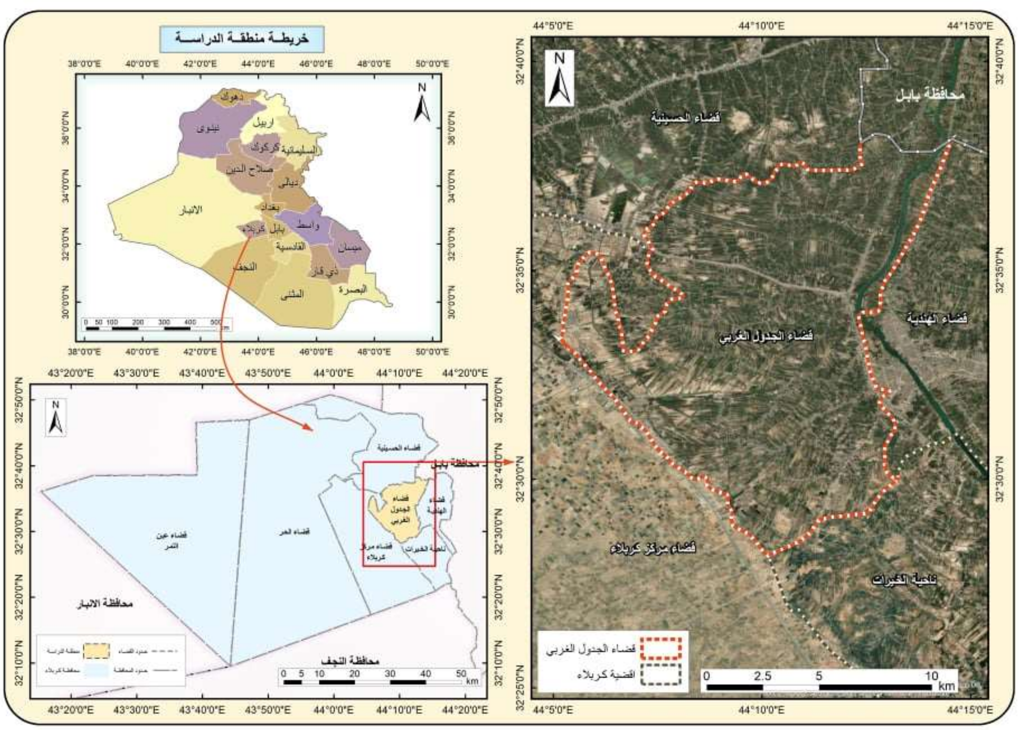

Fig 1. Study area

50 drill holes were selected representing the surface layer (0-30 cm) in the whole project (Fig 2), using the GPS system with a UTM coordinate , the soil sample were taken , then dried, crushed and passed through a sieve with the diameter 2 mm to measuring soil properties which represent soil particles analysis using pipette method, soil reaction (pH) using a pH meter and electrical conductivity (ECe)) in the extract of saturated soil paste using the Electrical Conductivity Bridge

, and the exchange capacity of positive ions (CEC)) using 1N ammonium acetate NH4OAc at (pH = 7.0) and soil content of carbonate minerals using acid (HCl 1N) , soil content of calcium sulfate minerals ($CaSO_4.2H_2O$) by acetone precipitation, and soil organic matter (OM) by wet digestion method according to the methods mentioned in Jackson, 1958 and Black, 1965.

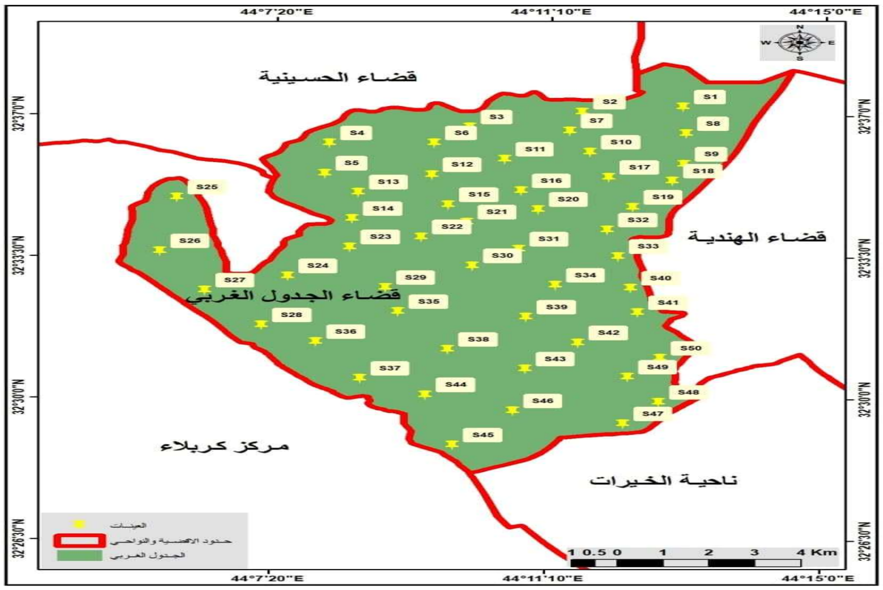

Fig. 2. Study soil sample

The mineral analysis included the removal of binding materials and removing salts from the samples by washing them with distilled water for three times, then calcium carbonate was removed using sodium acetate corrected at a pH of 5 [6]the organic matter was removed using a 14% sodium hypochlorite solution [7] Removal of free oxides by Na-citrate-bicarbonate-dithionite method according to [8] then the separation and fractionation process was carried out for the particles more than 50 microns by wet sieving method, and then the clay particles (less than 2 microns) were separated by the sedimentation process according to [9] mentioned in Black, 1965. X-ray diffraction examination of the clay particle prepared with five treatments as follow:

A- Magnesium and air drying. B- Magnesium and ethylene glycol. C- Potassium and air drying. D- Potassium and heating at 350° C. E- Potassium and heating at 550° C

using X-ray differection pattern to obtain the diffraction sheets, then to diagnose the types of clay minerals according to the method mentioned in Jackson, 1979. The minerals was calculated according to the intensity of the curve (Intensity Peak) and the height above the floor of the curve (to reflect the curve area) , an X-ray fluorescence (XRF) device was used to estimate the oxides ratios using the the methods mentioned by Jackson, 1968. Weathering indexes calculated as follow :

Silica-Alumina Ratio (SAR) = SiO_2 / Al_2O_3

Silica-Ferric Oxide Ratio (SFOR) = SiO_2 / Fe_2O_3

Silica-Sesquaoxide Ratio (SSR) = $SiO_2 / (Al_2O_3 + Fe_2O_3)$

Alkali earth – Aluminu Ratio (AEAR) = (CaO + MgO) / Al_2O_3

3. Results and Discussion

1-Soil Characteristics

The results in Table 1 indicate that the sand fraction content ranged between 204.0 - 512.7 gm kg^{-1} and an average of 360.2 gm kg^{-1}, and the values of clay fraction ranged between 124.8 - 464.0 gm kg^{-1} and an average of 286.2 gm kg^{-1}, while the silt content ranged from between 236–440.4 g kg^{-1} and an average of 353.5 gm kg^{-1} at a depth of 0–30 cm, the values of the degree of soil pH ranged between 7.1–8.1 and an average of 7.6, and the electrical conductivity values ranged between 3.1–7.2 dSm^{-1} and an average of 4.78 dSm^{-1} The values of the exchange capacity of soils ranged between 16.1 - 29.5 Cmmol charge. kg^{-1} with an average of 22.83 cmol. kg^{-1}, soil mineral carbonate values ranged between 17.8-30.2% and an average of 23.75%, the values of gypsum($CaSO_4$) content of soil ranged between 0.13-0.32% and an average of 0.198%, while the values of soil organic matter ranged between 0.57-1.32% with an average of 0.97%.

2- Clay Minerals

Clay minerals were diagnosed based on the different X-ray curves of each mineral when exposed to potassium, magnesium, ethylene glycol and heating coefficients mentioned in (Hepper et al, 2006). The results of the sharp X-ray examinations in (fig 3) showed the appearance of diffraction 10.04 Aº and diffraction 10.16 Aº in the clay samples saturated with magnesium and drying by air and its remaining constant in the other treatments. The second mineral at a basal distance of 5 Aº and with a high intensity indicates the presence of the dioctahedral mica (muscovite mineral). The figures also showed the presence of diffraction 14.49 Aº, diffraction 14 Aº, diffraction 13.81 Aº, diffraction 14.4 Aº, diffraction 14.2 Aº and diffraction 14.03 Aº in the samples of soil samples studied in the treatment of saturation with magnesium and air dry and keeping it constant. When the diffraction is 10.5 Aº and the diffraction is 10.51 Aº in the treatment saturated with magnesium and air-dry, and it remains constant in all treatments, the mineral is palygoriskite, and this result is consistent with the findings of [7]. The appearance of diffraction of 11.94 Aº and diffraction of 12.4 Aº in the treatment saturated with magnesium and air-dried indicates the presence of the irregular applied mineral Kaolinite - chlorite. It is clear from the results that the proportions of clay minerals that were diagnosed according to the different soils of the study and that there is a general homogeneity in the distribution of the proportions of minerals and their types horizontally within the locations of the soil samples in the study area. In general, the arrangement of minerals and according to the general average takes the following order:

Illite > Vermiculite > Palygoriskite > Chlorite > Montmorillonite > Kaolinite

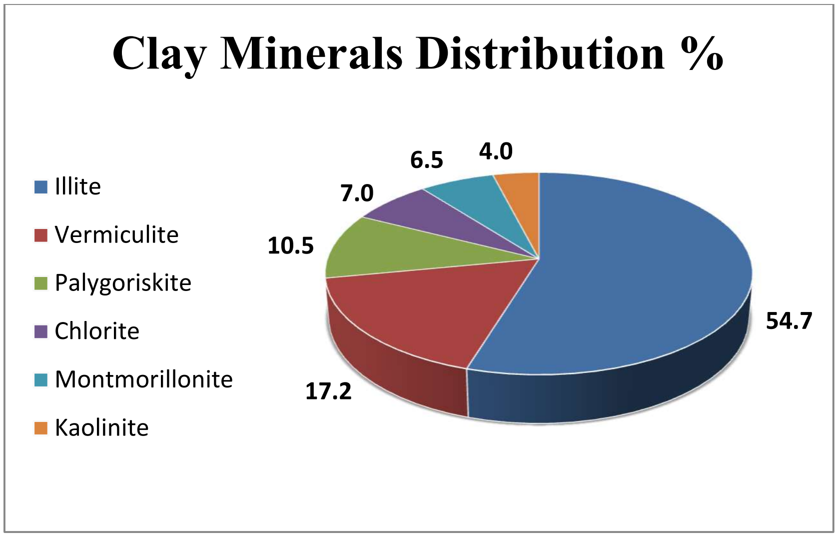

Fig 3. Clay Minerals Distribution

3- Elementry Oxides and Weathering Indexes

The chemical composition of modern river sediments is affected by several factors, on top of which is the chemical composition of rocks that have been subjected to the weathering process and climatic conditions. As well as other important factors, including topography of the weathering area, type of vegetation cover and type of land use (Biliniski, 2008). The sediments transported from weathered areas by erosion and weathering of source rocks are also enriched with organic and inorganic pollutants present in sewage discharged into surface waters, as well as those transported by surface runoff, and this contributes to the acquisition of oxide ions through the course of the river as well as rare elements [9]

The results indicated the predominance of silicon dioxide, calcium oxide, aluminum oxide, iron oxide, magnesium oxide, potassium and sodium oxides respectively (Fig. 4).

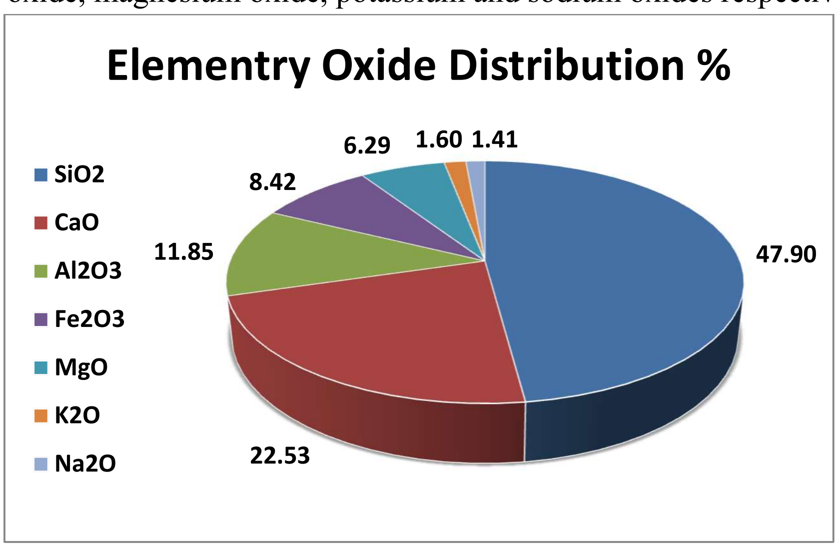

Fig 4. Elementry Oxide distribution

The results in table 1. indicate the dominance of silicon dioxide, and its ratio ranged between (32.4 - 39.7%) and an average of 36.80%. This high percentage of silica is due to the fact that the source material is rich in silica, and this was confirmed by the predominance of opaque minerals and quartz mineral for minerals separated by fine sand for the study soil, and this is consistent with a number of The researchers of the soils of central and southern Iraq, where they confirmed that the dominance of Chert mineral in relation to light minerals separated by sand is due to the fact that the material of the origin is rich in silica [10] and may return to sovereignty because it is one of the non-moving elements and resistance to weathering processes in addition to its high percentage in the source rocks subjected to the process of Weathering [11] followed by calcium oxide, which ranged between (14.4-19.8%) and averaged 17.31%, followed by aluminum oxide, which ranged between (7.1-10.7%) and averaged 9.10%, followed by iron oxide, which ranged between (5.3 – 7.8%) with an average of 6.47%, followed by magnesium oxide and its rate ranged between (3.2 - 6.3%) and an average of 4.83%, followed by potassium oxide and its rate ranged between (1.02 - 1.56%) and its rate ranged between (1.23%), followed by sodium oxide Its percentage ranged between (0.72 - 1.28%) and with an average of 1.08%. The decrease in the percentage of sodium oxide may be due to the effect of the alkanization process, which leads to the occupancy of the active surfaces of clay minerals and organic matter with sodium [12]

As for the values of weathering indexes, the values of SAR (SiO_2/Al_2O_3) index ranged between (3.08 - 5.34) and an average of 4.08, and the values of the weathering index (SFOR)) Silica-Ferrous ratio (SiO_2/Fe_2O_3) ranged between (4.60 - 7.02) with an average of 5.75 as shown in Fig. 5.

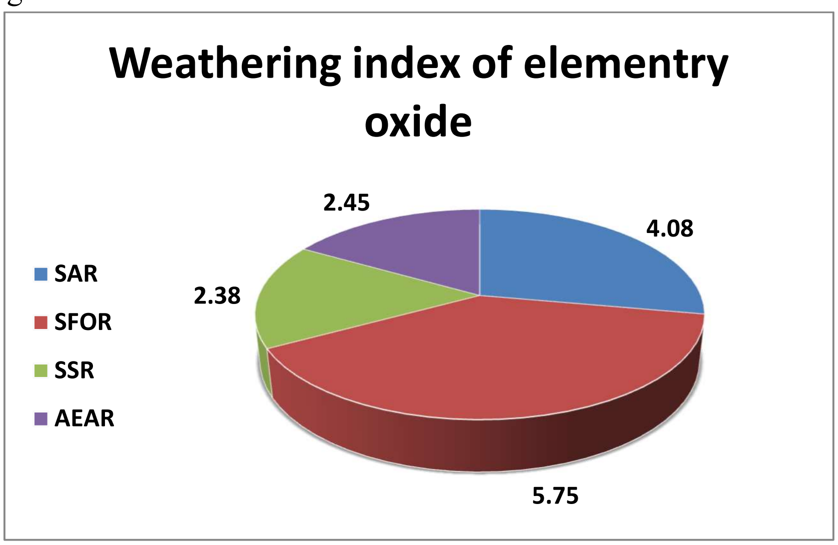

Fig 5. Weathering indexes of elementry oxides

Table 1. Soil characteristic , Elementry oxides , and Weathering index

				%										C mole		ds m^{-1}	gm kg^{-1}			Soil No.
2.482	2.457	6.396	3.988	1.34	1.03	4.9	16.2	5.3	8.5	33.9	0.95	0.21	26.8	22.6	7.6	4.8	353.1	366.5	280.4	S1
2.255	2.198	5.235	3.787	1.36	0.98	5.7	15.5	6.8	9.4	35.6	1.12	0.15	22.4	22.1	7.4	5.3	329.6	390.0	280.4	S2
2.848	2.581	5.536	4.835	1.31	1.11	6.1	16.4	6.9	7.9	38.2	0.94	0.19	23.6	24.5	7.2	6.2	337.7	426.3	236.0	S3
2.127	2.226	5.887	3.578	1.44	1.08	4.6	17.1	6.2	10.2	36.5	0.68	0.16	22.7	18.4	7.8	3.7	180.4	407.2	412.4	S4
2.609	2.470	5.828	4.287	1.38	1.04	5.2	17.5	6.4	8.7	37.3	0.74	0.32	24.8	19.1	7.8	4.1	201.8	317.6	480.6	S5
2.449	2.384	6.213	3.867	1.31	0.89	5.7	18.3	6.1	9.8	37.9	0.82	0.14	30.2	20.5	7.9	3.5	249.6	261.6	488.8	S6
2.523	2.424	5.810	4.159	1.36	1.13	5.4	16.8	6.3	8.8	36.6	0.94	0.18	26.8	20.8	7.8	4.2	262.5	365.4	372.1	S7
2.394	2.366	5.687	4.053	1.52	0.95	5.1	17.4	6.7	9.4	38.1	0.57	0.17	28.5	16.4	7.7	3.8	149.5	373.1	477.4	S8
2.423	2.402	5.881	4.062	1.43	0.91	5.7	17.8	6.7	9.7	39.4	0.88	0.13	26.3	20.1	7.5	5.6	259.6	380.4	360.0	S9
2.600	2.701	6.403	4.671	1.37	1.11	5.4	16.7	6.2	8.5	39.7	1.15	0.15	24.2	26.8	7.3	6.4	372.0	296.0	332.0	S10
2.490	2.229	5.122	3.948	1.56	0.89	5.7	18.2	7.4	9.6	37.9	0.95	0.25	23.3	21.5	7.5	5.1	256.0	422.0	322.0	S11
2.633	2.373	5.794	4.020	1.52	0.97	6.3	19.5	6.8	9.8	39.4	0.87	0.21	24.4	18.2	7.6	4.8	161.6	380.4	458.0	S12

Ann. For. Res. 65(1): 9038-9049, 2022
ISSN: 18448135, 20652445

2.571	2.251	4.947	4.132	1.44	1.08	5.8	17.6	7.6	9.1	37.6	0.76	0.19	25.2	17.4	7.8	3.3	164.4	429.1	406.5	S13
2.295	2.185	5.559	3.600	1.47	1.12	4.7	19.4	6.8	10.5	37.8	0.61	0.21	23.6	16.1	7.8	3.7	124.8	380.8	494.4	S14
2.846	2.388	5.443	4.256	1.12	1.09	4.8	17.4	6.1	7.8	33.2	0.92	0.14	26.7	19.5	7.9	3.2	223.0	428.8	348.2	S15
2.854	2.226	4.726	4.207	1.08	1.28	4.9	18.5	7.3	8.2	34.5	0.87	0.18	24.8	18.4	7.4	4.6	209.5	378.0	412.5	S16
2.602	2.237	4.974	4.065	1.02	1.13	5.3	18.9	7.6	9.3	37.8	1.18	0.26	19.2	20.5	7.3	4.8	231.4	380.0	388.6	S17
2.494	2.384	5.524	4.193	1.27	1.24	4.3	16.4	6.3	8.3	34.8	0.91	0.22	17.8	22.4	7.2	5.3	246.9	430.4	322.7	S18
2.463	2.375	6.333	3.800	1.15	1.17	4.7	18.7	5.7	9.5	36.1	1.23	0.18	20.3	27.2	7.2	5.8	392.0	388.0	220.0	S19
2.674	2.490	5.594	4.488	1.02	1.21	5.1	17.9	6.9	8.6	38.6	1.06	0.22	18.7	26.5	7.1	6.2	370.4	336.8	292.8	S20
2.924	2.387	5.042	4.532	1.11	1.09	4.9	18.2	7.1	7.9	35.8	0.94	0.15	21.1	23.1	7.5	4.7	253.7	358.0	388.3	S21
2.093	2.107	5.803	3.308	1.31	1.05	4.6	17.8	6.1	10.7	35.4	0.82	0.17	21.2	22.8	7.9	6.3	254.0	280.0	466.0	S22
2.298	2.380	5.875	4.000	1.22	1.11	5.4	16.2	6.4	9.4	37.6	1.02	0.13	20.1	23.4	7.9	6.2	269.6	320.8	409.6	S23
2.458	2.372	5.721	4.052	1.13	1.26	5.1	18.5	6.8	9.6	38.9	1.09	0.19	19.4	24.1	7.6	5.9	302.4	341.6	356.0	S24
2.341	2.133	4.757	3.868	1.27	1.12	5.2	16.1	7.4	9.1	35.2	1.07	0.25	18.2	26.5	7.5	4.7	376.0	342.0	282.0	S25

2.539	2.437	5.935	4.135	1.22	1.08	5.8	16.8	6.2	8.9	36.8	0.85	0.21	26.8	23.8	7.3	5.4	284.0	296.0	420.0	S26
2.588	2.348	6.082	3.825	1.31	0.98	5.3	19.8	6.1	9.7	37.1	0.76	0.19	22.4	22.9	7.4	5.1	270.1	257.6	472.3	S27
2.462	2.374	5.935	3.957	1.24	0.92	5.2	17.7	6.2	9.3	36.8	0.83	0.17	23.6	21.2	7.1	7.2	245.0	365.4	389.6	S28
1.912	1.994	4.603	3.520	1.09	1.03	3.3	16.2	7.8	10.2	35.9	0.64	0.15	22.7	16.3	7.2	6.8	150.0	438.0	412.0	S29
3.042	2.707	5.493	5.338	1.11	0.72	3.2	18.4	6.9	7.1	37.9	0.81	0.19	24.8	21.3	7.4	6.1	240.9	246.4	512.7	S30
2.410	2.514	5.397	4.705	1.05	0.96	3.9	14.9	6.8	7.8	36.7	0.73	0.24	30.2	17.8	7.4	5.7	174.4	410.0	415.6	S31
1.949	2.134	4.959	3.745	1.12	1.14	3.7	15.4	7.4	9.8	36.7	0.95	0.17	26.8	19.4	7.8	4.3	209.6	440.4	350.0	S32
2.000	2.137	5.013	3.724	1.15	1.07	4.1	16.9	7.8	10.5	39.1	0.81	0.22	28.5	20.1	7.8	3.8	224.6	359.8	415.6	S33
2.439	2.610	5.953	4.646	1.02	1.05	4.2	15.8	6.4	8.2	38.1	1.02	0.28	26.4	24.6	7.9	3.7	309.6	380.0	310.4	S34
2.220	2.539	6.206	4.297	1.09	1.01	3.7	16.5	6.3	9.1	39.1	0.92	0.32	24.2	19.5	8.1	3.1	212.0	348.0	440.0	S35
1.777	2.052	5.116	3.427	1.12	0.94	3.9	14.4	6.9	10.3	35.3	1.13	0.26	23.3	24.4	7.6	4.8	290.0	358.0	352.0	S36
2.096	2.281	5.219	4.053	1.09	1.13	3.8	15.9	7.3	9.4	38.1	1.09	0.19	24.4	25.9	7.4	5.3	319.6	310.8	369.6	S37
2.534	2.655	6.981	4.284	1.14	1.21	4.4	17.9	5.4	8.8	37.7	1.25	0.17	25.2	28.2	7.4	5.4	393.6	361.2	245.2	S38

1.853	2.270	6.333	3.539	1.13	1.08	4.1	14.8	5.7	10.2	36.1	1.18	0.16	23.6	28.7	7.3	5.9	397.5	307.8	294.7	S39
2.345	2.630	6.722	4.321	1.12	1.25	4.4	15.3	5.4	8.4	36.3	1.16	0.27	26.7	26.4	7.2	6.3	366.0	388.0	246.0	S40
2.416	2.620	7.019	4.18	1.14	1.27	4.3	17.2	5.3	8.9	37.2	1.32	0.24	24.8	29.5	7.5	4.6	448.0	348.0	204.0	S41
2.512	2.637	6.541	4.418	1.12	1.14	4.1	16.8	5.6	8.3	36.8	1.06	0.19	26.8	24.1	7.5	4.4	322.4	357.6	320.0	S42
2.930	2.391	5.555	4.198	1.28	1.08	4.6	19.6	6.2	8.2	34.6	1.24	0.18	21.9	28.2	7.7	3.8	436.0	342.0	222.0	S43
2.570	2.607	6.517	4.345	1.21	1.12	4.8	17.5	5.8	8.7	37.7	1.26	0.13	20.4	29.5	7.8	3.1	464.0	240.0	296.0	S44
2.551	2.580	6.733	4.183	1.16	0.98	4.7	18.6	5.7	9.1	38.1	1.06	0.15	18.5	25.4	7.8	3.4	318.4	267.6	414.0	S45
2.094	1.953	5.326	3.084	1.25	1.17	4.9	17.1	6.1	10.5	32.4	1.13	0.22	21.4	26.9	7.7	3.6	404.0	236.0	360.0	S46
2.798	2.590	6.313	4.393	1.23	1.11	5	18.6	5.9	8.5	37.1	1.02	0.25	23.2	25.1	7.5	4.1	314.0	428.4	257.6	S47
2.359	2.387	6.513	3.767	1.24	1.27	5.4	16.9	5.5	9.4	35.6	1.15	0.27	20.1	26.2	7.6	3.9	358.0	346.0	296.0	S48
2.794	2.481	6.137	4.165	1.23	1.13	4.9	19.2	5.9	8.6	35.9	0.91	0.19	24.6	20.3	7.8	3.6	230.4	349.2	420.4	S49
2.713	2.132	4.813	3.828	1.27	1.26	5.2	18.3	6.9	8.7	33.1	1.16	0.15	26.3	27.2	7.9	3.4	397.4	315.4	287.2	S50

References

1. Al-Jaf, Barzan Omar, 2013. Study of some mineral properties of fine sand separated in some forest soils in northern Iraq. Al-Qadisiyah Journal of Agricultural Sciences, 3(1): 73-83.
2. Al-Khafaji, Darwish Issa, Iyad Abdullah Khalaf Al-Dulaimi, Ammar Saadi Ismail and Muhammad Jarallah Farhan, 2016. Soil content of some oxides as a function of soil development in Nineveh Governorate / Northern Iraq. Tikrit Journal of Pure Sciences, 21(5): 139-146.
3. Al-Ani, Amal Muhammad Salih, 2006. Applications of numerical classification in the classification of some rivers shoulder chains in the Iraqi alluvial plain. PhD thesis, College of Agriculture, University of Baghdad, Iraq.
4. Al-Obaidi, Bassem Shaker Obaid and Adnan Muhaimid Hawass Al-Jubouri, 2016. The effect of agricultural exploitation on the formation of polarized clay minerals in some gypsum soils. Tikrit Journal of Agricultural Sciences, 16(2): 197-208
5. Al-Obaidi, Bassem Shaker Obaid and Salman Khalaf Issa, 2011. Mineral composition of fine sand separated in some Iraqi gypsum soils. Tikrit University Journal of Agricultural Sciences, 11(1): 205-219.
6. Baqer, Ghafra Zia and Abdul Mohsen Abdullah Radhi, 2018. Mineral analysis of some desert and sedimentary Muthanna Governorate soils. Al-Muthanna Journal of Agricultural Sciences, 6(2): 26-33.
7. Jar Allah, Raed Shaalan and Salman Khalaf Issa. 2016. Mineral Analysis of Cracked Blocks of Soils from Central Iraq. Al-Qadisiyah Journal of Agricultural Sciences. 6(2): 187-200.
8. Abdul Amir, Hamid Kazem (2016). Biological analysis and statistical constants of the map of soil units in the Great Musayyib Project / Babil Governorate. Karbala Journal of Agricultural Sciences, 4(4): 203-217.
9. Al-Ali, S. H. , 2010 . Geochemical and mineralogical study of the fluvial deposits at Abul Khasib area, south east of Iraq . Mesopot. J. Mar. Sci., 25 (2): 154 – 165.
10. Anderson ,J.U. (1963). An improved pretreatment for mineralogical analysis of samples . Containing organic matter ,Clays and Clay Min. 10:380-388.
11. Black ,C.A.(ed.). (1965) .Methods of soil analysis . Agron .Mono.9 , Part 2 . Amer .Soc. Agron ,Madison ,Wisconsin .
12. Bilinski, H., 2008. Weathering of sandstones studied from the composition of stream sediments of the Kupa River (Croatia). – Mineralogical Magazine 72(1): 23–26.
13. Chetelat, B., Liu, C., Wang, Q., Zhang, G., 2013. Assessing the influence of lithology on weathering indices of Changing river sediments. – Chemical Geology 359: 108–115.
14. Hepper, E.N., Buschiazzo, D.E., Hevia, G.G., Urioste, A. and Antón, L., 2006. Clay mineralogy, cation exchange capacity and specific surface area of loess soils with different volcanic ash contents. Geoderma, 135, pp.216-223.
15. Jackson, M.L. 1958. Soil Chemical Analysis. Prentice-Hall. INC. Englwood cliffs. N.Y.
16. Jackson , M.L., 1979. Soil Chemical Analysis Advanced Course. 2nd Ed. Madison. Wisconsin. USA.

17. Jackson,M.L.,(1968). Weathering of Primary and secondary minerals in soil.Trans,9th Int.Cong.Soil.Sci.,4:281-292.
18. Kilmer , V.J. and Alexander , L.T. 1949. Method of making mechanical analysis of soils.Soil Sci. 68 : 15-24.
19. Kunze, G.W. 1962. Pretreatment for Mineralogical Analysis. Reprint of Section Prepared for
20. Method Monograph Published by the Soil Science of America, p. 13.
21. Mehra ,O.P.and Jackson , M.L. (1960) . Iron oxide removal from soils and clay by dithionite – citrate system , buffered with sodium bicarbonate proceeding of 7th National conference on clays and clay minerals , p.317-327.
22. 1.
23. Tucker, M. E. 1991. Sedimentary petrology. An introduction to the origin of sedimentary rocks. 2ed. Blackwell Science LTD. UK.