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Characterization and Classification of Toposequence Soils Units in The Zakhikha Region, West of Ramadi- Western Iraq

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ABSTRACT

Depending on the geomorphological map and digital elevations of the Zakhikha area, five sites that differ in topography and geomorphology and represent the soil units present in the area were selected.Their locations are geographically defined and locally represented pedons are excavated,disturbed soil samples representing each diagnosed horizon were obtained from them, and transferred to the laboratory for the purpose of conducting some physical measurements and chemical analyzes on them. The soils were classified according to the American classification for the year 2014 for the family level. So that we completed the classification to the level of the series according to the Al-Agidi proposal of 1976 and 1981 for sedimentary and developed soils respectively. To study the effect of the geomorphological site on soil characteristics in the topographical sequence.

The results showed a significant effect of the geomorphological location on the morphological characteristics of the soil, the class of texture, and some soil chemical characteristics. Classically, the Entisols order was formed most of the soils of the region, with the TW415 (12.79%) and DE31(18.19) series which diagnosed within the foot slope and Toe slope units. As for the Aridisols order it constituted a smaller percentage of the total area of the study area, with a person under two sub order there are Calcids (14.82%) and Gypsids (21.76%), with a person under three sub great soil groups there are Typic Calcigypsids, Typic Haplocalcids and Typic Argigypsids.

INTRODUCTION

Soil surveying and classification undertakes the tasks of diagnosing and characterizing the soils, with degrees of intensity and the good enough characterization to serve the purposes of surveying, classification and management together. Detection of soils and the geomorphological and pedological interpretation of them and the accompanying changes in the characteristics of soils chemically, physically and biologically is one of the most important tasks required to determine the administrative procedures required to be implemented to manage these lands.

The most important goals of soil classification is to identify the different relationships that link the types of soils, to identify their best uses, as well as to predict soil productivity (Soil Science Division Staff, 2017). Improving soil resource management in order to develop sustainable agriculture can only be achieved by creating a broad and ready database with specific measures that can be achieved by the GIS, which was adopted by the FAO / UNESCO in 2003 in several projects

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for the purpose of building a database. Digital data for the world's soils, which I considered important to avoid increasing pressure on soil and water resources.

Al-Alusi (2011) indicated in his study of the 979.2 Km^2 area bounded between Haditha Dam and Wadi Horan, the presence of a gently sloping spur gradually from the west and southwest towards the east and northeast towards the Euphrates River, and that it is graded in height between 325-75 meters above sea level. The diagnosed terrestrial shapes are related to the nature of the ancient climate of the region, as the current climate is not capable to formation of these terrestrial shapes, as the shapes varied into water eroded earths, sedimentation, wind eroded and deposition forms as well as karst and evaporative forms with little vegetation cover in the area. Its soil within the order of Entisols, which accounted for 1.7%, while the desert soils were within the Aridisols order, which included a ratio of 98.3% of the total area.

Mahmoud and Mahaimid (2011) explained through their study of ten pedons distributed in three transects covering most of the major and minor physiographic units in some Iraqi Gypsiferous soils. The existence of a variation in the degree of development of the study pedons, whether within the same physiographic unit or between the different physiographic units, and this reflects the nature of the variation in the local factors of each soil and the role of the pedogenic and geomorphic processes in affecting the genetic side of the study soil. The results showed the presence of a interaction between the main sub soil diagnostic horizons, Gypsic, Calcic, and Argillic for developed soils, which indicates the passage of these soils through multiple stages of development of the formation during the previous period.

Al-Hinnawi and Habib (2012) when studying the effect of spatial change on the morphological and chemical characteristics of some soils of the western foot of Jabal Al Arab in the Syrian Arab Republic, that the topographic factor plays an important role in determining some soil characteristics such as depth, construction of the surface horizons, as well as the distribution of calcium carbonate. As well as some biological processes such as the phenomenon of expansion and contraction.

Mehnatkesh *et al.* (2013) indicated in their study of the relationship between soil depth and topographic location in a sloping region in the west of Iran. He showed there is a difference in soil depth in general with varied the test site for eleven sites in the study area, reaching 120, 60, 100, 130 and 140cm for sites summit, back slope, foot slope and toe slope respectively. This had an effect on the classification of studied soils, which are Typic Calcixerepts, Typic Xerorthents, Calcic Haploxerepts, Chromic Calcixererts and Chromic Calcixererts for above geomorphological location's respectively.

Al-Dulaimi and Al-Ani (2016) studied the geomorphological units confined between Wadi Al-Eidi and Wadi Jarin within Al-Jazirah region in Al-Anbar governorate, they observed that the region soils are low to moderately salinity and with low organic matter content, and their textures between medium-moderate coarseness, the classification of the landscape concluded that the landforms are diverse in the area within six land units, including erosion, water precipitation, erosion and wind deposition forms.

Hurayga *et al.* (2018) studied the spatial heterogeneity in the morphological and physiochemical properties of soil within different physiographic units in the lower sedimentary plain area in southern Iraq in the Rifai region / Dhi Qar governorate, by collecting soil samples from three pedons representing the soil of the river levee, river shoulders and the river basin, in three locations parallel to the Al-Gharraf river. The results showed the lowest coefficient of variation was recorded for soil reaction, bulk density, porosity and calcium carbonate content characteristics by 2.25, 6.04, 7.16 and 12.41% respectively. This indicates a slight heterogeneity and a state of homogeneous, while there was a medium heterogeneity and for the characteristics represented by sand, clay, silt, salinity and saturated conductivity in terms of recorded the coefficient of variation for these characteristics, which is 31.39, 34.24, 35.30, 47.06 and 54.30%, respectively.

Al-Ghazali (2018) pointed out when he studying the geomorphology of some soils west of Karbala governorate-Iraq, using geospatial technologies, classified in the order Aridisols and suborder Salids, also the area contains two sub great groups, Typic Haplosalids and Calcic Haplosalids.

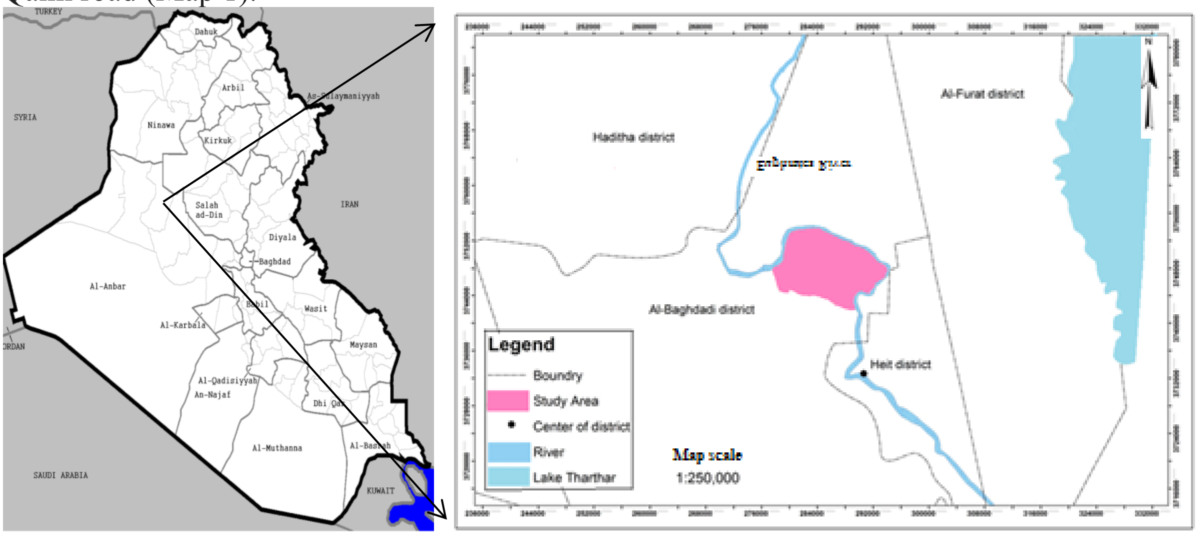
Chenxia *et al.* (2019) studied the effect of topography and type of land use on some soil characteristics, in Zhujiagou district, northwest China. The topographic sites from the land perspective under study included the crest (CT), upper slope (US), middle slope (MS), lower slope (LS), and finally the flat valley (FV), A significant differences were recorded with location heterogeneity, for the soil characteristics of clay content, bulk density, soil organic matter content and total nitrogen. The FV site showed the highest values in soil content of clay, organic matter and total nitrogen compared to other topographical sites under study.

The aim of this study is to characterize and classify toposequence soils in the Zakhikha area west of Ramadi in Iraq.

MATERIALS AND METHODS

1- Study area

The area of Zakhakha was chosen for the study, its covers an area of 12619 hectares located between longitudes 296000E and 276000E, and the latitudes 3754000N and 3741000N(UTM). I t is bordered on the North, East and West by the Euphrates River, and on the South by the Ramadi - Al Qaim road (Map 1).



Map 1. The administrative location of the study area.

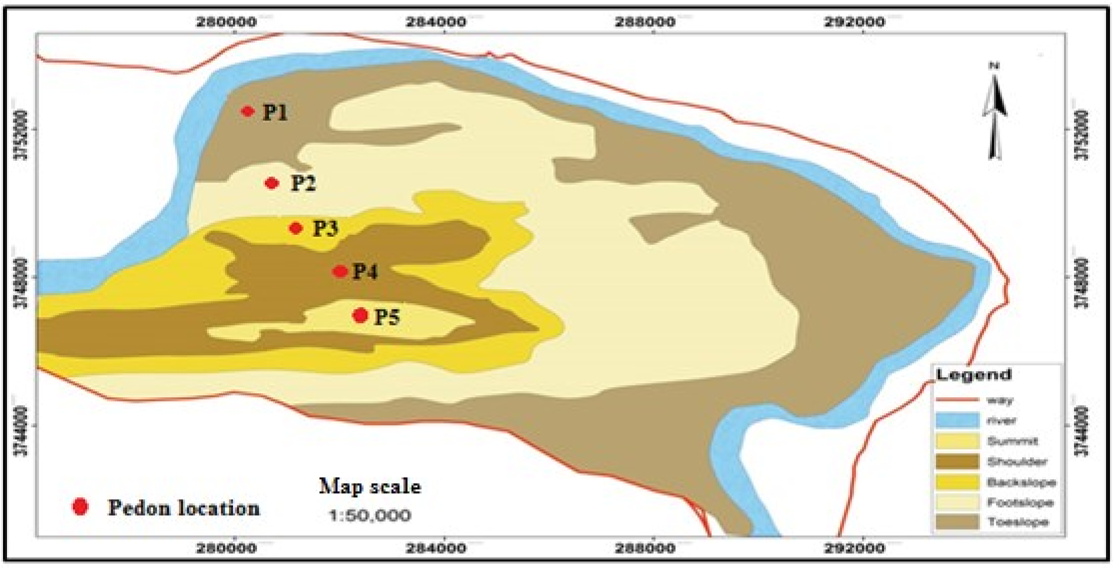
2- Preliminary procedures

Satellite images, topographical and geological maps, and available climatic information about the region have been utilized in order to determine the factors of soil formation and pidogenic processes prevalent in the region, as well as the available natural resources.

Pedogenic a study transect with length 6 Km was selected that passes through all the geomorphological units diagnosed in the region, and on the basis of that, five examination sites were chosen, whose locations were geographically determined using GPS(Map 2).

3- Field procedures

The pedons were dissected and morphologically descripted according to the American Soil Science Division Staff, 2017, after which excited samples representing each horizon were diagnosed and placed in plastic bags, numbered and transferred to the laboratory for the purpose of conducting some physical and chemical analyzes on them.



Map 2. Distribution of the physiographic units within the study area and the location of the pedons selected for the study.

4- Laboratory procedures

All soil samples were subjected to an estimate of the soil particles distribution using the pipet method contained in (Kilmer and Alexander, 1949). The degree of soil reaction (pH), electrical conductivity (ECe),SAR(ESP) and gypsum were estimated according to the methods mentioned in (Richards, 1954). Calcium carbonate and organic matter, were estimated in the soil according to the methods mentioned in (Jackson, 1958).

5- Office procedures

Based on the morphological description of the selected pedons for the study, and the results of laboratory analyzes for there. The soil was classified according to the American classification system (2014) and the classification was completed to the level of series based on the proposal of Al-Agidi (1976 and 1981).

6- Soil formation factors for the study area

6-1. Geological formation and parent material

The study area went through geological stages, tectonic movements, and inductive and sedimentary geomorphological processes that led to the formation and development of the prevailing terrestrial forms in the area, and the exposed geological formations in the study area can be observed from the oldest to the most recent, as the following:

6-1-1. Al-Fatha formation

This formation dates return to the Middle Miocene Age, and this formation is one of the important stratigraphic units in Iraq, and the thickness of this formation varies between 30-50 m. The gypsum rocks in this formation are characterized by their lack of hardness and are covered with a layer of clay that works to protect them from weathering. This formation was deposited under closed coastal marine environmental conditions with high salt concentrations and high thermal conditions, and this is evidenced by the periodic deposition of gypsum. Exposures of this formation appear as separate ridges with regular surfaces in the lower part of the study area (Rahim and Hagop, 1987).

6-1-2. Gypsum layer

It is a solid rock layer consisting of gypsum whose thickness ranges between 3-5m. This crust was deposited in a dry environment formed by the capillary property of the groundwater loaded with sulfate to form a very solid rock layer whose formation process takes hundreds of decades of time. It is relatively resistant to various induction processes and these appear in the central part of the study area, which is sediments dating back to the Pleistocene Quaternary era (Al-Dulaimi and Al-Ani, 2016).

6-1-3. Floodplain Deposits

They are sediments left by floods during different historical stages, and they consist of sand, silt and clay. These sediments were formed by the water of the Euphrates River, and appear in the form of bands that extend with the river and are characterized by little breadth and ranging in thickness between 1-2 m. They are sediments dating back to the Quaternary eon of the Holocene age.

6-1-4. Ancient earthen deposits

It is like a gypsum crust because it contains high proportions of secondary gypsum. As for the areas where gypsum is not present, the remaining soil is of sand, silt and clay with pieces of limestone and in those areas when the gypsum is exposed, the soil is gray color, and the thickness ranges between 0.5 -1.0 m on average, deposits of the Tetraplegic period of the Pleistocene and Holocene age.

6-2. Climate of the study area

According to the data of the meteorological station in Heet district and the analysis of the climatic characteristics (Table 1), it is show that the study area is characterized by a semi-desert(Arid) climate with long hot dry summers and short moderate winters.

The annual average temperature reaches 21.9°C in the region, a temperature starts to rise from April to September, with rates ranging between 13.9-25.4°C, and temperatures rise to 31.5-34.1°C during the months of June, July and August (General Authority For meteorology and seismic monitoring). Rainfall in the study area is characterized by fluctuating amounts, its fall is limited in the Autumn and winter seasons and does not fall in the summer months. According to the data recorded in the Heet climate station, the peak of rainfall will be in the month of April, this month recorded the highest rate of rainfall, which reached 27.3 mm. As for the months of November, December, January, February and March, the rates of rainfall were 14.5, 17.3, 16.0 and 18. 3 and 20.4 mm respectively, the annual rate of precipitation reaches 118.5 mm, with an average of 1.2 mm as for the months of June, July and August, no rainfall was recorded.

6-3. Geomorphology of the study area

The general landscape of the study area, is part of the sedimentary basin in Iraq, bordered by the desert to the west, most of the area's soils are caused by sediments of the Euphrates River with a clear slope from the west towards the east, and the highest elevation above sea level record was 140 m in the central part of the study area, while the low-lying areas were 65 m high in the part adjacent to the Euphrates, and the following geomorphological units were identified:

6-3-1. Summit Unit (SU)

This unit constitutes an area of 301.91 hectares of the study area (Table, 2), located in the southwestern part of the study area (Map, 2), its height ranges between 140-120 m above sea level. Its soils are loam texture in the surface and sandy clay loamin the subsurface horizons.

6-3-2. Shoulder unit (SH)

This geomorphological unit is located adjacent to the Summit geomorphological unit (Map,2), and according to the results of the cartographical analysis of the special map shown in Table 2, its area is 1862.02 hectares (14.74%) of its soils of moderately coarse texture, and in general this unit is higher than the units that followed by.

Table 1. Climate data for the Heet* district for the period (1995-2019).

The month	Minimum temperature average (C°)	Maximum temperature average (C°)	Monthly temperature average (C°)	Monthly temperature average of soil at depth 50 cm (C°)	The amount of rain (mm)	Relative humidity %	The evaporation (mm)	Average monthly soil Temperature at a depth of 50 cm (C°)
January	3.2	14.1	8.6	13.6	16.0	75.8	80.3	13.6
February	4.6	17.7	11.1	14.5	18.3	67.5	148.2	14.5
March	8.7	22.4	15.5	14.7	20.4	55.9	196.3	14.7
April	13.9	28.2	21.2	25.9	27.3	50.5	265.3	25.9
May	19.1	35.2	27.1	25.6	1.2	39.8	406.3	25.6
June	22.8	40.3	31.5	30.8	-	33.7	521.8	30.8
July	25.4	42.8	34.1	34.5	-	31.6	589.0	34.5
August	24.8	42.7	32.7	35.1	-	34.8	531.1	35.1
September	21.3	40.1	30.1	32.2	-	37.9	387.0	32.2
October	15.5	32.5	24.0	27.4	3.5	49.9	259.8	27.4
November	9.1	23.5	16.3	22.3	14.5	65.9	141.7	22.3
December	4.5	18.2	10.3	16.0	17.3	74.3	84.4	16.0
Annual rate	14.4	29.8	21.9	24.4		51.5		24.4
The total					118.5		3611.2	

*Heet meteorological station (33.63333°N - 42.81667° E), 70 m above sea level.

Table 2. Cartographical analysis of the geomorphological map of the study area.

Geomorphological unit	The area (ha)	**Percentage from total area**
Summit	301.91	**2.39**
Shoulder	1862.02	**14.74**
Back slope	1603.05	**12.69**
Foot slope	4570.40	**36.18**
Toe slope	4295.02	**34.00**
Total	12632.40	**100.00**

6-3-3. Back slope unit (BS)

This unit constitutes an area of 1603.05 hectares (12.69%) (Tab. 2), and its topography ranges between 125-85 m. Its soil has a moderately coarse texture.

6-3-4. Foot slope unit (FS)

This geomorphological unit constitutes a large area (36.18% of the study area) (Tab. 2). At sites lower than the black slope, its height ranges between 65-85 m, with a texture ranging from moderately fine to coarse texture.

6-3-5. Toe slope unit (TS)

This unit constitutes 4395.02 hectares and a percentage (34.00%)(Tab. 2), and represents the lowest point of topography compared to the geomorphological units diagnosed above.

6-4. Natural vegetation

The natural vegetation in the study area is affected in both quantitative and qualitative terms by the quality of the prevailing climate due to its occurrence within the desert climate, especially the factors of temperature and rainfall.

Perhaps the most prominent of these plants is desert type, which includes seasonal shrubs *Prosopis farcta, Tamarix aucherana*, *Anabasis articulate*, *Cornulaca leucantha*, *Rumex dentatus* and *Populus* *euphratica,* also thistle plants as *Aquilaria*, *Aristida*, *Layomychium farctua* and *Imperata cylindrical* . In addition to some short weeds and herbs adapted to harsh climatic conditions, which grow only during the period of rainfall as *Schangini aegyptiaca*, *Halocnemum strobilaceum*, *Malva L*. Mallow , *Aeluropus repens* , *Cressa Cretica, Capparis spinosa* and *Cladium mariscus* These areas are good pastures for sheep and camels.

Drought is a distinctive phenomenon of the region's climate, which affected the quality of the soil and consequently the quality of the natural vegetation. Therefore, we find that the vegetation cover is short and is represented by plants that are resistant to drought and most of them are short spiny plants in the areas far from the Euphrates and become denser by approaching the Euphrates River.

6-5. Temperature regime and soil moisture system

It is noticeable from the results of Tab. 1 that the average soil temperature at the annual depth of 50 cm and at the Heet monitoring station was more than 22 ºC, and the difference between the average temperatures in the summer and winter months was more than 5 ºC, so the soil temperature regime is Hyperthermic. Since the soils of the region remain dry for more than six months during the year and in a successive manner, which has little rainfall, so the soil moisture system is Torric (Aridic).

RESULTS AND DISCUSSION

1- The morphological characteristics of the soil

1-1.Soil depth

It is evident from the results of the Tab.3 that the depth of the study soil ranged between 75-140 cm. The first depth was recorded for the pedon P5 within the geomorphological unit (Summit), while the last depth was recorded for the pedon P1 within the geomorphological unit (Toe slope). According to Soil Survey Staff (2017) the pedon P1 was within deep soil, while P3 and P4 were within moderately shallow soils and P5 was within the shallow soils, due to the topographical location and its effect on the processes of weathering and water and wind erosion. Which affects soil removal and transfer to the sedimentation area (Al-Rawi, 2003).

The results of the Tab.3 showed that the thickness of the A horizon in the soils of the study area ranged between 10-21cm at the pedons P5 and P2, respectively. The observed difference in the extent of the thickness of this horizon is mainly due to the amount of sedimentation, the nature of the sediment and the topography of the ground from which these materials were deposited. Field tests have shown that the pedons located in the depression (the foot slope and the toe slope) the pedons P1 and P2, the depths of this horizon (A) have 20-21 cm for the pedons P1and P2 compared to the pedon P5 located within the summit, which has a depth of this horizon 10cm. The reason for the lack of thickness of the surface horizons compared to the subsurface of all pedons is that these surface horizons are more affected by external conditions and the physical and chemical weathering factors, than is the case in the subsurface horizons, as well as erosion of both types, and this is what was observed in the field within location P5.

Table 3. Some soil morphological characteristics of the studied pedons horizons

The geomorphological	Geographical coordinates	Land use	Pedon No.	Elevation m a.s.l	Horizon depth cm	Soil drainage Class (1)	Color		Texture Class (2)	Structure(3)	Consistence(4)			Root (5)	Boundary(6)	Notes
							Dry	Moist			Dry	Moist	Wet			
TS	280100E 3752300N	Vegetable	P_1	80	0-20	W	10YR8/3	10YR6/3	L	1msbk	sh	vfr	ss-sp	a f-m	cl: s	
					20-40		10YR7/4	10YR6/3	L	2msbk	sh	fr	ss-sp	p f-m	cl: s	
					40-55		10YR6/2	10YR5/2	LS	2msbk	so	vfr	so-po	p f-m	ab: s	
					55-70		10YR6/3	10YR5/4	LS	2msbk	so	fr	so-po	f f	cl: w	
					70-105		10YR5/2	10YR4/3	L	2msbk	sh	fr	ss-sp	f f	gr: s	Accumulation of $CaCO_3$
					105-140		10YR5/3	10YR4/2	L	2msbk	sh	fr	ss-sp	-		Accumulation of $CaCO_3$
FS	280400E 3750650N	Wheat	P_2	95	0-21	E	10YR4/3	10YR4/3	SCL	2msbk	So	vfr	ss-sp	pf	cl: s	Presence of stone
					21-40		10YR7/3	10YR6/4	SL	1fsbk	So	vfr	so-po	pfi	cl: s	Presence of stone
					40-72		10YR6/4	10YR5/4	LS	0	lo	lo	so-po	f f	gr: s	
					72-95		10YR7/4	10YR6/3	LS	0	lo	lo	so-po	-	gr: s	
					95-120		10YR7/3	10YR6/2	LS	1fsbk	so	vfr	so-po	-		Accumulation of $CaSO_3$
BS	281500E 3749000N	Wheat	P_3	110	0-19	M	10YR8/3	10YR7/3	SL	1msbk	sh	fr	so-po	p fi-f	cl: s	
					19-45		10YR7/4	10YR7/3	LS	2fsbk	so	vfr	so-po	f m	gr: s	Observed $CaCO_3$&$CaSO_4$ nodes
					45-70		10YR8/6	10YR7/6	SL	1csbk	sh	fr	so-po	-	cl: s	Accumulation of $CaSO_3$
					70-90		10YR7/6	10YR6/6	L	2fsbk	sh	fr	ss-sp	-		Accumulation of $CaSO_3$
SH	283000E 3748000N	Not agricultural use	P_4	130	0-15	M	10YR8/2	10YR7/2	SL	2msbk	so	fr	so-sp	af-fi	ab: w	
					15-30		10YR8/3	10YR7/3	SL	1fsbk	so	fr	so-sp	f f	cl:w	Observed $CaSO_4$ nodes
					30-55		10YR8/3	10YR7/3	SL	1csbk	so	vfr	so-sp	-	cl: s	Observed $CaCO_3$&$CaSO_4$ nodes
					55-80		10YR8/6	10YR7/6	SL	2fsbk	so	fr	so-sp	-		Observed $CaSO_4$ nodes
SU	283500E 3747500 N	Not agricultural use	P_5	140	0-10	W	10YR7/4	10YR5/8	L	0	lo	vfr	so-sp	f c-m	cl: s	Accumulation of $CaSO_3$
					10-40		10YR6/4	10YR5/4	CL	2cabk	So	vfr	so-sp	-	cl: s	Observed clay and $CaSO_4$
					40-75		10YR7/4	10YR6/4	CL	3cabk	vh	vfi	so-sp	-		Observed $CaSO_4$ nodes

(1)Soil drainage class: E: Excessively; W: well; M: Moderate

(2)Soil texture class: SL: sandy loam; L: loam; CL: clay loam; LS: loamy sand; SCLl: sandy clay loam

(3)Structure: Grade: 0: structure less; 1: weak; 2: Moderate ; 3: strong **Size:** f: Fine; m: Medium; c: Coarse **Type:** sbk: sub angular blocky; abk: angular blocky

(4)Consistence: Dry: sh ; Slightly hard; h: Hard; lo: Loose; so: Soft; vh: Very hard **Moist:** fr: Friable; fi: Firm; vfr: Very friable; sfr: slightly friable; lo: loose

Wet: so: non sticky; po: non plastic; ss: slightly sticky; sp: slightly plastic; s: sticky; p: plastic

(5)Root: Abundance: f: few; p: plentiful; a : Abundant Size: fi: fibrous; vf: very fine; f: fine; m: medium

(6)Boundary: cl: Clear; gr: Gradual; ab: Abupt; s; Smooh; w:Wavy.

1-2. Internal drainage

The diagnosis of this characteristic is very important to infer the nature of fluid movement in the soil body, as this characteristic is very important in the soil management and land evaluation, as the results of the morphological description of the study pedons indicated that the internal drainage class ranged between the excessively well drained class and the moderately well class

with the dominance of the moderately well class, and this is mainly due to the distance of the ground water level from the surface in the study area in addition to the coarse texture types prevalent in soils of the examination sites. The diagnosis of the excessively well drained class in pedon (P2) is due to the presence of stones in the soil body.

1-3. Soil color

It is evident from the results of Tab.3 that the Hue for all pedons horizons, in both dry and wet conditions, is 10YR, and this is consistent with Boersma *et al*. (1972) who was indicated that the Hue 10YR is present in horizons of well-drained soils.

As for the Value, its ranged between 4-8 in the dry state, with the prevalence of the 6 which indicating an increase in the relative purity of the predominant light wave length and a decrease in the white color ratio (Al-Agidi and Al-Issawi, 1989), which was between (2-8). From the study of this characteristic that the color of the studied soils tends to dark color especially (2-3) at the A horizon, due to its exposure to agricultural operations, including plowing, fertilization and irrigation, this is due to its high organic matter content compared to the subsurface horizons that follow. As for the spotting, its presence in the soils of the region has not been diagnosed.

1-4. Soil texture class

Through the morphological description and the results of the laboratory analyzes of the selected pedons for the study soils, it was found that the texture exists within the range of moderately coarseness and moderately softness (CL-SL) with the predominance of moderately rough textures with the limitations of the moderately softness textures, and the difference which was observed in the class of textures vertically in the body of the study soil is mainly due to the nature of sedimentation, especially in low geomorphological units (Al-Agidi, 1994) and this is consistent with Nadiwi *et al*. (2012) who pointed out that the nature of the topographic site has a great influence on the nature of the distribution of soil separations and thus the prevailing texture classes with the heterogeneity of the geomorphological site as well as the prevailing weathering conditions when each site and its effect on the texture class.

1-5. Soil structure

It is evident from Tab. 3 that there is a similarity in the type of soil structure, as it was of the sub angular blocky type in pedon P5 (at the geomorphological unit Summit), in addition to the diagnosis of the presence of some soils in a structural form due to the rough texture, especially in the two units, Shoulder and back slope with a diagnostic of the sizes between fine and coarse and coarse sizes were diagnosed in high-site pedons compared to fine and medium size which were prevalent in low-site topographically pedons, as for the strength of structure units, the prevalence was the medium class with the presence of the weak class in a compatible manner with soil texture.

1-6. Soil consistence

Table 3 indicates the examination of this characteristic in the study soil in the three cases, in the dry state it ranged between loose and very hard, with the presence of soft type, while in the wet state it ranged between a loose and very firm, with the presence of a friable type, while in the wet consistency state was ranged between non-sticky and sticky, with the non-sticky type being predominant, while the plasticity ranged between the non-plastic and the plastic type, with the prevalence of the slightly plastic type. This morphology property is mainly due to the dominant texture class, especially the practical size distribution of the soil separations that directly affect this characteristic, as well as the site of examination from the soil body and the influence of the pressure applied to the structural units, especially in the dry state of the soil.

1-7. Plant roots distribution

The nature of the distribution of the root system in the soil reflects the conditions that suit to the growth of the plant. Its noticed from the morphological description of the study pedons that the distribution of the roots differs from pedon to another in terms of depth and its diagnosis in the soil body, while is only present at a depth of 10 cm within the pedon P5 (Summit), its reached depths of 72, 105 cm at pedons P1 and P2 respectively, with the abundant type and plentiful in the cultivated sites compared to the few abundance in the uncultivated sites with the presence of sizes that ranged between fibrous and medium and varied according to the nature of the vegetation and cultivation.

1-8. Horizons boundary

It is evident from the results of Tab. 3 the presence of the types clear to abrupt and have in general a smooth topography, except for the wavy type which was recorded within the pedon P1, this variation in the nature of the boundaries between the horizons is mainly due to the nature of sedimentation in addition to the transfer operations and their intensity and what they affect in the shape of the boundaries between horizons. And the Fig.1 showing the morphological characterizations and their distribution according to their geomorphological location.

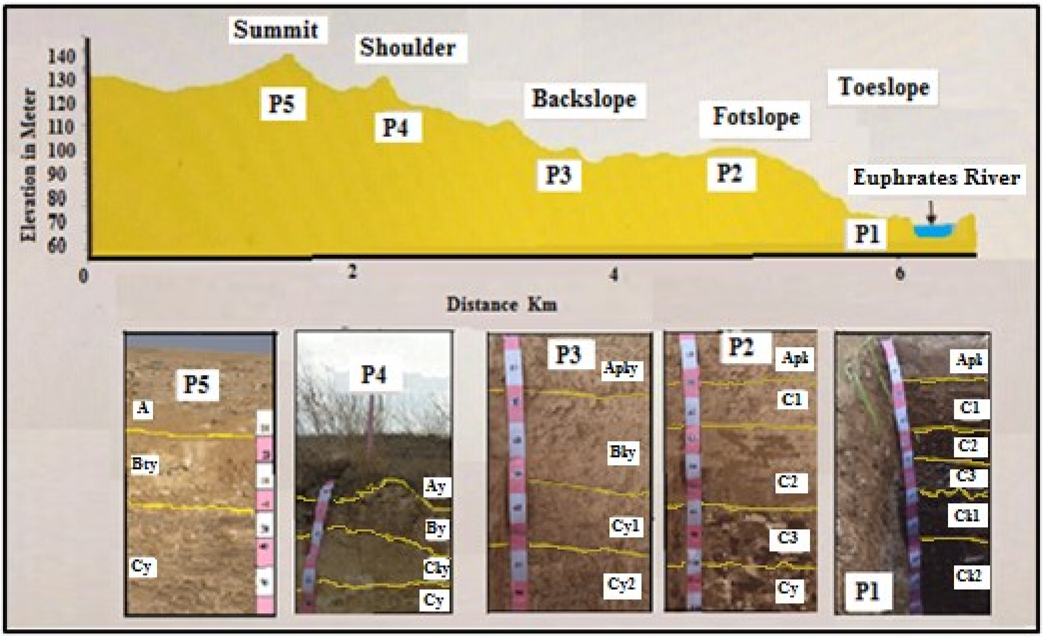


Fig. 1 The morphological description of the studied pedons within the geomorphological units.

2. Soil physical properties of the study area

2-1. Particle size distribution

Table 4 shows the particle size distribution of the separations of the understudy pedons horizons. Soil texture classes were varieties between LS which recorded at C2 and C3 horizons for pedon P1, and the horizons C2,C3 and Cy for pedon P2, and horizon Bky for pedon P3 and SCL which was recorded at horizon Apk for pedon P2.

It was noticed from the Fig. 2 that the percentage of weighted sand in the study pedons ranged between 22.4 - 72.3% for pedons P5 and P2 respectively, with a clear tendency to increase the proportion of this particle by moving from the summit geomorphological unit towards other geomorphological units, with an increase of 200%,193.7%, 141.1% and 117.9% , for geomorphological units Shoulder, Back slope, Foot slope and Toe slope unit respectively compared to Summit unit, on the contrary, the unit of the summit showed the highest weighted ratio of the silt separate reached 38.9%, with a percent decrease of 56.1%, 11.6%, 54.8% and 35.0% for the geomorphological units of the shoulder, the back slope, the slope foot and finally the toe slope respectively. Regarding the clay percentage, the decrease in its weighted rate for the topographical geomorphological units compared to the top unit was 59.2%, 57.1%, 46.5%, 56.6% for the shoulder units, back slope, slope foot and toe slope respectively. The variation in the particle size distribution of soil in both vertical and horizontal directions, is due primarily to the nature of the sedimentary environment in the area as well as the nature of the prevailing pidogenic processes that affect the nature of the volumetric distribution of soil separations, and this is consistent with what observed by Al-Rawi (2003).

Table 4. Some physical characteristics of the study soil

Pedon No.	Horizon	Depth (cm)	Total sand	Total silt	Clay %	Texture class
P1	Apk	0-20	45.4	32.6	22.0	L
	C1	20-40	26.3	49.3	24.4	L
	C2	40-55	83.9	4.5	11.6	LS
	C3	55-70	81.5	7.2	11.3	LS
	Ck1	70-105	41.4	39.3	19.3	L
	Ck2	105-140	36.4	46.9	16.7	L
P2	Apk	0-21	53.8	23.7	22.5	SCL
	C1	21-40	52.8	30.0	17.2	SL
	C2	40-72	78.1	4.5	14.4	LS
	C3	72-95	83.1	2.5	14.4	LS
	Cy	95-120	85.4	7.6	7.0	LS
P3	Apky	0-19	72.9	13.7	13.4	SL
	Bky	19-45	77.9	6.8	15.3	LS
	Cy1	45-70	63.8	18.6	17.6	SL
	Cy2	70-90	45.8	34.2	20.0	L
P4	Ay	0-15	67.5	19.3	13.1	SL
	By	15-30	52.7	31.6	15.7	SL
	Cky	30-55	72.9	9.2	17.9	SL
	Cy	55-80	70.1	14.4	15.5	SL
P5	A	0-10	42.0	38.0	20.0	L
	Bty	10-40	18.0	41.0	41.0	CL
	Cy	40-75	20.5	37.5	42.0	CL

3.Soil Chemical properties of the study area

3-1. Soil electrical conductivity

The results of Tab. 5 show the measured electrical conductivity values of the soil paste extract for the pedons horizons, its ranged between 1.4- 10.1 dSm^{-1}.The pedon P5 showed an increase in the values of this characteristic, as the weighted average reached 8.19 dSm^{-1}, compared to the lowest weighted mean recorded at P1, which reached 2.40 dSm^{-1}. It is noticed from Fig. 3 that there are significant differences between the geomorphological units in terms of the values of this characteristic. The highest value was recorded at the summit unit, while the lowest was recorded at the unit the toe slope, with a tendency to increase the electrical conductivity value of the geomorphological unit summit, due to the not agricultural use of the site of this geomorphological unit.

Table 5. Some chemical properties of the studied soil.

Pedon No.	Horizon	Depth (cm)	EC_e $dS.m^{-1}$	pH	S.O.M	$CaCO_3$	$CaSO_4 2H_2O$	CEC Cmol.(+). kg^{-1} soil	SAR	ESP
					$gmKg^{-1}soil$					
P1	Apk	0-20	1.8	7.8	8.3	290	9	18.3	1.706	1.241
	C1	20-40	1.5	7.8	4.1	225	8	15.4	1.513	0.962
	C2	40-55	1.4	7.8	1.2	200	30	7.4	1.505	0.951
	C3	55-70	1.9	7.9	0.5	230	40	7.8	1.648	1.158
	Ck1	70-105	2.9	8.3	0.2	430	30	14.2	2.087	1.786
	Ck2	105-140	3.0	8.3	nil	400	26	14.6	2.114	1.824
P2	Apk	0-21	2.8	8.5	8.0	420	50	20.1	2.076	1.771
	C1	21-40	2.3	8.0	3.6	300	10	15.5	1.845	1.440
	C2	40-72	2.1	8.2	0.8	325	25	8.2	1.758	1.316
	C3	72-95	2.2	8.2	0.2	330	20	7.8	1.831	1.421
	Cy	95-120	2.2	8.3	nil	325	165	6.9	1.790	1.361
P3	Apky	0-19	3.5	8.3	5.3	345	170	6.9	2.271	2.048
	Bky	19-45	2.8	7.4	1.1	175	61	6.0	2.028	1.703
	Cy1	45-70	2.6	7.5	nil	125	165	12.6	2.022	1.693
	Cy2	70-90	2.4	7.6	nil	250	179	8.6	2.070	1.761
P4	Ay	0-15	2.2	7.8	6.3	230	165	15.7	1.837	1.430
	By	15-30	2.3	7.5	4.1	275	397	12.2	1.797	1.372
	Cky	30-55	2.5	7.6	0.1	350	407	11.8	1.972	1.622
	Cy	55-80	2.1	7.4	nil	158	449	12.1	1.776	1.342
P5	A	0-10	3.3	7.8	0.3	339	42	12.2	2.203	1.950
	Bty	10-40	9.9	8.1	0.1	393	61	17.3	3.934	4.345
	Cy	40-75	10.1	8.1	0.05	396	357	23.2	3.959	4.380

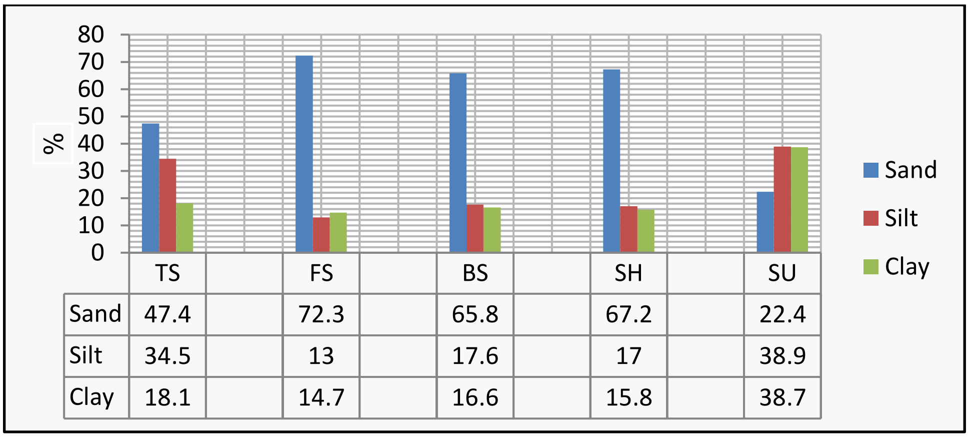


Fig.2 The mean weighted of soil particles in the study pedons and their horizontal distribution within the geomorphological site in the study area.

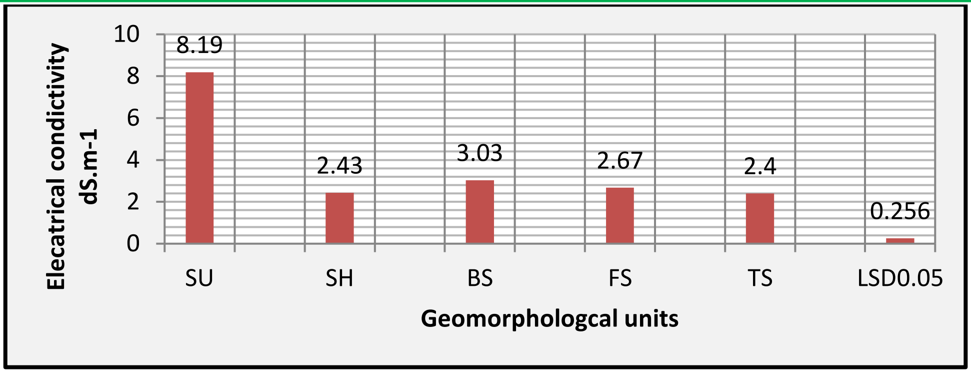


Fig. 3 The mean weighted of soil salinity within geomorphological units diagnosed in the study area.

3-2. Soil reaction degree

The values of this property to the studied pedons, are shown in Tab.5, its ranged between 7.4 - 8.5, which is identical to what was indicated by Bready (1974) that the degree of reaction in arid and semi-arid regions ranges between 7-9. In general, there is a trend of higher values of this characteristic is relatively in the studied soils due to the high calcium carbonate content, this is due to the existence of a positive relationship between this characteristic and the soil calcium carbonate content (Dregne, 1976), and this ratio supported the existence of a highly significant positive correlation to the degree of soil interaction with the soil content of calcium carbonate whose value reached (r = 0.765 **), while the observed decrease In some sites it is mainly due to the presence of gypsum, as shown in pedons P3and P4, and the reason for this is due to the high negative correlation of this characteristic with the soil content of gypsum, which reached (r = - 0.634 **).

3-3. Soil content of organic matter

It is evident from the results of the analyzes for this chemical characteristic in Tab.5 that the content of the study soil of organic matter ranged between 0.0 - 8.3 $gmKg^{-1}$, With a clear trend to increase the content of the surface horizons of organic matter compared to the subsurface horizons, the reason for this observed decrease in the soil content of this component in the study areas is due to the lack of vegetation cover as well as the high temperatures that lead to oxidation and rapid decomposition of organic matter and its loss from the soil. It is noticed from the Tab. 5 that the summit geomorphological unit had the lowest content of organic matter compared to the two low units foot slope and toe slope with significant differences. The increase in the content of these two physiographic units of organic matter is due to agricultural land use and its role in increasing the content of this component. Fig. 4 shows the mean weighted distribution of organic matter for a depth of 50 cm of soil for study pedons.

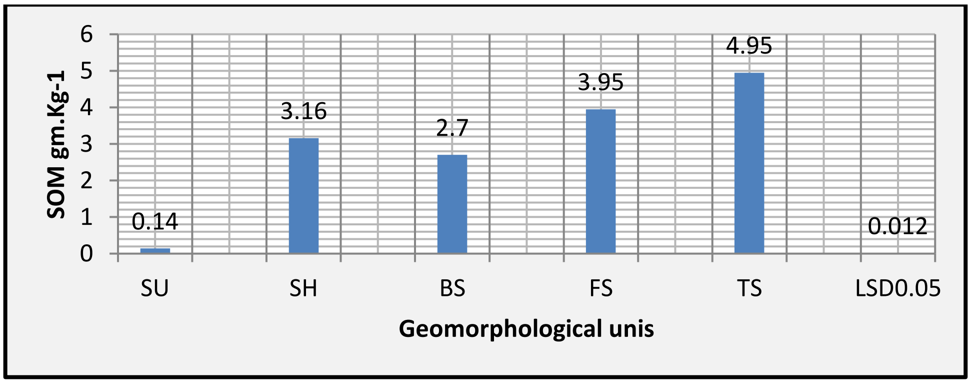


Fig. 4 The mean weighted rate of soil organic matter content for a depth of 50 cm in studied pedons.

3-4. Soil content of gypsum

It is noticed from the results of Tab.5 that the soil content of this component ranged between 8-449 gmKg^{-1}. The lowest content was recorded at the C1 horizon for pedon P1, while the highest value was recorded at the Cy horizon for pedon P4. The Fig.5 was showed the mean weighted rate of this component in the soils of the region. As it is evident that there are significant differences between the study pedons, as the highest value of gypsum was recorded in the pedon P4 (SH) and the lowest in the pedon P1(TS), and the recorded decrease in the soil content of gypsum in the low geomorphological units is due to the exposure of its soil to agricultural exploitation and the leaching of the gypsum compared to the higher units which not exploitation to cultivation. As for the vertical distribution of gypsum in the soil body, it is noticed from the results of Tab. 5 that there is a tendency to increase the soil content of this component with depth in all sites, and this is due to the nature of the original material from which the soil was formed in addition to the ease of dissolving gypsum and its transfer from the surface horizons to the Subsurface horizons by effect of water as a vector factor (Al-Mashhadani, 1994).

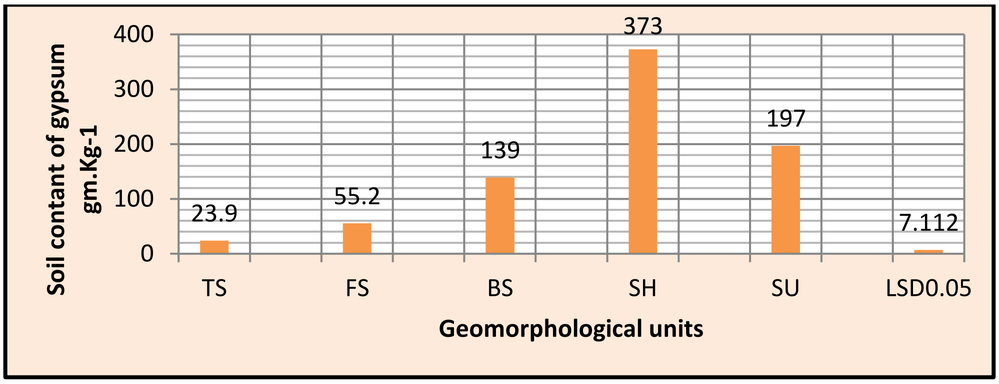


Fig. 5 The mean weighted rate of soil gypsum content in the studied pedons.

3-5. Soil content of calcium carbonate

It is evident from the results of Tab. 5 that the calcium carbonate content of the soil horizons of the studied pedons were ranged between 125-430 gm Kg $^{-1}$ soil, it was recorded at the Cy1 horizon for pedon P3 and the Ck1 horizon for pedon P1 respectively, and the reason for the high content of the soils of the region of this component is attributed to the nature of the parent material that formed the soil, with no homogeneity in the distribution of carbonate within the soil pedons. This is attributed to the fact that the source of carbonates in these soils is the erosion of limestone rocks, mechanical weathering of them, and the transfer of products by running water and ground pull, as well as wind erosion and sedimentation in the region. It is noticeable from Fig. 6 that the mean weighted rate of this component showed significant differences between the study pedons, as the highest value of this index was recorded at pedon P5 (Summit), while the lowest mean weighted rate was recorded at pedon P4 (Back slope).

3-6. The exchangeable sodium percentage

It is noticed from the results of Tab.5 that the values of this characteristics ranged between 0.951 - 4.380, as both values were recorded at the two horizons C2 in pedon P1 and Cy in pedon P5, indicating the presence of a narrow range of the value of this characteristic for the studied soils and the absence of a risk for sodium. To a decrease in the salinity values of the soil mainly in addition to the distance of the ground water from the surface, which prevents the occurrence of salts rise through the capillary property and the accompanying accumulation of sodium in the soil (Al-Zubaidi, 1989). And the Fig.7 shows the mean weighted average distribution of the exchange sodium percentage in the area's soils.

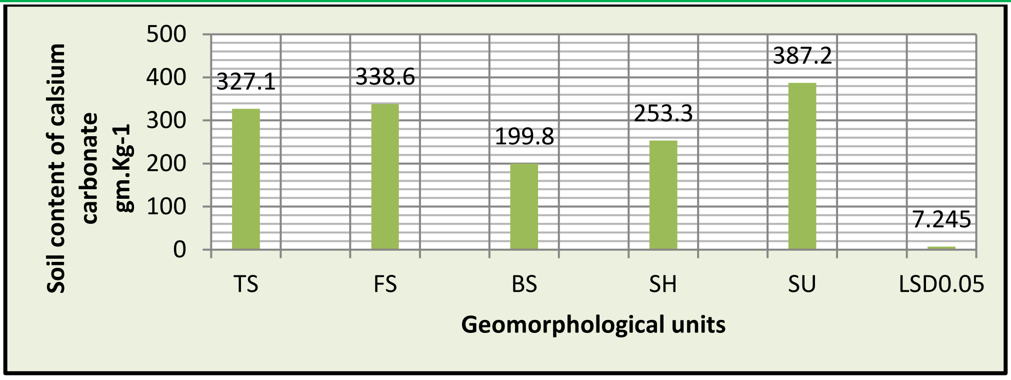


Fig. 6 The mean weighted rate of soil calcium carbonate content in the studied pedons.

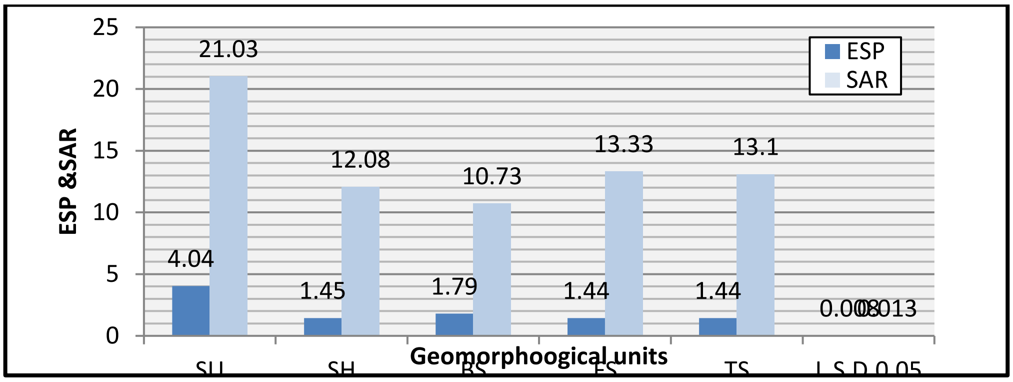


Fig.7 The mean weighted rate of soil exchangeable sodium percentage and sodium absorption ratio in the studied pedons.

4. Soils classification of study area

According to the morphological characteristics and the results of physical and chemical analyzes and the soil temperature and moisture, the soils of the study area were classified according to the American soil classification regime (2014) to the family level and completed to the series level according to the Al-Agidi proposal (1976 and 1981) which regarding sedimentary and developed soils respectively. As it is evident from Tab. 6, that the Entisols order was youngest formed soils characterized by the absence of pedological development in them through the absence of diagnosis of B horizons because of the conditions that do not allow the development of these soils, including geomorphological processes such as erosion and sedimentation, as well as lack of vegetation cover and low precipitation rates that did not exceed 118.5 mm (Table, 1), which do not allow some soil development processes. The soils of the Zakhakha region were characterized by their light-colored Ochric surface horizon and low organic matter content, and due to the nature of the prevailing environmental conditions in the region, the dry climate and the lack of vegetation cover, as well as the dominance of the sedimentary nature of the original material rich in calcium carbonate within the southwestern region of the study area and the gypsum and lime in the northeastern region of the study area. It was diagnosed four soil series within the order of Entisols, there are TW415, DE31, DW44, TM235. While the Aridisols order soils which was located within this region were characterized by an Aridic moisture regime, where the rate of water loss through evaporation processes is more than the average amount of rain falling in coldest months of the year. As shown in Tab. 1, which indicates that the soil does not have moisture for a long time, while the Soil temperature regime was of the very hot Hyperthermic type for the study area. Aridisols order was included two sub order, Calcids and Gypsids, and three sub great soil groups, which are: Typic Haplocalcids, Typic Calcigypsids and Typic Argigypsids, diagnosed within three soil series there are 122GKM, 122 XXM and 142 XXW.

Table 6. Soil classification of the study.

Geomorphological unit	Pedon No.	Order	Sub order	Great soil group	Sub great group	Family	Series
TS	1	Entisols	Fluvents	Torrifluvents	Typic Torrifluvents	Fine loamy; Mixed; Super active; Calcareous; Hyperthermic	TW415
FS	2					Coarse loamy; Mixed; Super active; Calcareous; Hyperthermic	DE31
BS	3	Aridisols	Calcids	Haplocalcids	Typic Haplocalcids	Clayey(fine); Gypsic; Active; Calcareous; Hyperthermic	122GKM
SH	4		Gypsids	Calcigypsids	Typic Calcigypsids	Fine loamy; Mixed; Super active; Calcareous; Hyperthermic	122XXM
SU	5			Argigypsids	Typic Argigypsids	Coarse loamy; Mixed; Super active; Calcareous; Hyperthermic	142XXW

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توصيف وتصنيف ترب متعاقبة طوبوغرافية في منطقة زخيخة غرب الرمادي غرب– العراق

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المستخلص

اعتماداً على خريطة الجيومورفولوجية والارتفاعات الرقمية لمنطقة زخيخة انتخبت خمس مواقع متغايرة طوبوغرافيا و جيومورفولوجياً وممثلة لوحدات الترب المتواجدة في المنطقة، تم تحديد مواقعها جغرافياً وحفرت فيها البيدونات الممثلة موقعياً، استحصلت منها عينات ترابية مثارة ممثلة لكل افق مشخص, ونقلت الى المختبر لغرض اجراء بعض القياسات الفيزيائية والتحاليل الكيميائية عليها، صنفت الترب حسب التصنيف الامريكي لعام 2014 لمستوى العائلة تم استكمل لمستوى السلاسل وفق مقترح العكيدي لعامي 1976 و1981 للترب الرسوبية والمتطورة على التوالي. لدراسة تأثير الموقع الجيومورفولوجي في صفات التربة في متعاقبة طوبوغرافية.

اظهرت النتائج وجود تأثير معنوي للموقع الجيومورفولوجي في صفات التربة المورفولوجية وصنف النسجة وبعض الصفات الكيميائية للتربة وتصنيفياً شكلت رتبة الانتيسول معظم ترب المنطقة مع تشخيص السلسلتين TW415 و DE31 (18.19%, 12.79%على التوالي)ضمن والحدتين الفيزوغرافيتين Foot slope و Toe slope. اما رتبة الارديسول فقد شكلت نسبة اقل من المساحة الكلية لمنطقة الدراسة شخص عندها تحت رتبتين هما Calcids(14.82%) و Gypsids(21.76%) وثلاث تحت مجاميع Typic Calcigypsids و Typic Haplocalcids و Typic Argigypsids.

الكلمات المفتاحية: ترب العراق: غرب العراق: وحدات الترب:متعاقبة طوبوغرافية: منطقة زخيخة.