SPATIAL VARIATION OF SOME SOIL PROPERTIES AND MAPPING THEM USING REMOTE SENSING DATA AND GEOGRAPHIC INFORMATION SYSTEMS

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Abstract

A field and laboratory study was conducted with the aim of studying the spatial variation of some morphological, physical and chemical characteristics of different areas in Basra Province, southern Iraq, using remote sensing technology by isolating soil units and identifying typical locations for digging pedons representing each soil unit. The results showed that there is a variation in some characteristics of the morphological soils between the pedons sites according to the landscape and the different source of sedimentation, and this discrepancy in general reflects the influence of the local factors of each pedons, including the physiographic location and the nature of land use . The study area was characterized by an Angular blocking structure, and the presence of a state of variation in the natural drainage between the studied sites, ranging from moderately well drained to excessive well drained, as for the depth of the soil, it can be described as very deep to moderately shallow. In addition, the results of the physical analysis showed that there was a variation in the texture in both vertical and horizontal directions in the study area with the dominance of silt and clay particles and a decrease in the percentage of sand particles in most regions, except for the pedons located in Umm Qasr and Safwan represented by pedons 4 and 5. The percentage of sand increased and the percentage of clay decreased, as well. Mean weight Diameter values increased at the surface horizons and decreased with depth . The results of the chemical analysis showed that the organic matter content of pedons ranged between 1.8 - 37.1 g kg^{-1} and that the highest values appeared in the surface horizons, especially in pedon 1, and the high calcium carbonate content throughout the study area ranged between 85 - 425 g kg^{-1} with the presence of homogeneity With depth .

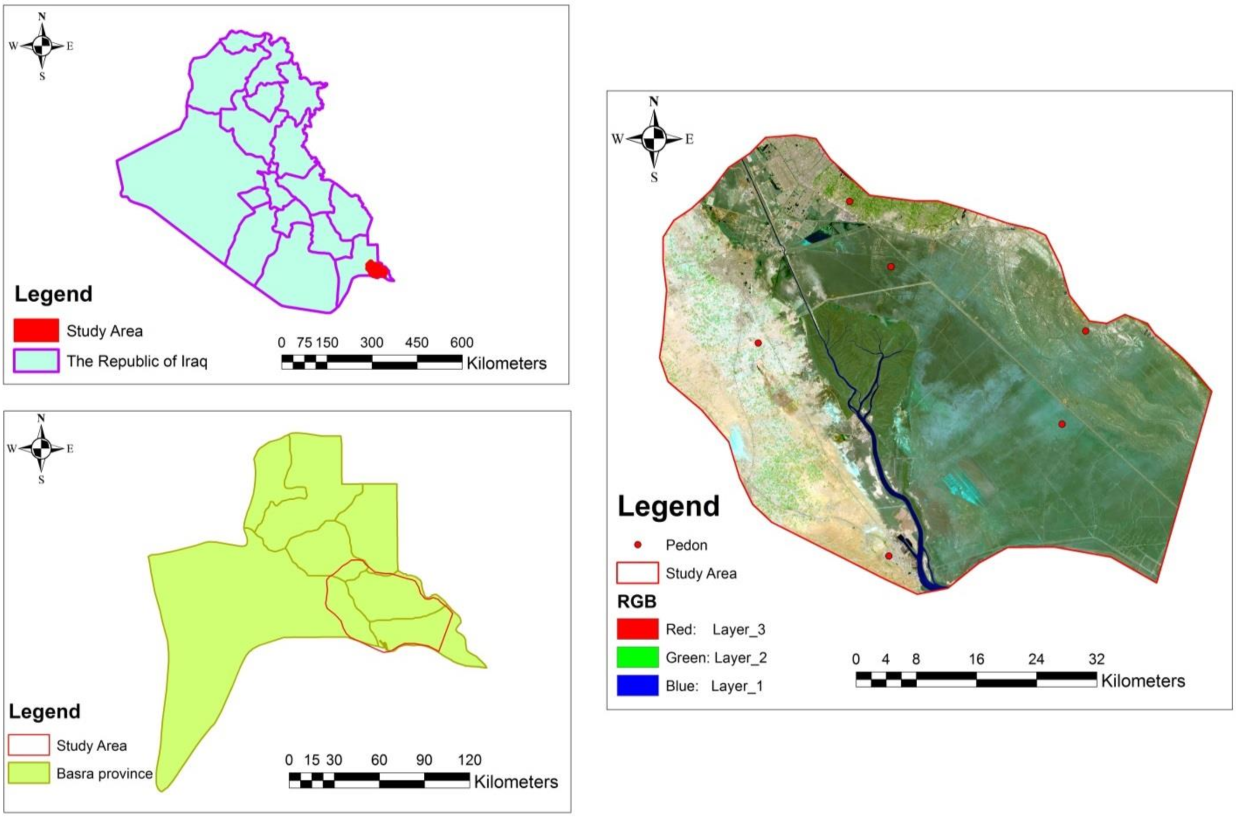
Key words : Soil characteristics , geographic information systems , DigitalMaps , spatial variation

Introduction

Significant advances in remote sensing have increased the possibility of using spectral data to detect soil characteristics. It has become possible to investigate the characteristics of soils in hard-to-reach areas, as well as the continuous quantitative extrapolation of the spatial distribution of soil characteristics and linking them with other data-related databases of soil using geographic information systems (Tranter et al., 2008) . Rossiter (1994) noted that remote sensing is a relatively easy and quick way to obtain information for a large geographical area, and its cost is very economical, and it is the only practical method through which information is obtained for hard-to-reach areas such as Antarctica . Al-Hamdani (2017) concluded that the application of the geographic information system has benefited in building a database for all cartographic units with their geospatial connections, which enabled them to deal with modern software, as well as their support for the process of updating and correcting many features and cartographic units derived from the traditional soil survey process. The arid and semi-arid regions are characterized by the lack of rainfall in them, and these areas occupy more than 30% of the surface of the globe, and alluvial soils constitute an important part of these areas distributed in various parts of the world as they occupy the areas adjacent to rivers, flood basins and rivers deltas, as well as their extension to cover part of the regions In Iraq, alluvial soils occupy an area estimated at about 120,000 km^2, and this area is about 60% of the area of cultivated land, as its soils vary spatially, including that of Basra Province, depending on the nature of the factors that formed the soil in it. The soils are distributed in Basra Province between sandy soils in desert areas, sedimentary soils formed in marshes, water bodies, tides, and coastal lands that differ in their characteristics and characteristics (Buringh, 1960).Many soils are similar in general conditions, such as vegetation cover, degree of natural drainage, and climatic conditions, except that they consist of different origin materials, so different soils result. And that the line separating these different soils may differ in morphological, physical, chemical and mineral characteristics, and this reflects the influence of the origin materials in forming soils to some extent within the transitional zone and the extent of the influence of neighboring areas on them (Al-Atab, 2008) . Al-Hayali (2017) indicated when studying in the alluvial plain in Basra Province that all pedons in the soil of the study area were characterized by the phenomenon of stratification, as they consist of different texture layers representing recently deposited layers at different times, and these differences in the texture result from the difference in the rate of water deposition. For suspended matter, and that the geomorphological factor is more influential than the pedogenic factor in forming the stratification of these soils, and consequently all soils were underdeveloped (Entisols) throughout the region. Due to the lack of surveys on the soils of Basra Province in general and the study area in particular, the study aimed to identify some of the morphological, physical and chemical properties of soils by studying the variation in their characteristics and their spatial distribution using geographic information systems andpreparing digital maps of their characteristics.**Materials and methods**

1 – Study Area

The study area is located in the alluvial plain in the Basra Province in southern Iraq within the administrative boundaries of Abu Al-Khasib district to the east and which extend south to the districts of Al-Faw and Umm Qasr, and it is bordered on the southwest by the districts of Al-Zubayr and Safwan. The study area is located within the hot and dry desert climate, where the amount of rainfall is 191.9 mm annually. Its soil is characterized by sedimentary origin material that goes back to Entisols order. As for its geographical location, it lies between latitudes 29 ° 59'45 "- 30 ° 32'34" north and longitudes 47 ° 37'21 "- 48 ° 22'35" east, with an area of 2895.177 km^2. 6 typical pedons representing the study area were determined using the GPS device (Fig. 1) .



Figure(1) Study area

2 – Determination of pedon sites using spectral reflectivity

The study area was visited several times in the field with the aim of determining the ideal sites for digging pedons representing the soil units in the study area. Some of the available topographical maps for the study area and a satellite image for the year 2019 were taken advantage of to survey the soil, as it was noted through this that most of these areas are not invested in agriculture, and they are abandoned lands with the exception of some areas along the Shatt al-Arab and some farms in the districts of Zubayr and Safwan. A soil survey was conducted based on the spectral reflectivity from the satellite image data as follows:

a - Satellite image

The satellite image captured by Landsat 8 satellite, The Operational Land Imager (OLI), was used with eleven spectral bandss on 8/15/2019 with a discrimination ability of 30 m. Satellite image was used in visual analysis and supervised and unsupervised classification in order to determine the dominant classes in the study area .

b - Digital processing of the satellite image

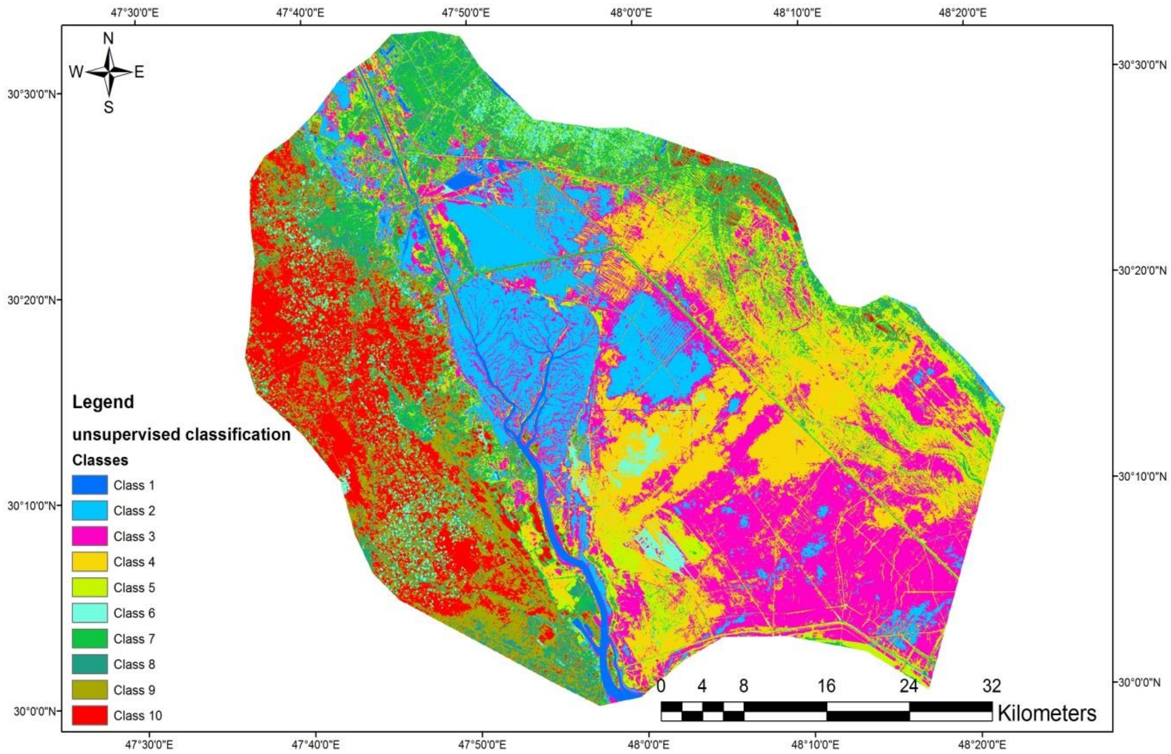
The digital processing of the satellite image was performed using the computer program Arc map 10.4.1. The spectral bands having the highest coefficient of variation (OIF) were selected for their ability to distinguish the differences of the soil surface, which were adopted to extract the appropriate combination. False color was chosen for the spectrum bands 7, 5 and 3 for RGB colors respectively to form the best color combination to distinguish the soils of the study area (Faleh and Shawan, 2012) .

c - Digital satellite image analysis

The use of both supervised and unsupervised digital analysis after obtaining the satellite image is fully corrected after performing all the steps for removing distortions resulting from multiple causes, as follows :

Unsupervised Classification

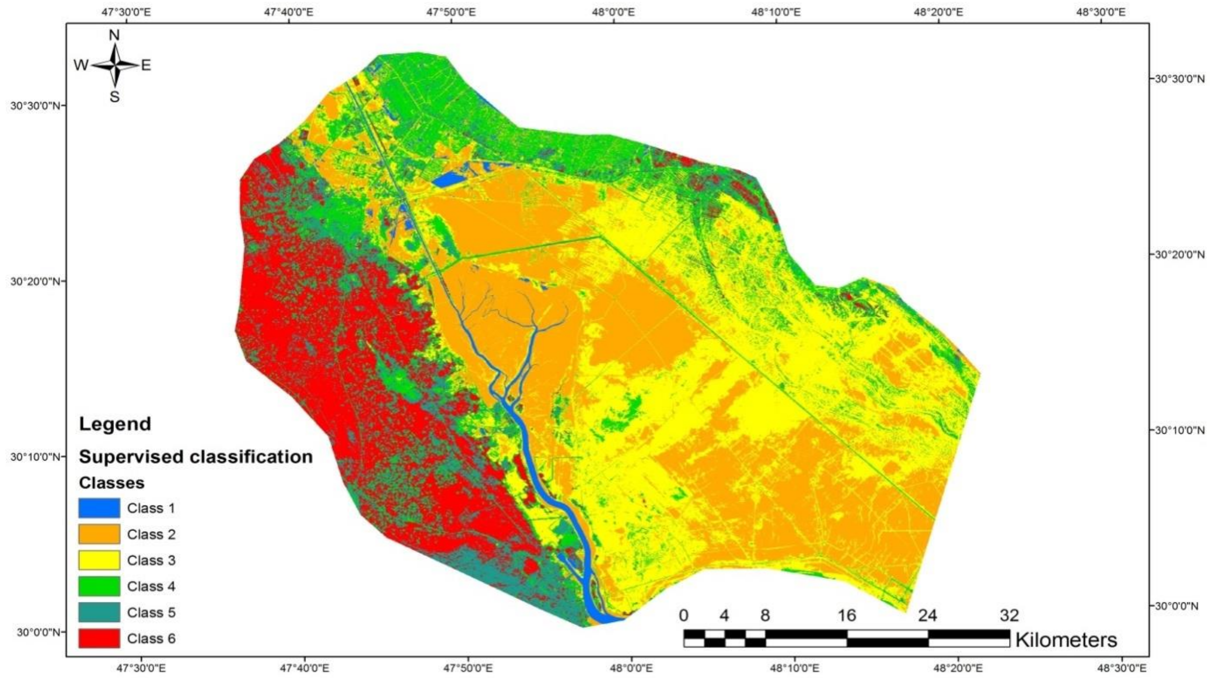
The digital satellite image process was performed using unsupervised classification application in Arc map 10.4.1 software. The classification process is performed automatically by the calculator. Training Area data are not used as a basis for classification. Rather, it includes algorithms that examine unknown pixels in the satellite image and combine them into a number of classes based on natural groupings in the satellite image values . The number of classes is determined by the researcher according to the required purpose, as 10 classes were identified at this stage (Figure 2) for the purpose of taking samples by the auger holes method representing all parts of the study area for the purpose of studying some soil characteristics (salinity, soil texture, lime content and organic matter) . Based on the results of the laboratory analysis of the auger holes samples, 6 pedons representing 6 soil units were selected during the supervised classification procedure in the subsequent stage.



Figure(2) Unsupervised Classification

Supervise Classification

The digital interpretation of the satellite image was performed using the application of Supervise Classification in the Arc map 10.4.1 program, by testing a number of training areas that included all cases of covariance in the study area after dividing the satellite image into a number to be determined depending on the state of variance in the characteristics of soil The study is in line with the results of field survey and laboratory analysis, that is, after obtaining the results of the analysis of auger holes specified in the stage of unsupervised classification, as 6 typical sites for digging pedons were identified within the predominant soil units in the study area Figure (3) .



Figure(3) Supervised Classification

3 – Field procedures

After determining the locations of 6 pedons distributed in each soil unit in the study area, using a GPS device to locate the pedons and dropping them on the map, some morphological characteristics were described based on (Soil Survey Staff 2003). Soil samples were obtained from each horizon for the purpose of conducting the required laboratory analyzes for the purpose of studying some physical and chemical characteristics .

4 – Prepare samples for laboratory analysis

Soil samples weighing 2 kg per sample were taken for some physical and chemical analyzes. The samples were left to dry air, then they were milled after drying and sifted with a sieve with a diameter of 2 mm holes and kept in nylon bags. Soil texture and weighted mean diameter were estimated according to the methods described in Black (1965), while both the organic matter and calcium carbonate were estimated as reported in Jackson (1958), and the electrical conductivity in the soil extract was estimated by following the methods described in Page (1982) .

5 – Preparing the geographic information systems database

The information about the study area was entered and stored in order to prepare it in the required spatial analysis process using geographic models within the ArcGIS 10.4.1 program to prepare maps of soil characteristics. As the data were entered into a special excel file that contains several pages through which these data are processed to obtain estimates used for the number of maps for each characteristic of the soil. This information included the locations of the pedons in the study area, the results of the physical and chemical analyzes, and the morphological characteristics, and their transformation into a database. Two types of features have been identified: Point features that represent a map of soil units and Polygon features that represent a map of soil units, and at this stage the process of linking data (Attribute tables) that represent a map of the distribution of soil units and the locations of the pedons with the rest Soil properties to obtain the required maps .

Results and discussion:

1 – Morphological Characteristics

The results of the soil investigations showed that there is a change in some morphological characteristics of the pedons according to the landscape position and the difference in the source of sedimentation, and this variation in the morphological characteristics between the pedons in general reflects the influence of the local factors of each pedon that affected the state of variation in the composition of those soils. These include the physiographic location, the nature of land use, the effect of ground water, the influence of microclimate factor, and the source of sedimentation .

a - Soil structure

The results of the morphological characteristics showed in Table 1 and Fig. 4, the spatial distribution of the soil structure in the horizons of the pedons 1, 2, 3 and 6 was of the Angular blocky type, while the structure class ranged from medium to coarse. and the dominance of the structure class (Medium) in the above pedons, and the degree of grade ranged from moderate to strong and the dominance was the degree of moderate grade. As for the pedons (4 and 5), their horizons were structure less. It is clear that the difference in soil construction among the studied pedons is due to the nature of the sedimentation process that affected the type of construction in previous periods, and the variation in the content of organic matter associated with the density of vegetation cover, which varies from barren soils to soils invested for agriculture. In addition, the soil utilization factor led to an improvement in soil construction in cultivated pedons, especially in the desert area, which led to an improvement in the type of construction. Roots and their effect on soil biology activity.

Table (1) Some morphological properties of pedons in the study area

Pedon No.	Horizon	Depth cm	Soil structure	Soil depth	Soil drainage	Mottling depth cm	Depth of table water cm	Location
1	A	0 – 40	3cabk	Moderately shallow	Imperfectly drained	50	115	Abu Al-Khasib
	C1	40 – 75	3mabk					
	C2	75 +	2mabk					
2	A	0 – 30	3cabk	Moderately shallow	Moderately well drained	80	120	Hamdan
	C1	30 – 55	3mabk					
	C2	55 – 80	2mabk					
	C3	80 – 115	2mabk					
3	A	0 – 40	2cabk	Moderately shallow	Moderately well	65	100	Faw
	C1	40 – 65	2cabk					

	C2	**65 – 100**	**2mabk**		**drained**			
	C3	**100 +**	**3mabk**					
4	**A**	**0 – 30**	**0**	**Very deep**	**Excessive well drained**	**Nill**	**500**	**Safwan**
	C1	**30 – 95**	**0**					
	C2	**95 +**	**0**					
5	**A**	**0 – 20**	**0**	**Very deep**	**Excessive well drained**	**Nill**	**500**	**Umm Qasr**
	C1	**20 – 75**	**0**					
	C2	**75 – 120**	**0**					
	C3	**120 +**	**0**					
6	**A**	**0 – 30**	**2mabk**	**Moderately shallow**	**Moderately well drained**	**55**	**100**	**Seba**
	C1	**30 – 55**	**2mabk**					
	C2	**55 – 100**	**2mabk**					

Tarim, 2010)Reference (Abbreviations:
Structure: 0 = structure less ;1 = weak ; 2 = moderate ; 3= strong ; vf = very fine ; f = fine ; m = medium ; c = coarse ; gr = granular ; abk = angular blocky ; sbk = subangular blocky.

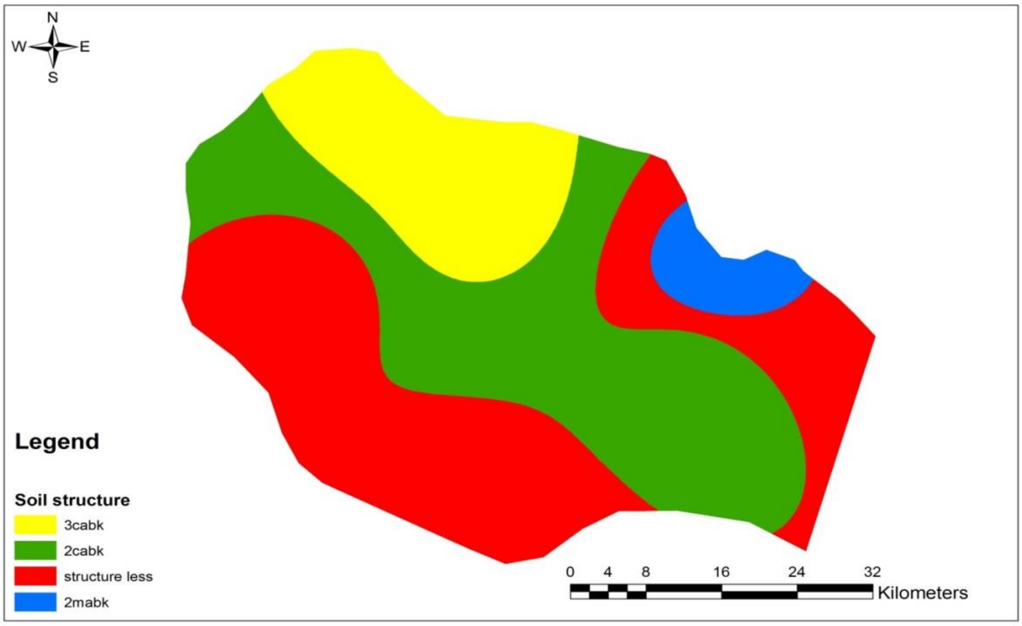


Figure (4) Spatial distribution of soil structure

b – Natural drainage of the soil

The results in Table 1 and Fig. 5 indicated the spatial distribution of natural drainage in the soil, whose grading classification was based on the classification contained in the Soil Survey staff (2003) by determining or measuring the first depth at which the mottling appears from the soil surface. It was noticed that although the depth of the ground water throughout the study area ranged between 100 - 500 cm, the depth of mottling ranged between 50 - 80 cm for pedons 1, 2, 3 and 6, as the depth of the mottling depends on the nature of the movement of water up and down in Soil body and texture, and the proximity of the mottling to the soil surface in some horizons is the occurrence of processes that led to the rise of ground water in previous periods, such as floods or high water discharges in the Shatt al-Arab. As the mottling depth of the above pedons was 50, 80, 65 and 55 cm respectively, so the condition of the natural drainage of the soil was of a moderately well drained type except for the pedon 1, which was imperfectly drained . As for the pedons 4 and 5, they were characterized by the absence of the mottling in their horizons, and this is due to the efficiency of their internal drainage and drop the ground water level in these areas, whose value was 500 cm, in addition to their height above sea level more than 15 m, and thus the state of natural drainage of the soil Excessive well drained type, and the difference in the depth of the ground water in the study area is related to the height of the pedon sites above sea level, and these results are consistent with what Al-Mousawi (2005) indicated. It can be concluded that the state of variation in the natural drainage between the studied sites depends on the presence of the color mottling and its depth throughout the soil sector, as well as the quality or poorness of the soil aeration that leads to the prevalence of the reduction conditions in it and this corresponds to Ali and Kotb (2010), who showed that there are some The color spotting in general can be attributed to the fact that some soils were inundated and were previously submerged by the water of the marshes .

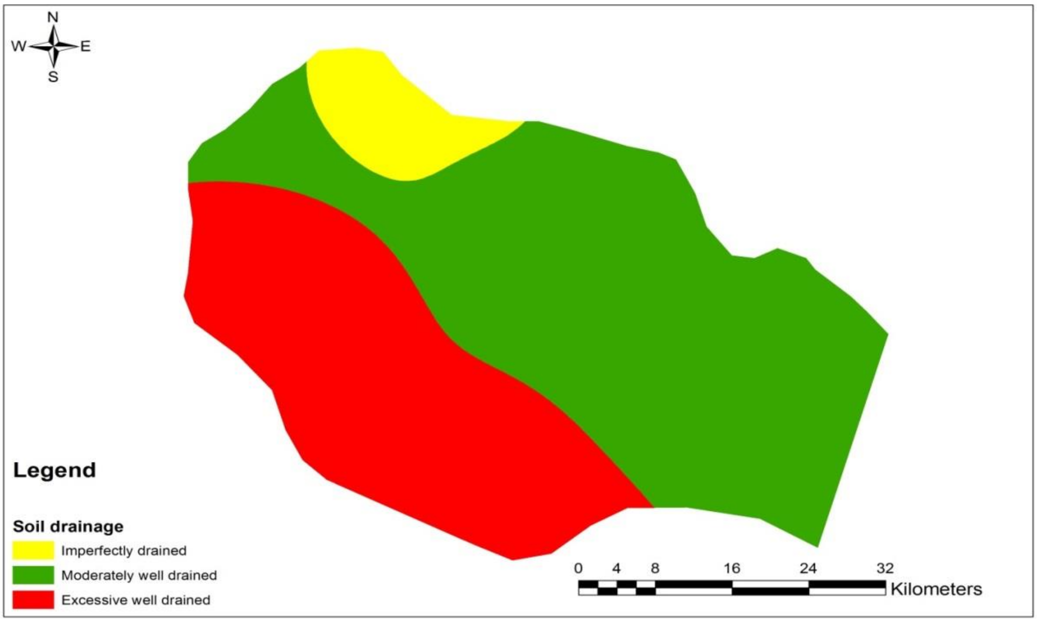


Figure (5) Spatial distribution of natural drainage

c - Soil depth

The results in Table 1 and Fig. 6 show the spatial distribution of the depth of the soil, which in its classification was based on measuring the depth from the soil surface to the boundaries of the rocky horizon, and since sedimentary soils do not have a rocky horizon, the depth of ground water was adopted as a determinant of soil depth. As the results indicated that the depth of the ground water ranged between 100 - 120 cm, so the depth of the soil reached 115, 120, 100 and 100 in pedons 1, 2, 3 and 6 respectively, and therefore the depth of the soil was moderately shallow in those pedons. Whereas, the depth of the ground water in pedons 4 and 5 was more than 500 cm and the soil depth was 500 cm, respectively. Therefore, the depth of the soil in these pedons can be described as Very deep. We conclude from the above that the greater the depth of the soil, the soil is considered good agricultural because it provides suitable conditions for fixing the roots and providing the necessary nutrients for the plant, as well as important in determining the type of crop to be planted .

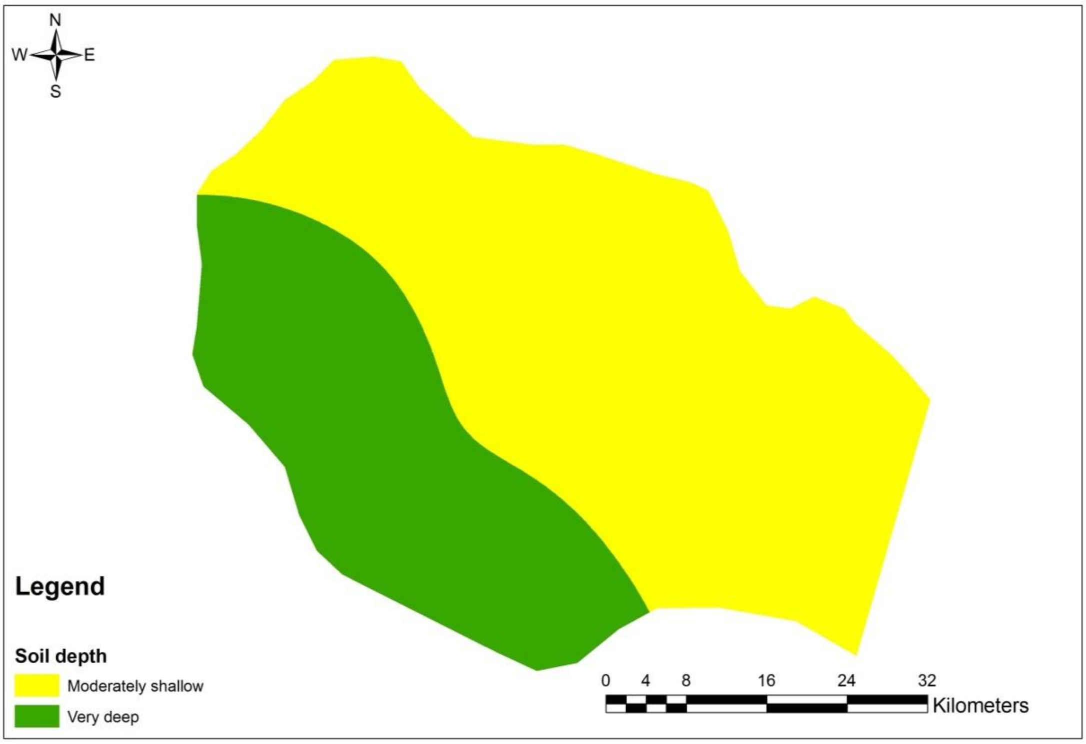


Figure (6) Spatial distribution of Soil depth

2 – Physical Characteristics

a – Volumetric distribution of soil particles

The results in Table 2 and Figures 7, 8 and 9 show Volumetric distribution of soil particles in the horizons of the pedons of the study area, as it is generally noticed that there is a difference in the distribution pattern of soil particles (sand, silt and clay) within a single soil pedon or between different soil pedons and this results from the variance In the sedimentary environment of the studied sites, if it was observed in the pedons 1, 2, 3 and 6 that the content of clay and silt was high in comparison to the small amount of sand in some horizons, and the dominance of silt particles in most horizons, as it ranged between 300.8 - 792.7 g kg^{-1} then Clay ranged between 173.3 - 604.3 g kg^{-1}, while sand ranged between 50.0 - 132.9 g kg^{-1}. While the results showed in the horizons of pedons 4 and 5 that the content of sand particles was high compared to those of clay and silts, as the values ranged between 503.9 - 888.9 and 80.3 - 149.0 and 19.4 - 355.3 g kg^{-1} for sand, clay and silts, respectively. As it is found that the surface horizons were the dominant ones for medium and medium finetexture, while fine and medium finetexture prevailed in most of the subsurface horizons. To illustrate the effect of spatial variation on soil texture class, Fig. 10, the results showed in pedons 1, 2, 3 and 6 that the soil textures were of medium to medium smoothness, while the soil tissues ranged from coarse to medium roughness in pedons 4 and 5. In the textures of the pedons of the study area as a result of the location of the pedon about the source of sedimentation and the nature of the sedimentation conditions, and because of the presence of more than one source of sedimentation in the study area, this led to a variation in the content of soil particles (sand - silt - clay), so when flooding each river transported materials subject to erosion. From its basin, then it continues to be transported to low-lying areas topographically, as the ability of the Karoon and Karkh rivers to transfer a more coarser river load than the Shatt al-Arab River due to the variation in the flow speed of the rivers at the borders of Basra and Khuzestan (Vanessa and Cecile, 2007) .

Table (2) Some physical and chemical properties of pedons in the study area

Pedon No.	Horizon	Soil texture gkg^{-1}			Texture class	MWD mm	EC dsm^{-1}	$CaCO_3$	O.M
		sand	silt	clay				gkg^{-1}	
1	A	73.4	739.5	186.1	SiL	1.2	6.54	400	37.1
	C1	54.0	770.6	173.3	SiL	0.95	4.45	385	20.6
	C2	92.8	721.4	185.5	SiL	0.44	5.46	420	18.5
2	A	97.4	532.2	365.9	SiCL	0.46	55.92	425	4.11
	C1	90.8	560.2	348.5	SiCL	0.30	18.43	410	3.9
	C2	94.0	300.8	604.3	C	0.29	13.49	425	3.7
	C3	57.3	710.3	230.6	SiL	0.25	10.53	460	3.6
3	A	78.0	621.1	300.4	SiCL	0.41	30.72	400	22.6
	C1	132.9	572.6	293.5	SiCL	0.31	32.4	415	22.6
	C2	70.3	642.5	283.5	SiL	0.16	36.24	415	18.5
	C3	70.0	570.2	350.9	SiCL	0.11	32.76	390	5.0
4	A	841.1	19.4	129.5	LS	0.11	2.85	130	4.1
	C1	762.0	96.3	140.6	SL	0.09	3.48	95	3.1
	C2	888.9	27.6	80.3	S	0.08	2.23	90	2.1
5	A	816.9	50.3	130.5	LS	0.11	1.20	175	2.1
	C1	503.9	355.3	140.5	L	0.05	1.30	175	2.0
	C2	818.0	26.3	149.0	LS	0.04	2.11	130	1.9
	C3	803.9	97.3	100.5	LS	0.03	6.75	85	1.8
6	A	50.0	792.7	457.2	SiC	0.41	7.38	420	29.6
	C1	100.1	459.5	440.4	SiC	0.34	7.28	405	26.8
	C2	90.0	500.2	409.7	SiC	0.34	7.58	405	22.6

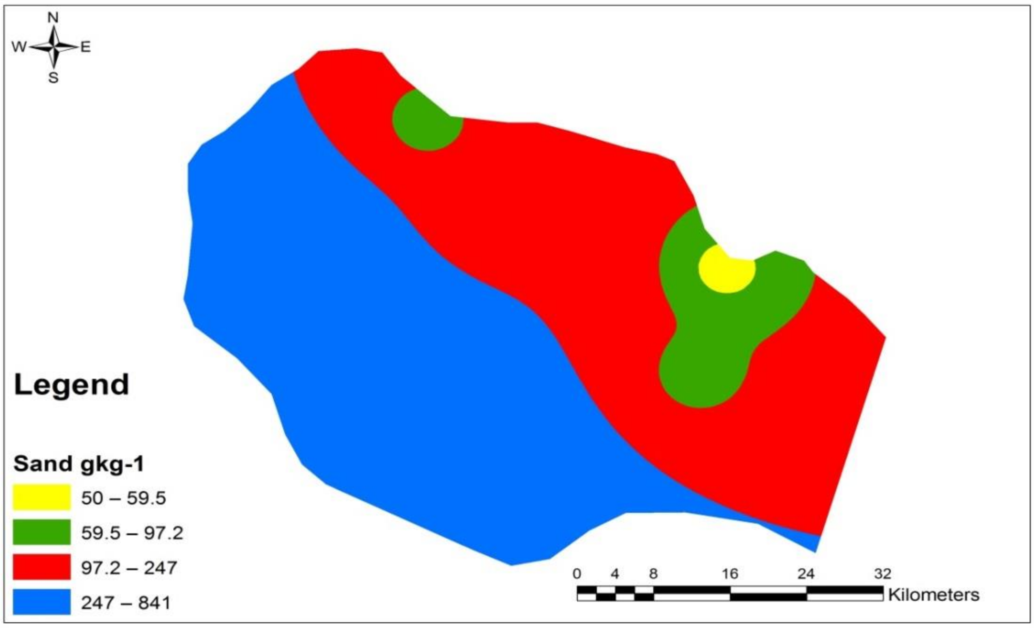


Figure (7) Spatial distribution of Sand particles

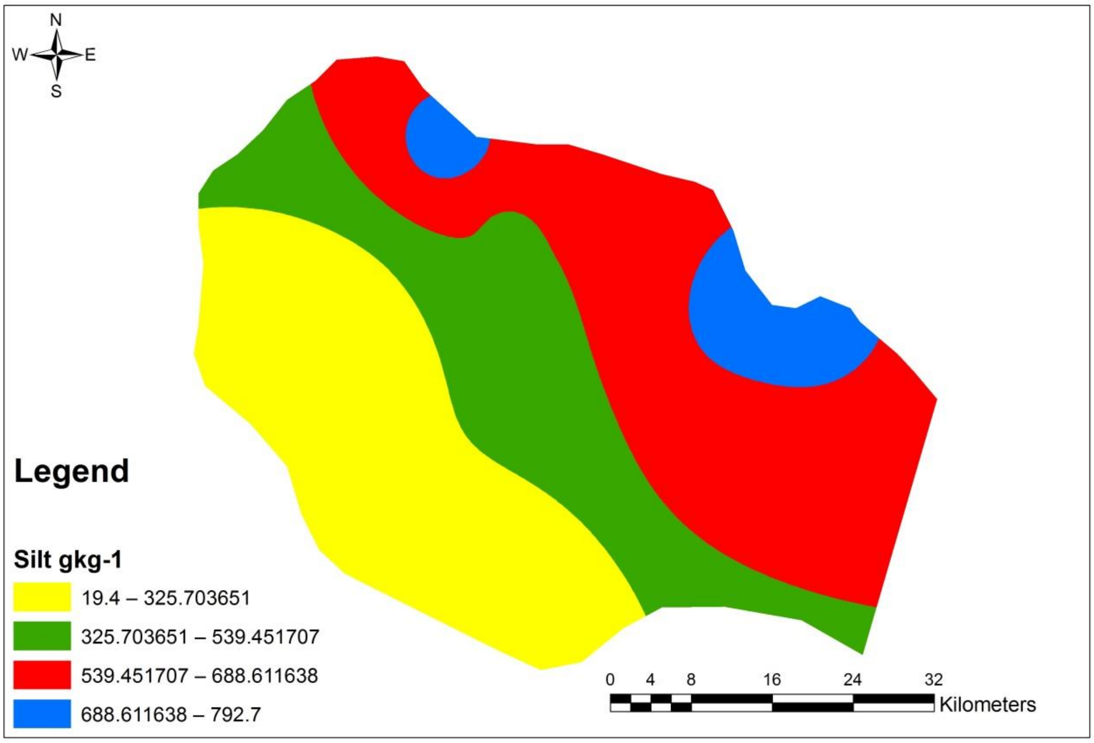


Figure (8) Spatial distribution of Silt particles

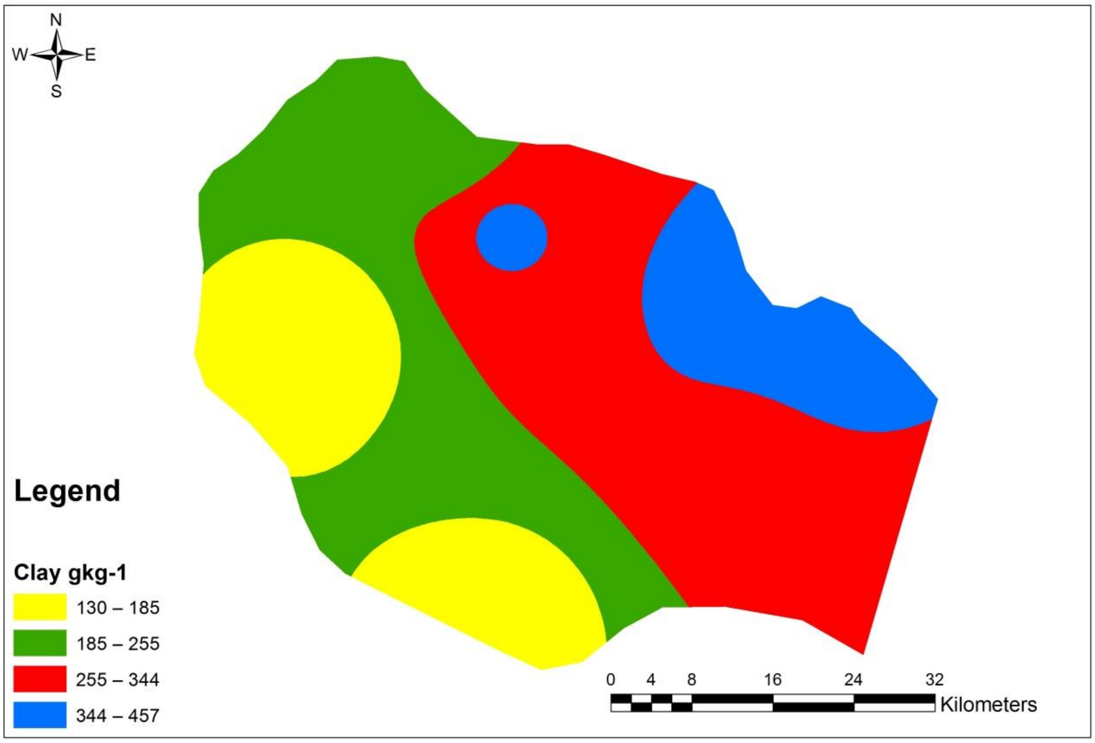


Figure (9) Spatial distribution of Clay particles

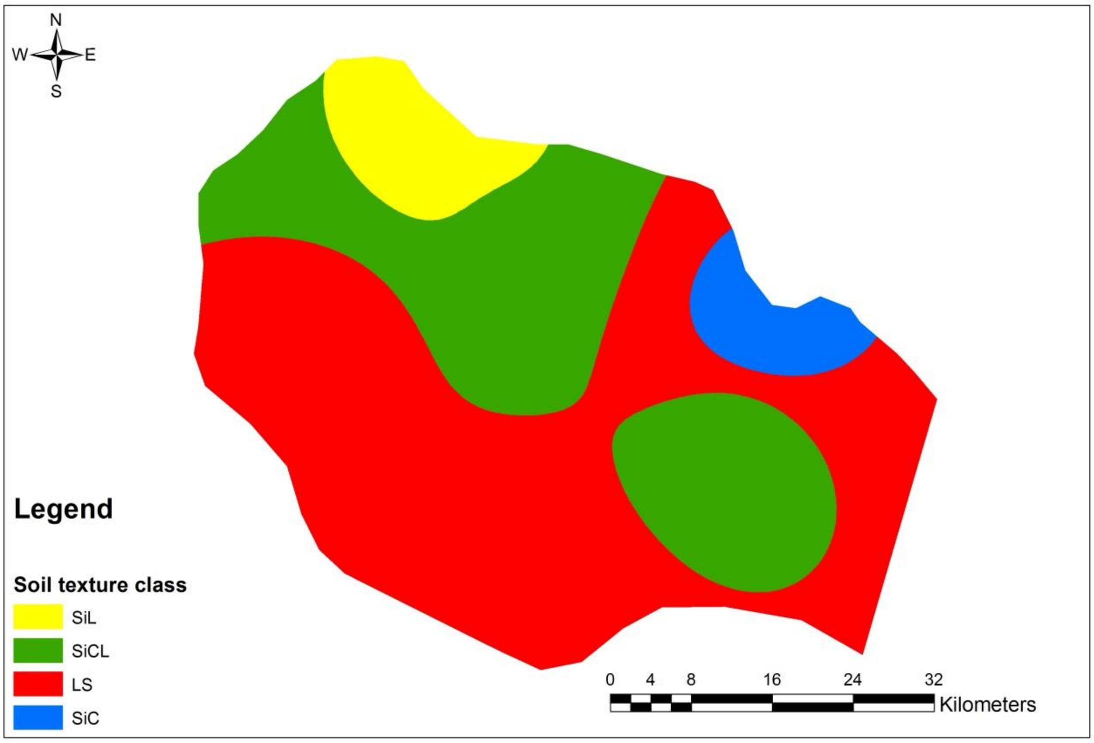
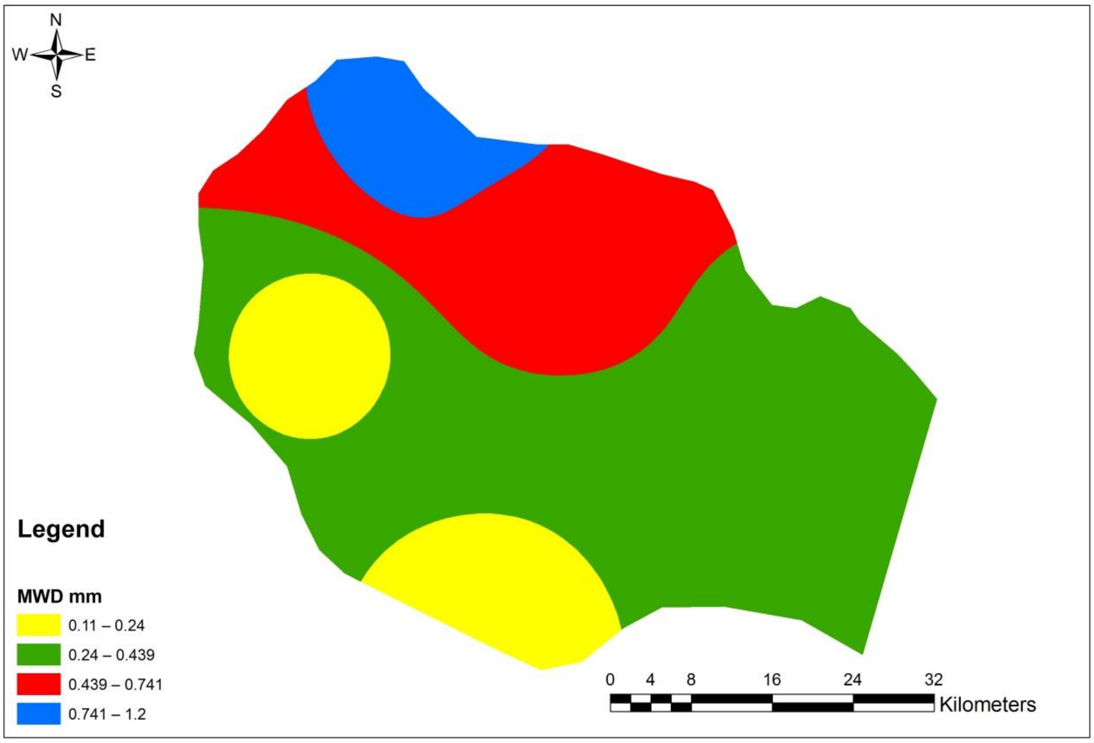


Figure (10) Spatial distribution of soil texture class

b – Mean weight Diameter

The results of Table 2 and Fig. 11 show the spatial distribution of the mean weight diameter values of the horizons of the pedons in the study area. The mean weight diameter of the horizons of the pedons 1, 2, 3 and 6 ranged between 0.11 - 1.20 mm, and that the mean weight diameter values of the surface horizons in these pedons were higher than the mean weight diameter values of the subsurface horizons, as the mean weight diameter of the surface horizons ranged between 0.41 - 1.20 mm, while for the subsurface horizons it ranged between 0.11 - 0.95 mm, and the highest values of the mean weight diameter of the surface horizons appeared at 1, which amounted to 1.20 mm due to the nature of exploitation Agricultural and the density of vegetation cover and the high content of organic matter. Whereas the mean weight diameter values for the horizons of the pedons 4 and 5 ranged between 0.03 - 0.11 mm, in general the values of the mean weight diameter in all the surface and subsurface horizons of these pedons were very low due to the increase in the soil content of sand particles, which reduces the stability of soil aggregations as well as their content. Little organic matter. In general, these pedons were characterized by lower mean weight diameter values of all their surface and subsurface horizons. It is noticed through the results that the mean weight diameter valuesvalue increases in some sub-horizons due to the increase in the content of clay particles in these horizons, and this corresponds to the defect (2008), which showed that the increase in the mean weight diameter values in the sub-horizons resulted from



an increase in the total clay content of the horizons with depth.

Figure (11) Spatial distribution of the mean weight diameter

3 – Chemical Characteristics

a – Soil salinity

The results in Table 2 and Fig. 12 show the spatial distribution of the electrical conductivity values of the horizons of the pedons of the study area. The horizons of the soil pedons showed a change in the salinity content among the pedons of the study area, as the Survey staff (2003) Soil classification related to the salt content of soils was adopted. It is noticed that the electrical conductivity values of the pedons in the study area are located between non-saline soils to highly saline soils and ranged between 1.20 - 55.92 dsm^{-1}. The lowest electrical conductivity appeared at the pedon 5 horizons with a range of 1.20 - 6.75 dsm^{-1}, while the highest electrical conduction values appeared at the horizons of pedons 2 and 3 with a range of 10.53 - 55.92 dsm^{-1}, as it was found that there is an effect of spatial variation, type and degree Agricultural investment in the values of electrical conductivity, as the results indicated that the electrical conductivity values of the horizons of pedons 1, 4, 5 and 6 are located between Non-saline soils to medium salinity, as they ranged between 1.20 - 7.58 dsm^{-1}. With continuous vegetation cover or previously planted, and the role of irrigation and tillage in washing salts downward and reducing the activity of the capillary property that encourages the salinization process (Al-Atab, 2008). As for the pedons 2 and 3, they did not show a specific pattern in their salt content according to the variability of their spatial location. The results of the electrical conductivity for their horizons showed that they are located between medium salinity to high salinity soils with a range of 10.53 - 55.92 dsm-1, and this is due to the occurrence of similar interference in the resultant effect Factors causing salinization represented by the level of critical land water, type of agricultural investment, and texture of the soil sector (Hayali 2017).

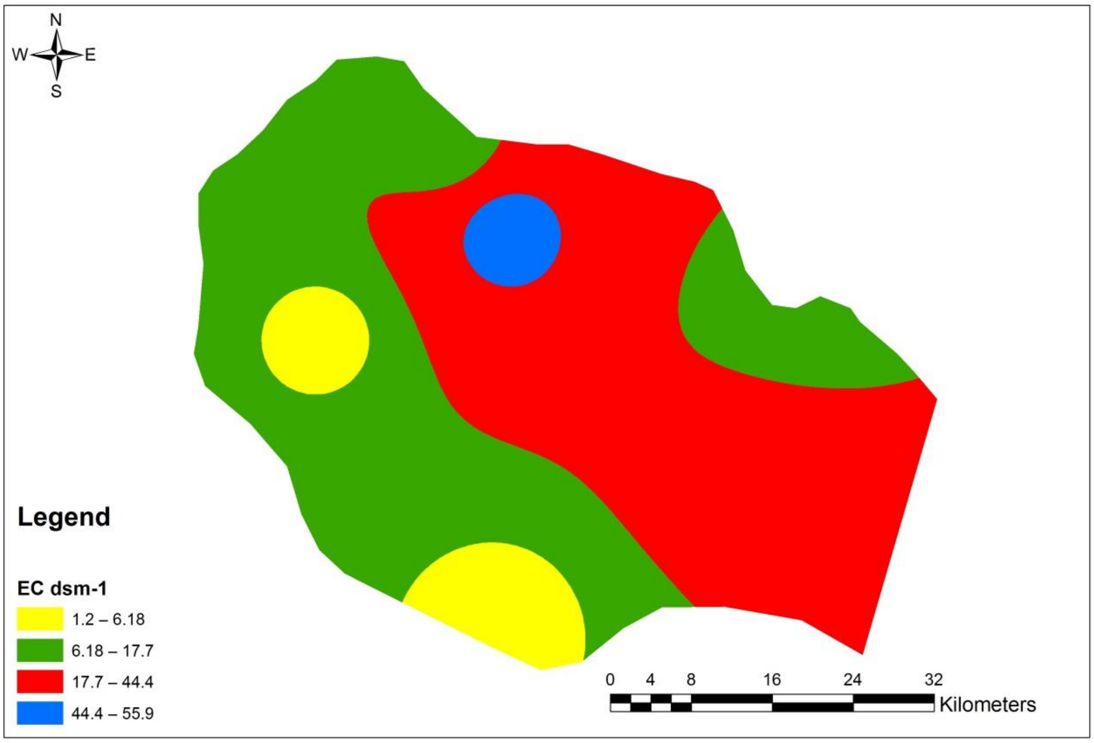


Figure (12) Spatial distribution of Soil salinity

b – Calcium Carbonate

The results in Table 2 and Fig. 13 show the spatial distribution of the content of soil horizons of calcium carbonate of pedons in the study area, as it is noticed that most of the horizons of the pedons in the study area had a high content of calcium carbonate, as it ranged between 85 - 425 g kg^{-1}, and that the distribution appears fairly homogeneous. What is in some of the horizons of the pedons in the study area, and this is due to the sedimentary nature of these pedons' materials and their source, which is characterized by the state of similarity in the original material and the nature of sedimentation (Al-Aqidi, 1986) As for the pedons 4 and 5, it is evident that their calcium carbonate content decreased according to the horizontal and vertical spatial variation, as it ranged between 85 - 175 g kg^{-1}, as it was characterized by a decrease in calcium carbonate in the original material as well as the weak contribution of ground water to the carbonate pool due to the increase in the depth of its presence in those Regions This reflects the contrast in the sources of the original material. The presence of calcium carbonate at this high percentage and under our conditions, it can be considered the main binding material in the studied soils and one of the soil components that may help in making the soil more cohesive and solid due to its occupation of the pores between particles .

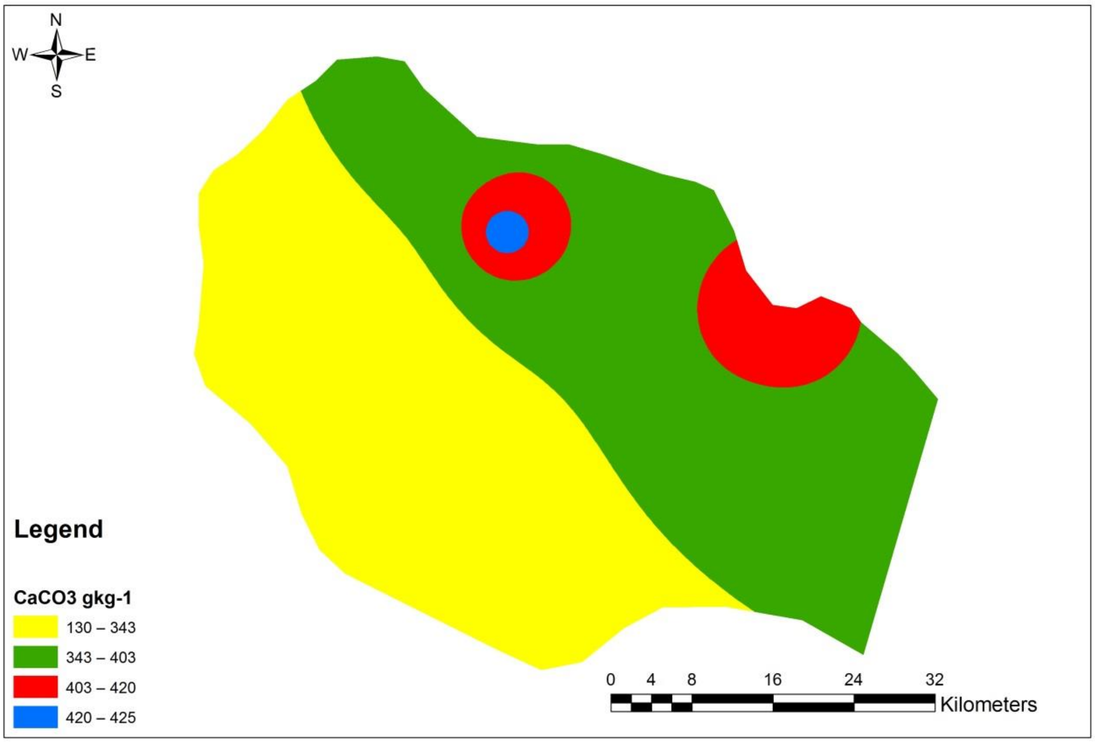


Figure (13) Spatial distribution of Calcium Carbonate

c – Organic matter

The results in Table 2 and Fig. 14 illustrate the spatial distribution of the values of the soil content of organic matter for the horizons of the pedons of the study area, in general there is a decrease in the rate of organic content in the study area, the values ranged between 1.8 - 37.1 g kg^{-1} due to the decrease in vegetation cover and agricultural investment, The decomposition of organic matter under the dry conditions that characterize the climate of the study area and the nature of the root systems (Al-Rawi, 2003). As for the effect of spatial variation on the organic content of the pedons in the study area, the horizons of the pedons 1, 3 and 6 showed the highest organic content at rates of 37.1, 22.6 and 29.6 g kg^{-1}, respectively, due to their location within areas with vegetation cover for continuous investment in planting palm trees and some Farms for economic crops. As for the pedons 2, 4 and 5, they showed a clear decrease in their organic content at rates not exceeding 4.11 g kg^{-1} due to the decrease in vegetation cover due to the low rates of rainfall, high salinity, lack of agricultural exploitation and decomposition rates of organic matter. In general, it appears that there are few differences in the distribution of organic matter among most pedons in the study area, and this may be due to the decrease in vegetation cover as well as the prevailing dry climatic conditions that help in the occurrence of oxidation processes due to high temperatures, and that the changes in the values of the organic matter content are clear and decrease with The depth, especially when moving from the surface horizons to the underlying horizons, and the studied soils are poor in their organic matter content, as are the soils of arid and semi-arid regions (Al-Atab et al., 2013) .

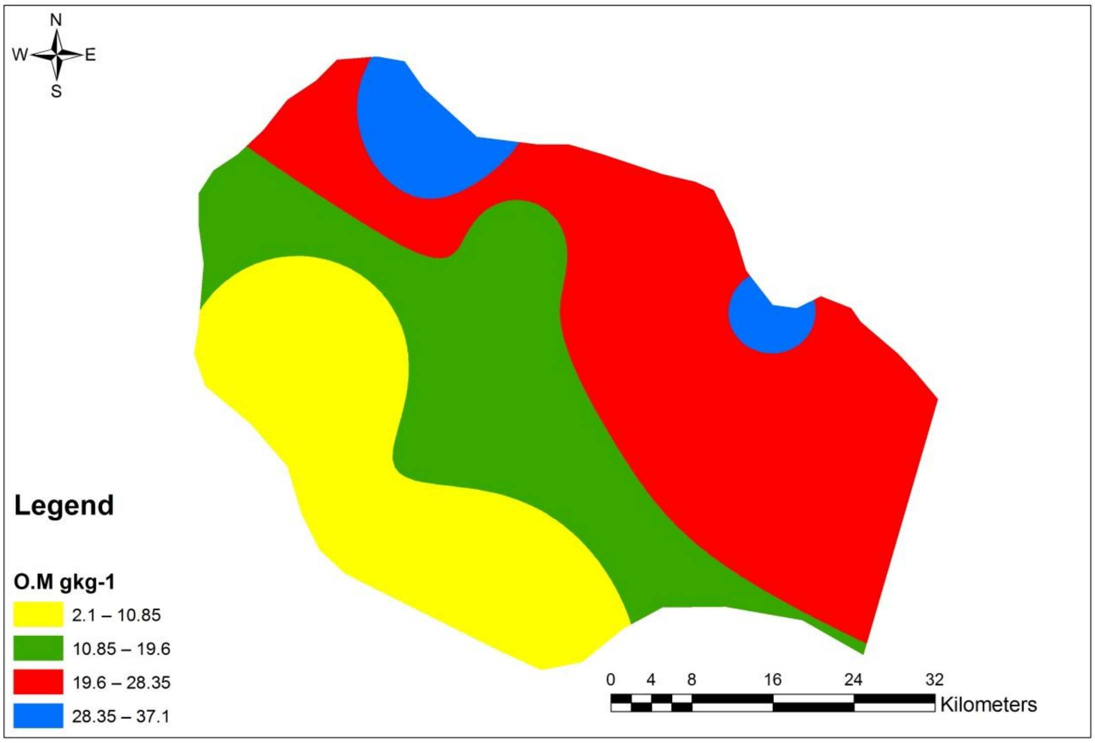


Figure (14) Spatial distribution of Organic matter

References

Al-Agidi , W. K. (1986). Physiology / Soil Surveying and Classification. University of Al Mosul.

Al-Atab, S, M, Muhammad A, K, and Hussein A, N. (2013). Variation of some physical and chemical characteristics of Katuf soils and river basins in Abu Al-Khasib district in Basra governorate. Basra Research Journal. Volume 38, Issue 1: 221--237.

Al-Atab, S, M. (2008). Variation in soil properties and their classification for some areas of Basra Governorate. PhD thesis - College of Agriculture - University of Basra.

AL-Hamadany, A ,S . (2017). Characterization , Classification and Prediction of Soil Map Units by Using Remote Sensing and GIS in Bahar – Alnajaf , IRAQ. PhD thesis - College of Agriculture - University of Basra .

Al-Hayali, M ,A . (2017). Classification of some soils of eastern Shatt Al– Arab region in Basrah province and evaluation of land suitability for agricultural purposes by using remote sensing technologies. PhD thesis - College of Agriculture - University of Basra .

Ali , R , R and Kotb , M , M . (2010) . Use of Satellite Data and GIS for Soil Mapping and Capability Assessment . J . of Nature and Science. 8(8) : 104 – 115 .

Al-Mousawi, N, A. (2005). Spatial variation of soil characteristics in Basrah Governorate, a study in soil geography. PhD thesis - Faculty of Arts - Basra University.

Al-Rawi, M, K. (2003). Characterization and distribution of the original materials for some sedimentary soils and their effect on the characteristics of soils. PhD thesis. College of Agriculture, University of Baghdad, Iraq.

Black , C . A . (1965) . Method of soil analysis , Am . Soc . of Agronomy No . 9 part I and II .

Buringh , P. (1960) . Soil and soil conditions in Iraq . Ministry of agriculture , Baghdad .Iraq.

Faleh, Ali and Jamal Shawan. (2012). Geographical Information Systems and Remote Sensing: Principles and Applications. Infoprant Press. Axe . The Kingdom of Morocco .

Jackson , M . L . (1958) .``Soil chemical Analysis `` . printice – Hall . Inc ., Engle wood cliffs . , N . Y .

Page , A . L . , R . H . Miller and D . R . Keeney . (1982) . Methods of soil analysis , part (2) 2nd ed . Agronomy g – Wisconsin , Madison . Amer . Soc . Agron . Inc . Publisher .

Rossiter ,D.(1994).Land Evaluation ,Lecture Notes .Comell University Crop & Atmospher Sciences.

Soil Survey Staff. (2003). Soil Taxonomy. Abasic system of soil classification for making and interpreting soil survey. 2nd edition. Agriculture Handbook No. 436. USDA.

Soil Survey Staff. (2003). Soil Taxonomy. Abasic system of soil classification for making and interpreting soil survey. 2nd edition. Agriculture Handbook No. 436. USDA.

Sullivan ,P. (2004) . Sustanable soil managenent . soil system guide .ATTRA.NCAT.PP:1-39.

Tarim , B . D . (2010) . Morphology, Physico-Chemical Properties and Classification of Soils on Terraces of the Tigris River in the South-east Anatolia Region of Turkey . Journal of Agricultural Sciences 16 (2010) 205 - 212 .

Tranter,G., B. Minasny, A. B. McBratney, R. A. Viscarra Rossel and B. W. Murphy.(2008). Comparing Spectral Soil Inference Systems and Mid-Infrared Spectroscopic Predictions of Soil Moisture Retention. Soil Sci. Soc. Am. J. 72:1394-1400.

Vanessa Mary An Heyvaert and Cecile Baeteman .(2007). Holocene sedimentary evolution and palaeocoastlines of the Lower Khuzestan plain (southwest Iran). Marine Geology 242 : 83–108 .