Plant Archives Volume 20 No. 2, 2020 pp. 6207-6213 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

CARTOGRAPHIC ANALYSIS AND THE HORIZONTAL AND VERTICAL HETEROGENEITY OF THE PHYSICAL CHARACTERISTICS OF THE SOIL OF MAHAWIL DISTRICT IN BABIL GOVERNORATE USING GEOGRAPHIC INFORMATION SYSTEMS

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Abstract

The study area was chosen in Al Mahawil district in Babil governorate between E 44°200’00"to E45°60’00" and N32°250’00"to N34° 490’00". Part of the district’s lands were surveyed which covers an area of 20112.84 hectares and lies about 20 km north of Hilla, the capital of Babil governorate. After determining 50 sites, with three depths of 0-30 cm, 30-60 cm and 60-90 cm, by means of auger hole and their coordinates were determined by a GPS device, a cartographic analysis of the soil map was performed to find out the percentage and frequency of each unit of soil. The horizontal and vertical variations of some physical properties were studied by the Kriging method and for various depths and by using geological statistics, the results showed that the ratio of the separation of sand is the most variable physical characteristics, followed by the ratio of silt separation, then the separation of the clay, then the apparent density of the least variation. 4463.60 meters and the lowest value of sand separator and the highest value of bulk density. The clay occupied the largest area, reaching 17877.77 hectares and the lowest area for bulk density, reaching 9512.93 hectares.

Key words: spatial covariance, physical properties, cartographic analysis, GIS

Introduction

The importance of studying soil variations in soil surveying and classification works such as classifying it and producing a map enables us to give accurate interpretations and data analysis of traits more precisely, as there are additional differences resulting from different human activities, especially in agricultural areas and that some of these changes are regular and predictable. And that studies of soil variations have produced results of great importance for soil surveys (Dent and Young, 1981). The use of geological statistics is an important tool for agricultural sciences and knowledge of the spatial variation of soil characteristics can be used in identifying areas with compacted soil problems that suffer from high bulk density and require a special soil management type (Souza *et al.,* 2006). Castrignano *et al.,* (2004) indicated that the physical characteristics are mostly heterogeneous in nature due to their association with many factors affecting them, including agricultural processes, but the soil bulk density is of little variation, especially in the subsurface depths, as a result of soil compaction. Reynolds *et al.,* 2007 explained that the physical properties of the soil, including the bulk density, change over time and the difference in distance and depth spatially as a result of natural and anthropogenic influences that depend on seasonal climatic conditions, soil management practices, the stage of crop growth and the associated biological activities.Peukert *et al.,* 2013 explained that the physical properties of soils are in varying degrees of heterogeneity due to the type of soil, its texture and the nature of soil management. The content of sand, silt and clay in sedimentary soils, variances from fine to coarse tissue gradient downstream in Turkey’s soils (Saglam *et al.,* 2011).

Tola *et al.,* 2017 indicated that mud and silt differed more than sand in soils located in southeastern Saudi Arabia, as the effective distance for silt reached 5.22 meters, for clay 28.18 meters for sand and for 99.11 meters for a total distance of 1600 meters, while (Ahmad *et al.,* 2018) found when they studied In the soils of northern Pakistan, silt contrasts with an effective distance

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of 31470 meters, mud by an impressive distance of 46463 meters and sand by a distance of 4,6080 meters, as the total distance was 330 km. Hence, the aim of this research is to prepare spatial distribution maps and predict the physical properties of the soil and to analyze the cartographic analysis of a map of the soil district of Mahawil in Babil governorate.

Materials and Methods

The study area was chosen in the district of Mahawil, which is located in the southwest of Babil governorate, with an area of 20112.84 hectares and about 20 km north of the city of Hilla, the capital of Babil governorate.

Length 44°200’00 “to 45°60’00" east and between two latitudes 32°250’00 “to 34°490’00" north Fig. 1.

After that, 50 sites were identified and their coordinates were determined by the global positioning device (GPS) according to the engineering networking system required by the spatial analysis procedures proposed by (Lark, 2009). Samples were obtained from four depths in those sites by means of auger hole and the samples were preserved and brought. To the laboratory, the texture was measured in a way to determine the natural drainage, a cartographic analysis of the map was performed to find out the percentage and frequency of each unit of soil for the purpose of determining the locations of samples in the larger and more frequent soil units to be representative of the study area and the necessary laboratory measurements were made of it. The method mentioned in (Richards, 1954), the bulk density according to the method mentioned before (Black, 1965).

After obtaining the data of laboratory measurements of the physical properties of the soil, it was included in the Excel file table, Excellency, after that, he was called into the GIS program and the coordinates were converted from the geographic system to the metric system UTM for the purpose of mapping and tracking the variations with Kriging technique. Geological statistics were used to calculate the variance function. The midsection using the Arc GIS 10.7 program, as the coordinates of the specified study sites, their coordinates are projected by the GPS device and a variogram is drawn and represents the relationship between the semivariance function with the distance h in order to find the effective distance and spatial dependability and the effective distance range is calculated and the spatial reliability is calculated according to the equation Adopted by (Iqbal *et al.,* 2005).

$$\text{Spatiality Dependent} = \text{nugget}/(\text{nugget} + \text{sill}) \times 100 \quad (1)$$

The spatial variability is described qualitatively according to equation (1)

The spatial variability is described as strong, if the ratio is less than 25% and the variability is described as moderate if the ratio is between 75-25% and the variability is described as weak if the ratio is more than 75%.

Results and Discussion

Cartographic analysis of the study area soils

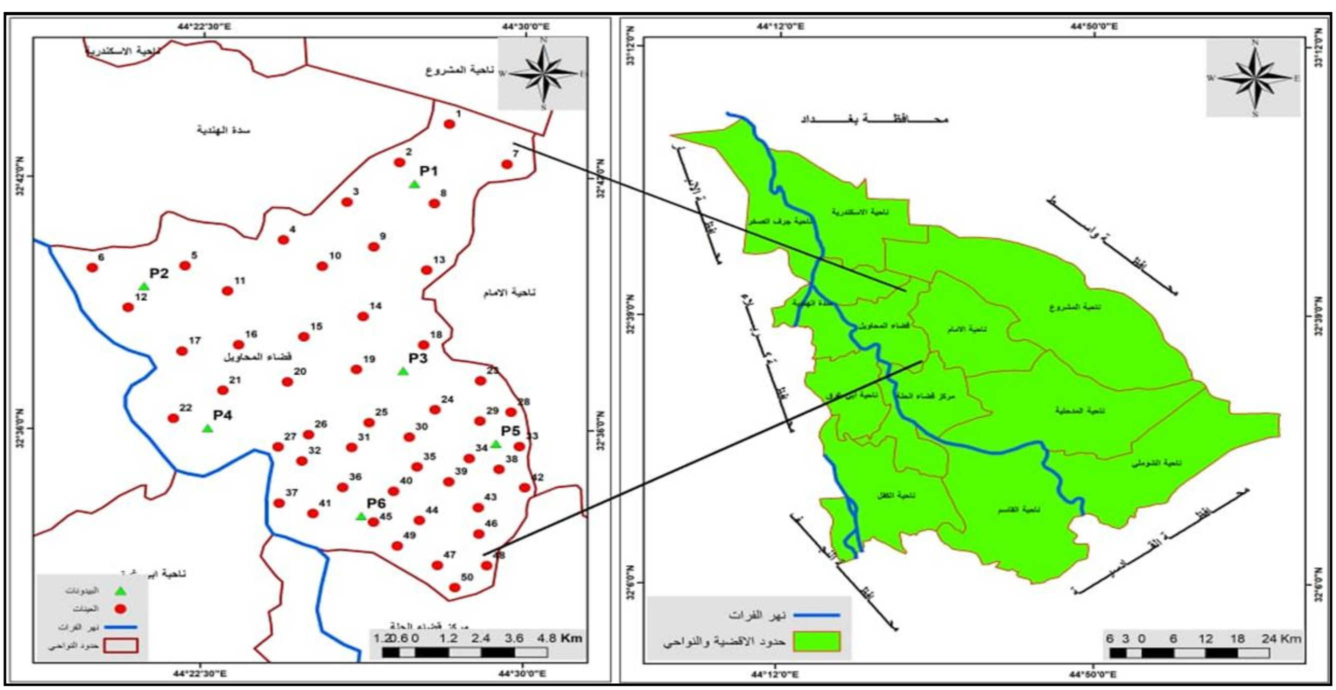

Fig. 1: A map of the location of the study area.

The results of table 1 and Fig. 2 indicate that the number of series diagnosed in the study area after conducting a cartographic analysis of a map of the region's soil chains reached 12 series, varying in area and frequency and 6 series were selected, including the most frequent ones, to be representative of the area and

Table 1: Cartographic analysis of soil chains in the study area.

Series NO.	Soil Series	Area (Hectares)	Percentage (%)	Frequency
1	TM1167	3535	17.58	7
2	TM1156	3117	15.50	5
3	MM11	2782.94	13.84	4
4	TM1166	2252.75	11.20	8
5	DM116	1557.5	7.74	4
6	TM1277	1393	6.93	6
7	TW554	1194.5	5.94	2
8	TM957	1057	5.26	3
9	DW55	1022	5.08	2
10	TW576	937.25	4.65	3
11	TW956	635.75	3.16	3
12	DW127	628.15	3.12	3
SUM		20112.84	100	50

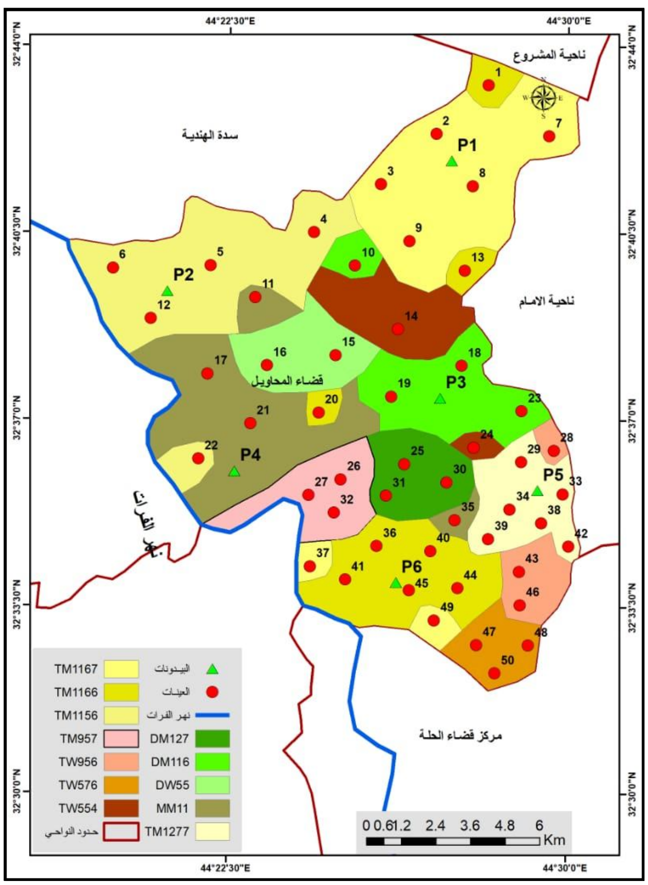

Fig. 2: Cartographic analysis map of soil series in the study area.

pedon was revealed in each series. As the results indicate that the TM1167 series occupied the largest area amounting to 3535 hectares, 17.58% of the total area and a frequency of 7 once, followed by the TM1156 series, as it occupied an area of 3117 hectares and 15.50% of the total area and repeated 5 once, then the MM11 series with an area of 2782.94 hectares, by% 13.84 and 4 once, followed by the TM1166 series, with an area of 2252.75 hectares, a percentage of 11.20 and a frequency of 8 once, as this series was the most frequent among the diagnosed series. Then the other series were graded according to their areas from largest to smallest areas as follows: DM116, TM1277, TW554, TM957, DW55 TW576, TW956 and DW127, as their areas were 1557.5, 1393, 1194.5, 1057, 1022, 937.25, 635.75 and 628.15 hectares, respectively.

It is also noticed that the DW127 series was the smallest area of the diagnosed series, as it occupied an area of 628.15 hectares, with a rate of 3.12% of the total area of the area, with a frequency of three once. The results of the table show that the diagnosed soil series have a prevalent texture in those series according to the twelve system, which is the silt clay, as it was prevalent in the larger soil series as well as in the most frequent soil series, that the predominant natural drainage is the moderate drainage. The spotting appeared at a depth of 50-90 cm, except in the TW554, DW55, TW576 and DW127 soil series, as it had good natural drainage, as the spotting appeared only at a depth of 150-90 cm and it was detected with no representative in the series with a larger area and more frequency.

Horizontal and vertical variances of the Kriging soil physical properties

Bulk density of soil:

The values of the bulk density of the soil of the study area ranged between 1.43-1.24 mcg m^{-3} for the first surface depth and between 1.46-1.25 mcg m^{-3} for the second depth and between 1.5-1.26 mcg m^{-3} for the third depth, as the bulk density values are affected by the soil texture. The value decreases with the increase in the content of clay and silt and its values increase with the increase in the separation of sand and total carbonate in the soil. Also, high levels of salts have affected the values of bulk density as well as the decrease in the content of organic matter in the soil and these results are consistent with (Isa, 2020). It is also noted from the results of table 2 that the bulk density increases as the soil moves away from the surface and these results are consistent with what was obtained (Abdul-Hussein, 2008). The reason may be attributed to the presence of natural vegetation

Table 2: Statistical analysis of soil physical properties using Kriging.

Prop-erty	Depth	nugget	Partial sill	Sill	Range	Model	Spatial variability	Classify variability
Bd	D1	0	0.003	0.003	4463.60	Circular	0	Strong
	D2	0	0.003	0.003	2798.17	Sherical	0	Strong
	D3	0	0.003	0.003	3645.16	Circular	0	Strong
Sand	D1	0.02	1.57	1.59	2363.19	Sherical	1.24	Strong
Silt	D1	0.10	1.90	2	3003.70	Circular	4.76	Strong
Clay	D1	0	1.00	1.0	2009.88	Sherical	0	Strong

at the surface, so the content of organic matter is higher than the subsurface depths, in addition to agricultural machinery and others. Causing the soil to be compacted at depths other than shallow.

The results of table 2 indicate that the statistical analysis of the bulk density and the depths D1, D2 and D3 indicated that the values of the variation of the bulk density of soils at those depths were somewhat small, especially in the first depth D1, as the values of the effective distance range for those depths reached 4463.60, 2798.17 and 3645.16 meters for the depths D1, D2 and D3 In succession, as the second depth, D2, the higher, was heterogeneous and the first depth, D1, was the least heterogeneous and the reason might be attributed to the compaction of the soil in the subsurface depths, which causes the bulk density of the soil to change and leads to its variation from one depth to another. As for the appropriate model to describe the covariance of this characteristic at those depths, the Circular model was the appropriate model in depth D1 and D2, while the Spherical model was the appropriate model to describe the covariance in depth D3 and all depths had a strong spatial dependence (Iqbal *et al.,* 2005), The reasons for the variation in soil bulk density values are attributed to the conditions of wetting and drying to which the soil is exposed, soil management and compaction operations through grazing and the passage of agricultural machinery, in addition to the nature of the use or non-exploitation of the land (Ozgoz *et al.,* 2010).

As for the spatial distribution of bulk density, it shows that the values of bulk density in the first depth D1 occupied the range 1.30-1.28 Mg m^{-3}, the largest area amounted to 8365.6 hectares and the percentage of 41.59% of the total area of the study area, while the range 1.25-1.24 mcg m^{-3} did not show an area specified on the spatial distribution map at this depth. As for the spatial distribution of the apparent density of the second depth D2, Table 3 and Fig. 3, 4 and 5, the range 1.40-1.32 mcg m^{-3} occupied the largest area of depth of 9452.3 hectares, with a percentage of 46.99% of the total area and the least area was within the range 1.27-1.25 mcg m^{-3}, as it reached 84.64 hectares, with a rate of 0.42% and the third depth,

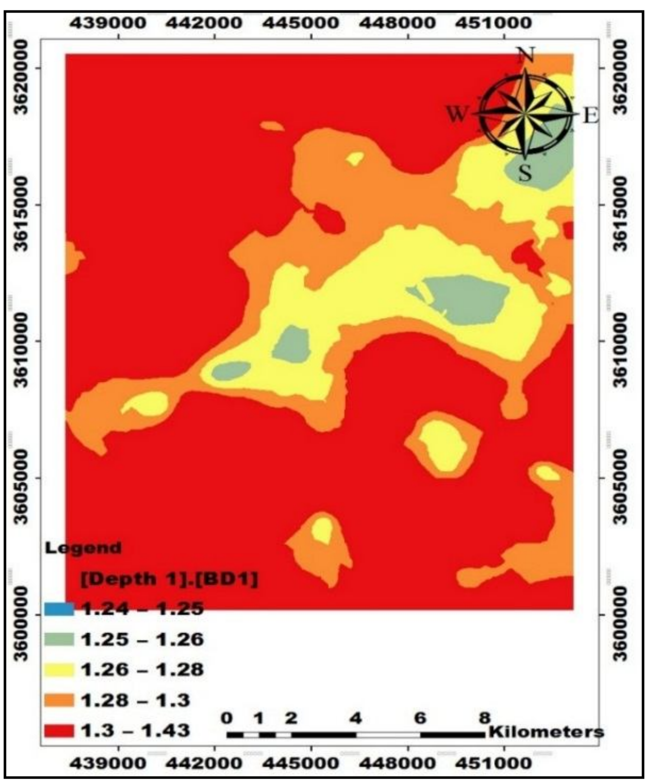

Fig. 3

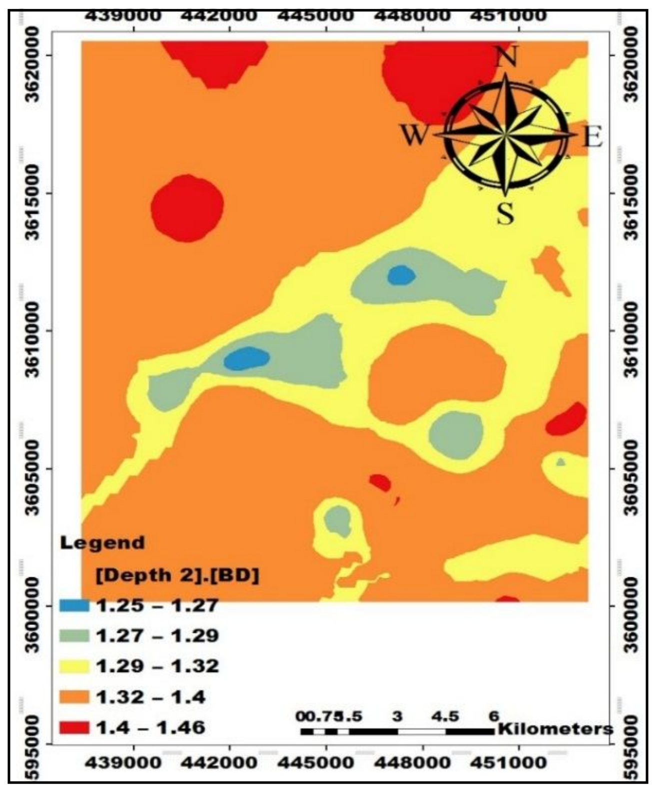

Fig. 4

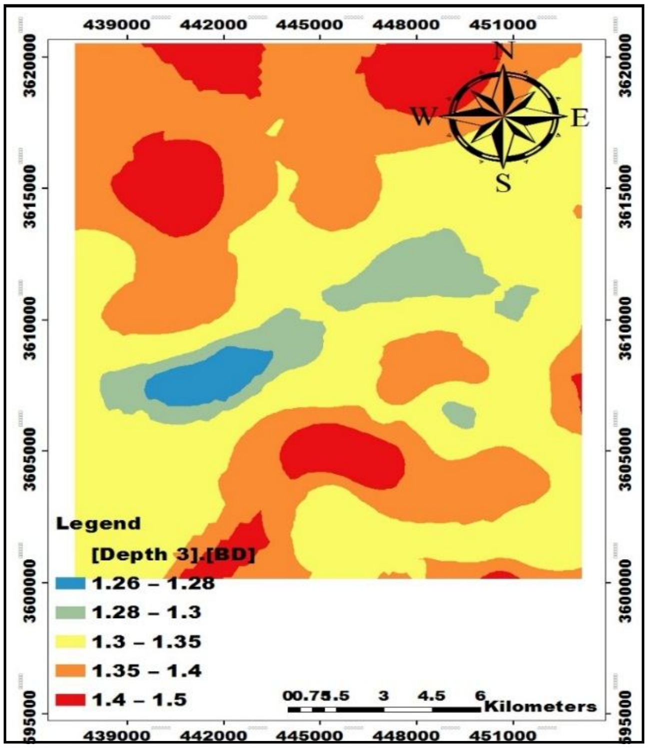

Fig. 5

Fig. 3, 4, 5: Spatial distribution of the bulk density of soil for depths of soil in the study.

D3, as shown in Fig. 2, that the range 1.35-1.30 mcg m^{-3} occupied the largest area, amounting to 9512.93 hectares, with a rate of 47.30%, while the lesser area was within the range 1.28-1.26 mcg m^{-3}, as it amounted to 53.06 hectares, or 0.26% of the total area.

It is noticed through the spatial distribution of the soil bulk density values that the low ranges of bulk density were of a small area and with a small percentage of the area of the study area and this is due to the environmental, locational and administrative conditions of the study soil area.

Volumetric distribution of soil separators

1- The sand

The results of the sand separator showed that its content at surface depth ranged between 457.0-10.0g kg^{-1} and its content was little compared to the content of silt and clay and the results of statistical analysis in table 3 showed that the sand was highly variable, as the effective distance reached range 2363.19 meters. The appropriate model that describes his heterogeneity was the spherical model and the spatial variability was strong as it was less than 25%.

The results of table 3 and Fig. 6 of the spatial distribution of sand separators showed that the range 456-116.83 g kg^{-1} occupied the largest area, reaching 14974.98

Table 3: Area and Percentages of physical soil characteristics in the study area.

Bd D1 area	%	Bd D2 area	%	D3 Bd area	%
0	0	84.64	0.420826	53.06	0.26
1300.77	6.47	2251.67	11.19519	1600.37	7.96
4764.17	23.69	6224.01	30.94546	9512.93	47.30
5682.3	28.25	9452.3	46.99635	5755.08	28.61
8365.6	41.59	2100.22	10.44219	3191.4	15.87
Sum 20112.84	100	20112.84	100	20112.84	100
Silt	%	Sand	%	Clay	%
37.8	0.19	0	0	67.96	0.34
1264.31	6.29	82.28	0.42	83.65	0.42
1623.4	8.07	2850.72	14.17	865.63	4.30
6303.67	31.34	2204.86	10.96	1217.83	6.05
10883.66	54.11	14974.98	74.45	17877.77	88.88
Sum 20112.84	100	20112.84	100	20112.84	100

hectares with 74% of the total area, while the range 10.0-30.18-10.0 g kg^{-1} did not show an area on a map spatial distribution.

It is noticed that the values of sand separation did not follow a specific pattern with depth, but varied between increase and decrease in the depths of the study soils and this may be due to the difference in sedimentation time and sediment source (Al-Mousawi, 2005).

2- The Silt

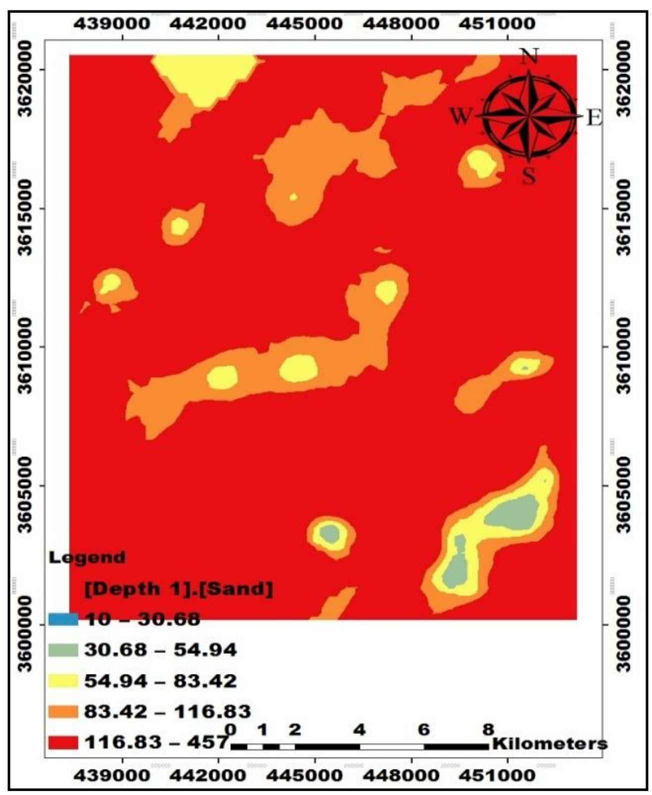

Fig. 6

The silt content ranged between 703.0-147.0 g kg^{-1}, as it is noted that the silt content is high in the soils of the study area. The results of the statistical analysis indicated in table 2 that the effective distance describing the variation of silt content was 3003.70 meters, which is less variation than sand and clay and the appropriate model describing its heterogeneity was the Circular model and that the spatial reliability was a strong variability because according to the equation (Iqbal *et al.,* 2005), It was less than 25% 0 as for the spatial distribution of silt. Fig. 7 notes that the range is 703.0-461.22 g kg^{-1}, it occupied the largest area, reaching 10883.66 hectares, with 54.11% of the total area, while the range was 147-253.02 g kg^{-1} the least. An area of 37.8 hectares, at a rate of 0.19%, which confirms the dominance of the high silt content in the soils of the study area.

3- The Clay

The results of table 2 show that the clay content ranged between 601.0-160.0 g kg^{-1} and the effective distance describing the mud variation was 2009.88 meters and the appropriate model describing its heterogeneity was a spherical model with strong spatial dependability. 8 The range 601.00-280.41 gkg^{-1} occupied the largest area and it is the dominant area within the mud content distribution map in the soils of the study area, as it amounted to 17877.77 hectares, with a percentage of 88.88% of the total area, while the other ranges had a small area and few percentages, as the range was 202.63-160.0 g kg^{-1} The least area as it reached 67.96 hectares, with a percentage of 0.34% of the total area of the study area.

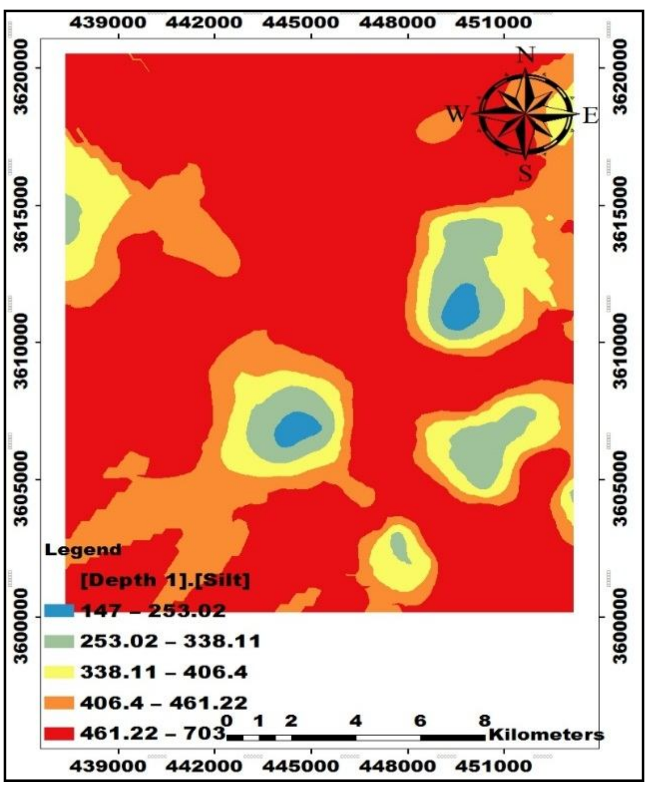

Fig. 7

The results confirm that there is a difference in the content of the three soil segments and the reason for this is due to the difference in wind speed between the sites and the difference in its ability to transfer the sand separated, given that the prevailing winds in the region are the northwest winds, in addition to the influence of the local conditions of each site and the consequences thereof. An effect on the activity of geomorphological processes that have a direct effect on the content of soil particles at each site, as it was noted from the results of the same table that the content of silt and mud is the most dominant and the reason is that the river sediments far from the headwaters of rivers, especially the Euphrates, are more smooth and increase in their content. From alluvial materials first, then clay, because these materials are transported to the farthest distances and begin to deposition depending on the sedimentation law, which indicates the existence of a gradient in the volumes and amount of sediment materials depending on the speed and energy of the carrier factor represented by moving water and these results are consistent with what he found

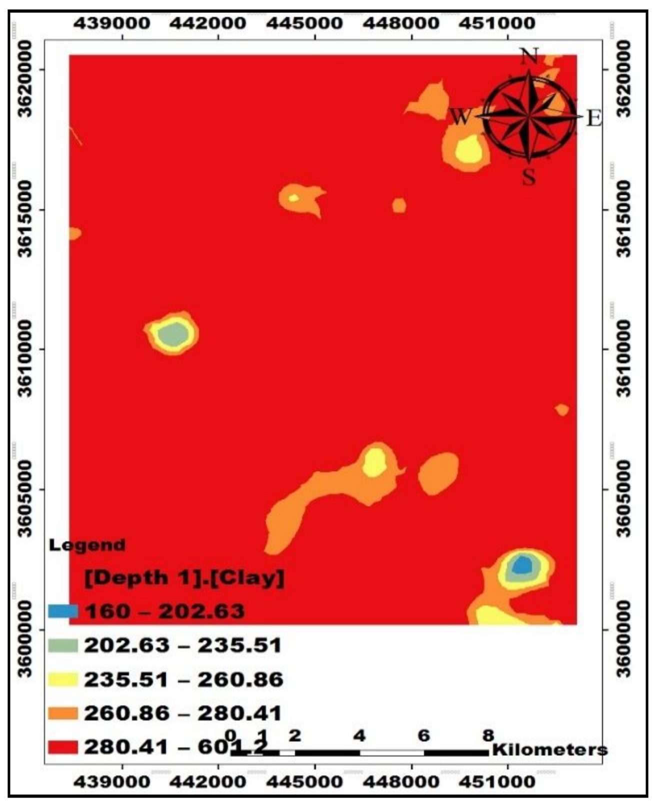

Fig. 8

Fig. 6, 7, 8: Spatial distribution of soil separations (sand, silt, clay) the study area for the surface depth.

(Ayoubi *et al.,* 2007).

Conclusions

It is concluded through this study that the bulk density of the soil was the least variable among the physical properties of the soil and that the appropriate model describing the heterogeneity of the physical properties of the soil was the spherical model and the circular model by 50% each.

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