SPATIAL VARIABILITY OF SOME PHYSICAL PROPERTIES IN RICE CULTIVATED SOIL USING GIS

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ABSTRACT

The study area was selected in the Abbasia district of Najaf Province, which is confined between two longitude 32° 06 42.8 ° to 32 ° 07 57.2 ° North and two latitude 44 ° 25 ° 16.4 ° to 44 ° 24 30.5° east. Coordinates of Pedons study locations were determined by GPS. Eight Pedons were detected for soils cultivated with rice, the Pedons were described morphologically. As well as interfaces samples was obtained randomly to four equal depths of 25-0 cm, 50-25 cm, 75-50 cm, 100-75 cm, for the study of spatial variability for the properties of those soils, the variability of physical properties using geological statistics, clay was the most variance of all horizons. The effective distance (Range) ranged between 91 - 180 m, followed by sand with a distance of 134 - 318 m in both horizons Ap and C1, and silt in both horizons C2 and C3, the effective distance (Range) ranged from 167 to 249 m. The trait that was less variability is the apparent density, with the distance between 368-55 m. The appropriate statistical models to describe the variability of soil properties when the geological statistics uses, and it was the spherical model and the Circular model by 50% for each. It found that the appropriate technology for obtaining soil samples be represented more efficiently, Depending on the effective range value with a strong spatial dependence of all the studied properties. As the number of samples that were calculated by the randomization law for physical properties between 5-797 samples, but when using geological statistics, the number of samples varied 5-28 sample. The soil of the study was classified under the order of modern soil composition (Entisol), under sub order of river deposits (fluvents), the great group (Torrifluvents) and sub group (Typic Torrifluvents).

Keywords: rice soils, physical properties, spatial variability, semivariance.
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التغاير المكاني لبعض الصفات الفيزيائية في الترب المزروعة بالرز باستخدام GIS

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الخلاصة

أختيرت منطقة الدراسة في ناحية العباسية في محافظة النجف التي تنحصر بين خطي طول "42.8 06 °32 الى 07 °32 "57.2 شمالاً ، ودائرتي عرض "16.4 25 °44 الى "30.5 44°24 شرقاً ، تم تحديد احداثيات مواقع بيدونات الدراسة بجهاز GPS وكشفت 8 بيدونات لترب مزروعة بالرز وكذلك استحصال عينات بينية بصورة عشوائية لإربعة اعماق متساوية من 0-25 cm و50-25 cm و 75-50 cm و100-75cm، لغرض دراسة التغاير المكاني لصفات تلك الترب . ان تغاير الصفات الفيزيائية بأستخدام الاحصاء الجيولوجي فقد كان الطين الصفة الاكثر تغايراً في جميع الافاق , اذ تراوحت المسافة المؤثرة Range بين 91 - 180 متر ، ثم تلاه الرمل بمسافة تراوحت بين 134 - 318 متر في الافقين Ap وC1، والغرين في الافقين C2 و C3 اذ تراوحت المسافة المؤثرة للغرين بين 167 – 249 متر ، اما الصفة الاقل تغايرا فقد كانت صفة الكثافة الظاهرية , اذ تراوحت المسافة المؤثرة بين 368-555 متر . اما النماذج الاحصائية الملائمة لوصف تغاير صفات التربة عند استخدام الاحصاء الجيولوجي فقد كان الانموذج الكروي Spherical والانموذج الدائري Circular بنسبة 50 % لكل منهما.

وجد ان التقنية الملائمة لاستحصال عينات التربة تكون ممثلة بصورة اكفأ حيث تعتمد على قيمة المسافة المؤثرة Range مع وجود اعتمادية مكانية قوية Strong لجميع الصفات المدروسة. اما عدد العينات التي تم حسابها بقانون العشوائية للصفات الفيزيائية فقد تراوحت بين 5-797 عينة. اما عدد العينات للصفات الفيزيائية عند استخدام الاحصاء الجيولوجي تراوحت بين 5 - 28 عينة ، صنفت ترب الدراسة تحت رتبة الترب الحديثة التكوين Entisol وتحت رتبة ترسبات الانهار fluvents والمجموعة العظمى Torrifluvents وتحت المجموعة , Typic Torrifluvents .

الكلمات المفتاحية : ترب الرز , الصفات الفيزيائية , التغاير المكاني , دالة التباين.
*البحث مستل من رسالة الباحث الاول.

1. INTRODUCTION

The study of spatial variations is an attempt to develop an efficient administrative system in terms of requirements for fertilizers and water in general, and the advancement of technology has helped a lot in this field, since it is possible to give accurate estimation of sampling and the relationship of this accurately measure the properties and predict the properties of locations not designated **[Wang, 2000].** The importance of studying the variability of soil properties for the success of agriculture or quality management and that the description of variability of soil characteristics is a good documentation of these qualities, as the determination of the extent of variability in the soil gives us more accurate estimates to be used in soil management and planning of land management projects and these variations may Are systemic variations or random variations. **Jabro et al., (2006); Sigua and Hudnall, (2008) c**onfirmed the need to characterize and diagnose the soil properties in the arable land suitable for agricultural use in each region and provided that these sites are typical and known in the description and classification and how to use, and thus will give very useful information about the values required in the investment and exploitation of various agricultural projects **[Young, 1980].** The study of the characteristics of soil cultivated with rice crop is closely related to the spatial variations that get to the cultivated soil, As the type of land use has a different effect in the variability of soil properties, due to the type of cultivated crop and its residues and its degradation speed in soil, He pointed out in his study that the effect of vegetation cover is different depending on the type of plants, When its type is annual plants such as rice, Their effect included change the soil interaction for the surface layer of the soil and the amount of organic substance, as well as the amount of bases exchanged and the influence of morphological properties is clear, especially with regard to the color and clarity of horizons **[Miles, 1985]**. Geological statistics can be used to describe and model spatial variability between the values of different soil properties by calculating the semivariance of these properties **[Bachmaier and Backes, 2008].** The research aims to study the spatial variability of the physical properties for rice soils.

2. MATERIALS AND METHODS

Information was collected about the study area. The Najaf Province Department of Agriculture was utilized to determine the study area that is characterized by the cultivation of the rice crop for a long period of more than 50 years. Al-Abbasid region was identified as represented area for rice cultivation in Najaf Province. The locations of the Pedons were then determined and their coordinates were obtained by means of a GPS device and random sampling of four equal depths (0-25, 25-50, 50-75, 75-100 cm) was obtained to follow the spatial variability of the soil properties. The study area placed in the Abbasid district of Najaf Province as shown in figure (1), which is confined between two longitude 32° 06 42.8 ° to 32 ° 07 57.2 ° North and two latitude 44 ° 25 ° 16.4 ° to 44 ° 24 30.5° east.

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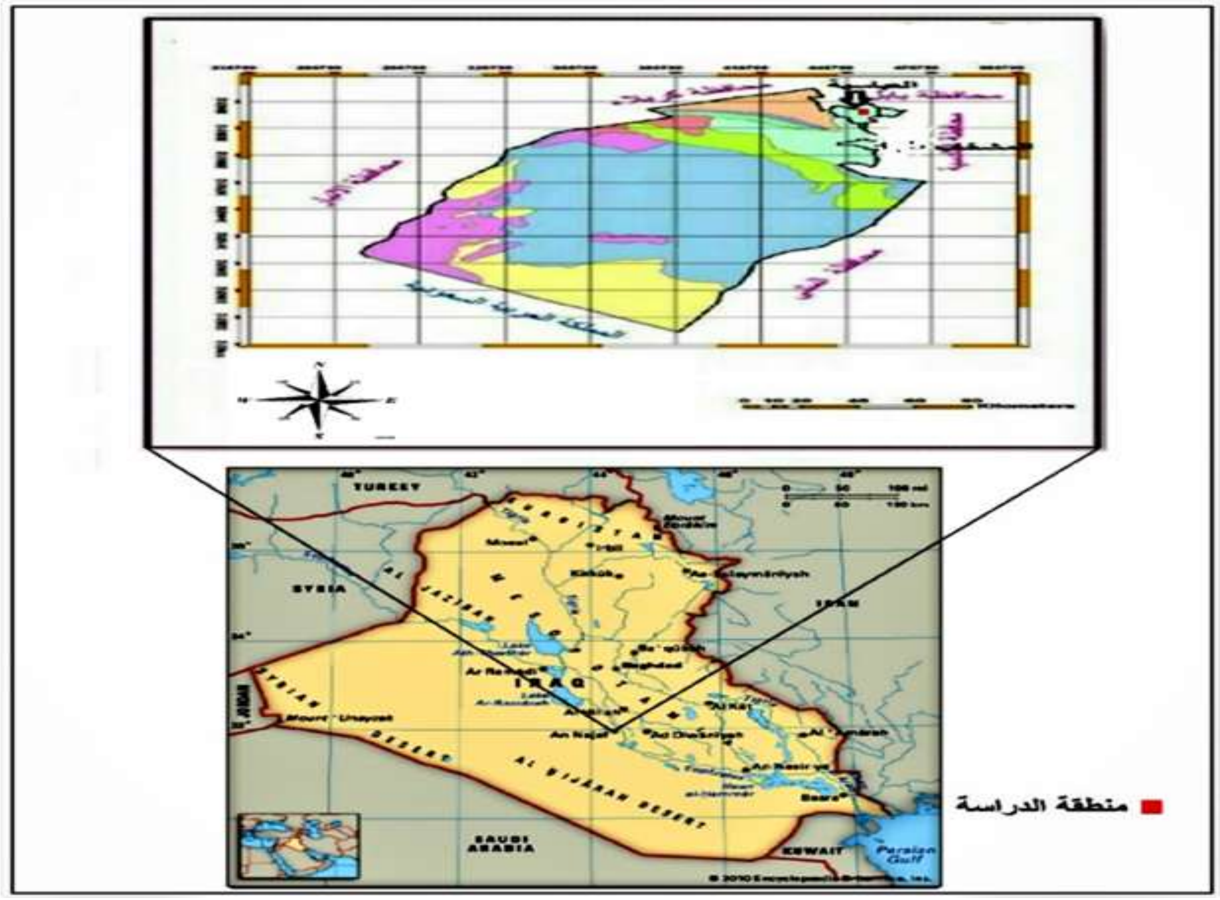

Figure 1: A map showing the location of the study area

After obtaining the soil samples in the surface horizons and sub-surface horizons, brought to college of Agriculture, The samples were grinded and sieved with a 2 mm sieve, Physical measurements were conducted and included the volumetric distribution of soil particles, The percentage of sand, silt and clay was estimated by a method of condensate according to the method described in [Black, 1965], The mass density was estimated by encapsulating soil models with paraffin wax as reported in [Black, 1965]. The geological statistic was used to calculate the half-variance function using the Arc9.3 program. The coordinates of the locations of the Pedons taken by the GPS device were demarcated so that it could take the distance readings from the program and a geographical correction of the locations of the studied Pedons for use in the program mentioned and then calculate the following:

1- Calculate semivariance as in equation (1).
2- Variogram plotting: The relationship between semivariance and the distance h is used to determine the effective distance (Range) and spatial variability
3- Calculating the effective distance (Range)

a) Spatial Dependence Method: The longest axis of the study area is divided, as it was the longest axis reached of 2587.628 m (2.59 km) on the effective distance (Range).

b) Using one of the randomization laws according to [Al-Nasser and Al-Merzouk, 1989]

$N= t^2\alpha\, \sigma^2/ (\alpha\bar{x})^2$ ……….(1)

Where N = number of samples required, tα = t value based on degrees of freedom, σ2 = variance α = significant levels (0.05), $\bar{x}$ = average

-Calculate the spatial variability as follows:

Spatial Dependence = nugget / (nugget + sill) ×100 …….(2)

In terms of the qualitative description of spatial dependence, we relied on equation (2) adopted by **[Iqbal et al., 2005]**, Strong spatial dependence is described as strong because the ratio is less than 25%, dependence is

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described as moderate if the ratio is between 25-75, If the ratio is more than 75%, it is described as weak.

2 - The randomization ratio calculates through the following equation:

The randomization percentage = SD/Sill×100 ……..(3)

The basic assumption of spatial analysis is that the proximal points of unknown points are more influential than others when determining the values of unknown points, Therefore, the estimation of their values should be based on the proximal points. The kriging method is more complex, Advanced mathematics is used to measure distances between all possible pairs of sampling points, This information is used to form an automatic spatial correlation of the specific surface to be formed **[Demers, 1989]**, The characteristics of this curve:

Sill: represents the maximum value of half-variance

Range: The value of the effective distance (Lag distance) that corresponds to the highest sill value

Nugget: represents the amount of error in measuring the values of sample point pairs.

3. RESULTS AND DISCUSSION

Horizontal variability of physical properties

Variability of soil separates

The distribution of soil separates (sand, silt and clay) was generally highly variable, as shown in Table (1). The values of the effective distance (Range) for the sand separates were 145.0, 134.0, 318.0 and 200.0 m for horizons Ap, C1, C2 and C3 respectively. Note that the less variance was at horizon C2, and the highest variance was at C1 horizon, this may be due to the seasonal wetting of the studied area as rice-cultivated soils. As for the silt separates, it was less variance than sand and clay, With an effective distance of 168, 240, 249 and 186m for the horizon Ap, C1, C2 and C3 respectively, This is probably due to the transfer of fine particles during the waterlogging process, and their variance values are vary accordingly. As for the clay separates, it was very high variance, with a range of 146, 91, 121 and 180 m for the horizons Ap, C1, C2 and C3 respectively. The highest variance was in the horizon C1; this is due to the movement of the clay and its descent from the upper horizons to the lower horizons. This is consistent with [Grandos, 2002; Hafshejani and Jafari, 2017]; found when they studied the distribution of soil separates in Khazestan province of Iran. The appropriate model that describes the variability of these separates was the circular model of all horizons of silt and clay separates. The spherical model was the model that describes the variance in all horizons. This is illustrated in spatial distribution maps as shown in Figure (1). The percentage of the area occupied by the sand separates in the horizon Ap, was the lowest proportion of 1.49%, a very low class of sand, with an area of 4264.95 m^2, while the very high class was 6.21 and with an area of 183861.71 m^2 as shown in Table (2). As for the horizon C1, the percentage of the area occupied by the sand separates with very low class was 3.69%, While the medium sand class occupied a high percentage of area, reached of 64.12%, and in horizon C2, a very high class was with a percentage of 38.62%, the medium class occupied a percentage of 23.78%. On horizon C3, The sand separates with the highest class occupied the highest percentage of area, reached of 55.94% as shown in Table (2). However, in this horizon, the percentage of sand with the lowest class was the lowest percentage of area, reached of %5.67; this confirms the effect of seasonal waterlogging process on the soil of the study area. As for the distribution of silt separates in the horizon Ap, a very low class occupied a high area of 59.0%, while the very high class occupied the lowest area of 0.18%. In the horizon C1, a very high silt class, which occupied the highest percentage of area, reached of 0.99%, while in horizon C2, the highest area for the silt in the very high class was 31.39%, the less percentage of area in the very low class, which reached of 0.12%, but in the horizon C3 was the highest percentage of area for the silt in the low class as 56.03%, the lowest percentage of area in the high class, which was 2.45%, This is due to the dominance of fine separates in the soil horizons and the variability of their distribution in soil values

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as a result of seasonal waterlogging process of these soils, This is what Hosseini et al. (2009) found when they studied the distribution of soil separates to the soil of southern Iran. There was a high variation in the distribution of soil separates, and attributed the cause to the wetting process and the irrigation processes.

Table 1: Statistical analysis of physical properties using geological statistic.

Properties	Horizon	Range(m)	Nugget	Partial Sill	Sill	Model	Spatiality Dependent %	Spatial dependence class
Sand	Ap	144.9859	0	15.77	15.77	Spherical	0	strong
	C1	133.933	0.02	70.907	70.93	Spherical	0.03	strong
	C2	318.217	0.2	300.79	300.99	Spherical	0.07	strong
	C3	200.412	1	25.52	26.52	Spherical	3.77	strong
Silt	Ap	167.791	0.01	40.69	40.7	Circular	0.02	strong
	C1	240.234	2.633	120.71	123.34	Circular	2.13	strong
	C2	249.044	0.003	147.07	147.07	Circular	0.002	strong
	C3	185.826	0.11	90.53	90.64	Circular	0.12	strong
Clay	Ap	145.6682	1.002	47.91	48.912	Circular	2.05	strong
	C1	90.9859	2.23	237.24	239.47	Circular	0.93	strong
	C2	120.643	1.1	306.39	307.49	Circular	0.36	strong
	C3	180.217	0.03	171.09	171.12	Circular	0.01	strong
bulck density	Ap	555.041	0	0.011	0.01	Spherical	0	strong
	C1	527.775	0	0.011	0.01	Spherical	0	strong
	C2	423	0	0.011	0.01	Spherical	0	strong
	C3	367.699	0.001	0.012	0.01	Spherical	7.69	strong

Table (2) shows that the clay separates were variability in the percentage of area occupied by its classes. However, the highest percentage of area occupied by the medium class in the horizon Ap, reached of 68.53% and the lowest percentage of area was in the highest class, reaching 4.09% in this horizon, Which confirms the transition of clay as a result of seasonal waterlogging process, The high class occupied the highest area in the horizon C1, reaching of %35.31, The medium class occupied the lowest area in this horizon, reaching of % 6.37, while in the horizon C2, the low class occupied the highest area, reaching of 39.13% While the very high class occupied the lowest area of 0.81% in this horizon. In the horizon C3, the high class occupied the highest percentage of area, reaching of 60.48%, The low class was the lowest area of 6.47% Which confirms the movement of clay and its transition from the upper horizons to the lower horizons as a result of seasonal waterlogging process, In addition to the rule of fine separates in those soils, This is what Itoh et al., (2002) obtained when they studied variability of the soils texture to Ultisols class.

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Table 2: The spatial distribution of areas and percentages physical properties

Properties \ Horizon	Ap			C1			C2			C3		
	Area(m)	%	Class	Area	%	Class	Area	%	Class	Area	%	Class
Sand	44264.95	1.49	Very low	109371.8	3.69	Very low	652950.8	22.05	Very low	564843.7	19.07	Very low
	131298.1	4.44	Low	280325.9	9.47	Low	42447.79	1.43	Low	167842.2	5.67	Low
	700396.2	23.65	Medium	1898778	64.12	Medium	704146.1	23.78	Medium	173623.6	5.86	Medium
	1901395	64.21	High	144176.9	4.87	High	418015.3	14.12	High	1656429	55.94	High
	183861.7	6.21	Very high	528563.7	17.85	Very high	143656.1	38.62	Very high	398477.2	13.46	Very high
Sum	2961216	100		2961216	100		2961216	100		2961216	100	
Silt	1749758	59.09	Very low	142277.5	4.805	Very low	3491.178	0.12	Very low	553486.5	18.69	Very low
	1123960	37.95	Low	591362.5	19.97	Low	645633.1	21.8	Low	1659122	56.03	Low
	27692.43	0.94	Medium	29390.03	0.99	Medium	780269.4	26.35	Medium	390835.5	13.2	Medium
	54459.81	1.84	High	743396	25.1	High	602313.6	20.34	High	72546.1	2.45	High
	5345.23	0.18	Very high	1454790	49.13	Very high	929508.8	31.39	Very high	285225.8	9.63	Very high
Sum	2961216	100		2961216	99.995		2961216	100		2961216	100	
Clay	132789.4	4.48	Very low	568874.7	19.22	Very low	503740.8	17.01	Very low	301433.6	10.18	Very low
	2029341	68.53	Low	604082.8	20.4	Low	1158770	39.14	Low	191465.2	6.47	Low
	271763.8	9.18	Medium	188707.3	6.37	Medium	668169.2	22.56	Medium	348683.1	11.77	Medium
	120972.7	4.09	High	553804	18.7	High	606513.6	20.48	High	1791071	60.48	High
	406349.4	13.72	Very high	1045747	35.31	Very high	24022.74	0.81	Very high	328562.9	11.1	Very high
Sum	2961216	100		2961216	100		2961216	100		2961216	100	
Apparent density	446599	15.08	Low	402924	13.61	Low	787528.1	26.59	Low	190548	6.43	Low
	563282.6	19.02	Medium	2211033	74.66	Medium	1210778	40.89	Medium	830666.2	28.06	Medium
	1951334	65.9	High	347259.4	11.73	High	962910	32.52	High	1940002	65.51	High
Sum	2961216	100		2961216	100		2961216	100		2961216	100	

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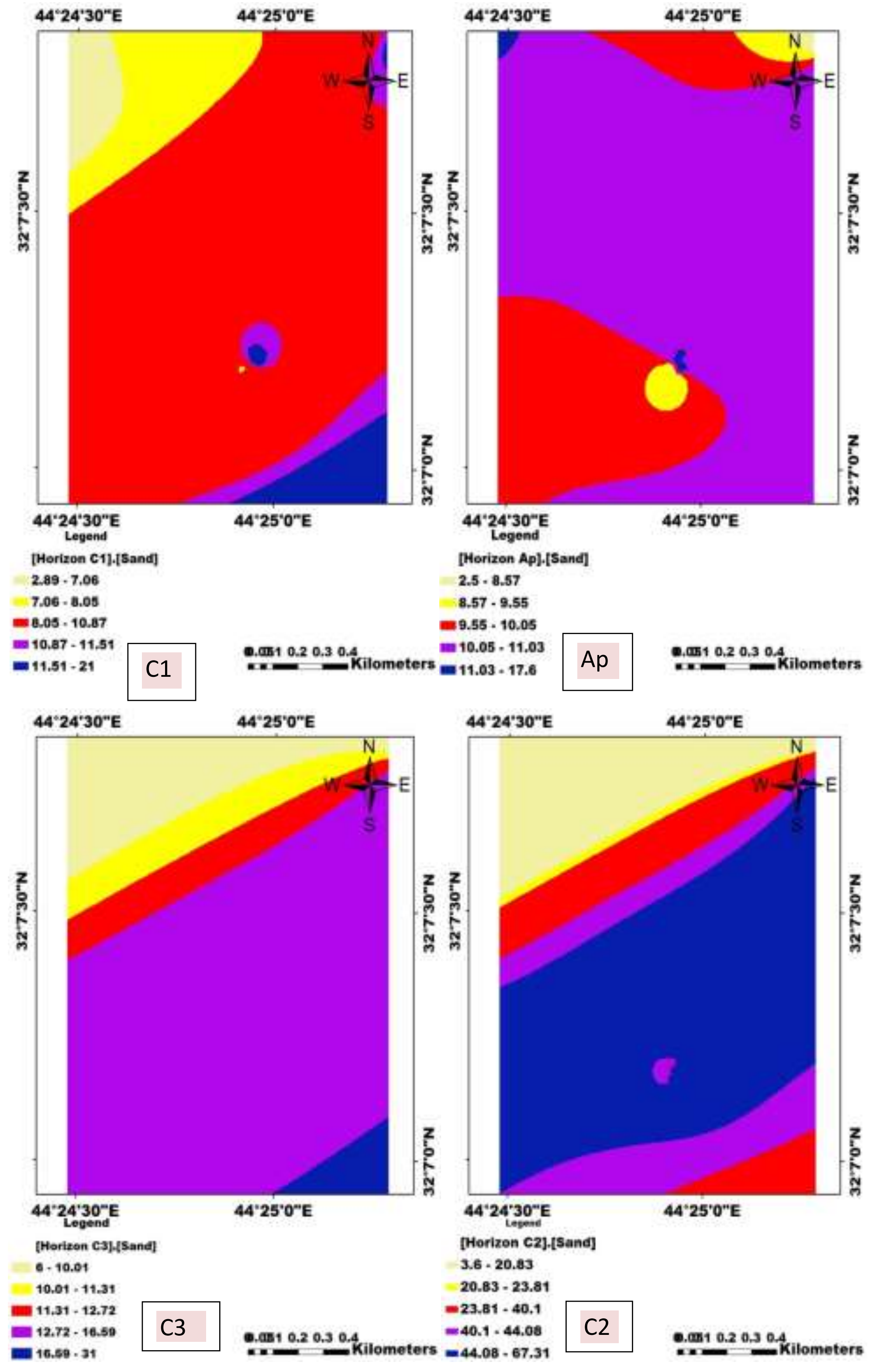

Figure 2: Map of the distribution of sand values for the horizons of the study soils.

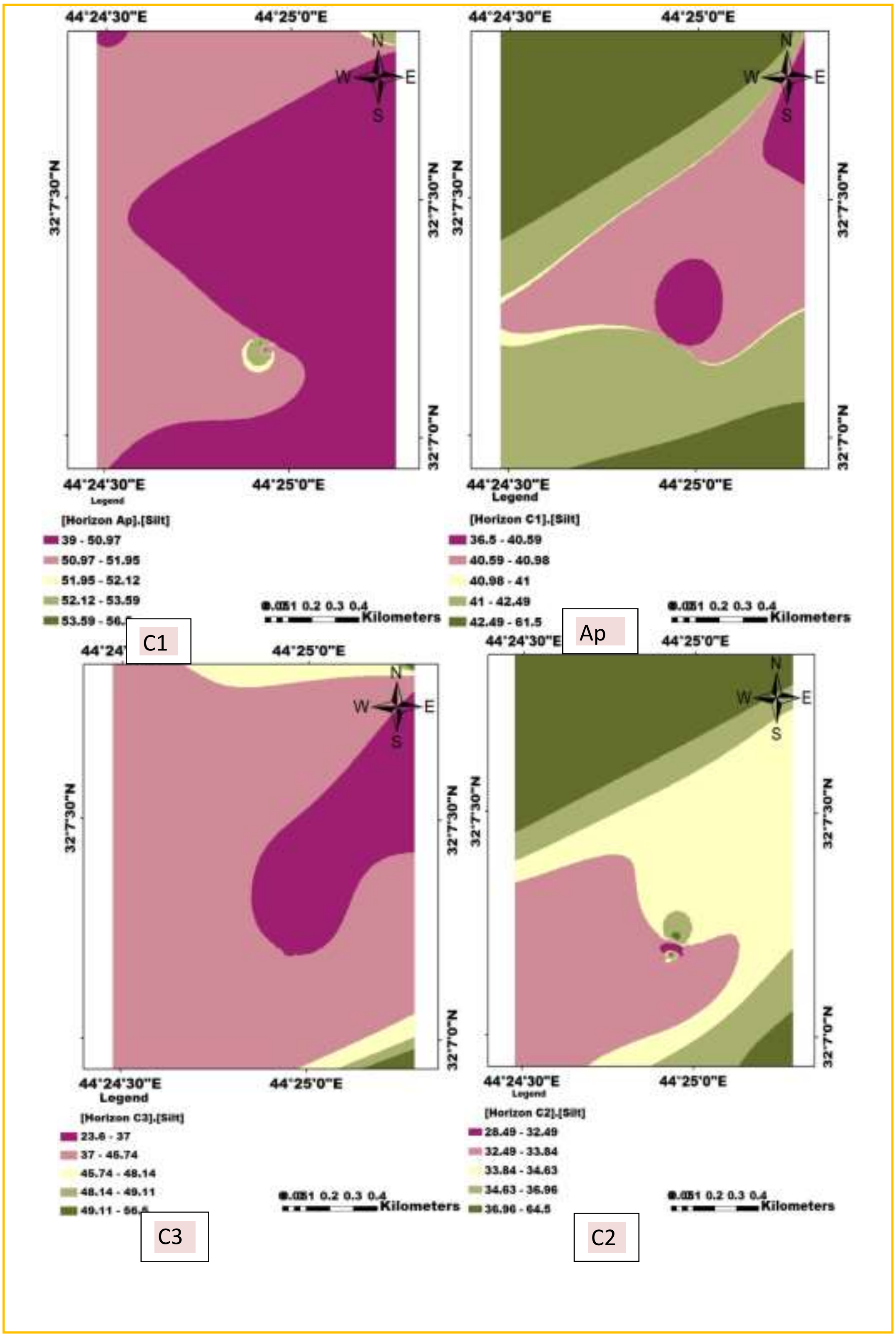

Figure 3: Map of the distribution of silt values for the horizons of the study soils.

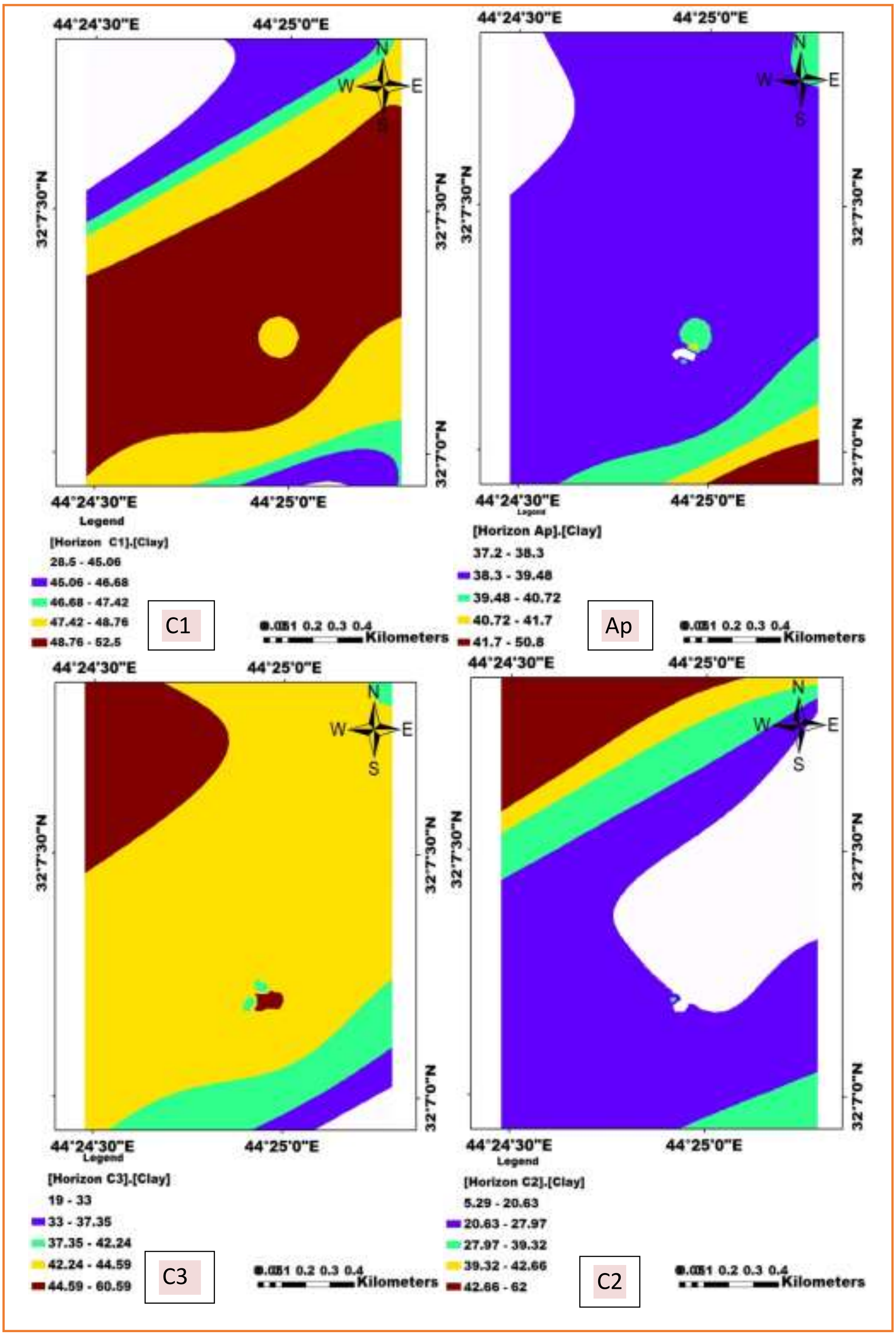

Figure 4: Map of the distribution of clay values for the horizons of the study soils.

The variability of apparent density

The results of the statistical analysis in Table (1) show that the variance of the apparent density was low compared to the other soil properties. The values of the effective distance (Range) of the apparent soil density were 555, 528, 423 and 368 m for Ap, C1, C2 and C3 respectively. Gulser et al., (2016), when studying the spatial variations of physical soil properties in Turkey's soil, found that one of the low variance properties was apparent density. Figure (5) shows the spatial

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distribution for the apparent density values of the study soil. The high density class occupied the highest area in the horizon Ap (65.9%). The lowest area was in the low class, reaching of 15.08% at this horizon. In the horizon C1 and C2, The medium density class occupied the highest area with 74.66% and 40.89% respectively, Followed by the low class with an area of 13.61% and 26.59% respectively. In the horizon C3, the high class occupied the highest area, reaching of 65.31%, followed by the medium class with 26.06%. The low class with an area of 6.43%, this confirms the effect of agricultural processes, in addition to soil body pressure which increases the apparent density values.

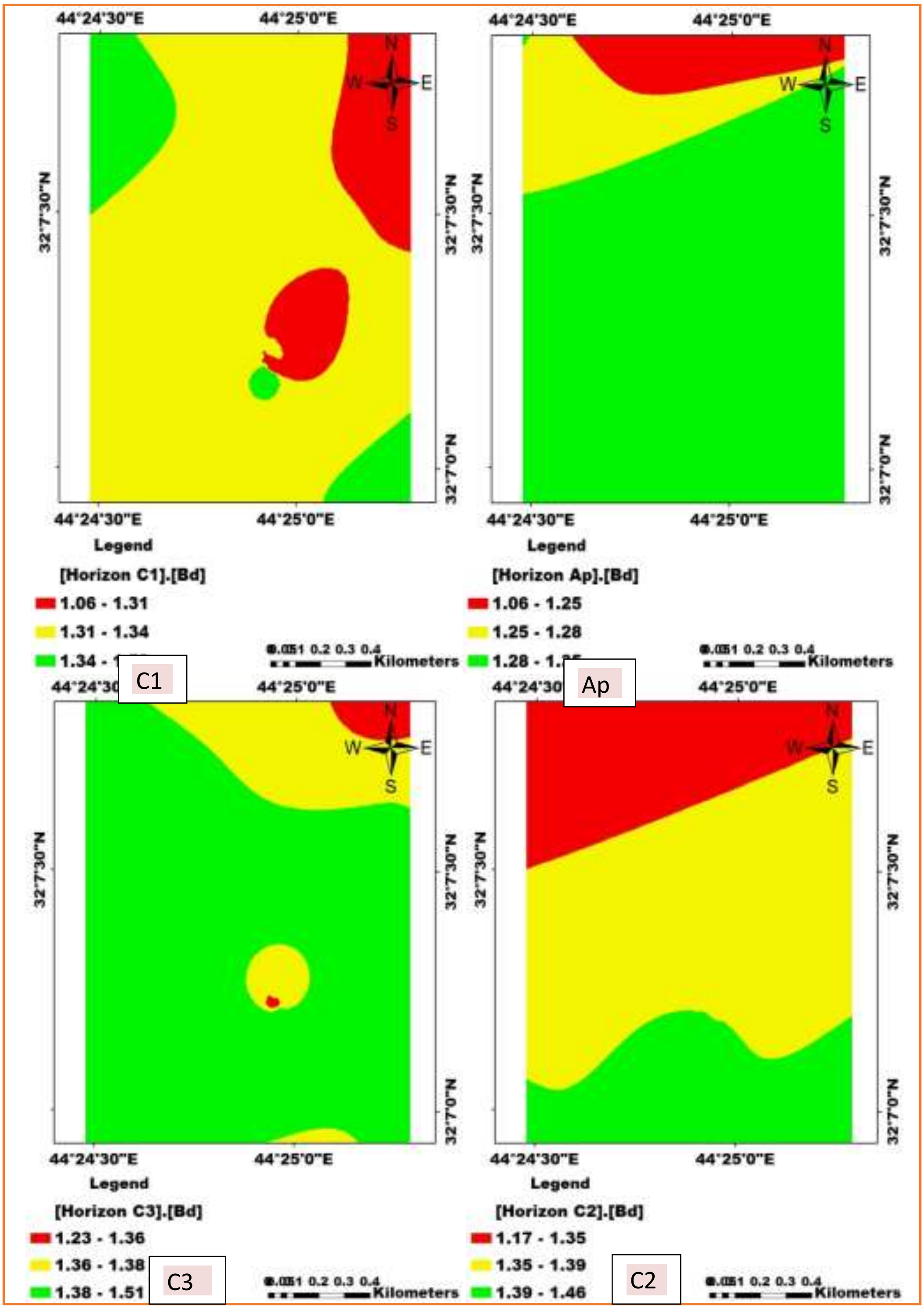

Figure 5: map of the distribution of apparent density values for the horizons of the study soils.

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The results in Table 1 showed that the spatial dependence of the physical properties was strong for all properties and in all horizons. As for the sampling and depending on the technique that takes into consideration the spatial correlation, the focus was on the effective distance in the calculation of the waterlogging processes in influencing the variability of properties. The clay was from the properties of high variability and apparent density from the properties of low variability. The number of samples when using the randomization law for physical properties ranged between 5-797 samples, As the lowest number of samples for apparent density trait in horizon C3 and the highest number of samples for sand trait in horizon C2, The large difference in the number of samples is observed when

The varariogram was drew after calculating the half-variance function according to Equation (1) through the GIS program and by using Geostatistics and Kriging technique, and plot the relationship with the Lag distance to see the spatial dependence or the effective distance (Range). number of samples representing the study path. The longest distance was divided on the effective distance as shown in figure (2). While the randomization rule was used to calculate the number of samples when using the traditional statistics. Table (3) shows that the number of samples required for the study of physical properties ranged from 5 to 28 samples, with the lowest number of samples for the apparent density properties in the horizons Ap, C1. The most number of samples was for the clay properties at the horizon C1. This confirms the effect of agriculture and geological statistics are used.

Table 3: Number of samples by random method and geological statistics of physical properties

Properties	Horizon	Randomity percentage	Number of samples by the random method	Number of samples by the geological statistics
Sand	Ap	26.33	302	18
	C1	7.64	470	19
	C2	7.18	797	8
	C3	23.67	328	13
Silt	Ap	15.94	32	15
	C1	6.69	65	11
	C2	7.35	146	10
	C3	12.17	108	14
Clay	Ap	11.46	35	18
	C1	2.73	36	28
	C2	5.75	566	21
	C3	6.63	164	14
Apparent density	Ap	862.44	10	5
	C1	1075.65	14	5
	C2	760.6	7	6
	C3	543.93	5	7

The percentage of random physical properties ranged between 1075-2.73% with the lowest random percentage for the clay trait in the horizon C1, and the highest random percentage for the trait of apparent density in the horizon C1.

CONCLUSIONS

1) The presence of spatial variations in the properties of the study soils horizontally and is important for the work of survey and classification of soils, especially in determining the boundaries between different soil units.
2) The spherical model and the circular circular model are the appropriate

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models for the properties of the study soil when geological statistics are used at 50% for each, and the other models did not give a clear representation of the variance function.

3) A strong spatial dependence of all properties of the study soil.

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