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Assessment of Spatial Variability and Mapping of Soil Texture in Western of Syria using Geographic Information System Techniques (GIS)

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Abstract

The study aimed to study the spatial variability of soil texture for soils around AL-Basel Lake in Safita Region which located in Tartous Governorate west of Syrian Arab Republic. Spatial maps of soil properties are invaluable in agricultural Production for assessing soil quality, planning land use and determining the suitability of cropping patterns. Geostatistics has been extensively used for quantifying the spatial pattern of soil properties and Inverse Distance Weight technique are proving sufficiently robust for estimating values at unsampled locations. The experiment was conducted on the soils of villages around AL-Basel lake The aim of this work is to study the spatial variability of soil texture. For this purpose ,90 Samples were collected. Results of Laboratory analysis of studied indexes were imported into ArcGis9.3 software and presented in form of Digital Maps that show the spatial Distribution of soil texture using Geostatistical Analyst and Inverse Distance Weight method was used in the Spatial Interpolation. Results of texture analysis showed that the soils have a texture between Loam and Silty Loam. Geostatistical analyst was used for unsampled points. Since 70.94 % of study area has Sand percentage (30-40) %, for Silt 57.73 % of study area has Silt percentage (40-50)% ,for Clay 71.97% of study area has Clay percentage (10-20)%,81.76% of study area has loam texture. This study thus provided a methodology that can help improve the accuracy and efficiency of soil texture mapping in areas using.

Keywords: Soil Properties, mapping, Spatial Variability, Soil Texture, Geographic Information System (GIS)

1. Introduction

Soil is the main part of any ecosystem and it the result of reactions between main rock, topography, climate across the time and has high spatial variability an inherent from natural variations of soil properties and also induced by management practices made it difficult quantify and classify (McCauley et al, 2005).Soil texture is the result of weathering and physical-chemical shatter of rocks and minerals and because differences in structure , the matters will weather in different ranges affected on the soil texture. Soil texture is simply defined as the relative proportion of Sand, Silt and clay separates (particles) found in the soil. The relative fraction of these soil particles is important because it can determine factors such as the soil water holding capacity, aeration and plant rooting depth. Variability in soil texture may contribute to the variation in nutrient storage and availability, water retention and transport and binding and stability of soil aggregates. It can directly or indirectly influence many other soil functions and soil threats such as soil erosion. Soil texture directly affects the porosity of soil, which in turn, determines its water-retention, flow characteristics, rate of water intake, nutrient-holding capacity and long-term soil fertility. (Deshmu and Aher,2014) (Adhikari et al,2015) show the applicability of Ordinary Kriging technique to characterize the spatial variation of soil texture i.e. sand and clay content on the basis of 100 samples collected over a forest mixed agriculture farming area covering about 250sq. km of Zala

County in western Hungary. (Aderonke and Gbadegesin.,2013) Support the usefull of using GIS in analyse. and use it in production of thematic maps. (Cooray et al,2012) Study Spatial Variability of Soil Characteristics along a Landscape Gradient in Bellanwila-Attidiya area. Selected physical and chemical properties of soil were analyzed according to the standard methods and the GIS maps were developed using ArcView GIS 3.2. The results indicated that selected chemical and physical parameters of soil varied across the land use gradient, except for temperature. According to the GIS maps there are apparent variations in distribution of soil properties. (Nayanaka et al,2010) in a Paddy Growing Alfisol Geostatistical Analysis of Soil properties used according to the calculated variograms the clay content exhibited a spatially structured variability highly. Maps of six soil textual classes was produced at 10m resolution across 430.076 ha that proved accurate in validation of 79% of the time (Akumu et al,2015). (Oberthur et al,1990) investigated the utility of three interpolation techniques that ignored descriptive "soft" information and one that used for mapping top soil texture classes.

The importance of reliable and timely information on soils cannot be overlooked in other to acquire spatial information of the soil properties, such information are necessary in the implementation of effective management strategies for sustainable agricultural production (Denton et al.,2017).Geostatistical methods quantify spatial distribution and variability based on the spatial scale of the study area , they have been widely applied to evaluate spatial correlation In soils to analyze the spatial variability of soil properties Such as soil physical, chemical and biological properties (Shit *et al*.,2016).Geostatistical Analyst provides a wide variety of tools for spatial data exploration , identification of data anomalies, evaluation of error in prediction surface models, optimal surface creation (Hengel,2007).Geostatistics provides an advances methodology that facilitates. The interpolation maps obtained with geostatistics are useful to better understand spatial variability and its influences The variability of spatial soil properties can be influenced by natural factors (such as particle-size composition and topography) and anthropogenic factors (such as land cover or management practices) (Tesfahunegn *et al,* 2011)

2. Study area

AL-Basel Lake ' Soils which represent The study area is located in Tartous City in the west of Arab Syrian Republic, close to a rural community covers approximately 106.55 km2 between longitude (36 2 -36 10) E and latitudes (34 44-34-49) N .The climate is Mediterranean, An average annual precipitation of 800 mm. Temperatures are characterized by great daily and seasonal variation with an average value of 10 C in January 29 C in August, a mean annual evaporation of 4mm/year and high humidity about (60-80)%.The highest Elevation above the sea level is 334m in Bdada, and the lowest is 39 m in Uraymah. Geologically, there are different types of soil parent materials with the area is Limestone, marn, dolomite. Calcium content of the soil is high.

3. Methodology

3.1 Sampling

90 surface soil samples (0-30 cm in depth) were collected from an area of 106.55 km2 .The interval between each two points from sampling ranged from (2-3) km as possible, Positions of samples were irregular and were accurately localized by the aid of Portable Global Positioning System (GPS) Receiver. Irregularity of sampling positions is proved by greater importance of determining of the rang of contamination than of using geometrically regular grid. Approximately 1kg of each sample was stored in polyethylene packages and transported to the laboratory. All soil samples were air- dried for several days at room temperature (20-22 C) and then ground and sieved to a size of 2 mm for analysis of their properties. Figure (1) shows the distribution of sample points by direction from the lake

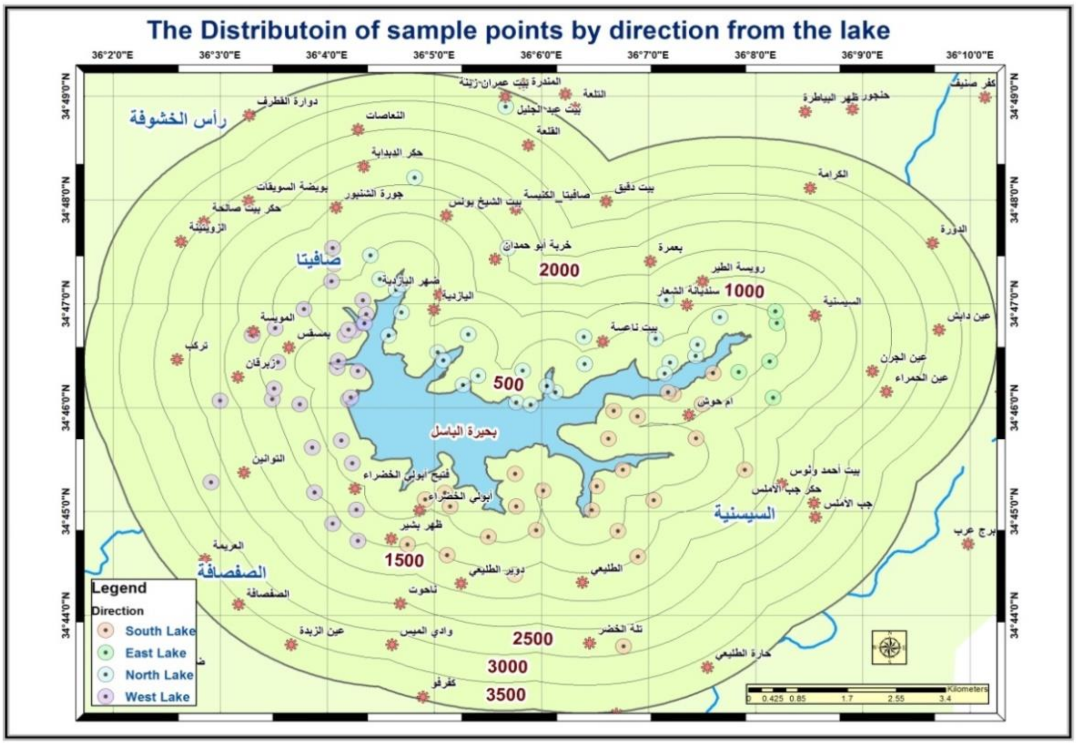

Figure (1): shows the distribution of sample points by direction from the lake

3.2 Laboratory Analysis

The soil samples were taken to the laboratory, air-dried, crushed and sieved using 2mm sieve mesh. Particle size analysis was carried out by Hydrometer method and classify soil types as American classification USDA (Gupta,2000). All samples were analyzed in AL-Baath University of Lands laboratory.

3.3 Predictive Mapping

Spatial maps of soil texture were designed with the help of GIS. Soil data preparation: Data set has been created as a Soil Data. This data set comprises soil texture content coming from each of the identified pedological horizons for 90 sampling locations covering 106.55 km2 of Safita Region. The required value of topsoil (0-30 cm) clay and sand content in percentage for each location has been derived as a weighted average of the sand and clay content of the samples coming from soil horizons identified within the first 30 cm of soil. The places of sampling points were determined the coordinates by means of GPS were marked on the digitized maps. The distribution soil texture components were computed using Geostatistical analysis. The soil texture values were used as the input data for texture soil in studied soils. Inverse Distance Weight method was used to interpolate and maps. Interpolation was used to estimate the values in the areas in which there is no data from the collected in the study area.IDW interpolator assumes that each input point has a local influence that diminishes with distance, and no assumptions are required for the data, being this method the most suitable for our irregular sampling. The GIS mapping technique was employed to studied the spatial distribution maps in soils of studied area with Geostatistical analyst. creating continuous surface, or map, from measured sample points stored in a point-feature. , The usefulness of this technique in environmental studies has already demonstrated by (Albanese *et al.,*2008).

4. Results and discussion

The results of Mechanical analysis of studied soils are presented in table (1).

Table 1: clarify results of Mechanical analysis and Soil Texture

Mechanical Analysis				
Station NO	Sand %	Clay %	Silt %	Soil Texture
1	33.9	14.6	51.5	(SiL) Silt Loam
2	21.4	12.1	66.5	(SiL) Silt Loam
3	25.9	14.6	59.5	(SiL) Silt Loam
4	13.9	12.1	74	(SiL) Silt Loam
5	22.4	12.1	65.5	(SiL) Silt Loam
6	38.15	15.1	46.75	(L) Loam
7	43.9	12.1	44	(L) Loam
8	46.4	15.1	38.5	(L) Loam
9	30.15	12.6	57.25	(SiL)Silt Loam
10	43.9	19.6	36.5	(L)Loam
11	26.4	13.1	60.5	(SiL) Silt Loam
12	18.9	12.1	69	(SiL) Silt Loam
13	36.4	14.6	49	(L) Loam
14	61.4	18.1	20.5	(SL) Sandy Loam
15	48	31.5	20.5	(SCL) Sandy Clay Loam
16	26.4	13.1	60.5	(SiL) Silt Loam
17	47.4	23.1	29.5	(L) Loam
18	36.4	28.1	35.5	(CL) Clay Loam
19	15.5	40.25	44.25	(SiC)Silt Clay
20	42.76	18.4	38.83	(L) Loam
21	36.5	19.3	44.2	(L) Loam
22	18.3	22.5	59.2	(SiL)Silt loam
23	30.5	31.5	38	(CL) Clay Loam
24	42.4	15.6	42	(L) Loam
25	33.9	19.6	46.5	(L) Loam
26	48.9	14.6	36.5	(L) Loam
27	53.15	18.85	28	(SL) Sandy Loam
28	21.5	14.3	64.2	(SiL) Silt Loam
29	32.4	15.6	52	(SiL) Silt Loam
30	26.4	12.1	61.5	(SiL) Silt Loam
31	39.4	20.85	39.75	(L) Loam
32	36.4	18.1	45.5	(L) Loam
33	38	34	28	(CL) Clay Loam
34	13.9	14.6	71.5	(SiL) Silt Loam
35	39	22	39	(L)Loam
36	44	22	34	(L) Loam
37	11.5	19.5	69	(SiL) Silt Loam
38	14	17	69	(SiL) Silt Loam
39	17.7	14.55	67.75	(SiL) Silt Loam
40	59	22	19	(SCL)Sandy Clay Loam
41	61.5	19.5	19	(SL) Sandy Loam
42	55.5	21.5	23	(SCL) Sandy Clay Loam
43	39	22	39	(L)Loam
44	54	19.5	26.5	(SL) Sandy Loam
45	21.5	24.5	54	(SiL)Silt Loam

46	46.5	22	31.5	(L)Loam
47	39	19.5	41.5	(L)Loam
48	59	19.5	21.5	(SL) Sandy Loam
49	21.8	18.26	60.24	(SiL)Silt Loam
50	58.5	20.5	21	(SCL) Sandy Clay Loam
51	34	17	49	(L)Loam
52	30.2	18.3	51.5	(SiL)Silt Loam
53	48. 75	17.6	34.4	(L)Loam
54	40.65	13.7	45.65	(L)Loam
55	36.5	25.3	38.2	(L)Loam
56	22.4	12.1	65.5	(SiL)Silt Loam
57	35.4	15.2	49.4	(L)Loam
58	24.3	18.50	57.2	(SiL)Silt Loam
59	22.5	36.40	41.1	(CL)Clay Loam
60	41.2	17.3	41.5	(L)Loam
61	31.5	21.5	47	(L)Loam
62	42.5	22.5	35	(L)Loam
63	44.5	12.5	43	(L)Loam
64	22.5	19.3	58.2	(SiL)Silt Loam
65	28.8	19.2	52	(SiL)Silt Loam
66	25.9	19.2	54.9	(SiL)Silt Loam
67	42.07	16.05	41.88	(L)Loam
68	40.15	15.1	44.75	(L)Loam
69	27.3	15.2	57.5	(SiL)Silt Loam
70	41.9	13.2	44.9	(L)Loam
71	36.5	22.4	41.1	(L)Loam
72	21.6	17.3	61.1	(SiL)Silt Loam
73	25.9	15.3	58.8	(SiL)Silt Loam
74	51	18.7	30.3	(L)Loam
75	49.5	19.3	31.2	(L)Loam
76	32.4	12.3	55.3	(SiL)Silt Loam
77	42	23	35	(L)Loam
78	37.5	19.4	43.1	(L)Loam
79	19.2	24.5	56.3	(SiL)Silt Loam
80	33.9	22.6	43.5	(L)Loam
81	41.3	24.2	34.5	(L)Loam
82	29.5	21.5	49	(L)Loam
83	35.75	15.5	51.25	(L)Loam
84	35.5	17.3	47.2	(L)Loam
85	19.8	25.3	54.9	(SiL)Silt Loam
86	22.3	21.5	56.2	(SiL)Silt Loam
87	37.4	15.3	47.3	(L)Loam
88	36.2	14.3	49.5	(L)Loam
89	27.5	18.5	54	(SiL) Silt Loam
90	17.5	29.5	53	(SiCL) Silt Clay Loam

Unit: : All values are in one Hundred Percent**(%)**

4.1 Sand Map:

As shown in the figure (2) results of sand percent ranged between (11.5-61.5)% Reached the highest value of Sand in the studied soils during the current study in the station NO (41) north of lake (61.5) %, while the lowest concentration in the station NO (37) west of the lake (11.5) %.

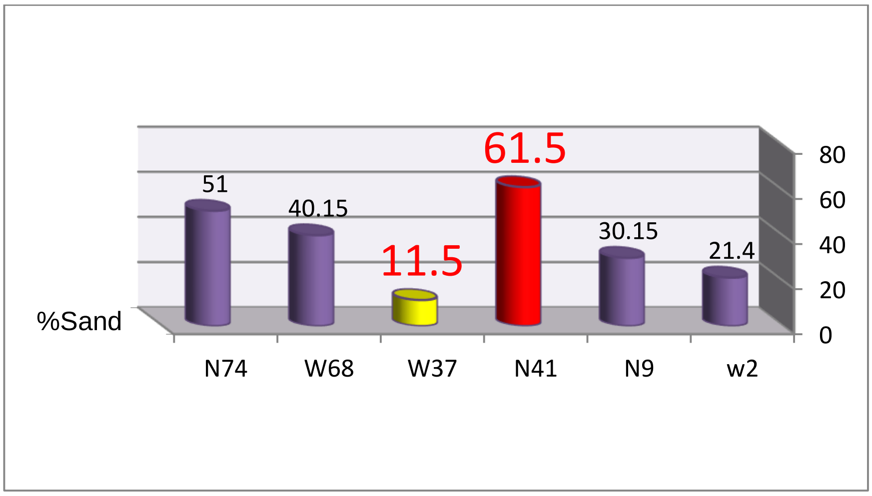

Figure (2): shows the Sand percent in the studied soils

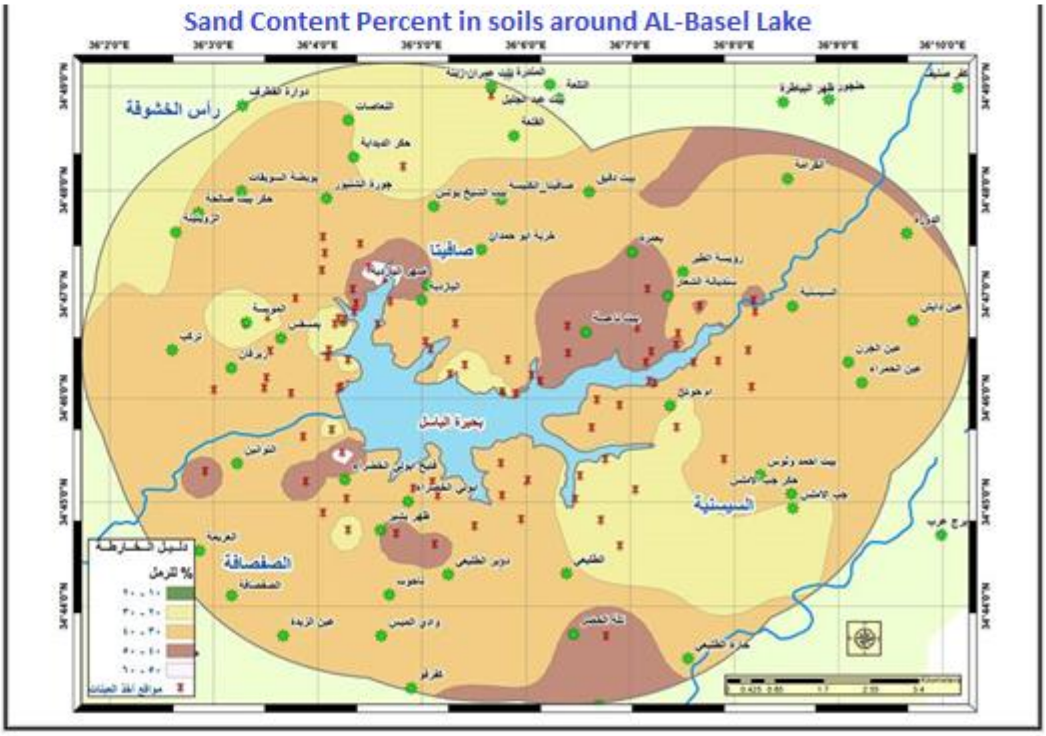

Figure (3): shows the Sand content in the studied soils

Results of Geostatistical analysis showed that the 70.94% of the study area the content of sand was (30-40) % while about 0.2% of the study area the content of sand was (50-60) %.

Table (2): shows the percentage of Sand distribution in the studied soils.

Concentration %	Area km2	%
10-20	0.018794	**0.02**
20-30	19.48	**18.28**
30-40	75.58893	**70.94**
40-50	11.25737	**10.57**
50-60	0.211199	**0.2**
Sum	106.55	**100%**

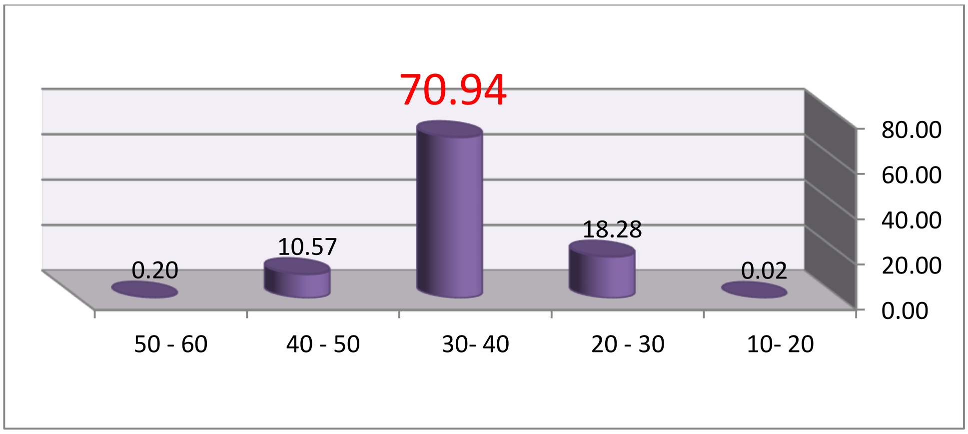

Figure (4): Shows the percentage of Sand distribution in the studied soils.

4.2 Silt Map

As shown in the figure (5) results of silt percent ranged between (19-74)% Reached the highest value of Silt in the studied soils during the current study in the station NO (4) north of lake (74) ppm,while the lowest concentration in the station NO (40) north of the lake (19) ppm.

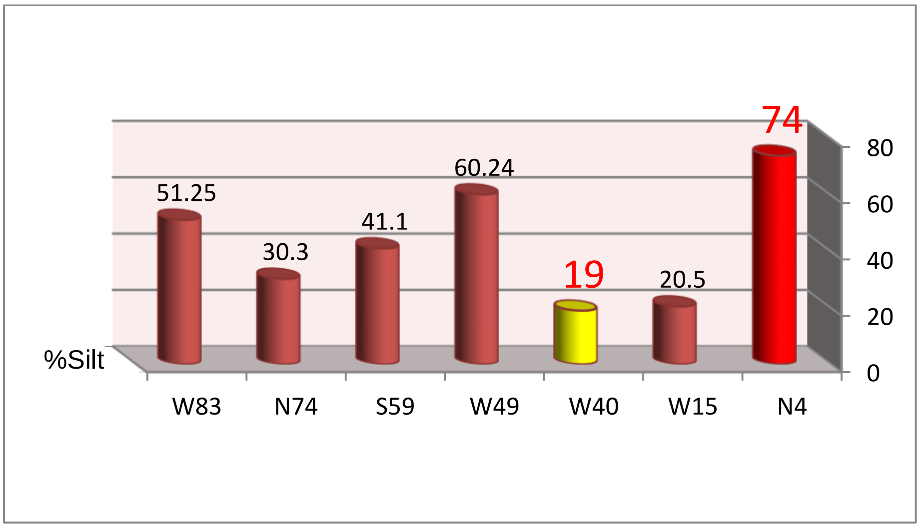

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Figure (5) :shows the Silt percent in the studied soils

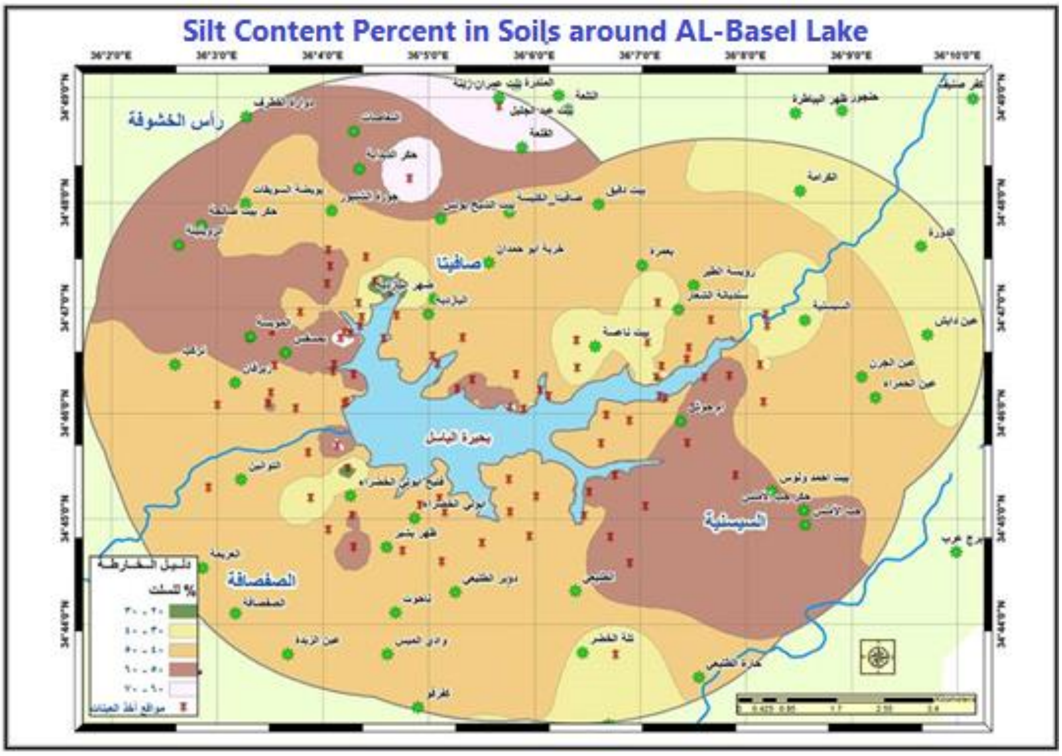

Figure (6): shows the Silt content in the studied soils

Results of Geostatistical analysis showed that the 57.73% of the study area the content of Silt was (40-50) % while about 2.88% of the study area the content of Silt was (60-70)%.

Table (3): shows the percentage of Silt distribution in the studied soils.

Concentration %	Area km2	%
20-30	0.185619498	**0.17**
30-40	15.26061615	**14.32**
40-50	61.51005086	**57.73**
50-60	26.53241949	**24.90**
60-70	3.063424566	**2.88**
Sum	106.55	**100%**

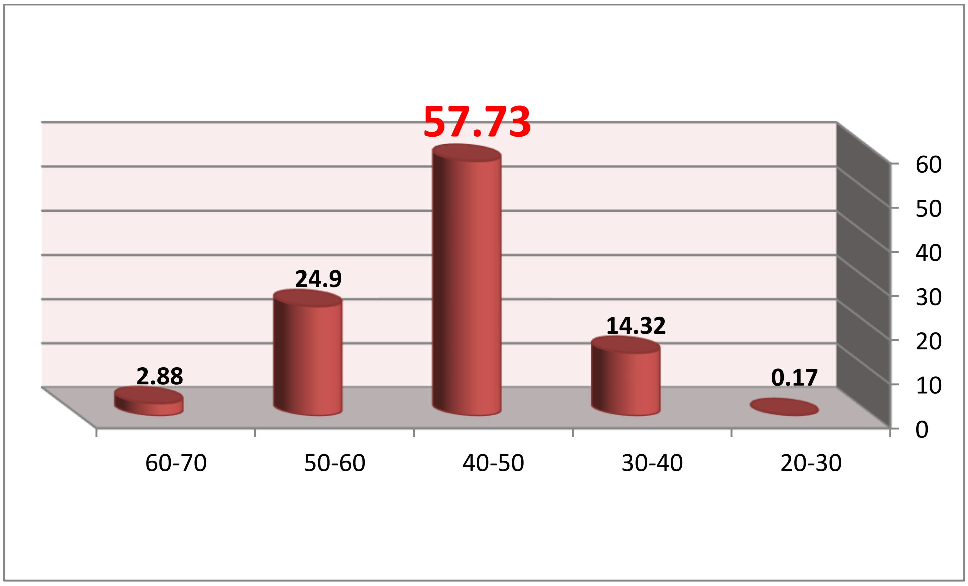

Figure (7): Shows the percentage of Silt distribution in the studied soils.

4.3 Clay Map:

As shown in Figure(8)results of clay percent ranged between(12.1-40.25)%Reached the highes value of Clay in the studied soils during the current study in the station NO (19)south of lake (40.25)%,while the lowest concentration in the station NO (7) north of the lake (12.1) %

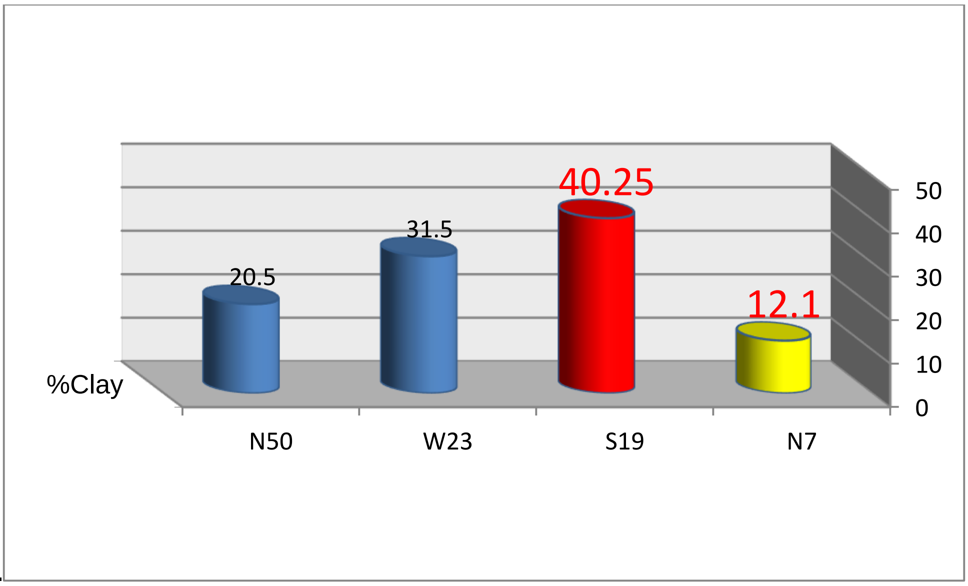

Figure (8): Shows the Clay content in the studied soils5. Conclusion

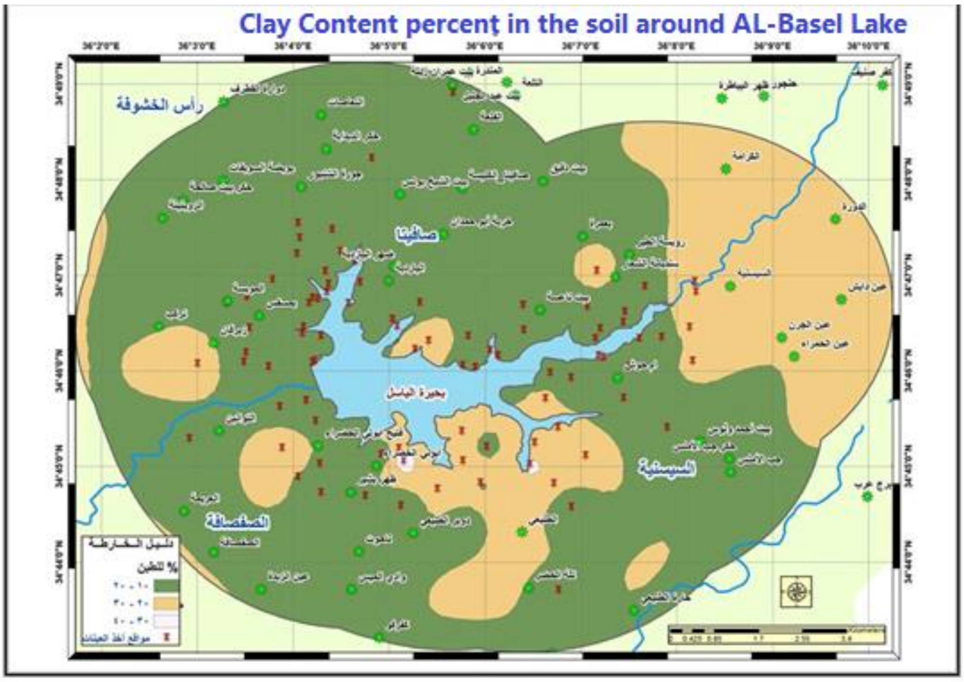

Figure (9): shows the Clay content in the studied soils

Results of Geostatistical analysis showed that the 71.97% of the study area the content of Clay was (10-20) % while about 0.13% of the study area the content of Clay was (30-40)%.

Table (4): shows the percentage of Clay distribution in the studied soils.

Concentration %	Area km2	%
10-20	76.68806731	**71.97**
20-30	29.73066331	**27.90**
30-40	0.133400123	**0.13**
Sum	106.55	**100%**

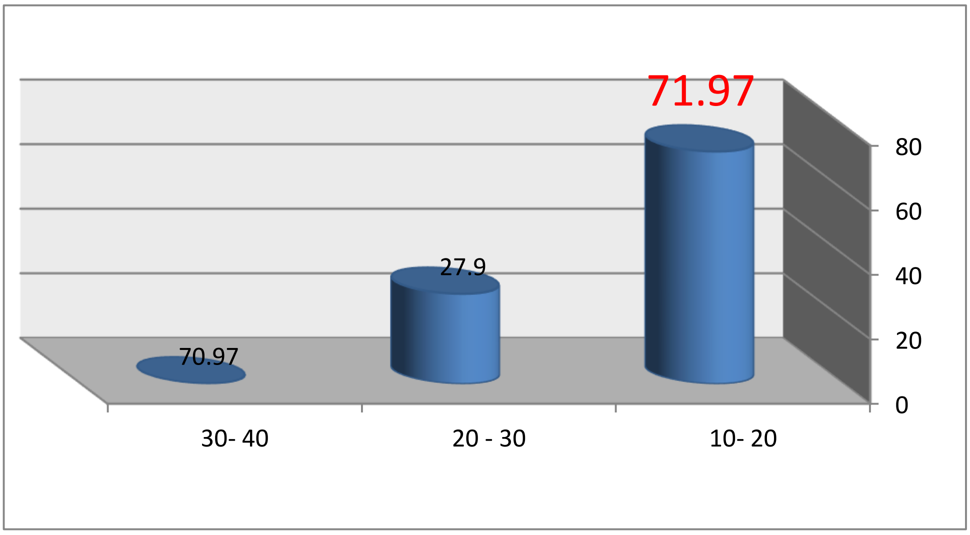

Figure (10): Shows the percentage of Clay distribution in the studied soils.

4.3 Soil Texture Map

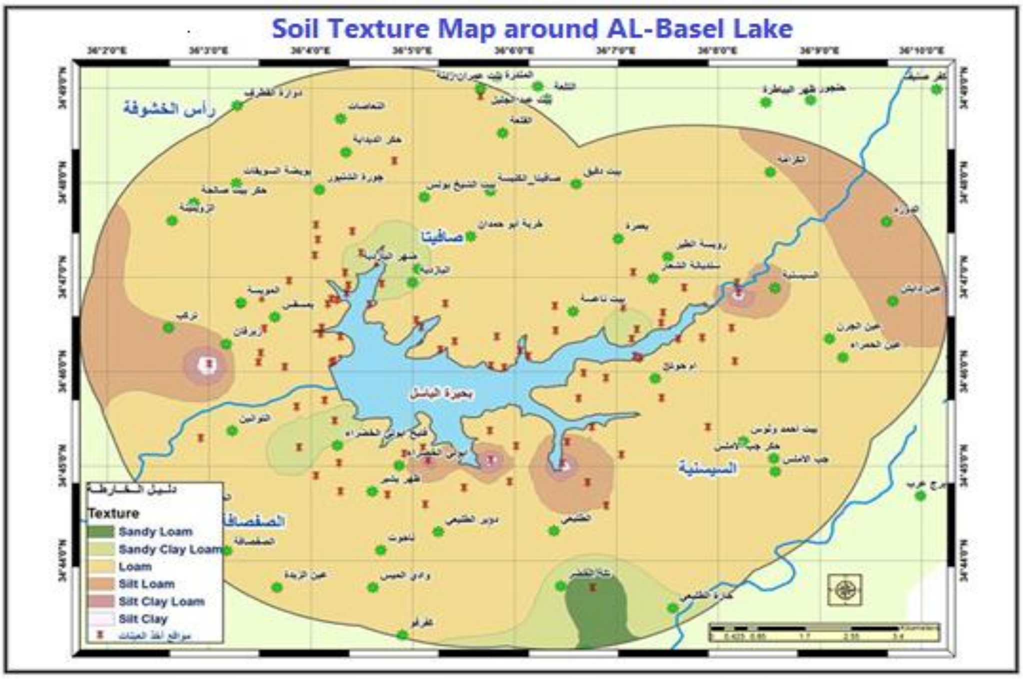

Figure (11): shows the soil Texture in the studied soils

Results of Geostatistical analysis showed that the 81.76% of the study area the texture was Loam while about 11.11% of the study area the texture was Silt Loam.

Table (5): shows the percentage of soil texture in the studied soils.

Concentration %	Area km2	%
Sandy Loam	1.199	**1.12**
Sandy Clay Loam	5.52	**5.18**
Loam	87.12	**81.76**
Silt Loam	11.84	**11.11**
Silt Clay Loam	0.71	**0.67**
Silt Clay	0.16	**0.15**
Sum	106.55	**100%**

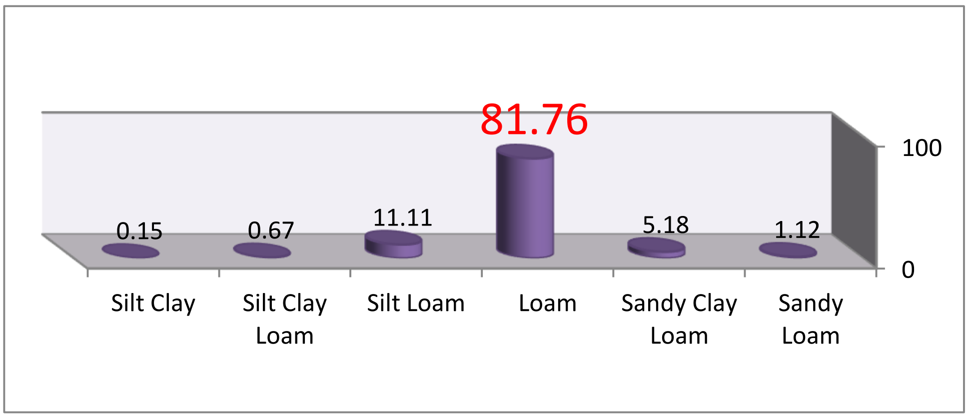

Figure (12): shows the percentage of soil texture in the studied soils.

5. Conclusions

There is a growing global need to generate high resolution digital soil maps for numerous ecological applications by modeling and mapping soil texture using GIS.The application of these techniques and approach could enable soil scientists to easily generate and improve current digital soil maps. Field estimates of soil texture are valuable surrogates for expensive and time-demanding laboratory measurements for soil texture classes. The results of our study shows an application of Geostatistics (specifically IDW) to study and analyze the spatial behavior of soil texture contents. The predicted maps thus obtained could be helpful to the farmers and soil management experts to design land management and soil and water conservation plans taking into account the spatial heterogeneity of soil texture. The results of an investigation of this type will be of great interest to environmental scientists, water resources planners, climatologists, decision makers, and resources managers. Moreover, in line with these out comes we suggest for further analysis by using other data layers like topographical parameters, land use, parent material, soil erosion and any other information which might influence the spatial distribution of soil texture in the Safita Region of western Syria.

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الملخص:
هدفت الدراسة الى دراسة الاختلافية المكانية في نسيج التربة للترب المحيطة ببحيرة الباسل في منطقة صافيتا التابعة إداريا لمحافظة طرطوس الواقعة غرب الجمهورية العربية السورية. تعتبرالخرائط المكانية لخصائص الترب ذات أهمية كبيرة في الإنتاج الزراعي لتقييم نوعية التربة ، التخطيط لاستعمالات الأراضي و تحديد الملاءمة للأنماط المحصولية . التحليل الجيوإحصائي قد استخدم كثيرا لتحديد النماذج المكانية لخصائص التربة و طريقة المسافة عكس الموزونة أثبتت أنها طريقة ذات كفاءة لتخمين القيم في المواقع التي لم تؤخذ منها عينات. التجربة كانت قد أجريت على ترب القرى حول بحيرة الباسل في منطقة صافيتا التابعة لمحافظة طرطوس غرب سورية .الهدف من هذه التجربة هو دراسة الإختلافية المكانية لنسيج التربة و لهذا الغرض 90 عينة سطحية كانت قد جمعت من عمق (30-0) سم . النتائج للتحاليل المخبرية للمؤشرات المدروسة تمت معالجتها وعرضت في صيغة خرائط رقمية تظهر التوزع المكاني لنسيج التربة باستخدام التحليل الجيوإحصائي و طريقة التثقيل المتعاكس للمسافة التي قد استخدمت في الاشتقاق المكاني. النتائج للتحاليل المخبرية لنسيج التربة قد أظهرت أن الترب تملك نسيج تربة يتراوح من لومي و سلتي لومي .التحليل الجيوإحصائي قد استخدم لتخمين القيم في المناطق التي لم تؤخذ منها عينات حيث تبين أن 70.94% من منطقة الدراسة كانت نسبة الرمل فيها (40-30)% و 57.73 % تمتلك نسبة سلت (50-40)% و71.97 % من منطقة الدراسة كانت نسبة الطين فيها (20-10)%، 81.76 % من منطقة الدراسة كان قوام التربة فيها لومي .هذه الدراسة لذلك تزود منهجية يمكن أن تساعد في تحسين الدقة و الكفاءة لإعداد خرائط نسيج التربة في عدة مناطق باستخدام عدة مصادر من البيانات المتاحة بشكل كبير.

الكلمات المفتاحية: خصائص التربة، إعداد الخرائط ، الإختلافية المكانية ، نسيج التربة ، نظام المعلومات الجغرافية.
