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Geostatistical Assessments for Characteristics of Soils around Naip Dam

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Abstract

Investigation and mapping spatial variations (distance-dependent variations) in soil characteristics with the aid of geostatistical methods will bring about significant savings for labor, time and cost in agricultural practices. From this point forth, this study was conducted around Naipköy dam to determine spatial distribution of physical and chemical soil characteristics. Soil samples were taken from both sides of Tekirdağ Ganos Mountain (the side towards Naip plain and the side towards Marmora Sea). The research site was divided into 1000 x 2000 m grids and disturbed samples were taken from 0-30 cm soil profile of 24 points. Soil samples were subjected to texture, organic matter, pH, EC, calcium, magnesium, potassium and phosphorus analyses. Analyses revealed that the sections towards Naip plain had quite high clay and silt contents because of clayey deposition over these sections. These samples also had high calcium and thusly pH values because of lime layers of these sections. Soil properties were mapped in ArcGIS/ArcMAP 10.6 software with the aid of Inverse Distance Weighting (IDW) method. The maps generated facilitated assessments made for the relationships between land use and physico-chemical soil characteristics. Statistical analyses revealed the least coefficient of variation (8.44%) for pH and the greatest coefficient of variation (73.51%) for phosphorus.

Key Words: Geostatistics, Naip, GIS, Soil, Tekirdag, IDW

Introduction

It is impossible to measure soil characteristics in every single point of large areas. Therefore, representative samples are taken from such fields and soil characteristics of these samples are linked to entire field. Since some fields have quite heterogenous structures, there may be great variations among the soil samples. In such cases, classical statistics have quite narrow confidence limits. It is assumed that selected sampling points were independent of each other and sample mean best represented the population mean in classical statistics. It is normal to have quite similar sampling points in themselves when the sampling points were close to each other. Such similarities are function of the distance and thus should not be considered independent of the distance. Therefore, levels of spatial variations (spatial dependency) in investigated parameters should be determined. Geostatistical methods are successfully employed to determine such spatial dependency (Öztas 1995).

It is quite significant to determine distance-dependent variations in soil physical and chemical characteristics for investigation and mapping of soil characteristics and developing proper management methods accordingly (Denton et al. 2017).

In spatial analyses, two similar stages are applied for regression analysis and geostatistical analysis. Initially, the models defining spatial dependencies between investigated soil properties and sampling points are determined. Then, interpolation methods are used to estimate the values of non-sampled points with the aid of the values of sampled points and spatial distribution maps are generated for investigated soil characteristics. In these two stages, Moran's I index can be used for spatial dependence, and spatial regression method can be used for interpolations (Anselin 2002, 2009, Anselin et al. 2012).

Several researchers employed highly reliable geostatistical methods to identify the relationships between sampling distances and investigated parameters and to model distance-dependent variations in such parameters (Turgut and Oztas 2012, Goovaerts 1998, Webster and Oliver 2007, Erdem et al. 2012, Günal et al. 2012, Glendell et al. 2014, Sabeti et al. 2017, Cao et al. 2017, Denton et al. 2017, Vasu et al. 2017, Başbozkurt et al. 2013).

Material and Method

Material

The research site, Naip plain is located within the provincial boundaries of Tekirdağ province in Northwest of Turkey. The site is positioned at northeast of Ganos Mountain and lower sections of Ana stream passing through the plain and flowing into Marmora Sea (Özşahin et al. 2018, Özşahin 2015). The research site covers majority of the lands of Uçmakdere, Naipköy, Çanakçı, Işıklar, Oruçbeyli, Işıklar, Avşar and Yazır districts of Tekirdağ province. The site includes northeast section of Ganos Mountain and samples were taken from both sides of the mountain. Northern skirts of the mountain include Naip plain and southern sections of the mountain extend till Marmora Sea. Maps of the research site are presented in Fig. 1.a,b,c.

Fig.1.a.

Fig.1.b.

Fig.1.c.

Fig. 1. a,b,c. Topographical map of the research site and satellite image of sampling points

Method

The research site, Northeast side of Ganos Mountain, covers about 60.000.000 m^2 area. For sampling points, the site was divided into 2000 m x 1000 m grids and samples were tried to be taken from the mid-section of each grid. Since the site has a quite rough topography, samples were not able to be taken from the mid-sections of some grids. Soil samples were taken from 0-30 cm soil profile of 24 points and brought to laboratory for analyses. Soil reaction (pH) was determined in 1:2,5 soil-water suspension with a glass-electrode pH meter (Jackson 1958), EC was determined in 1:2,5 soil-water suspension with Wheatstone Bridge conductivity device (Richards 1954); soil texture (grain size distribution) was determined in accordance with Bouyoucos hydrometer method (Bouyoucos 1953) and texture triangle was used to name the texture classes (Anonymous 1993). Organic matter (%) was determined with the aid of Smith-Weldon Method and Organic C method (Sağlam 2008). Ca, Mg and K contents were determined with the aid of

Ammonium Acetate method and P contents were determined with Sodium bicarbonate method (Sağlam 2008).

Spatial distribution maps of all parameters were generated in ArcMap 10.6 software by using Inverse Distance Weighting (IDW) method (Anonymous 2009).

Results

Entire analysis results of the research site and coordinates of sampling points are provided in Table 1.

Table 1. Coordinates of sampling points and analysis results

	Latitude	Longitude	Sand %	Silt %	Clay %	Teksture Classification	ph	EC	% OM	Magnesium	Calcium	Potassium	Phospor
N1	27,414608	40,837685	28,59	38,68	32,73	CL	5,84	145	3,59	330,33	1745,26	271,88	18,63
N2	27,418579	40,832470	44,68	30,64	24,68	L	7,10	232	0,72	591,61	3179,23	32,56	4,24
N3	27,394923	40,835019	31,70	46,09	22,20	L	6,02	74	0,72	170,43	704,56	105,43	8,82
N4	27,395116	40,846442	48,52	20,53	30,96	SCL	5,98	92	3,59	567,14	2718,33	74,13	11,38
N5	27,395212	40,855880	31,70	37,16	31,13	CL	7,18	578	3,74	201,91	5453,26	130,82	13,71
N6	27,374977	40,824819	34,88	33,52	31,60	CL	6,40	274	10,20	443,25	4996,73	276,66	27,25
N7	27,374478	40,837882	38,61	28,57	32,82	CL	6,24	174	5,60	279,62	2134,60	319,46	21,57
N8	27,374442	40,846791	31,58	33,09	35,33	CL	6,00	138	3,02	307,93	4609,42	111,37	8,70
N9	27,374611	40,855817	21,70	43,18	35,12	CL	7,14	206	1,58	169,12	7527,17	124,82	1,21
N10	27,395040	40,865242	17,50	45,29	37,22	SiCL	7,22	300	2,44	250,79	6777,77	227,00	19,54
N11	27,394778	40,874049	11,38	43,20	45,42	SiC	7,20	336	3,02	150,61	7419,62	308,99	18,43
N12	27,374724	40,874108	12,89	28,98	58,13	C	7,34	258	1,58	339,24	8730,43	123,12	8,49
N13	27,374583	40,864875	25,86	36,99	37,15	CL	7,20	340	4,17	144,66	7932,65	150,79	11,60
N14	27,355322	40,864965	12,87	45,55	41,58	SiC	7,44	266	1,87	106,55	8520,89	114,72	3,57
N15	27,343080	40,874037	3,18	39,92	56,90	SiC	7,15	415	1,58	164,43	9880,86	168,68	14,61
N16	27,355449	40,873933	8,66	39,37	51,97	C	7,28	300	1,72	364,33	8653,97	224,07	8,73
N17	27,331448	40,855909	8,41	41,56	50,03	SiC	5,99	99	2,44	513,65	4342,05	226,87	38,82
N18	27,355353	40,855938	11,12	48,58	40,30	SiC	7,40	203	1,58	191,34	8883,94	106,27	5,09
N19	27,347020	40,847258	25,06	41,54	33,40	CL	7,15	245	2,01	69,72	8239,22	69,40	4,70
N20	27,355211	40,838200	33,46	42,24	24,30	L	7,20	220	1,15	65,24	6067,42	74,78	4,57
N21	27,331692	40,838675	10,42	83,18	6,40	Si	7,36	297	1,29	350,00	7824,28	103,07	3,98
N22	27,331566	40,829214	18,57	75,01	6,42	SiL	6,65	270	2,59	776,97	3822,70	129,60	9,55
N23	27,354989	40,820087	27,77	35,00	37,23	CL	6,13	154	3,74	274,02	2337,84	286,49	17,85
N24	27,331685	40,819994	50,42	26,76	22,81	SCL	6,30	243	5,75	297,52	2469,10	285,71	34,12

The lowest sand content (3.18%) was obtained from the northern section of the research site between Oruçbeyli and Çanakçı districts and the greatest sand content (50.42%) was obtained from high-altitude southern sections of Ganos Mountain. The greatest silt content (83.13%) was obtained from the point between Işıklar and Semetli districts and the lowest silt content (20.52%) was obtained from the point between Naipköy and Yeniköy districts. The greatest clay content (58.13%) was observed around Çanakçı district and the lowest clay content (6.40%) was obtained from the point with the greatest silt content. As it was expected, the greatest pH (7.44) was obtained from northern part of the research site where Naip plain is located because of transported material and the lowest pH (5.84) was obtained from southern part of the site close to the coast. With regard to coefficient of variation, the lowest value (8.44%) was calculated for pH and the greatest value (73.51%) was calculated for phosphorus. Akgül et al. (1995) indicated that high coefficient of variation increased error margins in interpretation of investigated parameters with classical statistics. Statistical assessments on analysis results are provided in Table 2.

Table 2. Statistical assessments on analysis results

Descriptive Statistics								
	Std. Deviation	Range	Minimum	Maximum	Mean	Skewness	Kurtosis	Variation coeffifiency
% Sand	13,35534	47,24	3,18	50,42	24,5648	0,31	-0,791	54,37
% Silt	13,66123	62,65	20,53	83,18	41,0265	1,81	4,313	33,30
% Clay	13,0846	51,72	6,4	58,13	34,4087	-0,284	0,484	38,03
ph	0,57281	1,6	5,84	7,44	6,7879	-0,493	-1,592	8,44
EC	110,47853	504	74	578	244,125	1,039	2,477	45,25
% OM	2,07064	9,48	0,72	10,2	2,9038	2,094	5,896	71,31

Magnesium (mg/l)	177,93755	711,74	65,24	776,97	296,6839	1,044	0,941	59,98
Calcium (mg/l)	2752,7751	9176,3	704,56	9880,86	5623,8058	-0,196	-1,36	48,95
Potassium (mg/l)	86,97362	286,9	32,56	319,46	168,612	0,417	-1,217	51,58
Phospor (mg/l)	9,77592	37,61	1,21	38,82	13,2982	1,169	1,024	73,51

Within the research site, clay ratio of southern sections towards the Marmora Sea was lower than the clay ratio of the northern sections towards the Naip plain. Northern sections had quite high clay ratios. Muhacir formation of upper Oligocene-aged northern sections of the research site are mostly composed of clay deposits (Boyraz 1998). After all, Naip plain has been used to excavate clay for brick industry for years (Özşahin et al. 2018). On the other hand, northern sections of Ganos Mountain, the section towards the Marmora Sea, have greater sand contents because of the parent material. Greater pH levels of the sections with greater calcium levels in calcium and pH maps indicated that the maps were generated correctly. Laminated schists of the region are composed of dolomitic and thin limestone layers of marine deposits (Boyraz 1998). Thus, the sections of Naip plain towards the Marmora Sea had greater lime contents. Just because of these lime Stones, northern sections had greater calcium contents. Just because of high lime contents of northern sections of Ganos Mountain, pH levels were greater than the southern sections. Lower lime levels of southern sections were also attributed to parent material of forest cover of these sections. The maps generated with the aid of Inverse Distance Weighting (IDW) method for soil properties are presented in Fig. 2.

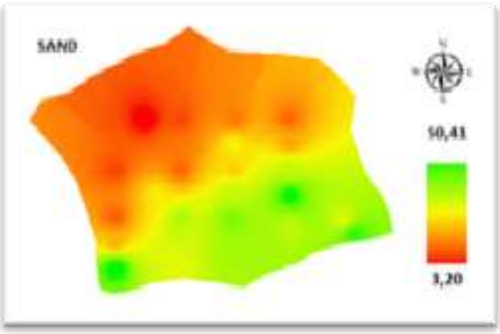


Fig.2.a.

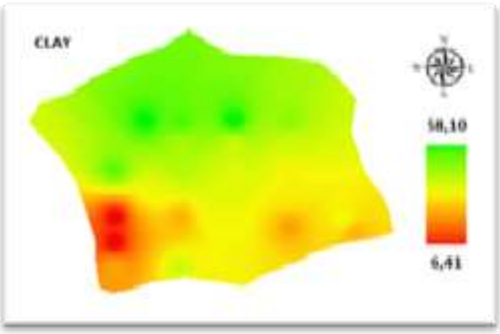


Fig.2.b.

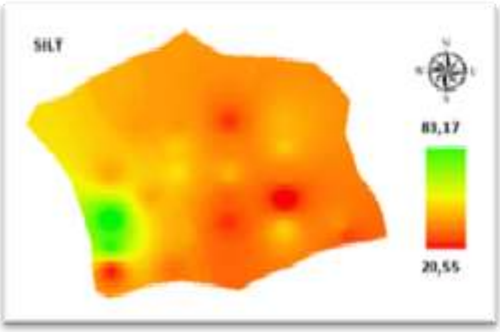


Fig.2.c.

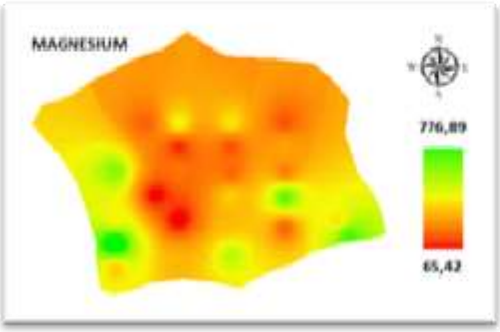
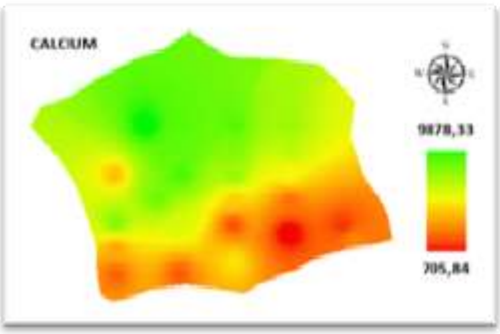


Fig.2.d.



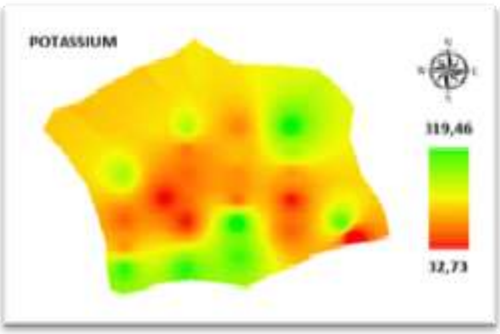
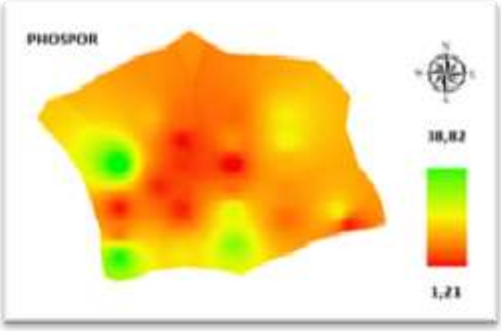


Fig.2.e. Fig.2.f.



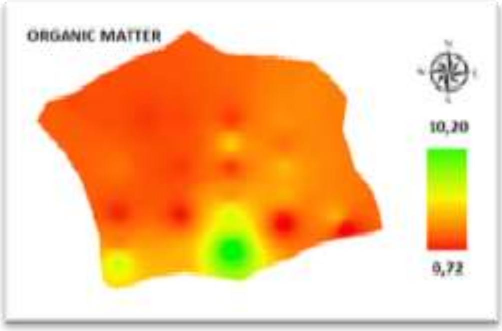
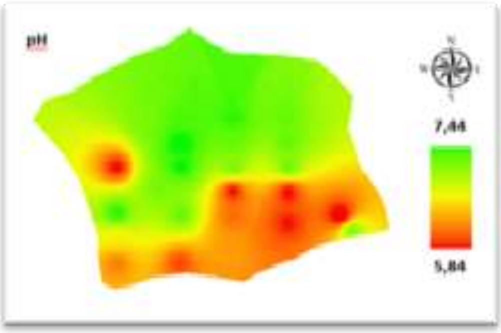


Fig.2.g. Fig.2.h.



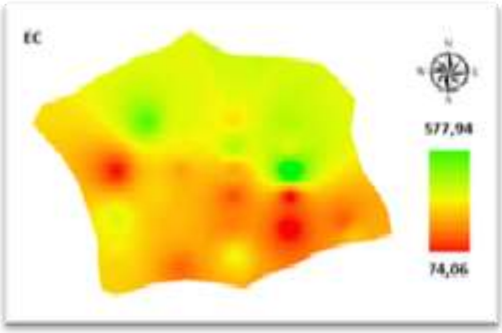


Fig.2.i. Fig.2.j.

Fig. 2. Maps of soil properties generated through IDW method

Because of sloped terrain, the research site is exposed to severe erosion. Besides, previous forest cover over the sections towards the Naip plain has already been replaced by idle vineyards. Parent material reached to surface from place to place and such a case resulted in differences in Mg, K and P contents, mostly related to parent material in some sections of the research site. Severe erosions created water conduits over the southern slopes of Ganos Mountain and eroded material then flows into the dam constructed in Naip district on the south of Ganos Mountain. Over the section with the greatest organic matter content, there is a delta towards the Marmora Sea. The delta around Ayvasıl district is mostly composed of transported material, thus has an organic matter content of about 10%. The pH level of that section was then at low levels.

Conclusion

Present findings revealed that spatial distribution of soil physical and chemical characteristics of the research site could be investigated. Sampling procedure plays a great role in identification of soil properties. Besides number of sampling points, homogeneous sampling is also a significant issue in such studies. However, it is quite hard to manage such a homogeneous sampling in practice. In other words, non-homogeneous samplings may not reveal accurate information about soil properties. Since soils exhibit continuous variations, interpolation methods can be used to estimate the values of non-sampled points. Spatial distribution maps generated through estimated data may reveal a general information about the soil properties and have great contributions to a database to be generated. Determination of soil nutrients may aid in fertilization and nutrition practices. Texture maps provide significant contributions to erosion works to be implemented.

It was observed in present study that clay and silt contents were at quite high levels over the northern sections of Ganos Mountain towards the Naip plain just because of transported material. Again because of lime layers of these transported material, calcium and accordingly pH levels of these sections were also high. Effects of parent material were dominant over the sections towards the Marmora Sea. Since the parent material is composed of sand stones, sand content was high and pH levels were low over these sections. Calcium content was also low in sections towards the Marmora Sea. Organic matter content of the sections around Naip plain was low because of erosion and anthropogenic activities, but greater in sections towards the Marmora Sea. Organic matter content was quite high especially over the upper sections of the delta around Ayvasıl district. Magnesium, potassium and phosphorus contents were low in sections around Naip plain because intense land use for agricultural purposes, but variations were observed based on intensity of land use. Considering the sloppy terrain and erosion cases of the research site, present maps help in finding solutions for rapid fill up of newly constructed Naip dam with transported material. Present findings on soil nutrients may also contribute to farmers in reducing labor, time and costs of agricultural practices.

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