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SPATIAL DISTRIBUTION OF SOME FERTILITY ELEMENTS IN SOME NORTHERN IRAQI SOILS USING GEOMATIC TECHNIQUES (REMOTE SENSING)

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Abstract

Twenty soil surface samples were collected to assess on a wide scale, the spatial distribution of soil properties including fertility ones. Where N P K were measured and spatially distributed. The least soil property variation in north of Iraq were soil pH, organic matter, and electrical conductivity where these properties are affected by the climatic conditions and zonal distribution of these features. Cation exchange capacity was correlated to clay content. Available nitrogen and phosphorus showed somewhat low content in soil while potassium showed high content in general and where also corresponded to the content of finer and coarser fraction of soil separates.
Keywords**:** spatial variability, N P K distribution, geotechnologies,

Introduction

Interest in lands and their fertility asset is increasing nowadays, where it's been very obvious that soil is the first natural resource that supports life for human beings (Foster and Magdoff 1998, Abbott and Murphy 2007). Therefore, many practices are applied in the field of soil fertility to increase the essential nutrients for plant growth (Sanginga and Woomer 2009, Altieri and Nicholls 2003, Mapfumo and Giller 2001). It is not easy to define soil fertility, because in fact it is a complicated definition that is affected by different external and internal factors (Jonson *et al*., 1997, Doran *et al*., 1999). Precipitation and temperature are affecting soil properties and fertility because it allows the potential properties to proceed in chemical and biological reactions that increase with the increase of both water and temperature (Franzluebbers 2002, Suseela *et al*., 2012, Alvarez and Lavado 1998). Also the main soil properties themselves are affecting the soil fertility properties (Alban 1982, Soltanpour and Schwab 1977) where cation exchange capacity is affecting soil content of nutrient for example (Moore 1980, Sharma *et al*., 2008, Bernal *et al*., 1993). Different internal factors are participating to affect the fertility characteristics of soil such as physical properties, aeration, soil depth, topography, biological activities, water availability and many other properties (Havlin *et al*., 2016, Gray 2005, Scoones and Toulmin 1998). Thus, soil fertility is divided to three parts, physical fertility, chemical fertility and biological fertility, where each property affects soil fertility in a different way (Almawsili 2018). Where these properties (Physical, chemical and biological) are formed due to different factors and processes (Yaalon 1975, Jenny 1994, Voroney 2007) and they show variation in their spatial distribution (Nielsen *et al*., 1973, Mulla and McBratney 2002, Ettema and Wardle 2002).

Moreover, soil properties are variable along soil-scape and they are very difficult to be measured in the whole area of any study, therefore, the term spatial variability of soil properties arise and allows us to find an approach to determine soil properties and collecting samples for better management of soil (Soulie *et al*., 1990; Wheib, 1997; Wheib, 2002; Iqbal *et al*., 2005; Muzuku *et al*., 2005 and Suliman, 2014). This study aims to determine the spatial distribution and variability of some soil properties including some fertility properties and expressing these properties using geotechnological approach.

Materials and Methods

Area of study

The area of study was representing the northern of Iraq namely Kurdistan area where 20 surface samples were randomly collected from Erbil, Suleimaniya, and Duhok. These samples were collected and GPS reading was recorded for each location. Figure (1) shows the distribution of soil samples locations.

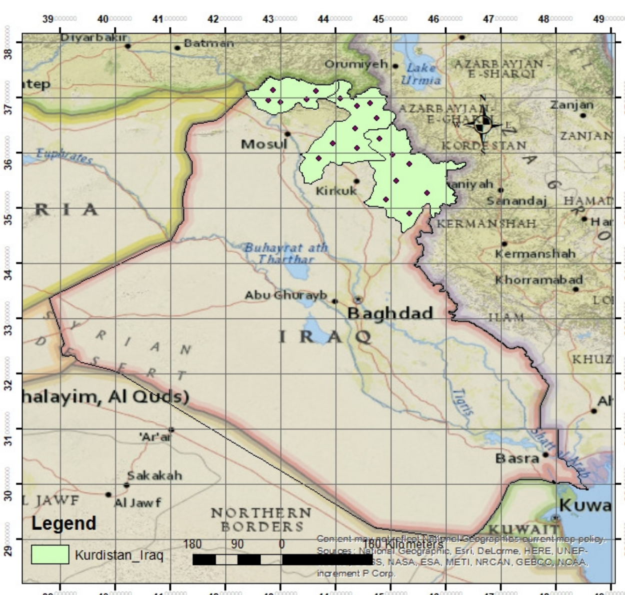


Fig. 1 : Study area and soil samples locations

Samples were collected in locked plastic bags and transferred for lab analysis.

Lab measures:

Physical properties:

Where particle size distribution was measured due to Day 1965.

Chemical properties:

- Electrical Conductivity EC was determined due to Richards 1954.

- pH was determined due to Richards 1954.
- Cation Exchange Capacity CEC was calculated due to Hesse 1971.
- Total Carbonate measured using calcimeter method described in Hesse 1971.
- Organic Matter OM was measured due to Walkly Black method described in Hesse 1971.

Fertility macro nutrients:

- Available Nitrogen was determined due to micro-Kjeldahl method that permits the available nitrogen to be precisely determined in the soil (Page 1982).
- Available Phosphorous was determined due to the method described in Jackson 1958.
- Available Potassium was determined using the method described in Black 1965.

Map preparations and geo-statistical analysis:

Arc GIS 10.3 for desktop was used to prepare maps of spatial distribution and variability of soil properties. Data of soil properties were kregged following the geostatistical analysis of ArcMap extensions. Resulted maps were used to show the variation in soil properties, and a general linear regression model was built for the spatial variogram shown in these maps (ESRI 2014).

Results and Discussion

Soil Chemical Properties

Table 1 shows chemical properties of the selected soils. Soil pH was ranging from 7.4-8.4. Where generally we can see that the lower pH values of soil existed in soils with higher electrical conductivity of soil extract and that is parallel to what Miller and Kissal2010, Chorom and Rengassamy 1997, and Brady and Weil 2008 found. Also the highest value of pH was related to higher content of organic matter, and that was also corresponded to what Suave *et al.*, 1998, You *et al.*, 1999 and Curtin et al 1998 found when they studied the relationship between soil organic matter and potential of hydrogen in soil.

Electrical conductivity was ranging from 0.58 to 20.70 $dS.m^{-1}$ but generally most of the soils were having a low content of salts due to the low value of the electrical conductivity of soil extract, where most of soil salinity classes were under the none saline to slightly saline soils (see figure)

Organic Matter was also showing different spectrum of organic accumulations in soil, from low content of organic matter to significant content of it. OM ranged from 0.21-2.92 $gm.kg^{-1}$ the higher content of organic matter was spatially distributed in a partially higher precipitation and lower degrees of temperature areas. It is considerable that most of these soils are representing a mollisols and entisols, where these soils considered having a relatively higher content of organic matter that other soil in Iraq as a basic part of their classification (Soil Survey Staff 1996).

Carbonate equivalent has ranged from 10.1-42.5 $gm.kg^{-1}$ in the tested soil samples. There was a general significant trend of soil content of organic matter and carbonate equivalent where the highest content of organic matter affected the content of total carbonate minerals in soil, and that could be related to the value of pH that is decreased due to organic matter accumulation where more acidity leads to less carbonate accumulation (Kove and Oschiles 2012, Wang *et al.*, 2015).

Table 1: Chemical properties of soils of study

Sample No	pH	ECe dS.m	N	P	K	OM $Kg.kg^{-1}$	$CaCO_3$ $Kg.kg^{-1}$	CEC $Cmolc.kg^{-1}$
			Available/ $mg.kg^{-1}$					
1	7.4	2.18	33.5	10.2	185	0.21	32.0	31.0
2	8.3	0.58	45.8	19.6	156	0.70	32.0	7.4
3	7.4	1.64	116.8	16.7	136	2.92	32.0	8.02
4	7.6	4.96	89.5	11.5	164	1.47	30.0	3.74
5	8.0	1.18	73.8	13.2	251	1.09	25.5	16.05
6	7.9	1.84	77.8	16.9	127	1.31	42.5	10.70
7	8.0	1.86	80.1	14.0	191	1.65	24.0	10.70
8	7.8	4.96	40.6	8.6	110	0.40	31.5	18.72
9	7.7	8.68	39.8	13.4	206	0.60	28.0	5.35
10	7.7	5.16	29.8	13.6	150	0.43	29.5	8.02
11	8.1	1.81	81.7	22.1	242	1.84	10.1	32.8
12	8.0	21.6	73.5	14.5	235	0.87	29.5	12.3
13	7.9	20.70	33.8	7.5	187	0.30	30.0	18.72
14	8.4	2.80	119.1	22.3	110	2.86	11.0	27.45
15	8.3	3.62	95.6	30.0	312	1.52	27.5	37.7
16	8.2	1.24	44.1	17.5	538	0.42	21.5	26.75
17	8.3	1.94	63.9	9.2	398	1.31	32.5	33.87
18	7.4	8.42	69.6	14.2	246	0.87	24.0	34.77
19	8.3	1.00	84.9	10.5	383	1.68	17.5	32.10
20	8.0	2.80	70.5	12.4	286	1.05	16.8	27.82

Cation exchange capacity was generally high. It ranged between 3.74-34.10 Cmolc.kg^{-1}. Where the highest value of this characteristic was related to clay content in soil. It was related to the content of the finer or coarser particles in soil as we can see that the finer soil textures have higher cation exchange capacity as shown in table 2.

Table 2 : Particle size distribution and texture of the studied soils

Sample No	Clay	Silt	Sand	Soil texture
	gm.kg^{-1}			
1	31.2	52.4	16.4	SiCL
2	15.7	45.5	38.8	L
3	17.6	42.3	40.1	L
4	9.5	23.9	66.6	SL
5	25.2	56.0	18.8	SiL
6	18.6	56.9	24.5	SiL
7	14.5	59	26.5	SiL
8	30.8	52.4	16.8	SiCL
9	42.5	49.1	8.4	SiC
10	20.4	57.1	22.5	SiL
11	33.8	50.4	15.8	SiCL
12	20.8	60.6	18.6	SiL
13	27.6	54.1	18.3	SiCL
14	25.8	53.7	20.5	SiL
15	44.5	48.8	6.7	SiC
16	26.6	53.3	20.1	SiL
17	38.8	42.4	18.8	SiCL
18	40.8	43.6	15.6	SiC
19	30.5	53.6	15.9	SiCL
20	30.7	56.6	12.7	SiCL

From table 2, we can see that soil texture was generally ranging from medium texture to fine texture except some sites were coarse textured the matter that led to low cation exchange capacity as mentioned above. Clay content was ranging from 9.5 gm.kg^{-1} to 44.5 gm.kg^{-1} of a sandy loam to silty clay soil textures respectively. The variation in clay content will definitely cause variation in other separates. The finer separate was correlated to the exchange capacity and organic matter and that is related to the high surfaces area of the organic matter which increases the soil surfaces in return, thus it increases the exchange capacity (Tiessen and Stewart 1981, Wang and Keller 2008).

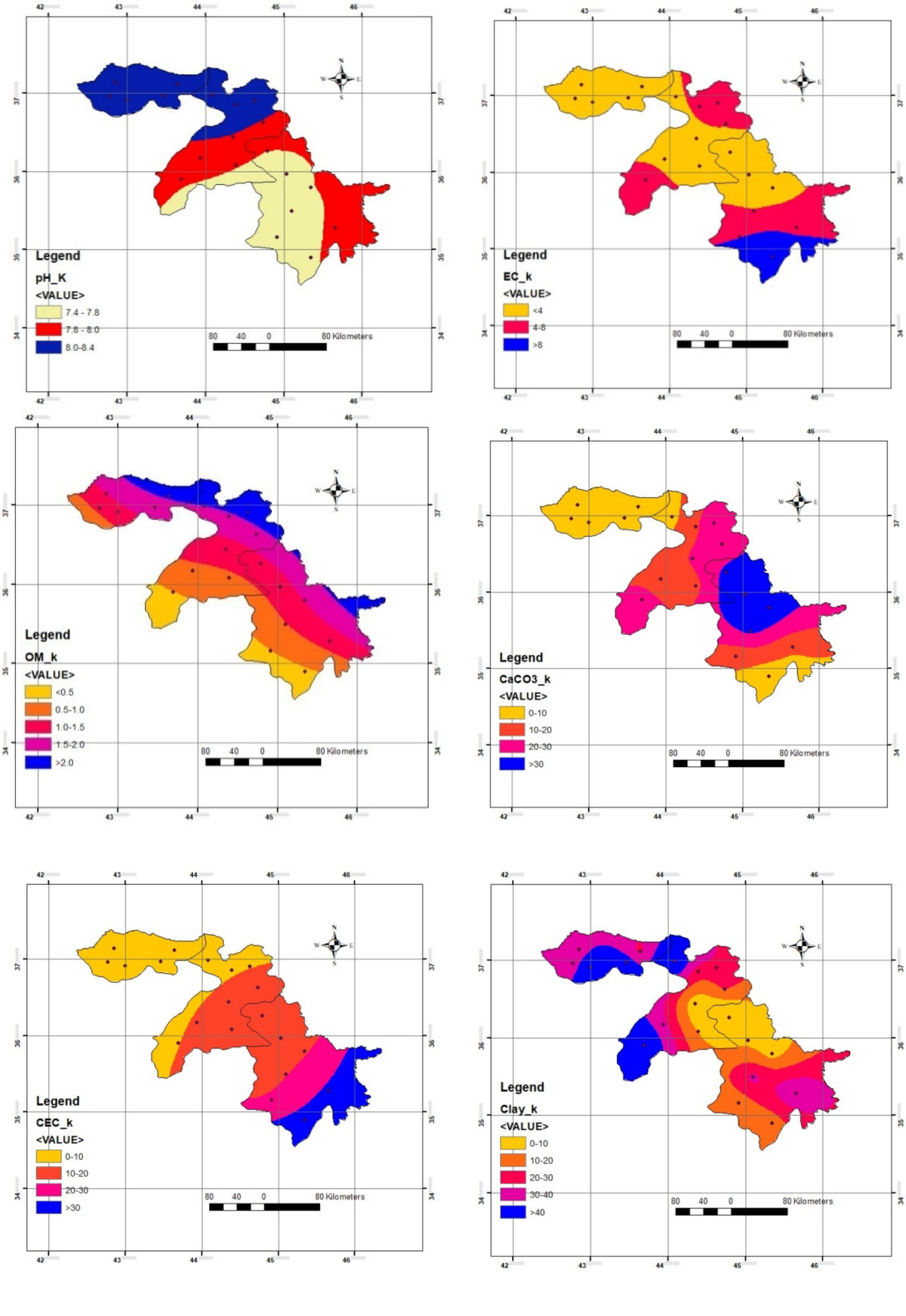
Nitrogen content was low in general, because of the virgin soil covering the landscape, although available nitrogen was ranging from 33.5 mg.kg-1 up to 119.1 mg.kg^{-1}. The highest values of nitrogen content refer to lands where their fields are under kind of management therefore it is exposed to fertilization and fertilizers as it will be mentioned below. Available phosphorus content was also low because of the nature of the calcareous soils and how they act on phosphorus fixation as insoluble compounds of phosphate (Helyar and Anderson 1971; Jensen *et al*., 1998; Braschi *et al*., 2003). Iraqi soils are considered to have enough amount of total and available potassium (Kanani *et al*., 1989; Al-Zubaidi 2001), therefore we can see that the content of available potassium in soil was high when compared to other virgin soils. It ranged between 100-251 mg.kg^{-1} where the highest contents were in coarser soil texture than the finer ones, and that's could be related to the common content of potassium feldspars in sand minerals (Sadusky *et al*., 1987, Sparks 1986; Pal *et al*., 2001) besides the fixation process of potassium in clayey soils (Wear and White 1961; Inoue 1983; Simonson 2009).

These figures above shows that soil pH and Electrical conductivity were the least variable properties in the studied area, where first these areas are receiving more quantities of precipitation with lower annual temperature the matter that doesn't support salt accumulation in soil. Also from seeing pH and EC distribution, they look related to the role of decreasing pH values with the increase of salts in soil extracts. Organic matter showed another distribution where the highest content was related to the highest areas in elevation, precipitation, and temperature, and that it is related to the increase of litters and accumulation of OM in soil other than oxidizing it in other areas. Carbonate equivalent did not show trend distribution because of parent material of soils in the area of study is considered to be highly calcareous therefore, the distribution was not following a law.

Cation exchange capacity was related in its distribution to clay and sand content, and that could also be followed through table 1 and 2.

Coarser textured soils were the least in the studied area, followed by finer textured soil, while medium textured soils have they most extensive distribution in the area of study (figure 2). Nitrogen, phosphorus, and potassium were distributed randomly in the soils of northern Iraq. Low content of any property will definitely eliminate variability in it. Therefore, variation in available nitrogen was not as wide as phosphorus and potassium showed because nitrogen is exposed to leaching in a hand and volatilization in another hand (Stenberg *et al*., 1999; Cameron *et al*., 2013)

Spatial distribution and soil variability:
Figure (2) shows the spatial distribution of soil properties.



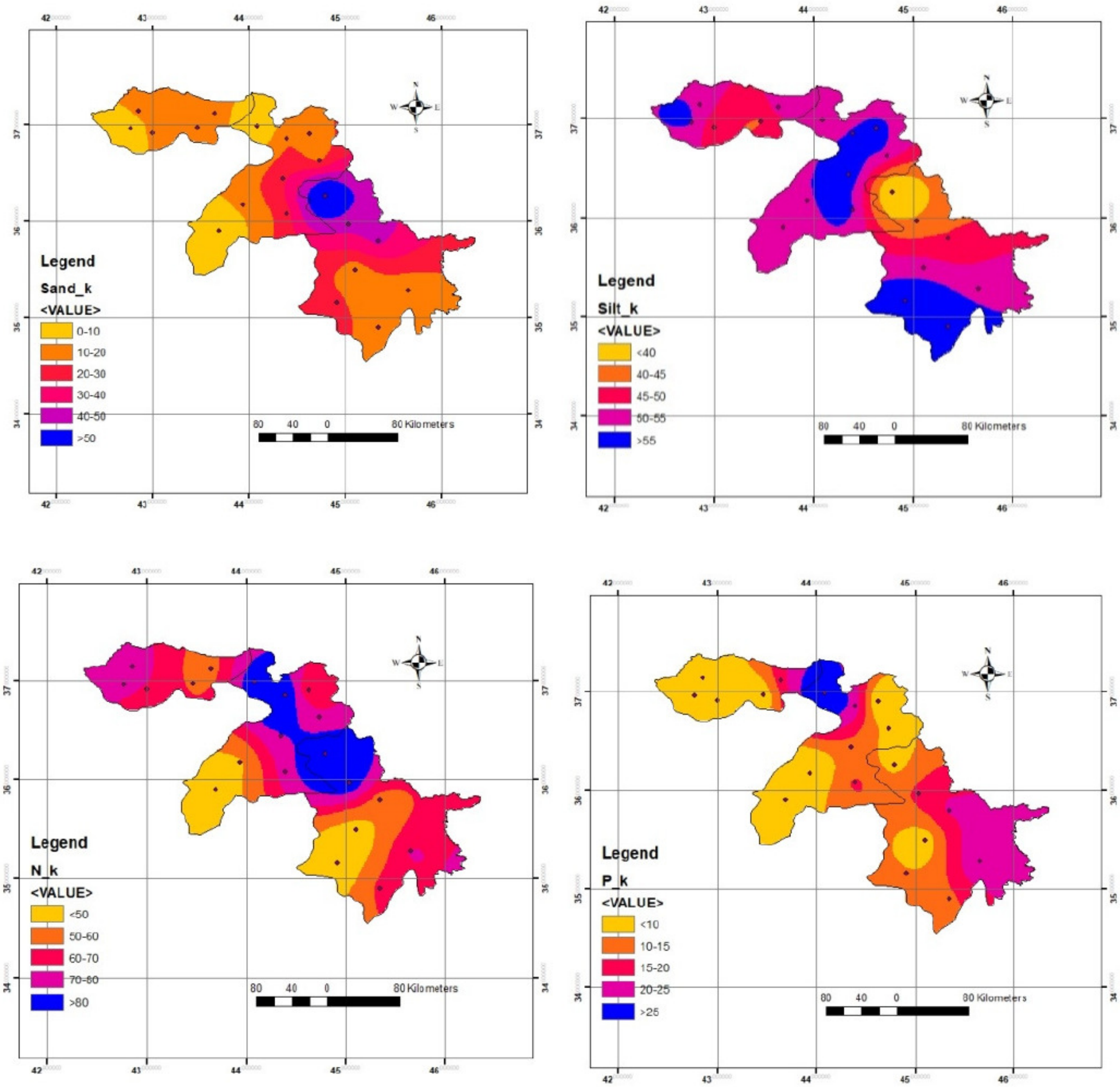


Fig. 2 : Spatial distribution of soil properties

References

Abbott, L.K. and Murphy, D.V. (2007). What is soil biological fertility?.In Soil Biological Fertility, Springer, Dordrecht (pp. 1-15)..

Alban, D.H. (1982). Effects of Nutrient Accumulation by Aspen, Spruce, and Pine on Soil Properties 1. Soil Science Society of America Journal, 46(4): 853-861.

AlmawsiliMuzaffa A.D. (2018). Alkaml fi ala'sdahwaltasmid.- tahlilalturbawalnabatwalma'a. Dar Al Kotob Al Ilmiyah. Beirut. ISBN-10: 2745187856.

Altieri, M.A. and Nicholls, C.I. (2003). Soil fertility management and insect pests: harmonizing soil and plant health in agroecosystems. Soil and Tillage Research, 72(2): 203-211.

Alvarez, R. and Lavado, R.S. (1998). Climate, organic matter and clay content relationships in the Pampa and Chaco soils, Argentina. Geoderma, 83(1-2): 127-141.

Al-Zubaidi, A. (2001). November.Potassium status in Iraqi soils.In Proceedings of the Regional Workshop on Potassium and Water Management in West Asia and North Africa.Johnsto, AE (ed.). International Potash Institute, Horgen, Switzerland, 129-124.

Bernal, M.P.; Roig, A. and Garcia, D. (1993). Nutrient balances in calcareous soils after application of different rates of pig slurry. Soil Use and Management, 9(1): 9-14.

Black, C.A. (1965a). Methods of Soil Analysis. Part(1). Physical properties. Amr. Soc. Agron. Inc. Publisher, Madison Wisconsin, USA.

Brady, N.C. and Weil, R.R. (2008). The nature and properties of soils (Vol. 360). Upper Saddle River: Pearson Prentice Hall.

Braschi, I.; Ciavatta, C.; Giovannini, C. and Gessa, C. (2003). Combined effect of water and organic matter on phosphorus availability in calcareous soils. Nutrient Cycling in Agroecosystems, 67(1): 67-74.

Cameron, K.C.; Di, H.J. and Moir, J.L. (2013). Nitrogen losses from the soil/plant system: a review. Annals of Applied Biology, 162(2): 145-173.

Chorom, M. and Rengasamy, P. (1997). Carbonate chemistry, pH, and physical properties of an alkaline sodic soil as affected by various amendments. Soil Research, 35(1): 149-162.

Curtin, D.; Campbell, C.A. and Jalil, A. (1998). Effects of acidity on mineralization: pH-dependence of organic matter mineralization in weakly acidic soils. Soil Biology and Biochemistry, 30(1): 57-64.

Doran, J.W.; Jones, A.J.; Arshad, M.A. and Gilley, J.E. (1999). Determinants of soil quality and health. Soil quality and soil erosion, 36.

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Ettema, C.H. and Wardle, D.A. (2002). Spatial soil ecology. Trends in ecology & evolution, 17(4): 177-183.

Foster, J.B. and Magdoff, F. (1998). Liebig, Marx, and the depletion of soil fertility: Relevance for today's agriculture. Monthly Review, 50(3): 32-46.

Franzluebbers, A.J. (2002). Soil organic matter stratification ratio as an indicator of soil quality. Soil and Tillage Research, 66(2): 95-106.

Gray, L.C. (2005). What kind of intensification? Agricultural practice, soil fertility and socioeconomic differentiation in rural Burkina Faso. Geographical Journal, 171(1): 70-82.

Havlin, J.L.; Tisdale, S.L.; Nelson, W.L. and Beaton, J.D. (2016). Soil fertility and fertilizers.Pearson Education India.

Helyar, K.R. and Anderson, A.J. (1971). Effects of lime on the growth of five species, on aluminium toxicity, and on phosphorus availability. Australian journal of agricultural research, 22(5), pp.707-720.

Inoue, A. (1983). Potassium fixation by clay minerals during hydrothermal treatment. Clays and Clay Minerals, 31(2): 81-91.

Iqbal, J.; Thomasson, J.A.; Jenkins, J.N.; Owens, P.R. and Whisler, F.D. (2005). Spatial variability analysis of soil physical properties of alluvial soils. Soil Science Society of America Journal, 69(4): 1338-1350.

Jenny, H. (1994). Factors of soil formation: a system of quantitative pedology. Courier Corporation.

Jensen, H.S.; McGlathery, K.J.; Marino, R. and Howarth, R.W. (1998). Forms and availability of sediment phosphorus in carbonate sand of Bermuda seagrass beds. Limnology and Oceanography, 43(5): 799-810.

Jensen, H.S.; McGlathery, K.J.; Marino, R. and Howarth, R.W. (1998). Forms and availability of sediment phosphorus in carbonate sand of Bermuda seagrass beds. Limnology and Oceanography, 43(5): 799-810.

Johnson, D.L.; Ambrose, S.H.; Bassett, T.J.; Bowen, M.L.; Crummey, D.E.; Isaacson, J.S.; Johnson, D.N.; Lamb, P.; Saul, M. and Winter-Nelson, A.E. (1997). Meanings of environmental terms. Journal of environmental quality, 26(3): 581-589.

Koeve, W. and Oschlies, A. (2012). Potential impact of DOM accumulation on fCO 2 and carbonate ion computations in ocean acidification experiments. Biogeosciences, 9(10): 3787-3798.

Mapfumo, P. and Giller, K.E. (2001). Soil fertility management strategies and practices by smallholder farmers in semi-arid areas of Zimbabwe. ICRISAT/FAO.

Miller, R.O. and Kissel, D.E. (2010). Comparison of soil pH methods on soils of North America. Soil Science Society of America Journal, 74(1): 310-316.

Moore, T.R. (1980). The nutrient status of subarctic woodland soils. Arctic and Alpine Research, 12(2): 147-160.

Mulla, D.J. and McBratney, A.B. (2002). Soil spatial variability. Soil physics companion, 343-373.

Mzuku, M.; Khosla, R.; Reich, R.; Inman, D.; Smith, F. and MacDonald, L. (2005). Spatial variability of measured soil properties across site-specific management zones. Soil Science Society of America Journal, 69(5): 1572-1579.

Nielsen, D.R.J.W.; Biggar, J.W. and Erh, K.T. (1973). Spatial variability of field-measured soil-water properties. Hilgardia, 42(7): 215-259.

Sadusky, M.C.; Sparks, D.L.; Noll, M.R. and Hendricks, G.J. (1987). Kinetics and Mechanisms of Potassium Release from Sandy Middle Atlantic Coastal Plain Soils 1. Soil Science Society of America Journal, 51(6): 1460-1465.

Sanginga, N. and Woomer, P.L. (2009). Integrated soil fertility management in Africa: principles, practices, and developmental process. CIAT

Sauve, S.; McBride, M. and Hendershot, W. (1998). Soil solution speciation of lead (II): effects of organic matter and pH. Soil Science Society of America Journal, 62(3): 618-621.

Scoones, I. and Toulmin, C. (1998). Soil nutrient balances: what use for policy?. Agriculture, Ecosystems & Environment, 71(1-3): 255-267

Sharma, P.K.; Sood, A.; Setia, R.K.; Tur, N.S.; Mehra, D. and Singh, H. (2008). Mapping of macronutrients in soils of Amritsar district (Punjab) A GIS approach. J. Indian Soc. Soil Sci, 56(1): 34-41.

Simonsson, M.; Hillier, S. and Öborn, I. (2009). Changes in clay minerals and potassium fixation capacity as a result of release and fixation of potassium in long-term field experiments. Geoderma, 151(3-4): 109-120.

Soil Survey Staff (1996). Keys to Soil Taxonomy. Seventh Edition, USDA Natural Resource Con-servation Service, Washington DC,

Soulie, M.; Montes, P. and Silvestri, V. (1990). Modelling spatial variability of soil parameters. Canadian Geotechnical Journal, 27(5): 617-630.

Stenberg, M.; Aronsson, H.; Lindén, B.; Rydberg, T. and Gustafson, A. (1999). Soil mineral nitrogen and nitrate leaching losses in soil tillage systems combined with a catch crop. Soil and Tillage Research, 50(2): 115-125.

SulimanAbdulhaleem Ali (2014). Spatial variability of some soil physical and chemical properties for alluvial soils between euphrates and tigris using time series analysis. Diyala journal of Agricultural sciences. 6(1): 159-171.

Suseela, V.; Conant, R.T.; Wallenstein, M.D. and Dukes, J.S. (2012). Effects of soil moisture on the temperature sensitivity of heterotrophic respiration vary seasonally in an old-field climate change experiment. Global Change Biology, 18(1): 336-348.

Tiessen, H.J.W.B. and Stewart, J.W.B. (1983). Particle-size fractions and their use in studies of soil organic matter: II. Cultivation effects on organic matter composition in size fractions 1. Soil Science Society of America Journal, 47(3): 509-514.

Voroney, R.P. (2007). The soil habitat.In Soil microbiology, ecology and biochemistry 25-49, Academic Press.

Wang, P. and Keller, A.A. (2008). Soil particle-size dependent partitioning behavior of pesticides within water–soil–cationic surfactant systems. water research, 42(14): 3781-3788.

Wang, X.; Wang, J.; Xu, M.; Zhang, W.; Fan, T. and Zhang, J. (2015). Carbon accumulation in arid croplands of northwest China: pedogenic carbonate exceeding organic carbon. Scientific reports, 5: 11439.

Wear, J.I. and White, J.L. (1951). Potassium fixation in clay minerals as related to crystal structure. Soil Science, 71(1): 1-14.

Yaalon, D.H. (1975). Conceptual models in pedogenesis: can soil-forming functions be solved?. Geoderma, 14(3): 189-205.