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CHARACTERIZATION OF SPATIAL VARIABILITY OF SOME PHYSIOCHEMICAL SOIL PROPERTIES OF MESOPOTAMIAN PLAIN SOILS

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ABSTRACT: *The present study is conducted to characterize the spatial variability of some soil physio-chemical properties (sand, silt, clay, pH ,EC_e ,CEC ,Esp ,O.M and $CaCO_3$) for selected soil series from Mid-Mesopotamian plain. Five soil series were recognized(MM5,MP5.Dw45,DF97,and DP45).Descriptive statistics were used including(Min., Max., Mean, Standard deviation , coefficient of variation, Skewness and kurtosis) .The results showed that, soils was differing significantly ($\rho \leq 0.05$) in all studied physio- chemical properties except for and $CaCO_3$.In addition, soils exhibited moderate to high spatial variability in the horizontal scale (cv=21.528-78.327%) in sand and OM respectively except in pH and O.M was of low spatial variability(CV=2.840-8.402%) respectively .Also, soils showed moderate to high vertical spatial variability in their physio-chemical properties (cv=16.949-88.337%) in sand and clay particles in MP5 and DW45 soil series respectively .On the other hand they showed low and high vertical spatial variability (CV=1.223-102.415%) in pH and O.M of DP45 and MP5 soil series respectively .Accordingly we see that, soil spatial variability must be studied thoroughly for precise soil management and accurate soil sampling system for taking effective management decisions that leads to sustainable agricultural production.*

KEYWORDS: Spatial Variability, Coefficient of Variation, Standard Deviation , Geomorphic Processes, Pedogenic Process, Skewness, Alluvial Soils.

توصيف التغايرات المكانية لبعض الصفات الفيزيوكيمياوية لبعض سلاسل الترب من وسط السهل الرسوبي العراقي

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المستخلص

أجريت هذه الدراسة بهدف تقويم التغايرات المكانية في بعض من الصفات الفيزيوكيمياوية لسلاسل ترب من وسط السهل الرسوب ي العراقي.تم تشخيص خمسة سلاسل تربة(الحي DF97 ، خفاجة DW45 ، اعتدال MP 5 ، عمارة MM5، غسان DP45

. تم إجراء تحليل تباين واقل فرق معنوي للبيانات وكذلك أخضعت البيانات الى ألإحصاء التوضيحي (أقل قيمة،أعلى قيمة، المتوسط،ألانحراف المعياري ،معامل ألاختلاف ،معامل ألالتواء ومعامل التفرطح).بينت النتائج وجود فروقات معنوية (ρ≤ 0.05) في صفات الترب الفيزيوكيمياوية موضوع الدراسة عدا كاربونات الكالسيوم.كما توجد تغايرات مكانية أفقية تراوحت بين المعتدلة الى العالية في صفات التربة (cv=21.528-78.327%) في مفصول الرمل والمادة العضوية وكذلك تغايرات مكانية عمودية (cv=16.949-88.337%) في مفصول الرمل والطين في تربتي عمارة MP5 و اعتدالDW45 من ناحية أخرى كانت هنالك تغايرات مكانية عمودية تراوحت بين المنخفضة الى عالية (CV=1.223-102.415%) في صفتي تفاعل التربةpH و المادة العضوية OMلتربتي غسان DP45 و عمارة MP5 . وتأسيسا على ذلك يجب دراسة تغايرات التربة بشكل معمق من اجل تحقيق نظام زراعة دقيق ونظام معاينة مضبوط لأغراض اتخاذ قرارات إدارة تربة فعال من اجل تحقيق إنتاج زراعي مستدام.

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كلمات مفتاحيه: تغايرات التربة ، معامل ألاختلاف، ألانحراف المعياري، معامل ألالتواء، معامل التفرطح، الترب الرسوبية ، العمليات الجيومورفية، العمليات البيدوجينية

Introduction: Soils as a natural bodies are inherently heterogeneous in nature because of the many factors that, contribute to their formation and the complex interactions of these factors, Maniyunda et al 2013[1].Soils are diverse, and dynamic system, Kavipoor 2012[2].Soil heterogeneities may arise from management activities]Sivarajan et al 2013[3] and can occur from land use and management strategies[4 Yasrebi et al 2008].Heterogeneity of soil properties is a general characteristics in semi arid and semi arid ecosystem Schlesinger et al 1996[5], Liu et al 2007 [6].Soils characterized by high degree of variability due to the interplay of physical ,chemical, biological and anthropogenic processes that operate with different intensities and at different scales and acting simultaneously ,Ghanty et al 2012[7], Serrano et al 2014[8].The differences in their characteristics associated with landscape position are usually contributed to the differences in the runoff ,erosion and deposition which effect soil gneisses Akhatanzzaman et al 2014[9].These characteristics can be a direct result of soil forming factors and their interactions ,Mann et al 2010 , Mzuku,2005[11].

Soil spatial variability is an important determinant of efficiency of farm inputs and yield,Sağlam,2011[12] as well as crop management and design and effectiveness of field research trials, Khan et al 2014[13].These variations differed among soil properties , and may reflect the impacts of plant, soil fauna, precipitation ,and management practices adopted in the area ,Jafari et al 2011[14].Consequently, soils can exhibit marked spatial variability at the macro-scale and micro-scale, Fathi ,et al 2014[15].High variability of soil properties might be related to variability of properties of flood sediments ,Rabi et al2014[16],and controlled by primarily the depositional environment where high energy systems deposit materials with high spatial variability ,Moss et al 2010[17].These processes and causes create pattern of nested variability or heterogeneity, this means that, soil properties may display spatial /or temporal patterns only over certain distances and not others Douaik.2011[18].

The characterization of spatial variability of soil attributes is essential to achieve a better understanding of the complex relations between soil properties and environmental factors, Gooverts ,1998[19].And, knowledge of spatial variability and relationships among properties is important for the evaluation of agricultural management practices ,Huang et al ,1999 [20] and the variability of physical and chemical properties of soil is unavoidable Fathi et al 2014[15].And, understanding the

distribution of soil properties in the field is essential in refining agricultural management practices , Akbas,2014[21].Information about soil variability is necessary for precision agriculture ,Biswas et al 2012[22].And ,farm inputs can be adjusted and applied to the fields precisely and management decisions can be made accordingly, Sivarajan et al 2013[3],and interpretation of them is a key element in site specific farming, Tuncay et al 2013 [23].Therefore it is important to study not only the extent of the surface spatial variability of soil properties but also the distribution of subsurface and deep soil horizons, Iqbal et al 2005[24] . Knowledge about soil physical and chemical properties can save time and money in planning and management spatial variations of soil that, influence soil and crop management efficiencies as well as the effectiveness of soil research Wasiullah [25].precision agriculture applies principles of farming according to field variability, Emadi et al,2008[26].It is noted that, spatial characterization is necessary to locate areas to be carefully managed for agricultural sustainable development Ghanty et al 2012 [7] and studying physiochemical properties provide basic information of better plant growth and management of the recourses[9]and provide insight into understanding ecosystem processes, Nkheloane et al,2012 [27].Understanding the magnitude and pattern in spatial variability of soil properties is necessary for improved management options application and strategies for sampling and design for field research trials, Khan, et al 2014 [13], such information is needed for enhancing agricultural production and provide as a base for further research by scientists.

Estimating spatial variability of soil properties is significant for evaluating environment and prerequisite for soil and crop specific management ,Iňgo et al 2012[28] ,and provides the factors and processes controlling potential in agriculture production , Akbas,2014 [21].Spatial variability should be studied in every field and understanding this variability has important application in agriculture ,environment ,hydrology and earth sciences ,Biswas, et al 2012 [22]. Alluvial soils are formed by rivers as accumulated sediments deposited at different times show large variations in their properties over short distances and stratification is particular characteristics of it,Gerrard.1987[29] ,and exhibit variations characteristics reflecting the composition of materials transported, Dengiz,2010[30] .For seeing the importance of spatial variability ,and because of limited or little information available for description of spatial variability of soil physiochemical properties of Mesopotamian plain ,this study was directed to characterize and evaluate the spatial variability of soil physiochemical properties of some soils in Mesopotamian plain .

MATERIALS AND METHODS

Study area: A strip transect of (350m*3000m),and(105 hectares) was used as study area .The study area is part of silted basin physiographical sub unit of lower Mesopotamian plain ,which is located about 17 km south of Kut town -Wasit province/Iraq [E 45° 54¯ 29.54= - 45° 53¯ 2.79=to 45° 54 ¯ 36.70=- 45° 53¯9.47= and N 32° 25¯ 36.77= - 32° 25¯28.68= to 32° 26¯41.59=- 32° 26¯ 33.83=],fig (1). Soils are alluvial formed from sediments of Tigris and Euphrates in addition to irrigation sediments of old and modern irrigation systems in the area. And, are characterized by stratification and vary with short distances, Buringh 1960[31]. The climate of study area is semi-arid with average annual precipitation(144 mm) and average monthly temperature (24° C) .The hottest and coldest months are(May to October ;December to February respectively).The soil moisture and temperature regimes are Aridic-Torric and hyperthermic respectively. The land is nearly flat with gentle slopes ranged 11-15 m above mean sea level and resulted from the old and recent irrigation levees, this characterizes the land with a distinct and unique soil-landscape pattern. The land use is cereal cultivation ,fallow or left for grazing. The natural vegetation in the area are, Agool (Alhagi maurorum), Shoke (Lagonychium fractum), Tarfah (Tamarix ramossima), Tertaia (Schanginiaa egytaca) and, Shuwail (Creassa cretiea L.). Field works : a semi-detailed soil survey was carried out using a free lance survey, for recognizing soil series in the study area. Soils were classified according to the soil classification system of Iraqi alluvial soil proposed by, Al-aqidi 1976,[32] and Five main soil series were recognized accordingly (Hai MM5, Amarah MP5, Itdal DW45, Khfajah DF97,and Ghassan DP45). Locations of representative pedons were chosen according to the central concept of each soil series recognized in the area of study. Soil profiles were dug and described systematically according to the specification listed in soil survey manual1993[33]. Soil samples were collected and prepared according to the systematic procedures recommended for the chemical and physical laboratory analyses.

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Laboratory analyses: Soil samples were subjected to physical and chemical analysis where required in this study using methods documented in Black,1965[34] particle size distribution was measured according to Black 1965 [34] methods: ,pH ; EC_e,CEC,OM,ESp,CaCO3 were measured using,21a,23b,,Walkelly and methods respectively ,USDA handbook No 60[35].

Statistical analysis: Analysis of variance and Lsd test were used at ($\rho<0.05$)to measure the variability among soils using SPSS 10 package[36]. Descriptive statistics including (Minimum ,Maximum ,Mean , standard deviation, ,coefficient of variation ,Skewness and kurtosis) were calculated with[SPSS10] to characterize the horizontal and vertical spatial variability of some soil physio-chemical properties among and within soils.

DISCUSSION AND RESULTS

Soil variability is an inherited characteristic reflecting soil forming factors ,the intensity of processes responsible for soil formation, and pedogeomorphic processes acting in the soil-landscape system. This variability is unavoidable phenomena in soil management tasks. The results showed that, studied soils revealed high spatial variability in their physio-chemical properties. Table(1) presents the analysis of variance of physio- chemical soil properties of examined soils. Soil content of sand ranged from 30 $gm.kg^{-1}$ to 780 $gm.kg^{-1}$ in C_2 and A horizons of DF97 (Khfajah) and DP45 (Ghasan) soil series respectively. Silt particles ranged from 100 $gm.kg^{-1}$ to 780 $gm.kg^{-1}$ in C_2 and A horizons of DF97 (Khfajah) and DP45 (Ghasan) soil series respectively. And, clay particles ranged from 90 $gm.kg^{-1}$ to 470 $gm.kg^{-1}$ respectively in C_1 Horizon C_2 and A horizons of DF97 (Khfajah) and DP45 (Ghasan) soil series respectively. Silt particles ranged from 100 $gm.kg^{-1}$ to 780 $gm.kg^{-1}$ in C_2 and A horizons of DF97 (Khfajah) and DP45 (Ghasan) soil series respectively. And, clay particles ranged from 90 $gm.kg^{-1}$ to 470 $gm.kg^{-1}$ respectively in C_1 Horizon of DW45(Itidal) and DF97(Khfajah) soil series respectively. The least significant differences were ($\rho\leq0.05$) 245.06, 202.765 and 113.529 respectively . These differences may be attributed to geomorphic and physiographic setting and positions of these soils in the soil- landscape , the location of the source of material deposited and its sediment type and quantity and not as a result of pedogenetic processes, Moss et al 2010[17], Buringh 1960[31]. Soil electrical conductivity also showed significant differences ,it ranged between 12.30 $dS.m^{-1}$ to 60.7 $dS.m^{-1}$ in C_2 and A horizons of DW45(Itidal).

Table (1): soil physiochemical properties of soil series in studied area and least significant difference.

Soil series	Property / Horizon	Sand $mg.Kg^{-1}$	Silt $mg.Kg^{-1}$	Clay $mg.Kg^{-1}$	Electrical conductivity $ds.m^{-1}$	pH	CEC Cmol . Kg^{-1}	Esp%	Organic matter $mg.Kg^{-1}$	$CaCO_3$ $mg.Kg^{-1}$
MM5 Hai	A	150.00	730.00	120.00	35.50	7.60	14.30	34.00	1.50	23.00
	C_1	450.00	440.00	110.00	16.40	7.60	10.90	21.00	1.10	21.00
	C_2	210.00	650.00	140.00	15.80	7.30	13.60	21.00	1.40	20.00
	C_3	100.00	650.00	250.00	19.80	7.70	22.10	24.00	1.10	18.00
	A	100.00	720.00	180.00	51.00	7.10	22.50	35.00	1.90	20.00

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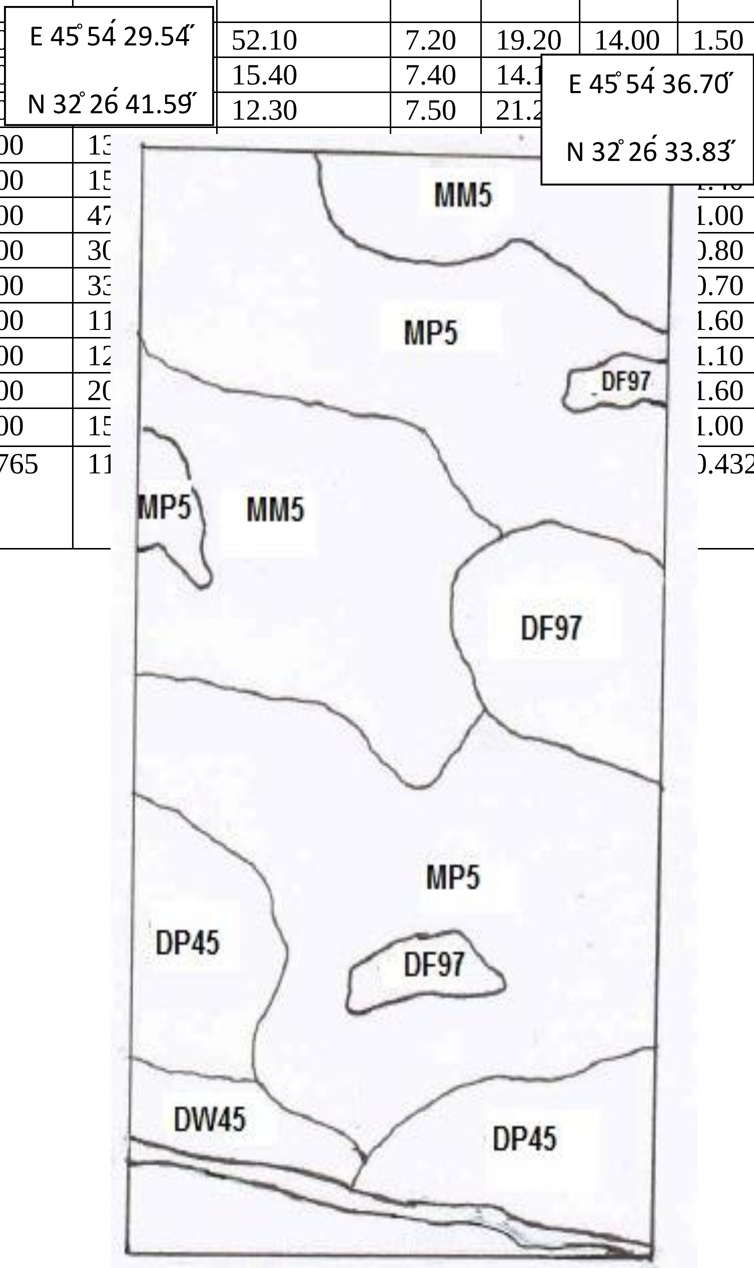
MP5 Amarah	C_1	140.00	710.00	150.00	32.10	7.40	16.30	28.00	0.40	17.00
	C_2	290.00	570.00	140.00	19.20	7.80	22.90	29.00	0.40	18.00
	C_3	420.00	460.00	120.00	17.10	7.90	11.60	27.00	0.30	19.00
DW45 Itidal	A	130.00	720.0	[illegible]	52.10	7.20	19.20	14.00	1.50	24.00
	C_1	330.00	580.0	[illegible]	15.40	7.40	14.1	[illegible]	[illegible]	25.00
	C_2	50.00	780.0	[illegible]	12.30	7.50	21.2	[illegible]	[illegible]	25.00
	C_3	600.00	270.00	13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18.00
DF97 Khfajah	A	70.00	780.00	15	[illegible]	[illegible]	[illegible]	[illegible]	1.40	18.00
	C_1	50.00	480.00	47	[illegible]	[illegible]	[illegible]	[illegible]	1.00	20.00
	C_2	30.00	670.00	30	[illegible]	[illegible]	[illegible]	[illegible]	.80	21.00
	C_3	50.00	620.00	33	[illegible]	[illegible]	[illegible]	[illegible]	.70	23.00
DP45 Ghasan	A	780.00	110.00	11	[illegible]	[illegible]	[illegible]	[illegible]	1.60	17.00
	C_1	760.00	120.00	12	[illegible]	[illegible]	[illegible]	[illegible]	1.10	21.00
	C_2	400.00	400.00	20	[illegible]	[illegible]	[illegible]	[illegible]	1.60	21.00
	C_3	750.00	100.00	15	[illegible]	[illegible]	[illegible]	[illegible]	1.00	20.00
Lsd ($p < 0.05$)		245.06	202.765	11	[illegible]	[illegible]	[illegible]	[illegible]	.432	Ns



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E 45° 53′ 2.79″
N 32° 25′ 36.77″

E 45° 53′ 9. 47″
N 32° 25′ 28.68″

Fig . 1 Location and soil map of study area

DF97(Khfajah) respectively. These differences are due to the soil management practices applied and practiced in the area , the close interface of ground water level, and the rule of river which is adjacent to DW45(Itidal) which acts as a natural drain for these soils. Table(2) presents the correlations between soil physio-chemical properties of the studied soils. The highest positive correlations were 0.965 and 0.941 between clay particles and electrical conductivity, and between sand particles and pH in C_1 and C_3 horizons respectively. . And, the highest inversely correlations were -0.997 and -0.981 between sand and silt particles ,and between $CaCO_3$ and ESp in A and C_2 in horizons respectively. Whereas, the lowest positive correlation

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was 0.008 between sand and organic matter in C_3 horizon , whilst, the lowest inversely correlation was -0.017 between ESP and clay particles in C_1 horizon.

The studied soils exhibited high horizontal variability in their content of sand ,silt and clay. Table (3) represent the extent of horizontal spatial variability of soil physio-chemical properties among soils in studied area .It shows ,that, sand, silt and clay were highly variable(>35%), and their coefficient of variation were 78.327%, 49.062% and 36.734% respectively. Sand and clay particles were positively highly skew (1.373) And (2.184)respectively and of platykurtic and leptokurtic shape of distribution (2.929) and (3.73 9) respectively. Whilst, Silt particles were negatively highly skew (-2.189) and of leptokurtic (4.830) distribution . The pattern of the horizontal variability of these particles in studied soils was taking the form of sand > clay > silt ,this is may be due to the location of these soils in respect to the location of the source of deposition, in addition to the type of the sediments carried by it, Al Mohaimeed 1999 [37]. Chemical

Table 2 spearman correlation matrix for soil properties variables A Horizon

$CaCO_3$	OM	ESP	CEC	pH	EC_e	C	Si	S	Soil property
	0							1	Sand
							1	-0.997	Silt
						1	0.632	-0.686	Clay
					1	0.792	-0.848	0.869-	EC e
				1	-0.973	0.881-	0.887-	0.914	pH
			1	-0.793	0.884	0.572	0.667	-0.679	CEC
		1	-0.158	0.054	-0.216	0.104	0.096	-0.099	ESP
	1	0.573	-0.270	-0.090	-0.098	0.524	-0.109	0.054	O.M
1	-0.110	-0.089	-0.161	-0.315	0.227	0.135	0.569	-0.546	$CaCO_3$

C_1 Horizon

$CaCO_3$	OM	ESP	CEC	pH	EC_e	C	Si	S	Soil property
								1	Sand
							1	- 0.822	Silt
						1	0.064	- 0.620	Clay
					1	0.645	0.414	- 0.751	EC_e
				1	-0.597	-0.557	0.824	0.965	pH
			1	0.827	0.698	0.927	0.414	- 0.853	CEC
		1	-0.025	0.619	0.020	-0.017	0.287	- 0.215	ESP

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.	1	-0.806	-0.162	0.368	0.767-	0.368	-0.642	0.509	O.M
1	0.668	-0.877	-0.054	-0.168	-0.675	-0.204	0.060	0.068	$CaCO_3$

C_2 Horizon

$CaCO_3$	O.M	ESp	CEC	pH	EC_e	clay	silt	sand	Soil property
								1	Sand
							1	-0.907	Silt
						1	0.029	-0.446	Clay
					1	-0.532	-0.072	-0.308	EC_e
				1	-0.460	-0.532	-0.555	0.721	pH
			1	-0.479	0.814	0.754	0.441	-0.712	CEC
		1	-0.112	0.445	0.176	-0.251	-0.617	0.657	Esp
	1	-0.287	-0.646	-0.164	-0.288	-0.047	-0.366	0.347	O.M
1	0.287	-0.981	0.022	-0.269	-0.271	0.177	0.527	-0.547	$CaCo_3$

C3 Horizon

$CaCO_3$	O.M	ESp	CEC	pH	EC_e	clay	silt	sand	Soil property
								1	Sand
							1	-0.978	Silt
						1	0.713	-0.843	Clay
					1	0.941	0.711	-0.824	EC_e
				1	-0.126	-0.261	-0.147	0.190	pH
			1	-0.567	0.634	0.795	0.821	-0.865	CEC
		1	0.137	0.515	0.138	0.026	0.628	-0.489	Esp
	1	-0.419	0.311	-0.135	-0.030	0.278	-0.119	0.008	O.M
1	-0.170	-0.225	0.150	-0.036	0.816	0.665	0.205	-0.355	$CaCO_3$

properties also showed high variability in the horizontal scale. The coefficient of variation of soil chemical properties ranged from2.840% to 47.794% for pH and CEC respectively. The highly variable property in the horizontal extent (c.v.=>35%) was CEC (c.v.=47.794%) and the moderately variable properties(c.v. =34%-15%) were O.M ,EC_e and ESP, their coefficients

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of variations were 21.528%,29.835% and 33.434% respectively .The low variable properties (c.v.<15%) were pH and $CaCO_3$ their coefficients of variation were 2.840% and 8.402% respectively. Most chemical properties were highly positively skew (0.730,0.912,0.945 and 1.1750) for pH,$CaCO_3$,ECe and CEC respectively, except for Esp was symmetrical (-0.006) and they were of leptokurtic to platy kurtic shape of distribution 0.178,7.275,2.475,-0.710 and 1.130 for EC_e, pH ,CEC, O.M, and $CaCO_3$ respectively. These variation in chemical properties are mostly related to the type of soil management practiced and applied in the area of study ,the nature of soil parent material ,quality of irrigation water used and the role of the depth of ground water ,Al agidi 1990 [38],Almohammed,199 [37], Al-Aatab, 2008[39], Aldolaimi,2009 [40] , Abel Chemura ,et al 2014 [41] ; Ally-Said Matano,

Table (3): Descriptive statistics of the horizontal spatial variability of some physio-chemical properties of some soil series in Mesopotamian plain.

Property series / soil	sand mg.Kg^{-1}	silt mg.Kg^{-1}	clay mg.Kg^{-1}	EC_e Ds.m^{-1}	pH	CEC Cmol. Kg^{-1}	ESP%	OM mg. Kg^{-1}	$CaCO_3$ mg. Kg^{-1}
MM5	227.500	617.500	155.000	21.878	7.525	15.225	75.000	1.275	20.500
MP5	237.500	615.000	147.500	29.850	7.550	18.325	29.750	0.750	18.500
Dw45	277.500	587.500	135.000	23.500	7.350	17.700	11.500	0.975	23.000
DF97	50.000	637.500	312.500	38.300	7.237	32.975	18.525	0.975	23.000
DP45	672.500	182.500	145.000	18.325	7.825	8.750	19.000	1.325	19.250
Min.	30.000	100.000	90.000	12.300	7.100	6.800	9.000	0.300	17.000
Max.	780.000	780.000	470.000	60.700	7.900	40.100	35.000	1.900	25.000
Mean	293.000	528.000	254.000	26.370	7.505	18.595	20.755	1.085	20.350
St.d	229.499	193.598	124.619	7.867	0.213	8.887	6.939	0.235	1.710
C.V%	78.327	36.734	49.062	29.835	2.840	47.794	33.434	21.528	8.402
Skewness	1.373	-2.189	2.184	0.945	0.730	1.175	-0.006	-0.596	0.912
Kurtosis	2.929	4.830	3.739	0.178	7.275	2.475	-0.324	-0.710	1.130

St.d= standard deviation ; C.V = Coefficient of variation ,CEC= Cation of exchangeable capacity ; Esp =Exchangeable sodium percentage ;OM=Organic matter; EC_e=Electrical conductivity, [42] the pattern of spatial variability of chemical properties was taking the form CEC>ESP>EC>O.M>$CaCO_3$>pH.And the shape of spatial variability pattern of physio-chemical properties was S>c>CEC>silt>ESp>Ec>O.M>$CaCO_3$>pH. Moreover, soils exhibited High(cv=>35%) to moderately(cv=15-35%) vertical spatial variability in their content of sand ,silt and clay (table 4).The coefficient of variation of sand particles ranged between 27.077% to 88.337% in DP45(Ghasan) and DW54(Itidal) soil series respectively .Sand particles were moderately(0.570) to highly skew (1.516) in MP5 (Amarah) and MM5 (Hai) soil series respectively, and of platy Kurtic to leptokurtic distribution except for DF97 (Khfajah) was symmetrical (1.5) . The pattern of vertical spatial variability of sand particles having the form of DP45 < DF97 <MP5<MM5<DW45.

The coefficient of variation in silt particles ranged between 19.524% to 79.577% in DF97 and DP45 respectively. And, the particles were highly skew (-1.426) to approximately symmetrical (-0.34) in MM5 (Hai) and DF97 (Khfajah) soil series respectively ,and, were of platy kurtic distribution except for DP45 (Ghasan) was of leptokurtic (3.936) distribution. The vertical

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variation pattern of silt particles was taking the form of DP45 > DW45 > MP5 > MM5 > DF97. Clay particles showed vertical spatial variability as well .The coefficient of variation of clay particles ranged from 16.949% to 41.998% in MP5 (Amarah) and DF97 (Khfajah) soil series respectively. Clay particles were mostly moderately skewed(-0.752 to 0.56) for MP5,DW54 and DP45 ,though, they were highly skewed (1.784) in MM5 and approximately symmetrical in DF97(-0.112).Clay particles were of platy kurtic distribution in all soil series except in MM5 was of leptokurtic distribution(3.223) .The pattern of vertical spatial variability of clay particles was taking the form of DF97 > MM5 > DP45 > DW45 > MP5 . Sand particles were the most variable parameter in the vertical direction and clay was the lowest one, and the pattern of their variability took the form of (Sand> Silt > clay) in studied soils . These variations may be attributed to different cycles of deposition that soils of the area which was subjected to ,and the different types of sediments deposited in each cycle ,al agidi 1994[43], Muhaimeed and Salih Alani,2013 [44].

Table 4:Descriptive statistics for the vertical spatial variability of physiochemical properties of soils of the study area.

Soil series	Statistical parameter	Sand $mg.Kg^{-1}$	Silt $mg.Kg^{-1}$	clay $mg.Kg^{-1}$	EC_e $Ds.m^{-1}$	pH	CEC $Cmol.Kg^{-1}$	Esp %	O.M $mg.Kg^{-1}$	$CaCO_3$ $mg.Kg^{-1}$
MM5	Mean	227.500	617.500	155.000	21.875	7.525	15.225	25.000	1.275	20.500
	St.d	155.000	124.197	64.549	9.252	0.170	4.812	6.164	0.206	2.081
	C.V %	68.131	20.112	41.645	42.297	2.269	31.616	24.657	16.169	10.154
	Skewness	1.516	-1.426	1.784	1.794	-0.752	1.429	1.707	0.199	0.000
	Kurtosis	2.388	2.681	3.223	3.210	0.342	2.611	2.829	-4.858	0.390
MP5	Mean	237.500	615.000	147.500	29.850	7.550	18.325	29.75	0.750	18.500
	St.d	146.600	123.962	25.000	15.581	0.369	5.406	3.593	0.768	1.290
	.V % C	61.726	20.156	16.949	52.200	4.896	29.502	12.080	102.415	6.978
	Skewness	0.570	-0.629	0.560	1.091	-0.475	-0.607	1.696	1.977	0.000
	Kurtosis	-2.207	-2.422	0.928	0.038	-2.716	-2.168	3.014	3.928	-1.2
DW45	Mean	277.500	587.500	135.000	23.500	7.350	17.700	11.500	0.975	23.000

	St.d	245.136	227.651	34.156	19.109	0.129	3.131	2.081	0.309	3.366
	C.V %	88.337	38.749	25.301	81.316	1.756	17.692	18.101	26.761	14.637
	Skewness	0.846	-1.274	-0.752	1.973	0.000	-0.068	0.000	1.137	-1.887
	Kurtosis	-0.597	1.198	0.342	3.912	-1.200	-2.168	0.390	0.757	3.576
DF97	Mean	50.000	637.500	312.500	38.3000	7.275	32.975	18.525	0.975	20.500
	St.d	16.329	124.465	131.244	15.290	0.170	8.897	2.408	0.309	2.081
	C.V %	32.659	19.524	41.998	39.924	2.347	26.983	13.003	31.750	10.154
	Skewness	0.000	-0.340	-0.112	1.732	0.752	-0.984	1.550	1.137	0.000
	Kurtosis	1.500	0.790	1.248	3.066	0.342	-0.584	2.713	0.757	0.390
DP45	Mean	0672.50	182.500	145.000	18.325	7.825	8.750	19.000	1.325	19.230
	St.d	182.094	145.229	34.156	1.820	0.095	2.120	4.690	0.320	1.707
	C.V%	27.077	79.577	25.301	9.936	1.223	24.234	24.686	24.162	8.871
	Skewness	-1.971	-1.033	-0.752	1.973	0.854	0.775	-0.542	-.083	0.752
	Kurtosis	3.909	3.936	0.342	3.912	-1.289	-1.125	-0.152	0.757	0.342

Soils also showed a vertical spatial variability in their chemical properties . MM5 (Hai) , DW45 (Itidal) , DF97(Khfajah) soil series exhibited high variability (CV>35%) in EC values. . Their coefficients of variation were 42.297% ,52.200% and 41.998 respectively.

Whilst, MP5 (Amarah) soil series showed high vertical spatial variability (CV>35%) in OM and EC values and their coefficients of variation were 102.41% and 52.2 % respectively.MM5 (Hai), DW45 (Itidal), ,and DP45 (Ghassan) soil series showed moderate variability (CV=35%-15%) in CEC, Esp and OM only ,their coefficients of variation were 31.606%, 24.297% and 16.169% for MM5(Hai) ;17.692%,18.101%,and 26.762% forDW45 (Itidal) Soil series and 24.234 , 24.686 , 24.162 for DP45 (Ghassan) soil series respectively.However.DF97 (Khfajah) soil series showed moderate vertical variability in CEC and OM with coefficient of variation 26.983% and 31.75% respectively. All soil series showed low vertical spatial variability in pH and $CaCO_3$ except for Dp45 soil series was in EC ,pH and $CaCO_3$ with coefficient of variation 9.936%,1.223% and 8.871% respectively .These variation are attributed to different soil managements , the local environment revealed in the area , quality of irrigation water used

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,few and sparse natural vegetation, the calcareous nature of parent material and tillage effects[4,14,38,39,40,44,].

Soil Horizons showed high(CV=>35%) to moderate (CV=35%-15%) horizontal spatial variability in terms of the amount of sand, silt and clay particles (table 5). Sand was the highest variable parameter (CV%=121.971%) in A horizon and was the lowest in C_3 (CV=79.642%) . And A horizon was the most variable horizon in sand content and, the pattern of spatial variability was A > C_1 > C_2 > C_3 soil horizons. Silt particles also vary horizontally in soil horizons , their highest coefficient of variation was in A horizon (CV=64.037%) and the lowest were in C_2 horizon (CV=22.992%) . The pattern of horizontal spatial variability of soil horizons in terms of coefficient of variation in silt particles content was taking the form A > C_3 > C_1 > C_2 . Soil Horizons vary considerably in terms of their content of clay particles as well. Their coefficients of variation ranged from 19.549% to 84.633% in A and C_1 horizons respectively .The pattern of clay particles spatial variability was taking the shape C_1 > C_3 > C_2 > A. In this respect sand showed the highest variability in A (CV=121.971%) ,C_2 (CV=80.785%) and C_3 (CV=79.642%) horizons and the lowest variable were clay particles in A (CV=19.540%) and C_3 (cv=46.426%) horizons. Whereas, silt was the lowest variable in C_1 (CV=47.447%) and C_2 (CV=22.992%) horizons .These variation are not as a result of pedogenic processes, but they are attributed to the geomorphic aspects and to the different cycles of flooding and sedimentations processes that, the area was subjected to, and to the quantity and type of the load which was carried with flooding water and its velocity at time of sedimentation[9;16 Al Mohaimeed17; 37,39,40,38 Al agidi1990;44]. In addition, soil horizons showed horizontal spatial variability in their chemical properties. The horizontal variability of soil chemical properties of soil horizons ranged between low (<15%) and high (>35%) .A,C1 and C2 horizons showed horizontal variability ranged from CV=(4.667% , 2.66%), (59.151%,58.581%) and (3.304%,50.815%%) in pH and CEC respectively .But , C3 Horizon showed horizontal spatial variability ranged between (CV=3.304%-39.334%) in pH and O.M respectively. A horizon showed high ,moderate and low spatial variability in EC (36.390%) and CEC(59.151%) ; Esp(34.050); and pH ,O.M and $CaCO_3$ respectively. C1 horizon Show high horizontal variability in Ec (36.396%(and CEC (58.581%) and moderate horizontal variability in Esp(32.295%) and OM(32.442%),though low horizontal variability in pH(2.66%) and $CaCO_3$) was found .C2 horizon showed high variability in Cec(50.815%),OM(45.91%),EC(43.081%) and Esp(36.655%).But showed low variability in pH(3.399%) and $CaCO_3$(12.1%). C_3 horizon ,have horizontal variability as well in O.M(39.334%),Esp(36.159%) and CEC (35.114%).And moderate horizontal variability in EC_e (26.571%) .And has low variability in pH(3.304%) and $CaCO_3$(10.500%). The form of their spatial horizontal variability pattern was taking the form of (CEC>Ec_e>ESp>$CaCO_{3>}$>O.M >pH) , (CEC>Ec_e>O.M>ESp>$CaCO_{3>}$ >pH),(CEC> >O.M> EC_e >ESp>$CaCO_{3>}$ >pH) and (O.M> ESp> CEC > EC_e $CaCO_{3>}$> pH) in A,C_1,C_2 and C_3 horizons respectively. These horizontal variations of chemical properties are due to different soil management practices used in the area and other factors mentioned above.[4;14;37,38;39;40].

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Table (5) descriptive statistics for the horizontal variability of some physio-chemical properties of soil horizon.

Horizon / Soil property	A			C_1			C_2			C_3		
	mean	St.d	C.V %	mean	St.d	C.V %	mean	St.d	C.V %	mean	St.d	C.V %
Sand mg.Kg^{-1}	246.000	300.050	121.971	346.000	279.510	80.785	169.000	157.734	80.476	384.000	305.826	79.642
Silt mg.Kg^{-1}	612.000	281.726	64.037	466.000	219.705	47.447	614.000	141.173	22.992	420.000	234.201	55.762
Clay mg.Kg^{-1}	142.000	27.748	19.540	188.000	159.122	84.633	190.000	66.332	34.911	196.000	90.994	46.426
EC_e ds.m^{-1}	43.940	15.989	36.390	22.360	08.132	36.396	20.300	08.745	43.081	18.880	05.016	26.571
pH	07.360	00.343	04.667	07.500	00.200	02.666	07.500	00.254	03.399	07.660	00.260	03.304
CEC Cmol. Kg^{-1}	20.700	12.244	59.151	15.860	09.291	58.581	21.740	11.047	50.815	16.080	05.646	35.114
ESP%	25.800	08.786	34.055	19.100	06.186	32.295	19.620	07.191	36.655	18.500	06.689	36.159
O.M mg.Kg^{-1}	01.580	00.192	12.174	00.940	00.304	32.442	01.040	0.477	45.91	00.780	00.311	39.334
$CaCO_3$ mg.Kg^{-1}	20.400	03.490	14.449	20.400	02.966	14.541	21.000	02.549	12.100	19.500	02.073	10.500

St.d= standard deviation C.V= Coefficient of variation

CONCLUSIONS AND RECOMMENDATIONS

Estimating spatial variability of soil physio-chemical attributes is significant issues for evaluating environments and prerequisite for soil and crop management and sustainable agriculture in addition to identifying zones of degradation. Studied soils have pronounced a horizontal and vertical spatial variability in their physio-chemical characteristics .These variations was within and among pedons of the studied soil series . Pedogeomorphic processes and soil management practices were the main participant aspects, that caused these variations. CEC, and EC were the most variable parameters and showed high variability in most soils. In contrary, pH and $CaCO_3$ were the least variable properties and show low spatial variability in most studied soils as well. Type ,load and the location of sedimentation source (agent) was effective in producing these variations in both horizontals and vertical extents. Hence, deep study and evaluation of soil spatial variability is crucial for best and effective soil sampling scheme, correct allocation of experimental stations ,better soil management practices,

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delineating a site specific management units and sustainable agriculture.

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