

FORMATION AND DEVELOPMENT OF VERTISOLS IN SELIVANY PLAIN AT DUHOK GOVERNORATE, KURDISTAN REGION, IRAQ

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ABSTRACT

The study area located at the Selivany plain in Duhok governorate, Kurdistan Region, Iraq. Forty-three soil samples were taken from horizons in all studied pedons then physically and chemically analyzed according to standard methods. The studied soils were slightly alkaline non-saline. The values of CEC increased with increasing clay content. The studied soils considered Vertisols and occurs pedoturbation, in turn, trans-locating organic matter from surface to subsurface and deep horizons, additionally, existing plant roots contribute in increasing organic matter in these horizons, and the humification process can occur in different soil horizons. Total carbonate content increased with increasing depth in subsurface horizons this due to the origin of limestone parent materials. The differences in carbonate distribution manner indicated to development. The studied soils contain a considerable amount of active carbonate that affecting different soil properties. Relatively high clay content in studied soils and its content at the surface horizons are lower than it at subsurface horizons. The high value of clay and silt content indicates to soil development. The following pedogenic processes can be specified loss, gain, leaching, illuviation, eluviation, alkalization, humification, lessivage, desalinization, calcification, decomposition, synthesis, pedoturbation, and braunification. Humification processes of organic matter are predominate because the ratio of carbon to nitrogen (C / N) is less than 25. According to the criterion (Total clay in B-horizon / Total clay at A-horizon) most of the studied pedons (1, 3, 6, 7, 8, 9, 10, 12, 13, and 14) considered as well developed soils. The ratio of (Active carbonate/ Total carbonate) was high ranged between (0.31-3.14%), and this may be due to the high weathering intensity of parent material, as a result of increased the ratio mass of active carbonate to total carbonate.

KEYWORDS: Soil Development, Texture, Clay, Soil horizons, Active carbonate, Total carbonate

1. INTRODUCTION

Soil development includes many process of weathering, fracturing, and comminution of rock into mineral soil particles (Mavris *et al.*, (2010), and it takes into consideration the complex interactions among earth material (bedrock, rocks, clay, and sand), the topography, the climate and living organisms, the location of certain elements in the landscape (Madigan and Martinko, 2006). Obviously, calcareous horizons are usually considered to have developed as the subsurface calcic or petrocalcic horizon of soil (Durand *et al.*, 2018). Accumulation of clay by illuviation in soils is a proven reality since the occurrence of illuvial clay horizon known as the argillic horizon that has been recognized in Soil Taxonomy as a subsurface diagnostic horizon

for grouping soils at the order level (Bockheim *et al.*, 2014). The argillic (textural B) horizons of a large number of calcareous sodic soils developed in the loamy-textured parent material and in the semi-arid part of Indo-Gangetic Plains in India are developed due to illuviation of the fine clay under ustic soil moisture regime (Srivastava *et al.*, 2002). Concurrently, Elliott, and Drohan, (2009) concluded, abundant carbonate in alluvial parent materials can prevent the development of argillic horizons. Otherwise, accumulations of clays and oxides reflect the stage of pedogenic development.

The age of a soil formation identifies the properties of soil in various ways, for instance, the soil formation can change the physical, chemical and mineralogical compositions of soils, or it can form a number of different soil horizons. With the time, the soil formation,

mobilization and redistribution of elements during weathering sequenced by several pathways (Carnicelli and Costantini, 2013). The collection of pedogenic calcium carbonates is an important pedogenic procedure for arid and semi-arid regions and horizons enhanced with pedogenic calcium carbonate are often the most distinguishing features in such soils, and the appearance of both calcium carbonate aggregation and oriented clay at the same horizon indicates a complicated history of carbonate leaching, secondary calcite deposition, and clay illuviation (Khormali *et al.*, 2012). The parent material characters and chemical composition plays a substantial role in defining soil properties, particularly through the early development stages. Soils developed on parent material that is coarse grained and formed of minerals resistant to weathering are probably presented coarse grain texture. Fine grain soil develops where parent material consists of brittle, readily weathering minerals. Soils formed over sandstone are low in soluble bases and coarse texture, making leaching easier (Earthonlinemedia.com, 2020). In line with this Egli *et al.*, (2014) suggest a clay accumulation index which yielded a useful relationship between clay accumulation and age in Bt horizons (Argillic horizons). Soil textural analysis is a key component of any minimum data set used for assessing soil quality and sustainability of agricultural-management practices (Kettler *et al.*, 2001). This study aimed to specify soil formation and development in different locations at Sulaivani plain according to the particular criteria.

2. METHODS AND MATERIALS

2.1. Study Area and Field Works with Soil Samples Preparation

The study area located at the Selivany plain in Duhok governorate, Kurdistan Region, Iraq (Figure, 1). Digging (14) pedons, one in each study location, and specify soil horizons according to the principles of soil survey staff (2006) with taking (43) soil samples from horizons in all studied pedons, then air dried, grinded and sieved by (2) mm sieve for physical and chemical analysis. The area of each study location was approximately equal to (100) Donum.

2.2. Laboratory Analysis

Particles size distribution determined by hydrometer method as described by (Klute, 1986). Soil pH and EC were measured in soil suspension (1:1) (soil: water) with using pH-meter, and EC-meter according to (Rowell, 1996). Soil organic matter was determined by wet combustion method with using potassium dichromate as oxidizing agent (Walkley and Black, 1965). Total carbonates measured with using calcimeter device (Loeppert and Saurez, 1996). Active carbonate was determined by using ammonium oxalate (0.2) N according to the method of Kozhekov and Yakovleva (1977). Cation exchange capacity was measured by flame photometer as used by (Polemio and Roads, 1977). Total soil nitrogen was determined after digesting the soil sample by sulfuric acid (H_2SO_4), according to (Bremner and Mulvaney, 1982), with using Kjeldahl apparatus.

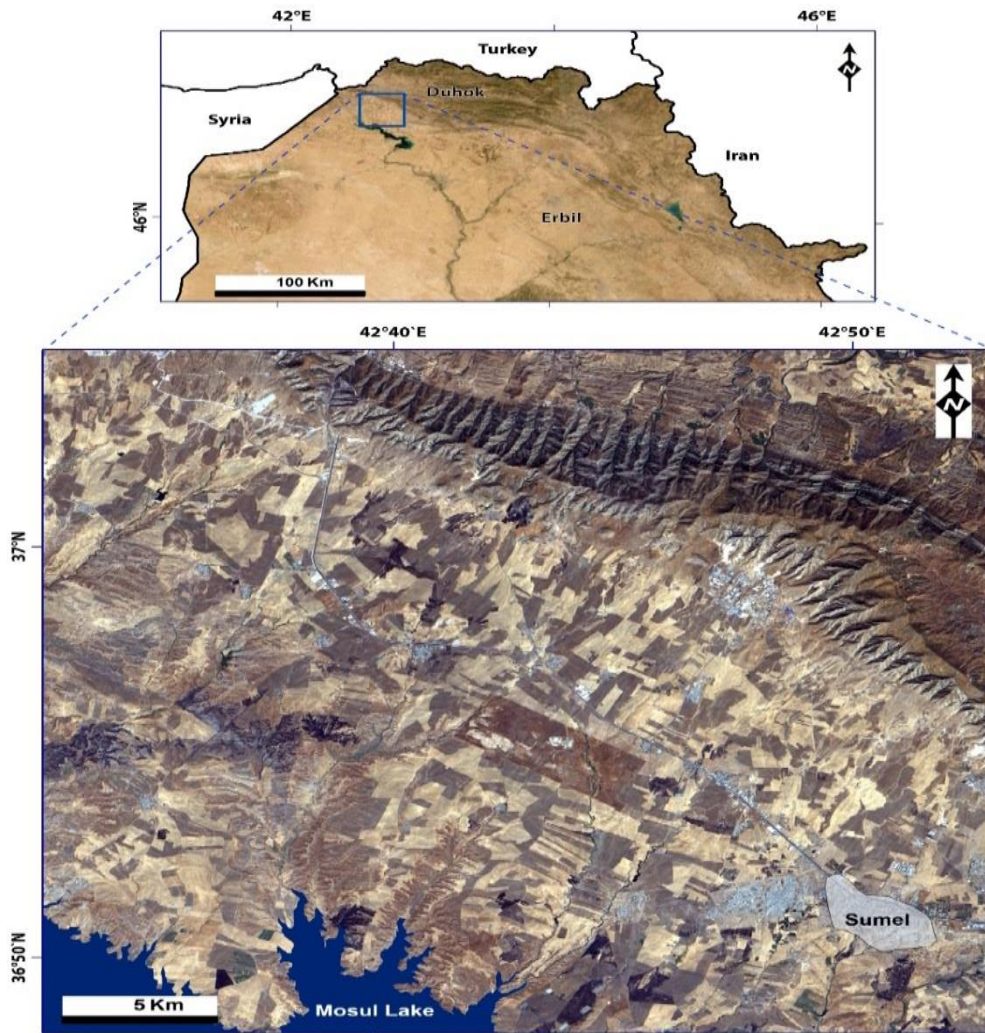


Fig. (1): Image showing the location of the study area (using Landsat 8)

3. RESULTS AND DISCUSSION

3.1. Soil Reaction and Electrical Conductivity

The pH of the studied soils is slightly alkaline as a result of the increasing calcium carbonate and in general the pH value of the studied pedons tends to rise slightly with increasing depth, this is due to the fact that the studied soils are derived from calcareous. The lowest value of soil pH was (7.14) on the horizon (B1hk) in pedon (1) attributed to the influence of humified organic matter and organic acids formed as a result of the decomposition organic matter, while the highest value of soil pH was (7.87) in the subsurface horizon (Bw) of pedon (12) due to the increase of active calcium carbonate and the low content of organic matter at this horizon (Table, 1). The results of the electrical conductivity for all the samples denoted that the soils of the studied locations were not saline soils and have low values of EC, the studied soils derived from limestone parent

material and contain a high amount of calcium carbonate that is low soluble in water (Table, 1).

3.2. Cation Exchange Capacity (CEC)

Generally the values of CEC increased with increasing clay content and low sand when the highest value was $36.24 \text{ Cmole}_c.\text{kg}^{-1}$ in (Bt) horizon in pedon (9) which has clay content (511 g. kg^{-1}) and sand (49 g. kg^{-1}), while the lowest value of CEC ($14.34 \text{ Cmole}_c.\text{kg}^{-1}$) was found in (Ap) horizon in pedon (1) which has the value of clay content (226 g. kg^{-1}) and sand (559 g. kg^{-1}) (Table, 1). These results agreed with Khresat and Qudah (2006) who showed that CEC values are dependent on soil texture. CEC increased in deep soil horizons in study pedons (3, 7, 8, 9, 10, 12, 13, and 14) as a result of increase clay content towards the downward direction of soil pedons by rainfall action, and occurring of lessivage process, whereas CEC values decrease with depth in pedon (5, and 11), this may be due to the effect of decrease clay content with depth. The cation exchange

capacity fluctuated between increase and decrease in study pedons (1, 2, and 4) this may be attributed to the conditions of each soil pedon moreover the effect of cracks, soil structure, and carbonate, (Table, 1).

3.3. Organic Matter

The highest organic matter content (47) g. kg⁻¹ was found in the lower horizon (Ch) in pedon (14) at Msirike location, this is because of existing large cracks that causes translocate of organic matter as a litter from upper horizons to lower horizon. The lowest value (15) g. kg⁻¹ was noted in (Ap) horizon in pedon (1) at Marina location (Table, 1) as a result of digging pedon near the valley and increase slopping, in turn, increase erosion and removal of organic matter. The results indicated that the amount of organic matter was higher in the soil surface and decrease with depth in soil pedons (3, 4, 5, 7, 8, 11, and 13) this is due to the accumulation of the considerable amount of plant residuals (litter) at the upper part of the soil, and increasing organisms activity in the biosphere at the root zone, in turn, causes decomposition of litter and increasing humified organic matter in the surface horizon of soil under the effect of optimum soil moisture regime and optimum soil temperature regime, since there is a close association between the precipitation, temperature and the level of soil organic matter as observed by Pulleman *et al.*, (2000).

In spite of ordinarily, soil organic matter accumulates at surface soil horizons, however, the organic matter content was decreased in some soil surface horizons and increased towards downward in the subsurface and deep horizons as shown in pedons (1, 2, 9, 10, 12, and 14), this was attributed to different reasons such as occur erosion process as a result of rainfall effect and increase location slope, on the other hand, study soils considered Vertisols that contain cracks in different sizes and occurs pedoturbation of soil in pedon by up to down it and self- churning of pedon materials, in turn, trans-locating organic matter from surface horizons to subsurface and deep horizons, additionally, existing plant roots contribute in increasing organic matter in these horizons. We have noticed and concluded in many pedons of study locations the organic matter was higher in the subsurface and deep horizons more than it in surface horizons this is attributed to the effect of cracks because of study soils followed Vertisols order according to USDA soil taxonomy. Consequently, the humification process can

occur in different soil horizons not just in surface horizons in Vertisols in contrast to other soil orders that have ordinarily, high organic matter in surface horizons.

3.4. Total and Active Carbonate

The amount of total carbonate content generally increased with increasing depth in the subsurface or downward soil horizons this due to the origin of parent materials that were derived from limestone, the carbonate distribution pathway explained the vertical increase in some study pedons as in pedons (4, 6, 8, and 9), (Table, 1) but in general, the distribution pattern showed fluctuation in carbonate content among soil horizons in remaining study pedons. Total carbonate content values were ranged between (180.9-319.8) g.kg⁻¹ of study soils. The lowest value of carbonate (180.9 g.kg⁻¹) showed in soil horizons (B2ss, Ch, and B2th) in pedons (2, 5, and 7) respectively, this may be due to the conditions of soil formation in each pedon separately. While, the highest value was found in the subsurface horizon (Bw) in pedon 12 at Gerash location, this highest value due to the high weathering of parent materials, which was derived from limestone and occurring calcification process that included accumulation of calcium carbonate because of rainfall effect. Generally studied soils consider as calcareous that have a high content of carbonate minerals as a result of the calcification pedogenic process. The differences in distribution manner, and carbonate minerals content along soil pedons and among its horizons indicated to development of studied soils, contrary, in the immature soil, carbonate distribution ordinarily is homogeneous as a result of decrease the effect of pedogenic factors in the soil formation. On the other hand, the comparison of total carbonate in surface horizons of study pedons appear the high value in pedon (12) but commonly the general distribution of total carbonate in (Ap) surface horizon was located in two major zones the first was in a gray zone (200- 220) g. kg⁻¹ that include pedons (1, 2, 4, 6, 8, 9, and 10) and the second was in the brown zone (220- 240) g. kg⁻¹ which include pedons (5, 7, 11, 13, and 14) (Figure, 2)

The value of active carbonate ranged between (70- 280) g. kg⁻¹ which was found in (Bh) horizon in pedon (8) and (Bw) horizon in pedon (12) respectively. The distribution of active carbonates in soil pedons (2, 4, 9, 10, 11, 12, and 14) of study locations generally increased with depth as a result of leaching and most the active carbonates are associated with clay

particles that are increasing with depth, and these results agreed with similar results of (Rashid, 2017) about carbonate distribution. On the other hand, the active carbonate in the remaining study pedons fluctuated between increasing and decreasing and this is due to the conditions of each soil pedon (Table 1). The

studied soils contain a considerable amount of active carbonate that affecting soil properties such as reducing cation exchange capacity through coating soil particles and increasing this particle size in turn decrease adsorption cations on it surfaces, increase soil pH values, and causes calcification pedogenic process.

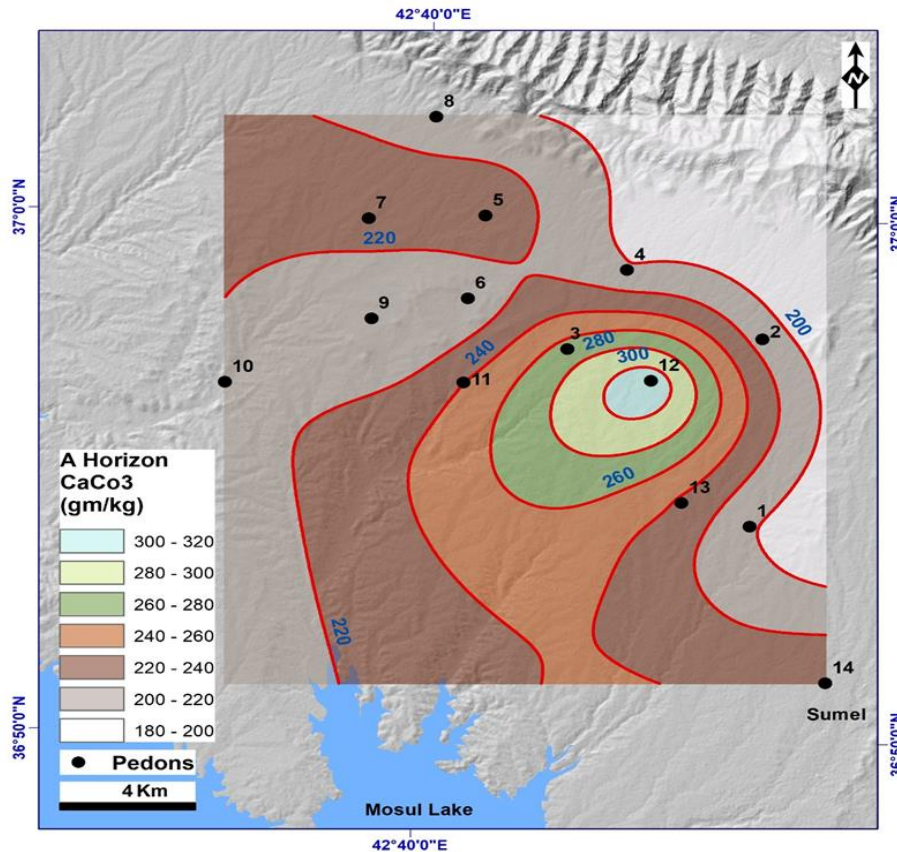


Fig. (2): Spatial distribution of total calcium carbonate in (A) horizon of the studied pedons

3.5. Particles Size Distribution

The particle size distribution indicated to a relatively high clay content of soil samples and its content at the surface horizons is lower than that of the subsurface and deep horizons for most studied pedons. In spite of this, in other pedons, the clay content fluctuated between increasing and decreasing for different soil horizons. An increasing in clay content with increasing soil depth may be due to in situ clay formation, or may be due to the lessivage process as a result of leaching. The highest clay value was (551 g kg^{-1}) in the surface horizon (Ap) at Kwashi location and in the underlying horizons (B2t, and B1ss), (541 g Kg^{-1}) at Shkavdle and Kwashi locations respectively, whereas the lowest clay content value was (191 g.kg^{-1}) in the surface and subsurface horizons (Ah, and Bw) in pedon (6) at Batile1 location

and in (Ch) horizon in pedons (11) at Batile2 location. Figure (3) show the scatter process in the clay content distribution in the surface (Ap) horizon of study pedons on different contour lines and was not concentrated on a particular contour line, this is due to the wide differences in clay content of A horizon for the study pedons and cannot be specified particular zone of clay content distribution and considering as the major zone of clay content in spite of this, the clay content was in the general range demands of Vertisols formation. Despite the fluctuation in silt content in some pedons (2, 4, 5, and 11) but the distribution of silt content in most study pedons (1, 3, 6, 7, 8, 9, 10, 12, 13, and 14) has a reverse pattern with clay content that was decreasing with depth as a result of alluvial deposits as illustrated by (Wright, 1990), in addition to the effect of loess

deposits. Sand content has different patterns of distribution in all studied pedons, and there is no uniform pattern of sand distribution in soil horizons of study pedons but in general, in many pedons was concentrated at surface horizons whereas in other pedons concentrated in subsurface horizons (Table, 1). In general, the

high value of clay and silt content indicates to soil development and the clay content increasing towards subsurface horizons of soil pedons by the mechanical migration of fine soil particles as a result of increasing precipitation in the study locations.

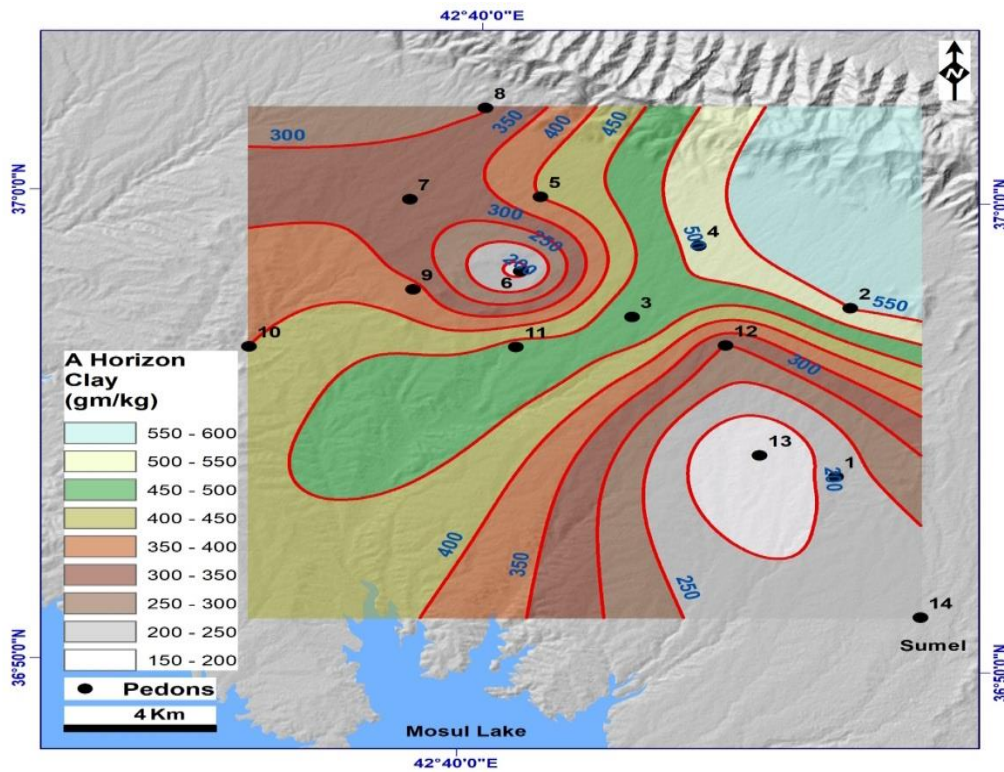


Fig. (3): Spatial distribution of clay content in (A) horizon of the studied pedons

3.6. Development of Study Soils

The soil C: N, ratio is a good indicator of the status of pedogenic processes for soil development. The high C: N ratio (> 25 on a mass basis) indicates that organic matter is accumulating faster than it is decomposing. Evidently, when the C/ N ratio is low that indicates the dominance of the humification process, whereas if the C/ N ratio is high that means the dominance of the littering process. Study results showed that most of the soil C: N ratio values ranged from (4.51) to (26.99), (Table, 2) indicating that the organic matter is thoroughly broken down. Generally, in many studied locations, humification processes of organic matter are predominate because the ratio of carbon to nitrogen (C / N) is less than 25, and as mentioned above, a decrease in the C / N ratio is an indication of an increase in decomposing organic matter in the soil because it is agricultural land which always cultivated and rain-fed irrigated depending on the annual

precipitations since the soil moisture regime was Xeric and because the climate of study locations similar Mediterranean Sea climate at the same time the high activities of organisms, especially macro-organisms (Rodents, worms...etc.) as has been mentioned in the morphological description of the study locations all of these reasons played an important role in the decomposition of soil organic matter and increase humus formation (humification) concurrently, decreased soil organic matter content as a litter that caused decrease C/N ratio, and relatively led to soil development. While in contrast, accumulation of organic matter (litter) and the littering process is dominants at the surface horizon (Ap) in soil pedons, 7, 11, and 14 at Gereshin- cross, Batile, and Misirke locations respectively. consequently, and as mentioned above, the increase in C/ N ratio in these pedons is considered an indicator of less decomposition organic matter and accumulation of litter on the

soil surface because of the weeds and very difficult to decomposition it.

Total clay in B horizon / Total clay at A horizon, which is also one of the important indicators for specifying the soil development, if the ratio is more than 1, the soil is classified as highly developed soil and in contrast, if the ratio is less than 1 then the soil is considered moderately developed (Gunal and Ransum, 2006). Depending on this opinion the most of the studied locations in pedons (1, 3, 7, 8, 9, 10, 12, 13, and 14) considered as well developed soils because, clay particles translocate from surface soil horizons to the subsurface horizons and its accumulation there to form illuvial horizons richer with clay particles. As well as the study soils have more differentiation in their horizons as a result of the high intensity pedogenic processes particularly eluviation, illuviation, lessivage, humification, calcification, and weathering processes. All these processes evented over a long period of time, consequently caused genesis and development of soil horizons which are rich with clay minerals; this result agrees with similar results that were indicated by (Alonso *et al.*, 2004). While in pedons [2, 4, and 11] are considered as moderately developed soil because the ratio of total clay in B-horizon/ total clay in A-orizon is less than 1, and the soils of pedons (5) considered as not developed soil because it only consists of two horizons (A and C) and absence of B horizon because this soil considered Inceptisols that mean the weathering process and other pedogenic processes have not occurred in enough intensity to translocate clay from the upper surface in turn did not form the B horizon.

The ratio of Active carbonate/ Total carbonate is another index used for explaining the soil development, as much as this ratio increases it means the intensity of pedogenic processes increase and horizons more differentiation. Generally, the ratio of (Active carbonate/ Total carbonate) was high and the ratio was ranged between (0.31-3.14) and this is maybe due to the high weathering intensity of parent material, which was derived from limestone and caused accumulation of calcium carbonate, so increased the ratio mass of active carbonate to total carbonate. This proves the previous results that indicate the study soils were more development (Table, 2).

Depending on the chemical, and physical analysis of study soils, the following pedogenic processes can be indicated loss, gain, leaching, illuviation, eluviation, alkalization, humification, lessivage, desalinization, calcification, decomposition, synthesis, pedoturbation, and braunification, these considered the major pedogenic processes for soil formation and represent an important criterion in studying soil development. According to these processes, can be differentiated studied pedons to different horizons as a result of vigorously occur these processes. The results proved that the studied soils were development, because of the occurrence of many important pedogenic processes that were previously mentioned. On the other hand, soil forming factors have an important role in developing the soils under study, particularly climate which overlaps with other factors. The intensity of these factors specifies vigorous of soil forming processes that are dominant in studied pedons.

Table (1): Some Chemical and Physical Properties of the Studied Pedons

Pedon	Depth	Location	pH	EC dS.m ⁻¹	PSD g.kg ⁻¹			Texture	O.M. g.kg ⁻¹	CEC Cmole _c . kg ⁻¹	Total Carbon ate g.kg ⁻¹	Active Carbonat e g.kg ⁻¹	
					CLA Y	SAND	SILT						
1	Ap	0 - 30	Marina	7.37	0.22	226	559	215	Sandy Clay Loam	15.24	14.347	202.00	140
	B1hk	30 - 120		7.14	0.23	286	379	335	Clay Loam	31.13	20.527	315.63	130
	B2hk	120 - 165		7.84	0.24	371	379	250	Clay Loam	21.86	18.172	277.76	130
2	Ap	0 - 15	Kwashi	7.77	0.20	551	74	375	Clay	24.51	32.452	210.42	80
	B1ss	15 - 45		7.45	0.21	541	9	450	Clay	28.48	32.747	231.46	140
	B2ss	45 - 130		7.74	0.33	486	4	510	Clay	21.86	28.672	180.96	140
3	Ap	0 - 12	Bastki	7.69	0.30	491	34	475	Silty Clay	35.11	31.572	269.34	190
	B1ss	12- 40		7.85	0.21	476	84	440	Silty Clay	33.78	30.557	248.30	190
	B2ss	40- 145		7.72	0.29	526	84	390	Clay	33.12	32.924	277.76	160
4	Ap	0 - 25	Balqusi	7.7	0.32	516	109	375	Clay	21.86	30.172	202.00	140
	B1ss	25- 75		7.74	0.35	476	74	450	Silty Clay	20.54	27.907	210.42	180
	B2ss	75- 125		7.76	0.27	501	99	400	Silty Clay	15.90	28.230	231.46	200
5	Ap	0 - 26	Asihe	7.38	0.36	401	74	525	Silty Clay	41.73	28.397	231.46	140
	Ch	26 - 88		7.41	0.33	351	99	550	Silty Clay Loam	35.11	24.572	180.96	140
6	Ah	0 - 22	Batil 1	7.51	0.38	191	219	590	Silty Loam	35.11	16.572	206.21	160
	Bw	22- 42		7.38	1.04	191	274	535	Silty Loam	31.13	15.777	227.26	100
	Cth	42- 82 C- horizon		7.59	0.54	401	169	430	Silty Clay	41.07	28.264	273.55	86
	Ab	0- 28(Burred)		7.75	0.32	401	119	480	Silty Clay	31.80	26.409	286.17	220
	Bb	28- 38		7.77	0.30	226	244	530	Silty Clay	17.22	26.409	235.67	140
	Cb	38- 73		7.65	0.33	331	224	445	Clay Loam	21.86	20.922	277.76	140
7	Ap	0 - 30	Gereshin Cross	7.62	0.21	331	109	560	Silty Clay Loam	35.77	23.704	231.46	190
	B1h	30 - 70		7.73	0.22	226	54	720	Silty Loam	28.48	16.997	186.34	140
	B2th	70- 140		7.51	0.26	506	19	475	Silty Clay	35.11	32.322	180.96	140
8	Ap	0 - 35	Gereshin	7.7	0.30	296	124	580	Silty Clay Loam	30.47	20.894	202.00	150
	Bh	35- 95		7.16	0.31	331	89	580	Silty Clay	28.48	22.247	223.05	70

				Loam									
	Ch	95- 150		7.8	0.23	366	209	425	Clay	22.52	22.804	235.67	130
									Loam				
9	Ap	0- 15	Smile Ava	7.7	0.34	366	64	570	Silty Clay	18.55	22.010	202.00	90
									Loam				
	Bt	15- 130		7.78	0.27	511	49	440	Silty Clay	28.48	36.247	210.42	170
									Loam				
10	Ap	0- 20	Shkavdle	7.76	0.36	401	69	530	Silty Clay	25.17	25.084	218.84	90
									Loam				
	B1w	20- 53		7.82	0.27	296	119	585	Silty Clay	23.85	19.569	197.80	170
									Loam				
	B2t	53- 152		7.81	0.27	541	19	440	Silty Clay	26.50	32.349	210.42	140
									Loam				
11	Ap	0- 22	Batil 2	7.55	0.28	471	74	455	Silty Clay	37.10	30.969	239.88	130
									Loam				
	Bh	22 - 67		7.47	0.23	261	219	520	Silty Clay	27.16	18.482	185.17	120
									Loam				
	Ch	67- 140		7.61	0.30	191	244	565	Silty Clay	25.17	14.584	227.26	160
									Loam				
12	Ap	0- 16	Gerash	7.69	0.28	296	64	640	Silty Clay	23.85	19.569	311.42	200
									Loam				
	Bw	16- 88		7.87	0.31	331	54	615	Silty Clay	17.89	20.127	319.84	280
									Loam				
	Bss	88- 165		7.53	0.50	366	54	580	Silty Clay	31.80	24.659	260.92	240
									Loam				
13	Ap	0- 17	Moqble	7.76	0.37	156	154	690	Silty Clay	34.45	14.689	235.67	140
									Loam				
	Bh	17- 82		7.68	0.37	226	164	610	Silty Clay	27.82	16.864	239.88	130
									Loam				
	Ch	82- 150		7.47	0.39	261	129	610	Silty Clay	24.51	17.952	197.80	90
									Loam				
14	Ap	0- 42	Msirike	7.41	0.32	226	154	620	Silty Clay	39.08	19.117	239.88	90
									Loam				
	Bh	42- 77		7.58	0.35	261	139	600	Silty Clay	40.41	21.132	214.63	80
									Loam				
	Ch	77- 127		7.51	0.34	261	114	625	Silty Clay	47.03	22.456	256.71	140
									Loam				

Table (2): Parameters Used in Soil Development Criteria

Pedon	Depth	Location	Active Carbonate / Total Carbonate	Total Clay in B Horizon / Total Clay in A Horizon	C/N ratio	
1	Ap	0 - 30	0.69	1.454	4.51	
	B1hk	30 - 120	0.41		21.50	
	B2hk	120 - 165	0.47		9.06	
2	Ap	0 - 15	0.38	0.932	16.92	
	B1ss	15 - 45	0.60		14.75	
	B2ss	45 - 130	0.77		7.55	
3	Ap	0 - 12	0.71	1.02	18.18	
	B1ss	12- 40	0.77		17.50	
	B2ss	40- 145	0.58		17.15	
4	Ap	0 - 25	0.69	0.947	11.32	
	B1ss	25- 75	0.86		10.64	
	B2ss	75- 125	0.86		8.23	
5	Ap	0 - 26	0.60	-	14.41	
	Ch	26 - 88	0.77		12.12	
6	Ah	0 - 22	0.78	1.00	18.18	
	Bw	22- 42	0.44		16.12	
	Cth	42- 82 C-horizon	3.14		21.27	
	Ab	0-28(Burred)	0.77		0.564	13.17
	Bb	28- 38	0.59			5.95
	Cb	38- 73	0.50			9.06
7	Ap	0- 30	0.82	1.106		24.70
	B1h	30- 70	0.83		9.83	
	B2th	70- 140	0.77		14.55	
8	Ap	0 - 35	0.74	1.118	21.04	
	Bh	35- 95	0.31		14.75	
	Ch	95- 150	0.55		15.55	
9	Ap	0- 15	0.45	1.396	7.68	
	Bt	15- 130	0.81		11.80	
10	Ap	0- 20	0.41	1.044	13.04	
	B1w	20- 53	0.86		9.88	
	B2t	53- 152	0.67		13.72	
11	Ap	0- 22	0.54	0.554	25.62	
	Bh	22 - 67	0.65		11.25	
	Ch	67- 140	0.70		17.38	
12	Ap	0- 16	0.64	1.177	9.88	
	Bw	16- 88	0.88		9.26	
	Bss	88- 165	0.92		13.17	
13	Ap	0- 17	0.59	1.449	11.89	
	Bh	17- 82	0.54		11.53	
	Ch	82- 150	0.46		8.46	
14	Ap	0- 42	0.38	1.155	26.99	
	Bh	42- 77	0.37		16.74	
	Ch	77- 127	0.55		24.36	

4. CONCLUSIONS

According to the obtained results of this study it can be concluded the study soils were non- saline slightly alkaline, and CEC increased with increasing clay content towards the downward direction of soil pedons. Total

carbonate content increased with depth, and the active carbonates are associated with clay particles that are increasing with depth. Many pedons of study locations have higher organic matter in the subsurface and deep horizons more than it in surface horizons and humification process occur in different soil horizons not just

in surface horizons in Vertisols. There is a scatter process in the clay content distribution in the surface (Ap) horizon on different contour lines and was not concentrated on a particular contour line, and the high value of clay and silt content indicates to soil development. The major pedogenic processes that are indicated to the soil development are loss, gain, leaching, illuviation, eluviation, alkalization, humification, lessivage, desalinization, calcification, decomposition, synthesis, pedoturbation, and braunification. Determining the following criteria C: N, ratio, Active carbonate/ Total carbonate, and Total clay in B horizon / Total clay at A horizon generally, proved the development of the studied soils.

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چیبوون و پیشکەفتنا فیرتیسولزل دەشتا سلێفانهی ل پارێزگەها دهوکی، هەرێما کوردستانی، عێراق

پوخته

ناوچهیا فه کولینی دکهفته دهشتا سلێفانهیا ل پارێزگهها دهوکی، هەرێما کوردستانی، عێراق. (14) پیدوون هاتنه کولان، هەرئیک ل جههکی جودایی ناوچهیا فه کولینی و هاتنه وه سفکر لگور زانستا شیوی وان (morphology)، ب وهرگرتنا (43) نمونهیان ژ ناخا ئاسویین ههر پیدوونکی هاتیه فه کولین. ناخ دئیتیه نیاسین ب ناخهکا پیچهک تفتن CEC. د پرانیا کویراتیا ئاسویان دا ژ پیدوونین فه کولین لسه هاتیه کرن زیدهبوو ژ نهگهري زیدهبوونا پیکهاتا تهقنی. ناخین ناوچهیا فه کولینی دهینه هژمارتن ژ ناخین Vertisols ژ نهجامی فه گوهاستنا مادا نهندامی ژ ئاسویین سهري بو ئاسویین نزم دناف ناخی دا، و ههروهسا ههبوونا رهین رووهکی و دارا. هه می بهایین کاربوناتی د ئاسویین پیدوونین فه کولین لسه هاتیه کرن، زیده دبیت ب زیدهبوونا کویراتی ژ نهگهري کرپارا کلسوونی چونکی ژیدهري مادا دهیک بهري کلسی بوو. جیاوازی د دابه شبونا ریژا کاربوناتی پیچهره بو پیشکەفتنا ناخی. ناوچهیا فه کولینی دهیتیه هژمارتن کو ریژا کاربونی چالاک تیدا باشه و کارتیکرنی ل سهري سیفاهتین ناخی یین جیاوازی دهکته. هه بوونا ریژا تهقنی ل ئاسویین سهري بهرچاقتربوو ژ ئاسویین خاری. ریژا زوو (clay and silt) ئامانج ب پیشکەفتنا ناخی ددهن. نه م دشین نیشانی ب قان کرپارین سهرهکی بکن یین دناف ناخین فه کولین لسه هاتیه کرن دا هاتین (ژدهستان، وهرگرتن، شویشن، لسهرئیککومقه بوون، ههري رابوون، کرپارا نه لکالیبوون، رپسوون، ل کیمی دان، ژیرنا خوی، کالسیبوون، ههلیانا مادهی نهندامی، چیکرن، ئیکبوون)، و نه فه دئینه نیاسین ب چیبوونین سهرهکی بو چیبوونا ناخی و پیشکەفتنا وی. د گهلهک ناوچهیان دا یین فه کولین لسه هاتیه کرن، کرپارا رپسوونا مادهی نهندامی لدهستیکی دئیت چونکی ریژهیا کاربونی بو نایترۆجینی (C/N) کیمتره ژ 25. ب پشتبهستن لسهر (هه می ناخا د ئاسویین A دا/ هه می ناخا د ئاسویین B دا) ناخین فه کولین (1, 3, 6, 7, 8, 9, 10, 12, 13, و 14) لسهر هاتینه کرن دئینه هژمارتن ژ ناخین باش پیشقه چوون بخوه فه دیتی ژ نهگهري دندکین تهقنی یین هاتینه فه گوهاستن ژ ئاسویین بهرته بو یین کویرتر دبن

روبيّن ئاخىّ قه كو گهلهك زهنگين بوويه ب دندكين تهقنى. ريزّا (كاربوناتيّ چالّاك / هه مى كاربوناتى) يا بلنبوو و دناقهرا (3.14-0.31%) دا. دبیت ئهقه بو كرياتا سهقاكارىي بزقرت ئهوا لسهر ماددهيى دهيك رويداي، ههروهكى ئهجامين بهريّ دياركرى كو ئاخا قهكولين لسهر هاتيه كرن گهلهك يا ييشكهفتى بوو زلاين چيبوونى قه.

شوكه بهيف: ييشكهفتنا ئاخى، دابهشبوونا قه باره يى پرتكان، تهفن، ئاسويين ئاخى، كاربوناتى چالّاك، هه مى كاربوناتى

تكوين و تطوير الفيرتيسولز في سهل السليفاني في محافظة دهوك، إقليم كردستان، العراق

الخلاصة

تقع منطقة الدراسة في سهل سليفاني في محافظة دهوك، إقليم كردستان، العراق. أخذت 43 عينة تربة من آفاق بيدونات الدراسة ثم تحليلها فيزيائيا و كيميائيا وفقاً للطرق القياسية. كانت التربة المدروسة قليلة القلوية و الملوحة. قيم السعة التبادلية الكاتيونية تزداد مع زيادة محتوى الطين في التربة. تعتبر تربة الدراسة فيرتيسولز و هذا ما يسبب تذبذبا للمواد العضوية في بعض الآفاق لسطحية و تزداد في الآفاق تحت السطحية و العميقة، و هذه الزيادة تعزى الى مساهمة جذور النباتات الموجودة في تلك الآفاق بالإضافة الى المساهمة في عملية الترطيب في آفاق التربة المختلفة. يزداد المحتوى الكلي للكاربونات مع زيادة العمق في الآفاق تحت السطحية و تعود هذه الزيادة الى الحجر الجيري (المادة الاصل) الذي تكونت منه هذه التربة. تشير الدراسة الى الاختلاف في توزيع الكربونات في التربة حيث تحتوي التربة المدروسة على كمية كبيرة من الكاربونات النشطة التي تؤثر على خصائص التربة المختلفة. يرتفع المحتوى الطيني في التربة المدروسة نسبيا و محتواه في الآفاق السطحية أقل منه في الآفاق تحت السطحية. تشير القيمة العالية لمحتوى الطين و الطمي الى تطور التربة. العمليات البيدوجينية التالية يمكن الاشارة اليها في ترب الدراسة (الفقد، الكسب، الغسل، الكسب البيدوجيني، الفقد البيدوجيني، القاعدية، التبدل، النقل الميكانيكي، عدم التملح، التكلس، التحلل، التصنيع، الخلط الذاتي للتربة و الدكّانة). تسود عمليات التبدل (تكوين الدبال) للمواد العضوية لأن نسبة الكاربون الى النيتروجين (C / N) أقل من (25). و وفقاً للمعيار (إجمالي الطين في الأفق B / إجمالي الطين في الأفق A) في معظم بيدونات الدراسة (1، 3 و 6 و 7 و 8 و 9 و 10 و 12 و 13 و 14) اعتبرت ترب الدراسة جيدة التطور. نسبة (الكربونات النشطة / الكربونات الكلية) كانت عالية و تراوحت بين (3.14-0.31)، و هذا ربما يعود الى التجوية العالية للمادة الأصل نتيجة زيادة نسبة كتلة الكربونات النشطة إلى مجموع الكاربونات.

الكلمات المفتاحية: تطور التربة، النسجة، الطين، آفاق التربة، الكاربون الفعال، الكاربون الكلي