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GENESIS OF ARGILLIC AND CALCIC HORIZONS IN SOME NORTHERN IRAQI SOILS

Ahmad S. Muhaimeed[1], S. N. Aziz[2] and I. M. Amin[3]
[1]College of Agriculture, Baghdad University, Iraq
[2]Sulaimini University
[3]Salah-Aldeen University
E-Mail: profahmad1958@yahoo.com

ABSTRACT

Two study sites were selected in Northern Iraq under different climatic conditions. The first site located in Ibraheemawa city-Al Sulaemini Governotrate lies within Zagroz mountain physiographic unit, in folds zone formed from limestone during Miocene period. The climate of this region is sub humid with mean annual rain fall, more than 1300 mm/year and mean annual temperature 18.7^{o}C. The second site located in Saleemawa city at Dalia Governa tore lies within foot hill physiographic unit formed from lime stone parent rock during the Miocene period and under semiarid climatic conditions with mean annual rain fall 360 mm/year and mean annual temperature 24.3^{o}C. Two pedons within each site were exposed, described and sampled for laboratory analysis. The results of morphological, physical and chemical properties of the studied pedons indicated some differences between soils of the two regions due mainly to the effect of climatic conditions and the nature of parent material. Studied soils show some variation in the amount and distribution pattern of soil components with depth. Soils pedons in Ibraheemawa show a greater degree of soil development reflected by thick mollic epipedon with thick Argillic horizons, lower content of calcium carbonate, soluble salts with high conent of total clay, fine clay and silt. The studied soils were classified as Mollisols and Aridisols in the two regions, respectively.

Keywords: soil, argillic horizon, calcic horizon, pedogenic processes.

INTRODUCTION

Soil formation may be define as a transformation process of geological materials (parent materials) to pedological material (soil) by some natural factors (Jenny, 1980). He added that the parent material and topography as initially state for soil development, but the climate and organism express the average of the chemical and biological reaction interference (pedogenic processes). Buol *et al*., 2003 indicated that present-day soils may carry the imprint of a combination of pedogenic processes and geologic processes not presently active at that site. They added that complexity of soil genesis is more common than simplicity. Some processes that influence soil composition are spasmodic and disrupt soil features formed by other processes that are rather continuous over time.

One of soil development indicator is the presence of B horizon in soil solum. Collins and Fenton, 1982 emphasized the knowledge of soil development by calculating the value of clay content in B horizon to that in A horizon, and whenever this ratio exceed 1 or more, it means increase soil development.

Argillic horizon is normally a subsurface horizon with a significantly higher percentage of clay overlying soil material and shows evidence of clay illuviation such as clay film (Soil Survey Staff, 2010). Argillic horizon can be found under different climatic conditions ranging from dry to humid with different common properties reflecting the dominant climatic conditions. Many researchers indicated the presence of Argillic horizons in under different climatic conditions in Iraq (Al-Tae *et al*., 1969; Muhaimeed, 1994; Muhaimeed *et al*., 2000) the presence of Argillic horizon in soils of dry conditions due to the effect of paleoclimatic conditions (Nettleton *et al*., 1974). Calcic horizon is an illuvial horizon in which secondary carbonate has accumulated to significant extent. It is one of the most common horizon in arid, semiarid and sub humid regions in Iraq. Calcic horizon found with other horizons mainly salic and gypsic. The main objectives of this study are : (1) to evaluate the effect of climatic conditions on genesis of calcic and argillic horizons. (2) to classify some soils in northern Iraq using soil taxonomy.

MATERIALS AND METHODS

Two study sites were selected represent different climatic conditions in Northern Iraq. The first site located in Ibraheemawa region, Al Sulaemini Governorate between longitude lines 45˚ 54 31 and 45 55 10 eastern and latitude 35 41 15 and 35 41 37 northern. The site lies within Zagros Mountains physiographic unit and in folds zone formed during Miocene period (Naqash and Hambarson, 1985). Soils of the study site formed from lime stone formation and under sub humid climatic conditions with mean annual precipitation of 1305.5 mm/yea and mean annual temperature 18.7^{o}C. Soil moisture regime is xeric with soil temperature regime is thermic. The second site located in Sherwana region in Diala governorate, between two longitudes lines 45 20 08 and 45 21 29 eastern and between latitude lines 34 34 20 and 34 34 41 northern. This site lies within foot hill physiographic unit formed during the Miocene period .Soils of this site formed from lime stone formation, and under semiarid climatic conditions climate with mean annual precipitation of 360.5 mm/year and 24.3^{o}C, mean annual temperature. Soil moisture regime is Torric and soil temperature is Hyperthermic.

Two pedons within each of the selected sites were exposed and described morphologically according to soil survey manual (Soil Survey Division Staff, 1993). Soil samples were taken from each soil horizon for laboratory analysis. Particle size distribution was determined by using international pipette method (Kilmer an Alexander, 1949). Bulk Density was determined by clod method as described by Black, 196 5. Organic matter was determined by oxidation method using chromic. Acid (Hesse, 1972). Total carbonate minerals content was determined using the Acid neutralization method (Richards, 1954). Active lime was measured after precipitation as a calcium oxalate using 0.2 N ammonium oxalate (Galet, 1972). Soil pH was measured on 1:1 soil: water suspension (Richards, 1954). Cation Exchange capacity was measured according to the methods of Papanicolaou, 1976. Electrical conductivity was measured according to 4b method as described by Richards, 1954.

RESULTS AND DISCUSSIONS

The studied pedons were described according to Soil Survey Division Staff, 1993 and classified according to Soil Survey Staff, 1999 and 2010, as following:

Soil morphology and classification

Pedon-1

Classification	Fine silty. Mixed, thermic, super active of pachic Argixeroll
Location	3km northwest of Penjween and 200m west of Sairanband Road
Parent material	Alluvium Lime stone
Slope	1% plan
Drainage	well
Elevation	1260 m above sea level
Land use	different grain crops

Horizon Depth (cm)

Ap 0-25 Grayish brown (10YR 5/2) d; very dark grayish brown (10YR3/2) m; Silt clay Loam; moderate medium sub angular blocky; slightly hard (d), friable (m), slightly sticky, slightly plastic (w), few fine pores; common fiber and medium roots; diffused wavy boundary.

A12 25-48 Pale brown (10YR6/3) d, very dark grayish brown (10YR 3/2) m, silty clay loam; moderate medium to fine angular blocky; firm (m), slightly sticky, slightly plastic (w); common fine pores; few fine roots; diffused wavy boundary.

E 48-85 light yellowish brown (10YR6/4) d, brown-dark brown (10YR4/3) m; silt loam; with 5% fine gravel; weak medium sub angular blocky parting to crumb; Friable (m), non sticky, plastic (w); common fine pores; very fine roots, gradual wavy boundary.

Bt1 85-150 Grayish brown (10YR5/2) d, very dark grayish brown (10YR4/2) m; silt clay; Weak medium sub angular blocky paring to fine crumb; friable (m), slightly stick, plastic (w); prominent continues dark yellowish brown (10YR4/4) m clay skin, few medium pores, few rusty mottling at 100 cm, diffuse smooth boundary.

Bt2 150-170 Grayish brown (10YR 5/2) d, dark grayish brown (10YR4/2) m; silty clay; Moderate medium angular; friable (m), sticky, plastic (w); medium roots, diffused smooth boundary.

C 170-200 Brown (10YR5/3) d, dark brown (10YR4/3) m, silty clay loam; moderate medium angular blocky; hard (d), firm (m), slightly sticky, slightly plastic.

Pedon-2

Classification	Fine silty, mixed, thermic, super active of Pachic Argixerolls.
Location	3 km northwest of Penjween city and 200m west of Sairanband village
Parent material	alluvium limestone.
Slop	1 %
Drainage	moderate
Elevation	1259 m above sea level
Land use	wheat crop

Horizon Depth (cm)

Ap 0-30 Grayish brown (10YR5/2) d, very dark grayish brown (10YR 3/2) m; silty clay Loam; moderate medium sub angular blocky; hard (d), friable (m), non sticky, slightly plastic (w); few fine pores; few fragments of stone; common fine and medium roots; gradual smooth boundary.

AB 30-80 Gray (10YR5/1) d, very dark grayish brown (10YR 3/2) m; loam; with 5% of gravel; massive; friable (m), slightly sticky, slightly plastic (w); common macro pores; few fine and medium roots; few nodules of carbonate; gradual Smooth boundary.

Bt1 80-125 Pale brown (10YR 6/3) d, brown-dark brown (10YR 4/3) m; silt clay; moderate, medium, prismatic and angular; friable (m), sticky, plastic (w); few fine pores; very few fine roots; gradual clear boundary. Gradual smooth boundary.

Bt2 125-180 Pale brown (10YR 6/3) d, dark gray (10YR 4/2) m; silty clay loam; massive; sticky, plastic (w); few fine pores; few fine roots; dark brown (10YR 4/3) clay skin; gradual, smooth boundary.

C 180-200 Pale brown (10YR6/3) d, dark yellowish brown (10YR4/4) m; silt clay loam moderate medium angular blocky; hard (d), firm (m), slightly sticky, plastic (w)

Pedon-3

Classification	Loamy, mixed, hyperthermic, superactive, calcareous of Typic Haplocalcid
Location	1km northeast of Salehaga village and 5km east of Sherwana city
Parent material	lime stone
Slope	1% plan
Drainage	well
Elevation	229m above sea level
Land use	wheat crop

Horizon depth (cm)

Ap 0-20 light yellowish brown (10YR 6/4) d, dark yellowish brown (10YR 4/4) m; loam; weak medium sub angular blocky; friable (m), slightly sticky, slightly plastic (w; common fine pores; many fiber medium roots; gradual smooth boundary.

B1 20-80 very pale brown (10YR 7/3) d, dark brown (10YR 4/4) m; loam; moderate Medium sub angular blocky; hard (d), friable (m), slightly sticky, slightly plastic (w); few macro pores with common medium pores; few fine roots; gradual smooth boundary.

Bk1 80-110 very pale brown (10YR5/6) d, yellowish brown (10YR5/6) m; loam; strong Medium to fine sub angular blocky; friable (m), slightly sticky, slightly plastic (w); common medium pores; very few fine roots; common soft powder of carbonate accumulation; gradual smooth boundary. Bk2 110-180 light yellowish brown (10YR 6/4) d, dark yellowish brown (10YR4/4) m; sandy loam with 5 % fine gravel; moderate fine sub angular blocky; hard (d), slight sticky, slightly plastic (w); common carbonate nodules.

Pedon-4

Classification	Fine loamy, mixed, hyperthermic, super active calcareous of atypic calciargids
Location	1km northeast of Salehage village, and 5km east of Sherwana city
Patent material	alluvium limestone
Slope	1% nearly level plan
Drainage	well
Elevation	217 m above sea level vegetation

Horizon depth (cm)

Ap 0-30 light yellowish brown (10YR 6/4) d, dark yellowish brown (10YR 4/4) m; loam; massive; friable (m), non sticky, non plastic (w); common fine pores; common very fine and medium roots; gradual smooth boundary.

Btk1 30-105 light yellowish brown (10YR 6/) d, yellowish brown (10YR 5/6) m; silt clay loam; strong medium angular blocky; hard (d), sticky, plastic (w); very few fine roots; few accumulation of soft powder carbonate; gradual smooth boundary.

Btk2 105-138 very pale brown (10YR 7/3) d, dark yellowish brown (10YR4/4) m; clay loam; strong medium sub angular blocky; hard (d), sticky, plastic (w); few fine roots common nodules of carbonate; gradual smooth boundary.

C very pale brown (10YR7/4) d, yellowish brown (10YR 5/6) m; loam; moderate fine sub angular blocky; soft slightly plastic (w); few accumulation of carbonate Nodules.

Particle size distribution data for all studied pedons with in two regions are shown in Table-1. Comparison of the data indicates some differences between the pedons of two regions in the amount of soil components and the pattern of their distribution within the studied pedons. In general, silt content was the dominant fraction followed by clay and sand in the pedons 1 and 2 in Ibraheemawa region. While sand showed higher content than clay in pedon 3 and 4 in sherwan. These results reflect the effect of climatic conditions and the nature of parent materials between the two region.

The amount of total clay in the pedons of Ibraheemawa (pedon 1 and 2) is at its maximum in B horizon. The total clay values ranged from 177 g/mg in E horizon of pedon 1 to 519.5 g/km in BT horizon of pedon 2. The pattern of total clay distribution decreases with depth then Increases in BT, then decreases in C horizon. This type of distribution may be due to the effect of Pedogenic processes and to some extent to geomorphic processes. The increment of clay content in the surface horizon of the pedons 1 and 2 in Ibraheemawa city due to the effect of geomorphic processes mainly the transportation of fine particles by erosion from the surroding upland soils and deposition of fine materials on the surface soils occupying low plan area.

Table-1. Some physical properties of the studied pedons.

Pedon-1

Horizon	Depth (cm)	Total sand (g/kg)	Total silt (g/kg)	Total clay (g/kg)	Fine clay (g/kg)	Fine clay/ total clay	Total clay (B/A)	Bulk density (Mg/m³)
Ap	0-25	85.5	620.9	293.6	165.4	0.56	1.78	1.31
AB	25-48	172.0	564.9	263.1	151.4	0.58		1.36
E	48-85	208.9	611.4	177,0	105.9	0.60		1.48
Bt1	85-150	56.7	520.5	429.9	255.9	0.60		1.45
Bt2	150-170	49.0	508,8	440.2	259.0	0.59		1.48
C	170-200	53.5	547.7	398.7	124.1	0.54		1.43

Pedon-2

Horizon	Depth(cm)	Total sand (g/ kg)	Total silt (g/kg)	Total clay (g/kg)	Fine clay (g/kg)	Fine clay/ total clay	Total clay (B/A)	Bulk density (Mg/m³)
Ap	0-28	126.7	590.1	283.2	165.4	0.56	1.78	1.31
AB	28-80	366.4	467.8	165.8	151.4	0.58		1.36
B1	80-125	139.4	567.9	292.6	105.9	0.60		1.48
Bt1	125-180	41.1	546.2	412.7	255.9	0.60		1.45
Bt2	180-200	42.4	583.1	374.5	124.1	0.59		1.48

Pedon-3

Horizon	Depth (cm)	Total sand (g/kg)	Total silt (g/kg)	Total clay (g/kg)	Fine clay (g/kg)	Fine clay/ total clay	Total clay (B/A)	Bulk density (Mg/m³)
Ap	0-20	324.7	467.0	208.3	29.7	0.14	1,10	1.32
B1	20-80	315.5	449.1	235.4	39.2	0.17		1.38
Bk1	80-110	335.8	443.0	221.2	36.6	0.17		1.44
Bk2	110-180	765.7	131.3	103.0	26.9	0.26		1.47

Pedon-4

Horizon	Depth (cm)	Total sand (g/kg)	Total silt (g/kg)	Total clay (g/kg)	Fine clay (g/kg)	Fine clay/ total clay	Total clay (B/A)	Bulk density (Mg/m³)
Ap	0-30	327.5	465,2	207.3	31.8	0.15	1.33	1.38
Btk1	30-105	189.5	518.5	292.0	60.1	0.21		1.46
Btk2	105-138	313.5	426.0	260.6	124.1	0.48		1.50
C	138-160	475.0	329.8	195.2	41.7	0.21		1.54

Table-2. Some chemical properties for the studied pedons.

Pedon-1

Horizon	Depth (cm)	O.M. g/km	Total lime g/km	Active lime g/km	pH	ECe ds/m	CEC Cmol/kg. soil	BSP
Ap	0-25	16.5	10	5	7.3	0.54	37.2	82.7
AB	25-48	12.5	20	10	7.5	0.41	39.6	76.6
E	48-85	2.5	75	5	7.0	0.32	34.9	71.2
Bt1	85-150	9.5	70	20	7.1	0.50	45.5	79.2
Bt2	150-170	7.5	65	20	7.3	0.26	44.3	88.6
C	170-200	6.7	65	10	7.3	0.51	41.1	80.1

Pedon-2

Horizon	Depth(cm)	O.M. g/km	Total lime g/km	Active lime g/km	pH	ECe ds/m	CEC Cmol/kg. soil	BSP
Ap	0-28	18.1	30	10	7.0	0.37	38.5	69.6
AB	28-80	13.0	20	5	7.0	0.48	27.1	74.5
B1	80-125	6.5	60	10	7.0	0.38	43.8	63.8
Bt1	125-180	4.7	50	20	7.1	0.19	41.1	79.2
Bt2	180-200	4.5	55	15	7.1	0.29	41.2	68.4

Pedon-3

Horizon	Depth(cm)	O.M. g/km	Total lime g/km	Active lime g/km	pH	ECe ds/m	CEC Cmol/kg. soil	BSP
Ap	0-20	15.3	250	95	7.9	0.63	26.2	81.4
B1	20-80	8.1	305	105	7.5	0.50	22.9	91.6
Bk1	80-110	5.2	305	130	7.2	0.38	21.7	96.9
Bk2	110-180	2.1	248	60	7.2	0.54	14.4	82.2

Pedon-4

Horizon	Depth(cm)	O.M. g/km	Total lime g/km	Active lime g/km	pH	ECe ds/m	CEC Cmol/kg. soil	BSP
Ap	0- 30	13.8	245	70	7.8	0.56	26.9	98.2
Btk1	30-105	9.1	320	105	7.1	0.50	26.9	90.2
Btk2	105-138	7.2	310	100	7.1	0.50	22.1	97.1
C	138-160	1.0	260	85	7.7	0.37	22.1	90.1

The increment of total clay and fine clay in B horizon of pedons 1 and 2 may due to the effect of some pedogenic processes including elevation and illuvation. These pedons located in the area with sub humid climatic conditions receiving more than 1300 mm/year mean annual rain fall. This fact reflected by low content of carbonate in these pedons due to the activity of decalcification process. The results of the field distribution show the presence of clay skin in the lower part of B horizons in these pedons which indicate the translocation of clay fraction from the surface horizon to subsurface horizons.

Distribution pattern of total and fine clay in the pedons of Ibraheemawa indicates significant differences between the eluvial and illuvial horizons. The value of the average clay content in B horizons to the average value of clay content in A horizon is more than 1.2, which meets the criteria required for the formation of argillic horizon (soil Survey Staff, 1999).

Total clay and fine clay contents are at their maximum in B horizons and decrease with depth in pedons at Selehaga region. The increment of clay content in illuvial horizons of pedon 3 and 4 comparison to eluvial horizons seems to be sufficient to meet the criteria for Argillic horizon formation. This type of Argillic formation can not be related to semiarid climatic conditions of Selehaga city, but may be greatly related to the effect of the paleo - climatic conditions, which were more humid than the dominant conditions of the present days. This fact reflected by the presence of Calic horizons within the depth of Argillic horizons with in these pedons which may caused by the new addition of calcareous materials to these pedons from the upland area by erosion and sedimentation processes during the dry period.

Clay distribution in pedons of Shelehaga region is more homogeneous than that of pedons in Ibraheemawa region. This is may be due to one or more of the following effects: First, Ibraheemawa region is older and received high mean annual rain fall causing more activities of geological and pedological processes including weathering, eluviations, illuviation and decalcification to act on the soils of Ibraheemawa region comparing to the soils of Selehaga region. Secondly, the role of up land near the mountains, which made continuous sedimentation and accumulation of fine materials on soil surface allowing fine clay to accumulate. These variations of the dominant local factors and their effects on the soils whit in the two regions were reflected by the variations of some chemical properties of the studied soils. Pedons 1 and 2 in Ibraheemawa show a lower value of total carbonate and salinity with relatively higher organic matter content with depth. Pedons 3 and 4 in Selehaga region show a high accumulation of carbonate in the subsurface horizons and

meet the criteria of Calic horizom formation while, pedons of Ibraheemawa region do not showed this criteria.

CONCLUSIONS

Soils of the two regions show some differences in the degree of soil development reflected by the variations in the morphological, physical and chemical properties due mainly to the effect of climatic conditions and some geological and pedological processes. Soils of selehaga region show two stages of soil formations: The first stage includes formation of Argillic horizon taken place during the more humid paleo climatice conditions. The second stage represents formation of calcic horizon taken place during late dry climatic condition which allows the accumulation of calcium carbonate and the formation of K horizons.

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