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SOIL DEVELOPMENT STUDIES OF SOME ZONES OF ENCROACHMENT BETWEEN THE NILE DELTA AND THE DESERT IN QALUBEYA GOVERNORATE.

Mousa, A.M.; B.H. Naguib and M.A. Khalil
Soils, Water and Environment Res. Institute, Agric. Res. Center, Giza, Egypt.

ABSTRACT

The current study aims to following up the changes which may take place in some morphological and pedogenic characteristics on three soil orders, Vertisols, Entisols and Aridisols in Qalubeya Governorate. Six soil profiles were selected to represent six soil groups.

Twenty-nine profiles were examined, six out of them representing this study. (RHD) relative horizon distinctness was made by a comparison of adjacent horizons. The second rating scale (RPD) was made by a comparison of the last horizon to the above horizons in the same profile. Some chemical properties such as salts, pH, calcium carbonate and gypsum were applied to calculate the points of pedogenic factors. Also Profile Development Index (PDI) values were calculated from horizon index values using quantitative profile index methods.

The RHD values coincide with those of RPD ratings and Profile index values. Data revealed that the clear differentiation between the older soils (*Typic Torrerts*), the recent soil (*Vertic Torriflavents, Typic Torrifluvents, Typic Torriorthents* and *Typic Torripsamments*) and Aridisols (*Typic Calciorthids*). The study occurs that the soils of Typic Torrerts had developed more than the other soils of Entisols and Aridisols.

Key words: Distinctness, Development, Quantitative Index, Qalubeya Governorate.

INTRODUCTION

Qalubeya Governorate lies north of Cairo within an area having a pear-shape in the recent Nile alluvial deposits in the south eastern part of the Nile Delta, Map(1). It has an area of approximately 224 thousand feddans (941 Km^2). The area is located between longitudes $31^{\circ}\ 14^{-}$ and $31^{\circ}\ 30^{-}$ East and latituteds $30^{\circ}\ 10^{-}$ and $30^{\circ}\ 20^{-}$ North. It is bounded on its east by the Eastern desert. The elevation of area ranges between 15 and 14 m a.s.l (above sea level) from south to north; and between 50 and 15m a.s.l from east to west and is gently sloping towards the west and north.

The surface of the Delta in the south is relatively smooth if compared to its surface in the north (Abu Al-Izz, 1971).

The average mean annual temperature is about 19.9°c with great difference between summer and winter (75°c). The maximum temperature (34.2°c) is usually recorded in June, and the minimum of 6.1°c in February. The relative humidity recording has a mean monthly of about 64.5%. The maximum relative humidity exist in August (70.4%), and the minimum of 54.5% in May (Ali,1982).

The climate of the studied area is characterized by an extreme aridity; long hot rainless summer, short rainy mild winter, high evaporation and low relative humidity. Table (1) shows the meteorological data of 10

years; recorded by meteorological station at Bahtim. The Nile Delta is formed from alluvial suspended material and the sand brought about the Nile. The sand and suspended matter mixture were deposited from the river during the transition period between Palacolithic and Neolithic time (about 8000-10000 year B.C). (El-Badawy, 1978).

Table (1): Climatological normal of Qalubeya Governorate (average of 10 years(1978-1987). Recorded by meteorolgical station at Bahtim.

Month	Temperature °C			Mean total rainfull (mms)	Mean of evaporation piche (mm/day)	Relative humidity %	Wind velocity Km/hr
	Max	Min	Mean of day				
Jan.	18.9	6.2	12.6	3.4	3.7	66.7	5.3
Feb.	20.5	6.1	13.3	3.1	4.6	63.9	5.6
Mar.	22.9	7.7	15.3	3.5	5.2	64.6	5.6
Apr.	27.9	10.7	19.1	0.5	6.6	59.5	5.5
May.	31.4	13.9	22.7	0.6	8.5	54.5	5.4
Jun.	34.2	17.5	25.9	0.0	8.7	55.3	4.8
Jul.	33.4	19.0	26.2	0.0	6.0	65.7	3.3
Aug.	32.9	19.0	25.9	0.0	4.8	70.4	2.6
Sep.	32.0	17.2	24.6	0.0	5.2	57.8	3.0
Oct.	29.5	15.0	22.3	0.1	5.0	66.9	3.7
Nov.	24.1	10.8	17.4	2.5	3.4	69.4	3.5
Dec.	19.9	7.4	13.6	2.2	2.8	69.7	4.1
Annual mean	27.3	12.5	19.9	15.9	5.0	54.5	4.4

Harb (1985) classified the soils of the River Nile-Valley as Torripsamments, those of the Alluvial-Calluvial deposts as Terrifluvents, Papearthids and Calciorthids. He classified soils of the desert deposits as Torripsamments, Paleorthids, Calciorthids and Gypsiorthids.

Shanawany (1992) in their studied of soil classification of an area in Qalubeya Governorate found that the soils are classified according to USDA (1975) into six soil sub great groups as follows:

Sub great group(1) : *Typic Torrerts*, clayey montmorillonitic (calcareous)
Sub great group(2) : *Vertic Torrifluvents*, clayey mixed (calcareous)
Sub great group(3) : *Typic torrifluvents*, Coarse loamy, mixed
Sub great group(4) : *Typic Torriorthents*, sandy, mixed (calcareous)
Sub great group(5) : *Tyic Torripsamments*, siliceous
Sub great group(6) : *Typic Calciorthids*, sandy, mixed, thermic

Characterization of the soil parent material is necessary for a meaningful interpretion of soil morphology and pedology (Arnold, 1968). Blizi and Ciolkosz (1977) presented an easy, field morphology rating system, to evaluate quantitatively the degree of soil development. The system includes two soil rating scales namely; the relative horizon distinctness (RHD) and the relative profile development (RPD). In the first scale, morphological features of two adjacent horizons, in a pedon, are compared to identify depositional or parent material discontinuities. While in the second scale, a comparison of the features of discrete horizons with the C horizon within a pedon. Meixner and Singer (1981) applied this system to a chronosequence in San Joaquin valley in California. They reported that the rating values were generally less than 10 and were proportionate to the degree of horizon differentiation. Values exceeding 10, however, allocated soils were observed and suspected discontinuous parent materials. They added that although RPD increased with age yet, A-horizons of younger soils and B-horizons of older soils acquired the highest RPD values. Harden (1982) suggested a modification to this index, based on field description, to improve the quantitative assessment of the degree of soil profile development.

The aim of this study is to estimate and evaluate the soil horizons distinctness of the studied area by applying different rating scales. Also, a new modification for the rating scales, to account for secondary soil formation, was implicated in the study.

MATERIALS AND METHODS

Twenty nine profiles were examined and 6 out of them were chosen to represent the different soils in the studied area. The profiles were dug to 150 cm or less according to depth of hard pans or rocks and morphologically described according to FAO system (1977), (Table 2). Soil samples representing the subsequent morphological variation within the entire depth of each profile were collected for laboratory analyses including particle size distribution, EC_e, pH and $CaCO_3$ according to the methods described by Richards (1954).

Method used for evaluating profile development

The method used for profile evaluating in the field morphology scale which is proposed by Bilizi and Ciolkosz (1977). In this method they defined two rating scales:

A- Relative Horizon Distinctness (RHD) which is a comparison of the morphological features of two adjacent horizons.

B- Relative Profile Development (RPD) which is a comparison of the morphological features of each horizon with the C horizon within the profile.

The soils were evaluated and the points were assigned as described by Meixner and Singer (1981) as follows:

1- Colour (dry and moist): one point is assigned for any class change in hue and for any unit change in value or chroma.

2- Texture: one point is assigned for each class change on the texture triangle.

3- Structure: one point is assigned for any change in type of aggregated structure, for each unit change in grade (1,2,3) and for each class change in size (vf, f, m, c, vc), irrespective of the aggregate type.

4- Consistence:one point is assigned for any class change in dry (lo, so, sh, h, vh, eh) and moist (lo, vfr, Fr, Fi, Vfi, efi) Consistence.

5- Boundaries: points are assigned according to the distinctness of the lower or shared horizon as follows diffuse-0, gradual1-, clear-2, abrubt-3, and very abrubt-4.

6- Clay films: one point is assigned for each change in frequency or thickness at any single location.

Profile index values, were also calculated according to Harden (1982). Additionally the soil content of secondary formations (Carbonate, gypsum and salts) were calculated according to Salem et al, (1997).

RESULTS AND DISCUSSION

Soil classification of the studied profiles has been conducted up to the family level depending on the soil taxonomy system; using USDA Keys of soil Taxonomy (1975 & 1992). The soils were classified as Vertisols, Entisols and Aridisols.

The order Entisols having four suborders; namely, fluvents (profiles 2&9), orthents (profile 21) and psamments (profile 4). While the order Vertisols having one suborder; namely, Torrerts (profile 13) and the order Aridisols having one suborder; namely, orthids (profile 3). This classification is justified by morphological description and some chemical analyses data (Table 2). Climatological data indicate that the soil temperature regime of these area is thermic. Table (3) shows the soil taxonomy classification up to the family level according to USDA (1975&1992).

The soil description in Table (2) shows that no diagnostic horizons in profile 13, 2, 4, 9 and 21, where profile 3 have Calcic horizon, respectively.

They are olso characterized by narrow range of soluble salts (0.48-9.9 dsm^{-1}) having neutral pH (7.5-8.5) and low gypsum content (0.03-1.93%). However calcium carbonate content was range between (0.24-15.2%). Table (2) shows the morphological description of six profiles covering different stages of some zones of encroachment between the Nile Delta and Desert in Qalubeya Governorate. The soils were evaluated and prospective points were assigned as described by Meixner and Singer (1981) and the soil rating scale as applied. In addition, rating points of secondary components (Carbonate, gypsum and ECe) along with the pH values of the soil paste were recorded in Table (4), (Salem et al., 1997).

Relative Horizon Distinctness (RHD)

The values of the RHD rating are listed in Table(5). Values are plotted at the boundary between horizons to give relative distinctness of graphical representation (Fig.1).

It appears that the Vertisols soils (profile No.13) have RHD ratings lie between 4 and 16 (Table 5) indicating that a very clear distinctness. As many properties are contributed to the rating the horizons c_1, c_2, c_3 and c_4 which are suggested to point to big differences. The RHD ratings, are more than 10 densting no depositional or parent material discontinuities is detected, (Meixner and Singer, 1981).

As for profiles No.2 and 4 representing recent soils Vertic Torrifluvents and Typic Torripsamments having (RHD) rating lie between 3 and 7 (Table 5) indicating a slight distinctness. Also the distinctness was not clear in profiles No. 9 and 21 representing recent soils Typic Torrifluvents and Typic

Torriorthents having (RHD) rating lie between 2 and 9 (Table 5) indicating a slight distinctness.

In profile No.(3) representing Aridisols, Typic Clciorthids having (RHD) rating 7 (Table 5) indicating a weak distinctness.

The recent soils, Entisols, have little distinctness more than the oldest Vertisols.

Relative Profile Development (RPD)

Values of RPD rating of the studied profiles are listed in Table(6). Values are plotted at the midpoint of the horizon to give graphical representation of the relative profile development of the soils, (Fig.2).

Data revealed that the profile No.(13) representing the Vertisols (*Typic Torrerts*, clayey, montmorillonitic, thermic) has the highest RPD rating (9) with an average of (9) RPD/cm based on colour, texture, and clay film properties at the lower boundary. Since all layers have the same RPD rating. The rating clearly reflected a good development of the Torrerts.

The profiles 2,4 representing the Entisols (*Vertic Torrifluvents*, clayey, mixed, thermic and *Typic Torripsamments*, sandy, mixed, thermic) having RPD rating ranged between 2-6 with an average of 4.7 and 4.0 RPD/cm, respectively.

In respecting soils of *Typic Torriorthents* which represented by profile No.(21). whose RPD rating ranged between 1-9 and *Typic Torrifluvents* which represented by profile No.(9) whose RPD rating ranged between 4-7. This indicates low development has been occurred in comparison to the *Typic Torrerts*.

As for the soil of *Typic Calciorthids* which are represented by profile No.(3), RPD rating ranged between 0-7. (Table 6) indicating a weak development than the other recent soils.

Quantitative Index Methods

Profile Development Index (PDI) which described by Harden (1982) was applied for six profiles covering the different soil sub great groups. At the request of such evaluation the following considerations were taken into account:

(1) The area under study is geographically a very small one, extending only few square Kilometers. All deposits were considered as belonging to the same parent material and the same geomeorphic units.

(2) As no geological stratification was evidenced through the morphological description or the analyses of the previously discussed RHD rating of the morphological rating scale methods.

The parent material of all soils under study was scoped to be sand, single grains structure, soft and very friable when moist, non-sticky, non-plastic on wet consistence. The colour notations of “10YR 4/2 dry” and “10YR 3/3 moist” are used as basic colours of the parent material. pH value is 8.2 In addition to secondary formation (salts, carbonate and gypsum) were assigned nil.

The field properties of the studied profiles, as accumulated and abbreviated from the morphological descriptions, which are described in

Table(2) are quantified (step1), and normalized (step2). All the normalized properties are summed up for each horizon (step 3) and divided by ; the number of investigated properties (step4).
This number resembles other normalized property ranges from 0 to 1 and is called the Horizon Index. It is of interest to note that missing data would not affect the range of this index.

Each horizon index is multiplied by the horizon thickness to yield index-cm of development. Summation of the index-cm of all horizons in the profile represents the final step No.(5). The resultant is the profile development index.

The field properties of the soils under study quantified and combined into the development index are given in Tables 7 and 8.

It appears from Table(7) that the horizon index values of the vertisols (*Typic Torrerts*, clayey, montmorillonitic, thermic) representing by profile No.13 are moderate : 0.29, 0.30, 0.17 and 0.24 for the C_1, C_2, C_3 and C_4 horizon respectively. Indicates that the values of the subsurface C_2 is higher than those of the other horizons

Table (7): The field properties of profile N0.(13) quantified and combined into the development index.

Quantified soil field properties				
	C_1	**C_2**	**C_3**	**C_4**
Texture	110	110	40	80
Rubefication	20	30	20	20
Structure	10	10	10	10
Dry consistence	20	20	10	20
Moist consistence	10	10	0	10
Melanization (value)	20	20	20	20
PH	0.2	0.25	0.10	0.0
Normalized data				
Texture	1.0	1.0	0.4	0.7
Rubefication	0.18	0.27	0.18	0.18
Structure	0.17	0.17	0.17	0.17
Dry consistence	0.22	0.22	0.11	0.22
Moist consistence	0.11	0.11	0.00	0.11
Melanization (value	0.30	0.30	0.01	0.00
PH	0.02	0.03	0.01	0.00
Sum normalized properties	2.00	2.10	1.17	1.68
Divided by number of properties	0.29	0.30	0.17	0.24
Miltiply by horizon thicknes	11.6	9.0	8.5	7.2

Sum Horizon products 36.3 profile development
Profile Development Index = 0.242 dev. Ind./cm
Profile Development Index (for 100 cm) 24.2%
Divided by profile thickness

The horizon index values of profile No, 2,4,9 and 21 representing recent soil Entisols (Fluvents, Torrifluvents, vertic Torrifluvents, clayey, mixed, thermic), (Fluvents, Torrifluvents, Typic Torrifluvents, Coorse loamy, mixed, thermic), (Orthents, Torriorthents, Typic Torriorthents, sandy, mixed, thermic) are (0.19, 0.21, 0.22 and 0.23), (0.13, 0.12, 0.17and 0.12), (0.02, 0.06, 0.03 and 0.02) and (0.01, 0.04, 0.02 and 0.04) for C_1, C_2, C_3 and C_4 horizons, respectively. These profiles have relatively lower horizon index values than those obtained for the same vertisols. Profile No.13.

Profile 3 representing Aridisols have low horizon index values in all horizons, based on all investigating properties (Table 8). This may be related to its soil type (*Typic Calciorthids*, sandy, mixed, thermic).

From the discussion presented here it may be concluded that the vertisols has an impace on the development of soil profiles. The results reflect the medium soil formation processes under the prevailing aridic conditions.

Table (8): Field properties of the studied profile, quantified and combined into the development index.

Prof. N0		Horizons Distinguished			
		C_1	C_2	C_3	C_4
13	**H I**	0.29	0.30	0.17	0.24
	PDI **PDI** **PDI(for100cm)**	36.3 for profile(1) 0.242cm 24.2%			
2	**H I**	0.19	0.21	0.22	0.23
	PDI **PDI** **PDI(for100cm)**	31.6 for profile 2 0.211 cm 21.1%			
3	**H I**	0.08	0.01	-	-
	PDI **PDI** **PDI(for100cm)**	3.0 for profile 3 0.03cm 3%			
4	**H I**	0.13	0.12	0.17	0.12
	PDI **PDI** **PDI(for100cm)**	19.9 for profile 4 0.133 cm 13.3%			
9	**H I**	0.02	0.06	0.03	0.02
	PDI **PDI** **PDI(for100cm)**	4.7 for profile 9 0.031 cm 3.1%			
21	**H I**	0.01	0.04	0.02	0.04
	PDI **PDI** **PDI(for100cm)**	4.1 for profile 21 0.027 cm 2.7%			

CONCLUSIONS

Soil development is assessed using the recent morphology rating scale approach, and the quantitative index methods. Both methods revealed that differentiation between profiles of different soil orders

(Vertisols, Entisols and Aridisols) was mainly related to the presence and distinctness of the formation processes and the developed horizon.

The relative horizon distinctness (RHD) rating is increased by increasing the soil development, since the recent soils Entisols and Aridisols have little distinctness more than the older Vertisols.

The relative profile development (RPD) ratings is also increased by increasing the soil development. The (RPD) rating averages for the Entisols and Aridisols are (4.7, 4, 5.3 and 5) and 7, respectively. While it was 9 in the Vertisols.

The horizon index values of the quantitative method varied with the soil formation processes and soil development, these are (31.6, 19.9, 4.7 and 4.1) and 3.0 for soil Entisols and Aridisols (prof. 2, 4, 9 and 21) and 3, respectively. While it was 36.3 in the Vertisols (profile 13).

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دراسة تطور الاراضى لبعض مناطق التداخل بين الدلتا والصحراء فى محافظة القليوبية

محمد عبد الرحمن موسى – بهجت حنا نجيب – محمد عصام عطية خليل
معهد بحوث ألاراضى والمياة والبيئة – مركز البحوث الزراعية – جيزة

تهدف الدراسة اساسا الى تتبع التغير فى الخواص المورفولوجية والبيدوجينية فى الاراضى الحديثة Entisols وأراضى الوادى القديمة Vertisols & Aridisols وقد اختير لذلك عدد ستة قطاعات تغطى ستة مجاميع أراضى.

- فحصت تسعة وعشرون قطاع ستة منها تمثل هذة الدراسة وطبق عليها معدلات القياس Rating scale وقدر بها الوضوح النسبى للافاق(RHD) وكذلك التطور النسبى للقطاع الارضى (RPD) ويعتمد تقدير (RHD)على مقارنة الافق بالافق الذى يلية فى القطاع الارضى.
- كذلك تم تقدير (RPD) عل اساس مقارنة الأفاق المختلفة مع الافق الأخير (مادة الأصل) فى القطاع الأرضى. وقد أخذ فى الاعتبار بعض الخواص الكيميائية مثل الأملاح وكربونات الكالسيوم والجبس ودرجة الpH عند تقدير هذا التطور. كما تم حساب قيم Profile Index من قيمة Horizon Index وذلك بطريقة المعامل الكمى للقطاع الارضى Quantitative profile.
- وقد وجد أن قيم RHD تتوافق مع قيم RPD وقيمة PDI التى أظهرت الاختلاف الواضح بين الاراضى القديمة الممثلة فى أراضى *Typic Torrerts* والاراضى الحديثة والممثلة فى اراضى Entisols وتشمل (*Vertic Torrifluvents,Typic Torriluvents, Typic Torriorthents* and *Typic Torripsamments*) وأراضى Aridisols وتشمل:- *Typic Calciorthids*
- وقد أظهرت النتائج أن الأراضى *Typic Torrierts* عالية التطور أكبر من الاراضى الاخرى Entisols and Aridisols.

Table (3) : soil classification of the studied profiles.

Prof. N0.	Order	Sub order	Great group	Sub great group	Family
13	Vertisols	Torrerts	Torrerts	Typic Torrerts	Clayey, montmorillonitic, thermic
2	Entisols	Fluvents	Torrifluvents	Vertic Torrifluvents	Clayey ,mixed, thermic
9	"	"	"	Typic Torrifluvents	Coarse loamy, mixed, thermic
21	"	Orthents	Torriorthents	Typic Torriorthents	Sandy, mixed, thermic
4	"	Psamments	Torripsamments	Typic Torripsamments	Sandy, mixed, thermic
3	Aridisols	Orthids	Calciorthids	Typic calciorthids	Sandy, mixed, thermic

Table (4) :The suggested rating points for the soil components : carbonate, gypsum, EC and pH of the soil paste; by Salem et al (1997).

Carbonates or gypsum			EC_0 dSm^{-1}			pH values		
Terminology	Quantity	Rating points	Terminology	Quantity	Rating points	Terminology	Values	Rating points
Very few	<5	0	Non saline soil	<2	1	Ultra acid	<3.5	1
Few	5->15	1	Very slightly saline soil	2-<4	1	Extremely acid	3.5-4.1	1
Common	15-<40	2	Moderately saline soil	4-<8	1	Very strongly acid	4.5-5.0	1
Many	40-<80	3	Highly saline soil	8-<16	1	Strongly acid	5.1-5.5	1
Dominant	>80	4	Extremely saline soil	<16	1	Moderately acid	5.6-6.0	1
						Slightly acid	6.1-6.5	1
						Neutral	6.6-7.3	1
						Slightly	7.4-7.8	1
						Moderately alkaline	7.9-8.4	1
						Strongly alkaline	8.5-9.0	1
						Very strongly alkaline	>9.0	1

FAO (1977)** * USDA (1993).**

Table (5): Relative horizon distinctness (RHD) rating of the studied profiles.

Profile N0.	Depth (cm)	Colour		Texture classes	Struct. Type	Consistence				Secondary form			Clay Film	Lower boundary	pH	RHD
		Moist	Dry			Dry	Moist	Wet		EC_e	$CaCO_3$ K	$CaSO_4$ GY				
								ST	PL							
13	C_1/C_2	1	0	0	1	0	0	0	0	0	0	0	0	2	0	4
	C_2/C_3	1	1	3	0	1	1	2	2	0	0	0	3	1	1	16
	C_3/C_4	2	0	2	0	1	1	1	1	0	0	0	0	1	1	10
2	C_1/C_2	0	0	1	0	0	0	0	0	0	0	0	0	1	1	3
	C_2/C_3	0	2	0	0	0	0	0	0	0	0	0	0	1	0	3
	C_3/C_4	1	2	1	0	0	0	0	0	0	0	0	0	1	1	6
3	C_1/C_2	0	0	2	0	0	0	1	1	1	1	0	0	1	0	7
4	C_1/C_2	1	0	0	0	0	0	0	0	1	0	0	0	1	1	4
	C_2/C_3	1	3	0	0	0	0	0	0	1	0	0	0	1	1	7
	C_3/C_4	1	3	0	0	0	0	0	0	1	0	0	0	1	1	7
9	C_1/C_2	1	0	0	0	0	0	0	0	0	0	0	0	2	1	4
	C_2/C_3	1	1	1	0	0	0	1	1	0	0	0	0	1	0	6
	C_3/C_4	0	1	0	0	0	0	0	0	0	0	0	0	1	0	2
21	C_1/C_2	1	2	2	0	0	0	1	1	1	0	0	0	1	0	9
	C_2/C_3	1	2	0	0	0	0	0	0	1	0	0	0	1	1	6
	C_3/C_4	1	2	0	0	0	0	0	0	0	0	0	0	1	1	5

Table (6): Relative profile development (RPD) rating of the studied profiles.

Profile N0.	Depth (cm)	Colour		Texture classes	Struct. Type	Consistence				Secondary form			Clay Film	Lower boundary	pH	RPD
		Moist	Dry			Dry	Moist	Wet		EC_e	$CaCO_3$ K	$CaSO_4$ GY				
								ST	PL							
13	C_1/C_4	2	1	1	1	0	0	1	1	0	0	0	0	2	0	9
	C_2/C_4	1	1	1	0	0	0	1	1	0	0	0	3	1	0	9
	C_3/C_4	2	0	2	0	1	1	1	1	0	0	0	0	1	0	9
2	C_1/C_4	1	0	2	0	0	0	0	0	0	0	0	0	1	0	4
	C_2/C_4	1	0	1	0	0	0	0	0	0	0	0	0	1	1	4
	C_3/C_4	1	2	1	0	0	0	0	0	0	0	0	0	1	1	6
3	C_1/C_2	0	0	2	0	0	0	1	1	1	1	0	0	1	0	7
4	C_1/C_4	1	0	0	0	0	0	0	0	1	0	0	0	2	0	4
	C_2/C_4	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
	C_3/C_4	1	3	0	0	0	0	0	0	1	0	0	0	1	0	6
9	C_1/C_4	0	0	2	0	0	0	1	1	0	0	0	0	1	0	5
	C_2/C_4	1	0	2	0	0	0	1	1	0	0	0	0	1	1	7
	C_3/C_4	0	1	1	0	0	0	0	0	0	0	0	0	1	1	4
21	C_1/C_4	1	2	2	0	0	0	1	1	1	0	0	0	1	0	9
	C_2/C_4	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	C_3/C_4	1	2	0	0	0	0	0	0	0	0	0	0	1	1	5

Table (2): Morphological and chemical properties of the studied profile.

Profile N0.	Horiz-ons	Depth (cm)	Colour		Texture classes	Struc-ture	Consistence				Clay Film	Boun-dary	EC_e ds/m	pH :2.5	$CaCO_3$ %	Efferve-scence	$CaSO_4$ %
			Moist	Dry			Moist	Dry	Wet ST	Wet PL							
13	C_1	0-40	10YR4/2	10YR 5/2	C	SA	FR	HA	VST	VPL		CS	0.76	7.90	3.04	S	0.14
	C_2	40-70	10YR 4/2	10YR 5/3	C	SB	FR	HA	VST	VPL		DS	0.81	7.95	3.39	S	0.14
	C_3	70-120	10YR 4/2	10YR 5/2	SL	SB	VFR	SHA	SST	SPL	S	DS	1.18	8.10	2.83	SL	0.10
	C_4	120-150	10YR 4/2	10YR 5/3	CL	SB	FR	HA	ST	PL			1.14	8.20	2.04	SL	0.09
2	C_1	0-40	10YR 3/3	10YR 4/3	Scl	SB	FR	SHA	VST	VPL		DS	1.21	7.90	2.74	S	0.12
	C_2	40-90	10YR 3/3	10YR 4/3	SC	SB	FR	SHA	VST	VPL		DS	1.26	7.50	3.70	S	0.10
	C_3	90-120	10YR 3/3	10YR 5/2	SC	SB	FR	SHA	VST	VPL	-	DS	1.41	7.60	3.26	S	0.11
	C_4	120-150	10YR 3/2	10YR 4/3	C	SB	FR	SHA	VST	VPL			1.31	7.90	2.78	S	0.11
3	C_1	0-30	10YR 3/2	10YR 4/2	ScL	MA	VFR	So	SST	SPL	-	CW	5.86	8.05	8.04	S	0.04
	C_2	30-90	10YR 3/2	10YR 4/2	S	MA	VFR	So	ST	NPL			4.45	8.30	15.22	S	0.03
4	C_1	0-40	10YR 3/2	10YR 5/6	S	SG	Lo	Lo	NST	NPL		DS	9.90	8.20	0.57	SL	1.93
	C_2	40-70	10YR 3/3	10YR 5/6	S	SG	Lo	Lo	NST	NPL		DS	9.70	8.30	0.61	SL	1.63
	C_3	70-100	10YR 3/2	10YR 6/4	S	SG	Lo	Lo	NST	NPL	-	DS	5.16	8.20	0.57	SL	0.29
	C_4	100-150	10YR 3/3	10YR 5/6	S	SG	Lo	Lo	NST	NPL			1.30	8.40	0.26	None	0.04
9	C_1	0-15	10YR 3/2	10YR 4/2	SL	MA	VFR	So	SST	SPL		DS	1.42	7.60	1.04	None	0.09
	C_2	15-50	10YR 2/2	10YR 4/2	SL	MA	VFR	So	SST	SPL	-	CS	0.70	7.90	2.35	None	0.16
	C_3	50-80	10YR 3/2	10YR 4/3	LS	MA	VFR	So	NST	NPL		CS	0.56	8.15	2.96	None	0.06
	C_4	80-150	10YR 3/2	10YR 4/2	S	MA	VFR	So	NST	NPL			0.48	7.60	0.44	None	0.03
21	C_1	0-30	10YR 3/2	10YR 4/2	SL	MA	VFR	So	SST	SPL		DS	3.34	8.10	3.30	S	0.04
	C_2	30-60	10YR 3/3	10YR 4/4	S	MA	VFR	So	NST	NPL	-	DS	2.18	8.30	2.35	S	0.08
	C_3	60-110	10YR 3/2	10YR 4/2	S	MA	VFR	So	NST	NPL		DS	2.12	8.50	3.13	S	0.11
	C_4	110-150	10YR 3/2	10YR 4/4	S	MA	VFR	So	NST	NPL			1.40	8.25	0.24	SL	0.11

Texture.
S: sand
C: clay
LS: loamy sand
SL: sandy loam
SCl:sandy clay loam
SC: sand clay

Structure
SB: subangular blocky
MA: massive
SG: single grains
SA: subangular

Consistence
Dry: HA: hard, S: slightly, Lo: loose, So: soft
Moist: v: very, FR: friable
Wet: ST:sticky, PL: plastic, N: none, S: slightly

Boundary.
CS:clear smooth
DS:diffuse
CW: clear wavy

Effervescence
S: strong
SL: slightly
V: very