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Pedological Development of South El-Amiria Soils Using Field Morphology Rating System

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Abstract

The current study was used the field morphological rating scale for evaluating pedological development through determining the Relative Horizons Distinctness (RHD) and the Relative Profile Development (RPD) of soil . Some chemical and physical properties were used to evaluate the pedogenic factors as a result of being affected by process and factors of soil formation due to the distinct effect of climatologically environment. The RHD ratings were made by a comparison of adjacent horizons. Average of RHD ratings on the level of physiographic unit show that soils of windblown sand older than soils of lacustrine plains. The RPD ratings were made by a comparison of the C horizon to the horizons above it in the profile. The average RPD ratings of lacustrine plains under Aridisols order were less than windblown sand, which most area belong to Entisols order. So, studies of pedological development need more attempts to include different features of the international soil development.

Keywords: South El-Amiria soils, Relative Horizons Distinctness (RHD), Relative Profile Development (RPD).

Introduction

Bilzi and Ciolkosz (1977) presented a system for a rating scale developed to quantitatively evaluate several important morphological properties of soils. The rating scale was used in the following two ways: (1) to determine the relative distinctness of horizon and (2) to determine the relative development of soil profile. The determination of relative distinctness of horizons was made by a comparison of adjacent horizons while the determination of the relative profile development was made by a comparison of the C horizon to the horizons above it in the profile. The rating scale was effective in evaluating pedological development of soils developed in a humid–temperature climate.

Additional morphological factors may be needed to evaluate pedological development of soils developed in other climatic regimes. So, additional soil contents of secondary formations (carbonate, gypsum and salinity) and pH values according to Salem *et al* (1997) are more suitable for the soils of an aridic regime such as the soils under study.

According to Meixner and Singer (1981), Relative Horizon Distinctness (RHD), a comparison of the morphological features of two adjacent horizons, was tested as a means of identifying depositional or parent material discontinuities. Relative Profile Development (RPD), a comparison of the morphological features of discrete horizons with the C horizon within a pedon, was compared with soil age.Also, Meixner and Singer (1981) concluded that using a field soil morphology rating system to evaluate a chronosequence of soils in the northeastern San Joaquin Valley, California. Relative Horizon Distinctness (RHD) ratings generally were less than 10. The RHD ratings greater than 10 were obtained for observed and suspected parent material or soil formation discontinuities. Although monogenetic soil formation will result in high RHD ratings in some cases, the soils tested here usually had high RHD

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ratings at discontinuities. Relative Profile Development (RPD) ratings increased with age Maximum values were in the A horizons of younger soils and in the B horizons of older soils.

The objective of the work is to evaluate the soil development under two different physiographic units in south El-Amiria**.**

Materials and Methods

The study area is located between longitudes 29° 47´ 55´´and 30° 30´ 05´´East and latitudes 29° 29´ 30´´ and 30° 30´ 05´´ North in the Western Desert (Map 1). The pedological features of this area are studied by Zayed et al. (2020). Interpretation of soil morphology and development depends upon a correct evaluation of soil parent material (Arnold, 1968).

Generally, the studied area occupies with windblown sand in the southern most part, dunes from four to five meters high occurring near the Gianaclis read. The difference in the height of the dunes decreases north-ward and they dwindle to the thin blanket of sand over the compact soils of Gianaclis plain which are also occasionally exposed in the dune valleys. The Gianaclis plain extends northwards to limestone ridge of Amiria, and north eastwards until it deps gently below the alluvial deposits of the Nile delta. The plain is an old sea floor, presumably of the early Pleistocene age, and is almost flat. The soils are compact coarse textured loams with an abundance of hard and soft lime concretions (UNDP\ FAO, 1963).

Nine soil profiles along area South El-Amiria, which represent two physiographic units i.e. Lacustrine plains and windblown sand were described according to FAO (2006). Different physical and chemical properties were determined according to Burt (2004).

The climatological data of the study area belong to "Thermic" temperature regime and "Torric" moisture regime according to USDA (2014). These data are given and illustrated in work of Zayed et al. (2020).

The field morphology rating system (Bilzi and Ciolkosz, 1977) was used to determine both RHD and RPD of nine soil profiles as representing the two physiographic units . The soils were evaluated and points assigned as described below.

1- Color (dry and moist): One point is assigned for any class change in hue and for any unit change in value or chroma. For example, a change from 10 YR 4/6 to 5 YR 3/8 would have a value of 5 for the twofold class change, the one – unit change in value, and two – unit change in chroma. Where two colors are observed (other than mottles), each one is compared, and the average difference is used.

2- Texture: One point is assigned for each class change on the textural triangle. In addition, a change from nongravelly to gravelly or very gravelly is assigned one or two points, respectively.

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. For example, a change from weak, very fine subangular blocky (Ivf sbk) to moderate, medium angular blocky (2m abk) is assigned a value 4. When the change is from no aggregated to aggregated structure (or vice versa), however, only the grade of the aggregate type is evaluated, in addition to the one point assigned for the type change. For example, a change from massive to weak, fine subangular blocky (1f sbk) is assigned a value of 2.

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- Clay films: One point is assigned for each class change in frequency or thickness at any single location. Clay films are not observed in the current study.

6- Boundaries: Points are assigned according to the distinctness of the lower or shared horizon as follows: diffuse-0, gradual-1, clear-2, abrupt-3 and very abrupt-4.

7- The chemical rating system (Salem, et al.,1997) was evaluated and points assigned as follow :

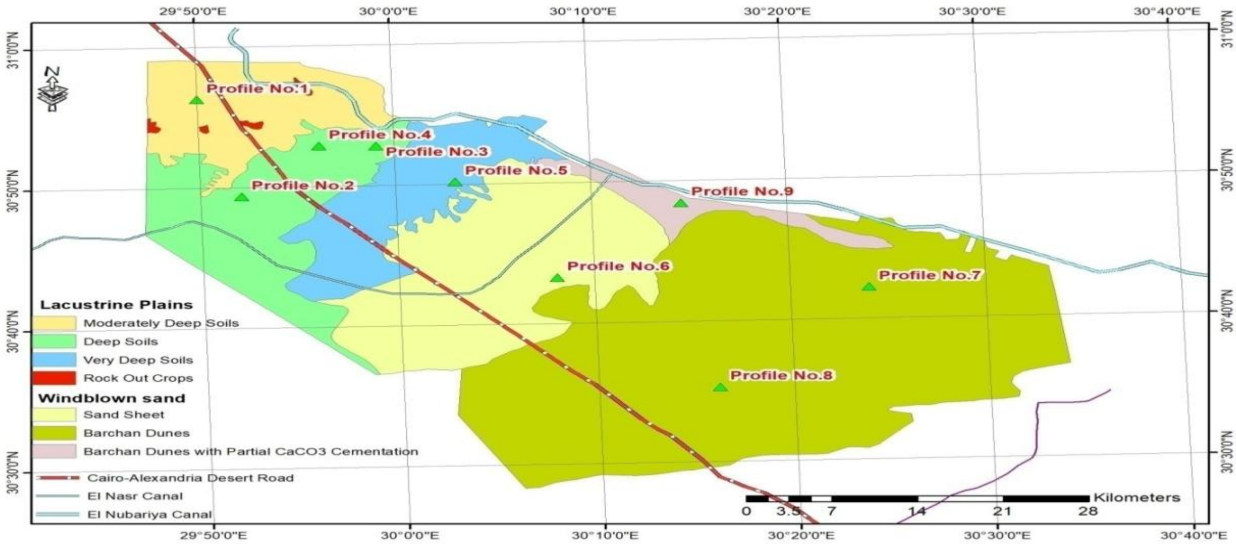
7.1- Carbonate or gypsum: one point is assigned for each class change in quantity (vf, f, c, m, d).

7.2- Soluble salts (dS/m): One point is assigned for each class change in quantity (non, very slightly, moderately, highly, extremely saline).

7.3- The pH value of soil paste: One point is assigned for each class change in quantity (ultra-acid, extremely acid, very strongly acid, strongly acid, moderately acid, slightly acid, neutral, slightly alkaline, moderately alkaline, strongly alkaline and very strongly alkaline).

Results and Discussion

Data in Table 1 show the morphological and chemical properties of five profiles covering soils of lacustrine plains and four profiles representing soils of windblown sand. The data were evaluated and prospective points were assigned as described by Bilzi and Ciolkosz (1997), Meixner and singer (1981) and Salem *et al*. (1997), and the soil rating scale are applied.



Map 1. Location of the studied area (C.F. Zayed et al., 2020)

Relative horizon distinctness:

The values of Relative Horizon Distinctness (RHD) rating are listed in Table 2. The same values are plotted at the boundary between horizons to give graphical representation of the relative horizon distinctness of the soils, Fig 1.

Soils of profiles 1, 2, 3, 4 and 5 are representing the physiographic unit of lacustrine plains, which have Relative Horizon Distinctness (RHD) between 4 and 15 (Table 2), indicating a very slightly distinctness within soil profiles 2, 3 and 5 may be due to very few properties are contributed to the ratings of the subdivisions C_1, C_2 or C_3, which are suggested to point out minor differences. The distinctness of the horizon boundary and variations in dry and moist color, and distinctness of lower boundary contributed most of the rating . Soils of profile 1 have higher values of RHD ratings (10 and 15) in this unit, where as soil color, consistence and secondary formation account for most of the difference in the RHD values. Data of RHD values between upper two layers of profile 4 recorded rating 10 due to variation in dry and moist color and distinctness of lower boundary. The obtained differences may be due to pedologic rather than geologic processes. On the other hand, soils of profile 1 consider the oldest one than the other representative profiles in this unit . According to Meixner and Singer (1981), the Relative Horizon Distinctness (RHD) ratings greater than 10 were obtained for observed and suspected parent material or soil formation discontinuities is detected. The previous conclusion of profile one differs with Meixner and Singer (1981) conclusion, which has an environment of Mediterranean climate with a xeric moisture regime (MAP = 310 mm) and a thermic temperature regime (MAT= 16 C°) in northeastern San Joaquin Valley, California, while the current study was affected by an aridic moisture regime (MAP: 199.4 mm, Zayed et al., 2020) and thermic temperature regime (MAT = 20.1C^0).

Soils of profiles 6, 7, 8 and 9 are representing the physiographic unit of windblown sand. Values of Relative Horizon Distinctness (RHD) differ from 6 to 10 ratings, for soil profiles 7, 8 and 9, while soils of profile 6 record 13 ratings. From the previous discussion, limit of 10 rating according to Meixner and Singer (1981) may be considered not suitable in our environment. So, soils of profile 6 consider as an older than other representative profiles follow by profiles 7, 8 and 9 respectively, i.e., soils of profile 9 are the youngest. Soils of profile 6 have highest RHD ratings of sum, dry and moist color, ratings of lower boundary and secondary formation of salt accumulations.

Soils of lacustrine plains have average RHD ratings differ from 4.67 to 12.14 with an average of unit about 7.26. On the other hand, soils of windblown sand have average RHD ratings change from 8 to 13 with an average of unit about 10.0 which probably indicate horizon distinction in windblown sand soils may be older than soils of lacustrine plains.

Relative profile development

Values of Relative Profile Development (RPD) ratings of the studied soil profiles are shown in Table (3). The previous values at midpoint of the horizon plotted to give graphical representation of the relative profile development of the soils which illustrated in Fig. (2).

Data of RDP ratings in C_2/C_3 of profile 1 record higher values, may be due to effect of higher accumulation of secondary salts and not a results for effect of the depositional discontinuity.

Soils of profiles 4 and 5 have RPD ratings in surface layer nearly twice that in the sub- surface horizon. Soil color, may be consider a limiting factor in calculating both RHD and RPD ratings where the three soil color properties of hue, value and chroma change as a soil develops.

The Munsell soil color charts are to quantify these changes. Color value decreases as A horizons or surface layers darken with organic matter accumulation.

Data of Zayed *et al*. (2020) show that surface layer of all representative profiles have higher contents of organic matter. So, color hues become redder and chromas become brighterwith soil age if pigments are available in oxidizing environments. Change in hue and chroma is called rubification (Kubiena, 1970).

Soils of profile 9 appear in the subsurface horizon rating slightly decrease than the surface one, this may be due to the same effect of organic matter contents, too.

According to Zayed et al. (2020) soils of profiles of lacustrine plains are classified as follows, respectively: Gypsic Haplosalids, Typic Calcigypsids, Gypsic Hoplosalids, Typic Haplocalcids and Typic Calcigypsids, respectively. While, soils of windblown sand are classified as follows, respectively: Typic Haplocalcids, Typic Torripasmments (profiles 7 and 8) and Typic Haplocalcids (profile 9), according to USDA (2014).

Generally, soils of lacustrine plains appear more pedogenic process than soils of windblown sand, where, all represent active profiles of the first unit belong to Aridisols order, while the second most of area belong to Entisols order. Studying of relative development rating show average of the first unit just 7.0, while the second unit records 10.65 as average of unit.

So, studying of pedological development needs more attempts to include changes around the world.

Table 1 . Morphological feature and some chemical and physical properties of the studied soil area

Profile No.	Horizon	Soil of layer depth (Cm.)	Colour		Texture	Structure	Consistence		Clay films	Lower boundaries	$CaCO_3$ %	Gypsum %	pH	EC dS/m
			Dry	Moist			Dry	Moist						
Physiographic unit : Lacustrine plains														
1	C_1	0- 20	10 YR 7/4	10 YR 6/4	SiL†	M□	Sh	Fr□	N□	Gradual	30.03	2.58	8.20	4.98
	C_2	20 - 60	10 YR 6/6	10 YR 5/6	SiL	M	Sh	Fr	N	Gradual	37.22	7.91	8.00	83.03
	C_3	60 - 90	10 YR 7/4	10 YR 6/4	SiL	M	H□□	Fi	N	----------	45.26	1.72	8.00	1.61
2	C_1	0 - 50	10 YR 6/4	10 YR 5/4	SiCL‡	M	Sh	Fr	N	Gradual	37.64	6.71	8.47	3.28
	C_2	50 - 110	10 YR 7/4	10 YR 6/4	SiCL	M	Sh	Fr	N	----------	37.22	4.13	8.22	6.76
3	C_1	0 - 45	10 YR 6/3	10 YR 5/3	SiCL	M	Sh	Fr	N	Clear	28.76	5.68	7.60	267.9
	C_2	45 - 110	10 YR 7/3	10 YR 6/3	SiCL	M	H	Fi□□	N	----------	29.61	3.10	7.59	39.22
4	C_1	0 - 30	10 YR 6/6	10 YR 5/6	SL††	M	Sh	Fr	N	Clear	38.00	1.03	7.65	0.58
	C_2	30 - 80	10 YR 7/3	10 YR 6/3	SL	M	Sh	Fr	N	Clear	27.00	0.69	7.55	0.92
	C_3	80 - 150	10 YR 7/4	10 YR 6/4	SL	M	Sh	Fr	N	----------	36.37	1.20	7.56	1.38
5	C_1	0 - 30	10 YR 6/3	10 YR 5/3	CL‡‡	M	H	Fi	N	Gradual	30.30	38.18	7.50	7.59
	C_2	30 - 70	10 YR 7/3	10 YR 6/3	CL	M	H	Fi	N	Gradual	34.26	18.20	8.26	4.31
	C_3	70 - 130	10 YR 7/4	10 YR 6/4	CL	M	H	Fi	N	----------	30.87	12.90	8.32	3.93
Physiographic unit : Windblown Sand														
6	C_1	0 - 50	10 YR 6/8	10 YR 5/8	S†††	M	H	VFr□□□	N	Clear	9.30	1.72	7.69	4.68
	C_2	50 - 100	10 YR 6/4	10 YR 5/4	S	M	H	VFr	N	----------	11.18	1.72	7.08	1.27
7	C_1	0 - 20	10 YR 7/6	10 YR 6/6	S	Lo□□	Lo□□□	Lo□□□□	N	Gradual	2.53	1.55	8.00	4.78
	C_2	20 - 100	10 YR 8/4	10 YR 7/4	S	Lo	Lo	Lo	N	----------	2.53	1.55	7.75	0.97
8	C_1	0 - 20	10 YR 8/6	10 YR 7/6	S	Lo	Lo	Lo	N	Diffuse	3.38	0.69	7.54	2.43
	C_2	20 - 100	10 YR 8/2	10 YR 7/2	S	Lo	Lo	Lo	N	----------	3.38	1.72	7.26	3.96
9	C_1	0 - 40	10 YR 5/3	10 YR 4/3	LS‡‡‡	M	H	Lo	N	Clear	13.18	1.38	7.66	1.13
	C_2	40 - 80	10 YR 6/3	10 YR 5/3	S	M	Sh	Lo	N	Abrupt	9.75	1.20	7.87	1.96
	C_3	80 - 120	10 YR 6/6	10 YR 5/6	S	M	H	Lo	N	----------	14.38	1.72	7.58	1.27

SiL† : Silty loam **SiCL**‡ : Silty Clay Loam**SL**†† : Sandy Loam **CL**‡‡ : Clay Loam **S**††† : Sand **LS** ‡‡‡: Loamy Sand **M**□ : Massi**Lo**□□ : Loose **Sh**□ : Slightly hard **H**□□ : Hard **Lo**□□□: Loose **Fr**□ : Friable **Fi**□□ : Firm **VFr**□□□: Very friable**Lo**□□□□: Loose **N**□ : Not observed

Table 2. Relative Horizon Distinctness (RHD) Ratings of the studied profiles

Profile No.	Horizon	Color		Texture	Structure	Consistence		Clay films	Lower Bound-aries	$CaCO_3$ %	Gypsum %	pH	EC dS/m	RHD	Average of RHD profile	Average of RHD unit
		Dry	Moist			Dry	Moist									
Physiographic unit : Lacustrine plains																
1	C_1/C_2	3	3	0	0	0	0	0	1	0	1	0	2	10	12.14	7.26
	C_2/C_3	3	3	0	0	1	1	0	1	1	1	0	4	15		
2	C_1/C_2	1	1	0	0	0	0	0	1	0	1	1	1	6	6.00	
3	C_1/C_2	1	1	0	0	1	1	0	2	0	1	0	0	7	7.00	
4	C_1/C_2	4	4	0	0	0	0	0	2	0	0	0	0	10	6.50	
	C_2/C_3	1	1	0	0	0	0	0	2	0	0	0	0	4		
5	C_1/C_2	1	1	0	0	0	0	0	1	0	0	1	0	4	4.67	
	C_2/C_3	1	1	0	0	0	0	0	1	0	1	0	1	5		
Physiographic unit : Windblown Sand																
6	C_1/C_2	4	4	0	0	0	0	0	2	0	0	1	2	13	13.00	10.0
7	C_1/C_2	3	3	0	0	0	0	0	1	0	0	1	2	10	10.00	
8	C_1/C_2	4	4	0	0	0	0	0	0	0	0	1	0	9	9.00	
9	C_1/C_2	1	1	1	0	1	0	0	2	0	0	0	0	6	8.00	
	C_2/C_3	3	3	0	0	1	0	0	3	0	0	0	0	10		

Table 3. Relative Profile Development (RPD) Ratings of the studied profiles .

Profile No.	Horizon	Color		Texture	Structure	Consistence		Clay films	Lower Bound -aries	$CaCO_3$ %	Gypsum %	pH	EC dS/ m	RPD	Average of RPD profile	Average of RBD unit
		Dry	Moist			Dry	Moist									
Physiographic unit : Lacustrine plains																
1	C_1/C_3	0	0	0	0	1	1	0	1	1	0	0	2	6	8.70	
	C_2/C_3	3	3	0	0	1	1	0	1	1	1	0	4	15		
2	C_1/C_2	1	1	0	0	0	0	0	1	0	1	1	1	6	6.00	
3	C_1/C_2	1	1	0	0	1	1	0	2	0	1	0	0	7	7.00	
4	C_1/C_3	3	3	0	0	0	0	0	2	0	0	0	0	8		
	C_2/C_3	1	1	0	0	0	0	0	2	0	0	0	0	4	6.50	
5	C_1/C_3	2	2	0	0	0	0	0	1	0	1	1	1	8		
	C_2/C_3	1	1	0	0	0	0	0	1	0	1	0	1	5	6.80	7.00
Physiographic unit : Windblown Sand																
6	C_1/C_2	4	4	0	0	0	0	0	2	0	0	1	2	13	13.00	
7	C_1/C_2	3	3	0	0	0	0	0	1	0	0	1	2	10	10.00	
8	C_1/C_2	4	4	0	0	0	0	0	0	0	0	1	0	9	9.00	
9	C_1/C_3	4	4	1	0	0	0	0	2	0	0	0	0	11		
	C_2/C_3	3	3	0	0	1	0	0	3	0	0	0	0	10	10.6	10.65

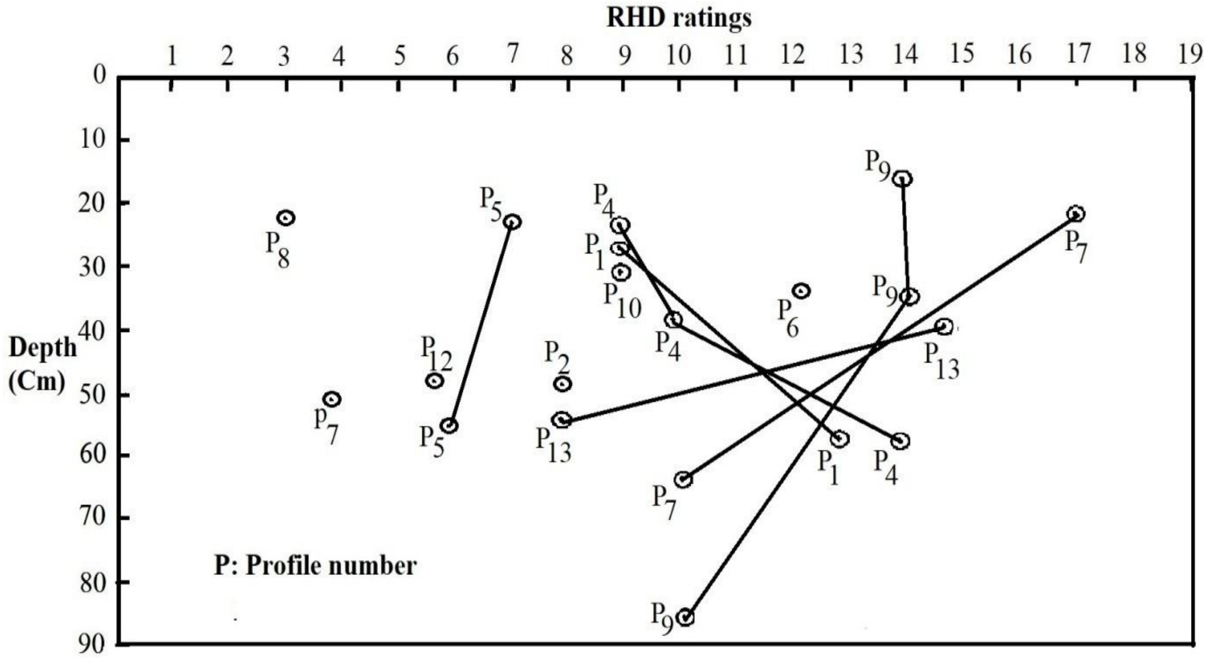


Fig. 1. Relative horizon distinctness (RHD) ratings.
Data points are pointed at boundary between the horizons

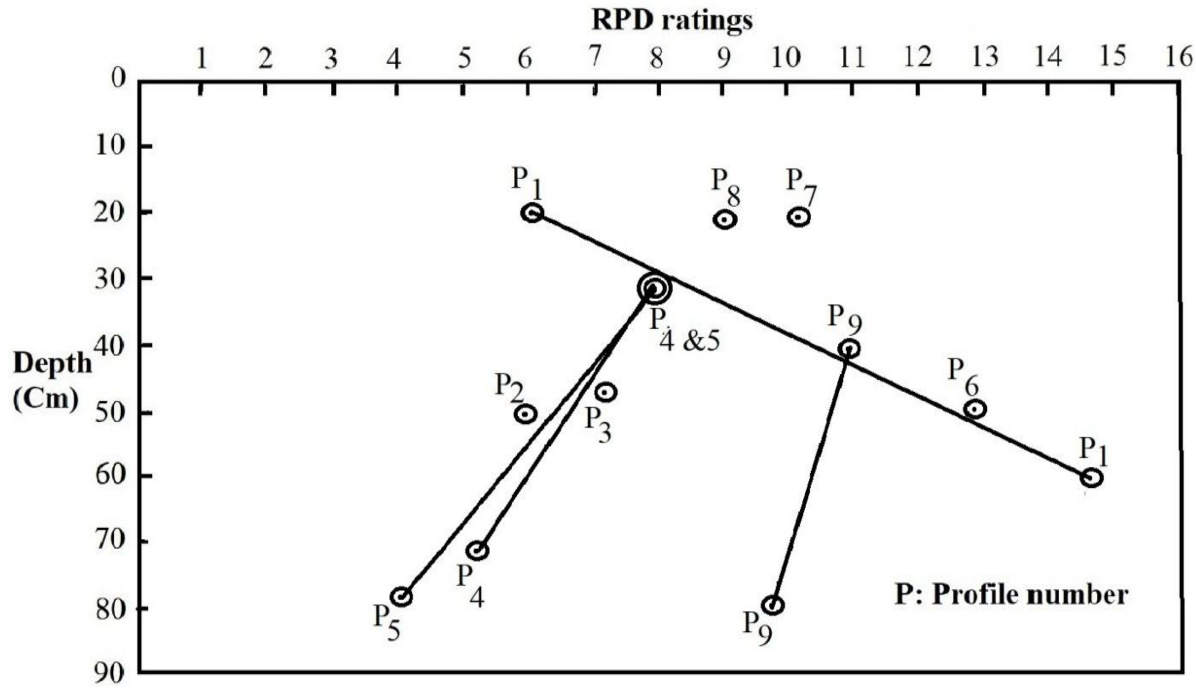


Fig. 2. Relative profile development (RPD) ratings.
Data points are plotted at the midpoint of the horizons.

Conclusion

The studies of pedological development must be taken into account the environmental and climatic conditions around the world. Orin other words, scientists of arid zone soils must determine the effective factors and its rate to be able to calculate the degree of development. In our opinion, these studies must be locally based.

This study used the Relative Horizons Distinctness (RHD) and the Relative Profile Development (RPD) of soil . Also, some chemical and physical properties were used to evaluate the pedogenic factors. These ratings show that soils of lacustrine plains, which belong to aridisols order, have an average RPD ratings less than windblown sand, which most area belong to Entisols order.

Conflicts of interest

The authors declare no conflicts of interest.

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