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Evaluation of pedological development of soils developed on lower reaches of Siwalik hills through field morphology rating system

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ABSTRACT

The field morphology rating scale was used to compare adjacent horizons with each other to give a comparison of the relative distinctness of horizons or to compare horizons in the solam with the C-horizon to give a relative profile development in soils occurring on alluvial landscape of Siwalik Hills. Relative horizon distinctness (RHD) in soil ranged from 1-14. The RHD of young undifferentiated soils varied according to consistence, coarse fragments and the nature of horizon boundary in the solum, whereas the same for older well developed soils varied according to colour, texture, structure and consistence in the profile. Relative profile development (RPD) of the younger soil developed on unstable landforms were low and maximum values were observed in A-horizon, while the values were higher in the soils developed on stable landforms and maximum values were in B-horizon.

1. INTRODUCTION

Soil morphology and the relative development of profile have been used significantly in the determinations of degree of development of soils and surficial depositions (Balster and Parsons 1968; Gile 1975). The soil formation under different landforms and occurrence of parent material discontinuities or other disturbance is sometimes difficult to determine. The morphology of soil reflects in a cumulative way the alteration of the parent material by soil forming processes. These can then be more quantitatively characterized and distinguished from those due to pedogenesis. Bilzi and Ciolkosz (1977) described a system for rating soil morphology and profile development using field morphological data. Using field morphological rating soils were evaluated for Chhotanagpur plateau of West Bengal (Sarkar *et al*. 1997) and Ghiladhari watershed of North Brahmaputra valley of Assam (Deka *et al.* 2009). The information on pedogenesis of soils using soil morphology rating for Siwalik region is scanty. The Siwalik fall in the sub-tropical region, have a peculiar climatic setting which is different from the Himalayas and plains. Geologically the Siwalik hills constitute sedimentary rocks such as sandstones, siltstones, conglomerates and clays (Wadia 1976) whereas foothill areas include recent deposits of alluvial and/or colluvial nature. The present study attempts to evaluate pedological variation in terms of developments of soils of Panja Rao sub-watershed of Saharanpur district (U.P) using field morphological rating system.

2. MATERIALS AND METHODS

The study area is situated between $30^0$14' to $30^0$21' N latitude and $77^0$33.5' to $77^0$42.5' E longitudes. The landforms of the study area are Siwalik hill, piedmont plain, alluvial plain and flood plain. Four representative pedons were studied for present investigation. Pedon 1 occurring on hills and ridges

under thin forest, pedon 2 on piedmont plain are under pasture, pedon 3 on alluvial plain and pedon 4 in flood plain under cultivation. The climate of this area is semiarid sub-tropical with ustic moisture regime with mean annual precipitation 900 mm and hyperthermic regime with mean annual temperature 26^{0}C (Aggarwal *et al*. 2002). Two indices of soil development *viz.* relative horizon distinctness (RHD) and relative profile development (RPD) were calculated from the soil morphological data as defined by Bilzi and Ciolkosz (1977). RHD was determined by comparing the morphological features of two adjacent horizons and RPD by comparing of the morphological feature of each horizon with the C horizon within each pedon. Soil profiles were studied in the field and soils were classified to the Key to Soil Taxonomy (Soil Survey Staff 1998). The soils were evaluated and points assigned as described below.

3. RESULTS AND DISCUSSION

Colour

One point is assigned for any class change in hue and for any unit change in value or chroma.

Texture

One point is assigned for each class change on the textural triangle. In addition, a change from non-gravelly to gravelly [coarse fragments (<7.5 cm) 15 to 35%] or very gravelly [coarse (<7.5 cm) >35%] is assigned one or two points, respectively.

Coarse Fragments/Stoniness (>7.5 cm diameter)

Points are assigned according to the volume of coarse fragments (>7.5 cm diameter) present in the matrix of the soil (1 for <35%, 2 for 35-80% and 3 for >80%).

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 aggregate type. If the type of structure is different, one unit change is assessed for type.

Consistence

One point is assigned for each class change in dry (lo, ss, sh, h, vh, eh), moist (lo, vfr, fr, fi, vfi, efi) and wet (so, ss, s, vs, po, ps, p, vp) consistence. *Boundary:* one point is assessed for gradual boundary, two points for clear boundary and three points for an abrupt boundary.

Clay Films

One point is assigned for class change in abundance or thickness at a single location. Thus, when a horizon with no film is compared with one having thin patchy cutans the value assigned is 1.

Morphological Characteristics

The morphology of the soils is presented in Table 1. The soils of the hilly terrain (P1) are shallow, dark greyish brown to dark yellowish brown, gravelly sandy loam to clay loam with A-C horizon primarily due to variation in parent material (Sawhney *et al.* 2000). This soil is classified as loamy skeletal, mixed, hyperthermic Typic Ustorthents. The soils on piedmont plain (P2) are moderately deep, greyish brown to dark brown, gravelly, sandy loam to loamy sand subsurface horizon due to sorting of sediment and are classified as loamy over sandy skeletal, mixed hyperthermic Typic Ustorthents. Soils of alluvial plain (P3) are very deep, dark brown to olive brown, sandy loam to silty clay loam in texture with sub-angular blocky structure in the sub-surface horizons which might be due to their fine texture and sufficient exposure to pedogenic processes and are classified as coarse loamy, mixed hyperthermic fluventic Haplustepts. The soils in flood plain (P4) are very deep, yellowish brown to dark brown, sandy loam to silty clay loam with sand base at 58 to 117 cm. This soil is classified as coarse loamy, mixed hyperthermic Typic Ustifluvents due to periodic deposition of new sediments much faster than the soil development (Chakraborty *et al*. 1979).

Relative Horizon Distinctness (RHD)

The values of RHD ratings are listed in Table 2 and plotted in Fig 1 (a). The pedon 1 has RHD ratings between 1 and 5. The distinctness of the horizon boundaries and coarse fragment has contributed mostly to the ratings in hills and ridges Sarkar *et al*. (1997). In pedon 2 and 3, RHD values are in the range of 2 to 10 and high ratings (10 for the pedon 2 and 9 for the pedon 3) are observed at B/C horizon transition on the basis of colour, structure and consistency. The very abrupt boundary and clear change in color and structure contributed to the RHD rating 10 for A2/C transition in pedon 2 and of 9 for B/C transition in pedon 3. The RHD values for pedon 4 varies between 3 to 14. The lower value *i.e.*, 3 is contributed by consistency and boundary and higher value *i.e.*, 14 is contributed by texture, colour consistency and boundary. Values above 10 indicate differences that may well be due to geogenic, rather than pedogenic, processes (Meixner and

Table 1

Morphological properties of soils

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence DMW	Coarse fragments (%)		Boundary
						Gravel, (<7.5cm)	Cobble, Boulder, Stones (>7.5 cm)	
Pedon 1: Siwalik hills (slope, 33-50%), Loamy skeletal mixed hyperthermic Typic Ustorthents								
A	0-16	10YR 4/2	Sl	m1gr	s fr ss	10-15	-	cs
A1	16-38	10YR 4/3	Sl	m1sbk	- fr ss	30-35	-	gs
A2	38-58	10YR 4/3	Sl	m1sbk	- fr ss	40-45	-	gs
A3	58-78	10YR 4/3	Sl	m1sbk	- fr ss	50-55	-	gs
C	78-110	10YR 4/3	Sl	m1sbk	- fr ss	65-70	-	-
Pedon 2: Piedmont plain (slope, 5-10%), Loamy over sandy skeletal mixed hyperthermic Typic Ustorthents								
A	0-15	10YR 4/3	Sl	m1sbk	fr ss ps	-	-	cs
A1	15-41	10YR 3/3	Sl	f1sbk	fr ss ps	10-15	-	cs
A2	41-59	10YR 3/3	Sl	f1sbk	vfr so po	60-70	25-30	gs
C	59-105	10YR 4/4	Ls	-	vfr so po	60-80	-	-
Pedon 3: Alluvial plain (slope, 0-2%), Coarse loamy mixed hyperthermic fluventic Haplustepts								
Ap	0-17	10YR 4/3	Sl	m2sbk	sh fr ss po	-	-	cs
Bw1	17-45	10YR 4/3	Sil	m2sbk	fr ss ps	-	-	cs
Bw2	45-74	10YR 4/3	Sil	m2sbk	fr ss ps	-	-	Gs
B	74-102	10YR 3/3	Sl	f1sbk	vfr ss ps	-	-	Cs
C	102-160	10YR 3/3	L	m2sbk	fr s p	-	-	-
Pedon 4: Flood plain (slope, 0-3%), Coarse loamy mixed hyperthermic Typic Ustifluvents								
Ap	0-15	10YR 4/3	Sl	f1sbk	vfr so po	-	-	Gs
A1	15-42	10YR 5/4	Ls	m	vfr so po	-	-	Cs
A2	42-58	10YR 5/4	Sl	f1sbk	fr ss po	-	-	Cw
ICI	58-89	10YR 5/4	S	m	vfr so po	-	-	Cs
IIC2	89-117	10YR 4/4	S	m	fr so po	25-30	-	Ci
IIIC3	117-150	10YR 4/3	Sicl	m	fi s p	40-50	-	-

Table 2

Field morphology ratings of soils

Horizon	RHD	Horizon	RPD
Pedon 1			
A/A1	5	A/C	5
A1/A2	1	A1/C	3
A2/A3	3	A2/C	3
A3/C	3	A3/C	3
Pedon 2			
A/A1	4	A/C	6
A1/A2	5	A1/C	7.5
A2/C	10	A2/C	6.5
Pedon 3			
Ap/Bw1	5	Ap/C	9
Bw1/Bw2	2	Bw1/C	7
Bw2/B	7	Bw2/C	6
B/C	9	B/C	7.5
Pedon 4			
Ap/A1	7	Ap/IC1	7.5
A1/A2	8	A1/IC1	3
A2/IC1	9	A2/IC1	6.5
IC1/IIC2	3		
IIC2/IIIC3	14		

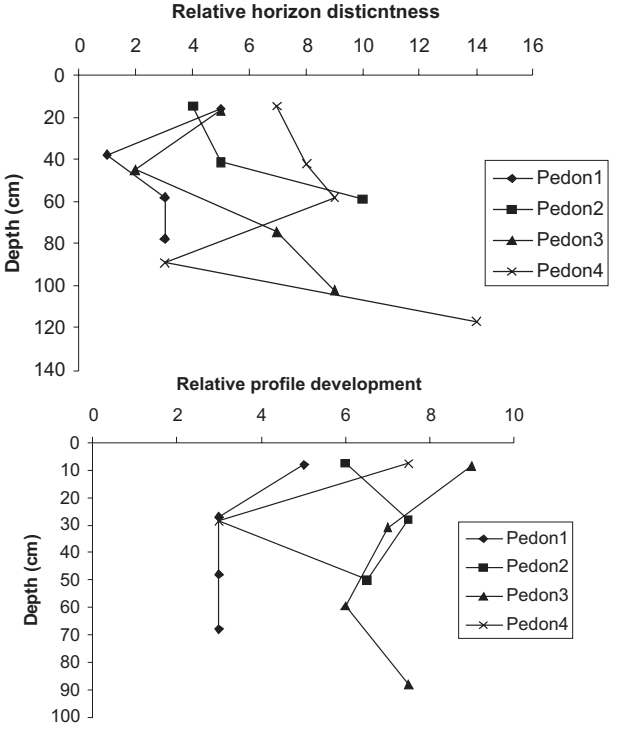

Fig. 1. (a) Relative horizon distinctness (RHD) and (b) Relative profile development (RPD) ratings

Singer 1981). Therefore RHD ratings of relatively young soils *i.e*., pedon 1 vary on the basis of the variation in consistence, coarse fragment and the nature of horizon boundary in the solum whereas for relatively older and well differentiated soils *i.e*. pedon 3 this occurs on the basis of colour, texture, structure and consistence that appear with weathering and soil formation. Similar findings were also reported by Sarkar *et al*. (1997) and Deka *et al*. (2009).

Relative Profile Development (RPD)

RPD ratings of different pedons are presented in Table 2 and plotted in Fig 2 (b). The RPD values for pedon 1 ranges from 3 to 5 with maximum value 5 in the surface A horizon. The lower RPD values indicated that the development of profile was very slow. Pedon 2 and pedon 3 had RPD rating between 6 and 9 and maximum values (7.5 for pedon 2 and 9 for pedon 3). The larger the rating scale values for a particular horizon the greater its pedological development. The RPD values for pedon 2 and pedon 3 shows slight variation among different horizons but there have been some profile development as indicated by the value greater than 5 (Bilzi and Ciolkosz 1977). Giri et al. (1994) also reported that the larger the rating scale values for particular horizon, the greater was its pedological development. The RPD for pedon 4 varies from 3 to 7.5 showing somewhat erratic trend in RPD with depth, which may be due to slight stratification resulting from flooding. Under the stable landform condition, soil profile development results in the changes of different soil morphological parameters thereby leading to more RPD values (Meixner and Singer, 1981). Based on the relative profile development rating values, the profile under the study can be arranged in the sequence *viz.*, pedon 1 < pedon 2 < pedon 4 < pedon 3, which also close agree with the RHD ratings.

4. CONCLUSIONS

The study reveals a close relationship between landforms units and profile development in the lower Siwalik. The poorly developed hills and ridges soils lacked distinct diagnostic horizons then moderately well developed piedmont and alluvial plain. The pedogenic development of the soils assessed through field morphological rating system revealed that the RHD and RPD values of the pedons help in judging the development and age of the soil.

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