Agropedology, 1997, 7, 14-21.

Characterization and classification of some soils of Shiwalik Hills in Himachal Pradesh

R. V. Sudhakar Rao, S. K. Mahapatra, T. P. Verma, G. S. Sidhu and K.P.C. Rana

National Bureau of Soil Survey and Land Use Planning, Regional Centre, IARI Campus, New Delhi-110 012. India.

Abstract

Nine representative soil profiles occurring on different physiographic units in Shiwalik hills of H.P. were identified, characterized and classified to establish the soil-physiography relationship. The study shows that the physiography influences the soil development. The soils on steep slopes are shallow, excessively drained, severely eroded, and belong mostly to Entisols (Lithic and Typic Udorthents). Soils occurring on terraces are shallow to medium deep, relatively well developed and the major soils are Inceptisols (Dystric Eutrochrepts) followed by Entisols (Typic Udorthents). Soils of piedmonts are moderately deep, comparatively well developed and are mostly classified as Inceptisols (Udic Ustochrepts) and Entisols (Ustorthents). In fluvial valley, soils are subject to occasional flooding and thus are classified as Entisols (Typic Ustifluvents and Typic Ustipsamments).

Additional key words : Physiography, soil orders, pedogenesis.

Introduction

Soils in hilly areas exhibit differences in their characteristics and profile development with the change of physiography and altitudes (Gupta and Chera 1996). Soils in Shiwalik hills of Himachal Pradesh (H.P.) have a significant contribution in total agricultural production of the state. To improve and maintain the productivity of these soils a detailed information about them and the suggestions to manage them are essential. With this in view the present study was undertaken to identify and characterize some soils of different physiographic units in Shiwalik hills of Himachal Pradesh.

Materials and methods

The study area covers parts of Una, Kangra, Hamirpur and Bilaspur districts of the north-western part of Himachal Pradesh. The climate is sub-humid to humid with warm summer and cold winter. Mean annual rainfall varies from 1000 to 1400 mm, which is mostly received during June to September. The mean summer temperature and winter temperature of the area are 29.2^0C and 13.6^0C respectively. The soil mositure regimes are udic and ustic and the temperature regimes, thermic to hyperthermic. The altitude varies from about 300 to 1000 m above msl. The area is drained by Sutlej and Beas rivers and their tributaries. The natural vegetation consists of Sal (*Shorea robusta*), Toona (*Cederala Toona*), Eucalyptus (E. Globulus), Babool (*Acacia arabica*), Dhaman (*Grewia optiva*) and Mango (*Mangifera indica*), mostly found on lower slopes. On steep slopes forest species like Pine (*Pinus roxburgghii*) and bushes are dominant.

The study area has distinct physiographic units viz., steep slopes with forest cover and pastures, cultivated terraces, upper and lower piedmonts and fluvial valley (Table 1). Based on physiography nine typical representative soil pedons were selected and studied for their morphological characteristics (Soil Survey Staff 1966 and Sehgal *et al.* 1987). Soil samples of each horizon of the profiles were collected and analysed for their physical and chemical properties (Black 1965 and Jackson 1973). Soils were classified as per Soil Taxonomy (Soil Survey Staff 1992).

Table 1. Soil-site characteristics

Location			Altitude (m)	Physiography	Slope (%)	Present Land Use
P1	Samoh (Bilaspur)	31°24′N 76°43′E	800	Steep slopes	30-50	Pastures
P2	Bharari (Hamirpur)	31°35′N 76°33′E	995	Steep slopes	30-50	Forest cover
P3	Bandala (Bilaspur)	31°17′N 76°46′E	700	Steep slopes	30-50	Forest cover
P4	Badi (Kangra)	31°53′N 76°12′E	600	Terraces	5-8	Cultivated
P5	Gharna (Kangra)	31°53′N 76°25′E	650	Terraces	3-5	Cultivated
P6	Chauki Minar(Una)	31°35′N 76°12′E	450	Piedmonts	3-5	Cultivated
P7	Padoil (Kangra)	31°50′N 76°18′E	550	Piedmonts	1-3	Cultivated
P8	Basal (Una)	31°31′N 76°12′E	300	Fluvial valley	1-3	Cultivated
P9	Gugled (Una)	31°32′N 76°18′E	450	Fluvial valley	1-3	Cultivated

Results and discussion

Morphological characteristics

The salient morphological properties of the soils are described in table 2. The data show that soils vary with respect to their physiographic situations. Pedons (P1, P2 & P3) representing soils on steeply sloping Shiwalik hills receive relatively high rainfall and therefore have udic mositure regime. Soil development is almost negligible as these soils are subject to severe erosion. P1 soils are developed on sandstones and are very shallow having lithic contact at a depth of 17 cm, excessively drained, gravelly sandy loam in texture and yellowish brown (10 YR 5/4). The major land use is pasture. P2 soils are developed on sandstones and are moderately deep (about 75 cm) well drained, sandy loam and light yellowish brown (10 YR 6/4) whereas P3 soils are developed on shale and are moderately deep (75 cm), well drained, loam calcareous and dark brown (7.5 YR 4/4). Both the soils are covered by forest vegetation.

Table 2. Morphological characteristics of the soils

Profile	Horizon	Depth (cm)	Boundary	Colour (moist)	Texture
			Soils of steep slopes		
P1	Loamy, Lithic Udorthents				
	A1	0-17	as	10YR 5/4	sandy loam
	C	17+ (weathered sandstone)			

P2	Coarse loamy, Typic Udorthents				
	A1	0-12	cs	10 YR 5/4	sandy loam
	A2	17-27	gs	10 YR 6/4	sandy loam
	A3	27-46	cs	10 YR 6/4	sandy loam
	AC	46-74	-	10 YR 6/4	loamy sand
	C	74+ (weathered sandstone)			
P3	Loamy-skeletal, calcareous Typic Udorthents				
	A1	0-14	cs	7.5 YR 4/4	loam
	A2	14-30	gs	7.5 YR 4/4	loam
	A3	30-51	gs	7.5 YR 4/4	loam
	A4	51-75	as	7.5 YR 4/4	loam
	C	75+ (weathered shale)		-	-
		Soils of terraces			
P4	Coarse-loamy, Typic Udorthents				
	A1	0-13	cs	10 YR 5/4	sandy loam
	A2	13-28	gs	10 YR 4/4	loam
	A3	28-50	cs	10 YR 4/4	loam
	AC	50-75	-	10 YR 4/4	sandy loam
	C	75+ (boulders and stones)			
P5	Coarse-loamy, Dystric Eutrochrepts				
	Ap	0-10	cs	10 YR 5/4	sandy loam
	Bw1	10-25	gs	10 YR 4/4	sandy loam
	Bw2	25-46	gs	10 YR 5/4	sandy loam
	Bw3	46-75	cs	10 YR 5/4	sandy loam
	BC	75-90	-	10 YR 6/4	sandy loam
		Soils of piedmonts			
P6	Coarse-loamy, Typic Udorthents				
	A1	0-16	cs	10 YR 5/6	sandy loam
	A2	16-27	gs	10 YR 5/6	sandy loam
	A3	27-50	gs	10 YR 5/6	sandy loam
	A4	50-70	cs	10 YR 5/6	sandy loam
	AC	70-95	-	10 YR 5/6	sandy loam
	C	95+ (weathered material)			
P7	Coarse-loamy, Udic Ustochrepts				
	Ap	0-10	cs	10 YR 4/4	sandy loam
	A2	16-30	cs	10 YR 4/4	loam
	Bw1	30-58	gs	10 YR 5/6	loam
	Bw2	58-90	gs	10 YR 5/6	loam
	Bw3	90-120	cs	10 YR 5/6	loam
	BC	120-150	-	10 YR 5/6	loam

		Soils of fluvial valley			
P8	Coarse-loamy, calcareous Typic Ustifluvents				
	Ap	0-15	cs	10 YR 4/3	sandy loam
	A2	15-29	gs	10 YR 5/4	sandy loam
	AC	29-52	cs	10 YR 5/4	sandy loam
	C	52+ (boulders)			
P9	Typic Ustipsamments				
	Ap	0-16	cs	10 YR 5/4	loamy sand
	C1	16-53	gs	10 YR 6/4	sand
	C2	53-90	gs	10 YR 6/4	sand
	C3	90-110	-	10 YR 6/4	sand
	C4	110+ (boulders)			

(as-abrupt, smooth; cs - clear, smooth; gs-gradual, smooth)

Soils on terraces : Two pedons (P4 and P5) were studied in this physiographic unit. P4 soils are moderately deep, well drained, dark yellowish brown (10 YR 4/4) and loam to gravelly loam developed on conglomerates and boulders. P5 soils are formed on sandstones and relatively well developed having cambic 'B' horizon. These soils are moderately deep, well drained, light yellowish brown (10 YR 5/4) in colour with sandy loam texture and subangular blocky structure. They are mainly cultivated to rainfed crops.

Soils of piedmonts : The soils represented by pedons P6 and P7 are developed over colluvial and alluvial materials. P6 soils occur on upper piedmonts having 3-5% slope and are moderately deep, well drained, yellowish brown (10 YR 5/6), and sandy loam in texture. P7 soils occur on lower piedmonts with 1-3% slope and are deep, well drained, yellowish brown to dark yellowish brown (10 YR 5/6 to 10 YR 4/4) with loam texture and medium moderate subangular blocky structure. Soils of upper piedmonts are comparatively less developed than those of lower piedmonts. This may be due to the reason that the former occurs on high gradients and subject to erosion whereas in lower piedmonts because of low gradients soils are relatively stable and also deposited materials are more fine in texture in comparison to upper piedmonts. Thus the later soils are more suitable for cultivation of wide range of agricultural and horticultural crops.

Soils of fluvial valley : Two pedons (P8 and P9) were studied in this physiography. P8 soils are developed in alluvium on the plains of Soan river with very gentle slopes (1-3%) and are moderately deep and stratified. Stones and boulders are present in the subsurface horizons. They are yellowish brown (10 YR 5/4) and sandy loam in texture. P9 soils are deep, somewhat excessively drained, light yellowish brown (10 YR 6/4) and sandy in texture. These soils had less time for soil development due to occasional flooding and seasonal deposition of washed materials.

Physical and chemical properties

The physical and chemical properties of the soils are given in table 3. The soils, in general, contain higher amounts of coarser fractions (sand and silt) compared to clay. Kaistha and Gupta (1994) also reported the same observation in some soils of the

Table 3. Physical and chemical characteristics of the soils

Profile	Depth (cm)	pH (1:2.5)	Org.C	$CaCO_3$	Coarse sand (2000 -200μm)	Find sand (200- 50μm)	Silt (50- 2μm)	Clay (<2μm)	Sand/ sand
			----------		----------	%	----------		
P1	Lithic Udorthents (Steep slopes)								
	0-17	6.6	0.53	-	18.4	49.5	15.1	17.0	4.5
P2	Typic Udorthents (Steep slopes)								
	0-12	6.3	0.97	-	33.3	32.6	27.1	7.0	2.4
	12-27	6.6	0.62	-	37.9	33.6	16.5	12.0	4.3
	27-46	6.5	0.42	-	42.7	33.3	14.0	10.0	4.7
	46-74	6.4	0.23	-	44.7	34.7	12.6	6.0	6.4
P3	Typic Udorthents (Steep slopes)								
	0-14	7.7	0.54	4.4	34.7	15.1	38.7	11.5	1.3
	14-30	7.9	0.43	6.9	38.3	16.2	34.5	11.0	1.6
	30-51	8.0	0.31	6.9	35.9	16.5	36.6	11.0	1.4
	51-75	8.0	0.27	11.7	34.9	16.3	37.3	11.5	1.4
P4	Typic Udorthents (Terraces)								
	0-13	5.8	0.89	-	13.7	41.0	32.4	13.0	1.7
	13-28	6.1	0.77	-	15.1	33.4	33.6	18.0	1.4
	28-50	6.4	0.69	-	15.5	33.9	33.6	17.0	1.5
	50-75	6.2	0.58	-	23.8	34.4	25.4	16.5	2.3
P5	Dystric Eutrochrepts (Terraces)								
	0-10	5.9	1.00	-	18.9	40.4	24.8	16.0	2.4
	10-25	6.3	0.54	-	17.3	47.4	21.4	14.0	3.0
	25-46	6.7	0.42	-	18.5	47.2	21.4	13.0	3.1
	46-75	6.9	0.23	-	21.0	46.5	20.6	12.0	3.3
	75-90	6.9	0.21	-	23.3	42.7	22.7	11.0	2.9
P6	Typic Udorthents (Piedmonts)								
	0-16	6.7	0.58	-	10.5	44.6	31.3	13.5	1.8
	16-27	6.7	0.54	-	8.8	54.6	24.7	12.0	2.6
	27-50	7.1	0.12	-	8.9	52.5	26.5	12.0	2.3
	50-70	7.1	0.12	-	8.3	56.8	24.9	10.0	2.6
	70-95	7.0	0.10	-	8.1	59.2	24.7	8.0	2.7
P7	Udic Ustochrepts (Piedmonts)								
	0-16	6.3	0.46	-	13.0	39.0	36.5	11.5	1.4
	16-30	6.1	0.27	-	12.5	36.9	39.2	11.5	1.3
	30-58	6.0	0.26	-	10.9	33.2	42.0	14.0	1.1
	58-90	6.0	0.23	-	6.5	28.6	47.5	17.5	0.7
	90-120	5.9	0.19	-	7.4	27.8	46.9	18.0	0.7
	120-150	6.0	0.12	-	7.7	28.4	43.8	20.0	0.8

P8	Typic Ustifluvents (Fluvial valley)								
	0-15	7.6	0.61	1.44	8.0	47.8	34.4	9.5	1.6
	15-29	8.0	0.27	0.67	10.0	48.2	31.8	10.5	1.8
	29-52	8.0	0.38	0.19	13.4	47.3	28.9	10.5	2.1
P9	Typic Ustipsamments (Fluvial valley)								
	0-16	7.2	0.69	-	42.6	41.9	8.0	7.5	1.3
	16-53	7.4	0.28	-	59.1	37.5	2.0	1.5	1.6
	53-90	7.3	0.15	-	58.7	36.5	3.3	1.5	1.4
	90-110	7.6	0.12	-	65.3	31.6	1.7	1.5	1.4

north-western Himalaya. It may be due to the removal of finer particles by water erosion. Sand/silt ratio shows irregular distribution in the pedons indicating lithological discontinuities. P3 and P8 soils are calcareous and other soils are non-calcareous. The calcareousness is due to parent rocks in P3 soils and calcareous fluvial deposits in P8 soils. Soil pH varies from 5.8 to 8.0. P3 and P8 soils are slightly alkaline (pH 8.0), P4 soils are slightly acidic whereas other soils are neutral in reaction. Presence of $CaCO_3$ in P3 and P8 soils may be the reason for higher pH in these soils whereas leaching of bases due to high rainfall and vegetation seems to be the main reason for lower pH in P4 soils. Organic carbon generally decreases downward in all the pedons except P8 which has irregular distribution of it, indicating fluventic nature of the soils. Cation exchange capacity of these soils varies from 0.7 to 13.0 cmol $(p^+)kg^{-1}$. Generally these soils have low to medium CEC depending on the content of clay and organic carbon. The high CEC values in the surface of P5 soils may be due to higher amount of organic carbon. Base saturation of these soils increases with depth and varies from 59 to 93 per cent depending on the physiography and leaching of bases.

Table 4. Ion exchange properties of the soils

Profile	Depth (cm)	CEC	Exchangeable Cations				Base saturation (%)
			Ca^{2+}	Mg^{2+}	Na^+	K^+	
			cmol (p+) /kg				
P1	0-17	6.03	1.79	1.35	0.47	0.12	61
P2	0-12	5.18	1.76	1.04	0.43	0.28	68
	12-27	6.31	2.00	1.47	0.23	0.22	62
	27-46	5.80	1.87	1.38	0.43	0.19	66
	46-74	3.05	1.17	0.44	0.37	0.16	70
P3	0-14	5.67	2.09	1.27	0.36	0.25	70
	14-30	5.49	2.17	1.19	0.45	0.30	75
	30-51	5.22	2.30	1.10	0.40	0.20	77
	51-75	5.18	2.48	1.60	0.42	0.24	80
P4	0-13	8.94	2.70	2.08	0.54	0.25	62
	13-28	9.52	2.97	2.04	0.52	0.27	60
	28-50	9.19	3.01	2.03	0.48	0.20	62
	50-75	8.09	3.06	1.56	0.51	0.22	66

P5	0-10	10.99	4.12	1.68	0.40	0.18	59
	10-25	7.59	2.26	1.96	0.48	0.16	64
	25-46	6.60	2.76	1.76	0.48	0.16	73
	46-75	6.03	2.49	1.55	0.47	0.12	77
	75-90	4.82	2.07	1.14	0.48	0.09	78
P6	0-16	7.24	2.45	1.41	0.44	0.26	63
	16-27	6.03	2.43	0.97	0.44	0.22	67
	27-50	6.03	2.37	0.87	0.43	0.16	64
	50-70	5.18	2.30	0.74	0.41	0.16	69
	70-95	4.40	2.00	0.65	0.37	0.16	72
P7	0-16	5.32	1.47	0.86	0.51	0.48	62
	16-30	4.97	1.47	0.87	0.48	0.44	64
	30-58	6.74	1.89	1.01	0.54	0.42	57
	58-90	8.09	3.15	1.10	0.49	0.32	62
	90-120	9.51	3.80	1.45	0.49	0.28	63
	120-150	9.94	4.28	1.58	0.48	0.28	66
P8	0-15	4.42	2.79	1.06	0.27	0.10	96
	15-29	4.46	2.50	1.18	0.54	0.15	96
	29-52	4.27	2.50	0.97	0.41	0.23	95
P9	0-16	3.97	1.80	0.95	0.38	0.21	84
	16-53	1.06	0.38	0.22	0.20	0.16	90
	53-90	0.71	0.31	0.14	0.13	0.09	94
	90-110	0.71	0.32	0.15	0.12	0.09	95

Soil Classification

Soils on steep slopes and terraces occur in thermic temperature regime while soils of piedmonts and fluvial valley occur in hyperthermic temperature regime. The soils on the steep slopes, P1, P2 and P3 are classified as loamy Lithic Udorthents, coarse loamy Typic Udorthents and loamy-skeletal Typic Udorthents, respectively. The soils on terraces P4 and P5 are classified as coarse loamy Typic Udorthents and coarse loamy Udic Ustochrepts, respectively. Soils of fluvial valley P8 and P9 are stratified and classified as coarse loamy Typic Ustifluvents and Typic Ustipsamments, respectively.

In the steep slopes, the soils lack development as they are lost due to severe erosion and therefore, belong to Entisols. The terraces are relatively stabilized due to conservation practices and the soils key out as Inceptisols. On the piedmonts, because of low slope gradient and less soil erosion the soils are at the initial stage of development and are classified as Inceptisols. They are highly suitable for cultivation of crops especially under assured irrigation. In the fluvial valley, the soils are subjected to repeated flooding and deposition and hence they lack development. Yet, these soils have good potential for agriculture and variable land use in the rabi season.

References

Black, C. A. (1965). 'Methods of Soil Analysis' (Am. Soc. Agron. Inc.: Madison, Wisconsin, U.S.A).

Gupta, Sanjay, K., and Chera, R. S. (1996). Soil characteristics as influenced by slope aspects in middle Siwaliks. *Agropedology* **6** , 43-48.

Jackson, M. L. (1973). 'Soil Chemical Analysis', (Prentice Hall of India Pvt. Ltd.: New Delhi.)

Kaistha, B. P., and Gupta, R. D. (1994). Morphology and characteristics of a few Entisols and Inceptisols of North- Western Himalayan Region. *J. Indian Soc. Soil Sci.* **42**, 100-104.

Sehgal, J.L., Saxena, R. K., and Vadivelu, S. (1987). 'Soil Resource Mapping of Different States in India. 'Tech. Bull. 13, (NBSS&LUP: Nagpur.)

Soil Survey Staff (1966). 'Soil Survey Manual', Agric. Handb US Dept. Agric., 18, Indian reprint, (Oxford & IBH Pub. Co.: New Delhi.)

Soil Survey Staff (1992) 'Keys to Soil Taxonomy (5th Edition)', SMSS Tech. Monog. 19, (Pacahoutas Press, Inc.: Blacksburg, Virginia.)