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Characterization and classification of soils of selected watershed area of Haryana, North-west India

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ABSTRACT

In the present study, undertaken in 2017–18 at CCS Haryana Agricultural University, eight typical pedons representing micro watersheds, viz. Motipura (P1 and P2), Sainiwas (P3 and P4), Jhumpa (P5 and P6), Budhsheli (P7 and P8), in semi-arid ecosystem of Jhumpa Kalan watershed of Bhiwani district of Haryana, were studied for morpho-physical, chemical characteristics and their classification. Results indicated that soils of micro watershed pedons varied in colour from dark brown to dark yellowish brown with sand to loamy sand texture along with higher sand content as compared to silt and clay. These soils were slightly to moderately alkaline in reaction and non-saline. The bulk density, available water content, organic carbon (OC), cation exchange capacity (CEC) and base saturation varied from 1.38 to 1.62 Mg/m^3, 2.04 to 13.78%, 0.06 to 0.27%, 2.21 to 7.85 cmol (p$^+$)/kg and 88.36 to 98.57% respectively. Due to the presence of ustic/arid soil moisture regime, hyperthermic temperature regime and low organic matter content, the soils were classified into Typic Torripsamments (P4 and P8)/ Ustipsamments (P1, P2 and P3) and Typic Calciorchids (P7)/ Cambiorchids (P5).

Key words: Characteristics, Classification, Hyperthermic, Pedon, Watershed

Comprehensive land use not only rationalizes how land and soils are presently used but also how they can best be used and managed for agriculture. Food security is a challenging task facing the populous nation like India. Similarly, concept of watershed based holistic development has emerged as one of the potential approaches in rainfed areas, which can lead to higher productivity and sustainability in agricultural production. Watershed or basin or catchment refers to any topographically delineated area that can collect water and is drained by a river system with an outlet (Brooks *et al*.1994).

Characterization and classification of soils are important to understand the nature of soil resources. The data generated based on the profile characteristics will serve as a benchmark for monitoring and evaluating the likely changes in soil characteristics periodically under different cropping systems because of the introduction of different soil management techniques (Ravikumar *et al*. 2009). More than ever before, a renewed attention is being given to soils due to rapidly declining area for agriculture, declining soil fertility, increasing soil degradation, unsystematic land use policies and irrational and imbalanced use of inputs (Kanwar 2004). Hence, a detailed study for characterization and classification of soils is needed to realize the concept of watershed approach successfully (Sitanggang *et al.* 2006). Keeping the above facts in view, the present study was undertaken to characterize and classify the soils of Jhumpa Kalan micro watersheds, Bhiwani (Haryana).

MATERIALS AND METHODS

The study was conducted in 2018 in an area is situated between 28° 46' to 28° 49' N latitudes and 75° 31' N to 75° 34' E longitudes, with an average elevation of 225 m amsl. The total geographical area under study is about 3000 ha covering the micro watersheds, viz. Motipura, Sainiwas, Jhumpa and Budhsheli (Haryana). The mean annual soil temperature was about 25ºC. The average rainfall in the district as a whole was 360.8 mm.

For detailed soil survey the topographic maps of India (1:50000) and aerial photographs were used for site selection and profile excavation. Based on geomorphic-soil relationship, eight profiles were exposed and studied. For each profile description, morphological characteristics such as different horizons, depths, soil colour, texture were demarked in each pedon in the field and were recorded according to FAO guidelines (1993) for soil profile description. Sampling of each pedon was done under pedological horizons and 2-3 kg of soil was collected.

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Soil colour was determined by using Munsell Colour Chart. Particle size distribution, particle density and bulk density of the soils was determined by International Pipette method (Piper 1950), Pycnometer method (Means and Parcher 1963) and core method (Blake 1965) respectively. Moisture retention capacity of soils at 0.03 and 1.5 Mpa was determined with Richard's pressure plate (Bruce and Luxmoore 1986). The *p*H and electrical conductivity of the soils in soil: water (1:2) suspension was measured by glass electrode and conductivity meter respectively (Jackson 1973). Calcium carbonate in soil samples was estimated by rapid titration method (Puri 1949). CEC was determined by neutral normal ammonium acetate extraction (Jackson 1973). Exchangeable calcium and magnesium were also determined in neutral normal ammonium acetate extract by Versanate titration method (Cheng and Bray 1951). The soils of study area were classified according to Soil Taxonomy (Soil Survey Staff 2006).

RESULTS AND DISCUSSION

Morpho-physical characteristics: The results on morpho-physical characteristics of soils are presented in Table 1. All the studied pedons were very deep (150+ cm) and exhibited A-C horizons except P5 which exhibited Cambic B-horizon; A-(B)-C in profile development. Horizon boundaries of the all the pedons varied from abrupt to gradual in distinctness and smooth to wavy in topography. The colour of the studied pedons varied from dark brown (7.5 YR) to yellowish brown (10 YR) with dominant hue of 10YR, value (3-5) and chroma (3-6). This variation in the soil colour was a function of textural makeup, topographic position, mineralogy, chemical composition and moisture regimes of the soil (Dinesh *et al.* 2017).

The texture of the studied pedons varied from sand to loamy sand. Sand constitutes the bulk of the mechanical fractions, which may be assigned to dominance of physical weathering and siliceous nature of parent material. The soils of pedons P1, P4, P6 and P8 were sandy in texture in all horizons, whereas pedons P2, P3, P5 and P7 were sand (surface horizon) to loamy sand (subsurface horizon). The variation in texture was primarily due to parent material and differential degree of weathering (Dinesh *et al.* 2017).

The data revealed that water retained at 0.03 and 1.5 MPa varied from 6.29 to 18.80% and 3.65 to 9.11% respectively. The available water of soils was higher in pedon P7 (8.67 to 13.78 %), whereas the low available water was observed in pedon P6 (3.70 to 5.41%). Bulk density of pedons varied from 1.38 to 1.62 Mg/m^3 and increasing pattern was observed with depth, which may be ascribed to progressive compaction due to filling of pores by alluvial materials and lower organic matter. Dinesh *et al*. (2017) reported the increase in bulk density down the profile because of low organic matter and compaction of soil aggregates. The particle density and total porosity varied from 2.45 to 2.64 Mg/m^3 and 34.29 to 47.96% respectively, in studied pedons. However, no trend in particle density was observed with depth.

Chemical characteristics: Data on the chemical properties are presented in the Table 2. *p*H of the studied soils ranged from 7.3 to 8.5, according to *p*H classes these

Table 1 Morpho-physical characteristics of different pedons

Horizon	Depth (cm)	Horizon boundary	Colour (moist)	Sand (%) (2.0-0.05 mm)	Silt (%) (0.05-0.002 mm)	Clay (%) (<0.002 mm)	Texture	Bulk density (Mg/m^3)	Particle density (Mg/m^3)	Pore space (%)	Percent moisture retention (Mpa) 0.03	1.5	Available water (%)
Motipura													
P1 (Sandy, Mixed, Hyperthermic, TypicUstipsamments)													
Ap	0-14	c-s	10 YR 4/3	88.80	7.10	4.10	s	1.34	2.57	47.96	12.99	6.60	6.39
C1	14-53	c-s	4/4	88.80	8.80	2.40	s	1.40	2.61	46.54	12.50	6.50	6.00
C2	53-79	c-s	4/3	90.50	5.70	3.80	s	1.41	2.56	44.92	11.90	6.30	5.60
C3	79-142	c-w	4/3	89.40	3.70	5.90	s	1.52	2.54	40.16	12.33	6.43	5.90
C4	142-177+	c-w	4/3	92.15	1.85	6.00	s	1.54	2.54	39.37	11.60	6.20	5.40
P2 (Coarse loamy, Mixed, Hyperthermic, Typic Ustipsamments)													
Ap	0-25	a-s	10 YR 4/4	93.90	3.80	2.30	s	1.40	2.62	46.56	14.61	6.23	8.38
C1	25-58	c-w	4/4	90.45	5.55	4.00	s	1.52	2.59	41.31	16.23	6.20	9.25
C2	58-86	c-w	3/4	83.60	10.40	6.00	ls	1.54	2.56	39.84	16.40	6.95	9.45
C3k	86-119	c-w	3/4	81.10	8.90	10.00	ls	1.57	2.57	38.91	16.54	6.79	9.75
C4	119-135+	c-w	3/3	82.00	7.50	10.50	ls	1.59	2.58	38.37	16.58	6.71	9.87

Contd.

Horizon	Depth (cm)	Horizon boundary	Colour (moist)	Sand (%) (2.0-0.05 mm)	Silt (%) (0.05-0.002 mm)	Clay (%) (<0.002 mm)	Texture	Bulk density (Mg/m^3)	Particle density (Mg/m^3)	Pore space (%)	Percent moisture retention (Mpa)		Available water (%)
											0.03	1.5	
Sainiwas													
P3 (Coarse loamy, Mixed, Hyperthermic, Typic Ustipsamments)													
Ap	0-36	c-w	10 YR 4/3	87.85	6.35	5.80	s	1.40	2.60	46.15	8.80	4.18	4.62
AC	36-89	c-w	3/3	83.20	10.65	6.15	ls	1.44	2.54	43.31	12.90	4.53	8.37
C1	89-133	a-w	3/3	82.60	11.60	5.80	ls	1.52	2.49	38.96	13.56	4.07	9.49
C2	133-152	c-w	5/3	84.80	11.00	4.20	ls	1.54	2.47	37.65	13.47	4.08	9.39
C3	152+	c-w	5/4	82.55	13.35	4.10	ls	1.58	2.48	36.29	13.64	4.13	9.51
P4 (Sandy, Mixed, Hyperthermic, Typic Torripsamments)													
Ap	0-27	c-s	10 YR 4/4	95.65	2.35	2.00	s	1.51	2.59	41.86	6.29	3.11	3.18
C1	27-115	c-s	4/4	97.05	1.05	1.90	s	1.56	2.56	39.11	6.35	3.67	2.68
C2	115-165	c-s	4/4	95.85	2.10	2.05	s	1.57	2.58	39.15	6.38	3.65	2.73
C3	165+	c-s	3/3	92.70	3.70	3.60	s	1.62	2.54	36.22	6.78	3.58	3.20
Jhumpa													
P5 (Coarse loamy, Mixed, Hyperthermic, Typic Cambiorchids)													
Ap	0-17	c-w	10 YR 4/3	93.20	2.90	3.90	s	1.41	2.64	46.59	9.32	5.45	3.87
AB	17-60	c-s	4/4	90.70	7.10	2.20	ls	1.44	2.57	43.97	11.79	9.11	2.68
B1k	60-82	c-s	4/4	87.50	8.60	3.90	ls	1.49	2.55	41.57	10.65	6.55	4.10
C1k	82-164	c-s	5/3	84.45	11.35	4.20	ls	1.55	2.51	38.25	12.65	4.39	8.26
C2k	164-202	c-s	5/4	81.65	12.45	5.90	ls	1.57	2.49	36.95	12.71	3.61	9.10
P6 (Coarse loamy, Mixed, Hyperthermic, Typic Torripsamments)													
Ap	0-19	c-s	7.5 YR 4/4	94.15	4.65	1.20	s	1.38	2.59	46.72	7.35	3.89	3.45
C1	19-80	c-w	3/4	93.25	4.75	2.00	s	1.50	2.57	41.63	5.79	3.70	2.09
C2	80-126	c-w	4/4	93.00	4.70	2.30	s	1.53	2.54	39.76	7.32	5.24	2.08
C3	126-224	c-w	4/4	93.85	3.25	2.90	s	1.56	2.55	38.82	7.35	5.31	2.04
C4	224+	c-w	4/4	94.55	3.45	2.00	s	1.60	2.49	35.74	7.56	5.41	2.15
Budhsheli													
P7 (Coarse loamy, Mixed, Hyperthermic, Typic Calciorchids)													
Ap	0-17	g-s	10 YR 4/4	88.80	6.59	4.61	s	1.38	2.61	46.97	16.80	6.26	10.54
AC	17-55	c-s	4/4	83.20	11.26	5.54	ls	1.41	2.59	45.46	17.08	7.84	9.24
C1	55-129	c-s	4/4	80.42	10.32	9.26	ls	1.48	2.51	41.04	18.80	5.02	13.78
C2k	129-169	c-s	5/4	84.77	9.81	5.42	ls	1.53	2.49	38.55	15.10	3.90	11.20
C3	169-207	c-s	5/6	92.04	4.80	3.16	s	1.58	2.47	36.03	14.70	6.03	8.67
C4	207+	c-s	5/6	92.70	3.93	3.37	s	1.61	2.45	34.29	15.20	5.86	9.34
P8 (Sandy, Mixed, Hyperthermic, Typic Torripsamments)													
Ap	0-24	g-s	7.5 YR 4/4	93.20	5.20	1.60	s	1.47	2.63	44.11	8.18	4.57	3.61
AC	24-62	c-s	4/4	92.10	5.70	2.20	s	1.44	2.54	43.30	7.91	3.93	3.98
C1	62-155	c-s	4/4	90.20	6.30	3.50	s	1.50	2.49	39.76	8.20	4.31	3.89
C2	155+	c-s	4/4	89.90	4.90	5.20	s	1.54	2.47	37.65	8.24	4.12	4.12

Horizon boundary: D–Distinctness: a, abrupt; c, clear; g, gradual; d, diffuse; T – Topography: s, smooth, w, wavy; Texture: s, sand; ls, loamy sand

Table 2 Chemical properties of different pedons

Horizon	*p*H (1:2)	EC	OC	$CaCO_3$	CEC	Ca^{2+}	Mg^{2+}	Na^+	K^+	ESP	BSP
		(dS/m)	(%)		cmol(p^+)/kg						
P1											
Ap	7.85	0.04	0.22	Nil	5.28	2.70	1.76	0.28	0.24	5.30	94.41
C1	7.73	0.03	0.21	Nil	4.89	2.27	1.72	0.25	0.31	5.11	93.13
C2	7.75	0.24	0.16	Nil	4.93	2.19	1.69	0.26	0.42	5.27	92.47
C3	7.70	0.14	0.12	Nil	6.09	3.00	1.94	0.32	0.38	5.25	92.49
C4	7.52	0.03	0.08	Nil	5.71	2.70	1.70	0.43	0.39	7.53	91.34
P2											
Ap	7.61	0.04	0.27	Nil	4.81	3.20	0.70	0.37	0.28	7.69	94.58
C1	7.78	0.04	0.18	Nil	5.10	3.40	0.60	0.57	0.28	11.18	95.09
C2	7.56	0.04	0.14	Nil	5.70	3.60	0.90	0.43	0.33	7.54	92.31
C3k	7.50	0.05	0.11	0.75	7.81	5.10	1.70	0.43	0.21	5.51	95.27
C4	7.64	0.05	0.10	1.93	7.85	4.90	1.72	0.47	0.18	5.99	92.58
P3											
Ap	7.73	0.04	0.27	Nil	5.69	3.90	1.04	0.35	0.23	6.15	96.97
AC	7.49	0.05	0.24	Nil	5.72	3.80	0.89	0.37	0.21	6.47	92.15
C1	7.58	0.06	0.17	Nil	5.67	3.70	0.77	0.42	0.23	7.41	90.26
C2	7.60	0.09	0.15	4.40	5.34	3.80	0.50	0.53	0.18	9.93	93.77
C3	7.60	0.08	0.12	7.60	5.31	3.10	1.00	0.57	0.16	10.73	90.98
P4											
Ap	7.46	0.03	0.27	Nil	3.89	2.90	0.50	0.24	0.19	6.17	98.57
C1	7.33	0.02	0.21	Nil	3.82	3.00	0.30	0.27	0.16	7.07	97.67
C2	7.61	0.02	0.16	Nil	4.10	3.30	0.20	0.35	0.18	8.54	98.23
C3	7.56	0.05	0.10	Nil	4.86	3.70	0.30	0.39	0.18	8.02	93.98
P5											
Ap	8.10	0.26	0.24	0.23	7.08	3.50	2.50	0.51	0.25	7.20	95.48
AB	8.20	0.17	0.16	1.25	5.89	3.40	1.90	0.23	0.17	3.90	96.77
B1k	8.30	0.18	0.14	1.45	6.09	2.10	2.90	0.61	0.15	10.01	94.58
C1k	8.00	0.21	0.11	7.33	5.79	2.70	2.10	0.37	0.17	6.39	92.22
C2k	8.10	0.32	0.08	7.53	6.98	3.30	2.60	0.34	0.11	4.87	90.97
P6											
Ap	7.90	0.19	0.27	Nil	4.21	2.10	1.20	0.21	0.21	4.98	88.36
C1	7.50	0.20	0.19	Nil	4.89	2.70	1.70	0.19	0.20	3.88	97.95
C2	8.10	0.14	0.13	Nil	4.90	2.60	1.30	0.34	0.12	6.93	88.97
C3	8.20	0.18	0.11	Nil	5.10	3.10	1.20	0.42	0.08	8.23	94.11
C4	8.40	0.08	0.06	0.45	4.92	3.00	1.00	0.45	0.10	9.14	92.47
P7											
Ap	7.80	0.12	0.19	Nil	7.00	3.70	1.70	0.75	0.34	10.71	92.71
AC	8.10	0.10	0.14	Nil	6.21	2.90	1.80	0.76	0.08	12.23	89.21
C1	8.50	0.16	0.13	10.75	7.82	4.70	2.00	0.67	0.11	8.56	95.65
C2k	8.50	0.20	0.08	11.73	6.14	4.50	0.60	0.62	0.14	10.09	95.43
C3	8.50	0.18	0.06	5.25	5.35	3.50	0.80	0.61	0.09	11.40	95.23
C4	8.30	0.19	0.06	Nil	5.30	3.60	0.70	0.75	0.09	14.15	96.98
P8											
Ap	7.50	0.12	0.22	Nil	4.84	2.90	0.92	0.73	0.14	15.08	96.90
AC	7.30	0.10	0.19	Nil	5.78	3.80	0.84	0.82	0.11	14.18	96.36
C1	7.30	0.08	0.14	Nil	5.82	3.70	1.10	0.81	0.10	13.91	98.10
C2	7.80	0.08	0.10	Nil	6.56	4.30	0.70	0.92	0.09	14.02	91.61

Table 3 Correlation matrix among physico-chemical properties

Parameter	*p*H	EC	OC	$CaCO_3$	CEC	Ca^{2+}	Mg^{2+}	Na^+	K^+	ESP	BSP	Sand	Silt	Clay
*p*H	1													
EC	0.58**	1												
OC	-0.43**	-0.25	1											
$CaCO_3$	0.48**	0.41**	-0.40*	1										
CEC	0.24	0.25	-0.34*	0.35*	1									
Ca^{2+}	-0.01	-0.17	-0.26	0.30	0.64**	1								
Mg^{2+}	0.34*	0.54**	-0.09	0.15	0.57**	-0.21	1							
Na^+	0.14	0.02	-0.33*	0.15	0.40*	0.42**	-0.10	1						
K^+	-0.36*	-0.19	0.31*	-0.30	-0.04	-0.24	0.16	-0.41**	1					
ESP	0.04	-0.08	-0.25	0.03	0.03	0.21	-0.36*	0.91**	-0.45**	1				
BSP	-0.15	-0.11	0.20	-0.05	-0.16	0.21	-0.24	0.05	-0.15	0.15	1			
Sand	-0.10	-0.06	0.26	-0.53**	-0.70**	-0.46**	-0.35*	-0.18	0.01	0.08	0.37*	1		
Silt	0.12	0.14	-0.16	0.55**	0.45**	0.22	0.29	0.14	-0.11	-0.02	-0.39*	-0.910**	1	
Clay	0.03	-0.08	-0.32*	0.32*	0.82**	0.67**	0.31	0.17	0.12	-0.13	-0.22	-0.80**	0.48**	1

*, ** significant at 0.05 and 0.01 probability level, respectively

were neutral to alkaline in reaction. All the pedons exhibited higher *p*H value at lower depths as compared to surface depth except pedons P1 and P3 which showed decreasing pattern. The electrical conductivity varied between 0.02 to 0.61 dS/m in the studied pedons indicating that the soils were non-saline. It may be due to light texture of soils. The soils were low in organic carbon content (0.06 to 0.27%). The low organic carbon content in these pedons may be ascribed to aridic moisture regime, hyperthermic temperature regime, low rainfall and poor vegetation. Ahuja *et al.* (1997) also reported the low content of organic carbon in dunal soils. Calcium carbonate concretions were absent in the pedons P1, P4 and P8 but in P2, P3, P5, P6 and P7 pedons increasing pattern was observed with depth (0.23 to 11.73%). The possibility of *in situ* formation of $CaCO_3$ may be due to calcification process in aridic climatic conditions. Ahuja *et al*. (1997) also reported such activities in sand dune toposequences of Haryana.

The CEC of soils was low (3.82 to 7.85 cmol (p^+)/kg) which may be ascribed to sandy nature of the soil and their low clay and organic carbon content. Dinesh *et al*. (2017) attributed low CEC of the soils of north-eastern Haryana to dominance of illite and low organic matter. A significant positive correlation was observed between CEC and clay (r = 0.82) and silt (r = 0.45) signifying that clay and silt were the principal factors that influenced CEC (Table 3). Contrarily, negative and significant correlation was observed between CEC and sand content (r=-0.70) which may be ascribed to predominance of quartz.

The exchangeable bases exhibited different regular and irregular trends because of topographic position. Among exchangeable cations, calcium was dominant (2.10 to 5.10 cmol (p^+)/kg) in all the pedons followed by magnesium (0.20 to 2.90 cmol (p^+)/kg), sodium (0.19 to 0.92 cmol (p^+)/kg) and potassium (0.08 to 0.42 cmol (p^+)/kg). Dinesh *et al.* (2017) ascertained similar results in north-eastern Haryana. Base saturation percentage (BSP) ranging from 88.36 to 98.57% dominated the exchangeable complex. The BSP of soils was high because of the occurrence of high exchangeable calcium.

Soil classification: Based on rainfall, evaporation and geomorphic position the soils of the area were grouped into two moisture regimes, i.e. Ustic (rainfall 300-1000 mm) and Aridic (rainfall <300 mm). The mean annual soil temperature was much higher than 22°C and the difference between mean summer and mean winter soil temperature was more than 5°C (data not shown). Thus, the soils of the study area qualify for ustic and udic soil moisture regime, hyperthermic soil temperature regime. Based on soil temperature and mixed minerals the soils were placed under hyperthermic and mixed mineralogy family respectively.

The soils of the studied pedons were placed under the order Entisols except pedon P5 and P7. The soils under Entisols were immature, lacked pedogenic development and horizon differentiation. The soils of pedons P5 and P7 were placed under Aridisols due to presence of cambic and calcic subsurface horizons and aridic soil moisture regime (SMR). The soils of the pedons (Entisols) placed under great groups of Ustipsamments (presence of ustic SMR) and Torripsamments (presence of sand to loamy sand texture and aridic SMR). The soils of Aridisols were classified as Cambiorchids and Calciorchids. Because of variation in particle size distribution, these soils were classified as sandy, coarse loamy family.

The study indicated that there were considerable variations in the morpho-physical, chemical characteristics of the soils depending on their geomorphic position in the area. The texture of soils varied from sand to loamy sand. Among exchangeable cations, calcium was dominant followed by magnesium, sodium and potassium. Soil classification revealed that sprinkler irrigation and growing of crops, viz. guar, oilseeds, gram, pearl millet and cotton are the best suggestions for these soils.

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