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Characterization and Classification of Soils of Upper Rangit Basin in Sikkim

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ABSTRACT

Twenty soil series have been identified in nine broad landform units through reconnaissance soil survey on 1:50,000 scale. Soils are usually brown (10YR 2/2) to dark brown (10YR 3/3) at surface due to high organic carbon content. Soil structures are fine, weak, granular in surface and fine to medium, moderate and subangular blocky in sub soils. Soils are acidic (pH 4.3-5.3), pH values are comparatively higher in subsoils. Base saturation percentage of soils is fairly high. Three soil orders viz. Inceptisols, Entisols and Mollisols have been identified. Entisols characterized with no diagnostic subsurface horizon cover an area of 11118.70 ha. Inceptisols with cambic subsurface horizon covers 59164.95 ha. Mollisols with mollic epipedon are distributed in 52855.56 ha.

INTRODUCTION

Upper Rangit basin, lying in between 27°07' to 27°37' N and 88°01' to 88°25'E belongs to Himalayan mountainous ecosystem. It is part of Tista basin and shows great variations in soils due to differences in altitude, slope, vegetation and parent material (Das, *et al.*, 1996). Soils of this eco-system are fragile and susceptible to degradation. There is hardly any in depth study on these soils. Hence the present study has been undertaken to characterize and classify the soils to prepare a strong and authenticate data base for planning of any developmental programme.

MATERIALS AND METHODS

The upper Rangit basin covers an area of 1,35,828 ha. River Rangit originates from Talung glacier in north-west of Sikkim and flows to join river Tista at Nayabazar in South Sikkim. The area of the basin experiences a great contrast in climate varying from subtropical to alpine due varying altitudes from 375 m msl to more than 4000 m above msl. Average annual rainfall varies from 1550 mm to 3500 mm. Soil temperature classes are divided into hyperthermic (>22°C), thermic (15°C-22°C), mesic (8 °C-15 °C) and cryic (<8°C). Northern part of the basin area belongs to mesic and cyric soil temperature regime.

A reconnaissance soil survey was carried out by using physiographic base maps on 1:50,000 scale (Sehgal *et al.*, 1989). Soil series were identified as per criteria laid down by Sehgal (1992). In field morphological properties of different pedons were studied (Soil Survey Staff, 1995) and horizonwise soil samples were collected for analysis of physico chemical properties of soils using methods outlined by Black (1965a, b). Soils were classified according to USDA Soil Taxonomy (Soil Survey Staff, 1999).

RESULTS AND DISCUSSION

Landscape has a bearing in the development of soils. A close relationship between landscape, vegetation and soils has been well documented (Sawhney *et al.* 1992; Das *et al.*, 1993). The hypothesis has helped in identifying 20 soil series under nine landform units. Soil series is the lowest level of distinct soils identified for natural resource management and named after a village where

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the typifying pedon have been first identified. Three soil series (Sl.No.1 to 3) occur on very high mountain (>3500 m msl) of glacial and periglacial region. Eight soil series (Sl. No.4 to 11) have been identified in high mountain (2000 to 3500 m msl) of glacio-fluvial and upper fluvial zone. Two soil series occurs in each of the four landform units viz. lower fluvial zones (Sl.No.11 & 12), valley (Sl.No.14 & 15), ridge (Sl.No.16 & 17) and escarpment (Sl.No.18 & 19). Ghorlebhir soil series belong to rocky cliff.

Dominant colour of surface horizon are very dark brown (10YR 2/2) to dark brown (10YR 3/3) while the sub-surface horizons are very dark grayish-brown (10 YR (3/2) to yellowish brown (10YR 5/6). The colour value ranges between 2 to 4 and chroma 2 to 3 for surface soils. The same for subsoils ranges from 3 to 5 and 2 to 6 respectively (Table 1). The value notation generally tends to decrease with depth except in soils of valley where hue is constant suggesting there by uniformity in relative lightness of color. The subsurface horizons are either constant or increased in chroma that indicates decreasing greyness. There is a concomitant increase of clay in subsoil due to translocation of clay in B horizon. This is probably due to the continuous removal of clay through heavy rainfall. These results are in agreement with those observed by Lahiri and Chakravarti (1989). Soils are fine-loamy in texture with clay enriched subsurface due to vertical clay movement. These textural variations may be attributed to in situ weathering under different climatic conditions (Verma *et al.*, 1990) and vegetation cover (Walia and Chamuah, 1996). Dominantly soils are fine, weak, granular in structure in all surface soils and fine to medium, moderate, subangular blocky in subsoils. The soils are highly melanised- sheroidal structure in several cases because of intimate mixing up of the humus with soil separates. Building up of humus in soils is favoured by luxurious growth of vegetation (Gangopadhyay *et al.* 1990). Soil series developed in lower fluvial zone and valley have a tendency of forming subangular blocky structure due to favourable microbial activity producing organic gum binding agent (Ramana Murthy and Sharma, 1992). A tendency to form subangular blocky structure in subsoils compared to granular structure in A horizon is also due to greater intensity of wetting and drying cycles in surface horizon and absence of the same in subsoils (Hutchins *et al.*, 1976). Soils have been developed on non-calcareous parent materials under high rainfall. They are free of $CaCO_3$ and soluble salts in the profile. They are acidic (pH 4.3-5.3), the pH values are comparatively higher in subsoil. This is expected because of higher rate of leaching loss of bases and high percentage of organic matter at surface. The build up of organic carbon in soils follows altitudinal pattern (Lahiri *et al.* 1995), being highest in high attitudes. Organic carbon content of agricultural land is lower than that of forest soils due to less turn over and faster decomposition of organic matter (Saikh *et al.*, 1998). CEC of soils varies from 8.1 to 20.9 c mol(+)/kg in surface and 3.9 to 19.5 cmol(+)/kg in subsurface. They are, in general, higher in surface layer as compared with subsurface soils. Vvalues are similar to those reported by Avasthi and Avasthi (1996) for some soils of Sikkim. CEC of soils decreases with increase of elevation and decrease with depth. High values of CEC in the surface soils is due to high content of organic matter. Exchangeable bases are generally high in surface layer decreasing with depth due to large amount of biomass returning the same to the soil surface (Gangopadhyay *et al.*, 1996).

Different soil forming processes viz. decalcification, illuviation, humification and melanization have influence the genesis of different types of soils in the basin area (Das *et al.*, 2007). Three soil orders viz. Entisols, Inceptisols and Mollisols have been identified covering an area of 11118.70 ha, 59164.95 ha, and 52855.56 ha respectively (Table 2). Soils with no diagnostic horizon belong to Entisols orders. They have been subdivided into Cryorthents (developed under cryic soil moisture regime) and Udorthents (developed under Udic soil moisture regime) covering 510.47 ha. and 10,608.23 ha respectively. Soils belonging to Inceptisols have ochric, mollic or umbric epipedons. They have been grouped under Cryepts and Udepts at suborder level. Udepts have two great groups viz. (i) Dystrudepts characterized with umbric or ochric epipedon underlain by structural or colour cambic B horizon and base saturation <60 % (ii) Eutrudepts with ochric or mollic epipedon followed by cambic B horizon and base saturation >60 %. Soils with mollic epipedon (rich in organic matter and high in base saturation) are placed under Mollisols order. Based on two moisture regimes (cryic and udic), Mollisols have been subdivided into Cryolls and Udolls at suborder level. Great group Haplocryolls and Hapludolls convey the central concepts of suborders Cryolls and Udolls respectively. Soils under suborder Udolls having argillic horizon (clay enriched subsurface horizon due to translocation) are placed under Argiudolls great group. Upper Rangit basin is endowed with potential soil resources. Maintaining of these valuable and unrenewable resources in its high productivity with ecological harmony is the most important issue. Twenty soil series identified in the area will be very useful to the different user agencies, planners, administrators and decision makers for any integrated development programme of the basin.

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Table 1. Important morphological and physico-chemical properties of different soil series

Soil series	Soil colour (moist)		Texture		Soil structure		pH (1:2.5)		OC (g mkg-1)		CEC cmol(+)kg^{-1}		B.S.%	
	Surface	Sub-soil	Surface	Sub-soil	Surface soil	Sub-soil	Sur-face	Subsoil	Sur-face	Subsoil	Sur-face	Subsoil	Sur-Face	Subsoil
Zongri	10YR 3/2	10YR 3/3 to 10YR 4/4	Sil(g)	Sil to Sl(g)	f1 gr	f1gr	4.9	5.0	35	12 to 28 (Mean 20)	12.6	8.9 to 12.0 (Mean 10.4)	55	56 to 59 (Mean 58)
Pangdingtar	10YR 2/2	10YR 3/2 to10YR 3/3	Sl	Sl(g)	cr	cr	4.7	4.8-5.0 (Mean 4.9)	39	12-28 (Mean 20)	12.0	7.7 to 10.0 (Mean 8.9)	51	55 to 57 (Mean 56)
Phodi	10YR 2/2	10YR 3/3 to 10YR 3/2	Sl(g)	Sl (g)	f1gr	cr	4.5	4.6	26	10 to 19 (Mean 14.5)	8.1	3.9 to 6.3 (Mean 5.1)	48	459 to 55 (Mean 52)
Jambuk	10YR 2/2	10YR 3/2 to 10YR 4/4	Sl(g)	Sl to sl(g)	f1gr	f1gr	4.6	4.6 to 4.9 (Mean 4.7)	34	20 to 17 (Mean 8.5)	8.3	8.0 to 8.1 (Mean 8.0)	50	53 to 56 (Mean 55)
Tisirtang	10YR 3/2	10YR 3/4 to 10YR 4/4	S1	Sl(g)	cr	cr	5.0	5.2-5.3 (Mean 5.3)	20	7 to 9 (Mean 8.0)	16.5	11.0 to 14.8 (Mean 12.9)	62	64 to 69 (Mean 67)
Yaksam	10YR 2/1	10YR 3/4	Sl	Sl to Sl(g)	f1gr	f1gr	4.5	4.6 to 5.0 (Mean 4.8)	37	29 to 35 (Mean 32)	10.4	10.7 to 11.1 (Mean 10.9)	51	51 to 58 (Mean 55)
Lapdang	10YR 2/2	10YR 3/2 to 2.5YR 3/3	Sl	Sil to Sl(g)			5.2	5.1 to 5.3 (Mean 5.2)	28	10-26 (Mean 21.5)	18.3	8.6 to 17.8 (Mean 14.2)	47	48 to 55 (Mean 51)
Dhupidanga	10YR 3/2	10YR 3/3 to 10YR 5/6	Sil	Sil	cr	cr	5.0	5.3 to 5.6 (Mean 5.5)	27	8 to 26 (Mean 17.0)	19.8	19.1 to 19.3 (Mean 19.2)	51	55 to 58 (Mean 57)
Sapong	10YR 3/2	10YR 3/3 to 10YR 6/2	Sil	Sil	f1gr	f1gr	4.6	4.6 to 5.1 (Mean 5.0)	23	11-17 (Mean 14)	19.8	4.7 to 8.5 (Mean 5.9)	56	59-63 (Mean 61)
Siribadam	10YR 2/3	10YR 3/3 to 10YR 4/3	Sil	Sicl	f1sbk	m2sbk	4.3	4.4 to 5.3 (Mean 4.8)	27	9 to 24 (Mean 14.5)	20.9	13.4 to 19.5 (Mean 16.0)	52	53 to 56 (Mean 55)
Tinkitam	10YR 3/3	10YR 4/6 to 10YR 4/6	Sil	L to sl (g)	f1sbk	cr	4.3	4.5-5.1 (Mean 9.9)	26	7-18 (Mean 11)	10.6	4.1 to 8.1 (Mean 5.9)	52	59 to 61 (Mean 60)
Namgaon	10YR 3/3	10YR 4/3 to 10YR 5/6	Sil	Sil to sil(g)	f1gr	f1sbk	5.8	5.8 to 6.1 (Mean 5.9)	33	12 to 25 (Mean 11.5)	11.4	5.4 to 9.4 (Mean 7.1)	41	43 to 52 (Mean 49)
Tashiding	10YR 6/3	10YR 4/4 to 10YR 6/3	L	L to L(g)	f1sbk	m2sbk	5.5	5.6-5.8 (Mean 5.7)	23	13 to 21 (Mean 15.6)	9.0	8.5 to 10.5 (Mean 9.6)	46	48 to 49 (Mean 48)
Chamluk	10YR 4/3	10YR 4/3 to 10YR 4/4	Sil	Sil to Sil(g)	f1sbk	m2sbk	6.0	6.1 to 6.5 (Mean 6.2)	21	3 to 18 (Mean 9.3)	10.6	4.1 to 8.1 (Mean 6.0)	52	50 to 61 (Mean 60)
Chautare	10YR 3/3	10YR 3/3 to 10YR 5/4	L	L to L(g)	f1sbk	sg	6.2	6.3 to 6.5 (Mean 6.4)	32	18 to 30 (Mean 25.3)	12.1	6.4 to 10.8 (Mean 8.7)	60	67 to 69 (Mean 68)
Snon	10YR 3/2	10YR 4/4	Sicl	sicl to sicl(g)	f1gr	f1sbk	4.3	4.4 to 4.8 (Mean 4.5)	35	34 to 15 (Mean 23.6)	16.5	12.5 to 15.5 (Mean 13.7)	45	41 to 50 (Mean 4.5)
Mangalbare	10YR 3/3	10YR 4/6 to 10YR 3/6	Sicl	Sicl to cl(g)	f1gr	f1gr	4.5	4.6 to 4.8 (Mean 4.7)	27	23 to 25 (Mean 24.3)	16.4	12.5 to 14.8 (Mean 13.3)	55	54 to 57 (Mean 56)
Kumuk	10YR 3/2	10YR 3/3 to 10YR 5/3	L	L to Sl (g)	f1gr	f1gr	5.2	5.2 to 5.4 (Mean 5.3)	27	11 to 25 (Mean 18)	12.5	7.7 to 5.2 Mean 6.4)	68	65 to 69 (Mean 67)
Nambu	10YR 3/2	10YR to 3/4	Sl	Sl(g)	f1gr	f1gr	5.1	5.1 to 5.2 (Mean 5.1)	27	15 to 19 (Mean 17)	9.5	7.0 to 8.9 (Mean 7.9)	64	57 to 61 (Mean 59)
Rock Gharlobhir	10YR 4/4	-	Sl (g)	-	f,1,gr	-	4.8	-	2.6	-	3.4	-	44	-

* Symbols are according to the notations used in Soil Survey Manual (Soil Survey Staff, 1995)

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Table 2. Classification of soils

S.No.	Soil series	Soil Taxonomy (classified at family level)	Soil Order	Characteristics	Area (ha)	% of TGA
1	Zongri	Loamy skeletal, cryic Humic Dystrudepts	Inceptisols	Moderately shallow, cambic horizon	12771.78	9.40
2	Pangdingtar	Loamy-skeletal, cryic Typic Haplocryolls	Mollisols	Moderatdy shallow, mollic horizon	8514.53	6.27
3	Phedi	Loamy-skeletal over fragmental, cryic Typic Cryorthents	Entisols	Moderatdy shallow, no diagnostic horizon	510.47	0.38
4	Jambuk	Loamy-skeletal,, mesic Humic Dystrudepts	Inceptisols	Moderatdy shallow, cambic horizon	11301.60	8.32
5	Tisintang	Loamy-skeletal,, mesic Typic Udorthents	Entisols	Moderately shallow, no diagnostic horizon	7534.40	5.55
6	Yaksom	Coarse-loamy, thermic Pachic Hapludolls	Mollisols	Moderatdy shallow, mollic horizon	5273.45	3.88
7	Lapdang	Loamy-skeletal, thermic Humic Pachic Dystrudepts	Inceptisols	Moderately shallow, cambic horizon	3515.63	2.59
8	Dhupidanga	Corse-loamy, thermic Entic Hapludolls	Mollisols	Moderatdy deep, mollic horizon	6059.32	4.46
9	Sapong	Fine-loamy, thermic Dystric Eutrudepts	Inceptisols	Deep, cambic horizon	4039.54	2.97
10	Sribadam	Fine-loamy, thermic, Typic Argiudolls	Mollisols	Moderately deep, mollic horizon	11060.10	8.14
11	Tinkitam	Coarse-loamy, thermic Dystric Eutrudepts	Inceptisols	Deep, cambic horizon	7373.40	5.43
12	Namgaon	Loamy-skeletal, thermic Humic Dystrudepts	Inceptisols	Deep, cambic horizon	4674.17	3.44
13	Tashiding	Loamy-skeletal, thermic Typic Dystrudepts	Inceptisols	Deep, cambic horizon	3116.12	2.30
14	Chamluk	Fine-loamy, hyperthermic Humic Eutrudepts	Inceptisols	Deep, cambic horizon	1232.66	0.90
15	Chautare	Coarse-loamy, hyperthermic Typic Dystrudepts	Inceptisols	Deep, cambic horizon	821.78	0.61
16	Sinon	Fine-loamy, thermic Humic Pachic Dystrudepts	Inceptisols	Deep, cambic horizon	5006.87	3.68
17	Mangalbare	Fine-loamy, thermic Entic Hapludolls	Mollisols	Deep, mollic horizon	3337.92	2.46
18	Kumuk	Loamy-skeletal, thermic Entic Hapludols	Mollisols	Moderatdy shallow, mollic horizon	14352.98	10.57
19	Nambu	Loamy-skeletal, thermic Humic Eutrudepts	Inceptisols	Moderatdy shallow, cambic horizon	9568.66	7.04
20	Ghorlebhir	Loamy-skeletal, thermic Lithic Udorthents	Entisols	Shallow, no diagnostic	4610.75	3.40
				horizon	3073.83	2.26

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3	Phedi	Loamy-skeletal over fragmental, cryic Typic Cryorthents	Entisols	Moderately shallow, no diagnostic horizon	510.47	0.38
4	Jambuk	Loamy-skeletal,, mesic Humic Dystrudepts	Inceptisols	Moderately shallow, cambic horizon	11301.60	8.32
5	Tisintang	Loamy-skeletal,, mesic Typic Udorthents	Entisols	Moderately shallow, no diagnostic horizon	7534.40	5.55
6	Yaksom	Coarse-loamy, thermic Pachic Hapludolls	Mollisols	Moderately shallow, mollic horizon	5273.45	3.88
7	Lapdang	Loamy-skeletal, thermic Humic Pachic Dystrudepts	Inceptisols	Moderately shallow, cambic horizon	3515.63	2.59
8	Dhupidanga	Corse-loamy, thermic Entic Hapludolls	Mollisols	Moderately deep, mollic horizon	6059.32	4.46
9	Sapong	Fine-loamy, thermic Dystric Eutrudepts	Inceptisols	Deep, cambic horizon	4039.54	2.97
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19	Nambu	Loamy-skeletal, thermic Humic Eutrudepts	Inceptisols	Moderately shallow, cambic horizon	9568.66	7.04
20	Gharlebhir	Loamy-skeletal, thermic Lithic Udorthents	Entisols	Shallow, no diagnostic horizon	4610.75 3073.83	3.40 2.26

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