Agropedology, 2003, 13, 39-49

Characterization and classification of the soils of upper Maul khad catchment in wet temperate zone of Himachal Pradesh

V.K. Sharma and Anil Kumar

Department of Soil Science, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur 176 062, India

Abstract

Micro landuse planning is essential for sustaining livelihood of hill people which is primarily based on intensive soil survey data. During a detailed soil survey of upper Maul khad catchment in wet temperate zone of Himachal Pradesh, six soil series with 21 phases were identified. The Surar, Kalu-di-Hatti (KDH), Lohna, Chandpur, Tanda and Holta soil series had 38.8, 10.4, 3.9, 3.2, 25.3 and 17.9 per cent area in the catchment, respectively. The soils are acidic and associated with mixed mineralogy. Surar soils (Lithic Udorthents), representing the soils of forests and pastures on moderately to extremely steep hill slopes are shallow, sandy loam, granular, medium in available N and low in available P and K. The soils are low in CEC [5.3 cmol (p+) kg^{-1}], medium in OC (7.0 g kg^{-1}) and had base saturation of 45 per cent. KDH and Lohna soils (Typic Dystrudepts), representing the soils of croplands on very gently to strongly sloping fluvio-glacial terraces are moderately deep to deep, loamy sand to sandy loam, granular to sub-angular blocky, low to medium in available N and P and medium in available K. Bulk density of these soils ranged from 1.55 to 1.72 Mg m^{-3}. The soils are low in CEC [4.4 to 6.9 cmol (p^+) kg^{-1}], and low to medium in OC (3.3 to 8.7 g kg^{-1}) and base saturation (48 to 60%). Chandpur and Tanda soils (Typic Hapludalfs), representing the soils of croplands on very gently to strongly sloping fluvio-glacial terraces are deep, sandy loam to clay loam, granular to sub-angular blocky, low to medium in available N and P and medium to high in available K. Bulk density of these soils ranged from 1.38 to 1.55 Mg m^{-3}. The soils are low to medium in OC (2.7 to 8.9 g kg^{-1}) and CEC [7.1 to 13.6 cmol (p+) kg^{-1}], and medium in base saturation (51 to 62%). Holta soils (Typic Paleudalfs), representing the soils of tea gardens on very gently sloping to moderately sloping fluvio-glacial terraces are deep, loam to silty clay loam, sub-angular blocky, low to high in available N, low to medium in available P and high in available K. Bulk density of theses soils ranged from 1.35 to 1.40 Mg m^{-3}. The soils are low to high in OC (3.5 to 12.5 g kg^{-1}), medium in CEC [11.9 to 14.8 cmol (p^+) kg^{-1}] and low to medium in base saturation (43 to 56%).

Additional keywords : Hill soils, soil survey, soil morphology, physical and chemical characteristics.

Introduction

Sustainable landuse planning on watershed basis in only a way before us to face major challenges like burgeoning population, food demands, shrinking cultivable land resources and increasing soil health hazards. Such planning in hill agro-ecosystems must have its primary focus on harnessing potential of their varied micro-agro-ecological conditions for commercial commodity production (Sharma 2002, Sharma and Anil Kumar 2003). Since soil is the base for every production system, knowledge of properties, extent and distribution of soils at farm/micro level is extremely important for evolving rational landuse plans (Challa 1999). As regards Himachal Pradesh, enough soil data at reconnaissance level have been generated by NBSS&LUP, AIS&LUS, CSKHPKV and other agencies. However, scanty information is available on detailed soil surveys for the state due to its topographical, climatic and financial constraints. Present study aims to provide detail information on the soils of the Maul khad catchment, representing fluvio-glacial terraces and hill slopes in wet temperate zone of Himachal Pradesh. Maul khad is one of the important streams feeding to Beas river.

Materials and methods

The upper Maul khad catchment is situated between 32°04'40" to 32°07'33" N latitude and 76°31'25" to 76°34'07" E longitude at an altitude varying from 1000 to 1600 m above msl and belongs to Agro-eco region No. 14 *i.e.* Western Himalaya, warm sub-humid eco-region (Sehgal *et al.* 1990). Gneiss, granite, phyllite, slate, sandstone and some unassorted deposits are the main sources of parent material for soil formation in north-west Himalaya (Wadia 1966). The climate is wet termperate with an average annual rainfall of 250 cm, mostly distributed during mid June to August. Mean maximum and minimum soil temperatures are 24.7 and 9.3°C, respectively. The soils have 'udic' soil moisture and 'thermic' soil temperature regimes. The natural vegetation includes *Pinus roxburghii* associated with *Albizzia stipulata, Bauhinia variegata, Cedrela toona, Grewia optiva, Morus alba Prunus padus, Pyrus pashia, Lantana spp. and Eupatorium spp.*

A detailed soil survey of the upper Maul khad catchment (746 ha) was carried out as per standard method (AIS&LUS 1970) using cadastral maps as base map. Soil morphology was studied according to Soil Survey Division Staff (1995). Horizonwise soil samples collected from representative pedons of series were air dried and processed for the determination of important physico-chemical characteristics with standard procedures (Black 1965). The soils were classified taxonomically (Soil Survey Staff 1998).

Results and discussion

Six soil series (with 21 phases) namely Surar, Kalu- di- Hatti, Lohna, Chandpur, Holta and Tanda were mapped (Fig.1, Table 1).

Table 1. Soil phases of upper Maul khad catchment

Soil series/ phases	Description	Area (%)
Surar : Loamy, mixed, thermic Lithic Udorthents		
1a	Severely eroded, extremely steep (>50%), sandy loam	34.3
1b	Moderately eroded, steep (33-50%), sandy loam	1.0
1c	Slightly eroded, moderately steep (15-25%), sandy loam	3.5
KDH : Coarse-loamy, mixed, thermic Typic Dystrudepts		
2a	Moderately eroded, moderately sloping (5-10%), loamy sand	1.2
2b	Slightly eroded, strongly sloping (10-15%), sandy loam	8.0
2c	Slightly eroded, gently sloping (3-5%), sandy loam	1.2
Lohna : Coarse-loamy, mixed, thermic Typic Dystrudepts		
3a	Slightly eroded, strongly sloping (10-15%), sandy loam	1.5
3b	Slightly eroded, gently sloping (3-5%), sandy loam	1.3
3c	Slightly eroded, very gently sloping (1-3%), sandy loam	1.1
Chandpur : Coarse-loamy, mixed, thermic Typic Hapludalfs		
4a	Slightly eroded, strongly sloping (10-15%), sandy loam	0.3
4b	Slightly eroded, gently sloping (3-5%), loam	1.5
4c	Slightly eroded, gently sloping (3-5%), sandy loam	1.4
Tanda : Fine-loamy, mixed, thermic Typic Hapludalfs		
5a	Moderately eroded, gently sloping (3-5%), loam	3.2
5b	Moderately eroded, moderately sloping (5-10%), sandy loam	3.4
5c	Moderately eroded, strongly sloping (10-15%), loam	0.7
5d	Slightly eroded, moderately sloping (5-10%), sandy loam	3.8
5e	Slightly eroded, very gently sloping (1-3%), loam	11.1
5f	Slightly eroded, gently sloping (3-5%), loam	3.1
Holta : Fine-silty, mixed, thermic Typic Paleudalfs		
6a	Moderately eroded, moderately sloping (5-10%), loam	2.4
6b	Slightly eroded, gently sloping (3-5%), loam	14.6
6c	Slightly eroded, very gently sloping (1-3%), sandy loam	0.9
	River-bed	0.5

Surar series occurring intensively on moderately to extremely steep hill slopes represents pine forests and pastures whereas other soil series, *viz.* KDH, Lohna, Chandpur, Tanda and Holta, on very gently to strongly sloping fluvio-glacial terraces represent the cultivated land. Holta series occurs mainly under tea gardens. The area under built-up, cropland, tea gardens, forests, pastures including scrub land and river bed in the catchment was 13.4, 24.5, 14.1, 29.4, 18.1 and 0.5 per cent, respectively.

Morphological characteristics : Lohna, Chandplur, Holta and Tanda series soils sere deep (>1m) and that of KDH was medium in depth (Table 2). Generally, these soils were brown to yellowish brown on the surface and dark brown to dark yellowish brown in the sub-surface. Soils are sandy loam to loam in texture, granular to sub-angular blocky in structure and soft to hard in consistence (dry) on the surface whereas the sub-surface soils are loamy sand to silty clay loam in texture, sub-angular blocky in structure and loose to extremely hard in consistence (dry). The soils are characterized by the presence of eluvial (Ap & AB) and illuvial (BA, Bw, Bt & BC) horizons of varying thickness. On the contrary, the soils on hill slopes (Surar series) are shallow in depth, brown in colour, sandy loam in texture, granular in structure and soft in consistence (dry). These soils have A and Cr horizons. Thin to moderately thick and patchy to continuous clay cutans were the peculiar features of Chandpur, Tanda and Holta soils.

Physical properties : The clay, silt and sand contents of these soils vary from 9.0 to 36.4, 11.1 to 49.6 and 14.3 to 81.9 per cent, respectively (Table 3). In general, sub-soils of all pedons show higher clay content as compared to surface horizons due to the clay illuviation. Gupta and Tripathi (1992) also reported illuviation, leaching, decalcification, humification and melanization as major soil forming processes in North-West Himalaya. The sand/silt ratio in the catchment ranges from 0.3 to 7.4. Mean sand/silt ratio is lowest in Holta (0.4) followed by Tanda (1.0), Chandpur (1.7), Lohna (2.8), Surar (4.4) and KDH (6.7). Sharma *et al.* (1986) also reported sand/silt ratio (<2) in terrace soils (Ustochretps) of Punjab.

The bulk density ranged from 1.38 to 1.62 Mg m^{-3} on surface and 1.35 to 1.72 Mg m^{-3} in sub-surface horizons. The bulk density tended to increase with depth. The variation in bulk density is attributed to organic matter content, texture *etc.* The water retention of soils at 33 and 1500 kPa suctions varied from 8.1 to 26.4 and 5.5 to 16.4 per cent respectively. The differences in water retention between soils may be ascribed mainly to the variation in contents of organic and inorganic soil colloids. The clay content was significantly correlated with water retention at 33 kPa (r=0.98) and 1500 kPa (r=0.97).

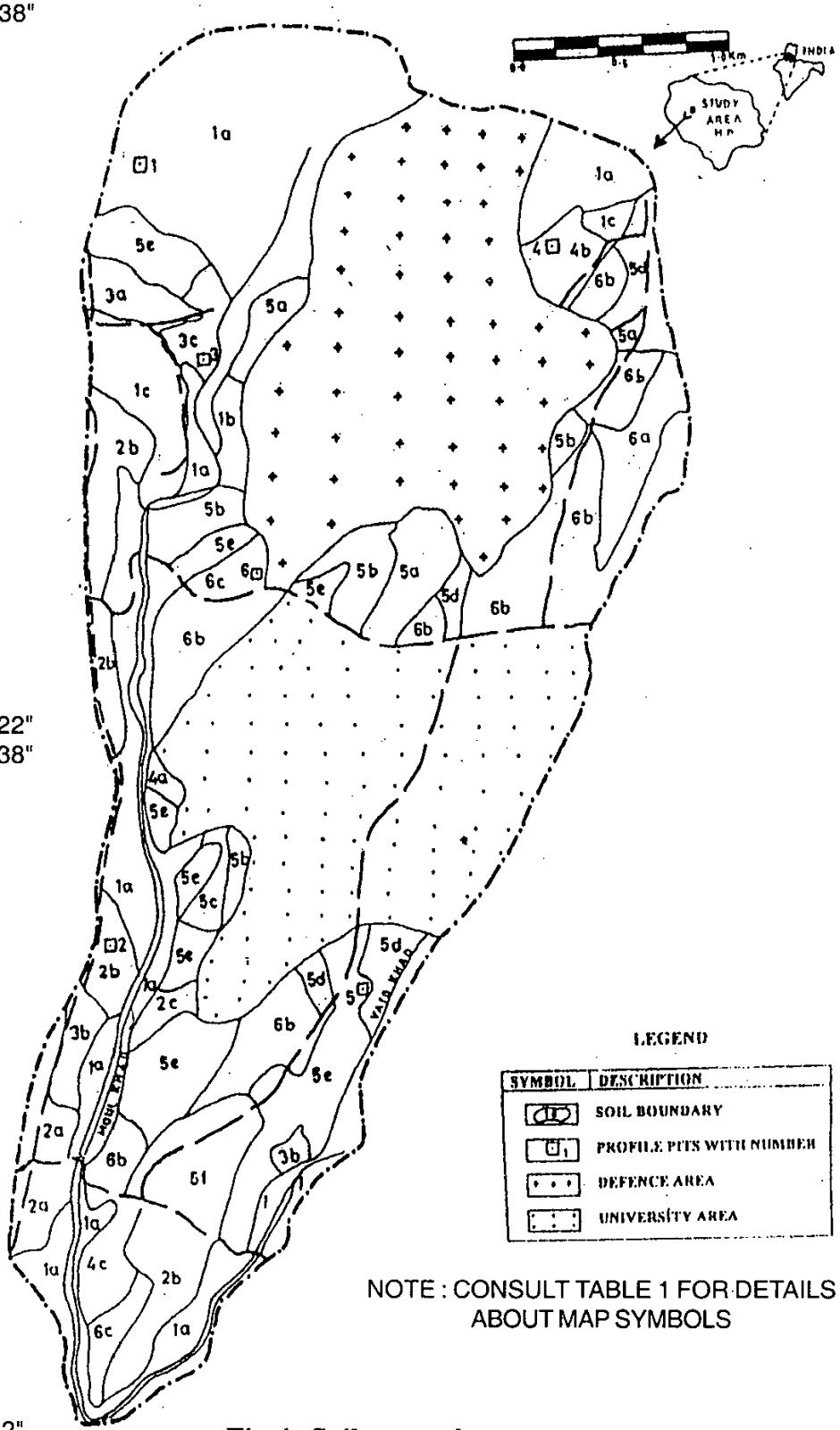

Fig 1. Soil map of upper Maul catchment

Table 2. Morphological characteristics of soils*

Horizon	Depth (cm)	Colour	Texture	Structure	Consistence	Boundary	Special features
Surar (Hill slopes under pine forests)							
A	0-14	10YR4/3	sl	f1gr	s f ss ps	cb	
Cr	14-29	Weatherd rock					
R	29	Hard rock					
KDH (Fluvio-glacial terraces under croplands)							
Ap	0-12	10YR4/3	sl	m1gr	s f ss ps	cs	
Bw	12-32	10YR4/4	sl	m2sbk	sh fr ss ps	cs	
BC	32-57	10YR4/6	ls	0	l l ss po	gs	
R	57+	Hard rock					
Lohna (Fluvio-glacial terraces under croplands)							
Ap	0-16	10YR4/3	sl	m1sbk	sh fr ss ps	gs	
AB	16-34	10YR4/3	sl	m2sbk	sh fr ss ps	cs	
Bw1	34-67	10YR5/3	sl	m2sbk	h fr ss ps	gs	
Bw2	67-107	10YR5/3	sl	m2sbk	h fr ss ps	gs	
Bw3	107-150	10YR5/3	sl	m2sbk	h fr ss ps		
Chandpur (Fluvio-glacial terraces under croplands)							
Ap	0-18	10YR5/3	sl	m1gr	sh fr ss ps	gs	
AB	18-46	10YR5/4	sl	m2sbk	h fi ss ps	cs	
Bt1	46-79	10YR4/3	l	m2sbk	h fi s p	gs	clay cutans (tn, p)
Bt2	79-127	10YR4/3	l	m2sbk	h fi s p	gs	clay cutans (tn, p)
Bt3	127-155	10YR4/3	sl	m2sbk	h fi ss ps		clay cutans (tn, p)
Tanda (Fluvio-glacial terraces under croplands)							
Ap	0-14	10YR4/3	l	m2sbk	h fi s p	cs	
BA	14-40	10YR4/4	l	m2sbk	h fi s p	as	
Bt1	40-61	10YR4/6	cl	m3sbk	h vfi vs vp	gs	clay cutans (tn, p)
Bt2	61-105	10YR4/6	cl	m3sbk	vh vfi vs vp	gs	clay cutans (tn, p)
Bt3	105-154	10YR4/6	l	m3sbk	h fi s p		clay cutans (tn, p)
Holta (Fluvio-glacial terraces under tea gardens)							
Ap	0-18	10YR4/3	l	m2sbk	h fi s p	as	
Bt1	18-42	10YR4/4	cl	m3sbk	vh vfi vs vp	cs	clay cutans (tn, p)
Bt2	42-75	10YR4/4	sicl	c3sbk	eh vfi vs vp	gs	clay cutans (mtk, p)
Bt3	75-113	7.5YR4/4	sicl	c3sbk	eh vfi vs vp	gs	clay cutans (mtk, c)
Bt4	113-152	7.5YR4/4	sicl	c3sbk	eh vfi vs vp		clay cutans (mtk, c)

*Abbreviations used are as per Soil Survey Manual (AIS&LUS 1970)

Table 3. Physical and chemical characteristics of soils

Depth (cm)	Mechanical separates (%) Clay	Silt	Sand	Sand/ silt ratio	BD (Mg m^{-3})	Water retention (kPa) 33	1500	pH 1:1	1:2.5	OC (g kg^{-1})	Available nutrients (kg ha^{-1}) N	P	K
Surar : Loamy, mixed, thermic Lithic Udorthents													
0-14	9.0	17.0	74.0	4.4	1.62	9.4	5.5	5.1	5.5	7.0	310	7	110
KDH : Coarse-loamy, mixed, thermic Typic Dystrudepts													
0-12	9.9	13.6	76.5	5.6	1.62	10.6	7.6	5.3	5.7	8.7	345	12	142
12-32	11.4	11.7	76.9	6.6	1.57	12.5	8.0	5.4	5.8	6.3	298	09	149
32-59	7.0	11.1	81.9	7.4	1.72	8.1	5.9	5.4	5.8	5.1	185	05	130
Lohna : Coarse-loamy, mixed, thermic Typic Dystrudepts													
0-16	12.3	25.5	62.2	2.4	1.58	13.2	7.8	5.0	5.4	7.7	295	13	188
16-34	13.0	22.7	64.3	3.8	1.55	13.6	7.8	4.9	5.4	6.4	210	9	192
34-67	14.9	23.5	61.6	2.6	1.55	14.0	8.1	5.1	5.5	4.9	160	6	210
67-107	14.2	21.2	64.6	3.0	1.60	11.2	7.8	5.0	5.6	3.3	160	6	210
107-150	13.8	21.2	65.0	3.1	1.60	11.2	7.8	5.1	5.6	3.3	145	6	166
Chandpur : Coarse-loamy, mixed, thermic Typic Hapludalfs													
0-18	13.6	32.4	54.0	1.7	1.55	14.1	7.3	5.0	5.5	8.9	305	14	196
18-46	15.0	32.4	52.6	1.6	1.55	14.8	7.8	4.9	5.5	7.3	295	12	210
46-79	19.2	30.9	49.9	1.6	1.48	17.6	8.8	5.2	5.6	4.2	210	10	224
79-127	20.6	30.9	48.5	1.6	1.48	17.0	8.8	5.2	5.6	3.7	160	6	180
127-155	16.3	29.7	54.0	1.8	1.52	14.8	7.8	4.9	5.3	2.7	160	6	180
Tanda : Fine-loamy, mixed, thermic Typic Hapludalfs													
0-14	18.0	38.1	43.9	1.2	1.46	17.6	9.5	5.2	5.7	7.8	325	15	296
14-40	20.6	36.5	42.9	1.2	1.49	18.5	10.1	5.3	5.6	3.6	284	13	284
40-61	28.8	37.7	33.5	0.9	1.40	21.6	14.5	5.2	5.7	4.7	184	8	272
61-105	31.0	40.3	28.7	0.7	1.38	22.8	15.2	5.0	5.6	4.3	170	6	272
105-154	23.8	40.3	35.9	0.9	1.48	20.6	11.8	5.0	5.7	4.3	170	6	220
Holta : Fine-silty, mixed, thermic Typic Paleudalfs													
0-18	23.2	45.5	31.3	0.7	1.38	18.5	9.2	4.8	5.1	12.5	585	18	340
18-42	29.9	49.6	20.5	0.4	1.40	21.6	13.3	4.8	5.2	7.5	426	14	310
42-75	36.4	49.3	14.3	0.3	1.35	26.4	16.4	4.6	5.2	6.5	310	10	365
75-113	33.2	47.9	18.9	0.4	1.38	24.3	15.3	4.6	5.3	3.5	175	7	365
113-152	30.3	49.3	20.4	0.4	1.40	22.1	14.0	4.9	5.3	3.5	180	7	289

BD = Bulk density, OC = Organic carbon

Chemical properties : All soils are acidic in reaction with pH varying from 5.1 to 5.7. Generally, horizons with high clay content exhibited higher pH. Low pH in these soils may be ascribed to the combined effect of soil forming factors particularly vegetation, parent material and climate. The nature of the tea crop and use of ammoniacal fertilizers by farmers results in lowest pH values in surface and sub-surface soils of Holta series. Organic carbon content ranges from 2.7 to 12.5 g kg^{-1} and is higher in surface as compared to sub-surface soils. As per Gangopadhyay *et al.* (1989), vertical distribution of Ca/Mg ratio in a soil indicates vegetational effects on soil formation. KDH soils show evidences of active role of vegetation in mobilizing Ca^{+2} and Mg^{+2} to surface layers. The spatial variation in OC content may be attributed to differential additions through plant leaf fall and manuring.

The CEC varies from 4.4 to 14.8 cmol (p+) kg^{-1} and seems to be dependent on clay and organic matter (Table 4). The clay content was significantly and positively correlated with CEC (r=0.98). Among different cations, Ca^{+2} dominated the exchangeable complex followed by Mg^{+2}, K^{+} and Na^{+}. The per cent base saturation of soils in upper Maul khad catchment ranges from 45 to 62 indicating moderate soil fertility status. The CEC/ clay ratio (0.39 to 0.59) indicate mixed mineralogy of the soils. Horizontal and vertical distribution of available N, P and K in soils (Table 3) are controlled by soil composition (organic/ inorganic matter), plant nutrient recycling and prevailing nutrient management practices. Most of the farmers apply N fertilizers (40-60 Kg ha^{-1}) and FYM (5-10 t ha^{-1}) only but at varying rates. Available N and P decreased with depth. As K availability is largely controlled by clay minerals, available K content had irregular trend of distribution with soil depth and was significantly and positively correlated with clay content (r=0.87). The surface soils were medium to high in available N, low to medium in available P and low to high in available K while subsoils were low to medium in available N and P and low to high in available K. Available N, P and K contents varied from 145 to 585, 6 to 18 and 110 to 365 kg/ha respectively.

Soil classification : The presence and absence of diagnostic horizons *viz.* cambic and argillic indicated the Surar soils to be classified as Entisols, KDH and Lohna soils as Inceptisols and Chandpur, Holta and Tanda soils as Alfisols. The soils on fluvio-glacial terraces under croplands and tea gardens in upper Maul khad catchment are classified as Inceptisols and Alfisols while those on hill slopes under pine forests and pastures as Entisols. Based upon other characteristics and properties studied, the soils are classified at family level as follows :

Table 4. Exchange characteristics of soils

Depth (cm)	CEC	Exchangeable cations				Ca/Mg ratio	Base saturation (%)	CEC/Clay ratio
		Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}			
	---------- Cmol (p+) kg^{-1} ----------							
Surar : Loamy, mixed, thermic Lithic Udorthents								
0-14	5.3	1.3	0.7	0.3	0.1	1.9	45	0.59
KDH : Coarse-loamy, mixed, thermic Typic Dystrudepts								
0-12	5.7	1.9	0.9	0.2	0.2	2.1	56	0.58
12-32	6.6	2.2	1.2	0.3	0.2	1.8	59	0.58
32-59	4.4	1.6	0.8	0.1	0.1	2.0	60	0.63
Lohna : Coarse-loamy, deep, mixed, thermic Typic Dystrudepts								
0-16	6.2	1.6	0.9	0.3	0.2	1.8	48	0.50
16-34	6.9	1.9	1.1	0.3	0.2	1.7	51	0.53
34-67	6.9	2.1	1.1	0.4	0.2	1.9	55	0.46
67-107	5.5	1.9	0.6	0.3	0.2	3.2	55	0.39
107-150	5.5	2.0	0.6	0.3	0.1	3.3	55	0.40
Chandpur : Coarse-loamy, mixed, thermic Typic Hapludalfs								
0-18	7.1	2.2	0.9	04	0.2	2.4	52	0.52
18-46	7.3	2.4	0.9	0.5	0.2	2.7	55	0.49
46-79	8.3	3.1	1.0	0.6	0.3	3.1	60	0.43
79-127	8.6	3.4	1.2	0.6	0.2	2.8	62	0.42
127-155	7.5	2.3	0.9	0.4	0.2	2.6	51	0.46
Tanda : Fine-loamy, mixed, thermic Typic Hapludalfs								
0-14	8.7	3.2	1.4	0.4	0.3	2.3	61	0.48
14-40	8.9	3.3	1.2	0.4	0.3	2.8	58	0.43
40-61	12.8	4.7	2.1	0.8	0.3	2.2	62	0.44
61-105	13.6	4.6	2.5	1.0	0.3	1.8	62	0.44
105-154	10.4	3.3	1.5	0.7	0.2	2.2	55	0.44
Holta : Fine-silty, mixed, thermic Typic Paleudalfs								
0-18	12.7	3.1	1.4	0.5	0.4	2.2	43	0.55
18-42	12.5	3.8	1.4	0.8	0.4	2.7	51	0.42
42-75	14.8	5.1	1.9	0.8	0.4	2.7	55	0.41
75-113	13.3	4.1	2.1	0.8	0.4	2.0	56	0.40
113-152	11.9	4.1	1.4	0.7	0.3	3.0	54	0.39

KDH soils : Coarse-loamy, mixed, thermic Typic Dystrudepts

Surar soils : Loamy, mixed, thermic Lithic Udorthents

Lohna soils : Coarse-loamy, mixed, thermic Typic Dystrudepts

Chandpur soils : Coarse-loamy, mixed, thermic Typic Hapludalfs

Tanda soils : Fine-loamy, mixed, thermic Typic Hapludalfs

Holta soils : Fine-silty, mixed, thermic Typic Paleudalfs

References

AIS&LUS (1970). Soil Survey Manual (All India Soil and Land Use Survey Organization, New Delhi).

Black, C.A. (1965). Methods of Soil Analysis, Part-2. American Society of Agronomy, Madison, Washington.

Challa, O. (1999). Land resource evaluation for district level planning: an approach. *Journal of the Indian Society of Soil Science* **47**, 298-304.

Gangopadhyay, S.K., Das, P.K., Nath. S. and Banerjee, S.K. (1989). Pedogenic characteristics of the soils supporting forest vegetation in the foot hill region. *Journal of the Indian Society of Soil Science* **37**, 775-781.

Gupta, R.D. and Tripathi, B.R. (1992). Genesis of soil in wet temperate and sub-alpine climatic zones of North-West Himalaya. *Journal of the Indian Society of Soil Science* **40**. 505-512.

Sehgal, J., Mandal, D.K., Mandal, C. and Vadivelu, S. (1990). Agro-ecological regions of India. National Bureau of Soil Survey and Land Use Planning, *Technical Publication* No.24 Nagpur.

Sharma, V.K. (2002). Emerging call for intensive soil survey of arable lands in hill agro-ecosystems. Indian Farmers Digest **35**, 18-20.

Sharma, V.K. and Anil Kumar (2003). Sustainable land use planning for upper Maul khad catchment in mid-hills zone of Himachal Pradesh. *Indian Journal of Soil Conservation* **31** : 139-147.

Sharma, P.K., Sehgal, J.L., Saggar, S. and Chand, K.S. (1986). Soils of Kandi area in Punjab and their suitability for land use planning. *Journal of the Indian Society of Soil Science* **34,** 133-141.

Soil Survey Division Staff (1985). Soil Survey Manual, Handbook 18. U.S.D.A., Washington, D.C.

Soil Survey Staff (1998). Keys to Soil Taxonomy, Eighth Edition. USDA, Washington, D.C.

Wadia, D.N. (1966). Geology of India (The English Language Book Society and MacMillan & Co. Ltd., London.

Received : February 2001 ; Accepted January 2003