Characteristics and erodibility of some degraded soils of the hill region of Uttar Pradesh

H.N. Singh and Om Prakash*

Department of Soil Science, G.B. Pant Univ. of Agriculture and Technology, Pantnagar 263 145, India

Abstract

Eleven soil pedons including 5 pedons from grazing lands and six from poorly managed agricultural lands were studied within an altitudinal range of 850 to 1700 M above msl where slope ranges from 2 to 58 per cent. The results indicated that the soils are shallow to deep (30–101 cm), are dominated by chert and/or gravel (26–46% w/w) and sand (51–83% in <2 mm fraction) contents. The available water capacity of the soils is very poor (3–7 cm) and infiltration rate is high (12–156 mm/hr), that leads to poor soil moisture storage. The soils are acidic in reaction (5.2–6.0 pH), low in CEC (8–13 cmol (p+) kg^{-1}) and low in base saturation (38–56%) resulting to poor nutrient storage and various nutritional problems for the vegetation. These soils had poor aggregation as the values of average mean weight diameter (MWD) varied from 0.17 to 0.68 mm in surface soil and from 0.10 to 0.50 mm in subsoil. On the basis of several erodibility indices/ratios/factors, these soils are classified as highly erodible and conservation and management methods for increasing productivity are suggested.

Additional keywords : Hill soils, grazing lands, degraded agricultural lands, soil erodibility.

Introduction

The problem of land degradation in the U.P. hills is quite serious and about 19.4% of the total area (51125 km2) is covered by different kinds of waste lands including culturable wastes, grazing lands, degraded agricultural lands, fallow and the areas unsuitable for cultivation (Anonymous 1992). However, the magnitude of soil erosion and land degradation depends largely on various soil and terrain conditions specially vegetative cover, slope gradient and inherent physical and chemical properties of the soil. Therefore, a thorough understanding of these parameters is essential for assessment of soil loss, soil productivity and for planning effective soil and water conservation programmes in the area. With this view, this study was conducted in upper parts of Ramganga catchment to evaluate physical and chemical properties of some grazing and degraded agricultural lands in relation to their productivity and erodibility.

Materials and methods

The Ramganga catchment lies between 29°30' to 39°55'N latitudes and 70°35' to 79°35'E longitudes in the middle Himalayas covering an area of 3076 km2 in several districts of Garhwal and Kumaon divisions. Geological formations in the area include mica schists, granitic gneiss, quartzitic sandstone and quartzitic limestone (Satyanarayana *et al.* 1968). The total annual rainfall in the area varies from 730 to 2425 mm. The mean maximum air temperature during summer (May and June) is 28°C and during winter (December and January) the mean minimum air temperature is 13°C.

Study comprises 5 pedons from grazing lands and 6 pedons from degraded agricultural lands showing variable slope (2 to 58%) and elevation (850 to 1700 M above msl.). Surface and subsurface soil samples were analysed for various physical and chemical properties by using standard analytical procedures as described by Black (1965) and Jackson (1973). Infiltration rate at each site was measured in situ with the help of a self dispensing infiltrometer. Erodibility of the soil was determined by using soil ratio and erosion indices as described by various workers viz. clay ratio (C.R.) (C : % sand + % silt/% clay, Bouyoucos 1935), silt/clay ratio (Chakrabarti 1971), clay/moisture equivalent ratio (Chibber *et al.* 1961), dispersion and erosion ratios (D.R. = % undispersed silt + clay/% dispersed silt + clay x 100 and E.R. = D.R./% colloidal/moisture eq., Middleton 1930) and erosion index (E.I. = D.R./% clay/0.5 WHC, Sahi *et al.* 1977). In determining the soil losses from an area by using Universal Soil Loss Equation, the values of erodibility factor (K) are required. With that point in mind, the values of erodibility factor (K1 and K2) were computed by using mathematical models of Wischmeier *et al.* (1971) and Romkens *et al.* (1977), respectively.

Results and discussion

Physical properties of the soils : All the soils are shallow to deep and the depth varies from 30 to 61 cm in case of grazing lands and 45 to 101 cm in agricultural lands (Table 1). Chert and gravel content is quite high and varies from 26 to 46% in surface soil and from 14 to 53% in subsoil. All the soils are coarse textured and contain high sand (50–82%), medium silt (12–35%) and low clay (5 to 16%) content. The sand content was observed relatively higher in agricultural lands as compared to grazing lands. Relatively higher percentage of coarser soil fractions indicate high degree of soil erosion specially in poorly managed agricultural lands. The data on mean weight diameter of aggregates also indicate higher soil erosion in agricultural lands as compared to grazing lands because low values of water stable aggregates (WSA) is responsible for higher soil erosion in agricultural lands whereas higher values resist to soil erosion in grazing lands.

Table 1. Physical and chemical properties of degraded soils of U.P. hills

Sl. No.	Profile location	Soil depth (cm)	Char./gr. (%)	Sand (%)	Silt (%)	Clay (%)	MWD (mm)	Avail. WHC (cm)	IR (mm/hr)	pH (1.2)	O.C. (%)	CEC (cmol kg^{-1})	B.S. (%)
						A. Grazing lands							
1.	Okhalkhatta	0–23	36	66	23	11	0.29	5.85	12	5.2	1.39	10.4	41
	(1700 m, 2%)*	23–61	30	66	2	12	0.26	–	–	5.4	0.51	7.8	46
2.	Bhet	0–7	36	65	24	11	0.53	3.56	24	5.2	1.29	11.4	40
	(1050 m, 7%)*	7–30	31	62	29	9	0.32	–	–	5.4	0.50	9.7	33
3.	Basnalagaon	0–15	28	65	28	7	0.38	4.46	24	5.4	0.93	7.8	40
	(8.50 m, 14%)*	15–55	20	68	24	8	0.36	–	–	5.6	0.70	7.2	38
4.	Shauna	0–22	46	57	32	11	0.24	3.58	63	6.0	1.42	8.4	46
	(900m, 40%)*	22–44	53	58	30	11	0.13	–	–	6.1	0.66	7.6	47
5.	Panduwakhal	0–11	42	52	35	14	0.68	4.23	60	5.4	1.36	11.6	42
	(1550m, 58%)*	11–45	33	50	44	16	0.50	–	–	5.4	0.78	10.0	34
						B. Degrated Agricultural lands							
6.	Dadhoi	0–31	30	74	18	8	0.17	4.00	66	5.7	0.30	7.2	56
	(1400m, 70%)*	31–45	38	77	16	7	0.08	–	–	5.7	0.12	4.8	42
7.	Naini	0–19	26	69	21	10	0.34	5.93	54	6.1	1.60	10.0	55
	(1700m, 11%)*	19–80	23	68	21	11	0.16	–	–	6.2	0.29	6.0	42
8.	Tharandari	0–23	35	75	18	7	0.31	7.72	1.56	5.5	1.97	11.9	36
	(1300m, 14%)*	23–101	28	74	15	10	0.18	–	–	5.3	0.32	7.8	35
9.	Bina	0–33	39	76	15	9	0.20	5.33	24	5.1	0.96	9.8	48
	(1525m, 14%)*	33–45	39	66	21	12	0.12	–	–	5.1	0.27	8.1	55
10.	Talli Mirai	0–10	35	79	12	9	0.21	4.11	48	6.0	1.07	9.2	42
	(1150m, 30%)*	10–48	14	79	12	9	0.16	–	–	6.3	0.25	6.5	52
11.	Ghingharikhal	0–11	46	82	13	5	0.16	5.41	108	6.0	0.76	9.8	35
	(1650m, 47%)*	11–51	33	69	23	9	0.10	–	–	6.0	0.56	7.2	31

*Figures in the parentheses indicate elevation and % slope.

Most of the rain water is either lost as surface runoff or percolates rapidly down the profile resulting in poor water storage (3.5 to 7.2 cm) in the profile. The data on infiltration rate also indicate rapid movement of water in the profile resulting in leaching of most of the base cations and available nutrients. This is in accordance with the results reported by Singh *et al.* (1999) for the soils of Ramganga catchment in U.P. hills.

Chemical properties of the soils : The pH of the soils vary from 5.1 to 6.3 and show acidic range which may be either due to leaching of bases from the profile or acidic parent material. Organic carbon content was relatively higher in surface layers of both grazing and agricultural lands as compared to subsurface layers. Cation exchange capacity in all the soils is low and varies from 7.2 to 11.9 c mol kg^{-1} in surface soils and from 4.8 to 10.0 c mol kg-1 in subsoils. The low values of CEC are mainly because of the low clay content in these soils. The concentration of all the base cations is low. Base saturation varies from 35 to 56% in surface layers and from 31 to 55% in subsurface layers. Acidic pH and low base status result in poor plant growth and nutrient deficiencies (Menon, 1983).

Soil erodibility : The results on various soil erodibility indices/factors (Table 2) indicate that the values of clay ratio and silt/clay ratio were quite high due to dominance of coarser fractions in the particle size distribution in all the soils.

Table 2. Soil erodibility indices of some degraded soils of U.P. Hills

S. No.	Profile name	Soil depth (cm)	C.R.	S./C.	C/ME	D.R.	E.R.	E.I.	K_1*	K_2**
					A. Grazing lands					
1.	Okhalkhatta	0–23	8.2	2.1	0.87	33.5	39.9	48.0	0.34	0.18
		23–61	7.6	1.9	1.20	36.4	49.4	44.9	0.37	0.24
2.	Bhet	0–7	8.4	2.2	0.62	35.6	57.5	60.4	0.32	0.18
		7–30	10.4	3.3	1.10	46.1	30.4	81.0	0.40	0.29
3.	Basnalgaon	0–15	13.9	4.2	0.45	45.5	93.9	53.9	0.35	0.13
		15–55	11.4	3.0	0.67	57.0	85.1	83.7	0.38	0.31
4.	Shauna	0–22	8.0	2.9	0.85	30.9	37.2	41.0	0.38	0.16
		22–44	7.8	2.7	1.20	44.3	36.3	57.4	0.35	0.26
5.	Panduwakhal	0–11	6.0	2.5	0.74	35.0	53.8	54.3	0.37	0.18
		11–45	5.3	2.1	1.10	37.4	36.8	38.4	0.36	0.16

				B. Degraded Agricultural lands						
6.	Dadhoi	0–31	11.4	2.2	0.68	31.3	46.8	62.3	0.22	0.19
		31–45	13.9	2.2	0.24	42.1	56.9	93.6	0.19	0.18
7.	Naini	0–19	8.6	2.0	0.68	34.7	36.3	39.6	0.25	0.18
		19–80	8.3	2.0	1.0	37.9	47.1	38.8	0.32	0.15
8.	Tharamdari	0–23	12.7	2.3	0.51	46.1	49.0	59.8	0.30	0.14
		23–101	9.8	1.5	0.85	48.8	67.6	64.5	0.31	0.17
9.	Bina	0–33	10.2	1.7	0.66	31.3	48.2	59.9	0.34	0.13
		33–45	7.2	1.8	1.20	32.0	49.2	59.8	0.37	0.15
10.	Talli Mirai	0–10	10.4	1.4	0.65	42.9	46.0	62.5	0.36	0.12
		10–45	10.5	1.4	0.81	46.0	58.2	66.6	0.33	0.14
11.	Ghingharikhal	0–11	18.6	2.6	0.35	30.3	46.7	54.8	0.35	0.24
		11–51	12.2	2.8	0.68	36.9	51.0	65.7	0.36	0.25

* Computed by the model of Wischmeier et al. (1971);

** Comuputed by the model of Romkens et al. (1977).

High dispersion ratio was observed in all the soils and it varies from 30.3 to 46.1 in surface and 36.4 to 57.0 in subsoils. Similarly the values of E.R. and E.I. are also very high. The values of E.R. vary from 36.8 to 93.9 and the values of E.I. vary from 38.8 to 83.7. Using the criteria of Middleton (1930) a soil having DR >15.0 and E.R. >10.0 is considered to be erodible. As all these soils have very high values of D.R., E.R./E.I., they may be considered as highly erodible (Singh and Prakash, 1985; Datta *et al.*, 1990).

The 'K1' values vary from 0.19 to 0.40 and 'K2' values from 0.12 to 0.31. The 'K2' values are lower than 'K1' values in all the soils indicating that Romkens model may not be suitable for these soils. The values of erodibility factor are mostly higher for subsoils indicating higher susceptibility of subsoils to erosion, resulting in soil degradation (Singh and Prakash, 1985).

Conclusion

Considering the values of various chemical and physical properties of the soil, slope, terrain conditions and high values of erodibility indices, these soils need special management practices for soil and water conservation and permanent vegetative cover to check further degradation of these lands. The present land uses (grazing and agriculture) need to be replaced by more effective soil and water resource conserving systems like forestry, agroforestry, silvi-pasture, controlled and rotational grazing and enclosure of severely degraded sites for natural regeneration.

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