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Soil Mineralogy

CHEMICAL CHARACTERISTICS OF SOME FOREST LANDS IN DEHRA DUN AND ADJOINING AREAS (U.P.)

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Soil clays from five soil profiles under different permanent vegetative cover were investigated for their chemical properties. Analysis of sesquioxide coatings suggested their mainly crystalline nature. The SiO_2/Al_2O_3, SiO_2/R_2O_3 and C.E.C. values exhibited no systematic variation with the depth, probably because of their origin from reworked sediments. Amorphous Fe and Al in sesquioxide coatings indicated different stages of weathering of the soils.

Key Words : Soil Clays; Chemical Analysis; Forest Soils

INTRODUCTION

THERE are several techniques for the characterization of soil clays/clay minerals to obtain relevant information (Raman & Ghosh, 1974). Chemical analysis is being used quite extensively as compared to other techniques (Narain & Gupta, 1975). However, information about clays of forest soils of India especially with reference to their weathering stages and natural vegetation appears to be meagre (Shukla *et al.*, 1965; and Singh & Singhal, 1981). In the present paper, therefore, characteristics of soil clays from some important soil groups of India under diverse kind of permanent vegetation have been reported.

MATERIAL AND METHODS

Soil profiles, viz., Pathri (P_1, P_2), Shahmansur (P_3) and Chilawali (P_4) of the Siwalik Forest Division (U.P.) and Dudhli (P_5) of the East Dehra Dun Forest Division (U.P.) were selected. The vegetation of Pathri area is in seral stage with savannah composition consisting of scattered and stunted trees with low rounded crowns standing in dense grasses. Natural vegetation of Shahmansur and Chilawali area is generally devoid of any tree growth except some scattered trees of secondary serials. Comparatively, the vegetation around Chilawali is better than Shahmansur. The

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Dudhli forest, however belongs to moist deciduous forest and seems to be of climax in nature.

The particle size analysis of the soils were carried out according to Jackson (1967) and < $2\mu m$ fractions collected by sedimentation. A part of the sample was treated with dithionite-citrate-bicarbonate (DCB) to remove sesquioxide coatings (Mehra & Jackson, 1960), whereas the other was subjected to single four hrs extraction with $(NH_4)_2$ C_2O_4—$H_2C_2O_4$ buffer at pH 3.0 to estimate amorphous Fe & Al (Bigham *et al.*, 1978). Fe and Al released in both the treatments where estimated by atomic absorption spectrophotometric methods after destroying the interferents. DCB treated Na-samples were analysed for total chemical analysis as per the method of Jackson (1967) and the FeO contents of the deferrated samples determined according to Roth *et al.* (1968) except that 1, 10 O-phenanthroline was added after the HF digestion of the sample (Olson, 1965). Cation exchange capacity (C.E.C.) was however, determined by usual NH_4OAC method.

Results and Discussion

Deferrated Clays

The SiO_2/Al_2O_3 (2.82–3.17) and SiO_2/R_2O_3 (2.35–2.66) ratios and C.E.C. values (22.64 to 32.35 meq/100 g) indicate the presence of illite and chlorite in P_1 and P_2 soils (Chatterjee & Dalal, 1976; Gupta *et al.*, 1977). Predominance of illite over in chlorite these samples can also be seen by the fair amount of K_2O and Fe_2O_3 in them (Weaver & Pollard, 1973; Ghosh *et al.*, 1976). Higher values of C. E. C. and MgO in P_2 soil in comparison to P_1 soil however, indicate a greater tendency on part of former towards smectite formation as also corroborated by their X-ray diffraction patterns studied earlier (Maheshwari *et al.*, 1981).

The higher SiO_2/Al_2O_3 and SiO_2/R_2O_3 ratios and higher C. E. C. values in respect of P_3 and P_4 soils as compared to P_1 and P_2 soils (Table I), indicate larger proportion of smectite group of minerals in the former as also observed during their XRD, infra-red and DTA studies (Maheshwari, 1982). The higher C. E. C. values however in the argillic horizon of P_3 soils can however be accounted for by translocation of fine clay from the A_1 horizon. The SiO_2/Al_2O_3 and SiO_2/R_2O_3 ratios of P_5 soil are lower than P_1, P_2, P_3 and P_4 soils probably on account of higher proportion of kaolinite in it. The high values of C. E. C. K_2O and MgO in this soil further suggests the presence of illite, vermiculite and chlorite minerals in addition to kaolinite.

Analyses of DCB and Oxalate Extracts

It can be seen from the analyses of DCB and Oxalate extracts (Table II) that the contents of DCB — Fe_2O_3 and DCB — Al_2O_3 in these soil clays are higher in comparison to contents of Oxalate—Fe_2O_3 and Oxalate—Al_2O_3 (0.07 to 0.22 per cent) which can be accounted for by the crysta llinenature of their sesquioxide coatings (Schwartmann, 1959). The active Fe however, which is the ratio of Oxalate—Fe_2O_3 to DCB—Fe_2O_3 $((Fe)_0/(Fe)_d)$ is less than unity in all the profiles.

TABLE I

Total Chemical Analysis of Deferrated Na-clays of Pedons

Profile	Depth (cm)/ Horizon	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	FeO %	MgO %	K_2O %	MnO %	TiO_2 %	L.O.I.* %	SiO_2/Al_2O_3	SiO_2/R_2O_3*	C.E.C. meg/ 100g
Pathri (P_1)	0—9A_1	47.68	25.70	5.96	1.46	3.43	4.32	0.30	0.02	10.33	3.15	2.61	29.53
	—66B_2	49.38	26.51	5.36	1.38	2.95	4.30	0.21	0.03	9.42	3.17	2.66	22.64
	—110B_3	48.34	28.18	5.12	1.22	2.97	4.10	0.19	0.02	9.75	2.92	2.50	25.63
	—160IIA_1	46.91	27.84	5.17	1.37	3.15	4.01	0.21	0.03	10.63	2.86	2.46	28.53
Pathri (P_2)	0—17A_1	45.82	24.86	8.00	1.86	3.83	3.78	0.20	0.03	10.83	3.13	2.55	29.56
	—84B_{31}	45.70	25.68	6.42	1.90	3.75	3.60	0.18	0.04	10.20	3.02	2.40	32.35
	—84+...B_{32}	44.01	26.52	6.02	1.87	3.94	3.68	0.16	0.04	11.05	2.82	2.35	27.89
Shahmansur (P_3)	0—13A_1	50.85	22.87	5.06	0.87	4.71	2.78	0.10	0.08	9.56	3.78	3.23	49.52
	—69B_{21}	49.60	24.86	5.29	0.74	4.61	2.75	0.12	0.06	10.03	3.39	2.93	57.23
	—158B_3	48.94	25.68	5.00	0.70	4.19	2.83	0.11	0.05	10.38	3.23	2.80	49.86
	—180C	48.94	25.68	4.73	1.06	4.76	2.78	0.12	0.07	10.09	3.24	2.96	48.05
Chilawali (P_4)	0—30A_1	46.75	24.86	4.54	0.83	4.52	3.53	0.12	0.10	10.83	3.20	2.88	43.54
	—100B_{21}	46.90	25.68	4.37	0.87	4.61	3.56	0.14	0.09	10.21	3.17	2.81	45.34
	—170B_{22}	47.65	25.68	4.74	0.97	4.67	3.67	0.10	0.10	10.37	3.15	2.62	43.24
Dudhli (P_5)	0—7A_1	44.56	31.82	4.86	1.10	1.79	3.15	0.09	0.12	10.78	2.38	2.12	39.43
	—16B_{21t}	44.61	32.65	4.66	1.01	1.68	3.10	0.08	0.10	10.15	2.32	2.10	43.56
	—66B_{22t}	44.44	33.31	4.38	0.98	1.73	3.00	0.07	0.10	10.38	2.18	2.05	42.63
	—110IIB_{21}	43.52	34.14	3.18	0.65	1.32	2.24	0.10	0.11	11.42	2.09	2.02	44.36
	—137IIB_{22}	43.35	32.47	4.12	0.70	1.80	2.46	0.10	0.12	11.23	2.13	2.01	41.85
	137+...IIB_3	44.39	32.81	4.62	0.35	1.83	2.64	0.12	0.12	10.67	2.21	2.10	42.68

*Loss on ignition.
**Includes Fe as Fe_2O_3.

TABLE II

Analysis of DCB and Oxalate Excrates of Soil Clays of Pedons

Profile	Depth (cm) and horizon	Fe_2O_3 DCB %	Fe_2O_3 Oxalate %	Fe_2O_3 Difference	$(Fe)_o/(Fe)_d$	Al_2O_3 DCB %	Al_2O_3 Oxalate %	Al_2O_3 Difference	$(Al)_o/(Al)_d$	$(Fe)_d/(Al)_d$
Pathri	0—9 A_1	5.37	0.75	4.62	0.14	0.72	0.22	0.50	0.30	7.46
(P_1)	—66B_2	6.56	0.77	5.79	0.12	0.79	0.19	0.60	0.24	8.05
	—110B_3	6.80	0.79	6.01	0.12	0.80	0.18	0.69	0.22	8.50
	—160IIA_1	7.06	0.83	6.23	0.12	1.10	0.21	0.89	0.19	6.42
Pathri	0—17A_1	3.70	0.89	2.81	0.24	0.42	0.18	0.24	0.43	8.80
(P_2)	—84B_{31}	3.73	0.78	2.95	0.21	0.38	0.16	0.22	0.42	9.81
	84+...B_{32}	4.33	0.68	3.65	0.16	0.41	0.15	0.26	0.37	10.56
Shah-	0—13A_1	5.25	0.69	4.54	0.13	0.54	0.21	0.33	0.39	9.72
mansur	—69B_{21}	4.86	0.70	4.16	0.14	0.52	0.19	0.33	0.36	9.34
(P_3)	—158B_3	5.25	0.66	4 59	0.13	0.50	0.14	0.36	0.28	10.50
	—180C	5.75	0.56	5.19	0.10	0.41	0.10	0.31	0.24	14.00
Chilawali	0—30A_1	5.58	0.47	5.11	0.08	0.73	0.21	0.52	0.29	7.64
(P_4)	—100B_{21}	5.55	0.57	4.98	0.10	0.69	0.22	0.47	0.32	8.04
	—170B_{22}	5.94	0.54	5.40	0.09	0.71	0.20	0.51	0.28	8.36
Dudhli	0—7A_1	7.60	0.40	7.20	0.05	0.59	0.17	0.42	0.29	12.88
(P_5)	—16B_{21t}	7.20	0.38	6.82	0.05	0.47	0.16	0.31	0.34	15.32
	—66B_{22t}	7.16	0.37	6.79	0.05	0.37	0.13	0.25	0.32	19.35
	—110IIB_{21}	7.05	0.27	6.78	0.04	0.28	0.08	0.20	0.28	25.18
	—137IIB_{22}	7.02	0.21	6.81	0.03	0.25	0.09	0.16	0.36	28.08
	137+...IIB_3	7.12	0.19	6.98	0.03	0.20	0.07	0.13	0.35	35.85

Subscripts o and d refer Oxalate and DCB extractable.

The higher ratio in P_1, P_2, P_3 and P_4 soils as compared to P_5 soil suggests comparatively more weathering of the latter. Higher active iron ratio in P_2 soil than P_1 soil may be attributed to its high water table which maintains lower redox potential and thus more reactivity of Fe. In the P_3 and P_4 soils the amount of DCB$-Fe_2O_3$ is same but the $(Fe)_0/(Fe)_d$ ratio is slighly higher in the former which may be due to difference in their internal drainage conditions.

The content of DCB$-Al_2O_3$ is lower than the content of DCB$-Fe_2O_3$ in all the profiles axamined. This indicates substitution of Fe^{3+} by Al^{3+} in the structure of haematite and goethite as also observed during their Mössbauer studies (Maheshwari, 1982).

The active Al (called Oxalate$-Al_2O_3$/DCB$-Al_2O_3$ and abbreviated as $((Al)_0/(Al)_d)$ is slightly higher in the P_2 soil as compared to others, to suggest of its comparatively young habitat. The $(Fe)_d/(Al)_d$ ratios exhibit increasing trend with the depth of all the soils except in P_1, where this ratio increases with depth except in the II A_1 horizon due to lithological discontinuity.

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