SOIL, VEGETATION AND PARENT MATERIAL RELATIONSHIP IN MALDEOTA AREA OF MUSSOORIE FOREST DIVISION, UTTARAKHAND[1]

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Introduction

A good deal of plant nutrients are derived from the weathering of minerals. Reserve and availability of nutrients depend largely on the mineralogical composition of soils and their parent material. The mineralogical studies have special importance in forestry where the tree growth last for a long period and depends to a large extent on the minerals as a source of nutrients from the soils.

Geology and soil are the controlling factors in the local distribution of vegetation particularly in regions where the mean annual rainfall is less than 2000 mm and their detailed study is necessary in order to appreciate their effect on the forests of the area dealt with.

Some of the independent studies in the Himalayas have been carried out with special emphasis on pedology, vegetation and mineralogy (Yadav, 1963; Singhal *et al.*, 1987 and 1989; Dhir, 1967; Dhar and Jha, 1978; Raina *et al.*, 2001). However, there is a lack of information on the studies regarding interrelationship between soil, geology, and vegetation of the study area. This study was, therefore, taken up to understand soil formation in relation to forest vegetation and geology in these moist deciduous forests of Maldeota.

Material and Methods

The area under investigation is located in Doon valley at the foothills of Garhwal Himalayas. Geographically, the Doon valley is situated in between latitude 29°35' to 30°30'N and longitude 77°38' to 78°20'E and stretching in North-West – North-East direction following the main Himalayan ranges. More precisely speaking, this is a longitudinal synclinal valley with the river Ganga on the East and the Yamuna on the West. Northern and southern boundaries are formed by peaks of Mussoorie and Shiwalik ranges respectively. Maldeota is located about 18 kms towards North-East of Dehra Dun between 750-1,050 m above msl. The minimum and maximum annual temperatures vary from 3.6°C in December and 35.3°C in May. The total annual rainfall of the valley is 1,805.0 mm with the maximum 625.0 mm in the month of August. In all three representative sites under different vegetation on different parent materials were selected for soil profile examination. The morphological characteristics were studied as per the procedure outlined in the Soil Manual (Soil Survey Staff, 1975). The morphological characteristics of different soil profiles are described in results and physical and chemical characteristics are described in Table 1. The varying fractions of sand, silt

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Table 1

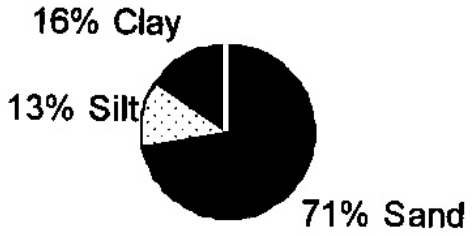
Physical and chemical characteristics of the three sites in Maldeota

Parent Material	Depth	Sand (%)	Silt (%)	Clay (%)	pH	Organic Matter (%)	CEC [cmol (p+)/kg]	Ex.Ca	Ex.Na	Ex.K	WHC
Quartzite	0-20	60.0 (50.7954)	20.0 (26.5768)	20.0 (26.5718)	6.0	4.76 (12.6065)	20.6	2.375	1.410	0.280	40.28
with	20-30	70.0 (56.8298)	15.0 (22.7870)	15.0 (22.7732)	6.1	4.00 (11.5393)	18.1	1.875	1.520	0.310	41.17
shale	30-45	75.0 (60.0348)	10.0 (18.4230)	15.0 (22.7953)	6.0	3.80 (11.2457)	16.7	1.875	1.370	0.290	35.32
	45-60	70.0 (56.8186)	12.5 (20.7116)	17.5 (15.0522)	5.8	4.00 (10.7881)	16.4	1.750	1.330	0.210	42.85
	60-75	85.0 (67.2919)	5.0 (12.7831)	10.0 (18.3962)	6.0	2.07 (8.2752)	11.3	1.000	1.260	0.140	28.87
Limestone	0-15	65.0 (53.7580)	20.0 (26.5785)	15.0 (22.7963)	7.9	5.07 (13.0190)	30.1	4.750	1.410	0.490	39.73
with	15-30	70.0 (56.8186)	22.5 (28.3300)	7.5 (15.9009)	8.1	2.52 (9.1378)	16.8	4.250	1.330	0.330	36.37
dolomite	30-50	70.0 (56.8298)	25.0 (30.0150)	5.0 (12.9119)	8.1	3.21(10.3259)	25.9	4.875	1.300	0.330	36.34
	50-70	80.0 (63.4823)	10.0 (18.4424)	10.0 (18.4434	8.2	1.72 (7.5272)	2.9	3.125	1.070	0.130	60.68
	70-90	67.5 (55.2723)	27.5 (31.6442)	5.0 (12.9219)	7.9	6.17 (14.3890)	11.5	5.625	1.520	0.550	50.25
Sandstone	0-20	85.0 (67.2547)	5.0 (12.7831)	10.0 (18.4136)	7.2	1.59 (7.2459)	7.5	1.750	1.110	0.230	35.08
with	20-40	80.5 (63.8430)	5.0 (12.8644)	10.0 (18.4230)	7.2	0.79 (5.0818)	6.3	1.500	1.020	0.130	32.56
phospho-	40-60	90.0 (71.6227)	0.0 (0.0000)	10.0 (18.4185)	7.4	0.59 (4.3974)	21.0	1.250	1.130	0.150	28.90
rite	60-80	90.0 (71.6495)	0.0 (0.0000)	10.0 (18.4024)	7.9	0.62 (4.5132)	5.7	1.750	1.000	0.110	30.47
	80-100	65.0 (50.8191)	25.0 (30.0066)	10.0 (18.4230)	8.0	0.83 (5.2264)	19.7	0.375	1.260	0.140	34.62

Values in the parentheses are transformed values of % by Arc sine transformation

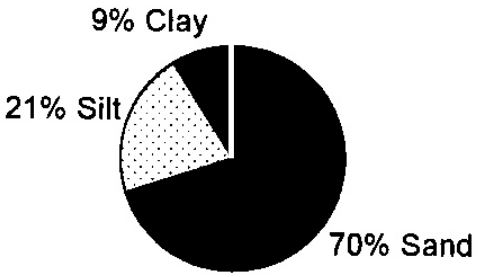
and clay in different sites are presented schematically in Figs. 1 - 3. Soil samples were analyzed using standard methods described by Piper (1950) and Jackson (1967). The phytosociological analysis of the vegetation was done on each site by nested quadrat method (Ambasht, 2000). The vegetation data was quantitatively analyzed for density, frequency, dominance and abundance and from this IVI was determined (Tables 2-4). The importance value index (IVI) is determined as the sum of relative density, relative frequency and relative dominance (Mishra, 1968).

Fig. 1



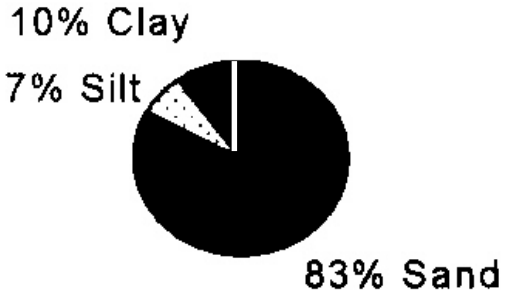
Sand, silt and clay % in I profile

Fig. 2



Sand, silt and clay % in II profile

Fig. 3



Sand, silt and clay % in III profile

Statistical Analysis : All data were analyzed by means of variance analysis (ANOVA) followed by Duncan's multiple range test. Percentages were transformed according to y=arc. Sin (aqr (x/100)) before ANOVA.

Results and Discussions

The soil parameters were appropriately related with the type of vegetation in each profile as follows:

Effects of Vegetation : Soils supporting mixed vegetation of *Acacia catechu, Grevillea robusta, Eucalyptus tereticornis, Pongamia pinnata,* and *Psidium guajava* had dark brown to olive brown A horizon and brown to yellowish brown B horizon. Soil under mixed vegetation cover of *Toona ciliata* and *Bombax ceiba* had brown to light brownish grey A horizon and greyish brown to pale brown B horizon. Water Holding Capacity varies with variation in organic matter i.e. it increases with increasing organic matter and decreases with decreasing organic matter. Soil vegetation relationship in different Forest Divisions of the Himalayan region has been studied by Minhas *et al.* (1997), Singhal *et al.* (1987), etc.

The morphological characteristics show only slight variation in the nature and degree of horizon development. The

Table 2

Density, Frequency, Abundance, A/F ratio and IVI of all the species in the first site.

Species	Density	Frequency	Abundance	A/F ratio	Rel. Density	Rel. Frequency	Rel. Dominance	IVI
Acacia catechu	7.80	80.00	9.75	0.12	11.40	11.11	37.21	59.72
Adhatoda vasica	20.80	100.00	20.80	0.21	30.41	13.89	7.40	51.70
Grevillea robusta	1.40	20.00	7.00	0.35	2.05	2.78	39.84	44.66
Lantana camara	8.80	100.00	8.80	0.09	12.87	13.89	3.89	30.65
Murraya koenigii	8.60	100.00	8.60	0.09	12.57	13.89	1.95	28.41
Zizyphus jujuba	5.00	80.00	6.25	0.08	7.31	11.11	0.42	18.84
Boerhaavia diffusa	5.80	60.00	9.66	0.16	8.48	8.33	0.01	16.82
Eucalyptus tereticornis	2.20	40.00	5.50	0.14	3.22	5.56	3.62	12.40
Parthenium sp.	3.20	40.00	8.00	0.70	4.68	5.56	0.02	10.26
Pongamia pinnata	0.35	40.00	3.00	0.07	1.75	5.56	2.46	9.76
Opuntia dillenii	2.40	20.00	12.00	0.60	3.51	2.78	2.12	8.41
Agave americana	0.80	20.00	4.00	0.20	1.17	2.78	0.26	4.21
Psidium guajava	0.12	20.00	4.00	0.20	0.58	2.78	0.80	4.16

Table 3

Density, Frequency, Abundance, A/F ratio and IVI of all the species in second site

Species	Density	Frequency	Abundance	A/F ratio	Rel. Density	Rel. Frequency	Rel. Dominance	IVI
Toona ciliata	2.95	100.00	5.33	0.05	8.84	9.68	42.72	61.24
Adhatoda vasica	16.00	100.00	16.00	0.16	26.52	9.68	1.90	38.10
Bombax ceiba	0.67	66.67	1.00	0.01	1.11	6.45	22.20	29.75
Lantana camara	9.00	100.00	9.00	0.09	14.92	9.68	0.87	25.47
Murraya koenigii	8.33	100.00	8.33	0.08	13.81	9.68	1.12	24.61
Acacia catechu	3.50	100.00	6.33	0.06	10.50	9.68	3.55	23.73
Mallotus philippensis	2.33	100.00	2.33	0.02	3.87	9.68	7.00	20.55
Carrisa conjesta	5.00	100.00	5.00	0.05	8.29	9.68	1.28	19.25
Agave americana	3.33	66.67	5.00	0.07	5.52	6.45	5.37	17.34
Adina cordifolia	1.00	66.67	1.50	0.02	1.66	6.45	8.12	16.23
Grevillea robusta	1.67	66.67	2.50	0.04	2.76	6.45	5.85	15.06
Zizyphus jujuba	1.33	66.67	2.00	0.03	2.21	6.45	0.02	8.68

Table 4

Density, Frequency, Abundance, A/F ratio and IVI of all the species in the third site.

Species	Density	Frequency	Abundance	A/F ratio	Rel. Density	Rel. Frequency	Rel. Dominance	IVI
Bauhinia vahlii	4.00	100.00	4.00	0.04	4.80	6.67	74.90	86.37
Adhatoda vasica	12.33	100.00	12.33	0.12	14.80	6.67	2.67	24.14
Euphorbia hirta	11.67	100.00	11.67	0.12	14.00	6.67	0.06	20.73
Cynodon dactylon	10.00	100.00	10.00	0.10	12.00	6.67	0.03	18.70
Parthenium sp.	9.00	100.00	9.00	0.19	10.80	6.67	1.12	18.59
Tithoria sp.	5.67	100.00	5.67	0.06	6.80	6.67	1.97	15.44
Rumex acetosella	5.00	100.00	5.00	0.05	6.00	6.67	1.77	14.44
Woodfordia fruticosa	1.67	100.00	1.67	0.02	2.00	6.67	5.00	13.67
Aerva scandens	4.33	100.00	4.33	0.04	5.20	6.67	1.38	13.25
Eupatorium cannabium	4.67	100.00	4.67	0.05	5.60	6.67	0.09	12.36
Eugeinia dalbergiodes	3.67	100.00	3.67	0.04	4.40	6.67	1.14	12.21
Murraya koenigii	2.67	100.00	2.67	0.03	3.20	6.67	1.80	11.67
Pogostemon patchouli	4.00	100.00	4.00	0.04	4.80	6.67	0.01	11.48
Cassia fistula	0.67	66.67	1.00	0.01	0.80	4.44	5.47	10.71
Lantana camara	3.00	66.67	4.50	0.07	3.60	4.44	2.40	10.44
Eirophorum comosum	1.00	66.67	1.50	0.02	1.20	4.44	0.20	5.84

soils developed under young and sparsely growing *Acacia catechu, Grevillea robusta, Eucalyptus tereticornis, Pongamia pinnata, Psidium guajava* had 30 cm deep A horizon and 75 cm deep B horizon. The soil development under *Toona ciliata* and *Bombax ceiba* showed 30 cm thick A horizon and deeper (90cm) B horizon. The sequence of horizons under very sparsely growing *Bauhinia vahlii* was A_1- A_3-B_1-B_2-C in which the thickness of A horizon was 40 cm and that of B horizon 80 cm.

Effects of parent material : Site with quartzite and shale has lesser soil depth (75 cm) in comparison to site II (90 cm) and site III (100 cm). In case of 3rd site which had sandstone mixed with phosphorite as parent material, A horizon had light olive brown to light yellowish brown colour and pale brown to light yellowish brown B horizon. Inspite of higher organic matter content in the first two profiles, the values and chroma of the soils in the third profile are higher due to phosphorite mixed in the soil. The soils formed over limestone are more basic (8.04) than the soils developed from sandstone (7.54). Organic matter content is high in soil profile with shale and limestone while it is low in soil profile with sandstone. The reason is that the latter was not supporting enough tree species to account for leaf litter. The mechanical composition indicates that sand

Table 5

Variability estimates for given physical and chemical properties of soil

Sl. No.	Character	Range			Mean			SD			CV%		
		Site I	Site II	Site III	Site I	Site II	Site III	Site I	Site II	Site III	Site I	Site II	Site III
1.	Sand % (t.v.)	60-85	65-80	65-90	58.4	57.2	65.0	5.8	3.6	6.9	9.9	6.3	10.6
2.	Silt % (t.v.)	5-20	10-28	0-25	20.7	27.0	11.1	5.0	4.9	11.7	24.0	18.0	105.1
3.	Clay % (t.v.)	10-20	5-15	10-10	21.1	16.6	18.4	6.2	4.0	1.2	29.1	23.8	6.3
4.	Organic matter % (t.v.)	2.1-4.8	1.7-6.2	0.6-1.6	10.9	10.9	5.3	1.5	2.7	1.1	14.0	24.4	21.2
5.	PH	5.8-6.1	7.9-8.2	7.2-8.0	6.0	8.0	7.5	0.1	0.1	0.4	1.8	1.7	5.0
6.	CEC	11.3-20.6	2.9-30.1	5.7-21.0	16.6	17.4	12.0	3.4	10.9	7.6	20.5	62.7	63.4
7.	Exchangeable Ca	1.0-2.4	3.1-5.6	0.4-1.8	1.8	4.5	1.3	0.5	0.9	0.6	27.9	20.4	42.9
8.	Exchangeable Na	1.3-1.5	1.1-1.5	1.0-1.3	1.4	1.3	1.1		0.2	0.1	0	12.6	9.4
9.	Exchangeable K	0.1-0.3	0.1-0.6	0.1-0.2	0.2	0.4	0.2		0.2		0	44.8	0
10.	Water Holding Capacity	28.9-42.9	36.3-60.7	28.9-35.1	37.7	44.7	32.3	5.7	10.6	2.6	15.1	23.8	8.2

Table 6

F-values for test of significance of different variables

Sl. No.	Variables	Sources		
		Treatment (Parent material)	Sub-treatment (Horizon)	Treatment x Sub-treatment
1.	Sand % (t.v.)	67.3*	20.2*	36.4*
2.	Silt % (t.v.)	376.8*	80.7*	81.6*
3.	Clay % (t.v.)	4.0	2.6	1.6
4.	Organic matter % (t.v.)	932.5*	82.4*	64.1*
5.	pH	41.0*	0.2	0.7
6.	CEC	137.2*	252.4*	180.8*
7.	Exchangeable Ca	483.0*	8.3	18.8*
8.	Exchangeable Na	13.6*	2.5	1.7
9.	Exchangeable K	16.8*	4.3	3.3
10.	Water Holding Capacity	3744.1*	975.2*	1008.4*

* These F values differ significantly among sources ($P<0.01$) according to Duncan's multiple range test

and silt fraction were higher in the soil profiles (Figs. 1, 2 and 3). Higher sand and silt fractions were due to the richness of parent material in these fractions. Site with sandstone has highest sand percentage (82.1%) in comparison to 72% of site I and 70.5% of site II. Among the different types of parent material, the content of Exchangeable Ca^{2+} was maximum in site with limestone (4.6) and minimum in site with sandstone (1.48). Site with sandstone gives rise to coarse textured light soil.

Characteristics of the soils : The soils were in general moderately to strongly basic (Table 1). The variation in soil pH under different forest vegetation ranged from 6.0 to 8.2. In general the pH was lower in the upper horizons than in the lower ones. Organic matter content was generally high with maximum accumulation in the surface horizon. It increased with the depth but without a definite trend. Cation Exchange Capacity of the soils varies from 2.9 to 30.1 cmol. (p+) Kg^{-1}, which is nfluenced by the amount of clay fraction and organic matter. Among the exchangeable cations, Ca^{2+} was dominant, followed by Na^{+}.

Effect on vegetation : In site I, *Acacia catechu* had maximum IVI but maximum abundance is of *Adhatoda vasica* as quartzite gives rise to only shallow soil and supports non-exacting species. In the site II maximum IVI is of *Toona ciliata* while *Adhatoda vasica* has maximum abundance as it has highest Cation Exchange Capacity (17.44 cmol (p^{+}) kg^{-1}) and limestone supports these species. Site II also has highest Water Holding Capacity (44.67) in comparison to 37.7 of site I and 32.3 of site III so was supporting maximum biomass. The site III is supporting only

one type of tree species because sandstone gives rise to only light soils.

Conclusion

Out of the three sites chosen for study the site II on which *Toona ciliata* and *Bombax ceiba* spp., etc. were growing exhibited higher organic matter content, Water Holding Capacity and Cation Exchange Capacity in contrast and comparison to site I and II with different species. So site II will probably have better percolation rate and reduced run-off.

The statistical results show that clay percentage is not varying significantly between the treatments i.e. clay percentage is almost the same even when the three-parent materials are different. Whereas clay percentage, pH and Exc. Na are not varying significantly between the subtreatments i.e. % of clay, pH and amount of Exc. Na are showing slight change with increasing depths. Analysis of interactions of treatments and sub-treatments show that in the same fashion clay percentage, pH and Exc. Na are somewhat same at similar depths in the three parent materials.

SUMMARY

Interrelationship of soil, vegetation and geology was studied in Maldeota area of Mussoorie Forest Division, Uttarakhand (altitude 750 to 1,050 m above msl). The physical and chemical properties of the soils under different vegetative covers were related to various vegetational parameters and parent materials. The results showed that range in pH was from 6.0 to 8.2 while water holding capacity varied from 28.9 to 60.7. Organic matter content was generally high with maximum accumulation in the surface horizon. Cation exchange capacity of the soils varies from 2.9 to 30.1 cmol. (p+) kg^{-1}. Elluviation and illuviation processes were well marked in most pedons, which results in horizon distinction.

मसूरी वन मण्डल, उत्तराखण्ड के मालदेवता क्षेत्र में मृदा, वनस्पति और पैतृक वस्तु में सम्बन्ध

रचना तिवाड़ी

सारांश

मसूरी वन मण्डल, उत्तराखण्ड (ऊंचाई माध्य समुद्र तल से 750 से 1050 मी० तक) की मृदा, वनस्पति और भौमिकी के अन्तर्सम्बन्ध का अध्ययन इसके मालदेवता क्षेत्र में किया गया। विभिन्न वनस्पति आवरणों की मृदाओं की भौतिक और रासायनिक विशेषताओं का सम्बन्ध विविध वनस्पति परिमापों और पैतृक वस्तु से स्थापित किया गया। इससे मिले परिणाम दिखाते हैं कि पीएच की परिसीमा 6.0 से 8.2 तक है जबकि मृदा की जलधारण क्षमता 28.9 से 60.7 तक है। जैव पदार्थ की मात्रा सामान्यतः ज्यादा है तथा इसका अधिकतम संचयन तल सस्तर पर हुआ है। मृदाओं की धनायन विनिमय क्षमता 2.9 से 30.1 Cmol (P+) किग्रा तक रहती पाई गई। अपोढ़न और न्युद्वहन प्रक्रियाएं अधिकांश मृदाओं में सुस्पष्ट दिखाई पड़ रही थी जिससे सस्तर पृथकता बन रही थी।

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