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Physio-chemical status of soil of a temperate Himalayan forest at Agrakh-Kunjapuri area of district Tehri Garhwal, Uttarakhand, India

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Abstract

The study area Agrakhal-Kunjapuri lies in district Tehri Garhwal. The present area of investigation lies at 30° 5' N latitude and 78° 23' E longitudes ranging in elevation of temperate zone and is covered with dense oak forest. Soil samples were collected from representative sites of the study area in each season viz. winter, summer and rainy. From each site, the composite samples (mixture of three soil samples) were collected from different depths (0-10, 15-25, and 30-40 cm). Soil samples of each site was analyze for physio-chemical characteristics. The soil of the study area was of clay-loam type. The biotic disturbance was found to be a determining factor of community formation, along with topography, soil and moisture.

Key words: ***Physical and chemical features of soil, temperate zone, Garhwal Himalaya***

Introduction

The Himalaya has been an interesting source of attraction and curiosities to the human-beings for its beautiful mountainous ranges, gorges, valleys and ravines covered with complex vegetation in the from forests, grasslands, marshes and meadows, in different topography, soil and climates. The manifold aspects of Himalayan ecosystem have attracted the attention of naturalists, philosophers, saints and scientists from time to time. A number of soil variation found in physio-chemical features in different vegetation zones of Garhwal Himalaya. Several Gujjars and local shepherds cross it with their cattle during early summer months. Their cattle cause damage to the vegetation and soil of the area. The road construction has also affected the vegetation and soil of the area. Most common constituents of this forest area are *Quercus leucotrichophora*, *Lyonia ovalifolia*, *Rhododendron arboreum*, *Symplocos paniculata* and *Myrica esculenta*. According to Auden (1934), Bhargava (1972), and Aggarwal and Kumar (1973), igneous (e.g. granite), sedimentary (e.g. conglomerate, limestone, and shale), and metamorphic rocks (e.g. quartzite, slate, gneiss and schist) are found in this zone of Garhwal Himalaya. At high elevations, the low mean summer temperature is due to a combination of various factors. Because of the low atmospheric density, the air is relatively transparent both to incoming and outgoing thermal radiation and hence little amount of energy is trapped within troposphere (Billings *et. al.* 1977).

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Study area

The study area Agrakhal-Kunjapuri lies in district Tehri Garhwal. The present area of investigation lies at 30° 5' N latitude and 78° 23' E longitudes ranging in elevation from 1200 to 1800 m in the montane zone and is covered with dense oak forest. This area is relatively cooler than low montane zone, so climate of the study area is monsoonic montane temperate. Due to presence of types of micro-climatic conditions, soil composition varies for each slope site. The temperature is usually higher at the surface during the day and the inversion type at night (Bliss 1956).

Materials and Method

For recording the soil characteristics of different sites of the study area, extensive field studies were conducted for three years (December 1993 to November 1996). Soil samples were brought to the laboratory, air dried and stored in polyethene bags for physical and chemical analysis.

(A) Physical Characteristics:

(a) Soil Moisture

For the estimation of soil moisture content, samples of soil from three depths were collected during summer, rainy and winter season. 20 gm soil samples in triplicate from each depth were accurately weighed, oven dried at 105 °C for about 24 hours and weighed again, and expressed as percentage moisture content on oven dry weight basis.

$$\text{Moisture percentage} = \frac{\text{Loss of weight on drying}}{\text{Dry weight of soil}} \times 100$$

(b) Soil Texture

It refers to the relative proportion of the various groups of individual particles. Three size fractions of soil i.e. sand, silt and clay were determined by pipette method (Michael 1984).

(c) Water Holding Capacity (WHC)

The percentage quantity of moisture held by soil in the form of films when fully saturated expressed the water holding capacity. Water holding capacity of the soil was estimated by the methods described by Piper (1944).

(B) Chemical Characteristics

(a) pH

Hydrogen ion concentration or nature of soil (soil: water as 1:2.5) was measured with the help of Systronics pH meter.

(b) Cation Exchange Capacity (CEC)

It was determined by Ammonium saturation (leaching at pH 7.0) as given by Piper (1944).

(c) Exchangeable K, Ca, Na and available P

Exchangeable potassium, calcium, sodium and available phosphorus were extracted by N-ammonium acetate solution (leaching at pH 7.0) as given by Piper (1944). K and Ca concentrations were determined by Systronics Flame photometer, P was estimated with the help of Digital Spectrophotometer and Na was determined by Atomic Absorption Spectrophotometer (Pye Unican 3200).

(d) Total Nitrogen

The total nitrogen of the soil of study area was determined by Macrojeldahl method (Piper 1944).

(e) Organic Carbon

The organic carbon of the soil was determined by the method of Walkley and Black as outlined by Piper (1944).

Results and Discussion

Water holding capacity of the soil decreased with increasing depth of soil and was recorded maximum for rainy as compared to other seasons. Soils of all northern slopes had high moisture percentage in all the seasons in comparison to south facing slopes. All the soils up to the depth of 40 cm were black to brown in colour. The nitrogen content was highest in 0-10 cm depth level in most of the seasons and sites. The total nitrogen ranged from 0.10 to 0.56 % for soils of different seasons and depths. The maximum C/N ratios were 15.00, 17.78 and 17.50 for winter, summer and rainy seasons respectively, while minimum values for these seasons were 7.38, 7.96 and 7.24. Exchangeable quantities of calcium, potassium and sodium varied with the level of the depth

Physical Characteristics of the soil

Soil profile is well developed with distinct A-B-C layers. Table 1 shows that soils of all northern sites has high moisture percentage in all the seasons in comparison to south facing slopes. In most of the seasons, moisture content decreased with increasing soil depths. During winter season high moisture content (36.99 %) was observed in both north and south-west slope soils at 0-10 cm depth while lowest (19.05 %) was recorded for 30-40 cm depth in north-west site soil. Soil depth of 15-25 cm has moderate percentage of moisture in comparison to 0-10 cm depth. During summer, percentage of soil moisture was very low in comparison to other seasons. In this season highest moisture content was recorded for 15-25 cm depth in the soils of south-east (24.22 %) and north-west slopes (23.46 %), while lowest (10.19 %) was observed at 0-10 cm depth in south-west slope soil. Mostly soil depth of 30-40 cm has high amount of moisture (ranging from 13.31 % on south-west to 24.22 % on south-east slope) in comparison to 0-10 cm depth (ranging from 10.19 % on south-west to 18.34 % on north-west site). Rainy season showed a high moisture percentage at 0-10 cm depth on all the study sites, ranging from 48.89 % (on north-west slope) to 38.90 % (on south-west site). In most of the observations other depths of soil (15-25 and 30-40 cm) also had high percentage of moisture as compared to winter and summer seasons.

Table 1. Physical properties of the soil of study site (Agrakhal-Kunjapuri area)

Site	Soil depth (cm)	Moisture (%)			WHC			Soil Texture (%)		
		W	S	R	W	S	R	Sand	Silt	Clay
SE	0-10	31.58	11.73	40.93	58.62	45.66	63.07	55.60	26.50	18.00
	15-25	24.48	24.22	33.78	43.16	38.72	57.26	56.76	22.42	20.82
	30-40	20.48	20.12	29.22	39.37	35.68	51.73	63.96	19.20	16.84
NW	0-10	30.44	18.34	48.89	56.28	50.14	66.64	51.50	24.00	24.50
	15-25	22.22	23.46	36.99	44.06	42.68	53.36	52.76	14.60	32.64
	30-40	19.05	20.48	28.62	38.42	39.03	49.01	55.97	18.40	25.63
N	0-10	36.99	16.28	42.86	55.86	42.93	64.12	49.03	23.42	27.55
	15-25	29.31	18.16	35.59	43.16	39.13	53.46	51.63	26.31	22.06
	30-40	26.58	14.29	27.39	38.14	36.44	50.19	58.78	14.32	26.90
NE	0-10	25.00	11.42	41.22	57.14	44.68	62.56	48.66	16.84	34.50
	15-25	22.95	17.65	30.48	44.28	38.12	56.74	56.03	19.80	24.17
	30-40	20.97	16.28	24.96	40.05	30.17	50.62	68.64	13.43	17.93
S	0-10	35.14	14.94	39.86	50.16	42.94	59.22	17.88	26.80	55.32
	15-25	33.93	15.98	36.16	42.00	38.78	52.38	16.32	27.45	56.23
	30-40	31.00	16.96	28.78	38.10	33.90	48.24	65.09	12.32	22.59
SW	0-10	36.99	10.19	38.90	54.66	40.56	61.72	52.99	26.40	20.61
	15-25	33.92	15.94	33.03	42.76	34.28	55.21	59.78	19.80	20.62
	30-40	30.15	13.31	22.99	38.62	31.19	51.02	70.76	12.47	16.77

Water Holding Capacity (WHC) of the soil decreased with increasing depth of soil and was recorded highest for rainy season as compared to other seasons. 15-25 cm and 30-40 cm depths of soil showed low percentage of water holding capacity as compared to 0-10 cm depth in soil the whole study area. At 0-10 cm depth, water holding capacity ranged from 50.16 (south site) to 58.62 % (south-east slope), from 42.00 (south) to 44.28 % (north-east site) at depth of 15-25 cm, and 38.10 (south) to 40.05 % (north-east slope) at 30-40 cm depth during winter season while for summer season the values ranged from 40.56 (south-west) to 50.14 % (north-west) at 0-10 cm depth, 34.28 (south-west) to 42.81 % (north-west) at 15-25 cm depth, and 30.17 (north-east) to 39.03 % (north-west) at 30-40 cm depth. During rainy season, the highest value of water holding capacity was recorded at 0-10 cm depth ranging from 59.22 to 66.64 % in comparison to 15-25 cm and 30-40 cm depths which showed 52.38 to 57.26 % and 48.25 to 51.73% values respectively. Thus water holding capacity decreases rainy to winter and to summer season (Table 2).The textural status of soil was clayey-loam type. The amounts of sand, silt and clay were recorded in different percentages at different depths and slopes.The sand was found with high value in comparison to silt and clay. The amount of sand increases with soil depths. At 0-10 cm depth, percentage of sand ranged from 48.66 to 55.60 %, silt 16.84 to 26.80 % and clay 17.88 to 34.50 %, at 15-25 cm depth sand from 51.63 to 59.78 %, silt 14.60 to 26.31 % and clay from 20.62 to 32.64 %, while 55.97 to 70.76 % sand, 12.32 to 19.20 % silt and 16.77 to 26.90 % clay were recorded at depth of 30-40 cm. The maximum percentage of sand content was found on south-west slope (70.76 %) at 30-40 cm depth while minimum on north-east site (48.66 %) at depth of 0-10 cm. The highest percentage of silt and clay were recorded on south slope (26.80 %) and north-east slope (34.50 %) at 0-10 cm depth, while lowest on south slope (12.32 %) and south-west slope (16.77 %) at 30-40 cm soil depth respectively. All the soils up to the depth of 40 cm are black to light brown in colour.

Chemical Characteristics: of the soil

The chemical characteristics of the soils of each study site are compiled in Table 3. The soils of all the study sites and depths were acidic in nature due to the presence of high composition of organic matter. Organic carbon was observed maximum in the upper layer (0-10 cm) of all the sites but it

Table 2. Chemical properties of the soil of study site (Agrakhal-Kunjapuri)

Site	Season	Soil depth (cm)	pH	Orga. Carb. (%)	Tot. Nitro. (%)	C:N	Av. P (%)	Exchan. Cations		
								Ca (m.e.%)	K (m.e.%)	Na (m.e.%)
SE	Winter	0-10	6.0	3.86	0.42	9.19	0.024	0.42	0.18	0.04
	Winter	15-25	5.9	3.46	0.28	12.36	0.020	0.40	0.14	0.03
	Winter	30-40	6.8	2.72	0.20	13.60	0.008	0.28	0.08	0.03
SE	Summer	0-10	5.8	3.72	0.43	8.65	0.022	0.40	0.16	0.05
	Summer	15-25	6.0	3.62	0.36	10.06	0.018	0.40	0.14	0.04
	Summer	30-40	7.0	2.72	0.24	11.33	0.006	0.26	0.08	0.02
SE	Rainy	0-10	6.0	3.84	0.46	8.35	0.020	0.40	0.14	0.05
	Rainy	15-25	5.4	4.10	0.56	7.32	0.018	0.48	0.18	0.06
	Rainy	30-40	6.7	3.04	0.42	7.24	0.016	0.32	0.10	0.04
NW	Winter	0-10	6.6	2.70	0.24	11.25	0.020	0.42	0.24	0.07
	Winter	15-25	6.7	2.40	0.20	12.00	0.012	0.36	0.18	0.07
	Winter	30-40	7.2	2.10	0.14	15.00	0.006	0.24	0.12	0.02
NW	Summer	0-10	6.4	2.68	0.24	11.17	0.020	0.40	0.24	0.06
	Summer	15-25	6.8	2.40	0.20	12.00	0.012	0.42	0.18	0.07
	Summer	30-40	7.0	2.10	0.12	17.50	0.008	0.24	0.14	0.04
NW	Rainy	0-10	6.2	2.40	0.22	10.90	0.020	0.36	0.20	0.08
	Rainy	15-25	6.0	2.98	0.22	13.55	0.020	0.54	0.24	0.06
	Rainy	30-40	6.6	2.30	0.16	14.38	0.014	0.32	0.20	0.04
N	Winter	0-10	6.2	2.61	0.23	11.35	0.017	0.44	0.18	0.06
	Winter	15-25	5.8	2.02	0.20	10.10	0.008	0.36	0.16	0.05
	Winter	30-40	6.6	1.45	0.16	09.06	0.006	0.26	0.12	0.05
N	Summer	0-10	6.2	2.47	0.22	11.23	0.017	0.44	0.16	0.05
	Summer	15-25	5.6	2.10	0.20	10.50	0.007	0.46	0.16	0.06
	Summer	30-40	6.7	1.60	0.14	11.43	0.007	0.36	0.12	0.05
N	Rainy	0-10	6.8	2.40	0.20	12.00	0.014	0.42	0.16	0.06
	Rainy	15-25	5.4	2.87	0.22	13.05	0.014	0.48	0.18	0.07
	Rainy	30-40	6.2	2.06	0.18	11.44	0.008	0.40	0.16	0.06
NE	Winter	0-10	6.4	2.98	0.26	11.46	0.018	0.44	0.20	0.05
	Winter	15-25	6.2	2.46	0.20	12.30	0.012	0.36	0.16	0.05
	Winter	30-40	6.8	1.48	0.10	14.80	0.006	0.32	0.14	0.02
NE	Summer	0-10	6.3	2.98	0.26	11.46	0.016	0.42	0.20	0.05
	Summer	15-25	6.3	2.45	0.18	11.61	0.014	0.36	0.16	0.04
	Summer	30-40	6.8	1.60	0.11	14.55	0.010	0.23	0.14	0.03
NE	Rainy	0-10	6.0	3.40	0.20	17.00	0.016	0.36	0.16	0.04
	Rainy	15-25	6.1	3.20	0.24	13.33	0.016	0.40	0.18	0.05
	Rainy	30-40	6.6	2.10	0.12	17.50	0.008	0.32	0.16	0.04
S	Winter	0-10	5.8	4.72	0.51	9.26	0.018	0.46	0.20	0.07
	Winter	15-25	6.2	3.86	0.43	8.98	0.010	0.36	0.18	0.05
	Winter	30-40	6.8	2.10	0.21	10.00	0.008	0.24	0.12	0.02
S	Summer	0-10	5.8	4.80	0.45	10.67	0.018	0.42	0.20	0.07
	Summer	15-25	6.0	4.16	0.45	9.24	0.012	0.34	0.16	0.06
	Summer	30-40	6.8	2.66	0.18	14.78	0.008	0.24	0.12	0.04
S	Rainy	0-10	6.0	4.36	0.36	12.11	0.016	0.40	0.22	0.06
	Rainy	15-25	5.6	4.20	0.52	8.08	0.014	0.42	0.42	0.07
	Rainy	30-40	6.2	2.98	0.39	7.64	0.010	0.40	0.24	0.05
SW	Winter	0-10	6.1	4.26	0.54	7.89	0.018	0.46	0.18	0.06
	Winter	15-25	6.0	3.84	0.52	7.38	0.016	0.42	0.16	0.04

	Winter	30-40	7.2	3.20	0.22	14.55	0.006	0.12	0.16	0.04
SW	Summer	0-10	6.0	4.14	0.52	7.96	0.016	0.42	0.18	0.04
	Summer	15-25	6.2	4.00	0.43	9.30	0.016	0.48	0.14	0.02
	Summer	30-40	7.0	3.20	0.18	17.78	0.004	0.12	0.12	0.02
SW	Rainy	0-10	5.8	4.20	0.46	9.13	0.016	0.38	0.18	0.08
	Rainy	15-25	5.8	4.10	0.42	9.76	0.020	0.42	0.16	0.08
	Rainy	30-40	6.6	3.06	0.22	13.91	0.010	0.26	0.16	0.02

decreased with increasing soil depths. In most of the study sites, the percentage of organic carbon was recorded highest during rainy season (2.66 to 4.46 %) in comparison to other seasons i.e. winter and summer throughout the study area except south site where maximum percentage of organic carbon was recorded in summer (4.80 % at 0-10 cm depth) and winter (4.72 % at 0-10 cm depth) seasons. The minimum value of organic carbon was found on north site during winter season at 30-40 cm depth (1.45 %). pH value of soil was recorded low as well as variable for each season, depths and sites ranging from 5.8 to 7.2. During winter season, pH value ranged from 5.8 to 7.2 and in summer from 5.6 to 7.0 while during rainy from 5.4 to 6.7 at different depths. The maximum pH of soil was observed during winter (7.2 at 30-40 cm depth on north-west and south-west slopes) while minimum was recorded during rainy season (5.4 at 15-25 cm depth on south-east and north sites). These results may be attributed to the presence of predominant amount of absorbed hydrogen ions, metallic cations and organic matter.

The amount of total nitrogen content was found to be high at 0-10 cm depth level in most of the seasons and sites (Table 2). The percentage of nitrogen varies from 0.10 to 0.54 % during winter, 0.11 to 0.52 % in summer, and from 0.12 to 0.56 % in rainy season. The percentage of nitrogen content was reduced with increasing depths of soil which was due to the presence of high percentage of dead and decaying organic matter on upper surface of soil. The ratios of carbon to nitrogen were found very high for all seasons. The maximum C/N ratios were 15.00, 17.78 and 17.50 for winter, summer, and rainy seasons respectively, while minimum values for these seasons were 7.38, 7.96 and 7.24. The available amount of phosphorus decreased with increasing depths for all the sites and seasons except south-west slope where soil depth of 15-25 cm had more percentage (0.020 %) of phosphorus than for 0-10 cm depth (0.016 %) during rainy season. The highest amount of phosphorus was found during winter (0.006 to 0.024 %) in comparison to summer (0.004 to 0.022 %) and rainy seasons (0.008 to 0.020 %), but in the latter season each soil below the depth 0-10cm showed highest percentage of phosphorus in comparison to other seasons. The highest average value of phosphorus was recorded for south-east site (0.017 %) in all the seasons. The exchangeable quantities of calcium, potassium and sodium varied with the level of the depth (Table 2). Calcium was recorded higher for soil depth of 15-25 cm (0.54 % on north-west, 0.48 % on south-east site during rainy and 0.48 % for south-west site in summer) in comparison to 0-10 cm and 30-40 cm depths whereas percentage of calcium ranged from 0.42 to 0.46, 0.40 to 0.44 and 0.36 to 0.42 % (at 0-10 cm soil depth), and 0.12 to 0.32, 0.12 to 0.36 and 0.26 to 0.40 % (at 30-40 cm soil depth) for winter, summer and rainy seasons respectively. The average amount of calcium was recorded highest for north (0.40 %) followed by south-west slope (0.34 %). Similarly other exchangeable cations i.e. potassium and sodium were recorded highest for the rainy season as compared to winter and summer. Sodium had very less amount. For potassium the values varied from 0.08 to 0.24 % in winter and summer, and 0.10 to 0.42 % during rainy, while percentage values of sodium ranged from 0.02 to 0.07 % for winter and summer and 0.02 to 0.08 % in rainy season for different depths and sites. Thus approximately cations present in the exchange complex of the soils show higher values during rainy season. The soils of road side and near villages have suffered a great loss through the road construction, heavy footed buffaloes and horses. Mining in rocks of the south-east facing slope (forest site near the road) also promoted the soil erosion of the study area.

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