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Variation in Soil Physico-Chemical Properties in Temperate Forests of Khatling Valley, Western Himalaya, India

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Abstract: The current study seeks to understand the physico-chemical properties of soil along different altitude in Khatling valley of Western Himalaya. Four sites were examined for different physico-chemical characteristics between 1500-3500m amsl. The investigation found that the soils at all of the study sites were acidic and had a sandy loam texture. The range of the water holding capacity and moisture content values across the research area was 35.59±4.22 to 38.91±3.97% and 14.77±0.12 to 17.39±1.13% respectively. In the studied area the values for total nitrogen ranged from 0.19±0.02 to 0.37±0.04%, available phosphorus (10.23±2.45 to 15.97±2.63kg ha-1), available potassium (122.95±17.58 to 212.90±19.67kg ha-1), organic carbon (0.92±0.35 to 3.09±0.63%) and organic matter (1.58±0.60 to 5.32±1.09%) respectively. Organic carbon and total nitrogen displayed a positive correlation with altitude ($r = 0.992$ and $r = 0.865$, respectively) but a negative correlation with soil depth. In contrast, there was a negative association between altitude and the amounts of available phosphorus ($r = -0.941$) and potassium ($r = -0.941$). The available phosphorus indicates a positive relation with the depth of soil, whereas available potassium did not exhibit a consistent pattern with depth. This finding of this study suggest that soil physico-chemical properties vary with altitude and soil depth.

Keywords: Altitude • Khatling valley • Physico-chemical properties • Soil sample • Soil analysis

Introduction

Soil is one of the complex and dynamic natural deposits that consists of abiotic (solid, liquid, gaseous) and biotic components (microorganisms). The solid components are minerals and organic compounds while water constitutes the liquid. The growth of the plants and plant community is impossible without soil. Hence, this is an essential factor for any community dependent on soil, whether directly or indirectly. Nature and composition of soil vary considerably with geological formations, aspects, degree of slope, climate and vegetation (Paudel and Sah 2003; Sheikh and Kumar 2010, Rawat et al. 2021). Climate and geology can primarily explain soil chemical variations (Fujii et al., 2018). However, terrain, soil composition, and stand traits are the main determinants of the regional variation in SOC, N, and P. (Jiang et al., 2017). Calcification, loamification, and acidification support the depth-dependent gradients in soil's physical and chemical features, which account for the majority of soil characteristics (Goebes et al., 2019). Since Uttarakhand is a hilly area, there are significant differences in the species composition, atmospheric and geographical condition, as well as rapid changes in these factors over short distances (Joshi et al 2013, Joshi and Negi 2015, Tewari et al. 2016).

Variability in the soil's structure and composition within a landscape is what affects how different plant species grow and flourish. Understanding the characteristics of the soil is crucial for developing and managing forest ecosystems and for growing crops because it helps us to understand the reproductive process, rate of growth, organization, and structure of the growing stock. As per the literature survey, no work has been undertaken in Khatling valley so far. Hence, the study was intended to investigate the physico-chemical characteristic of the soil along the altitudinal gradient.

Materials and methods

Study area

The Khatling valley is situated in Uttarakhand, western Himalaya, India. Geographically, it lies at 30º19'53"N to 30º51'38"N latitude and 78º29´11"" E to 79º01'53" E longitude. Due to the uneven landscape the altitude varies from 600 m.asl (Tehri) to 6000 m.asl (Khatling). The watershed's northern and northeastern regions feature over 70° steep slopes, whereas the valley bottoms and lower areas have mild slopes of less than 15° (Table1).

Pinus roxburghii, *Quercus leucotrichophora*, *Rhododendron arboreum*, *Lyonia ovalifolia*, *Quercus semecarpifolia* were the dominant tree of this region. Based on altitude four forest sites were selected and classified as S1, S2, S3, S4 (Table 1). The majority of soil had a sandy texture, and an acidic pH. The entire year is distributed into three main seasons: summer, rainy and winter while spring and autumn are transitional seasons. In January and February, snowfall occurs.

Table 1: Description of the selected sites in Khatling valley, Tehri, Uttarakhand

S.No	Sites	Altitude (m)	Latitude	Longitude	Aspect
1	S1	1500-2000	30°31′19.13″N	78°44′40.02″E	NE
2	S2	2000-2500	30°35′34.30″N	78°49′22.03″E	NE
3	S3	2500-3000	30°40′62.7″N	78°51′13″E	NE
4	S4	3000-3500	30°41′24.65″N	78°50′806″E	SE

**N=North, SE=South West*

Methodology

Each location, designated as S1, S2, S3, and S4, the sample were collected from different depths: 0–10 cm, 11–20 cm, and 21–30 cm. Five samples of each depth were mixed together and randomly selected from various locations within each site to create the composite soil samples. The samples were taken to the lab for additional analysis after being carefully wrapped in plastic bags with field notes. Physical characteristics were examined in the laboratory of the Department of Botany and Microbiology, Garhwal University, Srinagar (Garhwal) whereas chemical properties were examined in the Regional Soil Testing Laboratory, Srinagar Garhwal (Government of Uttarakhand), India.

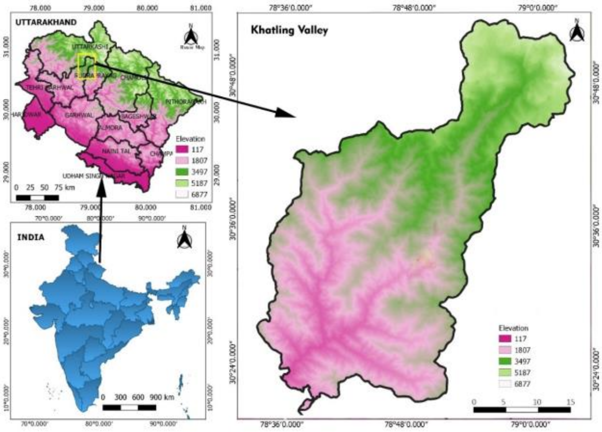

Figure 1: Map of the study area

Table 2. Physical properties of soil

Site	Soil Layer	Hue	Value/ Chroma	Colour	Moisture %	WHC %	Sand %	Silt %	Clay %	Textural class
S1	Upper	7.5 YR	4/4	Brown	16.08	36.60	63.24	31.01	5.75	Sandy loam
	Middle				18.01	38.99	64.09	29.30	6.61	
	Lower				18.07	36.73	64.38	29.22	6.40	
	Mean± SD				**17.39± 1.13**	**37.44± 1.34**	**63.90± 0.59**	**29.84± 1.01**	**6.25±0.45**	
S2	Upper	7.5 YR	4/6	Strong Brown	14.54	37.57	57.17	36.97	5.86	Sandy loam
	Middle				15.72	33.05	57.38	35.94	6.68	
	Lower				14.77	38.77	57.31	36.59	6.10	
	Mean± SD				**15.01± 0.62**	**36.46± 3.02**	**57.29± 0.11**	**36.50± 0.52**	**6.21±0.42**	
S3	Upper	7.5 YR	3/3	Dark Brown	14.77	38.95	56.60	35.72	7.68	Sandy loam
	Middle				14.54	34.92	56.42	35.63	7.95	
	Lower				15.17	42.85	57.38	35.22	7.40	
	Mean± SD				**14.83± 0.32**	**38.91± 3.97**	**56.80± 0.51**	**35.52± 0.26**	**7.68±0.27**	
S4	Upper	7.5 YR	¾	Dark Brown	14.80	32.76	54.60	36.72	8.68	Sandy loam
	Middle				14.87	33.58	55.76	35.96	8.28	
	Lower				14.63	40.44	56.38	36.56	7.07	
	Mean± SD				**14.77± 0.12**	**35.59± 4.22**	**55.58± 0.90**	**36.41± 0.40**	**8.01±0.84**	

Abbreviations: *WHC=Water Holding Capacity*

Soil Chemical properties

Sites	Soil depth	Soil Layer	pH	OC %	SOM %	N %	P kg ha-1	K kg ha-1
S1	0-10	Upper	5.07	1.27	2.19	0.21	13.27	231.2
	10-20	Middle	5.2	0.91	1.57	0.18	16.12	215.4
	20-30	Lower	5.5	0.57	0.98	0.17	18.53	192.1
		Mean±SD	**5.26±0.22**	**0.92±0.35**	**1.58±0.60**	**0.19±0.02**	**15.97±2.63**	**212.90±198.67**
S2	0-10	Upper	5.17	2.46	4.24	0.31	10.5	171
	10-20	Middle	5.27	1.79	3.09	0.24	13.2	180.9
	20-30	Lower	5.4	1.07	1.84	0.16	15.4	205.5
		Mean±SD	**5.28±0.12**	**1.77±0.70**	**3.06±1.19**	**0.24±0.07**	**13.03±2.45**	**185.80±17.76**
S3	0-10	Upper	5.11	3.06	5.28	0.33	9.7	196.37
	10-20	Middle	5.23	2.61	4.5	0.24	12.5	173.15
	20-30	Lower	5.38	1.89	3.26	0.19	15.3	147.8
		Mean±SD	**5.24±0.14**	**2.52±0.59**	**4.34±1.02**	**0.25±0.07**	**12.50±2.80**	**172.44±24.29**
S4	0-10	Upper	4.97	3.74	6.45	0.41	7.9	104.64
	10-20	Middle	5.14	3.04	5.24	0.37	10	124.5
	20-30	Lower	5.47	2.48	4.28	0.34	12.8	139.7
		Mean±SD	**5.19±0.26**	**3.09±0.63**	**5.32±1.09**	**0.37±0.04**	**10.23±2.45**	**122.95±17.58**

Abbreviations: *OC= Organic carbon, SOM= Soil organic matter, N=Nitrogen, P= Phosphorus, K= Potassium*

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Physical properties

The soil texture was determined following Pandeya et al., (1968) while the USDA textural triangle was utilized to recognized the classes of texture. The Munsell soil colour chart was used to identify the soil's colour. Miller and Donahue (1990) were followed to calculate the percentage of moisture in soil, while Misra (1968) was followed to calculate the soil samples' ability to hold water.

Chemical properties

The soil pH was analyzed by a digital pH meter and rapid titration method of Walkley (1947) was utilized to determine the percentage of organic carbon available in the soils. Utilizing the organic carbon (%) factor of 1.724, the soil organic matter (%) were computed. The available phosphorus was calculated following Olsen et al., (1954). The Ammonium Acetate Method of Morwin and Peach (1951), was followed to extract the potassium and then final estimation was done with the help of flame photometer. The Kjeldhal technique by Bremner and Mulvaney's (1983) was followed for total nitrogen estimation.

Results

The soil samples analyzed in this investigation had the hue of 7.5 YR, value between 3 and 4, and chroma between 3 and 6. All of the study sites had sandy loam soils as their predominant texture. The colour ranged from brown to dark brown. The values for water holding capacity and moisture content ranged from 35.59±4.22 to 38.91±3.97 % and 14.77±0.12 to 17.39±1.13 % respectively. The soils were of acidic nature for all the sites. The values for total nitrogen ranged from (0.19±0.02 to 0.37±0.04 %), available phosphorus (10.23±2.45 to 15.97±2.63 kg ha^{-1}), available potassium (122.95±17.58 to 212.90±19.67 kg ha^{-1}), organic carbon (0.92±0.35 to 3.09±0.63 %) and organic matter (1.58±0.60 to 5.32±1.09 %) across the study sites.

Organic carbon and total nitrogen displayed a positive correlation with altitude (r = 0.992 and r = 0.865, respectively) but a negative correlation with soil depth. In contrast, there was a negative association between altitude and the amounts of accessible phosphorus (r = -0.941) and potassium (r = -0.941). Available phosphorus demonstrated a positive correlation with soil depth, however available potassium did not exhibit a consistent association with depth.

Discussion

In the present study, the sandy loam textural class of soils are in agreement to the findings of Sheikh and Kumar (2010) and Rawat *et al*. (2021) for some other temperate forests of Garhwal. Brown to dark brown of soil is also reported by Thakur and Bisht (2020) from Western Himalaya along an elevational gradient of 1900 to 3600m. Saha *et al*. (2018) and Rawat *et al*. (2021) have also revealed identical results from different temperate forests of Garhwal Himalaya.

The acidic nature of soils is in accordance to the Rawat et al., 2021 and Malik and Haq, 2022 reported from temperate forest of Upper Yamuna Forest Division in Uttarkashi and Kedarnath Wild Life Sanctuary (KWLS) of Western Himalaya. According to the previous studies by Thakur and Bisht (2020) and Rawat et al. (2021) the soil pH gradually decreased with the rise in altitude, the present findings have somewhat followed the similar trend. The mean values of water holding capacity and moisture content are within the range as noted by Sharma *et al*. (2010a and 2010b) respectively.

The results show a higher concentration of soil nutrients like total nitrogen and organic carbon in the top soils of the studied forests along the altitudes. This indicates with increasing soil depth in mountains, nutrient concentrations fall. It could be because decomposition of organic materials occurs in the uppermost layers of soils (Gupta and Sharma, 2009;

Gairola et al., 2012). The increase in available phosphorus along soil depths is in accordance to Tiwari *et al*. (2013). The mean values of available potassium are in agreement to the values noted by Sheikh and Kumar (2010) for the forests of Garhwal Himalaya.

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