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Soil properties along altitudinal gradient in Himalayan temperate forest of Garhwal region

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ABSTRACT

The aim of the present study was to analyse the soil properties in different seasons at varying altitudes. The study was carried out in Dhanaulti forest, falls under temperate region of Garhwal Himalaya in Uttarakhand State, India. Physical properties and chemical properties of the soil were estimated using all standard procedures. In the present study, sand particles were reported highest (77.21%) in rainy season followed by in summer (70.17%) and winter (63.15%) seasons. The silt and clay particles also followed similar trend as sand which reduced in order of rainy > summer > winter seasons. The water holding capacity of soil ranged from 62.13 to 67.70%. The majority of soils were dark brown to dark yellowish brown in colour, which is considered having higher potential of water holding capacity. The values of nitrogen ranged between 0.01 to 0.012% (upper altitude), 0.009 to 0.011% (middle altitude) and 0.007 to 0.011% (lower altitude). The effects of altitudes and seasons in nitrogen show significant variation. Potassium ranged between 102.29 and 206.22 kg ha^{-1}. The combined effect of season and soil-depth also showed significant variation in level of potassium. The soil organic carbon values were between 0.14 and 0.19% and pH values ranged between 6.33 and 6.75 which was slightly acidic in nature.

1. Introduction

Vegetation plays an important role in soil formation [6]. Plant tissues (from aboveground litter and belowground root detritus) are the main source of soil organic matter (SOM), which influences physico-chemical characteristics of soil such as pH, water holding capacity (WHC), texture and nutrient availability [13]. Forest soil influences the composition of forest stand, ground cover, rate of tree growth and other factors. Physico-chemical characteristics of forest soils vary in space and time due to variations in topography, climate, physical weathering processes, vegetation cover, microbial activities, and several other biotic and abiotic variables. The physical properties of soil were generally influenced by vegetation [25].

The growth of vegetation depends upon the nutrient supplying capability of the soil [12]. The selective absorption of nutrient elements by different tree species and their capacity to return them to the soil brings about changes in soil properties [30]. Concentration of elements in the soils is a good indicator of their availability to plants. Their presence in soil would give good information towards the knowledge of nutrient cycling and bio-chemical cycle in the soil–plant ecosystem [22].

Himalayan forests play an important role in tempering the inclemency of the climate, in cooling and purifying the atmosphere, in protecting the soil, in holding the hill slopes in position, and in buffering up huge reserves of soil nutrients. The Garhwal Himalaya has vast variations in the climate, topography, and soil conditions, which form a very complex ecosystem.

The present study was carried out in Dhanaulti area which is located in the Garhwal Hills and shows pure patches of *Cedrus deodara* with other associated species of *Quercus leucotrichophora*, *Pinus wallichiana*, *Cupressus torulosa* and *Rhododendron arboreum*. The studies on physico-chemical properties of soils of Garhwal Himalaya have been carried out by several workers [2,9,28]. But the studies on physico-chemical properties of soil in Dhanaulti forests in Garhwal Himalaya has so far not been reported by any worker with altitudinal gradients. Thus the hypothesis of the study was focused that: (i) Do physico-chemical properties of soil change with the altitudes? (ii) Do seasons change the physico-chemical properties of soil with increasing elevation? To test the hypothesis, the objectives selected for the study were: (i) To understand physico-chemical properties of soil along altitudinal gradient and, (ii) To understand the seasonal variation in physico-chemical properties of soil along altitudes.

2. Materials and methods

2.1. Study area

The study was carried out to analyse physico-chemical properties of soil at three different altitudes of woody tree species in forests near

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Dhanaulti in Garhwal Himalaya of Uttarakhand. Dhanaulti located in the Garhwal Hills between 30′ 45° N and 78′ 25° E. The place of work is about 2 hour's journey from capital city of Dehradun and is situated at an altitude of 2286 m. The forests have thick tree cover of *Cedrus deodara*, *Quercus leucotrichophora*, *Rhododendron arboreum*, *Pinus roxburghii* etc. The Moist *Cedrus deodar* forest (Type –12/C_1C; Champion and Seth, 1968) is found between altitudes of 1750–2150 m a.s.l. *Cedrus deodara* is mainly observed in pure patches, while few scattered individuals of other associated species such as *Quercus leucotrichophora*, *Pinus wallichiana*, *Cupressus torulosa* and *Rhododendron arboreum* are also found.

Three sites (Fig. 1: Location map) selected for the study on the basis of altitude were categorized as upper, middle and lower (Table 1). The soils of this region vary according to aspect, altitude and climate, and are generally young and thin. Due to sharp variation in geoecological conditions, the soils of this region do not form a complete group. Soils of Dhanaulti area belong to mollisols and of Satengal to inceptisols. All these polypedons are members of fine sandy loam, mixed, messic family. These soils developed from different parent materials are in equilibrium with geogenic factors. All pedogenic processes are active in the study area. The soils are generally acidic in nature with pH increasing with depth. The climatic data of the study area is given in Fig. 2. The temperature in this area is cool throughout the year. The summer months are cool. The winters are not very freezing but provide a misty view of distant mountains. The summer temperature ranges from 31 °C to 7.5 °C while the winter temperature ranges from 7 °C to 1 °C.

Table 1
Details of the study area.

Location	Altitude	Geographic's	Elevation (m a.s.l)	Aspect
Dhanaulti	Upper	N30°24′434″ E078°17′894″	2350	North west
	Middle	N30°25′209″ E078°17′867″	2200	North west
	Lower	N30°25′336″ E078°17′811″	2050	North

2.2. Methodology adopted

2.2.1. Soil sampling

For the nutrient analysis of soil at three different altitudes, soil samples were collected seasonally i.e., winter, summer and rainy. In each season at each altitude three (3) soil samples, each for three depths i.e., 0–10, 10–20 and 20–30 were collected. Therefore, in each site a total of nine (9) soil samples were collected. Thus, at three different altitudes a total of 27 samples were collected seasonally and a period of three seasons in a year, a total of 81 samples of soil were collected for the study (Table 2).

Soil texture (%) of sand, silt and clay was determined by the proportion of soil particles using sieves of different particle size. The water holding capacity (WHC) of soil was calculated using 20 g of air dry soil from each sample, placed in crucible and weighed, after knowing the weight of crucible + soil, the samples were placed in water for 24 h to absorb the moisture. The samples were again weighed and water holding capacity was calculated using following formula:

$$\text{Water holding capacity } (\%) = \frac{W_2 - W_3 - W_4}{W_3 - W_1} \times 100$$

where, W_1 = weight of crucible; W_2 = weight of crucible + saturated soil; W_3 = weight of crucible + soil; W_4 = amount of water retained by fitter paper. Soil colour of collected soil samples was assessed using Munsell soil colour chart.

Soil pH was estimated using soil water ratio of 1:2.5 ratio and further, pH of soil was determined directly with the help of control dynamic digital pH meter. Soil organic carbon was estimated using rapid titration methods [33]. Nitrogen (N), phosphorus (P) and potassium (K) were analysed at Central Soil and Water Conservation Research and Training Institute (CSWCRTI), Dehradun, India. Available phosphorus was determined using method of Olsen et al. [20]. Potassium was

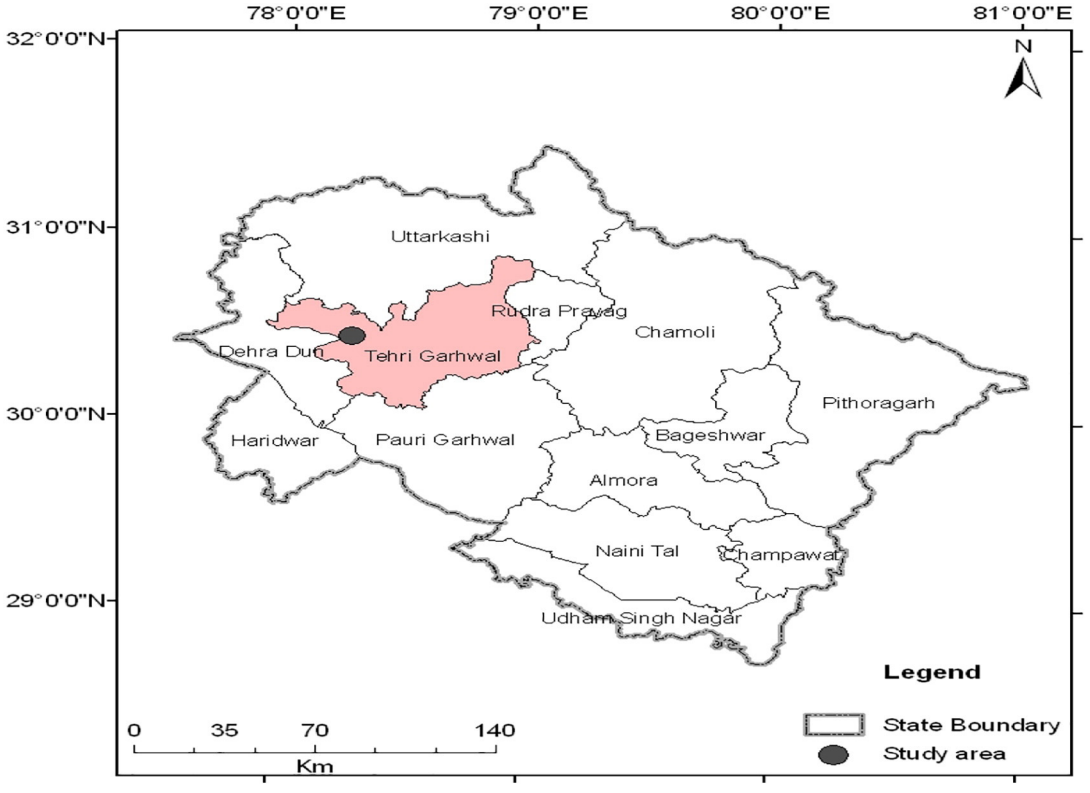

Fig. 1. Location map of the study area in Uttarakhand.