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Characteristics of soil: physical and chemical propertiesIn Different Sites at Rudraprayag district Garhwal (Uttarakhand), India.

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Abstract:

This study deals with the soiltemperature, humidity, rainfall, soil moisture, temperature, water holding capacity, pH, organic carbon, Phosphorus, Nitrogen, and Potassium.of the different sites i.e., Badhani, Bhanaj, Kakda-kund, Khaliyan and Kot of Rudraprayag, District, Garhwal Himalaya. In depth 0-10cm, Kakda-kund and Kot show highest temperature (16.0ºC). In depth, 11-20 cm Kot shows maximum temperature (15.3ºC). Highest temperature recorded in the depth of 21-30cm from Kot (14.0ºC). The highest soil moisture recorded from Khaliyan (28.0%) lowest from Badhani and Bhanaj (16.9%) in the depth of 21-30cm.The highest water holding capacity recorded from Kot (79.2%) and lowest from Bhanaj (42.9%) in the depth of 21-30cm. The maximum amount of clay in the depth of 0-10cm recorded from Khaliyan (39.0%) whereas Kakda-kund (21.3%) in the depth of 21-30cm. The highest amount of sand in the depth of 0-10cm recorded from Kakda-kund (39.0%) whereas minimum from Khaliyan (15.9%) in the depth of 11-20cm. Highest silt recorded in the depth of 21-30cm from Khaliyan (48.9%) and lowest fromKot (32.0%) in the depth of 0-10cm. In the depth of 0-10cm, Badhani and Kot,Kakda-kund (11-20 and 21-30 cm) show the maximum pH (7.2) and minimum Kot and Badhani (21-30 cm).In the depth of 0-10cm, Kakda-kund show highest organic carbon (714 kg ha^{-1}) and lowest from Kot (494 kg ha^{-1}) in the depth of 21-30cm. The highest Phosphorus recorded from Badhani and Kot (21.80 kg ha^{-1}) and lowest from Bhanaj (15.30 kg ha^{-1}) in the depth of 21-30cm. In the depth of 0-10cm, Khaliyan,Kakda-kund (11-20 cm), and Bhanaj(11-20 cm)contributed highest Nitrogen content (0.78kg ha^{-1}) and minimum (0.38 kg ha^{-1}) for Kot (11-20 cm) Badhani (21-30 cm).The highest Potassium recorded from Khaliyan (227.20 kg ha^{-1}) in the depth of 0-10cm and lowest from Kakda-kund(100.80 kg ha^{-1}) in the depth of 11-20cm.

[J. P. Mehta*, Subodh Kumar and KusumPharswan**Characteristics of soil: physical and chemical properties In Different Sites at Rudraprayag district Garhwal (Uttarakhand), India.]**

Key Words: Garhwal Himalaya, soil temperature, humidity, rainfall, soil moisture, temperature, water holding capacity, pH, organic carbon, Phosphorus, Nitrogen, and Potassium.

1. Introduction

Organisms in soil live in their own environment, which, undergo biological manifestations (Saksena, 1967). The word soil comes from the Latin word "solum," which literally translates to "ground." Soil is the upper most layer of earth in which "plants grow, a black or dark brown material typically consisting of a mixture of organic remains, clay, and rock particles. The nature of the soil is one of the most important factors in determining the heavy metal content of food plants (Heath and Gifford, 2002). A plant is a living organism (a kind that includes trees, shrubs, herbs, grasses, sedges, ferns, and mosses) that usually grows in a permanent site, where it absorbs water and various inorganic substances by using its roots. The plant synthesizes the nutrients in the water and substances it has absorbed through a process called photosynthesis. Different scientist according to their specialized field describes this as non-water surface of the earth. The vegetation influences the physical and chemical properties of soil to a great extant. Vegetation has a pronounced effect on many soil properties (Banerjee et al., 1985 and Miles, 1985).

The vegetation improves the soil structure, infiltration rate, water holding capacity, hydraulic conductivity and aeration (Iiorkar and Toley, 2001). Soil also greatly influences the productivity of agro-ecosystems. The recent teaching of some pedologists present soil as a "continually changing medium, which is a function of the geological substratum, environmental influences and activity of organism" (Stebutt, 1930) A soil is a good material for the roots for nourishment and support the whole plants and ground cover vegetation. The effect of textural properties of soil frequently reflected in the composition and the rate of survival for the any vegetation. Concentration of elements in the soil is a good indicator of their availability to plants. Their presence in the soil would well information towards the knowledge nutrient cycling and bio-chemical cycle in the soil-plant ecosystem (Pandit and Thampon, 1988). Change in nutrient cycling processes that arise due to change in a flora may reflect alternation in the soil microbial community related to the differences in the quantities and qualities of inputs to the soil by different plants species (Grieson and Adams, 2000). Nutrient dynamics may also become altered as a result of change in the physical properties of the soil cause by introduction of new plants species (Kelly et al., 1998 and Ehrenfeld. 2001).Soil also play an important role in the global carbon budget and green house effects (Jha et al., 2003). Soil generally becomes thicker and better developed with age, relative degree of soil development is a useful mean of differentiating deposits and geomorphic surfaces of various age, especially when variation in the other factors are minimal (Birkeland,1999).

Forest in general have a greater influence on soil conditions that most of other plant ecosystem types, due to a well developed 'O' horizon, moderating temperature and humidity at the soil surface, input of litter with high lignin content, high total net primary production and high water and nutrient demand (Binkley and Giardina, 1998). Moreover, different tree species can differ significantly in their influence on soil properties as well as soil fertility (Augusto et al., 2002).

Himalayan forest 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 big reserves of soil nutrients. The Garhwal Himalaya has diverse vegetation ranging from sub-montane to alpine zones. There are vast variations in the climate, topography and soil conditions in the region, which form a very complex ecosystem. Soil resources in Uttarakhand varies from the deep, alluvial and fertile soils of the Tarai tract to the recently laid down alluvium of the dun valley; the thin fragile soil of the Siwalik hills; the black soils of the temperate zone; and the arid bare soil of the inner dry valleys. Soils in the valley bottom are more fertile than those found on the ridge top due to the presence of a large quantity of humus, mineral nutrients, moisture and suitable soil depth. This natural resource is depleting gradually, day by day, as soil erosion in the area is increasing with the increase in deforestation and degradation. Soil have tow types of properties like, physical (soil texture or mechanical composition, color, moisture contains, water holding capacity, temperature, bulk density and porosity) and chemical (soil pH, organic carbon contains, nitrogen contains, phosphorus contains and potassium contains).

2. Material and methods

The present investigation conducted in five sites viz., Badhani, Bhanaj, Kakda-kund, Khaliyan and Kot in Rudraprayag District, Garhwal Himalaya. Badhani, Khaliyan and Kot situated in Lastear gad valley in Jakholi, Bhanaj in Kyunja gad valley and Kakda-kund in left bank of river Mandakini, respectively. Badhani leis between 30°30'19.77"N-78°56'18.65"E (2,541-2,719m amsl) N-W aspect and 40-46° slope, Bhanaj 30°24'56.33"N-79°09'12.18"E (2,129-2,408m amsl) with N-E aspect and 41-44° slope, Kakda-kund 30°30'11.63"N-79°05'17.24"E (968-1,027m amsl) with W-S aspect and 29-32° slope, Khaliyan 30°28'03.93"N-78°55'50.31"E (1,829-2,045m amsl) with E-S aspect and 37-41° slope and Kot between 30°30'00.78"N-78°55'34.20"E (2,094-2,205m amsl) with E-S aspect and 35-43° slope, respectively. Mandakini is the main watershed of the district covers the area 1, 68,049 hectare including 5 sub- watersheds and 40 micro-watersheds (www.uttara.com).

The dominant plants species of the study sites are *Quercusleucotrichophora, Acer acuminatum,Skimmiaanquetillia,Urticadioica, U. ardens,Boenninghauseniaalbiflora, Hoya longifolia,Galiumacutum, G. asperifolium, G. aparine,Stellariamonosperma,Taraxacumofficinale,Ischaemumrugosum,Eriophorumcomosum,Arundodonax,Actinidi acallosa,Abruspricatorius,Cynodondactylon,Codonopsisrotundifoia, Clematis barbellata, Rosa brunonii,Thamnocalamusfalconeri, T. spethiflora*and*Sinarundineria falcate*.

The nature and type of soil vary with topography and climate of the district. Mostly the soil is clay loam and sandy loam mixed with pebbles. Soil in the area is course texture well drained and acidic with pH level verging between 4-5.5 (Sundriyal, 1992). The soil of the district is Brown forest soil, red to dark, black clay type. Physical and chemical properties of the forest soil in study area described in chapter 3 in detail.

The climate of the area largely varies depending on elevation, altitude and latitudinal variation, direction of the mountains, forest, slopes, rainfall and temperature. The northern, northwestern, northeastern and western part of the district is perennially under snow cover; here the climate is sub-arctic type as the area represented by lofty Himalayan Range. Severe winter and comparatively higher rainfall are the characteristic features of the northern part. The year may be divided into four seasons viz., the cold winter season, (December to February), the hot weather season (March to May), southwest monsoon season (June to September) followed by post monsoon season (October to November).

As the elevation of the district ranges from 800-8000 m above mean sea level the climate of the region very largely depend on altitude. The winter season is from about mid November to March. As most of the region situated on the Southern slopes of the outer Himalayas, monsoon currents can enter through the valley, the rainfall being heaviest in the monsoon form June to September. It is a well-known fact that the increase in altitude is directly proportional to the temperature decrease. Accordingly there is a decrease of 0.55ºC for every temperature recorded at the meteorological 100 m rise in elevation if the slope and aspect remain regular and uniform (Kharakwal, 1993). January is the coldest month after which the temperature begins to rise till June-July. Temperatures vary with elevation. During the winter, cold waves in the wake of western disturbances may cause temperature to fall appreciably. Snow accumulation in valleys is considerable.The related humidity is high during monsoon season, generally exceeding 70% on the average. The driest part of the year is the pre monsoon period when the humidity may drop to 35 during the afternoon, during the winter months humidity increases towards the afternoon at certain high stations (Kumar, 2010)**.** Larger part of the district is situated on the southern slopes of the outer Himalayas, monsoon currents can penetrate through trenched valleys, the rainfall reaches its maximal in the monsoon season that spans betweens June to September. Rainfall, spatially, is highly variable depending upon the altitude. In the Lesser Himalayan Zone, (1000-3000m amsl) maximum rainfall occurs about 70% to 80% in southern half. August is the rainiest month. Rainfall rapidly decreases after September and it is the least in November. About 55 to 65% rainfall

occurs in the northern half in Central Himalayan Zone (Kumar, 2010). About 17% of the annual precipitation occurs in winter season. In the southern part of the district at Rudraprayag the average annual rainfall is around 1220.18 mm while in the central part at Chandrapuri the average annual rainfall is 1750.9 mm and the rainfall in the northern part at Okhimath is 1995 mm. The overall average rainfall in the district is 1485 mm. Month wise district rainfall and departure of rainfall (in %) from 2007 to 2011 are given in table 1.5. The composite soil sample (5 samples from each site viz., four samples from corner and one from the centre) were collected from different sites in triplicate at different depth of the soil profile like upper , middle and lower (0-10cm,11-20cm and 21-30cm depth) to estimating the physical and chemical properties of the soil. Spade and khurpi used for soft moist soil while in case of hard and dry soil screw type apparatus like kudal used. Grass, leaf litter, foliage were removed from ground surface. All the samples air-dried and analyzed simultaneously. All fives soil samples collected, mix with each other, and kept into a clean polythene bag with the suitable description and identification.

Soil temperature regulates the seed germination, sprouting, and root growth. Soil temperature resulting from the solar radiation changes with the depth and time of the day (Donahue et al., 1987). The moisture contain of the soil samples were calculated as per following slandered method given by (Mishra, 1968). The composite soil samples were determined as sand, silt and clay by sieve method as suggested by Mishra, (1968). The water holding capacity (WHC) of the soil samples determined by the methods as describes by Mishra (1968). The colour of the soil determined with the help of Munsellcolour chart in the terms of Hue, value and chroma characteristics. The chemical properties of the composite and air-dried soil samples are given as following- The soil pH was determined by Electronic method (Misra, 1968) Organic carbon percentage in soil was determined following Piper, (1944). The amount of phosphorus was calculated was using regression equation (Jackson, 1958). Total Nitrogen in the soil was determined following the procedure of Jackson, (1958).The the amount of potassium was calculated using regression equation (Jackson, 1958).

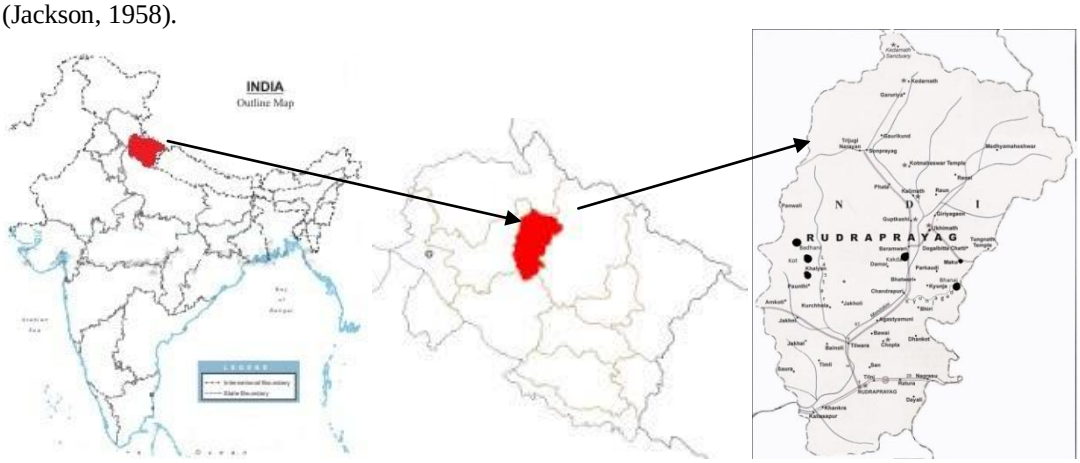


Figure 1.1 Location map of study area**3. Results**

On the basis of collection and laboratory analysis, the soil from different depth and sites in Rudraprayag district show following physical (Table-3.1) and chemical properties (Table- 3.2).

Soil Physical Characteristics: In depth 0-10cm, Kakda-kund and Kotshow highest temperature (16.0ºC) and Bhanaj show lowest (12.0ºC). In depth, 11-20 cm Kot shows maximum temperature (15.3ºC) and minimum for Bhanaj (11.5ºC). Highest temperature recorded in the depth of 21-30cm from Kot (14.0ºC) and lowest from Bhanaj (11.0ºC). The highest soil moisture recorded from Khaliyan (28.0%) and lowest from Bhanaj (19.0%) in the depth of 0-10cm. In the depth of 11-20cm the highest soil moisture recorded from Khaliyan (26.9%) and lowest from Bhanaj (18.8%).The highest soil moisture recorded from Khaliyan (23.5%) and lowest from Badhani and Bhanaj (16.9%) in the depth of 21-30cm. The highest water holding capacity recorded from Kot (79.2%) and lowest from Badhani (65.2%) in the depth of 0-10cm.In the depth of 11-20cm the highest WHC recorded from Kot (71.8%) and lowest from Bhanaj 51.8%).The highest WHC recorded from Kot (63.7%) and lowest from Bhanaj (42.9%) in the depth of 21-30cm. The maximum amount of clay in the depth of 0-10cm recorded from Khaliyan (39.0%) whereas minimum from Kakda-kund (27.0%). In the depth of 11-20cm Khaliyan show maximum (36.9%) and minimum for Kakda-kund (25.6%). Highest clay recorded in the depth of 21-30cm from Khaliyan (34.8%) and lowest from Kakda-kund (21.3%).

The highest amount of sand in the depth of 0-10cm recorded from Kakda-kund (39.0%) whereas minimum from Khaliyan (17.0%). In the depth of 11-20cm Kakda-kund show maximum (36.5%) and minimum for Khaliyan (15.9%). Highest sand recorded in the depth of 21-30cm from Kakda-kund (37.3%) and lowest from Khaliyan (16.3%).

The maximum amount of silt in the depth of 0-10cm recorded from Badhani (43.0%) whereas minimum from Kot (32.0%). In the depth of 11-20cm Badhani show maximum (47.6%) and minimum for Kot (35.4%). Highest silt recorded in the depth of 21-30cm from Khaliyan (48.9%) and lowest from Kot (35.3%). Soil of the study sites characterized by loam predominating sand/silt. Soil colour varied yellowish brown (10 YR 5/4) to dark brown (10 YR 5/3). Badhani (Yellow brown to brown), Bhanaj (Brown to dark brown), Kakda-kund (Dark brown), Khaliyan (Gray brown to dark brown) and Kot show that the brown to dark brown soil.

Soil Chemical characteristics: In the depth of 0-10cm, Badhani and Kot show the maximum (7.2) pH and minimum (7.1) from Bhanaj, Kakda-kund and Khaliyan. In the depth of 11-20cm Kakda-kund represented the maximum pH (7.2) and minimum for Kot (6.3). Highest pH were recorded in the depth of 21-30cm from Kakda-kund (7.2) and lowest from Badhani (6.3). In the depth of 0-10cm, Kakda-kund show highest organic carbon (714 kg ha^{-1}) and Kot contributed lowest (504 kgha^{-1})In the depth of 11-20 cm Kakda-kund, show maximum organic carbon (703 kg ha^{-1}) and minimum for Kot (498 kg ha^{-1}). Highest organic carbon recorded in the depth of 21-30cm from Kakda-kund (699 kg ha^{-1}) and lowest from Kot (494 kg ha^{-1}). The highest amount of Phosphorus recorded from Bhanaj, Kakda-kund and Khaliyan (21.60 kg ha^{-1}) and lowest from Badhani (19.30 kg ha^{-1}) in the depth of 0-10cm. In the depth of 11-20cm the highest Phosphorus recorded from Kakda-kund (21.60 kg ha^{-1}) and lowest from Bhanaj (17.10 kg ha^{-1}).The highest Phosphorus recorded from Badhani and Kot (21.80 kg ha^{-1}) and lowest from Bhanaj (15.30 kg ha^{-1}) in the depth of 21-30cm. In the depth of 0-10cm, Khaliyan sites contributed highest Nitrogen content (0.78kg ha^{-1}) and Kakda-kund show lowest (0.52 kg ha^{-1}). In the depth of 11-20 cm, Kakda-kund and Bhanaj represented maximum Nitrogen contents (0.78 kg ha^{-1}) and minimum for Kot (0.38 kg ha^{-1}). Highest Nitrogen content recorded in the depth of 21-30cm from Kakda-kund (0.65 kg ha^{-1}) and lowest from Badhani and Kot (0.38 kg ha^{-1}). The highest amount of Potassium recorded from Badhani (210.30 kg ha^{-1}) and lowest from Bhanaj (119.80 kg ha^{-1}) in the depth of 0-10cm. From the depth of 11-20cm the highest Potassium recorded from Khaliyan (223.20 kg ha^{-1}) and lowest from Kakda-kund (100.80 kg ha^{-1}). The highest Potassium recorded from Khaliyan (227.20 kg ha^{-1}) and lowest from Kakda-kund (120.70 kg ha^{-1}) in the depth of 0-10cm.

3. Discussion

Soil gives a reliable and close relationship between the geomorphology and the vegetation types of the area. It serves a basic growth medium for a useful for development of the plants species in the nature. Physical and chemical properties of the soil influenced by the canopy cover and litter cover. Under favorable conditions, organic material decomposed by the microorganism and progressively merged into the minerals of soil through mineralization and humiliation. Soil temperature depends on the amount of heat reaching the soil surface and dissipation of heat in the soil. Temperature within a site ranges between11.6-13.0ºC (Badhani), 11.0-12.0ºC (Bhanaj), 13.5-16.0ºC (Kakda-kund), 13.8-15.0ºC (Khaliyan) and 14.0-16.0ºC (Kot) whereas across the sites, it ranges 11.0 (Bhanaj) - 16.0ºC (Kakda-kund and Kot). Nautiyal, (1996) recorded the soil temperature range 5.80-9.90ºC in Panwalikantha, Garhwal Himalaya. Soil moisture ranges between 16.9-21.0% (Badhani), 16.9-19.0% (Bhanaj), 21.6-24.0% (Kakda-kund), 23.5-28.0% (Khaliyan) and 20.0-23.0% (Kot) whereas across the sites, it ranges 16.9-28.0%, respectively for Badhani and Khaliyan. Joshi, (1988) reported the soil moisture in Panwalikantha range 65-84%. The similar values of moisture % were also reported by Dhaulakhandi, (1996) conducted soil moisture range 19.8-36.9% from Oak forest of Bhagirathi valley in Garhwal Himalaya. Raturi, (2002) reported the soil moisture range 11.0-31.0% in different forest types of Rudraprayag District, Garhwal Himalaya. Water holding capacity of soil is directly governed by the soil texture. The water retention and transmission properties vary according to soil texture (Kumar et al., 2002). Water holding capacity of the soil decreased with increasing depth of the soil. The soil water holding capacity (WHC) within a site ranges between 42.9-65.2% (Badhani), 53.3-69.3% (Bhanaj), 51.9-73.1% (Kakda-kund), 55.5-70.2% (Khaliyan) and 63.7-79.2% (Kot), whereas, across the sites, it ranges from 42.9 (Badhani)-79.2% (Kot). Raturi, (2002) reported the value for water holding capacity range 65.0-70.0% in different forest types of Rudraprayag District, GarhwalHimalaya.The soil texture is an important factor for water holding capacity. It indicates how well a particular texture of soil holds the water. In soil texture, clay within a site ranges between 32.1-38.0% (Badhani), 28.9-33.0% (Bhanaj), 21.3-27.0% (Kakda-kund), 34.8-39.0% (Khaliyan) and 27.8-31.0% (Kot), whereas, across the sites, it ranges 21.3 (Kakda-kund)-39.0% (Khaliyan). Sand within a site ranges between 19.0-20.3% (Badhani), 25.9-28.0% (Bhanaj), 36.5-39.0% (Kakda-kund), 15.9-17.0% (Khaliyan) and 35.3-37.0% (Kot), whereas, across the sites, it ranges 15.9 (Khaliyan) -39.0% (Kakda-kund). Silt within a site ranges between 43.0-47.6% (Badhani), 39.0-45.2% (Bhanaj), 34.0-41.3% (Kakda-kund), 41.4-48.9% (Khaliyan) and 32.0-35.4% (Kot), whereas, across the sites, it ranges 32.0 (Kot)-48.9% (Khaliyan). Joshi, (1988) reported the soil texture range 17.68-38.47% (sand), 18.25-43.15% (silt) and 21.75-37.35% (clay) in Panwalikantha in TehariGarhwal. Dhaulakhandi, (1996) conducted soil texture range 21.05-52.10% (sand), 23.4-45.0% (silt) and 21.0-39.5% (clay) from Oak forest of Bhagirathi valley in Garhwal Himalaya. Semwal et

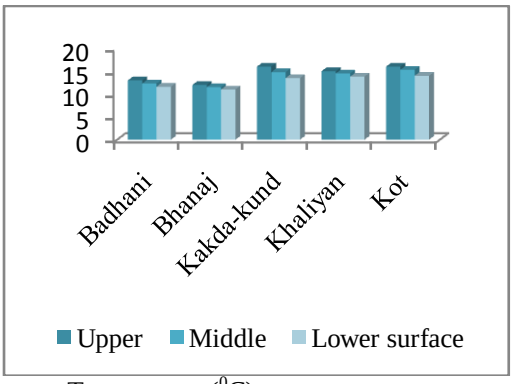
al., (2009) reported the soil texture ranges from 22.20-29.80% (sand), 33.65-52.68% (silt) and 25.26-36.50% (clay) in different forest types of the Rudraprayag, Garhwal Himalaya. Raina and Gupta, (2013) show the range 61.50-64.25% (sand), 18.11-20.77% (silt) and 19.78-17.73% (clay) in different forest types in Garhwal Himalaya. The colour of soils is a function of a number of factors viz., forest type, weathering of different types of mineral bearing rocks, nature of litter decomposition and by other environmental factors. The colour of soil is a reliable indicator of soil properties. Darker colours usually indicate higher organic matter contains. The soil colour varied yellowish brown (10 YR 5/4) to dark brown (7.5 YR 5/6) in the present study. The soil colour was in under present study is comparable to other Himalayan forest studied by Rawat and Singh, (1988), Singh and Singh, (1992), Semwal, (1996) and Raturi, (2002). A fertile soil generally has a pH range between 5.5 and 7.2, which makes the essential elements and nutrients available to the flora. In chemical properties of the soil in the present study, pH within a site ranges from 6.3-7.1 (Badhani), 7.0-7.2 (Bhanaj), 7.1-7.2(Kakda-kund), 6.8-7.1 (Khaliyan) and 6.3-7.2 (Kot), whereas, across the sites, it ranges 6.3 (Badhani and Kot)-7.2 (Bhanaj, Kakda-kund and Kot). The findings of the present study agreement with the studies made by Singh and Singh, (1992) show the pH range 4.0-6.1 for different forest types of Himalaya. Dhaulakhandi, (1996) conducted pH value range 6.1-6.5 from Oak forest of Bhagirathi valley in Garhwal Himalaya. Semwal, (1996) also reported a pH range 4.1-6.1. Raturi, (2002) reported pH range 5.9-6.1 for different forest types of Rudraprayag District, Garhwal Himalaya. Kiran, (2003) observed that the pH range 6.7-6.9 in Mandakini basin. Naithani, (2004) studied the range of pH 6.8-7.2 in Laster gad valley. Raina and Gupta, (2013) show the range 6.1-6.9 for different forest types in Garhwal Himalaya. Organic carbon within a site ranges 541.0-559.0 kg ha^{-1}. (Badhani), 593.0-602.0 kg ha^{-1}.(Bhanaj), 699.0-714.0 kg ha^{-1}.(Kakda-kund), 623.0-631.0 kg ha^{-1}.(Khaliyan) and 494.0-504.0 kg ha^{-1}.(Kot), whereas, across the sites, it ranges from 494.0 (Kot)-714.0 kg ha^{-1}.(Kakda-kund).Dhaulakhandi, (1996) reported the range of 1.60-4.80% from Oak forest of Bhagirathi valley in Garhwal Himalaya. Kiran, (2003) observed that the range 0.41-0.61% in Mandakini basin. Naithani, (2004) studied the range 6.3-8.3% in Laster gad valley. Sharma et al., (2009) also reported range 0.05-0.6% in Garhwal Himalaya. Bahuguna et al., (2012) reported that the carbon range 0.21-0.55% in Kedarnath Wild Life Sanctuary (KWLS) in Rudraprayag District, Garhwal Himalaya. Phosphorus is inevitable for the vital growth processes in plants. It is observed that P is found in all terrestrial systems in the form of organic and inorganic matter, while organic P forms are the major available source of phosphorus. Phosphorus within a site ranges 19.3-21.8 kg ha^{-1}. (Badhani), 15.3-21.6 kg ha^{-1}.(Bhanaj), 20.7-21.6kg ha^{-1}.(Kakda-kund), 19.8-21.6 kg ha^{-1}.(Khaliyan) and 20.2-21.8 kg ha^{-1}.(Kot), whereas, across the sites, it ranges 15.3 (Bhanaj)-21.8 kg ha^{-1}.(Kot).Raturi, (2002) reported phosphorus range 12.28-15.93 kg ha^{-1}. for different forest types of Rudraprayag District, Garhwal Himalaya. Kiran, (2003) observed that the phosphorus range 18.9-24.3 kg ha^{-1}. inMandakini basin. Semwal et al., (2009) reported the phosphorus range 0.19-0.92 % in different forest types of the Rudraprayag, Garhwal Himalaya. Nitrogen is most essential element for all growth process in plants. Nitrogen is an important nutrient within a limit, for plant growth, especially in cold regions. Microorganisms play an important role in N cycle. The major source of soil nitrogen is from organic materials. The release of nitrogen from organic matter decomposition is a major source of usable nitrogen (Donahue et al., 1987). Nitrogen within a site ranges 0.4-0.7 kg ha^{-1}. (Badhani), 0.4-0.8 kg ha^{-1}.(Bhanaj), 0.5-0.8 kg ha^{-1}.(Kakda-kund), 0.4-0.8 kg ha^{-1}.(Khaliyan) and 0.4-0.8 kg ha^{-1}. (Kot), whereas, across the sites, it ranges 0.4 (Bhanaj, Kakda-kund, Khaliyan and Kot)-0.8 kg ha^{-1}. (Badhani, Bhanaj, Khaliyan and Kot). Joshi, (1988) reported the nitrogen in Panwalikantha range 0.2-1.0 kg ha^{-1}. Dhaulakhandi, (1996) reported nitrogen range 0.09-0.23% from Oak forest of Bhagirathi valley in Garhwal Himalaya. Kumar, (1997) recorded range 0.2-0.4 kg ha^{-1}. in Temperate Himalayan forest in TehariGarhwal. Raturi, (2002) reported the value for nitrogen range 0.12-0.21 % in different forest types of Rudraprayag District, Garhwal Himalaya. The mineral potassium is an important factor for the growth of vegetation (Gairola et al., 2009). Potassium within a site ranges 210.3-222.6 kg ha^{-1}. (Badhani), 119.8-121.6 kg ha^{-1}.(Bhanaj), 100.8-125.4 kg ha^{-1}.(Kakda-kund), 125.3-224.4 kg ha^{-1}.(Khaliyan) and 175.3-220.4 kg ha^{-1}.(Kot), whereas, across the sites, it ranges from 100.8 (Kakda-kund)-224.4 kg ha^{-1}.(Khaliyan).Dhaulakhandi, (1996) reported potassium range 0.007-0.025% from oak forest of Bhagirathi valley in Garhwal Himalaya. Raturi, (2002) reported the value for nitrogen range 166.0-184.0 kg ha^{-1}. in different forest types of Rudraprayag District, Garhwal Himalaya. Semwal et al., (2009) reported the potassium range 1.55-2.86% in different forest types of the Rudraprayag, Garhwal Himalaya. Sharma et al., (2009) also reported range 210.4-214.7 kg ha^{-1}. inGarhwal Himalaya.

Table-3.1-Physical properties of the soil in different study sites

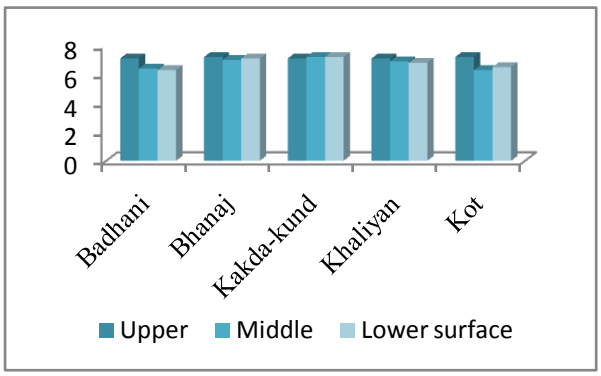
S. No.	Sites	Soil depth (cm)	Soil temperature (°C)	Moisture %	Water holding capacity (WHC) in %	Texture in %			Soil color
						Clay	Sand	Silt	
1.	BADHANI	0-10	13.0	21.0	65.2	38.0	19.0	43.0	Yellow brown to brown
		11-20	12.3	19.3	51.8	32.1	20.3	47.6	
		21-30	11.6	16.9	42.9	33.5	19.1	47.4	
2.	BHANAJ	0-10	12.0	19.0	69.3	33.0	28.0	39.0	Brown to dark brown
		11-20	11.5	18.8	60.8	30.2	26.3	43.5	
		21-30	11.0	16.9	53.3	28.9	25.9	45.2	
3.	KAKDA - KUND	0-10	16.0	24.0	73.1	27.0	39.0	34.0	Dark brown
		11-20	14.8	23.1	60.8	25.6	36.5	37.9	
		21-30	13.5	21.6	51.9	21.3	37.3	41.3	
4.	KHALIYAN	0-10	15.0	28.0	70.2	39.0	17.0	41.4	Gray brown to dark brown
		11-20	14.5	26.9	63.5	36.9	15.9	47.2	
		21-30	13.8	23.5	55.5	34.8	16.3	48.9	
5.	KOT	0-10	16.0	23.0	79.2	31.0	37.0	32.0	Brown to dark brown
		11-20	15.3	21.8	71.8	29.3	35.3	35.4	
		21-30	14.0	20.0	63.7	27.8	36.9	35.3	

Table-3.2- Chemical properties of soil in different study site.

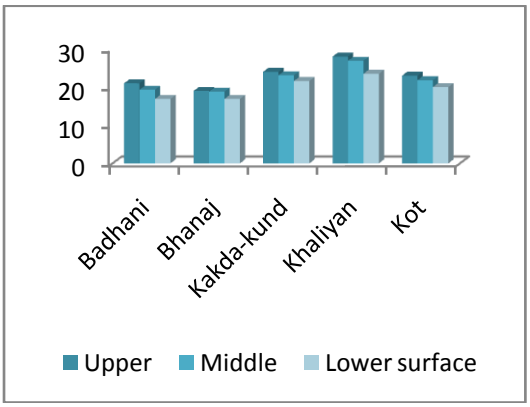
S. No.	Sites	Soil depth (cm)	Soil pH	Organic carbon kg ha^{-1}	Phosphorus kg ha^{-1}	Nitrogen kg ha^{-1}	Potassium kg ha^{-1}
1.	BADHANI	0-10	7.1	559.0	19.3	0.7	210.3
		11-20	6.4	548.0	21.3	0.4	222.6
		21-30	6.3	541.0	21.8	0.4	212.9
2.	BHANAJ	0-10	7.2	602.0	21.6	0.7	119.8
		11-20	7.0	597.0	17.1	0.8	121.6
		21-30	7.1	593.0	15.3	0.4	119.8
3.	KAKDA - KUND	0-10	7.1	714.0	21.6	0.5	125.4
		11-20	7.2	703.0	21.6	0.8	100.8
		21-30	7.2	699.0	20.7	0.7	100.8
4.	KHALIYAN	0-10	7.1	631.0	21.6	0.8	125.3
		11-20	6.9	628.0	19.8	0.4	224.2
		21-30	6.8	623.0	19.8	0.4	224.4
5.	KOT BANGAR	0-10	7.2	504.0	20.2	0.8	175.3
		11-20	6.3	498.0	21.1	0.4	210.4
		21-30	6.5	494.0	21.8	0.4	220.4



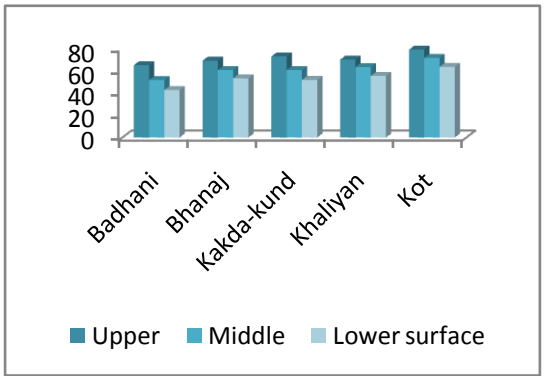
Temperature (^{0}C)



pH

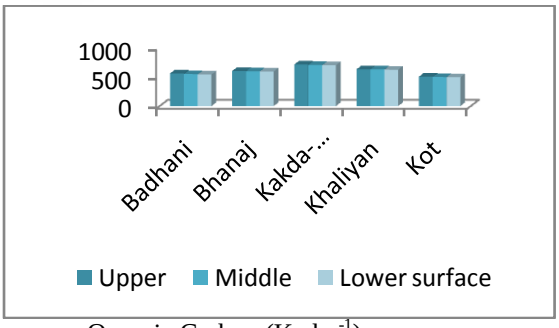


Moisture (%)

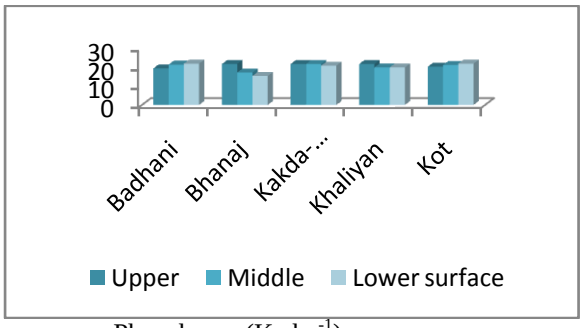


Percent Water Holding Capacity (WHC)

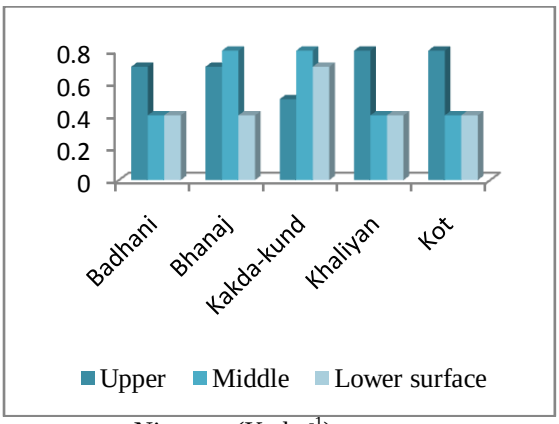
Fig. 3.1. Physical properties of soil in different surfaces at all study sites.



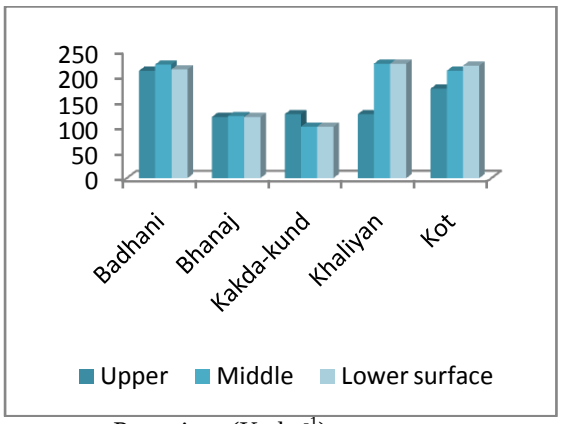
Organic Carbon (Kg ha^{-1})



Phosphorus (Kg ha^{-1})



Nitrogen (Kg ha^{-1})



Potassium (Kg ha^{-1})

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