EFFECT OF BIOTIC DISTURBANCE ON SOIL CHARACTERISTICS OF A MIXED- OAK FOREST IN KUMAUN HIMALAYA

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Abstract : A study was conducted in mixed oak forest zone of Nainital catchment (Uttarakhand) in the Kumaun Himalaya for determining the impact of biotic disturbance on physical and chemical characteristics of soil. Three sites viz. undisturbed, moderately disturbed and highly disturbed were selected in a mixed oak forest and each site was further divided into three sub sites; Hill Base, Hill Slope and Hill Top. The findings indicated that there was more accumulation of nutrients in the undisturbed site as compared to moderately and highly disturbed sites. Sand particle was maximum in highly disturbed site and minimum in undisturbed site while, silt and clay showed a reverse trend. Maximum organic carbon (2.19%) was observed in surface soil (0-10 cm) at hill top of undisturbed forest and minimum (1.01%) in deep soil (20-30 cm) at hill base of highly disturbed site. Maximum nitrogen (0.36%) and organic matter content (3.78%) was observed in undisturbed forest as compared to moderately and highly disturbed sites. Results of present study indicated that there is an urgent need of value addition protection, forestation and environmental awareness programme for local people so that forests, particularly in degraded or disturbed forest area, can be saved.

Keywords : Disturbance, Oak forest, Kumaun Himalaya, Soil characteristics, Soil nutrients.

INTRODUCTION

Physico-chemical characteristics of forest soils vary in space and time due to variation in topography, climate, weathering processes, vegetation cover, microbial activities and several other biotic and abiotic factors (Paudel and Sah, 2003). It also appears that nature of the soil is largely a function of vegetation it supports. The vegetation influences the physical and chemical properties of soil in various ways; plant tissues (above and below ground litter) are the main source of soil organic matter, which influences the physico-chemical characteristics of soil such as, texture, water holding capacity, pH and nutrients availability (Johnston, 1986). It improves the soil structure, infiltration rate, water holding capacity, hydraulic conductivity and aeration (Ilorkar and Totey, 2001, Kumar et al., 2004). Moreover, vegetation forms the canopy over the earth surface and protects the soil from the direct impacts of rain drops, resulting into reduced soil erosion and increase in soil moisture.

The soil often contained and acts upon a much more extensive portion of the plant body than does the atmosphere. Moreover, vegetation has played a remarkable role in the formation of soil in which plants are anchored and from which they obtain their water and nutrients. Changes in nutrient cycling processes that arise due to change in a flora may reflect alteration in the soil microbial community related to the differences in the quantities and qualities of inputs to the soil by different species of plants (Grieson and Adams, 2000). Nutrient dynamics may also become altered as a result of change in the physical properties of the soil caused by introduction of new species (Kelly et al., 1998, Ehrenfeld, 2001). There is a variety of mechanism through which changes in the species composition of a community may alter nutrient cycling processes. (Hodge *et al*., 2000; Ehrenfeld, 2001). Forest disturbance can alter environmental conditions by changing light availability and soil conditions (Fredericksen and Mostacedo 2000).

The present investigation was undertaken to study the effect of biotic disturbance on soil characteristics at different depth in a mixed oak forest of Nainital, Kumaun Himalaya .

MATERIAL AND METHOD

Study Area : The investigations were undertaken in mountain zone (2,100 – 2,500 m asl) of district Nainital in the Kumaun Hiamlaya (Lat. 29°19'-30°49'N and long. 79°22'-79°38'E), during the period of 2008-2010. Geologically the study sites were located in the lesser Himalayan zone with complex mixture of sedimentary, low grade metamorphose and igneous rocks of Krol series (Valdiya 1980). A total of three sites, with varying levels of biotic disturbance were selected in mixed-oak forest viz. undisturbed, moderately disturbed and highly disturbed .Each site was further sub divided into three sub-sites according to position viz. Hill Base, Hill Slope and Hill Top. Climate of the study area was montane, temperate and monsoon type (Singh and Singh 1992). There are three main seasons: the winter (mid-December to mid -February); the summer (April to mid -June) and the rainy (mid-June to mid-September).The mean minimum temperature ranged from -2° C (January) to 16°C (October) and mean maximum temperature varied from 15° C (November) to 30° C (May). The annual rainfall was 2195 mm.

Soil Sampling and Analysis*:* Soil samples were randomly collected from each selected site from three depths i.e. 0-10 cm (surface layer), 10-20 cm (middle layer) and 20-30 cm (deeper layer) with the help of a soil corer. Soil samples were brought to the

laboratory and dried in shade. Coarse materials including stones and piece of roots, leaves and other plant parts were removed manually. Soil samples were analyzed for particle size distribution (texture) and other physical and chemical characteristics. Fresh samples were weighed, dried in an oven at 80^{o}C till constant weight. The weight of fresh soil and oven dry weight of same soil sample was expressed as percentage of moisture content. Soil mechanical analysis was done to find out the percentage of different size particles, such as sand, silt and clay through sieve method as proposed by Misra (1968). Soil pH was determined in 1:5 soil solution ratio using pH meter (pH scan-2 electrode). Composite soil samples were used for chemical analysis. Nitrogen estimation was done by the Micro-Kjeldahl procedure (Misra, 1968). Organic carbon was determined following procedure described by Walkley and Black (1934).

RESULT

Soil texture: The soil had high proportion of silt and clay particles and low sand in undisturbed site as compared to moderately and highly disturbed site (Table 1). Across the positions, sand particles increased from base to top while silt and clay decreased.

Moisture content: In all the three sites the soil moisture content at three depths varied from 22.91 to 49.92% and values were always higher for undisturbed site and decreased towards highly disturbed site (Fig. 1). The minimum and maximum values of moisture content ranged between 31.5 and 50% in undisturbed, 35 and 37% in moderately disturbed and 23 and 34% in highly disturbed mixed oak forest, respectively.

Soil pH: The pH values of the soils were highly acidic (5.47to 5.86) for the undisturbed site as compared to moderately disturbed (5.54to 6.06) and highly disturbed site (6.20 to 6.37) possibly due to high humus content and low biotic stress (Table 2). Dimri, *et al* (1987) reported that high amount of humus in forest soils was responsible for low pH.

Table 1. Soil texture as affected by biotic disturbance and position in a mixed- oak forest.

Forest site	Position	Sand	Silt	Clay
Undisturbed	Hill Base	54.23±1.18	23.26±0.92	22.51±1.21
	Hill Slope	45.79±1.08	30.25±1.01	23.96±1.06
	Hill Top	56.28±1.27	22.23±2.01	21.48±0.43
Moderately disturbed	Hill Base	59.12±0.21	21.88±1.53	19.00±1.20
	Hill Slope	55.95±2.18	23.31±2.13	20.74±0.82
	Hill Top	61.15±2.72	19.93±0.45	18.92±0.63
Highly disturbed	Hill Base	65.82±1.17	20.20±0.46	13.98±0.35
	Hill Slope	58.67±1.08	21.49±1.34	19.84±0.85
	Hill Top	65.35±1.01	18.68±1.12	15.97±0.64

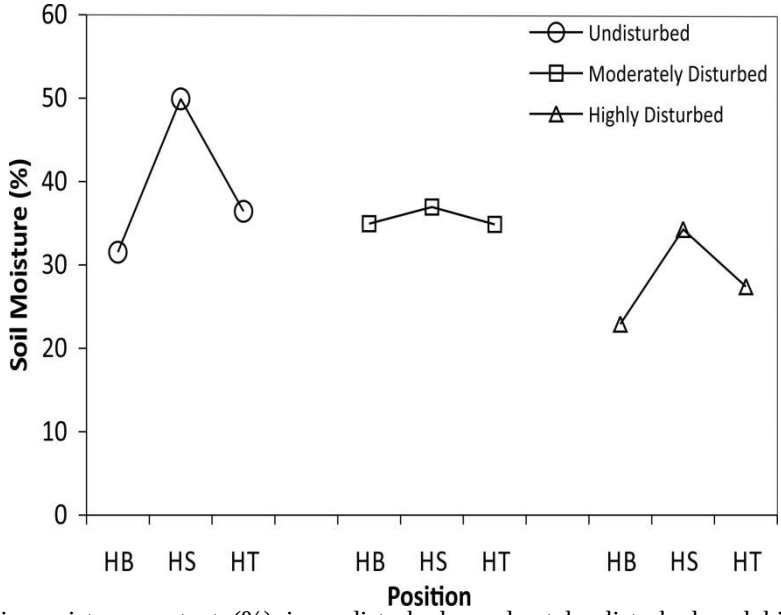

Fig. 1 Variations in moisture content (%) in undisturbed, moderately disturbed and highly disturbed site (position= HB-Hill Base; HS- Hill Slope and HT- Hill Top)

Organic Matter, Total nitrogen (N) and Total carbon (C): Variation in soil organic matter in undisturbed site was 3.1 to 3.8%, in moderately disturbed sites was 2.0 to 3.6% and in highly disturbed forest site was 1.7 to 2.7 % (Table 2). The total soil carbon in undisturbed site was 137.8 t ha^{-1}, while total nitrogen was 21.86 t ha^{-1}, in moderately disturbed site total carbon was 134.99 t ha^{-1}, while nitrogen was 20.64 t ha^{-1} and in highly disturbed site total carbon was 116.81tha^{-1}, while nitrogen was 16.92 tha^{-1} (Fig. 3). Among the three sites, undisturbed site had more carbon and nitrogen compared to the moderately disturbed site and highly disturbed site. ANOVA indicated significant difference between sites (df = 2, F = 4.652, $p < 0.05$).

Table 2. Chemical properties of soil as affected by biotic disturbance and position in a mixed- oak forest

Forest site	Position	pH	Carbon	Organic Matter	Nitrogen (%)	C:N Ratio
Undisturbed	Hill base	5.86	1.91	3.29	0.36	5.36
	Hill slope	5.47	1.88	3.25	0.28	6.81
	Hill top	5.69	2.10	3.63	0.32	7.49
Moderatly disturbed	Hill base	5.69	1.88	3.25	0.27	6.96
	Hill slope	5.54	1.54	2.65	0.24	6.48
	Hill top	6.06	1.40	2.42	0.22	6.26
Highly disturbed	Hill base	6.37	1.10	1.90	0.20	5.61
	Hill slope	6.20	1.20	2.07	0.18	6.80
	Hill top	6.28	1.41	2.44	0.17	8.51

C:N ratio: The C: N ratio was high in disturbed site and low in undisturbed site (Table 2). The high C:N ratio in disturbed forest may be due to slow release of nutrients.

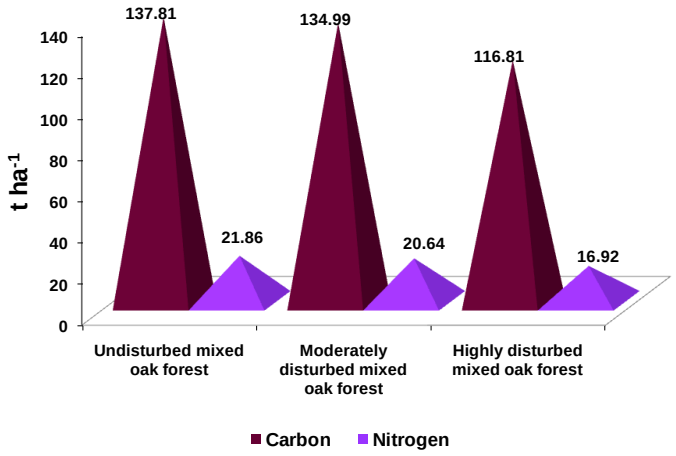

Fig. 2. Total soil Carbon and Nitrogen (t ha^{-1}) in different forest sites

DISCUSSION

Forest soils influence the composition of forest stand and ground cover, rate of tree growth, vigour of natural reproduction and other silviculturally important factors (Bhatnagar, 1968). By affecting moisture availability, nutrient supply or soil organic matter to microbial decomposition, soil texture may affect the productivity of the forest ecosystem (Schimel *et al.*, 1996). In the present study percentage of sand in soil was maximum (68.8%) in highly disturbed mixed oak forest and minimum (41.1%) in the undisturbed sites, while silt (36.1%) and clay (15.4%) was maximum in the undisturbed site and minimum in the highly disturbed sites. Across the sites, soil moisture was maximum in the undisturbed site (59.2%) and minimum in the highly disturbed site (21.3%). Saxena and Singh (1980) reported that oak forests were characteristically moist, fire free (Champion and Seth, 1968) and closed canopied with high water holding capacity (Saxena, 1979). Dense canopy of oak in undisturbed site produced the higher amount of litter which influenced the texture of soil and increase water retention capacity of the soil (Sheikh and Kumar 2010). The lopping and cutting of trees in highly

disturbed site resulted in open canopy with excessive loss of soil moisture. Bulk density was higher in the highly disturbed site possibly due to trampling effect as compared to undisturbed site, while porosity showed a reverse trend. The soil pH is known to influence the availability of plant nutrient and has been shown as a good indicator of forest soil fertility (Waring and Major 1964). In the present study soil pH ranged between 5.73 and 6.28. The acidic nature of soil is also reported by several other workers for oak dominated forests of Himalaya (Bhandari, *et al*., 2000; Dhanai, *et al.*, 2000; Kumar, *et al*., 2004). It was towards lower range (5.47 to 5.86) in undisturbed site and towards higher range (6.20 to 6.37) in highly disturbed site. Robertson and Vitousek (1981) and Adams and Sidle (1987) have also reported high soil pH in disturbed forest ecosystems. Soil organic matter (SOM) increased from highly disturbed site to undisturbed site. The higher soil organic matter in undisturbed site could be due to higher inputs and lower removal rate of litter which enriches SOM. The lower SOM in highly disturbed site is indicator of open canopy of trees which provide low inputs of leaf litter to the soil. Percent nitrogen also increased with increase in total organic matter. Singh and Singh (1991) have reported high organic matter in oak forests and stated that the nitrogen also increased with increase in organic matter.

The C:N ratio was high in disturbed site and low in undisturbed site. Singh and Singh (1991) and Sah (2007) also reported high C:N ratio in disturbed forest sites and suggested that high sand contents in soil may be one of the reasons for higher C:N ratio. Ulrich (1971) reported that the C:N ratio reflects the release of nitrogen in the soil through organic matter and indicates the rate of decomposition of organic matter in the forest soil. Kawahara and Tsutauni (1972) have reported that generally the soil of a forest stand attains the steady state when the C:N ratio reaches 10 and at this level release of nutrients is rapid due to mineralization.

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