Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

December 2017, Volume 30, Issue 2, Page 176-180

Soil Characteristics in the Disturbed and Undisturbed Plots of a Sal (*Shorea robusta*) Forest in the Shiwaliks of Indian Himalayan Region

Swanti Sharma[1*] • Kusum Arunachalam[1] • A. Arunachalam[2]

[1]School of Environment and Natural Resources, Doon University, Dehradun 248001, Uttarakhand
[2]Indian Council of Agricultural Research, Krishi Bhawan, New Delhi 110001

ARTICLE INFO

Article history:
Received 29 August 2016
Revision Received 15 February 2017
Accepted 8 June 2017

Key words:
Soil, Nutrient, Disturbance, Forests

ABSTRACT

In the Uttarakhand Shiwaliks, tropical moist forests dominate and amongst the dominant trees, *Shorea robusta* marks maximum abundance that governs the quality of soil in the region and enables net primary productivity. Sal tree has good leaf area to harness carbon from the atmosphere and accumulate in their biomass leading to carbon sequestration. Reportedly, litter fall rate is substantial to add much organic matter in to the soil through decomposition process. Eventually, the soils in the sal forests shall provide a good habitat for decomposing microorganisms that mineralize the nutrients and also helps in the accumulation of Soil organic carbon in a much more labile form. Understanding the soil properties following forest disturbances is important for developing strategies for the restoration and management of degraded lands. The present study was conducted in a sal forest at two soil depths (0-5 and 5-15 cm) in a disturbed and undisturbed plot. The results revealed disturbance resulted in considerable increase in air temperature and light intensity in the forest and decline in the soil nutrients concentration. Correlation revealed that soil moisture content was negatively correlated with clay content in the disturbed plot, whereas they were positively correlated with each other in the undisturbed site. Soil organic carbon and soil nitrogen content were positively correlated with each other in both the study sites.

1. Introduction

Forests constitute a key natural resource as well as a source of environmental services, and are considered valuable, because they provide a wide range of benefits to the society: products (timber, fuelwood, fodder, green manure, minor produce, medicines, *etc*.), ecosystem services (soil conservation, hydrological regulation, carbon sequestration, *etc*.) and repository of biodiversity (Ramachandra, 2007). Soil is a complex mixture of solids, water and gases. Soil is formed partially by the breakdown of rocks and minerals on the surface of the earth. The remainder of soil is composed of organic compounds from the decomposition of plants, animals, insects, bacteria, mold and fungi. Water and air are trapped in the spaces between soil particles. Because the components of soil can vary widely, soils are classified into large groups. Soils may not be the same even if they fall in the same general classification. The composition of the soil is location specific because physical and chemical factors vary between the locations. The makeup of a soil high in clay is totally different from the composition of a fine loam. Soil provides nutrients, anchorage, and water to plants. Forest soils influences the composition of forest stand, the ground cover, rate of tree growth, vigour of natural reproduction and other silviculturally important factors (Bhatnagar, 1968). Physico-chemical characteristics of forest soils vary in space and time because variation in topography, climate, weathering processes, vegetation cover, microbial activities (Paudel and Sah, 2003) and several other biotic and abiotic factors.

*Corresponding author: swati.sharma69@gmail.com

Nutrients supply varies widely among ecosystems (Binkly and Vitousek, 1989), resulting in differences in plant community structure and its production (Ruess and Innis, 1977). The nature of soil profile, pH and nutrient cycling between the soils and trees are the important dimensions to determine the site quality. The vegetation influences the physico-chemical properties of the soil to a great extent. It improves the soil structure, infiltration rate, hydraulic conductivity and aeration (Ilorkar and Totey, 2001; Kumar *et al.,* 2004). In the Uttarakhand Shiwaliks, tropical moist forests dominate and amongst the dominant trees, *Shorea robusta* marks maximum abundance at least in the lower ranges of the Shiwaliks. The Sal tree has good leaf area to harness the carbon from the atmosphere and accumulate in their biomass leading to carbon sequestration. Reportedly litter fall rate is substantial to add much organic matter in to the soil through decomposition process. Thus, the soils in the Sal forests shall provide a good habitat for decomposing microorganisms that mineralize the nutrients and also helps in the accumulation of Soil organic carbon in a much more labile form. Illicit felling of trees and lopping is one of the important anthropogenic disturbances in the forests of Uttarakhand Shiwaliks. Felling of trees creates gap in the forest canopy and alterations in the forest floor, resulting in the deterioration of nutrient status of soil. The changes in the properties of soil due to various disturbances has been studied by different researchers in the subtropical region of northeast India (Arunachalam *et al.*, a 1996, b 2000, c 2002). Thus, although, as will be seen, soil is extremely complex, an understanding of its physical characteristics and the chemistry occurring in it are important in its analysis and the instruments used in this analysis (Conklin, 2005).

The present study was conducted to analyze the physico-chemical properties of soil in a Tropical Moist forest of Lacchiwala Forest Reserve near Dehradun.

1.1 Study Sites

The study was carried out in Lacchiwala Forest Reserve at Dehradun (Uttarakhand). The study site is covered with unstratified and unasserted pebbles and boulders. The pebbles consist mostly of quartzite with appreciable mounds of krol limestone, the gravels at places are interbedded with silty clay bands. Soil consists of sandstones and conglomerates which are often soft and friable. Bands of clay are interbedded with these sandstones and conglomerates, giving cohesion to the soil and thereby improving its physical qualities. The area experiences tropical monsoon climate with three seasons in a year, *viz.* summer (April to mid June), rainy (mid June to September) and winter (November to February). The months of March and October constitute transition periods, respectively between winter and summer, and between rainy and winter seasons.

One disturbed N 30º 15’ 33.1”, E 78º 02’ 58.1”, 644.1 and one undisturbed N 30º 15’ 31.8”, E 78º 02’ 32”, 537.5 plot were selected for detailed study. The criterion for selection of plots as disturbed and undisturbed was based on the canopy cover and human interference. For instance, the disturbed site has experienced illicit felling and lopping for the past 10 years. There are habitation near forest. Forest floor is also lacking herbs, shrubs and tree saplings.

Table 1. Microclimate and soil (0-5 cm) physical characteristics of disturbed and undisturbed forest sites

Physical parameters	Disturbed Site	Undisturbed Site
Microclimate		
Air temperature (ºC)	31.24 ± 1.34	29.61 ± 1.24
Relative humidity (%)	57.17 ± 3.00	39.65 ± 1.75
Light intensity (Lux)	663 ± 3.15	369 ± 4.51
Rainfall (mm)	45.34 ± 1.60	42.68 ± 1.60
Soil properties		
Texture		
Sand (%)	69.67 ± 1.16	65.48 ± 0.24
Silt (%)	10.70 ± 0.80	14.00 ± 0.28
Clay (%)	19.51 ± 0.38	20.28 ± 0.08
Bulk density (g cm^{-3})	1.40 ± 0.02	1.25 ± 0.03
Water Holding Capacity (%)	45.77 ± 6.50	58. 88 ± 1.16
Moisture (%)	7.53 ± 1.15	12.3 ± 1.2

2. Material and Methods

2.1 Soil Sampling

Soil sampling was done both in the undisturbed and disturbed plots during March, April and May 2011, representing winter and summer seasons respectively. From each plots, soil samples were collected randomly from the depth of 0-5 cm and 5-15 cm using soil auger, after removing the litter layer on the ground and were mixed depth wise to obtain composite samples. The field moist soil was brought to the laboratory in the polythene bags. After removing stones, pebbles and large pieces of plant material, the samples were sieved by 2-mm mesh size sieve and tested for soil physico-chemical properties.

Soil texture was determined by Bouyouncos hydrometer method (Bouyouncos, 1962) and bulk density (Klute, 1988) by soil core method. Water holding capacity (WHC) was determined according to Keen's box method given in Piper (Piper, 1944), while soil moisture was determined gravimetrically by keeping 10 g of field moist soil in an hot air oven at 105 ºC for 48 hours. Soil pH and electrical conductivity were determined in a soil-water suspension (1:2.5 w/v H_2O) using a digital pH meter and E.C meter respectively. Soil organic carbon was determined by dichromate oxidation and titration with ferrous ammonium sulphate (Walkley and Black, 1934) and total organic carbon by dry combustion method. Total Kjeldahl nitrogen was estimated following semi-micro Kjeldahl procedure by acid-digestion, distillation and titration.

Table 2. Soil pH and nutrient concentration in disturbed and undisturbed forest stands

Parameters	**Month**	**Study sites/Soil depth (cm)**			
		Disturbed		**Undisturbed**	
		0-5 cm	**5-15 cm**	**0-5 cm**	**5-15 cm**
pH	March	6.81 ± 0.03	6.62 ± 0.13	6.79 ± 0.66	6.31 ± 0.26
	April	6.93 ± 0.05	6.6 ± 0.08	6.91 ± 0.01	6.15 ± 0.18
	May	7.22 ± 0.07	7.01 ± 0.04	6.98 ± 0.02	6.93 ± 0.00
E.C (µS/cm)	March	165.7 ± 9.75	175.3 ± 9.78	165.7 ± 9.75	172.2 ± 14.8
	April	156 ± 9.90	175 ± 9.82	149.5 ± 14.8	195 ± 42.4
	May	266.5 ± 14.8	204.8 ± 25.8	152.5 ± 25.7	132.9 ± 11.1
Organic Carbon (g/kg)	March	15.9 ± 1.19	8.11 ± 5.66	11.9 ± 3.88	10.8 ± 4.75
	April	18.7 ± 7.02	12.5 ± 6.85	15.3 ± 2.66	5.1 ± 2.52
	May	4.46 ± 0.35	4.10 ± 0.2	11.5 ± 0.25	7.6± 0.20
Total Nitrogen (g/kg)	March	0.32 ± 0.01	0.14 ± 0.02	0.44 ± 0.00	0.32 ± 0.00
	April	0.42 ± 0.01	0.21 ± 0.01	0.39 ± 0.02	0.02 ± 0.02
	May	0.52 ± 0.03	0.24 ± 0.00	0.97 ± 0.03	0.54 ± 0.00
Phosphate (µg/g)	March	0.17 ± 0.04	0.13 ± 0.07	0.07 ± 0.02	0.05 ± 0.01
	April	0.06 ± 0.00	0.02 ± 0.01	3.56 ± 0.13	0.07 ± 0.00
	May	11.7 ± 0.02	9.55 ± 0.02	13.0 ± 0.53	12.5 ± 0.02
Sodium (g/kg)	March	0.19 ± 0.03	0.15 ± 0.07	0.29 ± 0.07	0.23 ± 0.05
	April	0.12 ± 0.02	0.11 ± 0.02	0.14 ± 0.06	0.11 ± 0.01
	May	0.23 ± 0.03	0.21 ± 0.02	0.25 ± 0.03	0.20 ± 0.02
Potassium (g/kg)	March	1.14 ± 0.03	0.92 ± 0.22	1.28 ± 0.11	0.77 ± 0.09
	April	1.5 ± 0.30	1.3 ± 0.27	1.13 ± 0.10	0.87 ± 0.02
	May	5.98 ± 0.05	3.94 ± 0.07	0.96 ± 0.05	0.56 ± 0.07
Nitrate (g/kg)	March	0.14 ± 0.02	0.05 ± 0.00	0.12 ± 0.00	0.07 ± 0.00
	April	0.13 ± 0.00	0.08 ± 0.00	0.17 ± 0.00	0.09± 0.00
	May	0.09 ± 0.06	0.05 ± 0.00	0.02 ± 0.06	0.01 ± 0.00
Sulphate (mg/kg)	March	0.12 ± 0.04	0.11 ± 0.02	0.34 ± 0.12	0.33 ± 0.10
	April	0.16 ± 0.01	0.14 ± 0.05	0.69 ± 0.22	0.15 ± 0.05
	May	0.02 ± 0.00	0.01 ± 0.00	0.02 ± 0.00	0.01 ± 0.00
Calcium (g/kg)	March	0.10 ± 0.02	0.08 ± 0.00	0.10 ± 0.02	0.08 ± 0.00
	April	0.08 ± 0.1	0.05 ± 0.2	0.09 ± 0.1	0.05 ± 0.2
	May	0.11 ± 0.00	0.09 ± 0.00	0.11 ± 0.00	0.10 ± 0.00
Magnesium (g/kg)	March	0.13 ± 0.05	0.08 ± 0.01	0.14 ± 0.05	0.12 ± 0.01
	April	0.25 ± 0.2	0.22 ± 0.1	0.19 ± 0.2	0.15 ± 0.1
	May	0.41 ± 0.00	0.35 ± 0.01	0.43 ± 0.00	0.34 ± 0.01

Available and Exchangeable sodium and potassium was determined using flame photometer (Jackson, 1958). Calcium and Magnesium was determined by EDTA titration. Soil nitrate and sulphate content was determined using colorimetric method. One-way ANOVA was used to analyse the variation between soil properties of both the study sites, at two depths, during three months. Correlation test was applied to study the relationship between soil characteristics.

3. Results

In the undisturbed forest stand air temperature, relative humidity, light intensity and rainfall were lower than the disturbed sites (Table 1). Clay content, silt content, WHC and moisture content were greater in the undisturbed site, and declined along a disturbance gradient. Correlation revealed that soil moisture content was negatively correlated with clay content in the disturbed plot whereas they were positively correlated with each other in the undisturbed site. Soil organic carbon and soil nitrogen content were positively correlated with each other on both the study sites. Sand content was negatively correlated with silt content in both disturbed and undisturbed sites. However, sand content was negatively correlated with clay content in the disturbed site ($r = -.940$; $P < 0.01$, $n = 18$) and was positively correlated with clay content in the undisturbed site. Clay content was negatively correlated with silt content ($r = -.940$; $P < 0.01$, $n = 18$) and significantly correlated with sand content ($r = .902$; $P < 0.01$, $n = 18$) in the disturbed site. Clay content was negatively correlated with silt content and positively correlated with sand content in the undisturbed site (Table 6).

4. Discussion

The undisturbed plot was characterized by well-defined vegetation stratification with large number of trees whereas, the disturbed plot had a few number of trees. Illicit felling of trees and lopping resulted changes in the microclimate and soil physico-chemical properties. The disturbance at the study plot was responsible for increasing light intensity, humidity and air temperature. The chemical characteristics of soil differed markedly between the disturbed and undisturbed plot. Low soil pH in the undisturbed plot may be attributed to the accumulation of partially decomposed organic matter on the forest floor and lower rate of leaching leading to greater accumulation of reaction products in the soil (Arunachalam *et al.,* 1999), while high soil pH in the disturbed plot was due to low accumulation of decomposed organic matter. Significantly greater soil total nitrogen and available phosphorus concentration in the undisturbed plot may be due to greater inputs of organic matter through above and below ground litter. The lesser exchangeable potassium on both the plots indicated the presence of the unweathered primary minerals containing this element in the soil. Interactions of carbon, nitrogen and phosphorus cycles in forest ecosystem are influenced by disturbance. For instance, availability of nitrogen may control the rate of carbon fixation and organic matter accumulation. Phosphorus availability may affect nitrogen fixation rate and carbon: nitrogen ratio in the litter may influence its decomposition rate and net nitrogen mineralization (Roy and Singh, 1995). The higher nutrient recorded in the undisturbed site may be attributed to greater litter production and higher decay rate in this site. Moreover, higher population of both bacteria and fungi in the undisturbed site has also contributed to high nutrient content in this site.

Table 3. Pearson correlation coefficients between soil properties across study sites, n = 18

	Clay	**N**	**Silt**	**clay**	**Sand**
Disturbed site					
Soil moisture	$-.179^{ns}$				
Organs C		$.011^{ns}$			
Sand			$-.995^{**}$	$-.940^{**}$	
Silt				$.902^{**}$	$-.995^{**}$
Clay			$-.940^{**}$		$.902^{**}$
Undisturbed site					
Soil moisture	$.055^{ns}$				
Organs C		$.453^{ns}$			
Sand			$-.965^{**}$	$.317^{ns}$	
Silt				$-.556^{ns}$	$-.965^{**}$
Clay			$-.556^{ns}$		$.317^{ns}$

($^{ns}P > 0.05$, $^{*}P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$).

Conclusion

From the study covering the advent of spring and early summer months, it is easily conceivable from the results that sal forested soils of this region does not show any deficiency of the bases and other plant nutrients in general. The inherent fertility of the soils is good. The undisturbed site had greater litter production, higher decay rate and higher population of bacteria and fungi all have contributed to the nutrient enrichment in the soil.

References

Arunachalam A, Maithani K, Pandey H, R. Tripathi (1996). The impact of disturbance on detrital dynamics and soil microbial biomass of a Pinus kesiya forest in north-east India. *Forest Ecology and Management*, 88(3): 273-282.

Arunachalam K, A. Arunachalam (1999). Recovery of a felled sub-tropical humid forest: microclimate and soil properties. *Ekologia*, 18(3): 287-300.

Arunachalam A, K. Arunachalam (2000). Influence of gap size and soil properties on microbial biomass in a subtropical humid forest of north-east India. *Plant Soil*, 223: 185-193.

Arunachalam A. (2002). Dynamics of soil nutrients and microbial biomass during first year cropping in an 8-year jhum cycle. *Nutrient Cycling in Agroecosytem*, 64: 283-291.

Bouyoucos G. (1962). Hydrometer Method Improved for Making Particle Size Analyses of Soils1. *Agron J*, 54(5): 464.

Bhatnagar H.P. (1968). Soils from different quality Sal (Shorea robusta) forests of Uttar Pradesh. *Tropical Ecology,* 6: 56-62.

Binkley D, P.M. Vitousek (1989). Soil nutrient availability. *Physiological Plant Ecology: Field Methods and Instrumentation,* pp.75-79.

Conklin A.R. (2005). Introduction to soil chemistry, Analysis and Instrumentation. *167, Wiley Publications.*

Ilorker V.M. (2001). Floristic diversity and soil studies in Navegaon National Park (Maharashtra). *Indian J For,* 24(4): 442-447.

Jackson M.L. (1958). Soil Chemical Analysis. *Prentice-Hall, Inc., Englewood Cliffs, NJ.*

Klute A. (1988). Methods of Soil Analysis 2d ed., pt. 1; Physical and Mineralogical Methods. *Soil Science*, 146(2): 138.

Piper C.S. (1944). Soil and Plant Analysis, John Wiley and Sons, New York, USA.

Kumar M. (2004). Physico-chemical properties of forest soil along altitudinal gradient in Garhwal Himalaya *J Hill Res,* 17(2): 60-64.

Paudel S, J.P. Shah (2003). Physico-chemical characteristics of soil in tropical Sal (Shorea robusta Gaertn.) forests in eastern Nepal. *Himalayan J Sci,* 1(2): 107-110.

Ramachandra T.V. (2007). Vegetation status in Uttara Kannada District. *Malaysian J Sci*, 6: 1-26.

Ruess J, G. S. Innis (1977). A grassland nitrogen flow simulation mode. *Ecology,* 58: 348-429.

Roy S, J.S. Singh (1995). Seasonal and spatial dynamics of plant available N and P pools and N mineralization in relation to fine roots in a dry tropical forest habitat. *Soil Biology & Biochemistry* 27: 33-40.

Walkley A, I.A. Black (1934). An examination of the Degtjareff method for determining organic carbon in soils: Effect of variations in digestion conditions and of inorganic soil constituents. *Soil Science,* 63: 251-263.