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Physico-chemical investigation of soil in some forests of Tarai, Kumaun Himalaya, Uttarakhand, India

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Abstract
The physico-chemical properties of soils were analyzed in some forests of Tarai area of Kumaun Himalaya. Soil colour varied from grayish brown to light brownish gray and soil texture varied from silty clay loam to sandy loam. Average soil moisture, pH, organic carbon, organic matter, total nitrogen and available potassium were maximum reported at site II however water holding capacity and available phosphorus were maximum at site I.

Keywords: Forest soil, Kumaun Himalaya, Nutrient status, Physico-chemical analysis.

Introduction

Soil is one of the important ecological factors. The system is very complex and dynamic, undergoing continuous change and the rates of such changes being influenced by a number of other factors of the environment. Plants 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. The vegetation of a particular area influences the chemical properties of soil to a great extent and 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 (Singh *et al.,* 1986). Forest land is rapidly being converted into agriculture or pasture-land, which may cause significant changes in soil fertility and it may also influence secondary succession and biomass production (Lu *et al.*, 2002). Nutrient status of some Himalayan and other forests have been studied by Shrestha (1979); Pandey and Singh (1981); Toky and Ramakrishnan (1982, 1983); Negi *et al.* (1983); Chaturvedi and Singh (1987); Rawat and Singh (1988); Singh and Bhatnagar (1997); Paudel and Sah (2003) and Kumar *et al.* (2006). However, the physicochemical properties of forest soil in Tarai region of Kumaun Himalaya are still unknown. Thus, this investigation was undertaken to study the nutrient status in the forest soil in Tarai of Kumaun Himalaya.

Materials and Methods

Study area: Present study sites were situated in Tarai region Kumaun Himalaya near Kashipur (Uttarakhand). Site I (Jurkha Forest) is mixed deciduous and plantation forest of *Eucalyptus hybrid* L. Herit., *Tectona grandis* L.f. with 558.38 ha forest area and Site II (Gulzarpur Forest) is mixed deciduous forest of *Acacia catechu* Willd., *Bombax ceiba* L., *Butea monosperma* (Lamk).Thub., *Dalbergia sisso* Roxb., *Ficus racemosa* L., *Mallotus philippenensis* Muell. Arg., etc, with 674.61 ha forest area (Source: Department of Tarai West forest division, Ramnagar). The climate of the area is monsoonic. The mean maximum atmospheric temperature varied from 16.7±2.26°C in January to 37.9±1.04°C in May and mean minimum atmospheric temperatures ranged from 8.2±1.20°C in January to 23.4±0.98°C in July. Annual rainfall was 1407.9±185.24 mm. Maximum rainfall was recorded during rainy season. This study was conducted from April 2007 to March 2008.

Soil analysis: The soil samples were monthly taken from 15 cm deep cores in randomly three areas in each of the mixed deciduous and plantation forests. Total 36 soil samples were collected from each side in a year (April 2007 to March 2008). The collected soil samples were packed in airtight polythene bags and taken to the laboratory for analysis. The soil colour was determined by Munsell's soil color chart, soil texture was recorded by hand touch, soil moisture and water holding capacity were estimated as methods described by Misra (1968), soil pH was recorded by ELICO LI 613 pH meter, organic carbon

was estimated by method given by Walkley and Black (1934), organic matter was determined as formula organic carbon x factor 1.724, total nitrogen was estimated by the Micro-Kjeldahl method (Misra, 1968), available phosphorus and available potassium were estimated by Phosphomolybdic Blue Colorimetrically and Flame Photometer (Jackson, 1958) respectively.

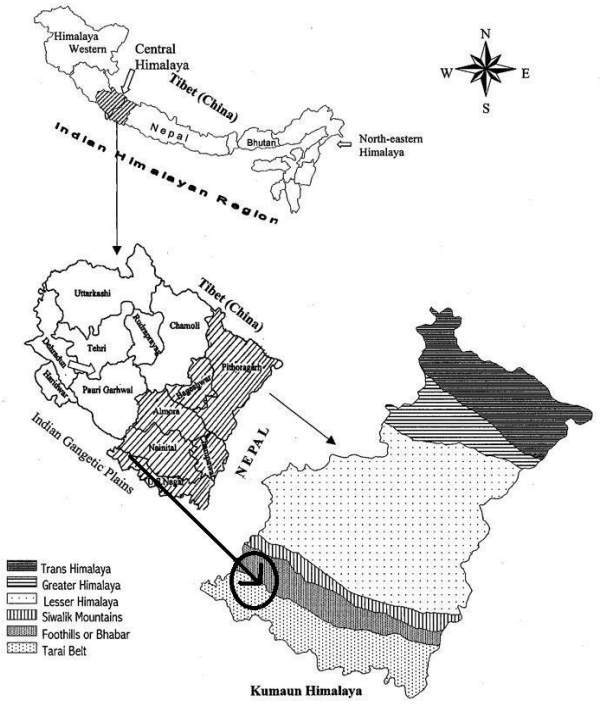

Fig 1. General map of study area

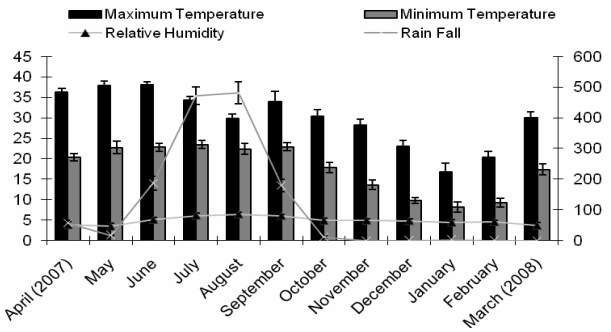

Fig 2. Ombrothermic diagram for microclimatic analysis April 2007 ï March 2008

Results and Discussion

Soil colour and texture: In the present study, soil colour varied from brownish gray to grayish brown in different forest sites (Table 1). Soil of site I (Jurkha forest) site was sandy loam and silty clay loam in site II (Gulzarpur forest). Site II is situated near Kosi and Dabka rivers so these rivers deposit more sand and silt by flood in these forests. Lodha *et al*. (1982) observed the colour of some Rajasthan soil as grayish brown, olive brown *etc*. According to Shah (1999), sandy loam texture is very common in the Shivalik foot hills (Tarai and Bhawar) and Dun valley which support dense sal forests and other valuable timber trees. The soil texture of study sites was sandy loam type which is suitable for regeneration of high quality trees (Gupta, 1951).

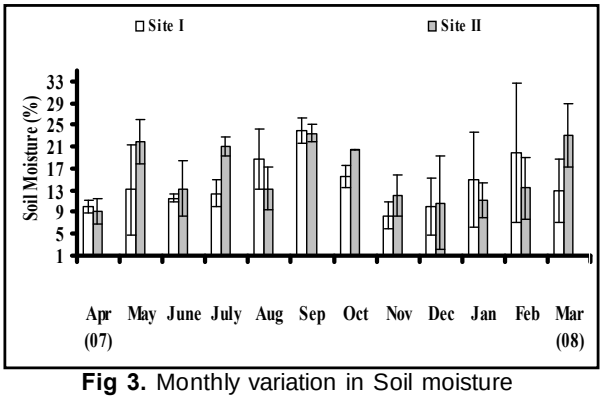

Fig 3. Monthly variation in Soil moisture

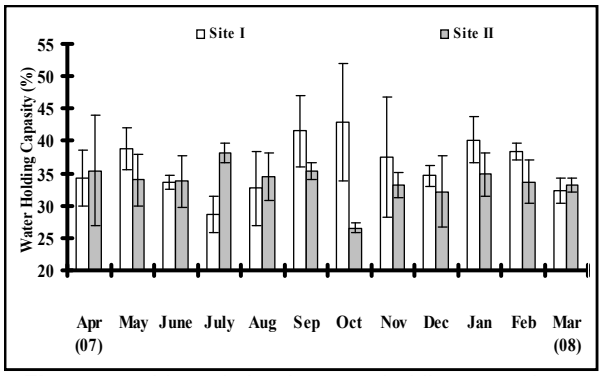

Fig 4. Monthly variation in water holding capacity

Soil moisture content: In site I the average moisture contents in soil was 14.29±4.62% and varied from 08.33±2.46% to 23.99±2.36% which increased during the rainy season and reached its peak valve in September (23.99±2.36%) and minimum in November (08.33±2.46%). There was a constant increase from April to September but showed slight variation from November to March, however it ranged from 09.13±2.45% to 23.46±1.52% with peak in September and lower in April 2007 with average 16.09±5.42% at site II (Fig. 3). In site II the average moisture contents in soil was 16.09±5.42% at site II. Similar result was reported by Yadav (2005) in the range of 5.91-34.90% at open grassland and 6.93-33.57% at protected grassland of Bhawar area of Ramnagar Uttarakhand. Sheikh and Kumar (2009) estimated soil moisture in oak and pine forest of Garhwal Himalaya as 17.73% to 24.50%, 6.22% to 13.18% and 9.89% to 21.79% in oak forest sites I, II and III however 4.70% to 6.0 %, 6.35% to 8.63% and

Table 1. Seasonal analysis of colour and texture in soil

Season		Area		Season		Area	
		Site I	Site II			Site I	Site II
Summer	Soil colour in dry	2.5 Y 6/2	2.5 Y 5/2	**Winter**	Soil colour in dry	2.5 Y 6/2	2.5 Y 6/2
	Soil colour in wet	2.5 Y 4/2	2.5 Y 3/2		Soil colour in wet	2.5 Y 4/2	2.5 Y 3/2
	Soil texture	Sandy loam	Silty clay loam		Soil texture	Sandy loam	Silty loam
Rainy	Soil colour in dry	2.5 Y 6/2	2.5 Y 6/2	**Spring**	Soil colour in dry	2.5 Y 5/4	5 Y 6/3
	Soil colour in wet	2.5 Y 4/2	2.5 Y 4/2		Soil colour in wet	2.5 Y 3/2	2.5 Y 4/2
	Soil texture	Sandy loam	Sandy loam		Soil texture	Silty clay loam	Silty clay loam

12.08% to 13.62 % in pine forest sites I, II and III respectively. Khera *et al.* (2001) estimated soil moisture ranging between 4.6% to 15.4% in Central Himalaya of Kumaun.

Soil water holding capacity: In site I average water holding capacity was 36.27±4.26% and in site II it was 33.73±2.73%. In site I, higher percentage was recorded in October (42.90±9.04%) and the lower recorded in July (28.56±2.82%). It increased from July to October, but in remaining months it fluctuated. In site II, higher percentage was recorded in September (38.17±1.47%) and the lower percentage was recorded in October as 26.50±0.77% (Fig. 4). Similar results were reported by Yadav (2005) as 10.66-58.10 at open grassland and 11.87-56.82 at protected grassland of Bhawar area of Ramnagar Uttarakhand. Ghosh and Dhyani (2005) reported it as 30.76 % in protected grassland and 26.86% in rain fed agricultural soil at Almora Kumaun. Khera *et al.* (2001) estimated it in Central Himalaya of Kumaun in a range between 25.1% to 43.7%.

Soil pH: The average value of soil pH in site I was recorded as 6.97±0.45 and varied from 6.12±0.34 to 7.53±0.03 in July and April respectively. In site II average value was 7.05±0.70 and varied from 6.06±0.03 to 8.31±0.27 in September and March respectively (Fig. 5). The soil pH was normal in nature in all the forest sites. Similar results were observed by Khera *et al.* (2001) in Central Himalaya of Kumaun and found that the soil was neutral to basic and it ranged between 7.0 and 8.4, but Sheikh and Kumar (2009) estimated that pH of oak forest soil ranged 5.80 to 6.27 which indicated that the soil was acidic in nature and pH of pine forest ranged 5.42 to 6.71 in oak and pine forest of Garhwal Himalaya. Yadav (2005) reported it in the range of 6.0-7.7 at open grassland and 6.0-7.7 at protected grassland of Bhawar area of Ramnagar Uttarakhand. Sharma and Kumar (1992) reported it in the range of 5.02-5.70 at some natural forest stands in Lansdowne forest range of Garhwal Himalaya but Singh and Bhatnagar (1997) reported 4.8 and 6.2 in pine-oak forest of Kumaun Himalaya respectively.

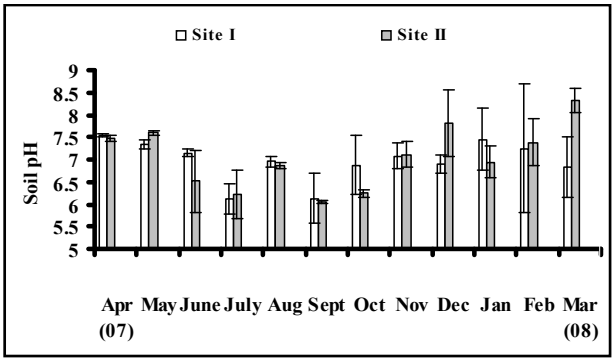

Fig 5. Monthly variation in soil pH

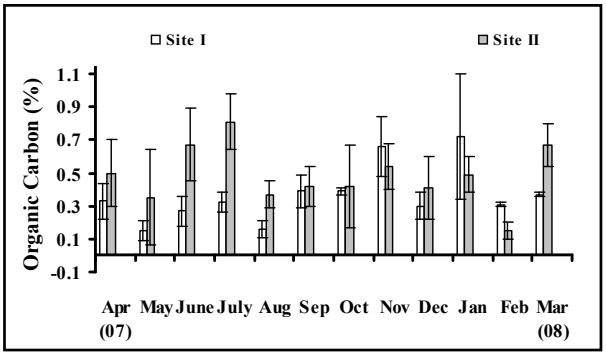

Fig 6. Monthly variation in soil organic carbon

Soil organic carbon: In site I the average amount of organic carbon was 0.36±0.17%. The minimum and maximum amount was 0.15±0.06% and 0.72±0.38% recorded in May and January respectively. In site II it was 0.48±0.17%. The minimum and maximum amount was 0.15±0.05% and 0.81±0.17% recorded in February and July respectively (Fig. 6). Singh and Bhatnagar (1997) reported 1.77 and 1.84 in pine and oak forest of Kumaun Himalaya respectively, whereas Kumar *et al.* (2006) reported in range of 0.47 to 0.68 %. Khera *et al.* (2001) in Central Himalaya of Kumaun observed that the soil organic carbon was maximum as compared to present study as 0.80%-2.30%. Rawat and Mathpal (1981) investigated some agricultural soils of Almora district in which organic carbon ranged from 0.25% to 3.12%. However Yadav (2005) reported it in the range of 0.34-1.05 at open grassland and 0.34-1.20 at protected grassland of Bhawar area of Ramnagar Uttarakhand, but Sharma and Kumar

Table 2. Physico-chemical properties of forest soil

Parameters	Area	Average Value	d. f.	F value	LSD	P
Soil moisture (%)	**Site I**	14.29±4.62	11, 24	1.82	NS	NS
	Site II	16.09±5.41	11, 24	4.48	10.12	< 0.01
Water holding capacity (%)	**Site I**	36.27±4.26	11, 24	2.25	8.28	< 0.05
	Site II	33.73±2.73	11, 24	1.50	NS	NS
pH	**Site I**	6.97±0.45	11, 24	1.81	NS	NS
	Site II	7.05±0.70	11, 24	9.17	0.91	< 0.01
Organic Carbon (%)	**Site I**	0.36±0.17	11, 24	4.66	0.31	< 0.01
	Site II	0.48±0.17	11, 24	2.89	0.29	< 0.05
Organic matter (%)	**Site I**	0.63±0.30	11, 24	4.68	0.54	< 0.01
	Site II	0.83±0.30	11, 24	2.86	0.51	< 0.05
Total Nitrogen (%)	**Site I**	0.00308±0.0011	11, 24	9.18	0.0014	< 0.01
	Site II	0.00475±0.0037	11, 24	58.61	0.0019	< 0.01
Available Phosphorus (kg ha^{-1})	**Site I**	5.38±1.75	11, 24	16.27	1.71	< 0.01
	Site II	4.88±1.30	11, 24	3.00	2.19	< 0.05
Available Potassium (kg ha^{-1})	**Site I**	89.36±42.24	11, 24	3.61	87.89	< 0.01
	Site II	96.89±40.32	11, 24	4.23	77.53	< 0.01

NS (Not significant), d.f. (Degree of freedom), ± (Standard deviation)

(1992) reported it in the range of 0.26-2.29 at some natural forest stands in Lansdowne forest range of Garhwal Himalaya. Ghosh and Dhyani (2005) reported the organic carbon as 0.92% in protected grassland and 0.83% in rain fed agricultural soil at Almora, Kumaun. According to Tamirat (1992) soils that form under forests tend to accumulate high levels of soil organic carbon near the surface and have lower carbon levels in the subsoil.

Soil organic matter: In site I average value of organic matter was 0.63±0.30% and varied from 0.26±0.11% to 1.24±0.67% in May and January respectively. In site II average value was 0.83±0.30% and ranged from 0.26±0.10% to 1.39±0.30% in February and July respectively (Fig. 7). Soil organic matter values in present study sites were lower as compared to Khera *et al.* (2001) in central Himalaya of Kumaun. They estimated organic matter ranged between 1.40% to 4.0%. Yadav (2005) reported it in the range of 0.59-1.81 at open grassland and 0.59-2.07 at protected grassland of Bhawar area of Ramnagar Uttarakhand but Ghosh and Dhyani (2005) reported it as 1.58% in protected grassland and 1.42% in rainfed agricultural soil at Almora Kumaun.

Soil available nitrogen: The average value of total nitrogen was 0.00308±0.0011% and varies from 0.00150±0.0007% to 0.00497±0.0003% in September and June respectively at site I. In site II the average value was 0.00475±0.0037% and ranged from 0.00259±0.0006% to 0.01623±0.0022% in March and July respectively (Fig. 8). Yadav (2005) reported it in the range of 0.041 - 0.120% at open grassland and 0.053 - 0.144% at protected grassland of Bhawar area of Ramnagar Uttarakhand, however Ghosh and Dhayani (2005) reported it as 0.11% in protected grassland and 0.07% in rain fed agricultural soil at Almora Kumaun.

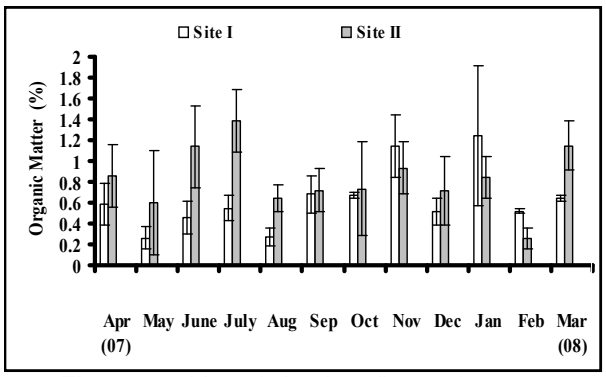

Fig 7. Monthly variation in soil organic matter

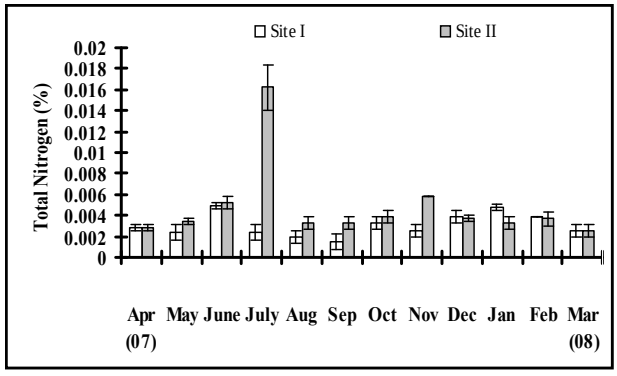

Fig 8. Monthly variation in total Nitrogen

Soil available phosphorus: In site I the average value of available phosphorus was 5.38±1.75 kg ha^{-1} and varied from 4.50±0.00 kg ha^{-1} to 9.00±0.00 kg ha^{-1}, however in site II it was 4.88±1.30 kg ha^{-1} and varied from 4.50±0.00

kg ha^{-1} to 9.00±4.50 kg ha^{-1} (Fig. 9). It was within the reported range of Shrestha (1979) who found it to be from 1.03 to 71.15 kg ha^{-1} and Singh *et al.* (2009) in the range of 11.42-13.45 kg ha^{-1} (oak) and 21.90-24.18 kg ha^{-1} (pine) forest of Garhwal Himalaya. Kumar *et al.* (2006) reported range values of soil available phosphorus as 9.67 to 10.67 kg ha^{-1}. Sharma and Kumar (2001) reported it in the range of 8.47-33.88 kg ha^{-1} at some natural forest stands in Lansdowne forest range of Garhwal Himalaya. Yadav (2005) reported it in the range of 4.00-13.50 kg ha^{-1} at open grassland and 4.40-14.60 kg ha^{-1} at protected grassland of Bhawar area of Ramnagar Uttarakhand.

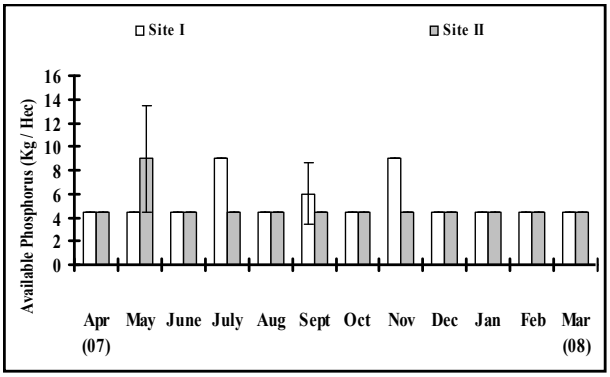

Fig 9. Monthly variation in soil available Phosphorus

Soil potassium: In site I the average value of available potassium was 89.36±42.24 kg ha^{-1} and varied from 22.66±6.02 kg ha^{-1} to 147.33±67.26 kg ha^{-1} in August and December respectively. In site II the average value was 96.89±40.32 kg ha^{-1} and varied from 24.33±7.02 kg ha^{-1} to 144.00±65.48 kg ha^{-1} in August and March (Fig. 10). These values were similar as reported by Kumar *et al.* (2006) and Singh *et al.* (2009) as 141.87 to 172.48 kg ha^{-1} and 99.02-108.90 kg ha^{-1} (oak) and 89.98-116.48 kg ha^{-1} (pine) in subtropical forest of Garhwal Himalaya respectively. Sharma and Kumar (1992) reported it in the range of 15.2-35.2 kg ha^{-1} at some natural forest stands in Lansdowne forest range of Garhwal Himalaya however Yadav (2005) reported it in the range of 72.00-212.00 kg ha^{-1} at open grassland and 63.00-342.00 kg ha^{-1} at protected grassland of Bhawar area of Ramnagar Uttarakhand.

Conclusion

Based on above results and discussion it was concluded that the nutrients status of these areas was lower as compared to forest soil of Central Himalaya (Oak and Pine forest). Uttarakhand is an emerging state of India and various industries are well established in Tarai and Bhawar regions of Uttarakhand, it leads various anthropogenic

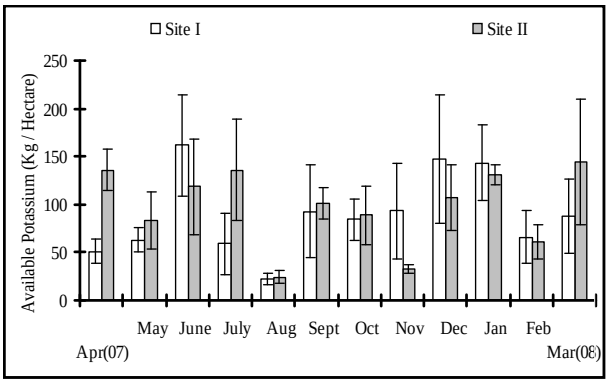

Fig 10. Monthly variation in soil available Potassium

activities in forests like collection of soil for construction of industries. In addition, collection of minerals from river, deforestation and excessive grazing cause removal of nutrients from top layer of soil. Therefore, these forests wherever present should be protected for enrich soil nutrient supply.

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