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Soil Characteristics in Moist Tropical Forest of Sunsari District, Nepal

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Abstract

The physico-chemical properties of soils of tropical moist forest (Charkoshe jungle) in Sunsari district of eastern Nepal were analyzed. The samples were collected during summer season from three depths: upper (0-15 cm), middle (15-30 cm) and deep (30-45 cm). They were analyzed for texture, pH, moisture, water holding capacity, organic carbon, total nitrogen, organic matter and microbial biomass carbon and nitrogen. The forest soil of upper and middle layers was loamy whereas that of deep layer was sandy loam. The pH value was lower (5.6) in upper layer than in the deep layer (6.6). The moisture content, water holding capacity, organic carbon, total nitrogen and organic matter were higher in upper layer and decreased with increasing depth. The higher level of soil nutrients in upper layer was due partly to reduction in the loss of top soil and partly to the increased supply of nutrients from the decomposed form of litter and fine roots of the forest plants. The average value of microbial biomass carbon in the soil was 676.6 µg $g^{-1}$and microbial biomass nitrogen was 59.0 µg g^{-1}.

Key words: organic carbon, total nitrogen, microbial biomass, Charkoshe jungle

Introduction

In tropical forest ecosystems, soil nutrients play an important role in the formation of plant communities, their species and structural diversity. Soil conservation has fundamental significance for biodiversity conservation and sustainable land use (Karpachevsky 1977). Additionally, change in diversity may be related to initial nutrient condition of the soil. Theresa and Bowman (1997) showed that nutrient enrichment increased the biodiversity in poor soils. Kumar *et al.* (2006) and Homeier *et al.* (2010) reported the positive correlation between soil variables and tree diversity. The growth of *Shorea robusta* (Sal) and other tree species, such as *Terminalia alata* and *Syzygium cumini*, in tropical forests are highly influenced by nitrogen, phosphorus, potassium, and soil pH (Bhatnagar 1965).

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. Soil- vegetation system plays an important role in the global carbon cycle. Soil is the largest pool of terrestrial organic carbon (Mikhailova 2006). Soil contains about 1.5-3 times more organic carbon than vegetation (Wang *et al.* 2004) and about twice as much carbon than is present in the atmosphere (Lal 2004). It is estimated that the world's forest store 283 Gega ton of carbon in their biomass alone, and 638 G t carbon in the ecosystem as a whole including dead wood, litter and soil up to 30 cm depth (FSI 2005). Carbon in the form of organic matter is a key element to healthy soil.

The Bhaber region comprising the Charkoshe jungle of eastern Nepal is characterized by the presence of porous, non-water logged lomy soil, which supports the growth of dense sal forest with valuable timber and non-timber plants. This type of biological diversity is essential for human survival, economic well being and livelihood of local communities (Sagar *et al.* 2003, Zhu *et al.* 2007). However, the tropical forests are disappearing at alarming rates which results in the loss of biological diversity along with the water resources and non-timber forest products (Lamb *et al.* 2005). In such a condition, mechanisms to conserve nutrients in the forest ecosystem are important in order to develop effective management and planning strategies to protect the remaining forest.

Soil microbial biomass, though represents a small fraction of total soil organic matter pools but it is an active fraction due to its rapid turnover rate and fast release of available nutrients to the plants. It plays a crucial role in nutrient cycling far greater than its size (Walley *et al.*1996). The size and turnover of soil microbial biomass affects the quantity of plants-available nutrients and thus it has been used as an index of soil fertility (Hassink *et al.* 1991). It may play an active role in preventing nutrient leaching through immobilization in many systems (Vitousek & Matson 1984).

In Nepal, information on soil microbial biomass is limited. Mandal (1999) has estimated microbial biomass in the soil of plateau sal forest. Thus, in the present work an attempt has been made to estimate the soil microbial biomass in relation to soil organic carbon and total nitrogen as well as the soil physical properties in tropical moist forest located in Bhaber region of eastern Nepal.

Methodology

Study area

The present study was conducted in the Sal bearing tropical moist forest, located in the Bhabar belt of Sunsari district, Nepal (longitude 86°53'E to 87°21'E and latitude 26°24'N to 26°52'N). The forest was dominated by *Shorea robusta Gaertn.* Other main associates were *Lagerstroemia parviflora* Roxb., *Terminalia alata* Heyne ex Roth., *Mallotus philippensis* (Lam.) Mull.-Arg., *Adina cordifolia* Benth. & Hook f. ex Bran and *Dillenia pentagyna* Roxb. Top soil of the study area was typical loam. The climate is tropical monsoon type. The year is divisible into three distinct seasons: summer, rainy and winter. Mean monthly minimum temperature ranged from 8.1°C to 25.4°C and maximum temperature ranged from 22.4°C to 33.9°C. The average annual rainfall was 2021.3 mm.

Soil sampling and analysis

Soil samples were collected from 35 sampling plots, established randomly within the study area. At each sampling plot the soil was collected in the summer season (May, 2011) from three pits (10X10X15 cm^3) in three different depths: upper- 0-15 cm, middle- 15-30 cm and deep- 30-45 cm. For each depth the soils of three pits were composited and pooled as one replicate. The collected soil samples were packed in polythene bags and taken to the laboratory for analysis. Soil analyses were performed at the Department of Botany, Post Graduate Campus, Biratnagar.

Air dried soil samples were sieved through a 2 mm mesh screen and used for further analyses. Texture, moisture, pH, water holding capacity and bulk density of the soil were determined following Piper (1966). Organic carbon was estimated by dichromate oxidation method (Kalembasa & Jenkinson 1973). Total nitrogen estimation was determined by Micro- Kjeldhal method. Soil microbial biomass C and N were estimated by chloroform fumigation extraction method (Vance *et al.* 1987, Brookes *et al.* 1985).

Results and Discussion

The physico-chemical characteristics of forest soil were estimated at different soil depths as upper, middle and deep. The texture of the soil was loamy in upper and middle layers whereas it was sandy loam in the deep layer. Sand content increased while silt and clay decreased depth-wise (Table 1). Bulk density was minimum (1.28 g/cm^3) in the upper layer which increased depth-wise. ANOVA suggested that bulk density of the soil was significantly different at three different depths ($P < 0.001$). Water holding capacity (WHC) was higher (47%) in the upper layer which decreased depthwise. The pH value was minimum (5.6) in the upper layer and maximum (6.6) in deep layer. The moisture content of the soil during summer was 8.4% in the upper layer and gradually decreased with increasing depth (Table 2).

Organic carbon was maximum (3.07%) in the upper layer which decreased to minimum (1.17%) in the deep layer (Table 3). ANOVA suggested that organic carbon in the soil was significantly different at three different depths ($P < 0.001$). Total nitrogen in the soil decreased depthwise, which was maximum (0.24%) in the upper layer and minimum (0.09%) in the deep layer (Table 3).

It was also significantly different at different depths ($P < 0.001$). The organic matter content in soil was higher (5.3%) in the upper layer which was due to higher accumulation and decomposition of forest litter. It reduced depthwise and minimum (2.0%) in the deep layer (Table 3).

Table 1. Soil texture in the tropical moist forest of Sunsari district, Nepal. (Values are mean ± SE.)

Depth (cm)	Textural class			Texture classification
	Sand (%)	Silt (%)	Clay (%)	
0-15	45.0 ± 2.7	37.9 ± 2.3	17.1 ± 1.0	Loam
15-30	51.2 ± 2.6	32.9 ± 1.6	15.9 ± 0.8	Loam
30-45	66.7 ± 3.3	26.5 ± 1.3	6.8 ± 0.3	Sandy loam

Table 2. Water holding capacity (WHC), moisture, pH and bulk density (BD) of the soil in tropical moist forest of Sunsari district, Nepal. (Values are mean ± SE.)

Depth (cm)	WHC (%)	Moisture (%)	pH	B D
0-15	47.0 ± 2.8	8.4 ± 0.5	5.6 ± 0.3	1.28 ± 0.08
15-30	39.0 ± 2.3	8.0 ± 0.5	5.8 ± 0.3	1.45 ± 0.09
30-45	28.4 ± 1.7	7.8 ± 0.5	6.6 ± 0.3	1.51 ± 0.09

Table 3. Organic carbon, total nitrogen, C: N ratio and organic matter of soil in tropical moist forest of Sunsari district, Nepal. (Values are mean ± SE.)

Depth (cm)	Organic carbon (%)	Total nitrogen (%)	C : N ratio	Organic matter (%)
0-15	3.07 ± 0.15	0.24 ± 0.01	12.8	5.3 ± 0.25
15-30	1.34 ± 0.12	0.12 ± 0.02	11.2	2.3 ± 0.20
30-45	1.17 ± 0.10	0.09 ± 0.01	13.00	2.0 ± 0.10

The soil microbial biomass carbon (MB-C) was 676.6 $\mu g\ g^{-1}$ and microbial nitrogen (MB-N) was 59.0 $\mu g\ g^{-1}$ of the dry soil (Table 4). The ratio of MB-C: MB-N was found 11.5. Soil microbial biomass C and N as percentage of soil organic C and total N were 2.2 and 2.5 respectively (Table 5).

Table 4. Soil microbial biomass C, N and their ratio in tropical moist forest of Sunsari district, Nepal. (Values are mean ± SE.)

Depth (cm)	MB-C ($\mu g\ g^{-1}$)	MB-N ($\mu g\ g^{-1}$)	MB-C: MB-N
0-15	676.6 ± 37	59.0 ± 3.8	11.5

Table 5. Soil microbial biomass C and N as percentage of soil organic C and total N in tropical moist forest of Sunsari district, Nepal.

Depth (cm)	Microbial biomass as % of	
	Organic C	Total N
0-15	2.2	2.5

The organic carbon showed positive correlation with total N and MB-C (Fig. 1 and 2). Similarly, MB-C also showed positive relationship with MB-N (Fig. 3).

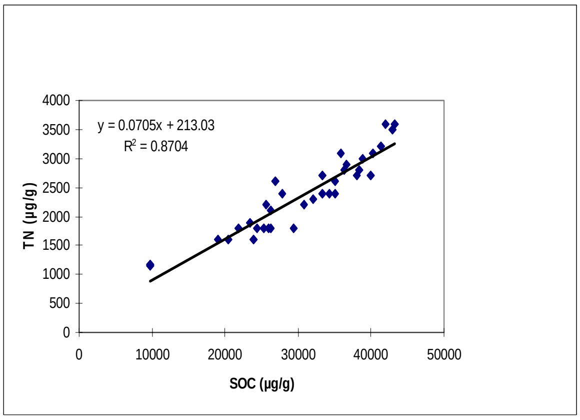

Fig. 1. Relationship between soil organic C and total N

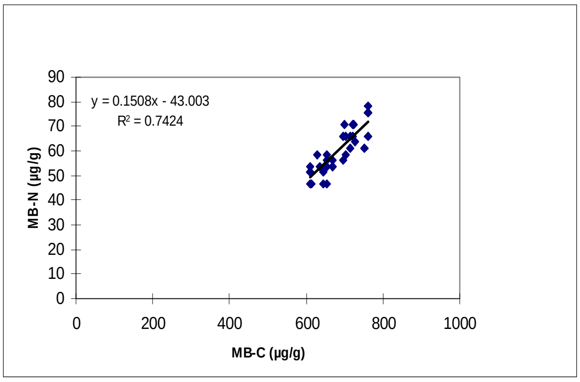

Fig. 3. Relationship between MB-C and MB- N

Soil texture in the study area was loamy type which has been reported suitable for good Sal regeneration and high quality trees (Gupta 1951). The chemical characteristics of soil differed markedly with the increasing depths. The higher value of organic matter on the surface layer may be because of more forest litter accumulation and decomposition. The pH value in the present study (5.6-6.6) was similar as reported by Sigdel (1994) in Royal Chitwan National Park (5.90-6.42) but was lower than the value of *S. robusta* dominated central Himalayan forests (6.7-6.8) (Singh & Singh 1985). The upper layer of the soil showed acidic nature which may be due to the formation of organic acids from the higher amount of partially decomposed organic matter on the forest floor. There was gradual decrease in soil organic C and total N with increasing soil depth. Similar results were also

Moreover, total N exhibited strong positive correlation with MB-N (Fig. 4).

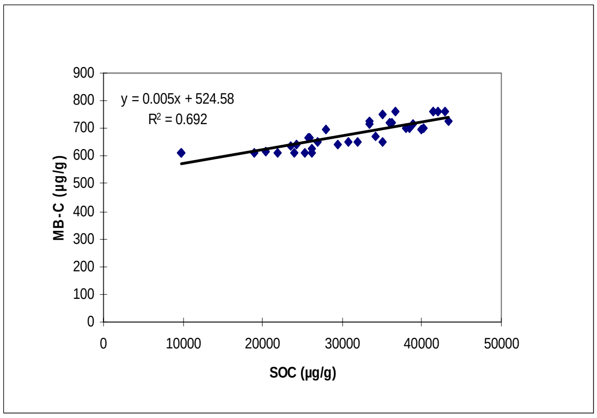

Fig. 2. Relationship between soil organic C and MB-C

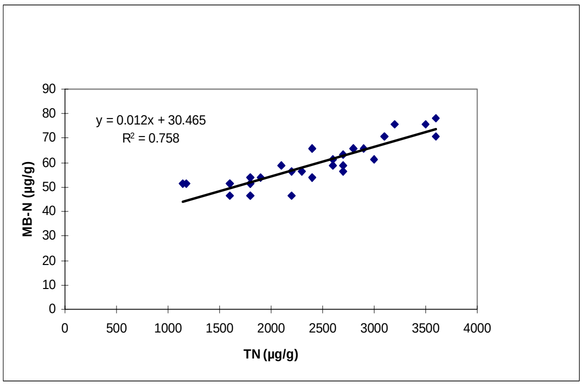

Fig. 4. Relationship between total N and MB-N

observed by Barbhuiya (2008) in tropical rainforest ecosystem of Assam, India. It could be due to greater inputs of organic matter through the above ground litter.

Soil micro-organisms are potentially very important to increase the level of soil fertility. The level of soil MB-C (676.6 µg g^{-1}) was comparable with that of the A horizon soil of tropical rain forest of China (700 µg g^{-1}; Yang & Insam 1991). Further, MB-C and MB-N levels of present work were also comparable with the corresponding levels (MB-C: 867 µg g^{-1}, MB-N: 75 µg g^{-1}) reported in dry tropical forest of India (Srivastava *et al*. 1989). Soil microbial biomass as percentage of organic C and total N in the present study is closely related with the values (2.8- 2.9 respectively) reported by Srivastava and Singh (1991) in dry tropical forest of India. High MB-C: MB-N ratio (11.5) in the soil of present forest may reflect the dominance of fungi in soil microbial biomass. An increase in the size of microbial biomass can be used as an index of soil fertility as it regulates the decomposition and mineralization processes to produce the available nutrients in soils (Hassink *et al*. 1991).

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