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Variations in soil N-mineralization and nitrification in seasonally dry tropical forest and savanna ecosystems in Vindhyan region, India

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Abstract: N-mineralization and nitrification rates were studied, during May 1996 to June 1997, at six sites in Vindhyan region (four forest and two savanna sites) differing in terms of dominant vegetation, nutrient status, topography and soil moisture regime. During an annual cycle the maximum N-mineralization and nitrification rates were recorded in rainy season and minimum in summer season in all study sites. The annual N-mineralization and nitrification rates were highest at Hathinala forest moist site having maximum moisture content, organic-C, N and water holding capacity of soil than other study sites. N-mineralization and nitrification rates differ significantly across the sites and seasons. These rates were significantly correlated with soil moisture and mineral-N contents. The result suggested that variations in rates of N-mineralization and nitrification in the studied dry tropical ecosystems are related to differences in soil moisture content, nutrient status and vegetational cover in combination with other environmental factors.

Resumen: Las tasas de mineralización de N y de nitrificación fueron estudiadas de mayo de 1996 a junio de 1997, en seis sitios de la región Vindhyan (cuatro sitios de bosque y dos de sabana) que difieren en términos de la vegetación dominante, el estatus de los nutrientes, la topografía y el régimen de humedad del suelo. Durante un ciclo anual las tasas máximas de mineralización del N y de nitrificación fueron registradas durante la estación lluviosa, y las mínimas en el verano, en todos los sitios de estudio. Las tasas anuales de mineralización de N y de nitrificación tuvieron sus picos en el sitio húmedo del bosque Hathinala, el cual tiene mayores contenidos de humedad, C orgánico, N y capacidad de retención de agua en el suelo que los otros sitios de estudio. Las tasas de mineralización del N y de nitrificación fueron significativamente diferentes entre sitios y estaciones. Estas tasas estuvieron correlacionadas significativamente con los contenidos de humedad en el suelo y de N mineral. El resultado sugiere que las variaciones en las tasas de mineralización de N y de nitrificación en los sistemas tropicales secos estudiados están relacionadas con las diferencias en el contenido de humedad en el suelo, el estatus de los nutrientes y la cobertura vegetal, en combinación con otros factores del ambiente.

Resumo: As taxas de mineralização e nitrificação foram estudadas entre Maio de 1996 e Junho de 1997 em seis locais na região de Vindhyan (quatro locais na floresta e dois na savana) diferindo no que respeita à vegetação dominante, status nutricional, topografia e regime hídrico do solo. Durante o ciclo anual, e em todas os locais estudados, as taxas máximas de mineralização e de nitrificação do N foram registadas na estação chuvosa e os mínimos na estação de verão. As taxas anuais de mineralização e nitificação do N foram mais elevadas no local húmido da floresta de Hathinala com um teor de humidade, C orgânico e capacidade de retenção de água maior do que nos outros locais estudados. As taxas de mineralização e nitrificação diferiram significativamente através dos locais e estações. Estas taxas

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apresentaram-se significativamente correlacionadas com a humidade do solo e com o teor de N mineral. Os resultados sugerem que as variações nas taxas de mineralização e nitrificação nos ecossistemas tropicais secos estudados estão relacionados com as diferenças no teor de humidade do solo, o status nutricional e a cobertura vegetal em combinação com outros factores ambientais.

Key words: Forest, N-mineralization, nitrification, soil moisture, savanna.

Introduction

The tropical deciduous forest supports a nutrient deficient soil and heterogeneous mosaic of plant communities (Singh 1989). Although nutrient availability, topography and climatic factors are important in determining the distribution and productivity of forest ecosystems, associated nutrient cycling characteristics through soil microbial processes (N-mineralization and nitrification) are important in the functioning of these ecosystems. The N-availability depends upon topography (Raghubanshi 1992), micro relief and seasonality (Roy & Singh 1995). The rate of supply of available-N generated by N-mineralization involves the microbial conversion of more complex organic-N into simpler available mineral-N ($NH_4^+ - N + NO_3^- - N$). Nitrification involves the transformation of $NH_4^+ - N$ into $NO_3^- - N$ carried out by two different physiological groups of chemoautotrophic bacteria. The rates of soil N-mineralization and nitrification not only governs the availability of mineral-N for plant growth but also indicate the ability of soil to retain N, especially after disturbances (Haynes 1986). Since, the mineralization of organic materials and the release of mineral-N, from either native soil or decaying litter is the result of complex interactions between microbial population and their activities.

The major factors that limit N-mineralization and nitrification are environmental parameters like temperature, aeration, soil moisture, pH, soil organic matter, quantity and quality and soil type (Arunachalam & Arunachalam 1999; Banerjee *et al.* 1999; Kiese *et al.* 2003; Owen *et al.* 2003). De Neve *et al.* (2003) also reported soil moisture as the important factor controlling N-mineralization and nitrification at sites he investigated. Fluctuations in environmental conditions (temperature, moisture and aeration) affect N-mineralization and nitrification by altering microbial population size (Jha *et al.* 1996a). Vegetation also affects N-mineralization and nitrification through both litter quality and quantity (Berg & Staff 1981). Vitousek *et al.* (1982) investigated the potential N-mineralization, nitrification and immobilization in a wide range of ecosystems and concluded that N-poor sites produced refractory organic nitrogen compounds and produced litter with high C:N ratio. It may be suggested that litter quality (dominant vegetation) and quantity may be the major factors controlling N-mineralization and possibly nitrification in present studied ecosystems.

Dry tropical ecosystems in the Vindhyan region in India are characterized by strong seasonality and wide variation in plant species diversity due to physiographic and anthropogenic disturbances (Roy & Singh 1995). N dynamics has been studied with reference to dominant vegetational cover nutrient pool and moisture status in dry tropical forest ecosystems situated across a gradient of topography in the Vindhyan region (Raghubanshi *et al.* 1990). Although, several studies have concentrated on soil nutrient dynamics in the above regions by selecting only one or other given sites on a temporal scale but the limitations of the previous investigations were that they were not able to decipher differences in vegetational cover or topographical variations. The present study focuses on comparison of seasonal variations in N-mineralization and nitrification rates in soil in six different ecosystems (four forest sites and two savanna sites) located in Vindhyan region. An attempt was made to quantify the influence of soil moisture on rates of N-mineralization and nitrification to improve our predictions of these processes under field conditions.

Materials and methods

Area description

The study sites were distributed in Mirzapur and Sonbhadra districts of Uttar Pradesh, situated between 24 and 26° N latitude and 82 and 84° E longitude. The altitude ranges between 299 and 355 m above mean sea level. The climate is tropical monsoonal, with the year divisible into winter (November-February), summer (April-mid June) and rainy (late June-October) seasons. The mean monthly minimum temperature ranges between 13.4 and 30.7 °C and the mean monthly maximum between 23.4 and 40.2 °C. About 9 months of the year are dry and 3 months are moist, the later receiving about 87% of the total annual rainfall (mm) due to the south-west monsoon.

The study sites were located in dry deciduous forests and savannas in the Vindhyan plateau. Two forest sites were studied, one in the Hathinala region (moist and dry sub-sites), and the other in the Marihan region (Kotwa hill top and Kotwa hill base sub-sites). The latter site was characterized by the presence of topographic depressions; litter accumulation in these 'troughs' give rise to patchy microsites which are different in appearance from the adjoining non-patchy milieu (flats) (Roy & Singh 1995). The Barkaccha young savanna site, near Marihan forest and another Telburva old savanna site near Hathinala site were selected for present investigation. The soils of these sites are residual, well-drained Ultisols, derived from Kaimur sandstones (Dhandraul orthoquartzites), sandy to sandy loam in texture and reddish to reddish brown in colour (Singh *et al.* 1989). The intensively leached soil was shallow, low in nutrients and organic matter and having moderate water holding capacity (Roy & Singh 1995). Annual rainfall in Hathinala region averaged 1201 mm and in Marihan region it averages 1037 mm.

Vegetation

The Hathinala moist site was dominated by *Shorea robusta* C.F. Gaertn with a density of 2210 woody plants ha^{-1} (net production: 16.6-18.8 t ha^{-1} year^{-1}). The Hathinala dry site was dominated by *Ziziphus glaberima* (Sedgw.) Santap., with 950 woody plants ha^{-1} (net production: 14.2-16.7 t ha^{-1} year^{-1}). The Kotwa hill top was dominated by *Boswellia serrata* (Roxb.) with tree density 490 ha^{-1}. The Kotwa hill base was dominated by *Acacia catechu* (L.f.) Wild with a tree density of 627 ha^{-1} (net production: 11.3-19.2 t ha^{-1} year^{-1}). However, the Barkaccha site was previously dominated by tall grasses, thorny semi-arid bushes, and sparse trees, which were cleared manually in 1979 for cultivation. Since then, the area remained fallow and no cultivation was practiced. Consequently, vegetation began to develop gradually and at present it is dominated by *Ziziphus oenoplia* (L.) Mill. The Telburva site was dominated by *Heteropogon contortus* (L.) P. Beauv ex. R. & S, with a tree density of ligneous components ranging from 180-330 ha^{-1} (net production: 0.57 t year^{-1}). Other characteristic features of the above sites are described elsewhere (Pandey & Singh 1992; Roy & Singh 1995; Singh & Singh 1993).

Soil sampling

Soil samples were collected seasonally during the annual cycle May 1996 to June 1997. In order to randomize, total of 3 samples were collected (soil monoliths 10 x 10 x 10 cm) at approximately 50 m intervals at each site. The soil samples were stored in air-tight metal container and transported to laboratory within 24 hours of collection. In laboratory, the composite soil samples were sieved through a 2 mm mesh screen. Large pieces of plant materials (live roots) were removed by hand-sorting. After dividing these samples into two parts, one part was used for analysis of mineral-N ($NH_4^+ - N$ and $NO_3^- - N$) and the second part was used for the determination of N-mineralization and nitrification.

Soil analysis

The textural class of soil was analyzed by passing the soil through sieves of different mesh sizes (Indian Standards 1965). Soil pH was determined by using pH meter (1:2, soil : water ratio) and water holding capacity by Piper (1944) method. Organic-C and organic-N were determined as described by Walkley (1947) and Jackson (1950), respectively.

Gravimetric soil moisture was determined by drying soil sub-samples at 105^{0}C for 24 hours in a hot air oven (Buresh 1991). Ammonium-N ($NH_4^+ - N$) was determined on 2 M KCl extract of soil samples by phenate method (APHA 1985). The optical density was read at 630 nm. Nitrate-N ($NH_4^+ - N$) was measured on $CaSO_4$ soil extract by phenol disulphonic acid (PDSA) method (Jackson 1958). The optical density was measured at 420 nm. *In situ* rates of N-mineralization and nitrification rates were determined seasonally for each site for a 30 day period at the sampling point using the field incubation technique (Anderson & Ingram 1989). Rate of N-mineralization was calculated as the difference in the concentration of inorganic-N ($NH_4^+ - N + NO_3^- - N$) ions in the incubated and initial sample. Nitrification rate was calculated as the difference in $NO_3^- - N$ concentration in the incubated and initial sample (Hart *et al.* 1994; Jha *et al.* 1996)

Statistical analysis

All results are expressed on an oven-dried soil (105°C, 24 hours) basis. Seasonal value means of three replicates of each sample were analyzed through one-way or two-way ANOVA and by regression analysis using Statgraphics Software (Statistical Graphics Corporation 1986).

Results

Physico-chemical properties of soil

The physico-chemical properties of soils of different investigated sites are presented in Table 1. The textural class across different sites is sandy to sandy-loam. Moderate water holding capacity existed at different study sites, and was recorded maximum at Hathinala moist site (46.3%) and minimum at Kotwa hill base site (38.3%). At all the sites, soil pH was slightly acidic except Telburva savanna having slightly alkaline pH (7.2). Organic-C was maximum at Hathinala moist site (28,295 µg g^{-1} dry soil) and minimum at Telburva savanna (8,822 µg g^{-1} dry soil). The organic-N was highest for Hathinala moist site (2168 µg g^{-1} dry soil) and lowest for Telburva site (783 µg g^{-1} dry soil). ANOVA showed significant differences for water holding capacity ($F_{5,17}$ = 60.87, p = < 0.0001), pH ($F_{5,17}$ = 69.27, p = < 0.0001), organic-C ($F_{5,17}$ = 425.50, p = < 0.001) and organic-N ($F_{5,17}$=101.59, p=< 0.0001).

Soil moisture

The seasonal variation in gravimetric soil moisture at different investigated sites is shown in Fig. 1. Across the study sites a marked seasonal variation was observed in soil moisture content, with maximum recorded during rainy season and minimum in summer season. Within the annual cycle, at different sites the gravimetric soil moisture ranged from 6.3 to 24.3% (Fig. 1). The annual mean indicated that soil moisture content was recorded maximum for Hathinala moist site (17.9%) and minimum for Telburva site (11.9%). ANOVA revealed significant differences in soil moisture due to season ($F_{5, 17}$ = 133.70; p = < 0.0001), but the differences due site was not significant ($F_{5, 48}$ = 1.54, p = < 0.1929). The site x season interaction was also significant ($F_{10, 36}$ = 6.10, p = < 0.0001).

Mineral-N ($NH_4^+ - N + NO_3^- - N$)

Mineral-N ($NH_4^+ - N + NO_3^- - N$) content of soils at all the sites was maximum during summer season and minimum in the rainy season (Fig. 2). The values observed for winter season were intermediate between rainy and summer

Table 1. Physico-chemical properties of soils of different investigated sites.

Sites	Soil properties				
	Soil type	WHC (%)	pH	Organic-C (µg g^{-1} dry soil)	Organic-N(µg g^{-1} dry soil)
Hathinala (M)	S	46.4	6.4	28,295	2,168
Hathinala (D)	S	45.6	6.4	27,024	1,322
Kotwa (HT)	SL	45.2	6.3	22,344	1,342
Kotwa (HB)	SL	38.1	6.3	19,111	1,113
Barkaccha	SL	40.1	6.6	16,356	1090
Telburva	S	41.0	7.2	8,822	783
LSD*	-	01.4	0.2	1,392	143

S = sandy, SL = sandy loam, M = moist site, D = dry site, HT = hill top, HB = hill base, WHC = water holding capacity, *Significance level < 0.05%.

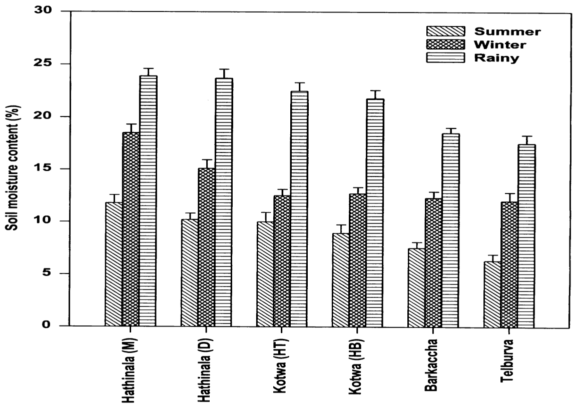

Fig. 1. Seasonal variations in soil moisture content for six different study sites (May 1996- June 1997); Vertical bars represent ± 1SE; M = moist site, D = dry site, HT = hill top, HB = hill base.

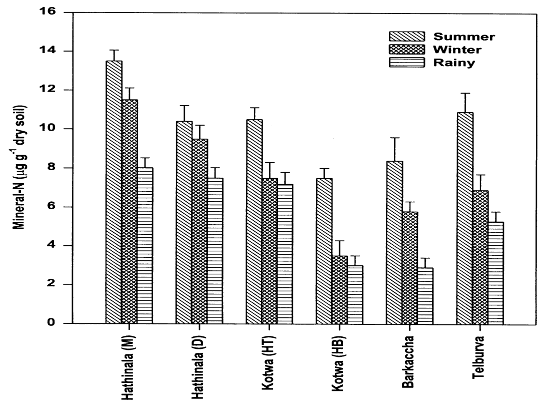

Fig.2. Seasonal variations in mineral-N content for six different study sites (May 1996- June 1997); Vertical bar represent ± 1SE; M = moist site, D = dry site, HT = hill top, HB = hill base.

seasons. Amongst different study sites, mineral-N content was highest at Hathinala moist site (annual mean 10.9 ± 1.5 µg g^{-1} dry soil) and lowest at Kotwa hill base site (annual mean 4.7 ± 1.3 µg g^{-1} dry soil). ANOVA indicated that differences in mineral-N content due to sites ($F_{5, 48}$ = 10.29; p = < 0.001), seasons ($F_{2, 51}$ = 16.26; p = < 0.001) and site x season ($F_{10, 36}$ = 3.12; p = < 0.007) were significant.

N-mineralization and nitrification rates

N-mineralization and nitrification rates in all sites were highest during the rainy season and lowest during the summer season (Table 2). Differences in N-mineraliation and nitrification rates due to sites ($F_{5, 48}$ = 5.30; p = < 0.0006, and $F_{5, 48}$ = 5.39; p = 0.0006, respectively) and seasons ($F_{2, 51}$ = 35.43; p = < 0.001 and $F_{2, 51}$ = 35.11; p = < 0.0001, respectively) were significant. The site x

Table 2. Seasonal averages of N-mineralization and nitrification rates (µg g^{-1} mo^{-1} ± 1SE) at different investigated sites (1996-1997) by the burried bag method for the upper 10 cm of soils.

Sites	Seasons			Annual mean
	Rainy	Winter	Summer	
	N-mineralization			
Hathinala (M)	37.7 ± 0.5	24.6 ± 2.2	11.8 ± 2.1	24.7 ± 7.5
Hathinala (D)	33.5 ± 1.7	19.8 ± 1.9	9.6 ± 1.9	20.9 ± 6.9
Kotwa (HT)	31.9 ± 1.0	17.3 ± 2.2	8.2 ± 1.3	19.1 ± 6.9
Kotwa (HB)	16.9 ± 0.6	9.3 ± 1.6	4.3 ± 0.1	10.2 ± 3.7
Barkaccha	16.4 ± 0.8	9.2 ± 1.7	4.7 ± 0.1	10.1 ± 3.4
Telburva	20.3 ± 3.8	2.9 ± 0.4	0.6 ± 0.1	7.9 ± 6.2
	Nitrification			
Hathinala (M)	25.6 ± 0.8	17.7 ± 2.9	6.7 ± 0.5	16.6 ± 5.5
Hathinala (D)	22.0 ± 0.6	14.8 ± 2.3	5.7 ± 0.6	14.2 ± 2.7
Kotwa (HT)	15.8 ± 1.2	8.1 ± 1.8	3.1 ± 0.1	8.9 ± 3.7
Kotwa (HB)	15.3 ± 1.1	6.8 ± 1.3	2.6 ± 0.2	8.2 ± 3.8
Barkaccha	13.8 ± 1.3	6.8 ± 1.2	2.4 ± 0.3	7.7 ± 3.3
Telburva	8.1 ± 1.1	3.2 ± 0.5	1.2 ± 0.1	4.1 ± 2.0

M = moist site, D = dry site, HT = hill top, HB = hill base.

season interactions were also significant for N-mineralization ($F_{10, 36}$ = 108.45; p = < 0.0001) and nitrification ($F_{10, 36}$ = 35.58; p = < 0.009).

The increase in N-mineralization and nitrification rates during the wet season was much more conspicuous for the Hathinala moist site than other sites (Table 2). N-mineralization and nitrification rates were significantly related to soil moisture and mineral-N at all the study sites, but while the slopes of relationships were positive for soil moisture, and they were negative for mineral-N (Table 3).

Discussion

The present study indicate significantly lower organic-C and organic-N in Telburva savanna soil than remaining sites, and it may result due to (a) by prominent deforestation by people for fuel purpose (b) intensive cattle grazing, and (c) heavily eroded surface area (unpublished observation). All these three factors may attribute to low input of organic matter into the soil. The contact between the plant residues and microbes in erosional soil is reduced and may result in lower decomposition. Thus, inputs of organic matter decreases and output of soil organic matter increases in erosional soils. According to Srivastava & Singh (1991), deforestation (conversion of forest into cropland) may result in loss of 51.2% organic-C, and 52.7% organic-N in the Vindhyan plateau. The Hathinala moist site had significantly higher organic-C, N, WHC and soil moisture content which may be due to increased input of organic matter by plant residues (litter) of dense Sal forest. Singh & Singh (1993) reported that most organic matter input in tropical forest soil is in the form of litter fall. The presence of adequate soil moisture and neutral pH in all the three seasons in Hathinala moist site enhances microbial activity, as a result greater input of carbon and nitrogen occurs in the soil via higher decomposition rate.

Our study sites are located in a region characterized by strong seasonality, varied topography and vegetational cover with nutrient deficient soil, which correspond to strong seasonality in nutrient availability, N-mineralization and nitrification rates (Fig. 2 and Table 2). This is in conformity to other reports for seasonally dry tropical forests, savannas and

Table 3. Regression parameters, correlation coefficients and significance levels for the relationships of N-mineralization and nitrification rates by burried bag method (Y, µg g^{-1} mo^{-1}) with soil moisture (X, %) and mineral-N contents (X, µg g^{-1} dry soil) for study sites for the upper 10 cm soil. Regression analyses were performed on seasonal pooled data.

X-variable	a	b	n	r^2	p
		N-mineralization			
Soil moisture[a]	4.39	0.95	54	0.96	0.0000
Soil moisture[c]	1.89	0.06	54	0.97	0.0000
NH_4^+-N[b]	2.40	-0.70	54	0.69	0.0051
NH_4^+-N[a]	4.62	-0.19	54	0.57	0.0122
NO_3^--N[b]	1.98	-0.59	54	0.94	0.0000
NO_3^--N[c]	1.30	-0.06	54	0.85	0.0004
Mineral-N[b]	2.87	-0.64	54	0.84	0.0004
Mineral-N[c]	2.11	-0.06	54	0.70	0.0004
		Nitrification			
Soil moisture[a]	6.18	0.96	54	0.99	0.0000
Soil moisture[c]	2.02	0.06	54	0.98	0.0000
NH_4^+-N[b]	1.88	-0.54	54	0.68	0.0061
NH_4^+-N[a]	4.17	-0.18	54	0.52	0.0223
NO_3^--N[b]	1.54	-0.46	54	0.93	0.0000
NO_3^--N[c]	1.16	-0.05	54	0.80	0.0014
Mineral-N[b]	2.40	-0.49	54	0.83	0.0006
Mineral-N[c]	1.97	-0.06	54	0.65	0.0073

[a]$Y = aX^b$ (a is in log), [b]$Y = \exp(a + bX)$, [c]$Y = a + bX$

croplands (Jha *et al.* 1996a; Roy & Singh 1995). Highest concentration of mineral-N ($NH_4^+ - N + NO_3^- - N$) in the soil occurred during the dry period while the lowest concentrations were recorded for wet period. Similar dry season's maximum of mineral-N has been reported from other dry tropical ecosystems (Jha *et al.* 1996b; Neill *et al.* 1995; Roy & Singh 1995). High concentration of mineral-N during the dry period may reflect low vegetation demand for the nutrients and increase in supply due to microbial cell death (Jaramillo & Sanford 1985). Air drying of soil and subsequent microbial cell death increases available soil-N (Okano 1990). The low concentration of mineral-N during the wet season could be due to heavy nutrient demand by vigorously growing plants (Singh *et al.* 1989) which is shown to be correlated with fine root dynamics (Roy & Singh 1995). Further, leaching, surface runoff and denitrification may also contribute to this reduction.

The rainy season maximum and summer season minimum N-mineralization and nitrification rates at all study sites, reflected in the reciprocal relationship between these rates and the size of mineral-N pools (Table 3). A greater significant positive relationship of N-mineralization and nitrification rates with soil moisture (Table 3) and a sharp increase in the "N-mineralization and nitrification rates" with the onset of rainfall indicated that both the processes were strongly water limited. Stottlemyer & Toczydlowski (1999) also reported maximum N-mineralization and nitrification rates in increased soil moisture condition in a mature boreal forest in Michigan. Vestgarden *et al.* (2003) found greater *in situ* N-mineralization and nitrification during the month of September and October in Scot pine (*Pinus sylvestris* L.) stand at Amli, southern Norway. Owen *et al.* (2003) found lower rates of both processes in a forest ecosystem in north-eastern Taiwan during the summer, which were positively related to soil moisture content. As in the present study they also showed that N-mineralization rate was positively correlated with $NO_3^- - N$ content (nitrification rate) of the soil. Similar to the present study, a pronounced seasonal variation of gross nitrification rate was reported by Kiese *et al.* (2002) from intact soil cores from a Montana tropical rainforest site in the Atherton Table lands (Kauri Creek) and from a lowland tropical rain forest site in the coastal lowlands (Bellenden Ker), Queensland, Australia. Singh *et al.* (1989) suggested that main sources of easily mineralizable N during the wet period could be the high wet season turnover of microbial biomass in organic-C rich soil in dry tropical forest ecosystem. This might be the possible reason for higher N-mineralization rate in Hathinala moist site than the rest of the study sites.

Our study indicated that the N-mineralization and nitrification rates differ significantly across the study sites, the highest values were recorded for Hathinala moist site and lowest for Telburva savanna site (Table 2). It has been suggested that vegetational cover and topographic situation may greatly influence the rate of N-mineralization and nitrification in dry tropical deciduous forest ecosystem (Raghubanshi 1992). Vegetation also affects N-mineralization through litter quality and quantity (Berg & Staff 1981). Since site and season interaction was significant in the present investigation, it may be argued that action of season across the study site was different and may be related to topographic characteristic of each site, including vegetational cover, quality and quantity of soil organic matter, organic-N and/or N-mineralization and nitrification rates. Soil organic matter improves aeration of the soil, which is crucial for the functioning of microorganism in soil. Thus, higher organic-C in the soil of Hathinala moist forest site (dominated by Sal) may be attributed to higher N-mineralization and nitrification rate than the Telburva savanna site.

All the investigated sites in present study were characterized by a strong seasonal variation in N-mineralization and nitrification rates. Greater N-mineralization and nitrification rates during the wet period in comparison to dry period led to greater significant positive relationship of N-mineralization and nitrification rate with soil moisture. The result indicate that at these nutrient poor sites, greater N-mineralization and nitrification were needed during the wet period to furnish strong demand of inorganic-N by the plants to support their growth during this period. Further, it may be concluded that each of the study sites had distinct rates of N-mineralization and nitrification rates, possibly in response to distinct in vegetational cover, topography, soil moisture content and nutrient status. Low N-mineralization and nitrification rates at Telburva savanna site, in comparison to forest sites, result due to low soil moisture, WHC and organic-C content. For the present study, the ranking was Hathinala moist site > Hathinala dry site > Kotwa hill top > Kotwa hill base > Barkaccha > Telburva.

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