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Research Article

EFFECT OF ANTHROPOGENIC ACTIVITIES ON MICRO-ENVIRONMENT AND SOIL CHARACTERISTICS ALONG DISTURBANCE GRADIENT IN THE SUB-TROPICAL FOREST OF MIZORAM NORTH EAST INDIA

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ABSTRACT
This study was conducted during 2010-2011 (pre-monsoon and post-monsoon seasons) to determine effect of anthropogenic disturbances (extraction of timber, collection of fuel-wood, sandstone extraction, developmental activities) on soil characteristics and status of nutrients in the sub-tropical forest of Mizoram, North East India. Three stands, one each representing undisturbed (disturbance index <10%), moderately disturbed (disturbance index 10 to 50%) and highly disturbed (disturbance index (>50%) stands were demarcated for detailed study. The results depict that anthropogenic activities led to thinning of vegetation mainly woody plants, and resulted into change in micro-environment, forest floor and soil characteristics. The concentration of nutrients namely, organic carbon, total nitrogen and available phosphorus was decreased from undisturbed to highly disturbed forest stands. Increase in C: N ratio from undisturbed to highly disturbed stand, indicating loss of soil fertility with increase in degree of disturbance. High rate of litter decomposition leads to soil pH more acidic in top-soil during post-monsoon season. The organic carbon, total nitrogen and available phosphorus contents were reported high in top-soil, with exception that the phosphorus content was generally higher in sub-soil during post-monsoon season that could be linked with leaching with percolating water.

Key Words: *Anthropogenic Disturbance, Sub-Tropical Forest, Top-Soil and Sub-Soil, Vegetation*

INTRODUCTION
The northeast India is known for it's very high plant diversity and regarded as hot spot of biodiversity, and is an extension of the eastern Himalayan complex. Rao and Hijra (1986) have reported that about fifty per cent species of Indian flora is confined to this part of country. Highly undulating topography leads to marked vegetation composition irrespective of forest type and distance (Mishra *et al.*, 2003, 2004, 2005). Change in species composition is one of the major causes for determination of status and release of nutrients in soil, as chemical composition of soil is largely governed by nature of vegetation (Mishra and Laloo, 2006).

The disturbance is one of the major factors, which determines plant communities in natural ecosystems and status of soil nutrients (Armesto and Pickett, 1985). Destruction of forest is responsible for alteration in vegetation composition in terms of habits (Mishra *et al.*, 2004).

The present study was conducted with an aim to study effect of anthropogenic disturbance on micro-environment, forest floor and soil characteristics in the sub-tropical forest of Tanhril area in Aizawl district of Mizoram.

Description of Study Area and Study Site
The Mizoram (21° $56^{'}$- 24° $31^{'}$ N and 92° $16^{'}$- 93° $26^{'}$ E) is one of the 8 states fall under northeast India, and covers an area of 21,081 km^2. The tropic of cancer divides the state into two almost equal parts. The state is bordered by Myanmar to the east and south, Bangladesh to the west , and by the states of Assam, Manipur and Tripura to the north. In local Mizo language, Mizoram means land of highlanders, rise to just more than 2000 metre asl near the Myanmar border.

Aizawl (21° $58^{'}$- 21° $85^{'}$ N and 90° $30^{'}$- 90° $60^{'}$ E), the state capital which is 1132 metre asl. The altitude in Aizawl district varies from 800 to 1200 metre asl. The study site Tanhril (altitude 875 metre asl) is situated in the west part of the district. The major anthropogenic activities are extraction of timber, collection of fuel-wood, cattle grazing, developmental activities and sandstone quarrying. Sandstone quarry is prevalent following excavation method.

The climate of the area is typically monsoonic. The annual average rainfall is amounting to *ca.* 2350 mm. The area experiences distinct seasons. The ambient air temperature ranges from 20 to 30 ^{0}C in summer and 11 to 21 ^{0}C in winter. The forest vegetation falls under three major categories i.e., tropical wet evergreen forest, tropical semi-evergreen forest and sub-tropical forest (Champion & Seth 1968). The important tree species in the forests are *Schima* spp., *Quercus* spp, *Rhus* spp., *Glochidion* spp., *Artocarpus* spp., *Shorea robusta, Tectona grandis.*

For detailed study, one study plot (200m x 200m) each representing undisturbed (disturbance index <10%), moderately disturbed (disturbance index 10 to 50%) and highly disturbed (disturbance index >50%) forest stands were demarcated.

MATERIALS AND METHODS

The study was conducted during 2010-2011 and soil samples were collected in pre-monsoon (April to May) and post-monsoon (September to October) seasons from top layer nutrient uptake zone (0-15 cm) and sub-layer (15-30 cm). The samples were analysed for total kjeldahl nitrogen (TKN), available phosphorus (Molybdenum blue method) and organic carbon (Walkley & Black method). Soil moisture content was determined gravimetrically by drying 10 gram of field-moist sample at 105^{0}C for 24 hours in a hot air oven. Soil pH was measured electrometrically by digital pH meter using 1:2.5 suspensions of soil and water. The methods as outlined in Allen *et al.,* (1974) and Anderson and Ingram (1993) were adopted for analysis of chemical composition of soil. The C: N ratio was also calculated.

Accumulation of litter was determined by collecting litter samples from the forest floor by using quadrat (0.5m x 0.5m size) method. Litter thickness was also measured in each forest stand.

The micro-environmental conditions such as ambient and soil temperature, humidity and light intensity were also measured during the time of sampling.

RESULTS

Micro-Environment

Ambient temperature was increased from undisturbed to highly disturbed stand. A similar trend in result was noticed for soil temperature and values were lower than air temperature in all cases. The values of air and soil temperature were higher during pre-monsoon season. Relative humidity decreased from undisturbed to highly disturbed stand, and values were higher during post-monsoon season. Likewise, light interception followed a similar trend of results in Table 1.

Forest Floor Characteristics

The litter thickness declined from undisturbed to highly disturbed stand, and it was higher during post-monsoon season. On the contrary, litter accumulation on forest floor followed reverse trend in results, and more values were observed during pre-monsoon season in Table 2.

Soil Characteristics

Soil moisture content was decreased from undisturbed to highly disturbed stand. Top-soil had more moisture content than sub-soil, and greater values were recorded during post-monsoon season. The soil pH was in acidic range and acidity decreased from top-soil to sub-soil during pre-monsoon season; however, it was increased from top-soil to sub-soil during post-monsoon season. The organic carbon, total nitrogen and available phosphorus decreased from undisturbed to highly disturbed stands. Top-soil had higher organic carbon and nitrogen contents in all stands; however, available phosphorus content was high in sub-soil during post-monsoon season with some exceptions. The C: N ratio was increased from undisturbed to highly disturbed standin Table 3.

Table 1: Micro-environment in the undisturbed, moderately disturbed and highly disturbed forest stands

Forest stand	Parameter						
	Air temperature (^{0}C)		Soil temperature (^{0}C)		Relative humidity (%)		Light interception (%)
	Pre-monsoon season	Post-monsoon season	Pre-monsoon season	Post-monsoon season	Pre-monsoon season	Post-monsoon season	
Undisturbed stand	27.4±1.5	25.5±1.1	21.5±0.4	22.4±1.4	53±2.5	59±4.1	83±7.4
Moderately disturbed stand	30.5±1.6	27.0±1.8	22.3±1.1	23.7±1.7	50±2.9	56±2.6	71±4.8
Highly disturbed stand	34.2±1.0	29.9±1.6	24.9±1.0	24.7±1.2	37±2.4	52±2.5	53±5.9

±, Standard error

Table 2: Forest floor characteristics in the undisturbed, moderately disturbed and highly disturbed forest stands

Forest stand	Parameter			
	Litter thickness (cm)		Litter accumulation (kg ha^{-1})	
	Pre-monsoon season	Post-monsoon season	Pre-monsoon season	Post-monsoon season
Undisturbed stand	2.1±0.5	2.6±0.7	7970±59	5830±893
Moderately disturbed stand	1.7±0.9	2.3±0.5	5650±82	4270±74
Highly disturbed stand	1.2±0.6	1.4±0.5	3050±59	2830±56

Abbreviation: ±, Standard error

Table 3: Soil characteristics in the undisturbed, moderately disturbed and highly disturbed forest stands

Soil characteristics	Soil Depth (cm)	Seasons/ Forest stands					
		Pre-monsoon			Post-monsoon		
		UD	MD	HD	UD	MD	HD
Soil moisture content (%)	0-15	30 ±2.1	25 ±1.7	21 ±2.3	44 ±3.4	39 ±2.9	35±2.5
	15-30	24 ±1.3	19 ±2.2	15 ±0.9	27 ±1.7	30 ±2.3	31±2.6
Soil pH	0-15	4.6 ±0.12	5.1 ±0.14	5.2 ±0.16	5.7 ±0.21	5.8 ±0.17	5.5 ±0.16
	15-30	4.8 ±0.08	5.5 ±0.10	5.7 ±0.11	5.2 ±0.12	5.1 ±0.11	5.3 ±0.15
Organic carbon (%)	0-15	3.4 ±0.10	3.2 ±0.09	2.7 ±0.11	2.9 ±0.11	2.6 ±0.13	2.4 ±0.12
	15-30	2.6 ±0.13	2.4 ±0.11	2.1 ±0.12	2.3 ±0.15	1.9 ±0.09	1.6 ±0.09
Total kjeldahl – N (%)	0-15	0.28 ±0.02	0.24 ±0.01	0.18 ±0.01	0.26 ±0.02	0.21 ±0.02	0.19 ±0.03
	15-30	0.20 ±0.01	0.17 ±0.02	0.12 ±0.02	0.19 ±0.03	0.14 ±0.03	0.10 ±0.01
C/N ratio	0-15	12.14 ±0.4	13.33 ±0.6	15.00 ±0.5	11.15 ±0.5	12.38 ±0.9	13.16 ±1.0
	15-30	13.00 ±0.3	14.12 ±0.8	17.5 ±1.2	11.58 ±0.16	13.57 ±0.9	16.00 ±0.7
Available – P x10^{-2} (%)	0-15	0.26 ±0.04	0.20 ±0.05	0.14 ±0.03	0.30 ±0.05	0.30 ±0.07	0.28 ±0.06
	15-30	0.24 ±0.05	0.20 ±0.04	0.10 ±0.03	0.32 ±0.04	0.36 ±0.03	0.23 ±0.02

Abbreviation: ±= Standard error ; UD= undisturbed stand ; MD= Moderately disturbed stand ; HD= Highly disturbed stand.

DISCUSSION

The status of nutrients in soil is largely depending upon nature and extent of vegetation (Mishra and Laloo, 2006). Release of nutrients from litter through decomposition process is recognized as an important part of the nutrient cycle whereby essential mineral elements tied up in the plant biomass are made available for further plant growth (MacLean and Wein, 1978). Litter layer plays an important role in forest growth on soils (Perala and Alban, 1982) and leaf litter accumulation enhances soil chemicals (Singh and Mudgal, 2000). The finding of present study was supported by the above statement.

Microbial growth and activity are highly determined by soil pH (Alexander, 1977). The pH range as noticed during present study indicated high microbial biomass and it was a favourable condition. Arunachalam and Pandey (2003) have also argued that the pH range of 4.5 to 6.0 supports optimum bacterial and fungal growth. Availability of organic carbon is important in controlling nutrient cycling and soil biological activity. Greater organic carbon content in top-soil and soil under undisturbed condition indicating more microbial biomass, which may be due to increased moisture content (Arunachalam *et al.*, 1996, Arunachalam and Pandey 2003, Mishra and Laloo 2006 and Mishra 2011). Fine particles (clay) helped in retention of more organic carbon and nitrogen under undisturbed condition. Arunachalam and Pandey (2003) have also reported a similar trend of results. Increased nitrogen content in soil under undisturbed condition depicts high rate of litter decomposition, the decomposition rate is more rapid on nitrogen rich site (Gosz, 1981; Vitousek *et al.*, 1994 and Prescott, 1995) and nutrient supply to the soil due to decomposition of litter is reduced with increase in degree of disturbance (Conn and Dighton, 2000 and Zimmer, 2002). Increased C: N ratio from undisturbed to highly disturbed stand, indicating loss of soil fertility with increase in level of disturbance (Arunachalan and Pandey, 2003; Mishra and Laloo, 2006 and Mishra, 2011)

Low available phosphorus in top-soils during post-monsoon season may due to (i) luxuriant growth of herbaceous species and tree seedlings that leads to more uptakes of phosphorus, and (ii) reduced mineralization and/or increased nutrient loss from top-soil through leaching and runoff (Vitousek *et al.*, 1982; Mishra and Laloo, 2006 and Mishra 2011).

The findings of the present study are in conformity with the work of Mishra (2009, 2010, 2011 and 2012) and Mishra and Laloo (2006).

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