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Full Length Research Paper

Vegetation composition and soil nutrients status from polyculture to monoculture

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The study was conducted on status of nutrients in three major types of forests namely, broad-leaved, mixed pine and pine forests in Meghalaya, considering altitude and seasonality as variables. The findings revealed that the change in micro-environmental conditions as influenced by attitude and seasonality has marked effect on status and release of nutrients in the soil of representative forest stands at markedly difference. The ambient and soil temperature was sharply greater at high altitude (Upper Shillong) and values were decreased from broad-leaved to pine forests. The soil temperature was lower than air temperature in all cases. The soil temperature at low altitude (Umroi) during post-monsoon season was higher than pre-monsoon season; however, on the contrary, it was higher during pre-monsoon season in other cases. The light interception decreased from broad-leaved to pine forests, and greater values were recorded at high altitude. The light interception and temperature played a key role in determining relative humidity, and as a result more relative humidity was recorded at high altitude and the values were decreased from broad-leaved to pine forests. The litter thickness and litter accumulation on forest floor at high altitude was about two fold greater than representative forest at low altitude. The values were higher during post-monsoon season, except that more litter thickness was noticed during pre-monsoon season at high altitude; this could be linked with high litter production and low rate of litter decomposition. Soil moisture content was always higher in top-soil, and post-monsoon season showed greater values. Soil pH ranged from 4.6 to 5.8 in top-soil, and from 4.8 to 6.3 in sub-soil. High rate of litter decomposition leads to greater soil pH in top-soil during post-monsoon season. The organic carbon, total nitrogen and available phosphorus contents were more in top-soil, with exception that the phosphorus content was generally higher in sub-soil during post-monsoon season. The values for soil moisture, organic carbon, nitrogen, and phosphorus were markedly higher at high altitude with respect to forest types and seasonality. Normally, the nutrient poor soil has high C:N ratio, and on account of this fertility of soil decreased from polyculture to monoculture. The finding reveal that the C:N ratio was increased from broad-leaved to pine forests, and more values were observed in sub-soil.

Key words: Altitude, monoculture, nutrient release, polyculture, seasonality, top-soil and sub-soil, vegetation.

INTRODUCTION

The plant communities in natural habitat are largely determined by disturbance, and anthropogenic activities such as clear felling of trees, collection of fuel-wood and grazing of domesticated animals are the major threat to habitat destruction and loss of biodiversity. Large scale destruction of forest leads to alteration in the vegetation landscape of a place, and as a result of this, pine gradually replaces broad-leaved species on the disturbed sites (Armesto and Pickett, 1985). In Northeast India, Meghalaya is known for very high plant diversity and regarded as hot spot of biodiversity (Ramakrishnan, 1992). This state occupies about 13% of the total geographic area of Northeast India. With its great topographic and climatic diversity, the state has perhaps a wide range of natural vegetation communities than any other part of the country. The range of vegetation communities has resulted in very rich flora from tropical mixed deciduous type to subtropical broad-leaved and/or pine forests, supporting diverse nature of soil. The climate of the state is monsoonic and the soil is lateritic and oxisol type (Pascoe, 1950). The major vegetation in Meghalaya falls under broad-leaved (tropical and subtropical evergreen and semi-evergreen forests and moist deciduous forest), broad-leaved with pine and pine forests, and they covers about 48.3, 4.5 and 7.1% of the total geographical area of the state, respectively (Porwal et al., 2001). In the state, pine forests are confined between 800 and 2000 m asl (Mishra and Laloo, 2006). In the last few decades, continued struggle between human population and resource need have led to massive destruction of forests, leading to change in vegetation and finally replacement of broad-leaved species with pine (Mishra et al., 2004; Mishra, 2010).

Despite disturbance and type of forest, the change in vegetation composition in similar type of forest situated in vicinity but at varied altitude is a peculiar characteristic of the forests in Meghalaya. The status and release of nutrients in forest soil are highly linked with micro-environment, litter dynamics, altitude and type of vegetation. Polyculture supports nutrient enrichment condition, and on the contrary monoculture land is nutrient poor (Mishra and Laloo, 2006; Mishra, 2010).

The present research work was an attempt to determine how status and release of nutrients in soil are linked with altitude and seasonality in similar and different kinds of forests.

MATERIALS AND METHODS

For detailed study, two sampling stations were selected in Meghalaya at varied altitude, that is, 1000 to 1100 m asl (Umroi), and 1900 to 2000 m asl (Upper Shillong). The soil samples were collected from top layer nutrient uptake zone (0 to 15 cm) and sub-layer (15 to 30 cm) during pre-monsoon (April to May) and post-monsoon (September to October) seasons. The soil samples were analysed for total kjeldahl nitrogen (TKN), available phosphorus (Molybdenum blue method) and organic carbon (Walkley and Black method). Soil moisture content was determined gravimetrically by drying 10 g of field-moist sample at 105℃ for 24 h in a hot air oven. Soil pH was measured electrometrically by digital pH meter using 1:2.5 suspensions of soil and water. For all analyses, 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. The micro-environment (ambient and soil temperature, humidity and light interception) was measured at the time of sampling. Accumulation of litter was determined by collecting litter samples from the forest floor by using quadrat (0.5 × 0.5 m size) method. Litter thickness was also measured in each forest stand.

RESULTS AND DISCUSSION

Vegetation composition

Vegetation composition at low altitude depicts that *Schima wallichii* (dominant), *Castanopsis tribuloides, Garcinia cowa, Castanopsis kurzii* and *Callicarpa arborea* were important tree species in broad-leaved;. *S. wallichii* was replaced by pine in mixed pine and pine forests. The other important tree species were *Saurauia roxburghii*, *Erythrina stricta* and *Kydia calycina* in mixed pine forest, and *Fucus gibbosa*, *Persea gamblei, Persea gamblei* and *Wendlandia ligustrina* in pine forest. Theaceae, the dominant family in broad-leaved forest was replaced by Pinaceae in mixed pine and pine forests. The co-dominant families were Fagaceae, Clusiaceae, Verbenaceae and Lauraceae in broad-leaved; Saurauiaceae, Lauraceae and Fabaceae in mixed pine, and Moraceae, Anacardiaceae and Lauraceae in pine forest. Similarly, vegetation composition in the forests at high altitude showed that *Phoebe attenuata* was dominant species in broad-leaved forest, and other important species in the forest were *Myrica esculenta, Quercus griffithii, Lindera latifolia,* and *Knema linifolia*. The co-dominant species were *P. gamblei, Litsea salicifolia, Prunus cerasoides* and *Morus indica* in mixed pine forest, and *Schima wallichii, Eurya acuminate, M. esculenta* and *Rhododendron arboretum* in pine forest. Lauraceae, the dominant family of broad-leaved forest was replaced by Pinaceae in mixed pine forest; however, Theaceae became co-dominant family in pine forest. Other important families in later case were Lauraceae, Myricaceae and Ericaceae. The co-dominant families were Myricaceae, Fagaceae, Myristicaceae and Symplocaceae in broad-leaved forest; Rosaceae, Anacardiaceae and Moraceae.

Micro-environment

Ambient and soil temperature increased from broad-leaved to pine forests, and it was markedly low in representative forest at high altitude. Soil temperature was always lower than air temperature in representative forest type. At Umroi, the temperature ranged from 27.4 to 34.2℃ for air and 21.5 to 24.9℃ for soil during pre-monsoon season, and from 25.5 to 29.9℃ for air and from 22.4 to 24.7℃ for soil during post-monsoon season. Similarly, at Upper Shillong, temperature ranged from 15.6 to 21.6℃ for air and from 12.8 to 17.7℃ for soil during pre-monsoon season, and from 13.2 to 17.9℃ for air and from 10.2 to 13.8℃ for soil during post-monsoon season. Relative humidity was highly governed by ambient temperature and there was inverse relationship between these two parameters. The relative humidity decreased from broad-leaved to pine forests, and values were markedly high in the forests at high altitude, and greater values were recorded during post-monsoon season. At low altitude, the highest value (59%) was noticed in broad-leaved forest during post-monsoon season, however, lowest value (37%) was observed in pine forest during pre-monsoon season. Similarly, the relative humidity was maximum (96%) in broad-leaved forest during post-monsoon season and minimum (73%) in pine forest during pre-monsoon season. The light interception followed a similar trend in result as in case of relative humidity, and the values were greater in the representative forest stand at high altitude. The values ranged from 53% in pine forest to 83% in broad-lead forest at low altitude, and from 58% in pine forest to 94% in broad-leaved forest at high altitude. The values for all the parameters were in between broad-leaved and pine forests, in case of mixed pine forests.

Forest floor characteristics

The litter thickness and its accumulation on forest floor at high altitude were markedly high. The litter thickness in different types of forests at Upper Shillong was about two fold higher than that of representative forest stand at Umroi, and the values declined markedly from broad-leaved to pine forest at both the places. The greater values were recorded during post-monsoon season at Umroi. On the contrary, pre-monsoon season showed higher values at Upper Shillong. During pre-monsoon season, the value was decreased from 2.1 cm in broad-leaved forest to 1.2 cm in pine forest at Umroi, and from 4.7 cm in broad-leaved to 3.0 cm in pine forest at Upper Shillong. However, during post-monsoon season, there was decline in value from 2.6 cm in broad-leaved forest to 1.4 cm in pine forest at Umroi; from 4.2 cm in broad-leaved forest to 2.6 cm in pine forest at Upper Shillong. Similarly, the litter accumulation on forest floor was also decreased from broad-leaved to pine forest, and more values were observed during pre-monsoon season. The litter accumulation was amounting to 7970 $kgha^{-1}$ in broad-leaved forest and 3050 $kgha^{-1}$ in pine forest at Umroi and 10290 $kgha^{-1}$ in broad-leaved forest and 5640 $kgha^{-1}$ in pine forest at Upper Shillong, during pre-monsoon season. However, values decreased from 5830 $kgha^{-1}$ in broad-leaved to 2830 $kgha^{-1}$ in pine forest at Umroi, and from 8660 $kgha^{-1}$ in broad-leaved to 3370 $kgha^{-1}$ in pine forest during post-monsoon season at Upper Shillong. The mixed pine forests showed all the values in between broad-leaved and pine forests.

Soil characteristics

Soil moisture content was markedly higher (from 32% for sub-soil in pine forest to 74% for top-soil in broad-leaved forest) in forests at Upper Shillong than Umroi (from 15% for sub-soil in pine forest to 44% for top-soil in broad-leaved forest). Top-soil possessed more moisture content than sub-soil, and greater values were recorded during post-monsoon season. There was a marked variation in values from top-soil to sub-soil in the forests at Upper Shillong. 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. Soil pH ranged from 4.5 to 5.8 in top-soil and from 4.8 to 6.3 in sub-soil.

Top-soil had higher organic C and TKN in all types of forests during both the seasons, however, available phosphorus contents was high in sub-soil during post-monsoon season with some exceptions. The organic C, TKN and available phosphorus decreased from broad-leaved to pine forest. The values were markedly higher in the representative forests at Upper Shillong. The organic C content ranged from 1.6% in sub-soil of pine forest during post-monsoon season to 3.4% in top-soil of broad-leaved forest during pre-monsoon season at Umroi; from 2.6% in sub-soil of pine forest during pre-monsoon season to 5.2% in top-soil of broad-leaved forest during post-monsoon season at Upper Shillong. Similarly, the TKN value ranged from 0.12% in sub-soil of pine forest to 0.28% in top-soil of broad-leaved forest during pre-monsoon season at Umroi; from 0.21% in sub-soil of pine forest to 0.58% in top soil of broad-leaved forest during post-monsoon season at Upper Shillong. The available phosphorus ranged from 0.0014 to 0.0042% in top soil, and from 0.001 to 0.0046% in sub-soil. The values were higher in sub-soil than top-soil during post-monsoon season at both altitudes. The C:N ratio increased from broad-leaved to pine forests, more values were recorded in sub-soil. Normally, low C:N ratio was noticed during post- monsoon season, and soil at Umroi had higher values than Upper Shillong in representative forest. The values ranged from 8.96 to 12.14 for top-soil and from 10.30 to 13.00 for sub-soil in broad-leaved forests; from 9.40 to 13.57 for top-soil and from 11.48 to 14.12 for sub-soil in mixed pine forest; from 11.54 to 15.00 for top-soil and from 12.89 to 17.5 for sub-soil in pine forests.

DISCUSSION

The result on vegetation composition was in conformity with the work of Mishra and Laloo (2006). Preponderance of pine and elimination of broad-leaved species from natural vegetation are highly linked with disturbance (Mishra et al., 2004, Mishra, 2010). The replacement of broad-leaved species with pine is an indicative of disturbance that impacted micro-environment of forest to a great extent (Mishra et al., 2004; Mishra and Laloo, 2006). The findings of present study are in support of the aforementioned statement and indicating increased degree of disturbance from broad-leaved to pine forest. Increase in temperature, and on the contrary decrease in relative humidity and light interception from broad-leaved to pine forest may be correlated with the disturbance with increased degrees from broad-leaved to pine forests. Marked variation in micro-environment at two altitudes is highly governed by ambient temperature that determines other variables under any forest (Mishra et al., 2004; Mishra, 2010)

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 status and release of nutrients in soil is largely depending on nature of vegetation; polyculture leads to release more nutrients in soil than monoculture (Mishra and Laloo, 2006; Mishra, 2010). Release of nutrient 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 decomposition is highly governed by temperature. Increased litter thickness and litter accumulation of forest floor at high altitude (Upper Shillong) may be due to low rate of litter decomposition followed by low microbial activity (Mishra and Laloo, 2006; Mishra, 2010).

Microbial growth and activity are highly determined by soil pH (Alexander, 1977). The pH range of 4.3 to 6.0 as noticed during present study indicated high microbial biomass and it was more favourable in the forests at Upper Shillong. Arunachalam and Pandey (2003) have also argued that the pH range of 4.5 to 6.0 supports optimum bacterial and fungal growth. High pH in sub-soil during post-monsoon season may be due to leaching of chemicals through percolating water. Availability of organic C is important in controlling nutrient cycling and soil biological activity. Greater organic C content in soils at Upper Shillong indicated more microbial biomass, which may be due to increased moisture content. The finding of present study was in conformity with the work of Arunachalam et al. (1996), Arunachalam and Pandey (2003), Mishra and Laloo (2006), and Mishra (2010). Fine particles (clay) help in retention of more organic C and TKN in soil of upper Shillong than sandy soil of Umroi. Arunachalam and Pandey (2003) have also reported a similar result. Increased TKN in broad-leaved forest depicted high rate of litter decomposition, the decomposition rate is more rapid on nitrogen rich site (Gosz, 1981; Prescott, 1995). More release of nutrients in broad-leaved forests indicated enhanced rate of decomposition of mixed litter, which could be attributed to its diverse chemical composition as compared to single-species litter. Chemical composition of the leaf litter determines rate of decomposition (Vitousek et al., 1994), and nutrient supply to the soil due to decomposition of litter is enhanced from monoculture to polyculture (Conn and Dighton, 2000; Zimmer, 2002). Low available phosphorus in top-soils during post-monsoon season may due to (1) luxuriant growth of herbaceous species and tree seedlings that leads to more uptakes of phosphorus, and (2) reduced mineralization and/or increased nutrient loss from top-soil through leaching and runoff (Vitousek et al., 1982; Mishra and Laloo, 2006). Normally, nutrient poor soil shows high C:N ratio (Arunachalan and Pandey, 2003). Increased C:N ratio from broad-leaved to pine forest indicated that the soil in former case is nutrient rich, and in later case nutrient poor. High C:N ratio indicated low nitrogen content and/or high organic C content in the soil.

REFERENCES

Alexander M (1977). Introduction to soil microbiology. 2nd Ed. John Wiley and Sons, New York.

Allen AE, Grimshaw HM, Parkinson JA, Quarmby C (1974). Chemical Analysis of Ecological Materials. Blackwell Scientific Publications, Oxford.

Anderson JM, Ingram JSI (1993). Tropical Soil Biology and Fertility - A Handbook of Methods (2nd Ed), CAB International, Wallingford, U.K.

Armesto J, Pickett STA (1985). Experiments on disturbance in old-field plant communities: impact on species richness and abundance. Ecol., 66: 230-240.

Arunachalam A, Maithani K, Pandey HN, Tripathi RS (1996). The impact of disturbance on detrital dynamics and soil microbial biomass of a *Pinus kesiya* forest in northeast India. For. Ecol. Manage., 88: 273-282.

Arunachalam A, Pandey HN (2003). Ecosystem restoration of jhum fallows in northeast India: microbial C & N along altitudinal and successional gradient. Restoration Ecol., 11: 168-173.

Conn C, Dighton J (2000). Litter quality influences on decomposition, ectomycorrhizal community structure and mycorrhizal root surface acid phosphatage activity. Soil Biol. Biochem., 32: 489-496.

Gosz JR (1981). Nitrogen cycling in coniferous ecosystems. In: Terrestrial nitrogen cycles, F.E. Clark & T. Rosswall (ed.), Ecol. Bull. (Stockholm), 33: 405-426.

MacLean DA, Wein RW (1978). Weight loss and nutrient changes in decomposing litter and forest floor material in New Brunswick forest stands. Can. J. Bot., 56: 2730-2749.

Mishra BP (2010). A study on the micro-environment, litter accumulation on forest floor and available nutrients in the soils of broad-leaved, mixed pine and pine forests at two distinct altitude in Meghalaya, northeast India. Curr. Sci., 90(12): 1829-33.

Mishra BP, Laloo RC (2006). A comparative analysis of vegetation and soil characteristics of montane broad-leaved, mixed pine and pine forests of northeast India. In: P.C. Trivedi (ed.), Advances in Plant Physiology. I.K. International Publishing House, New Delhi, pp. 185-197.

Mishra BP, Tripathi OP, Tripathi RS, Pandey HN (2004). Effects of anthropogenic disturbance on plant diversity and community structure of a sacred grove in Meghalaya, northeast India. Bidivers. Conserv. 13(2): 421-436.

Pascoe EH (1950). A manual of the geology of India and Burma. Geological Survey of India, Government of India Publication, pp.24-26.

Perala DA, Alban DH (1982). Biomass, nutrient distribution and litterfall in Populus, *Pinus* and *Picea* stands on different soils in Minnesola. Plant Soil, 64: 177-192.

Porwal MC, Talukdar G, Singh H, Tripathi OP, Tripathi RS, Roy PS (2001). Biodiversity characterization at landscape level using Remote Sensing and Geo-spatial Modeling in Meghalaya. In: Biodiversity and Environment: Remote Sensing and Geographic Information System Perspectives, Roy PS, Singh S, Toxoleus AG (eds.), Indian Institute of Remote Sensing, Dehradun, pp. 206-215.

Prescott CE (1995). Does nitrogen availability control rates of litter decomposition in forests? Plant Soil, 1681-69: 83-88.

Ramakrishnan PS (1992). Shifting agriculture and sustainable development: an interdisciplinary study from north-eastern India, Man and Biosphere, 10, UNESCO, The Parthenon Pub. Group, Paris.

Singh JN, Mudgal V (2000). Assessment of mineral content of tree leaf litter on Nokrek Biosphere Reserve and its impact on soil properties. Trop. Ecol., 41: 225-232.

Vitousek PM, Gosz JR, Grier CC, Mellilo JM, Reiners WAA (1982). Comparative analysis of potential nitrification and nitrate mobility in forest ecosystems. Ecol. Monogr., 52: 155-177.

Vitousek PM, Turner DR, Parton WJ, Sanford RL (1994). Litter decomposition on the Mauna Loa environmental matrix, Hawin patterns, mechanisms, and models. Ecol., 75: 418-429.

Zimmer M (2002). Is decomposition of woodland leaf litter influenced by its species richness? Soil Biol. Biochem., 34: 277-284.