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VEGETATION CHARACTERIZATION AND LITTER PRODUCTION ON THE REHABILITATED MINED AREA OF MUSSOORIE HILLS, INDIA

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Abstract

The floristic diversity of four different age series in rehabilitated mined area which represents the degraded ecosystem was examined. Phytosociological analysis revealed that the highest number of plant species (38 nos.) including tree, shrubs, herbs and grasses were found in eight years old (Site II) rehabilitated site followed by eleven years old (Site I)and six years old (Site 3) (33 nos.) and least was in four years old Site IV (29 nos.). Maximum total basal area was represented by site I followed by site II, site III and site IV. With reference to annual litter production it was highest in Site I (5286 Kg/ha) followed by Site III (1193.2 Kg/ha), Site II (804.0 kg/ha) and least in Site IV (262.0 Kg/ha).

Keywords: *Phytosociological analysis; Vegetational composition; litter production; mined area.*

Introduction

Litter fall is a principal pathway for the return of nutrients to the soil and its deposition on the ground floor resides in the formation and renewal of forest floor, which helps in conservation of soil moisture and improves its physico-chemical properties. The transfer of matter and energy through litterfall maintains the integrity of an ecosystem. Litter which constitutes dead organic remains of forest vegetation, the carcasses of the herbivores and the predators of herbivores plays a significant role in determining the moisture status, runoff pattern and liberation of mineral elements accumulated in the aerial parts of the vegetation.

If surface litter is not removed and allowed to decompose and contribute to nutrient cycling, the soil can support higher productivity of trees by Miller [1]. The litter on the forest floor acts as input–output system of nutrient and the rates at which forest litter falls and subsequently, decomposes contribute to the regulation of nutrient cycling and primary productivity, and to the maintenance of soil fertility in forest ecosystems was done by Olson [2], Singh et al. [3], Fioretto et al. [4], Onyekwelu et al. [5] and Pandey et al. [6].

The significance of plant species diversity for ecosystem functioning is a central issue in current ecological research as per Hooper et al. [7] and Balvanera et al. [8]. According to Lorenzen et al. [9] and Spehn et al. [10], to date, most studies have focused on diversity–productivity relationships in experimental grasslands or forest plantations. In these studies, positive relationships have generally been found between primary productivity and plant

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species diversity by Spehn et al. [10]. In case of degraded restored ecosystem, selection of plant species which can survive in poor substratum (which is devoid of nutrients) is of prime importance to ameliorate the site. The process of litter production and decomposition varies with the plant species and within a species growing under different site conditions.

In this context, the quantitative evaluation of litter production and decomposition rates with respect to the vegetation characteristics offer an opportunity to understand ecosystem processes and those factors that control organic matter production and decomposition rates.

Materials and methods

Study area

The study area is located between 30^0 25’ to $30^0$30’ N Lat. and $78^0$0’ to $78^0$5’ E long. at an elevation of 1700- 1850m above msl, under Bhitreli reserved forest of Mussoorie Forest Division (Fig.1).

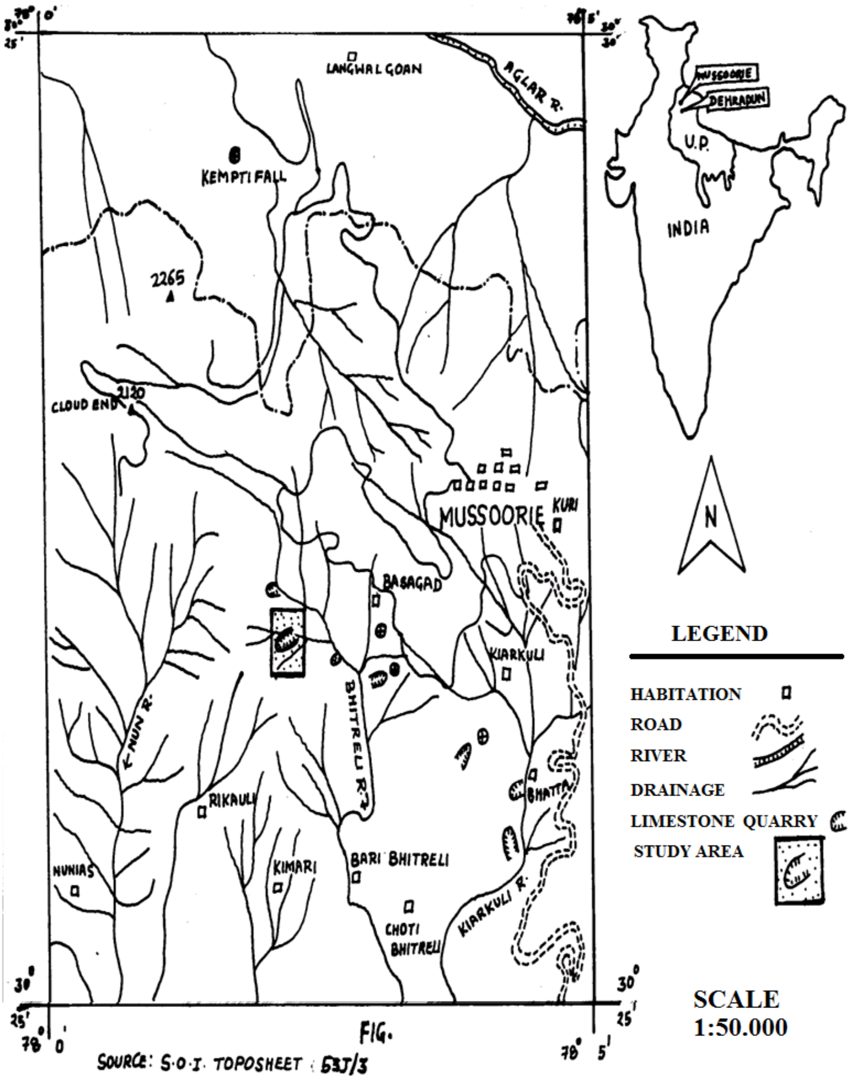

Fig. 1. Map of the study area

Study area (lambidhar) is entirely built on pure limestone and in krol belt (Fig. 2). Limestone is present in various forms such as dolomite, argillaceous-limestone etc. The climate of an area is rigorous dry for most part of the year. The year is broadly divided into three seasons viz., summer (April to mid June), rainy (mid June to mid September) and winter (November to March). Study site was divided into four different experimental sites according to their age as: Site I- Eleven years old rehabilitated plot; Site II- Eight years old rehabilitated plot; Site III- Six years old rehabilitated plot; Site IV- Four years old rehabilitated plot.

Fig. 2. General view of degraded limestone mine (Lambidhar)

Vegetation Analysis

To find out the relationships between vegetation structure, composition and organic matter accretion and decomposition, vegetation analysis of restored mined sites has been carried out during the course of present study. The vegetation survey was carried out by using litter plot sampling procedure by Misra [11]. Data obtained were quantitatively estimated for frequency, density and abundance by Curtis and Intosh [12]. The Importance Value Index (IVI) for each species was determined as the sum of relative frequency, relative density and relative dominance.

$$\text{Related frequency} = \frac{\text{frequency of the 'i' species}}{\text{total frequency of the plots}} \times 100 \qquad (1)$$

$$\text{Relative density} = \frac{\text{number of individuals of the species 'i'}}{\text{Total number of individuals in the plot}} \times 100 \qquad (2)$$

$$\text{Relative dominance} = \frac{\text{sum of the basal area of individuals of the same species}}{\text{total basal area of the plot}} \times 100 \qquad (3)$$

Importance Value Index (IVI) = relative dominance + relative frequency + relative density

Litter production

Litter production studies were carried out by litter plots using ground sampling method given by Medwecks-Kornas [13] and Suckachev & Dylis [14]. Three permanent litter plots of size 5X5m were laid out at three different points of each sites. All the litter plots were initially cleared. The litter accumulation over the month was collected and weighed to obtain the fresh weight and samples were brought to the laboratory for oven dry weight estimation at 80^0C till the constant weight.

Results and discussions

Vegetational Analysis

In four selected sites, the vegetative composition varies with age of site/ year of plantation are presented in Table 1. Maximum life forms were present in Site II represented by the presence of 38 nos. of species followed by Site I (33 nos. of species), Site III (33 nos.) and least in Site IV (29 nos.).

Table 1. Total Basal Cover (TBC) of different plant forms in study sites

Plant forms	Site I	Site II	Site III	Site IV
Trees	1	1	1	1
Shrubs	18	13	12	10
Herbs	5	10	8	8
Grasses	3	7	5	6
Seedlings	6	7	7	4
Total	**33**	**38**	**33**	**29**

Total Basal Cover for trees and shrubs ($cm^2/25m^2$) and herbs and grasses (cm^2/m^2) as reported in Table 2, was highest in Site I (161.88) followed by Site II (102.92), Site III (100.53) and lowest in Site IV (82.12). As Site I and Site II shown equal composition of plant forms but the sites greatly varied in TBC due to the highly variation in basal cover of shrubs (Site I - 127.74 whereas for Site III- 40.44).

In terms of vegetation, maximum number was reported in Site II but the total basal cover of all plant forms (102.92) was lower than Site I due to the variation in the TBC of shrubs (59.05) and herbs & grasses (12.67) in Site II. The least number of plant forms in Site IV contributed lowest basal cover (82.12).

Table 2. Number of species of different plant forms in four study sites

Plant forms	Site I	Site II	Site III	Site IV
Trees	30.16	31.20	39.60	3.17
Shrubs	127.74	59.05	40.44	71.35
Herbs and grasses	3.98	12.67	20.49	7.60
Total	161.88	102.92	100.53	82.12

The dominant species of trees, shrubs, herbs and grasses are shown in Table 3 and 4. The most dominant species of trees and shrubs with their *IVI* (*Importance Value Index*) were in order for Site I: *Eupatorium glandulosum* (79.04) > *Coriaria nepalensis* (60.51) > *Cupressus torulosa* (39.51) > *Hypericum patulum* (16.77) > *Nepeta hindostana* (12.40) whereas in case of herbs and grasses the most dominant species was *Bidens biternata* (156.76) followed by other species.

For Site II the order of the dominant species of tree and shrubs: *Eupatorium glandulosum (83.67) > Cupressus torulosa (61.29) > Rumex hastatus(30.51) > Hypericum patulum (26.43) > Debregeasia hypoleuca (15.87).* In case of herbs and grasses, the most dominant species was *Chrysopogon fulvus* (56.16) whereas *IVI* (*Importance Value Index*) of dominant trees and shrubs species (Site III) was in order: *Cupressus torulosa* (85.72) > *Eupatorium glandulosum* (60.48) > *Rumex hastatus* (36.31) > *Colebrookia oppositifolia* (26.47) > *Coriaria nepalensis*

(19.29) while in case of herbs and grasses (Table 4) the most dominant species was *Chrysanthemum leucanthemum* (85.08) followed by the other species. For Site IV, floristic composition of trees and shrubs with their dominance as: *Eupatorium glandulosum* (114.21) > *Artemisia roxburghii* (36.95) > *Hypericum patulum* (27.08) > *Rumex hastatus* (26.15) > *Debregeasia hypoleuca* (24.80). While in case of herbs and grasses (Table 4), the most dominant species with their IVI: *Artemisia roxbughii* (62.40).

Table 3. The *Importance Value Indices* (IVI) of dominant species of trees and shrubs in each sites

	Species	Frequency (%)	Density (Plants/25m^2)	Abundance	TBA (cm^2/25m^2)	IVI
Trees and Shrub species of Site I	*Eupatorium glandulosum*	80.00	17.60	22.00	52.45	79.04
	Coriaria nepalensis	80.00	9.40	11.75	49.73	60.51
	Cupressus torulosa	80.00	5.20	6.50	30.16	39.51
	Hypericum patulum	80.00	2.20	2.75	3.96	16.77
	Nepeta hindostana	60.00	1.40	2.33	3.50	12.40
Site II	*Eupatorium glandulosum*	100.00	14.20	14.20	29.68	83.67
	Cupressus torulosa	100.00	5.20	5.20	31.20	61.29
	Rumex hastatus	60.00	5.40	9.00	7.56	30.51
	Hypericum patulum	100.00	3.40	3.40	4.08	26.43
	Debregeasia hypoleuca	60.00	1.60	2.67	3.52	15.87
Site III	*Cupressus torulosa*	80.00	6.60	8.25	39.60	85.72
	Eupatorium glandulosum	80.00	9.60	12.00	11.23	60.48
	Rumex hastatus	60.00	4.40	7.33	8.80	36.31
	Colebrookia oppositifolia	40.00	3.60	9.00	5.87	26.47
	Coriaria nepalensis	40.00	1.00	2.50	7.20	19.29
Site IV	*Eupatorium glandulosum*	100.00	18.80	18.80	41.36	114.21
	Artemisia roxburghii	100.00	5.80	5.80	7.08	36.95
	Hypericum patulum	80.00	4.00	5.00	4.96	27.08
	Rumex hastatus	80.00	3.00	3.75	6.06	26.15
	Debregeasia hypoleuca	100.00	2.20	2.20	4.47	24.80

Table 4. The Importance Value Indices (IVI) of dominant species of herbs and grasses in each sites

	Species	Frequency (%)	Density (plants/m^2)	Abundance	TBA (cm^2/m^2)	IVI
Site I	*Bidens biternata*	60	18.80	31.33	2.26	156.76
	Cnicus wallichii	20	0.20	1.00	0.34	15.30
	Cymbopogon distans	20	0.40	2.00	0.21	12.86
	Oreganum vulgare	20	0.60	3.00	0.13	11.68
	Andrachne cordifolia	20	0.40	2.00	0.13	10.85
Site II	*Chrysopogon fulvus*	60	9.40	15.67	5.08	56.16
	Gentiana argentea	60	22.40	37.33	1.01	38.50
	Micromeria biflora	100	8.80	8.80	0.35	21.99
	Arthraxon lancifolius	60	4.00	6.67	1.20	19.57
	Apluda mutica	100	4.00	4.00	0.68	19.24
Site III	*Chrysanthemum leucanthemum*	40.00	11.80	29.50	11.56	85.08
	Galium aperine	60.00	3.60	6.00	4.32	35.51
	Apluda mutica	100.00	9.20	9.20	0.46	32.77
	Bidens biternata	100.00	5.80	5.80	0.52	26.19
	Chrysopogon fulvus	20.00	3.00	15.00	0.60	11.38
Site IV	*Artemisia roxburghii*	80.00	5.80	7.25	3.25	62.40
	Galium aparine	80.00	10.40	13.00	0.52	34.17
	Chrysopogon fulvus	60.00	3.40	5.67	1.29	30.16
	Arthraxon lancifolius	60.00	7.20	12.00	0.45	25.47
	Bidens biternata	80.00	3.80	4.75	0.37	21.23

Litter Return

Litter in Kg/ha along with percent contribution of litter production to the total litter in different age stand is shown in Table 5. The annual litter production in 11 years old rehabilitated site (Site I-5286.4 Kg/ha) was higher than that of eight years old (Site II - 804.0kg/ha), six years old (Site III-1193.2kg/ha) and four years old (Site IV-262.0kg/ha) rehabilitated area. This difference in litter production between the sites could be mainly attributed to species composition and their dominance. According to Sundarapandian and Swamy [15] tree species composition was important for litter production within the same climate range.

Table 5. Monthly litter fall (kg/ha) in four study sites

Sites	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
I	340.0 (6.43)	384.0 (7.26)	404.0 (7.64)	316.0 (5.98)	393.2 (7.44)	289.2 (5.47)	196.0 (3.71)	608.0 (11.50)	820.0 (15.51)	660.0 (12.48)	572.0 (10.82)	304.0 (5.75)	5286.4
II	60.0 (7.46)	44.4 (5.52)	72.4 (9.00)	67.2 (8.36)	172.0 (21.4)	154.4 (19.20)	64.0 (7.96)	12.0 (1.49)	28.0 (3.48)	33.6 (4.18)	80.0 (9.95)	16.0 (1.99)	804.0
III	100.0 (8.38)	60.4 (5.06)	100.0 (8.38)	110.4 (9.25)	152.0 (12.74)	200.0 (16.76)	68.0 (5.70)	108.0 (9.05)	80.0 (6.70)	79.2 (6.64)	75.2 (6.30)	60.0 (5.03)	1193.2
IV	48.0 (18.32)	16.0 (6.11)	24.4 (9.31)	17.2 (6.56)	14.8 (5.65)	5.6 (2.14)	8.0 (3.05)	8.0 (3.05)	20.0 (7.63)	12.0 (4.58)	48.0 (18.32)	40.0 (15.27)	262.0

*Figures in parenthesis refers to percentage contribution

The higher litter production in Site I was due to the presence of large number of shrub species than the other sites (Table 1). Shrubs generally have a quality to produce more foliage, which in turn is responsible for producing more organic matter. A regular increase in litter yield with increasing age of rehabilitated site in present study was also attributed due to the continuous development of community structure as well as canopy cover. The results of litter fall in the present study were in agreement with the study conducted in sodic lands by Tyagi [16] and Garg [17].

Whereas Site II recorded lower value of annual litter production than Site III the reason was due to the variations in plant composition and their behavior in these Sites. The species like *Coriaria nepalensis*, *Rumex hastatus* (shrubs), and *Cupressus torulosa* (tree) and grasses which have relatively high dominance in Site III than Site II was contributing more litter over the year in Site III.

Though the basal cover of shrubs in Site IV was comparatively higher, even than the litter production was very less comparatively to the other sites. It also depends on the foliar phenology and crown structure. This is an agreement with Binkley et al. [18].

Annual variation in litter production of four study sites shows statistically significant differences (Table 6).

Table 6. Statistical analysis of annual litter fall in four study sites

	Site I	Site II	Site III	Site III
Site I	–	185.40***	146.37***	255.01***
Site II	185.40***	–	6.55**	38.48***
Site III	146.37***	6.55**	–	62.42***
Site IV	255.01***	38.48***	62.42***	–

* P <0.05, **P < 0.01, *** P < 0.001

Conclusions

In conclusion, the selection of species in restored area is of prime importance. Although the study sites were belongs to the same climatic region but it was explained by the results of litter production that it was driven by the vegetation composition and the age of the plantation.

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