Composition and Diversity of Tree Saplings in Raniganj Coalfield of West Bengal

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Received: January 08, 2019 Accepted: February 21, 2019

ABSTRACT: *Present work reports the composition and diversity of tree saplings in an age series of overburden dumps in two Open Cast Project (OCP) - Bansra and Sonepur Bazari of Raniganj Coalfields. Garhjungle, a natural forest was also included to compare the status of tree sapling between a disturbed area and a natural forest. Overburden (OB) dumps of 1yr, 9yr, 12yr, 18yr and 21yr were present in Bansra OCP whereas, 3yr dump in Sonepur Bazari OCP. No saplings observe in 0yr and 1yr dump. Saplings of 19 tree species were recorded during the study out of which 12 belonged to Garhjungle exclusively. Leucaena leucocephala and Ziziphus jujuba in OB dumps and Shorea robusta in Garhjungle were the dominant species based on their importance values. Diversity indices varied among different OB dumps and Garhjungle. Number of saplings and species heterogeneity increased while evenness decreased with increase in dump age. Garhjungle showed high species turnover and low similarity when compared with OB dumps.*

Key Words: *Coal mining, Overburden, Species diversity, Tree sapling*

1. Introduction

In the progress of a country mining of coal plays an important role, though mining affects the local environment during the commercial exploitation of coal. Mining is generally operated either as opencast or underground depending on the depth of coal seam below the ground. Opencast mining results in removal of soil with vegetation which gathers and form overburden (OB) dumps. It causes destruction of ecosystem by changing topography, drainage system and loss of biodiversity (Chaulya, *et al.*, 2000). Revegetation of overburden dump was required to conserve the environment and its biodiversity (Hazarika, *et al.*, 2006). But top layer of OB dump is deficient in major nutrients which makes the establishment of plants difficult (Arshi, 2015). So, it is important to understand the vegetation status and soil properties in OB dump. In the present study documentation of composition and diversity of tree saplings in different OB dumps and a natural forest is made. This study would help to understand the regeneration status of tree species in changing ecological condition.

2. Materials and Methods

2.1 Study Area

The present investigation has been carried out in Bansra OCP and Sonepur Bazari OCP of Eastern Coal Field Limited (ECL) in Raniganj of West Bengal; the birth place of coal mining in India (Fig1.1). Geographically Bansra OCP lies between latitudes 23° 37′ 38.75″ N and 23° 38′ 52.66″ N, and longitudes 87° 07′36.50″ E and 87° 08′52.01″ E whereas Sonepur Bazari OCP lies between latitudes 23° 40′58.74″ N and 23° 41′47.64″ N, and longitudes 87° 12 ′55.93″ E and 87° 13 ′57.62″ E. Garhjungle forest extends between 23°26'43.78"N and 23°37'16.93"N latitudes to 87°22'37.72"E and 87°35'32.08" longitudes.

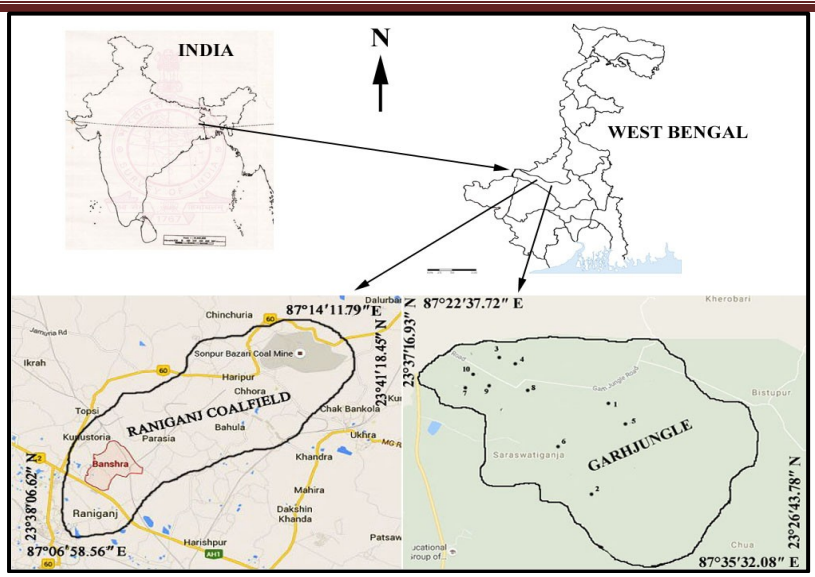


Figure 1. Location of the study sites. (Source: Malakar and Gupta (Joshi) 2018).

2.2 Vegetation Sampling

Natural succession of saplings was studied in an age series of overburden dumps in post monsoon period. Local staffs of Eastern Coalfield Limited were approached to get permission and secondary information about the overburden dumps. Seven overburden dumps of different ages, *i.e.*, 0 year, 1 year, 9 years, 12 years, 18 years and 21 years were chosen from Bansra OCP, where 3 years old dump was selected from Sonepur Bazari OCP. A natural forest Garhjungle was selected as a control site to compare the status of saplings. In each dump 10 quadrats were laid randomly. The saplings of trees (< 1cm dbh, height >30 cm) were recorded in two 5m × 5m quadrats within a 10m × 10m quadrat. GPS (Garmin Oregon 550) was used to record latitude and longitude values of each quadrat. Species that could not be identified during the study were serially numbered and brought to the laboratory for identification by consulting taxonomist and regional floras (Prain, 1903; Sanyal, 1994). Herbarium specimens were prepared of the collected species. Families were categorized as mentioned in the "Flora of Bilaspur" (Panigrahi and Murti, 1989; 1999). However scientific names and author citations were updated following the website The Plant List (www.theplantlist.org) on 21.07.2018.

2.3 Data Analysis

Phytosociological characters like frequency, density, abundance were calculated for each species of tree sapling according to Misra (1968). Importance value index (IVI) was estimated as the sum of relative density, relative frequency to attain maximum possible value of 200 (Lopez *et al.*, 2008; Williams-Linera, *et al.*, 2005).

Various diversity measures like Shannon-Wiener index (H') (Shannon and Weaver, 1949), Simpson's index (Cd) (Simpson, 1949), Pielou's Evenness (E) (Pielou, 1966), and Margalef's index of species richness (M) (Margalef, 1968) were calculated as:-

$H' = -\sum_{i=1}^{S} pi \ln pi$

$Cd = \sum_{i=1}^{S} (pi)^2$

$E = H'/H^{max}$; $H^{max} = \ln(S)$

$M = (S-1)/\ln N$

Where, S=total no of species; pi= ni/N; ni= total no of individual of "i^{th}" species; N= total no of individual of all species; ln= natural log.

Beta Diversity was measured as within habitat beta diversity (β) (Whittaker, 1972), Species turnover (β_d) (Wilson and Shmida, 1984) and Similarity Index (IS) (Jaccard, 1928):

$\beta = Sc/S$

$\beta_d = (b+c)/(2a+b+c)$

$IS = (a/a+b+c) \times 100$

Where, Sc= total no. of species; S= average no. of species per sample; a=total no. of species common in both sites; b and c= No. of species occurring in one or other site only.

3. Results and Discussions

3.1 Species composition and structure

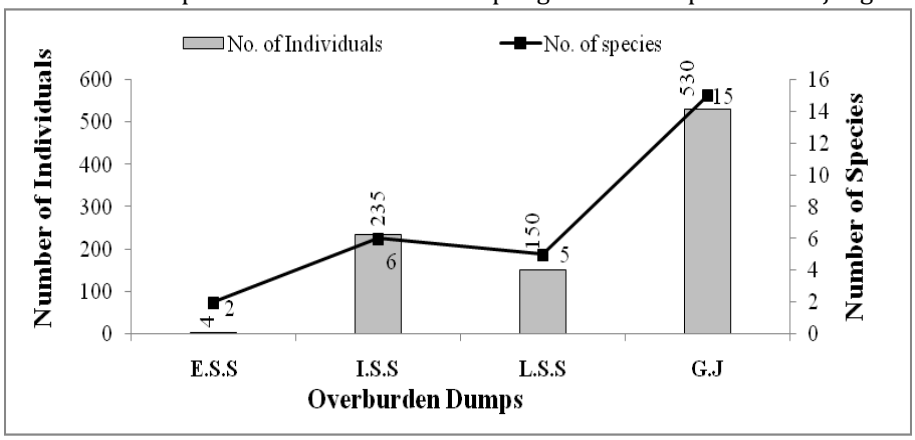
In this study no vegetation was observed in 0yr dump and started observing from 1yr dump. 1yr and 3yr dump together were designated as early colonizing species or early successional stage. Intermediate successional stage represented 9yr and 12yr dumps whereas late successional stage included 8yr and 21yr dumps. In this paper the vegetation strata consisting of tree saplings only are shown. Table 1.1 shows the importance value index (IVI) of tree saplings recorded from different OB dumps and Garhjungle. Figure 1.2 shows the number of individuals and number of species belonging to tree saplings from overburden dumps and Garhjungle. Tree saplings were present from 3yr dump to 21yr dump, no saplings were recorded from 1 yr dump. According to Kumar *et al.* (2011), establishment of trees in mine spoils take time. Malakar *et al.* (2015) also reported dominance of herb and grasses in early stage of succession. In this study, different OB dumps were dominated by saplings of different tree species. Saplings belonging to 19 species were recorded during the study out of which 12 were present in Garhjungle exclusively and four in OB dumps only. In early successional stage saplings of only two species under two families with four individuals were recorded. Here *Dalbergia sissoo* and *Ziziphus jujuba* showed equal importance with IVI of 100 each. *Dalbergia sissoo* was restricted to 3yr dump only whereas *Ziziphus jujuba* was present in all overburden dumps as well as the natural forest. In this study, number of species present as saplings was more in intermediate stage than in early successional stage. Hazarika *et al.* (2006) also reported greater number of trees and shrubs in older than younger dumps. Intermediate successional stage was represented by saplings of six species under six families with 235 individuals. Intermediate successional stage was dominated by *Ziziphus jujuba* in 9yr and by *Leucaena leucocephala* in 12yr dumps with IVI of 164.96 and 98.3, respectively. Saplings of *Leucaena leucocephala* were first observed in 12yr dump and present upto 21yr dump. *Streblus asper*, another important species after *Leucaena leucocephala* and *Ziziphus jujuba*, was noticed first in 9yr dump and present upto 21yr dump but its importance decreased. 12yr dump had more number of species as saplings. Late successional stage was composed of saplings of five species under five families with 150 individuals. *Leucaena leucocephala* and *Ziziphus jujuba* were dominant as sapling in 18yr and 21yr dumps, respectively with high IVI. Garhjungle had more number of species, families and individuals as sapling when compared with OB dumps. In Garhjungle saplings of 15 species under 14 families with 530 individuals were present. *Shorea robusta* got highest IVI in Garhjungle followed by *Buchanania cochinchinensis* and *Madhuca longifolia* var. *latifolia*. Ganguli *et al.* (2016) reported *Shorea robusta* as the dominant tree species in Garhjungle. Three species *Ziziphus jujuba*, *Alangium salviifolium* and *Phoenix sylvestris* were recorded form Garhjungle as well as from any of the OB dumps.

Table 1. Importance Value Index (IVI) of Saplings in different OB dumps and in Garhjungle.

Species Name	**Family**	**Overburden Dumps**					**Garh jungle**
		3 yr	9 yr	12 yr	18 yr	21 yr	
Dalbergia sissoo DC.	Fabaceae	100	-	-	-	-	-
Ziziphus jujuba Mill.	Rhamnaceae	100	**164.96**	34.92	87.35	**119.85**	7.39
Streblus asper Lour.	Moraceae	-	35.04	27.5	10	17.47	-
Leucaena leucocephala (Lam.) de Wit	Mimosaceae	-	-	**98.3**	**102.64**	50.87	-
Alangium salviifolium (L.f.) Wangerin	Alangiaceae	-	-	19.55	-	-	7.81
Phoenix sylvestris (L.) Roxb.	Arecaceae	-	-	11.38	-	5.9	7.73
Azadirachta indica A.Juss.	Meliaceae	-	-	8.35	-	5.9	-
Shorea robusta Gaertn.	Dipterocarpaceae	-	-	-	-	-	**71.19**
Buchanania cochinchinensis (Lour.) M.R.Almeida	Anacardiaceae	-	-	-	-	-	35.84
Madhuca longifolia var. *latifolia* (Roxb.) A.Chev.	Sapotaceae	-	-	-	-	-	34.4
Diospyros melanoxylon Roxb.	Ebanaceae	-	-	-	-	-	14.97
Acacia catechu (L.f.) Willd.	Mimosaceae	-	-	-	-	-	3.51
Tectona grandis L.f.	Verbanaceae	-	-	-	-	-	3.32

Acacia nilotica (L.) Delile	Mimosaceae	-	-	-	-	-	3.32
Schleichera oleosa (Lour.) Merr.	Sapindaceae	-	-	-	-	-	3.17
Pterocarpus marsupium Roxb.	Fabaceae	-	-	-	-	-	2.94
Limonia acidissima Groff	Rutaceae	-	-	-	-	-	1.47
Haldina cordifolia (Roxb.) Ridsdale	Rubiaceae	-	-	-	-	-	1.47
Syzygium cumini (L.) Skeels	Myrtaceae	-	-	-	-	-	1.47

Figure 2. Number of species and individuals of saplings in OB dumps and Garhjungle.



3.2 Species Diversity

No specific trend was observed in diversity indices of saplings with increase in age of OB dumps (table 1.2). Increase in heterogeneity was observed from 3yr to 21yr dumps with lower values in 9yr and 18yr dumps. Various studies showed continuous increase in species richness with increase in the age of dumps (Jha and Singh, 1991; Pandey and Singh, 1985; Lie *et al.*, 2008). Overall decrease in evenness was observed with increase in dump age. Within habitat beta-diversity was very high in 3yr dump indicating very heterogeneous habitat in this dump; in other dumps within habitat beta diversity was comparatively small and increased from 9yr to 21 yr dumps. Intermediate stages of 9yr and 12yr showed high dominance and species richness. In Garhjungle heterogeneity and species richness were high when compared with OB dumps whereas, evenness and dominance showed lowest values. Beta-diversity as habitat heterogeneity was near the value observed in intermediate successional stage. According to Hazarika *et al.* (2006), diversity of naturally occurring plant species increases with time.

Table 1.2 Diversity indices for tree saplings in OB dumps and Garhjungle.

OB Dumps	Diversity index				
	H'	**E**	**M**	**Cd**	**β**
3 yr	1	1.45	0.72	0.5	11.76
9 yr	0.61	0.88	0.24	0.75	2.13
12 yr	1.55	0.87	0.97	0.49	3.64
18 yr	0.98	0.89	0.48	0.57	4
21 yr	1.42	0.88	0.89	0.44	4.76
Garhjungle	2.34	0.86	2.23	0.3	3.85

Table 1.3 Beta diversity and similarity index of saplings in OB dumps and Garhjungle

Saplings	**3 yr**		**9 yr**		**12 yr**		**18 yr**		**21 yr**	
Dumps	**β_d**	**IS**	**β_d**	**IS**	**β_d**	**IS**	**β_d**	**IS**	**β_d**	**IS**
9 yr	0.5	33.33								
12 yr	0.75	14.29	0.5	33.33						

18 yr	0.60	25	0.2	66.67	0.33	50				
21 yr	0.71	16.67	0.43	40	0.09	83.33	0.25	60		
Garhjungle	0.88	6.25	0.88	6.25	0.71	16.67	0.89	5.88	0.8	11.11

Increase in beta-diversity of saplings was observed with increase in difference of dump age (table 1.3). Turnover of species was less between 3yr and 9yr dumps than between 3yr and any other dump. Similarly species turnover was highest between 21yr and 3yr dumps than between 21yr and any other dump. However, some overburden dumps closer to each other in age showed more species turnover among themselves than other like 9yr dump showed more turnover of species with 12yr dump than with 18yr dump. Highest turnover was observed between 12yr and 3yr dumps whereas, lowest between 12yr and 21yr dumps. Garhjungle showed high species turnover with all overburden dumps.

Similarity index showed trend just opposite of species turnover. It decreased with increase in difference of dump age. 3yr dump showed highest similarity with 9yr dump, and 12yr dump with 21yr dump. 3yr dump showed lowest similarity with 12yr and 21 yr dumps. But 21yr dump showed lower similarity with 18yr dump than with 12yr dump. Garhjungle had very low similarity when compared with all OB dumps

Conclusions

The present work showed increase sapling diversity (heterogeneity) with increase in the age of dump, while evenness decreased. OB dump also displayed low similarity and high species turnover with natural forest. As the saplings increased with time, this indicates more chances of survival of saplings and their conversion into mature trees in hostile environment. From comparative analysis of saplings of OB dumps with natural forest, it can be concluded that succession was in progressive direction but still not sufficient to fully recover the dumps from disturbance. Further analysis of other layers of vegetation will throw more light on successional changes in vegetation.

Acknowledgements

We thank the officials of Raniganj coalfields (Eastern Coalfields Limited) for providing permission and secondary information about overburden dumps. We also thank Prof A. Mukherjee, Department of Botany, University of Burdwan for helping in species identification. First author is thankful to UGC, New Delhi for financial assistance in the form of Rajiv Gandhi National Fellowship.

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