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Ecological analysis of tree species at two reclaimed sites of Sukinda chromite mining region of Odisha, India.

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Abstract

Present study was carried out at two opencast chromite mining sites located at Sukinda, Jajpur, Odisha. Two over burden dump sites were selected for vegetation analysis out of which one site was one year old and other 18 year old. The dump plantation was done at one year old site by the Tata steel mines and at 18 year old sites by Saruabil Mines, which are lease holders to extract chromite ore from these mines. Phytosociological analysis was done by quadrat method on these sites to observe the differences in structural growth pattern of tree species after reclamation. The parameters like density, Basal area and Importance Value Index (IVI) were calculated at different aspects of these two dumps to find out the impact of aspect and age on density, basal area and growth pattern of tree vegetation on reclaimed over burden sites. A total of 18 species were recorded a one year old site representing 14 families whereas 29 species at 18 year old site representing 16 families were recorded. Colonisation by natural species like *Holarrhena pubescens*, *Mallotus philippinensis* and *Trema orientalis* was observed at 18 year old site. Exotic species viz., *Acacia auriculiformis* and *Cassia siamea* dominated at drier sites of west and south aspects whereas north and east aspect were favorable habitat for native species at one year old site. Replacement of exotic species with native species has been suggested while comparing the dominance of species as our results establish that native species like *Pongamia pinnata, Ficus benghalensis, Alstonia scholaris, Terminalia alata* compete well with exotic species. The study highlights the ecological significance of native species which are effective ecological tools towards conserving the biodiversity and enhancing the ecological services in a restored habitat.

Keywords: Chromite, fertile, Sukinda valley, Precambrian, over burden dump, Phytosociology.

Introduction

Restoration of degraded area by biological means for overall ecological improvement is an old practice. Opencast mining activities alter the habitat by removing of existing vegetation which affect the ecological services and structure and function of ecosystem. Process of natural restoration takes lower time; therefore, there have been several attempts worldwide to adopt various methods to accelerate the restoration process. The reclamation of derelict and degraded land requires Socio-economic, biological and technical inputs to restore a functional and self-sustaining soil-plant ecosystem (Anwer et al., 2001).

Due to unfavorable physical structure and chemical properties of degraded lands, vegetation development on the waste takes longer time (Tordoff et al. 2000, Krzaklewski and Pietrzykowski 2002). For re-vegetation of overburden dumps, biological reclamation may provide good results depending on the selection of appropriate species and other parameters such as climate, physical and chemical properties of dump materials, topography and surrounding vegetation (Singh and Jha 1992). Vegetation covers help in protecting the soil surface from erosion therefore, all effort may be made by facilitating native species and by accelerating the recovery of genetic diversity in restored habitat. The cases of biological restoration, much emphasis has been given towards exotic species for faster reclamation in various degraded mined as well as natural degraded areas. Whether these species will restore the ecological services and achieve the desired charact4er of natural ecosystem? The restoration ecology is receiving increasing attention (Bradshaw 1997, Pensa et al., 2004) but community succession and needs much focus to carry out ecological research (Zhang, 2005) as degradation of natural habitats by anthropogenic activities and faster rate of biodiversity loss witnessed now than ever. Globally, about 20 percent of total deforestation in developing countries may be attributable to mining (Bahrami et al., 2010). The mine spoil contains large quantity of rock fragments which are recalcitrant and devoid of nutrients and organic matter to support biological species pool. Both plant and microbial growth cannot sustain low organic matter content and unfavorable pH (Agrawal et al., 1993; Burgharadt, 1993).

The present study examines the extent of vegetation recovery and ecological stability at one year and 18 year old reclaimed over burden Chromite mining dumps of Sukinda valley on the basis of phytosociological parameters and suggests some measures for adopting improved reclamation methods in the area.

Study area

The study site is located in Sukinda valley of Jajpur district in Odisha. The district has a total area of 2899 sq km consisting of ten blocks, with fertile lands on the bank of river Baitarini which produces large amount of cash crops every year. 97% of India's chromites ore is available in Sukinda. Several mining companies are operating in the area of 50 sq km from Kansa to Maudlin. A natural stream 'Damsala' flows through the middle of this mining area and joins the river Brahmani. The Sukinda chromite deposits formed by residual concentration is being extracted mostly by opencast mining method, however, underground mining is also being done in Kathpal mines. Other mining companies are planning to start underground mining to extract Chromite ore from depths where opencast is not possible or is economically not viable. The mining lease areas falls in eastern part of Sukinda chrome ore belt and lies in a westerly sloping valley between the quartzite ridge of Mahagiri hill in the South and Daitary hill in the north and is located in survey of India toposheet No. 73G/16 (Lat.21^0 03' & Long. 85^0 47'). The total forest area in the district is 7711 ha (FSI, 2011) with mostly subtropical forest concentrated in the blocks of Danagadi and Sukinda. Total annual rain fall is 1014.5mm. The average maximum and minimum temperatures are 38^0 C and 12^0 C respectively (Fig. 1). The topography of the area is mostly plain in the opencast mining locations with hills surrounding the Sukinda valley. The climate is sub tropical. The study area is shown in Fig. 2. One year old over burden reclaimed dump of M/S Tata steel Mines and 18 year old reclaimed over burden dump of Sukinda mines of Saruabil Mines of M/S Misrilal was selected to study the changes in structural characteristics of vegetation at both sites. One year old site is named as 'D1' and 18 year old site as 'D8' in the present paper.

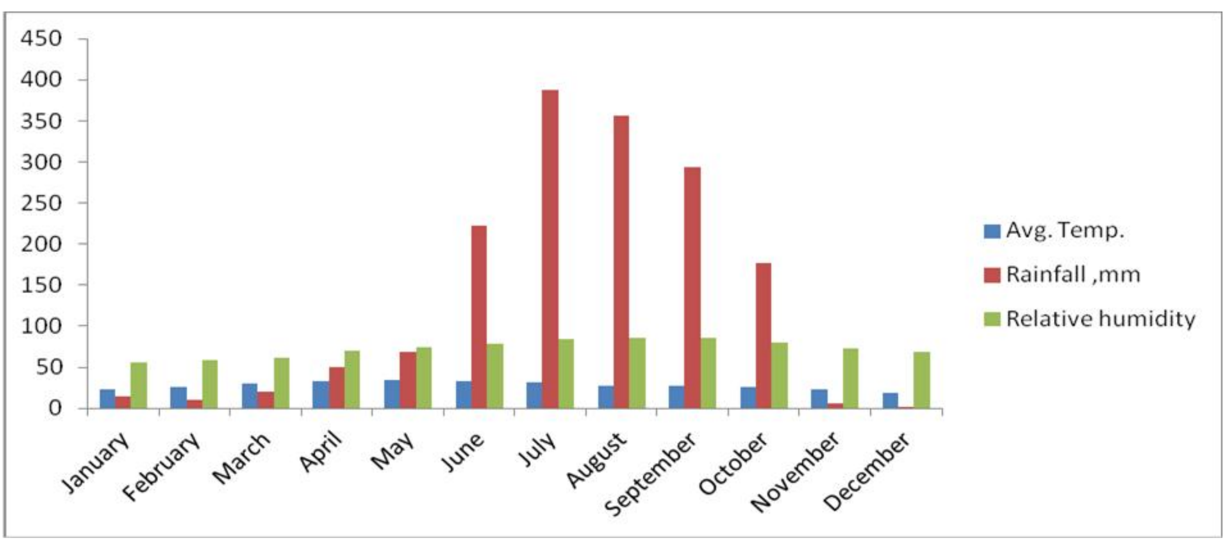

Fig. 1. Monthly Average temperature (^{0}C), rainfall(mm) and relative humidity(%) pattern in Sukinda region Odisha

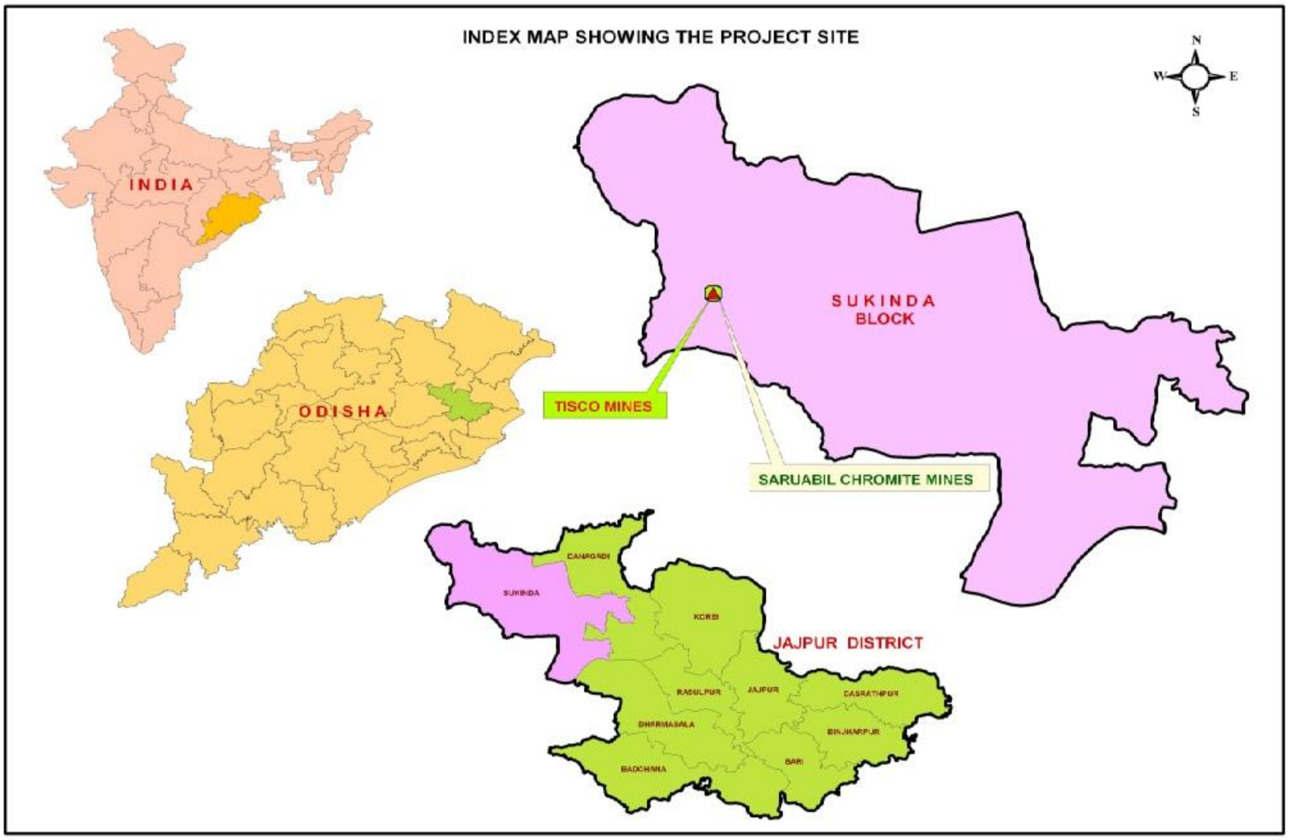

Fig.2 . Location of the study sites

Materials and Methods

The phytosociological study was carried out during December 2009 to August, 2011 by laying quadrats of 10mx10m for the tree species following Misra (1968). Nine quadrats were laid on each aspect i.e. North, South, East and West, totaling to 36 quadrates at each site. A total of 72 quadrats were laid and vegetation sampled in a period of two years to study structural Vegetation parameters. The diameter values recorded for trees were converted to basal area. The dominance of a plant species is determined by calculating the Importance Value Index (IVI) of species. The IVI was computed by summation of the value of the relative frequency (RF), relative density (RDI) and relative dominance (RD) (Curtis, 1959; Misra, 1968).

Results and Discussion

Table 1 and Table 2 provide the Basal Area, density and IVI of the tree species at 1 year and 18 year old reclaimed OB dump sites. At one year old site, a total of 18 species was recorded with total basal area of 1.686 m^2/ha^{-1} and a mean basal area of 0.099 m^2 per tree. Average tree density was observed 197.74 trees / ha^{-1}. 17 tree species were recorded on the east aspect of which, *Pongamia pinnata* was the dominant species. On the west, North and South aspects, a total of 17 tree species were recorded. *Acacia auriculiformis* was the dominant species at all these three sites with IVI values ranging from 37 to 50 and density 590 to 899 per ha.

A total of 29 tree species across different aspects of 18 year old reclaimed OB dump site of Saruabil chromite mines was encountered whereas species number across all aspects of the dump was same (16-17) but pattern of dominance differed. *Ficus benghalensis* was dominant species on east aspect with IVI of 69.48 but *Azadirachta* exhibited highest density. On the west and north aspects, Cassia *siamea* was dominant species. *Acacia auriculiformis* exhibited dominance on the south aspect of this site.

Table 1. Phytosociological **parameters of tree species at different aspects of OB-II (D1) site** (Values in the parenthesis denote numbers of species. B. A. = Basal Area; D=Density; IVI= Importance Value Index)

			East(17)			West(17)			North(17)			South(17)		
Sl No.	**Name of the species**	**Family**	**B.A.**	**D**	**IVI**	**B.A.**	**D**	**IVI**	**B.A.**	**D**	**IVI**	**B.A.**	**D**	**IVI**
1	*Acacia auriculiformis*	Mimosaceae	0.05	543.90	26.16	0.05	592.00	37.43	0.06	669.70	39.27	0.08	899.10	50.22
2	*Ailanthus excelsa*	Simaroubaceae	0.01	74.00	6.32	0.01	107.30	11.24	0.00	44.40	5.02	0.00	66.60	7.28
3	*Albizia lebbeck*	Mimosaceae	0.03	262.70	16.62	0.02	284.90	21.06	0.04	358.90	26.25	0.04	540.20	31.75
4	*Alstonia scholaris*	Apocynaceae	0.01	166.50	12.05	0.01	107.30	11.86	0.00	33.30	4.10	0.00	51.80	5.66
5	*Annona squamosa*	Annonaceae	0.00	81.40	7.11	0.06	44.40	18.75	0.00	22.20	2.50	0.00	33.30	3.84
6	*Azadirachta indica*	Meliaceae	0.03	362.60	19.73	0.04	403.30	27.97	0.05	388.50	28.66	0.04	458.80	28.97
7	*Bambusa vulgaris*	Poaceae	0.01	88.80	8.30	0.02	96.20	11.31	0.02	185.00	15.74	0.01	88.80	8.46
8	*Cassia siamea*	Caesalpiniaceae	0.06	273.80	18.80	0.00	358.90	18.20	0.06	492.10	34.08	0.05	458.80	31.30
9	*Casuarina equisetifolia*	Casuarinaceae	0.01	162.80	11.64	0.05	96.20	20.92	0.01	170.20	11.68	0.00	77.70	7.79
10	*Mimusops elengi*	Sapotaceae	0.00	33.30	3.56	0.00	33.30	3.94	0.00	33.30	3.68	0.04	25.90	13.22
11	*Musa paradisica*	Musaceae	-	-	-	-	-	-	-	-	-	0.00	18.50	2.69
12	*Peltophorum pterocarpum*	Caesalpiniaceae	0.03	314.50	18.26	0.03	292.30	22.97	0.03	384.80	25.70	0.03	333.00	23.40
13	*Phyllanthus emblica*	Euphorbiaceae	0.00	151.70	10.90	0.00	159.10	10.43	0.01	236.80	15.02	-	-	-
14	*Pongamia pinnata*	Fabaceae	1.42	318.20	100.80	0.02	277.50	21.18	0.04	458.80	28.62	0.03	532.80	28.88
15	*Syzigium cumini*	Myrtaceae	0.02	355.20	19.15	0.02	384.80	23.83	0.04	551.30	31.75	0.03	758.50	33.39
16	*Terminalia arjuna*	Combretaceae	0.02	159.10	12.12	0.01	266.40	18.10	0.02	266.40	20.14	0.01	173.90	14.50
17	*Terminalia bellirica*	Combretaceae	0.00	55.50	5.07	0.00	55.50	5.84	0.00	33.30	3.79	0.00	51.80	5.53
18	*Terminalia catappa*	Combretaceae	0.01	29.60	3.35	0.04	55.50	14.97	0.00	44.40	4.01	0.00	25.90	3.11

Table 2. Phytosociological parameters of species at different aspects of D8 site (Values in the parenthesis denote numbers of species. B. A. = Basal Area; D=Density; IVI= Importance Value Index)

			East(16)			West(16)			North(17)			South(16)		
Sl No.	**Name of the species**	**Family**	**B.A.**	**D**	**IVI**	**B.A.**	**D**	**IVI**	**B.A.**	**D**	**IVI**	**B.A.**	**D**	**IVI**
1	*Acacia auriculiformis*	Mimosaceae	3.45	207.20	27.06	2.36	207.20	34.47	2.99	284.90	41.83	1.77	222.00	42.72
2	*Acacia mangium*	Mimosaceae	0.12	37.00	6.22	-	-	-		-	-	-	-	-
3	*Albizia lebbeck*	Mimosaceae	0.36	37.00	6.49	0.38	62.90	10.69		-	-	-	-	-
4	*Alstonia scholaris*	Apocynaceae	-	-	-	0.47	88.80	13.35		-	-	0.43	81.40	15.99
5	*Anacardium occidentale*	Anacardiaceae	0.28	33.30	5.79	0.45	59.20	11.27	0.60	85.10	13.87	0.16	37.00	7.73
6	*Azadirachta indica*	Meliaceae	0.16	244.20	28.99	1.90	210.90	31.91	1.48	207.20	28.15	0.77	103.60	23.48
7	*Buchanania lanzan*	Anacardiaceae	-	-	-	0.64	85.10	13.79		-	-	0.68	66.60	15.73
8	*Cassia occidentalis*	Caesalpiniaceae	3.09	96.20	13.30	-	-	-		-	-	-	-	-
9	*Cassia siamea*	Caesalpiniaceae	0.09	214.60	40.76	3.62	255.30	44.27	3.57	259.00	44.18	1.18	207.20	35.18
10	*Diospyros montana*	Ebenaceae	-	-	-	0.45	48.10	8.97	0.30	74.00	11.45	0.30	33.30	7.83
11	*Ficus benghalensis*	Moraceae	15.28	29.60	69.48	-	-	-	0.18	48.10	7.75	-	-	-
12	*Ficus racemosa*	Moraceae	-	-	-	-	-	-	0.03	33.30	4.77	-	-	-
13	*Ficus religiosa*	Moraceae	-	-	-	-	-	-	0.14	29.60	4.98	-	-	-

14	*Glochidion lanceolarium*	Euphorbiaceae	57.79	44.40	7.95	0.82	62.90	13.96		-	-	-	-	-
15	*Holarrhena pubescens*	Apocynaceae	-	-	-	-	-	-	0.77	107.30	16.39	-	-	-
16	*Anogeissus acuminata*	Anacardiaceae	0.57	37.00	5.52	-	-	-	0.97	70.30	14.47	-		-
17	*Lagerstroemia parviflora*	Lythraceae	-	-	-	-	-	-	0.84	140.60	19.83	-	-	-
18	*Macaranga peltata*	Euphorbiaceae	0.23	48.10	8.17	0.84	85.10	15.65	0.64	81.40	13.29	-	-	-
19	*Madhuca indica*	Sapotaceae	-	-	-	0.84	48.10	11.93		-	-	0.59	29.60	10.99
20	*Mallotus philippinensis*	Euphorbiaceae	-	-	-		-	-		-	-	0.32	55.50	12.36
21	*Peltophorum pterocarpum*	Caesalpiniaceae	2.70	181.30	24.59	1.81	233.10	32.59	1.01	185.00	24.41	0.82	140.60	26.39
22	*Pongamia pinnata*	Fabaceae	2.35	162.80	21.91	0.49	118.40	17.12	0.60	118.40	16.21	0.51	96.20	19.25
23	*Semicarpus anacardium*	Anacardiaceae	0.21	37.00	6.33		-	-		-	-	0.49	62.90	15.44
24	*Shorea robusta*	Dipterocarpaceae	-	-	-	0.47	55.50	10.82		-	-	0.48	40.70	11.65
25	*Simarouba glauca*	Simaroubaceae	-	-	-	-	-	-		-	-	0.14	92.50	13.64
26	*Syzigium cumini*	Myrtaceae	-	-	-	0.82	85.10	14.54	1.25	188.70	25.14	0.73	218.30	31.62
27	*Terminalia alata*	Combretaceae	0.12	29.60	5.01	-	-	-	0.56	37.00	8.62	-	-	-
28	*Terminalia bellirica*	Combretaceae	-	-	-	-	-	-	0.01	33.30	4.67	-	-	-
29	*Trema orientalis*	Ulmaceae	2.64	148.00	22.43	0.51	96.20	14.65		-	-	0.23	55.50	10.00

The IVI of *Acacia auriculiformis*, *Albizia lebbeck*, *Alstonia scholaris*, *Pongamia pinnata*, *Syzigium cumini* and *Terminalia bellirica* was greater at one year old site, where as IVI of *Azadirachta indica*, *Cassia siamea*, *Peltophorum pterocarpum*, was maximum in 18 year old site. A comparison of common species across aspects at the one year old site indicates that IVI of *Pongamia pinnata* was maximum on the east aspect. *Acacia auriculiformis*, *Albizia lebbeck*, *Azadirachta indica*, *Syzigium cumini* and *Terminalia bellirica* exhibited higher IVI on south aspect of the site. IVI of *Cassia siamea* was maximum on the north aspect. The south facing slopes experience more unfavourable growth conditions due to the lower capacity to conserve soil moisture (Cano et al., 2002; Tormo et al., 2006). At the 18 year old site, *Albizia lebbeck* exhibited higher IVI on east and west aspects, *Terminalia bellirica* on north aspect and *Acacia auriculiformis*, *Alstonia scholaris* and *Syzigium cumini* on south aspect and *Azadirachta indica*, *Albizia lebbeck*, *Cassia siamea* and *Peltophorum pterocarpum* on the west aspect of site. *Pongamia pinnata* exhibited maximum growth on the east aspect.

The species, *Ailanthus excelsa*, *Annona squamosa ,Bambusa vulgaris ,Casuarina equisetifolia*, *Mimusops elengi, Musa paradisica, Phyllanthus emblica, Terminalia arjuna ,Terminalia catappa* planted at one year old site were not available on 18 year old site. Similarly, the species *Acacia mangium, Anacardium occidentale, Anogeissus acuminata, Buchanania lanzan, Cassia occidentalis, Diospyros montana, Ficus benghalensis ,Ficus racemosa ,Ficus religiosa,Glochidion lanceolarium, Holarrhena pubescens*, *Lagerstroemia parviflora ,Macaranga peltata*, *Madhuca indica, Mallotus philippinensis, Semicarpus anacardium, Shorea robusta ,Simarouba glauca*, *Terminalia alata ,Trema orientalis* were found only at 18 year old site. Nine species were common for both sites (*Acacia auriculiformis, Albizia lebbeck, Alstonia scholari,s Azadirachta indica ,Cassia siamea, Peltophorum pterocarpum ,Pongamia pinnata, Syzigium cumini and Terminalia bellirica).*

At one year old site, a total of 18 species represented 14 families with three species from Combretaceae, 2 species from Mimosaceae and Caesalpiniaceae and one species each from Simaroubaceae, Apocynaceae ,Annonaceae, Meliaceae, Poaceae, Casuarinaceae, Sapotaceae, Musaceae, Euphorbiaceae, Fabaceae and Myrtaceae. At 18 year old site, a total of 29 species were recorded from 16 families with 4 species from Anacardiaceae family, 3 species each from Mimosaceae, Caesalpiniaceae, Moraceae and Euphorbiaceae and 2 species each from Apocyanaceae and Combretaceae. Only one species represented from each family of Meliaceae, Ebenaceae, Lythraceae, Sapotaceae, Fabaceae, Dipterocarpaceae, Simaroubaceae, Mytraceae and Ulmaceae. There is no any ecological guideline for plantation of degraded habitats in India. For example Malakar et al., (2015) observed tree species at reclaimed site mostly were from Leguminaceae family followed by Malvaceae and Euphorbiaceae. Similarly, there is no guideline in respect of number of plants to be planted in an unit of area of degraded site. Various reclaimed sites in India have been studied and it is reported that the degraded areas were planted with 42 species (Kumar et al., (2011), 19 species (Sadhu et al., (2011), 58 species from Raniganj coalfield (Das et al., (2013), 41 species in Kobra coal field (Chandra (2014) and 10 species from Mahanadi coalfields Ekka and Behera (2011). In the present study, a total 65 tree species were used for reclamation of Chromite mine soil dumps across both sites, with 18 tree species at 1 year old site and 29 species at 18 year old site. At one year old site, the native species *Azadirachta indica*, *Syzigum cumini* and *Pongamia pinnata* competed well with the *A. auriculiformes* and *C. siamea* and dominance was not pronounced. However, the latter two Species along with *Ptero carpum* exhibited greater dominance than native species at 18 year old site. However, *Syzigium cumini* and *A. Indica* were still most successful native species at this site competing well with the exotic species. Specific use of native and indigenous species for re-vegetation of mine spoil has also been suggested by Banerjee et al., (1996) and Jha and Singh (1993). These results emphasise the importance of conserving bio-diversity by improving natural colonisation (Bradshaw, 1997). The native species must be encouraged in plantation even if these needs nurturing (Bradshaw, 1996, 2000) or suitable substrate (Martinez-Ruiz and Marrs, 2007) in some situations, as these species may stand better in terms of enhancing ecological services and restoring structure and function of a natural habitat with high biodiversity.

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