



Distribution Pattern of Herb and Tree Species at Reclaimed over Burden Dumps of Chromite Mine in Sukinda Region, Odisha, India

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Abstract

Two overburden dump sites were selected for vegetation study out of which one site was reclaimed one year back and other site 18 year back. Tree species were planted at these sites with mostly regular distribution. Herbaceous vegetation development on these sites were analysed along with tree layer to find out their development in term of extent of presence and distribution. The initial pattern of herb species distribution is contagious. In subsequent years of development of vegetation, the herb species found to follow random distribution. Development of tree canopy and increase in shade on ground floor may be one of the dominant factors for the herb species to develop random distribution characteristics along the course of succession. The species richness is similar at both the sites which indicate contribution by local surrounding gene pool of the natural ecosystem of Sukinda valley.

Key Words: Chromite mining, Sukinda, Overburden, Reclamation, Species, Ecosystem, Odisha

Introduction

Biodiversity and ecological assessment in natural and degraded ecosystems are important tools to explore the ecosystem dynamics (Dennis & Ruggiero, 1996). The species diversity of the plant community increases with the decrease in anthropogenic disturbance (Bhattacharya, 1994). Anthropogenic disturbances such as mining may significantly lower plant species richness. Species richness can be interpreted as a function of the environmental stress and intensity of management which tend to prevent potentially competitive species for attaining size and vigor (Upadhyay *et al.*, 1989). Local factors determine the overall dynamics and floristic character of communities (Ashton, 1993). The mining activities drastically alter the physical and biological nature of the area (Singh *et al.*, 2002). Ecological restoration is the process of repairing the damage caused by humans to the diversity and dynamics of indigenous ecosystems (Jackson *et al.*, 1995). Plant species establish at degraded sites through natural recruitment and survive through nutrient conservation and this process helps in establishment of plants, animals and the detritivore community in the ecosystem (Jackson *et al.*, 1995). The process of ecological restoration initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability (SER, 2002). Due to intensification of the agricultural practices or other land use changes such as mining, natural resources are fast depleting and exhausting from natural and semi-natural ecosystems. This problem has led to the growth of the science of restoration ecology. Returning damaged ecosystems to a condition that is structurally and functionally similar to the state prior to the disturbance is known as ecological restoration (Cairns, 2002; Cairns & Heckman, 1996). Society for Ecological Restoration defines ecological restoration as the process of assisting the recovery and management of ecological integrity. Restoration efforts mainly include plantation activity on the lands damaged by human activity (Filcheva *et al.*, 2000), and vegetate rapidly a degraded area by sowing the seeds and vegetative parts and selecting varieties of cultivated plants or planting trees and shrubs (Szarek-Lukaszewska and Grodznska, 2007). There are also ecological methods that consist of introducing local plant species that grow in the immediate neighbourhood, not far from the area to be reclaimed (Upadhyay *et al.*, 2011). Orissa contains about 94% of the country's total reserve of chromite which is localized in Sukinda and Baula belts. Large scale mining of chromite in this belt is going on since more than two decades to meet domestic as well as overseas industrial demands. The chromite mining in the Sukinda valley during last two-three decades has created degraded areas like overburden dumps, mining pits and degraded water bodies and air pollution. Research has revealed the impact on the food chain of Sukinda valley and enhanced chromium concentration in cultivated fields, milk, fruit and aquatic grasses etc. Several studies have also highlighted the impact of water discharged into Damsala river (the lone perennial water sources) which receives all the waste water from mining area with a high concentration of the hexavalent chromium in the water. Opencast chromite mining generates enormous quantity of overburden (OB). The stripping ratio varies from 1:5 to 1:10. Unless managed properly, run offs from the OB dumps have the potential of polluting the water bodies by siltation and leaching of Cr (VI). Proper rehabilitation of the OB dumps is essential to prevent run offs carrying silt and Cr (VI) to water bodies which can be achieved by stabilizing the dumps with plantation and construction of retention walls and recycling of effluents. Construction of garland drain around dumps and mining, providing settling pits, arrangements for treatment of the runoff water and proper management of active and old OB dumps are the mitigation measures for better environmental management. The present study analyses the species composition and distribution and colonization pattern of both tree and herb species at two reclaimed dump sites of Chromite mines of Sukinda region, Odisha.

Study Area

The study site is located in Sukinda valley of Jajpur district in Odisha at a distance of 130 km from the state capital

city Bhubaneswar. This district is surrounded by river Baitarini and the districts Keonjhar and Bhadrak in the north; Cuttack in the south; Dhenkanal in the east and Kendrapara in the west. Sukinda Tehsil with Head Quarter at Sukindagarh town (38 KM towards west from District head quarter) is bounded by Korei, Byasanagar Tehsil in East, Danagadi Tehsil in North, Rasulpur Tehsil in South. Nearby towns are Byasanagar, Bhuban, Anandapur and Jajapur. Jajpur district with a total area of 2899 sq km has ten blocks with most fertile lands on the bank of river Baitarini which produces a large amount of cash crops every year. Sukinda valley contains 97% of India's chromite ore. Several mining companies are operating in the area spread over of 50 sq km. A natural stream Damsala is flowing in the middle of this valley, which joins the river Brahmani. The location of study site is shown in Figure 1. One reclaimed one year old and other 18 year old overburden dump of was selected for the study belonging to respectively Sukinda Mines of M/s Tata Steel and Saruabil Mines of M/s Misrilal Mines.

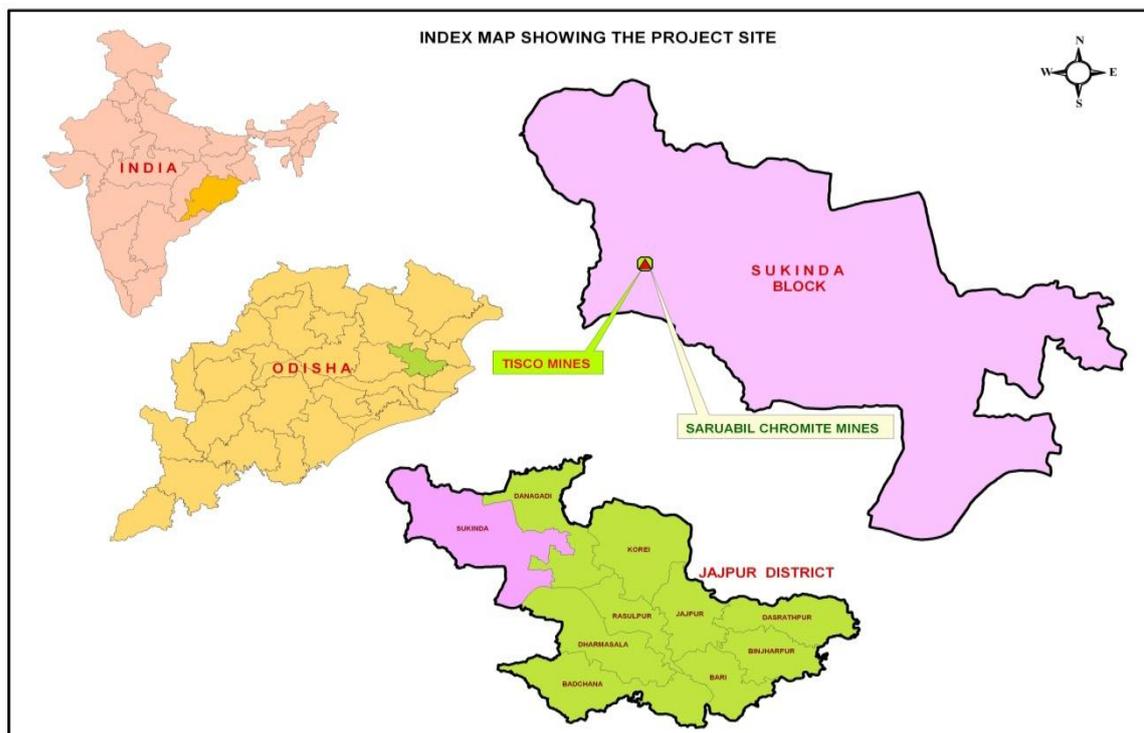


Fig. 1. Location of the study site

Materials and Methods

The phytosociological study was carried out during December 2009 to August, 2011 by laying quadrats of 10m x 10m for the tree and 1m x 1m for the herb species following Misra (1968). Three quadrats were laid on each site at slope, base and top of each aspect i.e. North, South, East and West. A total of 36 quadrats were laid at each site. The structural parameters, i.e. abundance, frequency and distribution pattern of both tree and herb species on the basis of quadrat study were calculated. Abundance is defined as total number of individuals found divided by total number of quadrats of occurrence and frequency is total number of quadrats of occurrence divided by total number of quadrats studied. Abundance frequency ratio gives the idea of distribution pattern of the species. It is calculated by dividing abundance of a species with its corresponding frequency. Curtis & Cottam (1956) used this ratio to indicate the distribution pattern of a species as regular (<0.025), random (0.025-0.05) and contagious (>0.05). The present paper mainly focuses on changes in distribution pattern of tree and herb species at both the study sites.

Results and Discussion

Table 1 provides phytosociological structural parameters of all the 18 tree species on different aspects of 1 year old reclaimed OB dumps of Sukinda mines. Distribution pattern of all the species at this site indicates that *Acacia auriculiformis* is reported on all the four aspects with contagiously distribution. *Cassia siamea*, *Peltophorum pterocarpum*, *Pongamia pinnata* and *Syzigium cumini* on the aspect, *Azadirachta indica* along with the above species on the west and *Albizia lebbek* on the south aspect are randomly distributed. At this site, maximum number of species is randomly distributed. From the data of all the 29 tree species sampled on different aspects of 18 year reclaimed OB dump of Saraubil chromite mines (Table 2), it is observed that only one species in south side i.e. *Diospyros montana* was contagiously distributed. *Acacia auriculiformis* was the most abundant species on all aspects except west aspect. *Cassia siamea* was the most abundant species on west aspect having random distribution. All species on east aspect exhibited regular distribution, however *Cassia siamea* and *Peltophorum pterocarpum* were randomly distributed. *Acacia auriculiformis* and *Cassia siamea* were randomly distributed on north and south aspect and *Syzigium cumini* showed regular distribution on the north and south aspects. Regular distribution was noticed for *Azadirachta indica* on east and south aspects and *Peltophorum pterocarpum* on south aspect. Phytosociological data of 62 herb species recorded on different aspects of 1 year old reclaimed OB dump is given in Table 3. No species was found with regular distribution. Five Species on the east aspect, 8 species on north aspect and 7 species on south aspect were randomly distributed. It means that most of the species at all aspects are contagiously distributed.

Table 1. Phytosociological parameters of tree species on different aspects of one year old site (values in the parenthesis denote number of species)

Sl No.	Name of the species	Family	East(17)			West(17)			North(17)			South(17)		
			A	F	A/F	A	F	A/F	A	F	A/F	A	F	A/F
1	<i>Annona squamosa</i>	Annonaceae	1.29	62.96	0.02	1.00	44.40	0.02	1.00	22.22	0.05	1.00	33.33	0.03
2	<i>Alstonia scholaris</i>	Apocynaceae	1.80	92.59	0.02	1.53	70.40	0.02	1.00	33.33	0.03	1.17	44.44	0.03
3	<i>Cassia siamea</i>	Caesalpiniaceae	2.74	100.00	0.03	3.59	100.00	0.04	4.93	100.00	0.05	4.59	100.00	0.05
4	<i>Peltophorum pterocarpum</i>	Caesalpiniaceae	3.15	100.00	0.03	2.93	100.00	0.03	3.85	100.00	0.04	3.33	100.00	0.03
5	<i>Casuarina equisetifolia</i>	Casuarinaceae	1.83	88.89	0.02	1.30	74.10	0.02	2.09	81.48	0.03	1.17	66.67	0.02
6	<i>Terminalia arjuna</i>	Combretaceae	1.79	88.89	0.02	2.67	100.00	0.03	2.67	100.00	0.03	1.81	96.30	0.02
7	<i>Terminalia bellirica</i>	Combretaceae	1.25	44.44	0.03	1.15	48.20	0.02	1.00	33.33	0.03	1.17	44.44	0.03
8	<i>Terminalia catappa</i>	Combretaceae	1.00	29.63	0.03	1.36	40.70	0.03	1.33	33.33	0.04	1.00	25.93	0.04
9	<i>Phyllanthus emblica</i>	Euphorbiaceae	1.78	85.19	0.02	2.15	74.10	0.03	2.37	100.00	0.02	-	-	
10	<i>Pongamia pinnata</i>	Fabaceae	3.19	100.00	0.03	2.78	100.00	0.03	4.59	100.00	0.05	5.33	100.00	0.05
11	<i>Azadirachta indica</i>	Meliaceae	3.63	100.00	0.04	4.04	100.00	0.04	3.89	100.00	0.04	4.59	100.00	0.05
12	<i>Acacia auriculiformis</i>	Mimosaceae	5.44	100.00	0.05	5.93	100.00	0.06	6.70	100.00	0.07	9.00	100.00	0.09
13	<i>Albizia lebbek</i>	Mimosaceae	2.63	100.00	0.03	2.85	100.00	0.03	3.59	100.00	0.04	5.41	100.00	0.05
14	<i>Musa paradisiaca</i>	Musaceae										1.00	18.52	0.05
15	<i>Syzigium cumini</i>	Myrtaceae	3.56	100.00	0.04	3.85	100.00	0.04	5.52	100.00	0.06	7.59	100.00	0.08
16	<i>Bambusa vulgaris</i>	Poaceae	1.33	66.67	0.02	1.63	59.30	0.03	2.00	92.59	0.02	1.50	59.26	0.03
17	<i>Mimusops elengi</i>	Sapotaceae	1.00	33.33	0.03	1.00	33.30	0.03	1.00	33.33	0.03	1.00	25.93	0.04
18	<i>Ailanthus excelsa</i>	Simaroubaceae	1.43	51.85	0.03	1.38	77.80	0.02	1.20	37.04	0.03	1.20	55.56	0.02

Table 2. Phytosociological parameters of tree species on different aspects of 18 year old site (values in the parenthesis denote number of species)

Sl No.	Name of the species	Family	East(16)			West(16)			North(16)			South(16)		
			A	F	A/F	A	F	A/F	A	F	A/F	A	F	A/F
1	<i>Anacardium occidentale</i>	Anacardiaceae	1.00	33.33	0.03	1.00	59.30	0.02	1.28	66.67	0.02	1.00	37.04	0.03
2	<i>Buchanania lanzan</i>	Anacardiaceae	-	-		1.44	59.30	0.02	-	-		1.50	44.44	0.03
3	<i>Anogeissus acuminata</i>	Anacardiaceae	1.25	29.63	0.04	-	-		1.27	55.56	0.02	-	-	
4	<i>Semicarpus anacardium</i>	Anacardiaceae	1.00	37.04	0.03	-	-		-	-		1.00	62.96	0.02
5	<i>Alstonia scholaris</i>	Apocynaceae	-	-		1.41	63.00	0.02	-	-		1.29	62.96	0.02
6	<i>Holarrhena pubescens</i>	Apocynaceae	-	-		-	-		1.53	70.37	0.02	-	-	
7	<i>Cassia occidentalis</i>	Caesalpiniaceae	1.37	70.37	0.02	-	-		-	-		-	-	
8	<i>Cassia siamea</i>	Caesalpiniaceae	2.15	100.00	0.02	2.65	96.30	0.03	2.59	100.00	0.03	2.15	96.30	0.02
9	<i>Peltophorum pterocarpum</i>	Caesalpiniaceae	1.81	100.00	0.02	2.33	100.00	0.02	1.85	100.00	0.02	1.58	88.89	0.02
10	<i>Terminalia alata</i>	Combretaceae	1.00	29.63	0.03	-	-		1.00	37.04	0.03	-	-	
11	<i>Terminalia bellirica</i>	Combretaceae	-	-		-	-		1.00	33.33	0.03	-	-	
12	<i>Shorea robusta</i>	Dipterocarpaceae	-	-		1.00	55.60	0.02	-	-		1.00	40.74	0.03
13	<i>Diospyros montana</i>	Ebenaceae	-	-		1.18	40.70	0.03	1.11	66.67	0.02	1.29	25.93	0.05
14	<i>Glochidion lanceolarium</i>	Euphorbiaceae	1.00	44.44	0.02	1.00	63.00	0.02	-	-		-	-	
15	<i>Macaranga peltata</i>	Euphorbiaceae	1.00	48.15	0.02	1.28	66.70	0.02	1.38	59.26	0.02	-	-	
16	<i>Mallotus philippinensis</i>	Euphorbiaceae	-	-		-	-		-	-		1.00	55.56	0.02
17	<i>Pongamia pinnata</i>	Fabaceae	1.83	88.89	0.02	1.39	85.20	0.02	1.60	74.07	0.02	1.24	77.78	0.02
18	<i>Lagerstroemia parviflora</i>	Lythraceae	-	-		-	-		1.65	85.19	0.02	-	-	
19	<i>Azadirachta indica</i>	Meliaceae	2.44	100.00	0.02	2.11	100.00	0.02	2.15	96.30	0.02	1.17	88.89	0.01
20	<i>Acacia auriculiformis</i>	Mimosaceae	2.07	100.00	0.02	2.07	100.00	0.02	2.85	100.00	0.03	2.22	100.00	0.02
21	<i>Acacia mangium</i>	Mimosaceae	1.00	37.04	0.03	-	-		-	-		-	-	
22	<i>Albizia lebbbeck</i>	Mimosaceae	1.00	37.04	0.03	1.13	55.60	0.02	-	-		-	-	
23	<i>Ficus benghalensis</i>	Moraceae	1.00	29.63	0.03	-	-		1.00	48.15	0.02	-	-	
24	<i>Ficus racemosa</i>	Moraceae	-	-		-	-		1.00	33.33	0.03	-	-	
25	<i>Ficus religiosa</i>	Moraceae	-	-		-	-		1.00	29.63	0.03	-	-	
26	<i>Syzigium cumini</i>	Myrtaceae	-	-		1.53	55.60	0.03	2.13	88.89	0.02	2.19	100.00	0.02
27	<i>Madhuca indica</i>	Sapotaceae	-	-		1.00	48.20	0.02	-	-		1.00	29.63	0.03
28	<i>Simarouba glauca</i>	Simaroubaceae	-	-		-	-		-	-		1.47	62.96	0.02
29	<i>Trema orientalis</i>	Ulmaceae	1.48	100.00	0.02	1.37	70.40	0.02	-	-		1.36	40.74	0.03

However, distribution pattern of a species is different from one aspect to other in case of some species. Distribution pattern of 62 herb species on different aspects at 18 year old site of Saruabil chromite mines is given in Table 4. Two species viz., *Mimosa pudica* on the east aspect and *Mallotus philippensis* (seedling) on the west aspect exhibited regular distribution. Random distribution by *Vernonia cineria*, *Mimosa pudica*, *Aerva lanata* and *Acacia auriculiformis* and contiguous distribution by *Atylosia scarabaeoides*, *Cynodon dactylon* and *Evolvulus nummularius* was observed on east aspect. *Aerva lanata*, *Cynodon dactylon* and *Mallotus philippensis* were randomly distributed on west aspect. On the north aspect, *Cynodon dactylon*, *Flacourtia ramontchii* were randomly distributed and *Amaranthus viridis*, *Commelina benghalensis*, *Evolvulus nummularius*, *Mariscus paniceus*, *Tephrosia purpurea* and *Mimosa pudica* were contagiously distributed. Trend of distribution on the South aspect showed that *Aerva lanata*, *Chromolaena odorata*, *Cynodon dactylon*, *Flacourtia ramontchii*, *Mimosa pudica*, *Mitragyna parviflora* (seedling) and *Oplismenus burmanii* were randomly distributed where as *Atylosia scarabaeoides*, *Cyperus compressus*, *Evolvulus nummularius* and *Elephantopus scaber* were contagiously distributed. Our results indicate that with the increasing age of the reclaimed sites, there are less number of herb species showing contagious distribution as species with random distribution have increased at 18 year old site. Increase in tree layer canopy therefore, reduces the scope of contagious distribution by herb species.

Table 3. Phytosociological parameters of Herb species on different aspects of one year old site(values in the parenthesis denote number of species)

SI No.	Name of the species	Family	East(43)			West(37)			North(38)			South(40)		
			A	F	A/F	A	F	A/F	A	F	A/F	A	F	A/F
1	<i>Justicia gendarussa</i>	Acanthaceae	2.50	22.22	0.11	2.50	22.20	0.11	2.50	22.22	0.11	1.40	18.52	0.08
2	<i>Achyranthes aspera</i>	Amaranthaceae	-	-	-	1.67	22.20	0.08	-	-	-	1.36	40.74	0.03
3	<i>Aerva lanata</i>	Amaranthaceae	-	-	-	1.50	14.80	0.10	1.20	18.52	0.07	1.20	18.52	0.07
4	<i>Aerva sanguinolenta</i>	Amaranthaceae	-	-	-	-	-	-	-	-	-	1.40	18.52	0.08
5	<i>Alternanthera sessilis</i>	Amaranthaceae	-	-	-	1.00	18.50	0.05	-	-	-	-	-	-
6	<i>Amaranthus viridis</i>	Amaranthaceae	2.08	44.44	0.05	2.40	37.00	0.07	1.00	25.93	0.04	1.83	22.22	0.08
7	<i>Calotropis gigantea</i>	Asclepiadaceae	1.00	14.81	0.07	1.20	18.50	0.07	-	-	-	1.00	11.11	0.09
8	<i>Calotropis Procera</i>	Asclepiadaceae	1.14	25.93	0.04	1.25	14.80	0.08	1.50	22.22	0.07	1.25	14.81	0.08
9	<i>Hemidesmus indicus</i>	Asclepiadaceae	-	-	-	1.40	18.50	0.08	1.17	22.22	0.05	1.33	11.11	0.12
10	<i>Blumea lacera</i>	Asteraceae	-	-	-	-	-	-	1.00	14.81	0.07	1.00	18.52	0.05
11	<i>Elephantopus scaber</i>	Asteraceae	1.20	18.52	0.07	2.29	25.90	0.09	-	-	-	1.50	14.81	0.10
12	<i>Vernonia cineria</i>	Asteraceae	1.33	22.22	0.06	1.00	11.10	0.09	1.00	14.81	0.07	1.00	14.81	0.07
13	<i>Cleome viscosa</i>	Capparaceae	1.55	40.74	0.04	1.20	18.50	0.07	1.25	29.63	0.04	-	-	-
14	<i>Commelina benghalensis</i>	Commelinaceae	1.67	22.22	0.08	-	-	-	-	-	-	-	-	-
15	<i>Commelina obliqua</i>	Commelinaceae	-	-	-	1.20	18.50	0.07	1.50	22.22	0.07	-	-	-
16	<i>Tonningia axillaris</i>	Commelinaceae	1.80	18.52	0.10	-	-	-	-	-	-	-	-	-
17	<i>Ipomea coccinea</i>	Convolvulaceae	2.40	18.52	0.13	1.67	33.30	0.05	2.50	14.81	0.17	2.80	18.52	0.15
18	<i>Ipomea pestigridis</i>	Convolvulaceae	1.33	22.22	0.06	1.00	18.50	0.05	1.20	18.52	0.07	1.60	18.52	0.09
19	<i>Merremia umbellata</i>	Convolvulaceae	-	-	-	-	-	-	1.25	14.81	0.08	-	-	-
20	<i>Lagenaria siceraria</i>	Cucurbitaceae	1.00	14.81	0.07	-	-	-	-	-	-	-	-	-
21	<i>Luffa aegyptiaca</i>	Cucurbitaceae	1.43	25.93	0.06	-	-	-	-	-	-	-	-	-
22	<i>Trichosanthes cuspidata</i>	Cucurbitaceae	2.14	25.93	0.08	1.50	14.80	0.10	1.00	14.81	0.07	-	-	-
23	<i>Cyperus compressus</i>	Cyperaceae	-	-	-	1.78	33.30	0.05	2.00	44.44	0.05	1.88	29.63	0.06
24	<i>Cyperus diffusus</i>	Cyperaceae	1.50	22.22	0.07	-	-	-	-	-	-	-	-	-
25	<i>Mariscus paniceus</i>	Cyperaceae	1.83	22.22	0.08	-	-	-	1.50	22.22	0.07	1.18	40.74	0.03
26	<i>Dioscorea wallichii</i>	Dioscoreaceae	-	-	-	1.10	37.00	0.03	1.33	33.33	0.04	1.40	18.52	0.08
27	<i>Croton bonplandianum</i>	Euphorbiaceae	1.67	22.22	0.08	-	-	-	-	-	-	-	-	-
28	<i>Euphorbia hirta</i>	Euphorbiaceae	-	-	-	1.00	22.20	0.05	-	-	-	-	-	-
29	<i>Jatropha curcas</i>	Euphorbiaceae	1.00	18.52	0.05	1.67	22.20	0.08	1.33	11.11	0.12	1.33	11.11	0.12
30	<i>Phyllanthus virgatus</i>	Euphorbiaceae	1.17	22.22	0.05	-	-	-	1.25	14.81	0.08	1.00	14.81	0.07
31	<i>Aeschynomene indica</i>	Fabaceae	1.50	22.22	0.07	-	-	-	-	-	-	-	-	-
32	<i>Atylosia scarabaeoides</i>	Fabaceae	1.20	18.52	0.07	2.50	81.50	0.03	2.00	22.22	0.09	2.33	33.33	0.07

33	<i>Crotalaria albida</i>	Fabaceae	1.00	14.81	0.07	1.33	33.30	0.04	1.00	18.52	0.05	1.73	40.74	0.04
34	<i>Crotalaria calycina</i>	Fabaceae	2.67	22.22	0.12	-	-	-	-	-	-	-	-	-
35	<i>Stylosanthes hamata</i>	Fabaceae	2.80	55.56	0.05	2.85	48.20	0.06	4.00	22.22	0.18	3.13	55.56	0.06
36	<i>Tephrosia maxima</i>	Fabaceae	-	-	-	2.13	29.60	0.07	-	-	-	-	-	-
37	<i>Tephrosia purpurea</i>	Fabaceae	1.25	14.81	0.08	2.00	40.70	0.05	2.00	51.85	0.04	2.50	22.22	0.11
38	<i>Vigna mungo</i>	Fabaceae	2.67	22.22	0.12	2.71	25.90	0.11	-	-	-	2.83	22.22	0.13
39	<i>Zornia gibbosa</i>	Fabaceae	-	-	-	-	-	-	1.60	18.52	0.09	1.40	18.52	0.08
40	<i>Flacourtia jangomasi</i>	Flacourtiaceae	1.75	14.81	0.12	1.40	18.50	0.08	1.00	3.70	0.27	2.17	22.22	0.10
41	<i>Canscora diffusa</i>	Gentianaceae	-	-	-	-	-	-	1.67	22.22	0.08	1.50	14.81	0.10
42	<i>Lygodium flexuosum</i>	Lygodiaceae	-	-	-	1.50	22.20	0.07	1.33	33.33	0.04	1.25	29.63	0.04
43	<i>Lagerstroemia parviflora</i>	Lythraceae	2.00	25.93	0.08	-	-	-	-	-	-	-	-	-
44	<i>Woodifolia fruticosa</i>	Lythraceae	-	-	-	-	-	-	1.00	7.41	0.14	1.00	14.81	0.07
45	<i>Acaccia pennata</i>	Mimosaceae	2.67	22.22	0.12	-	-	-	1.00	14.81	0.07	-	-	-
46	<i>Mimosa pudica</i>	Mimosaceae	2.40	55.56	0.04	2.75	59.30	0.05	1.80	37.04	0.05	2.50	81.48	0.03
47	<i>Mollugo pentaphylla</i>	Molluginaceae	-	-	-	1.75	14.80	0.12	-	-	-	1.50	22.22	0.07
48	<i>Boerhavia diffusa</i>	Nyctaginaceae	1.75	14.81	0.12	-	-	-	-	-	-	-	-	-
49	<i>Biophytum sensitivum</i>	Oxalidaceae	1.60	18.52	0.09	-	-	-	-	-	-	-	-	-
50	<i>Cynodon dactylon</i>	Poaceae	2.25	29.63	0.08	2.38	59.30	0.04	2.54	48.15	0.05	2.36	51.85	0.05
51	<i>Eragrostis ciliaris</i>	Poaceae	2.13	29.63	0.07	-	-	-	1.00	14.81	0.07	1.00	11.11	0.09
52	<i>Oplismenus burmanii</i>	Poaceae	1.55	40.74	0.04	1.00	7.41	0.14	1.18	40.74	0.03	1.00	29.63	0.03
53	<i>Panicum miliare</i>	Poaceae	1.00	14.81	0.07	2.60	18.50	0.14	1.00	14.81	0.07	1.00	14.81	0.07
54	<i>Paspalidium flavidum</i>	Poaceae	-	-	-	-	-	-	1.67	22.22	0.08	-	-	-
55	<i>Penisetum pedicellatum</i>	Poaceae	1.80	18.52	0.10	1.00	22.20	0.05	-	-	-	1.25	14.81	0.08
56	<i>Saccharum spontaneum</i>	Poaceae	1.50	22.22	0.07	-	-	-	-	-	-	-	-	-
57	<i>Mitragyna parvifolia</i>	Rubiaceae	-	-	-	-	-	-	1.60	18.52	0.09	1.60	18.52	0.09
58	<i>Spermacoce articularis</i>	Rubiaceae	1.33	22.22	0.06	1.67	22.20	0.08	1.00	18.52	0.05	1.00	11.11	0.09
59	<i>Spermacoce hispida</i>	Rubiaceae	1.50	22.22	0.07	1.00	18.50	0.05	1.40	18.52	0.08	1.25	14.81	0.08
60	<i>Chorchorus olitonius</i>	Tiliaceae	1.57	25.93	0.06	-	-	-	-	-	-	-	-	-
61	<i>Corchorus aestuans</i>	Tiliaceae	1.33	22.22	0.06	1.20	18.50	0.07	-	-	-	1.00	11.11	0.09
62	<i>Clerodendrum indicum</i>	Verbenaceae	1.60	18.52	0.09	1.80	18.50	0.10	1.40	18.52	0.08	2.80	18.52	0.15

Among the herbaceous families, the family *Euphorbiaceae* and *Poaceae* represented greater number of species at one year old site and family *Fabaceae* and *Poaceae* at 18 year old site. There is no significant difference in herb species richness between these two reclaimed sites. We recorded 37-43 herb species at one year old site 35-47 herb species at 18 year old site, therefore, there is not much difference in species richness. Herb species content was higher on the east aspect of 18 year old site, compared to east aspect of one year old. The species number on south aspect decreased marginally at the older site. The importance of adjacent gene pool of surrounding natural vegetation and dormant seeds or plant remains has been highlighted by several workers in aiding the restoration of degraded habitats. These gene pools allow species to establish and coexist (high richness and evenness values), improving natural colonisation of the dumps (Martínez-Ruiz *et al.* 2001; Martínez-Ruiz & Fernández-Santos, 2005). One of the means for conserving biodiversity by improving natural colonization has been emphasized by Bradshaw (1997). We conclude that natural colonisation on these degraded sites by herb species may be due to adjacent seed source present in the surrounding natural vegetation. The succession and restoration of these sites may be faster if surrounding natural forests are protected well.

Table 4. Phytosociological parameters of Herb species on different aspects of 18 year old site (values in the parenthesis denote number of species)

SI No.	Name of the species	Family	East (47)			West (35)			North(37)			South(36)		
			A	F	A/F									
1	<i>Justicia gendarussa</i>	Acanthaceae	1.89	33.33	0.06	-	-	-	-	-	-	-	-	-
2	<i>Rungia pectinata</i>	Acanthaceae	1.33	22.22	0.06	-	-	-	-	-	-	-	-	-
3	<i>Adiantum incisum</i>	Adiantaceae	1.00	11.11	0.09	1.09	40.70	0.03	1.00	29.63	0.03	1.20	18.52	0.07
4	<i>Aerva lanata</i>	Amaranthaceae	1.25	44.44	0.03	1.36	40.70	0.03	1.00	29.63	0.03	1.38	29.63	0.05
5	<i>Aerva sanguinolenta</i>	Amaranthaceae	-	-	-	1.14	25.90	0.04	2.25	14.81	0.15	1.33	44.44	0.03
6	<i>Amaranthus viridis</i>	Amaranthaceae	1.00	14.81	0.07	-	-	-	1.82	40.74	0.05	1.40	37.04	0.04
7	<i>Catharanthus roseus</i>	Apocynaceae	2.67	33.33	0.08	-	-	-	-	-	-	-	-	-
8	<i>Amorphophallus paeonifolius</i>	Araceae	-	-	-	1.00	14.80	0.07	-	-	-	-	-	-
9	<i>Calotropis gigantea</i>	Asclepiadaceae	1.13	29.63	0.04	1.00	18.50	0.05	-	-	-	2.20	37.04	0.06
10	<i>Calotropis Procera</i>	Asclepiadaceae	-	-	-	2.78	33.30	0.08	1.33	11.11	0.12	-	-	-
11	<i>Hemidesmus indicus</i>	Asclepiadaceae	1.00	14.81	0.07	1.22	33.30	0.04	-	-	-	1.00	14.81	0.07
12	<i>Chromolaena odorata</i>	Asteraceae	1.46	48.15	0.03	1.00	14.80	0.07	1.33	11.11	0.12	1.58	44.44	0.04
13	<i>Elephantopus scaber</i>	Asteraceae	2.00	37.04	0.05	1.67	22.20	0.08	1.50	14.81	0.10	2.00	22.22	0.09
14	<i>Tridax procumbens</i>	Asteraceae	1.00	18.52	0.05	-	-	-	1.50	14.81	0.10	1.40	18.52	0.08
15	<i>Vernonia cineria</i>	Asteraceae	1.30	37.04	0.04	-	-	-	1.25	14.81	0.08	-	-	-
16	<i>Peltophorum heinii</i>	Caesalpiniaceae	2.67	33.33	0.08	-	-	-	2.50	22.22	0.11	-	-	-
17	<i>Cleome viscosa</i>	Capparaceae	1.75	44.44	0.04	1.50	22.20	0.07	1.00	14.81	0.07	1.56	33.33	0.05
18	<i>Combretum roxburghii</i>	Combretaceae	1.00	22.22	0.05	-	-	-	1.82	40.74	0.05	-	-	-
19	<i>Commelina benghalensis</i>	Commelinaceae	1.00	29.63	0.03	1.20	18.50	0.07	1.33	44.44	0.03	-	-	-
20	<i>Commelina obliqua</i>	Commelinaceae	-	-	-	1.67	22.20	0.08	2.00	18.52	0.11	2.40	18.52	0.13
21	<i>Evolvulus nummularius</i>	Convolvulaceae	2.73	55.56	0.05	1.17	22.20	0.05	3.75	29.63	0.13	2.50	66.67	0.04
22	<i>Merremia umbellata</i>	Convolvulaceae	1.33	22.22	0.06	1.50	44.40	0.03	1.33	22.22	0.06	-	-	-
23	<i>Cyperus compressus</i>	Cyperaceae	1.29	25.93	0.05	1.82	40.70	0.05	-	-	-	-	37.04	-
24	<i>Cyperus rotundus</i>	Cyperaceae	-	-	-	1.67	22.20	0.08	-	-	-	-	-	-
25	<i>Mariscus paniceus</i>	Cyperaceae	1.17	22.22	0.05	-	-	-	1.67	22.22	0.08	1.20	18.52	0.07
26	<i>Dioscorea wallichii</i>	Dioscoreaceae	1.33	22.22	0.06	1.67	33.30	0.05	1.36	40.74	0.03	1.30	37.04	0.04
27	<i>Glochidion lanceolarium</i>	Euphorbiaceae	1.00	14.81	0.07	-	-	-	1.20	18.52	0.07	1.17	22.22	0.05
28	<i>Jatropha curcas</i>	Euphorbiaceae	1.40	18.52	0.08	-	-	-	1.00	7.41	0.14	-	-	-
29	<i>Macaranga peltata</i>	Euphorbiaceae	1.33	22.22	0.06	-	-	-	-	-	-	-	-	-
30	<i>Mallotus philippensis</i>	Euphorbiaceae	-	-	-	1.33	55.60	0.02	-	-	-	-	-	-

31	<i>phyllanthus fraternus</i>	Euphorbiaceae	1.83	22.22	0.08	1.25	29.60	0.04	-	-	-	-	-	-
32	<i>Phyllanthus virgatus</i>	Euphorbiaceae	-	-	-	1.25	29.60	0.04	1.50	22.22	0.07	1.00	11.11	0.09
33	<i>Atylosia scarabaeoides</i>	Fabaceae	2.56	33.33	0.08	1.44	33.30	0.04	1.86	25.93	0.07	2.43	25.93	0.09
34	<i>Crotalaria prostrata</i>	Fabaceae	1.40	37.04	0.04	2.31	48.20	0.05	1.22	33.33	0.04	1.00	18.52	0.05
35	<i>Spatholobus roxburghii</i>	Fabaceae	1.40	18.52	0.08	-	-	-	1.25	14.81	0.08	1.40	18.52	0.08
36	<i>Tephrosia purpurea</i>	Fabaceae	1.86	25.93	0.07	1.33	22.20	0.06	1.67	22.22	0.08	1.44	33.33	0.04
37	<i>Zornia gibbosa</i>	Fabaceae	-	-	-	1.50	22.20	0.07	-	-	-	-	-	-
38	<i>Flacourtia jangomas</i>	Flacourtiaceae	1.36	40.74	0.03	1.00	14.80	0.07	1.92	48.15	0.04	1.89	33.33	0.06
39	<i>Ocimum sanctum</i>	Lamiaceae	2.00	7.41	0.27	-	-	-	1.00	3.70	0.27	1.33	11.11	0.12
40	<i>Lygodium flexuosum</i>	Lygodiaceae	1.45	40.74	0.04	1.17	22.20	0.05	1.33	22.22	0.06	1.00	11.11	0.09
41	<i>Abutilon indicum</i>	Malvaceae	-	-	-	-	-	-	-	-	-	1.40	18.52	0.08
42	<i>Sida cordata</i>	Malvaceae	1.20	37.04	0.03	2.41	63.00	0.04	1.20	37.04	0.03	1.60	18.52	0.09
43	<i>Sida acuta</i>	Malvaceae	-	-	-	1.40	37.00	0.04	-	-	-	-	-	-
44	<i>Tiliacora acuminata</i>	Menispermaceae	-	-	-	-	-	-	2.40	18.52	0.13	-	-	-
45	<i>Acaccia pennata</i>	Mimosaceae	1.67	22.22	0.08	-	-	-	-	-	-	-	-	-
46	<i>Albizia odoratissima</i>	Mimosaceae	-	-	-	-	-	-	1.75	14.81	0.12	2.00	18.52	0.11
47	<i>Mimosa pudica</i>	Mimosaceae	1.71	77.78	0.02	1.67	33.30	0.05	2.10	74.07	0.03	2.00	77.78	0.03
48	<i>Embelia tsjeriamcottam</i>	Myrsinaceae	1.80	18.52	0.10	1.95	70.40	0.03	-	-	-	2.14	25.93	0.08
49	<i>Boerhavia diffusa</i>	Nyctaginaceae	1.40	18.52	0.08	-	-	-	-	-	-	-	-	-
50	<i>Biophytum sensitivum</i>	Oxalidaceae	1.33	22.22	0.06	1.00	14.80	0.07	1.83	22.22	0.08	1.60	18.52	0.09
51	<i>Cynodon dactylon</i>	Poaceae	2.76	62.96	0.04	2.14	51.90	0.04	-	96.30	-	3.19	100.00	0.03
52	<i>Eragrostis ciliaris</i>	Poaceae	1.60	18.52	0.09	-	-	-	-	-	-	-	-	-
53	<i>Oplismenus burmanii</i>	Poaceae	1.55	40.74	0.04	1.00	14.80	0.07	-	-	-	1.00	18.52	0.05
54	<i>Paspalidium flavidum</i>	Poaceae	-	-	-	1.00	14.80	0.07	1.00	14.81	0.07	1.88	29.63	0.06
55	<i>Perotis indica</i>	Poaceae	1.00	18.52	0.05	-	-	-	-	-	-	-	-	-
56	<i>Saccharum Spontaneum</i>	Poaceae	1.50	22.22	0.07	-	-	-	-	-	-	-	-	-
57	<i>polygala chinensis</i>	Polygalaceae	-	-	-	1.00	14.80	0.07	1.67	22.22	0.08	-	-	-
58	<i>Hedyotis hytida</i>	Rubiaceae	-	-	-	-	-	-	-	-	-	1.33	22.22	0.06
59	<i>Mitragyna parvifolia</i>	Rubiaceae	1.00	14.81	0.07	-	-	-	3.00	33.33	0.09	1.33	33.33	0.04
60	<i>Spermacoce hispida</i>	Rubiaceae	1.00	18.52	0.05	-	-	-	-	-	-	1.00	14.81	0.07
61	<i>Spermacoce articularis</i>	Rubiaceae	1.29	25.93	0.05	-	-	-	-	-	-	-	-	-
62	<i>Smilax zeylanica</i>	Smilacaceae	1.00	18.52	0.05	-	-	-	1.67	33.33	0.05	1.25	14.81	0.08

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