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Phytosociological Study of herbs species at two reclaimed sites of Sukinda Chromite mining region of Odisha, India

Etude phytosociologique d'espèces herbacées colonisatrices de sites à résidus d'exploitation de chrome dans la région d'Odisha en Inde

SUDHAMAYEE BEHURA*, M. KAR & V.P.UPADHYAY**

Résumé : Une étude de la végétation herbacée sur des sites d'exploitation de chrome de la région de Sukinda, district de Jaipur à Odisha (Inde) a mis en évidence globalement 62 espèces colonisatrices des terrains pollués dont 32 communes à deux friches choisies à titre de comparaison : l'une vieille de 1 an, l'autre de 18 ans.
Pour ce dernier site, 28 familles ont été recensées contre 24 pour le premier. Parmi ces familles dominent les Poaceae, les Fabaceae et les Euphorbiaceae. Les espèces les plus fréquentes sont : *Cynodon dacrtylon* et *Mimosa pudica.*
La densité de la végétation herbacée a aussi été évaluée dans les deux sites pour souligner la dynamique de la végétation.

Mots-clés : Exploitation de chrome, Vallée de Sukinda, Terrains pollués, Phytosociologie

Abstract : Present study was carried out in the Chromite mining region of Sukinda, District Jajpur, Odisha. Two overburden dump sites were selected for vegetation analysis out of which one site was one year old and other 18 year old. Vegetation analysis was carried out on these sites to observe the differences in density of herb species after reclamation. The density was calculated for herb species at different aspects of these two dumps to fund out the impact of aspect and age on density values of herbaceous vegetation on reclaimed over burden sites. Of the 62 herb species recorded at these reclaimed sites, 34 species were present at both sides. Higher number of species was recorded on east aspect at both the sites. Eighteen year old site was represented by 28 families compared to 24 families at one year old site. Herb species of family Poaceae, Fabaceae and Euphorbiaceae were more in number than other families. *Cynodon dactylon* and *Mimosa pudica* exhibited dominance across all aspects at both the sites.

Key words : Chromite, Sukinda valley, Over burden dump, Phytosociology,

INTRODUCTION

Mining of minerals generate huge quantity of solid wastes that are known as overburden and dumped as mounds in the mining area. These may later be used for back filling or reclaimed at dump site itself. Developing vegetation on these degraded habitats is a challenge today as specialized skill required to restore these areas. The ecological way of creating plant cover has been studied by several workers (COOKE & JOHNSON 2002, WHISENANT 2002, HOLZEL & OTTE 2003) including plant succession in areas degraded by human activity (PRACH & PYSEK 1994, LUBKE *et al.*1996, KIRMER & MAHN 2001, PRACH *et al*, 2001, WIEGLEB & FELINKS 2001, PYSEK *et al.*2003, WHITING *et al*. 2004).

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Mining activities may influence the existing vegetation and affect the structure and function of the natural ecosystem. The reclamation program of degraded land must consider socio-economic, biological and technical aspects to restore a functional and self- sustaining soil-plant ecosystem (ANWAR *et al*., 2001). Natural vegetation usually develops slowly in degraded land because of its unfavorable physical structure and chemical properties (TORDOFF *et al*. 2000**,** KRZAKLEWSKI & PIETRZYKOWSKI 2002) and therefore, re-vegetation of overburden (OB) dumps takes longer time to make a stabilized habitat.

Biological reclamation largely depends on the selection of appropriate species and various parameters such as climate, physical and chemical properties of dump materials, topography and surrounding vegetation (SINGH & JHA 1992). Man made efforts to develop plantation could achieve short term socio-ecological goals by protecting the soil surface from erosion, by facilitating native species and by accelerating the recovery of genetic diversity. Spontaneous vegetation succession or natural recovery as an alternative approach to restoration (BRADSHAW 1997, PENSA *et al*, 2004) and plant community succession is one of the important aspects of restoration ecology (ZHANG,2005). On a global scale about 20 percent deforestation in developing countries may be attributable to mining (BAHRAMI *et al*. 2010). Due to recalcitrant materials and lower organic matter, the mining spoils are not suitable for both plant and microbial growth (AGRAWAL *et al*., 1993; BURGHARADT, 1993) and therefore, human intervention to accelerate the process of restoration is needed. The present paper examines the reclamation of overburden dump sites of chromite mines in Sukinda region of Jajpur district of Odisha, India.

STUDY AREA

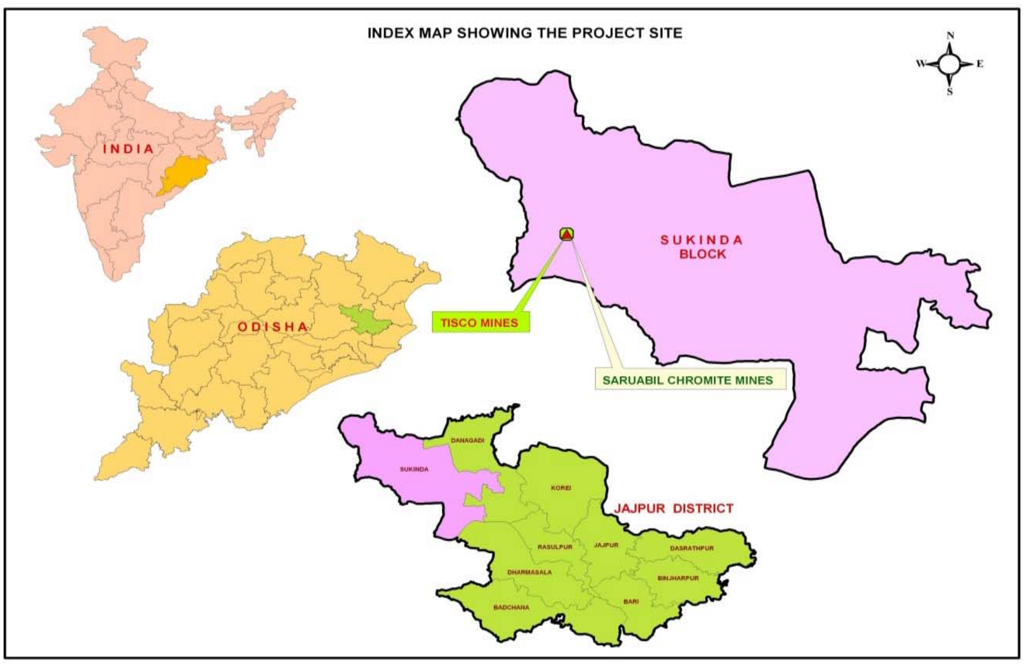
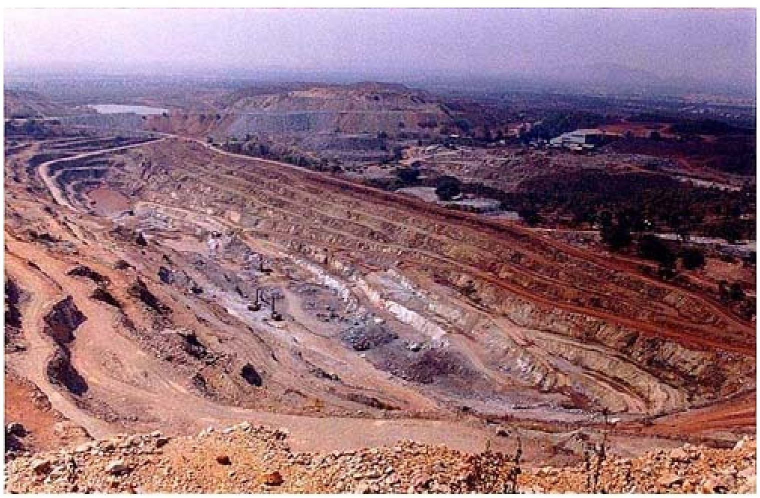


Figure 1: Location of study sites

The study site is located in Sukinda valley of Jajpur district in Odisha. Sukinda valley is at a distance of 130 km from the state capital Bhubaneswar, and is a Tehsil (Administrative Division) with its Head Quarter at Sukindagarh town. Sukinda consists of ten blocks, rich with most fertile lands on the bank of river Baitarini and produces large amount of cash crops every year. 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 valley contains 97% of India's chromites ore. FACOR, JINDAL

STAINLESS, MISRILAL MINES, IMFA, OMC and TATA STEEL etc. are operating in the area spread over of 50 sq km from Kansa to Maudlin. A natural stream Damsala is flowing in the middle of this valley, which joins the river Brahmani.

The Chromite mine in Sukinda started in 1960. Mining is done mostly by opencast mining method. However, underground mining is also done in a limited scale in the area. The host rock is hard ultra basic peridotite which hosts the Chromite ore. The mining lease areas is 296,858 hectares which 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. The sedimentary rock of this ultramafic belt extends up to 50 km and beyond. The ultramafics belong to the metamorphic rocks of pre-Cambrian age. The rocks of the area are associated with six sedimentary sequences separated by unconformities. The topography of the area is plane with a few rolling knolls and low ridges rising 10 to 30 metres. One year old overburden reclaimed dump of Sukinda TISCO mines of M/s TATA STEEL mines and 18 year old reclaimed over burden dump of SARUABIL Mines of M/s MISRILAL was selected for studying the changes in structural components of vegetation.



Photograph1 : Opencast Chromite Mining at Sukinda,Odisha,India

Photograph 2: Reclamation at D8 site of Saraubil Chromite Mine,Sukinda

The one year old site in named as D1 and 18 year old site as D8 in the present paper. The lease hold area is located in survey of India toposheet no.73G/16 (Lat.21^0 03' Long. 85^0 47') .The study site is shown in Figure 1. The total forest area in the district is 7711 ha (FSI, 2011). The forest is mainly concentrated in the blocks of Danagadi and Sukinda and is sub-tropical in nature. The Jajpur district is situated at an average altitude of 331 MSL. The climate is sub tropical. Average rain fall is 1014.5 mm. Average maximum and minimum temperatures are 38^0 C and 12^0 C respectively (Table 1).

Table 1. Average climatic conditions (average of year 1998- 2007) of Sukinda Valley, District Jajpur, Odisha

Month	Temperature (°C)		Rainfall (mm)	Relative Humidity (%)
	Maximum	Minimum		
January	30.62	14.82	14.2	56
February	35.05	17.10	9.6	59
March	39.49	21.23	19.7	62
April	42.61	24.07	49.6	70
May	43.49	25.59	68.4	74
June	41.18	26.21	222.9	79
July	36.85	25.56	388.0	84
August	32.16	22.55	356.0	86
September	31.86	22.29	293.9	85
October	31.47	18.89	176.9	80
November	29.83	15.98	5.9	73
December	26.44	12.37	2.3	68
Average	35.09	20.56		73
Total			1607.3	

MATERIALS AND METHODS

The phytosociological study was carried out from December 2009 to August, 2011 by laying quadrats of 1m x 1m for the herb species including seedlings of tree species (MISRA, 1968). Three quadrats were laid on each slope, base and top of each aspect i.e. North, South, East and West; thus, totaling to 36 quadrats at each site .The sampling was done twice for three seasons i.e. winter, summer and rainy during the study period. Therefore, a total of 72 quadrats were laid at each site in a period of two years in each rainy, winter and summer season totaling to 226 quadrats to study structural parameters of vegetation at one year (D1) and 18 year (D8) old reclaimed overburden dump site in chromite mining area of Sukinda Valley. On the basis of quadrat study, density was calculated to find out the numerical strength of a species and also the dominant species in different microhabitats of overburden dumps of these two sites.

RESULTS AND DISCUSSION

Table 2 and 3 provide the density of the herb species at different aspects of 1 year and 18 year old OB dumps. At one year old site, a total of 62 species of herbs was recorded. Among the herb species *Mimosa pudica* and *Stylosanthes hamata* were found dominant species across all aspects. However, *Atylosia scarabaeoides* was dominant species with density of 203.50 ha^{-1} on the west aspect. On the north aspect, the density was highest for *Cynodon dactylon*. On the south aspect, *Mimosa pudica* exhibited density 203.5 ha^{-1}. 62 species were encountered across all aspects of 18 year OB dump of Saruabil Chromite Mines. It is observed that *Cynodon dactylon* exhibited highest density across all aspects. On the west aspect, *Sida cordata* exhibited highest density. On north and south aspects, *Cynodon dactylon* had highest density values.

Table 2. Density of Herb species at different aspects of one year old (D1) site

			East(43)	**West(37)**	**North(38)**	**South(40)**
Sl No.	***Name of the species***	**Family**	**D**	**D**	**D**	**D**
1	***Acaccia pennata***	Mimosaceae	59.2	-	14.8	-
2	*Achyranthes aspera*	Amaranthaceae	-	37	-	55.5
3	*Aerva lanata*	Amaranthaceae	-	22.2	22.2	22.2
4	*Aerva sanguinolenta*	Amaranthaceae	-	-	-	25.9
5	*Aeschynomene indica*	Fabaceae	33.3	-	-	-
6	*Alternanthera sessilis*	Amaranthaceae	-	18.5	-	-
7	*Amaranthus viridis*	Amaranthaceae	92.5	88.8	25.9	40.7
8	*Atylosia scarabaeoides*	Fabaceae	22.2	203.5	44.4	77.7
9	*Biophytum sensitivum*	Oxalidaceae	29.6	-	-	-
10	*Blumea lacera*	Asteraceae	-	-	14.8	18.5
11	*Boerhavia diffusa*	Nyctaginaceae	25.9	-	-	-
12	*Calotropis gigantea*	Asclepiadaceae	14.8	22.2	-	11.1
13	*Calotropis Procera*	Asclepiadaceae	29.6	18.5	33.3	18.5
14	*Canscora diffusa*	Gentianaceae	-	-	37	22.2
15	*Chorcorus olitonius*	Tiliaceae	40.7	-	-	-
16	*Cleome viscosa*	Capparaceae	62.9	22.2	37	-
17	*Clerodendrum indicum*	Verbenaceae	29.6	33.3	25.9	51.8
18	*Commelina benghalensis*	Commelinaceae	37	-	-	-
19	*Commelina obliqua*	Commelinaceae	-	22.2	33.3	-
20	*Corchorus aestuans*	Tiliaceae	29.6	22.2	-	11.1
21	*Crotalaria albida*	Fabaceae	14.8	44.4	18.5	70.3
22	*Crotalaria calycina*	Fabaceae	59.2	-	-	-
23	*Croton bonplandianum*	Euphorbiaceae	37	-	-	-
24	*Cynodon dactylon*	Poaceae	66.6	140.6	122.1	122.1
25	*Cyperus compressus*	Cyperaceae	-	59.2	88.8	55.5
26	*Cyperus diffusus*	Cyperaceae	33.3	-	-	-
27	*Dioscorea wallichii*	Dioscoreaceae	-	40.7	44.4	25.9
28	*Elephantopus scaber*	Asteraceae	22.2	59.2	-	22.2

29	*Eragrostis ciliaris*	Poaceae	62.9	-	14.8	11.1
30	*Euphorbia hirta*	Euphorbiaceae	-	22.2	-	-
31	*Flacourtia jangomasi*	Flacourtiaceae	25.9	25.9	3.7	48.1
32	*Hemidesmus indicus*	Asclepiadaceae	-	25.9	25.9	14.8
33	*Ipomea coccinea*	Convolvulaceae	44.4	55.5	37	51.8
34	*Ipomea pestigridis*	Convolvulaceae	29.6	18.5	22.2	29.6
35	*Jatropha curcas*	Euphorbiaceae	18.5	37	14.8	14.8
36	*Justicia gendarussa*	Acanthaceae	55.5	55.5	55.5	25.9
37	*Lagenaria siceraria*	Cucurbitaceae	14.8	-	-	-
38	*Lagerstroemia parviflora*	Lythraceae	51.8	-	-	-
39	*Luffa aegyptiaca*	Cucurbitaceae	37	-	-	-
40	*Lygodium flexuosum*	Lygodiaceae	-	33.3	44.4	37
41	*Mariscus paniceus*	Cyperaceae	40.7	-	33.3	48.1
42	*Merremia umbellata*	Convolvulaceae	-	-	18.5	-
43	*Mimosa pudica*	Mimosaceae	133.2	162.8	66.6	203.5
44	*Mitragyna parvifolia*	Rubiaceae	-	-	29.6	29.6
45	*Mollugo pentaphylla*	Molluginaceae	-	25.9	-	33.3
46	*Oplismenus burmanii*	Poaceae	62.9	7.4	48.1	29.6
47	*Panicum miliare*	Poaceae	14.8	48.1	14.8	14.8
48	*Paspalidium flavidum*	Poaceae	-	-	37	-
49	*Penisetum pedicellatum*	Poaceae	33.3	22.2	-	18.5
50	*Phyllanthus virgatus*	Euphorbiaceae	25.9	-	18.5	14.8
51	*Saccharum spontaneum*	Poaceae	33.3	-	-	-
52	*Spermacoce articularis*	Rubiaceae	29.6	37	18.5	11.1
53	*Spermacoce hispida*	Rubiaceae	33.3	18.5	25.9	18.5
54	*Stylosanthes hamata*	Fabaceae	155.4	136.9	88.8	173.9
55	*Tephrosia maxima*	Fabaceae	-	62.9	-	-
56	*Tephrosia purpurea*	Fabaceae	18.5	81.4	103.6	55.5
57	*Tonningia axillaris*	Commelinaceae	33.3	-	-	-
58	*Trichosanthes cuspidats*	Cucurbitaceae	55.5	22.2	14.8	-
59	*Vernonia cineria*	Asteraceae	29.6	11.1	14.8	14.8
60	*Vigna mungo*	Fabaceae	59.2	70.3	-	62.9
61	*Woodifolia fruticosa*	Lythraceae	-	-	7.4	14.8
62	*Zornia gibbosa*	Fabaceae	-	-	29.6	25.9

Table 3. Density of Herb species at different aspects of 18 year old Dump (D8) site

			East (47)	**West (35)**	**North(37)**	**South(36)**
Sl No.	***Name of the species***	**Family**	**D**	**D**	**D**	**D**
1	*Abutilon indicum*	Malvaceae	-	-	-	25.9
2	*Acaccia pennata*	Mimosaceae	37	-	-	-

3	*Adiantum incissum*	Adiantaceae	11.1	44.4	29.6	22.2
4	*Aerva lanata*	Amaranthaceae	55.5	55.5	29.6	40.7
5	*Aerva sanguinolenta*	Amaranthaceae	-	29.6	33.3	59.2
6	*Albizia odoratissima*	Mimosaceae	-	-	25.9	37
7	*Amaranthus viridis*	Amaranthaceae	14.8	-	74	51.8
8	*Amorphophallus paeonifolius*	Araceae	-	14.8	-	-
9	*Atylosia scarabaeoides*	Fabaceae	85.1	48.1	48.1	62.9
10	*Biophytum sensitivum*	Oxalidaceae	29.6	14.8	40.7	29.6
11	*Boerhavia diffusa*	Nyctaginaceae	25.9	-	-	-
12	*Calotropis gigantea*	Asclepiadaceae	33.3	18.5	-	81.4
13	*Calotropis Procera*	Asclepiadaceae	-	92.5	14.8	-
14	*Catharanthus roseus*	Apocynaceae	88.8	-	-	-
15	*Chromolaena odorata*	Asteraceae	70.3	14.8	14.8	70.3
16	*Cleome viscosa*	Capparaceae	77.7	33.3	14.8	51.8
17	*Combretum roxburghii*	Combretaceae	22.2	-	74	-
18	*Commelina benghalensis*	Commelinaceae	29.6	22.2	59.2	-
19	*Commelina obliqua*	Commelinaceae	-	37	37	44.4
20	*Crotalaria prostrata*	Fabaceae	51.8	111	40.7	18.5
21	*Cynodon dactylon*	Poaceae	173.9	111	292.3	318.2
22	*Cyperus compressus*	Cyperaceae	33.3	74	-	77.7
23	*Cyperus rotundus*	Cyperaceae	-	37	-	-
24	*Dioscorea wallichii*	Dioscoreaceae	29.6	55.5	55.5	48.1
25	*Elephantopus scaber*	Asteraceae	74	37	22.2	44.4
26	*Embelia tsjeriamcottam*	Myrsinaceae	33.3	136.9	-	55.5
27	*Eragrostis cilliaris*	Poaceae	29.6	-	-	-
28	*Evolvulus nummularius*	Convolvulaceae	151.7	25.9	111	166.5
29	*Flacourtia jangomas*	Flacourtiaceae	55.5	14.8	92.5	62.9
30	*Glochidion lanceolarium*	Euphorbiaceae	14.8	-	22.2	25.9
31	*Hedyotis hytida*	Rubiaceae	-	-	-	29.6
32	*Hemidesmus indicus*	Asclepiadaceae	14.8	40.7	-	14.8
33	*Jatropha curcas*	Euphorbiaceae	25.9	-	7.4	-
34	*Justicia gendarussa*	Acanthaceae	62.9	-	-	-
35	*Lygodium flexuosum*	Lygodiaceae	59.2	25.9	29.6	11.1
36	*Macaranga peltata*	Euphorbiaceae	29.6	-	-	-
37	*Mallotus philippensis*	Euphorbiaceae	-	74	-	-
38	*Mariscus paniceus*	Cyperaceae	25.9	-	37	22.2
39	*Merremia umbellata*	Convolvulaceae	29.6	66.6	29.6	-
40	*Mimosa pudica*	Mimosaceae	133.2	55.5	155.4	155.4
41	*Mitragyna parvifolia*	Rubiaceae	14.8	-	99.9	44.4
42	*Ocimum sanctum*	Lamiaceae	14.8	-	3.7	14.8
43	*Oplismenus burmanii*	Poaceae	62.9	14.8	-	18.5
44	*Paspalidium flavidum*	Poaceae	-	14.8	14.8	55.5
45	*Peltophorum heinii*	Caesalpiniaceae	88.8	-	55.5	-
46	*perotis indica*	Poaceae	18.5	-	-	-
47	*phyllanthus fraternus*	Euphorbiaceae	40.7	37	-	-
48	*Phyllanthus virgatus*	Euphorbiaceae	-	37	33.3	11.1
49	*polygala chinensis*	Polygalaceae	-	14.8	37	-
50	*Sida cordata*	Malvaceae	44.4	151.7	44.4	29.6
51	*Rungia pectinata*	Acanthaceae	29.6	-	-	-
52	*Saccharum Spontaneum*	Poaceae	33.3	-	-	-
53	*Sida acuta*	Malvaceae	-	51.8	-	-
54	*Smilax zeylanica*	Smilacaceae	18.5	-	55.5	18.5
55	*Spatholobus roxburghii*	Fabaceae	25.9	-	18.5	25.9

56	*Spermacoce hispida*	Rubiaceae	18.5	-	-	14.8
57	*Spermacoce articularis*	Rubiaceae	33.3	-	-	-
58	*Tephrosia purpurea*	Fabaceae	48.1	29.6	37	48.1
59	*Tiliacora acuminata*	Menispermaceae	-	-	44.4	-
60	*Tridax procumbens*	Asteraceae	18.5	-	22.2	25.9
61	*Vernonia cineria*	Asteraceae	48.1	-	18.5	-
62	*Zornia gibbosa*	Fabaceae	-	33.3	-	-

There are 34 common species at both sites (Figures 2, 3, 4). Among the common species, the density was highest at 18 year old site (D8). Two species viz., *Mimosa pudica* and *Cynodon dactylon* exhibited tremendous growth at 18 years old site compared to the younger 1 year old site (D1). *Achyranthes aspera, Aeschynomene indica, Alternanthera sessilis, Blumea lacera, Canscora diffusa, Chorcorus olitonius, Clerodendrum indicum, Corchorus aestuans, Crotalaria albida, Crotalaria calycina, Croton bonplandianum, Cyperus diffusus, Euphorbia hirta, Ipomea coccinea, Ipomea pestigridis, Lagenaria siceraria,Lagerstroemia parviflora, Luffa aegyptiaca, Mollugo pentaphylla, Oplismenus burmanii, Panicum miliare, Penisetum pedicellatum, Stylosanthes hamata, Tephrosia maxima, Tonningia axillaris, Trichosanthes cuspidats, Vigna mungo, Woodifolia fruticosa* were found only at D1 site and the species *Sida cordata, Abutilon indicum, Adiantum incissum, Albizia odoratissima, Amorphophallus paeonifolius, Catharanthus roseus, Chromolaena odorata, Combretum roxburghii, Crotalaria prostrata, Cyperus rotundus, Embelia tsjeriamcottam, Eragrostis ciliaris, Evolvulus nummularius, Glochidion lanceolarium, Hedyotis hytida, Macaranga peltata, Mallotus philippensis, Ocimum sanctum, Peltophorum heinii, Perotis indica, Phyllanthus fraternus, Polygala chinensis, Rungia pectinata, Sida acuta, Smilax zeylanica, Spatholobus roxburghii, Tiliacora acuminate* and *Tridax procumbens* were found only at D8 site.

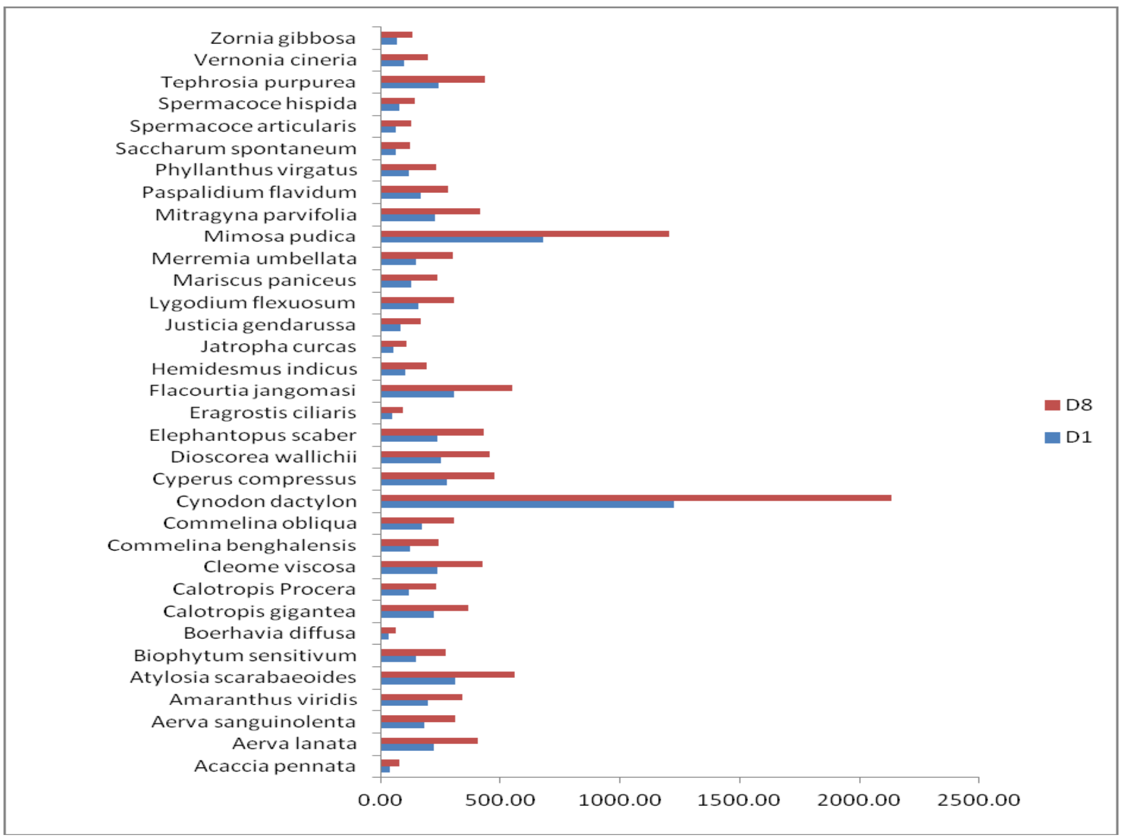


Figure 2. Density of common herb species at both Dump sites (number per ha)

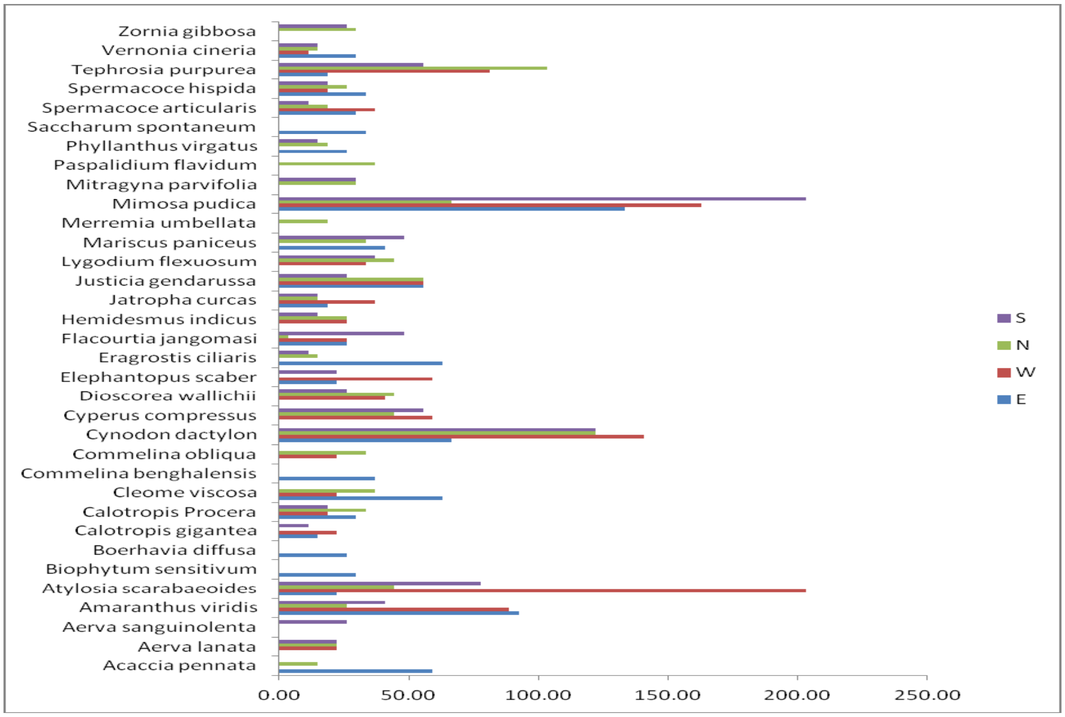


Figure 3. Density of common herb species at D1 dump site at different aspects

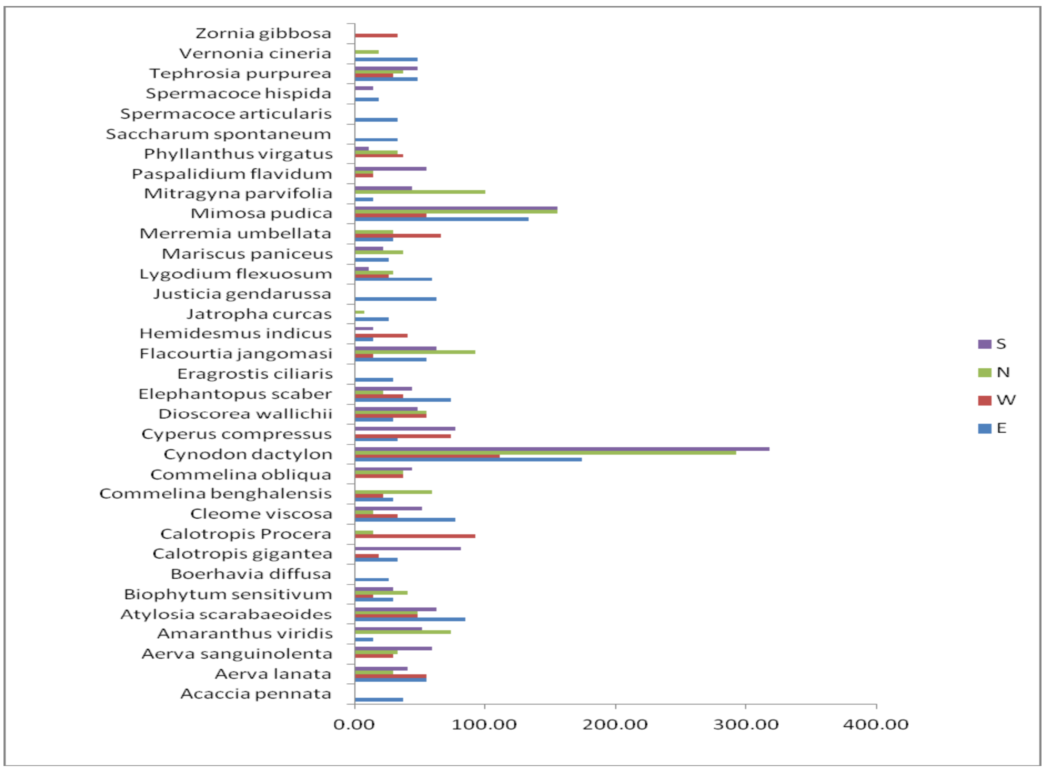


Figure 4. Density of common herb species at D8 dump site at different aspects

Among 34 common species, a total of 11 species were encountered on all the 4 aspects of D1 site (Fig. 3) viz., *Amaranthus viridis, Atylosia scarabaeoides, Calotropis Procera, Cynodon dactylon, Flacourtia jangomas, Justicia gendarussa, Mimosa pudica, Spermacoce articularis, Spermacoce hispida, Tephrosia purpurea, Vernonia cineria.* However, *Biophytum sensitivum, Boerhavia diffusa, Commelina benghalensis and Saccharum spontaneum* were found only on east aspect, and *Paspalidium flavidum and Merremia umbellata* on north aspect only. *Aerva sanguinolenta* was found in south aspect only. Of all the common species across four aspects at D1 site, two species having equal and highest density were *Mimosa pudica* on the south aspect and *Atylosia scarabaeoides* on the west aspect each with the density value of 203.5 ha^{-1}.

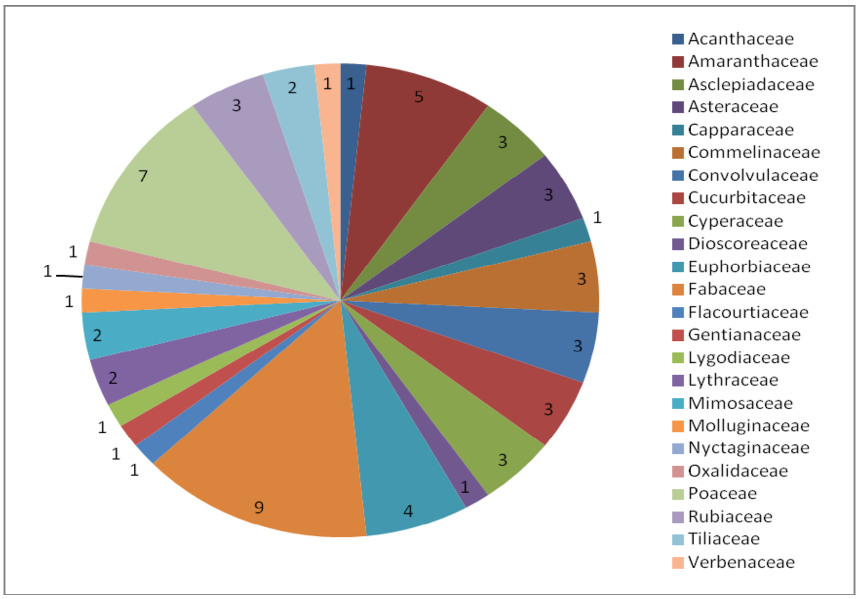


Figure 5. Different families and the number of species recorded at 1 year reclaimed Dump site.

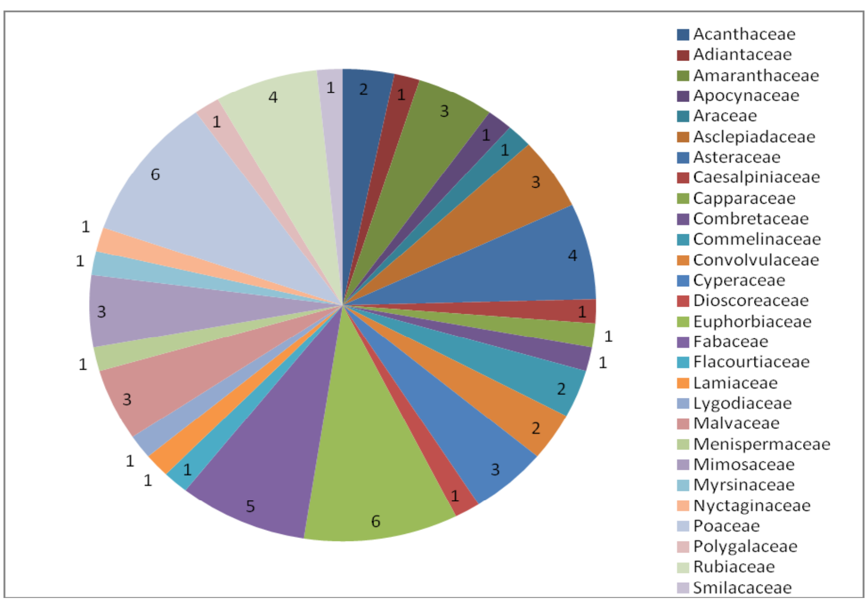


Figure 6. Different families and the number of species recorded at 18 year old reclaimed Dump site.

Among 34 common species at D8 site, 11 species were recorded on all the 4 aspects viz., *Tephrosia purpurea, Mimosa pudica, Lygodium flexuosum, Flacourtia jangomas, Elephantopus scaber, Dioscorea wallichii, Cynodon dactylon, Cleome viscosa, Biophytum sensitivum, Atylosia scarabaeoides and Aerva lanata.* A total of 6 species viz*., Acaccia pennata, Boerhavia diffusa, Eragrostis ciliaris, Justicia gendarussa, Saccharum spontaneum and Spermacoce articularis* were found on East aspect and the *Zornia gibbosa* was found only on west aspect of the dump (Fig. 4).

Tree plantation was done at both sites by selecting both native and exotic species.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 (BEHURA *et al.*2016**)**. In the present study, higher density at older site indicates the building up of better ecological conditions for growth of plants. More number of species was encountered from West, North and South aspects of one year old site compared to 18 year old site . However, the species number was greater on the East aspect at both the sites. More number of species at East aspect may be due to favourable moisture conditions. The south-facing slope experiences the more unfavourable growth conditions, because of its lower capability to conserve soil moisture (CANO *et al*., 2002; TORMO *et al*., 2006). Vegetation cover is considered as a key-indicator revealing the degree of restoration success because it clearly reflects changes in the rehabilitation process (YANG *et al*., 2006). The decrease in vegetation cover and change in floristic composition are the elements that characterize regressive evolution of rangelands (NEDJRAOUI, 2004 ; SLIMANI *et al*., 2010).

All the 62 species represented 24 families at one year old site (Fig. 5). Nine species were from Fabaceae family followed by seven species from Poaceae and five species from Amaranthaceae. Four species represented family Euphorbiaceae. The families like Asclepiadaceae, Asteraceae, Commelinaceae, Convolvulaceae, Cucurbitaceae, Cyperaceae and Rubiaceae had 3 species each. Two species each from families Lythraceae, Mimosaceae and Tiliaceae were identified. A total of 10 families was having only one species (Acanthaceae, Capparaceae, Dioscoreaceae, Flacourtiaceae, Gentianaceae, Lygodiaceae, Molluginaceae, Nyctaginacea,Oxalidaceae and Verbanaceae) (Fig. 5). At 18 year old site, 28 families were represented by 61 species (Fig. 6). Six species each were from Euphorbiaceae and Poaceae followed by five species from the Fabaceae and four species each from Asteraceae and Rubiaceae. Five families were identified having 3 species each (Amaranthaceae, Asclepiadaceae, Cyperaceae, Malvaceae and Mimosaceae). Families Acanthaceae, Commelinaceae and Convolvulaceae each has representation of 2 species and Adiantaceae, Apocynaceae, Araceae, Caesalpiniaceae, Capparaceae, Combretaceae, Dioscoreaceae, Flacourtiaceae, Lamiaceae, Lygodiaceae ,Menispermaceae, Myrsinaceae, Nyctaginaceae, Polygalaceae and Polygalaceae one species each (Fig. 5). More than half of the total species recorded from these two sites were present on both sites. Species of family Fabaceae and Poaceae were most represented. Whereas *Cynodon dactylon* and *Mimosa pudica* were dominate across all aspects at both the sites; however, the species *Atylosia scarabaeoides, Tephrosea purpurea* and *Amaranthus viridis* were represented with higher density only at one year old site. The grass and non-grass species are important with respect to the stages of successional colonization on the adverse habitats of mine spoil of Chromite mining region of Sukinda. Role of grasses as the initial colonizers during restoration of mined land has been highlighted by many workers (HELM 1995; SKEEL & GIBSON 1996). Fibrous root systems in grasses help arresting the erosion and helping to stabilize soil and conserve the moisture (HELM 1995). The role of grass species in changing the habitat conditions for subsequent colonizers has also been highlighted by several authors (ASHBY *et al*. 1989; HELM 1995). More number of species at both sites also indicates the availability of local gene pool in the surrounding environment. The adjacent gene pool of surrounding natural vegetation and dormant seeds or plant remains allow species to establish and coexist (high richness and evenness values), improving natural colonisation of the dumps (MARTINEZ-RUIZ *et al*., 2001; MARTINEZ-RUIZ & FERNANDEZ-SANTOS, 2005). BRADSHAW (1997) emphasized on conserving biodiversity by improving natural colonization. In the present study, we also observed number of common species at both sides and less variation species number and family which indicates that gene pool is same for both the sites. LAW & MORTON (1996) stated that the communities assembled from large species pools were inherently more resistant to invasions from exotic species.The natural species possess greater drought resistance and exhibit faster drought recovery and less annual variation in biomass production compared to species-poor communities (TILMAN & DOWING, 1994; TILMAN, 1996). It was observed that annual species are well represented in the study area because of their stress-tolerant character. The herbaceous cover varies from year to year in relation to rainfall, and can be strongly reduced by moisture limitations (MADON & MEDAIL, 1997). KING (2008) opined that drought-resistant plants can increase dynamics of biological resources and restore degraded vegetation, thus improving the severe conditions that limit the establishment of plant species in the rehabilitation. The Fabaceae and Poaceae were among the dominant families at one year old site and Euphorbiaceae and Poaceae at 18 year old site. EKKA & BEHERA (2011) observed on mine spoil dumps of different ages in an open cast coal field in Orissa that the family Poaceae contributed maximum species in different dumps which reflects the colonizing ability of the members of this family in coal mine spoil habitat. Capacity of grass species to tolerate drought, low soil nutrients and climatic stresses (HELM 1995; SKEEL & GIBSON 1996) may contribute to their success in colonizing the mines spoil. Our study also highlights the importance of surrounding natural habitat and need for biodiversity conservation to help making available herbaceous gene pool in degraded site for ecological restoration.

CONCLUSIONS

On the basis of phytosociological study at two reclaimed sites, a total of 62 herb species were recorded with *Mimosa pudica, Stylosanthes hamata, Atylosia scarabaeoides* and *Cynodon dactylon* exhibiting dominance at one year old site (D1) and *Cynodon dactylon* and *Sida cordata* at 18 year old site (D8). 34 species were common to both sites. *Mimosa pudica* on east and south aspects, *Atylosia scarabaeoides* on west aspect and *Cynodon dactylon* on north aspect exhibited maximum growth at D1 site and *Cynodon dactylon* on all the aspects at D8 site. At D1 site, of the 24 families, Fabaceae was the dominating family with nine species followed by Poaceae and Amaranthaceae having seven and five species, respectively. Euphorbiaceae and Poaceae family exhibited dominance with six species each followed by Fabaceae with five species, Asteraceae and Rubiaceae with four species each at D8 site. More than 50 percent of species are common to both sites, indicating that undisturbed surrounding natural pool of species may contribute to the success in colonizing the mines spoil. The study also highlights the importance of surrounding natural habitat and need for biodiversity conservation to help making available herbaceous gene pool at degraded sites for ecological restoration.

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REFERENCES

AGRAWAL, M., SINGH, J., JHA, A. K. & SINGH, J. S., 1993. Coal-based environmental problems in a low rainfall tropical region. 27-57. *In*: R.F. Keefer & K.S. Sajwan (eds.). Trace Elements in Coal Combustion Residues. Lewis Publishers, BocaRaton.

ANWER, HUSSAIN, M. I., MCNEILLY, T. & PUTWAIN, P.D., 2001. Amelioration of NPK on metals polluted bare and vegetated sites of trelogan mine. J. Biological Sci., 1: 280-283.

ASHBY, W. C., HANNIGAN, K. P. & KOST, D. A., 1989. Coal Mine reclamation with grass and legumes in southern Illinois. *Journal of Soil and Water Conservation* 44: 79-83.
BAHRAMI, A., EMADODIN, I., ATASHI, M. R. & BORK, H. R., 2010. Land-use change and soil degradation: A case study, North of Iran, *Agriculture and biology J of N.America*, 605.
BEHURA, SUDHAMAYEE, KAR, M. & UPADHYAY, V.P., 2016. Ecological analysis of tree species at two reclaimed sites of Sukinda chromite mining region of Odisha, India. *Int. J. Adv. Res. Biol. Sci*. 3; 51-59.
BRADSHAW, A.D., 1997. Restoration of mined lands using natural processes. *Ecol. Eng*. 8, 255–269.
BURGHARADT, W., 1993. Böden auf Altstandorten (Soils of contaminated land), 217229. In Alfred-Wegener-Stiftung (ed.). Die benutzte Erde. Ernst, Berlin.
CANO, A., NAVIA, R., AMEZAGA, I. & MONTALVO, J., 2002. Local topoclimate effect on short-term cutslope reclamation success. *Ecol. Eng.* 18, 489–498
COOKE, J. A. & JOHNSON, M. S., 2002. Ecological restoration of land with particular reference to the mining of metals and industrial minerals: a review of theory and practice. Environ Rev 10:41 –71.
EKKA, N. J. & BEHERA, N., 2011. Species composition and diversity of vegetation developing on an age series of coal mine spoil in an opencast coal field in Odisha, India. *Tropical Ecology* 52: 337-343.
FSI, 2011. Forest Survey of India, status of forests report Dehradun, India
HELM, D. J., 1995. Native grass cultivars for multiple revegetation goals on a proposed mine site in south-central Alaska. Restoration Ecology 20: 111-122
HOLZEL N. & OTTE, A., 2003. Restoration of a species- rich flood meadow by topsoil removal and diaspore transfer with plant material – *Appl. Veg. Sci.,* 6: 131- 149.
KING, E. 2008. Facilitative effects of *Aloe secundiflora* shrubs in degraded semi-arid ranglands in Kenya. - *Journal of Arid Environments*, 72: 358–369
KIRMER, A. & MAHN, E.G., 2001. Spontaneous and initiated succession on unvegetated slopes in the abandoned lignite-mining area of Goitsche, Germany- *Appl. Veg. Sci.*, 4:19-27.
KRZAKLEWSKI, W. & PIETRZY KOWSKI, M., 2002. Selected physicochemicals properties of Zinc and lead are tailings and their biological stabilization- *Water Air Soil pollut*., 141: 125-142.
LAW, R. & MORTON, R.D., 1996. Permanence and the assembly of ecological communities. *Ecology* 77, 762–775.
LUBKE, R. A., AVIS, A.M. & MOLL, J. B., 1996. Post- mining rehabilitation of coastal sand dunes in Zulu land, South Africa- *Land Sc. Urban plan*., 34: 335-345.
MADON, O. & M´ EDAIL, F., 1997. The ecological significance of annuals on a Mediterranean grassland (Mt Ventoux, France). *Plant Ecol*. 129, 189–199.
MART´INEZ-RUIZ, C. & FERNANDEZ-SANTOS, B., 2005. Natural revegetation on topsoiled mining-spoils according to the exposure. Acta Oecol. 28, 231–238.
MART´INEZ-RUIZ, C., FERNANDEZ-SANTOS, B. & G´OMEZ, J.M., 2001. Effects of substrate coarseness and exposure on plant succession in uranium-mining wastes. *Plant Ecol*. 155, 79–89.
MISRA, R., 1968. Ecology Work Book. Oxford and IBH Co., New Delhi.
NEDJRAOUI , D., 2004. Évaluation des ressources pastorales des régions steppiques algériennes et définition des indicateurs de dégradation. - CIHEAM, Cahiers Options méditerranéennes, 62: 239–244.
PENSA, M., SELLIN, A., LUUD, A. & VALGMA, I., 2004. An analysis of vegetation restoration on opencast oil shale mines in Estonia. *Restoration Ecology* 12 (2) :200-206.
PRACH, K., PYSEK, P. & BASTL, M., 2001. spontaneous vegetation succession in disturbed habitats : A pattern across seres- *Appl. Veg. Sci*., 4: 83-88.
PRACH K. &PYSEK, P., 1994. Spontaneous establishment of woody plants in central European derelict sites and their potential for reclamation- *Restor. Ecol.,*2:190- 197.
PYSEK, A., PYSEK, P., JAROSIK, V., HAJEK, M. & WILD, J., 2003. Diversity of native and alien plant species on rubbish dumps : effects of dump age, environmental factors and toxicity – *Diversity & distributions,* 9: 177-189.
SKEEL, V. A. & GIBSON, D. J., 1996. Physiological performance of Andropogal gerardii, Panicum virgatum and Sorghastrum nutans on reclaimed mine spoil. *Restoration Ecology* 4: 355-367
SLIMANI H., AIDOUD, A. & ROZÉ, F., 2010. 30 years of protection and monitoring of a steppic rangland undergoing desertification. - *Journal of Arid Environments*, 74: 685–691.
SINGH, J. S. & JHA, A. K., 1992. Restoration of degraded land: An overview. pp. 1-9. *In*: J. S. Singh (ed.) *Restoration of Degraded Land: Concepts and Strategies*. Rastogi Publication, Meerut, India.
TILMAN, D., 1996. Biodiversity: Population versus Ecosystem Stability. *Ecology* 77, 350–363.
TILMAN, D. & DOWING, J.A., 1994. Biodiversity and the stability in grasslands. *Nature* 367, 363–365.

TORDOFF, G.M., BAKER, A.J.M. & WILIS, A.J., 2000. Current approaches to the revegetation and reclamation of metalliferous mine wastes- *chemosphere*, 41: 219-228.
TORMO, J., BOCHET, E. & GARC´IA-FAYOS, P., 2006. Is seed availability enough to ensure colonization success? An experimental study in road embankments. *Eco. Eng*. 26, 224–230.
WHISENANT, S.G., 2002. Terrestrial systems (In: Hand book of ecological Restoration, Eds: M.R. Perrow, A.J.Davy) – Cambridge University Press, Cambridge, PP. 83-105.
WHITING, S.N., REEVES, R.D., RICHARDS, D., JOHNSON, M. S., COOKE, J.A., MALAISSE, F., PATON, A., SMITH, J. A.C., ANGLE, J.S., CHANEY, R.L., GINOCCHIO, R., JAFFIRE, T., JOHNS, R., MCINTYRE, T., PURVIS, O.W., SALT, D.E., SCHAT, H., ZHAO, F.J. & BAKER, A.J.M., 2004. Research priorities for conservation of matallophyte biodiversity and their potential for restoration and site remediation – *Restoration Ecol*., 12: 106- 116.
WIEGLEB, G. & FELINKS, B., 2001. Predictability of early stages of primary succession in post mining land scapes of lower Lusatia – *Appl. Veg. Sci*., 4: 5-18.
YANG H., LU, Q., WU, B., YANG, H., ZHANG, J. & LIN, Y., 2006. Vegetation diversity and its application in sandy desert revegetation on Tibetan Plateau. - *Journal of Arid Environments*, 65: 619–631.
ZHANG, J. T., 2005. Succession analysis of plant communities on abandoned cropland in the eastern lies plateau of chair. Journal of Arid Environment 63; 458-474.