Phytosociological Study Of Herb Species At Two Reclaimed Sites Of Sukinda Chromite Mining Region Of Odisha, India

Dr. Sudhamayee Behura*

*Department of Environmental Science, Raghunathjew Degree College, Ctc.

***Corresponding Author:** Dr. Sudhamayee Behura
Email: sudhamayee_behura@yahoo.co.in

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 two year old and other 15 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 find out the impact of aspect and age on density values of herbaceous vegetation on reclaimed over burden sites. Of the 58 and 56 herb species recorded at these reclaimed sites D2 and D7 respectively, 36 species were present at both sides. Higher number of species was recorded on east aspect at both the sites. Both the fifteen year and two year old sites was represented by 22 families. Herb species of family Poaceae, Amaranthaceae, Fabaceae and Asteraceae were the dominant families at D2 site where as families like Mimosaceae, Euphorbiaceae, Poaceae were more in number than other families at older site i.e. D7. *Amaranthus viridis* and *Cynodon dactylon* were theb dominant species on yonger site and *Cynodon dactylon and Evolvulous nummularius* exhibited dominance at older site.

Keywords: Chromite, Sukinda valley, over burden dump, Phytosociology, reclamation

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). 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. Restoration of mined areas is essential to restore the ecological balance of the ecosystem and maintain a self sustain ecosystem where in all essential ecological process take place (VERMA, 2003). 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 chromite ore belt at Sukinda is spread over an area of approximately 200 sq. km. in Jajpur district and is well-known chromite hub in the world (DAS & MISHRA 2010). The present paper examines the reclamation of overburden dump sites of chromite mines in Sukinda region of Jajpur district of Odisha, India. The climate of the region and the area of the study site is given in Table 1 and Figure 1 respectively.

STUDY AREA

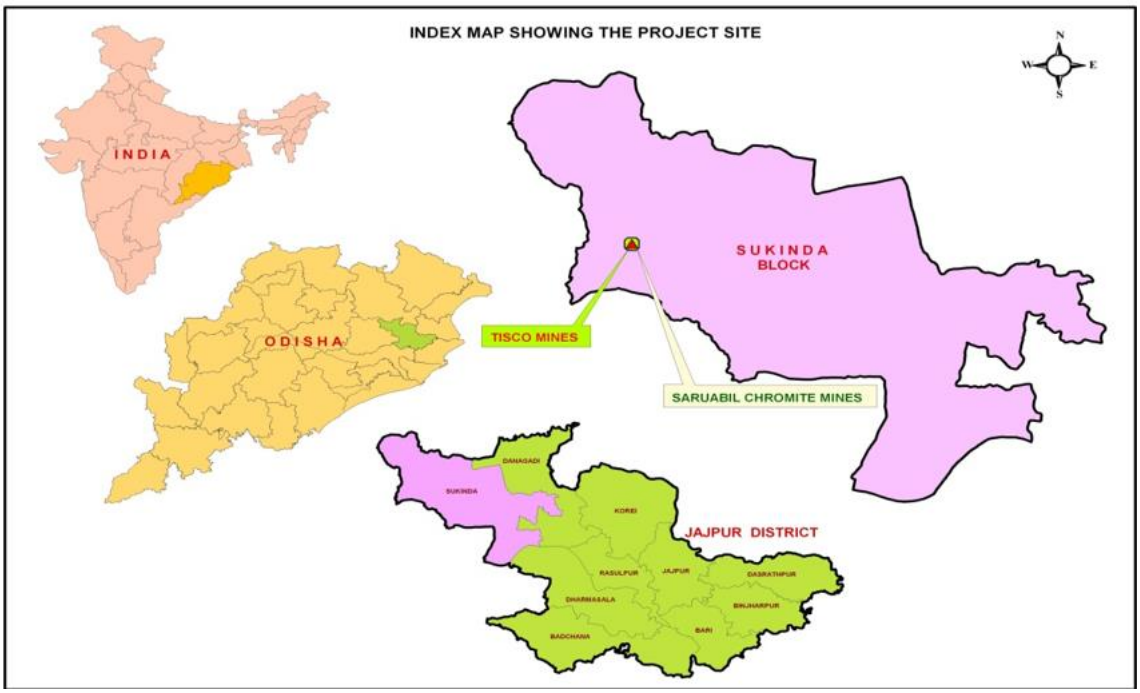

Figure 1: Location of study sites

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. Two year old overburden reclaimed dump and 17 year old reclaimed over burden dump of Sukinda TISCO mines of M/s TATA STEEL mines were selected for studying the changes in structural components of vegetation.

Photograph 1 : Opencast Chromite Mining at Sukinda,Odisha,India

Photo graph 2: Re- claimed 15, D7 site of Sukinda

The two year old site in named as D2 and 17 year old site as D7 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 two year (D2) and 17 year (D7) 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 2 year and 17 year old OB dumps. At two year old site, a total of 58 species of herbs was recorded. Among the herb species *Cynodon dactylon*, *Mimosa pudica*, *Evolvulous nummularius* and *Atylosia scarabaeoides* were found dominant species across all aspects. However, *Trichosanthes cuspidate* and *Penisetum pedicellatum* were found dominant with density of 151.70 ha^{-1} and 133.20 ha^{-1} respectively on east aspect. *Amaranthus viridis* was dominant species with density of 222.00 ha^{-1} on the west aspect. On the north aspect, the density was highest for *Atylosia scarabaeoides*. On the south aspect, *Cynodon dactylon* exhibited

density 181.30 ha^{-1}. 56 species were encountered across all aspects of 15 years OB dump of Sukinda Chromite Mines. It is observed that *Atylosia scarabaeoides and Cynodon dactylon* exhibited highest density across East aspect. On the west aspect, *Evolvulus nummularius* exhibited highest density. On north and south aspects, *Cynodon dactylon* and seedlings of *Mallotus Phillipensis* had highest density values respectively.

Table: 2. Density of Herb species at different aspects of Kakudia Dump(D2) site

			East(39)	West(32)	North(35)	South(31)
Sl No.	***Name of the species***	**Family**	**D**	**D**	**D**	**D**
1	*Abutilon indicum*	Malvaceae	33.30	-	-	-
2	*Achyranthes aspera*	Amaranthaceae	107.30	-	-	-
3	*Adiantum incissum*	Adiantaceae	-	-	18.50	-
4	*Aerva lanata*	Amaranthaceae	22.20	18.50	18.50	33.30
5	*Aeschynomena indica*	Fabaceae	-	-	29.60	-
6	*Albizia odoratissima*	Mimosaceae	29.60	22.20	25.90	33.30
7	*Alternanthera punjens*	Amaranthaceae	29.60	-	-	-
8	*Alternanthera sessilis*	Amaranthaceae	44.40	-	-	-
9	*Alysicarpus vaginalis*	Amaranthaceae	29.60	-	-	-
10	*Amaranthus viridis*	Amaranthaceae	81.40	222.00	66.60	48.10
11	*Atylosia scarabaeoides*	Fabaceae	62.90	-	107.30	77.95
12	*Biophytum sensitivum*	Oxalidaceae	-	-	14.80	-
13	*Blumea lacera*	Asteraceae	22.20	25.90	22.20	29.60
14	*Boerhavia diffusa*	Asteraceae	-	22.20	25.90	29.60
15	*Calotropis gigantea*	Asteraceae	-	-	11.10	-
16	*Canscora diffusa*	Asteraceae	22.20	-	-	-
17	*Capsicum annum*	Solanaceae	51.80	-	-	-
18	*Catharanthus roseus*	Apocynaceae	-	14.80	-	11.10
19	*Celosia argentea*	Amaranthaceae	40.70	-	-	-
20	*Chorchorus olitonius*	Tiliaceae	-	-	48.10	-
21	*Chromolaena odorata*	Asteraceae	18.50	-	18.50	-
22	*Cleome viscosa*	Capparaceae	-	59.20	55.50	51.80
23	*Commelina benghalensis*	Commelinaceae	-	70.30	55.50	62.90
24	*Commelina obliqua*	Commelinaceae	18.50	-	25.90	-
25	*Corchorus aestuans*	Tiliaceae	40.70	59.20	-	11.10
26	*Corchorus fascicularis*	Tiliaceae	44.40	-	-	29.60
27	*Crotalaria albida*	Fabaceae	81.40	18.50	-	25.90
28	*Crotalaria prostrata*	Fabaceae	-	-	18.50	-
29	*Croton bonplandianum*	Euphorbiaceae	103.60	70.30	-	51.80
30	*Cynodon dactylon*	Poaceae	74.00	214.60	92.50	181.30
31	*Cyperus compressus*	Cyperaceae	29.60	33.30	18.50	-
32	*Cyperus diffusus*	Cyperaceae	-	37.00	44.40	-
33	*Digitaria ciliaris*	Poaceae	40.70	22.20	18.50	11.10
34	*Dioscorea wallichii*	Dioscoreaceae	-	25.90	-	25.90
35	*Elephantopus scaber*	Asteraceae	-	70.30	-	48.10
36	*Eragrostis ciliaris*	Poaceae	48.10	59.20	59.20	66.60
37	*Evolvulus nummularius*	Convolvulaceae	51.80	-	92.50	-
38	*Flacourtia jangomas*	Flacourtiaceae	-	51.80	-	-
39	*Ipomea coccinea*	Convolvulaceae	40.70	-	-	-
40	*Ipomoea pestigridis*	Convolvulaceae	29.60	37.00	-	29.60
41	*Lagenaria siceraria*	Cucurbitaceae	-	25.90	44.40	-
42	*Luffa aegyptiaca*	Cucurbitaceae	-	59.20	25.90	37.00
43	*Lygodium flexuosum*	Lygodiaceae	25.90	11.10	33.30	59.20
44	*Mimosa Pudica*	Mimosaceae	48.10	85.10	96.20	48.10
45	*Oplismenus burmanii*	Poaceae	40.70	96.20	44.40	99.90
46	*Panicum miliare*	Poaceae	44.40	22.20	-	22.20
47	*Penisetum pedicellatum*	Poaceae	133.20	-	-	-
48	*Phyllanthus fraternus*	Euphorbiaceae	48.10	-	25.90	-
49	*Phyllanthus virgatus*	Euphorbiaceae	51.80	99.90	40.70	99.90

50	*Saccharum spontaneum*	Poaceae	14.80	11.10	11.10	-
51	*Sida acuta*	Malvaceae	25.90	18.50	40.70	18.50
52	*Sida Cordata*	Malvaceae	-	-	18.50	11.10
53	*Sida rhombifolia*	Malvaceae	22.20	-	22.20	22.20
54	*Spermacoce articularis*	Rubiaceae	-	33.30	51.80	85.10
55	*Tephrosia maxima*	Fabaceae	92.50	29.60	-	33.30
56	*Tephrosia purpurea*	Fabaceae	-	88.80	40.70	103.60
57	*Trichosanthes cuspidata*	Cucurbitaceae	151.70	-	-	-
58	*Woodifollia fruticosa*	Lythraceae	29.60	-	-	-

Table: 3 Density of Herb species at different aspects of Re-claimed 15 yr. Dump (D7) site

			East(41)	West(35)	North(33)	South(34)
Sl No.	***Name of the species***	**Family**	**D**	**D**	**D**	**D**
1	*Accacia pennata*	Mimosaceae	-	-	-	7.40
2	*Adiantum incissum*	Mimosaceae	33.30	44.40	22.20	7.40
3	*Aerva lanata*	Mimosaceae	62.90	48.10	55.50	51.80
4	*Aerva sanguinolenta*	Mimosaceae	29.60	-	-	-
5	*Albizia odoratissima*	Mimosaceae	11.10	18.50	22.20	18.50
6	*Amaranthus viridis*	Mimosaceae	18.50	-	-	-
7	*Amorphophallus paeonifolius*	Mimosaceae	37.00	-	-	-
8	*Atylosia scarabaeoides*	Mimosaceae	159.10	88.80	74.00	11.10
9	*Blumea lacera*	Asteraceae	18.50	14.80	-	-
10	*Boerhavia diffussa*	Nyctaginaceae	-	-	-	51.80
11	*Calotropis gigantea*	Asclepiadaceae	3.70	29.60	-	29.60
12	*Calotropis Procera*	Asclepiadaceae	11.10	14.80	-	-
13	*Cassia occidentalis*	Caesalpiniaceae	-	40.70	-	-
14	*Catharanthus roseus*	Apocynaceae	14.80	-	-	-
15	*Chromolaena odorata*	Asteraceae	14.80	48.10	107.30	40.70
16	*Cleome viscosa*	Capparaceae	22.20	37.00	37.00	25.90
17	*Commelina benghalensis*	Commelinaceae	25.90	-	40.70	-
18	*Commelina obliqua*	Commelinaceae	37.00	37.00	-	44.40
19	*Crotolaria albida*	Fabaceae	22.20	-	-	-
20	*Crotolaria prostrata*	Fabaceae	22.20	40.70	70.30	37.00
21	*Croton bonplandianum*	Euphorbiaceae	-	14.80	11.10	11.10
22	*Cynodon dactylon*	Poaceae	151.70	247.90	188.70	29.60
23	*Cyperus compressus*	Cyperaceae	37.00	29.60	29.60	25.90
24	*Dioscorea wallichii*	Dioscoreaceae	44.40	-	14.80	-
25	*Elephantopus scaber*	Asteraceae	33.30	29.60	7.40	29.60
26	*Eragrostis ciliaris*	Poaceae	-	7.40	7.40	59.20
27	*Euphorbia hirta*	Euphorbiaceae	22.20	7.40	7.40	7.40
28	*Evolvulus nummularius*	Convolvulaceae	107.30	170.20	140.60	62.90
29	*Flacourtia jangomas*	Flacourtiaceae	25.90	33.30	55.50	29.60
30	*Jatropha Curcas*	Euphorbiaceae	-	-	11.10	11.10
31	*Justicea gendarussa*	Acanthaceae	48.10	-	-	-
32	*Lygodium flexuosum*	Lygodiaceae	7.40	48.10	29.60	37.00
33	*Macaranga peltata*	Euphorbiaceae	-	40.70	70.30	55.50
34	*Mallotus phillippensis*	Euphorbiaceae	29.60	-	-	92.50
35	*Melochia chorchorifolia*	Sterculiaceae	-	-	22.20	-
36	*Mimosa pudica*	Mimosaceae	51.80	166.50	136.90	-
37	*Mitragyna parviflora*	Rubiaceae	25.90	-	25.90	-
38	*Oplismenus burmanii*	Poaceae	18.50	22.20	7.40	85.10
39	*panicum milliare*	Poaceae	11.10	-	-	-
40	*Paspalidum flavidum*	Poaceae	29.60	-	-	-
41	*Perotis indica*	Poaceae	-	33.30	29.60	48.10
42	*phyllanthus fraternus*	Euphorbiaceae	33.30	48.10	48.10	51.80
43	*Phyllanthus Virgatus*	Euphorbiaceae	-	7.40	-	-
44	*polygala chinensis*	Polygalaceae	33.30	-	-	-
45	*Rungia pectinata*	Polygalaceae	-	37.00	66.60	37.00

46	*Saccharum Spontaneum*	Polygalaceae	25.90	11.10	-	-
47	*Sida acuta*	Polygalaceae	25.90	7.40	14.80	14.80
48	*Sida cordata*	Malvaceae	33.30	14.80	-	29.60
49	*Sida rhombifolia*	Malvaceae	-	18.50	-	-
50	*Spermacoce articularis*	Malvaceae	14.80	22.20	22.20	44.40
51	*Tephrosia maxima*	Fabaceae	18.50	-	-	-
52	*Tephrosia purpurea*	Fabaceae	48.10	-	37.00	-
53	*Tridax procumbens*	Asteraceae	11.10	18.50	7.40	14.80
54	*Urena lobata*	Malvaceae	-	-	-	11.10
55	*Vernonia cineria*	Asteraceae	-	37.00	25.90	11.10
56	*Ziziphus Mauritiana*	Rhamnaceae	-	-	11.10	11.10

There are 36 common species at both sites **(Figures 2, 3, 4)**. Among the common species, the density of 14 species were highest at 17 year old site (D7) where as the density of rest of the species was found maximum at D2 site. Four species viz., *Aerva lanata, Croton bonplandianum, Eragrostis cilliaris* and *Lygodium flexuosum* exhibited tremendous growth at 17 years old site compared to the younger 2 year old site (D2). Where as some species like *Amaranthus viridis,Cynodon dactylon Elephantopus scaber,Oplismenus burmanii, Phyllanthus fraternus etc. shows maximum growth on D2 site compared to D7 site. Abutilon indicum, Achyranthes aspera, Aeschynomena indica, Alternanthera punjens, Alternanthera sessilis, Alysicarpus vaginalis, Biophytum sensitivum, Canscora diffusa, Capsicum annum, Celosia argentea, Chorchorus olitonius, Corchorus aestuans, Corchorus fascicularis, Cyperus diffusus, Digitaria ciliaris, Ipomea coccinea, Ipomoea pestigridis, Lagenaria siceraria, Luffa aegyptiaca, Penisetum pedicellatum, Trichosanthes cuspidate and Woodifollia fruticosa* were found only at D2 site and the species *Accacia pennata, Aerva sanguinolenta, Amorphophallus paeonifolius, Calotropis Procera, Cassia occidentalis, Euphorbia hirta, Jatropha Curcas, Justicea gendarussa, Macaranga peltata, Mallotus philippensis(seedling), Melochia chorchorifolia, Mitragyna parviflora, Paspalidum flavidum, Perotis indica, polygala chinensis, Rungia pectinata, Tridax procumbens, Urena lobata, Vernonia cineria and Ziziphus Mauritiana* were found only at D7 site.

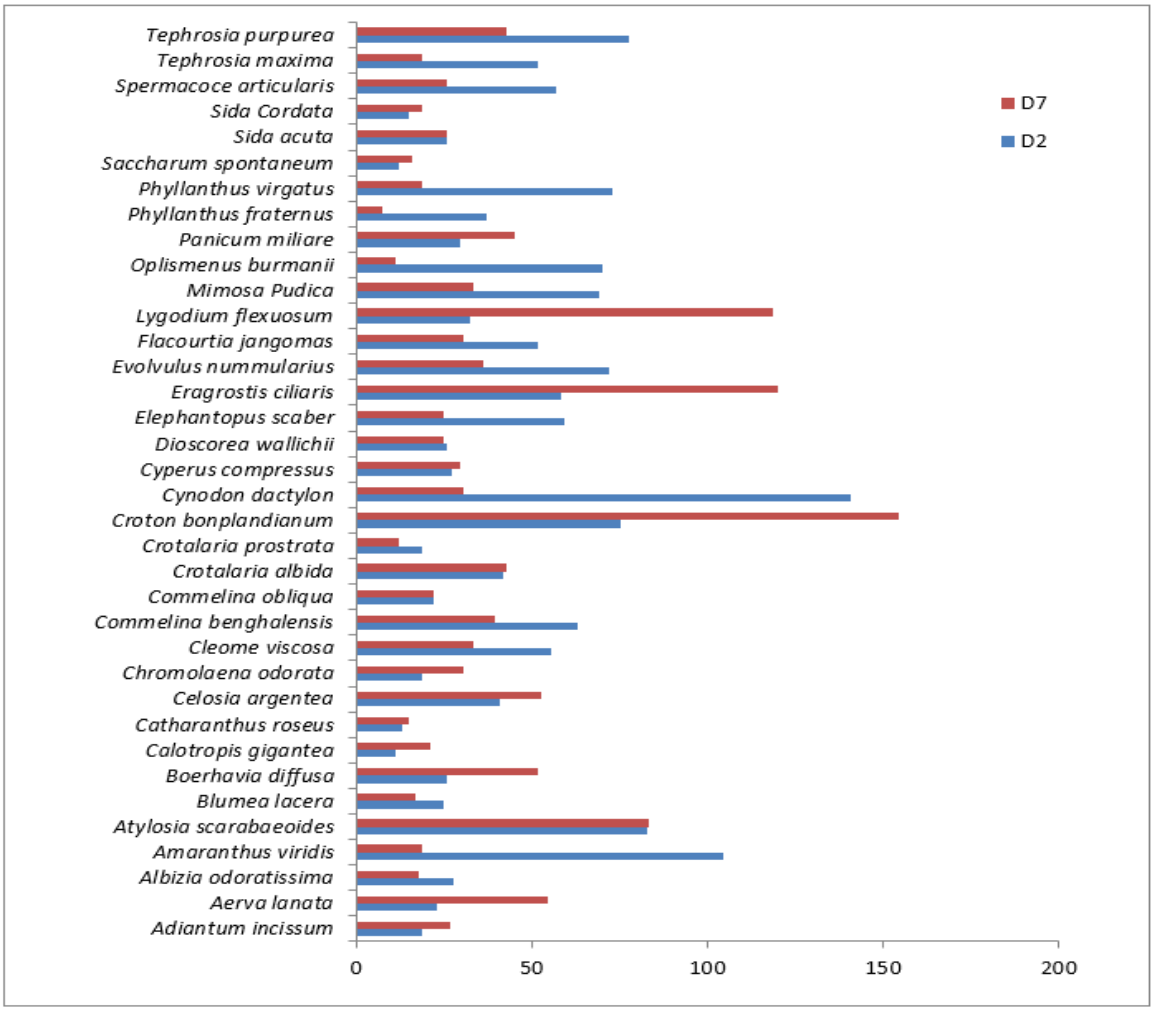

Figure 2 Density comparison of common species at both the sites.

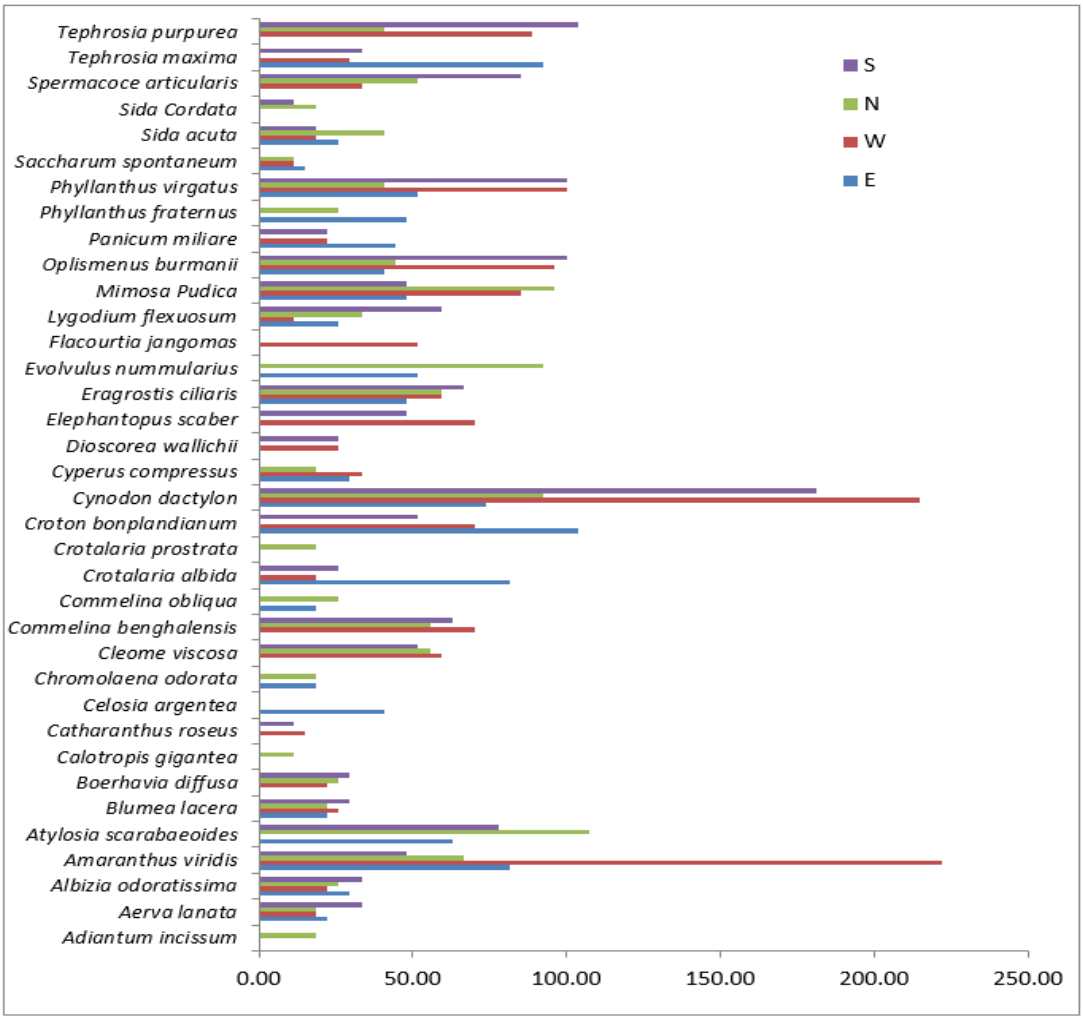

Figure 3 Density of common species at all aspects of D2 site

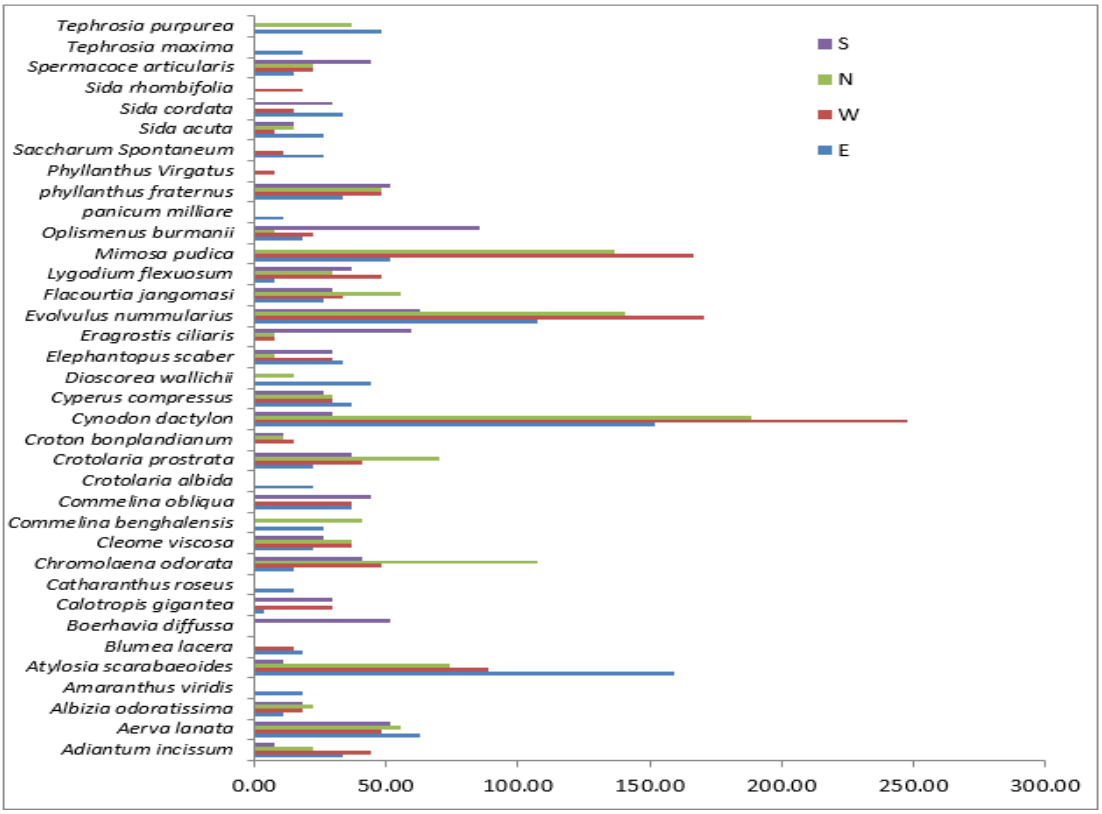

Figure 4 Density of common species at all aspects of D7 site

CONCLUSIONS

The above study shows that 58 and 56 herb species were recorded at D2 and D7 sites respectively. *Croton bonplandianum, Amaranthus viridis, Atylosia scarabaeoides* and *Cynodon dactylon* were the dominant species at D2 site and *Atylosia scarabaeoides, Cynodon dactylon* and *Oplismenus burmanii* were found dominant at D7 site. 36 common species were recorded at both D2 and D7 sites. At D2 site *Croton bonplandianum, Amaranthus viridis, Atylosia scarabaeoides* and *Cynodon dactylon* shows maximum growth on east, west, north and south aspects respectively and at D7 site *Cynodon dactylon* shows maximum growth on all the aspects except south. On D2 site out of the 58 species distributed in 22 families Amaranthaceae and Poaceae were the dominating families with seven species each followed by Asteraceae and Fabaceae having six species each. Where as Mimosaceae and Poaceae family was dominating with nine and seven species each followed by Poaceae with and Asteraceae with six and five species respectively on D7 site.

ACKNOWLEDGEMENT

Authors are grateful to Dr. P. C. Panda, Regional Plant Resource Centre, Bhubaneswar for helping in identification of herb species and to the Management of Saraubil Chromite Mines and Sukinda Chromite mines for according permission to carry out this research on their reclaimed dump sites.

References

1. 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.
2. 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.
3. 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.
4. BRADSHAW, A.D., 1997. Restoration of mined lands using natural processes. *Ecol. Eng*. 8, 255–269.
5. BURGHARADT, W., 1993. Böden auf Altstandorten (Soils of contaminated land), 217229. In Alfred-Wegener-Stiftung (ed.). Die benutzte Erde. Ernst, Berlin.
6. 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.
7. DAS,A., & MISHRA, S., (2010), Biodegradation of the metallic carcinogen hexavalent chromium Cr (VI) by an indigenously isolated bacterial strain, Journal of Carcinogen, Vol.9, No.6, pp 19-24.
8. FSI, 2011. Forest Survey of India, status of forests report Dehradun, India
9. 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.
10. 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.
11. 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.
12. MISRA, R., 1968. Ecology Work Book. Oxford and IBH Co., New Delhi.
13. 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.
14. PRACH, K., PYSEK, P. & BASTL, M., 2001. spontaneous vegetation succession in disturbed habitats : A pattern across seres- *Appl. Veg. Sci*., 4: 83-88.
15. 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.
16. 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.
17. 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.
18. 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.
19. 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.
20. 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.
21. VERMA, P K., (2003), Population dynamics and successional changes in restored limestone mines in Mussoorie hills. Ph.D. thesis submitted to Forest Resarch Institute (Deemed University), Dehradun.

22. 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.
23. 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.