

Species Composition And Some Physico-Chemical Properties Of An Age Series Of Overburden Dumps In Sukinda Chromite Mines, Jajpur, Odisha, India

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Abstract

Opencast mining replaces natural vegetation of an area with huge quantities of overburden dumps called mine spoils. Natural plant succession on these spoils cause changes in physico-chemical characteristic of soil leading to restoration and conservation of biodiversity. The present study, which was carried out in the Sukinda chromite mining region of the Jajpur district in Odisha, focused on vegetation composition and soil physico-chemical properties of an age series overburden dumps (OB) ranged in age from 1 to 18 years formed as a result of open cast mining activity of Saruabil and Tata steel chromite mines that were operated in this region.

Over the course of two-year reconnaissance survey, a total of 117 herb species of 41 families and 65 tree species of 25 families were identified from eight sites of the study area. Out of the eight sites, five were selected from the Tata Steel Mines with plantation ages of 1, 2, 4, 13, and 15 years, and three from the Saruabil Mines with plantation ages of 3, 14, and 18 years.

The sites were named based on the age of the plantations; for example, D1 was given to the location of a plantation that was one year old and so on.

At all the selected study sites, vegetation analysis was done for the planted tree species. The number of species were not demonstrated any particular pattern with the age of the sites. *C. dactylon*, one of the herb species, was present on each aspect of every site. *M. pudica* was present on every aspect of all sites except south of D5 and D7. *P. foetida* and *R. quinqennalaris* were observed on only east and south aspects of D6 and south aspect of D8, respectively.

However, species number of herb species was generally higher with increased number of tree species. The number of herb species recorded at different study sites were in the order of D4 (65)>D1 (62), D8 (62)>D2 (58)> D6 (56), D7 (56) > D5 (54) and D3 (40). Soil analysis results indicated that the clay content was less than 28% at all the sites. The soil was moderately acidic. pH was less than 6 at D8 and for other sites it varied from 6.1 to 6.5.

The trend of OC content at different sites was in the order of D8>D6>D7>D2>D1>D5>D4 and ranged between 0.695 to 0.11%. N content varied between 62.5 and 226.25 kg ha⁻¹. N content was maximum at dump 8 (D8) and minimum at D4. P content ranged between 5.45 and 9.58 kg ha⁻¹ across all the sites with a highest value at D8 and lowest at D2 and D5. K was found in the range of 37.63 and 349.44 kg ha⁻¹ with maximum at D6 and D8, and minimum at D1 and D3

Keywords: Overburden, Physico-chemical properties, Species composition, Overburden dump

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, AND 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 ETAL. 2004).

The overall dynamics and floristic character of communities are determined by local events (ASHTON, 1993). Soil structure controls some properties such as water retention and movement, aeration status and root perpetration (RUSSELL, 1971). Soil, particularly its fertility is considered to be the major factor determining the wide and diverse physiognomic forms of natural vegetation (QUIROZ NETO, 1982).

In the present study, our main objective was to study the natural vegetation cover of the overburden dumps and some of their physico-chemical properties controlling the establishment of vegetation. 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. Spontaneous vegetation

succession or natural recovery as an alternative approach to restoration (BRADSHAW 1997, PENZA ETAL., 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 ETAL. 2010).

The restoration ecology is receiving increasing attention (BRADSHAW 1997, PENZA ETAL., 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. "Natural" restorative succession processes on surface mining disturbances can be initiated by studying physical and chemical properties of the mine soil (JURINAK, 1982; CHAPIN, 1983) as OB dumps are environmentally very unstable. These dumps become sources of pollution when suitable controlling measures are not taken. The major mining effects i.e. destruction of original habitat and land, air pollution, water pollution and siltation can be addressed for restoration of vegetation cover which will fulfill the objectives of stabilization, pollution control, visual improvement and removal of threats to surrounding population (MAITI, 1994). Sometimes OB dumps are acidic in nature (pH: 4-5) causing elevated metal concentration and decrease in microbial activity, inhibiting soil organic matter decomposition and Nitrogen mineralization process.

Natural regeneration is usually impaired after major anthropogenic disturbances due to weed invasion (AWANYO ETAL. 2011). Soil moisture plays a vital role for initial plant establishment, therefore for initial start up of nutrient cycling in derelict sites, organic amendments have paramount significance. For the long term plant community stability on OB dumps, development of a functional soil microbial community is needed which are responsible for decomposition of plant litter, mineralization of plant nutrients, nutrient cycling and accumulation of organic matter.

Organic C content in soil is governed by the climate, the productivity of the vegetation and the age of the site (FILCHEVA ETAL. 2000). The degraded mined out areas and dumps/spoils have low moisture retention capacity and are poor in nutrients after mineral extraction, besides other adverse physico-chemical and physico-mechanical conditions like high gravel content, higher compaction, shortage of soil forming materials and organic matter (COPPIN AND BRADSHAW, 1982; MAITI AND SINGH, 2001). The organic matter is much lower than in the natural forest due to the lack of forest floor, litter, and water erosion (GOMA ETAL. 2008). Lack of vegetation cover on such dumps often leads to acute problem of soil erosion and environmental pollution (SINGH ETAL. 1996). Therefore, development of vegetation on the dumps is essential for the conservation of biodiversity and stable environment in the mining area (SINGH ETAL. 2002). All newly created mine soils, and many older ones, will require significant fertilizer element applications for the establishment and maintenance of any plant community. Organic matter is the major source of nutrients such as Nitrogen, and available P and K in unfertilized soils (DONAHUE ETAL. 1990). A level of Organic Carbon greater than 0.75% indicates good fertility (GHOSH ETAL. 1983) and the level of Organic Carbon in overburden may range from 0.35% to 0.85%. Organic carbon is positively correlated with available N and K and negatively correlated with Fe, Mn, Cu, and Zn (MAITI AND GHOSE, 2005). Phytosociological databases are most often designed for vegetation classification and as a source of information on the spatial distribution of vegetation or habitat diversity as required by the nature conservation agencies or forest management institutions (MISHRA ET AL. 2005). This data can be used for determining changes in vegetation, defining major environmental gradients, estimating species niches which become as a tool to develop restoration strategy. Some plants are tolerant to toxic metals (LOTHENBACH ET AL. 1998). The existence of these plant varieties is the result of evolution rather than innate physiological tolerance (BRADSHAW, 1993; WONG, 1982). Therefore, selection of appropriate plant species which can establish, grow and colonize metal contaminated soils is important for successful reclamation of the sites.

MATERIALS AND METHODS:

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 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 are 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.210 03' & Long. 850 (Fig.1. Location map of the study site.) 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 38⁰ C and 12⁰ C respectively (Fig. 2). 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.

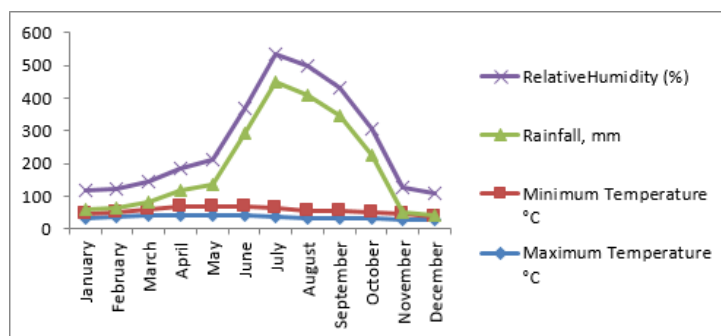


Fig.2: Average climatic conditions (average of year 1998-2007) of Sukinda Valley

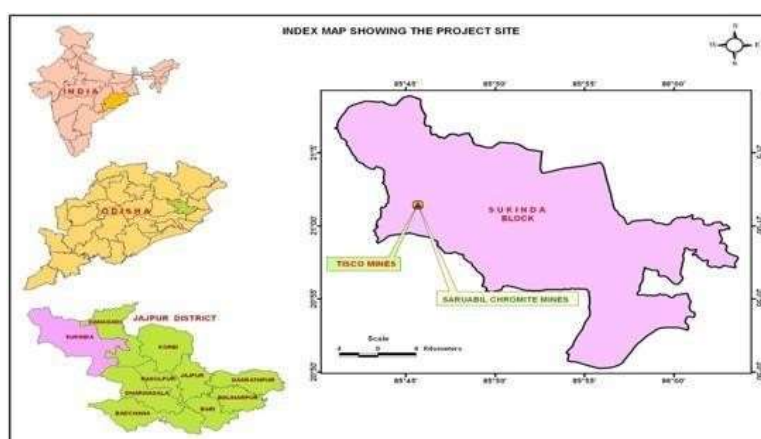


Fig.1: Location of study sites.

Vegetation Sampling:

Eight sites were selected for study, out of which 6 were from OB (Over Burden) dumps and two were reclaimed mining sites. All the study sites are in Sukinda chromite mining region and belong to two mining companies Viz. Tata steel mines and Saruabil mines. The Sukinda chromite mine of Tata steel started its operation in 1960 and has won several national and state level awards for safety. Saruabil mine named as Mirsilal mines private Limited is a family owned company which started the mining business since pre-independence in 1936. The Chromite ore area was taken over from the Maharaja of Keonjhar and mining was started during 1950's. The mining lease in Sukinda covers 296,858 hectares of land. A total of eight sites of different age were selected for vegetation study. Out of the eight sites, five sites with plantation age of 1, 2, 4, 13 and 15 years were selected from Tata steel mines and the sites having plantation age of 3, 14 and 18yrs were selected from Saruabil Mines. The sites were named as per the age of the plantation i.e. the dump of the plantation of 1yr old was named as D1 and so on. The study was carried out during December 2009 to August, 2011 by laying quadrates of 10mx10m for the tree and 1mx1m for the herb species as per the procedure given in Misra (1968). 3 quadrates were laid on each slope, base and top of each aspect i.e. North, South, East and West, totaling to 36 quadrates 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 quadrates were laid at each site in a period of two years in each rainy, winter and summer season totaling to 226 quadrates to collect ecological data on vegetation structural parameters.

Overburden (OB) Soil Sampling and Analysis:

Three overburden samples were collected from (0 -30 cm depth) at each of the eight dump sites. The samples were properly packed and brought carefully to laboratory for physical and chemical analysis. The overburden samples were air dried, cleaned, crushed in mortar and pestle and passed through a 10-mesh (2mm) sieve before analysis. Different types of physico-chemical analysis done were texture, pH, Electrical Conductivity (E.C), Organic Carbon (O.C.), Available Nitrogen, Available Phosphorus, Available Potassium. Percentage of sand, silt and clay was determined with the help of Bouyoucos hydrometer (Piper, 1950) and the textural classes were determined by the help of textural diagram. The pH of the soil samples was determined in 1:2 soils water suspension after equilibration for half an hour with intermittent stirring using the digital pH meter (JACKSON, 1967). The electrical conductivity of soil samples was determined in 1:2 soil water suspensions after equilibration for half an hour with intermittent stirring using the conductivity bridge. Conductivity meter of model: Systronics 306 was used for the purpose. Organic carbon content of the soil was determined by wet digestion procedure of walkley and Black as outlined in Soil Chemical Analysis (Jackson, 1973). Available Nitrogen was determined by using alkaline KMnO₄ method (Subbiah and Asija, 1956). Available Phosphorus in the soilsamples was determined by Bray's No. 1 method Available potassium was determined by taking 5 g soil samples in 100ml conical flask and 25 ml of 1 N Ammonium Acetate solution was added to it. Then it was shaken with the help of mechanical shaker for five minutes and the K concentration in the filtrate was analyzed by the help of a flame photometer using Potassium filter.

RESULTS AND DISCUSSIONS:

Phytosociological analysis of Tree and herb species at selected sites was carried out to find out differences in structural parameters. A list of tree species selected for plantation at different sites is given in **Table 1**. *Acacia auriculiformis*, *Azadirachta indica*, *Cassia siamea*, *Peltophorum pterocarpum* and *Pongamia pinnata* were planted at all sites. *Alstonia scholaris* and *Syzygium cumini* were planted at 7 sites and *Albizia lebbeck*, *Ficus benghalensis*, *Simarouba glauca*, *Terminalia arjuna* and *Terminalia bellirica* were available at more than 5 sites. D5 has highest number of species followed by D8, D7 and D6 whereas D1 has only 18 species. 20 species were found at D2; 19 species at each D3 and D4 sites. *Albizia odoratissima*, *Annona squamosa*, *Bambusa arundinaceae*, *Calycopteris floribunda*, *Cassia occidentalis*, *Clerodendrum viscosum*, *Cryptolepis buechananii*, *Eucalyptus tereticornis*, *Ficus amplissima*, *Ficus racemosa*, *Gmelina arborea*, *Jatropha curcas*, *Jatropha gossypifolia*, *Mimusops elengi*, *Morinda pubescens*, *Morus alba*, *Musa paradisiaca*, *Premna mucronata*, *Tectona grandis* and *Terminalia catappa* were recorded at one site only.

However, site of presence was different for these species. Across all the eight sites, 5 tree species were recorded at all sites. (**Table 1**) provides list of herb species at different sites. *Aerva lanata*, *Atylosia scarabaeoides*, *Calotropis gigantea*, *Cleome viscosa*, *Commelina benghalensis*, *Commelina obliqua*, *Cynodon dactylon*, *Cyperus compressus*, *Dioscorea wallichii*, *Elephantopus scaber*, *Flacourtia ramontchi*, *Lygodium flexuosum*, *Mimosa pudica*, *Oplismenus burmanii*, *Spermaceoce articularis*, *Tephrosia purpurea*, were recorded at all sites. *Aerva sanguinolenta*, *Amaranthus viridis*, *Calotropis procera*, *Chromolaena odorata*, *Evolvulus nummularius*, *Jatropha curcas*, *Justicia gendarussa*, *Phyllanthus fraternus*, *Saccharum spontaneum*, *Sida acuta* and *Sida cordata* were recorded at 7 sites and the species *Aerva sanguinolenta*, *Amaranthus viridis*, *Calotropis procera*, *Chromolaena odorata*, *Evolvulus nummularius*, *Jatropha curcas*, *Justicia gendarussa*, *Phyllanthus fraternus*, *Saccharum spontaneum*, *Sida acuta*, *Sida cordata*, *Mitragyna parvifolia*, *Paspalidium flavidum*, *Phyllanthus virgatus*, *Sida rhombifolia*, *Spermaceoce hispida* and *Tridax procumbens* were available at more than 5 sites. D4 has the highest number of species followed by D8 and D1; D3 has only 40 species. 58 species were found at D2 and 54 species at D5 site. D6 and D7 sites have 56 species each. *Agave sisalana*, *Alloteropsis cimicina*, *Alteranthera pungens*, *Breynia retusa*, *Breynia rhamnoides*, *Capsicum annum*, *Celosia argentea*, *Ceropegia tuberosa*, *Cissampelos pereira*, *Corchorus fascicularis*, *Crotalaria calycina*, *Eleusine indica*, *Hedyotis corymbosa*, *Jatropha gossypifolia*, *Tragia involucrata*, *Leptadenia reticulata*, *Ludwigia prostrata*, *Passiflora foetida*, *Rauwolfia serpentina*, *Rostellularia quinqueangularis*, *Spatholobus roxburghii*, *Tonningia axillaris* and *Ziziphus oenoplia* were present at one site only. However, site of presence is different. Across all eight sites, 16 herb species were common to all sites. PRASAD (1976) also reported the mechanism of survival of ground flora species under different growing conditions. EKKA AND BEHERA (2011) reported maximum number of herb species from Poaceae family during a study in open cast coal mine fields in Odisha. This indicates the colonizing ability of the members of these families in hostile mine spoil habitat. MALAKAR et al. (2015) also reported similar results in a Raniganj Coal fields, West Bengal. Various environmental factors determine the distribution of ground flora which in turn, appears to be related with woody vegetation and soil conditions (GODALL, 1952). BANERJEE et al. (1996) reported that number of tree and shrub species increased with the age of spoils.

Table 1: List of plant species (Tree) present (√) or absent (X) and its sites of presence in the overburden dump

Srl. No.	Species	Study sites								Sites of presence
		D1	D2	D3	D4	D5	D6	D7	D8	
1	<i>Acacia auriculiformis</i> A. Cunn. Ex Benth.	√	√	√	√	√	√	√	√	8
2	<i>Acacia holosericea</i>	X	X	X	√	X	X	√	X	2
3	<i>Acacia mangium</i>	X	√	X	X	X	√	√	√	4
4	<i>Acacia nilotica</i> (L.) Delile	X	√	X	X	X	X	√	X	2
5	<i>Ailanthus excelsa</i> Roxb.	√	X	X	X	√	X	√	X	3
6	<i>Albizia lebbeck</i> Benth.	√	√	X	X	√	√	X	√	5
7	<i>Albizia odoratissima</i> (L.f.) Benth.	X	X	X	X	X	X	√	X	1
8	<i>Alstonia scholaris</i> (L.) R. Br.	√	√	√	√	√	√	X	√	7
9	<i>Anacardium occidentale</i> L.	X	X	X	X	√	√	X	√	3
10	<i>Annona squamosa</i> L.	√	X	X	X	X	X	X	X	1
11	<i>Anogeissus acuminata</i> Roxb. ex DC.)	X	X	X	X	X	X	√	√	2
12	<i>Anogeissus latifolia</i> (Roxb.ex DC)	X	X	X	X	√	X	√	X	2
13	<i>Azadirachta indica</i> A. Juss.	√	√	√	√	√	√	√	√	8
14	<i>Bambusa arundinaceae</i> (Retz.) Willd	X	X	√	X	X	X	X	X	1
15	<i>Bambusa vulgaris</i> Schrad.	√	√	X	√	X	√	X	X	4
16	<i>Bombax ceiba</i> L.	X	X	X	X	√	X	√	X	2
17	<i>Buchanania lanzan</i> Spreng.	X	X	X	X	√	X	X	√	2
18	<i>Calycopteris floribunda</i> Lam.	X	X	X	√	X	X	X	X	1
19	<i>Cassia occidentalis</i> L.	X	X	X	X	X	X	X	√	1
20	<i>Cassia siamea</i> Lam.	√	√	√	√	√	√	√	√	8
21	<i>Casuarina equisetifolia</i> L.	√	√	√	X	X	X	X	X	3
22	<i>Clerodendrum viscosum</i> Vent.	X	X	X	X	√	X	X	X	1
23	<i>Cryptolepis buechananii</i> Roem. & Schult.	X	X	X	X	X	X	√	X	1
24	<i>Dalbergia paniculata</i> Roxb.	X	√	√	X	X	X	√	X	3
25	<i>Dalbergia sissoo</i> Roxb.	X	√	√	X	X	√	√	X	4

26	<i>Delonix regia</i> (Boj. ex Hook.)	X	X	X	√	X	X	√	X	2
27	<i>Diospyros montana</i> Roxb.	X	√	X	X	√	X	X	√	3
28	<i>Eucalyptus citriodora</i> Hook.	X	X	X	X	√	√	X	X	2
29	<i>Eucalyptus tereticornis</i> Sm.	X	X	X	X	√	X	X	X	1
30	<i>Ficus amplississima</i> Sm.	X	X	X	X	√	X	X	X	1
31	<i>Ficus benghalensis</i> L.	X	√	√	√	X	√	X	√	5
32	<i>Ficus racemosa</i> L.	X	X	X	X	√	X	X	X	1
33	<i>Ficus religiosa</i> L.	X	X	√	√	X	√	X	√	4
34	<i>Glochidion lanceolarium</i> (Roxb.) Dalz.	X	X	X	X	√	X	X	√	2
35	<i>Gmelina arborea</i> Roxb.	X	X	√	X	X	X	X	X	1
36	<i>Holarrhena pubescens</i> (Buch.-Ham) Waller	X	X	X	X	√	X	X	√	2
37	<i>Holoptelea Integrifolia</i> (Roxb.Planch.)	X	X	X	X	√	X	√	X	2
38	<i>Jatropha curcas</i> L.	X	X	X	√	X	X	X	X	1
39	<i>Jatropha gossypifolia</i> L.	X	X	X	√	X	X	X	X	1
40	<i>Lagerstroemia parviflora</i> Roxb.	X	X	X	X	√	X	√	√	3
41	<i>Macaranga peltata</i> (Roxb.) Muell- Arg.	X	X	X	X	√	√	X	√	3
42	<i>Madhuca indica</i> Gmel.	X	X	X	X	√	√	√	√	4
43	<i>Mallotus philippinensis</i> Muell- Arg.	X	X	X	X	√	√	X	√	3
44	<i>Mangifera indica</i> L.	X	X	X	X	√	√	√	√	4
45	<i>Mimusops elengi</i> L.	√	X	X	X	X	X	X	X	1
46	<i>Morinda pubescens</i> sm.	X	X	X	X	√	X	X	X	1
47	<i>Morus alba</i> Linn.	X	X	X	X	X	X	√	X	1
48	<i>Musa paradisiaca</i> L.	√	X	X	X	X	X	X	X	1
49	<i>Peltophorum pterocarpum</i> (DC). Baker ex. K.Heyne	√	√	√	√	√	√	√	√	8
50	<i>Phyllanthus emblica</i> L.	√	√	√	X	X	X	X	X	3
51	<i>Pongamia pinnata</i> (L.) Pierre	√	√	√	√	√	√	√	√	8
52	<i>Premna mucronata</i> Roxb.	X	X	X	X	X	X	√	X	1
53	<i>Semicarpus anacardium</i> L. f.	X	X	X	X	√	√	X	√	3
54	<i>Shorea robusta</i> Gaertn.f.	X	X	X	X	√	√	X	√	3
55	<i>Simarouba glauca</i> DC.	X	√	√	√	√	X	X	√	5
56	<i>Syzigium cumini</i> Skeels.	√	√	√	√	√	√	X	√	7
57	<i>Tamarindus indica</i> L.	X	X	X	X	X	√	√	X	2
58	<i>Tectona grandis</i> L.f.	X	X	√	X	X	X	X	X	1
59	<i>Terminalia alata</i> Heyne ex Roth.	X	X	X	X	√	X	√	√	3
60	<i>Terminalia arjuna</i> (Roxb.ex Dc.) Wight & Arn.	√	√	X	√	√	√	√	X	6
61	<i>Terminalia bellirica</i> (Gaertn.) Roxb.	√	X	√	X	√	X	√	√	5
62	<i>Terminalia catappa</i> L.	√	X	X	X	X	X	X	X	1
63	<i>Trema orientalis</i> (L.) Mill.	X	√	√	X	X	X	X	√	3
64	<i>Ziziphus mauritiana</i> Lam.	X	X	X	√	√	√	X	X	3
65	<i>Ziziphus oenoplia</i> L.	X	X	X	√	√	X	X	X	2

Table 2: List of plant species (Herb) present (√) or absent (X) and its sites of presence in the overburden dump

Study sites										Sites of presence
Srl. No.		D1	D2	D3	D4	D5	D6	D7	D8	
1	<i>Abutilon indicum</i> (L.) Sw.	X	√	X	√	X	√	X	√	4
2	<i>Acacia pennata</i> (L.) Willd.	√	X	X	√	X	√	√	√	5
3	<i>Achyranthes aspera</i> L.	√	√	X	√	X	X	X	X	3
4	<i>Adiantum incissum</i> Forssk.	X	√	√	X	√	√	√	√	6
5	<i>Aerva lanata</i> (L.)	√	√	√	√	√	√	√	√	8
6	<i>Aerva sanguinolenta</i> (L.)	√	X	√	√	√	√	√	√	7
7	<i>Aeschynomene indica</i> L.	√	√	X	X	X	X	X	X	2
8	<i>Agave sisalana</i> Perrine ex.Engelm.	X	X	X	√	X	X	X	X	1
9	<i>Albizia odoratissima</i> (L.f)Benth.	X	√	X	√	√	√	√	√	6
10	<i>Alloterospis cimicina</i> (L.) Stapf.	X	X	X	X	X	√	X	X	1
11	<i>Alternanthera pungens</i> Kunth .	X	√	X	X	X	X	X	X	1
12	<i>Alternanthera sessilis</i> (Linn.)R. Br. ex DC.	√	√	X	X	X	X	X	X	2
13	<i>Alysicarpus vaginalis</i> (L.) DC.	X	√	√	X	√	X	X	X	3
14	<i>Amaranthus viridis</i> L.	√	√	√	√	X	√	√	√	7
15	<i>Amorphophallus paeonifolius</i> (Dennst.) Nicolson	X	X	X	X	√	X	√	√	3
16	<i>Atylosia scarabaeoides</i> (L.) Benth.	√	√	√	√	√	√	√	√	8
17	<i>Biophytum sensitivum</i> (L.) DC.	√	√	X	√	X	X	X	√	4

18	<i>Blumea lacera</i> (Burm.f) Dc.	√	√	X	X	√	√	√	X	5
19	<i>Boerhavia diffusa</i> L.	√	√	X	X	X	X	√	√	4
20	<i>Breynia retusa</i> (Dennst.) Alston	X	X	X	√	X	X	X	X	1
21	<i>Breynia rhamnoides</i> (Retz.)Muell.Arg	X	X	X	√	X	X	X	X	1
22	<i>Calotropis gigantea</i> R. Br.	√	√	√	√	√	√	√	√	8
23	<i>Calotropis procera</i> R. Br.	√	X	√	√	√	√	√	√	7
24	<i>Canscora diffusa</i> (Vahl) R.Br.	√	√	X	X	X	X	X	X	2
25	<i>Capsicum annum</i> L.	X	√	X	X	X	X	X	X	1
26	<i>Cassia occidentalis</i> L.	X	X	X	√	√	√	√	X	4
27	<i>Catharanthus roseus</i> (L.) G.Don	X	√	X	√	X	X	√	√	4
28	<i>Celosia argentea</i> L.	X	√	X	X	X	X	X	X	1
29	<i>Ceropegia tuberosa</i> Roxb.	X	X	X	√	X	X	X	X	1
30	<i>Chromolaena odorata</i> (L.) R.King & H.Robins.	X	√	√	√	√	√	√	√	7
31	<i>Cissampelos pereira</i> L.	X	X	X	X	X	√	X	X	1
32	<i>Cleome viscosa</i> L.	√	√	√	√	√	√	√	√	8
33	<i>Clerodendrum indicum</i> (L.) Kuntze	√	X	X	√	X	X	X	X	2
34	<i>Combretum roxburghii</i> Spreng.	X	X	X	√	X	X	X	√	2
35	<i>Commelina benghalensis</i> L.	√	√	√	√	√	√	√	√	8
36	<i>Commelina obliqua</i> var. <i>viscida</i>	√	√	√	√	√	√	√	√	8
37	<i>Corchorus aestuans</i> L.	√	√	X	X	X	X	X	X	2
38	<i>Corchorus fascicularis</i> Lam.	X	√	X	X	X	X	X	X	1
39	<i>Corchorus olitorius</i> L.	√	√	X	X	X	X	X	X	2
40	<i>Crotalaria albida</i> L. Heyne.ex. Roth.	√	√	X	√	X	X	√	X	4
41	<i>Crotalaria calycina</i> Schrank.	√	X	X	X	X	X	X	X	1
42	<i>Crotalaria prostrata</i> Rottl. ex Willd	X	√	X	√	√	√	√	√	6
43	<i>Crotalaria retusa</i> L.	X	X	X	X	√	√	X	X	2
44	<i>Croton bonplandianus</i> Baill.	√	√	X	X	√	√	√	X	5
45	<i>Cynodon dactylon</i> (L.) Pers.	√	√	√	√	√	√	√	√	8
46	<i>Cyperus compressus</i> L.	√	√	√	√	√	√	√	√ [√] √ [√]	8
47	<i>Cyperus diffusus</i> Vahl.	√	√	X	X	X	X	X	X	2
48	<i>Cyperus rotundus</i> (L.)	X	X	X	X	√	X	X	√	2
49	<i>Digitaria ciliaris</i> (Retz.) Koeler	X	√	X	X	√	X	X	X	2
50	<i>Dioscorea wallichii</i> Hook.f.	√	√	√	√	√	√	√	√	8
51	<i>Elephantopus scaber</i> L.	√	√	√	√	√	√	√	√	8
52	<i>Eleusine indica</i> (L.)	X	X	X	√	X	X	X	X	1
53	<i>Embelia tsjeriamcottam</i> (Roem. &Schult DC.	X	X	√	X	√	√	X	√	4
54	<i>Eragrostis ciliaris</i> (L.) R.Br.	√	√	√	√	X	X	√	√	6
55	<i>Euphorbia hirta</i> L.	√	X	√	√	√	√	√	X	6
56	<i>Evolvulus nummularius</i> (L.) L.	X	√	√	√	√	√	√	√	7
57	<i>Flacourtia ramontchi</i> L. 'Herit.	√	√	√	√	√	√	√	√	8
58	<i>Glochidion lanceolarium</i> (Roxb.) Dalz.	X	X	X	X	√	X	X	√	2
59	<i>Hedyotis corymbosa</i> (L.) Lam.	X	X	X	X	X	√	X	X	1
60	<i>Hedyotis nitida</i> Wight & Arn.	X	X	X	X	√	√	X	√	3
61	<i>Hemidesmus indicus</i> (L.) R. Br.	√	X	X	X	√	X	X	√	3
62	<i>Ipomoea carnea</i> Jacq.	√	√	X	√	X	X	X	X	3
63	<i>Ipomoea pes-tigridis</i> (L.)	√	√	X	X	X	X	X	X	2
64	<i>Jatropha curcas</i> L.	√	X	√	√	√	√	√	√	7
65	<i>Jatropha gossypifolia</i> L.	X	X	X	√	X	X	X	X	1
66	<i>Justicia gendarussa</i> Burm.f.	√	X	√	√	√	√	√	√	7
67	<i>Lagenaria siceraria</i> (Molina) Standley	√	√	X	X	X	X	X	X	2
68	<i>Lagerstroemia parviflora</i> Roxb.	√	X	√	X	X	X	X	X	2
69	<i>Tragia involucrata</i> L.	X	X	X	X	X	√	X	X	1
70	<i>Leptadenia reticulata</i> (Retz.) Wight & Arn.	X	X	X	√	X	X	X	X	1
71	<i>Ludwigia prostrata</i> Roxb.	X	X	X	X	X	√	X	X	1
72	<i>Luffa aegyptiaca</i> Mill.	√	√	X	X	X	X	X	X	2
73	<i>Lygodium flexuosum</i> (L.) Sw.	√	√	√	√	√	√	√	√	8
74	<i>Macaranga peltata</i> (Roxb.) Muell-Arg.	X	X	X	X	X	X	√	√	2
75	<i>Mallotus philippensis</i> (Lam.) Muell- Arg.	X	X	X	√	√	X	√	√	4
76	<i>Mariscus panicus</i> (Rottb.) Vahl.	√	X	√	√	√	√	X	√	6
77	<i>Melochia corchorifolia</i> L.	X	X	X	X	√	X	√	X	2
78	<i>Merremia umbellata</i> (L.) Hall.f.	√	X	X	√	√	X	X	√	4
79	<i>Mimosa pudica</i> L.	√	√	√	√	√	√	√	√	8
80	<i>Mitragyna parvifolia</i> (Roxb.) Korth.	√	X	X	√	X	√	√	√	5
81	<i>Mollugo pentaphylla</i> L.	√	X	X	√	X	X	X	X	2
82	<i>Ocimum sanctum</i> L.	X	X	X	√	X	√	X	√	3
83	<i>Oplismenus burmanii</i> (Retz.) P. Beauv.	√	√	√	√	√	√	√	√	8
84	<i>Panicum miliare</i> auct.non Lam.	√	√	X	√	X	X	√	X	4
85	<i>Paspalidium flavidum</i> (Retz.) A.Camus.	√	X	√	X	√	√	√	√	6
86	<i>Passiflora foetida</i> L.	X	X	X	X	X	√	X	X	1
87	<i>Peltophorum pterocarpum</i> (DC.) Baker ex.K.Heyne	X	X	√	X	X	√	X	√	3
88	<i>Penisetum pedicellatum</i> Trin.	√	√	X	√	X	X	X	X	3

89	<i>Perotis indica (L.) Kuntze</i>	X	X	X	X	X	X	√	√	2
90	<i>Phyllanthus fraternus Webster,</i>	X	√	√	√	√	√	√	√	7
91	<i>Phyllanthus virgatus Forst.f.</i>	√	√	X	√	√	X	√	√	6
92	<i>Polygala chinensis auct. non L.</i>	X	X	X	X	√	X	√	√	3
93	<i>Rauvolfia serpentina (L.) Benth.ex.Kurz.</i>	X	X	X	X	X	√	X	X	1
94	<i>Rostellularia quinqueangularis(Koenig ex.Roxb.) Nees.</i>	X	X	X	X	X	√	X	X	1
95	<i>Rungia pectinata (L.) Nees.</i>	X	X	X	X	X	X	√	√	2
96	<i>Saccharum spontaneum L.</i>	√	√	√	X	√	√	√	√	7
97	<i>Sida acuta Burm. f.</i>	X	√	√	√	√	√	√	√	7
98	<i>Sida cordata (Burm.f) Borssum.</i>	X	√	√	√	√	√	√	√	7
99	<i>Sida rhombifolia L.</i>	X	√	√	√	√	√	√	X	6
100	<i>Smilax zeylanica L.</i>	X	X	X	X	X	√	X	√	2
101	<i>Spatholobus roxburghii Benth.</i>	X	X	X	X	X	X	X	√	1
102	<i>Spermacoce articulata (L.f.)</i>	√	√	√	√	√	√	√	√	8
103	<i>Spermacoce hispida L.</i>	√	X	√	√	√	X	X	√	5
104	<i>Stylosanthes hamata (L)</i>	√	X	X	√	X	X	X	X	2
105	<i>Tephrosia maxima L.) Pers.</i>	√	√	X	X	X	X	√	X	3
106	<i>Tephrosia purpurea (L.) Pers.</i>	√	√	√	√	√	√	√	√	8
107	<i>Tiliacora acuminata (Lam.) Miers</i>	X	X	X	X	X	√	X	√	2
108	<i>Tonningia axillaris(L.) Kuntze.</i>	√	X	X	X	X	X	X	X	1
109	<i>Trichosanthes tricuspidata Lour.</i>	√	√	X	X	X	X	X	X	2
110	<i>Tridax procumbens L.</i>	X	X	√	√	√	√	√	√	6
111	<i>Urena lobata L.</i>	X	X	X	√	X	X	√	X	2
112	<i>Vernonia cineria(L.) Less.</i>	√	X	X	√	X	X	√	√	4
113	<i>Vigna mungo (L.) Hepper.</i>	√	X	X	√	X	X	X	X	2
114	<i>Woodfordia fruticosa (L.) Kurz.</i>	√	√	√	X	X	X	X	X	3
115	<i>Ziziphus mauritiana Lam.</i>	X	X	X	√	√	X	√	X	3
116	<i>Ziziphus oenoplia(L.) Mill</i>	X	X	X	√	X	X	X	X	1
117	<i>Zornia gibbosa Sponoghe</i>	√	X	X	X	√	X	X	√	3
	Total	62	58	40	65	54	56	56	62	

The Clay content in the soil is less than 28% at all the sites. The sand content is more than 70% at D4, D5 and D7 sites. Silt content is highest at D6 followed by D3 site. Lower sand content was found at D6 site. The soil is moderately acidic. The variation of soil pH at different sites indicates that site I OB-II (D1), Kakudia dump(D2), OB dump (D4) and Reclaimed-15 dump(D7) exhibited pH value more than 6.5, where as at Magazine Dump site(D3) and Reclaimed-13 (D5), the pH value was between 6.1 and 6.05. At main Road side Dump (D6) of the Saruabil mines, and at Artificial Reservoir side Dump (D8), the pH value was observed less than 6. The soil samples of different sites are slightly acidic in nature. Electrical conductivity depends upon the water soluble salts. Soil electrical conductivity (EC) is a measurement that correlates with soil properties that affect crop productivity, including soil texture, cation exchange capacity (CEC), drainage conditions, organic matter level, salinity, and subsoil characteristics. EC values of different study sites are given in (Table 3) the electrical conductivity of soils ranged between 0.018 and 0.062. The EC values are within 0-2 range falling in Class A, according to Richards (1954) classification of soil salinity classes. The sites with more sand content (D4, D5, and D7) have lower conductivity value. Amount of available Organic Carbon (O.C) in soil is a critical factor to stimulate the micro flora and to determine the fertility status. The development of Organic layer and mineral distribution in soil influences the vegetation composition and production (Rawat, 2001). The OC is highest in the soil of the Dump 8 (0.695%) and minimum in dump 4 (0.11%). The trend of OC content at different sites is D8>D6>D7>D2>D1>D5>D4. Across the study sites, N content was maximum at dump 8 (D8) and minimum at dump 4 (D4) site. The N content varies between 62.5 and 226.25 kg ha⁻¹. Phosphorus distribution in soil is directly related to its chemistry, mobility and condition of mineralization as its supply in available form comes from solubilisation and rock weathering (Rawat, 2001). It is a relatively immobile nutrient element in forest and other soils (Arunachalam et al. 1997). Phosphorus content (P₂O₅) varies between 5.45 and 9.58 kg ha⁻¹ across all the sites (Table 3) with site D8 having highest concentration, D2 and D5 with lowest concentration of P₂O₅. Except D8 site, all other sites have low P₂O₅ content. Potassium is a structural element of soil minerals (notably feldspars and micas). It undergoes fixation and release phenomena associated with the clay minerals. Potassium is continuously recycled, as compounds of this element are very soluble, get easily leached and washed out of leaves by rain and enter the soil to be reabsorbed by the roots. Most Potassium in soil, however, is held as non-exchangeable cations in the lattices of clays. At the present study sites, the Potassium was found in the range of 37.63 and 349.44 kg ha⁻¹ (Table 3) and D6 having maximum concentration and D1 and D3 the minimum concentration of Potassium (Table 3)

CONCLUSION:

This study shows that fresh overburden soils lack vegetation cover. With increase in age of overburden dumps some physico-chemical properties like electrical conductivity, moisture content, water holding capacity and organic carbon content improved favoring vegetation growth. Further detailed analysis of physico-chemical properties including their seasonal variations, and comparison with adjacent natural forests will throw more light on the succession of vegetation.

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Site	Sand %	Silt %	Clay %	Textural class	pH	Ec	O.C. (k.g hact ⁻¹)	N (k.g hact ⁻¹)	P ₂ O ₅ (k.g hact ⁻¹)	K ₂ O (k.g hact ⁻¹)
OB dumpII (D1) site	65.40	16.00	18.60	Loam	6.9 2	0.062	0.157	73.75	6.76	37.63
Kakudia dump (D2) site	67.80	15.00	17.20	Loam	6.5 0	0.028	0.21	76.20	5.49	90.00
Magazine dump (D3) site	61.40	17.00	21.60	Loam	6.1 0	0.055	0.157	88.75	5.63	55.10
OB-X dump (D4) site	73.80	11.00	15.20	Sandy-loam	6.6 0	0.027	0.11	62.50	6.58	87.30
Reclaimed-13 (D5) site	72.80	10.00	17.20	Sandy-loam	6.0 5	0.018	0.13	77.50	5.49	84.60
Main road side(D6) site	53.40	19.00	27.60	Clay-loam	5.7 7	0.055	0.424	166.25	5.63	137.08
Reclaimed-15 (D7) site	82.80	5.00	12.20	Sandy-loam	6.6 2	0.026	0.38	86.20	6.58	98.00
Artificial reservoir side (D8) site	63.40	12.00	24.60	Clay-loam	5.8 5	0.048	0.695	226.25	9.579	349.44

Table 3: shows the mean values of some physicochemical parameters of overburden soil samples.