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Impact of plantation on Iron Ore Mined Overburden at Durg in Chhattisgarh, India

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Abstract

Impact of tree plantation at iron ore mined spoils was studied in central India including analysis of pH, electric conductivity, organic matter, available N, P, K exchangeable Mg, Ca and trace elements. It was observed that physicochemical properties of soil gradually improved along with the plant age and the concentration of trace elements decreased. Difference in species composition was observed on the overburden of different ages. A total of 72 species (excluding 27 planted tree species) comprising of 16 trees, 10 shrubs, 3 climbers, 10 grasses and 33 herbs were recorded growing naturally on mine spoil dump soil. Highest species richness was recorded on three year old dump where 60 species of herbs, shrubs and trees were recorded coming naturally. These plants have higher tolerance to unfavorable soil conditions and are mostly xerophytic in nature. On three year old dump Lantana camara (invasive species) was absent. Grass cover decreased with increase in age of overburden and it was lowest on 7 year old dump. Three invasive species, Lantana camara, Chromolaena odorata and Hyptis suaveolens present on overburden dump. Echinochloa colona, Euphorbia hirta, Gomphrena sp., Indigofera linnaei and Portulaca oleracea occurred commonly at all the sites. Among planted species maximum survival was observed in Albizia lebbeck followed by Cassia fistula, Cassia siamea, Dalbergia sissoo, while minimum survival was recorded in Delonix regia, Eugenia jambolana, Gmelina arboria, Tectona grandis after 9 years of plantation. Effect of plantation on eco-restoration of mine degraded land was studied and physicochemical properties of overburden soil were compared with the native soil. The results showed that pH, EC, organic carbon, NPK were lowest in fresh dumps and increases with age, and highest value for this parameter was recorded in soil sample of 9 year old plantation. The present study helps in understanding the future scope of plantation for eco-restoration of mine overburden soil.

Keywords: Degraded land, Exotic species, Lantana camara, overburden, Plantation, Re-vegetation, Succession.

Introduction

Iron is the fourth most abundant metal in earth core after Carbon Silicon and Aluminum. India is one of the top four exporters of the Iron ore. Most of the Iron ore is extracted through open cast mining. Mining of the ore have negative impact on environmental, the disturbance in the natural soil strata and destruction of native vegetation alters the structure and function of the ecosystem by changing nutrient dynamics and tropical interactions[1,2]. Mining changes the soil strata, which does not support natural vegetation and microbial growth due to unfavorable Physico-chemical properties like low organic-matter, low pH and low water-holding capacity and high compaction etc.[3,4]. Plantations play an important role in biological reclamation of mine spoils through modification of soil characteristics.

Plantation on overburden dump of Dalli-Rajhara areas was undertaken by different agencies like forest departments, Durg and Raipur; labor societies, etc. Plantations play an important role in soil conservation, the extensive root systems of the plantations holds the soil and prevent topsoil erosion. The plantations also contribute to the organic content of the soil. Addition of organic content facilitates microbial growth and it also has a positive effect on physical properties of the soil. Effect of plantation on different mine land was studied by many workers[4-6].

The present paper investigates the temporal changes in physicochemical properties of the mine spoil and species aggregation under plantations carried out on overburden dumps of Iron ore mines of Dalli-Rajhara.

Materials and methods

Study site: The present study was conducted in plantations carried out on mine overburden soils at Dalli - Rajhara hills of Chhattisgarh state (Figure-1). Which is located on a hill range of Balod District in the state of Chhattisgarh, India, these mine overburden are spread between 20°33'0" and 20°34' 30" N latitude and 81°1'0" and 81°4'30" longitude. The area is known for iron ore production, Dalli-Rajhara mines are surrounded by four other similar types of mines i.e. Dalli, Rajhara, Mahamaya, Dulky and Jharandalli. Jharan nala (water channel) is cutting across Dalli and Rajhara hills. The Meta sedimentary lithological units showed the following sequence: i. upper ferrugenous unit ii. middle iron ore, iii. ferruginous shales and banded haematite and quartzites (BHQ) iv. lower non-ferruginous unit. Thus the present deposit belongs to middle ferruginous units Atmospheric temperature in the region goes up to a maximum of 47ºC in the month of May/ June and comes down to 6.5ºC during December/January. The mean annual rainfall is 1400 mm, 75-80% of which occurs in the monsoon period. Mining activity was started in 1960 and continued till date. Total production in Rajhara mines 1.65 million ton iron ore/year and Dalli 3.5 million tons/year and stripping ratio of both mines 0.5 to 1[7]. Lease forest area of Rajhara hill is 719.60ha and Dalli is 100ha. Mining of iron ore has led to habitat fragmentation in this area. The native vegetation is restricted in small patches distributed randomly in the area. The plantation carried out on the over burden dumps forms connecting links between vegetation patches and forest.

The present study was conducted in plantations of overburden dumps of Dalli-Rajhara mines. Edaphic and Phytosociological attributes of plantations of different age viz. three year (planted in year 2011-2012), seven year (planted in year 2007-2008), eight year (Planted in 2006-2007) and nine year (2005-2006) was recorded. Edaphic and Phytosociological attributes plantations on undisturbed soil (adjoining plantation outside the overburden areas) were taken as control for the study (Figure-2).

Analysis of Physicochemical properties of soil: pH and electric conductivity were estimated[8]; Available potassium was estimated by Flame photometric method[9]; N was determined by the Kjeldahl method[10]; available phosphorus[11]; Exchangeable Cation (Ca^{++} and Mg^{++})[7] was also estimated. Estimation of Heavy metals was done by diethylene triamine pentacetic acid (DTPA) extraction method[12].

Figure-1: (A) Plantation in Dalli and Rajhara mine, (B-F) Grasses and invasive species naturally emerged on iron ore over burden soil

Status of natural vegetation: Plant succession on different age group dumps were studied by quadrate method during November-December 2013. Quadrant of $5m^2$ and $1m^2$ sizes respectively for trees and grasses were place randomly in the plantations.

On every dump 20 quadrant were placed 10 on each aspect. The data thus collected was analyzed for frequency, density and abundance[13].

Results and discussion

The physiochemical status of iron ore mined spoils of study site, are presented in Table-1.

Data (Table-1) of physicochemical property of the soil indicates that all the studied parameters of soil character had lowest value in fresh (0 year) dump. The soil was acidic (pH 5.54), similarly minerals content like N, P, K, Ca and Mg were also lowest among the collected soil samples.

OC were absent and soil texture was sandy. Analysis of the soil samples of the dumps of different age showed gradual increased in pH, EC, OC, N, P, K, Ca and Mg, the soil texture also increased with increase age of plantation. In 9 year old plantation soil pH increased by 81.47%, and EC had 36.64%. Organic matter was the maximum in 9 year old spoils which were slightly less in 8 year and minimum in 3 year old overburden. OC increased 253.76% in 9 year dump.

Available nitrogen (N) was the maximum in soil of 9 year old iron ore mined spoils. Available nitrogen increased significantly with the age of spoils. Available phosphorus (P_2O_5) concentration also followed the same trend with maximum concentration 23.95 kg/ha in 9 years old spoils. Available potassium (K_2O) estimated maximum 612.5 kg/ha in 9 years old spoils. Exchangeable Mg and Ca was maximum respectively 4.2 (meq/ 100g) and 8.9 (meq/ 100g) in 9 year dump.

Data (Table-1) indicate that pH and soil texture of the 9 year old dump and natural soil was similar, where as the concentration of OC, N, P, K, Ca and Mg showed significant difference at 0.226%, 109.76(kg/ha), 6.3(kg/ha), 275(kg/ha), 15.4(meq/100g) and 0.1 (meq/100g) respectively.

Trace elements: The concentrations of heavy metals in soil samples collected from plantation of different age are presented in Table-2. The value of concentration of trace elements obtained from spoils of different age groups was differs with each other. Among the various trace elements the maximum concentration of Fe was observed in all age group dumps.

However, Co showed minimum concentration in soil of fresh mine spoil. The concentration of heavy metal was reduced when age of overburden was increased. In natural soil only Fe, Cu and Mn was detected and other heavy metal concentration was present in BDL (below determine level).

Table-3 enlists the species planted on overburden dumps and their survival in the plantation. Survival percentage of the planted species was determined. Mixed species plantation was carried out on these over-burden dumps.

The initial number of plants of each spp. was not known. The spacing of plant was 5 x 5m. Hence, to determine the survival percentage and proportion of surviving plantation for the study area frequency and density was calculated based upon sampling by quadrate method. Data was mention in Table-3.

Table-1: Physicochemical analysis of overburden soil

Age of overburden	pH	EC (µS/ cm)	OC (%)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)	Ex.Ca (meq/ 100g)	Ex. Mg (meq/ 100g)	Soil texture
0 year	5.553 ±0.05	122.8 ±0.73	-	146.487 ±9.26	3.403 ±0.39	125.933 ±5.74	0.497 ±0.06	0.827 ±0.06	Sandy
3 year	6.107 ±0.13	289.97 ±4.1	0.188 ±0.01	232.747 ±6.13	13.923 ±0.63	270.467 ±4.55	4.733 ±0.65	2.600 ±0.78	Sandy loam
7 year	6.280 ±0.14	307.47 ±4.46	0.597 ±0.03	360.807 ±6.65	19.370 ±0.46	435.367 ±6.76	4.900 ±0.20	3.633 ±0.21	Sandy clay loam
8 year	6.380 ±0.17	325.8 ±6.45	0.659 ±0.02	389.207 ±6.08	21.490 ±0.74	552.367 ±2.89	7.433 ±0.5	4.300 ±0.27	Sandy clay loam
9 year	6.873 ±0.06	354 ±12.97	0.719 ±0.01	393.100 ±7.41	23.770 ±0.69	614.600 ±5.56	8.733 ±0.47	4.533 ±0.4	Sandy clay loam
Natural soil	7.433 ±0.31	438.5 ±18.00	0.963 ±0.03	504.300 ±7.56	31.670 ±2.58	881.700 ±5.61	26.267 ±1.79	4.767 ±0.12	Sandy clay loam
CD at 0.05%	0.9095781	15.272339	-	11.9919396	1.7026352	10.3932478	1.5774284	0.738944	-
SE	0.147215	23.10119	0.079452	28.318945	2.133423	59.085337	2.005886	0.341128	-

Table-2: Status of traces metals in iron ore mined spoils of different age group dumps

S. No.	Age of overburdens (Year)	Concentration of traces elements (ppm)						
		Ni	Pb	Mn	Zn	Fe	Cu	Co
1.	Natural soil	BDL	BDL	0.002±0.001	BDL	0.130±0.007	0.113± 0.008737	BDL
2.	0 year	0.136±0.01	1.340±0.08	0.178±0.003	0.189±0.048	0.608±0.057	0.481± 0.004163	0.0503± 0.0442982
3.	3 year	0.128±0.02	1.280±0.08	0.418±0.002	0.287±0.036	0.448±0.034	0.374± 0.018330	0.0404± 0.0326283
4.	7 year	0.127±0.00	1.303±0.05	0.173±0.008	0.196±0.006	0.536±0.029	0.449± 0.01253	0.0248± 0.0108761
5.	8 year	0.077±0.02	0.143±0.02	0.241±0.021	0.161±0.006	0.376±0.032	0.271± 0.006557	0.0014± 0.0007965
6.	9 year	0.063±0.02	0.047±0.03	0.107±0.124	0.139±0.008	0.272±0.005	0.153± 0.009849	0.0273± 0.0445128
CD at 0.05%		0.0095838	0.04172	0.04172	0.007*	0.04172	0.09741418	NS
SE		0.009051	0.116009	0.0244	0.016213589	0.029989749	0.026026041	0.004860265

BDL – Below determine level; *Significant at (*P = 0.01*)

Table 3: Survival of planted tree species on overburden dumps of different age group

Name of plant	3 Year	7 Year	8 Year	9 Year
Ailanthus excelsa Roxbs.	–	V	–	–
Albizia lebbeck (L.) Benth.	III	–	–	V
Annona squamosa L.	V	–	–	–
Azadirachta indica A. Juss	–	–	–	IV
Bamboo sp.	–	–	–	III
Butea monosperma (Lam.) Taub.	–	II	III	–
Cassia fistula L.	–	–	IV	V
Cassia siamea Lam.	–	–	V	V
Dalbergia sissoo DC.	–	–	V	V
Deloxin regia (Hook.) Raf.	–	–	–	II
Eucalyptus hybrid	–	V	V	–
Eugenia jambolana (Lamk.)	–	–	–	II
Ficus benghalensis L.	–	I	–	–
Ficus religiosa L.	–	II	–	–
Gmelina arboria Roxbs	–	–	–	II
Gmelina robusta A.Cunn.ex R.Br.	–	–	III	IV
Leucaena leucocephala (L.) Gillis and Stearm	–	V	–	–
Mangifera indica L.	V	–	–	–
Moringa pterygosperma Gaerth.	V	–	–	–
Peltophorum pterocarpum (DC.) K.Heyne	–	–	–	IV
Phyllanthus officinalis L.	III	–	–	IV
Polyalthia longifolia (Sonn.) Thwaites	–	V	–	–
Pongamia pinnata (L.) Pierre	–	III	V	–
Psidium guajava L.	V	V	–	–
Tamarindus indica L.	V	–	–	–
Tectona grandis L.F.	–	–	–	II
Terminalia arjuna (Roxb. ex DC.) Wight and Arn.	–	III	–	–

Survival category: I = very poor; II = poor; III = good; IV = very good; V = excellent; - = not planted

In 3 year old overburden 2 tree species *Phyllanthus officinalis* and *Albizia lebbeck* was present frequently and 5 species *Tamarindus indica*, *Psidium guajava*, *Moringa pterygosperma*, *Mangifera indica* and *Annona squamosa* were dominant species. Similarly in 8 year old overburden, two species *Butea monosperma* and *Gmelina robusta* were frequently present, four tree species *Cassia siamea*, *Dalbergia sissoo*, Eucalyptus hybrid and *Pongamia pinnata* were dominant species, Cassia *fistula* was commonly distributed in study area. In 7 year old overburden dump, two species *Terminalia arjuna* and *Pongamia pinnata* was present frequently, five species *Ailanthus excels*, Eucalyptus hybrid, *Leucaena leucocephala*, *Polyalthia longifolia* and *Psidium guajava* were dominant species, *Ficus religiosa* and *Butea monosperma* was present Occasionally while *Ficus benghalensis* was rare in the study area. Similarly in nine year old overburden Bamboo spp. were present frequently, four tree species *Albizia lebbeck*, *Cassia fistula*, *Cassia siamea* and *Dalbergia sissoo* were dominant and *Deloxin regia*, *Eugenia jambolana*, *Tectona grandis* and *Gmelina arboria* occurred occasionally in the study area and four species *Gmelina robusta*, *Peltophorum pterocarpum*, *Azadirachta indica* and *Phyllanthus officinalis* were commonly present.

Difference in species aggregation was observed on the iron ore mine overburden plantation of different ages. A total of 72 species comprising of 16 trees (seedlings/saplings), 10 Shrubs, 3 climbers, 10 Grasses and 33 Herbs (Table-4) were recorded. Highest species richness was recorded in three year old dump where 60 species of herbs and trees were growing naturally, while the lowest species richness was recorded in 8 year old dump mines. However, the species diversity on the 7 and 9 year old overburden mines were not very different, 35 and 37 species were recorded from these plantations respectively. In 3 year old spoil total 60 species of herbs and trees were recorded, 50.01% species was observed as dominated species. Similarly, in 8 year old dump total 31 species recoded, 58.06% species was observed as dominant. In 7 year old dump 48.57% species were dominant and on 9 year old dump 51.42% species recorded as dominant species. Out of 72 recorded species in the area, 7 plant species like *Acacia nilotica*, *Artocarpus heterophyllus*, *Blumea alata*, *Butea monosperma*, *Dalbergia sissoo*, *Indigofera pulchella* and *Tridax procumbens* were recorded in 3 year old plantation only. *Albizia odoratissima* was growing naturally only in 7 year old plantation. *Ailanthus excels, Albizia lebbeck, Azadirachta indica, Argemone mexicana* and *Dodonaea viscosa* were recorded only in 8 year old plantation. In 9 year old plantation *Cassia alata, Thevetia peruviana* and *Tecoma stans* were present naturally.

Lowest species richness was recorded in 7 year old plantations, some of the species (*Alysicarpus vaginalis*, *Casearia graveolens, Casearia tomentosa*, *Chrysopogon aciculatus*, *Cissampelos pareira*, *Cynodon dactylon*, *Dichanthium annulatum*, *Digitaria ciliaris*, *Dioscorea bulbifera*, *Eragrostis tenella*, *Mallotus philippensis, Alloteropsis cimiciana, Saccharum spontaneum, Synedrella nodiflora, Taraxacum officinale, Vernonia cinerea, Vitex negundo* and *Zornia gibbosa*) which were commonly found in all the plantation were not found in 7 year old plantation. Similarly in 8 year old plantation where *Acacia auriculiformis*, *Acmella uliginosa*, *Echinochloa crus-galli*, *Paspalidium flavidum*, *Setaria pumila, Synedrella nodiflora* and *Tragus* sp. were not growing naturally. *Lantana camara* (an invasive species) was absent only in 3 year old plantation, other plantation showed varying degree of lantana infestation.

Discussion: The pH of the soil solution directly influences the uptake of minerals and nutrient by plants, which are essential for the growth and establishment of the plant. Nutrient uptake is optimum in the soil with pH ranging 6.5 to 7.5[14]. In the current study the pH of the soil samples from the plantations on over burden ranged from 6.1 to 7.4. The soil samples are weakly acidic in nature in nature. Under lower pH plants cannot uptake N, P, K and other essential nutrients[14]. Also, the acidic soil facilitates uptake of toxic metals eventually leading to mortality[15].

In the study area, EC was found to be range between 289.97 to 354 µs/cm. In natural soils EC varies between 200 to 800µs/cm[16]. Low EC is an indicator of degraded land. Under the current study it was found that EC of soil increased with the age of plantation. With the increasing age, plantations contribute to the organic content in the soil. Addition of organic content by the plantations improves the soil texture and its water holding capacity.

In the current study the organic carbon % varied between 0.20 to 0.70. The soil samples from the plantations have low to medium organic carbon. Similar results were reported[17,18]. It was observed that the organic content in the samples from overburden plantation was lower than the samples collected from native soils collected from plantations on undisturbed soil outside the overburden areas. Dead and decaying plant debris (fallen leaves, dead root, bark and other decomposing plant and animal material) contribute to the organic carbon of the soil[19]. The decomposing organic matter in the upper layer of soil is one of the important component of soil ecosystem it supports the array of decomposers, including fungi and other organism. These organisms have important role in maintaining the cycling of nutrients in the soil making the whole system sustainable, however due to mining this entire system is disrupted[20]. Lower level of organic content in the mine overburden leads to depletion of organic pool[21].

Ideally the organic carbon should be more than 0.8%, soils having less than 0.4% of organic carbon are considered to be poor for growth of vegetation[22]. Organic matter contains N, P, K, Ca and Mg and other essential nutrients. High levels of organic matter leads to increased aggregation and infiltration capacity of mine spoils, which in-turn increase the availability of nutrients. Available carbon source plays an important role for stimulation of microflora in mine land[23].

Table-4: Status of natural vegetation in overburden dumps of different age group

Name of plant	3 year				8 Year				7 Year				9 Year			
	F	A	D	A/F	F	A	D	A/F	F	A	D	A/F	F	A	D	A/F
Acacia auriculiformis A. Cunn. ex Benth.	II	150	800	3.75	–	–	–	–	V	520	520	5.2	I	700	140	35
Acacia nilotica (L.) Delile	III	200	1200	3.33	–	–	–	–	–	–	–	–	–	–	–	–
Acmella uliginosa (Sw.) Cass.	III	200	1200	3.33	–	–	–	–	IV	1050	840	13.13	II	100	40	2.5
Albizia odoratissima (L.f.) Benth.	–	–	–	–	–	–	–	–	V	240	240	2.4	–	–	–	–
Alternanthera sessilis (L.) R. Br. ex DC.	V	1680	2000	16.8	–	–	–	–	–	–	–	–	–	–	–	–
Alysicarpus vaginalis (L.) DC	V	680	2000	6.8	V	1820	1820	18.2	–	–	–	–	V	180	180	1.8
Ailanthus excelsa Roxb.	–	–	–	–	V	1300	1300	13	–	–	–	–	–	–	–	–
Albizia lebbeck (L.) Benth.	–	–	–	–	IV	275	220	3.44	–	–	–	–	–	–	–	–
Azadirachta indica A. Juss	–	–	–	–	II	250	100	6.25	–	–	–	–	–	–	–	–
Anisomeles indica (L.) Kuntze	V	820	2000	8.2	III	133.33	80	2.22	–	–	–	–	V	780	780	7.8
Anogeissus latifolia (Roxb. ex DC) Wall ex Guill. & Perr.	–	–	–	–	–	–	–	–	I	100	20	5	–	–	–	–
Argemone Mexicana L.	–	–	–	–	V	1160	1160	11.6	–	–	–	–	–	–	–	–
Artocarpus heterophyllus Lam.	V	620	2000	6.2	–	–	–	–	–	–	–	–	–	–	–	–
Atylosia scarabaeoides (Linn.) Benth.	I	200	600	6.67	–	–	–	–	IV	550	440	6.88	–	–	–	–
Blumea alata (D. Don) DC.	V	400	2000	4	–	–	–	–	–	–	–	–	–	–	–	–
Bridelia retusa (L.) A.Juss.	I	100	400	5	–	–	–	–	V	340	340	3.4	–	–	–	–
Butea monosperma (Lam.) Taub.	I	500	400	25	–	–	–	–	–	–	–	–	–	–	–	–
Calotropis procera (Aiton) Dryand	V	1780	2000	17.8	–	–	–	–	V	1820	1820	18.2	–	–	–	–
Casearia graveolens Dalzell	V	340	2000	3.4	II	100	40	2.5	–	–	–	–	I	500	100	25
Casearia tomentosa Roxb.	V	680	2000	6.8	I	100	20	5	–	–	–	–	V	620	620	6.2
Cassia alata Benth (L.) Roxb.	–	–	–	–	–	–	–	–	–	–	–	–	IV	475	380	5.94
Chromolaena odorata (L.) King & H.E. Robins.	V	1480	2000	14.8	–	–	–	–	II	350	140	8.75	–	–	–	–
Chrysopogon aciculates (Retz.) Trin.	IV	300	1600	3.75	V	520	520	5.2	–	–	–	–	III	200	120	3.33
Cissampelos pareira L.	V	600	2000	6	V	240	240	2.4	–	–	–	–	V	620	620	6.2
Convolvulus arvensis L.	I	100	400	5	–	–	–	–	III	566.67	340	9.44	–	–	–	–
Convolvulus nummularis L.	II	100	800	2.5	–	–	–	–	V	1120	1120	11.2	–	–	–	–
Cynodon dactylon (L.) Pers.	V	500	2000	5	I	200	40	10	–	–	–	–	V	720	720	7.2
Dalbergia sissoo DC.	IV	175	1600	2.19	–	–	–	–	–	–	–	–	–	–	–	–
Dichanthium annulatum (Forssk.) Stapf	V	480	2000	4.8	IV	175	140	2.19	–	–	–	–	IV	875	700	10.94
Digitaria ciliaris (Retz.) Koeler	V	500	2000	5	IV	200	160	2.5	–	–	–	–	II	150	60	3.75
Dioscorea bulbifera L.	V	620	2000	6.2	III	166.67	100	2.79	–	–	–	–	V	1680	1680	16.8
Dodonaea viscosa Jacq.	–	–	–	–	IV	1625	1300	20.31	–	–	–	–	–	–	–	–
Echinochloa colona (L.) Link	I	100	400	5	V	1000	1000	10	III	300	180	5	V	480	480	4.8
Echinochloa crus-galli (L.) Beauv	III	100	1200	1.67	–	–	–	–	V	480	480	4.8	V	1300	1300	13
Eragrostis tenella (L.) P.Beauv.ex Roem.& Schult.	V	1000	2000	10	V	780	780	7.8	–	–	–	–	V	1780	1780	17.8
Euphorbia hirta L.	II	100	800	2.5	V	1780	1780	17.8	IV	1625	1300	20.31	III	300	180	5

Name of plant	3 year				8 Year				7 Year				9 Year			
	F	A	D	A/F	F	A	D	A/F	F	A	D	A/F	F	A	D	A/F
Evolvulus alsinoides (Linn.) Linn.	I	100	400	5	–	–	–	–	II	250	100	6.25	–	–	–	–
Gomphrena sps.	IV	275	1600	3.44	V	1620	1620	16.2	IV	400	320	5	II	250	100	6.25
Hyptis suaveolens (L.) Poit	V	780	2000	7.8	–	–	–	–	V	1340	1340	13.4	–	–	–	–
Ichnocarpus frutescens (L.) W.T.Aiton	II	100	800	2.5	–	–	–	–	V	660	660	6.6	–	–	–	–
Indigofera linnaei L.	V	740	2000	7.4	V	620	620	6.2	IV	475	380	5.94	V	620	620	6.2
Indigofera pulchella Roxb.	II	150	800	3.75	–	–	–	–	–	–	–	–	–	–	–	–
Lagerstroemia parviflora Roxb	III	166.67	1200	2.78	–	–	–	–	IV	375	300	4.69	–	–	–	–
Lantana camara L.	–	–	–	–	V	3100	3100	31	V	1780	1780	17.8	V	1540	1540	15.4
Leucas aspera (Willd)	I	100	400	5	–	–	–	–	II	250	100	6.25	–	–	–	–
Mallotus philippensis (Lam.) Muell. Arg.	V	480	2000	4.8	V	580	580	5.8	–	–	–	–	V	400	400	4
Merremia gangetica L.	II	150	800	3.75	–	–	–	–	V	1540	1540	15.4	–	–	–	–
Alloteropsis cimiciana (L.) Stapf.	V	340	2000	3.4	V	1160	1160	11.6	–	–	–	–	V	420	420	4.2
Nepeta sps	IV	100	1600	1.25	–	–	–	–	V	640	640	6.4	–	–	–	–
Nerium indicum (L.)	–	–	–	–	–	–	–	–	–	–	–	–	III	800	480	13.33
Paspalidium flavidum (Retz.)	IV	100	1600	1.25	–	–	–	–	V	1300	1300	13	IV	275	220	3.44
Portulaca oleracea L.	V	1000	2000	10	V	520	520	5.2	V	540	540	5.4	III	166.67	100	2.78
Ruellia tuberose L.	III	133.33	1200	2.22	–	–	–	–	II	500	200	12.5	–	–	–	–
Rungia pectinata (Retz.) Nees.	II	100	800	2.5	–	–	–	–	III	333.3	200	5.56	–	–	–	–
Saccharum spontaneum L.	V	1100	2000	11	II	250	100	6.25	–	–	–	–	III	466.67	280	7.78
Setaria pumila (Poiret) Roemer & Schultes	III	100	1200	1.67	–	–	–	–	IV	275	220	3.44	V	380	380	3.8
Spermacoce hispida L.	V	1480	2000	14.8	–	–	–	–	V	540	540	5.4	–	–	–	–
Synedrella nodiflora L.	III	200	1200	3.33	–	–	–	–	V	720	720	7.2	IV	175	140	2.19
Synedrella nodiflora(L.) Gaertn.	V	440	2000	4.4	V	3100	3100	31	–	–	–	–	V	640	640	6.4
Taraxacum officinale, Weber ex F.H. Wigg	V	500	2000	5	IV	525	420	6.56	–	–	–	–	IV	1625	1300	20.31
Tecoma stans (L.) Juss. ex Kunth	–	–	–	–	–	–	–	–	–	–	–	–	V	540	540	5.4
Tragus sp.	III	100	1200	1.67	–	–	–	–	V	380	380	3.8	III	566.67	340	9.44
Trema orientalis (Linn.) Blume	I	100	400	5	–	–	–	–	IV	425	340	5.31	–	–	–	–
Hemigraphis latebrosa (Roth) Nees	IV	325	1600	4.06	–	–	–	–	III	800	480	13.33	–	–	–	–
Tridax procumbens L.	V	2080	2000	20.8	–	–	–	–	–	–	–	–	–	–	–	–
Urena lobata L.	II	150	800	3.75	–	–	–	–	II	250	100	6.25	–	–	–	–
Vernonia cinerea (L.) Lessing	V	1080	2000	10.8	V	800	800	8	–	–	–	–	IV	175	140	2.19
Vitex negundo Linn.	V	1560	2000	15.6	I	100	20	5	–	–	–	–	III	200	120	3.33
Woodfordia furticosa (L.) Kurz	–	–	–	–	V	1120	1120	11.2	–	–	–	–	V	720	720	7.2
Ziziphus oenoplia (L.) Miller	V	780	2000	7.8	–	–	–	–	–	–	–	–	V	680	680	6.8
Zornia gibbosa Span.	V	840	2000	8.4	V	1340	1340	13.4	–	–	–	–	V	600	600	6
Ziziphus jujuba Mill.	IV	875	1600	10.94	–	–	–	–	V	620	620	6.2	–	–	–	–

I = rare; II = occasional; III = frequent; IV = common; V = dominant; -absent; F= frequency; A= abundance; D= density

In the present study, available nitrogen varied from 146.48 to 393.1 in selected areas of mines. Nitrogen content was found to be maximum (392kg/ha), at 9 year due to high organic content in the soil sample. N is essential in metabolic process, based on protein. Vegetative growth, reproductive maturity and biomass yield of the plant is totally dependent on supply of nitrogen[24]. Organic matter, Fertilizers are the chief source of nitrogen for the plant species growing on the overburden dumps. Leguminous plants fix nitrogen on their own, this nitrogen is also available for the other non leguminous plants[25,26].

Phosphorus content in the samples collected from Overburden dump ranged from 3.42 to 23.77 Kg/ha, which is lower than the ideal soil as described[17,27]. The high range of variation in available phosphorous in the study area may be explained by the fact that, in initial years due to poor mineralization and biological decomposition process in the overburden sample.

The phosphorous is trapped in the parent rock. With the passage of time the rock decomposes and the trapped phosphorous is available for the plants in form of Phosphorous pentaoxide. Phosphorus is valuable sources for plant growth; it enters the plant system through roots. P may be stored in the root or transported to the upper portions of the plants. The phosphorous is one of the important elements for synthesis of organic compound like nucleic acids, phosphor-proteins, phosphor-lipids, sugar phosphate, enzymes and Adenosine Tri Phosphate (ATP).

Improvement in the physicochemical properties of soil in plantations on overburden dumps may be attributed to control of soil erosion, addition of organic matter and humus with the increasing the age of plantations[5,28-30]. Mined soils are deficient in macronutrients especially N, P and K and micronutrients as well[31, 32] however, with increasing age of mine spoil the availability of (P_2O_5) and potassium (K_2O) increases[7]. This increase may be attributed to natural succession of vegetation on the dumps which add to the organic content and catalyze the organic decomposition of the parent rocks.

In the current study, it was observed that the heavy metal concentration was decreased with the aging of spoil. Such variation may occur due to vegetation succession process occurring on mine spoils. The toxic effect of accumulation of heavy metal in the plants growing on the mine spoil[32]. The order of ecological risk associated with the 8 heavy metals is Hg > Cd > As > Pb > Ni > Cu > Cr > Zn[33]. Heavy metals like Hg, Fe, Pb, Cr, Zn, Cu, Pb, Mn, Cr, Ni, and Cd are reported from the spoils of iron ore mine[34-37].

Trace elements are fundamental need for the growth of plants, but increased concentration of these elements in mine spoils may pose serious hazards to the plants. The establishment and growth of plants are restricted due to deficiency of nutrients in mined spoils. Heavy metals inhibit growth of micro-organism in soil[38], which is essential part of soil fauna. These organism play an important role in decomposition of organic matter and nitrogen fixation, thus soil having heavy metals are often poor in organic carbon and nitrogen[39]. Addition of organic matter decreases the bioavailability of heavy metals in soil and facilitate establishment of vegetation on such sites[40]. Natural process like precipitation, adsorption and formation of mineral complex also reduce the availability of heavy metals. The steady decrease in concentration of heavy metals with increasing age of plantations in the current study indicates that, either the metal are accumulated in the vegetative parts of different plant species or they forming complexes with other minerals through chemical reaction[41,29]. In some plant species heavy metals absorbed by the roots form complexes which are unavailable for translocation, and thus are sequestered in the plant tissues[42]. Soil fungus also plays an important role in reduction of heavy metal concentration in soil[43,44].

Plantation and Naturally Occurring Plants: Native species are always recommended for plantations on mine overburden[45,46], but often fast growing exotic species are preferred over native species[34,47-49] as these species exhibit faster growth than native species on degraded land during initial years of establishment[50,51]. Our study shows that planted species like *Albizia lebbeck, Butea monosperma, Cassia fistula, Cassia siamea, Dalbergia sissoo and Gmelina robusta* (Table-3) has established in the mine area and is now successfully regenerating. Plantation of these species is successful in land degraded by overburden of mine spoil. Hence, these plant species can be used to reclaim such area. These trees maintain sustainable bio-network through numerous processes such as maintenance of soil organic matter, rhizosphere growth and improved soil biological activity. With the passage of time, new self sustaining leaf litter and litter fall will be created by the plantations which help in formation of humic substances[28]. With gradual change in physicochemical properties of mine spoil, native species starts aggregating under the plantations. Mostly the first native species to colonize the plantations on overburden dumps have board ecological amplitude. Most of them are adapted for wide range of seed dispersal. Among the dominant native species recorded in the current study *Blumea alata, Calotropis procera, Chromolaena odorata, Dioscorea bulbifera, Ichnocarpus frutescens, Saccharum spontaneum, Synedrella nodiflora Taraxacum officinale* and *Tecoma stans* are dispersed through wind while *Bridelia retusa, Albizia odoratissima, Casearia graveolens, Casearia tomentosa, Cissampelos pareira, Convolvulus nummularis, Cynodon dactylon, Dichanthium annulatum, Euphorbia hirta, Hyptis suaveolens, Indigofera linnaei, Lantana camara, Mallotus philippensis, Merremia gangetica, Portulaca oleracea, Woodfordia fruticosa, Ziziphus oenoplia, Ziziphus jujuba* and other species are mostly dispersed by birds and animals. Plantations provide barrier to the air-borne seeds, at the same time they attract birds and other animals.

The seeds contributed from these dispersal agents form soil seed bank which emerges under favorable conditions[52-55].

Most of the native species occupying the overburden dump showed profuse growth and high biomass production. These characters are similar to the invasive species. In fact *Lantana camara, Chromolaena odorata* and *Hyptis suaveolens* are the invasive species which has grown profusely on these dumps. Profuse growths give competitive advantage to the species in maximum utilization of resources. Native species like *Argemone Mexicana, Calotropis procera, Casearia graveolens, Casearia tomentosa, Gomphrena* sp., *Euphorbia hirta, Indigofera linnaei, Merremia gangetica, Taraxacum officinale, Tridax procumbens, Zornia gibbosa, Zyzyphus jujube* and *Ziziphus oenoplia* showing tendency to grow in xeric conditions were among the most wide spread species, these species have adaptive advantage over other species because due to low water holding capacity of the mine spoil other species cannot survive in these conditions. During rainy season when water is not a constraint, at this time many grass species like *Chrysopogon aciculatus, Cynodon dactylon, Dichanthium annulatum, Digitaria ciliaris, Echinochloa colona, Echinochloa crus-galli, Eragrostis tenella, Paspalidium flavidum, Saccharum spontaneum, Setaria pumila,* and *Alloteropsis cimiciana* grow commonly on these dumps. *Echinochloa colona, Euphorbia hirta, Gomphrena* sp., *Indigofera linnaei* and *Portulaca oleracea* occurred commonly at all the sites. Species aggregation is determined by microenvironment, this explains the different species composition at different sites[56]. Most of the species recorded from the dump sites are common small herb species producing seeds in large quantities.

It was recorded that the plant species with higher tolerating capacity often produces extensive ground cover. Many species of plant growing naturally on the Overburden dumps, have special adaptation, for example *Calotropis procera* (Aak) is a fast growing, upright herbaceous, evergreen, plant with high salt and drought tolerance and low nutritional demand. Growth rate of this plant is high in summer that means it's a xerophytic plant. *Azadirachta indica* (Neem) is evergreen and drought tolerant plant. *Zyzyphus* sp. (Ber) are hardy tree, grow in extreme temperature, fruit quality is best under hot, sunny and dry condition. It consist the adaption in the form of Xerophytic plant. *Dalbergia sissoo* (Sissoo) are also growing quickly in full sun, and variety of soil type (Clay, loam, sand, acidic, occasionally wet and well drained). Strong tap root with numerous fibrous lateral root, spread rapidly and increase soil fertility, and prevent soil erosion. *Albizia odoratissima* show high resistance to weed competition, tolerance to drought and has high seed viability (seed germination of 99%). It regenerates naturally in sheltered areas. Germination of year-old seed decreases to 55-65%[57]. *Ailanthus excelsa* can grow on a variety of soils but thrives best on porous sandy loams. *Argemone mexicana* is one of the xerophytic plants that come well in dry porous soil[58].

Grasses were recorded at all the sites except 7 year old dumps; this may be due to the high density of *Lantana camara* at this site. *Lantana* sp. is a hardy species and can thrive well under xeric conditions. It also exhibits allelopathy, the chemical secreted by the plants inhibits germination and establishment of other competing species around its root zone. It is resistant to drought, fire, salinity this make it one of the most successful invasive species[59,60].

Similarly, in dump *Hyptis suaveolens* (Lamiaceae) is one of the most problematic dicotyledonous weed, broad leaved erect strongly aromatic herb. This weed grows on all types of well drained soils in areas. It is resistant to drought and salt spray. Invasion of *H. suaveolens* has been a problem in areas such as distributed pastures, overgrazed areas, open forests, plantations and slash and burn agricultural fields. The shrub is reported to highly allelopathic to vegetation. Its plant flowers and fruits throughout the year. Seeds are dispersed by animals, humans, field machinery and when attached to fur, clothing and mud[61,46].

Both the species were present in high densities on the overburden dumps, where maintenance of the plantation is not being carried out. The traits that favor invasiveness of a species are high tolerance against environmental extremes and greater adaptability to a wide range of habitats, high water, light and nutrient use efficiencies, zero or very sort dormancy, high productivity, high reproductive potential and vegetative mode of reproduction[62]. Anthropogenic disturbance always leads to colonization of the degraded land by exotic species in high densities[62,63].

Conclusion

The present study concludes that plantation on iron ore over burden soil help to improve the physico chemical characteristics of soil, such as pH (tends toward neutral), EC (increased), soil texture (sandy to sandy clay/ or loam), increase organic matter and nutrient status (N, P, K). Thus plantation improved the soil fertility and increased plant biomass on iron ore mined overburden dump. The improved soil conditions facilitate aggregation of native species. Concentration of heavy metal in the soil was reduced with increasing age of plantation. Population of grasses in initial age of plantation was higher, which reduces with age due to invasion by exotic species like *Lantana camara, Chromolaena odorata* and *Hyptis suaveolens*. High densities of invasive species have a negative impact on regeneration of native species.

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