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Vegetation Community Characteristics and diversity in different phases of mining at Charhi and Kuju coal mining areas, Jharkhand, India

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Abstract: The increase in the energy requirement of a country shows its economic advancement. Coal mining activity has increased considerably to compensate for the increased energy requirements. As a result, open-cast coal mining methods induced a drastic change in land use and seriously jeopardized the sustainability of the ecosystem. Once disrupted by open-cast or underground mining, the condition of the land cannot be entirely recovered, making it a non-renewable asset to the environment and support of human life. An attempt was made to study the existing flora of the different zones (operating, abandoned, control) of Charhi and Kuju Coal mining area, Jharkhand, India. From 2015 to 2018,173 species belonging to 75 families of angiosperms, terrestrial and aquatic ferns have been reported and identified so far from this study area. The most dominant family is Poaceae with the maximum number of species in the area, where mining has not yet been done. This paper's findings would help assess the dominant species in this area, which can be used for reclamation of the abandoned mining areas.

Introduction

In the last few decades, open-cast coal mining has had significant negative effects on the environment worldwide (Cravotta and Brady, 2015; Lechner et al., 2016). Due to extensive coal mining activities, nations including Australia, China, Europe, India, South Africa, and the USA have suffered greatly (Liang et al., 2017). According to Johnson and Hallberg (2005), 72,000 hectares of lakes and reservoirs as well as 19,300 km of rivers have been affected by coal and metal mines globally. Compared to underground mines, open-cast mines have substantially more dramatic impacts on water regimes and land disturbance (Lechner et al., 2014).

The impacts of such open cut mines start from the active mining phases to the post-mining phases (Liang et al., 2017). Cutting trees is unavoidable for mining. For open cast coal mining, the area must be completely stripped of vegetation to remove the overburden above the coal seam. By plantation, some non-local species around the mines, the green cover and vegetation diversity might increase, but the original native species get lost forever. This leads to changes in the properties of soil and extensive degradation of natural ecosystems such as forests and landscape scar beyond repair. It has been stated by Ghose (2004) that the coal industry rendered 500 ha of land biologically unproductive during 1994-95, and it rose to 1400 ha by 2000. Topsoil loses its productivity when stored for a long time. Apart from this, the essential nutrients (nitrogen and phosphorus) and organic matter become low due to mining, which makes reclamation by vegetative techniques tardy. Thus, insurmountable disturbance of flora, fauna, and soil biological systems are the result of coal mining activities. Even after mine closure, nutrient-deficient sandy soils are not conducive to revegetation. Colonization and establishment of vegetation become extremely difficult in such spoils. Some of the factors that hinder plant growth are soil acidity, toxic levels of trace elements, soil particle size, compaction

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and the resultant decrease in root penetrability and moisture stress. Many studies on the impacts of coal mining on soil quality and its vegetation have been published worldwide. For instance, several ecosystems in China have been damaged in the last three to four decades by mining exploitation in mining areas (Hu et al., 2000; Shi, 2002). Especially in Shanxi province, where coal mining has a long history of extensive vegetation degradation and ecosystems (Dongann et al., 2011). Chitade et al. (2010) studied the coal mining area of Chandrapur district of Maharashtra and researched the impact analysis of open-cast mines on land use/land cover using remote sensing and GIS technique, where they concluded that almost dense vegetation had been converted either into mine land or artificially created mountains of mine overburden. A Study was done in the area of Angul-Talcher coal mining region of Orissa, India, by Singh (Singh et al., 2010) to assess the change in the landscape of the coal mines and their associated industries in the area of Angul-Talcher region of Orissa by interpreting the seasonal remote sensing data by GIS. The type of land cover (forest cover, agricultural land, barren land, settlements, water bodies, and the mining area) was defined. He reported the lack of vegetation cover on acidic and hard compacted soil dumps often leads to the acute problem of soil erosion and environmental pollution in the area. Sarma et al. (2010) reported the impact of coal mining on plant diversity and tree population structure in the Jaintia Hills district of Meghalaya. Although certain areas have recorded a natural succession of several plant species on the arid overburden dumps (Borpujari, 2008; Hazarika et al., 2006), this is a very sluggish process (Singh and Jha, 1992). By plantation, some non-local species around the mines, the green cover and vegetation diversity might increase, but the original native species get lost forever. The diversity of local floral species generally declines in the active mining phases. In this study, the local floral species of the mining areas were enumerated and compared with respect to control areas. Enumeration data revealed a total of 173 species of plants (including trees, shrubs and herbs) belonging to 75 families, with the maximum number of species in the area where mining has not yet been done. Season-wise, diversity was found to be maximum in the monsoon season. Quadrat data indicated that most species are in clumped distribution patterns, with a few in the random distribution pattern. When enumerated through a quadrat study, the vegetation community revealed the species with the highest importance value index in the two seasons for the three representative areas. Among the trees, the species with higher IVIs were *Madhuca longifolia*, *Shorea robusta*, *Cassia siamea* and *Anthocephalus cadamba*. There was no difference in the two seasons. Among shrubs, the dominant species were *Lantana indica*, *Croton oblongifolius* and *Hyptis suaveolens*. While herbs *Cynodon dactylon*, *Curculigo orchioides*, *Eulaliopsis binata* and *Desmodium triflorum* were the dominant species. One of the objectives of enumerating the floral species in the mining areas was to find the dominant herb and shrub species which can be utilized for vegetative reclamation of the mined areas. The species' selection criteria depended on their dominance, extensiveness of the root system and metal uptake capacity. Therefore, in this study, the dominant plant species were enumerated as an option to reclaim the degraded land due to coal mining activities.

Materials and Methods

Study Area

The Charhi and Kuju Coal Mining Area, which is a part of the West Bokaro coal resources, is the subject of the study. It is located roughly between the latitudes of 23^{0}43'04" to 23^{0}51'42" and the longitudes of 85^{0}25'40" and 85^{0}39'50". The research area is within the administrative boundaries of the Jharkhand districts of Ramgarh, Hazaribagh, and Bokaro and is depicted on Survey of India Topo-sheets F45B5, F45B6, F45B9, and F45B10 (Fig.1).

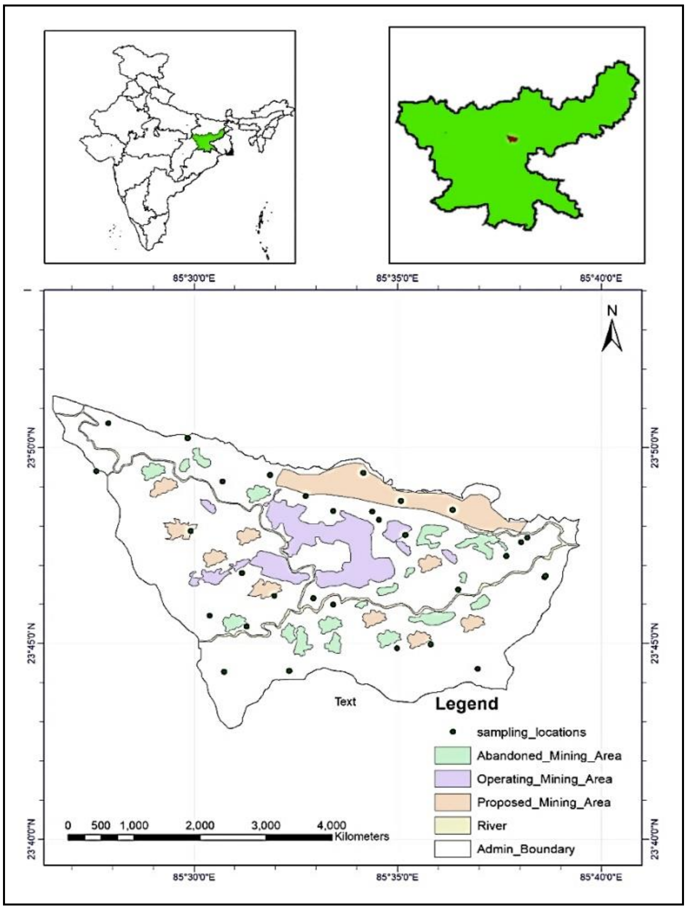

Figure 1. Location map of the study area.

The land slopes southeast ward and is drained by three streams (Nalas), Bokaronadi, Chutuanadi, and Chotanadi, the latter of which emerges from the research area as Bokaronadi. The Barakar formation dominates the geology of the study region, which is also characterised by alternating bands of coarse- to medium-grained sandstones, shales, and coal seams. In addition, there are grey shales and siderites banded carbonaceous sandy shales. There are 66 villages with a total population of about 1.9 lakh people in the study region that completely depend on mining and related ancillary businesses.

Vegetation Community structure Study by Quadrat method

The study aimed to enumerate the available plant species and obtain a broad representation of the existing floristic diversity in the mine lease areas and their surrounding areas. It is based on extensive field surveys from 2015 to 2017. Enumeration of species for trees, shrubs and herbs was carried out to develop baseline data for the floral diversity of the study area. Plant samples were collected and observed during a field survey for four years in different seasons. Photographs were taken and consulted with competent taxonomists from universities for identification. The plants identified were written according to their systematic positions with scientific name, common name and family. Plant specimens were collected by surveying all possible areas, including gradients of hillocks and valleys during the pre and post-monsoon periods. The author collected and processed all plant specimens (Jain and Rao, 1977). The specimens were identified using relevant literature (Hains, 1925).

Quadrat sampling is a method of obtaining the representative sample of a subset of a system. In this method, specific size square areas (quadrats) are selected randomly and the details of the species in this quadrat are collected. In the present study, quadrats of standard sizes were used, i.e., 10m*10m for trees, 5m*5m for shrubs and 1m*1m for herbs. The whole sampling area was divided into grids and representative grids were selected for conducting random quadrat sampling. A survey was conducted throughout the whole area before the quadrat study to gather the overall species enumeration data of the area.

The data collected from the quadrats involved the species count within the quadrat. The quadrat data are considered as representative samples for the whole study area. For the two study seasons a total of 60 quadrats were studied, i.e., 30 quadrats in the monsoon season (10 quadrats from each zone) and 30 in the summer season (10 quadrats in the control area and 10 quadrats each in the operating and abandoned zones).

Raunkiaer's and Whiteford's classification (Raunkiaer, 1934; Whiteford, 1949)

The plant community was classified based on the frequency values of different plant species in the area. The classification was based on the classification chart of Raunkiaer (1934) as Class A (0-20%), Class B (21-40%), Class C (41-60%), Class D (61-80%), Class E (81-100%). Whiteford's classification is based on another index, which depends on the ratio of abundance to frequency. It signifies the pattern of association of plant species in an area. The classification is Regular (Ratio of Abundance to Frequency is less than 0.025), Random (0.025 to 0.05), and Clumped (more than 0.05).

Importance Value Index (IVI) (Curtis, 1959)

The importance value index (IVI) gauges a species' dominance in a specific region. It is a typical inventorying tool used by foresters. The importance value index was calculated according to the following formula:

$$Frequency(\%) = \frac{No.\,of\ sampling\ units\ in\ which\ the\ species\ occured}{Total\ no.\,of\ sampling\ units\ studied} X100 \ldots\ldots\ldots\ldots (i)$$

$$Density = \frac{Total\ no.\,of\ individuals\ of\ the\ species\ in\ all\ the\ sampling\ units}{Total\ no.\,of\ sampling\ units\ studied} \ldots\ldots\ldots (ii)$$

$$\text{Abundance} = \frac{\text{Total no. of individuals of the species in all the sampling units}}{\text{No. of sampling units in which the species occured}} \ldots\ldots\ldots\ldots (iii)$$

$$\text{Relatice Frequency (R.F.)} = \frac{\text{Frequency of the species}}{\text{Total frequency of all the species}} X100 \ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

$$\text{Relative Density (R.D.)} = \frac{\text{Density of the species}}{\text{Total density of all the species}} X100 \ldots\ldots\ldots\ldots\ldots\ldots (v)$$

$$\text{Relative Dominance (R.Do.)} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} X100 \ldots\ldots\ldots\ldots (vi)$$

$$\text{IVI} = \text{R.F.} + \text{R.D.} + \text{R.Do.} \ldots\ldots\ldots\ldots\ldots\ldots (vii)$$

Results and discussion

Species Enumeration Data

The total species enumeration data of the study area (designated as control, operational and abandoned zones) indicated rich floral diversity in the overall region with spatial variation as well. A total of 167 species belonging to 75 families were found throughout the different parts of the study area. Most of the species found in the area had medicinal properties. Most of the species found in the study areas were frequent and abundant. However, a few 'Rare' and 'Endangered' species found in the area are highlighted in the enumeration list and field photographs of these species are Sundew (*Drosera indica*), Sonpatta (*Oroxylum indicum*), Junglibadam (*Sterculia urens*) given in Fig. 2.

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Figure 2. Field photos of Rare and Endangered species as per IUCN.

Species density during the monsoon was much higher in all three zones compared to the summer. Also, the highest number of species was found in the control zone, with a total of 123 species. In the summer, the species count decreased drastically in all the zones indicating that most of the species that thrived during the monsoon had died out. The vacant niches are dominated by species that are strictly summer-specific. This difference was more prominent in the case of herbaceous plants. During monsoon, a larger number of herb and shrub species were observed due to high moisture contents and favourable growth conditions.

In contrast, most herbaceous and shrub species vanished in summer due to excessive heat and dry conditions. However, on closer inspection, it was clear that the number of herbaceous species in the operating zone did not vary markedly between the seasons, as the unfavourable conditions due to mining practices persist in all seasons in such zone. A similar trend was seen in the case of shrubs in the abandoned zone, where the unfavourable conditions might have allowed a few dominant resistant species to proliferate. There were no marked differences in the species count values of trees throughout the zones. In the past, Sarma et al. (2005) reported similar results in the Jaintia Hills in Meghalaya. He found the highest herb and shrub species density in unmined areas as compared to mined ones.

Quadrat data of the vegetation community (Frequency, Abundance, Density and vegetation classification)

Vegetation classification of the plant community of the study zones was done using the Raunkiaer's and Whitford's classifications. In Raunkiaer's classification, the plant community was classified based on the frequency of the different plant species of the area. The Whitford classification was done based on the ratio of the species abundance to its frequency (Table 1, 2, & 3).

Data in Table 1 reflected that in the control zone during summer, all the species were found to exist in clumped patterns, thus indicating that none of the plant species was opportunistic. However, during the monsoon, some species were seen to exist in random and regular patterns, indicating some of the species to be of opportunistic and dominant behaviour (Mukherjee and Sarma, 2014).

The abandoned zone observations (Table 2) showed that more species exist in clumped patterns during monsoon compared to summer. In summer, most species exhibited tolerant behaviour due to decreased levels of soil moisture and nutrients and increased competition (Mukherjee and Sarma, 2014). Plant species tended to be more competitive during summer. From the abandoned area data, season-wise variation indicated that more species existed during the summer in clumped patterns due to less competition for soil nutrients and moisture. But during the monsoon, some species exhibit a random distribution pattern due to increasingly favourable conditions. Similarly, the vegetation classification of the plant community in the operating zone for the summer and the monsoon season is given in Table 3 shows that most of the species are in a clumped pattern.

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Table 1. Control Area-Vegetation classification of the plant community (Frequency, density, abundance, frequency class and Whitford's classification).

A. Summer

	Species	Freq. %	Freq. Class	Density	Abundance	Abundance/ Freq.	Whitford's Class
Trees	*Acacia auriculiformis*	15	A	1.05	7	0.467	**CLP**
	Bombax ceiba	5	A	0.05	1	0.200	**CLP**
	Butea monosperma	30	B	0.65	2.17	0.072	**CLP**
	Cassia siamea	20	A	0.65	3.25	0.163	**CLP**
	Calotropis gigantea	10	A	0.15	1.5	0.150	**CLP**
	Dalbergia sissoo	10	A	0.25	2.5	0.250	**CLP**
	Lagerstroemia parviflora	20	A	0.65	3.25	0.163	**CLP**
	Madhuca longifolia	65	D	4.75	7.31	0.112	**CLP**
	Shorea robusta	50	C	2.5	5	0.100	**CLP**
	Tectona grandis	5	A	0.05	1	0.200	**CLP**
	Vitex negundo	15	A	0.35	2.33	0.155	**CLP**
Shrubs	*Buteamonosperma*	5	A	0.05	1	0.200	**CLP**
	Croton oblongifolius	25	B	1.65	6.6	0.264	**CLP**
	Eupatorium odoratum	40	B	1.5	3.75	0.094	**CLP**
	Ipomoea fistulosa	55	C	3.2	5.82	0.106	**CLP**
	Lantana camara	70	D	2.7	3.86	0.055	**CLP**
	Phoenix sylvestris	25	B	0.45	1.8	0.072	**CLP**
	Sida acuta	5	A	0.15	3	0.600	**CLP**
Herbs	*Cassia absus*	25	B	1.1	4.4	0.176	**CLP**
	Cassia alata	5	A	0.3	6	1.200	**CLP**
	Cynodon dactylon	55	C	2.8	5.09	0.093	**CLP**
	Desmodium triflorum	20	A	1.4	7	0.350	**CLP**
	Elephantopus scaber	40	B	1.3	3.25	0.081	**CLP**
	Eulaliopsis binata	30	B	1.05	3.5	0.117	**CLP**
	Evolvulus nummularius	5	A	0.1	2	0.400	**CLP**
	Hemidesmus indicus	50	C	1.35	2.7	0.054	**CLP**
	Ichnocarpus frutescens	15	A	0.5	3.33	0.222	**CLP**
	Tridax procumbens	45	C	1.45	3.22	0.072	**CLP**

A, B, C, D - Raunkiaer's classification, **CLP -** Clumped

B. Monsoon

	Species	Freq. %	Freq. Class	Density	Abundance	Abundance/ Freq.	Whitford's Class
Trees	*Butea monosperma*	40	B	1.7	4.25	0.106	**CLP**
	Clistanthus colinus	10	A	0.3	3	0.300	**CLP**
	Diospyros melanoxylon	70	D	1.1	1.57	0.022	**RGL**
	Holarrhena antidysenterica	40	B	0.8	2	0.050	**RND**
	Lagerstroemia parviflora	50	C	1.5	3	0.060	**CLP**
	Semecarpus anacardium	20	A	0.7	3.5	0.175	**CLP**
	Shorea robusta	100	E	5.5	5.5	0.055	**CLP**
	Terminalia bellirica	10	A	0.1	1	0.100	**CLP**

Shrubs	*Alternanthera philoxeroides*	20	A	0.3	1.5	0.075	**CLP**
	Butea monosperma	20	A	0.7	3.5	0.175	**CLP**
	Clerodendrum infortunatum	30	B	0.8	2.67	0.089	**CLP**
	Croton oblongifolius	40	B	5.5	13.75	0.344	**CLP**
	Hibiscus trilobus	10	A	0.1	1	0.100	**CLP**
	Holarrhena antidysenterica	50	C	4.8	9.6	0.192	**CLP**
	Ichnocarpus frutescens	40	B	1.6	4	0.100	**CLP**
	Lantana camara	40	B	1.5	3.75	0.094	**CLP**
	Lantana indica	20	A	1.1	5.5	0.275	**CLP**
	Phoenix sylvestris	20	A	1.5	7.5	0.375	**CLP**
	Tephrosia purpurea	10	A	0.4	4	0.400	**CLP**
	Vangueria spinosa	40	B	1.8	4.5	0.113	**CLP**
Herbs	*Ampelocissus latifolia*	30	B	0.4	1.33	0.044	**RND**
	Aristolochia sp.	20	A	0.7	3.5	0.175	**CLP**
	Asparagus racemosus	20	A	0.4	2	0.100	**CLP**
	Barleria cristata	20	A	0.3	1.5	0.075	**CLP**
	Biophytum sensitivum	50	C	1.2	2.4	0.048	**RND**
	Cajanus scarabaeoides	70	D	1.1	1.57	0.022	**RGL**
	Cheilanthes farinose	30	B	0.3	1	0.033	**RND**
	Clistanthus collinus	20	A	0.4	2	0.100	**CLP**
	Cleome monophyla	20	A	0.7	3.5	0.175	**CLP**
	Curculigo orchioides	50	C	6	12	0.240	**CLP**
	Desmodium triflorum	50	C	2.5	5	0.100	**CLP**
	Dioscorea alata	30	B	0.6	2	0.067	**CLP**
	Dioscorea bulbifera	20	A	0.4	2	0.100	**CLP**
	Elephantopus scaber	80	D	4	5	0.063	**CLP**
	Evolvulus alsinoides	20	A	0.5	2.5	0.125	**CLP**
	Evolvulus nummularius	40	B	4.1	10.25	0.256	**RND**
	Leucas cephalotes	20	A	2	10	0.500	**CLP**
	Pergularia daemia	20	A	0.2	1	0.050	**RND**
	Roulfiate traphylla	10	A	0.2	2	0.200	**CLP**
	Smilax zeylanica	10	A	0.1	1	0.100	**CLP**
A, B, C, D - Raunkiaer's classification, **CLP=** Clumped, **RGL=** Regular, **RND=** Random							

Table 2. Abandoned Zone -Vegetation classification of the plant community (Frequency, density, abundance, frequency class and Whitford's classification).

A. Summer

	Species	Freq. %	Freq. Class	Density	Abundance	Abundance / Freq.	Whitford's Class
Tree	*Caesalpinia pulcherrima*	30	B	0.4	2	0.067	**CLP**
	Dalbergia sissoo	60	C	1.8	3	0.050	**RND**
	Mahua longifolia	20	A	0.7	3.5	0.175	**CLP**
	Shorea robusta	50	C	3.1	6.2	0.124	**CLP**
Shrubs	*Eupatorium odoratum*	80	D	2.1	2.63	0.033	**RND**
	Ipomoea fistulosa	30	B	1.3	4.33	0.144	**CLP**
	Lantana camara	80	D	3.1	3.88	0.049	**RND**
	Lantana indica	30	B	1	3.33	0.111	**CLP**

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Herbs	*Eulaliopsis binata*	100	E	3.6	3.6	0.036	**RND**
	Evolvulus nummularius	80	D	2.2	2.75	0.034	**RND**
	Tridax procumbens	30	B	0.7	2.33	0.078	**CLP**

B. **Monsoon**

	Species	Freq %	Freq. Class	Density	Abundance	Abun-dance/Freq	Whitford's Class
Trees	*Acacia catechu*	10	A	0.1	1	0.100	**CLP**
	Acacia nilotica	10	A	0.1	1	0.100	**CLP**
	Bougainvillea glabra	10	A	0.1	1	0.100	**CLP**
	Caesalpinia pulcherrima	20	A	0.3	1.5	0.075	**CLP**
	Dalbergia sissoo	100	E	2.4	2.4	0.024	**RGL**
	Haldina cordifolia	10	A	0.1	1	0.100	**CLP**
	Mahua longifolia	20	A	0.2	1	0.050	**RND**
	Vernicia fordii	10	A	0.1	1	0.100	**CLP**
Shrubs	*Hyptis suaveolens*	100	E	33.9	33.9	0.339	**CLP**
	Lantana camara	60	C	3	5	0.083	**CLP**
	Lantana indica	90	E	9.4	10.44	0.116	**CLP**
	Sida acuta	10	A	0.2	2	0.200	**CLP**
Herbs	*Ageratum conyzoides*	40	B	0.9	2.25	0.056	**CLP**
	Biophytum sensitivum	20	A	0.5	2.5	0.125	**CLP**
	Bryophyllum pinnatum	20	A	0.9	4.5	0.225	**CLP**
	Boerhavia diffusa	20	A	0.3	1.5	0.075	**CLP**
	Cleome monophyla	50	C	1.6	3.2	0.064	**CLP**
	Cynodon dactylon	20	A	1.2	6	0.300	**CLP**
	Dactylocteniumaegyptium	30	B	3	10	0.333	**CLP**
	Desmodiumtriflorum	90	E	11.5	12.78	0.142	**CLP**
	Evolvulusnummularius	20	A	1.9	9.5	0.475	**CLP**
	Euphorbia hirta	60	C	1.2	2	0.033	**RND**
	Heteropogon contortus	20	A	1.1	5.5	0.275	**CLP**
	Indigofera tinctorial	40	B	0.6	1.5	0.038	**RND**
	Melochiaco corifolia	30	B	1.4	4.67	0.156	**CLP**
	Oldenlandia corymbosa	30	B	0.9	3	0.100	**CLP**
	Saccharum spontaneum	70	D	12.8	18.29	0.261	**CLP**
	Sida cordifolia	30	B	1.2	4	0.133	**CLP**
	Commilena bengalensis	20	A	0.3	1.5	0.075	**CLP**
	Spermacoce hispid	20	A	0.7	3.5	0.175	**CLP**

A, B, C, D - Raunkiaer's classification, **CLP=** Clumped, **RGL**= Regular, **RND**= Random

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Table 3. Operating Zone -Vegetation classification of the plant community (Frequency, density, abundance, frequency class and Whitford's classification).

A. Summer

	Species	Freq %	Freq. Class	Den-sity	Abun-dance	Abun-dance/Freq.	Whitford's Class
Trees	*Adina cordifolia*	20	A	0.3	1.5	0.075	**CLP**
	Butea superba	10	A	0.6	1	0.100	**CLP**
	Caesalpinia pulcherrima	20	A	1.1	5.5	0.275	**CLP**
	Dalbergia sissoo	10	A	0.4	1	0.100	**CLP**
	Ficus religiosa	10	A	0.1	1	0.100	**CLP**
	Madhuca longifolia	50	C	2.5	5	0.100	**CLP**
	Shorea robusta	50	C	3.4	6.8	0.136	**CLP**
	Tectona grandis	10	A	0.1	1	0.100	**CLP**
	Vitex negundo	10	A	0.1	1	0.100	**CLP**
Shrubs	*Amaranthus tricolor*	10	A	0.1	1	0.100	**CLP**
	Hyptis suaveolens	20	A	0.7	3.5	0.175	**CLP**
	Ipomoea fistulosa	50	C	1.8	3.6	0.072	**CLP**
	Lantana camara	100	E	3	3	0.030	**RND**
Herbs	*Argemone mexicana*	30	B	1.4	4.67	0.156	**CLP**
	Cynodon dactylon	60	C	3.5	5.83	0.097	**CLP**
	Desmodium triflorum	10	A	0.9	1	0.100	**CLP**
	Elephantopus scaber	50	C	1.3	2.6	0.052	**CLP**

B. Monsoon

	Species	Freq %	Freq. Class	Density	Abun-dance	Abundance/ Freq.	Whitford's Class
Trees	*Alstonia scholaris*	10	A	0.1	1	0.100	**CLP**
	Anthocephalus cadamba	10	A	0.1	1	0.100	**CLP**
	Artocarpus lacucha	10	A	0.1	1	0.100	**CLP**
	Caesalpinia pulcherrima	10	A	0.1	1	0.100	**CLP**
	Dalbergia sissoo	40	B	0.7	1.75	0.044	**RND**
	Eucalyptus globulus	10	A	0.1	1	0.100	**CLP**
	Ficus religiosa	20	A	0.2	1	0.050	**RND**
	Peltophorum pterocarpum	10	A	0.1	1	0.100	**CLP**
	Bauhinia variegata	10	A	0.2	2	0.200	**CLP**
	Ricinus communies	10	A	0.1	1	0.100	**CLP**
	Odina wodier	10	A	0.1	1	0.100	**CLP**
Shrubs	*Cassia tora*	20	A	0.3	1.5	0.075	**CLP**
	Croton oblongifolius	30	B	0.8	2.67	0.089	**CLP**
	Eupatorium odoratum	10	A	1	1	0.100	**CLP**
	Hyptis sauveolens	80	D	7.4	9.25	0.116	**CLP**
	Lantana camara	30	B	1.5	5	0.167	**CLP**
	Lantana indica	20	A	0.8	4	0.200	**CLP**
	Parthenium hysterophorus	30	B	1.7	5.67	0.189	**CLP**
	Sida acuta	30	B	0.5	1	0.033	**RND**

	Urena lobata	30	B	1.1	3.67	0.122	**CLP**
	Cassia occidentalis	20	A	0.7	3.5	0.175	**CLP**
	Ocimumtenuiflorum	20	A	0.2	1	0.050	**RND**
Herbs	*Desmodium triflorum*	100	E	9.2	9.2	0.092	**CLP**
	Evolvulus nummularius	60	C	7.3	12.17	0.203	**CLP**
	Euphorbia hirta	10	A	0.1	1	0.100	**CLP**
	Oldenlandia corymbosa	30	B	0.7	2.33	0.078	**CLP**
	Pennisetum pedicellatum	10	A	0.4	4	0.400	**CLP**
	Saccharum spontaneum	80	D	8.4	10.5	0.131	**CLP**
	Sida cordifolia	20	A	0.8	4	0.200	**CLP**
	Tridax procumbens	40	B	0.8	2	0.050	**RND**
	Xanthium strumarium	10	A	0.2	2	0.200	**CLP**

A, B, C, D - Raunkiaer's classification,**CLP=** Clumped, **RND=** Random

Table 4. Summary of the Importance Value Index of the vegetation community in the study area.

		Summer	Monsoon
Trees	Control	*Madhuca longifolia* 34.93	*Shorea robusta* 40.77
	Abandoned	*Shorea robusta* 54.4	*Cassia siamea* 27.86
	Operating	*Shorea robusta* 38.49	*Anthocephalus cadamba* 18.67
Shrubs	Control	*Lantana indica* 17.62	*Croton oblongifolius* 12.26
	Abandoned	*Lantana indica* 27.35	*Hyptis sauveolens* 45.91
	Operating	*Lantana indica* 33.32	*Hyptis sauveolens* 25.21
Herbs	Control	*Cynodon dactylon* 15.95	*Curculigo orchioides* 13.84
	Abandoned	*Eulaliopsis binata* 32.85	*Desmodium triflorum* 20.67
	Operating	*Cynodon dactylon* 27.973	*Desmodium triflorum* 31.40

The table above shows the tree and shrub species of the three zones with the highest IVI values for two seasons, i.e., summer and monsoon. In the summer season, it is observed that among trees, Mahua (*Madhuca longifolia*) had the highest IVI value in the control area, while the abandoned and operating zones were dominated by patches of Sal (*Shorea robusta*). The shrub species that was found in abundance throughout the three zones with the highest IVI values was Putus or Lantana (*Lantana indica*). This is an invasive species and thus is opportunistic in nature and tends to be more tolerant (Pandey et al., 2014).In the monsoon, the tree species with the highest IVI value in the control area was Sal (*Shorea robusta*), one of the most abundant tree species in the whole study area. *Shorea robusta* has the highest relative contribution compared to the other species. The tree species with the highest IVI value in the abandoned area was Kassod (*Cassia siamea*). Kadamba (*Anthocephalus cadamba*) was the tree species with the highest IVI value in the operational zone. Among shrub species, Putri (*Croton oblongifolius*) had the highest IVI value in the control zone, while both the abandoned and operational zones were dominated by Ban tulsi (*Hyptis suaveolens*), which is the highest contributor and dominant shrub species of both the zones (Bumrungsri et al., 2006).

Conclusion

The present assessment of vegetation / floristic diversity in the Kuju & Charhi coal mining area showed that 167 plant species belonging to 65 families exist so far during pre and post-monsoon seasons in a year. The list states the common/local names of the species, their respective botanical names, and the family to which each belongs. Most of the species that were found in the area had medicinal properties and economic uses. In the summer season, it is observed that among trees, Mahua (*Madhucalongifolia*) had the highest IVI value in the control area, while the abandoned and operating zones were dominated by patches of Sal (*Shorea robusta*). The shrub species that were found in abundance throughout the three zones with the highest IVI values was Putus or Lantana (*Lantana indica*). This is an invasive species and thus is opportunistic in nature and tends to be more tolerant (Pandey et al., 2014). In the monsoon, the tree species with the highest IVI value in the control area was Sal (*Shorea robusta*), one of the most abundant tree species in the whole study area. *Shorea robusta* has the highest relative contribution compared to the other species. The tree species with the highest IVI value in the abandoned area was Kassod (*Cassia siamea*). Kadamba (*Anthocephalus cadamba*) was the tree species with the highest IVI value in the operational zone. Among shrub species, Putri (*Croton oblongifolius*) had the highest IVI value in the control zone, while both the abandoned and operational zones were dominated by Ban tulsi (*Hyptis suaveolens*), which is the highest contributor and dominant shrub species of both the zones (Bumrungsri et al., 2006). Species are important components in the composition of local forest vegetation. The existence of a species in a particular habitat depends on the associated species and the abiotic environment. Hence, the quantitative relationship between dominant and rare species is an important structural property in any community (Cao et al., 1996). The study showed that the regeneration of most of the woody species recorded in the surrounding mine lease areas was fairly good.

References

Borpujari, D. (2008). Studies on the occurrence and distribution of some tolerant plant species in different spoil dumps of Tikak open cast mine. *The Ecoscan*. 2 : 255-260.

Bumrungsri, S., Sripao, R.E., & Leelatiwong, C. (2006). A quantitative analysis of plant community structurein an abandoned rubber plantations on Kho-Hong Hill, Southern Thailand, Songklanakarin. *Journal of Science and Technology*. 28(3): 479-491.

Cao, M., Zhang, J.H., Feng, Z.L., Deng, J.W., & Deng, X.B. (1996).Tree species composition of a seasonal rain forest in Xishuangbanna, Southwest China. *Tropical Ecology*. 37: 183-192.

Chitade, A.Z, Manit, S.K., Ka, K., Chitade, J., & Katiyar,S.K. (2010). Department of Civil Engineering, Impact analysis of opencast mines on land use / land cover using remote sensing and GIS technique, A case study. *International Journal of Engineering Science and Technology*. 2(12): 7171-7176.

Cravotta, C.A., & Brady, K.B.C. (2015). Priority pollutants and associated constituents in untreated and treated discharges from coal mining or processing facilities in Pennsylvania, *USA. Applied Geochemistry*. 62: 1-23. doi:10.1016/j.apgeochem.2015.03.001

Curtis, J.T. (1959). The vegetation of Wisconsin, an ordination of Plant communities. *University Wisconsin Press*. Madison, Wisconsin.

Donggan, G., Zhongke, B., Tieliang, S., Shao, H., & Wen, Q. (2011). Impacts of Coal Mining on the Aboveground Vegetation and Soil Quality: A Case Study of Qinxin Coal Mine in Shanxi Province, China. *CLEAN – Soil, Air, Water*. 39: 219-225. doi:10.1002/clen.201000236

Ghose, M.K. (2004). Effect of opencast mining on soil fertility. *Journal of Scientific and Industrial Research*. 63:1006-1009.

Haines, H.H. (1921-1925). The Botany of Bihar and Orissa. London. (Repr. Ed. Calcutta, 1961).

Hazarika, P., Talukdar, N. C., Tendulka, P., & Singh, Y. (2006). Natural colonization of plant species on coal mine spoils at Tikak Colliery, Assam. *Tropical Ecology*.47(1): 37-46.

Hu, Z. Q., & Bi, Y.L. (2000). Study on the Concept of Reclamation and Its Relationship with Ecological Reconstruction. *Energy Environment Protection*. 14 (5): 13–16.

Jain, S.K., & Rao, R.R. (1977). A Handbook of Field and Herbarium Methods. Goyal Offsets, New Delhi.

Johnson, B.D., & Hallberg, K.B. (2005). Acid mine drainage remediation options, a review. *Science of the Total Environment*. 338: 3–14.

Lechner, A.M., Baumgartl, T., Matthew, P., & Glenn, V. (2014). The impact of underground longwall mining on prime agricultural land: a review and research agenda. *Land Degradation and Development*. 27(6): 1650-1663.

Lechner, A.M., Owen, K., & Ungerb, C. (2016). Spatial assessment of open cut coal mining progressive rehabilitation to support the monitoring of rehabilitation liabilities. *Resources Policy*. 50: 234–243.

Liang, Z., Ren, T., & Ningbo, W. (2017). Groundwater impact of open cut coal mine and an assessment methodology: A case study in NSW. *International*

Journal of Mining Science and Technology. 27: 861–866.

Mukherjee, A., & Sarma, K. (2014). Community structure of plant species in Okhla bird sanctuary, Delhi, India. *International Journal of Conservation Science*. 5: 397-408.

Pandey, B., Agrawal, M., & Singh, S. (2014). Coal mining activities change plant community structure due to air pollution and soil degradation. *Ecotoxicology* (London, England). 23(8):1474-1483. doi:10.1007/s10646-014-1289-4

Sarma, K., Rai, R.K., & Barik, S.K. (2005). Impact of coal mining on vegetation of Nokrek biosphere reserve, Meghalaya. In SinghOP (ed.) Mining Environment: Problems & Remedies. Regency publication, New Delhi. Pp.77—104.

Raunkiaer, C. (1934). The life forms of plants and statistical geography. Claredon, Oxford. Pp.632.

Sarma, K., Kushwaha, S., & Khuraijam, J.S. (2010). Impact of coal mining on plant diversity and tree population structure of Jaintia Hills district of Meghalaya, North east India. *New York Science Journal*. 3: 79-85.

Shi, H. (2002). Study on the Bio-environment Issues and Strategy in Coal Mine in Shanxi, Chongqing. *Environmental Science*. 24 (2): 11–12.

Singh, A.K, Mahato, M.K, Neogi, B., & Singh, K.K. (2010). Quality assessment of mine water in the Raniganj Coalfield Area India. *Mine Water and Environment*. 29: 248–262.

Singh, J. S., & Jha, A.K. (1992). Restoration of degraded land: an overview. In J. S. Singh (ed.) Restoration of Degraded Land: Concepts and Strategies. Rastogi Publication, Meerut, India. Pp.1-9.

Whiteford, P.B. (1949). Distribution of woodland plants in relation to succession and clonal growth. *Ecology*. 30: 199-208.

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