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# Diversity and composition of vegetation on aged coalmine overburden dumps in Sonepur Bazari area, Raniganj, West Bengal

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**Abstract**

Plant communities get disturbed due to open cast coal mining as large amount of overburden is dumped at the nearby areas of the mines. The vegetation on different age series of six overburden dumps (0, 4, 8, 12, 16 and 20 years) were analyzed during the post monsoon period of 2011 in Sonepur Bazari area, West Bengal, India. The plant species and other relevant criteria were recorded using randomly placed quadrats. Species richness, Diversity indices and Importance value index (IVI) were calculated using standard methods. Among monocots, the IVI of *Saccharum spontanium* was highest at all the over burden dumps. Among dicotyledons, *Croton bonplandianum* was the most important on OBD-4 and 8. On OBD-12 both *Croton bonplandianum* and *Lantana camara* were somewhat equally important. On OBD-16, *Croton bonplandianum*, *Tephrosia perpurea* and *Evolvulus nummularius* were most important where as on OBD-20 maximum importance value was shown by *Chromalaena odorata* and *Hyptis suaveolens*. Among tree species *Leucaena leucocephala* and *Zizyphus mauritiana* had highest IVI value on OBD-12 and *Butea monosperma*, *Dalbergia sissoo* and *Lagerstoemia strictus* on OBD-16. Finally *Butea monosperma* and *Dalbergia sissoo* showed highest IVI values on OBD-20. Diversity indices and species richness of non-grasses species was found getting increased with the age of OBD. Interestingly the grasses, specially *Saccharum spontanium*, were seen to grow as pioneers and got established under the prevailing high environmental adversity. On the contrary, other herbaceous and tree species were seen getting established at later stages of succession.

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## Introduction

Open cast coal mining, especially in the recent past, has been creating immense perturbations in the coal belts of West Bengal. The eventual land degradation and pollution have been damaging the vegetation as well as human health. The surface mining methods produce a dramatic change in the landscape due to large scale excavation, removal of overlying vegetation cover, topsoil and its supportive life-forms (Dash, 2001). The coalmine debris is heaped in the form of dumps around the mining area and is called spoil. These dumps change the normal land topography and affect the drainage system of the mining area (Chaulya *et al.,* 2000). The spoil is a mixture of disintegrated rocks and rocky soils with coal residues. This mixture is hostile to the growth of both plants and microbes because of impoverished organic matter content, detrimental pH, and draught arising from coarse texture or oxygen deficiency caused by compaction (Agarwal *et al.,* 1993). Due to the adverse physico-chemical and biological properties of mine spoil (Juwarkar *et al.,* 2004), natural succession of plant species on these dumps is often prevented. Lack of vegetation cover on such dumps often leads to acute problem of soil erosion and environmental pollution (Singh *et al.,* 1996). However, development of vegetation on the dumps is essential for the conservation of biodiversity and stable environment in the coalfield area (Singh *et al.,* 2002). The nature tries to restore normally by operating plant succession on spoils after certain interval of times (Borpujari 2008; Hazarika *et. al.*, 2006). The autophytoremediation of spoils often involves mycorrhizal association also with the species struggling hard to establish on overburdens in open cast coal mining sites (Ekka and Behera, 2010).

Considering the above facts in mind, an attempt was made to document vegetation cover developed as a result of natural succession on an age series of over burden dumps of the Sonepur Bazari area located in West Bengal, India.

## Materials and Methods

The present study was carried out at Sonepur Bazari area which is covered by the Surface Coal Mine Project and located in eastern part of Raniganj Coalfields, Burdwan, West Bengal, India. The geographical location of this site is at 23º48'' N latitude and 87º 47'' E longitude, the topography of which is slightly undulating and rolling marked by small ridges and valleys (Fig 1). The climate is tropical monsoonal with average temperature of 42º C during summer and a cold winter often experiencing temperature as low as 6º C. The average rainfall amounts to 1450 mm per year. The mine has been kept operational since 1995 and average strip ratio stands at 1:4.72 generating grade-B coal. Total land acquired for this project is 2404.85 ha including the land for over burden dumps. Within this area, a series of 6 over burdened dumps of different ages, henceforth referred to as age-series, was selected and named suffixing the respective age as OBD-0, OBD-4, OBD-8, OBD-12, OBD-16 and OBD-20, respectively. The average height of these dumps ranged from 0 to 50 m and quarry depth from 60 to 70 m. The naturally occurring plants on the selected overburden dumps were studied during November- December, 2011. For studying the over-burden communities quadrats were used, the minimum size of which was ascertained by species-area curve as 5 $m^2$ for OBD-4 and 10 $m^2$ for the rest. For the analysis of herbaceous grass, herb and tree vegetations separately, in each case 10 quadrats were laid unbiased on different parts of each dump. Plant specimens were collected, dissected and described following standard taxonomic methods and identified with the help of pertinent literature (Prain, 1903; Guha Bakshi, 1984) and authentic specimens preserved in the herbaria of the Botany Departments of both Burdwan University and B.B. College, Burdwan. The updated names of the plants were then arranged alphabetically under respective family. The relative values of density, frequency and dominance were determined following the method of Phillips (1959). Importance value index (IVI) of all plants was calculated by summing up the relative values of density, frequency and abundance or dominance (Curtis, 1959) with the help of Microsoft Word Excel software 2007 version. Also, the correlation studies between average IVI and age of the OBDs were done using the same software. Species diversity reflected by Shannon and Weaver Index ($H'$) and Simpson index (D) were determined using 'PAST' software (Hammer *et al*., 2001).

## Results and Discussion

After thorough survey no vegetation cover could be observed on the fresh mine spoil and it remained absent till the OBD was three years old due to unfavorable environmental conditions like salinity or acidity, drought arising from coarse texture or oxygen deficiency due to compaction (Deka Boruah *et al*., 2008). It may be poor water holding capacity, inadequate supply of plant nutrients and accelerated rate of erosion (Dowarah *et al*., 2009). Ekka and Behera (2011) observed that vegetation started growing from the 4$^{th}$ year after dumping. In all 9, 21, 46, 58 and 69 species were recorded from OBD-4, -8, -12, -16 and -20, respectively. On OBD-4, out of nine species two were monocots while rest seven were dicots. Euphorbiaceae and Poaceae dominated the site with two species each. 21 species were recorded from OBD-8 of which 5 were monocots and rest were dicots. Poaceae appeared as the largest family with 4 species. In all, 46 species were recorded from OBD-12 of which 41, including 5 tree species, were dicots and 5 monocots. Compositae and Fabaceae were dominant as they contained 6 and 7 species, respectively. On OBD-16, 58 species were recorded of which 5 were monocots and the rest *i.e.* 53 including 8 tree species were dicots. Fabaceae and Euphorbiaceae were dominant as they contained 8 and 7 species, respectively. Finally 69 species were recorded from OBD-20 of which 6 were monocot including 1 tree and 63 were dicot of which 13 were tree species, Fabaceae with 10 species was ascertained as the most dominant family.

Analysis of IVI values revealed *Saccharum spontaneum* as the most dominant monocot species on all the over burden dumps. Among dicotyledons, *Croton bonplandianum* was the most dominant species on OBD-4 and -8. On the OBD-12 *Croton bonplandianum* shared equal importance with *Lantana camara.* OBD-16 accommodated three dominant species of dicots, *i.e., Croton bonplandianum*, *Tephrosia perpurea* and *Evolvulus nummularius.* C*hromolaena odorata* and *Hyptis suaveolens* were the two most dominant species of OBD-20. Tree species started growing on twelve or more year old OBDs. Incidentally, *Leucaena leucocephala* and *Zizyphus mauritiana* scored the highest IVI value on OBD-12. On OBD-16, *Butea monosperma, Dalbergia sissoo* and *Lagerstoemia strictus* showed greater IVI values compared to other tree species. On OBD-20, *Butea monosperma* and *Dalbergia sissoo* showed greater values of importance than others. It was clearly observed that at initial stage of succession, the grass species contributed most towards the vegetation. This indicates a strong colonizing ability of grass members under very adverse conditions like drought, low soil nutrients and climatic stresses (Ekka and Behera 2011). The grasses, particularly $C_4$ species offer a superior tolerance of drought, low soil nutrients and other adverse soil conditions which prevails in coal mine spoils (Shu *et al.*, 2002; Singh *et al.*, 2002; Hao *et al.*, 2004). Helm (1995), Skeel

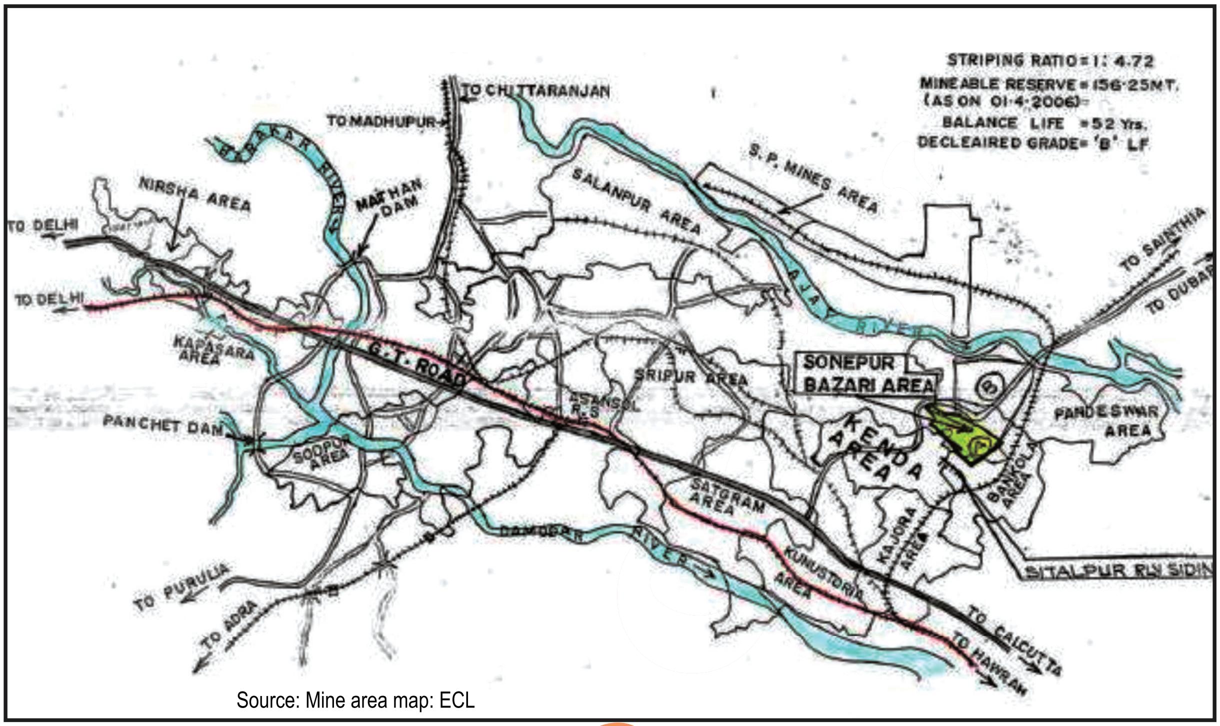


**Fig. 1 :** Map showing geographic location of study area

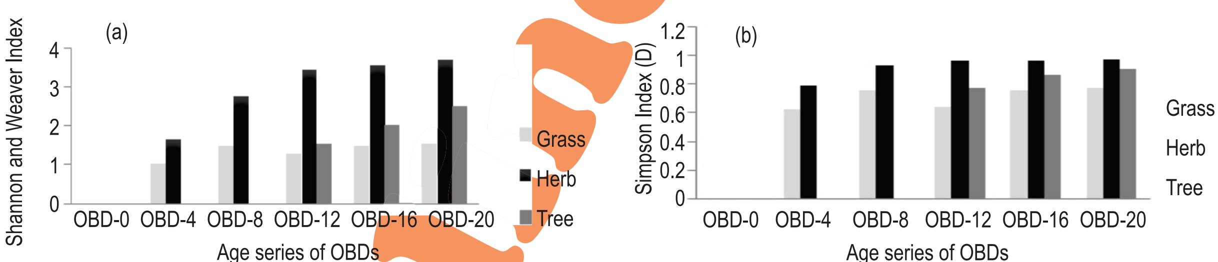


**Fig. 2 :** (a) Floral diversity in terms of Shannon and Weaver Index (H´), (b) Simpson Index (D) on different age series of OBDs

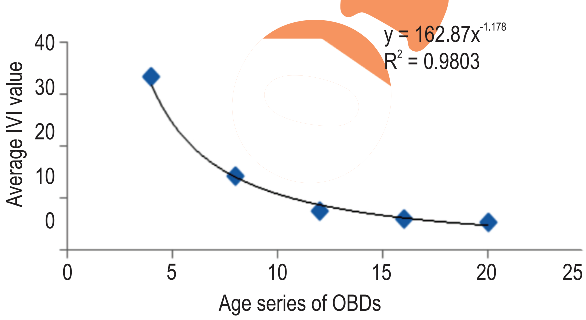


**Fig. 3 :** Scatter plot of dependent variable IVI against age series of OBDs

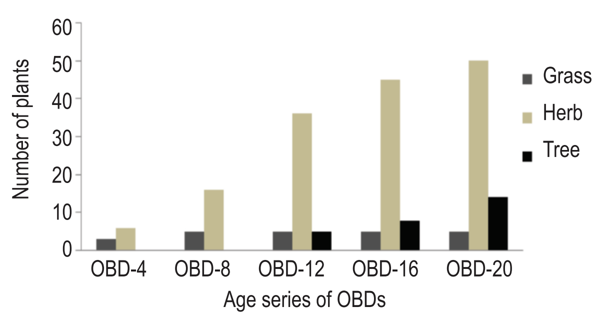


**Fig. 4 :** Species richness of different age series of OBDs

and Gibson (1996) also found that grasses can contribute substantially in vegetating the mine spoil. IVI values showed that during initial phase of succession, contribution of grass species was relatively more, and during later stages, the contribution of non-grass herbaceous species and trees became dominant flora of the area. This has also been reported by Hazarika *et al*. (2006), according to which the shrubs and tree species were dominant vegetation of older spoils. This clearly demonstrates the strategic importance of grass and non-grass herbs and trees with respect to the stages of sucessional colonization of the adverse habitats like coalmine spoil. This observation is at par with the views of Helm (1995) and Skeel and Gibson (1996). The fibrous root system of grasses are known for their efficiency to slow down the pace of erosion and help to stabilize soil and conserve the moisture content. Besides, the positive role of grass species-cover as 'nurse crop' for subsequent colonizers has also been well documented by Helm (1995). The species richness of grasses in OBD-4 was found to be 3 and then it increased to 5 and then remained static in older OBDs indicating that species richness of grasses initially increased but at subsequent stages it became stagnant. In case of herbs, the species richness increased gradually from 6-50 in relatively older spoils. However, as far as trees are concerned, the species richness was found to be 0 up to 8 year old OBD and later on it increased from 5-14 in older spoils (Fig.4). The diversity indices with respect to both Shannon and Weaver index and Simpson index also showed similar trends like those of species richness. In both Shannon and Weaver Index and Simpson index, it was found that grasses appeared as pioneer species on 4 year old OBD first with a diversity of 1.024 and 0.62 respectively with a subsequent increase in 8 year old OBD to 1.493 and 0.75, respectively. At later stages, grass diversities remained more or less constant. Similarly, the herbaceous species which appeared first on OBD-4 showed diversity indices of 1.65 and 0.79 with respect to H´ and D, respectively. Both H´ and D indices showed a gradual increase in herb diversity in relatively older spoil with a final diversity of 3.71 and 0.97. On other hand, the tree species first appeared on OBD-12 with Shannon and Weaver index of 1.55 and Simpson index of 0.77, respectively. The tree species showed further increase in diversity at older stages and reached a diversity of 2.5 and 0.9 respectively on 20 year old OBD (Fig. 2a and 2b).

The scatter plot of dependent variable IVI against age of OBD in years is shown in Fig. 3. Before attempting a regression analysis of data, it is often helpful to examine a scatter plot of data to see which regression model is likely to fit (McGarigal *et al*., 2000). It was observed that as the of OBDs increased there was a progressive decrease in the average IVI values, which could be best represented by a power function curve. Other curves like linear, logarithmic and exponential were also tried, but the power function provided best outputs of correlation coefficient. Here, the $R^2$ (correlation coefficient) value of 0.98 was very high and significant with variation in the dependent value *i.e.* IVI, which can be explained by 98% as a function of age of the OBDs. The two variables were strongly correlated as observed from this analysis. It was observed that the rate of fall in IVI values was quite steep during the initial 5-7 years, after which it slowed down and reached equilibrium 15 years onwards.

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