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A study on the Bulk density and its effect on the growth of selected grasses in coal mine overburden dumps, Jharkhand, India

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ABSTRACT

Coal is the prime source of energy in India. Opencast mining of coal damage a large land surface area, displace people from their natural home and cause agricultural losses. This raises a number of environmental challenges, including soil erosion, dust, noise, and water pollution impacts on local biodiversity. Generation of dump waste from opencast mines in Jharia coalfield threatens the social sustainability of land use pattern in many ways. The overburden dumps formed outside the open pits besides occupying the lands alter the surface topography and contribute to the environmental degradation. In the present paper authors have attempted to study the impact of physical properties of soil and his effect on the growth of some selected grasses over mine dumps. Bulk density plays a significant role in growth of selected grasses as observed during this experiment.

Keywords: Coal, Opencast mines, Overburden materials, Bulk density, Cymbopogan citrates.

1. Introduction

Coal is considered as India energy security. India is the third largest producer of coal in the world. Coal deposits in India occur mostly in thick seams and at shallow depths. The Geological Survey of India has estimated proven coal reserves of the country at 99.06 billion tonnes. Estimates of total coal reserves are much higher at 257.38 billion tonnes up to a depth of 1200 metres (GSI, 2007).

In India, mining now occupies second position in industrial sector after agriculture and has also found a very important role for the development of civilization, however mining begins about large scale destruction of environment in terms of deforestation, alternation of landscapes, and extinction of wildlife and other natural resources.

Opencast mining envolves displacement of large amount of overburden dumps materials (mine waste) to excavate the valuable mineral from the earth. The choice of mining method is largely determined by the geology of the coal deposit. Overburden is the waste material which is lies above the mineral deposit or coal seams. Overburden dumps consist of stones particles, which are extracted from coal during mining and for, further mining soil particles and stones should be removed (Maiti et al.,2001).The overburden waste generated through coal mining activities is obstinate in nature due to destruction of the balance between the landforms and soil erosion rates with the alternation of the basic nature of the materials. Mine spoils pose adverse conditions for soil microbes and plant growth due to its low organic matter and unfavourable soil chemistry, poor structure. The impact due to mining activities

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on the environment is mainly due to land degradation, siltation of agricultural fields, loss of flora and fauna, air and noise pollution (Subramaniyan, 2007).
At many places in coal mining areas the plantation done over the dumps and in most places it was difficult to establish plantation on the sloping sides of the dumps. Plantation generally influenced by the physical - chemical parameters of the mine waste (Rao and Santarem, 1995). It has been found that mine degraded lands are manmade, devoid of nutrients, low moisture content and more compacted. All these factors are responsible for limitation of plant growth (Bradshaw,1980).

2. Materials and methods

2.1 Study area

Jogidih, Benidih, Angarapathara, and Ramkanali were located in Govindpur area, Block II area and Katras area of Jharia coalfield (JCF), Jharkhand. JCF is one of the Lower Gondwana Coalfield of India, covering an area of about 72 km^2. This sickle shaped coalfield is about 40 km in length and approximately 12 km in width stretches from West to East and finally turns southward covering an area of about 450 sq. km. In this coalfield coal seams occur in association with sandstone and shale. At the time of coal mining the aquifer(s) in the associated sandstone gets partially excavated out (Fox, 1930). The location of sites is shown in the Figure 1. The brief details of sampling sites in the study area are summarised in Table 1.

Table 1: Description of sampling sites, JCF

S.No	Locations	Areas	Site detail
1	ESE garden	ISM, Dhanbad	Full of plants
2	Jogidih	Govindpur, JCF	It was having moderate vegetation cover
3	Benidih	Block II,JCF	It had low vegetation cover
4	Angarapathara	Katras, JCF	It had no vegetation cover
5	Ramkanali	Katras, JCF	It had negligible vegetation.

In this study, various types of overburden samples were collected from the four different colliery of JCF. Some grasses were collected from sampling sites of overburden dumps (OBD).The OBD collected at four different collieries were considered as experimental part and soil collected at ESE garden were considered as control part.

2.2 Collection of samples and analysis

A field survey was conducted during summer seasons for collecting overburden samples and grasses covering above mentioned area. The overburden samples were collected by metal tube coring tool operated manually. By coning quartering method samples volume were reduced to 1 kg and put in a plastic zip bags (Maiti et al.,2001). After collection the overburden samples from field, samples were air dried at the Geotechnical lab, Dept. of Environmental Science and Engg (ESE), ISM, Dhanbad and lightly crushed with a mortar

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and pestle then passed through 2 mm mesh sieve. All the analyses were done by the standard methods given by Jackson, 1967.

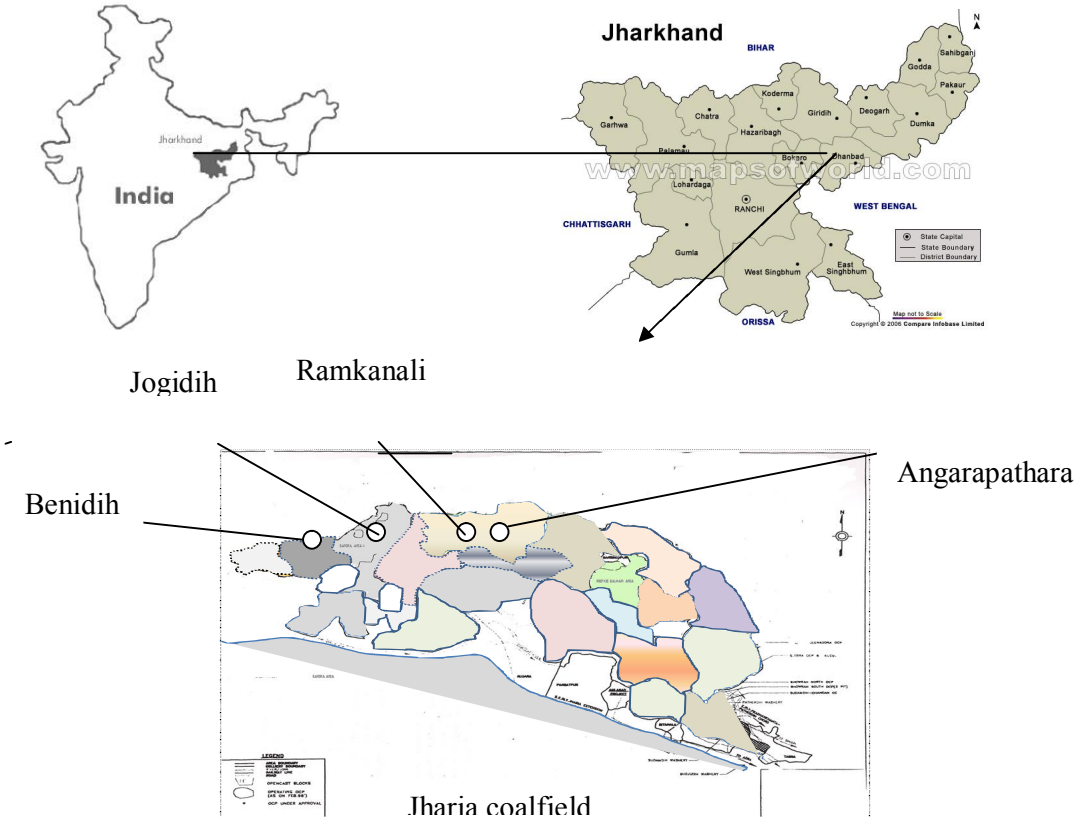

Figure 1: Map of study area, JCF, Dhanbad (Not to scale)

2.3 About selected grass

Lemon grass *(cymbopogan citratus)* is tall perennial grass. It is also suitable for poultry, fish, and seafood. Lemon grass has anti-fungal properties. It has medicinal properties and is used in Ayurvedic medicine. Categorisation of Lemon grass is shown in Table 2.

Table 2: Categorisation of Lemon grass

S. No	Classification	--
1	Kingdom	Plantae
2	Order	Poales
3	Family	Poaceae

2.4 Methodology

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Small pot experiments were conducted with overburden dump materials collected from four different collieries of JCF with one species of grass namely lemon grass (cymbopogan citratus). Soil of ESE garden considered as control soil for this study. For this purpose grass of one species along with 5 cm tillers above the root was taken for planting in different pot and regular observations regarding increase in height and numbers of tillers were recorded. After 6-8 months the grass from each pot of different overburden samples were taken out with root and washed with distilled water to free from the extra waste materials. Root lengths of lemon grasses were measured at periodic intervals in Laboratory. In Figure 1 earthen pot for grass plantation is shown.

Figure 1: Earthen pot for grass growth experiment

Bulk density of soil or mine waste was determined using by oven dry weight of a known volume of sample was taken and mass per unit volume was measured. Before taken the weight soil sample was rammed sufficiently to give normal compaction that can be observed in the field. The range of bulk density of soils are summarised in Table 3.

Table 3: Bulk density for different soils

S. N0	Type of soil	Bulk density (g/cm^3)
1.	Good soil	1.0 -1.5
2.	Forest soil	1.13 -1.20
3.	Grassland	1.20 -1.28
4.	Cultivated soil	1.35 -1.48

Source: Bradshaw, 1980

Specific gravity of soil or mine waste is the ratio of the weight of a given volume of soil particles in air to the weight of an equal volume of distilled water at a temperature of 4^0C. It is measured by pycnometer method. The specific gravity of most soils generally lies between 2.60 - 2.80 and for sands which lies that 2.65 (Head, 1984). The pore space of a soil is that portion of the soil volume which is occupied by air and water. The value of porosity must be less than 100%. The pore space in the samples was determined by first finding the bulk density of the samples using the method outlined in the above. After this the particle density of the samples was determined making use of the specific gravity valued determined (Mishra et al.,2007). pH was determined in soil to water ratio 1:2:5 with the help of pH meter, with

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glass electrode. pH is an important index of ecological condition of terrestrial environment. It indicates whether the soil is acidic or alkaline. Electrical conductivity and pH are considered as important factor for plant growth which directly or indirectly affects the nutrient cycling of plants. Electrical conductivity can be directly related to soluble salts concentration of the soil or mine waste at any particular temperature. The clear extract after pH determinations can be used for electrical conductivity measurement. The conductivity of the supernatant liquid is measured by with the help of a conductivity meter. The range of electrical conductivity of soils are summarised in Table 3.

Table 3: Electrical conductivity of soils

S.No	Category	Salinity (mmhos/cm)
1	Good	< 8
2	Fair	8 -16
3	Poor	>16

Source: Bradshaw, 1980

3. Results and Discussions

The results obtained for various physico - chemical characteristics of soil samples or overburden samples at different area are summarized in Table 4. The results of lemon grass growth on overburden samples are given in Table 5.

Table 4: Physico chemical analysis of overburden materials, JCF

S. No	Locations	Bulk density (g/cm^3)	Specific gravity	Porosity (%)	pH	Electrical conductivity dSm^{-1}
1	ESE garden	1.40	1.93	45.52	6.24	0.103
2	Jogidih	1.65	2.31	41.39	5.86	0.173
3	Benidih	1.68	2.34	41.21	5.54	0.167
4	Angarapathara	1.74	2.25	39.63	4.83	0.157
5	Ramkanali	1.77	2.28	39.48	4.74	0.164

The significance of physical parameters is not outlined in this paper. It should be understood that only bulk density and growth of plant is being discussed. Bulk density is a measure of the weight of the soil per unit volume, usually given on an oven dry basis. It is used as a measure of soil wetness, volumetric water content, and porosity. It is also a measurement of the compaction of the degree of compaction of the soil, which gives a comparative basis to indicate the strength of similar materials (Birkeland,1984).Materials with a high bulk density have very few air spaces with most of the fine pores filled with water (Janakiram et al.,2010). Bulk density of ESE garden soils and dump materials of selected area were found to be 1.40 g/cm^3 and 1.65 g/cm^3 at Jogidih,1.68 g/cm^3 at Benidih,1.74 g/cm^3 at Angarapathara, 1.77 g/cm^3 at Ramkanali. The soils of ESE garden were found to be good for selected growth of

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grass due to lower bulk density. Rest of the samples were found to be higher bulk density and growths of grass were reduced

Table 5: Details of grass growth on overburden materials, JCF

S.No	Category	Height of grass (cm)	No of Tillers	Root of grass (cm)
1	ESE garden	84	09	36
2	Jogidih	34	05	27
3	Benidih	31	03	24
4	Angarapathara	37	06	31
5	Ramkanali	39	04	33

Height of grass was found to be 84 cm at ESE garden, 34 cm at Jogidih, 31cm at Benidih, 37cm at Angarapathara, 39cm at Ramkanali. In other parameters, the tiller numbers were reduced in case of mine dump grasses while compared to control ESE garden soil. Root lengths of grasses were ranged from 24 cm to 33 cm on while compared to 36 cm of control soil.

From this data, it shows that more bulk density reduced the root length and limiting the root penetration growth in the dump soil. The root of the grasses has found to be increased with the decrease in bulk density on the dump soils (Lovesan et al., 1998). Further this was found to be decreased because nutrient ion movement is directly aided by water and air movement which are restricted by bulk density (Albrecht et al.,1982). The roots of lemon grass have found to be increased with the decrease in bulk density and similar findings were supported by Carter et al., 1987. Specific gravity was found to be 1.93 at ESE garden, 2.31 at Jogidih, 2.34 at Benidih, 2.25 at Angarapathara and 2.28 at Ramkanali. The presence of heavy metals in the form of oxides or other compounds could be the reason for high specific gravity in overburden samples. On the other hand, soils which contain appreciable quantities of peat or organic matter may have less specific gravity than 2.65, and sometimes below 2.0 (Head, 1984).Porosity is the ratio of the volume of voids in the sample to the total volume of the soil, expressed as a percentage. Pores result from the irregular shape of soil particles or from pushing and aggregation forces. When pore space is very small, soil charges retain water and impede drainage, resulting in poor aeration (Lovesan et al., 1998). Porosity was found to be 44.52% at ESE garden, 41.39% at Jogidih, 41.21% at Benidih, 39.63% at Angarapathara and 39.48% at Ramkanali. pH is a measure of hydrogen ion activity. It is measure of the intensity of acidity and alkalinity of the soil suspension and provides good identification of chemical nature of soil (Joshi et al., 2005). pH was found to be 6.24 at ESE garden, 5.86 at Jogidih, 5.54 at Benidih, 4.83 at Angarapathara and 4.74 at Ramkanali. The slightly acidic nature of the dump material is due to the geology of the rock. Electrical conductivity was found to be 0.103 dSm^{-1} at ESE garden, 0.173 dSm^{-1} at Jogidih, 0.167 dSm^{-1} at Benidih, 0.157 dSm^{-1} at Angarapathara, 0.164 dSm^{-1} at Ramkanali, which will not be a problem for normal plant growth.

4. Conclusion

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It is obvious from the experiments that soil samples collected from the ESE garden soil which has less value of bulk density the growth rate is comparatively more than that of mine dump soils. Growth of grasses shows that higher bulk density can restrict the growth of the plants. This base line data can be used for plantation on mine waste.

5. Suggestion

It can be recommended that careful management on the dump material is required to create an ideal bulk density for optimum plant growth. This could have been possible by proper reclamation of mined out area. Therefore, if some preventive steps are taken by the BCCL (A Unit of CIL), the overburden samples from opencast mines can be eco friendly.

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Abbreviations:

IARI: Indian Agriculture Research Institute, New Delhi.
GSI: Geological Survey India.
CIL: Coal India Ltd
BCCL: Bharat Coking Coal India Ltd
JCF: Jharia Coalfield

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