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Soil Stabilization on OB Dumps–Proposed Plan for a New Open Cast Mine

Anurag Tiwari[1], Amit Saxena[2] and Aishwarya Chandra Shekhar[3]

[1,2,3]CMPDIL, RI-V
E-mail: [3]aishwarya111990@gmail.com

Abstract—*Soil Erosion from the over burden dumps not only decreases soil's fertility but also leads to contamination of nearby rivers and streams. It can cause choking and blockage of small streams thereby disturbing the water channel. This paper addresses this issue by representing the Top Soil Stabilisation Plan with special reference to Jampali Open Cast Coal mine in the Raigarh Area of Chhattisgarh. The paper comprises two sections, viz. Soil Erosion Control Techniques and Top Soil Management Process. The first part explains how soil erosion can be controlled by using technical, physical and biological methods. The second part explains the importance and process of top soil management. It includes steps, viz. Volume Estimation of Top Soil, Stripping, Stockpiling, Stockpile Preservation, Site Preparation and Spreading and Monitoring.*

1. INTRODUCTION

Soil erosion is one of the most serious environmental and public health problems facing human society (Pimentel, 2006). The loss of soil from land surfaces by erosion is widespread globally and adversely affects the productivity of all natural ecosystems, as well as agricultural, forest, and rangeland ecosystems (Lal & Stewart, 1990). Jampali Open Cast Mine is a Coal Mining Site comprising Singhmouza-Jampali geological block in the Mand-Raigarh Coalfield of Raigarh district (Chhattisgarh). This area is of 4.88 Sq. km and is bound by latitudes 22°16'17" and 22°17'50" and longitudes 83°16'52" and 83°19'26". The total excavation area is 398 Ha which contains about 1.27 Mcum of Top Soil. Top Soil is usually 2-8 inches in thickness and has the highest concentration of organic matter and micro-organisms which allows most of the earth's biological activities to occur. It comprises rich humus with minerals and nutrients and its proper handling and management is necessary for vegetation growth. Top Soil Erosion has become a very common phenomenon in mining industry. The removal of upper most fertile layer of soil not only decreases soil's fertility and reduces its productivity, but also leads to contamination of nearby rivers and streams. During mining, in order to extract coal, a lot of earth material lying above it needs to be removed. This earth material removed is called Over Burden (OB) and consists of different components of soil and rocky material depending upon the region of excavation. The OB in Jampali consists of Alluvial soil, Top soil, Sub soil and Rocks. The extracted OB is then stacked in heaps, known as OB dumps. The OB dumps are susceptible to soil run off, leading to choking and blockage of the small streams and tributaries surrounding the Jampali OC and thereby disturb the water distribution channel. Thus, preventing soil erosion and managing the top soil is a matter of great concern and importance.

2. SOIL EROSION CONTROL MEASURES

In order to control soil erosion in over burden dumps, a step by step procedure needs to be followed so that the water flows through a proper path and does not take away with it the essential soil material. The measures can be categorized as Technical, Physical and Biological. The steps to be followed are:

2.1. Technical Measures

Technical measures include the handling and placement of the over burden material. The process involved is as follows:

2.1.1. Backfilling and Dozing: The top surface of the OB dumps is first leveled with the help of dozers as a first measure of land reclamation. Dozers crush the bigger lumps and help flatten the OB material to obtain maximum compaction. The slope angle should be such that dump is stable and does not encounter any slope failure accidents in the future. In order to maintain the slope stability, the angle of repose should not be more than 28°.

2.1.2. Grading: The OB dump is slightly graded so that surface water can drain through the slope. Grading helps in creating the surface topography level with mild gradient towards a pre-determined water path. This reduces the potential of precipitation to cut and erode the dump surface.

2.1.3. Terracing: Terraces will be made along the OB dump in such a way that the angle of overall slope is maintained well below 28°. Two terraces of 15m each will be constructed.

2.2. Physical Measures

Physical measures include the construction of structures to provide a pre-determined path for the water to flow through.

2.2.1. Water Coursing Channel: The topography of the area is planned and designed in such a way that the water takes a pre-determined path to flow and does not reach the other areas. Narrow water coursing channels are made in which water flown down through the check dams on the slopes gets collected and drifts through a preset channel down to the surface. From the surface, the water channel carries the water to garland drains through check dams.

2.2.2. Toe Walls: The water drifted to the ground level is then made to pass through the boulders. Boulders are big rocky structures which contain grains in a manner that when water passes through these, the soil particles present in the water get trapped in the boulders and the residual water flows through the structures. The commonly used toe walls are:

(a) Boulder Toe walls*:* Toe walls are low walled structures constructed at the bottom of an embankment to prevent slippage or spreading of the soil.

(b) Gabion Structures*:* A gabion wall is a retaining wall made of stacked stone-filled gabions tied together with wire mesh. The structure has greater strength and stability in terms of toe protection. The gabions will be constructed in areas having nearby habitation etc.

2.2.3. Garland Drains: The residual water on passing through the toe walls is directed through garland drains. A garland drain is a shallow ditch or trench for raining surface or subsoil water to the sedimentation pond.

2.3. Biological Measures

Biological measures include the activities which help in keeping the soil active maintain the moisture content of the soil.

2.3.1. Plantation: Plantation on the dump will be done to protect the soil from erosion, discourage weeds and maintain active populations of beneficial soil microbes. For this, plots of 2m*2m will be laid on dump top surface and plots of 1m*1m will be laid on dump slopes and likely grass and plant species will be grown.

Species for plantation: Grasses- Vetiver, Doob, Bamboo, Chirchira, Kansh; **Fruit bearing trees** - Jamun, Mango, Imli, Sitaphal, Bel, Ganga Imli, etc.; **Medicinal trees** - Neem, Karanj, Harra, Behara, Aonla, Arjun, Shikakai, Mahua, Kusum; **Timber value trees** - Teak, Shivan / Ghamar, Sissoo, Sisham, Safed Sirus, Peltaforum, Babool; **Ornamental trees** - Gulmohur, Kachnar, Amaltas, Saptaparni, Grevelia, Peepal, Palm tree.

Plantation of these species will help bind the soil together and prevent it from getting eroded. Plantation helps in conserving the soil moisture content and keeps the micro-organisms in the soil active to maintain the microbial activities in the soil and keep it fertile.

3. TOP SOIL MANAGEMENT

In addition to preventing soil erosion, managing the top soil is also very important to enhance vegetation on the dumps.

The objectives of Top Soil Management are to-

- Maintain a topsoil balance that achieves rehabilitation objectives during the life of mine.
- Ensure effective topsoil removal techniques are employed to maximize volumes of suitable topsoil removed and minimize wastage.
- Maintain topsoil viability during stripping, spreading, and stockpiling, through best practice techniques and effective stockpile design and treatment.

In accordance with the objective of providing sufficient stable soil material for rehabilitation and to optimize soil recovery, the top soil management includes the following steps:

1) Volume estimation of Top Soil, 2) Stripping, 3) Stockpiling, 4) Stockpile preservation, 5) Site preparation & spreading and 6) Monitoring

3.1. Volume estimation of Top Soil

It is vital to assess the actual volume of topsoil to be handled. After assessment of the total quantity, the area for top soil preservation/ application is identified and phase-wise programme for generation of top soil and its preservation/application is delineated as presented below:

Table 1: Volume estimation of top soil.

TOP SOIL MANAGEMENT, JAMPALI OC								
YEAR	QUARRY AREA OF EXCAVATION, HA	TOP SOIL REMOVED, MCUM	TOP SOIL REMOVED CUMMULATIVE, MCUM	TOP SOIL SPREADED, MCUM			TOP SOIL STACKED CUM MULATIVE, MCUM	REMARKS
				EXTERNAL DUMP	INTERNAL DUMP	TOTAL		
1	15.0	0.05	0.05	0.03	0.00	0.03	0.01	MAXIMUM AREA REQUIRED FOR STACKING TOP SOIL IS
2	25.0	0.08	0.13	0.03	0.00	0.03	0.06	
3	39.0	0.12	0.25	0.02	0.08	0.10	0.09	
4	39.0	0.12	0.38	0.02	0.12	0.14	0.07	
5	39.0	0.12	0.50	0.01	0.12	0.13	0.06	
6	25.4	0.08	0.58	0.00	0.08	0.08	0.07	
7	25.4	0.08	0.66	0.00	0.08	0.08	0.07	
8	25.4	0.08	0.75	0.00	0.08	0.08	0.08	

9	25.4	0.08	0.83	0.00	0.08	0.08	0.08	2.92 HA IN THE YEAR 3.
10	25.4	0.08	0.91	0.00	0.08	0.08	0.09	
11	17.2	0.06	0.96	0.00	0.07	0.07	0.07	
12	17.2	0.06	1.02	0.00	0.07	0.07	0.06	
13	17.2	0.06	1.07	0.00	0.07	0.07	0.04	
14	17.2	0.06	1.13	0.00	0.07	0.07	0.03	
15	17.2	0.06	1.18	0.00	0.07	0.07	0.01	
16	17.2	0.06	1.24	0.00	0.07	0.07	0.00	
17	10.8	0.03	1.27	0.00	0.03	0.03	0.00	
Total	398	1.27		0.12	1.16	1.27		

3.2. Stripping

Prior to the commencement of stripping, area has to be cleared off vegetation. Soil stripping is done with the help of dozers and hydraulic backhoe excavators to maximize the preservation of the quality of the soil. The HEMM operators and supervisors should be trained and made aware for the same. This will ensure that whole of the topsoil is salvaged and the quality of the stripped top dressing material is not reduced through contamination by unsuitable soils. Care has to be taken during stripping, stockpiling, and re-spreading to ensure that structural degradation of the soil is restricted and compaction does not occur during stockpiling.

3.3. Stockpiling

Wherever possible the top dressing material should be re-spread directly from stripped areas onto areas being rehabilitated. Where this is not possible, top dressed material should be stored in stock piles. Dumping of stock piles should be done dumped at places where they would not be disturbed by immediate future mining. The key points to be considered during stock piling are:

- When stock piling of top soil is done, the mound should not be higher than 1.20 m (Without amendments) and 3.0 m (With amendments).
- Gradient of the base where top soil is being stock piled should not be more than 1:2 for normal base and 1:3 for sandy silky slopes.
- The overall topography for the graded surface should be designed to minimize the uncontrolled flow of runoff.
- Dispersed sheet flow should be broken up by terraces or benches along the slope that also follow topographic contours.
- On a fine scale the ground surface can be roughened by the tracks of a bulldozer perpendicular to the slope.

3.4. Stockpile preservation

Stockpiling topsoil may result in disruption & loss of beneficial soil microorganisms and nutritional values, hence needs the following amendments during preservation:

3.4.1 Re-vegetation of the stockpile: will be done as scheduled below to protect the soil from erosion, discourage weeds and maintain active populations of beneficial soil microbes.

Temporary Seeding- To protect topsoil stockpiles by temporary seeding as soon as possible, within 30 days after the formation of the stockpile.

Permanent Vegetation- If stockpiles will not be used within 12 months they will be stabilized with permanent vegetation to control erosion and weeds.

3.4.2 Topsoil can be mixed with organic material or manufactured soil amendments to improve the growing capability.

3.4.3 To the extent practicable, above ground vegetation, including tree litter should be mixed or otherwise incorporated into the topsoil.

3.4.4 Application of Fertilizers: Stockpiled topsoil needs significant fertilizer application for the establishment and maintenance of vegetation. However, N application should not exceed 168 kg ha-1 to avoid suppression of legumes but not less than 85 kg ha-1 to support grass establishment. Phosphorus and K application should not exceed 300 and 125 kg ha-1, respectively.

3.4.5 Prior to the placement, the top 0.30 cm of stockpile material should be mixed with the remainder of stockpile to ensure that living organisms are distributed throughout the topsoil material at the time of final placement. In case, the material has been stockpiled for over nine month period, use of microorganisms inoculates may be necessary to re-establish microorganisms in the topsoil material. The quantity should be 200 ml for one Hectare area in case of Azatobactor and Rhizobium.

3.5 Site Preparation

Important points to be considered during site preparation are underlined below:

- Before spreading topsoil, establish erosion and sedimentation control structures such as diversions, berms, dikes, waterways and sediment basins.
- Maintain grades on the areas to be provided with topsoil according to the approved plan. Adjust grades and elevations for receipt of topsoil.

- Roughening- Immediately prior to spreading the topsoil, loosen the subgrade by disking or scarifying to a depth of at least 100 millimetres to ensure bonding of the topsoil and subsoil.
- Ensure that soil horizons are replaced in the same order that they were removed.
- Uniformly distribute topsoil to pre-mining thickness. If sufficient topsoil is available, a minimum compacted depth of0.5m on 3:1 slopes and 1m on flatter slopes is suggested. Do not spread topsoil while it is frozen or muddy.

3.6 Monitoring

Specific team / manpower should be deployed for this most important step of topsoil management. The team will monitor the area and quantum of top soil management with the authorities of mine on quarterly basis and regularly monitor the given points of significant importance:

3.6.1 Monitoring Erosion Control: This step is necessary during stock piling as well as reclamation stage of topsoil management. Take corrective measure in areas showing evidence of erosion, sedimentation or slope failure. This is a serious problem because erosion causes fertile farmland to lose nutrients and water retention ability.

3.6.2 Soil fertility maintenance: Organic or inorganic fertilizer should be applied periodically if vegetation growth is poor.

3.6.3 Regular monitoring: of top soil management should be done until vegetation is demonstrated to be successfully established.

3.6.4 Reseeding: Take appropriate measures to address evidence of invasive species or poorly established vegetation. Reseeding should be done, if germination is not uniform or poor.

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