Management of topsoil for geo-environmental reclamation of coal mining areas

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Abstract Topsoil is an essential component for land reclamation in mining areas. It is seriously damaged if it is not mined out separately without being contaminated, eroded and protected. Systematic handling and storage practices can protect topsoil while in storage and after it has been redistributed onto the regraded area. Impact of coal mining on topsoil quality in Indian context has been described. Systematic removal of topsoil, its storage practice, geometry of topsoil heap are discussed in this study. Removed topsoil should be reclaimed technically and its shelf-life period should be ascertained. To assess the shelf-life period, an investigation was conducted in a large opencast coal project. Soil dumps of different age classes in the area were identified and analyzed critically to evaluate the deterioration of soil quality with respect to time, and compared with those of unmined areas. Changes in soil quality showed a continuous decrease every year and ultimately became biologically sterile. Biological reclamation is essential if the soil is to be stored beyond the shelf-life period. Preservation of stockpiled topsoil, its redistribution on the regraded areas, nutrients and amendments to be added, are discussed briefly in this study.

Keywords Opencast · Reclamation · Shelf-life · Topsoil

Introduction

Almost in every mineral-bearing zone mining and land degradation have been inseparably connected. Irrespective of the scheme of exploitation, mining may be expected to affect the environment and ecology of the region. By far the greatest impact of mining on India’s soil resources with opencast mining has been a greater potential for the deterioration of soil quality than underground operations. In the process of opencast mining, the area is completely stripped of vegetation to remove the overburden covering the coal seam (Kundy and Ghose 1998a). There are several changes in the physical, chemical, and microbiological properties of soils as a result of storage, some caused by the actual construction of the storage rather than during the course of storage.

Topsoil is an essential component of land reclamation in mining areas (Kundy and Ghose 1994). The topsoil is very seriously damaged if it is not mined out separately in the beginning with a view to replacement in the area. This is particularly necessary to save topsoil for later use to protect the primary root medium from contamination and erosion, and hence its productivity (Kundy and Ghose 1997a). Sendlein and others (1983) indicate, however, that systematic handling and storage practices can protect the physical and chemical characteristics of topsoil while in storage and also after it has been redistributed onto the areas. Monitoring and implementation of these steps in accordance with site-specific modern technology will minimize the deterioration and provide a medium for plant growth.

Impact of mining on topsoil quality

Opencast mining is progressively increasing with India’s coal production. The coal production from opencast mining is likely to increase to 250 Mt/year (roughly 70% of the total) by the turn of this century. Ghose (1990) reported that every million tons of coal extracted by surface mining methods damages a surface area of 4 ha in India. The coal industry will have rendered an area of ~1,400 ha a year biologically unproductive by 200 A.D. (Chari and others 1989). Opencast mining also results in the formation of large overburden dumps and huge voids in the mining sites. By 2000 A.D., when coal production from opencast mining will rise to about 250 Mt, >500 Mm³ of overburden will have to be handled every year. Opencast mining also leads to rapid erosion of land because of slope stability problems and sometimes it can cause landslides. Land degradation may result in soil erosion, leading to the
destruction of watersheds, siltation, and the loss of valuable fertile soil.

**Topsoil removal**

Topsoil should be removed after clearing the vegetative cover from the areas to be disturbed and before any drilling, blasting, mining, or other surface disturbance. It is essential that stripping is to be carried out when the soil is as dry as possible. This will reduce the risk of compaction and damage to soil structure by keeping smearing and remolding to a minimum. Prolonged rainfall is unsuitable for stripping.

The stripping of topsoil from a site should normally be done by scrapers. The routing of scrapers during this operation must be planned to minimize the number of times machines travel over the soil, which causes compaction and damage to the soil structure. Further, careful control of operations is necessary to ensure planned stripping depths of the topsoil and subsoil. The soils should be stripped and stored separately. Inter-mining of these soils during the stripping operation is not good practice.

All topsoil should be removed in a separate layer from the areas to be disturbed. If the topsoil is less than 15 cm, a 15-cm layer, which includes the “A” horizon, and all the consolidated material (if the total available is less than 15 cm), should be removed and the mixture segregated and redistributed as surface soil.

The “B” horizon and a portion of the “C” horizon (or other underlying layers demonstrated to have qualities for comparable root development), should be segregated and replaced as subsoil.

**Topsoil storage**

The stockpiling of topsoil and the rationale behind it are as follows:

1. Topsoil and other materials removed should be stockpiled only when it is impractical to promptly redistribute such materials.
2. Stockpiled materials should be selectively placed on a stable area (not disturbed), and protected from wind and water erosion, unnecessary compaction, and contaminants, which lessen the capability of the materials to support vegetation when redistributed.

**Geometry of topsoil heap**

To maintain a maximum level of biological activity, the topsoil heaps should be constructed as follows:

1. To provide the maximum surface area.
2. To have slopes capable of avoiding erosion and gully formation.

Space constraints imposed by site specific factors and topsoil texture generally dictate the overall size and shape of the heaps, but, if possible, a maximum height of 5 m and a slope of 1:3 (i.e., 18.5° to horizontal) should be employed (Fig. 1). A stockpile of heavier soils should be as shallow as possible, ideally less than 1.0 m in height. As a rule of thumb, the following stock geometry may be maintained as far as possible to preserve the topsoil:

- **Height**
  1. 5.0 m (max.) for sandy soil;
  2. 2.0–3.0 m for loamy soil;
  3. 1.0 m for heavy clayey soil;
  4. 1.0–0.5 m (max.) for intermediate soil texture.

- **Slope**
  Same as mentioned above for soil of all types.

**Shelf-life concept**

Soil is an important product of nature. Apart from supporting plant growth, it provides a habitat for large numbers of animals and microorganisms. Perhaps the most significant contribution of the soil fauna and flora to higher plants is that of organic matter decomposition. By this process, plant residues are broken down, thereby preventing unwanted accumulation. Furthermore, nutrients held in organic combinations within these residues are released for use by plants: nitrogen is a prime example. At the same time, the stability of soil aggregates is enhanced not only by the slimy intermediate products of decay, but also by the most resistant portion: humus. Plants naturally profit from these beneficial chemical and physical effects. The fauna decomposes leaf litter and plant residues, thereby helping to cycle nutrients on which plant growth depends.

The soil is a dynamic natural body that has developed as a result of the pedogenic processes during and after weathering of rocks. Soils consist of mineral and organic constituents that are processed by physical, chemical, mineralogical, and biological properties; they have a variable depth over the surface of the Earth and provide a medium for plant growth for land plants. The topsoil is

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**Fig. 1**
Schematic diagram of soil store diagram