## MINE RECLAMATION METHODS & PRACTICES

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## LAND DEGRADATION

- All developmental activities damage or transform the original land-use.
- One of the environmental challenges facing mankind is land degradation
- Causes of land degradation are growing population, removal of vegetation, overgrazing, mining, industrial expansion, urbanization etc.

## **MAGNITUDE OF LAND DEGRADATION**

- It has been estimated that 23% of all usable land (excluding mountains and deserts) has been affected by land degradation
- Globally 43% of vegetated surface is degraded.
- About 60% of the global landscapes are disturbed by humans
- About 2000 Mha of soil, equivalent to 15% of the Earth's land area (an area larger than the United States and Mexico combined), have been degraded through human activities.
- About 70% of the land areas in 25 biodiversity hotspots are cleared.
- About 96.4 million hectare or 29.32% of land area of the total geographical area of India is degraded.
- 0.19 m ha of arable land is severely degraded due to mining activities in India.
- Roughly 8000 sq. km of land in India are despoiled due to open or surface and underground mining activities.
- Land degradation caused due to coal mining in India compared with the total land degradation area wise is not so significant, but the intensity of degradation is very severe.
- Ecosystems have also become extinct mainly due to land degradation

# What are the factors that contribute to land degradation?

- Deforestation
- Soil erosion
- Grazing
- Mining
- Dumping of solid waste
- Habitat conversion
- Unregulated irrigation

## **IMPORTANCE OF MINING**

- Mining forms the stepping stone for a country's development and economic success.
- Mining has been the foundation of society since the earliest times.
- The development of mankind and its standard of living have always essentially depended on the availability of mining products.

## IMPACTS OF MININGon WATERon WATER

#### on LAND

- Land degradation
- Land fragmentation
- Soil disruption
- ♦ Soil
- contamination
- Erosion

### Dusts (radioactive, toxic nuisance)

Groundwater table alteration Spring and borehole yield River or surface water diversion Turbidity Contamination of rivers Acid Rock Drainage Tailings

on AIR Carbon oxides Sulphur oxides, Nitrogen oxides Methane CFOs Dusts (radioactive, toxic nuisance)

## RECLAMATION and RESTORATION METHODS

### TERMINOLOGY USED IN MINE LAND STABILIZATION

## **Reclamation:**

There is no implication of returning to an original stage but rather to a useful one.

## **Restoration:**

Replication of site conditions prior to disturbance.

## **Rehabilitation:**

The action of restoring things to a previous conditions or a state. This appear rather similar to restoration but there is little or no implications of perfections.

## **Revegetation:**

Process of replanting and rebuilding the soil of disturbed land.

## **OBJECTIVES OF RECLAMATION**

- Bringing back the health and fertility of the landscape, sometimes leading to an improvement on original state of health and fertility.
- Allow flexibility in future land-uses or provides specifically for a planned land-use.
- Preparation of a landscape which is visually acceptable and fits into the surrounding landscape without discord.
- Removal and prevention of pollution.
- Provide an agreeable habitat for wild-life in a balanced eco-system.
- Provide for land which could be marketable in suitable situations.

## **TYPES OF RECLAMATION STRATEGIES**

**Post-mining reclamation** – reclamation only after all resources have been depleted from the entire mine.

**Interim reclamation** – temporary reclamation to stabilize disturbed areas.

**Concurrent (progressive or continuous) reclamation** – reclamation as minerals are removed; overburden and soil are immediately replaced.

**Segmental reclamation** – reclamation following depletion of minerals in a sector of the mine

**Mining to reclaim** - Mining the slope to the final contours reduces reclamation costs by eliminating some of the earthwork necessary for final reclamation

#### **RECLAMATION PLAN SHOULD ADDRESS THE FOLLOWING**

**TOPOGRAPHIC RECONSTRUCTION:** Importance of topographic reconstruction cannot be neglected because the resulting landforms are the foundation upon which reclamation practices are executed and eventual land uses emerge.

**REPLACEMENT OF TOPSOIL & SOIL RECONSTRUCTION:** Revegetation of the reclaimed surfaces require a suitable growth medium. Stock piling and reuse of top soil facilitates achievement of reclamation goals.

**REVEGETATION:** Revegetation is the principal goal of reclamation. Development of a permanent vegetation cover should aim to establish a plant community that will maintain itself indefinitely without artificial aid, and support native fauna.

**SITE MONITORING & MAINTENANCE:** Every reclamation success story is site specific. Therefore site monitoring and maintenance are very important.

### Land Preparation & Bio-Physical engineering measures

Nature of Mine spoil	Bio-physical engineering measures
Unstable mine spoil slopes mainly overburden dumps	Backfiling, levelling, installation of drainage and erosion control system Contour trenching - Continuous /staggered
Backfilled areas that have undulating terrain but not sloppy	Spread of soil balls inoculated with seeds of native species
Hard rocky benches left after removal of coal	Geojute/cocofibre matting
Drainage channels	Vegetative gully plugging, Gabion wall/Toe wall

## **EROSION CONTROL**

- A major objective of restoration is to establish a sustainable vegetation cover to stabilise the site and prevent or control erosion.
- Contour trenching continuous/ staggered, spread of bio-degradable coco fibre mats are some of the important treatment measures.
- Bio-engineering measures like vegetative gully plugging and brush fills are also very effective.

## Short-term erosion-control methods include:

mulching, slash windrows, straw bales, filter fabric fences, jute netting and/or mulch fabrics, brush sediment barriers, and plastic coverings.

## Long-term erosion-control methods include:

vegetation, diversion ditches, rock check dams, rock-lined ditches, and contours, berms, swales, and ditches.







Small, discontinuous terraces, berms, and furrows can effectively slow runoff and decrease sediment transport.



**STORM-**WATER DIVERSION The best strategy for storm-water control is to divert streams and overland flow around the mining site

### **Bench Terracing**

Overburden is to be stacked tier by tier and height of each such tier is proposed to be 30 m.

RETAIN

**VEGETATION TO** 

FILTER RUN-OFF



#### **Straw-bale sediment barrier**



#### Straw-bale barrier combined with a gravel check dam.



#### **Contour Trenching:**

- This consists of excavating shallow/ intermittent trenches across the OB slope.
- The spacing of trenches and their size(length, width and depth should be adequate to intercept 50% of the peak rainfall in semi-arid regions.
- Steep slopes (<60°) are stabilized by digging contour trenches (0.3 m x 0.45 m) at a vertical interval of about 2.0 m and planted with suitable plant species.





**SETTLING PONDS** are flat-bottomed excavations and can range from small hand-dug sumps to ponds covering several acres. They slow water velocities enough to allow sediment to settle out of suspension.



**RESTORING TOPOGRAPHY:** A key element in restoring topography is creating natural-looking slopes that blend with the surrounding landforms. Rectilinear slopes (top) are inap- propriate for reclamation in un- consolidated materials.



Wheel washes can be used to keep mud and rocks from being tracked onto roads. A permanent wheel wash can be installed near the exit to wash excess dirt and mud off truck tires. A series of railroad rails spaced 2 to 8 inches apart can be used to shake loose rocks and dirt while the vehicle is driving through the wheel wash Dirty water can be sent to a settling pond, or the wheel wash can be cleaned out with an excavator.



## **Contour Trenching & bunding**



#### Waste dump covering with coir/ fibre mat

Geotextiles are specially designed to provide erosion protection and stabilization of mined out slopes, OB dumps, tailing dams and other degraded areas. They hold in place the loose dumps, gravel, soil. These geo-textiles are available in rolls and are either made up of polyester fabric, jute, coir or wood fiber.







## **GEO-BLANKETING**

- An eco-friendly Geo-green Blanketing done for slope stabilization and erosion control.
- It has several n positive impacts on environment such as protective shield preventing action of rain beat and reducing surface run off, arrests immediate migration of soil, favors development of dense vegetation.

#### **Base Material:**

### Coir Fiber, Rice Straw, or Mixture of Both

#### **Erosion Control Netting Material:**

Polypropylene (photodegradable or UV stabilized), Jute, or Woven Geotextile

#### **Thread Material:**

Polypropylene (UV stabilized) or JuteErosion Control Netting Benefits

## **Geo-Blanketing for Dump Slope Stability**

## **OVERBURDEN MANAGEMENT**

- The individual dump should have maximum slope of 37 deg. and an overall slope not exceed **28 deg.**
- The external dump should have stretches of **retaining** wall at suitable locations.
- The wall should be constructed with suitable height and top surface. The wall will have weep holes to drain out water to the **garland drain**.
- The back-filled areas should be levelled to match with adjoining ground level.
- The completed dumps and the back-filled areas should be afforested in a planned way to increase their stability.

## **Best practices in OB stabilization**

#### Construction of gabion silt arrester



#### GABION WALLS AT THE TOE OF THE DUMP FOR ARRESTING THE SILT

## **Brush Fills**

- Brush fill is a continuous filling on small gullies with brush, branches of trees, stems of bushy vegetation, etc.
- If brush is placed across the gully, it is called a "brush plug".
- The main purpose of brush fills is to obliterate the gully with the soil that brush holds.



## Soil bioengineering techniques (use of living plant materials)



## **Gully Plugging**





#### **CRIB WALL**

A rectangular framework of timbers, soil, rock, and live cuttings. It is useful when space is limited or a slope cannot be cut back. Live crib walls offer immediate bank protection.



### **CREATING PONDS FOR WILDLIFE**





## The important steps involved in the development of site specific restoration technologies are:

- Selection of appropriate plant species, their associated microbial communities and soil invertebrates
- Plant species must be appropriate for the development of sustainable ecological system.
- Selection of fast growing and of primary colonizing nature
  - that will set the disturbed nutrient cycling process, productivity & regulation of water regime.
  - ✓ that will ensure rebuilding the damaged wild faunal habitat.
  - ✓ that will ameliorate the substratum and rebuild the organic matter.

 $\checkmark$  that can serve the requirements of local population.

- Development of inoculation technologies
- Monitoring of habitat responses

#### **Recommended Ecological Interventions**

- Protection of the area from biotic interference the concept of 'social fencing' that involves seeking the agreeable support of the local stakeholders (villagers/ tribals) by motivating them, rather than the barbed wire fencing that is conventionally adopted.
- 2. Construction of a network of flexible and semipermanent Soil and Water Conservation (SWC) structures to stabilize the eroding slopes, check erosion, improve moisture regime and conserve fertile soil/ fine scree for providing congenial micro environment for plant establishment and growth.
- 3. Raising vegetation cover of primary successional nature that paves way for plant communities of higher successional level providing ecological stability to derelict sites.

## **Protection/fencing**

- Live fencing is an economic way of fencing because once established living fences become permanent.
- Cheap to establish and maintain as compared to barbed wire and other dead fences, which need constant maintenance.
- Besides, a living fence around the mining area that is prone to biotic disturbance has multiple benefits.
- Besides protection from cattle, a living fence also provides a buffer, and with a appropriate choice of plants like Agave sislana or, Jatropha curcas, Jatropha gossypifolia etc. protection as well as greening of sites can even be achieved.
- It does however take two to three years to develop. The species suitable for live fence should be thorny, inedible and non-browsable for cattle and goats, hardy and relatively maintenance-free, adaptable to the local conditions, fastgrowing.

## Mulching

- Wood-cellulose fiber : Natural virgin wood cellulose fibers produced from wood chips or recycled wood pulp.
- **Paper :** Paper fiber can be made available from recycled wood pulp Industries.
- **Agromulch :** Forage crops, cereal straws, and grasses.
- Wood Shavings : Shavings can be obtained from deciduous trees. Whole leaves, shredded and composted can be used as shavings mulch.
- Sawdust: Saw dust is available from local sawmills or forest products industry. Saw dust is capable of absorbing water at 2 to 6 times its own weight. Decomposition of sawdust is more rapid than that of other wood residues because of the more finally divided materials and high cellulose contents.
- Stone Mulching : with tones available at the site.



#### **Species used for bio-engineering application.**

**Pennisetum purpureum** (Napier Grass) Cymbopogon nardus (Java Grass) Cymbopogon citratus (Lemon Grass) Cymbopogon martini (Palma Rosa Grass) Chryosopogon fulvus (Golda Grass) Dodonea viscosa Cymbopogon citratus, Cymbopogon martinii, Cymbopogon nardus Pennisetum purpureum Panicum maximum Crotalaria sp. Mimosa himalayana Debregeasia hypoleuca Vitex negundo Rumex hasatus Alnus nepalensis Bauhinia variegata Trema politoria





## **Hydro seeding**



#### Physical and biological reclamation of dump site

#### **Plantation on external dumps**

- Plantation on the overburden dumps can only be taken up after dumping activity is stopped and the site is proposed for plantation.
- A layer of topsoil should be spread over the area and roughly leveled.
- Coir net / blanket should be spread and native grass seed mix should be broadcasted uniformly on prepared slope.

#### Plantation on Top of Overburden

- Trenches of 45cm x 45cm should be dug on the flat top of the dump and excavated materials should be used to form bund on the dip side of the trenches to retain water during rain.
- Suitable benches should be made on the waste dump.
- Pits of size 60cm x 60cm should be dug on the benches at 2-3 meters intervals.
- The pits should be filled with a mixture of top soil, organic manure and phosphate fertilizer.
- Saplings should be planted in these pits during monsoon to ensure maximum survival.

#### **Plantation on Dump Slopes**

- Plantation on slope of the dump should start after the benches are ready.
- The terraces on the slopes should be sloped inward. Pits of size 60cm x 60cm should be dugs at 1.5m interval and filled with a mixture of topsoil, organic manure and phosphate fertilizer.
- The slopes and terraces should be covered with a layer of soil held with coir net blanket.
- Seeds of grass and small scrubs of local varieties should be sprinkled on the soil covering the dump slope.
- Seedling of the plants should be planted in pit in the slopes.

## **RECLAMATION COSTS**

- Cost of ecological restoration on mined out areas per hectare: Rs.2.5 lakhs
- Cost of Block Plantation through Forest Department per hectare: Rs.2.5 lakhs to Rs.4.0 lakhs
- Bamboo Gabion Plantation per tree by Forest department: Rs.2000=00
- Brick Gabion Plantation per tree by Forest department: Rs.7000=00
- Plantation per tree by Forest department in closed premises: Rs.1200=00
- Cost of Closure for UG mine area per hectare: Rs.1 lakh
- Cost of Closure for OC mine area per hectare: Rs.6 lakh
- ➤ NPV for diversion of forest land per hectare: Rs.5.65 55.55 lakhs
- Cost of Reclamation of mined out areas as per OSMR: \$5800/acre (Rs.10 lakhs/ha.)

### The Surface Mining Control and Reclamation Act, 1977 (SMCRA), USA

SMCRA is the primary federal law that regulates the environmental effects of coal mining in the United States and is one of the best in the World, with the following basic regulatory provisions.

- Standards of Performance. SMCRA set environmental standards that mines must follow while operating, and achieve when reclaiming mined land.
- **Permitting**. SMCRA requires that companies obtain permits before conducting surface mining. Permit applications must describe what the premining environmental conditions and land use are, what the proposed mining and reclamation will be, how the mine will meet the SMCRA performance standards, and how the land will be used after reclamation is complete.
- **Bonding**. SMCRA requires mining companies post a bond sufficient to cover the cost of reclaiming the site. This is meant to ensure that the mining site will be reclaimed even if the company goes out of business or fails to clean up the land. The bond is not released until the mining site has been fully reclaimed.
- Inspection and Enforcement. SMCRA gives government regulators the authority to inspect mining operations, and to punish companies that violate.
- Land Restrictions. SMCRA prohibits surface mining on certain lands, such as in National Parks and wilderness areas. It also allows citizens to challenge proposed surface mining operations on the ground that they will cause environmental harm.

Before Eco-restoration, July 2011

Grass Cover Establishing, Aug. 2012

> Bamboo & Other Species Establishing, Sep. 2013

#### ECOLOGICAL TRANSFORMATION STORY OF DAMODA ECO-RESTORATION SITE BCCL

3- tier plantation, 2016

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3- tier plantation established, August 2015

3- tier plantation established, Sept. 2014

3- tier plantation, 2018

Biodiversity Establishing at ER Site

#### Horticultural initiatives at BCCL's Eco Restoration Sites

Paddy grown at GKKC. Area



Mustard and Wheat cultivation at Lodna



Kusunda

Sugarcane grown at GKKC, Kusunda Area

Flowers grown at Muraidih, Barora



Maize cult

vation at

MC, Katras

Tomato and vegetables crops being grown at the Muraidib, Barora Area

# Thank You

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