REVIVAL OF DEGRADED ECOSYSTEM THROUGH ECOLOGICAL INTERVENTIONS: A SUCCESS STORY OF MURI, JHARKHAND

Dr Syed Arif Wali[1]
Associate Director and Senior Fellow
Dr Jitendra Vir Sharma[2]
Senior Director
Land Resources Division,TERI, India Habitat Centre, Lodhi Road, New Delhi - 110 003
E.mail: syed@teri.res.in & jv.sharma@teri.res.in
[1] Project Investigator [2] Project Advisor

Mining in India is an important activity as it provides materials for constructing infrastructure and a significant amount of energy and fertilizers that facilitate production of crops. Mining not only leads to infrastructural development but also contributes towards the national gross domestic product (GDP). However, it is also crucial to consider the detrimental impact of mining on the environment that could result into forest degradation, loss of biodiversity and ecosystem services, depletion and alteration of the quality of water resources, impact on livestock and human health, and environmental pollution. Considering these harmful impacts, it has been acknowledged that restoring mining areas is of utmost priority and such areas should be rejuvenated to compensate for the ecological damage that was caused due to past-mining activities. This article focuses on the restoration of the HINDALCO red mud dump site, highlighting the environmental, social, and economic benefits of my reclamation.

Background of the Site

The HINDALCO plant in Muri, Jharkhand, produces large amount of red mud waste, which is alkaline and poses serious environmental hazards. Located near the Swarnarekha River, the red mud dump site is surrounded by residential areas and agricultural fields. TERI undertook the challenge of transforming this inhospitable site into a green zone, providing technical assistance in soil amendments, plantation protocols, and water conservation techniques.

Figure 1: Mr Satish Pai, Managing Director, Hindalco Industries during his visit to TERI's Red to Green project site

Table 1: Amenders used

Name of the amender	Concentration (%)	Bulk density (tonne/m^3)
Gypsum	10	0.9
Farmyard manure (FYM)	10 or 20	0.9
Fly ash	15 or 25	0.7
Mychorriza	10 kg/ha	–

Challenges

Red mud, a byproduct of aluminium production, has a pH of over 11 due to high sodium content. Its poor substrate properties prevent plant growth, while during the dry season, red mud particles become airborne, and in the wet season, soda leaches into groundwater. These challenges made the land unproductive and environmentally hazardous.

Interventions

The project focused on rehabilitating the red mud dump area by converting the highly alkaline red mud into a more hospitable substrate capable of supporting vegetation. This was achieved through various physio-chemical treatments and landscaping activities to mitigate environmental degradation and prevent pollution from the red mud, which is a byproduct of bauxite mining. TERI's approach involved the following multiple interventions:

1. **Soil amendments**: To improve and enhance the impaired physico–chemical properties of red mud, different amenders will be used. The amenders include: gypsum, famyard manure (FYM), fly ash, and mycorrhizae. Based on previous experiences, TERI has standardized the following two most suitable protocol/ combinations in mine rehabilitation elaborated in Table 1:

Combination A: Red mud + Gypsum (10%) + FYM (20%) + Fly ash (15%) + Mycorrhizae

Combination B: Red mud + Gypsum (10%) + FYM (10%) + Fly ash (25%) + Mycorrhizae

2. **Water and soil management**: Extensive levelling, slope construction, and soil conservation measures were implemented to prevent erosion and water contamination.

3. **Plantation spacing**: Following soil preparation, tree species and shrub species were planted across the rehabilitated area. Trees were planted in pits spaced 5 m apart, while shrubs were planted in 2.5 m x 2.5 m spacing. Various grasses and leguminous species were also introduced on slopes using seed-sowing techniques like broadcasting and dibbling.
   The 48 trees species and 5 grass species planted are as follows:

Tree species

The tree species planted include Bougainvillia (*Bougainvillia* sp.), Subabul (*Leucaena leucocephala*), Babool (*Acacia nilotica* or *Vachellia nilotica*), Peltophorum (*Peltophorum* sp.), Balam Kheera (*Kigelia pinnata*), Sheesham (*Dalbergia sisso*), Putranjiva (*Putranjiva* sp.), Medicinal plants, Siris (*Albizia lebbeck*), Ashoka (*Saraca asoca*), Karanj (*Pongamia pinnata* or *Millettia pinnata*), Sindwar (*Vitex negundo*), Udhul (*Hibiscus* sp.), Croton (*Coadiaeum variegatum*), Gulab (*Rosa* spp.), Ber (*Ziziphus mauritiana*), Bamboo (*Dendrocalamus strictus*), Anwla (*Phyllanthus emblica*), Bel (*Aegle marmelos*), Gular (*Ficus racemosa*), Arjun (*Terminalia arjuna*), Jamun (*Syzygium cumini*), Karam (*Adina cardifolia*), Chilbil (*Holoptelea integrifolia*), Mango (*Mangifera indica*), Giloy (*Tinospora cordifolia*), Curry tree (*Murraya koenigii*), Nagkesar (*Mesua ferrea*), Kathal (*Artocarpus heterophyllus*), Neem (*Azadirachta indica*), Gamhar (*Gmelina arborea*), Sonajhuri (*Acacia auriculiformis*), Ratrani (*Cestrum nocturnum*), Dodonaea (*Dodonaea viscosa*), Sindoor (*Bixa orellana*), Sagwan (*Tectona grandis*), Bahera (*Terminalia bellirica*), Kachnar (*Bauhinia variegata*), Hedge (*Ligustrum ovalifolium*), Kusum (*Schleichera oleosa*), and Imli (*Tamarindus indica*)

Grass species

Sweet Sorghum (*Sorghum bicolor*), Sesbania (*Sesbania sesban*), Hamata (*Stylosanthes hamata*), Dubi (*Urochloa oligotricha*), and Deenanath (*Pennisetum pedicellatum*).

4. **Fencing and protection**: To protect the plantation area from grazing animals, barbed wire fencing was installed along the periphery. RCC pillars were used to anchor the fence.

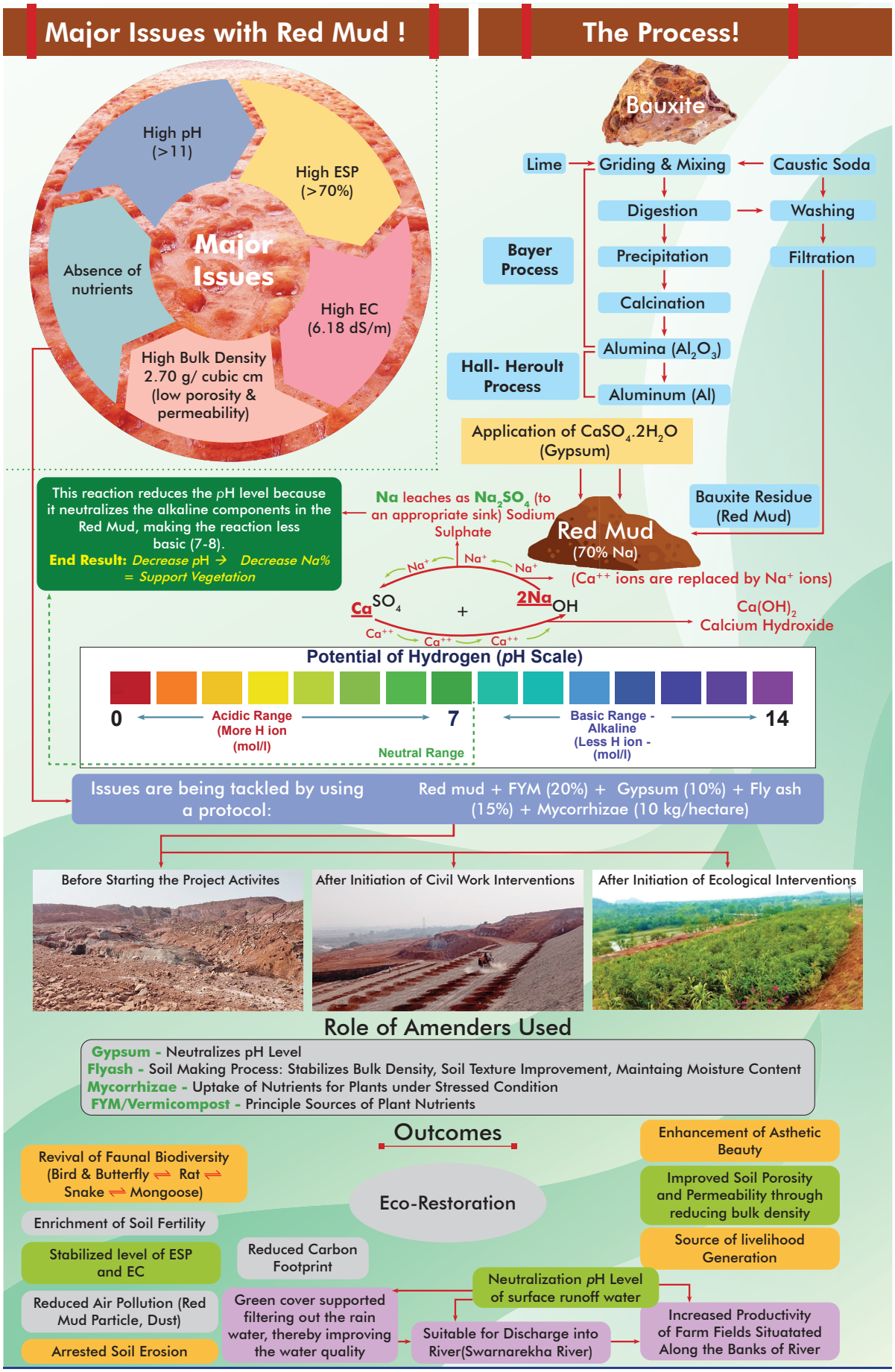

Figure 2: Major issues with Redmud and process of revival of degraded ecosystem through ecological intervention

Results

The restoration efforts yielded significant positive results. Table 2 depicts the two of states—before and after intervention.

Table 2: Before and after states of the site

Feature	Before intervention	After intervention
Vegetation	No vegetation, land had red dump	Species planted successfully grown
pH level	11 and above	Neutral pH 7.5, water is contamination free
EC and ESC level	High electrical conductivity (EC) and exchangeable sodium capacity (ESC)	Stabilized EC and ESC
Flora and fauna	No specific flora and fauna observed	**Flora**: Naturally grown species like Sasbania, Semal, Karanj, Neem, Indian jujube, Castor, Munja, Aristida, Amla, *Casia tora* **Fauna**: Birds, snakes, lizards, rats, butterfly, honey bee, mongoose, arthropods like millipede, different types of ants

Out of the **48 tree species**, the best-performing trees include Peltophorum (*Peltophorum* sp.), Karanj (*Pongamia pinnata*), Kachnar (*Bauhinia variegata*), Gamhar (*Gmelina arborea*), Arjun (*Terminalia arjuna*), Siris (*Albizia lebbeck*), Chilbil (*Holoptelea integrifolia*), Balam Kheera (*Kigelia pinnata*), Subabul (*Leucaena leucocephala*), Neem (*Azadirachta indica*), Moringa (*Moringa oleifera*), Baheda (*Terminalia bellirica*), Amla (*Phyllanthus emblica*), Ber (*Ziziphus mauritiana*), Bamboo Curry tree (*Murraya koenigii*), Kachnar (*Bauhinia variegata*), and Kaner (particularly red and yellow varieties) (*Nerium oleander*).

The best-performing **grasses** include Sweet Sorghum (*Sorghum bicolor*), Hamata (*Stylosanthes hamata*), and Dubi (*Urochloa oligotricha*).

The implementation of green vegetation cover on red mud ponds offers a multitude of environmental and socioeconomic benefits. By reducing bulk density, the soil porosity and permeability are improved, leading to enhanced water infiltration and reduced runoff. Moreover, the green vegetation layer acts as a natural buffer, neutralizing the pH of rainwater and ensuring its suitability for discharge into rivers, thereby maintaining ecological balance and supporting agricultural productivity. The project also contributes to a reduced carbon footprint, enhances aesthetic appeal, prevents red mud erosion, and creates new livelihood opportunities.

Conclusion

This article demonstrates the successful ecological restoration of a degraded red mud site. The project highlights the importance of a comprehensive approach that addresses both soil and vegetation restoration. The findings provide valuable insights for future restoration efforts in mining-impacted areas. By implementing effective restoration strategies, it is possible to mitigate the negative impacts of mining and promote sustainable land management.

Glimpses of redmud rehabilitation activities

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