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D. C. Jha
Bharat Coking Coal Limited, India

Rajkumar
Bharat Coking Coal Limited, India

Harish Pal
Bharat Coking Coal Limited, India

Mamta Rani
Bharat Coking Coal Limited, India

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Significance of grasses in establishment of ecological restoration in mined out degraded land in Jharia coalfield, Dhanbad

D.C. Jha, Rajkumar*, Harish Pal, Mamta Rani

Director (Tech), Bharat Coking Coal Limited, Dhanbad, India

*Corresponding author e-mail: rbansal09@gmail.com

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Introduction

This paper reviews the experience of ecological restoration adopted by Bharat Coking Coal Limited (BCCL), a Miniratna Company, a subsidiary of Coal India Limited, Government of India, Public Sector Undertaking to restore the mined out degraded land in Jharia Coalfield (JCF). JCF is one of the oldest coalfield of India and was mined in an unscientific manner for more than 100 years by the erstwhile private entrepreneurs until it was nationalised in 1972-73, due to which the coalfield was subjected to severe land degradation, mine fires and subsidence. The total degraded land in the JCF in 1986 was 6,294 hectares. In the span of ~25 years (1986-2011), BCCL had taken up plantation/afforestation on 3676 ha of degraded lands through District Forest Office. Now, BCCL is trying to restore these mined out degraded land ecologically. The ecological restoration is to establish a three-tier vegetation comprising of native species grasses as lower tier, shrubs and bushes as middle tier and trees as upper tier with an objective to establish biodiversity and food chain; to improve the local climate regime and socio-economic condition. In 2011, BCCL in association with Forest Research Institute (FRI), Dehradun and Prof. CR Babu, Centre for Environmental Management of Degraded Ecosystem (CEMDE), Delhi University started ecological restoration of the mined out degraded land and overburden dumps. Two study sites were taken up in 2011-12; one at Damoda (23°47'N and 86°30'E) of 7 ha and another at Tetulmari (23°81'N and 86°33'E) of 8 ha, respectively. The mined dumps were composed of big and small boulders of shaly sandstone, sandstone, shale and with traces of soil. Earlier, these dumps were profusely invaded by exotic weeds like *Parthenium hysterophorus*, *Croton bonplandianus*, *Xanthium strumarium* and *Eupatorium odoratum*, *Lantana camara*. Due to more than 100 years of mining and severe land degradation, there is no soil cover on the dumps and was poor in nutrients.

Efforts were specially made in selection of species which are native to the region; generate the large quantity of biomass to enrich the soil; ability to stabilize the soil structure; utility to the local community. Therefore, species of trees, shrubs, herbs, grasses with multiple use value like fuel, fodder, fruit, medicine were used during the process of ecological restoration.

In our study, the importance was given to the establishment of grass cover as grasses generate larger quantity of biomass; stabilize the slopes and bind the stratum. The grass cover also plays a key role in establishment of the lower trophic levels of the ecosystem. The grass species introduced are *Cenchrus ciliaris*, *Cenchrus setigerus*, *Pennisetum pedicellatum*, *Heteropogon*, *Stylosanthes hamata*, *Chrysopogon*, *Bothriochloa*, *Thysanolaena latifolia*, *Dichanthium*, *Arundo*, *Eragrostis*, *Cynodon dactylon*, *Chloris*, *Digitaria*, *Saccharum spontaneum*, and *Panicum*. In addition, Shrub species *Dodonaea viscosa*, *Vitex negundo*, *Dendrocalamus strictus*, *Dendrocalamus asper* and *Bambusa bambos*, *Woodfordia fruticosa*, *Calotropis procera*, *Cassia tora*, *Datura stramonium*, *Ziziphus mauritiana*, *Tephrosia purpurea*, *Adhatoda zeylanica* and *Agave sisilana* and the tree species *Albizia procera*, *Dalbergia sisso*, *Phyllanthus embilica*, *Albizia lebbeck*, *Bahunia variegata*, *Aegle Marmelos*, *madhuca indica*, *Ficus religiosa*, *Ficus hispida*, *Syzygium cumini*, *Casia Fistula* etc have been introduced.

Materials and Methods

First step was removal of invasive weeds like *Lantana camara*, *Eupatorium odoratum*, *Chromolaena*, *Parthenium* from the study sites followed by fencing to protect the site from cattle grazing by stone wall fencing, trench cutting all along the boundary of the site. Plant propagules of *Vitex negundo* and seeds of *Acacia arabica* were planted all along the periphery of sites for bio-fencing. The second step was preparation of seed balls of grass species seeds of *Cenchrus ciliaris*, *Cenchrus setigerus*, *Pennisetum pedicellatum*, *Heteropogon*, *Stylosanthes*, *Chrysopogon*, *Bothriochloa*, *Thysanolaena latifolia*, *Dichanthium*, *Arundo*, *Eragrostis*, *Cynodon dactylon*, *Chloris*, *Digitaria*, *Saccharum spontaneum*, *stylosanthis hamata*, and *Panicum Nitidum* by mixing with soil and cow dung in ratio of 1:10:5; spreaded all over the dump including slopes. *Dodonaea viscosa*, *Dendrocalamus strictus*, *Indigofera trita*, *Mucuna pruriens*, *Withania somnifera*, *Bambusa*

bambos among bushes/shrubs species were selected for second tier to attract insects, butterflies, bees, arthropods, birds and mammals. *Aegle marmelos*, *Albizia*, *Bauhinia purpurea*, *Butea*, *Dalbergia sissoo*, *Madhuca indica*, *Ziziphus*, *Phyllanthus emblica*, *Casia fistula*, *Terminalia arjuna*, *Phoenix Dactilyfera* etc. among native tree species as the third tier were introduced to create natural forest and establish biodiversity. The seeds of the various native species bushes/shrubs and trees were also spread over the sites to increase the floral density. All the plantation and seed broadcasting was done during the monsoon season. Regular irrigation was practiced to ensure the proper growth of the flora. Mulching was widely carried out by cutting down the matured grasses for moisture conservation.

Results and Discussion

Both the study sites before the ecological restoration were completely devoid of grass cover. With the initiation of ecological restoration, seeds of various grass species were sown and have completely covered ground of the site with eradication of weeds from the sites. Grasses like *Pennisetum pedicellatum*, *Cenchrus setigerus*, *Cenchrus ciliaris* and, *Saccharum spontaneum* have grown up to the height of 4-6 feet. Degradation of the biomass is triggering the top soil generation at the sites. Plants litter and root exudates provide nutrient-cycling to soil. The shrubs and bushes like *Dodonaea* have shown significant results. With in short period of 3 years, growth of bamboos is tremendous and many bamboos have grown to the height of 15-20 feet and have started propagating. The trees of *Albizia* and *Ziziphus* have grown up to the height of 12-15 feet and girth of 3-4 inches. *Bauhinia purpurea* has also shown good results with average height of 9-10 feet and diameter of 1.5 inches. Besides successful growth of flora, fauna like chameleons, frogs, grass hoppers, lizards, snakes, butterflies, mouse, rabbits, sparrows, parrots, squirrels, caterpillars, earthworms, centipedes etc have also been seen at the site after successful restoration indicating the development of a self-sustaining ecosystem and food chain.

The success of both the study sites was exemplary and un-precedential. This was achieved in spite of demanding challenges from highly degraded coal mining areas. The challenges consisted of absence of soil cover where the terrain comprised of boulders; the mined out degraded lands were thickly invaded by the exotic weeds and their removal from these sites.



Plate 1- Mined out degraded land study site, Damoda (2011-12)



Plate 2- Grass cover establishment and ecologically restored study site, Damoda (2014-15)

Conclusion

BCCL is the pioneer coal company in establishing the ecological restoration on mined out degraded land. The regulatory authorities have also started recommending the ecological restoration to other mining companies. The company has set an example in coal industry by achieving success in ecological restoration of mined out degraded land. The establishment of grass species play a significant role in ecological restoration grass species which have been successfully grown on degraded land. On the basis of growth of species grasses, bushes/shrubs, and tree species have been identified which can be planted for ecological restoration of mined out land. The grass species that can successfully be grown on mine out degraded land are *Cenchrus ciliaris*, *Cenchrus setigerus*, *Pennisetum pedicellatum*, *Heteropogon*, *Stylosanthes*, *Chrysopogon*, *Bothriochloa*, *Broom Grass*, *Dichanthium*, *Arundo*, *Eragrostis*, *Cynodon dactylon*, *Chloris*, *Digitaria*, *Saccharum spontaneum*, *S.hamata*, and *Panicum Nitidum* and various native species bushes, shrubs and trees can also be grown.

The establishment of grass cover has helped in generation of large quantity of biomass and increase the nutrient availability in the mined out lands and establishment of the ecosystem. The wide spread network of the roots of the grasses has helped in stratum binding and stabilization of the slopes. Various living beings of the lower trophic levels of the ecosystem like butterflies, bees, arthropods, insects etc have developed their niche in the grasslands and attracting the other higher trophic level organisms. On some overburden dumps with mine fire, it has been observed that establishment of grass cover on these overburden dumps have reduced these fires and prevent the further expansion of the fires. Subsequent to the success of the study sites, BCCL has drawn up a plan for ecological restoration of about 226 ha mined out degraded land up to 2018-19. BCCL has already started ecological restoration work on 120 ha of land.

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