USE OF BIOFERTILIZER FOR RECLAMATION OF SILICA MINING AREA[1]

Kumud Dubey*, V.K. Singh, C. M. Mishra and Ashwani Kumar[2]

Abstract. Mining is one of the necessary evils of the modern world. Mining gives rise to sharp changes in the landscape and causes adverse ecological impact due to depletion of flora and fauna and loss of fertile soil and also encourages soil erosion, deteriorates water quality and destroys microbial communities. There is, therefore, an urgent need to develop and extend technological measures to reclaim these areas for potential use. In most of the reclamation program, microbial deficiency creates problems in establishment of the plants and their natural growth. Use of beneficial microorganisms like VAM, Rhizobium, Azotobacter, Phosphate Solubilizing Microorganism (PSM), and Blue Green Algae (BGA) etc. in the reclamation program is helpful for prompt reclamation of the mining areas. The present study is aimed to explore the possibility of application of these microbes as biofertilizer in restoring, rehabilitating and increasing the productivity of the site through revegetation program. Site selected was a Silica mining site, which was severely degraded due to opencast mining. As a prelude for reclaiming this mining site, a nursery trial of selected species *viz. Acacia nilotica, Acacia catechu, Butea monosperma and Pongamia pinnata* was carried out to study effect of different bio-fertilizer combinations on their germination and growth behavior. The species selected are the predominating species of the area. The bio fertilizers used were *Azotobacter, Rhizobium*, Phosphate Solubilizing Microbes, Blue Green Algae and VAM combination. The germination and growth data of selected species after the inoculation with biofertilizers were recorded periodically. It was observed that these biofertilizers significantly affected the growth of species studied. Nursery trial results also indicated that germination time was also reduced in seeds inoculated with different bio fertilizer combinations as compared to control. These inoculated seedlings were then planted at Silica mining site and observed for their performance. It was observed that inoculated seedlings were performing better than the control.

Additional Key Words: Silica mining, Reclamation, *Azotobacter, Rhizobium*, Phosphate Solubilizing Microbes, Blue Green Algae and VAM

---

[1]Paper was presented at the 2006 Billings Land Reclamation Symposium, June 4-8, 2006, Billings MT and jointly published by BLRS and ASMR, R.I. Barnhisel (ed.) 3134 Montavesta Rd., Lexington, KY 40502.

[2]Kumud Dubey: Scientist, Centre for Social Forestry and Eco-Rehabilitation.337-Ashok Nagar, Allahabad-211001. India; V.K. Singh: Conservator of Forest, Centre for Social Forestry and Eco-Rehabilitation.337-Ashok Nagar, Allahabad-211001. India. Presently posted at Dharmshala, Himachal Pradesh, India; C. M. Mishra: Scientist, Forest Research Institute, Kanpur , Uttar Pradesh , India; Ashwani Kumar: Director, Forest Research Institute, Kanpur , Uttar Pradesh , India.

Proceedings America Society of Mining and Reclamation, 2006 pp 176-181
DOI: 10.21000/JASMR06010176

http://dx.doi.org/10.21000/JASMR06010176

Introduction

Mining industry is next only to the agriculture and is spread allover the world. The earth contains a vast richness of minerals, which human being extracts and fashions into various goods of daily use and serve the needs of industry. Since most of the mining areas are associated with forest, the exploration and exploitation of mineral wealth brings in complete destruction of forest and vegetation in the area and formation of new wastelands in the form of barren dumps of mine overburdens with consequential ecological disturbances and environmental hazards. Opencast mining, where ores are recovered from exposed areas scars the landscape, disrupts ecosystems and destroys microbial communities. Apart from unsightly impacts, the degraded environments created in the aftermath of opencast mining cannot support biomass development. Put another way, extensively mined land usually does not possess sufficient surface soil to anchor plants and the plant growth that does take place is inhibited by the presence of toxic metals. These sites, which in lay terms amount to toxic dumps, leave the land devoid of topsoil, nutrients and supportive micro flora and vegetation – in a word, barren. In India, gradual increase in such landscapes due to intensive mining activity endangers the forest productivity (Saxena and Chatterji, 1988a, 1988b). Such changes, in turn, carry adverse economic and social impacts for nearby communities whose residents depend on the region's natural resources for large portions of their incomes. Considering these negative impacts, the revegetation of these mining areas becomes imperative to counter hazards and restore the ecological balance. From the literature it follows that in India, serious and sincere reclamation measures based on scientific research findings have not been taken in most of the mined areas. Moreover this revegetation of the mining areas of the country is not achieving desired success because of high rate of mortality and slow growth of planted species.

The main issues to be considered in mined land reclamation are: nutrient deficiency, potentiality of erosion, dominance of coarse fraction leading to low moisture retention and lack of biological activities. In most of the reclamation program, microbial deficiency creates problems in establishment of the plants and their natural growth. Soil microbes not only fix nitrogen symbiotically but the microbes like Phosphate Solubilizing Microbes (PSM) render unavailable form of phosphorus to available form of phosphorus reduce the dependence on phosphorus from external sources. The use of biofertilizers for reclamation leads to achieve the fertility of barren dumps in a very short time, thus improving the water holding capacity of soil and creating topsoil to sustain high quality vegetation forever. Moreover, soil microbes also exhibit great metabolic versatility, which allows them to adapt to the low nutrient levels and adverse chemical and physical characteristics of mine wastes. There are several evidences that the disturbed sites may be revegetated more promptly when the seedling of planted species are pre-inoculated with microbial inoculants (Adholeya et al., 1997; Bhatia et al, 1998; Anon, 2002; Fay et al., 1999; Franco et al., 1997; Haselwandter and Bowen, 1996; Mishra, 1991; Reddell et al., 1999; Setiadi, 2002; Sharma et al., 2001; Sharma et al, 1997). But the uses of beneficial microorganisms like VAM, Rhizobium, Azotobacter, Phosphate Solubilizing Microorganism (PSM), and Blue Green Algae (BGA) etc. in the reclamation program has received less attention and poorly explored. Use of biofertilizers may be helpful in the development of a low cost technology to rehabilitate the mining areas and increase their productivity.

An important mine of Silica, a major mineral used in glass industry, is situated in Vindhyan Hills of Uttar Pradesh state and its extensive quarrying and open cast mining have resulted into long barren, unproductive and deeply irregular sloppy lands. But no serious and sincere measures pertaining to rehabilitation of silica-mined area of Uttar Pradesh have been reported. Field experimentation involving various components is still lacking which need to be taken up in a comprehensive manner. Thus the development of suitable technological package for reclamation of silica mined areas through a systematic research program is needed. Use of beneficial microorganisms like Vesicular arbuscular mycorrhizae (VAM), Rhizobium, Azotobacter, Phosphate Solubilizing Microorganism (PSM), and Blue Green Algae (BGA) etc. in the reclamation program is helpful for prompt reclamation of the mining areas(Setiadi, 2000;2001;2002). The present study is aimed to explore the possibility of application of these microbes as biofertilizer in restoring, rehabilitating and increasing the productivity of this silica-mining site through revegetation program.

Material and Methods

As a prelude for reclaiming this mining site, a nursery trial of selected species *viz. Acacia nilotica, Acacia catechu, Butea monosperma and Pongamia pinnata* was carried out to study effect of different bio-fertilizer combinations on their germination and growth behavior. The species selected are the predominating species of the area. The bio fertilizers used were *Azotobacter, Rhizobium*, Phosphate Solubilizing Microbes, Blue Green Algae and VAM combination. The biofertilizers were supplied with carrier medium (wood charcoal) in form of colony forming units and for VAM the medium was soil. In case of *Azotobacter,* there were $1.5 * 10^9$ cfu /gm of carrier medium, *in Rhizobium* it *was*$1.2 * 10^9$ cfu/gm, for Phosphate Solubilizing Microbes it was $1.5* 10^8$ cfu/gm, for Blue Green Algae it was $1* 10^8$ cfu/gm and for VAM combination it was $1.8* 10^7$ clamydospores/ gm of soil. In nursery trial the seeds of the selected species were sown in sterilized soil amended with different combinations of biofertilizers. The biofertilizers were applied as a layer in polythene bag at seed sowing depth and 5 gm of each biofertilizers were taken for each treatment. Total twelve treatments of biofertilizer combination were studied. These biofertilizer combinations were VAM combination (*Glomus fasciculatum* & *G.aggregatum*), *Rhizobium*+VAM , Azotobacter +VAM , *Rhizobium*+ PSM(Baciillus megathenium), Azotobacter+ PSM, Blue green algae(Nostoc sp.) + PSM ,*Rhizobium ,Azotobacter*, Blue green algae, PSM, VAM + *Azotobacter* + PSM +*Rhizobium* +Blue green algae and Control. Germination trend was recorded. Growth data (height) was recorded quarterly.

Results and Discussion

Germination percentage of the selected species was recorded and it was found that in case of Acacia *catechu* and *Acacia nilotica* the germination in biofertilizer combination , VAM+ *Rhizobium* , was best followed by the VAM combination and in case of combination of VAM with Azotobacter as compared to control. In case of *Butea monosperma* the germination percentage was best in combination, VAM + *Azotobacter* + PSM +*Rhizobium* +Blue green algae fallowed by with VAM combination, *Rhizobium*+ VAM and *Azotobactor* +VAM. It was observed that best germination of *Pongamia pinnata* was found with VAM combination fallowed by Azotobacter +VAM and VAM + *Azotobacter* + PSM +*Rhizobium* +Blue green algae (Table 1). As far as growth performance was observed, a significant improvement in the growth of all four plant species were seen in all biofertilizer combinations over control. In case of *Acacia catechue* the best growth was observed with combination VAM+ Rhizobium fallowed by combination VAM+ Azotobacter and VAM combination. Whereas, the best growth performance of *Acacia nilotica* was observed with VAM+ Azotobacter followed by VAM combination. The growth performance of *Butea monosprma* was better in combination, VAM + *Azotobacter* + PSM +*Rhizobium* +Blue green algae in comparison to the other combinations. *Pongamia pinnata* showed better performance with VAM combination in comparison to the others (Table 2). Plants were studied for the mycorrhizal association and root nodule formation. Mycorrhizal association was present in all four species but rhizobial nodules were observed in leguminous species only. All other microbial biofertilizers were present in the rhizosphere soil (data are not shown).

Table 1. Germination percentage of the selected species with different biofertilizer treatments.

S. No.	**Biofertilizer Combinations**	**Percentage of Germination**			
		A. catechue	***A. nilotica***	***B. monosperma***	***P. pinnata***
1.	Control	36.67	34	80	31
2.	*Rhizobium*	59	40	82	35
3	*Azotobacter*	59	39	84	52
4.	PSM	47	36	84	35
5.	Blue green algae	49	36	86	52
6.	VAM comb.	65	45	97	80
7.	*Rhizobium*+VAM comb.	66	52	86	62
8.	Azotobacter +VAM comb.	64	42	86	79
9.	*Rhizobium*+ PSM	52	41	96	52
10.	Azotobacter+ PSM	49	41	96	54
11.	Blue green algae + PSM	50	38	84	53
12.	VAM comb. + *Azotobacter* + PSM +*Rhizobium* +Blue green algae	56	38	100	63

Since plantation activities at problem sites require some additional attention to reduce transplantation shocks, disease incidence, drought conditions and nutritional deficiency. Inoculation of biofertilizers ensures the establishment of seedlings with minimal number of mortality in any plantation. In addition, integrating such biofertilizers as *Azotobacter, Rhizobium* and endomycorrhizal fungi on to the saplings would enable the plant species to become more tolerant to stress by ensuring continuous supplies of nutrients during their early stages of growth. The above studies reveal that inoculations of suitable microbes increase the plant growth and on the basis of their effect on the growth performance of the selected plant species the potential biofertilizer combinations can be selected for each species. After the field plantation trial of these inoculated seedlings at Silica mining area, the best performing combination may further be recommended for reclamation program of such degraded sites. Therefore, reclamation with biofertilizers seems to be an attractive and cost-effective alternative for revegetating the barren mine land.

Table 2. Growth Performance (Height) of the Selected Species with Different Biofertilizer Treatments.

S. No.	Biofertilizer Combinations	Height (in cm) after 6 months			
		A. catechue	***A. nilotica***	***B. monosperma***	***P. pinnata***
1.	Control	29.22	41.52	17.50	14.93
2.	*Rhizobium*	41.61	56.76	20.25	15.70
3	*Azotobacter*	40.27	58.38	22.23	18.82
4.	PSM	29.22	50.77	21.25	16.57
5.	Blue green algae	36.83	45.67	21.61	17.84
6.	VAM comb.	47.00	68.22	23.94	26.56
7.	*Rhizobium* +VAM comb.	48.94	67.95	23.89	17.84
8.	Azotobacter +VAM comb.	45.67	68.75	25.61	25.06
9.	*Rhizobium*+ PSM	44.50	60.11	22.42	20.79
10.	Azotobacter+ PSM	45.10	62.27	23.45	23.17
11.	Blue green algae + PSM	37.14	60.65	24.25	21.53
12.	VAM comb. + *Azotobacter* + PSM +*Rhizobium* +Blue green algae	36.94	60.65	25.76	23.08

Literature Cited

Adholeya A; Sharma MP; Bhatia N P; Tyagi C. (1997). Mycorrhizal Biofertilizers: a tool for reclamation and biofertilizer In proceeding: National Symposium on Microbial Technology in Environmental Management and Resource Recovery.1-2 October 1997. New Delhi.

Bhatia NP.; Adholeya A.; Sharma A.(1998). Biomass production and changes in soil productivity during long term cultivation of Prosopis juliflora inoculated with VAM and Rhizobium spp. In a semi-arid wasteland, Biology and Fertility of Soils, 1998,26:3,208-214. http://dx.doi.org/10.1007/s003740050369.

Anon, (2002).CBR - Centre for Biotechnology Research, Effect of bio- organic on soil and plant productivity improvement of post tin mine site at PT Koba Tin Project Area, Bangka. Centre for Biotechnology Research, Bogor Agricultural University, October 2002.

Fay DA; Mitchell DT; Parkes, MA. (1999). A preliminary study of the mycorrhizal association of tree seedlings growing on mine spoil at Avoca, Co. Wicklow, Biology and Environment: Proceedings of the Royal Irish Acad., Section B, 1999,99:1,19-26.

Franco AA; Faria SM-de; De Faria SM. (1997). The contribution of N_2 Fixing tree legumes to land reclamation and sustainability in the tropics. In international symposium on Sustainable agriculture for the tropics: the role of biological nitrogen fixation, Angra dos Ries, Rio de Janerio, Brazil, 29:5-6.

Haselwandter, K. and G.D. Bowen (1996). Mycorrhizal relations in trees for agroforestry and land rehabilitation in Forest Ecology and Management 81: 1-17. https://doi.org/10.1016/0378-1127(95)03661-X

Mishra A. (1991). Strategies for reclamation of mine areas through help of selected microbes, Symp. on strategies for ecosystem conservation, Bot. Section, 78th ISCA session: 64- (Abst.).

Reddell P; Gordon V;Hopkins MS. (1999). Ectomycorrhizas in E. tetrodonta and E. miniata in forest communities in tropical and their Role in rehabilitation of these forest following mining. Australian J. of Botany. 47:6,881-907. http://dx.doi.org/10.1071/BT97126.

Saxena, S.K. and Chatterji P.C. (1988a). Ecological imbalance caused by mining, 223-241 in Rajasthan and their Restoration. Mining and Environment in India. Joshi and Bhattacharya (eds.). HRG Publication Series, Nainital, India.

Saxena, S.K. and Chatterji P.C.(1988b). Mining activity and creation of wasteland in western Rajasthan, 41-61. Wasteland development and their utilization. Edited by K.A. Shankarnarayan, Scientific Publisher, Jodhpur

Setiadi, Y. (2002). Pengembangan cendawan mikoriza arbuskula sebagai agent biologis, untuk merehabilitasi lahan kritis di Indonesia. Makalah disampaikan dalam “Pengenalan Potensi Pupuk Biologis”, 9 Februari 2002, PT KobaTin, Bangka, 12 hal.

Setiadi, Y. 2002. Mycorrhizal inoculum production technique for land rehabilitation. Journal of Tropical Forest Management Vol. VIII, No. 1:51-64.

Setiadi, Y. 2001. Arbuscular mycorrhizal inoculum production for reforestation in Indonesia. International Workshop of BIO-REFOR, Tokyo, Japan. Oct 7-11, 2001.

Setiadi, Y. 2000. Mycorrhizal seedling production for enhancing rehabilitation of degraded forest in Indonesia. Workshop of Forest Restoration for Wildlife Conservation, Chiang Mai, Thailand. Jan 30 – Feb 4, 2000.

Sharma MP; Bhatia NP; Chauhan RKS; Adholeya A. (2001). A Mycorrhizal dependency and growth responses of Acacia nilotica and Albizzia lebbeck to inoculation by indigenous AM fungi as influenced by available soil P levels in a semi-arid Alfisol wasteland. New Forests. 21 (1): 89-104. http://dx.doi.org/10.1023/A:1010636614005.

Sharma MP; Bhatia NP; Gaur A; Adholeya A. (1997). Mycorrhizal dependency of Acacia nilotica and Eucalyptus tereticoris to inoculation of indigenous VA Mycorrhizal fugal consortium in marginal wasteland soil. In p*roceedings XIth World Forestry Congress* [Organized by Ministry of Forestry of Turkey and Food and Agriculture Organization. 13-22 October 1997. Antalya, Turkey.