

# CATALYTIC EFFECTS OF PLANTATION AND MICROBIAL INOCULATION IN NATURAL REGENERATION ON LIMESTONE MINED SPOIL

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## ABSTRACT

The experimental plantation of *Pongamia pinnata*, *Jatropha curcas*, *Ailanthus excelsa* and *Withania somnifera* supplemented with native microbial inoculants produced a catalytic effect on natural regeneration process in planted area on nutrient poor calcareous spoil. The planted area of the spoil showed accelerated immigration of surrounding flora which resulted into enhanced frequency, abundance, relative frequency of pioneering species as compared to unplanted area. Plantation supplemented with microbial inoculation has helped to accelerate jump start succession on mined spoil.

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### KEY WORDS

Limestone mine spoils;  
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## [I] INTRODUCTION

The natural plant succession is the important process in the vegetation development [1]. During mining activities the components of soil ecosystem of affected land is jeopardized. Natural recovery of such a harsh site of un-amended spoil is a slow process as the initial level of many nutrients in the successional process in mine spoil has been in the lower quantity [2, 3]. This is possibly the prime reason for slow vegetational development on un-amended mine spoils. Plantation may alter edaphic conditions and may play as a catalyst for natural regeneration on mine spoils. When the plantation is supplemented with microbial inoculants, Physico-chemical properties of soil are converted suitable for planted species and it allows other species to grow naturally and also provide shade to protect the herbaceous vegetation. Introduction of plant species attracts immigration of naturally grown surrounding plant species and if they established, may result into a distinctive floral cover on mined lands. During ecosystem development on mine spoils, accumulation of nutrients take place and ultimately a self-sustaining ecosystem is developed. Invasion of native herbaceous species along with planted species may play a significant role in increasing the floral diversity [4]. In the present investigation, an effort is made to explain how the plantation supplemented with microbial inoculants stimulates natural regeneration process on completely unvegetated mined out degraded land.

## [II] MATERIALS AND METHODS

### 2.1. Study site

The study area is an important centre of limestone mining activities. There are number of lime stone quarries and lime manufacturing units in operation. Due to extensive mining for lime stone, over burden dumps of mined out waste materials (spoil) is spread all through the area creating heaps or mounds of different age groups. The study site is located at Bistara on Jhukehi-Kaimur road in Katni district of Madhya Pradesh, India. The study site lies between 80° 27'29" E longitude and 23° 58' 36" N latitude at an altitude of 380.0 m (MSL) and the area falls under semi-arid ecological settings

### 2.2. Plantation and microbial inoculation

An experimental plantation was carried out on completely unvegetated limestone mined out spoil. Prior to planting soil nutrients level were analyzed. The spoil was planted with seedlings of *Jatropha curcas*, *Pongamia pinnata*, *Withania somnifera* and *Ailanthus excelsa*. All the seedlings were boosted up by inoculation of consortium of microbial inoculants like Arbuscular Mycorrhizal Fungi (AMF), *Pseudomonas fluorescens*, *Azospirillum sp.* and *Azotobacter sp.* These microbes were native these spoils and were well adapted to such soil conditions. After isolation from spoil, microbes were grown on their respective growth medium and were multiplied in bulk for field application. The seedlings were grown in polyethylene bags filled with soil collected from limestone mined spoils. Soil was ground to suitable size and duly sterilized before raising the seedlings. After sprouting in the seedlings, above consortium of microbial cultures were inoculated and due care was taken to avoid contamination. After six months of inoculation, the seedlings were transplanted to mined spoils and were allowed to acclimatize in

calcareous soil conditions. At the time of transplantation, again the seedlings were inoculated with consortium of microbial inoculants.

### 2.3. Planting technique

Before onset of monsoon, pits of 30cm<sup>3</sup> were dug at spacing of 2m×2m. There was no soil change made into pits and 6 months old seedlings were used for plantation. The seedlings were gently placed in the pits after removing the polyethylene bags. Seedlings were inoculated with microbial biofertilizers (either singly or in combination) at the time of plantation and the pits were covered with excavated soil immediately. There was sufficient moisture in the soil along the month of peak monsoon (July), which can help the growth and proliferation of inoculated microbial consortium. The application of different treatments was made by putting the inoculum in the rhizosphere of seedlings planted in mine spoil. The broth culture of bacterial inoculum was diluted 4 times and placed in the rhizosphere of plant @30 ml per plant. While AMF culture containing *Glomus mosseae*, *Glomus intraradices*, *Glomus deserticola*, *Gigaspora rosea*, *Gigaspora margarita*, *Acaulospora scrobiculata* and *Acaulospora denticulata* were placed in the rhizosphere @50g soil inocula having 300 infective propagules. The mixture of AMF and bacterial inoculant was added @ 50g of AMF inocula mixed with 30 ml. diluted bacterial culture and these were placed in the rhizosphere of the seedlings planted in the limestone mined spoil. The experiment was started in the month of July, 2004 and the observations on natural regeneration were recorded after two years of plantation in the month of August 2006.

### [III] RESULTS

Plantation of suitable species supplemented with microbial inoculants has catalyzed the process of invasion of native herbaceous flora on mined spoils. Plantation accelerated the natural succession process. In the present study the pioneering species which occurred in the spoil were *Phyllanthus niruri*, *Tridax procumbens*, *Ocimum gratissimum*, *Argemone mexicana*, *Zizyphus mauritiana*, *Acacia nilotica* and *Parthenium hysterophorus* which established through successional process in mined spoil [Supplementary Table-1]. In planted area, the natural regeneration of *Phyllanthus niruri* and *Argemone mexicana* was recorded highest with frequency (60% each) and abundance value of 1.8 and 2.2 respectively which was followed by *Tridax procumbens*, *Ocimum gratissimum*, *Parthenium hysterophorus*, *Acacia nilotica* and *Zizyphus mauritiana*. In planted area the abundance value was recorded highest (2.2) for *Argemone mexicana*. In unplanted area, the occurrence of colonizing species was less frequent. *Tridax procumbens* and *Argemone mexicana* represented in higher frequency (40%) followed by *Phyllanthus niruri*, *Ocimum gratissimum*, *Zizyphus mauritiana*, *Parthenium hysterophorus* and *Acacia nilotica*. The abundance was recorded maximum (1.7) for *Phyllanthus niruri* which was followed by *A. mexicana*, *P. hysterophorus*, *T. procumbens*, *O. gratissimum*, *Zizyphus mauritiana*, and *A. nilotica*. Although each species was occurring in both planted and unplanted area but the frequency of their occurrence and their abundance was greater in planted area as compared to unplanted area of the overburden dump.

### [IV] DISCUSSION

This could be the effect of plantation and microbial treatments given to the planted species which promoted the colonizers for establishment. The microbial population in rhizosphere possibly contributed in the availability of nutrients needed by the growing vegetation. In the dolomite mine spoils, plantations of *Gmelina arborea*, *A. auriculiformis*, *E. tereticornis* and *P. pinnata* produced the same effects on bauxite mine spoils [5]. Plantations may improve soil through rooting and incorporation of organic matter. With the passage of time there may be some modification in the physico-chemical characteristics in the mined spoil. Improvement of spoil conditions promoted plant succession of mined spoil. It is evident that by plantation, the spoil condition is modified and gradual development of ecosystem took place and resulted into natural succession of herbs and plant species. Thus, it is evident that the plantation on mined spoil initiated the natural succession process. The results of present study are in conformity with the results of other restoration ecologists who observed accelerated rate of natural succession after plantation on mine spoils [6]. There are similar reports of higher rate of natural succession after plantation on coal waste dumps [7].

### [V] CONCLUSION

Plantation on mined spoil created catalytic effects to restore soil fertility and ameliorate microclimatic conditions. The plantation supplemented with beneficial microbial inoculants has shown greater influence on the natural regeneration process on mined spoil. Consortium of bacterial inoculants and arbuscular mycorrhizal fungi is supposed to accelerate nitrogen fixation and phosphatase enzyme activity in the rhizosphere of plants which would have ensured the supply of nitrogen and phosphorus in the soil. More over, plant cover prevented soil from erosion thus increased the infiltration rate of the water in the soil. All these changes and favorable alteration of soil characteristics caused immigration of surrounding native herb and tree species and resulted into jump start succession on mined site.

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Supplementary Table–1: (As supplied by author)

S. No	Species Appeared	Planted area				Unplanted area			
		Frequency (%)	Relative frequency (%)	Abundance	A/F	Frequency (%)	Relative frequency (%)	Abundance	A/F
1.	<i>Phyllanthus niruri</i>	60	19.35	1.8	0.0305	30	15.8	1.7	0.055
2.	<i>Tridax procumbens</i>	50	16.12	1.8	0.036	40	15.8	1.5	0.037
3.	<i>Ocimum gratissimum</i>	50	16.12	1.3	0.025	30	15.8	1.0	0.033
4.	<i>Argemone mexicana</i>	60	19.35	2.2	0.037	40	21.09	1.5	0.037
5.	<i>Zizyphus mauritiana</i>	20	6.45	1.0	.05	20	10.5	1.0	0.05
6.	<i>Acacia nilotica</i>	30	9.7	1.7	0.057	20	10.5	1.0	0.05
7.	<i>Parthenium hysterophorus</i>	40	12.9	1.0	0.025	20	10.5	1.5	0.05

Table 1 -Natural regeneration in planted and unplanted area of limestone mined spoil