Sanjoy **Kumar**

PH.D. (ENVIRONMENTAL SCIENCE), M.SC. (BOTANY)

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RESEARCH INTERESTS

Soil Science, Ecosystem Ecology, Bio-geochemistry, Plant-soil interactions, Restoration Ecology, Forest Ecology, Climate Change

EDUCATION

- **Doctor of Philosophy.**, Department of Environmental Science and Engineering   *2008–2013*
  Subject: Environmental Science
  Institute: Indian Institute of Technology (ISM) [IIT(ISM)] Dhanbad, Jharkhand, India
  Thesis Title: Study of reclamation capabilities of thick alluvial soil cover in eastern part of Raniganj Coalfield, India

- **Master of Science**, Department of Botany   *2004–2006*
  Subject: Botany
  Institute: Vinoba Bhave University, Hazaribagh, Jharkahnd, India

- **Bachelor in Science**, Botany, Zoology, Chemistry   *2001–2003*
  University: Vinoba Bhave University, Hazaribagh, Jharkhand, India

RESEARCH EXPERIENCE

- **Dr. D.S. Kothari Postdoctoral Fellow**, IISc Bangalore, India   *October 2018-October 2021*
  Area: Forest Ecology and Bio geochemistry
  Proposal title: Nutrients Acquisition Strategies in Tropical Forests: Interaction among Nitrogen and Phosphorus through Plant-Microbial Mutualism in Mudumalai wildlife Sanctuary, TN, India

- **Project Scientist**, IIT Kanpur, India   *December 2017-July 2018*
  Area: Working on National Carbonaceous Aerosol Programme (NCAP)

- **DST-SERB, Postdoctoral Fellow**, IISc Bangalore, India   *November 2014-November 2017*
  Area: Carbon sequestration, bioenergy estimation, stable isotopes
  Proposal title : Bioenergy Potential and Carbon sequestration in reclaimed coalmine spoils

FIELD OBSERVATIONS EXPERIENCE

- Having three years postdoctoral work experience, working on nutrients dynamics in 19' 1-ha CTFS-Forest-Geo plots along the rainfall gradient in Mudumalai Wildlife Sanctuary TN, India.

- Having experienced of establishing experimental plot to monitoring changes in plant species in terms of species richness, density, above-ground biomass with changes in soil quality index along the chronosequence sites of different aged of reclaimed overburden mine dump sites.

- Field observation of vehicular exhaust emission around Bangalore road, India using Delta Ray, Isotope Ratio Infrared Spectrometer (IRIS)

- Measurement of Soil CO_2 flux in mined restored land using LI-COR long-term and multiplexed soil gas flux, Jharia Coalfield, Jharkhand, (India)

PUBLICATIONS

- **Kumar** S, Singh, A.K, and Ghosh, P. (**2018**). Distribution of soil organic carbon and glomalin related soil protein in reclaimed coal mine-land chronosequence under tropical condition. *Science of The Total Environment*, 2018, 625 1341–1350. https://doi.org/10.1016/j.scitotenv.2018.01.061; (**Citation: 42**)

- **Kumar** S and Ghosh P. (**2018**). Sustainable bio-energy potential of perennial energy grass from reclaimed coalmine spoil (marginal sites) of India. *Renewable Energy*, 2018, 123, 475-485. https://doi.org/10.1016/j.renene.2018.02.054; (**Citation: 12**)

- **Kumar** S, Maiti SK, and Chaudhuri S. (**2015**). Soil development in 2-21 years old Coalmine Reclaimed Spoil with Trees: A case study from Sonepur-Bazari Opencast Project, Raniganj Coalfield, India. *Ecological Engineering*, 85, 311-324, https://DOI: 10.1016/j.ecoleng.2015.09.043; (**Citation: 41**)

- **Kumar** S, Maiti SK, and Chaudhuri S. (**2013**). Soil Dehydrogenase Enzyme Activity in Natural and Mine Soil -A Review. *Middle East Journal of Scientific Research*, 13(7), 898-906, https://DOI:10.5829/idosi.mejsr.2013.13.7.2801; (**Citation: 132**)

- **Kumar** S, Chaudhuri S, and Maiti SK. (**2012**). Assessment of Physico-Chemical and Mineralogical properties of alluvial soil. *International Journal of Ecology and Development*: 23 (3): 25-39.

- **Kumar** S, Chaudhuri S, and Maiti SK. (**2011**). Assessment of VAM Spore Density and Root Infection from Alluvial Soil of Eastern Part of Raniganj Coalfield Areas. *Bioscan- An International Quarterly Journal of life science*: 6(3): 375-381; (**Citation: 4**)

- **Kumar** S and Ghosh P. Soil organic carbon dynamics under long-term restoration of coalmine spoils: Evidence from stable carbon (δ13C) isotopes. *Under Review- Scientific Report, Nature Publisher*.

- **Kumar** S. Stand structure rather than plant biodiversity influences carbon dynamics in restored coal mine sites (to be submitted in *Biogeoscience, Copernicus Publications*)

- **Kumar** S. Plant functional trait diversity outlines microbe-rhizosphere effects on mobilisation of phosphorus from organic matter in chronosequences reclaimed mine soils (to be submitted in *Ecology, Ecological Society of America, Wiley online library*)

- **Kumar** S. Plant functional trait diversity and species diversity drives ecosystem multifunctionlity in restored afforested sites under dry tropical condition (to be submitted in *Soil biology and biochemistry, Elsevier Publication*)

- **Kumar** S and **Sukumar** R. Soil bio-geochemistry across the tropical dry deciduous forest of Mudumalai Wildlife Sanctuary (under preparation)

- **h-index = 4; i10-index = 4; Total citation = 286 as per Google Scholar**

INSTRUMENTAL AND COMPUTATIONAL

- **Instruments**: Delta-Ray-IRIS, Flash-2000-IRMS-MAT253, SEM-EDAX, LICOR-GAS Flux Analyser.

- **Computer environments**: Windows and LINUX

- **Coding expertise**: R-SQUARE

AWARDS AND ACADEMIC ACHIEVEMENTS

- Dr. DS. Kothari Postdoctoral Fellowships, UGC, India (2018-2021).

- Selected for Talented Young Scientist Program (TYSP), China for Postdoctoral Fellowships in Peking University (2019).

- DST-SERB, Young Scientist Award for Postdoctoral Fellowships (2014-2017).

- IIT (ISM) Fellowships Entrance Test (2008-2013)

- Second topper in Master of Science in Botany , University level (2006).

CONFERENCES/WORKSHOPS

- Water future conference, Towards sustainable water future, (Divecha Centre for Climate Change, IISc Bangalore, India), 24-27 September, 2019.

- Monsoon day-discussion meeting, International Centre for Theoretical Sciences (ICTS) (Bangalore, India). 24 February, 2019.

- AGU Fall Meeting-2015 (San Francisco USA). 14-18 December, 2015.

- IIIrd International conference on Environmental , Industrial and Applied Microbiology, BioMicroworld (Lisban, Portugal), 2-4 , December, 2009.

- International Conference on Environmentally Sustainable Urban Ecosystems (IIT Guwahati, Assam, India), 24-26, February, 2012.

- International Society of Waste Management, Air and Water (Department of Civil Engineering, Jadavpur University, Kolkata, India) 24-27, November, 2011.

- Fourth International Conference on Plants Environmental Pollution (ICPEP-4), NBRI, Lucknow under the area Bio-indication Bioremediation (NBRI, Lucknow, India) 8-11, December, 2010.

- International Conference on Frontiers in Biological Science (InCaFIBS – 2010, NIT Rourkela, Orissa, India) 01-03, October, 2010.

- International conference on global climate change (Visva-Bharti, Santinikatan, West Bangle, India) 19-21, February, 2010.

- International conference on Recent Trend in Life Science (Vinoba Bhave University , Hazaribag, Jharkhand, India) 27-29, June, 2009.

IMPORTANT LINKS

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- ResearchGate: https://www.researchgate.net/profile/Sanjoy_Kumar

REFERENCES

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  Professor, Department of Environmental Science Engineering,
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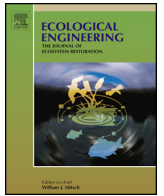
Soil development in 2–21 years old coalmine reclaimed spoil with trees: A case study from Sonepur-Bazari opencast project, Raniganj Coalfield, India

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ABSTRACT

Soil development is an integral process of mining spoil restoration, which is critical for vegetation establishment and may help to predict reclamation success. In this study, changes in soil properties, microbial activities and biomass, and plant community structure, were examined at different rehabilitated phases in chronosequence reclaimed coal mine spoils ecosystems, and discussed potential functional relationships. These reclaimed coal mine spoils were studied by taking manmade and naturally developed chronosequence sites covering successional ages in the ranges of 2 year, 5 year, 9 year, 15 year and 21 years with three depth profiles in the Raniganj Coalfield of India, and compared with natural forest close to the study area. Over time, significant changes in soil variables with respect to soil organic carbon (C_{org}) and nitrogen (N_{org}), texture qualities, moisture contents, exchangeable cations (Na^+, K^+, Mg^{2+}, Ca^{2+} and CECe), base saturation, soil microbial indices (enzymatic activities, microbial respiration quotient and microbial biomass carbon) were observed. In addition, increase in species richness and colonization of native species also observed with rehabilitated ages at chronosequence sites. Study indicates that changes in soil variables were related with succession, whereas functional/structural changes in vegetation were related to accumulation of organic matter, soil texture and enhanced microbial properties. The results indicate that age of restoration was the main driving force in terms of soil and vegetation compositional changes during ecorestoration. The study concludes that soil forming process is priming materials for vegetation development and these floristic changes mainly driven by abiotic and biotic component of the soil ecosystem.

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1. Introduction

Mining activities have made a significant contribution to India's economic developments. At the same time, they are also brought significant impairment to the environments in terms of land degradation (Maiti, 2013). In general, opencast mining degrades 2–10 times more lands than underground mining (Li, 2006). Open-cast mining is a major environmental disturbance which often leaves a landscape with no vegetation, changes in topography, alters soil and subsurface geological structures and very poor soil-forming materials for subsequent ecosystem development (Herath et al., 2009; Keskin and Makineci, 2009).

In such degraded ecosystems, the concept of ecological restoration should be the restoration of a healthy, long-term, self-sustaining ecosystem (Hobbs and Norton, 1996), with effective vegetation cover (Dazy et al., 2008) and a fully-functioning soil ecosystem (Moreno-de las Heras, 2009; Dölle and Schmidt, 2009), including appropriate soil biota and microbial processes (Helingerová et al., 2010; Lange et al., 2015). Ideally, a self-sustaining restored ecosystem should have at least a resemblance of the original soil dynamics (Walker and del Moral, 2009). Therefore, knowledge of how the soil develops during restoration is of particular importance to guide future ecological restoration (Dutta and Agrawal, 2003; Abreu et al., 2009; Courtney et al., 2009).

During mining reclamation or restoration process, the initial restoration treatment provides a starting soil material, although the physico-chemical properties of these new soils usually delay plant growth (Fu et al., 2010; Alday et al., 2011b). Successful forest reclamation approaches is a function of many factors, but one of the most important issues for the restoration of functional

Distribution of soil organic carbon and glomalin related soil protein in reclaimed coal mine-land chronosequence under tropical condition

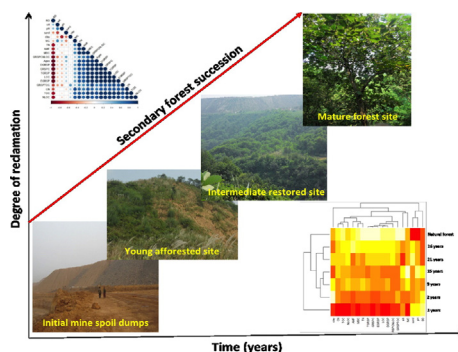Sanjoy Kumar [a,*], Ashutosh Kumar Singh [b], Prosenjit Ghosh [a]

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HIGHLIGHTS

- The fractions of SOC and GRSP increased with time since reclamation.
- The greater increase was seen in labile than stable SOC and GRSP fractions.
- The linear correlation was observed between fractions of SOC and GRSP.
- The other soil quality parameters also showed linear correlation with SOC and GRSP.
- The SOC and GRSP can be used as an indicators of reclaimed mine soil quality.

GRAPHICAL ABSTRACT

ARTICLE INFO

ABSTRACT

The revegetation on mine spoiled lands has potential to improve the status of reclaimed mine-soil quality. However, to date the temporal dynamics of labile and stable fractions of soil organic carbon (SOC) and glomalin related soil protein (GRSP) have not been satisfactorily demonstrated. We investigated SOC and GRSP fractions including labile particulate OC (POC) and easily extractable GRSP (EE-GRSP) and stable non-particulate OC (NPOC) and difficulty extractable GRSP (DE-GRSP) along with other important soil properties in six reclaimed mine lands chronosequence (1 to 26 years old) and a reference forest site in Raniganj Coalfield, India. Our results demonstrated that the accumulation of SOC and GRSP significantly increased with increasing age of the sites, with greater extent of increment after 26 years were seen in labile POC ($6.6\times$) and EE-GRSP ($11.5\times$) compared to stable NPOC ($1.8\times$) and DE-GRSP ($6.2\times$). The higher contribution of GRSP-C in NPOC compared to TOC across the sites, indicate the proximate role of GRSP in accumulation and stabilization of SOC during the pedogenesis. The multivariate analysis revealed strong association among arbuscular mycorrhizal fungi (AMF) spore density, microbial biomass carbon, SOCs and GRSPs, suggesting the factors involved in SOC accumulation likely contributed to AMF proliferation and GRSP enrichment during the reclamation process. Moreover, strong correlation of GRSP and SOC with soil's bulk density, pH, total N and C/N ratio, suggest increasing GRSP and SOC content resulted in multi-level improvement in soil properties. Our results highlight the importance of using GRSP and SOC as indicator during mine land reclamation.
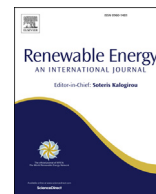
1. Introduction

Surface mining is the most common method of coal removal, often produced landscapes without soil or vegetation cover (Maiti, 2013). The immediate restoration of these landscapes to a self-sustaining

Contents lists available at ScienceDirect

Renewable Energy

Sustainable bio-energy potential of perennial energy grass from reclaimed coalmine spoil (marginal sites) of India

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A B S T R A C T

Usage of marginal lands to grow perennial grass for biomass feedstocks is a promising option to meet the bioenergy demand in India. In this context, the present work investigated the potential utility of two perennial grass species *Cenchrus ciliaris* (L.) and *Pennisetum pedicellatum* (Tan.) to be a new promising energy source for bioenergy. This study entails a detailed characterization of biomass feedstocks using proximate and ultimate analysis, and lignocellulosic fractions and thermogravimetric behaviour using TG-FTIR and Py-GC/MS spectrophotometry to evaluate their potential as an alternate green fuel to fossil fuels by measuring their thermochemical conversion functioning. Property analysis of perennial grass species showed a significant difference in moisture content (7.2—8.5%), volatile matters (80.5—82.4%), fixed carbon (11.3—18.9%), HHV (15—17.8 MJ/kg) and LHV (14.3—16.5 MJ/kg), which is very promising for bioenergy generation. Lignocellulosic fractions of biomass feedstocks are comparable to the previous studied biomass species including switchgrass and elephant grass. The individual decomposition experiments indicated that biomass feedstocks possess higher thermochemical reactivity and shorter devolatilization time. According to Py-GC/MS study, carbonyl compounds including aldehyde and ketones are the major volatile products, in addition to furans, benzenes, phenols, acids, and others. The TG-FTIR results showed that main gaseous products evolved during devolatilization are CO, CO_2, CH_4, and H_2O. All of the results and findings would help in characterizing the biomass as potential bioenergy feedstocks compatible with other biomass currently in use as supplementary fuel for power generation.

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1. Introduction

Globally, the energy sector faces a major challenge of providing energy at an affordable cost without adversely affecting the environment [1]. Almost one-quarter of world human populations are living under deficient basic energy demands that are not being met. Efforts to increase renewable energy resources in developing countries where per capita energy availability is low are needed [2]. Therefore, in recent years production of alternate energy, fuels and a variety of chemicals from lignocellulosic biomass has attracted scientific attention worldwide [3]. In this context, renewable bioenergy feedstocks act as a promising alternative resource to provide about 14% of the world's energy demand [4]. Moreover, lignocellulosic biomass mainly includes agricultural residue, wood waste, energy crops, noted energy grass species (switchgrass,

miscanthus, napier grass), and aquatic plants. Therefore, they are considered as a potential resource for meeting bioenergy demands [5]. Bioenergy can be readily converted to produce heat and electricity, and production of biofuels. As a sustainable energy sources, bioenergy feedstocks are widely available and receiving increased attention as a renewable substitute for fossil fuels. Conversely, if produced sustainably and used efficiently, it will reduce oil demand, addressed major environmental problems, and it can induce economic growth in a developing country. Other major prospective benefits of bioenergy cultivation include restoration of soil productivity of degraded land, improving access to quality of energy services, and reduction of major greenhouse gas emission [6].

In India, a number of different species variety of perennial grasses are available throughout the year which often grows in wild conditions and characterized as low input-high yielding biomass. Therefore, these energies grasses can be act as a potential resource for bioenergy feedstock without adversely affecting the soil C stocks [6]. Accordingly, the different varieties of perennial grasses (switchgrass, bermudagrass, elephantgrass, timothygrass) and

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Soil Dehydrogenase Enzyme Activity in Natural and Mine Soil - A Review

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Abstract: Soil enzyme activities are very sensitive to both natural and anthropogenic disturbances and show a quick response to the induced changes. Soil dehydrogenase enzymes are one of the main components of soil enzymatic activities participating in and assuring the correct sequence of all the biochemical routes in soil biogeochemical cycles. Dehydrogenase activity is measured by two methods using the TTC and INT substrate; however, various authors reported poor results when TTC is used as substrate. Different biotic and abiotic factors such as incubation time and temperature, pre-incubation, soil aeration and moisture content have significant effect on dehydrogenase activity in soil. Highest dehydrogenase activity is reported from forest soil in autumn seasons while the disturbed soil from coal mines soils containing lowest dehydrogenase activities along the soil erosion gradient of experimental slopes. Least value of enzymes activity is reported from polluted sites than restored and undisturbed sites. Dehydrogenase enzyme is often used as a measure of any disruption caused by pesticides, trace elements or management practices to the soil, as well as a direct measure of soil microbial activity.

Key words: Dehydrogenase Activity · Substrate · Mine Soil · Natural Soil

INTRODUCTION

Soil quality and its degradation depend on a large number of physical, chemical, biological, microbiological and biochemical properties, the last two being the most sensitive since, they respond rapidly to changes. The microbiological activity of a soil directly influence ecosystem stability and fertility and it is widely accepted that a good level of microbiological activity is essential for maintaining soil quality. The soil microbiological activity viz., the enzymatic activities play a key role in soil nutrient cycling, its activity is essential in both the mineralisation and transformation of organic matters and plant nutrients in soil ecosystem [1].

Soil enzyme activities are very sensitive to both natural and anthropogenic disturbances and show a quick response to the induced changes [2]. Therefore, enzyme activities can be considered effective indicators of soil quality changes resulting from environmental stress or management practices. These soil enzymes play a fundamental role in establishing biogeochemical cycles

and facilitate the development of plant cover. It is an important aspect of the below-ground processes and give insight into the relative changes in below-ground system functioning as a plant community develops over time. Enzyme activity in soil results from the activity of accumulated enzymes and from enzymatic activity of proliferating microorganisms [3]. They are usually associated with viable proliferating cells, but enzymes can be excreted from a living cell or released into the soil solution from dead cells. Study of soil enzymes gives information about the release of nutrients in soil by means of organic matter degradation and microbial activity as well as indicators of ecological change. Soil enzymes analysis helps to establish correlation with soil fertilization, microbial activity, biochemical cycling of various elements in soil, degree of pollution (heavy metals) and to assess the succession stage of an ecosystem. So, measurements of enzyme activity in degraded soils have useful in examining impacts of environmental change or management on soil enzyme activities. Several works have been reported the potential

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ASSESSMENT OF VAM SPORE DENSITY AND ROOT INFECTION FROM ALLUVIAL SOIL OF EASTERN PART OF RANIGANJ COALFIELD AREAS

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ABSTRACT

The indices of occurrence of VAM are widespread in natural vegetation, but intensity of distribution and root infection varies among types of species, nature of edaphic factors of soil. In this study, we observed that the VAM spore density and their colonization also positively correlated with depth of soil profile ($p < 0.05$); available nitrogen, organic matter and available phosphorous. The most commonly genus of VAM spores found in the study area are *Glomus, Gigaspora, Acaulospora, Enterophospora* and *Sclerocystis. Glomus* and their size frequency distribution range from 50-75 μm and 75-100 μm. The highest number of VAM spore density/5 g of soil were found as 360.0 ± 12.5 and for VAM spore density/100g of soil were found as 702.0 ± 23.87 in mine 3. The highest number of VAM spore density was reported under the *Acacia auriculoloformis*. The percentage of root colonisation observed in seven native species are; *Dalbergia sissoo* (91%), followed by *Prosopis juliflora* (84%), *A. auriculiformis* (79%) and *A. scholaris* (64%), *Polyalthia longifolia* (58%), *Cassia seamea* (31%), and *Azardirachta indica* (21%). The studies revealed that vesicular-arbuscular mycorrhiza is essential to assess the self-sustaining ecosystem of soil quality and which should be used for amendments in mine degraded soils for reclamation and restoration process.

INTRODUCTION

Opencast coal mining generates a variety of mineral wastes that are brought to the surface and replace the original topsoil. Topsoil is an essential component for land reclamation in mining areas. It is seriously damaged if it is not mined out separately without being contaminated, eroded and protected. Systematic handling and storage practices can protect topsoil while in storage and after it has been redistributed onto the degraded area. Impact of surface coal mining on topsoil quality in Indian context has been described. Most of the opencast operations are working at 100 m depth, with some up to 160 m depth (Bose, 2003) which generate huge amount of overburden materials. Overburden materials are waste rocks removed by opencast mining operations and dump outside, which is known as OB dumps. The overburden dumps are unstable and will also become source of pollution. These mine degraded soils are a man-made habitat which also presents a wide range of problems for establishing and maintaining a vegetation cover (Maiti, 1997). The adverse physico-chemical properties tend inhabits soil forming process and plant growth. So, stabilization of mining waste through revegetation usually requires the use of topsoil management to ameliorate the physical and chemical properties of the waste and to provide a source of energy for the reestablishment of a microbial community. The various soil factors that affect the establishment of plants in mine degraded soils. Among these

the most significant are moisture availability, mineral composition, soil texture, the quantity and quality of SOM, microbial and enzyme activities, mineral nutrients and others such as polycations, etc. According to Tate *et al*. (1985) states that apart from soil physical and chemical properties, long term plant community stability on mine degraded soils relies upon the development of a functional soil microbial community. One group of soil microorganism important to the development of long-term plant community structure is mycorrhizal association (Barca *et al.*, 1992).

Mycorrhiza is formed by association between a plants root and a fungus and by far majority of vascular plants are involved in there association. Mycorrhizal fungi are known to affects growth of most plant species in mine degraded areas. Phosphorus, nitrogen, zinc, and copper are the most commonly reported elements whose uptake is enhanced by mycorrhiza in plants; however, acquisition of other mineral nutrients required for plant growth may also be enhanced. They increase phosphorous uptake, enhance uptake of other plants nutrients by root system and are beneficial in the biological nitrogen fixation of rhizobium, biological control of root pathogens and drought resistance. It is also emphasized by several scientists, the beneficial role of vesicular arbuscular mycorrhizae in mine spoils revegetation. Also, the mycorrhizal associations are essential to the colonization of nutrient-deficient soil heaps left after mining (Brundrett, 1991). There