STUDIES ON VEGETATIONAL AND MICROBIOLOGICAL PROCESSES IN COAL MINING AFFECTED AREAS

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By

Subhasish Das Gupta

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We certify that the thesis entitled **"Studies on vegetational and microbiological processes in coal mining affected areas"** submitted by Mr. Subhasish Das Gupta for the degree of **Doctor of Philosophy** of the North-Eastern Hill University, Shillong, embodies the record of original investigation carried out by him under our supervision. He has been duly registered and the thesis presented is worthy of being considered for the award of the Ph.D. Degree. The work has not been submitted for any Degree of any other University.

B K Tiwari

Dr .B.K. Tiwari
Centre for Environmental Studies

Prof. R.S. Tripathi
Department of Botany

Supervisors

Forwarded

Head
Department of Botany
School of Life Sciences
N. E. H. U.
Shillong-793022

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Shillong

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(SUBHASISH DASGUPTA)

LECTURER IN BOTANY

RAID LABAN COLLEGE

SHILLONG.

CHAPTER I

GENERAL INTRODUCTION

Since the dawn of history, human beings have been dependent upon natural resources for food, shelter, clothing and energy. Thus the disturbance to ecosystem has been taking place ever since the use of the landscape commenced. Such disturbances were not perilous as long as human population was low and natural resources were in excess of the requirement. Before the industrial revolution got under way, agriculture and forestry together with the limited use of metals, served all human aspirations. With the advancement of technological knowledge, novel transformations of materials contributed to the enhancement of quality and comfort in life. The industrial development took a myopic view of natural resources and became the symbol of status for different countries.

The progress of mankind depends upon the judicious exploitation of natural resources. Utilization of these resources is of paramount importance in sustaining natural development in both developed and developing countries. Historically, mining is second only to agriculture as the world's oldest and most important activity. Mining provides various kinds of fuels for meeting energy requirements, metals for making engines and machines, ores for chemicals and fertilisers, clay for vases, rocks and stones for buildings, bridges and dams, gold, diamonds and precious stones for jewellery.

Coal has remained a vital energy source in the world for over two centuries. Hubbert (1973) noted that "during the eight centuries prior to 1860, it is estimated that cumulative production of coal amounted to 7 x 10^9 metric tonnes. By 1970, cumulative production reached 140 x 10^7 metric tonnes on a world's scale. Hence, the coal mined during the 110 year period from 1860 to 1970 was approximately 19 times that of the preceding eight centuries".

Though the world wide production of coal was 3.7 x 10^9 billion metric tonnes in 1977, the trends between 1960 and 1977 showed a gradual rise in production of coal in North-America, a decline in production in Western Europe and Japan and substantial increase in South Africa, Australia and India (Griffith and Clarke 1979). India is one of the fifth largest coal producing countries in the world. The production in India was about 154.30 million tonnes in 1985-86 and it is expected that the production level will reach 417 million tonnes by 2000 A.D. (Coal India 1986).

The Indian sub-continent is replete with minerals and almost every state has its own coal or metal resources. Soon after independence, India witnessed a spurt in the growth of heavy industries that needed a large amount of coal and metals. Mining operations began on a large scale and mine wastes, sewers and belching chimney pumped in large amounts of metals into soil, river channels and atmosphere. Most of the mining areas have been converted into degraded lands and are regarded as heavy metal hot spots due to the release of chromium, lead and mercury into the environment. Presently, in India, more than 80,000 ha of land are under various types of mining (Valdiya 1988).

Various types of mining activities have been going on in the country since then. Mining activities in Raniganj in West Bengal, Jharia in Bihar and Singrauli in Madhya Pradesh for coal, Bichhri, Khetri and Zawar in Rajasthan, Malanjkhand in Madhya Pradesh and Agnigundala in Andhra Pradesh for lead, zinc, copper and cadmium and in Neyveli in Tamil Nadu for lignite mines have reduced the adjoining areas to a pit-scarred and barren landscape. The fertility of lands in most of the areas has been reduced to the limit that is beyond redemption.

Though mining and use of minerals in India date back to the Indus-Valley Civilization, coal mining was first taken up in India in 1774 by Sumner and Heatly in Raniganj coal field (Tandon 1990). By 1830, several coal mines came up in the Raniganj coal area. In North-East, coal mining was initiated by Medlicott (1869, 1874). This was followed by the preliminary excavations by Fox (1935-38) in Garo Hills and some mining works by Arogyaswami and Desikachari (1949-1950) in south Khasi Hills. Coal fields of Garo Hills were reexamined by Arogyaswami, Sen, Rao and Puri in 1949-50. Some coal occurrences in Jaintia Hills were examined by shallow drilling by Dias in 1962-63 and Goswami and Dhara in 1963-64 (Bulletin of Geological Survey of India, 1969).

The state of Meghalaya is rich in mineral resources of which principal ones are coal, limestone and sillimanite. The forested as well as the mining areas are intimately linked. The extent of environmental perturbations due to mining can be gauged from the denudation of the forest cover in all the mine belts especially in the Jaintia Hills. During the past twenty years, the forests in Jaintia Hills have been ravaged by coal mining operations.

Coal deposits occur as seams of the Eocene age (Guha Roy, 1991). These deposits occur along the southern fringe of the Shillong plateau extending over a length of 400 km. In the hills of Meghalaya, the coal bearing sedimentary formations are sub-horizontal to gentle dipping in nature. The coal is found to occur in various places in Meghalaya namely : Laitryngew, Cherrapunjee, Laitduh, Mawbehlarkar, Mawsynram, Lumdidon, Langrin, East Darrangiri, Pynursla, Lyngkyrdem, Mawlong-Shella-Ishamati in Khasi Hills, West Darrangiri, Siju, Pyndengru-Balphakram, Salsella Block in the Garo Hills and Bapung, Lakadong, Sutnga, Jarain, Musiang-Lamare and Ioski in Jaintia Hills. Out of the total production of 3747000 tonnes of coal in Meghalaya, the largest contribution came from Jaintia Hills having 2786000 tonnes in 1991 (Meghalaya Statistics, 1996).

The prevailing land holding system is the greatest stumbling block in the mining of this precious mineral in Meghalaya. The mines are operated by private owners in a very unscientific and obsolete way by resorting to the **"rat hole"** method of mining. The "**rat hole method**" of coal mining employed by the private operators involves manual excavation which is crude, uneconomical and unscientific. In this method, pits ranging from 5 to 100 m^2 are excavated in to the soil till the coal seam is reached. The coal seam occurs at the depth ranging from 2 to 10 meters. Coal is then removed from this pit. Tunnels are made into the seam sideways and coal is brought into pits by wheel-barrows. From the pit, coal is taken outside in conical baskets.The columns of coal are left intact here and there to serve as pillars for supporting the soil above. Subsequently, these pillars are also cut down, as a result of which, the soil covering the coal seams sinks down forming large cracks on top. While digging the pits, the pieces of soil rocks above the coal seams are thrown haphazardly outside the pit creating coal mine spoils which cause large scale destruction to the surrounding land and vegetation often beyond replenishment.

Coal mine spoils when freshly tipped have a great range of particle size ranging from large pieces of shale to silt and clay (Molyneux 1963). At first, the shale is relatively bright blue or grey, but as weathering proceeds the colour becomes somewhat subdued. Much of the shale disintegrates into clay by dint of shale breaking down along its laminations thereby making fragments like slate in shape. Due to the occasional formation of mud and sand stone pieces within, the spoil becomes much more noticeable as weathering continues.

Coal mine spoils represent extremely rigid substrata for plant growth and development. Colonization, establishment and maintenance of vegetation on these spoils are enormously difficult. Among the factors which hinder the growth of plant species on these spoils, acidity merits special mention. Extreme acidity is caused due to the oxidation of iron pyrites (FeS_2) (Chadwick 1973, Caruccio 1975). So, colonization of spoils depends only on those species which have the tolerance to grow in nutrient-deficient habitats. The number of species colonizing them increases with the increase in pH of the substratum (Bradshaw and Chadwick 1980). Continued acidification for many years may lead to die back of well established vegetation (Costigan *et al.* 1981). Besides acids, coal mine spoils contain toxic levels of soluble elements such as Fe, Al, Mn and Cu. The physical factors which limit plant establishment and survival include high temperature, moisture stress (Richardson 1975), soil particle size (Down 1974), surface instability leading to erosion (Brierley 1956, Down 1975) and compaction (Hall 1957, Richardson 1975).

Soil fertility is also a major factor regulating plant growth. The two limiting nutrients on coal mine spoils are nitrogen and phosphorus (William 1975, Whittwer et al. 1981). The shortage of organic matter is attributed to the absence of litter. Organic matter is often found in the upper few centimetres of mine spoils (Schafer et. al.1980).

Ecology of mined lands has been the subject of extensive study the world over (Bradshaw *et.al.* 1986, Brenner *et.al.*1994). In India, Banerjee (1981), Singh and Jha (1987), Valdiya (1988), Saxena (1979), Mann and Chatterjee (1979), Prasad (1989), Jha (1989, 1990, 1992), Jha and Singh (1990, 1991) and Soni *et.al.* (1990) have made pioneering contribution to our understanding of the ecology of Indian mine spoils. In the context of Meghalaya , studies by Lyngdoh *et.al* (1992) and Lyngdoh (1995), Uma Shanker *et.al.* (1993) and Tiwari (1996) have proved to be precursors for future studies in this direction. An in-depth scanning of the literature available on various facets of coal mine spoil ecology and subsequent rehabilitation measures brought to the fore, the inadequacy of information pertaining to the coal mine spoil reclamation in Meghalaya. A review of existing literature revealed that no integrated study aimed at understanding the ecological and microbiological aspects of coal mine spoil has been undertaken. So far, coal mining in Meghalaya has been synonymous with the complete absence of any rehabilitation measures and tackling of environmental hazards by the societal segment engaged in this activity. It is with this objective in mind that a **study on vegetational and microbiological processes in coal mining affected areas** was undertaken in the Bapung coal mine belt of Jaintia Hills district encompassing the aspects viz.,

(i) edaphic changes in coal mine spoils undergoing natural recovery, (ii) vegetational changes on coal mine spoils of different ages, (iii) plant biomass, production and nutrient dynamics on coal mine spoils of different ages, (iv) microbial community changes on coal mine spoils undergoing natural recovery and (v) growth of a few selected plant species on mine spoils after chemical amendments.

The data collected on the above-mentioned aspects have been dealt with in detail in chapters 4-8. The objective of the present study has been spelt out in this chapter which is also the "**General Introduction**". The "**Review of Literature**" (chapter -2) gives an overview of researches done on the aspects related to the present study, such as characteristics of mine spoil habitat, species diversity, plant successional pattern,plant species phenology, biomass and primary production, nutrient build up, physico-chemical features of spoils, reclamation of these nutrient starved habitats. In addition to these aspects, the researches on the pivotal role played by microbial groups through functions such as respiration, mineralization, population dynamics, enzymatic activity and microbial biomass accumulation etc. have also been reviewed. A brief description of climate, soil and vegetation of the study area apart from the distribution and growth behaviour of three plant species under simulated conditions have been given in chapter -3. The critical discussion follows the results given in chapters 4-8. Major findings of the entire work have been discussed in an integrated manner in chapter-9 (**General Discussion**).