COMMUNITY DYNAMICS AND EDAPHIC CHANGES IN RELATION TO COAL MINING IN JAINTIA HILLS, MEGHALAYA

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I certify that the thesis entitled "Community dynamics and edaphic changes in relation to coal mining in Jaintia Hills, Meghalaya" submitted by Miss Tariang Lyngdoh for the degree of Doctor of Philosophy of the North-Eastern Hill University, Shillong, embodies the record of original investigation carried out by her under my supervision. She 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.

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CHAPTER 1

GENERAL INTRODUCTION

The progress of mankind depends upon the judicious exploitation of natural resources. Utilization of these resources is of paramount importance in sustaining national 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 fuels for meeting energy requirements, metals for making engines and machines, ores for chemicals and fertilizers, clay for vases, rocks and stones for buildings, bridges and dams, and gold, diamonds and other precious stones for jewellery.

Though extraction of mineral resources is essential for development, unfortunately, mining particularly, surface mining causes severe environmental problems. The first consequence of any mining operation is the removal of vegetation and the degradation of land. Land, our most important natural resource, is destroyed by the extensive excavation and dumping of infertile overburden materials in the vicinity of these mines, which also result in air and water pollution. In the headlong rush to increase our standard of living, the pace of destruction to land by mining has increased dramatically during the last few decades. Hence, there is an urgent need to slow down the pace of destruction to land and to reclaim the already disturbed land, because if this pace of destruction is allowed to continue and no effort is made to restore disturbed lands then man's very survival on earth may be threatened. This has led many countries to develop and adopt laws, national programmes and specific policies for environmental protection. The basis of most laws applicable to mining industry and its effect on land seeks to control land degradation management, protect resources and regulate land reclamation and landscape restoration (CHADWICK *et al.* 1987).

Before developing any technique to reclaim these drastically disturbed lands, there is a need to understand their physical and chemical limitations because if these limitations are identified they can be treated effectively and economically. Consequently, a specific discipline of ecology called mining ecology has developed where ecologists devote in studying the physical, chemical and biological characteristics of lands degraded as a result of mining (WALI & KOLLMAN 1977). Knowledge of these aspects is a prerequisite to planning their future use.

Coal mining results in pit scarred landscape because of the extensive excavations and heaps of unwanted debris on the adjacent unmined land. These heaps of debris consist of consolidated and unconsolidated overburden materials overlying the coal seams which have been disturbed, and haphazardly mixed during the mining activity. They form a waste material known as **'overburden'** or **'mine spoil'** (WALI 1987, JHA & SINGH 1990). Coal mine spoil heaps are also known as 'tips', 'rucks', and 'banks' in England and Wales, as 'bings' in Scotland and as 'refuse banks' in North America (GLOVER 1975).

Coal mine spoils represent extremely degraded and disturbed ecosystem. Ecosystem disturbance has been defined by WALI (1987) as "an event or a series of events that results in altering the relationships of organisms and their habitat from their natural state both spatially and temporally". Disturbance may be classed as 'drastic' when they are created by natural causes such as volcanic eruptions and large scale earthquake activity. Surface mining for coal and other minerals is the example of man-made drastic disturbance.

The utilization of coal as an energy source, both by means of steam engine and in the form of coke was a major characteristic of the First Industrial Revolution. In fact it was on coal that nations built their industrial power in the nineteenth and early twentieth centuries. There was a slump in the demand of coal as an energy source after World War II due to the availability of oil. However, steep price rise of liquid hydrocarbon fuels, led to the increased use of coal (WORLD BANK 1979, WILSON 1980). Coal has now been established as a relatively attractive fuel in many industrial applications, but its overall prospects will depend on economic growth in the major industrialized regions of the world and its acceptability from a social and management point of view (CHADWICK *et al.* 1987).

Between 70% and 90% of the total quantity of coal is utilized for electricity generation. A substantial amount of coal has also been used in iron, steel, aluminium and cement industries. India is one of the nine largest coal producing countries in the world. The production was about 154.30 million tonnes in 1985-1986 and it is expected that the production level will reach 417 million tonnes by 2000 AD (COAL INDIA 1986).

Geological evidences indicate that coal seams were formed due to the decay of the terrestrial plants during the time beginning from the Carboniferous up to the Tertiary age under the influence of hydrostatic pressure and geothermal heat. In this period, forest trees grew in abundance in swampy areas, which had to suffer several phases of intermittent yet slow sinking. One phase gave rise to the formation of one coal bed and again the area was brought under sedimentation by river flow giving rise to shale and sand stone deposits, thus burying the coal bed formed earlier. Good amount of sediments deposited in the basin of swampy regions gave rise to luxuriant growth of trees which after dying out formed new seams of coal deposits. Several cycles of such formations are recorded in different parts of the world. Since all these took place under swampy anaerobic conditions relatively, high amount of pyrites (FeS_2) was also deposited.

But when coal is mined, neither the low grade carbonaceous material nor the inorganic rocks associated with the coal seams are wanted. These form the **'overburden'** or the **'spoil'**. The low carbonaceous material which is high in nitrogen, sodium and chlorine is slow to weather and produces very little in the way of nutrients for plant growth (BRADSHAW & CHADWICK 1980).

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). Till the year 1830 several coal mines came up in the Raniganj coal field area. In the north east, coal mining was initiated by LA TOUCH (1882, 1883, 1884, 1889, and 1890). This was followed by the preliminary works of FOX (1935-38) in Garo Hills and detailed works of AROGYASWAMI and DESIKACHARI (1949-

1950) in southern Khasi Hills. Coal occurrence in Jaintia Hills were examined by shallow drilling in 1962-63 by J. P. DIAS and others (BULLETIN OF GEOLOGICAL SURVEY OF INDIA, 1969).

The State of Meghalaya is rich in mineral resources, of which the principal ones are coal, limestone, and sillimanite. These minerals are haphazardly mined because of individual ownership of lands. The ownership of land barring a few areas largely lies with the people. Coal deposits occur as thin seams which range in thickness from 30 cm to 1.5 m in the sedimentary rocks, sandstones and shale of the Eocene age (GUHA ROY 1991). These deposits usually 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 gently dipping in nature. Important coal fields of Meghalaya are Laitryngew, Cherrapunjee, Laitduh, Mawbehlarkar, Mawsynram, Lumdidon, Langrin, East Darrangiri, Pynursla and Lyngkyrdem, Mawlong-Shella-Ishamati in the Khasi Hills, West Darrangiri , Siju, Pyndengru-Balphakram, Salsella Block in the Garo Hills, and Bapung, Lakadong, Sutnga, Jarain, Musiang-Lamare and Ioksi in the Jaintia Hills.

Coal mining in Meghalaya is carried out by private operators and is done manually by **'Rat-Hole method'** which is very crude, uneconomical and unscientific (Plate 1.1 a&b). In this method pits ranging from 5 to 100 m^2 are excavated into the soil till the seam of coal is reached. The depth at which this seam occurs ranges from 2 to 10 metres. Coal is then removed from this pit. Tunnels are then made into the seam sideways and coal is brought into the pit by wheel-barrows. From the pit coal is taken outside by carrying in conical baskets. Here and there columns of coal are left intact 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 soil and rocks above the coal seams are thrown haphazardly outside the pit and thus cause large destruction to the surrounding land and vegetations (Plate 1.2 a&b, Plate 1.3).

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, a feature of this process being the breaking down of the shale along its laminations so that the fragments become slate like in shape. The pieces of mudstone and sandstone occasionally found within the spoil become much more noticeable as weathering continues. An important feature of the clay is its impermeability which leads to considerable surface run-off (MOLYNEUX 1963).

Coal mine spoils present very rigorous conditions for plant growth. Colonization, establishment and maintenance of vegetation on these spoils are extremely difficult. There are various factors which limit plant growth on these spoils. The principal factor is always extreme acidity caused due to the oxidation of iron pyrites (FeS_2) (CHADWICK 1973, CARUCCIO 1975). So, colonization of spoils is only by those species which have the ability to evolve tolerance (Plate 1.4 a&b). The number of species colonizing them increases with the increase in pH of the substratum (BRADSHAW & CHADWICK 1980). Continued acidification for many years may lead to die back of well established vegetation (COSTIGAN *et al.* 1981). Besides, acidic 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 surface 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 the major factor which regulates plant growth. Nitrogen and phosphorus are the two limiting nutrients on coal mine spoils (WILLIAMS 1975, WITTWER *et al.* 1981). IVERSON & WALI (1982) reported phosphorus as the limiting nutrient during colonization and early successional process on surface-mined lands in North Dakota. When nitrogen and phosphorus are inadequate, plant growth is adversely affected. Besides, organic matter is also deficient. This is due to the absence of litter. SCHAFER *et al.* (1980) reported that even in 53 year old spoil the organic matter is present only in the upper few centimetres.

Mining ecology has been extensively studied in different parts of the world. BANERJEE (1981), SINGH & JHA (1987), JHA (1989, 1990, 1992),) and JHA & SINGH (1990, 1992) have contributed much to our knowledge of the ecology of Indian mine spoils in dry tropical region. With the exception of few publications (LYNGDOH *et al.* 1992, UMA SHANKAR *et al.* 1993), there is no serious ecological studies on coal mine spoils of this region.

Considering the aforesaid facts, the present study on "**Community dynamics and edaphic changes in relation to coal mining in Jaintia Hills, Meghalaya**", was conducted in Jarain area of Jaintia Hills district to cover the following aspects.

1. Edaphic changes in coal mine spoils undergoing natural recovery.
2. Community dynamics on the spoils of different ages.
3. Biomass dynamics and net primary productivity in relation to age of the mine spoils.
4. Nutrient compartmentation in mine spoils of different ages.
5. Growth of a few selected species (e.g. *Eriosema chinense*, *Axonopus compressus*, and *Eragrostiella leioptera*) on soils from the unmined site and the mine spoils of two ages.

The experimental data on the above mentioned aspects have been presented in Chapters 4-8. These Chapters are preceded by chapters 1-3. The **General Introduction'** (present chapter) sets out the objectives of the study. The literature pertaining to various relevant aspects such as plant succession, biomass and productivity, edaphic properties and reclamation of coal mine spoils have been briefly reviewed in Chapter 2 (**Review of Literature**). A brief description of climate, soil and vegetation of the study area and morphology and distribution of a few plant species such as *Axonopus compressus*, *Eragrostiella leioptera* and *Eriosema chinense* are given in Chapter 3. The results presented in Chapters 4-8 have been critically discussed in the corresponding chapter. An attempt has also been made to integrate the major findings of the entire work under '**General Discussion**' (Chapter 9).

Plate 1.1a - Pit formed as a result of 'rat hole' method of mining on the plain surface

Plate 1.1b - Pit formed on the hill slope. Note the presence of the coal seam

Plate 1.2a - Heaps of debris consisting of haphazardly mixed materials

Plate 1.2b - Heaps of debris consisting mostly of slates

Plate 1.3 - Unmined land destroyed by mine seepage

Plate 1.4a - Portion of the heap colonized by *Axonopus compressus*

Plate 1.4b - Portion of the heap colonized by *Dicranopteris linearis*