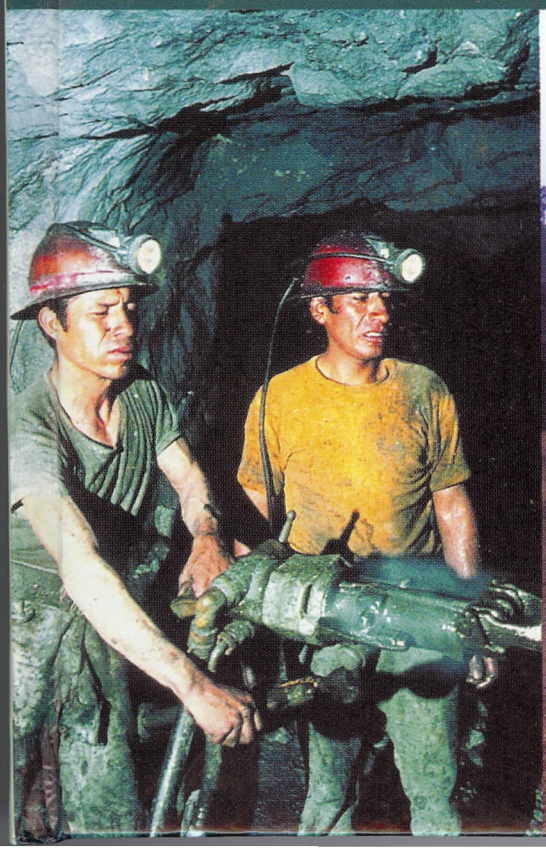
MINING ENVIRONMENT

Problems & Remedies

Editor
O.P. Singh



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Preface

India, endowed with rich mineral resources, produces 89 different minerals comprising of 4 fuel, 11 metallic, 52 non-metallic and 22 minor minerals. The country is the largest producer of mica, third largest producer of coal and lignite, fourth in iron production, sixth in bauxite and manganese, and tenth in aluminum production in the world. The metallic production of the country is mostly contributed by iron-ore, copper-ore, chromite and/or zinc concentrates, manganese ore, bauxite, lead concentrates, gold and silver. Amongst the non-metallic minerals, 92 percent of the aggregate value is shared by limestone, magnesite, dolomite, barytes, kaolin, gypsum, apatite and phosphorite, steatite and fluorite. In 1999–2000, total mineral production from over 3100 mines accounted for 550 million tones worth more than Rs. 452.3 billion.

During recent past, India has witnessed a spurt of mining activity to meet the growing industrial and commercial demands of minerals and metals. The extractive nature of mining activities creates a variety of impacts on the environment before, during and after mining operations. Large scale denudation of forest cover, scarcity of water, pollution of air, water and soil, and degradation of agricultural lands are some of the conspicuous environmental implications of the mining operation. In addition, mining leaves physically disfigured landscape due to haphazard dumping of overburden, caving in of the ground and subsidence of land.

The extent and nature of impacts can range from minimal to significant depending on a range of factors associated with each mining activity. The environmental impacts of mining, although significant, are generally confined to adjoining areas. The terrestrial and aquatic ecosystems surrounding mines become severely contaminated leading to adverse impacts on human health, agricultural and other socio-economic activities of the local people. Mining on forest land leads to deforestation and loss of biodiversity.

In India, a vast area of land is affected every year by mining and mining-related activities. Restoration of mining affected environment has been a challenging task and very little progress has been made considering the magnitude of the problem. In order to mitigate the adverse impacts of mining activities and rehabilitate the mining affected areas, it is important to understand various problems of mining environment and their management. Assessment and stock taking of the prevailing environmental problems of the mining areas are prerequisites for initiating necessary remedial actions. Experience sharing of actions already initiated is equally important in formulating strategies for ecorestoration of mining degraded areas. To address these issues, a National Symposium on 'Ecorestoration of Mining Affected Areas' was organized at Shillong in 2003. The Symposium, sponsored by North Eastern Council (NEC), Shillong, North-Eastern Hill University (NEHU), Shillong and Indian National Science Academy (INSA), New Delhi was attended by about 50 participants. The participants deliberated on various aspects of mining environment and its management. The financial assistance provided by NEC, NEHU and INSA, and moral and physical support rendered by the organizing committee members, particularly Prof. B.K. Tiwari, Dr. V.T. Darlong and Dr. S.K. Barik are gratefully acknowledged.

The organizers of the Symposium decided to compile and publish selected papers in the form of a book for the benefit of students, researchers, policy makers and all concerned for ecorestoration of mining affected environment. The present volume on 'Mining Environment — Problems and Remedies' is the out come of this effort. The book comprising of five

Sections includes a total of 18 Chapters. The Section- I includes two Chapters on Status of Minerals and Mining in India. Eight Chapters pertaining to Environmental Problems of Mining have been included in Section-II. The Section-III comprising of three Chapters deals with Ecorestoration of Mining Affected Areas. Section-IV of the book, devoted to Mining Policies, Regulations and Environmental Impact Assessment includes three Chapters. Finally, Section-V incorporates Notification issued by Ministry of Environment and Forests, Government of India on Environmental Impact Assessment and a Glossary of terms related to mining environment.

The chapters included in this book are contributed by researchers renowned in their respective areas. I gratefully acknowledge their valuable contributions. I also would like to thank Shri Arun K. Verma of Regency Publications for expeditious publication of this book.

Shillong O.P. Singh

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Abbreviations/Acronyms

AAS	Atomic Absorption Spectroscope
Al	Aluminum
AMD	Acid Mine Drainage
As	Arsenic
Au	Gold
Bi	Bismuth
BNHS	Bombay Natural History Society
BOD	Biochemical Oxygen Demand
BR	Biosphere Reserve
$Ca(OH)_2$	Hydrated lime
$CaCO_3$	Limestone
CaO	Pebble quicklime
CBA	Coal Bearing Area
CO	Carbon monoxide
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
Cu	Copper
Cu_2S	Chalcosite
$CuFeS_2$	Chalcopyrite
DGM	Directorate of Geology and Mining
DGMS	Director General of Mines Safety
DMR	Directorate of Mineral Resources
DO	Dissolve Oxygen
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FCA	Forest (Conservation) Act

Fe	Iron
$Fe(OH)_3$	Ferric hydroxide
Fe_2+	Ferrous ion
Fe_2O_3	Hematite
$Fe_3(OH)_4$	Ferrihydrite
Fe_3^+	Ferric ion
$Fe_8O_8(OH)_6SO_4$	Schwertmannite
FeAsS	Arsenopyrite
FeOOH	Goethite
FeS	Pyrrhotite
FeS_2	Iron disulfide (Pyrite)
FeS_2	Marcasite
FeS_2	Marcasite
FRI	Forest Research Institute (Dehradun)
G & M	Geology and Mining
GGS	Group Gathering Station
GSI	Geological Survey of India
H^+	Hydrogen ions
H_2O	Water
HgS	Cinnabar
IBM	Indian Bureau of Mines
MCR	Mineral Concession Rules
MECL	Mining Exploration Corporation Limited
MMDR Act	Mines and Minerals (Development and Regulation) Act
Mn	Manganese
Mo	Molybdenum
MoEF	Ministry of Environment and Forests
Na_2CO_3	Soda ash
NaOH	Caustic soda
NEERI	National Environmental Engineering Research Institute (Nagpur)
NGO	Non-Governmental Organization
NH	National Highway
NH_3	Ammonia
Ni	Nickel
NiS	Millerite
NOx	Nitrogen oxides

NWAP	National Wildlife Action Plan
O_2	Oxygen
OB	Over burden
OCP	Open cast Mining Practice
Pb	Lead
PbS	Galena
PM_{10}	Particulate matter of diameter less than 10 micron
$PM_{2.5}$	Particulate matter of diameter less than 2.5 micron
RC-NAEB	Regional Centre-National Afforestation and Eco-development Board
RSPM	Respirable Suspended Particulate Matter
S	Sulfur
SAIL	Steel Authority of India Ltd
Se	Selenium
SEA	Strategic Environmental Assessment
SIA	Social Impact Assessment
SO_2	Sulfur dioxide
SO_4^{2-}	Sulfate ion
SPCB	State Pollution Control Board
SPM	Suspended Particulate Matter
TDS	Total Dissolve Solid
TERI	Tata Energy Research Institute
WII	Wildlife Institute of India
Zn	Zinc
ZnS	Sphalerite

CHAPTER 7

Impact of Coal Mining on Vegetation of Nokrek Biosphere Reserve, Meghalaya

K. Sarma, R.K. Rai and S.K. Barik

ABSTRACT

The impact of coal mining on vegetation has been studied on three mining areas and adjacent unmined areas in Nokrek Biosphere Reserve. Due to extensive coal mining, large areas of Nokrek Biosphere Reserve have been turned into degraded land, creating unfavourable habitat conditions for plant growth. Mining of coal has caused massive damage to landscape and biological communities. It was found that the number of tree species got reduced due to mining. The unfavourable habitat conditions prevailing in the coal mined areas might have reduced the regeneration of many tree species, thereby reducing the number of tree species in the mined areas. The number of shrub species recorded was much less in comparison to trees and herbs. Although the number of tree and shrub species was reduced due to mining, the number of herb species colonizing the mined areas was found higher than the unmined sites. Besides, certain herb species invaded the newly created habitats due to mining. Fifteen among tree, 4 among shrub and 28 among herb species were found only in mined sites, while 27 tree species, 4 shrub species and 16 herb species were found exclusively in the unmined sites. The density of trees, shrubs and herbs also got reduced due to mining. The dominance was shared by many species both at mined and unmined areas. In unmined sites, *Castanopsis kurzii, Ficus racemosa, Ostodes paniculata, Dysoxylum gobara, Caryota urens, Persea duthei* and *Macropanax undulatus* were dominant tree species, while *Bridelia monoica, Schima wallichii, Ficus hispida, Spondius pinnata, Meliosma wallichii* and *Bauhinia variegata* were dominant trees in the

mined sites. *Citrus* spp., *Hiptage benghalensis, Clerodendrum wallichii, Elsholtzia blanda* and *Psychotria erratica* were the dominant shrub species in the unmined areas while in the mined areas *Clerodendrum wallichii, Agapetes variegata, Millitia pachycarpa, Desmodium racemosa, Lantana camara* and *Olea dentana* were dominant. Among the herb species, *Davallia* spp., *Piper longrum* and *Asplenium* spp. were the dominant in umined areas and in the mined areas *Eupatorium adenophorum, Pteris* spp., *Thysanolaena maxima, Asplenium* spp., *Eleusine corocana* and *Inula cappa* were dominant species. Shannon's diversity index for tree species was low in the mined sites than that of the unmined sites at Budugiri and Faramgiri. However, at Budu Wathegiri, the trend was reverse. This has been attributed to the existence of bigger trees and causing less damage to the trees during mining operation. The herb species diversity, however, increased with mining activity. Unmined sites had better tree regeneration than the mined sites. Most of the tree species showed contagious distribution pattern both at unmined and mined sites. Due to mining, the contagiousness has increased.

Introduction

The unscientific mining of coal poses serious threat to the environment. Some of the environmental consequences of coal mining are, reduction of forest areas, greater soil erosion, air, water and soil pollution, and damage to various species population. In addition, surface mining of coal causes massive damage to landscape and biological communities (Down and Stock, 1977). Plant communities, which occur naturally are disturbed by mining activity and become impoverished because mining environment alters the natural conditions and provides a very rigorous condition for plant growth.

The north-eastern state of Meghalaya has rich natural vegetation as well as large reserve of mineral resources. During the last few decades, there has been phenomenal increase in mining of coal, limestone and sillimanite, thus causing large-scale destruction of the natural vegetation of the state. Among all the mining operations, coal mining has been largely responsible for the degradation of forests of Meghalaya. The primitive 'rat-hole' method of coal mining is being adopted by the private miners. Such unscientific method of mining has

been causing serious damage to various ecosystems in a given landscape. The study of plant communities of the coal mining affected areas is of great interest to the ecologists. The studies related to the floristic composition of the coal mining areas have been conducted by various workers in different parts of the world (Fyles *et al.* 1985, Game *et al.* 1982, Singh and Jha 1987, Jha and Singh 1990). Prasad and Pandey (1985) have studied natural plant succession in the rehabilitated bauxite and coal mine overburden of Madhya Pradesh. Jha and Singh (1990) have analysed the vegetation, developing naturally on dry subtropical mine spoils. Till today, a few studies (Lyngdoh *et al.* 1992, Lyngdoh 1995, Pandey *et al.* 1993 and Dasgupta 1999) have been carried out on the natural succession of plant communities of coal mine affected areas of Meghalaya. In the present study, an analysis of plant communities of coal mined areas and the adjacent unmined areas have been carried out to understand the impact of coal mining on plant diversity and community structure in Nokrek Biosphere Reserve.

Study Sites

The Nokrek Biosphere Reserve is one of the 13 Biosphere Reserves so far notified in India and one of the 4 Biosphere Reserves of North-East India. The Nokrek Biosphere Reserve was notified on 1st September 1988. In the western part of Meghalaya, an area of 820 sq km covering all the three districts of Garo Hills viz., East Garo Hills, West Garo Hills and South Garo Hills has been designated as Nokrek Biosphere Reserve. The Biosphere Reserve is lying between 25°18′39″N and 25°36′7″N latitudes and 90°13′30″E and 91°37′17″E longitudes (Fig. 1). The Nokrek Biosphere Reserve is a unique area with a number of rare and endangered plants and animals.

In Garo Hills, the total reserve of coal has been estimated to be 359 million tones and a considerable portion of this deposit falls under the Nokrek Biosphere Reserve. Because of complex geological setting, peculiar land holding system and lack of infrastructure, unscientific extraction of coal in unorganized sector within the Biosphere Reserve is going on and the area of coal mining in this region is increasing day by day. Coal mining started within the Biosphere Reserve in the

LOCATION OF NOKREK BIOSPHERE RESERVE

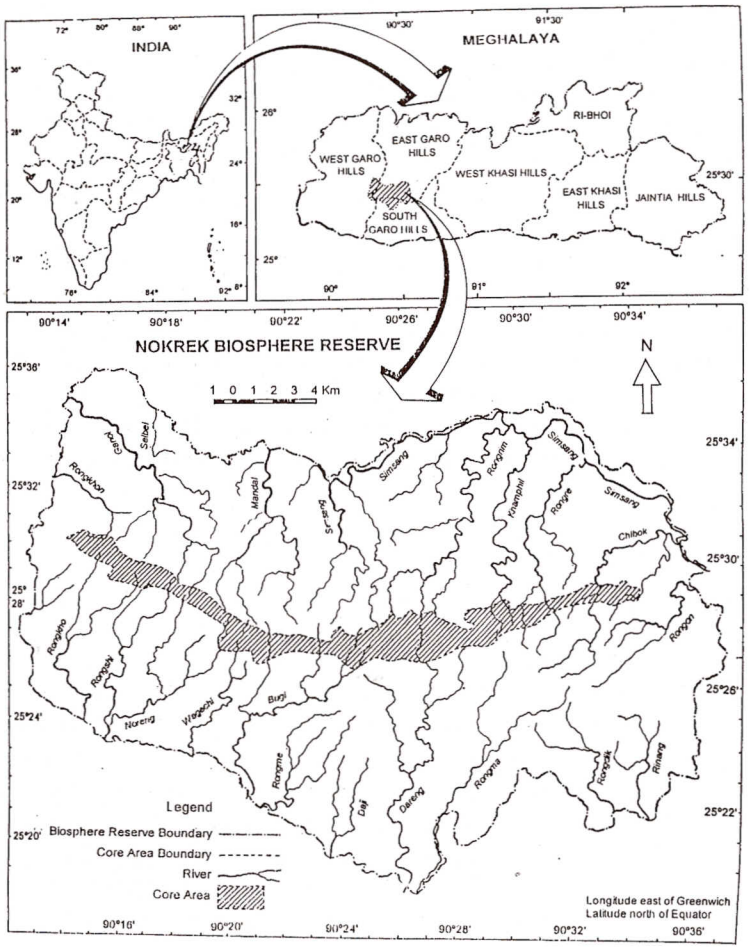

Figure 1: Location map of Nokrek Biosphere Reserve

year 1985 at Darrangiri and at present coal is being extracted from 18 coal mining sites (Fig. 2). The whole buffer area of the Biosphere Reserve is degraded and disturbed due to large-scale coal mining, shifting cultimvation and other human activities. Uncontrolled and unscientific mining operation within the Biosphere Reserve has been detrimental to the fragile ecosystem.

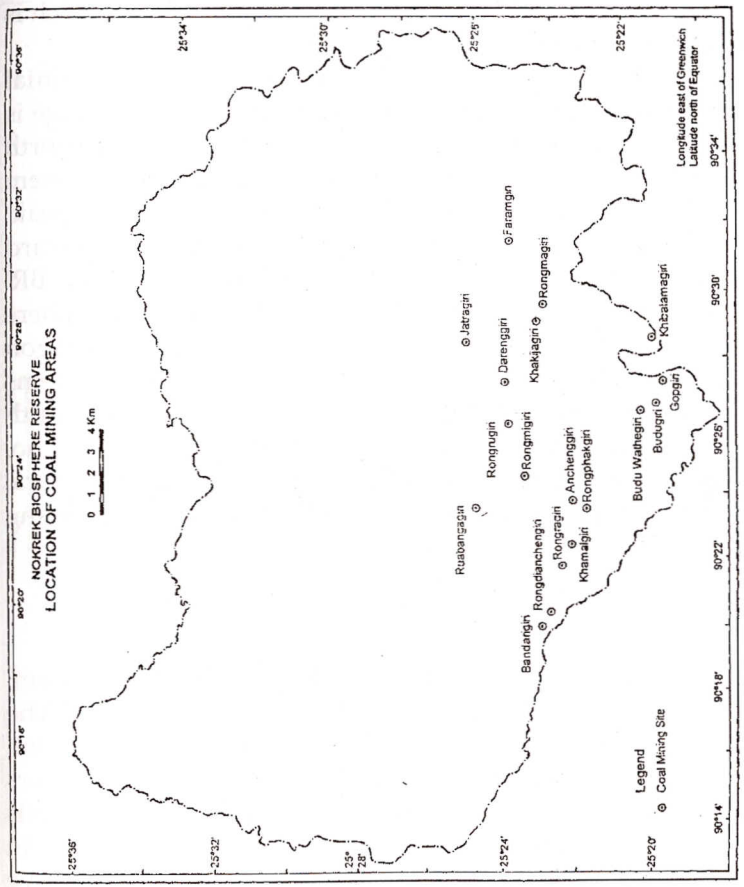

Figure 2: Location of various coal mining areas in Nokrek Biosphere Reserve

Physiography

Nokrek Biosphere Reserve is located in the Tura Range, which is a part of Meghalaya Plateau, having an average altitude of 600 m. The highest point in this region is the Nokrek peak (1412 m) lying within the Biosphere Reserve. The core area of the Biosphere Reserve (BR) is Nokrek National Park, which is spread over an area of 47.48 sq. km.

Several springs and streams comprise the perennial drainage system of the Biosphere Reserve. The Tura range is the source of these drainage systems comprising of both north and south flowing rivers. Simsang is the main drainage system of the Biosphere Reserve, which originates near Nokrek peak. From the source, it flows directly north and takes an eastward turn from where it forms the northern boundary of the BR. The main tributaries of Simsang river which drain the Biosphere Reserve are Rongrim, Khamphil, Rongre, Chibok, Rongon and Chibe. The other north flowing main drainage systems are Mandal, Ganol, Selbel and Ronkhen. The main south flowing rivers which ultimately flow to Bangladesh are Ronkho, Rongshi, Noreng, Wagechi, Dareng, Bugi, Rongme, Ginura, Daji, Mindri, Jetra, Thokong, Rongma, Rongdik and Rinang (Fig. 3).

Soil

The soil of most part of the Biosphere Reserve is a red loam. The soil is poor in silica but rich in clay forming materials. The soil is generally loamy but often found clay to sandy loam. The surface horizon, which is about 30 cm thick has colours ranging from reddish brown to dark reddish brown. The soils are rich in organic matter and nitrogen but deficient in phosphorous and potassium. The soil of the Biosphere Reserve is acidic in nature.

Climate

The general climate of the study area is monsoonic and is directly influenced by the south-west monsoon. Based on the climatic conditions, the year may be divided into summer,

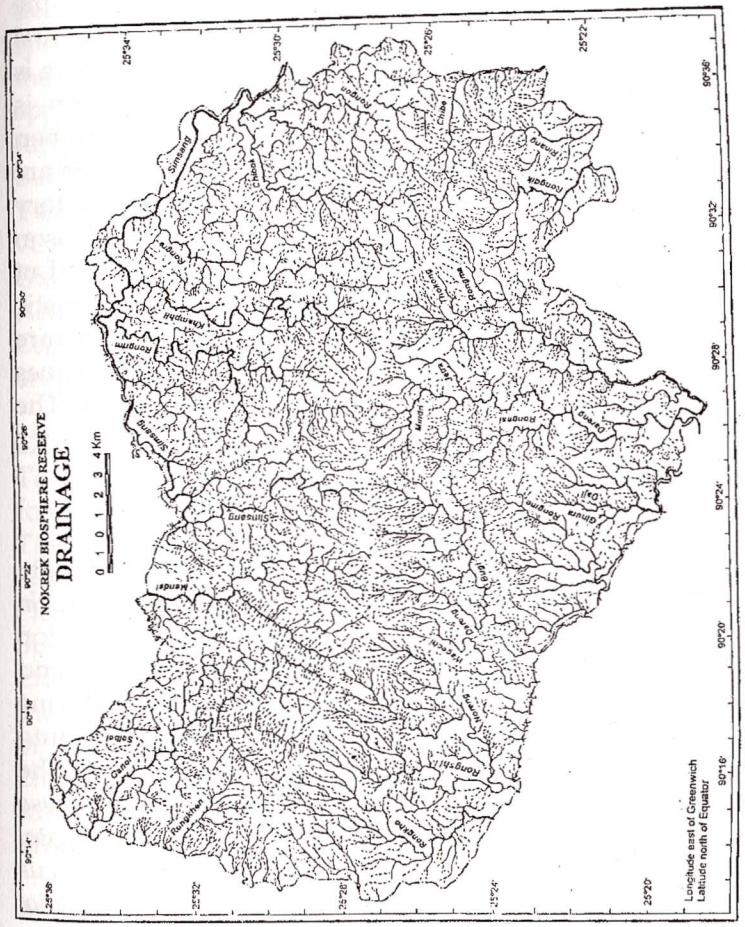

Figure 3: Drainage map of Nokrek Biosphere Reserve

rainy, autumn and winter seasons. The summer season (April to mid May) is characterized by relatively high temperature, occasional thunderstorms and high velocity wind. In this season, the average maximum temperature goes up to 30.7°C. The rainy season commences with the onset of south-west monsoon in mid May and lasts upto September. This is the wettest period of the year and about three fourth of the annual rainfall is received during this period. The air temperature is close to that of the summer season. The rainy season is followed by a brief autumn during October and November. The sharp decline in rainfall and lowering of temperature are the characteristic features of this season. It is a transitory period between rainy and winter seasons. The winter season extends from December to March. It is the coldest period of the year. Morning fog and dry weather are the characteristic features of this season. A few intermittent light showers are also received during this period. The mean temperature goes down to 7.5°C during mid winter i.e., December/January. The area receives the mean annual rainfall of 2400 mm.

Vegetation

The vegetation of Nokrek Biosphere Reserve can be broadly classified into tropical and subtropical types depending on the altitude. The tropical vegetation are found upto an elevation of about 1000 m. It includes evergreen, semievergreen and moist deciduous forests, bamboo brakes, grasslands riverine forests and swamps. The forests could be distinguished into three distinct vertical layers viz., tree, shrub and herb. The trees in the upper canopy include *Aesculus assamica, Aporusa wallichii, Bridelia retusa, Butea monosperma, Castonopsis armata, Cryptocarya andersonii, Dillenia indica, Dillenia pentagyna, Ficus* spp., *Gmelina arborea, Grewia* spp., *Gymnosporia salicifolia, Hovenia acerba, Largerstroemia parviflora, Leea macrophylla, Munronia pinnata, Pilioatigma malabaricum, Schima wallichii, Schleichera trijuga, Shorea robusta, Syzygium kurzii, Talauma hodgsonii, Terminalia belerica, Terminalia chebula, Toona ciliata,* and *Vitex peduncrularis. Engelhardtia spicata, Ficus prostrata, Helicia robusta, Hibiscus macrocarpus, Miliusa velutina* and *Zizyphus rugosa* form the lower canopy of the forest. The main

shrub species are: *Acacia concinna, Bauhinia acuminata, Capparis zeylanica, Eupatorium adinoforum, Garcinnia lancifolia, Mimosa himalayayana* and *Mussaendra roxburghii.* Several species of bamboo form thickets of secondary vegetation, which cover substantial area of the Biosphere Reserve. The ground flora in deciduous forests is generally poor. In evergreen forests, species of *Alpinia, Amomum, Colocasia,* and *Hedychium* dominate the ground flora. The epiphytic climbers such as *Rhaphidophora* spp., *Hoya* spp. and many stem parasites are seen in these forests. A few species of epiphytic orchids viz., *Aeridis, Bulbophyllum, Dendrobium, Eria, Liparis, Photidota, Thunia* and *Vanda* are seen in the evergreen forests. The herbaceous vegetation is less profuse and includes the members of Oxlidaceae, Balsaminanceae, Acanthaceae, Leeaceae, Fabaceae, Asteraceae and Poaceae. Besides, *Sida* spp. and *Leea* spp., *Coffea bengalensis, Impereta cylindrica* and *Chromolaena odorata* are also prominent.

The subtropical vegetation occurs at elevations beyond 1200 m above sea level. This type of forest is restricted to the Tura peak and Nokrek peak only. These are mainly evergreen forests but a few elements of deciduous forest are also seen. The upper canopy is composed of species like *Castanopsis hystrix, Kevia floribunda, Tamula phellocarna, Dryntes lancifolia, Ficus* spp., *Vitex altissima, Adina cardifolia* and *Sterculia villosa.* Species such as *Persea gamblei, Persea villosa, Carnicia paniculata, Eriobotrya bengalensis, Quercus semiserrata* and *Litsea* spp. form the middle canopy of the forest. The lower canopy comprises of *Aglata roxburghii, Mitrephora tomentosa, Premna multifolia, Litsea* spp. and *Ficus* spp. The shrub layer is dominated by *Munronia pinnata, Eriobotrya angustissima, Antistriphe oxyantha, Strobilanthes glomeratus* and *Erianthus* spp.

Methods

Three coal mining sites viz., Budugiri, Budu Wathegiri and Faraamgiri were selected in Nokrek Biosphere Reserve for the study. At each site 100 ha of mined areas were demarcated for detailed study. In adjacent unmined areas, an area of 100 ha each was also demarcated for vegetation sampling for control. For tree components, 10 quadrats of 10 m × 10 m size each

were laid randomly in the unmined and mined demarcated areas at each site. For shrub species, 10 quadrats of 5 m × 5 m size each in mined and unmined areas were laid. The herb species were studied by laying 40 quadrats each of 1 m × 1 m size in mined and unmined areas. The species found in quadrats were identified with the help of the herberia of Botany Department, North-Eastern Hill University and Botanical Survey of India, North-Eastern Circle, Shillong.

Quantitative community characteristics such as frequency, density, basal area and importance value index (IVI) of each component were determined by following the methods as outlined by Mishra (1968) and Muller-Dombois & Ellenberg (1974).

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats of occurrence of a species}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrats studied}}$$

$$\text{Basal cover} = \text{Density} \times \text{Average basal area of individuals of a species}$$

Basal area was calculated for herbs and shrubs based on the measurement of stem diameter at basal level and for trees CBH at 1.37 m height.

$$\text{Abundance} = \frac{\text{Number of individuals of a species}}{\text{Number of quadrats of occurrences of the species}}$$

The distribution pattern of the species in the forests were studied by Whitford's index (Whitford 1948).

$$\text{Whitford's index} = \frac{\text{Abundance(A)}}{\text{Frequency(F)}},$$

If A/F ratio: <0.025 -Regular distribution
0.025–0.05 -Random distribution
>0.05 -Contagious or clumped distribution

Shannon's index of General Diversity was calculated by using the formula

$$\overline{H} = -\Sigma(n_i/N) \ln (n_i/N)$$

Where, $\overline{H}$ = Shannon's index of general diversity
n_i = importance value index of a species
N = total importance values of all species

Results and Discussion

Floristic composition

The total number of plant species found in the mined areas was significantly less than the unmined areas (Fig. 4). The number of tree species was higher in the unmined areas (31–44 species) than the mined areas (25–26 species). With the exception of herb species at Budugiri site, the tree and shrub species showed a drastic reduction in their number due to mining. The number of shrub species was much less in comparison to trees and herbs at all the three sites (Table 1). Fifteen tree species, 4 shrub and 28 herb species were exclusively found in mined sites, while 27 tree species, 4 shrub species and 16 herb species were exclusively found in the unmined sites (Table 2).

Table 1: Species composition in unmined and mined areas at three sites in Nokrek Biosphere Reserve

Species Composition	*Budugiri*		*Budu Wathegiri*		*Faramgiri*	
	Unmined	*Mined*	*Unmined*	*Mined*	*Unmined*	*Mined*
			Tree			
Number of species	38	25	31	26	44	25
Number of genera	35	24	29	26	36	20
Number of families	26	20	20	19	28	16
			Shrub			
Number of species	5	6	16	13	18	17
Number of genera	5	5	15	12	16	17
Number of families	5	5	14	12	14	14
			Herb			
Number of species	28	33	26	17	18	18
Number of genera	26	31	26	16	17	18
Number of families	23	26	22	10	16	15

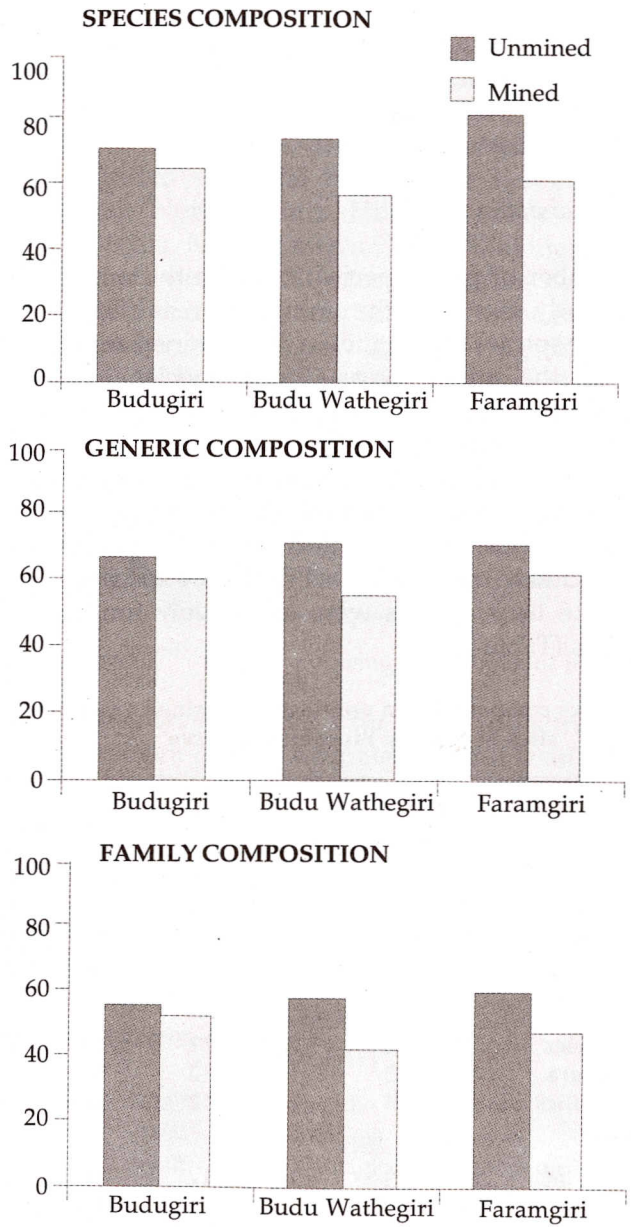

Figure 4: Total number of species, genera and family found in the mined and unmined areas at three sites of Nokrek Biosphere Reserve

Table 2: Plant species found exclusively in unmined and mined areas of the Nokrek Biosphere Reserve

Unmined	*Mined*
Tree species	
Antidesma acuminatum Wall. Ex Wt	*Alchornea tiliaefolia* Muell.-Arg.
Artemisia nilagirica (Clarke.) Pamp.	*Anacardium occidentale* linn.
Casearia Kurzii Cl.	*Bauhinia variegata* Linn.
Citrus medica Linn.	*Bridelia monoica* (Lour.) Merr.
Clausena heptaphylla (Roxb.) W. & A.	*Callicarpa arborea* Roxb.
Cleidion spiciflorum (Burm.) Merr.	*Cordia grandis* Roxb.
Daphne composita (L.f.) Gilg	*Duabanga grandiflora* (Roxb. ex. DC.) Walp
Dysoxylum gobara (Buch.-Ham.) Merr.	*Erythrina stricta* Roxb.
Ficus gasparriniana Miq.	*Euonymus attenuatus* Laws.
Garcinia paniculata (G. Don.) Roxb.	*Meliosma wallichii* Planch ex. Hk.f.
Helicia nilagirica Bedd.	*Prunus cerasoides* D. Don
Homonia riparia Lour.	*Saurauia nepaulensis* DC.
Kydia calycina Roxb.	*Schima wallichii* (DC.) Korth.
Litsea cubeba Lour.	*Spondius pinnata* (Linn. f) Kurze.
Litsea salicifolia (Roxb. Ex Nees) Hk.f.	*Writhtia coccinea* Roxb.
Maesa indica (Roxb.) Wall.	
Melodinus khasianas Hk.f.	
Ostodes paniculata Bl.	
Picrasma javanica Bl.	
Rhus javanica Linn.	
Saprosma ternatum Hk.f.	
Skimmia laureola (Dc.) Sieb ex Walp.	
Sterculia hamiltonii (O) Ktze.	
Syzygium cumini (Linn.) Skeels	
Terminalia bellerica (Gaertn) Roxb.	
Titrameles nudiflora R. Br.	
Zizyphus mauritiana Lamk.	
Shrub species	
Ardisia odontophylla DC	*Agapetes variegata* Roxb.
Calophyllum polyanthum Choisy	*Clerodendrum viscosum* Vent.
Psychotria erratica Hk.f.	*Clerodendrum wallichii* Merr.
Rubus ellipticus Sm.	*Elscholtzia blanda* Benth.

(contd...)

(Table 2 contd...)

Unmined	*Mined*
	Herb species
Arisaema tortuosum (Wall.) Schott.	*Agapetes variegata* Roxb.
Cynotis vaga Lour.	*Cyperus compressus* Linn.
Dischidia nummularia R. Br.	*Desmodium racemosa* (Thunb.) DC.
Elatostemma rupestre (D. Don) Wedd.	*Digitaria ciliaris* (Reitz.) Koel.
Erythroxylum kunthianum Wall. ex Kurz.	*Embelia ribes* Burn. F
Hoya lanceolata Wall ex D. Don.	*Eupatorium adenophorum* Spreng.
Marchantia sp.	*Eupatorium odoratum* Linn.
Molineria capitulata Lour.	*Hedyotis scandence* D. Don.
Olax acuminata Wall.	*Ipomea simosa*
Piper longum Linn.	*Jasminium lanceolarum* Roxb.
Pogestemon auricularis Hask.	*Leea cripsa* Linn.
Psychotria erratica Hk.f.	*Morinda angustifolia* Roxb.
Smilax ferox Kunth	*Murrya paniculata* Linn.
Strobilanthus discolor Nees.	*Ophiopogon parviflorus* (Hook) f. Hara.
Tacca laevis Roxb.	*Oxalis* sp.
Vandelia multiflora (Roxb) D.Don.	*Phyllanthus raticulatus* Poir.
	Piper thomsonii Hk.f.
	Plantago major Hook.f.
	Plectranthus ternifolius D.Don
	Spondius pinnata (Linn.f.) Kurz.
	Selinum striatum Cl.
	Senecio griffithii Clarke.
	Senecio scandens Buch.-Ham.ex D. Don
	Solanum tora
	Stephania japonica (Thunb.) Miers.
	Thysanolaena maxima (Roxb.) O. Ktze.
	Triumfetta tomentosa Bojer
	Zanthoxylum armatum Hk.F.

Since the mined and unmined areas had similar climatic, edaphic and physiographic features the difference in species composition could be attributed to the mining activities. This is in agreement with the findings of Das Gupta (1999), Baig (1992), Jha & Singh (1990). Leisman (1957) and Gibson *et al.* (1985) stressed the importance of surrounding vegetation and

the dissemination efficiency of propagules in spoil seed banks for rapid colonization of mined areas. Bradshaw & Chadwick (1980) working on the colliery spoils reported that the number of species colonizing on spoil was influened by its pH. Decline in pH in mine spoils is one of the serious problems associated with coal mining activity. Lowering of pH strongly affects the plant growth in various ways including the availability of a large number of essential nutrients in the soil.

Density

The total plant density in mined areas ranged between 3250 and 4161 stems per ha. while that in the unmined areas ranged between 6720 and 7260 stems per ha. The density of trees, shrubs and herbs in mined areas were significantly lower ($P<0.01$) than the unmined areas at all the three sites (Fig. 5).

The unmined areas had greater plant diversity compared to that of the mined stands because of acidic pH, moisture stress and nutrient property of the latter. Similar results have also been reported by Lyngdoh (1995) and Das Gupta (1999).

Dominance Pattern

The dominance pattern was different for tree, shrub and herb components. The dominance was concentrated in one or two species in case of shrub and herb, while in case of trees dominance was distributed more or less evenly among many species (Table 3). The dominant species in mined and unmined areas even at the same site were also different except that in Faramgiri, where *Ficus racemosa* was the dominant tree species both in mined and unmined areas. The dominant tree species in the unmined areas at three sites were also different. At Budugiri, *Kydia calycina* and *Dysoxylum gobara* were dominant and codominant, while at Budu Wathegiri, *Ostodes paniculata* and *Persea duthei* were dominant and codominant, respectively. However, in mined areas there was some similarity in dominant species composition. At Budugiri mined areas *Bridelia monoica* was the dominant tree species. *Schima wallichii, Bauhinia variegata* and *Spondius pinnata* were codominant species. *Ficus hispida* was dominant at Faramgiri mined site. *Ficus racemosa,*

Meliotus wallichii and *Schima wallichii* were codominant at this site. *Schima wallichii* and *Spondius pinnata* were dominant in mined sites at Budu Wathegiri while *Ficus hispida* and *Meliotus wallichii* were codominant at this site. The common important tree species found at all the three mined sites were, *Schima wallichii, Spondius pinnata, Bauhinia variegata, Ficus hispida* and *Meliotus wallichii.* The common important tree species in the unmined sites were *Dysoxylum gobara, Ostodes paniculata* and *Macropanax undulatus. Citrus* spp., *Hiptage benghalensis, Clerodendrum wallichii, Elsholtzia blanda, Psychotria erratica* were the dominant shrub species in the unmined areas while in the mined areas *Clerodendrum wallichii, Agapetes variegata, Millitia pachycarpa, Desmodium racemosa, Lantana camara, Olea dentana* were dominant. Among the herb species *Davallia* spp., *Piper longrum and Asplenium* spp. were the dominant in unmined areas while in the mined areas *Eupatorium adenophorum, Pteris* spp., *Thysanolaena maxima, Asplenium* spp., *Eleusine corocana* and *Inula cappa* were dominant species.

Table 3: Importance value index of tree species found in the mined and unmined areas at three sites in Nokrek Biosphere Reserve

	Importance Value Index					
	Budugiri		Budu Wathegiri		Faramgiri	
Tree species	Unmined	Mined	Unmined	Mined	Unmined	Mined
Acacia pennata	3	6.8	6.9	5.7	3.6	–
Alangium chinesis	–	–	14.1	5.9	–	–
Albizia chinensis	–	7.1	13.7	10.3	3.7	16.9
Alchornea tiliaefolia	–	7.1	–	–	–	–
Alnus nepalensis	–	–	–	–	3.6	–
Anacardium occidentale	–	12.6	–	14.2	–	–
Antidesma acuminatum	10.2	–	7.7	–	3.2	–
Antidesma diandrum	–	–	–	–	5.5	–
Aporusa dioica	–	–	–	–	–	11.6
Aporusa oblonga	4.4	10.5	12.2	11.6	–	–
Ardisia paniculata	–	–	–	11.5	–	–
Artemisia nilagirica	18	–	–	–	3.3	–
Bauhinia variegata	–	20.8	–	16.5	–	7.4
Baccaurea sapida	–	–	–	–	10.9	–
Beilshmiedia assamica	–	–	–	7.5	–	–
Beilshmiedia fogifolia	–	–	–	–	3.2	–

	Importance Value Index					
	Budugiri		Budu Wathegiri		Faramgiri	
Tree species	Unmined	Mined	Unmined	Mined	Unmined	Mined
Beilshmiedia roxburghiana	–	–	–	–	4.1	–
Bridelia monoica	–	55.2	–	–	–	–
Briedellia pubescens	–	–	–	6.2	–	–
Bridelia stipularis	–	7.7	–	–	8	8.4
Callicarpa arborea	–	9.6	–	8	–	11.2
Calophyllum polyanthum	–	–	–	–	3.8	–
Camellia cauduca	–	–	–	–	–	7.8
Camellia sinensis	–	–	–	–	3.4	–
Carryota urens	–	–	10.1	–	22	–
Casearia kurzii	8.2	–	34	–	–	–
Castanopsis hystrix	–	–	–	–	3.1	–
Castanopsis indica	14.8	–	10.2	–	11.5	9.0
Castanopsis kurzii	9.4	–	–	–	13.4	8.1
Castanopsis purpurella	–	–	–	–	6.6	8.4
Celastrus robustus	–	–	–	–	–	12.3
Celtis tetrandra	–	–	5.1	–	3.4	–
Citrus medica	6.9	–	–	–	–	–
Citrus sp.	–	–	16.6	–	–	–
Clausena heptaphylla	11.3	–	–	–	–	–
Cleidion spiciflorum	2.7	–	–	–	–	–
Cordia fragrantissima	–	–	–	8.1	–	–
Cordia grandis	–	7.3	–	–	–	–
Daphne composita	2.7	–	–	–	3.8	–
Derris robusta	–	–	–	5.7	3.2	–
Duabanga grandiflora	–	7.7	–	8.9	–	14.5
Dysoxylum gobara	21.5	–	3.7	–	11.8	–
Echinocarpus murex	15	7.2	2.7	5.9	8.0	–
Erythrina stricta	–	17.9	–	33.2	–	10.21
Euonymus attenuatus	–	9.1	–	–	–	–
Euonymous lawsonii	–	–	–	–	9.6	–
Ficus elastica	–	–	–	–	4.8	–
Ficus gasparriniana	3.2	–	–	–	–	–
Ficus hispida	–	6.9	–	20.7	3.3	30.1
Ficus racemosa	–	–	4.6	–	23.5	18.7
Garcinia paniculata	7.7	–	3.2	–	–	–
Gaultheria fragrantissima	–	–	–	–	7.6	–
Glochidion oblatum	2.9	7.2	–	5.9	–	–
Glycosmis arborea	–	–	–	–	8.7	–
Helicia nilagirica	2.6	–	–	–	5.5	–

(contd...)

(Table 3 contd...)

	Importance Value Index					
	Budugiri		Budu Wathegiri		Faramgiri	
Tree species	*Unmined*	*Mined*	*Unmined*	*Mined*	*Unmined*	*Mined*
Homonia riparia	3.0	–	5.2	–	4.7	–
Ilex odorata	–	–	–	–	5.4	–
Kydia calycina	22.1	–	–	–	–	–
Lindera caudata	–	–	–	–	3.9	–
Litsea cubeba	3.5	–	7.0	–	3.1	–
Litsea salicifolia	8.7	–	–	–	3.3	–
Macaranga denticulata	3.8	6.6	7.4	–	8.6	7.3
Macroponax undulatus	10.3	–	20.8	5.5	12.9	–
Maesa indica	15.9	–	9.5	–	9.7	–
Maesa tetrandra	10.6	–	–	–	–	7.5
Mallotus phillipensis	–	–	4.6	–	–	–
Meliosma wallichii	–	8.7	–	16.6	–	21.1
Melodinus khasianas	5.7	–	4.6	–	6.4	–
Micromelum integrimum	10.2	–	12.1	9.8	8.4	–
Ostodes paniculata	9.2	–	22.2	–	3.5	–
Ostodes sp.	–	–	4.1	–	–	–
Persea duthiei	–	–	21.0	–	–	–
Picrasma javanica	3.1	–	3.9	–	4.0	–
Prunus cerasoides	–	7.7	–	14.3	–	–
Prunus wallichii	–	–	–	–	–	9.6
Randia fasciculata	–	–	–	–	–	7.9
Randia longiflora	8.0	–	–	–	3.8	8.4
Randia wallichii	–	7.5	6.2	6.1	–	8.2
Rhus javanica	3.5	–	–	–	–	–
Sapium baccatum	–	–	–	8.4	–	11.6
Saprosma ternatum	2.9	–	7.2	–	10.3	–
Saurauia nepaulensis	–	7.3	–	6.0	–	7.9
Schima wallichii.	–	25.8	–	23.8	–	18.9
Skimmia laureola	8.1	–	12.5	–	6.2	–
Spondius pinnata	–	19.1	–	23.8	–	16.9
Sterculia hamiltonii	3.1	9.3	2.7	–	–	–
Syzygium cumini	2.7	–	–	–	–	–
Talauma hodgsonii	–	–	4.0	–	–	–
Terminalia bellerica	12.4	–	–	–	–	–
Tetrameles nudiflora	2.8	–	–	–	–	–
Writhtia coccinea	–	7.2	–	–	–	–
Zizyphus mauritiana	5.8	–	–	–	–	–
	300	300	300	300	300	300

'–' Indicates absence of the species.

Table 4: Importance value index of shrub species found in the mined and unmined areas at three sites in Nokrek Biosphere Reserve

	Importance Value Index					
	Budugiri		Budu Wathegiri		Faramgiri	
Shrub species	*Unmined*	*Mined*	*Unmined*	*Mined*	*Unmined*	*Mined*
Acanthopanax aculeatum	–	–	7.3	–	–	–
Aeschyranthus acuminatus	–	–	14.2	–	–	–
Agapetes variegata	–	64.6	–	–	–	23.3
Ardisia odonophylla	51.9	–	–	–	27.2	–
Baliospermum calycina	–	–	–	–	–	11.9
Casia alata	–	–	–	–	22.1	–
Citrus medica	–	–	–	16.3	29.1	11.9
Citrus sp.	109.4	36.2	13.47	19.9	6.46	–
Clerodendrum viscosum	–	43.0	–	–	–	–
Clerodendrum wallichii	–	69.9	50.6	17.9	–	–
Combretum acuminatum	–	–	–	17.1	–	13.9
Croton caudatus	–	–	–	–	6.4	–
Cyathula tomentosa	–	–	–	22.4	16.9	13.9
Desmodium racemosa	–	–	–	44.7	8.4	–
Dracaena angustifolia	–	30.3	27.9	23.7	13.8	–
Dracaena elliptica	–	–	32.2	–	18.1	–
Elscholtzia blanda	–	55.5	8.7	–	42.9	–
Embelia ribes	–	–	–	19.9	9.6	11.9
Erythroxylum kunthianum	–	–	30.1	–	16.9	–
Glycosmis arborea	–	–	–	–	15.1	16.4
Hedyotis scandence	–	–	–	–	5.6	–
Hiptage benghalensis	–	–	63.3	–	–	–
Jasminium adenophyllum	–	–	–	–	–	11.9
Lantana camara	–	–	–	–	–	43.9
Melastoma malabathricum	–	–	–	–	–	11.9
Millitia pachycarpa	–	–	–	56.2	–	–
Mimosa pudica	–	–	–	–	–	12.8
Mussaenda roxburghii	–	–	–	23.7	–	–
Olax acuminata	–	–	11.5	–	–	27.7

(contd...)

(Table 4 contd...)

	Importance Value Index					
	Budugiri		Budu Wathegiri		Faramgiri	
Shrub species	*Unmined*	*Mined*	*Unmined*	*Mined*	*Unmined*	*Mined*
Olea dentata	–	–	–	–	–	42.7
Olea dioica	–	–	22.4	–	–	–
Pogestemon auricularis	–	–	–	–	25.4	–
Psychotria adenophylla	–	–	–	–	8.4	–
Psychotria erratica	84.9	–	–	–	13.7	–
Rubus ellipticus	52.92	–	–	–	–	–
Sarchochlamys pulcherrima	–	–	11.4	–	–	–
Smilax ferox	–	–	–	–	14.1	15.1
Sonerila maculata	–	–	–	–	–	16.4
Stephania hernandifolia	–	–	–	15.6	–	–
Sterculia roxburghii	–	–	–	–	–	13.9
Viburnum foetidum	–	–	7.0	–	–	–
Vitex vestuta	–	–	–	22.4	–	–
	300	300	300	300	300	300.00

'–' Indicates absence of the species.

Table 5: Importance value index of herb species found in the mined and unmined sites at three sites in Nokrek Biosphere Reserve

	Importance Value Index					
	Budugiri		Budu Wathegiri		Faramgiri	
Shrub species	*Unmined*	*Mined*	*Unmined*	*Mined*	*Unmined*	*Mined*
Agapetes variegata Roxb.	–	1.0	–	–	–	8.8
Agave sisalana Engelm	–	–	0.1	0.8	–	–
Ainsliaea latifolia (D. Don) Sch.	–	–	0.9	–	–	–
Anaphalis adnata Wall. ex DC.	–	–	–	13.2	–	12.6
Arisaema tortuosum (Wall.) Schott.	0.7	–	–	–	–	–
Asplenium sp.	32.6	–	31.8	18.3	34.1	8.9
Curculigo orchioides Gaertn.	–	–	1.8	8.6	1.9	7.9

	Importance Value Index					
	Budugiri		Budu Wathegiri		Faramgiri	
Shrub species	*Unmined*	*Mined*	*Unmined*	*Mined*	*Unmined*	*Mined*
Cyanotis barbata	4.9	–	–	–	–	11.7
Cyanotis cristata (Linn.) D. Don.	–	–	4.8	–	–	–
Cynodon ternatus A. Rich.	–	–	–	–	5.3	–
Cynotis vaga Lour.	0.9	–	0.9	–	0.9	–
Cyperus compressus Linn.	–	10.2	–	–	–	5.9
Cyperus pilosus Vahal.	–	–	22.3	–	23.8	–
Davallia sp.	46.0	–	44.7	28.0	47.4	–
Dendrocalamus sp.	–	–	–	2.1	–	–
Desmodium racemosa (Thunb.) DC.	–	11.1	–	–	–	–
Digitaria ciliaris (Reitz.) Koel.	–	–	–	2.2	–	–
Dischidia nummularia R. Br.	0.7	–	0.7	–	–	–
Dracaena angustifolia Roxb.	–	9.8	–	–	–	–
Dracaena elliptica Thunb.	–	5.4	–	–	–	–
Elatostema rupestre (D. Don) Wedd.	1.2	–	–	–	–	–
Eleusine corocana (L.) Gaeth	–	–	–	21.3	–	–
Embelia ribes Burn. F.	–	2.5	–	–	–	–
Erythroxylum kunthianum Wall ex Kurz.	0.9	–	–	–	–	–
Eulalia pallens Hack.	–	–	–	21	–	–
Eupatorium adenophorum Spreng.	–	16.8	–	–	–	6.7
Eupatorium odoratum Linn.	–	8.2	–	–	–	–
Eupatorium sp.	–	–	–	6.9	–	–
Galinsoga parviflora Cav.	–	–	0.9	–	0.9	–
Gleichenia sp.	0.7	–	0.7	–	0.8	14.9
Hedychium coccineum Smith	–	–	1.5	–	1.6	–

(contd...)

(Table 5 contd...)

	Importance Value Index					
	Budugiri		Budu Wathegiri		Faramgiri	
Shrub species	*Unmined*	*Mined*	*Unmined*	*Mined*	*Unmined*	*Mined*
Hedyotis scandence D. Don.	–	1.6	–	–	–	–
Hiptage benghalensis (Linn.) Kurz.	0.9	9.3	0.9	–	–	–
Hoya lanceolata Wall ex D. Don.	2.2	–	–	–	–	–
Impereta cylindrica (Linn.) P. Beauv.	–	–	1.3	11.4	–	–
Inula cappa (Buch.–Ham. ex D. Don.) DC.	–	–	–	–	–	16.4
Ipomea simosa	–	3.8	–	–	–	–
Jasminium lanceolarum Roxb.	–	8.5	–	–	–	–
Leea crispa Linn.	–	6.2	–	–	–	–
Lycopodium sp	–	–	–	–	25.6	–
Lygodium sp.	24.4	6.2	–	–	–	–
Marchantia sp.	0.9	–	–	–	–	–
Molineria capitulata Lour.	1.4	–	3.7	–	–	–
Morinda angustifolia Roxb.	–	8.1	–	–	–	–
Murrya paniculata Linn.	–	3.3	–	–	–	–
Olax acuminata Wall.	2.8	–	17.3	–	–	–
Ophiopogon parviflorus (Hook) f. Hara.	–	3.5	–	–	–	2.9
Osmunda javanica	3.8	–	0.7	10.4	–	–
Oxalis cornicalata Linn.	–	–	10.5	–	–	–
Oxalis sp.	–	2.5	–	–	–	–
Paedaria foetida Linn.	0.7	–	43.4	0.8	–	–
Pyllanthus raticulatus Poir.	–	7.5	–	–	–	–
Piper griffithii C. DC.	–	–	–	–	–	4.6
Piper longum Linn.	44.2	–	0.7	–	46.7	–
Piper sp.	–	–	–	5.8	–	–
Piper thomsonii Hk.f.	–	2.7	–	–	–	–
Plantago major Hook.f.	–	0.8	–	–	–	33.0
Plectranthus ternifolius D. Don	–	2.8	–	–	–	–
Pogestemon auricularis Hask.	1.5	–	–	–	–	–

	Importance Value Index					
	Budugiri		Budu Wathegiri		Faramgiri	
Shrub species	*Unmined*	*Mined*	*Unmined*	*Mined*	*Unmined*	*Mined*
Pogestemon auricularis Hask.	1.5	–	–	–	–	–
Polygala glomerata Lour.	0.7	–	0.7	13.5	0.8	–
Polygonum capitatum D. Don.	–	–	3.1	–	0.8	–
Pteris sp.	1.7	16.3	–	–	1.8	27.1
Spondius pinnata (Linn.f.) Kurz.	–	7.1	–	–	–	–
Saprosma ternatum Hk.f.	3.2	–	–	–	–	–
Selinum striatum Cl.	–	14.2	–	–	–	–
Senecio griffithii Clarke.	–	4.0	–	17.5	–	6.5
Senecio scandens Buch.-Ham.ex D. Don	–	0.6	–	–	–	–
Smilax ferax Kunth	17.4	–	–	–	–	–
Solanum tora	–	1.4	–	–	–	4.4
Stephania japonica (Thunb.) Miers.	–	2.5	–	–	–	–
Strobilanthus discolor Nees	0.7	–	–	–	–	–
Swertia pulchella D. Don.	1.4	–	2.4	–	–	–
Swertia pulchella D.Don.	–	–	–	–	1.4	7.2
Tacca laevis Roxb.	2.4	–	2.5	–	2.6	–
Tapiria hirsuta (Roxb.) Hk.f.	–	0.6	0.7	–	–	–
Thysanolaena agrostis Nees.	–	–	–	–	2.7	–
Thysanolaena maxima (Roxb.) O. Ktze.	–	16.4	–	–	–	20.4
Triumfetta tomentosa Bojer	–	3.3	–	–	–	–
Vandelia multiflora (Roxb) D.Don.	0.7	–	–	–	0.8	–
Wrightia coccinea Roxb.	–	–	–	6.2	–	–
Zanthoxylum armotum Hk.f.	–	2.1	–	–	–	–
	200	200	200	200	200	200

'–' Indicates absence of the species.

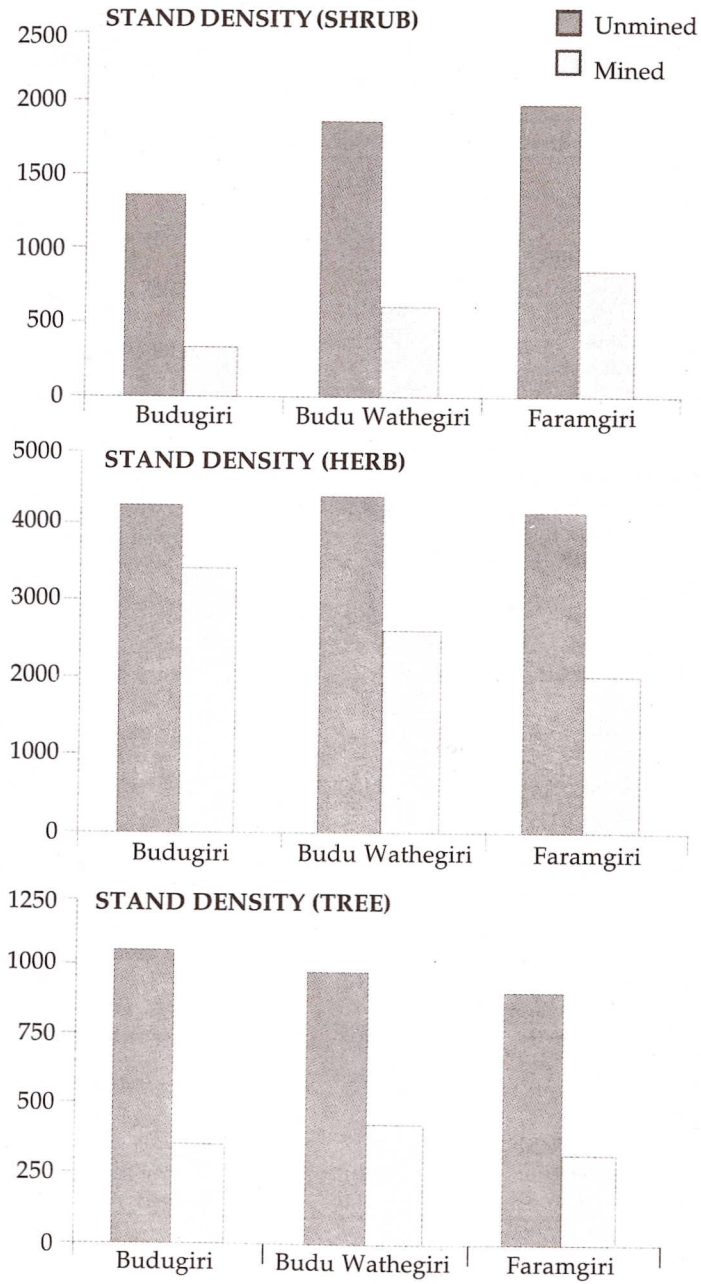

Figure 5: Stand density (stem ha^{-1}) as affected by mining at three sites of Nokrek Biosphere Reserve

Species Diversity

Shannon's diversity index for tree species was low in the mined sites than the unmined sites both at Budugiri and Faramgiri, indicating the adverse impact of mining on tree diversity (Table 6). However, at Budu Wathegiri, the trend was reverse. This could be attributed to the existence of bigger trees and causing less damage to the tress during mining operation by the miners. The diversity index for herbs increased with mining suggesting that mining operation enhanced the colonization of certain species in the newly created habitats due to mining.

Table 6: Shannon's species diversity index in unmined and mined areas of Nokrek Biosphere Reserve

Plant	*Budugiri*		*Budu Wathegiri*		*Faramgiri*	
	Mined	*Unmined*	*Mined*	*Unmined*	*Mined*	*Unmined*
Tree	2.97	3.42	4.30	3.33	3.13	3.60
Shrub	1.75	1.34	2.39	2.33	2.65	2.74
Herb	2.37	2.25	2.65	2.25	2.62	2.01

Distribution Pattern

Plant populations exhibited three patterns of spatial distribution — contagious or clumped, random and uniform or regular. Most tree species showed contagious distribution pattern both in the unmined (89.5%, 62.5% and 86.3%) and mined (95.8%, 88.5% and 100%) areas at Budugiri, Budu Wathegiri and Faramgiri, respectively (Table 7). This is in agreement with the findings of Rao *et al.* (1990), who observed that due to disturbance contagiousness increased.

Patchiness, or the degree to which individuals are aggregated or dispersed, is crucial to the understanding of how species uses resources, and how it is used as a resource. Besides, the distribution pattern of species population is often related to its reproductive biology. Webb *et al.* (1967), Ashton (1972) and Austin *et al.* (1972) indicated that in the absence of major disturbance, soil and water conditions play major roles in controlling species distribution pattern.

Table 7: Proportion (%) of tree species under different distribution pattern in the unmined and mined areas of Nokrek Biosphere Reserve

Distribution	*Budugiri*		*Budu Wathegiri*		*Faramgiri*	
Pattern	*Unmined*	*Mined*	*Unmined*	*Mined*	*Unmined*	*Mined*
Regular	0	0	0	0	0	0
Random	10.5	4.2	37.5	11.5	11.4	0
Contagious	89.5	95.8	62.5	88.5	86.3	100

The contagious distribution pattern for most tree species indicated the mosaicness of the forest stands. The increase in contagiousness of more species due to mining suggests the increase in patchness of the natural vegetation due to mining.

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Section V

Appendices

Appendix I

Notification on Environmental Impact Assessment of Development Projects

Ministry of Environment & Forest, Government of India, New Delhi

No. Z-12013/4/89-IA-I Dated: the 27th January, 1994

1. S.O.60(E) Whereas a notification under clause (a) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986 inviting objections from the public within sixty days from the date of publication of the said notification, against the intention of the Central Government to impose restrictions and prohibitions on the expansion and modernisation of any activity or new projects being undertaken in any part of India unless environmental clearance has been accorded by the Central Government or the State Government in accordance with the procedure specified in that notification was published as S.O.No. 80(E) dated 28th January, 1993;

   And whereas all objections received have been duly considered;

   Now, therefore, in exercise of the powers conferred by sub-section (1) and clause (v) of sub-section (2) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986) read with clause (d) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986, the Central Government hereby directs that on and from the date of publication of this notification in the Official Gazette expansion or

modernisation of any activity (if pollution load is to exceed the existing one) or a new project listed in Schedule I of this notification shall not be undertaken in any part of India unless it has been accorded environmental clearance by the Central Government in accordance with the procedure hereinafter specified in this notification.

2. Requirements and procedure for seeking environmental clearance of projects:

I. (a) Any person who desires to undertake any new project or the expansion or modernisation of any existing industry or project listed in Schedule I shall submit an application to the Secretary, Ministry of Environment and Forests, New Delhi.
The application shall be made in the proforma specified in Schedule II of this notification and shall be accompanied by a project report which shall, inter alia, include an Environmental Impact Assessment Report/ Environment Management Plan and details of public hearing as specified in Schedule IV prepared in accordance with the guidelines issued by the Central Government in the Ministry of Environment and Forests from time to time.

(b) Cases rejected due to submission of insufficient or inadequate data and plans may be reviewed as and when submitted with complete data and plans. Submission of incomplete data or plans for the second time would itself be a sufficient reason for the Impact Assessment Agency to reject the case summarily.

II. In case of the following site specific projects:

(a) mining;
(b) pit-head thermal power stations;
(c) hydro-power, major irrigation projects and/or their combination including flood control;
(d) ports and harbours (excluding minor ports);
(e) prospecting and exploration of major minerals in areas above 500 ha.,

The project authorities will intimate the location of the project site to the Central Government in the Ministry of

Environment and Forests while initiating any investigation and surveys. The Central Government in the Ministry of Environment and Forests will convey a decision regarding suitability or otherwise of the proposed site within a maximum period of thirty days. The said site clearance shall be granted for a sanctioned capacity and shall be valid for a period of five years for commencing the construction, operation or mining.

III. (a) The reports submitted with the application shall be evaluated and assessed by the Impact Assessment Agency and if deemed necessary it may consult a Committee of Experts, having a composition as specified in Schedule-III of this Notification. The Impact Assessment Agency (IAA) would be the Union Ministry of Environment and Forests. The Committee of Experts mentioned above shall be constituted by the IAA or such other body under the Central Government authorised by the IAA in this regard.

(b) The said Committee of Experts shall have full right of entry and inspection of the site or, as the case may be, factory premises at any time prior to, during or after the commencement of the operations relating to the project.

(c) The Impact Assessment Agency shall prepare a set of recommendations based on the technical assessment of documents and data furnished by the project authorities and supplemented by data collected during visits of sites of factories, if undertaken and details of public hearing.
The assessment shall be completed within a period of ninety days from receipt of the requisite documents and data from the project authorities and completion of public hearing and decision conveyed within thirty days thereafter.
The clearance granted shall be valid for a period of five years from commencement of the construction or operation of the project.
No construction work, preliminary or otherwise, relating to the setting up of the project may be

undertaken till the environmental and/or site clearance is obtained.

IV. In order to enable the Impact Assessment Agency to monitor effectively the implementation of the recommendations and conditions subject to which the environmental clearance has been given, the project authorities concerned shall submit a half-yearly report to the Impact Assessment Agency. Subject to the public interest, the Impact Assessment Agency, shall make compliance reports publicly available.

V. If no comments from the Impact Assessment Agency are received within the time limit, the project would be deemed to have been approved as proposed by project authorities.

3. Nothing contained in this Notification shall apply to:

   (a) any item falling under entry nos. 3, 18 and 20 of the Schedule-I to be located or proposed to be located in the areas covered by the Notifications S.O. No.102(E) dated 1st February, 1989; S.O. 114(E) dated 20th February, 1991 S.O. No. 416(E) dated 20th June, 1991 and S.O. No.319(E) dated 7th May, 1992.

   (b) any item falling under entry Nos. 1, 2, 3, 4, 5, 7, 9, 10, 12, 13, 14, 16, 17, 19, 21, 25 and 27 of Schedule-I if the investment is less that Rs.50 crores.

   (c) Any item reserved for Small Scale Industrial sector with investments less than Rs.1 crore.

4. Concealing factual data or submission of false, misleading data/reports, decisions or recommendations would lead to the project being rejected. Approval, if granted earlier on the basis of false data would also be revoked. Misleading and wrong information will cover the following:

   - False information.
   - False data.
   - Engineered reports.
   - Concealing of factual data.
   - False recommendations or decisions.

R. Rajamani, Secy.

Schedule-I

(See paras 1 and 2)

List of projects requiring environmental clearance from the central government

1. Nuclear Power and related projects such as Heavy Water Plants, nuclear fuel complex, rare earth.
2. River Valley projects including hydel power, major irrigation and their combination including flood control.
3. Ports, Harbours, Airports (except minor ports and harbours).
4. Petroleum Refineries including crude and product pipelines.
5. Chemical Fertilisers (Nitrogenous and Phosphatic other than single superphosphate).
6. Pesticides (Technical).
7. Petrochemical complexes (Both Olefinic and Aromatic) and Petro-chemical intermediates such as DMT, Caprolactam, LAB etc. and production of basic plastics such as LDPE, HDPE, PP, PVC.
8. Bulk drugs and pharmaceuticals.
9. Exploration for oil and gas and their production, transportation and storage.
10. Synthetic Rubber.
11. Asbestos and Asbestos products.
12. Hydrocyanic acid and its derivatives.
13. (a) Primary metallurgical industries(such as production of Iron and Steel, Aluminium, Copper, Zinc, Lead and Ferro Alloys).
    (b) Electric arc furnaces (Mini Steel Plants).
14. Chlor-alkali industry.
15. Integrated paint complex including manufacture of resins and basic raw materials required in the manufacture of paints.
16. Viscose Staple fibre and filament yarn.
17. Storage batteries integrated with manufacture of oxides of lead and lead antimony alloy.

18. All tourism projects between 200 m–500 meters of High Tide Line or at locations with an elevation of more than 1000 meters with investment of more than Rs. 5 crores.
19. Thermal Power plants.
20. Mining projects (major minerals) with leases more than 5 hectares.
21. Highway Projects except projects relating to improvement work including widening and strengthening of roads with marginal land acquisition along the existing alignments provided it does not pass through ecologically sensitive areas such as National Parks, Sanctuaries, Tiger reserves, Reserve forests.
22. Tarred Roads in Himalayas and/or Forest areas.
23. Distilleries.
24. Raw Skins and Hides.
25. Pulp, paper and newsprint.
26. Dyes.
27. Cement.
28. Foundries (individual).
29. Electroplating.

Schedule-II

(See Sub-para 1(a) of Para 2)

Application form

1. (a) Name and Address of the project proposed
   (b) Location of the project
   Name of the place
   District, Tehsil
   Latitude/Longitude
   Nearest Airport/Railway Station
   (c) Alternate sites examined and the reasons for selecting the proposed site
   (d) Does the site conform to stipulated land use as per local land use plan
2. Objectives of the project
3. (a) Land Requirement
   Agriculture Land:

Forest land and Density of regetation:
Other (specify):
(b) (i) Land use in the Catchment/ within 10 kms. radius of the proposed site:
(ii) Topography of the area indicating gradient, aspects and altitude:
(iii) Erodability classification of the proposed land:
(c) Pollution sources existing in 10 km. Radius and their impact on quality of air, water and land
(d) Distance of the nearest National Park/Sanctuary Biosphere Reserve/Monuments/heritage site/Reserve Forest
(e) Rehabilitation plan for quarries/borrow areas
(f) Green belt plan
(g) Compensatory afforestation plan

4. Climate and Air Quality
   (a) Windrose at site
   (b) Max./Min./Mean annual temperature
   (c) Frequency of inversion
   (d) Frequency of cyclones/tornadoes/cloud burst
   (e) Ambient air quality data
   (f) Nature and concentration of emission of SPM, Gas (CO, CO_2, Nox,CHn etc.) from the project
5. Water balance
   (a) Water balance at site
   (b) Lean season water availability
   (c) Source to be tapped with competing users (River, Lake, Ground, Public supply)
   (d) Water quality
   (e) Changes observed in quality and quantity of ground water in the last 15 years and present charging and extraction details
   (f) (i) Quantum of waste water to be released with treatment details
   (ii) Quantum of quality of water in the receiving body before and after disposal of solid waste
   (iii) Quantum of waste water to be released on land and type of land

(g) (i) Details of reservoir water quality with necessary Catchment Treatment Plan
(ii) Command Area Development Plan

6. Solid wastes
   (a) Nature and quantity of solid wastes generated
   (b) Solid waste disposal method
7. Noise and Vibrations
   (a) Sources of noise and vibrations
   (b) Ambient noise level
   (c) Noise and Vibration control measures proposed
   (c) Subsidence problem if any with control measures
8. Power requirement indicating source of supply
   Complete environmental details to be furnished separately, if captive power unit proposed
9. Peak labour force to be deployed giving details of
   - Endemic health problems in the area due to waste water/air/soil borne diseases
   - Health care system existing and proposed
10. (a) Number of village and population to be displaced
    (b) Rehabilitation Master Plan:
11. Risk Assessment Report and Disaster Management Plan
12. (a) Environmental Impact Assessment
    (b) Environment Management Plan
    (c) Detailed Feasibility Report
    (d) Duly filled in questionnaire

    } Report prepared as per guidelines of MOEF issued from time to time
13. Details of Environmental Management Cell

I hereby give an undertaking that the data and information given above are true to the best of my knowledge and belief and I am aware that if any part of the data/information submitted is found to be false or misleading at any stage, the project be rejected and the clearance given, if any, to the project is likely to be revoked at our risk and cost.

Date: Signature of the applicant with
Place: name and full address

Given under the seal of organisation on behalf of whom the applicant is signing.

In respect to item for which data are not required or is not available as per the declaration of project preponent, the project would be considered on that basis.

Schedule-III

(See Sub-para III(a) of Para 2)

Composition of the expert committees for environmental impact assessment

1. The Committees will consist of experts in the following disciplines:
   (i) Eco-System Management
   (ii) Air/Water Pollution Control
   (iii) Water Resource Management
   (iv) Flora/Fauna Conservation and Management
   (v) Land Use Planning
   (vi) Social Sciences/Rehabilitation
   (vii) Project Appraisal
   (viii) Ecology
   (ix) Environmental Health
   (x) Subject Area Specialists
   (xi) Representatives of NGOs/Persons Concerned With Environmental Issues.
2. The Chairman will be an outstanding and experienced ecologist or environmentalist or technical professional with wide managerial experience.
3. The representative of IAA will act as Member-Secretary.
4. Chairman and members will serve in their individual capacities except those specifically nominated as representatives.
5. The membership of a Committee shall not exceed 15.

Schedule-IV

(See Sub-para I of Para 2)

Procedure for public hearing

1. Process of Public Hearing

Whoever apply for environmental clearance of projects, shall submit to the concerned State Pollution Control Board twenty sets of the following documents namely:

(i) An executive summary containing the salient features of the project both in English as well as local language.
(ii) Form XIII prescribed under Water (Prevention and Control of Pollution) Rules, 1975 where discharge of sewage, trade effluents, treatment of water in any form, is required.
(iii) Form I prescribed under Air (Prevention and Control of Pollution) Union Territory Rules, 1983 where discharge of emissions are involved in any process, operation or industry.
(iv) Any other information or document which is necessary in the opinion of the Board for their final disposal of the application.

2. Notice of Public Hearing

(i) The State Pollution Control Board shall cause a notice for environmental public hearing which shall be published in at least two newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality concerned. State Pollution Control Board shall mention the date, time and place of public hearing. Suggestions, views, comments and objections of the public shall be invited within thirty days from the date of publication of the notification.
(ii) All persons including bona fide residents, environmental groups and others located at the project site/sites of displacement/sites likely to be affected can participate in the public hearing. They can also make oral/written suggestions to the State Pollution Control Board.

Explanation

For the purpose of the paragraph person means:

(a) any person who is likely to be affected by the grant of environmental clearance;
(b) any person who owns or has control over the project with respect to which an application has been submitted for environmental clearance;
(c) any association of persons whether incorporated or not likely to be affected by the project and/or functioning in the field of environment;
(d) any local authority within any part of whose local limits is within the neighbourhood, wherein the project is proposed to be located.

3. Composition of public hearing panel

The composition of Public Hearing Panel may consist of the following namely:

(i) Representative of State Pollution Control Board;
(ii) District Collector or his nominee;
(iii) Representative of State Government dealing with the subject;
(iv) Representative of Department of the State Government dealing with Environment;
(v) Not more than three representatives of the local bodies such as Municipalities or panchayats;
(vi) Not more than three senior citizens of the area nominated by the District Collector.

4. Access to the Executive Summary

The concerned persons shall be provided access to the Executive Summary of the Project at the following places namely:

(i) District Collector Office;
(ii) District Industry Centre;

(iii) In the Office of the Chief Executive Officers of Zila Parishad or Commissioner of the Municipal Corporation/Local body as the case may be;
(iv) In the head office of the concerned State Pollution Control Board and its concerned Regional Office;
(v) In the concerned Department of the State Government dealing with the subject of environment.

[No.Z-12013/4/89-IA.I] R.H.Khwaja, Jt.Secy.

Foot Note: The Principal notification was published vide No. S. O. 60(E) dated 27th January, 1994 and subsequently amended vide No. S. O. 356(E) dated 4th May, 1994.

Explanatory note Regarding the Impact Assessement Notification Dated 27th January, 1994

1. Expansion and modernisation of existing projects
A project proponent is required to seek environmental clearance for a proposed expansion/modernisation activity if the resultant pollution load is to exceed the existing levels. The words "pollution Load" will in this context cover emissions, liquid effluents and solid or semi-solid wastes generated. A project proponent may approach the concerned State Pollution Control Board (SPCB) for certifying whether the proposed modernisation/expansion activity as listed in Schedule-I to the notification is likely to exceed the existing pollution load or not. If it is certified that no increase is likely to occur in the existing pollution load due to the proposed expansion or modernisation, the project proponent will not be required to seek environmental clearance, but a copy of such certificate issued by the SPCB will have to be submitted to the Impact Assessment Agency(IAA) for information. The IAA will however, reserve the right to review such cases in the public interest if material facts justifying the need for such review come to light.

2. Availability of summary feasibility report, EIA/EMP report etc. to concerned parties or groups
The project proponent will have to submit an executive summary incorporating in brief the essence of project details

and findings of environmental impact assessment study which could be made available to concerned parties or environmental groups on request.

3. Clarification about concerned parties or environmental groups
The concerned parties or environmental groups will be the bonafide residents located at or around the project site or site of displacement or site of alleged adverse environmental impact.

4. Public hearing
Public hearings could be called for in case of projects involving largedisplacement or having severe environmental ramifications.

5. Requisite information required for site clearance/project clearance
(a) Site Clearance: Site clearance will be given for site specific projects as mentioned in para-2(ii) of the notification. Project proponents will be required to furnish information according to the environmental appraisal questionnaires for site clearance, as may be prescribed by the IAA from time to time. Additional information whenever required by the IAA will be communicated immediately to the project proponents who will then be required to furnish the same within the time frame specified.
(b) Project clearance: In addition to the application form as mentioned in Schedule II to the notification, project proponents are required to furnish the following information for environmental appraisal:

(i) EIA/EMP report (20 copies);
(ii) Risk Analysis report (20 copies): however, such reports if normally not required for a particular category of project, project proponents can state so accordingly, but the IAA's decision in this regard will be final;
(iii) NOC from the State Pollution Control Board;
(iv) Commitment regarding availability of water and electricity from the competent authority;
(v) Summary of Project report/feasibility report (one copy);

(vi) Filled in questionnaire (as prescribed by the IAA from time to time) for environmental appraisal of the project;
(vii) Comprehensive rehabilitation plan, if more than 1000 people are likely to be displaced, otherwise a summary plan would be adequate.

As a Comprehensive EIA report will normally take at least one year for its preparation, project proponents may furnish Rapid EIA report to the IAA based on one season data (other than monsoon), for examination of the project. Comprehensive EIA report may be submitted later, if so asked for by the IAA.

The requirement of EIA can be dispensed with by the IAA, in case of project which are unlikely to cause significant impacts on the environment. In such cases, project proponent will have to furnish full justification for such exemption, for submission of EIA. Where such exemption is granted, project proponents may be asked to furnish such additional information as may be required.

6. Submission of insufficient or inadequate data

Regarding cases liable to be rejected due to inadequacy of data, it is clarified that the IAA will make such rejection within 30 days from the date of submission of the proposal. While rejecting a proposal due to insufficient or inadequate data after the first evaluation, the IAA may also stipulate additional requirement of information/clarification for impact assessment purposes if deemed essential due to the specific nature of location of the proposed project whose data as prescribed is not available, the IAA can examine the project on the basis of available data.

7. Application form

(i) In order to remove any hardship to the project proponent in providing any information, the project proponent may, where some information is not available or would cause inordinate delay, mention this in their application form. The IAA may consider the project proposal based on the information available.
(ii) Quality and quantity of ground water.

(iii) If 15 years data on the quantity and quality variation of ground water is not available with the concerned Department or Authorities, the project proponent may mention this accordingly in the application form prescribed in Schedule-II to the notification. Further, in case of projects, where ground water is not to be used, and effluents are not to be discharged on the land, the requirement of ground water variation data for the previous 15 years will be dispensed with.
(iv) A project proponent may write the words "Not Applicable" while filling the application form as mentioned in Schedule-II to the notification in respect of items which are not relevant for the purposes of the proposed project.

8. Exemption for projects already initiated

For projects listed in Schedule-I to the notification in respect of which the required land has been acquired and all relevant clearances of the State Government including NOC from the respective State Pollution Control Boards have been obtained before 27th January, 1994, a project proponent will not be required to seek environmental clearance from the IAA. However those units who have not as yet commenced production will inform the IAA.

CIRCULAR No. Z-12013/14/98 IA-I Dated April 22, 1998 of Ministry of Environment and Forests, Government of India

Sub: Prospecting and Exploration of Major Minerals in the areas above 500 ha.- Site clearance under EIA notification No. S.O.60(E) dated 27th January, 1994 as amended on4th May, 1994 and 10th April, 1997 — Clarifications reg.

The question of site clearence for projects involving aerial reconnaissance/aerial surveys for prospection or reconnaissance operations undertaken for preliminary prospecting has been examined. It was noted that these operation do not include pitting, trenching, drilling or sub surface excavation involving disturbance to earth.

It is hereby clarified that for aerial prospection surevys / aerial reconnaissance, which do not include pitting, trenching, drilling or subsurface excavation involving disturbance to

earth, no prior site clearance is required under EIA Notification dated 27th January, 1994 (as amended from time to time). However, site clearance has to be obtained before undertaking ground operations like pitting, trenching, drilling, road construction etc. leading to disturbance to earth in specific areas for exploration of minerals. In this respect the normal procedure in force will mutatis mutandis apply.

(R.H. Khwaja)
Joint Secretary to the Government of India

To All Concerned

CIRCULAR No. Z-12013/14/98 IA Dated October 27, 1998 of Ministry of Environment and Forests, Government of India

Sub: Prospecting and Exploration of Major Minerals in the areas above 500 ha.- Site clearance under EIA notification No. S.O.60(E) dated 27th January 1994 as amended on 2.5.94 and 10.4.87. -Clarifications reg.

The question of sale clearence for mining projects involving surveys for prospecting or reconnaissance operations undertaken for preliminary prospecting has been noted that test drilling exercise for confirmation of mineralization in the already identified anomalies involves on an average one bore hole in a block approximately 100 square kilometers (10000 ha.).

It is hereby clarified that for test drilling on a scale not exceeding one bore hole hundred square kilometers, no prior site clearence including public hearing is needed under the provision of the EIA notification of January, 1994 as amended from time to time. However, necessary approval under the Forest(Conservation) Act, 1980 has to be obtained in case of involvement of forestland.

Site clearence, however, has to be obtained before undertaking prospecting and exploration exercise. In this respect, the normal procedure in force will mutatis mutandis apply.

(V. Rajagopalan)
Joint Secretary to the Government of India

To All Concerned

CIRCULAR No.Z-12013/14/98-IA Dated March 16, 1999 of Ministry of Environment & Forests, Government of India

Sub: Prospecting and Exploration of Major Minerals in the areas above 500 ha. Site clearance under EIA notification No. S.O. 60(E) dated 27th January, 1994 as amended on 4-5-94 and 10-4-97 – Clarification reg.

Attention is invited to this Ministry's Circular of even no Dated 27th October '98 on the above subject regarding test drilling and site clearance.

It has been brought to the notice of the Ministry that in large areas more than one anornaly has been noticed and therefore, one bore hole will not give the clear picture in regard to the true potential. Finely the testing of the material obtained from one borehole may not give the correct picture of the grade and the size of the deposit. This may result in deposits with good potential and viable economic size escaping identification. A thorough and systematic scout-drilling program will improve the chances of finding mineral deposits within a realistic timeframe.

In view of the above, it is clarified that test drilling on a scale not exceeding 5 bore holes per 100 square kilometers would require to prior site clearance including public hearing, under and provision of EIA Notification of January '94 as amended from time to time. However necessary approval under Forest Conservation Act, 1989 would have to be obtained in case forest land is involved.

Site clearance has to be obtained before undertaken prospecting and exploration exercises in this respect, the normal procedure in force will mutatis mutandis apply.

(V. Rajagopalan)
Joint Secretary to the Government of India

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Appendix II

Glossary

Acid: Any of a class of substances that liberate hydrogen ions in water are usually sour and corrosive, and have a pH of less than 7.

Acid mine drainage (AMD): Acidic run-off water from mine waste dumps and mill tailings ponds containing sulphide minerals. Also refers to ground water pumped to surface from mines. Such drainage often requires treatment to neutralize acidity before it can be released into the natural environment.

Acid mine water: Mine water that contains free sulfuric acid, mainly due to the weathering of iron pyrites.

Acidic precipitation: Rain or snow that have a low pH, caused by sulphur dioxide and nitric oxide gases from industrial activity released into the atmosphere.

Acidic rocks: Usually refers to an igneous rock carrying a high (greater than 65%) proportion of silica.

Acid rain: The precipitation of dilute solutions of strong mineral acids, formed by the mixing in the atmosphere of various industrial pollutants — primarily sulfur dioxide and nitrogen oxides with naturally occurring oxygen and water vapour.

Act: In the legislative sense, a bill or regulation passed by the Parliament; a law.

Active mine: A mine is active if it has an owner and mining activities are carried out on the site.

Aerosol: A suspension of small liquid or solid particles in gas.

Agglomeration: A method of concentrating valuable minerals based on their adhesion properties.

Airborne survey: A survey made from an air craft to obtain photographs, or measure magnetic properties, radioactivity, etc.

Air pollution: Toxic or radioactive gases or particulate matter introduced into the atmosphereusually as a result of human activity.

Alluvial, alluvium: Relatively recent deposits of sedimentary material laid down in river beds, flood plains, lakes, or at the base of mountain slopes.

Amendment: A change or addition to an existing law or rule.

Anthracite: see Ranks of coal

Aquaculture: The controlled rearing of fish or shellfish by people or corporations who own the harvestable product, often involving the capture of the eggs or young of a species from wild sources, followed by rearing more intensively than possible in nature.

Aquifer: Underground source of water.

Ash: Incombustible residue left over after incineration or other thermal processes.

Asthma: A condition marked by labored breathing, constriction of the chest, coughing and gasping usually brought on by allergies.

Atmosphere: the 500 km thick layer of air surrounding the earth which supports the existence of all flora and fauna

Back: The roof or upper part in any underground mining cavity.

Backfill: Mine waste or rock used to support the roof after coal removal.

Barren: Said of rock or vein material containing no minerals of value, and of strata without coal, or containing coal in seams too thin to be workable.

Basalt: An extrusive volcanic rock composed primarily of plagioclase, pyroxene and minor olivine.

Base: Any compound that will combine with an acid and neutralize it, forming a salt; also bottom or support for any structure.

Beneficiation: The treatment of mined material, making it more concentrated or richer.

Biodegradable: Waste material composed primarily of naturally-occurring constituent parts, able to be broken down and absorbed into the ecosystem. Wood, for example, is biodegradable, for example, while plastics are not.

Biodiversity: Variability among living organisms viz., animals, plants, fungi, and microorganisms. It exists at three levels i.e., Genetic diversity, Species diversity and Habitat/ Ecosystem diversity.

Biomass: (1) The amount of living matter in an area, including plants, large animals and insects; (2) plant materials and animal waste used as fuel.

Biosphere: (1) The part of the earth and its atmosphere in which living organisms exist or that is capable of supporting life; (2) the living organisms and their environment composing the biosphere.

Biosphere Reserve (BR): A part of an international network of preserved areas designated by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Biosphere Reserves are vital centers of biodiversity where research and monitoring activities are conducted, with the participation of local communities, to protect and preserve healthy natural systems threatened by development. There are 13 BRs in India designated by Ministry of Environment and Forest, Government of India.

Biotic: Of or relating to life.

Birth defects: Unhealthy defects found in newborns, often caused by the mother's exposure to environmental hazards or the intake of drugs or alcohol during pregnancy.

Bituminous: see Ranks of coal.

Calcareous: Like limestone or calcium carbonate, or composed of same.

Calcine: Name given to concentrate that is ready for smelting (i.e., the sulphur has been driven off by oxidation).

Calorie: Heat required to raise the temperature of 1 gram of water by 1 degree Centigrade.

Calorific value: The quantity of heat that can be liberated from one pound of coal or oil measured in BTU's.

Cancer: Unregulated growth of changed cells; a group of changed, growing cells (tumor).

Carbon dioxide (CO_2): A naturally occurring greenhouse gas in the atmosphere, concentrations of which have increased (from 280 parts per million in pre-industrial times to over 350 parts per million today) as a result of humans' burning of coal, oil, natural gas and organic matter (e.g., wood and crop wastes).

Carcinogens: Substances that cause cancer.

Clean coal technologies: A number of innovative, new technologies designed to use coal in a more efficient and cost-effective manner while enhancing environmental protection. Several promising technologies include: fluidized-bed combustion, integrated gasification combined cycle, limestone injection multi-stage burner, enhanced flue gas desulfurization (or "scrubbing"), coal liquefaction and coal gasification.

Chlorofluorocarbons (CFCs): Stable, artificially-created chemical compounds containing carbon, chlorine, fluorine and sometimes hydrogen. Chlorofluorocarbons, used primarily to facilitate cooling in refrigerators and air conditioners, have been found to damage the stratospheric ozone layer which protects the earth and its inhabitants from excessive ultraviolet radiation.

Closed mine: A mine is closed if licensed mining activities are finished for the mine or when there is no ongoing mining activity.

Coal: A solid, brittle, more or less distinctly stratified combustible carbonaceous rock, formed by partial to complete decomposition of vegetation; varies in color from dark brown to black; not fusible without decomposition and very insoluble.

Coal dust: Particles of coal that can pass a No. 20 sieve.

Coal Gasification: The conversion of coal into a gaseous fuel.

Coal mine: An area of land and all structures, facilities, machinery, tools, equipment, shafts, slopes, tunnels, excavations, and other property, real or personal, placed upon, under, or above the surface of such land by any person, used in extracting coal from its natural deposits in

the earth by any means or method, and the work of preparing the coal so extracted, including coal preparation facilities; "Colliery".

Coal reserves: Measured tonnages of coal that have been calculated to occur in a coal seam within a particular property.

Coal washing: The process of separating undesirable materials from coal based on differences in densities. Pyritic sulfur, or sulfur combined with iron, is heavier and sinks in water; coal is lighter and floats.

Coke: A hard, dry carbon substance produced by heating coal to a very high temperature in the absence of air.

Collar : The term applied to the timbering or concrete around the mouth or top of a shaft. The beginning point of a shaft or drill hole at the surface.

Compost: Process whereby organic wastes, including food wastes, paper, and yard wastes, decompose naturally, resulting in a product rich in minerals and ideal for gardening and farming as a soil conditioners, mulch, resurfacing material, or landfill cover.

Containment pond: Structure for the accumulation of solid, chemical or dangerous substances in order to prevent their dispersal into the environment.

Contamination: Pollution.

Crusher: A machine for crushing rock or other materials. Among the various types of crushers are the ball mill, gyratory crusher, Handsel mill, hammer mill, jaw crusher, rod mill, rolls, stamp mill, and tube mill.

Demonstrated reserves: A collective term for the sum of coal in both measured and indicated resources and reserves.

Deposit: Mineral deposit or ore deposit is used to designate a natural occurrence of a useful mineral, or an ore, in sufficient extent and degree of concentration to invite exploitation.

Dioxin: A man-made chemical by-product formed during the manufacturing of other chemicals and during incineration. Studies show that dioxin is the most potent animal carcinogen ever tested, as well as the cause of severe weight loss, liver problems, kidney problems, birth defects, and death.

Drainage: The process of removing surplus ground or surface water either by artificial means or by gravity flow.

Drilling: Piercing a hole in rock. In exploration, drilling allows for samples of the rock to be taken. In mining, it is used to insert explosives for blasting.

Dump: To unload; specifically, a load of coal or waste; the mechanism for unloading, e.g. a waste dump (also called heap, pile, tip, spoil pike, etc.).

Dump sites: Waste disposal grounds.

Ecosystem: An interconnected and symbiotic grouping of animals, plants, fungi, and Microorganisms in relation to a specific environment.

Endangered species: Species in danger of extinction throughout all or a significant part of its range.

Environmental Impact Assessment (EIA): A written report, compiled prior to a production decision, that examines the effects proposed mining activities will have on the natural surroundings of an exploration property.

Era: A large division of geologic time; the Precambrian era, for example.

Erosion: The breaking down and subsequent removal of either rock or surface material by wind, rain, wave action, freezing and thawing and other processes.

Estuary: A bay or inlet, often at the mouth of a river, in which large quantities of freshwater and seawater mix together. These unique habitats are necessary nursery grounds for many marine fishes and shellfishes.

Excavation: Extraction of solid earth material from the ground for mineral mining.

Exploration: The search for mineral deposits and the work done to prove or establish the extent of a mineral deposit; Prospecting and subsequent evaluation.

Extraction: The process of mining and removal of ore from a mine; separation of desired mineral from ore.

Fault: A break in the Earth's crust caused by tectonic forces which have moved the rock on one side with respect to the other; faults may extend for many kilometres, or be only a few centimetres in length; similarly, the movement or displacement along the fault may vary widely.

Fault zone: A fault, instead of being a single clean fracture, may be a zone hundreds or thousands of feet wide. The fault zone consists of numerous interlacing small faults or a confused zone of gouge, breccia, or mylonite.

Fauna: The total animal population that inhabits an area.

Ferrous: Containing iron.

Fire damp: The combustible gas, methane, CH4. Also, the explosive methane-air mixtures with between 5% and 15% methane. A combustible gas formed in mines by decomposition of coal or other carbonaceous matter, and that consists chiefly of methane.

Fixed carbon: The part of the carbon that remains behind when coal is heated in a closed vessel until all of the volatile matter is driven off.

Flora: The total vegetation assemblage that inhabits an area.

Flotation: A form of concentration of certain minerals from gangue based on their different surface reaction to chemical flocculants. A reagent (chemical flocculants) is used to adhere to the target mineral, which then rises to the top of the flotation cell with injected air, where it can be collected.

Fluidized Bed Combustion: A process with a high degree of ability to remove sulfur from coal during combustion. Crushed coal and limestone are suspended in the bottom of a boiler by an upward stream of hot air. The coal is burned in this bubbling, liquid-like (or "fluidized") mixture. Rather than released as emissions, sulfur from combustion gases combines with the limestone to form a solid compound recovered with the ash.

Fly ash: The finely divided particles of ash suspended in gases resulting from the combustion of fuel. Electrostatic precipitators are used to remove fly ash from the gases prior to the release from a power plant's smokestack.

Formation: Any assemblage of rocks which have some character in common, whether of origin, age, or composition. Often, the word is loosely used to indicate anything that has been formed or brought into its present shape.

Forests: Lands on which trees are the principal plant life, usually conducive to wide biodiversity.

Fossil fuel: A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals; compare to alternative energy.

Fracture: A general term to include any kind of discontinuity in a body of rock if produced by mechanical failure, whether by shear stress or tensile stress. Fractures include faults, shears, joints, and planes of fracture cleavage.

Gangue: Rock surrounding a mineral or precious gem in its natural state.

Gasification: Any of various processes by which coal is turned into low, medium, or high Btu gases.

Geiger counter: An instrument used to measure radioactivity (e.g., that which emanates from certain minerals) by means of a Geiger- Mueller tube. It detects the gamma rays and indicates the frequency or intensity either visually (by dial or flashing light), audibly (by earphones) or both.

Geochemistry: The study of the chemical properties of rocks; The use of a broad spectrum of chemical elements and ratios and their patterns, which are naturally dispersed around ore deposits, to detect concealed ore bodies.

Geologist: One who studies the constitution, structure, and history of the earth's crust, conducting research into the formation and dissolution of rock layers, analyzing fossil and mineral content of layers, and endeavoring to fix historical sequence of development by relating characteristics to known geological influences (historical geology).

Geology: The science concerned with the study of the rocks which compose the Earth.

Geophysical survey: A scientific method of prospecting that measures the physical properties of rock formations. Common properties investigated include magnetism, specific gravity, electrical conductivity and radioactivity.

Geophysicist: A scientist who practices geophysics

Geophysics: The study of the physical properties of rocks and minerals; The use of the physical, magnetic or electrical properties of rock formations, minerals and orebodies to remotely detect new ore deposits, either by ground or airborne surveys.

Geothermal: Pertains to the heat of the Earth's interior.

Global climate change: This term usually refers to the gradual warming of the earth caused by the greenhouse effect. Many believe this is the result of man-made emissions of greenhouse gases such as carbon dioxide, chlorofluorocarbons (CFC) and methane.

Global warming: Increase in the average temperature of the earth's surface.

Grain: In petrology, that factor of the texture of a rock composed of distinct particles or crystals which depends upon their absolute size.

Greenhouse effect: The process that raises the temperature of air in the lower atmosphere due to heat trapped by greenhouse gases, such as carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, and ozone.

Greenhouse gas: A gas involved in the greenhouse effect e.g. carbon dioxide, chlorofluorocarbons (CFC), methane etc.

Grinding: Means of reducing ore into very small particles by means of pressure or impact. Different types of grinders are used in the processing plant to obtain the desired dimension.

Groundwater: Water below the earth's surface; the source of water for wells and springs.

Habitat: (1) The natural home of an animal or plant; (2) the sum of the environmental conditions that determine the existence of a community in a specific place.

Hazardous waste: Material that, given its quantity, concentration and composition or its corrosive, inflammable, reactive, toxic, infectious or radioactive characteristics, presents a real or potential danger to human health, safety and public well-being or poses a danger to the environment if it is not stored, treated, transported, eliminated, used or otherwise managed. Mine tailings are not normally hazardous waste.

Hematite: The most common iron ore, it is a natural iron oxide that is reddish or brown in colour.

Hydraulic: Of or pertaining to fluids in motion. Hydraulic jacks lift through the force transmitted to the movable part of the jack by a liquid. Hydraulic control refers to the mechanical control of various parts of machines, such as coal cutters, loaders, etc., through the operation or action of hydraulic cylinders.

Hydrocarbon: A family of chemical compounds containing carbon and hydrogen atoms in various combinations, found especially in fossil fuels, e.g., methane, butane, propane etc.

Hydrofluorocarbons: Used as solvents and cleaners in the semiconductor industry, among others; they possess global warming potentials that are thousands of times greater than CO_2.

Igneous rocks: Rocks formed by the solidification of molten material that originated within the Earth.

In situ: In the natural or original position. Applied to a rock, soil, or fossil when occurring in the situation in which it was originally formed or deposited.

Indicated coal resources: Coal for which estimates of the rank, quality, and quantity have been computed partly from sample analyses and measurements and partly from reasonable geologic projections.

Industrial minerals: Non-metallic, non-fuel minerals used in their natural state in the chemical and manufacturing industries; they require some beneficiation. Examples: asbestos, gypsum, salt, graphite, mica, gravel, building stone and talc.

Inferred coal resources: Coal in unexplored extensions of the demonstrated resources for which estimates of the quality and size are based on geologic evidence and projection. Quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repletion of which there is geologic evidence; this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence.

Infrastructure: Construction necessary for mining, such as certain buildings, gas pipes, water lines, sewage and water systems, telephone cables and reservoirs. It may also

include roads, railways, airports and bridges, as well as transmission lines, electrical cables, pylons and transformers.

Kaolin: Also known as china clay, kaolin is a white alumina-silicate clay used in porcelain, paper, plastics, rubber, paints and many other products.

Lacustrine deposit: Sediments deposited on the bottom of lakes.

Lakes: Substantial inland bodies of standing water.

Land use: The way in which land is used. Some of the examples of land use are forest, agriculture, wasteland, human settlement.

Laterite: A residual soil developed in tropical countries, out of which the silica has been leached. May form orebodies of iron, nickel, bauxite and manganese.

Leachable: Extractable by chemical solvents.

Leaching: A chemical process for the extraction of valuable minerals from ore; also, a natural process by which ground waters dissolve minerals, thus leaving the rock with a smaller proportion of some of the minerals than it contained originally.

Lignite: refer to Ranks of coal

Liquefaction: The process of converting coal into a synthetic fuel, similar in nature to crude oil and/or refined products, such as gasoline.

Lithology: The character of a rock described in terms of its structure, color, mineral composition, grain size, and arrangement of its component parts; all those visible features that in the aggregate impart individuality of the rock.

Macroscopic: Visible to the unaided eye.

Magmatic ore deposit: Formed by differentiation of mineral in magma.

Magmatic segregation: An ore-forming process whereby valuable minerals are concentrated by settling out of a cooling magma.

Magnetic gradient survey: A geophysical survey using a pair of magnetometers a fixed distance apart, to measure the difference in the magnetic field with height above the ground.

Magnetic separation: A process in which a magnetically susceptible mineral is separated from gangue minerals by applying a strong magnetic field; ores of iron are commonly treated in this way.

Magnetic survey: A geophysical survey that measures the intensity of the Earth's magnetic field.

Magnetite: Magnetic iron ore, being a black iron oxide containing 72.4% iron when pure.

Measured coal resources: Coal for which estimates of the rank, quality, and quantity have been computed from sample analyses and measurements from closely spaced and geologically well-known sample sites, such as outcrops, trenches, mine workings, and drill holes.

Methane: A potentially explosive gas formed naturally from the decay of vegetative matter, similar to that which formed coal. Methane, which is the principal component of natural gas, is frequently encountered in underground coal mining operations and is kept within safe limits through the use of extensive mine ventilation systems.

Methane monitor: An electronic instrument often mounted on a piece of mining equipment, that detects and measures the methane content of mine air.

Mine: A plant built to extract an ore or mineral substance either underground or from the surface. When the ore is extracted underground, the mine needs a system of excavations in the rock to gain access to the ore areas. When the ore is mined from surface, the ore is extracted from one or several pits.

Mineral deposit: Mineralized mass that may be economically valuable, but whose characteristics require more detailed information. An orebody being mined may be called a deposit.

Mine development: The term employed to designate the operations involved in preparing a mine for ore extraction. These operations include tunneling, sinking, cross-cutting, drifting, and raising.

Miner: One who is engaged in the business or occupation of extracting ore, coal, precious substances, or other natural materials from the earth's crust.

Mineral: An inorganic compound occurring naturally in the earth's crust, with a distinctive set of physical properties, and a definite chemical composition.

Mineral processing: Process of extraction and concentration of economic minerals contained in ore. Mineral processing includes various procedures that rely on the mineral's gravimetric and magnetic characteristics, on its colour, and on reagents to make target particles float to the surface (flotation).

Mining: Activity whose purpose is the extraction, concentration, and smelting of economic minerals from a mineral deposit. It includes exploration (in the strict sense), development of mineral deposits, constructing the mine and mining, i.e., extracting and processing the ore or tailings.

Mining activities: The activities of prospecting, extraction and primary in situ processing of minerals.

Mining site: Mining site is the location of mining operation including the area or areas of excavation and adjoining areas or nearby facilities for materials handling, processing and waste disposal.

Mining waste: Any substance or object resulting from exploration, mining, quarrying, and physical and chemical treatment of minerals, which the holder discards or intends or is required to discard.

Native metal: A metal occurring in nature in pure form, uncombined with other elements.

Nitrogen oxides (NOx)- Harmful gases (which contribute to acid rain and global warming) emitted as a byproduct of fossil fuel combustion.

Nodule: A rounded lump or mass of mineral.

Noise pollution: Environmental pollution made up of harmful or annoying noise.

Non:metallic: Containing little or no metal; industrial mineral.

Ore: A natural aggregate of one or more minerals that can be mined and profitably sold under current conditions, or from which one or more minerals can be profitably extracted.

Orebody: Mineralized mass whose characteristics have been determined and deemed to be commercially viable. The term "orebody" is used once the economic limits of the mineralized mass and its grade have been examined.

Ore reserves: The portion of a mineral deposit that can be profitably mined. Use of this term implies both an appropriate detailed knowledge of all the geological, engineering, economic and environmental parameters that might affect the profitability of the operation. For a new mining project or for the mining of new zones in an existing mine, a formal feasibility study is conducted to evaluate all parameters of the project.

Organic maturation: The process of turning peat into coal.

Overburden: Layers of soil and rock covering a coal seam or any other mineral. Overburden is removed prior to surface mining and replaced after the coal is taken from the seam.

Particulate: Of or relating to minute discrete particles; a particulate substance.

Particulate pollution: Pollution made up of small liquid or solid particles suspended in the atmosphere or water supply.

Peat: The partially decayed plant matter found in swamps and bogs, one of the earliest stages of coal formation.

Pegmatite: A coarse-grained, igneous rock, usually irregular in texture and composition, similar to a granite in composition; it usually occurs in dykes or veins and sometimes contains valuable minerals.

Pellet: A marble-sized ball of iron ore bonded by clay and fused for hardness.

Permit: As it pertains to mining, a document issued by a regulatory agency that gives approval for mining operations to take place.

PM10: Particulate matter less than 10 microns in diameter.

Pneumoconiosis: A chronic disease of the lung arising from breathing coal dust.

Pollution prevention: Techniques that eliminate waste prior to treatment, such as by changing ingredients in a chemical reaction.

Population: (1) The whole number of inhabitants in a country, region or area; (2) a set of individuals having a quality or characteristic in common.

Possible reserve: Ore deposits whose continuity has been determined from limited sampling information and reasonable extrapolation. It does not stand alone but is an extension of, or additional to, proven or probable reserves. Possible reserves are excellent targets for increasing a probable reserve and for extending the deposit over a larger and generally deeper area.

Primary crushing: Process of reducing blasted ore into smaller fragments so that it can be transported to the processing plant. In underground mines, the primary crusher is often located underground or at the entrance to the processing plant.

Probable reserve: Ore deposits whose continuity has been confirmed by samplings on a relatively detailed grid. The density of the grid allows for fairly precise determination of tonnage, density and mineral and metal content sufficient to prepare draft preliminary mining plans. Developing a new mine is usually undertaken with probable reserves.

Prospecting: In the broad sense, prospecting refers to exploration. In the strict sense, prospecting describes the search for surface mineralized showings (by prospectors). In the broad sense, prospecting refers to exploration. In the strict sense, prospecting describes the search for surface mineralized showings (by prospectors).

Proven reserve: Ore deposits whose tonnage, density and mineral or metal content are known in detail. This implies that sampling and drilling have been carried out in a regular grid located near mine workings. The term is generally restricted to that part of a reserve that is being developed or mined or for which there is a detailed mining plan.

Pyrite: A hard, heavy, shiny, yellow mineral, FeS_2 or iron disulfide, generally in cubic crystals. Also called iron pyrites, fool's gold, sulfur balls. Iron pyrite is the most common sulfide found in coal mines.

Quarry: Site where stone, rock and construction materials are extracted. Open-pit operation.

Ranks of coal: The classification of coal by degree of hardness, moisture and heat content. "Anthracite" is hard coal, almost pure carbon, used mainly for heating homes. "Bituminous" is soft coal. "Subbituminous" is a coal with a heating value between bituminous and lignite. It has low fixed carbon and high percentages of volatile matter and moisture. "Lignite" is the softest coal and has the highest moisture content. It is used for generating electricity and for conversion into synthetic gas.

Reclamation: The restoration of land and environmental values to a surface mine site after the coal is extracted. Reclamation operations are usually underway as soon as the coal has been removed from a mine site. The process includes restoring the land to its approximate original appearance by restoring topsoil and planting native grasses and ground covers.

Reconnaissance: A preliminary survey of ground.

Recovery: The proportion or percentage of coal or ore mined from the original seam or deposit.

Refining: Extracting and purifying metals and minerals.

Refractory ore: Ore that resists the action of chemical reagents in the normal treatment processes and which may require pressure leaching or other means to effect the full recovery of the valuable minerals.

Rehabilitation: Restoring an old mining site for a new industrial function, recreational use, or to a natural state.

Remediation: Relates to those actions taken to investigate, prevent, minimize or otherwise resolve the effects or potential effects on human health or the environment of a release or threatened release of a hazardous substance.

Reserve: That portion of the identified coal resource that can be economically mined at the time of determination. The reserve is derived by applying a recovery factor to that component of the identified coal resource designated as the reserve base.

Resources: Concentrations of coal in such forms that economic extraction is currently or may become feasible. Coal

resources broken down by identified and undiscovered resources. Identified coal resources are classified as demonstrated and inferred. Demonstrated resources are further broken down as measured and indicated. Undiscovered resources are broken down as hypothetical and speculative.

Run:off: Precipitation that the ground does not absorb and that ultimately reaches rivers, lakes or oceans.

Quartz: Common rock-forming mineral consisting of silicon and oxygen.

Quartzite: A metamorphic rock formed by the transformation of a sandstone rock by heat and pressure.

Sandstone- A sedimentary rock consisting of quartz sand united by some cementing material, such as iron oxide or calcium carbonate.

Scintillation counter: An instrument used to detect and measure radioactivity by detecting gamma rays; more sensitive than a geiger counter.

Scrubber: Any of several forms of chemical/physical devices that remove sulfur compounds formed during coal combustion. These devices, technically know as flue gas desulfurization systems, combine the sulfur in gaseous emissions with another chemical medium to form inert "sludge," which must then be removed for disposal.

Seam: A stratum or bed of coal.

Sedimentation: Formation of sediment. A sediment is a natural deposit created by the action of dynamic external agents such as water, wind and ice.

Settling pond: Basin or pond that allows solid materials in suspension to settle.

Shale: A rock formed by consolidation of clay, mud, or silt, having a laminated structure and composed of minerals essentially unaltered since deposition.

Slag: The waste product of the process of smelting.

Solid waste : Non-liquid, non gaseous category of waste from non-toxic household and commercial sources.

Soot: A fine, sticky powder, comprised mostly of carbon, formed by the burning of fossil fuels.

Stratosphere: The upper portion of the atmosphere (approximately 11 km to 50 km above the surface of the earth).

Strip mining: Mining technique in which the land and vegetation covering the mineral being sought are stripped away by huge machines, usually damaging the land severely and limiting subsequent uses.

Subsidence: The gradual sinking, or sometimes abrupt collapse, of the rock and soil layers into an underground mine. Structures and surface features above the subsidence area can be affected.

Sulphur (S): Element that occurs in a nature state or in compounds such as sulphides.

Sulfur dioxide (SO_2): A heavy, smelly gas which can be condensed into a clear liquid; used to make sulfuric acid, bleaching agents, preservatives and refrigerants; a major source of air pollution in industrial areas.

Surface mine: A mine in which the coal lies near the surface and can be extracted by removing the covering layers of rock and soil.

Surface water: Water located above ground (e.g., rivers, lakes).

Tailings dam: Structure designed to contain mine tailings and waste water.

Tailings pond: A low-lying depression used to confine tailings, the prime function of which is to allow enough time for heavy metals to settle out or for cyanide to be destroyed before water is discharged into the receiving watershed.

Tailings: Sludge, mineral residue and waste water (apart from final effluent) resulting from ore extraction or processing and the slag from pyrometallurgical operations.

Threatened species: Species of flora or fauna likely to become endangered within the foreseeable future.

Toxic: Poisonous.

Toxic emissions: Poisonous chemicals discharged to air, water, or land.

Toxic sites: Land contaminated with toxic pollution, usually unsuitable for human habitation.

Toxic waste: Garbage or waste that can injure, poison, or harm living things, and is sometimes life-threatening.

Tunnel: A horizontal, or near-horizontal, underground passage, entry, or haulage way, that is open to the surface at both ends. A tunnel (as opposed to an audit) must pass completely through a hill or mountain.

Underground mine: Also known as a "deep" mine. Usually located several hundred feet below the earth's surface, an underground mine's coal is removed mechanically and transferred by shuttle car or conveyor to the surface.

Uraninite: A uranium mineral with a high uranium oxide content. Frequently found in pegmatite dykes.

Uranium: A heavy, radioactive, silvery-white metal (atomic number 92) used in the explosion of nuclear weapons (especially one isotope, U-235).

Volatile matter: The gaseous part, mostly hydrocarbons, of coal.

Volcanic rocks: Igneous rocks formed from magma that has flowed out or has been violently ejected from a volcano.

Volcanogenic: A term used to describe the volcanic origin of mineralization.

Water quality: The level of purity of water; the safety or purity of drinking water.

Water table: The underground level at which the ground is saturated with water. The level at which water will stand in an excavation.

Wetland: Land (marshes or swamps) saturated with water constantly or recurrently; conducive to wide biodiversity.

Wildlife: Animals living in the wilderness without human intervention.

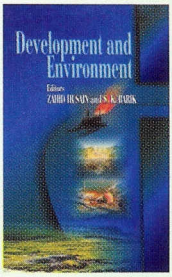
Zircon: A durable, crystalline form of zirconium silicate that is commonly found in placer deposits.

Zone: An area of distinct mineralization.

Zone of oxidation: The upper portion of an orebody that has been oxidized.

OTHER BOOKS OF INTEREST

DEVELOPMENT AND ENVIRONMENT



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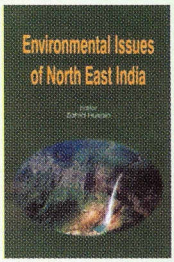

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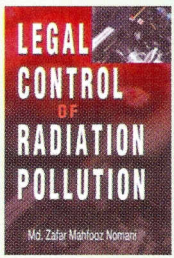

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