VASCULAR FLORA OF NATURALLY REVEGETATED COALMINE SPOILS IN A DRY TROPICAL ENVIRONMENT

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ABSTRACT: A list of vascular plant species was compiled for an age-series of coalmine spoils on different microsites at Jhingurda colliery in Madhya Pradesh. Species were assigned an abundance rating based on their occurrence in quadrats viz: 1=occasional, 2=frequent, and 3=abundant. A total of 81 species representing 23 families were found at different sites/microsites. Poaceae, Fabaceae and Asteraceae were the predominant families. *Butea monosperma* was the most frequent woody component of the vegetation. The frequent/abundant herbs and forbs were *Xanthium strumarium*, *Cassia tora*, *Tephrosia purpurea*, *Aristida adscensionis*, *Daesystenium seyguptium*, *Bothriochoa pertusa* and *Eragrostis tenella*. *Colotropis procera*, *Zizyphus gisberrima* and *Woodfordia fruticosa* were the important shrubs.

Keywords: Coalmine spoil, flora, natural revegetation, vascular plant species.

INTRODUCTION

Coal India Limited has projected a total land requirement for coal mining till 1994-1995 of 116691.60 ha of which 31.18 per cent is the forest land and rest is non-forest land. Coal production is projected at 226 x 10^4 t by 1989-1990 and 417 x 10^4 t by 2000 A.D. The contribution of open-cast coal mining has increased to 50 per cent by 1984-1985 and will go upto 57 per cent by 1989-1990 (Sinha, 1987).

Land degradation is caused by open-cast coal mining and dumping of huge amounts of overburden materials on adjacent unmined lands. The adverse effects are the disruption of the geology-soil-plant stability circuit (Harthill and McKeil, 1979); drastic disturbance of the flora, fauna, hydrological relations and soil biological systems; disequilibrium in the geomorphic system (Soulilier and Toy, 1986); increased nutrient export from the system (O’Neill et al., 1979) and depletion of soil organic pool (Parkinson, 1979). Usually the coalmine spoils are physically, nutritionally and microbiologically recalcitrant medium for plant growth.

The unrehabilitated post-mining physical, chemical and biological characteristics create a specific mining ecology (Wali and Kollman, 1977). Understanding the site specific ecology, including plant succession, and soil development is crucial for expedient rehabilitation. Thompson et al. (1984) argued that natural plant invasion and succession can be an important part of the vegetation development of disturbed sites. Wali and Freeman (1973) and Lees and Wali (1977, 1978) have suggested that an adequate understanding of natural revegetation processes should be included in all reclamation efforts.
Vegetation potential of any area is dependent upon physical environmental limitations and edaphic-biotic components and their interactions. Soil surface characteristics, climate and vegetation after open-cast coal mining. Individual species successes and community composition are governed by local site variables. The substrate conditions on individual mine sites act as an “environmental sieve” (Harper and White, 1970; Hulst, 1978). Most suited species are able to establish and become an important component of the community.

A consideration of flora of naturally revegetated coalmine spoils has not received the level of attention required in restoration programmes in India.

An integrated study dealing with the assessment of natural vegetation and the environmental characteristics of coalmine spoils was undertaken. The present paper is a part of this study and documents the vascular plant species that colonized an age-series of coalmine spoils in a dry tropical environment in Madhya Pradesh.

STUDY SITES

The study sites are located within a radius of about 5 km in Jhingurda block, north-eastern part of Northern Coal Field Ltd. Singrauli, between 24°10’ 20°-24° 12’ 31” N lat. and 82° 42’-82° 44’ 30” E long. and at 350-450 m altitude in Madhya Pradesh, India. The climate is tropical monsoonal. Mean daily minimum temperature within the annual cycle ranges from 6.4-28°C and mean daily maximum from 20-42°C. The annual rainfall averages 934 mm, of which 795 mm occurs between late June-September. The rocks are medium to coarse-grained sand stone clays with ferruginous bands and carbonaceous shales. The soils are ultisols.

The native vegetation is a typical mixed dry deciduous forest dominated by Boswellia serrata Roxb ex Colebr., Lagerstroemia parviflora Roxb., Wrightia tomentosa R. and S. and Anogeissus latifolia Wall.

Open-cast coal mining was started in 1965 at Jhingurda colliery and overburden materials were haphazardly dumped on adjacent unmined deforested lands. No attempt was made to reclaim the abandoned landscape. Only recently, from 1986, plantations of Eucalyptus sp., Acacia auriculiformis A. Cunn. ex Benth., Cassia siamea Lank., Dalbergia sissoo Roxb., Prosopis juliflora (Swartz. DC and Dendrocalamus strictus (Roxb.) Nees have been started on coalmine spoils.

An age-series of coalmine spoils (5, 10, 12, 16 and 20 yr) were selected for the present study. Following the criteria of Barth and Martin (1984) these spoils were characterised as “generic” in nature and were found non-toxic to plants (Singh and Jha, 1987). In rainy season herbaceous vegetation covers the mine spoils rapidly and biomass peaks in late September or early October (Jha and Singh, 1988).

MATERIAL AND METHODS

A list of vascular plant species occurring on different microsites was compiled
during 1986 and 1987 for each of the
colaime spoils. The microsites were slope
(about 35 per cent), coalpatch, undulating
surface and flat surface.

Herbaceous species were assigned a
gross abundance rating based on their
presence in 1 x 1 m square quadrats placed
at random on each microsite. Nine
quadrats were used per microsite in each
mine spoil. Species occurring in 1, 2-5,
and > 5 quadrats were rated as 1 occa-
sional, 2 frequent, and 3 abundant,
respectively. Species which did not occur
in quadrats but were present on the mine
spoil were also listed and called rare.
Only a few shrub and tree species were
found, therefore, their presence on sites
were recorded separately.

RESULTS AND DISCUSSION

A total of 81 species representing 23
families of vascular plants occurred in the
study sites. The largest plant families
were: Poaceae (25), Fabaceae (12),
Asteraceae (9), Amaranthaceae (4) and
Convolvulaceae (4). The predominance
of Asteraceae and Poaceae on mined
lands has also been reported by Brierly
(1956), Wali and Freeman (1973),
Alvarez et al. (1974), Glenn-Lewin (1979),
Jonescu (1979), Russell (1985) and Prasad

20-yr old flat surface was the richest
microsite with 21 herbaceous species.
On the 20-yr old site, number of tree
species was also high. 10-yr old coal-
patch microsite was the poorest with only
9 herbaceous species.

On the > 12-yr old sites Butea
monosperma was the most frequent species
among the woody components. Coloni-
zation by this leguminous tree increased
with the age of the mine spoil. Alongwith
Butea monosperma, Dalbergia sissoo,
Holoptelea integrifolia and Acacia nilotica
occurred on the 16-yr old site. Cassia
fistula, Carissa carandas, Holoptelea
integrifolia, Diospyros melanoxylon,
Azadirachta indica and one unidentified
tree species and two unidentified shrubs
occurred on the 20-yr old site in addition
to Butea monosperma.

Calotropis procera, Woodfordia fruticosa and Zizyphus glabrerrima were the
most frequent shrubs on all sites.
Presence and abundance of grasses and
forbs are given in Table 1. Some impor-
tant frequent/abundant grasses and forbs
on different sites/microsites were:

5-yr old: Dactylolomentum aegyptium,
Aristida adscensionis, Digitaria setigera,
Tridax procumbens, Cassia tora, Cassia
pumila, Xanthium strumarium and Tephrosia
purpurea.

10-yr old: D. aegyptium, A. adscensionis,
D. setigera, T. procumbens, C. pumila, X.
strumarium, T. purpurea, Bothriochloa
pertusa, Indigofera linifolia. Lepidagothis
hamiltoniana and Zornia gibbosa.

12-yr old: A. adscensionis B. pertusa, T.
procumbens D. aegyptium, Erigonitis
tenella. Alysicarpus monilifer, Urochloa
penicoides, C. tora, C. pumila T. purpurea,
Borreria stricta, X. strumarium, Desmodium,
triflorum, Sida cordata and Hetoropogon
contortus.
Table 1: Presence and abundance of vascular plant species on different sites / microsites.

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<td>Glossocardia boviallea</td>
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<td>Sporobolus diander</td>
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20-yr old : *A. adscensionis*, *B. pertusa*, *T. purpurea* *C. tora*, *D. aegyptium*, *X. strumarium*, *A. monilfer*, *D. triflorum* and *E. tenella*.

*Aristida adscensionis*, *Bothriochloa pertusa*, *Dactyloctenium aegyptium*, *Tephrosia purpurea*, *Tridax procumbens*, *Cusia tora* and *Xanthium strumarium* were the most abundant species on most of the microsites/sites. Other grasses and forbs listed in Appendix 1 were rare on different sites / microsites.

Leisman (1957), Harrington (1982) and Gibson *et al.* (1985) have emphasized the importance of surrounding vegetation and the dissemination efficiency of propagules upon spoil seed banks. It has been observed that the spoils are typically colonized by plants adapted for long-distance or efficient seed dispersai, for example lead and zinc mine spoils in Oklahoma (Gibson, 1982) and coal mine spoil in Pennsylvania (Bramble and Ashly, 1955), New Mexico (Wanger *et al.* 1978) and Great Britain (Brierley, 1956; Hall, 1957).

The proportions of annual and perennial species fluctuated considerably between the microsites and between the spoil ages. With the exception of coalpatch microsite the proportion of annual species was lower on the 20-yr old site compared to 5-yr old site. Reverse was true for perennial species. Annuals comprised, across the age series of spoil, 63.1, 47.7, 65.2 and 54.2 per cent of total species recorded in quadrats, respectively on slope, coalpatch, undulating surface and flat surface.

The proportion of legumes in the vascular flora across spoils ages was 35.1, 27.5, 36.2, and 33.3 per cent on slope, coalpatch undulating surface and flat surface, respectively. Grasses comprised 33.6, 35.4, 32.9 and 41.9 per cent of the flora across spoil ages on slope, coalpatch, undulating surface and flat surface, respectively. These statistics show a prevalence of grasses and legumes on revegetating coalmine spoils. The grass : legume : other forbs ratio was 0.9:0.1, 0.9:0.9:1, 0.75:0.75:1, 1.1:0.75:1 for slope, coalpatch, undulating surface and flat surface, respectively. This ratio for the total vascular flora was (Appendix Table 1) 0.75:0.33:1. The grasses are beneficial in checking erosion and the legumes have ameliorative benefits on both the physical and chemical properties of spoils because majority of them are potential N-fixers. Alexander (1989a, b) has compared the beneficial effect of *Acacia albida* and *Eucalyptus camaldulensis* on the Ten-mine spoil in Jos Plateau, Nigeria, and recommended that *A. albida* has an ability to improve both the nutrient status and physical conditions in the top 20 cm of the soil beneath its canopy, whereas *E. camaldulensis* caused a progressive increase in soil acidity and reduction of base content, although organic C increased. *Robinia pseudoacacia* an N-fixing legume raised soil N levels considerably more than the other non-leguminous species in Ohio coalmine spoil, U.S.A. (Vimmerstedt *et al.*, 1989).
APPENDIX Table 1:

Acacia nilotica L. Willd. ex Delile
Achyrantes aspera L.
Aeschynomene indica L.
Ageratum conyoides L.
Alternanthera pungens HBK
Alternanthera sessilis (L.) R. Br. ex DC.
Alysicarpus monilifer (L.) DC.
Apluda mutica L.
Argemone mexicana L.
Aristida adscensionis L.
Atylostia scarabaeoides (L.) Benth.
Azadirachta indica A. Juss.
Bidens bidentata (Lour.) Merrill and Sheriff
Borreria articularis (L. F.) F. N. Will.
Borreria stricta (L.F.) K. Schum. (=Borreria pusilla (Wall) DC.)
Bothriochloa pertuns L.
Brachiaria reptans (L.) Gardner and Hubbard
Butea monosperma (Lamk.) Taub.
Calotropis procera (Ait.) Ait f.
Carissa carand L. var. congesta (W.) Bedd. (=C. congesta W.)
Cassia fistula L.
Cassia pumila Lamk.
Cassia tora L.
Mimosaceae
Amaranthaceae
Fabaceae
Asteraceae
Amaranthaceae
Amaranthaceae
Fabaceae
Poaceae
Papaveraceae
Poaceae
Fabaceae
Meliaceae
Asteraceae
Rubiaceae
Rubiaceae
Poaceae
Poaceae
Fabaceae
Asclepiadaceae
Apocynaceae
Caesalpiniaceae
Caesalpiniaceae
Caesalpiniaceae
Celosia argentea L.
Cenchrus ciliaris L.
Corchorus conniveans L.
Crotalaria albida Heyne.
Cynodon dactylon (L.) Pers.
Cyperus compressus L.
Dactyloctenium aegyptium (L.) Willd.
Dalbergia sissoo Roxb.
Desmodium motorium (Houtt.) Merr.
Desmodium triflorum (L.) DC.
Dichanthium annulatum (Forssk.) Stapf.
Digitaria biformis Willd. (=D. bicornis (Lamk.) R. and S.)
Digitaria setigera R. and S.
Diospyros melanoxylon Roxb.
Echinops echinatus Roxb.
Eclipta alba (L.) Hassk. E prostrata (L.) L.
Eleusine indica (L.) Gaertn.
Eragrostis gangatica (Roxb.) Steud.
Eragrostis tenella (L.) P. Beauv.
Eragrostis unioloides (Retz.) Nees and Steud.
Eragrostiella bifaria (Vahl.) Bor.
Euphorbia hirta L.
Evolvulus alsinoides (L.) L.
Evolvulus nummulario (L.) L.
Fimbristyliis alboviridis Clarke
Glossocardia bospallea (L. f.) DC
Hackelchloa granularis (L.) O. Ketze.
Heteropogon contortus (L.) P. Beauv, ex R. and S.
Holoptelia integrifolia Planch
Indigofera linifolia (L. f.) Retz.
Indigofera linnaei Ali
Ipomoea eriocarpa R. Bt. (=I hispidu, R. and S.)
Lounaea procumbens (Roxb.) Ramayya and Rajagopal
Lepidagathis hamiltoniana Nees.
Leucas aspera Link. (=L. plukenetii Roth.) Spreng.
Melanocenchris jacquemontii Jaub and Spach
Merremia tridentata (L.) Hall. f.
Ocimum basilicum L.
Oldenlandia affinis (R.and S.)DC.(=Hedyotis affinis R. and S.)
Parthenium hysterophorus L.
Phyllanthus simplex Retz. (=P. virgatus Forst. f.)
Plectranthus mollis (Ait.) Spreng.
Rungia repens (L.) Nees.
Saccharum munja Roxb. (=S. arundinaceum Retz.)
Saccharum spontaneum L.
Setaria glauca (auct.)
Setaria intermedia R. and S.
Setaria pumila (Poir.) R. and S.

Cyperaceae
Asteraceae
Poaceae
Ulmaceae
Fabaceae
Convolvulaceae
Asteraceae
Acanthaceae
Lamiaceae
Poaceae
Convolvulaceae
Lamiaceae
Scrophulariaceae
Asteraceae
Euphorbiaceae
Lamiaceae
Acanthaceae
Poaceae
Poaceae
Poaceae
Poaceae
Sida cordata (Burm. f.) Borss.
Solanum xanthocarpum Schrad and Wendl. (= S. surattense Burm. f.)
Sporobolus diander (Retz.) P. Beauv. (=S. indicus (L.) R. Br. var. diander (Retz.) Joy and Gued.
Tephrosia purpurea (L.) Pers
Tridex procumbens L.
Urochloa panicoides P. Beauv.
Woodfordia fruticosa (L.) Kutz.
Xanthium strumarium L.
Zizyphus gobetrima (Sedgw.) Santapau
Zornia gibbosa Span.

Malvaceae
Solanaceae
Poaceae
Poaceae
Asteraceae
Poaceae
Lythraceae
Asteraceae
Rhamnaceae
Fabaceae

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