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Techniques & Strategy for Mined out Areas

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PREFACE

The Bulletin on 'Reclamation/Restoration Techniques and Strategy for Mined out Areas' is the 37th in the series of Bulletins brought out by the Indian Bureau of Mines. The growing awareness has culminated into strict Environmental Laws & Social pressures on the mining operations. The ever increasing mining activities in our country has a direct bearing on the environment, society and economic growth and as such our Society has become concerned about the environment which is directly related to human life. The Mining Industry has reacted positively by inducting these aspects as a mode of standard mining practice. A beginning has been made for reclamation of mined out areas and significant work has been done in a few mines. However, mining industry is looking forward to concurrent reclamation as a whole and for better post-mining land use, wherever it is applicable.

The bulletin reflects the highlights on relevance of the subject in the Indian context with a critical analysis of the approach initiated so far. In the light of social, environmental, economical and regulatory bonds, the aims and objects of formulation and implementation of a successful reclamation plan has been discussed in the bulletin. Besides, the process of reclamation viz. restoration, vegetation and aftercare management, etc. have also been discussed. Adequate emphasis have also been laid to understand the necessity of adopting Reclamation Policy at the planning stage and to achieve the successful impact of the policy on execution before, during and after cessation of mining operations.

The Indian Bureau of Mines presents this bulletin from the information derived from various sources namely, mineowners, reports and literature etc. including external sources.

I hope, this bulletin will be able to spread the essence of scientific and strategic Reclamation Plans for environment - friendly mining operations and would be useful to the technocrats, scientists, economists, planners, academic institutions, students of mining, environmentalists and other persons dealing with mining operations.

Nagpur
Date : 18.08.2000

(A. N. BOSE)
Controller General
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1. Introduction

1.1 In India, population density is one of the highest in the world - about 250 per sq.km. and acquisition of land both for taking mining projects and for the creation of large mine-waste dumps has already become a serious problem in many parts of the country adding a new dimension to the environmental management by the way of compensation and rehabilitation of the displaced persons, giving employment to the oustees, social tension, cultural invasion into the life style of tribal and economically vulnerable people. The reclamation plan in developed countries is an integral part of mine planning, whereas in India this has just been incorporated through the introduction of Mining Plan/Schemes.

1.2 It is interesting to note that though there are over 9,000 mining leases for major minerals with a cumulative lease area of over 0.7 million hectares (as on 01.01.95) excluding notified minor minerals for civil and construction purpose, a little less than 50% of them have individual lease area of 25 hectares in size or less and a few [20% only] have lease area in excess of 100 hectares each. Mining operations, especially opencast mining, generate considerable quantities of spoils depending upon the nature of occurrence of the deposit, method of mining adopted etc. The solid waste management is an essential component of any mining operation as it is one of the critical factors causing degradation of land and effects siltation and rolling mass downhill. Sometimes dumps are the major sources of dust which gets airborne and affects surrounding land and nearby habitates where this dust finally settles. To the onlookers it gives an ugly and repulsive look.[1]

Two terms are commonly used to describe the reclamation process-restoration and reclamation itself. Stevens, an expert on the subject, defined restoration as returning the land to an acceptable environmental condition, the land being in a fit state either for reservation or ready for special treatment preparatory to redevelopment. However, the widely acceptable meanings of the terms are that restoration implies restoring the land to something like its original form and use and reclamation implies that the land will be returned to a form and productivity that is useful and in conformity with a prior land use plan and is not derelict. Further restoration is often applied to progressive or short life excavations, when the land can be quickly and obviously returned to its original state. Restoration is often used to indicate that the biological properties of the soil are being put back to what they were, but reclamation does not necessarily imply an inferior land use.[2]

In India the concept of reclamation gained some significance during last three decades. Earlier there were number of small mines with many private ownership when much attention was paid to the profitability of operations and lesser to the safety and welfare aspects and almost none to the social and environmental issues. There was hardly any comprehensive thinking for reclamation.

The mining and mineral Industry was considered to be a key factor in the economic growth of country. A strategy was evolved for a long term sustained growth. Now more attention is being paid for a planned development of mining sector. Now efforts are being made to design high production oriented mines. This led to the thrust towards high mechanization specially in opencast mining. The activity involved huge quantities of earth movement work resulting in land degradation in form of huge dumps. With environmental awareness people started realizing the impacts of these mining activities and a common feeling persisted that something is required to be done about this. This particular aspect brought the very concept of adoption of reclamation along with the standard mining operations.

The last fifteen years also witnessed changes in economic, social and environmental spheres. There is a growing awareness about the environmental issues which was a topic of least concern earlier. The systematic scientific evaluation and analysis of the various environmental impacts to formulate a scheme of eco-friendly operations has become an integral part of any Industrial set up. Similarly in mining Industry also need for environmental studies and restoration of the environment through reclamation was felt.

Some mining companies have already taken initiative in the field of reclamation. They have successfully formulated long-term reclamation plans and execution as well but much is desired to be done. Now mining industry make reclamation and restoration an integral part of concurrent mining operations while planning but it is necessary to look into the matter of restoration of earlier excavated sites where reclamation was not thought of.

With the opening up of our economy and ever increasing global competition the search for cost effective means to achieve higher productivity through bulk production has already become a trend in our mining industry. So we are going to see rapid growth of opencast mining in the near future and more thrust on the related environmental aspects. With regulation becoming stringent, people becoming aware and the issue of reclamation and restoration is about to gain more and more prominence in future mining operations.

2. Nature of Land Degradation

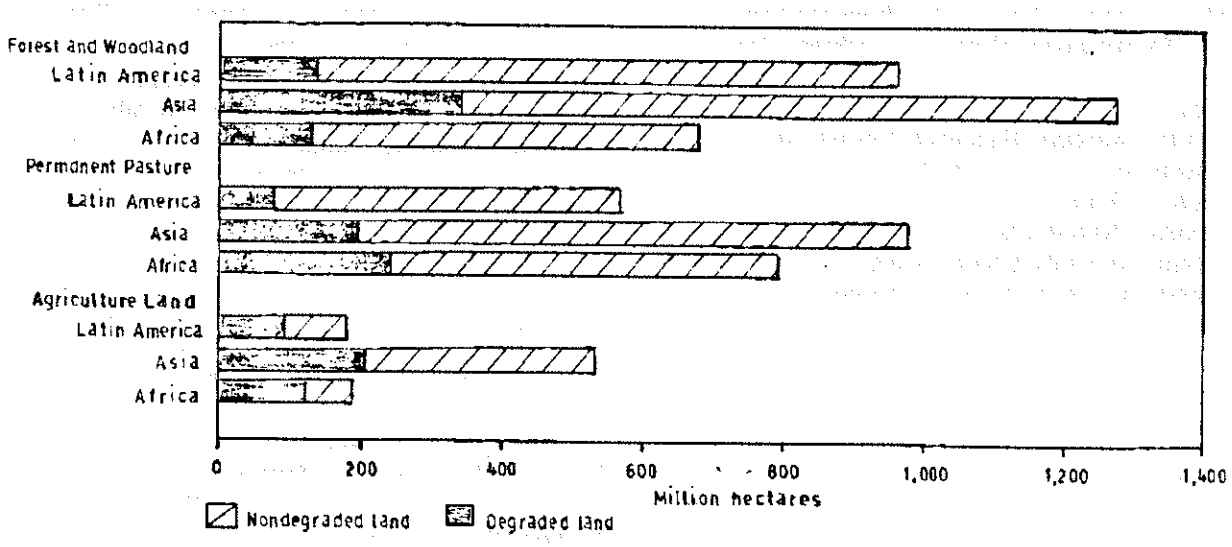
Land degradation in the alteration and spoiling of land, rendering it worthless for any useful purpose. Mining operations results in various types of damages to the environment of which air, water and noise pollution are important, but most important are land degradation and loss of vegetation (in some cases). Though water and air pollution due to dust are, many at times, caused the land degradation, it has been kept beyond the preview of this chapter. Different types of land degradations which is the single most serious element of environmental impact, are discussed in the following paragraphs. The degree of damages in the land varies with topographic setting within which mining operations are carried out, the type and depth of overburden, the type and dimensions of the deposits mined and climatic conditions especially rainfall and wind velocity including its duration.

2.1.0 Types of Degradation

Land degradation takes a number of forms, including depletion of soil nutrients, salinisation, agrochemical pollution, soil erosion, vegetative degradation as a result of overgrazing and cutting of forests for farmland and mining. All these types of degradation cause a decline in the productive capacity of the land, reducing potential yields.

Existing estimates of the current global extent and severity of the problem should be considered indicative at best. The Global Land Assessment of Degradation (GLASOD), based on the impressions of experts, estimates that nearly two billion hectares world wide or i.e. 22 percent of all crop land, pasture, forest and woodland have been degraded since mid century. The region wise land degradation throughout the world is depicted in the figure 2.1.

Some 3.5 percent of the two billion total is estimated to have been degraded so severely that the degradation is reversible only through costly engineering measures, if at all. Just over 10 percent has been moderately degraded and this degradation is reversible only through major and farm investments. About 38 percent of 1.5 billion hectares crop land worldwide is degraded to some degree. Africa and Latin America appear to have the highest proportion of degraded forest land and Asia has the highest proportion of degraded forest land.



-Note - Degraded land includes slightly moderately strongly and extremely degraded areas.

Fig 2·1 Regional land Degradation by Type of Land Use, 1945-90

Various sources suggest that 5 to 10 million hectares are being lost annually to severe degradation. If this trend continues, 1.4 to 2.8 percent of total crop land, pasture and forest land will have been lost by 2020. Declining yields (or increasing input requirements to maintain yields) could be expected over a much larger area. These data are, however, likely to overestimate the problem, as they do not account for the effects of land improvements, which also appear to be widespread.

2.1.1 Loss of Vegetation

The mining operations specially those related to opencast workings, loss of vegetation would take place, due to breaking ground, dumping over burden and other infrastructural facilities like structure/building, roads, workshops, beneficiation/ extraction plants and tailing ponds. Further, there are instances of subsidence of ground supporting vegetation which gets affected or destroyed as observed in clay mines of Pali district in Rajasthan. In some cases agricultural land also gets lost or affected. Loss of vegitation may results in drastic changes in climatic conditions like rainfall, temperature and humidity due to destruction of original vegitation. This ultimately may result in disappearance of existing wild life, resident, migratory birds, animals and aquatic organisms. Kudremukh Iron Ore Project is an example where mining operations have already effected the flora and fauna. Last 30 years have observed 50 times increase in mineral production at the cost of several million hectares of good agricultural land and forest land. Field surveys of India has indicated that 2700 species of flowering plants and 150 species of medicinal plants and herbs are in danger in Gandhamardan Reserve Forest area as a consequent of mining operations for bauxite in Orissa. Another burning example is that of Dehradun-Mussourie limestone belt where a series of small scale mining had created an eco-imbalance polluting the environment severely. One more example is Bijolia sand stone belt of Rajasthan where area covered by mining activity has increased by 36.5 times (spread over an area of 617 sq.km.) resulting in 47% decrease in forest cover, 90% decrease in dense forest, 14% decrease in land under agriculture and 67.5% increase in the waste land. [53]

2.1.2 Siltation

There are many instances of siltation of low lying lands around waste/mineral dump yards. This siltation affects fertility and usefulness of such lands.

2.1.3 Pits/Excavations

Unlike underground mines, opencast workings itself cause extensive damage to the land. Specially in hill - slope areas where excavations are done for mining not only damage the area excavated, but also affect uphill lands causing land slides and vegetation loss and in many cases driving out fauna from their habitats. Mining of sand stone in Bijolia area has also effected the hydrological regime, blocking the channels and lowering the water table. Blocking of channels has further resulted in stagnating water bodies in the mine pits and labour colonies which has resulted in increase in suffering of workers form malaria by 50% [53].

2.1.4 Waste Dumps

These dumps block useful and arable lands for indefinite period. Apart from degradation of land on which dump itself stands, they also degrade lands sometimes due to leachate, change of local drainage pattern and groundwater conditions, sloughing of boulders towards the foot where vegetation exists.

2.1.5 Soil Quality

Due to excavations for mining and allied activities soil sequences get disturbed. Further due to loosening of the ground natural compactness suffers deterioration and as a result erosion takes place specially where differential topography and high rainfall exist. In some cases pH of soil also gets adversely affected due to dump leachates. Water holding properties and the water table itself also may be affected which may make recovery with vegetation difficult.

2.1.6 Damage to Agricultural Land - Creation of Wasteland

Surface mining may result in constant decline of green and cultivable areas which is by way of blockage of land for mining and allied activities. An estimate indicates this to the tune of 60% by waste dumping, 23% by pit excavation and 17% by others. Degradation caused by small scale mining is highest out of these and is more serious in case of minor minerals. It is worth noting that

agricultural land has reduced from 56.87% to 49.94% and waste land has increased from 2.8% to 21.67% in a span of 20 years in Bijolia area of Rajasthan where sand stone quarries are being worked[52].

2.1.7 Soil Erosion, Landslide and Hydrological Imbalance

Over burden and waste materials are cut and cast down the hill slope in mining of hill top deposits. This may destroy vegetation over a large area. Casting down of waste rocks from hills in iron ore mines of Goa may cover paddy fields and agricultural lands in due course of time. Deforestation and soil erosion due to such work have caused land slides and hydrological imbalance in the Himalayan region. Drying of streams in a large Indian bauxite project has caused a considerable environmental problem. Department of Environment has done a study in bauxite mining in Gandhamardan Reserve Forest of Orissa, which has forecasted drying up of 150 springs.[53]

2.1.8 Visual Intrusions

For mining activities natural landscape is disturbed as pits, waste dumps etc., create scenic blight. Such aspect of land degradation is very significant in populous areas and spots of tourist importance. With the increase in size of mining machinery and equipment, high technology development and improvement in blasting techniques, there is a trend towards surface mining and it has been expanded to more prominent locations.

2.1.9 Infrastructures

Construction of approach and network roads, buildings including residential colony, beneficiation plants and other secondary and ancillary facilities causes considerable damage to the land surrounding the mine.

2.1.10 Tailing Ponds

Most of the metalliferous mines are having process plants attached to them and tailings disposal is a common phenomenon for which tailing ponds are required. These ponds are considerable expanse of land and artificially created ponds also need lands for construction of dams for the purpose of the confinement of tailings. Further the discharge from these ponds, sometimes cause damage to the lands lying downstream.

2.1.11 Effect on Habitat

This aspect is one of the most important implications. Uprooting the local population and shifting the same to another place has been observed at Singrauli area in coal sector, Goa in iron ore sector, Orissa in bauxite sector and Madhya Pradesh in copper sector.[53] It has also been observed at Rampura Agucha Mine of Rajasthan in lead and zinc sector.

3. Restoration of Mined out Areas

3.0.1 Necessity of Land Reclamation

It is necessary to reclaim the land affected by mining due to following reasons :[53]

- To put the land into productive use like agriculture,forestry or recreational purposes.
- To check soil erosion from dump leading to destruction of watersheds and siltation of river.
- Accumulation of huge quantity of water in worked out pits may pose threat to life and property.
- To combat adverse visual impact.

This requires two stage planning i.e premining planning and post mining land use and monitoring. First stage considers all necessary measures to be taken for making second stage effective.This requires Environmental Impact Assesment (EIA) to be prepared. This should clearly bringout the likely impact of mining on environment, both biotic and abiotic and the likely extent of degradation, which may occur to the environment in the absence of any abatement measures. And to prepare this statement baseline information are required which includes geology/ geomorphology, climate, hydrology / hydrogeology, hydrogeochemistry, and soil. Generation of information may also be required on quality of water, air and noise level, topography, land use pattern, demography of the area etc. [53]

3.0.2 Reclamation Planning Implementation

For successful reclamation following points are to be considered[53].

* Listing inventory of premining condition.
* Monitoring flexibility of mining programme in the light of efficient land reclamation.
* Evaluation of the post mining requirements of the region and to decide on the needs and desire of the affected ground.
* To make reclamation planning suitable to technoeconomical and socio-political environment.
* To assess the physico- chemical characteristics of overburden.
* Extra cost of preservation, re-handling, spreading and leveling of subsoil and topsoil.
* Knowledge of hydrogeological/ geomorphological conditions.
* Aesthetic and/or historic value of land.

3.1.0 Restoration Strategy

Before considering the strategy for reclaiming mined out area it is important to decide in which form the reclaimed land would be made available for use either to the society or to the individual and strategy for reclamation will depend on one of the "possibilities" of land use after reclamation or combination thereof. The various "possibilities" are detailed below:

1. Afforestation of mineral workings during and/or post mining operations is the major and most common after-use actioned through reclamation. Where specific usefulness of land could be decided, afforestation is normally planned through the site could have been considered for better possibilities of land use.

2. Agriculture : Some form of agricultural use may be possible in sites that are adjacent to farmland provided the soil and topography are favourable. With increasing knowledge and experience, however, it is becoming evident that top soil is not always essential to produce a productive soil. Agricultural and horticultural crops can be grown in a variety of materials. The range of possibilities include arable cropping, grazing in either productive low land or over upland pasture. The only constraint apart from the site is that there must be some integration into the local rural agricultural pattern. But it would be inappropriate to establish pasture in an area of arable cropping, even though the grazed pasture would recreate the soil structure more rapidly.

3. Housing and Industry : Many quarries specially of building materials which are near urban areas often lend themselves to development for residential accommodation or industrial purpose.

4. Sports and Intensive Recreation : All types of quarries either in urban or residential areas can provide extensive facilities for formal or informal recreation. Sometimes these abandoned quarries can be made for ideal recreation. But in a more formal way disused workings can provide excellent sites for sporting activities such as sports pitches, golf courses, race tracks, rifle and archery ranges

and locating sailing, canoeing, swimming, angling and water skiing. Further some pits form natural amphitheatre so that pit edges can be shaped as seating areas. But quarries in rural areas have a similar potential for less intensive creation.

5. Land fill and Waste Disposal : Large quantities of waste and refuse are generated by urban and industrial centres where waste disposal assumes significant importance and poses great difficulty. The potential of worked out pits and quarries as great receptacle is of paramount help. Filled sites can be developed for other uses afterwards. However final contours after such filling should be compatible with surroundings and after - use requirements.

6. Aminity, non-intrusive recreation and education : Most of Indian quarries are happened to be in rural area where recreation and amenity are restricted. These worked out quarries/mines can serve this purpose of sports and recreation as already have been discussed. They can be developed as parks, open water, wildness including picnicking.

The aim of the strategy should be to formulate a set of landscape objectives. The procedure that will be involved are illustrated as a flow chart in fig.3.1.[2]

For new developments, much of the strategy will be linked closely to planning application portion. In general following steps may be considered.

1. Outline and scope of the project : This simply entails a consideration of the proposed extraction process - the scope and scale, and mineral production requirements for plant, spoil disposal, land take, etc.

2. Site survey and appraisal : At this stage, the existing site conditions should be surveyed in detail to identify topographical features, land use and classification, climate, water levels and movements, ownership boundaries, roads, existing

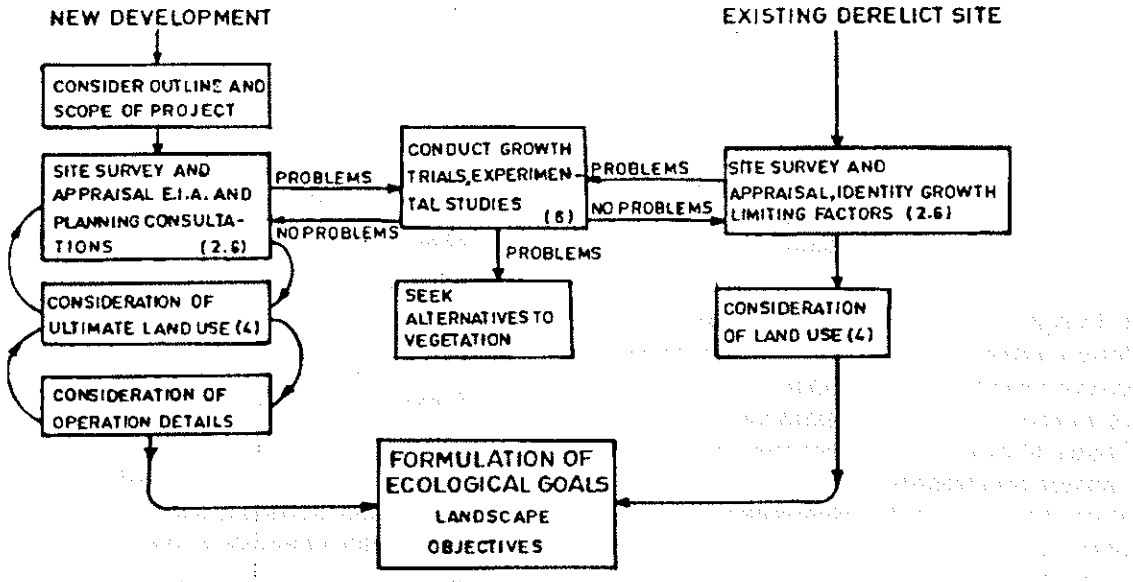


Fig 3.1 FORMULATION OF RESTORATION STRATEGY

7. Nature conservation and wild life refuges : Colonisation of natural and volunteer species of many direct quarries has led to the development of many attractive species - rich animal, plant and insect communities. This is usually fortutions rather than planted. Hence cost of reclamation is very little.

8. Water storage and supply : There are many quarries that contain water can provide a useful water storage facility and also facilitate ground recharge for agriculture and cultivation.

vegetation and special factors such as prevailing winds, views and importance of any nature conservation, amenity or landscape intersects. In addition a detailed assessment should be made of the quantity and quality of any overburdens, spoils, wastes and the likely final shape and size of the extraction. In short, an Environmental Impact Assessment (EIA) should be made covering both the aspects - beneficial and harmful of the operation on the natural environments. This assessment would offer enough scope for consideration of

alternative actions, so that the best (or least environmentally damaging) can be chosen.

3. Consideration of after - use : As already has been discussed in foregoing paragraphs, this is the most important aspect which controls the entire strategy. But due to the long term nature of quarrying, it is often not possible or desirable to have detailed after - use plans at the beginning of the project. However early definition of landscape and after use objectives which can be received and updated periodically with appropriate details is probably the best approach in many cases. In this way any changing emphasis on land use or variations in working methods and restoration techniques can be allowed for as the scheme is implemented.

4. Formulation of landscape objectives : Majority of the after - use objectives includes afforestation, so the type of vegetation required in particular, its function, productivity and management requirements. Cost - benefit analysis normally play an important role in the formulation. The final landscape objectives should identify :

a) final contours, water levels (if any), drainage, etc.,
b) obsolete plant/buildings to be cleared or retained,
c) new positions of roads, paths, water courses,
d) general indication of quality and species of plants, grass, trees, shrubs, etc.

5. Design of operational details and working plans : Where extraction of mineral/rock, processing and environmental requirements are outlined, the operation and working details can be formulated. These should aim to minimise environmental damage and maximise an economic working and environmental benefits. Now detailed plan for each phase of working and restoration/reclamation will be necessary.

6. Alternative to Vegetation: Due to techno-economic reason and/or other priority after-use of the exploited land, creation of vegetation cover may not be the means of reclamation/restoration of the used land. These priorities after-use are - burying undesirable waste, stabilisation of physical and chemical environment of eroding spoil tips etc., without any treatment and accommodating alternative use of by-products such as low grade fill apart from making water sports/reservoir and/or other recreation support.[2]

3.2.0 Principles of Rehabilitation

The type of mining and the characteristics of the particular mineral deposit both affect the degree to which mining disturbs the landscape. Underground mining usually causes little surface disturbance and rehabilitation is restricted to tailings dumps, removal of buildings and equipment, and making the area safe. Surface mining results in the destruction of the existing vegetation and soil profile. Removal of overburden and waste rock and its replacement in waste dumps or the mined-out pit can significantly change the topography and stability of the landscape. Some overburdens may release salt, or contain sulfidic material which can generate acid mine drainage. These materials can sometimes be selectively placed so that they don't cause problems, or they may require special rehabilitation treatments.[3]

These are the basic principles of rehabilitation which should always be followed.

* Prepare a rehabilitation plan prior to the commencement of mining.
* Agree on the long-term post-mining landuse objective for the area with the relevant government department, local government councils and private landowners. The landuse must be compatible with the climate, soil topography of the final landform and the degree of management available after rehabilitation.
* Progressively rehabilitate the site, where possible, so that the rate of rehabilitation is similar to the rate of mining.
* Prevent the introduction of noxious weeds and pests.
* Minimise the area cleared for mining and associated facilities to that absolutely necessary for the safe operation of the mine.
* Reshape the land disturbed by mining so that it is stable, adequately drained and suitable for the desired long-term landuse.
* Minimise the long-term visual impacts by creating landforms which are compatible with the surrounding landscape.
* Reinstate natural drainage patterns disrupted by mining wherever possible.
* Minimise the potential for erosion by wind and water both during and following mining.
* Remove or control residual hazardous materials. Identify and potentially toxic overburden or

exposed strata and manage them so as to prevent environmental damage.

* Characterise the top soil and retain it for use in rehabilitation. It is preferable to reuse the topsoil immediately rather than storing it in stockpiles. Only discard if it is physically or chemically undesirable, or if it contains high levels of weed seeds or plant pathogens.
* Consider spreading the cleared vegetation on disturbed areas.
* Deep rip compacted surfaces to encourage infiltration, allow plant root growth and key the topsoil to the subsoil, unless sub-surface conditions dictate otherwise.
* Ensure that the surface one or two metres of soil is capable of supporting plant growth.
* If topsoil is unsuitable or absent, identify and test alternative substrates, eg. overburden that may be suitable substitute after addition of soil improving substances.
* Revegetate the area with plant species consistent with the post-mining landuse.
* Meet all statutory requirements.
* Make the area safe.
* Remove all facilities and equipment from the site.
* Monitor and manage rehabilitated areas until the vegetation is self-sustaining and meets the requirements of the landowner or land manager, or until their management can be integrated into the management of the surrounding area.

3.3.0 Rehabilitation of Mine Sites

Environmental problems in mines are mainly associated with mine "waste" and mine site abandonment. In India mining industry produces waste in the form of soil and sulphide ores. Apart from this, some lands are affected by acid - generating mine waste and lay tailings, mostly at working mine site.

Waste rock dumps and tailing ponds are the most visible end result of the mining process. For the most part, the visual "pollution" which depends on the eye of the beholder, can be effectively managed through recontouring and rehabilitation during operation. Waste rock and tailing from the mining and processing of sulphide ores are more difficult problems. The effect of weathering can produce sulphuric acid which inturn can harden the release of heavy metals and other toxic elements into solution. Unless this weathering is prevented or the acidic water is treated, the resulting acidic mine drainage can pose a threat to human health and the environment as a whole. The more difficult task is that, while waste water treatment plants are efficient and effective during the operating life of the mine, they do not provide any walk away solution to the problem that can persist for centuries. In other cases where fill material is brought from other sites those are to be tested for their toxicity and trace of atomic minerals. If harmful constituents are found either these are not to be used as fill material or to be used after treatment to bring the toxicity with in safe limits. This problem points towards significant financial and scientific challenges. Both levels of Government and industry are required to work together especially when no such efforts has been made so far in the country. However, there are two indirect solutions known to us - one is maximization of waste utilization and the other, recycling the products. But the former is again a matter of technology and money whereas later is feasible and beneficial not only from environmental view point, but also from the angle of resource utilization.

Our 20% of the metals produced in the country are recycled, especially steel, copper, lead, zinc and aluminium. And there is further scope of bigger share for recycling which may include scraps not only from within the country, but also buy the way of importing scraps from abroad. This practice can reduce to some extent pressure on mining, in turn environmental damage and the cause for rehabilitation of mine site.

The Policy of Federal - Provincial - Industry Cooperation plays an important role not only for economic development of a country but also in the field of post mining reclamation especially when it is a non remunerative but expensive and time consuming process. The compulsative mechanism should be such that objectives of reclamation are convincing to all concerned. These objectives can be achieved through interaction of government, industry working groups, environmental round table, public fora etc. Scientific research also plays a vital role as that helps develop economically viable means of reclamation.

Till recently no attempt was made towards the post mining reclamation and rehabilitation of worked out pits or reclamation of working pits in stages concurrently with the mining operations with

the aim of using reclaimed areas for better use by the community and worked out quarries were left out in such a poor and degraded condition that these quarries had no practical value and utility to the society and the expanse of damaged and degraded land remain as negative property to them for indefinite time. In case of very large mining projects, scientific reclamation planning is a multi - disciplinary task and requires mining and civil engineers, geologists, landscape architects, soil scientists, horticulturists, land use experts and hydrologists.

3.3.1 Soil Preservation

The soil needs to be preserved in such a way that nutrients present therein are preserved and not degraded. For this purpose soil should be protected against erosion by water and wind by the way of vegetation and leguminous plants which helps nutrition and improvement of nitrogen level in the soil.

The reclaimed land should be first tried with crops and then followed by other vegetation. Soil amendment measures should be taken so that water holding capacity remains at the satisfactory level.

Biologically active soil layers should be atleast 80 - 120 cms thick for farming and 120 - 200 cms thick for plantation. But top soil thickness should be atleast 25 - 40 cms on well established ground for forestry purpose.

On investigations related to available quality and quantity of the overburden and top soil if any, reclamation technique is identified to suit the site specific conditions and calender plans for reclamation are drawn including realistic court of reclamation.

The objective of reclamation is to return the aimed out alienable lands to the society for better utilization. If there is no problem related with conservation of animates, backfilling should be done concurrently with mining operations. Thus reclamation plans are based on the proposed use of the degraded land and may be for forestry, agriculture or for recreational purpose or even for town planning and construction.[4]

It is necessary to store the top soil separately which is the fertile portion of the earth crust. Depending on the soil conditions the top soil of thickness varying between 10 cms to 500 cms need to be scraped and dumped in nearby site where mining operation is not expected to come in near future. This material is proposed to be used for surfacing the underfertile and/or rocky and waste material like overburden which is either in the form of dumps or the backfill. This top soil should be conserved promptly, against the transportation by water or wind erosion keeping vegetal cover of grasses and bushes. For this purpose max 20° slope can be maintained. However, in the heavy rainfall area the slope angle should be further less. For proper drainage of this soil it should be dumped on plain ground, but trenches are to be dug around the dumps and plantation of grasses and short duration trees can be adopted. To retain or improve the nitrogen content of the soil leguminous plants can be planted as nitrogen fixer especially when the top soil so removed is expected to be used up in the next 5 - 10 years.

3.3.2 Methods of Rehabilitation for different Excavations

3.3.2.1 Shallow pits

In India, metalliferous mining sector is such where operations are carried out manually in scattered fashion. As a result a large area of the lease remains blocked as degraded land. Such situations are encountered in the mines of limestone, dolomite, bauxite, iron and manganese ores where float ore/mineral mining is practiced. Such shallow and small pits cannot be converted into small water ponds either for fish breeding or for cultivation. The situation is further aggregated by sporadic heaps of waste/overburden dumps around such pits. If such pits are not proposed for large scale mining in near future, they should be backfilled with available waste/overburden and these can be reclaimed by grading the filled up overburden and by a blanket of 25 - 40 cms thick cover of soil mixed with fertilizer/manure for growing crops, vegetables, etc.; but plantation should be avoided as future felling of plants/trees, which is restricted under forest act, may be required for possible mining of the minerals/ores lying beneath.

If shallow pits have large areas in pre - mining agriculture fields, these can be reclaimed by backfilling and levelling with suitable soil layers. Such reclaimed areas can be renewed for agricultural purpose. For example, many areas from float ores have been worked out in the neighbourhood of Mansar Mine of MOIL have been refilled with overburden, levelled and reclaimed by spreading the top soil stored earlier. These reclaimed fields are being tilted now for agriculture purpose.

In cases shallow pits are abondoned, but overburden/waste materials is not available for backfilling, such pits can be proposed for forestry by selecting local varieties/species and planting the same on such shallow pits after grading the slopes to a suitable gentle slope. For this purpose small circular pits on grid pattern of 2m x 2m x1m are dug and filled with suitable mix of soil and fertlizers. The selected saplings are then planted in these pits at the time of onset of monsoon. As after care of such plantation is necessary, proper fencing of the pits/quarries is equally important to guard against cattle and arrangement is also necessary for watering and manuring at intervals as per the advice of horticulturist/botanist engaged for the purpose.

3.3.2.2 Large deep quarries and pits

Where scale of production and overburden removal is very high and as a result deep quarries/ pits are formed. In such cases where not much mineral wealth is left out below the pit bottoms, these are the ideal cases where concurrent or subsequent backfilling can be considered as a vital means of reclamation, subsequent backfilling is a costly proposition compared to concurrent backfilling as the former case needs rehandling of overburden. If concurrent backfilling is not technically feasible, subsequent backfilling is beyond the economic justification, such deep pits can be considered for water reservoirs provided they are not in arid zone where neither storm water nor ground water is available. These water reservoirs can be used for pisciculture, domestic purpose or for agriculture.

Alternately they can be transformed into large lakes, can be planned and developed as recreation spots with proper land seaping and planned plantation around their peripheries and along approach roads, parks, etc., with flower garden including other facilities on the bank of such lakes for attracting urban tourists. And this type of reclamation/rehabitation will also generate residual business giving opportunity of self employment of local people. However, the banks and the slopes of such proposed lakes should be stone pitched with cement mortar to avoid collapsing of wall rocks especially those areas of slopes/banks where traffic is anticipated to be more for e.g. a leading mining company in Goa has converted one of their large worked out pits in one of their mines into a fresh water reservoir where pesciculture is being experimented. Besides, the water from this pit is being used for watering the extensive plantation done on the banks of this pit. Similarly in a limestone belt in Madhya Pradesh, one mining company has developed recreational environment around one of their worked out pits providing facilities like swimming pool, a park with fountain and by planting different species of trees on the bank of a huge fresh water lake created out of a old pit worked out earlier. Where overburden waste is not enough for the purpose of backfilling, the worked out pits can be reclaimed in this manner and for this purpose ideal deposits in India are limestone, manganese, dolomite, iron ore,etc.

If backfilling of worked out pits is considered feasible by dumping overburden/waste generated from the neighbouring mines, the same can be done, but care should be taken that the topography of the reclaimed pits matches with the surroundings. As the overburden/waste normally contains less nutrients, after backfilling with these material and preparing the filled area with the dozer, a layer of 25 to 40 cm thickness of fertile soil mixed with suitable manure should be put over the area. These reclaimed pits can be taken up later for plantation of suitable saplings of local varieties, but preference should be given to those which do not attract cattle.

Where suitable top soil is not easily available, the reclaimed area can be converted into grassland or pasture.

Thus, such a reclaimed pit will not pose any environmental problems of any nature. During backfilling of pits care should be taken for compaction layer by layer. A layer of 2.5m to 3.5m thick can be compacted by plying dumpers and/or other heavy earth moving machine and finer compaction can be achieved by rollers. Compaction is very important as it prevents undue subsidence and failure of slopes. Better compaction can be achieved when different sizes of materials including fines are used as backfill. Natural compaction by rain water is very effective.

So, the large abandoned pits can be reclaimed and rehabilitated without any environmental malady and at the same time overburden/waste which is detrimental to the environment can be effectively managed and utilised.

When large deposits occur on the hill top region they are worked by contour strip mining adopting mechanised methods. By removal of overburden as well as mineral by forming systematic

benches around the hill side, artificial shelves are created on one side of the hill. As a result excavated area of the hill is damaged and the existing flora thereon is cut and removed. Unless these are reclaimed by plantation choosing local varieties of saplings, the area does not blend with adjacent landscape and interfere with natural aesthetic of the area.

By implementing preplanned afforestation programme in those parts of the quarry where operations are discontinued due to depletion of minerals/ores, grown up trees in benches on grid pattern adds green beauty. Such green views can be seen on hill slopes and planes planted by forest department along Sawantwadi - Mumbai highway.

Alternatively, if the worked out quarries at the hill tops are to be abandoned a couple of years back, but before abandonement, good number of trees grown up in big pots/drums at the nursery can be replanted on benches in such hill top quarries at the beginning of the rainy season as per the preplanned replantation programme. This method can convert the damaged landscape of the hill into a grown up green belt within a short span of time without any sign of deforestation blights.

In another limestone mine in Raipur district, Madhya Pradesh, 37 trees each of 6 years old standing on mine benches which were to be advanced for production, were successfully transplanted in a new site which was foreseen not to be disturbed in future. Of these trees, 30 survived. This success story is worth experimenting by big mine managements in their mines.

3.3.2.3 Backfilling of existing quarries with overburden and topsoil

Soil disturbed by the surface mining are highly susceptible to erosion and difficult to stabilise by vegetation. Further, they contain toxic elements, therefore it is necessary that top soil be stored and preserved wherever feasible, from the ground considered for mining. Depending on the quality, scrapped on first instance, should be top soil of thickness of 10 to 150 cm depending on availability. This soil is to be dumped in the nearby site which is not going to be disturbed due to mining or any other related activities. This material is meant for recovering the ground after backfilling the mined out pit with rocky and coarse material. The top soil dumps should be conserved properly against the transportation by water or wind erosion by having vegetal cover of grass, bushes and preferably of leguminious plants. Further digging of trenches around the dumps and plantation short life trees.[5]

3.4.0 Solid Waste Management

Mining operations, especially opencast mining, generate considerable quantities of spoils depending upon the nature of occurrence of the deposit, topography of the area, method of mining adopted, etc. Thus solid waste management is an essential component of any mining operation. Disposal of overburden and waste is done in predetermined locations usually within the leaseholds and they need proper design, stabilisation and revegetation to contain the degradation of land. These aspects have been dealt with in this chapter.[6]

3.4.1 Dump Management

External dumps are permanent sources of land pollution through wash off with rains and airblown dust through wind action. They also present an ugly and repulsive look to the viewer, if not duly afforested. The following measures are recommended to minimise land pollution due to external dumps:

(A) The design of the waste dumps should accommodate progressive rehabilitation to ensure a minimum area of disturbance at any one time and to establish final rehabilitation at the earliest opportunity. Alternative uses for part of the material, such as in landfill or road construction, may also be possible. It is advisable to acquire sufficient extra area over and above the mining lease area to cater to a planned external dump.

(B) The following basic objectives for waste dump need be considered in the planning phase, wherever possible (e.g. if open-pit design permits, or more than one open-pit is proposed) waste rock should be returned to previously excavated areas.

* The height, area and shape of the waste rock dump to be designed having regard to the area of land available, the general topography of the area and the vegetation, in the area.

* All completed surfaces of the waste dump should be stable and able to resist long term erosion.

* whereever it is possible to use a portion of waste dump for building purposes or as road material, such material should be stacked separately so that it is not burried under or mixed with unusable

material and can be transported to its place of use whenever necessary.

* Top soil (20 cm) should be scraped out from the dump site in advance and preserved in low height dumps, duly covered with grass and vegetal cover to preserve its fertility/biomass.

* Previously stockpiled subsoil and topsoil should be spread on all completed surfaces wherever practicable and re-vegetated with suitable vegetation.

* The designed land construction of the waste dumps should be such that the completed outslopes do not exceed 20° from the horizontal.

* Drainage should be constructed to handle heavy rainfall events. Appropriate garland drains and drains at individual terrace should be provided to guide the rain water to main drainage channel without wash off of the dumps.

In meeting these objectives, it is essential that consideration is given to the aesthetic of the constructed waste dump. The long distance perspective of the shape and colour of the dump in relation to the surrounding landscape needs to be assessed from the main access ways and viewing points of the site. At closer range the view of the dump area should provide the viewer with a impression that the area has been rehabilitated to both blend with the natural land form and that the area supports a stable vegetative cover similar to the surrounding area. These factors should be established as only term objectives and planned from the beginning of the operation and provided in the statutory mining plan for approval of IBM.

(C) Design of dumps : Since external dumps, which can not be used for backfilling of old pits or otherwise, must be afforested for greenery and land stability. Their outer ultimate slopes must be very gentle, preferably not more than 20°, because steeper the slope more difficult it is for biological rahabilitation. An estimated relationship between the angle of dump slope and efficiency of revegetation, as given in Fig. 3.2 may be kept in view for general guidance in this regard.

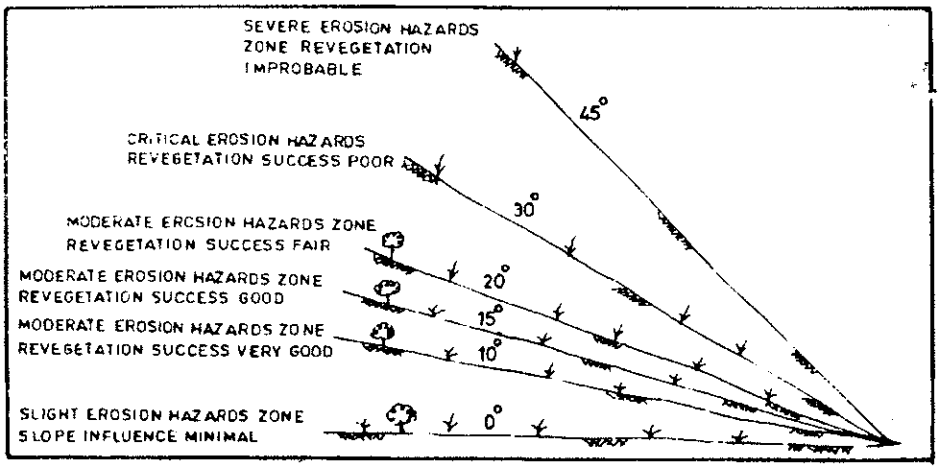


Fig 3.2 INFLUENCE ANGLE OF SLOPE ON REVEGETATION AND EROSON

It may be noted that long unbroken slopes allow surface run-off to accelerate and produce rill and gully erosion. Therefore, even a gentle slope of 20° should be of short length so that the vertical height of individual terrace is not more than 10 m. and to obviate formation of gully along the slopes for 10 m height of the bench a berm of at least 4 m width should be provided, the berm having a gentle slope (say 0.5%) inwards into the dump (Fig. 3.3 and 3.4). The rain water from these berms is drained through rock lined vertical drains provided at suitable intervals. The number of vertical drains required is dependent on final slope angles. On steeper slopes, the catchment area for the vertical drains need to become smaller to ensure that run off water does not exceed the design capacity of the drainage systems. Individual catchment areas should not exceed 2 hectares on fourteen degree slopes, 1.25 hectares on eighteen degree slopes and 1 hectare on 20° slopes.

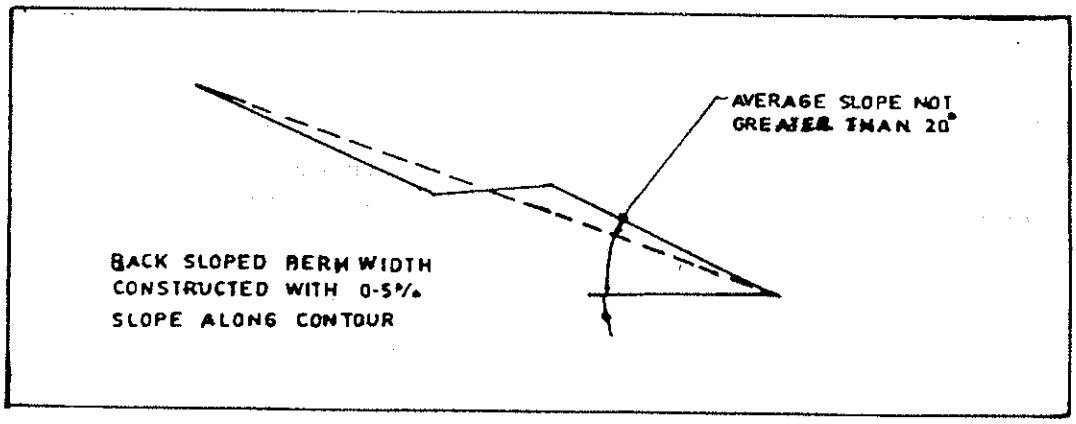


FIG.3-3 : BASIC SLOPE PROFILE FOR MOST WASTE DUMPS

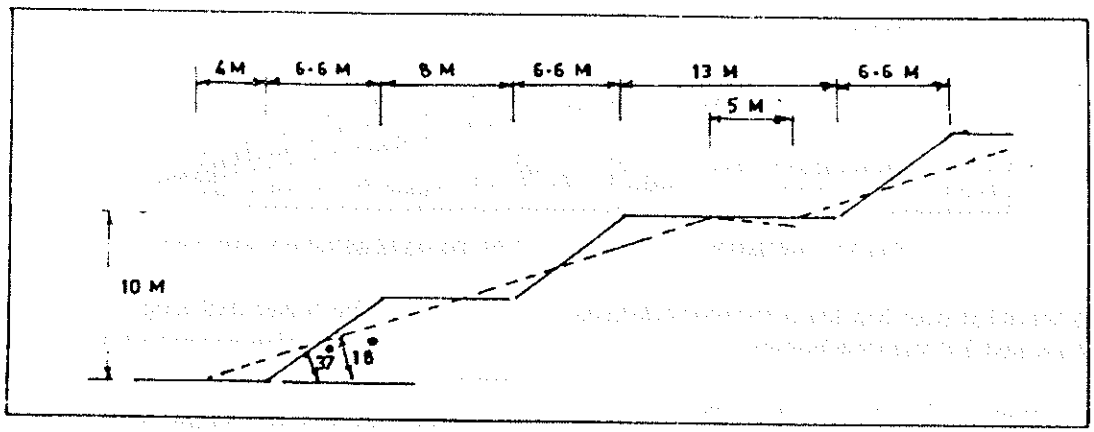


FIG.3-4: EXAMPLES OF WASTE DUMP CONSTRUCTION TECHNIQUE

LEGEND:

——— PROFILE DURING CONSTRUCTION TO MINIMISE EARTHWORKS

– – – PROFILE AFTER RECONTOURING TO LESS THAN 20° SLOPE

It needs to be emphasized that these drainage structures should be maintenance free and designed to last for decades to ensure that no failure occurs before vegetation is well and truly established. Waterways need to be lined with rock and not just hard clay chunks. Alternatives may include meshing secured in place, only conveyer belting or half round pipe.

(D) Retreating Pyramidal bench formation with concurrent rehabilitation

With the common practice of short-term dump management in Indian mines where dump faces always advance away from the pit, one rarely gets a dead face for biological rehabilitation, since the dumping face is always 'active' under such situation the dump face can be stabilised and rehabilitated by afforestation only after the end of mine life. Therefore, a radical change in the practice is recommended. This is by adopting retreating pyramidal system with concurrent rehabilitation. The system, in nutshell, provides for building up the outer edge of the planned and ultimate dump first and then retreating back wards while afforesting and rehabilitating the outer 'dead' faces.

(E) Dumping in Vallies

Vallies are natural drains in hilly areas. In mines in hilly terrain where there is no other place for dumping waste material, even deep vallies can be utilised for waste dumping. In such case base of the dump i.e. bottom of the vallies are to be filled with big boulder, above this smaller boulders and still smaller boulders and so on and on top finer materials are to be dumped. This will enable rain water to pass during rains from the voids between big boulders. The thickness of big boulders will depend upon the size of the valley, precipitation in the area and catchment area for water which will flow in that particular valley some fines will be carried away along with rain water and this will require check dams on down stream where fines will settle and clear water will pass away through hume pipes. These check dams have to be cleared periodically so that after filling with fines to its full capacity, they are not carried further down with rain water. Over this filled material soil can be spread and plantation can be done to add to the aesthetic beauty of the area. By this not only waste can be successfully disposed off, but the necked rocks in the valley can be converted into lush green area. This has been done successfully in a wollastonite mine in Sirohi district of Rajasthan.

3.4.2 Dump Rehabilitation

Establishing a vegetative cover is the only best term strategy for stabilization and erosion control. To begin this process the topsoil should be replaced to all similar depths as that removed from the site originally (i.e. 200-300 mm). If topsoil is in short supply it may be necessary to place the topsoil in strips. This at least provides areas of improved surfaces for regeneration.

To increase the success of vegetation establishment, rehabilitation techniques should aim to increase rainfall infiltration. The term used for this approach is "water harvesting". Many specific techniques have been developed for various applications. The most basic of these techniques is to leave the surface of the dump as rough as possible by deep ripping along the contour after the topsoil has been spread. The roughness and ripping allows for water penetration and provides places for seeds to lodge. Replacing pre-stripped vegetation also helps this process and reduces wind erosion. Creating a surface which enhances water harvesting will also help to leach soil salts out of the surface profile and aid the revegetation programme.

In areas where salt content of the overburden is high it is recommended that the dumps be screened with overburden of the lowest possible salt content. This is usually from material closer to the surface. This selective handling of overburden may be considered expensive. However, such treatments will be required to provide a suitable environment for plant growth, as it will take many years for the salts to leach out of the surface layers. The screening material needs to be covered by topsoil.

In all cases the surface and faces of waste dumps will need to be ripped to break composition and to allow water penetration. This ripping will usually be carried out by a dozer after the topsoil and old vegetation material is spread. It is stressed that water harvesting and erosion control are the key issues in establishing the final surface for the rehabilitation programme.[6]

3.4.3 Safeguard against Water

Water is a transport medium of metals in a number of potentially polluting situations.

i) Movement of metals into plants and thus effect the environment.
ii) Movement laterally or vertically into unpolluted soil.
iii) Movement into water courses and then to other aquatic and terrestrial habitats.

Metals are transported in water in three principal ways :
(a) in solution
(b) suspended as particles of spoil
(c) Absorbed on to non-spoil particles such as organic matter.

To what extent these three modes of transportation are significant depends on several factors like mineralogy, pH and erodibility of the spoil. In addition, other site specific conditions such as rainfall and degree of natural colonisation are important.

Early reclamation scheme concentrated on methods of development and sustenance of vegetation cover and achievement of appropriate landform and drainage measures to control erosion. Emphasis should be placed on the use of coarse materials as capillary break layers. These measures were very successful at grossly polluted and derelict site where a vegetation cover has already been established and erosion of spoil heaps and the resulting sediment load of the adjacent river much reduced. However, experiences in western countries show that :

(a) the use of coarse capping materials will prevent upward capillary movement of the materials but will allow downward percolation of water to the spoil surface.

(b) land drain in or near the metalliferous waste may pick up metal contamination and result in a source of pollution of adjacent water courses.

(c) locally available granular material, although from a non-mining source, may contain high levels of metals which may be leached out causing aquatic pollution.

These factors have led to the use of techniques which isolate contaminated solid and spoils from water, these techniques are principally :

(i) Removal of spoil materials from near to water courses, which requires careful investigation prior to the work to ascertain the contamination status of the underlying material (Fig.3.5).

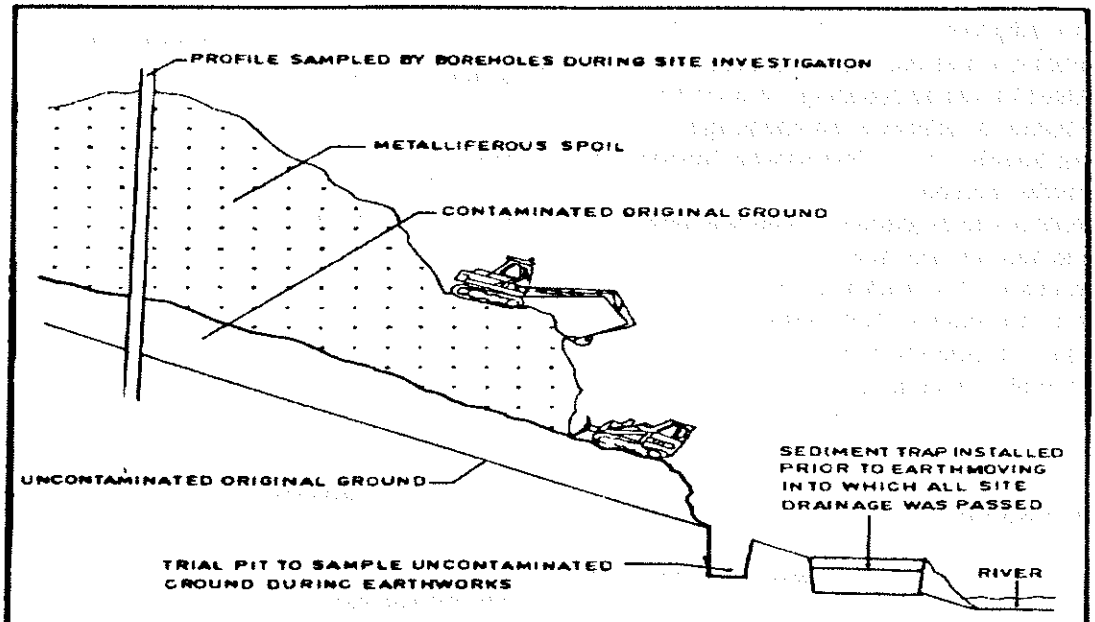


Fig.3.5 SCHEMATIC DIAGRAM OF TAILINGS REMOVAL ON THE SLOPE DOWN TO THE RIVER

(ii) Cut-off drainage to prevent uncontaminated water which enters the site from becoming contaminated. This may need deep drains to rock head and combined with the re-routing of the surface drainage water, is an important method of preventing movement of contaminated water around the site. Successful drainage work is dependent on a comprehensive investigation of the existing and potential flows of water and their metal loads through a site.

(iii) The use of impermeable barrier on the original ground where the spoil heap is proposed to be dumped. The commonest use is a high density polyethylene membrane. This method has the following implications for the reclamation scheme:

(a) Care has to be taken that final slopes are gentle enough to prevent the capping material slipping off the membrane. The recommended slope is normally less than 16%.

(b) The capping has to be deep enough to support vegetation in dry conditions.

(c) If tree plantation is derived, depth layers of capping materials are needed. This can be difficult and costly because of the depth of material needed to support tree growth.

(d) Particular attention has to be paid to surface drainage.

(e) After - use of the site has to be carefully considered so that the membrane does not become damaged.

During a reclamation scheme treatment of water arising may be necessary. After completion of the scheme any contaminated water arising may be needed to be treated by a more permanent solution such as wet land. Some former sites are so grossly polluted and the underlying original ground so permeable that ground and groundwater are contaiminated to many meters below the original ground surface and although the technique of covering and of rerouting water can be applied at these sites, there will be continuing problem for many years. With long term responsibilities placed on the mine operators for the waste they produce, it is clear that for new mine operators pre - developing planning and investigation are critical to effective land reclamation. This applies particularly to investigations of soil and hydrological conditions to determine locations and methods of spoil disposal.

Of the techniques described only removal of the material from the site is felt - safe. The covering systems described still have contaminated material in sites. Whether the material is protected by a system using directly sown vegetation or by a membrane, it is sensitive to disturbance and must be managed properly to maintain its integrity for all time.[7]

4. Revegetation in Mining Area

The concept of revegetation is accepted in mined out areas. The practical methods of site preparation which can help overcome the various problems related to establishment and growth of plants in quarry situations are described in this chapter. Many of them may be incorporated as a normal part of the quarry operations. The following aspects can be considered.

4.1.0 Soil Characteristics

For a successful reclamation, the different characters of the soil play an important role. During the course of mining even when the soil is preserved for respreading, these soil characteristics undergo a variety of changes which becomes an important factor for plant establishment. A brief discussion of each of these character will throw some light on the vital link between them and vegetation cover for the purpose of reclamation.[8]

Soil Water

The growth of all plants used in reclamation is more or less proportional to the amount of water in the soil. There is hardly any growth on dry soils. Growth goes up with the soil becoming wet from dry till water reaches a level when oxygen is driven out from the soil. At this point most plants stop growth. Water is used by the plant to build tissue and to transport raw materials to the leaves for food manufacture as well as to transport the manufactured food to other parts of the plant. Lack of water can cause plant cells to fail, to multiply or increase in size resulting in cessation of plant growth.

Soil water also has an effect on the uptake of nutrients from the soil. As the soil moisture is increased from the lowest point at which plants can live to the ideal soil moisture contents there is a corresponding increase in nutrient uptake. The soil moisture at surface is needed for seed germination.

All soil moisture can be classified as being in one of the three status. Immediately after a heavy rain, the soil pores will be filled with water and practically all air will be excluded. The water will be moving downward into the lower soil layers. At this point the soil is saturated with water (fig.4.1 a). After a period of time downward movement of water will cease and air will move back into the larger pore spaces. This soil moisture state is called field capacity (Fig.4.1 b). This is probably the point at which plants can most easily obtain water. The soil at surface and below (due to plant use) continue to dry till a point is reached when plants can no longer absorb the remaining moisture. This point is called the wilting point (fig.4.1 c). A short period at the wilting point will kill young plants, and a longer period will kill mature plants.

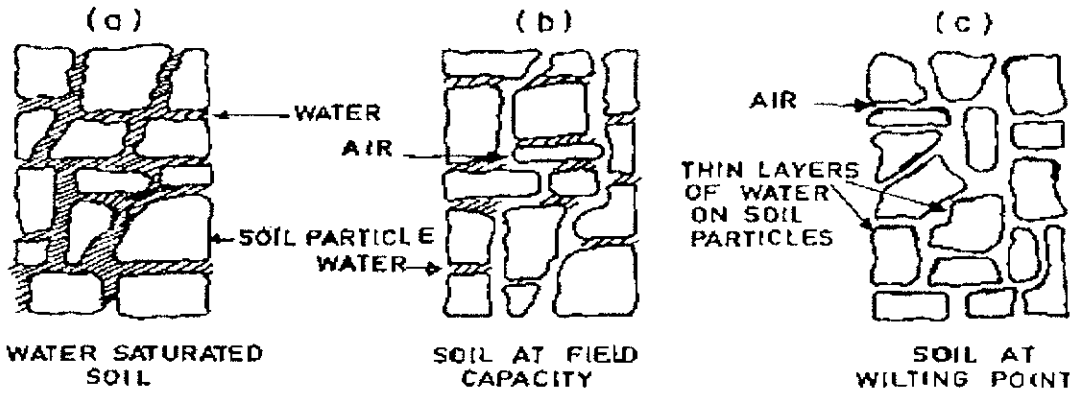


Figure-4-1 Relative amounts of water and air in a soil at three soil moisture conditions.

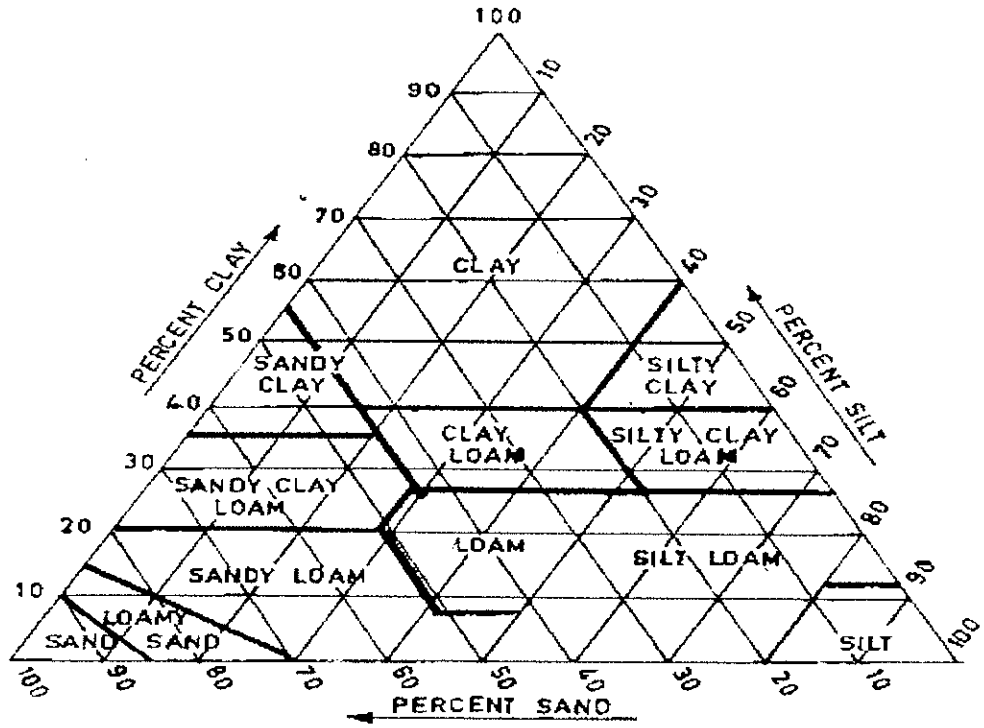


Figure 4-1 (d) Soil texture nomograph.

Soil Texture

Soil texture is determined by the relative percentage of sand, silt and clay found in a soil. The only thing that determines whether a soil particle is sand, silt, or clay is the size of the particle. Sand is any soil particle between the sizes of 2.0 m.m. and 0.05 m.m. in size and clay is anything less than 0.002m.m. The size of a particle also determines whether or not material can be called soil. Any material greater than 2.0 m.m. in diameter is not considered soil. There is no lower size limit for soil.

If a soil was composed of 40 percent sand, 40 percent silt and 20 percent clay, the texture classification would be loam, if it were 60 percent sand, 30 percent silt and 10 percent clay, the texture would be sandy loam. Sand with 60 percent or more clay is classified as clay regardless of the particle sizes of the rest of the soil.

Soils that have high sand contents are said to have a coarse texture, and those with high silt or clay contents are said to have a fine texture. Coarse soils such as sands allow water to enter the soil freely, but they may also allow water to pass through the soil without retaining enough for plant use. On the other hand, fine soil particles such as clays have a tendency to prevent the movement of water from the soil surface down into the soil. Once water enters a clay soil, the clay retains the water well. In many cases clay holds much of the soil water so tightly that it is unavailable to roots. Intermediate textures, such as silt loams, sandy loams, sandy clay loams and loams, have a more desirable combination of characteristics than sand or clay and allow water to enter the soil. However, they also retain available water in the root zone for plant use. Fig. 4.2 shows the approximate effect of texture on a soil's ability to hold water.

Soil structure can modify the effect of soil texture and significantly change soil moisture relationships. Therefore, soil structure can cause a wide range in available and unavailable water content for any given soil texture.

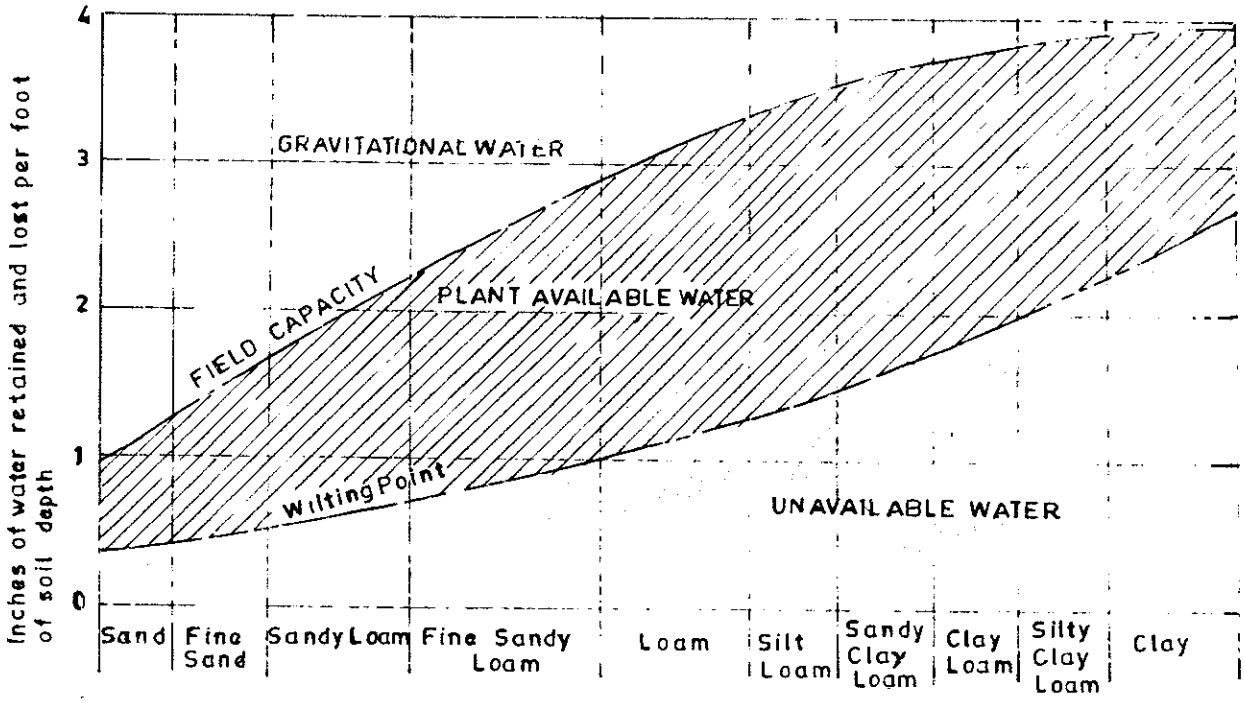


FIG. 4·2 : EFFECT OF TEXTURE ON A SOIL'S ABILITY TO HOLD WATER

This ability of a soil to allow water to enter and then store the water comes about because of the number and sizes of pores in the soil. Without pores, there would be no water or oxygen in the soil and both of these are vital for plant growth. Generally, two types of pores exists in most soils, macropores and micropores. There is hardly any sharp line of distinction between these two types. However, a macropore is a pore large enough to allow fast movement of air and water through the soil whereas in micropores air movement is much slower and water movement also is of a type of slow capillary movement. Macropores are needed to get water and air into the soil and well distributed throughout the root zone. However, micropores are also necessary to hold some of the water by capillary action for the roots to utilise until the next rain.

Sandy soil usually has less total pores space than clay soil and most of them are macropores. This means that the movement of air and water through the soil is fast but little water is held for root zone. In case of fine textured soils like clays, the pore spaces are more but these being micropores the movement of air and water is very slow.

A good balance of solid and pore space in a soil is about 50:50 with the pore spaces equally divided between macro and micropores (Fig. 4.3).

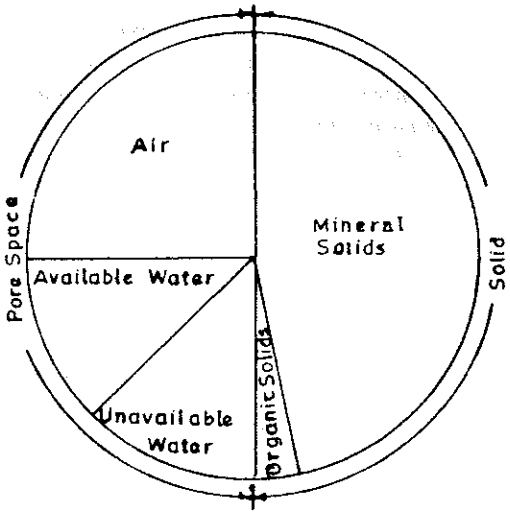


Figure 4.3 : PROPORTIONS OF SOLIDS, WATER, AND AIR THAT WOULD PROVIDE A GOOD PLANT GROWTH MEDIUM.

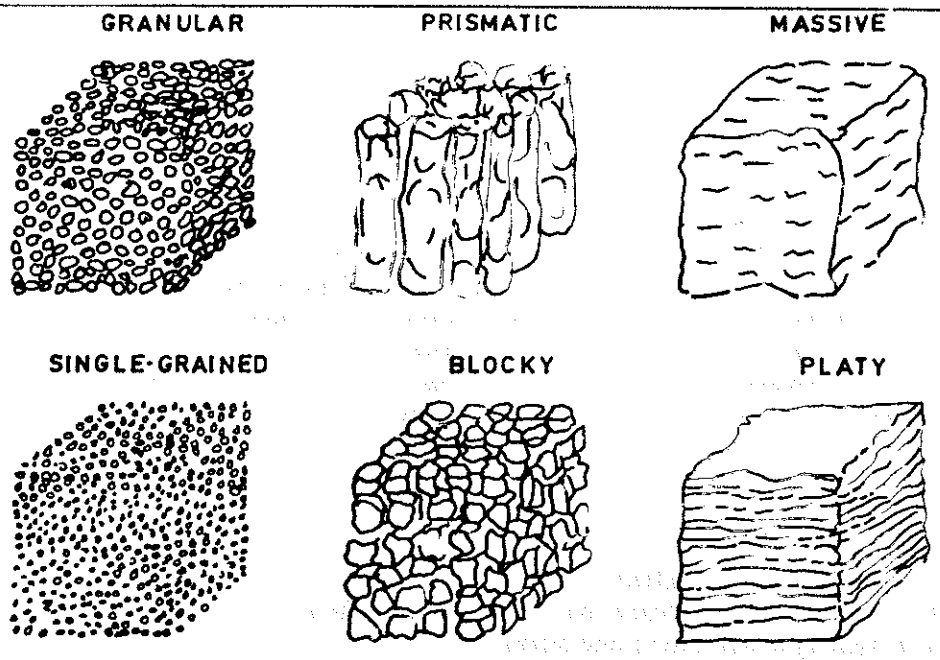
Soil Structure

Structure of soil modifies soil properties and almost always does so in a beneficial way. Soil structure is the aggregation of soil particles into clusters of particles that produce a characteristic form. Different soil structures are depicted in fig.4.4.

Initially most soils on reclaimed surface mines will have no structure. Any structure in the original soils will have been destroyed by moving the soil from one place to another and by compaction with equipment in the replacement and grading processes.

Unstructured, sandy soil is classified as single grained. Clay soils without structure tend to be large expenses of soil material with few macropores. These soils are classified as massive. Both single-grained and massive soils occur in mine soils.

There are several processes or factors that will restore structure to a mine soil. Wetting and drying moves the soil particles back and forth and causes some particles to move close together and others to move further apart. This sort of action causes aggregates to form with spaces between them. Freezing and thawing and the movement of



Name	Unit Size	Where Found	Permeability	Comments
Granular	1/2" or less diameter	Surface soil	Rapid	High in organic matter
Prismatic	Up to 6" in diameter	Subsoil	Moderate	
Massive	Unlimited	Surface soil or subsoil	Slow	Unstructured unweathered clay
Single grain	Sand size	Surface soil or subsoil	Rapid	Unstructured sands
Blocky	Up to 4" in diameter	Subsoil	Moderate	
Platy		Surface soil	Slow	Virgin surface soils

Figure 4.4 Structured and unstructured soils. Source: U.S.D.I. and U.S.D.A., Irrigation on Western Farms Agr. Inf. Bul. No. 199, 1959

roots through the soil have much the same effect as wetting and drying.

Organic matter in the soil may have more to do with the development of structure in a soil than any other factor. The much used on a mine soil and the stems, leaves and roots of plants growing on a mine soil all contribute to the organic matter in a soil. Micro-organisms that decay organic matter and the products produced by decay cause sands to aggregate and form granules. These products also aid in breaking massive clays and forming them into granules.

Some of the nutrients in a soil can influence the formation of granules. If a soil has an excess of sodium, the soil granules tend to fall apart, with sands becoming single grains and clays becoming massive. However, calcium tends to make clays or humus aggregate to form granules.

Soil Organic Matter

Organic matter is the rotting or decomposing remains of plants or animals. The stage of decomposition can be anything from fresh material that has just fallen to the ground to material that has broken down into liquids, slimes and gums. Some of the more important effects of organic matter are as follows :

- Fresh organic matter on the soil surface reduces the impact of falling rain drops thereby reducing the possibility of sealing of soil cracks and pores which allow the water to infiltrate due to direct hitting of these drops with force.

- Fresh material also slows the lateral movement of water over the soil surface thereby reducing the soil erosion.

- The organic material at soil surface reduces the soil temperature and blocks the movement of drying winds bringing down the loss of water from surface.

- Fresh organic matter keeps the soil moisture intact by covering the surface which is very essential for seed germination.

- It provides food for insects, worms and rodents. These burrrow into the soil which help supply of water and oxygen to it.

- The decomposed organisms release carbon dioxide, which forms carbonic acid. This acid helps to decompose minerals and release nutrients for plant growth.

- Decomposed organic matter produces slimes and gums, which are invaluable in the formation and stabilisation of soil structures forming cracks for water and air to move into the soil.

- Decomposed matter itself absorb and hold water which is very important in case of sandy soil where water and nutrients move through soil out of root zone.

Soil Depth

The final soil characteristic affecting the availability of soil water to plants is soil depth. Soil depth can be defined as the distance from the soil surface down to anything that prevents a plant root from growing and absorbing water and nutrients. A layer of rock, toxic chemicals, tight clay, or a water table can be the factor that prevents roots from penetrating deeper into a soil. It is obvious that a shallow soil (e.g. 25 cm of soil over sandstone) cannot absorb or store as much water as one metre of the same soil over a sandstone. A mine soil is unlikely to have any of the other soil depth limiting factors except toxic elements. Most plant roots will not penetrate a soil layer saturated with water such as a water table as such a soil would not have enough oxygen to allow roots to absorb water and nutrients.

Soils can be too deep, this is particularly true when soils are sandy or coarse-textured and there is no soil horizon that has properties to stop water from moving quickly below the zone where roots can absorb the needed water. Such soils would support more plant growth if a finer textured, stony or compacted soil horizon were present 1 to 2 metre below the soil surface to keep soil water from moving too deeply and too quickly.

Soil Air

The amount of air in a soil is determined to a large degree by the amount of water in the soil. As water moves into a soil it will displace the air.

There are two soil conditions that usually result in poor soil aeration. The first occurs in compacted soil where there are few or no large soil pores.

A massive soil would be an example of this condition. The second is any situation in which the soil pores are filled with water. This can occur immediately after a rain or when the soil is flooded for some other reason such as a high water table. Well-drained soil with good structure is likely to be well-aerated and will not restrict plant growth. However, a soil with a compacted layer near the surface or a high water table will prevent proper soil aeration and thereby restrict root development.

Soil Acidity

Soil acidity, soil calcium, soil magnesium and liming are all closely related where soils and plant growth are concerned. Surface mining is considered to be a prime resource of acid soils by many people. This is true in many cases but surface mining also produces alkaline soils. Soil acidity causes problems that result in poor plant growth. These problems can be grouped into three general categories: decreased availability of nutrients, increased availability of toxic elements and decreased activity of beneficial soil organisms. Fig.4.5 shows the general effect of soil acidity on nutrient availability and microbiologic activity.

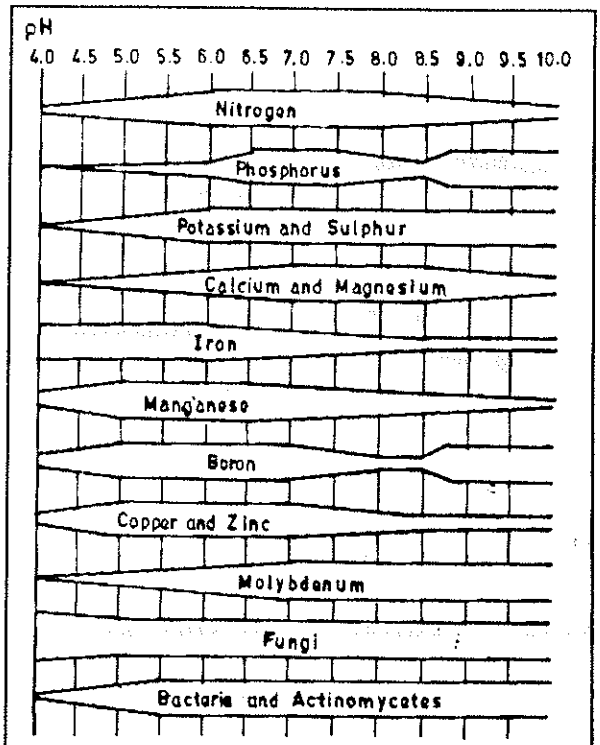


Figure 4.5 : EFFECT OF SOIL ACIDITY ON NUTRIENT AVAILABILITY AND MICRO BIOLOGIC ACTIVITY. MAXIMUM AVAILABILITY AND ACTIVITY ARE INDICATED BY THE WIDEST PART OF THE BAR.

Soil Organisms such as bacteria and actinomycetes are adversely affected by the soil acidity. When the soil pH decreases to approximately 5.5, both bacteria and actinomycetes activity decreases significantly. This is important for such things as nitrogen fixing organisms. Fungi are not greatly affected by soil pH itself, but fungi become less active at higher pH due to the increased activity of bacteria and actinomycetes and the resulting competition.

Most natural soils range in pH from 4.0 to 8.5. However, for practical purposes, any pH between 6.0 and 8.0 is considered near neutral. Most crop grow best at a pH between 6.0 and 9.0. Some plants, such as azaleas, Irish potatoes and cranberries, grow best on a more acid soil.

The usual method of correcting soil acidity is to add finely ground limestone and disc it into the soil. The amount of limestone needed to counteract soil acidity is determined by several factors other than soil pH.

Pure lime is technically calcium oxide (CaO). However, the term lime is used to mean other materials such as calcium hydroxide ($CaOH_2$) and calcium carbonate ($CaCO_3$). Calcium carbonate in the form of ground limestone is the material most often used to raise the pH of soils. The fineness to which the limestone is ground is of prime importance. In order to quickly neutralise soil acidity, limestone should be fine enough so that about 90 percent will pass through a 10 mesh screen and 50 percent through a 60 mesh screen.

Limestone must be well mined with the soil in order to be most effective. Mining the limestone with the soil to a depth of at least 15 cms is required. It corrects soil acidity, supplies calcium to soil, supplies magnesium to the soil (if dolomatic limestone is used) reduces the activity of injurious agents in soil, increases the speed of organic matter decay to release nutrients to the soil and increases the crop yield through all these actions.

4.1.1 Soil Movements

When large quantities of soils or overburdens are being moved it is normal practice to use the most cost effective, often the largest, machinery available, and to compact the deposited material so that it is stable since stability is essential. However, compaction of all but the coarsest soils tends to make them inhabitable by plants and so every effort should be made to reduce the

inhabitory effects of compaction at the soil surface if successful plant growth is to be achieved.

Any soil will suffer some structural damage when it is moved. The care with which movement is done will effect the quality of the final result, and the cost of movement by various methods should be set against this.

4.1.2 Topsoil and Subsoil Movement

When topsoil material which is having good amount of organic matter, it is worth saving for respreading except it is having extremely poor quality and an alternative material is available.

The topsoil can be distinguished from the immediataly underlying subsoil by a desk colour of humus and organic matter. The subsoil itself weathered and broken down material, usually soil material is superior to the underlying material which, in many cases, is rock. Both the layers should be removed separately from any other material/overburden, though the topsoil is most important. The whole soil profile is a valuable resource and should not be lost by mixing with other materials/wastes.

There are numerous limits imposed on the depths of topsoil stripping by the machinary available, or the time resources. Excavators and wheel scrapers are most cost effective, they can remove layers for restoration of natural plant communities.

In those cases where high quality agriculture restoration is not required, stripping a single layer of 100-300 mm will be adequate, a good subsoil layer burying only required where the ground surface to be covered is extremely poor. It may be acceptable to respread the soil over a large area than it was removed from, proving the final depth is sufficient. Every hectare spread to depth will require 500 m^3 of soil. Wherever possible, topsoil should not be stockpiled, but transferred continuously from its original position to its new location. This is both economically and biologically sound, as doublehandling will increase the cost of soil handling as well as increasing the possibility of structural damage. Progressive restoration is possible in certain cases, and ways of achieving this are shown in fig 4.6. and 4.7.

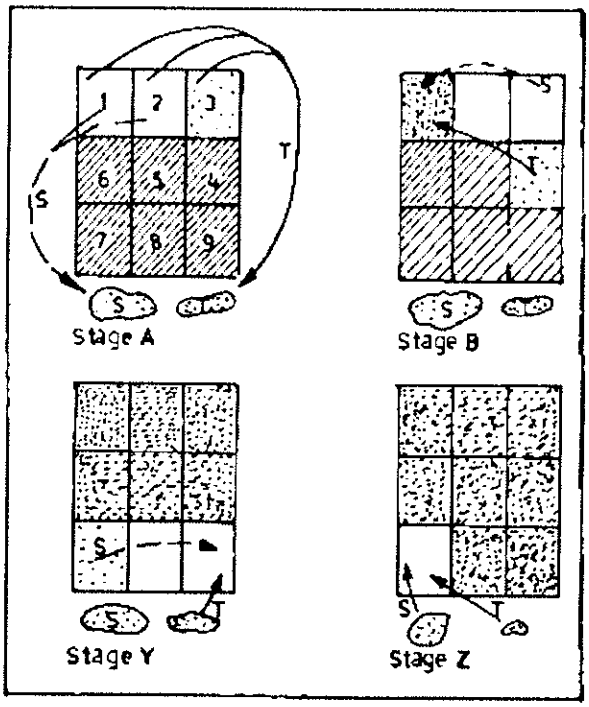


Figure 4.6 : PROGRESSIVE RESTORATION PLAN INVOLVING - THE DIRECT MOVEMENT OF SOIL. THE NUMBERS INDICATE THE SEQUENCE OF WORKING . S = SUBSOIL, T = TOPSOIL

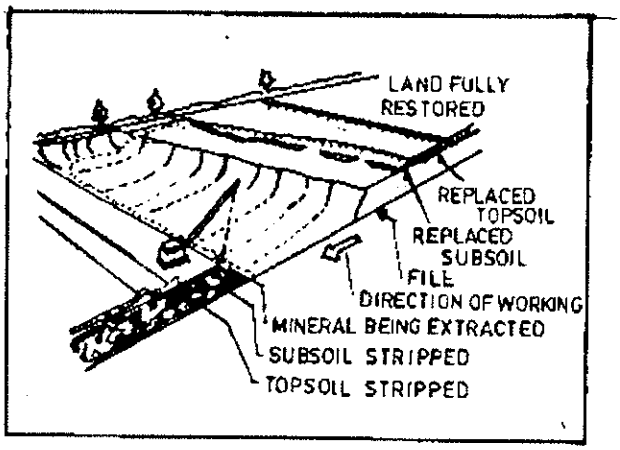


Figure 4.7 : PROGRESSIVE EXTRACTION AND RESTORATION OF A SHALLOW DRY PIT.

Topsoil (including from other source)

This is an obvious first choice for apparent quality reasons, but several possible disadvantages are as follows :

i) It is expensive because of transport cost and often it also has an inflated scarcity value ;

ii) It is susceptible to damage and loss of structure during movement and storage ;

iii) It is sometimes of poor quality and can be inferior in potential to a nearby source of subsoil ;

iv) Sometimes it is too fertile for the projected after use, giving rise to masses of raw plant growth ;

v) It may contain many seeds of noxious and undesirable weeds that are difficult to control.

Imported top soil therefore, should be used carefully and only when really necessary, with due consideration of quality and quantity of material available, and derived vegetation cover. Best results sometimes can be achieved without it, by using other bulk amendments or subsoil.

4.2.0 Soil Conditioner

This is a manufactured product organic in origin. The commonest are based on seaweed extract. Ground lignite can also be used. They are usually good at improving the water and nutrient holding capacity of coarse and sandy soils, especially in the short term plant establishment. Large quantities of soil conditioners will usually be required to have any lasting beneficial effect, which can be expensive. Generated from wood processing industry, waste like sawdust, clippings, and bark can all be used for opening of the texture heavy soils. Wood residue have a very high C/N ratio. Shredded bark residue are the most useful, as they have some nutrients and good water holding capacity.

4.3.0 Inorganic Amendments

The improvement of physical properties of waste dump sometimes can be improved by adding to it or covering it with suitable material which may be available nearby. This can be any overburden, silts or inert waste material that has properties complementary to the waste material of spoil. Coarse textured sandy or rock spoils can be improved with the addition of fine material such as silts or clay to improve water holding capacity, ion exchange capacity and reduced leaching. Fine textured (clay) waste dump can be imposed by addition of coarse sandy material, well mixed by ploughing.

Acid and alkaline spoil material, when occur together or within haulage distance, they can be sometimes mixed neutralise both potential problems. In such case, care must be taken to test beforehand whether it is safe to do so for making the spoil material.

Except a few, most of the spoil materials have good potential for soil-forming properties, with a loamy and sandy texure but normally lacking only nutrients and the living organic component of a good top soil. For taking correct measure , overburden layers to be removed should be surveyed and sampled before taking up the actual excavation.

4.3.1 Organic Amendments

For the purpose of amelioration organic matter is an excellent ingredient since it contains nutrients, improves the water holding capacity of light sandy or stony soils and improves aeration and drainage in heavy soils. It provides the basis for soil structure and the beginning of a nutrient cycle.

Variety of sources gives good products of organic material. The choice will depend predominantly on what is available in sufficient quantities nearby (list is already given in Table 4.1). Different types of organic matters are available - like farm manure of cattle, pigs, chicken etc., spurt mushroom, sewage sludge, peat etc,. But a few of these may be toxic also especially for young seedlings as they contain sometimes high quantities of copper and ammonia.

4.3.2 Application and Use of Organic Amendments

For nutrients organic amendments are not added primarily but with high rates they may add significant qualities of nitrogen, phosphorous and potassium to the soil. The amount of each nutrient element applied can be calculated by the formula - kg/ha of element = R X Concentration (%) 10, where R = rate of application (dry tonnes/ha) of organic material. Concentrations are usually expressed as a percentage or as parts per million (1ppm = 0.0001%) of dried solids, and not of the material as supplied, because water contents vary considerably. Much of the nutrient content of organic wastes is bound in organic matter and then only slowly available to plants. The rate of

Table 4.1 : Organic bulk amendments

Material	Usual composition (% of dry solids)				Usual application rates (dry t/ha)	Special problems or advantages
	N	P	K	O.M.		
Farmyard manure	0.6-2.5	0.1	0.5	24-50	5-40	Variable
Pig slurry	0.2-4.0	0.1	0.2	3	5-20	High water content, possibly high Cu
Poultry manure, broiler	2.5-4.0	0.9-2.5	1.6-2.5	60-80	2-10	High level of ammonia
Poultry manure, battery	1.5	0.5	0.6	35	2-10	
Sewage sludge, digested	2.0-4.0	0.3-1.5	0.2	45	5-50	Possibly toxic metals and pathogens
Sewage sludge, raw	2.4	1.3	0.2	50	5-50	
Mushroom compost	2.8	0.2	0.9	95	5-20	High lime content
Domestic refuse, composted	0.5	0.2	0.3	65	20-70	Contains miscellaneous objects
Blewery sludge, digested	1.5	0.9	0.3		5-20	Uncommon, low in nutrient
Peat	0.1	0.005	0.002	50	5-10	Variable, high C/N
Straw	0.5	0.1	0.8	95	5-20	
Sawdust	0.2	0.02	0.15	90		
Woodchips	0.2	0.02	0.1	90	10-30 (3-9 cm layer)	High C/N
Bark	0.3	0.09	0.7	90		
Lignite, ground	1	0	0	0		High C.E.C.

microbial decomposition and this availabilty of nitrogen will depend on the C/N ratio, those waste with ratio greater than 10 will decompose only slowly and those with a ratio more than 30 will actually deplete the availability of N in the soil. When organic matter with a C/N ratio greater than 30 is used, additional nitrogen will need to be added. A good soil contains about 5% of organic matter, this is approximately 100 tonnes/ha to 15 cm depth. The ratio commonly applied vary considerably, between 1 - 100 dry tonnes/ha. The most useful rate of application of organic material are included in table 4.2.

Prior to spreading, the soil surface should be ripped or cultivated to increase inflitration and prevent surface run off. If large quantities are to be applied, it should be in more than one dose with perhaps a cultivation between.

Following application, it is usually better to incorporate the organic material into the soil surface 150 - 300 mm depth as soon after application as possible. This will prevent run off during heavy rains and wind erosion, reduce nitrogen (ammonia) loss and eliminate offensive odours.

Table 4.2 : A guide to nutrient inputs for establishment and maintenance of vegetation of infertile soils

To establish maintenance periodically	Repeat applications periodically every 3-5 years or as soil analysis suggests
To establish Autumn } Spring }	Annual maintenance
To establish Early spring } Midsummer } Latesummer }	Annual maintenance

4.4.0 Nutrients Requirements

The plants will require adequate quantities of nitrogen and phosphorous, and some potassium, calcium and magnesium. The amount that must

Table 4.3 : Levels of extractable soil nutrients that suggest deficiencies

Index*	Concentration in soil (extractable) p.p.m. (mg/kg) P	K	Mg	Amount in soil p.p.m.(mg/kg) P	K	Mg	Degrees of Deficiency
0	0-7	0-45	0-20	0-13	0-90	0-37	Severe, all soils require fertiliser
1	8-13	46-90	21-40	14-22	91-180	38-75	Mild, grazed swards will require fertiliser
2	14-20	91-185	41-75	23-37	181-360	76-150	Little, only productive swards and arable soils requir fertiliser
3	21-35	186-300	76-135	38-67	361-600	151-260}	
4	36-55	301-450	136-200	68-105	601-900	261-375}	None, levels adequate for most
5	56-75	451-700	201-270	106-150	901-1350	376-525}	arable and grazed uses
6	76-110	701-1200	271-460	151-210	1351-2250	526-900}	
9	>215	>2770	>1100	>420	>5400	>2250	Excess, some salinity problems

* *A.D.A.S. classification*

be applied will depend on the initial fertilizers of soil material and on the requirements of crops. For non-intensive agricultural use it is not necessary to apply precise quantities, but it is crucial to provide sufficient quantities to maintain plant growth. A guide to fertilizer rates suitable for low intensity user is given in Table 4.3.

The fertilising startegy on infertile soil must take into account two basic requirements. Firstly, the nutrients required to establish a suitable ground cover and secondly the inputs necessary to maintain the vegetation and allow for build up of the soil fertility through organic matter. This relates particularly to nitrogens, as the soil-plant system will rely on inputs of nitrogen either from fertiliser or fixed by legumes until organic soil-nitrogen levels of about 700 kg/ha will ensure sufficient mineralisation and recycling. The leguminous N-fixation can supply all the soil plant-system's nitrogen requirements provided other soil conditions are suitable. Most legumes require higher levels of phosphorous than grass and a pH > 5.5. Under this condition they can fix 50-150 kg/ha/yr. But a legume-bedded sward will require some nitrogen fertiliser initially, in order to establish well, but continuous high nitrogen input (more than 150/kg/ha/yr) will cause the grass to outgrow and crowd the legumes, unless the sward is mown or grazed.

Lime and calcium requirements

The soil which is neutral in nature, will have always sufficient calcium and magnesium. Addition of limestone to acid soil will also supply the plants requirements for calcium and possibly magnesium and some micro nutrients, depending on the type of lime. The quantity of lime requirements can be estimated by a lime requirement test, if the soil pH and texture are known.

4.4.1 Fertilisers

Most common, cheap and relatively simple way of applying plant nutrients is from chemical fertilisers. They cannot replace a self-sustaining and recycling soil-plant system (except in certain highly intensive agricultural and horticultural situations), but they will help this to be built up in a short time. Fertilisers should be thought of as a "one-off" operation, and immature ecosystems on reclaimed areas will need some management if they are to develop soils quickly and successfully.

4.4.2 Liming and Placement of Fertilisers

Soluble fertilisers will wash from the soil down into the root zone, but slow-release fertilisers and lime cannot be effectively used by the plant unless they are well mixed and incorporated into the root zone (150 -300mm) by some cultivation. The zone of influence of lime and phosphorous fertilisers particularly is very limited unless they are incorporated.

Application of soluble fertilisers will be most effective if they are made when the plant needs them, at critical growth stage such as spring(N) and autumn (p and k), so soluble nitrogen fertilisers are best applied "little and often" rather than in big doses. Slow release fertilisers, in combination with soluble fertilisers, are a good way of ensuring long term nutrient supply, though they are at least three times as expensive as soluble compound fertilisers. The nutrients will be released naturally at the beginning of the growing seasons as microbial activity increases with temperature (<40° C). But when fertilisers incorporation at latter stage is difficult, not more than 50 kg N/ha and 250 kg p/ha should be applied at seeding.

4.4.3 Methods of Fertiliser Application

(a) Broadcast: This is the most common method, either by hand or by using an agricultural spinner mounted on a tractor or below an aircraft (or helicopter). Broadcasting is the best method for all areas that are not too steep for access (i.e., less than 20%). Aircrafts are useful when ground conditions are difficult or for large areas . Many types of spinner are available and great care must be taken to get an even coverage of fertiliser at the correct rate, taking into account swathe width, speed of travel and rate of spinning. Grilled and granulated materials spread best by spinner, powder or moist materials will bridge in the hopper and are difficult to apply evenly. Broadcasting by land is time consuming but is less often the best way of treating inaccessible or small areas. Broadcast equipment using a pneumatic blowing technique is now available with application and coverage similar to water-based techniques.

(b) Liquid and Slurry: Soluble materials can be applied in solution with special injection,dribble or spraying equipment. The best way to treat steep banks or inaccessible areas is with a jet or spray of water. Insoluble material can be applied in a water slurry, providing the pumping equipment is suitable and the tank is kept agitated to prevent settling.

4.5.0 Surface and Seedbed Preparation

The final surface microphotography will greatly influence the success of seedling establishment - a coarse surface is essential. It will receive broadcast seed well, reduce surface water run off and decrease infiltration, it will give a good soil seed contact and better germination and root growth, and the seed will easily become buried by the action of rains. Small areas of any topography can be simply worked using hand tools to prepare a seedbed, large areas require machinery.

4.5.1 Shallow Slope and Flat Areas

When the area is accessible to cultivating machinery, i.e a slope not more than 1:5 (20% or 11°), full cultivation can be employed to obtain the best soil surface. Depending on the quantity and workability of the soil, the following operations can be carried out :

a) Deep cultivation (150-300 mm) with subsoiler spirng time cultivation, or heavy discs, 1 or 2 passes, the last along the contour (or slight angle to it). This operation can be combined with incorporation of bulk amendments, manures, fertilizers, lime etc.

b) Remove any large stones or other obstructions.
c) Apply fertilisers (if not already).
d) Disc, 2 passes. e) Cambridge Roll, 1 pass - Heavy soils only.
f) Chain-harrow, 2 passes - Steps (e) and (f) should be repeated until a firm seedbed is formed.
g) Sow seed Harrow, 1 pass or cambridge Roll, 2 passes (if heavy soil).

4.5.2 Steep Slopes

On some slopes steeper than 1.5 it is possible to work up and down the slope with a tracked or a double-tyre 4-wheel drive vehicle to obtain a rough surface. Ripping/scarification in this direction is usually better than none at all, but may lead to gully erosion in high rainfall areas. As an alternative a special tool for loosening the soil surface and breaking a crust on steep banks is available. If seed does remain on the soil surface, it must be mulched to ensure good establishment. To improve seed reception and infiltration on steep slopes, ledging, furrowing or gouging across the slope will be of great benefit. Less severe slopes can be worked across with a tracked vehicle, the steepest can be worked with a long-armed excavator especially equipped with a auger, or long teeth to scarify the surface.[2]

4.6.0 Revegetation on Waste Dumps

It is a requirement of mine operators today that they dispose of waste materials in a safe, environmentaly acceptable and permanent manner. Chemical and physical; techniques exist for dust control and stabilisation against water erosion but the long term objectives of waste rehabilitation can only be realistically achieved by the use of vegetation as a basis for landscaping, stabilisation and pollution control. Vegetation on active waste dump is not possible. It can be done only on dead dump over which no further dumping is to be done. However in some cases where dumps are dead for a short period, to avoid air-borne dust due to high wind, surface can be vegetated by grass. An example is illustrated in Plate No.5. It is widely recognised that wastes from metalliferous mines, especially acidic ones, are very difficult materials for vegetation.

The reasons that metal mine wastes present difficulties for plant growth are complex. In some case the main cause is the mineralogy of the original material. The presence of significant quantities of iron pyrites (FeS_2), which may not be removed during ore beneficiation, often leads to acid waste as the mineral is comminuted during processing and then undergoes oxidation and hydrolysis to generate sulphuric acid by a continuous, slow release process. Usually, the other main chemical problem is residual quantities of the target metals that processing of the ore has failed to recover; but there may also be elevated levels of associated non-target metals and metalloids (eg. As, Sb) left in the waste after beneficiation. Finally, in many operations large quantities of waste rock are also produced, material whose metal content is below the cut-off point for economic beneficiation. Although this material has usually not been through a crusher, and has low levels of metal, it can be a major source of metal pollution by leaching, especially since in many operations it can account for as much as half of the total material that is mined and stacked on the land surface.

Many metals (eg. copper, zinc) are essential trace elements at low concentrations but toxic to plants at high levels. It is not possible to state specific thresholds for toxicity as the balance point varies with the associated minerals and the species concerned. Other elements (eg.lead, mercury) are less toxic to vegetation but hazardous to livestock that may graze vegetation which has accumulated such metals either via the roots or as surface dusts. These metals may go to the body of human being or animal through food chain and may in such cases be harmful.

Before considering the revegetation work that has been undertaken in recent years is appropriate to consider whether this is the best and only solution. In an era when recycling of materials is viewed with enthusiasm, especially as means of conserving national resource the prospects for re-use of mine waste must be assessed. Recovery of residual metal value is limited by economies of scale, location and tonnages of raw material and the re-use of mine waste as a substitute in glass and brick manufacturing is not technically feasible. Alternative commercial outlets (eg. abrasives) are too small to be significant. Coarse rock waste can sometimes be put to limited use in road construction land surfacing but, again, supply is usually far in excess of local market demand and economic factors limit the transport distance that can be contemplated. In the case of fine tailings, almost invariable deposit as a wet slurry, dewatering to produce a more stable filter cake with more flexible disposal options is sometimes feasible but more often limited by technological and economic factors.[6]

4.6.1 Establishment of Vegetation

The essential aims of vegetation establishment are simple. Firstly, long term stability of the land surface, which ensures that there is no surface erosion by dust or wind. Second, reduction of leaching throughputs, lessening the amounts of potentially toxic elements released into local water-courses. The first aim is readily achieved by a continuous vegetation cover, especially where the cover density is at least 100% and relatively low growing. With lower densities erosion may begin to occur [4]. The degree to which the second aim is met by a vegetation cover depends on the ambient climate. The vegetation will intercept and return rainfall to the atmosphere by evapotranspiration. In temperate climates the amount intercepted and returned will be up to 50% of the total, in the wet tropics less than 25% and in the dry tropics more than 75%. However, these values are affected by the distribution of the rainfall; it is more difficult for vegetation to intercept and re-evaporate

precipitation if it falls in the form of intermittent, heavy storms.

4.6.2 Use of Normal Species

Direct establishment of vegetation is an attractive option on paper but it is a subject of the potential difficulties mentioned previously, in the case of recent workings, by the formidable problems created by the seals of modern tailing dams. Direct seeding of mine waste is much cheaper than any other method, nearly all of which involve some form of governing - usually with soil or a substitute material. In situations where the waste has little residual metal, or where the metal is not available to plants, normal species can be established directly with the assistance of fertiliser. Because the long term growth of vegetation depends on an adequate supply of nitrogen legumes such as white clover (Trifolium repens) or birdsfoot trefoil (Lotus corniculatus) and related species are an important component of the seed mixture, since they have the capacity to supply nitrogen by fixation of atmospheric recourses[7].

Unfortunately, straightforward seeding with conventional grass species and fertilisers is often unsuccessful, at least on older tailings, because of the toxic residual levels of metals with or without acidity as well. Under these circumstances grasps seedlings persist for only a few weeks. Alternative methods such as the transplantation of trees and mature plants, have been equally unsuccessful in the past. A great deal of research has been conducted to try to develop a low cost seeding method for use by regulatory authorities and the mining industry. This is possible if metal tolerant plant material is used.

4.6.3 Use of Metal Tolerant Populations

A close examination of even the most toxic waste from old metal mines, from eras when processing technology was crude and inefficient, nearly always reveals a sparse natural vegetation cover. Sometimes this is limited to only a few plants with a characteristic narrow range of species. Supplied with fertiliser, these plants are apparently able to hold and indeed thrive under conditions where imported plant material dies in a short time. It is now known that these natural coloniseres are special metal-tolerant populations of non-species that have become genetically adapted to thrive on metal contaminated sites.

Recognising the revegetation potential of these plants, a breeding programme was initiated in the 1970's in order to produce commercial cultivars bearing the same characteristics as the natural plant material. As a result of this three cultivars are now available commercially enabling direct seeding of quite large, toxic areas. These three, and associated tolerances, are : Festuca rubra cv. 'Goginan' (lead-zinc), Agrostis capillaries 'Parys' (copper) and Agrostis capillary's cv. 'Goginan' (lead-zinc). The value of the cultivars for seeding unstable and toxic tips is considerable since revegetation can be achieved by direct simple treatment with simple inorganic fertilisers.

Costs are low with certain limitations. For example, the tolerance system is specific and there is only a small amount of cross-tolerance so that a particular cultivar is unlikely to thrive on mine waste containing toxic levels of metals other than those to which it has evolved an adaptation. Furthermore, grazing of the sward for agricultural purposes is not always possible and the recreations, or trampling resistance of the ground cover is low mainly because of the inherent nutritional, poverty of the waste.

The species mentioned are adapted to temperate climates. Research in various parts of the world shows that similar metal tolerant populations can be found in species adapted to other, more extreme climates, such as Cynodon dactylon. These can easily be developed in mine waste revegetation.

4.6.4 Covering Systems

The principle behind direct seeding of tolerant populations is to counter any toxicity problems that may exist. Useful as it may be, this approach is not always suitable. The most common alternative is based on covering the waste to isolate it. This avoids toxicity by providing a suitable depth of cover material into which the chosen vegetation can root and cover material is topsoil, subsoil or overburden. However, it is rarely feasible, for economic reasons, to provide depths of cover greater than 300 mm, and in the case of some modern tailings the load-bearing capacity precludes the use of most forms of civil engineering equipment required by the covering approach.

Because of the pressing need in some situations to develop a vegetation cover with specific land use prospects (eg. sportsfields, grazing land), the surface cover approach has been researched in some detail, faced with the problems of achieving a permanent vegetation cover on as shallow a layer of imported material as possibile, extensive trials were undertaken at Y-Fan lead-zinc mine in West Wales betweeen 1975 and 1982. The objective was to develop treatment systems that would prevent root accumulation of toxic metals, eliminate vertical migration of soluble metal salts in the transportation stream and provide a vegetation cover that would survive, independently of regular maintenance, becasue of the high management costs the latter incurs. These trials also examined novel possiblities for revegetation, including migration barriers to metal movement (eg. clay, coarse brick rubble) and the results have been used to develop the specifications for several large scale revegetation projects elsewhere.[7]

The essence of the technique is that a coarse, free-draining material prevents upward movement of metal during dry periods, and at the same time permits vegetation establishment using normal techniques. One of the great benefits of the covering approach is that it is often possible to make use of what is effectively one category of waste to overcome the problems of another form of waste. For example, domestic refuse and non-pyritic colliery waste have both been used to great effect in resolving the pollution problems of metalliferous mine sites.

A well known example of revegetation on the covering principle is that of Parc mine, Nr. Llanwrst in North Wales. This old abandoned lead-zinc mine had a tailings dam of 6 ha that, until 1977, was undergoing severe erosion with consequent pollution of the River Conwy, an important salmon and trout river. The erosion was caused by the steep, angular shape of the dam and the absence of a proper containment wall. The tailings posed a threat to the river as a total of 235,000 tonnes remained in an unstable state. No single reclamation technique suited the range of limitations that existed, so a combination of covering and tolerance was used. The dam was re-contoured and 200 mm cover of quarry shale placed as a single layer, before seeding with a mixture based on F. rubra cv. 'Merlin' with accompanying white clover (Trifolium repens). The advantage of including tolerant vegetation in the final product was that a shallow layer of cover was then viable because the grass roots, when they develop satisfactorily usually the cover material is penetrated into the tailings beneath the cover, continued to give a physical stability to them and persistence of the sward. The scheme was an outstanding success and an excellent cover has been maintained up to the present day. Costs were kept within sensible economic limits by this unconventional approach to revegetation.[7]

The same broad style of revegetation has been used in the Mediterranean region particularly in Spain, for decommissioning tailings dams, where wind erosion and the residual copper levels are just too high to enable the simple direct seeding systems described earlier to succeed. In this circumstances infertile but weathered surface rock and shale was strippped from the base slopes of pine wood and adjacent to the tailing areas and placed upon the tailing surface as a shallow, 200 mm layer. Trials showed that native burried seed from the natural seedbanks pariticularly Pinus pinaster and P. pinea) provided sufficient viable propagules for re-establishment of an encouraging young woodland without any further effort or expending apart from the use of limestone and conventional fertilisers as aids to establishment. This approach, simple covering with a shallow layer of local seed-rich soil and application of NPK fertiliser at 400 kg/ha, has been outstandingly successful on a large scale tailings facility of 60 ha.[7]

In Northern Spain, where the climate is sub-Mediterranean, the cover approach has been employed successfully using non toxic mine overburden. Following trials, direct seeding of tree and shrub seed on to a 500 mm layer of overburden was undertaken on two very large tailing areas at a disused copper mine, using slow -release NPK fertiliser and a seed mixture dominated by Eucalyptus globlus and E. camaldulensis with Acacia retinoides, Pinus spp. and Berula spp. as nurse species. The results have been excellent. The dual objects of erosion control and amenity improvement are close to being met less than three years after seeding.

A similar covering approach has been deployed successfully at the copper tailings dam of the old Avoca mine in Co. Wicklow, Republic of Ireland. This has tailing dam, in two sections is well concealed in the Avoca River valley but was

subject to serious erosion problems before the tolerance approach by direct seeding presented too great a risk in view of the relative slowness of sward establishment by this method. Accordingly, a two-layered cover approach was adopted in which a layer of shale, 200-300 mm deep, was placed on the tailings surface to isolate the material and overlain with 75-100 mm of topsoil and subsoil to provide a strongly supportive medium for cover vegetation. The surface was then treated with conventional limestone and fertilisers before being sown with a traditional agricultural seed mixture.

With careful management the results were outstanding in the first two years. A casp hay was taken from the reclaimed surface in the summer following the year of reclamation and the yield during that same year was 2.7 x the national average for the Republic of Ire. The quaility of the product was such that there were no constraints upon feeding the productive livestock. In recent years the management of the same has changed and the sward has been permitted, quite deliberately, to deteriorate and become invaded by other species. The grass surface now supports gorse (Ulex europaeus) and broom (Sarothammuns scoparius) plant wide range of herbaceous species, and is now carrying a significant compliment of wildlife. In particular it provides excellent cover for pheasent which have been bred for decades in local woodlands.[7]

5. Selection of Plant Species

5.1.0 General Principle and Criteria

For a particular combination of site conditions and afteruse, selection of the right plant species is a job for a specialist. Because the suitable species will vary greatly over the world due to climatic differences, only one region, temperate geographical belt, is considered under this chapter in details. Unfortunately due to non availability of enough information from tropical countries like India, selection of species for this type of climatic condition could not be discussed in details. The main selection criteria involves considerations of after use, climate, soil and the role required of the plants, whether primary colonisers, soil builders or climax communities.[2]

Local site and economic conditions exercise are over-riding control on how the site can be used. But the first consideration must be the afteruse taking into account the topography and soil potential. The appropriate species for agricultural, forestry, woodland, recreation and amenity, or wild areas can then be chosen. Thus palatability and productivity for grazing and water-resistance for recreation areas will be important characters for grass and legumes; growth rate and timber quality for timber trees; nativeness and wildlife value for wild and semi-wild areas.

Wild low intensity amenity areas need species with low management and fertility requirements, and should rely on native and locally adopted species. Introduced species can make a useful contribution to a flora, and on difficult sites, they may be vital, being perhaps the only plants that can survive. Species that provide food (berries, nuts, fruits, foliage) and shelter for insects, birds and animals will be useful ; native species will support a wider range of insects and animals and will, generally contribute more to the ecology of the area than exotic introductions.

On every extreme sites it will not be possible to consider plants for afteruse first. There may only be a very limited number of plants that will tolerate the site conditions, ever with some amelioration, so after use will depend on the species, not vice-versa. Exactly this is the case with most of the Indian mines where reclamations are considered.

5.1.1 Climate

Each of the world's climatic zones has a distinct and characteristic range of plant species, a range of macro-and micro-climate variation within each major zone that will have plants adapted to local extremes. Plants characteristics such as drought resistance, first hardiness and tolerance of exposure will be important. The micro-climate is considerably modified by topography, thus site factors such as slope aspects and altitude should form part of the site climatic profile, as well as pattern and intensity of rainfall, growing season, degree of exposure, and temperatures.

5.1.2 Soil

Combined with climate, the physical and chemical soil conditions will determine the species that grow on any site. Based on simple soil classification systems, pH, texture and fertility soil depths and availability of moisture, species that can grow and perform well can be identified. In extreme environments plant tolerance rather than performance will be important, particularly for extreme acidity, alkalinity or heavy metals.

There will usually be scope for ameliorating adverse site conditions to suit a particular range of plants required. However, unless the soil has any real potential for the intended afteruse without requiring uneconomic levels of continual management, it is always better to choose adapted plant species where possible. Here it can be said that many reclamation schemes fail because agricultural species use to maintain them than it was possible or feasible to give.

5.1.3 Plant Phasing

Generally there is a tendency, particularly with trees, to consider only the climax vegetation (tall trees). Natural Communities development through a succession from pioneer species through to climax, each phase preparing the ground for the next. While it is impractical to mimic this exactly during reclamation, it is important to consider a plant

succession for both underground cover and trees. Grassland may be required as either a quick pioneer soil stability, as a soil builder under developing woodland, or as a climax for grazing, many pioneer trees will act as a quick growing nurse for slower mature forest trees that find difficult to establish in fresh ground, or in the open. Nitrogen - fixing species (herbs, shrubs and trees) will play a crucial role in the soil building and development stages on sterile reclaimed spoil.

The vegetation establishment strategies can therefore have three stages primary colonizing, secondary and tertiary, though these may often be combined into one or two stages. All stages can be introduced at the same time, or within a short period, with the time taken for developing of each stage giving the succession, or alternatively introduction of final stage can be delayed until early stages have sufficiently modified the site.

a) Primary colonizers : For erosion control on steep or unstable slopes these are usually quick growing grasses or cereals, often called cover or *nurse crops.* Such is the usual method of introduction. Many tree species considered pioneer colonizers of new habitats, developing into shrub and alternatively woodland, these species are adopted to establishment in a competitive, hostile environment and often grow well from seed.

b) Secondary stage : These will be the species which build up soil structure and fertility, and are very often combined with the primary phase. They are essentially legumes, together with grasses, herbs, trees and shrubs. Seed is again the usual method of introduction, though many trees and shrubs can also be planted.

c) Tertiary or climax stage : These will be the species which form the final derived plant community, which can be grass based sward managed by grazing or cutting, or shrub or tree community. These are some special communities in this stage that will require special treatment and management, such as health land, coniferous land, grassland, etc. Many climax communities could be established directly without earlier strategies then include agricultural swards and health land.

5.1.4 Ecotypes

Within any species there can be a wide range of genetic variability in growth habitats and tolerance of climate and soil conditions. Genetically distinct local types within species are called ecotypes. This ecotypic variation has been exploited by man for many years to produce a wide range of cultivated varieties (cultivars) for agricultural and other uses.

1) Grasses and herbs : Most commonly available cultivars have been developed for agriculture or sports turf use. For nonagricultural use it is important to select the most suitable; quick establishment, tolerance of nutrient poor conditions or other site conditions. It may be necessary to screen a number of possible cultivars suitable for use on a particular site; commercially available cultivars may not resemble local wild types growth habitat and site tolerance very closely.

There is some evidence that species and cultivars with low growth rates and low responses to increasing fertilisers are better adapted to the poorest sites where they will encounter environmental stresses. Although there has recently been some effort to select and breed grass cultivars tolerant to extreme sites, such as *metal toxicity,* there is still great reliance on such cultivars sold for more intensive uses.

2) Trees : Other than garden ornamental, which are monthly chosen, there are no tree cultivars as such. However, seed is usually collected from recognised areas, and geographical locality of the seed source is known as its *provenance.* Foresters have long been aware of the importance of selecting seed and plants with the correct provenance to suit timber production on any particular site. Locally collected seed may be of poor quality (purity and germination) than bought seed, but it will usually produce plants better adapted to that locality. Trees will usually be planted as ground saplings. When plant or seed material must be bought in, details of its provenance should be obtained from the supplier.

5.1.5 Land Habit and Growth Form

1. Trees and shrubs : The growth rate, nature height and sown shape of trees and shrubs will effect their selection for screening purposes and resistance to expense. Their ability to *suck* from roots or cut stem *(pollards and coppice)* may also be important. Root growth will effect tolerance to drought, stability in wind and the ability to plants close to buildings.

2) Grasses and herbs : For uncut low maintenance vegetation a short or prostrate growth habit is desirable. The ability to spread vegetatively by rhizomes or stolons to colonise new areas will also be an advance highly vigorous and spreading plants will be competitive to trees and should not be selected for sowing in tree plantations. Root growth and depth of rooting will determine the plants ability withstand drought, and to bind soil particles together effectively. To encourage wild herbs to colonise a sward, non-competitive grass species with an open or tufted habit are preferred. Conversely for agricultural areas a closed sward will exclude undesireable weeds.

5.1.6 Mixtures

Having made a list of suitable species, they can be combined in various ways to form species mixtures. Not all the species may be required, especially if the list is the long one, and other factors such as availability, price or personal preference will decide exactly which will be included. The proportions of each species will depend on the role each has to play, and its competetive ability. But long term species composition is normally not very predictable, because of the large number of environmental factors effecting the mixture during the developement.

1. Trees and shrubs : Pioneer or mouse species are best established to give a ratio of 1:5 to 1:3 with appropriate climax species. This should give sufficient early usual impact and protection to the slow growing species without them being swamped by the quick growing ones. Higher proportions of nurse species will mean more frequent management to thinout as they grow. Area intended to be wild or natural should be similar to natural stands, with 3-6 species. The mixture should also take into account both vertical woodland structure as well as horizontal i.e, with canopy and understorey species.

2. Ground cover : The main component is generally grass species, mixed 2:1 to 4:1 with legumes for nitrogen fixation and soil building. herbs can also be added to increase the wildlife interest and diversity. Most sites are variable in topography and soil conditions and a diverse mixture with a range of species, about 6-10, will allow for this variability. Diversity also gives flexibility to changes in sites conditions and are adoptable sward. Pioneer/cover crops should be kept to a single suitable species at a low proportion in the mix, so that they do not dominate the sward and suppress slower species.

5.2.0. Species Selection in Temperate Climate

5.2.1 Cultivars

The range of cultivars available for a variety of uses changes continually, though there are many old favourite that go on for a long time. Up-to-date information on the available cultivars and their characteristics can be obtained from seed houses, or from published informations. A list of grass and legume cultivars suitable for revegetation of infertile sites and available at the present time is given in Table 5.1.

Table 5.1 : Grass and legume cultivars suitable for use on reclaimed sites - Law maintenance

Species	Cultivars	Comments
Lolium Perenne	Manhattan	
	Majestic	Prostrate sports
	Stadion	turf cultivars
	Pelo	Prostrate
	Melle	Grazing cultivar
Festuca rubra rubra	S59	Slender creeping
	Dawson	type,least
	Merlin	aggressive
	Moncorde	Strong creeping
	Reptans	type, aggressive
Festuca rubra commutata	Waldorf	
	Koket	
	Highlight	
	Erika	
Poa pratensis	Geronimo	
	Patade	
	Prato	
	Newport	
	Sydsport	
	Fylking	
Agrostis tenuis	Highland	Tall, aggressive
	Holfior	type
	Bardot	
Trifolium repens	Kent Wild White	Medium leaved
	N.Z.Grasslands	
	Huia	Medium leaved
	S184	Small leaved
	S100	Large leaved
Trifolium subterraneum	Mount Barker	

5.2.2 Wild Species

Wild species are those which are not in general cultivation, and so are not available in large quantities. Special techniques such as collecting seed-rich litterand topsoil, transplanting *twives* or hand collecting seeds from wild communities must be adopted. Some wild flower mixes are commercially available, but these are variable in composition and quality and usually consists of a few common and often alien species. They rarely have the diversity or balanced species content suitable for truly wild areas, but they can be used to improve and otherwise uninteresting grassed area, when visual amenity is important.[2]

5.2.3 Indian Context

In India, as here been discussed elsewhere, growing vegetation itself is the objective rather than specific use of such reclaimed land where mining has been done. This is because most of the mined out lands are hortile in terms of nutrients of the soil and climate (arid and semiarid region). So choice of vegetation for specific purpose is absent in many cases marginal mine operators' economics do not permit spending money on revegetation or fresh vegetation especially when soil amendments and its amelioration is involved. However, in India some particular species are found suitable in mixing area of particular minerals. Table 5.2 details some of such plant species in mined out area of various minerals.[7]

Table 5.2 : Suitable species for mine areas

Mine Area	Suitable Plant
Gypsum	Prosporis Cineraria (Khejri) zizyphus mauratiana (ber)
Fuller's Earth	Acacia Senegal (Kumta) Salvadora
Bentonite	(Pilu, Jal), Maytenus emerginata (Kankra)
Ochre	Acacia nilotica(babool) Butea Monosperam (Palasordhak) Euphorbia nerifobia (thor)
Marble	Khejri and Vilayati babool
Limestone	Vilyati babool, arunji and ber
Rock Phosphate	Acacia Catechu (Khair), Delbergia Sissoo(Shisam),Leucacna leucoplala (Subabul),Cupressus sempervirem (Saru) Eucalyptus hibrid. Salix tetrasperma (Jalmala),Pirus roxburghii(Chir), Albazzia lebbeck(Siris)
Zinc Tailings	Ficus tomantosa (Pathphodi) Vilayati babool and neem
Lignite	Eucalyptus hybrid, subabul, Casuarina. Dalbergia sisoo, Accacianilotica,Eucalyptus citriodira
Bauxite	Acacia auriculiformis, Eucaluptus camaldubenis, Grazillar etridofobia, Pinus, roxburghi, Pinus Caribaca, Gravillca robusta
Iron ore (Kudremukh)	Gulmohar, Rain tree, Dalberia siris, Jacaranda, Cassia fistul, Acacia auriculiformis, Bombax malabaricum, Paltsforum, Bauhinia, Talscbit, Avakande, Millingtoria, Cassia spectablings

Table 5.3 : Plants for some refractory sites

Saline Water logged	..	Tamarix dioica
Area liable to inundation	..	Acacia nilotica, Butea Monosperma
	..	Zizyphus mauratiana, Lagerstroemia floreginae
Salty lands	..	Eucalyptus, Phoenix, Tamarix, Thespesia, Salvadora, Parkinsonia aculeata, Prosposis chileusis

6. Aftercare Management of Restored Land

If a reclaimed area is to develop successfully it is essential that it is managed to ensure good soil and vegetation development. This is an integral and vital part of the whole reclamation scheme, and should be considered right from the planning stage. Aftercare should begin as soon as the planting and seeding are completed, and the plants begin to grow.[2]

1. The management components are : monitoring to assess the progress and development of the soil and vegetation, aftercare, the addition of fertilisers, etc; maintenance of the structural components, and the long-and-short term strategy.

2. Grasslands will be managed by either grazing or mowing. Grazing management should aim to maintain productivity and stocking of the area. Sheep and cattle are the most useful grazing animals. Both grazing and mowing will greatly influence the composition of the sward.

3. Woodland and forestry management should aim to maintain the optimum stand of trees for the purpose. Important components are replacing lost trees or thinning as necessary, weeding to reduce competition around young trees, and maintaining fertility.

4. In plantations there are many steps that can be taken to enhance the wildlife interest, even in those managed purely for timber production.

5. The build-up of soil nutrients, particularly nitrogen, can be monitored to assess the progress of the reclamation. Fertilising and vegetation management should aim to promote a steady increase in soil nitrogen around 700 kg/ha. Grazing will encourage recycling of nutrients from the vegetation back to the soil.

Management for ecosystem development is the third and final stage of reclamation process. It begins as soon as the planting and seeding is completed and the plants begin to grow. It is no less important than the planning and establishment phases, but it is often the most neglected.

Once the soil has been ameliorated and the plants established, the system will eventually develop on its own. However, the process of development and building of a complex ecosystem, whether natural or agricultural, may take long which may be unacceptable. Some degree of management and aftercare will always be necessary, related to the desired after-use.

This period of fairly intensive aftercare would eventually be replaced by normal management practices, when the soils and plants are sufficiently well established. The length of this period can vary from 2 - 10 years, depending on both the starting point and the level to which the productivity is to be raised.

6.1.0 Management Components

6.1.1 Management

The level of management required, and thus an approximate cost, can be determined early, at the site planning stage, by considering the nature and properties of the area (climate, soil, physical and chemical properties), and the after-use. In general, the level of management required is proportional to the productivity and intensity of use.

The management strategy developed from this advanced planning must remain sufficiently flexible to allow for the progress and problems highlighted by the monitoring of the area. The management strategies appropriate to a range of after-uses are outlined in Table 6.1.

The strategy can be considered in two stages: the short term, following the establishment, and the longer term, when special management requirements gradually give way to normal management practices associated with the required after-use. The short-term period has a fairly arbitrary length, depending on the rate of progress, but three to five years is appropriate in most cases, providing the initial scheme was designed with care.

Although the importance of aftercare to the success of the final reclamation scheme cannot

Table - 6.1 : Outline of 5-year management strategy for reclaimed areas

Year	Wildlife area	Grassland			Forestry and woodland
		Low land productive	Upland poor	Amenity	
1.	Check establishment fertiliser	Check establishment of grass and legume. Fertilise, cut if necessary	Check establishment of grass and legume Fertilise, cut or begin grazing.	Check establishment of grass and legume Fertilise. Cut if necessary	Check establishment arrange replacements. Weeding-herbicide or 2-3 cuts. Fences.
2.		Begin grazing. Check legume. Fertilise.	Begin grazing. Check legume. Fertilise.	Fertilise. Cut if necessary.	Check growth. Fertilise Weeding. Fences.
3.	Check progress and soil nutrients, wild species	Check progress-soil nutrients and sward. Fertilise.	Check progress-soil nutrients and sward. Fertilise if necessary.	Check progress-soil nutrients and Sward fertilise if necessary. Cut as necessary.	Check growth and soil fertility. Fences. Fertilise as necessary.
4.		Fertilise.	Fertilise and lime if necessary.	Fertilise if necessary. Cut as necessary.	Check growth and Fences.
5.		Install permanent drainage. Reseed if necessary. Lime and fertilise.	Check soil fertility and sward. Fertilise.	Install permanent drainage if necessary. Check fertility and sward. Fertilise. Cut as necessary.	Check growth and soil fertility. Fertilise as necessary. Fences.
Long Term	Monitor vegetation development.	Consider replacing sward every 5-10 years. Check fertility regularly.	Check fertility and sward periodically	Annual cutting, check; fertility and sward occasionally.	Periodic checks on growth and soil fertility. Thinning timber production, apply forestry techniques and management.

be overstressed, there will be some schemes for which a quick and inexpensive reclamation process is important, with minimal time and with resources expended.

In these cases, where the final result is not so critical, there will be very little, if any, aftercare. This is not to say that it is ignored, but that non-management is planned and allowed for in the reclamation.

This will also be the case for wilderness and low/no-maintenance areas, where repeated interference may, infact, be detrimental. Sometimes there will be a choice between an aftercare programme involving a large initial capital expenditure with subsequent small annual revenue expenditure, and a programme involving a small initial expenditure with subsequent larger annual expenditure. The decision between these two options will involve consideration of many economic, financial and ecological factors.

6.1.2 Monitoring

A regular monitoring programme will follow the progress and development of the soil and vegetation. The important factors are :

(i) the nutrient status of the soil, including turnover and availability.
(ii) the composition and health of the vegetation, particularly the quantity of desired species relative to the total vegetation present.

Comparing these with required or expected values, a critical assessment of improvement or regression can be made, and any problems detected at an early stage. A simple visual inspection will be sufficient in some cases, though rough impressions can be misleading and systematic recording should be maintained when possible. If any problems or symptoms are evident, then a more detailed survey will determine the specific causes and effects.

6.1.3 Aftercare

This includes any additions of fertilisers, seeds, plants, grazing, harvesting, mowing, rotational crops, etc., that are required to maintain and develop the site potential. The management strategy can broadly contain these provisions, but the exact timing and quality has to be determined by continuous monitoring. The importance of nutrients, especially nitrogen, in the development of a soil-plant system has been discussed in chapter - 3. The aim of aftercare is to build up the fertility until a natural cycle develops (around 700 kg N/ha in the surface 300 mm of soil). This can be achieved by maintaining legumes as a source of nitrogen, providing sufficient other nutrients, especially phosphorous, and encouraging the natural cycle of breakdown of plant litter.

In the first 1-2 years or so, however, the nitrogen will be contained in the nodules and vegetation of the legume and not available to grass, so the sward may be nitrogen deficient even though there is a good legume growth. Grazing will provide a useful means of removing much of the standing crop of grass, etc., and returning nutrients to the soil, though overgrazing will lead to nutrients leaching out, and loss of fertility.

6.1.4 Maintenance

Upkeep, repair and maintenance of fences, drains, and other structural components must not be neglected. However well constructed, some upkeep will always be necessary, though the level should reflect their necessity in the short and long term.

The control of animals on the site, whether desirable or undesirable ones, will require continual inspection and upkeep of fences and gates. It will only take one break in a fence for a very short while for a whole tree plantation to be ruined by grazing and browsing animals.

6.1.5 Succession

Whether intended or not, the vegetation established on a site will gradually change in response to environmental and management factors. In the absence of grazing the direction of this change is generally to scrub and then some form of woodland.

Tree plantations, being essentially climax or near-climax vegetation, will change relatively little in the long term. Grasslands, however, are under continual pressure to change and evolve, though this process is extremely slow. This change is inevitable unless some form of management such as grazing, burning or cutting interferes. Even in the short term, grassland composition will change from that sown as other grassland species invade.

6.2.0 Grassland Management

6.2.1 Grazing

Whether productive lowland or less-productive upland grazing, the aim will be to maintain productivity and stocking of the area. For amenity areas where the grassland is not maintained for productive purposes, grazing can be a very useful alternative to mowing as a management tool. It can also be cheaper than mowing, even if the economic return on the grazing is not taken into account. It is important to select the right sort of animal, the correct stocking rate and the best grazing regime. Newly-developed soils are fragile, and must therefore be treated with care. They need sufficient time for the sward to establish well so it can resist trampling. A minimum of three months (excluding any dormant winter periods) and upto twelve months on heavy soils is necessary. The sward should be cut and the cutting left on site to build up the organic matter of the soil. Heavy cuttings should not be left because they may partially smoother the sward; in such cases hay or silage can be made.

The immature soils are very susceptible to poaching by animals' feet, especially when they are wet, so grazing periods should be restricted to the summer months only. On sites where restriction or control of animal access is not possible, sowing at the beginning of the growing season, so the sward develops quickly, will keep animal damage to a minimum.

(1) Grazing animals

Sheep are the ideal choice in most cases. Being small, they do not cause much trampling damage, and breeds can be chosen to suit almost any area and type of sward. They will graze cleanly and closely, encouraging root growth and a dense sward. Cattle are an alternative (usually beef stock, calves or heifers, rarely dairy cows), but trampling damage can be extensive.

They should not, therefore, be used in the first year. Horses are very selective grazers, and will only graze part of the area available because they leave other parts for their dung and should thus be avoided. However, if there is no alternative to horses the sward should be mown 2-3 times per year to help maintain the sward quality.

(2) Stocking rate

This depends on the fertility and the grazing regime adopted, and expert advice should be sought. As a guide, on poorer sites 1-5 sheep per hectare, 0.2-1 cattle per hectare is appropriate over extended periods, with perhaps twice this on the most fertile sites.

(3) Grazing regime

Unrestricted access throughout the year is common in upland areas, with the fairly low stocking rate given above. It tends to leave a patchwork of vegetation as palatable species are grazed, leaving unpalatable ones to increase.

Periodic grazing at fairly high stocking rates (5-20 sheep per hectare) will give more control over the sward, with less selective grazing. If the area is large enough it can be broken down into smaller nits grazed on a rotational basis.

If tall and aggressive grasses such as cocksfoot are not to dominate the sward, it must be grazed thoroughly during the most rapid growth period, during spring or early summer. Less palatable species are often more acceptable during this period of flush growth as well. Most grazed areas will benefit from at least one cutting each year to remove the taller growth of vegetation that has not been grazed.

(4) Grass quality

The species composition of the sward will determine the productivity to a great extent, so it is important to maintain a high proportion of more palatable species. Normal agricultural practices for replanting leys or more permanent grassland can be followed after five years or so.

The mineral content and balance in the soil and the sward is important because mineral deficiencies in stock grazing on infertile soils are fairly common. In particular copper, magnesium, manganese, cobalt and sodium deficiencies can occur in both sheep and cattle, especially during the spring when growth rates are highest and the grass flushes. Lime-rich soils can also induce mineral deficiencies by locking up the minerals in an unavailable form. It is advisable to have the mineral content of the soil land grass checked periodically so that feed supplements can be given if necessary, or the soil treated. Specialist advice should be sought in this matter.

(5) Occupation arrangements

Only rarely will the mineral operator or site owner be able or willing to maintain appropriate stocking regimes on reclaimed areas, as they tend to be small and isolated from each other. All but the largest sites will need to be integrated into a larger farming system, usually through local farmers. It is important to include these local considerations at the planning stage, and to make sure that local farmers could accommodate the site in their normal operations. Any leasing arrangements must give the farmer some incentive to improve the sward and soil , but at the same time retain a degree of control by the owner over the management. In some cases a period of close control, when all materials are paid for by the owner or operator, is adopted.

As an alternative to a full agricultural tenancy, there are various forms of occupation that a mineral operator can permit whilst retaining full control over the aftercare of the land. These include partnership or contract farming, employing a farm manager, agistment, or an 11-month-per-year grazing license.

Only a nominal rent, if any, would be charged, and regular monitoring checks on the soil fertility and sward would be made by the owner/operator or an appointed specialist. After a specified period (often five years), when the soil has well established, the arrangements can follow more traditional lines.

6.2.2 Mowing

Like grazing, mowing reduces the standing crop of vegetation. Unlike grazing, it is not selective, all the vegetation is cut to the same degree. Mowings can be removed, or left on the ground to decompose and recycle. For newly-reclaimed areas mowing can be a useful alternative

to grazing if the soil is liable to trampling damage or suitable grazing animals are not available. The crop can be removed as hay or silage if the grass is of good quality.

The after-use dictates the mowing intensity to a great extent:

(a) Close-mown turf (7-12 mm, 20-30 cuts per year) will rarely be applicable to reclaimed areas, except where exceptional resistance to wear is required, such as sports fields.

(b) Intermediate length turf (12-35 mm, 10-25 cuts per year) is suitable for recreation grounds, outfields and country parks, etc.

(c) Long turf (35-100 mm,k 2-6 cuts per year) is suitable for general recreation, conservation, picnic areas, banks, verges and public open space generally. It can be cut with rotary mowers or flails fairly cheaply. A wide range of herbaceous species can invade that are excluded from more intensively mown areas.

The timing of cutting, as with grazing, will influence the composition of the ward. Cutting during the period up to flowering and seed setting (late summer) will reduce the herb content. Cutting earlier in the year will reduce the taller dense growth of grasses and allow slower growing species, especially herb, legumes and wild flowers, to grow successfully and set seed.

6.2.3 Low-maintenance areas

Very often these areas of grassland will be managed for conservation and wildlife interest, as either a stage in the progression to woodland, or as grassland for it's own interest. If the invasion of shrubs is to be controlled some form of dusting or grazing will be necessary yearly or every 2-3 years.

Planned progression of grassed areas to scrub and woodland will depend to a large extent on the fertility. A gradual build-up of the soil nutrient pools, especially nitrogen through legumes, is the aim. Plantations are often mown between the rows of trees to keep the sward looking tidy, but from the biological point of view this is totally unnecessary.

6.2.4 Fertility

A continual input of nitrogen and to a lesser extent phosphorus and potassium will maintain the growth of the sward. In mature soils this is achieved mainly by cycling of nutrients through decomposition of plant litter, supplemented by fertiliser or manures when the system is cropped. The aim of management of grassland on reclaimed areas should be to gradually increase the soil nitrogen pool by the use of fertilisers, manures and particularly legumes. Eventually such a build-up will produce sufficient nutrients in the soil so that natural cycling can then supply most of the requirements. In the case of nitrogen, such a level is reached which the total in the soil is 700 kg N/ ha. In the case of area intended as a species-rich rough grassland, once the level of about 700 kg N/ha in the soil is reached, a wide range of shrub and scrub species will invade. If this is not desired, and if a diversity of wild flowers is to be retained, soil nitrogen levels should remain below this level. Legumes must be kept under control by low phosphorus or lime level, and cutting and removal of the standing crop can sometimes help to reduce the fertility if it gets too high and a last resort, the area can be completely stripped of the developed soil and the succession process allowed to begin again.

Extractable phosphorus, potassium and magnesium levels of index 1 or greater will maintain good sward growth (especially legumes) on low-maintenance areas, and index 2 or 3 for more productive areas. Recommendations for fertilising grazed swards are given in Table 6.2.

Table 6.2 : Fertiliser rates for productive grazed swards

(a) Nitrogen

kg N/ha/yr	Herbage dry matter t/ha	Cow grazing days* per hectare
	Grass-clover swards	
0	6.6	330
100	8.4	420
200	9.8	490
300	11.0	550
	All-grass swards	
0	3.2	160
100	6.2	300
200	8.6	430
300	11.4	520

* *Based on 15 kg dry matter intake per cow per day. For non-dairy cattle and sheep, 5-10 kg dry matter intake per day is appropriate.*

b) Phosphorus and potassium, all grass swards

P or K index	kg/ha/yr			
	Grazed swards		Ungrazed swards	
	P	K*	P	K
0	25	60	15	30
1	12	30	nil	nil
2	8	20	nil	nil
over 2	nil	nil	nil	nil

* *To avoid risk of hypomagnesia (Mg deficiency) K should not be applied in the sprig to grazed swards.*

The nitrogen status is determined by total nitrogen and a nitrogen-mineralisation test; mineralisable-N of between 50 and 100 kg N/ha will be sufficient to maintain good sward growth without fertilisers or legumes. Under normal mineralisation rates, this amount of N will become available form a total soil N of 700-1,000 kg N/ha.

6.3.0 Forestry and Woodland Management

6.3.1 Weeding

The need to reduce competitions to the young plants from a dense ground cover, and the methods that can be employed, are already discussed. Weed control with residual herbicides or mechanical weeding will be necessary for 2-3 years. Plantations where the ground cover, either wild or sown, is very aggressive will need 2-3 visits per year. Weeding will not be necessary when the ground is left bare and unsown, or sown with a non-competitive seed-mixture.

6.3.2 Replacements

The replacement of dead trees during the year or two following planting (beating up) will be necessary when losses of more than 15%occur in timber plantations, or more than about 25% in woodland areas. If the losses are unevenly distributed in area or in species, some replacement will still be necessary.

Monitoring at the end of the first growing season or during the second to record the species survival will determine the extent and amount of beating up required. Plantations planted by outside contractors must be monitored jointly early during the first growing season, determine liability for replacing poor or badly planted stock.

6.3.3 Woodland Plantations

(1) Maintenance

An annual inspection of the plantation for 3-5 years after planting will allow monitoring of the growth and health of the trees. At the same time, support-stakes and securing ties can be checked and loosened, and some selected pruning undertaken. Pruning should cut out all the dead wood back to a healthy live bud or shoot. Fenced plantations adjacent to grazing land or where wild browsing animals (rabbits, deer, etc.) are numerous will require frequent checks to ensure the security of the fencing. Repairs must be made immediately.

When denser growth at ground level is required for screening purposes, particularly around the edges of plantations and in major sight-lines, the tops (leading shoots) of the young trees can be cut back to promote bushy growth. Similarly, coppicing, cutting the main stem back to within a metre of ground level, will make the plant send up a dense growth of suckers. Only some species will coppice successfully.

(2) Thinning

Spacings of two metres between plants at planting time will be far too dense as the woodland develops; the trees will grow very tall and could become unstable. As a thumb rule, thinning is necessary as the crowns begin to overlap, usually at 5-10 years of age. Two or three thinning will be required, giving final spacings of about 10-15 metres between mature trees.

Care must be taken to maintain the correct species balance, bearing in mind that the nurse species should eventually be thinned out altogether to leave just the climax. Successive thinnings should therefore remove the less successful nurses, and any climax trees that are excess to the requirements of the final stand.

A natural thinning process will occur eventually if the plantations are just left, but the development

of the climax woodland structure will take much longer, and any economic value in the thinnings is lost.

6.3.4 Timber Plantations

The management of plantations for the production of timber is a matter for the specialist forester. The management regime requires basic information on area, species, rate of growth, yield potential (yield class) and age of the crop to determine thinning and cutting cycles.

6.3.5 Fertility

The soil fertility requirements for low-maintenance swards generally apply, tree plantations as well. In the absence of a good legume-swear maintain good health and growth of trees a reasonable supply of nitrogen, phosphorus and potassium is necessary, about 50 g N, 10 g P and 20 g K per tree applied periodically (every 2-3 years) for young trees. Nitrogen fixing nurse trees and shrubs can be used to great effect. Large, well established trees will not need fertilising if the ground cover and early fertilising has built up the soil fertility sufficiently. If the trees are obviously growing poorly or are in check, soil tests or preferable foliage analysis will identify specific problems.

Surface broadcasting of fertiliser is satisfactory where the ground cover is not too vigorous or is controlled, but nitrogen may overstimulate grass growth, which will leave little remaining for the tree, An alternative to broadcasting for small plantations or individual trees is to place the fertiliser at a greater depth, 200-300 mm (8-12 in), around the tree using a crowbar or auger. For small trees (1-5 m high) about 3 holes are drilled around each tree, ½-1 m away from the trunk, and fertiliser placed in either a liquid, granule or pellet form (special treepellet formulations are available). Slow release fertilisers generally give better results.

6.3.6 Wildlife Conservation

The following measures (after 5) can be taken as the woodland matures to enhance the wildlife value of both timber and woodland plantations;
(i) Encourage plant diversity by; (a) opening the canopy to let in light and encourage the field layer,
(b) control or limit grazing by domestic or wild animals, since grazing will damage the field layer and prevent natural regeneration of the tree species, and will damage young trees in immature plantations.
(ii) Maintain structural diversity by
(a) planting understorey and shrub layers as well as a canopy.
(b) Thinning and replanting to give a variable age structure, and to encourage the field layer.
(iii) Encourage other habitats
(a) leave some dead and dying wood standing, and some fallen logs and stumps for fungi and insects.
(b) leave scattered large old trees,
(c) encourage some species with flowers and fruit,
(d) make glades and paths winding and not straight,
(e) maintain streams and ponds, and avoid excessive drainage.
(iv) retain shelter by restricting clear felling to small noncontiguous blocks where possible. Also avoid undertaking the main management and felling activities during the main breeding seasons.
(v) Use pesticides and herbicides carefully and selectively if at all.

In general, when left to themselves woodland areas will develop their own wildlife interest without assistance and in their own time. However, having created artificially the basic woodland structure by planting , it is sometimes necessary to import woodland plant species, because they are not at all mobile, but not animals or insects, since if the right conditions are maintained, these will colonise themselves.

6.4.0 Fault Finding

Regular monitoring will identify and allow for correction of problems at an early stage. But very often schemes are neglected, or monitoring is only sporadic, and serious problems can develop. Some of the faults most commonly encountered, the causes, the factors to check for diagnosis, and the remedies are outlined in Table 6.3. This table is not exhaustive, and since apparent symptoms can be misleading at times, skilled advice should be sought whenever there is any doubt as to the cause of impaired performance or death.[2]

Table - 6.3 : Fault finding and remedies for common reclamation management problems

Symptoms	Causes	Diagnosis	Remedies
Swards			
Legumes disappear	Acidity	pH<5.0	Liming
	Low phosphorus	Extractable P< 10 mg/kg	P - fertiliser
	Grass competition	Sward height >20 cm	Graze of cut
Large bare patches	Salinity	Conductivity >4 mmhos/cm²	Allow natural leaching and resow, apply gypsum
	Acidity	Pyrite and acid leachate	Incorporate lime and resow
	Drought	Stones > 80%	Amelioration with fines
Poor growth, moribund	Nutrient deficiency	Extractable nutrients low	Fertiliser
		Total and mineralisable N low	Fertiliser or legumes
		Excessive leaching (low C.E.C.) and organic matter	Amelioration with fines
	Compacted soil	void ratio <30%	Deep cultivation
	Acidity	pH <5.0	Liming
Thick matted grass, moribund, no decomposition	Nutrient deficiency	Soil N and P as above	Fertiliser
	Acidity	Surface pH <4.5	Liming
	Low N in vegetation	C/N ratio > 30/1	Grazing, N-fertiliser
Dense, overproduction	Too fertile	Presence of "Weed" species	Cutting, remove herbage
Trees			
Fail to establish	Poor stock or bad handling and planting	Stock and planting condition	Carefully replant
	Drought	Low rainfall, coarse soil	Mulches or Watering
Poor growth rates	Nutrient deficiency	Soil N and P as above Foliar analysis	Fertiliser
Dieback or death	Compaction	Void ratio <30% Limited root extension	Deep cultivation
	Drought	Low rainfall	Mulches or Watering
		Coarse soil, stones or gravel > 80%	Amelioration with fines
	Waterlogging	Wet, black soil	Drainage, plant more suitable species
	Competition	Dense vegetation	Cutting, herbicides
	Disease	Check for symptoms of fungi or insects.	Pest control

7. Reclamation : Statutory Framework and Status

It is gratifying to note that with commendable foresight, environmental protection has been stressed in the Indian Constitution under directive principles, but no statutory provision for restoration of land after mining, were made until recent past. The provisions in Art 48 A states "the State shall endeavour to protect and improve the environment and to safeguard the forest and the wild life of the country". The constitution has made protection and improvement of natural environment for every Indian Citizen, a part of his fundamental duties in Art 51 A[53].

Mining & allied operations poses environmental problem in a variety of ways. All the three major constituents of environment : land, air and water bear the burn of mining activities. Transportation of minerals, dry crushing and grinding, drilling and blasting, wind action over mineral and waste dumps contribute to the Air pollution. Deposition of suspended solids in the near-by water courses, washoffs from flotation, leach plants, waste dumps and tailings, acid water drainage and toxic metal effluents are the most common water pollution problems in mining areas. But, the most serious of the three is land degradation, particularly caused by surface mining. Some visible environmental problems posed by the Mining Industry in India were brought out in a working group meeting held in 1981 in Thailand on Environmental Management in Mineral Resources Development, organised by the Economic and Social Commission for Asia and Pacific. The problems cited were mostly concerned with the physical degradation of the surrounding land and water resources by siltation thereby damaging the agricultural land and endangering the life of the habitats settled in low lying areas.

7.1.0 National Mineral Policy : Environment Protection

The Government of India has taken a number of steps and equipped the concerned regulation agencies and the authorities for enforcement of the enactments and regulations related to environment including reclamation and rehabilitation.

National Mineral Policy 1993 shows the concern and emphasis on Mineral Development & Protection of Environment[6]. It goes like "Extraction and development of minerals are closely interlinked with other natural resources like land, water, air and forest. The area in which minerals occur often have other resources presenting a choice of utilisation of the resources. Some such areas are ecologically fragile and some are biologically rich. It is necessary to have comprehensive view to facilitate the choice or order of land use keeping in view the needs of development as well as needs of protecting the forests, environment and ecology. Both aspects have to be properly coordinated to facilitate and ensure a sustainable development of mineral resources in harmony with environment.[9]

Mining activity often leads to environmental problems like land degradation particularly in opencast mining, land subsidence in underground mining, deforestation, atmospheric pollution, pollution of rivers and streams, disposal of solid wastes etc. affecting the ecological balance of the area. Open-cast mining in areas with actual forest cover leads to deforestation, prevention and mitigation of adverse environmental effects due to mining and processing of minerals and repairing and revegetation of the affected forest area and land covered by trees in accordance with the prescribed norms and established forestry practices shall form integral part of mine development strategy in every instance.

Mining operations shall not ordinarily be taken up in identified ecologically fragile and biologically rich areas. Strip mining in forest areas should as far as possible be avoided and it should be permitted only when accompanied with comprehensive time bound reclamation programme.

No mining lease would be granted to any party, private or public, without a proper mining plan including the environmental management plan approved and enforced by statutory authorities. The environmental management plan should adequately provide for controlling the environmental damage, restoration of mined areas and for planting of trees according to the prescribed norms as far as possible, reclamation and afforestation will proceed concurrently with mineral extraction.

Efforts would be made to convert old disused mining sites into forests and other appropriate forms of land use.[9]

7.2.0 Statutory Framework

To achieve the goal of minimum environmental damage & subsequent restoration as a result of mining activities, various legislations have been framed in India. The principal legislations for regulation of mining to protect environment can be broadly classified as[10].

7.2.1 Environment & Forest Laws

(1) Environment (Protection) Act, 1986

This is an act to provide for the protection and improvement of environment and the prevention of hazards to human beings, other living creatures with a view to enable better co-ordination of the various regulating agencies in the area of environmental protection and to establish an authority / authorities with adequate powers for environmental protection, regulation of discharge of environmental pollutants and handling of hazardous substances, speedy response towards related issues and deterrent punishment to those who endanger human environment safety and health.

(2) Environment (Protection) Rules, 1986

These rules are framed by the Central Government under section 6 and 25 of the said Act. The rule 3 stipulates the standards of emission / discharge of environmental pollutants as specified in the schedule. However, Central/State Government may impose more stringent standards than specified in schedule depending upon the quality of "recipient system" i.e. part of the environment such as soil, water or air. Schedule I does not include Mining Industry but a number of mineral based industries such as caustic soda, oil refinery, thermal power plant, cement, stone crushing, fertilizer, aluminium, calcium carbide, copper, lead and zinc smelting, sulfuric acid, iron and steel (integrated). Schedule II lays down the general standards for discharge.

The Ministry of Environment & Forest vide it's notification No.GSR329(E) dated 13.03.1992 amended the Environment(Protection) Rules including a new provision viz. Rule 14, for submission of environmental audit report. As per this rule, every person carrying on an industry, operation or process requiring consent under Water Act, Air Act or authorisation under the Hazardous Wastes (Management & Handling) Rules 1989, shall submit an environmental audit report for the financial year in the prescribed form V to the concerned State Pollution Board on or before 15th May every year from 1993 onwards[11].

The Form V has 9 parts A to I in which the following information have to be incorporated -

1. Water consumption cu.m./day in process cooling domestic and consumption per unit production.

2. Raw material consumption.

3. Pollution generated in water and air as compared to prescribed standards.

4. (a) Generation of hazardous wastes and solid wastes from
   (i) Process and
   (ii) Pollution control facility.
   (b) Quantity recycled or reutilised
   (c) Additional characteristics of the waste.

5. Impact of pollution control measures on conservation of natural resources and consequently on cost of production.
6. Additional investment proposed for environment protection.

The Government of India proposed 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 it's notification published as S.O.No.80(E) dated 28th January, 1993.

After giving due consideration to all the objections received, Government of India issued a notification on 'Environmental Impact Assessment of Development Projects' published as S.O.60(E) dated 27th January, 1994.

MINISTRY OF ENVIRONMENT AND FORESTS

NOTIFICATION

ON

Environmental Impact Assessment of Development Projects
New Delhi, the 27th January, 1994
(As amended on 04/05/1994)

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 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 to 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 the 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 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 & 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 technical assessment of documents and data, furnished by the project authorities, supplemented by data collected during visits to sites or factories if undertaken, and interaction with affected population and environmental groups, if necessary summary of the reports, the recommendation and the conditions, subject to which environmental

clearance is given, shall be made available subject to the public interest to the concerned parties or environmental groups on request. Comments of the public may be solicited, if so decided by Impact Assessment Agency, within thirty days of receipt of proposal, in public hearings arranged for the purpose after giving thirty days notice of such hearings in at least two newspapers. Public shall be provided access, subject to the public interest, to the summary of the reports/Environmental Management Plans at the Headquarters of the Impact Assessment Agency.

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, where required, and decision conveyed within thirty days thereafter.

The clearance granted shall be valid for a period of five years for commencement of the construction or operation.

No construction work, preliminary or otherwise, relating to the setting up of the project may not 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 than 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.

Further the Government of India by its Notification No.S.O. 318(E), dated 10th April 1997 made the public hearing statutory for the purpose of grant of environment clearance. The above Notification states as follows. [12]

MINISTRY OF ENVIRONMENT AND FORESTS

NOTIFICATION

New Delhi, the 10th April, 1997

S.O.318(E)- Whereas by notification of the Government of India in the Ministry of Environment and Forests, No.S.O.60(E), dated the 27th January, 1994(hereinafter referred to as the said notification) issued under sub-section(1) and clause(V) of sub-section(2) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986) (hereinafter referred to as the said Act) read with clause(d) of sub-rule(3) of rule 5 of the Environment Protection, Rules, 1986 (hereinafter referred to as the said rules), the Central Government imposed certain restriction and prohibitions on the expansion and modernisation of any activity or the undertaking of any project, unless environment clearance has been granted by the Government ;

And whereas, sub-rule(4) of rule 5 of the said rules provides that, whenever it appears to the Central Government that it is in public interest to do so it may dispense with the requirement of notice under clause(a) of sub-rule(3) of rule 5 of the said rules;

And whereas, the Central Government is of the opinion that it is in public interest to dispense with the requirement of notice under clause(a) of sub-rule(3) of rule 5 of the said rules;

Now, therefore, in exercise of the powers conferred by sub-section(1) and clause(V) of subsection(2) of section 3 of the said Act read with sub-rule(4) of rule 5 of the said rules, the Central Government thereby makes the following further amendments in the said notification, namely :

(1) in paragraph 2

(a) in sub-paragraph I, in item(a), for the words "and an Environment Management Plan", the words. "Environment Management Plan and details of public hearing as specified in Schedule IV" shall be substituted;

(b) in sub paragraph III for item(c), the following shall be substituted, namely :

(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 .

(2) in Schedule-1, for item 21, the following item shall be substituted, namely: "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",

(3) after Schedule-III, the following Schedule shall be added at the end, namely :

Schedule IV

(See sub-para 1 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) Rule 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 bonafide residents environmental groups and other located at the project site/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

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 Department of the 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 Officer of Zilla 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 .

(3) Environmental Auditing

Environmental audit has been made mandatory in India as per the Ministry of Environment and Forests, Government of India notification dated 13th March, 1992. Rule 14 of the Second Amendment Rules, 1992 framed under Environment (Protection) Act, 1986 envisages submission of environmental audit report. According to it, every person carrying on an Industry, operation or process requiring consent under section 25 of the Water (Prevention and Control of Pollution) Act, 1974 or under section 21 of the Air (Prevention and Control of Pollution) Act, 1981 or both or authorisation under the Hazardous Wastes (Management and Handling) Rules, 1989 issued under the Environment (Protection) Act, 1986 shall submit an environmental audit report for the financial year ending the 31st March in form V to the concerned State Pollution Control Board on or before the 15th day of May every year, beginning 1993. Audit report should contain information about -

(1) Water consumption,

(2) Raw material consumption,

(3) Air and water pollutants generated,

(4) Characteristics of solid wastes and hazardous wastes and their disposal,

(5) Impact of the pollution control measures on conservation of natural resources and on the cost of production,

(6) Additional Investment Proposal for environmental protection and abatement of pollution and,

(7) Any other particulars in respect of environment protection and abatement of pollution.

Environmental Audit is an effective tool for the management of any Organisation for performance assessment and exercising control over the various parameters of Environment Management. The concept of environmental audit emerged out of the need of intense analytical monitoring experienced by the management of various organisations in the light of strict environmental legislation and growing social awareness. In the year 1970 some companies chalked out their own environmental audit system. The primary object of such audit was to provide management with the ready analysis of environment management performance on a day-to-day basis, it's strengths and weaknesses, modifications required and equipping it for a better overall control.

There are three essential phases in environmental audits, Pre-audit activities, On-site audit and Post-audit activities. The object of

pre-audit activities is to prepare an audit team to operate at maximum efficiency. It includes selection and priorities of site, developing an audit plan which defines the technical and geographical parameters, time and scope of the proposed investigation including background/ baseline information of the plant/project and criteria to be used in evaluation.

The essential elements of the on-site audit are an inspection of the operation facilities and interviews with the staff. It includes

(1) Identifying and understanding management control systems,

(2) Assessing management control systems,

(3) Gathering audit evidence,

(4) Evaluating audit findings and

(5) Reporting audit findings

The Post-audit activities involve preparation of draft and final report, and development of action programme. The process involves

(1) Evaluation of the equipment and it's performance, including emissions and effluents,

(2) Listing of all environmental, health and safety regulations with which the industry has to comply,

(3) Evaluation of the adequacy of the licence for the activities currently undertaken at the site,

(4) An assessment of training of personnel regarding operation of the plant, procedures in emergency, use of protective equipment and clothing and adherence to the prescribed standards of environment, health and safety and

(5) Full assessment of the current standards of operation at the site with detailed recommendations.

Environmental audit is a valuable tool providing benefits as follows :

(1) Management tool for information on environmental performance, it's goals and objects.

(2) Safeguard the environment and substantiate compliance with the local, regional and national laws and regulations, and also with the company policy and standards.

(3) Ensures independent verifications, identifies matters needing attention and provides timely warning to the management of potential future problems.

(4) Reduced exposure to litigation and penal action.

(5) Increasing employee awareness of environmental policies and responsibilities.

(6) Evaluation of training programmes.

(7) Identifying potential cost savings including those resulting from waste minimization.

(8) Providing an upto-date environmental data base.

(9) Providing an information base for use in emergencies and evaluating the effectiveness of emerging response.[13]

More details about environmental auditing is given in chapter on Environment Management System in para 7.5.11.

(4) Hazardous Waste (Management and Handling) Rules, 1989

The Ministry of Environment and Forests came out with Wastes (Management and Handling) Rules, July, 1989 under the Environment (Protection) Act, 1986. The main purpose for promulgation of these Rules was for management and handling of hazardous substances.

Guidelines for occupier/generator of hazardous wastes.

The occupier or generator is required to take all the necessary steps for proper handling and disposal of hazardous chemicals. The occupier or generator is also responsible for collection, reception, treatment, storage and disposal of these wastes either himself or through the operator of a facility. The generator is allowed to store a maximum quantity of 10,000 kg (22,000 pound) or a truck load whichever is less of his hazardous wastes on - site for a maximum period of 90 days. They may extend the storage period under unforseen circumstances on case-to-case basis. The occupier/generator may be allowed to store their hazardous wastes only in closed specified

containers in the designated protected areas. Prior approval of the regulatory body is required for this purpose. Labelling of the containers must conform to the guidelines in this regard.

When the hazardous wastes are to be shipped for disposal, it must be done through the use of manifest. This is to track the waste from the point of its production till its final disposal sometimes referred to as 'cradle to grave'. The authorities should ensure that the occupier/generator sends a copy of the manifest to them as soon as the hazardous waste is shipped for ultimate treatment and disposal. The generator of the waste is required to make sure that their waste has been disposed off only in the notified and approved disposal facilities. It is the responsibility of both the Board as well as the generator to inspect the on-site storage areas for proper and safe storage of the hazardous waste.

Guidelines for transportation of hazardous waste.

The Board is required to register the authorised transporters for transportation of hazardous wastes only in the specified transport vehicles. This is required to make sure that the transporters of the waste, such as the drivers and the helpers are trained sufficiently to respond to any spill or any other emergency. The law specifically prohibits import of hazardous wastes for dumping and disposal into the country. However, import of such wastes may be allowed for processing or re-use as raw material. This must be approved by the Board before import of the chemical. Hazardous waste has been categorised into 18 categories as shown in table 7.1.

Table 7.1 Categories of Hazardous Waste

Waste category	Type of waste	Regulatory quantities kg/year
1.	Cyanide wastes	1
2.	Metal finishing wastes	10
3.	Waste containing water soluable chemical compounds of lead, zinc, copper, chromium, nickel, selenium barium and antimony.	10
4.	Mercury, arsenic, thalium and cadmium bearing wastes	5
5.	Non-halogenated hydrocarbons incl. solvents	200
6.	Halogenated hydrocarbons incl. solvents	50
7.	Wastes from paints, pigments, glue, varnish and printing ink	250
8.	Wastes from dyes and dye intermediates containing inorganic chemical compounds	200
9.	Wastes from dyes and dye intermediates containing organic chemical compounds	50

(Contd.)

(Table 7.1 Concld.)

Waste category	Type of waste	Regulatory quantities kg/year
10.	Waste from oil and oil emissions	1000
11.	Tarry wastes from refining and tar residues from distillation or pro-lytic treatment	200
12.	Sludges from treatment of waste-waters containing heavy metals, toxic organics, oils emulsions, spent chemical, incineration ash	*
13.	Phenols	5
14.	Asbestos	200
15.	Wastes from manufacture of pesticides, herbicides and its formulating units	5
16.	Acid/alkaline/slurry	200
17	Off-specification and discarded products	*
18	Discarded containers, and container liners of hazardous and toxic wastes	*

* *Irrespective of any quantity*

Guidelines for owner/operator of hazardous waste storage, treatment and disposal facility

The Board is required to issue licence to the owner/operator of hazardous wastes management facility for storage, treatment and disposal after having satisfied with their technical, financial and managerial capabilities. Inspection of the hazardous waste storage areas at the generator location are also to be carried out for proper storage facilities and containment systems. The Board has to identify and establish standards for Principal Organic Hazardous Constituents (POHC) for stack emissions from incinerator. Also to monitor the stack emissions, effluent and ground water quality regularly. Each hazardous waste management facility must have an approved emergency/ contigency plan which must have been duly approved by the Board. The Board has to check the records of the facility periodically, such as the waste deposited, and the mode of disposal, such as incineration, landfill, etc. The owner/operator should indicate the proposed treatment and disposal scheme to be followed for the hazardous waste.[14]

(5) The Public Liability Insurance Act, 1991

Purpose of this act is to provide for public liability insurance for the purpose of providing immediate relief to the persons affected by accident occurring while handling any hazardous substance and for matters connected therewith or incidental thereto. The Act defines an 'accident' as 'involving a fortuitous, sudden or unintentional occurrence while handling any hazardous substance resulting in continuous, intermittent or repeated exposure to death of or injury to, any person or damage to any property but does not include an accident by reason only of war or radio-activity.

For the first time, this Act holds the owner

liable for death or injury to any person, damage to any property resulting from an accident. The 'claimant shall not be required to plead and establish that the death, injury or damage in respecf of which the claim has been made was due to any wrongful act, neglect or default of any person. Only workman has been excluded from this Act as he is covered under the Workmen's Compensation Act. This insurance is required within a period of one year. Penalties for not taking this insurance are heavy. This act provides for immediate relief in case of death or injury to be paid immediately. This amount is payable by the insurance coverage of the spiller or the company where the accident has occurred. Additional compensation, if any, will have to be settled through the court.

(6) Indian Forest Act, 1927

As per this Act the forest area can be grouped in three categories reserved forest, village forest and protected forest. This Act empowers the State Government to constitute any forest land or waste land as reserved forest which is Government property or it has proprietary rights or entitlement to the whole or part of the forest produce of that land. Village forests are those reserved forest assigned to a village community for fulfilment of their requirement of timber and other forest produces by the State Government. State Government can also constitute any forest land or waste land as protected forest which is a property of Government but not included in reserved forest.

Note : Forest area so constituted is not to be used for mining and allied activities (includes waste disposal site) without prior approval of Central Government.

In addition to these legislations in India, which seeks to prevent degradation of the environment including land degradation arising out of mining operations are

A. Mines and Minerals (Regulation and Development) Act, 1957
B. Wild Life Protection Act, 1972
C. Water Act, 1974
D. Water Cess Act, 1977
E. Forest (Conservation) Act, 1980
F. Forest (Conservation) Rules, 1981
G. Air (Prevention and Control of Pollution) Act, 1981
H. Water (Protection) Act, 1986
I. Mineral Conservation and Development Rules, 1988

(7) State Forest Acts

Many State Governments are also having their own Forest Acts on the lines of the Indian Forest Acts.

7.2.2 Mining Laws

The law discussed above do not fully address to the specific provisions about the conservation of environment pollution control and land reclamation in mining areas. This is only with the amendment of Mines and Minerals (Regulation and Development) Act, 1957 that an express provision was made with regard to the above aspects in mining areas.[15]

It can be observed that MMRD Act, 1957 (Prior to Amendment) provide for Central Government rule making power under clause 12 of section 13 and it is also mentioned that the rules may provide for disposal or discharge of any tailings, slime or other waste products arising from any mining or allied operations within lease area. When we examine the corresponding provisions in the Mineral Concession Rules which governs the grant of PL or ML, we find that there is hardly anything about the conditions mentioned in the Act concerning the pollution. However, other provisions regarding felling of trees, restriction of surface operations in any prohibited area, reserved or protected forest have been made.

Further, if we look into the bindings of Mining lease deed, certain restrictions and conditions are prescribed in part III pertaining to the erection of building and use of certain land, changes in land use pattern, entry into reserved forest and cutting down or injuring any tree or timber in said land. But again we find that these restrictions are not absolute in nature and a prior permission of competent authority excepting in a few cases will take care of these restrictions.

Thus it becomes very evident that the said provisions do not seem to be adequate to protect environment and check pollution (including land degradation). Moreover, there were hardly any provisions for abatement measures and Land reclamation. In context of the above MMRD Act was amended in July 1986, the Mineral Concession (Amendment) Rules, 1987 was notified on Feb 10th, 1987 and Mineral Conservation and Development Rules, 1988 on Oct. 24th, 1988.

Under the perspective of these new amendments it has now become obligatory to take all the precautions to protect the environment and control of pollution during the various operations conducted by the holder of prospecting licence or mining lease and also for restoration, reclamation and rehabilitation of land affected by prospecting or mining operations. Under section 4 A (1) of the MMRD Act, 1957 the Government has also assumed the power to terminate PL or ML prematurely in the interest of natural environment, flood control measures, prevention of pollution, (which includes land degradation also) public health and communication and safety of buildings, monument or other structures.

After the amendment, the conditions for grant of PL and ML as laid down in section 5 (2) is as follows :

No mining lease shall be granted by the State Government unless it is satisfied that (only relevant portion is reproduced below):

There is a mining plan duly approved by the Central Government for the development of mineral deposits in the area conserved. The Government of India, vide it's order No. SO. 445 (E) dt. 28/04/ 1987 authorised certain officers of IBM to exercise the powers for approving the mining plans.

This is a very significant amendment in the principal Act and to achieve the objectives necessary amendments in the Mineral Concession Rules, 1960 were also made.

As per these amendments every application for the grant or renewal shall accompany a duly approved mining plan by the Central Government. This mining plan includes proposal for land reclamation also.

Besides geological, mining and other details it should contain the following environmental aspects

Assessment of impact of mining activity on forest land surface and environment including land degradation.

Details of scheme for restoration through afforestation and other means.

Land reclamation.

Use of pollution control devices and such other measures as may be directed by the Central or State Government from time to time.

Information regarding nature and extent of land chosen for dumping overburden waste and tailings i.e. type of land etc. and nature of waste.

Several deletions and additions were also made in Rule 27 of M.C.R, 1960 regarding the environmental aspects in case of every mining lease. Some of the significant additions is sub clause (s) to Rule 27 reads as

The lease shall

(i) take immediate measures for planting in the same area or any other area selected by the Central or State Government not less than twice the number of trees destroyed by reasons of mining operations.

(ii) look after them during the subsistence of the lease after which these trees shall be handed over to the State Forest Department or any authority nominated by the Central or State Government.

(iii) Restore to the extent possible other flora destroyed by the mining operations. Similar is the provision under Rule 41(2) of MCDR, 1988.

Under clause 11 (c) of the mining lease agreement the lessee shall take measures for the protection of environment like planting of trees, reclamation of land, use of pollution control devices and such other measures as may be prescribed by the Central and State Government from time to time at his own expenses.

The section 18 of the principal Act has also been amended. In the sub section (1) of the said section the words " for the conservation and development of minerals in India", have been substituted by "for the conservation and systematic development of minerals in India and for the protection of environment by preventing or controlling any pollution which may be caused by prospecting or mining operations."

As a result of the significant changes in section 18 of the principal Act which empowers the Central Government to make rules for conservation and development of minerals, the Central Government made new MCDR, 1988 and notified it on October 24, 1988. The MCDR, 1988 contains a chapter on environment. The important relevant provisions of this chapter are as follows:

The terms "Environment", "Environmental

pollutant" and "Environmental pollution" have the same meaning while dealing in MCDR, 1988 as defined in the Environmental (Protection) Act, 1986. As per this Act -

i) "Environment" includes water, air and land and the inter relationship which exists among and between water, air and land and human beings, other living creatures, plans, micro-organism and property,
ii) " Environmental pollutant" means any solid, liquid or gaseous substance present in such concentration as may be or tend to be injurious to the environment,
iii) "Environmental pollution" means the presence in the environment of any environmental pollutant.

Under the Rule 3, of MCDR, 1988, it has now been made obligatory for every holder of PL or ML to take all possible precautions for the protection of environment and control of pollution while conducting prospecting, mining, beneficiation or metallurgical operations in the area.

Rule 32 stipulates for the storage and utilisation of top soil. The top soil which is excavated during prospecting or mining operations is generally thrown along with other waste rock, hence does not become available for restoration/rehabilitation of the area. It has, therefore, been provided in this rule that every holder of PL and ML shall remove the top soil separately, utilise for restoration or rehabilitation of land or store it in a separate heap for future use since it is necessary for land reclamation and rehabilitation. It is not only the storage but the top soil should also be vegetated to maintain humus and fertility of the soil. The vegetal cover on the top soil will also help in checking it's erosion or escape during monsoon.

The effective storage of overburden and waste rock etc. has been dealt in Rule 33. Since, insufficient care taken for the dumping and storage of different types of solid wastes generated during mining operations were resulting in environmental hazards, land and stream pollution and adverse impacts on mineral conservation, so it has now been made obligatory that the overburden, waste rock, rejects and fines generated during prospecting and mining operations as well as tailings, slimes and fines produced during sizing, sorting and beneficiation or metallurgical operations should be stored in separate dumps. Further, it has also been provided that these dumps shall be properly secured to prevent escape of material there from in harmful quantities which may cause degradation of environment and to prevent cause of floods. Providing of vegetal cover or afforestation may be most effective way to prevent the escape of material.

Regarding the site selection for dumps, tailings and slimes the provision under sub clause (3) states that such a site should be as far as possible on an impervious ground to ensure minimum effects of leaching due to precipitation. It is very significant in respect of materials containing toxic substance such as sulphide ores. Where such an impervious surface is not available the same may be provided artificially to prevent the percolation of leachates below the subsurface & subsequent seepage to the water table/bodies and aquifers etc.

Sub clause (4) of this rule states that overburden/waste rock etc should be back-filled into the main excavations to the maximum extent possible in order to restore the land to its original form and use as far as practicable. Such a practice will reduce the demand of land for storage and subsequent environmental degradation. Subsidence, in case of underground mines can be minimised by backfilling of worked out stopes with the waste rock.

This is also very obvious if the dumps are left unattended without any treatment or vegetal cover they will become the source of persistent pollution. So Sub Rule 5 says that the waste dumps should be suitably terraced and stabilized through vegetation or otherwise. Such measures should be started right from the beginning of the dumping so that the escape of material, if any, may be checked in the initial stages itself. There are a number of modes of rehabilitation of dumps during the course of dumping and the most suitable one can be undertaken.

The sub clause 6 provides for disposal of fines, rejects, tailings from mines, beneficiation or metallurgical plants in a suitable way so as not to cause land degradation or damage to agricultural field, pollution of surface water bodies and ground water or cause floods due to their flow. It would mean that a proper tailings pond of suitable design on an impervious ground should be constructed to arrest the flow and store the fines. This will also give the chance to the suspended material to settle down or it's treatment to make it suitable for reuse or final discharge to the water streams.

It has now been made obligatory under the Rule 34 that every holder of PL or ML shall undertake the phased restoration and rehabilitation of lands affected by prospecting or mining operations and shall complete this work before conclusion of such operations while earlier there was no attempt on the part of licensee or lessee to restore or rehabilitate the land disturbed, damaged or occupied by mining or ancillary operations.

For control of surface subsidence Rule 36 stipulates that the stopping method of an underground mine should be such so as to keep the surface subsidence minimum to avoid land degradation.

According to the Rule 45 in connection with restoration of flora it is now obligatory for lessee to protect the flora of the area held under PL or ML as well as of the nearby area and in case it becomes necessary to fell trees from the area then the lessee will have to plant twice the number of trees destroyed by him in the same area or in other area. He has also to look after them during subsistence of the lease, after which these trees shall be handed over to the State forest department or any other authority as may be nominated by the Controller General, Indian Bureau of Mines or the authorised officer.

7.3.0 Status of Indian Mines

In India, the trend of reclamation though started with a slow pace but soon all the concerned started responding positively. Mine ownership whether Govt. or private has acquired good knowledge and experience in the field of mine restoration, rehabilitation and reclamation. Government too responded very positively by amending and bringing new legislations to minimise & control the adverse impact on environment due to mining. A complete statutory framework has been provided to safeguard/ repair the environmental aspects.

IBM too is contributing through its various agencies while enforcing the concerned laws in the Indian mines. IBM has gained success in inspiring mine ownership to achieve exemplary goals in the area of environmental protection & restoration. Every year Mine Environment and Mineral Conservation Week is being celebrated in different mines in India under the flagship of IBM. The ever-increasing response and data shows an all round improvement in the area of Reclamation in Indian mines.[16]

Table 7.2 : Reclamation Status in Indian Mines

Name of mine with lease area	Mineral worked	Mature Land availability for reclamation	Degradation of land	Land reclaimed	Cumulative plantation		Protection measure & special features
					Area(ha.)	No's	
Dehradun Region							
1. Manal mine (C.C.I.) LA. 794 ha.	Limestone	155307 (1995-96)	26 ha.	15 ha.	31.5 ha.	51000	Construction of check dams & retaining walls
2. Kashlog mine (Guj. Ambuja Cement Ltd.) LA. 488.06 ha.	Limestone	950474 (95-96)	10.5 ha.	--	14.9 ha.	41740	Check dams, check filters parapet walls constructed, regular monitoring of air, water noise pollution & ground vibration.
3. Gagal mine (A.C.C. Ltd.) LA. 265.97 ha.	Limestone	1922680 (95-96)	22 ha.	10 ha.	17 ha.	700000	Use of sequential blasting machine to control ground vibration.
4. Malla mine (A.C.C. Ltd.) LA. 327.40 ha.	Limestone	177685 (95-96)	87 ha.	--	89 ha.	338000	Retaining wall, garland drain, garland parapet, check dams construction.

(Contd.)

Table 7.2 (Contd.)

Name of mine with lease area	Mineral worked	Mature Land availability for reclamation	Degradation of land	Land reclaimed	Cumulative plantation		Protection measure & special features
					Area(ha.)	No's	
5. Jhiroli mine (Himalaya Magnesite Ltd.) LA. 53.20 ha.	Magnesite	20416	35 ha.	19.73	19.73	50,000	Check dams & retaining walls. FIMI award in 1993.
6. Dharapani mine (Himalaya Magnesite Ltd.) LA. 219.04	Magnesite	15525	11 ha.	-	5.8	6000	Check dams & retaining walls.

Name of mine	Mineral worked	Production (Year) (tonnes)	Lease area (ha.)	Matured Land availability for reclamation	Land recla-imed	Cumulative plantation		Protection measure & special features
						Area (ha.)	No's	
7. Chandak mine (magnesite & minerals ltd.)	Magnesite	11225 (95-96)	513.68	N.A.	3	18	20000	Check dams, retaining walls etc.
8. Gothra mohabtabad mine	Silica sand	26064 1462039 (ordinary sand)	296	30	2.3	14.81	18000	Plantation on dumps
9. Maldeota mine (M/s. P.P.C.L.) Underground	Rock phosphate	68,000	84.579	--	--	17	200500	Check dams, Settling tank for treatment of mine effluents
10. Durmala mine (M/s. P.P.C.L.) Underground	--	50,000	137.98	3.062 (Opencast working)	--	12	150000	--

Note : The common variety of trees in the above mines are Tun, Shisham, Gulmohar, Poplar, Mango, Khair, Kikar, Jamun, Neem, Silver Oak, Pine, Ritha.

Name of mine	Mineral worked	Production (Year) (tonnes)	Lease area (ha.)	Matured Land availability for recla-mation	Land recla-imed	Cumulative plantation		Protection measure & special features
						Area (ha.)	No's	
Hyderabad Region								
1. Zuari mine (Zuari Cement)	Limestone	--	1022.56 (acres)	3 acres by waste dumps	--	30 acres	3000 70% survival	Noise, dust and illumination survey studies of blast vibrations.
2. K.C.P. mine Ltd. (M/s. K.C.P. Ltd.)	Limestone	600000 to 100000 sand	161.51 (ha.)	--	--	7 ha.	7000 18000 (Colony area) 90% survival	Properly located waste dump for plantation. Top black is well protected.

(Contd.)

Table 7.2 (Contd.)

Name of mine	Mineral worked	Production (Year) (tonnes)	Lease area (ha.)	Matured Land availability for reclamation	Land reclaimed	Cumulative plantation		Protection measure & special features
						Area (ha.)	No's	
3. Kakatiya mine (M/s. Kakatia Cements Ltd.)	Limestone	1200 per day	121.4 ha.	--	8	24	30,250 (80%) survival	Proper stacking of sub grade material. Regular air sampling water sprinking on haul roads, Dust collectors being used with drills. Use of SBM and monitoring of mine effluents.
4. Vishnupuram (Wadapalli mine M/s. Raasi Cement Ltd.)	Limestone	600000	528.598 ha.	44.5	--	17.17	5621 9391 (out by lease)	Separate conservation of top soil, water sprinkling, wet drilling studies for ground vibration, Regular monitoring of air, noise & water.
5. Basantnagar mine (Kesoram Cement)	Limestone	10,06,740	360.25	--	--	127	29000 (80-81%) survival	Water sprinkling on haul roads, elector static precipitator in plant.
6. Jaggayyapeta mine (Vishakhapatnam Steel Plant)	Limestone	360000	2195	--	--	70	125950 (51.5%) survival	Development of green area, fully equipped crushing plant with dust extracting system. Regular dust & noise survey.
7. Priyadarshini cement mine (Priyadarshini Cement Ltd.)	Limestone	1000000	252	31.24	--	3,200 M	15000 100000 (Plant colony)	Soil conservation, Separate stacking of subgrade mineral. Reclaimed area converted into fruit garden. Use of dust extractors, use of SBM, water sprinkling. 6 monthly noise survey

Name of mine	Mineral worked	Production (Year) (tonnes)	Lease area (ha.)	Matured Land availability for reclamation	Land reclaimed	Cumulative plantation		Protection measure & special features
						Area (ha.)	No's	
Nagpur Region								
1. Malanjkhand copper mine (M/s. H.C.L.)	Copper	2027000	479.898	--	--	20.24	50,500 11,390 (out of lease) 85% survival	
2. Rajhara iron ore mine (M/s. B.S.P.)	Iron	2158000	241.76	5.2	--	30.00	75,000	

(Contd.)

Table 7.2 (Contd.)

Name of mine	Mineral worked	Production (Year) (tonnes)	Lease area (ha.)	Matured Land availability for reclamation	Land reclaimed	Cumulative plantation		Protection measure & special features
						Area(ha.)	No's	
3. Dalli Mech. iron ore mine (M/s. B.S.P.)	Iron	3422000	813.19	5.2	--	21.0	53,570	
4. Bailadiala iron ore mine Dep. No. 5 (M/s. N.M.D.C.)	Iron	5558000	672.25	--	--	20.39	42,000 800 (outside lease) (90-95%) survival	
5. Bailadiala iron ore mine Dep. No. 14 & 11c (M/s. N.M.D.C.)	Iron	6656000	2763.662	18.0	18.0	30.00	50,000 (90%) survival	Bio mass generation on waste dump & contour bunding
6. Jamul mine (M/s. A.C.C. Ltd.)	Limestone	525000	269.950	7.875	7.875	10.0	5000 4800 (outside lease (95 to 98%) survival	Well developed picnic spot.
7. Raymond cement mine (M/s. Raymond Cement)	Limestone	1743000	521.887	0.80	0.39	10.20	40,580 2,630 (outside lease) 100% survival	
8. Chikla manganese ore mine (M/s. MOIL)	Manganese	91100	155.67	2.7	1.93	1.93	64% survival	
9. Ukwa manganese ore mine (M/s. MOIL)	Manganese	50000	132.97	10.24	2.0	5.0	19000 100% survival	Afforestation

(Contd.)

Table 7.2 (Concld.)

Name of mine	Mineral worked	Production (Year) (tonnes)	Lease area (ha.)	Matured Land availability for reclamation	Land reclaimed	Cumulative plantation		Protection measure & special features
						Area (ha)	No's	
Udaipur Region								
1. Gujarat Ambuja limestone mine (M/s. Gujarat Ambuja Cements Ltd.)	Limestone & Marl	2059967 (Limestone) 782215 (Marl)	276.0	N.A.	48.89 ha	25.37 (within lease) 46.43 (outside lease)	53315 40,500 91% survival	98 varieties of different plants, air water & noise survey studies for blast vibrations.
2. Narmada cement limestone mine (M/s. Narmada Cement Co.Ltd.)	Limestone & Marl	1410876	565.93	N.A.	8.0	10.75 (within lease) 73.0 (out of lease)	16,179 136,720 (90-93%) survival	Use of pre splitting and line drilling with deck charging
3. Adityana limestone & clay mine (M/s. Saurashtra Cement Ltd.)	Limestone & Marl	566056 (Limestone) 30414 (Marl)	643.02	N.A.	N.A.	11.10 (within lease) 11.05 (outside lease)	9165 39041 86% survival	
4. Sidhee limestone mines (M/s. Gujarat Sidhee Cement Ltd.)	Limestone	2100000	254	N.A.	NIL	9.2 0.676	11561 (within lease)	
5. Porbandar Cement Works Limestone Quarry (M/s. H.M.P Cement Ltd.)	Limestone	220000	424.28	N.A.	7.67	7.67	7000 (95-98%) survival	
6. Mevasa mine Survey No. 212 (M/s. Carborundum Universal Ltd.)	Bauxite	7344	3.612	0.80	8.84	0.36	75 (70%) survival	

7.3.1 Reclamation : Experience in Indian Mines

(Some Case Studies)

India is a vast country having a land-mass of an area 3.26 million sq.kms with population of around 900 million at present. India is having around 16% of global population but only 2.6% of land mass, thus making per capita land availability much less than any other country in the world. Therefore, the conservation, reclamation and proper utilisation of the land-mass are more essential in India than in any other developing or developed country to sustain. The present forest cover in India is around 12% instead of desired 33%. There are about 10,000 mining leases covering an area of around 7,400 sq.km. It is roughly estimated that the area granted by the State Governments under Minor Mineral Concession Rules and quarry permits may be around 5000 sq.km or so. The area under coal covers may be around 14,500 sq.km. Thus the total lease area comes around 27,000 sq.km including all minerals except oil and this may not exceed 0.82 percent of the total land mass of our country. It has also been observed that only 30 to 40% of the lease area are mineralised and worked and the rest of the area is used for the infrastructures and other purposes. Some of the leases remain dormant or idle which makes the actual disturbed/degraded land mass exclusively due to mining, further less.[17]

It is the constitutional function of the State to protect forests, fauna and flora. It is the constitutional duty of the citizen to cooperate and collaborate with the State. The mining industry is committed to take adequate measures to protect the forests, flora; and an all India movement has already been started to plant trees at the mines site and to stop the degradation of land. Crores of trees have been planted at the mines with a survival rate of 60% to 65% even in adverse conditions like that of western Rajasthan. Unfortunately, due to lack of information and misinformation, mining is being sinned for more than it is damaging the environment in India, as stated earlier mining leases occupy less than 1% of the total land use and only a fraction of these leases really cause degradation. Records show the following alarming rate of depletion of forest areas for reasons other than mining during five years period for which data gathered for the periods from 1972-75 and 1980-82 is as follows[18] :

(a) Punjab and Chandigarh	55.4%
(b) Rajasthan	47.1%
(c) Haryana	47.0%
(d) Gujarat	46.5%
(e) Delhi	44.4%

Compared to this, States like Bihar, Madhya Pradesh and Orissa whose economy depends heavily on mining, forest depletion rates were as follows :

(a) Bihar	11.2%
(b) Madhya Pradesh	16.9%
(c) Orissa	18.5%

It is a known fact that forest and land degradation are being caused on a large scale under pressure of population, dams, reserviors, wood based industries and roads etc. As per the estimates published, out of every lost hectare of forest cover in India

0.71%	is agricultural project
0.12%	is claimed by river valley projects
0.04%	is by new industries
0.02%	is by roads and communications
0.11%	is by other miscellaneous purposes including mining.

Thus it will be observed that out of every one hectare of land lost under forest cover 99% is for purposes other than mining.

It will be most suitable to discuss the work done in the Indian mining industry to safeguard the environment & its restoration in the light of the above facts. In some of the mining areas in India exemplary work has been done towards restoration of environment. Some of them, we will discuss in the form of brief case studies. However, the achievements in the field of Land-restoration only will be discussed.

(1) Neyveli Lignite Corporation Ltd.

NLC is an integrated industrial complex, with two mines, two thermal power stations and two chemical units, situated about 200 km. south of Chennai in an area of 480 sq.km. Presently, NLC's total power generation capacity is 2070 MW and lignite mining excavation capacity is 17 million tonnes per annum[19]. By this an area of about 200 hectares of land is disturbed every year[49].

TARGET EVALUATION FOR RECLAMATION PLAN

Status of the native soil of Mine-I & Mine-II with reference to various vital elements like texture, value of pH, electrical conductivity, colour, fertility status (availability of organic matter, nitrogen, phosphorous, potassium etc.) have been analysed and compared with the status of the soil in the dumping areas of the mines. The details are furnished in the following Table 7.2A with the actions required to be taken to improve the quality of the dump soil.

It is found that the fertility level of the present dumps has to be elevated to nearly five folds by the application of suitable techniques.

During the course of mining for every tonne of lignite about eleven tonnes of overburden are removed. There are four numbers of external dumps, two for mine-I in 330 hectares area and two for mine-II in 100 hectares of land. After initial few years, backfilling was restored to mined out areas. The top-soil usually gets mixed up with the other soils during excavation and the quality of soil in the outside dumps as well as the backfilled areas is completely altered and devoid of any structure without any load of micro flora & fauna. Practically this soil has no nutrients like nitrogen, phosphorous and potassium (N.P.K).

To set the goals for reclamation the Centre for Applied Research and Development (CARD) of NLC determined the fertility status of pre-mined soil through a number of lab analysis which is depicted by the histograms (Fig.7.1).

The various tests conducted in the lab for vital element like texture, pH value, electrical conductivity, colour, fertility status (organic matter & N.P.K.), it was revealed that the fertility level of the present dumps has to be elevated to nearly five folds by the application of suitable techniques.

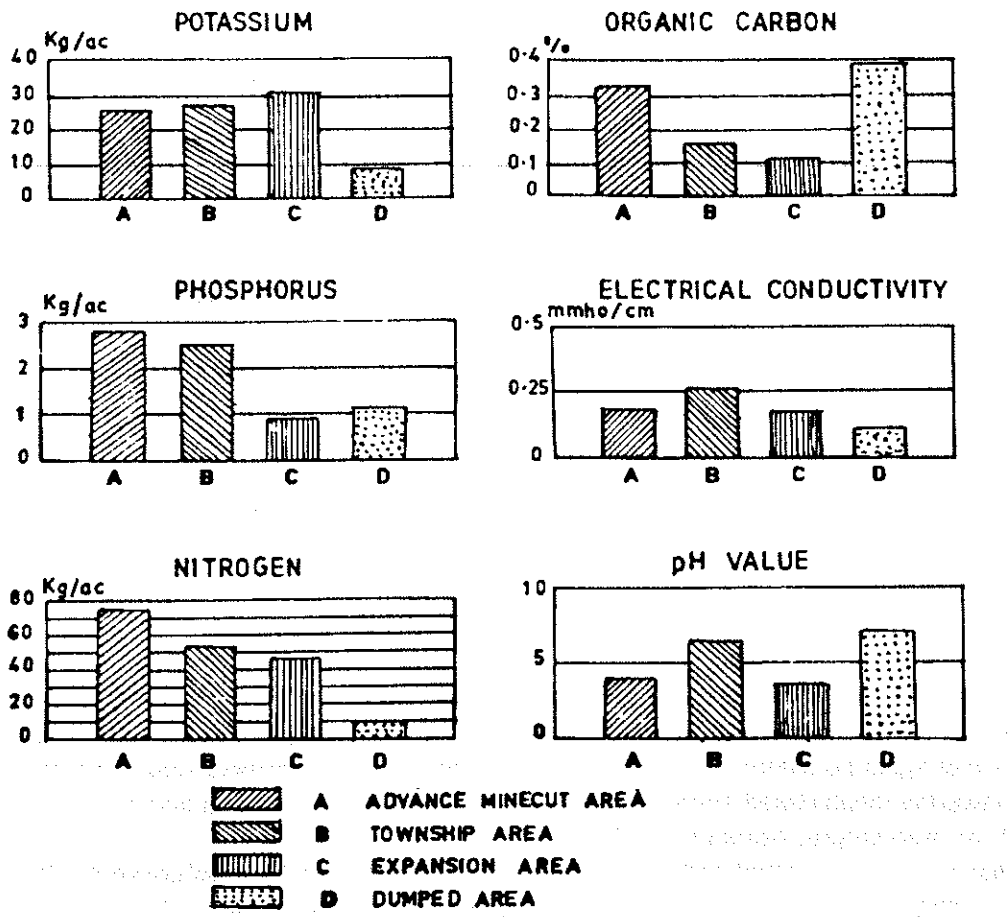


Fig. 7·1 Fertility status of pre-mined soil at Neyveli Lignite Mine

TABLE 7.2 A :TARGET EVALUATION FOR RECLAMATION

Element	Target of status of native soil		Status of dump soil	Remarks
	Mine-I	Mine-II		
Colour	Red	Black grey	Brown, pink	Multitude due to presence of iron
Texture	Sandy Loam	Clayey	Sandy Clay	Plastic with water. Hard when dry. To be improved. Reclamation is necessary
pH value	6.00	8.00	6.20	Tending to be acidic. No harmful effect on plantation
Electrical conductivity m mhos/cm	0.40	0.22	0.08	No harmful effect
Organic matter as 'C' %	0.16	0.18	0.04	Reclamation is necessary
Available nitrogen 'N' kg/ac	63.00	48.50	11.20	Reclamation is necessary
Available potash K_2O kg/ac	29.00	50.00	8.20	Reclamation is necessary
Available phosphorous	2.50	7.00	0.60	Reclamation is necessary
Total Cation exchange capacity in e/100 gm	-	-	7.80	Reclamation is necessary

To overcome the impacts of land degradation it was thought to adopt latest techniques for recultivation of Agricultural/Horticultural Crops, to finally develop the rehabilitated land for productive use such as agriculture, horticulture, forestry, pasture, fish-culture, recreation, setting up wildlife habitats and sanctuary.

Tree species like Eucalyptus, Accacia, Subabul, Bamboo, Vagai, Neem etc. were planted on the dumps, agane was planted on the slopes to check the soil erosion. Apart from this plantation gunny bag method was also practiced on slopes.

In 1988 the idea of converting the mined and backfilled area into agricultural land was mooted, initially for an area of 25 acres. Accordingly, the topsoil was brought from other places and spread

to a thickness of around 30 cms. For soil structure and fertility, ingredients like Sawdust (25 t/ha), Fly-ash (1 t/ha), Gypsum (3 t/ha), Farmyard manure (50 cu.m./ha) and Pressmud (50 cu.m./ha) were applied to the dump soil. In the first instance, 40% of the quality of ingredients required was added and the areas watered and ploughed. Subsequently, "Green manure crop" like sunhemp, daincha, calapagonium etc. were sown. These ingradients were useful in following way.[49]

Saw Dust : This makes the soil more porous. On decay, saw dust develops into a good substructure for holding the moisture giving a good soil texture in course of time. It also acts as a plant protection chemical for controlling the nematode multiplication.

Fly ash : Its high silica (50-55%) helps in the nutrients of the soil. In addition other micro nutrients required for crops like aluminium, sulphur etc. are also available in fly ash.

Press-mud : This waste from sugar factory contains NPK and calcium which helps in the crop growth. In comparision to cattle manure it can be said that press-mud acts as an injection taking cattle manure as a tablet. It also helps in multiplication of micro organism, improving the soil fertility and its texture.

Gypsum : It corrects the pH of the soil along with loosening the same (mine soil is sticky when moist and hard when dry). In turn it helps in making use of the nutrients into available form.

First green manure crop yielded 25 tonnes of Biomass per hectare. The same was ploughed in situ and again 40% quantity of each ingradient was added. The second crop showed a Biomass yield of 33 tonnes per hectare. Again, the crop was ploughed in situ and the third crop was raised by inserting remaining 20% ingradients. The Biomass yield rose to 45 t/ha. Nodules were developed in the roots varying from 180 to 200. The crop was ploughed before flowering and later crops like cereals, paddy, millets, sugarcane and banana were raised.

In order to transform the spoil-banks into suitable lands trails were carried out for reclamation without application of top soil. As top soil application is a laborious and costly process and soil fertility do not retain in long storage, this new experiment was taken up without top soil in 1991.[49] Ministry of coal has sanctioned a co-ordinated Research Project for a period of 4 years with an outlay of Rs. 44 lakhs to CARD and faculty of Agriculture, Annamalai University, under S & T Grant. The research has shown that application of farmyard manure, pressmud, biodigested cowdung slurry, composted coirpith or vermicompost at 20 tonnes/hectare together with the recommended N.P.K., fertiliser, lignite, flyash, gypsum and humic acid, exerted profound influence on the physio-chemical properties of the spoil. The yield of some of the crops is as given below :

	Crop yield	**tonnes/hectare**
1.	Paddy	6.5
2.	Banana	25.0
3.	Sugarcane	115.0
4.	Maize	8.0

In respect of land reclamation, it has been programmed in such a manner that every year, the area available through backfilling will be taken up for the above task in which, agriculture, horticulture and forestry programmes will be taken up in equal proportions, by adopting the reclamation techniques evolved. A tie-up arrangement has also been proposed for the cultivation of sugarcane every year in 100 acres of mines spoils and supplying the produce to sugar mills.

An attempt to grow grass on the dumped slopes was made with almost 100% success. The gradient of slope was maintained at 25° and it was pretreated with top soil application of silt from sewage, fodder, etc., for improving the fertility. The grass species used are Brachieria, Multicacynodon Dactylon, Panicum maximum, Echinocholona-sp etc.

Consequent upon the efforts made to evolve/ adopt the latest technologies of land reclamation the soil fertility status of afforested area improved considerably. The results are shown with the help of histograms Fig.7.2.

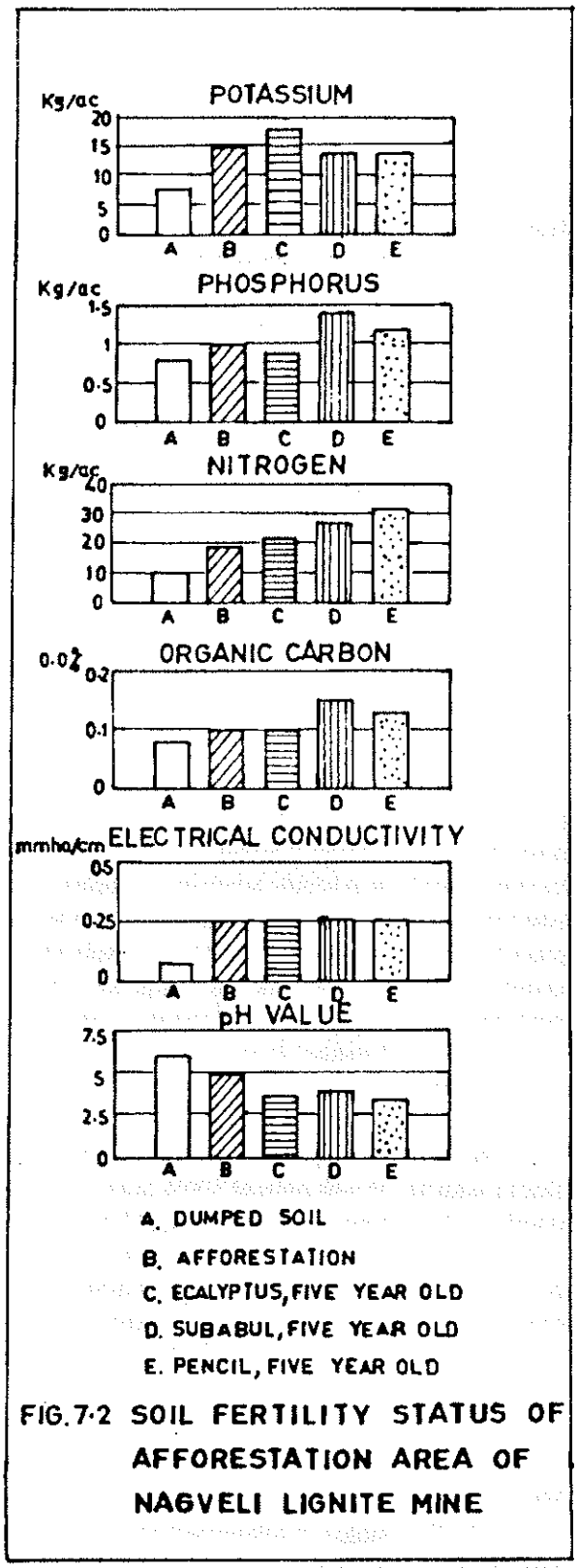


FIG. 7·2 SOIL FERTILITY STATUS OF AFFORESTATION AREA OF NAGVELI LIGNITE MINE

It is an important factor that the concept of reclamation was given due importance at the project formulation stage in N.L.C. even at a time when the environmental awareness in Indian mining scene was at primitive stage. The modified land use pattern due to environmental activities in Neyveli mining area in 1995 was as follows :

Land use pattern	Pre-mining stage	Post-mining stage
1. Forestry	1.91%	30%
2. Agriculture	65.66%	40%
3. Pasture land	0.24%	20%
4. Waste land & others	29.63%	10%

In addition this reclamation has also resulted in the following [49] :

(a) Creating breeding and multiplication atmosphere for migratory birds. More than 70 species of migratory birds have been identified.

(b) Fish culture

(c) Honey production due to different variety of seasonal flowering plants.

Jabalpur Region

This region consists of about 800 leases spread over 18 districts of Madhya Pradesh and 7 districts of Uttar Pradesh. Out of them about 300 mines are working mines. It can be seen from the figures obtained as on 01/04/1996 around 26 lakh trees have been planted covering about 1345 hectares, of area which is around 8% of total lease area. As good as 69% trees are planted within the mining lease area whereas 31% are outside the lease area. The rate of survival achieved is upto 86.7%. The total area reclaimed is about 478 hectares and around 412 hectares of which has been rehabilitated too.[20]

11,532 hectares of area is under the leaseholds of mechanised mines out of which about 5720 hectares is mineralised. 1642 hectares fall in forest land which consists 14.3% of total lease area. The acquired area comes around 52% (5980 hect.) of the total lease area. As per the information obtained about 20 lakh trees have been planted in 1116 hectares which is about 9.7% of the total lease area. 63% plantation has been done in lease area. The rate of survival is as high as 90%. The area covered by the waste dumps is over 281 hectares

(about 2.5% of total lease area). 71% of the total waste dumps are duly stabilized. Approximately 60% of the total top soil (72 lakh/m^3)scrapped is used for plantation and reclamation. 373 hectares of the area has been reclaimed and 90% of it has been rehabilitated.

Upon compilation of the information received from the semi-mechanised and manual mines it is revealed that a total of 5.39 lakh trees have been planted over an area of 226.4 hectares which is about 5% of the total leasehold area (4506 hect.) The rate of survival achieved is around 73%. The waste dumps spread over an area of 159 hect. which consists of 3.52% of lease area. About 60% of such dumps have been stabilised out of the matured area 105 hectares have been reclaimed and 75% of which has been partially/fully rehabilitated.

(2) Jaypee Rewa Cement

There are two mechanised captive limestone mines for cement plants of M/s Jaypee Rewa Cement covering 4 leases of about 990 hectares. Both the mines are fully mechanised opencast mines. Thickness of topsoil varies from nil to 3 m in these mines. This is stripped & stacked separately on non-mineralised barren area. The assessment of work done towards reclamation and rehabilitation is tabulated as under :[21]

Table 7.3

Total lease area (hect.)	Area exploited (as on 1.4.96) (hect.)	Area reclaimed/ rehabilitated (hect.)	Area occupied by dumps (hect.)	Dumps stabilised (hect.)
990	77.25	31	8.5	6.5

The status of plantation as on 1.4.96 is as under :

Within lease area			Outside lease area		
Trees planted	Area occupied (hect.)	Survival rate	Trees planted	Area occupied (hect.)	Survival rate
74,000	20.25	100%	3,63,000	74	100%

(3) Sagmania Limestone Mines

Sagmania Limestone Mines of Satna Cement Works of M/s. Birla Jute & Industries Ltd. is located at village - Sagmania, tehsil - Raghurajnagar, distt. Satna (M.P.). The total lease area is 10 sq.km. It was started in 1957 and presently production from this mine is 7500 tonnes/day.[22]

It is fully mechanised opencast mine being worked with two benches at present. The height of first bench is 9-10 m and the second bench is 5-6 m high. The average thickness of overburden is 3 metres (2 m black cotton soil & 1 m high magnesia limestone).

Land degradation in general varies from 7 to 9 hectares annually. Average production is around 2.5 million tonnes and around 1 million tonnes of overburden is handled per year. Till date around 175 hectares of area has been degraded.

The overburden black cotton soil is dumped all along the mining lease boundary line and other places in order to make mounds of 5-6 m height for arresting all types of environmental pollution. The black cotton soil is also stacked in dump yards. Also the black cotton soil is used during final backfilling phase for further plantation over it in order to rehabilitate the area. High magnesia limestone is dumped in dump yard and used to form the strong base during the initial phase of backfilling.

Extensive plantation programme has been chalked out in non potential zone, residential area and all around the mining lease area. Dumps are properly rehabilitated by plantation and are provided with garland drains. Excavated area is being backfilled and remaining part will be converted into water reservior. The environment management status is as below :

Table 7.4

Description	1991-92	1995-96
Planted area (hect.)	43.34	70
No. of trees planted	56683	127851
Plantation outside lease (hect.)	104	124
Trees planted outside lease	89600	164851
Area occupied by dumps (hect.)	37.43	60.71
Area stabilised (hect.)	30	58.6
Top soil generated (m^3)	176000	51945
Top soil utilised (m^3)	150000	51945
Area matured for reclamation (hect.)	30	57.5
Area reclaimed (hect.)	25	56.05
Area rehabilitated (hect.)	3	55.55
Subgrade mineral generated (tonnes)	232885	588245
Subgrade mineral utilised (tonnes)	32885	588245

Some Case Studies from Nagpur Region

(4) A Case Study on Bauxite Mine

The above bauxite mine is located in Sahyadri range of western ghats with a beautiful landscape. The terrian is rugged and the deposit is on a plateau top raising to about 990 m above MSL. Nallahs/tributaries are flowing down in the valley portion which ultimately joins into the water reservior, located 3 kms from the plateau.[23]

The major portion of the area is covered with laterite and bauxite. However, at places, thin and scanty soil cover is also present. The mine has been planned for an annual production of 6.60 lakh tonnes of bauxite with a generation of around 5 lakh tonnes of waste. Due to non availability of sufficient barren area over which the waste can be dumped. It is planned to have a sequential block extraction so that the waste generation in one block can be stacked over the other block till the simultaneous backfilling operation in the mined area of the pit can be started. The planned life of mine is about 10 years.

Environmental Status before Mining

As per the survey conducted the quality of air within the 10 km radius of rural areas is well under prescribed norms of ISI. The ground water level is at 60 m below the surface. The nallahs are seasonal and water flows during the rainy season only. The water analysis of streams and ground water shows that it is as per prescribed norms except that the ground water from some of the wells in nearby villages contain high contents of suspended particles.

Environmental Impacts of Mining

As a result of mining a large excavation of about 12 m depth covering about 60% of the plateau will be formed. Only about 33% of the affected area is estimated to be backfilled creating a large reservoir covering about 60 hectares of land. No major activity like construction of colony is proposed so far hence the land degradation by mining is about 20% of the total lease area. Since the ground water occurs below 80 m depth from the plateau top

and mining is proposed upto a depth of 12 m which will not disturb the impervious clay layer existing at bottom. There is no effect anticipated on ground water. There is an anticipation of marginal increase in the airborne dust in sanctuary area and nearby villages.

Protection Measures

The topsoil removed will be properly stacked with terracing and retaining wall. To retain/improve the soil quality, plantation of legumes and grasses over these dumps has been proposed. Designs of waste and subgrade dumps have been made based upon their rock mechanics properties and the overall safe slope angle at 27°. Surrounding the waste dumps, a retaining wall has been designed. Garland drains of adequate size, to carry the precipitated water as well as the run off/wash off, are designed. Settling tanks of adequate size are also designed to remove the solid suspensions before discharge. Further to check the siltation several check dams are also provided.

(5) Afforestation of Pathariya Limestone Mine

Pathariya limestone mine is located in Durg, Madhya Pradesh. The total lease area is 73.89 hectares. The soil, one of the main requirement of vegetation to grow and survive, is almost absent at Pathariya mine. However, a soil cover of meager thickness varying from 0.2 m to 0.5 m is existing at southern side of lease. The available soil has been dumped within 7.5 m of mining lease boundary. Plants like Eucalyptus, Acacia, Subabul etc. are planted on the bund. The green belt thus developed, does not only enhance asthetic beauty but also arrest dust and noise if emanate from working places.

Pathariya mine has not yet reached it's final depth. Since complete reclamation is not possible at this stage so the final face of top bench is covered with alluviam soil which is around 1 m thick at the bottom and about 0.3 m at the top. Suitable saplings like Tacoma, Lantena Drift, Bamboo have been planted. Saplings so planted are growing in natural way. The total area covered is 150 sq.m. with 153 saplings. To grow the plants on the final bench 1.5 m deep holes with 110 mm diameter were charged lightly with explosive & 25% black cotton soil mixed with sand used as stemming. After blasting these holes to create cracks in the rock the saplings like Neem, Peepal, Subabul, etc., were planted on the stemming material in the bore holes. Suitable, surface irrigation system was provided. The water trickling down the hole carry soil with it & fills the larger cracks which accommodate roots to anchor the plant. With the help of minute cleavages the active roots draw air & water. Periodical application of fertiliser and proper monitoring helps saplings to grow and lead normal life (Fig 7.3).

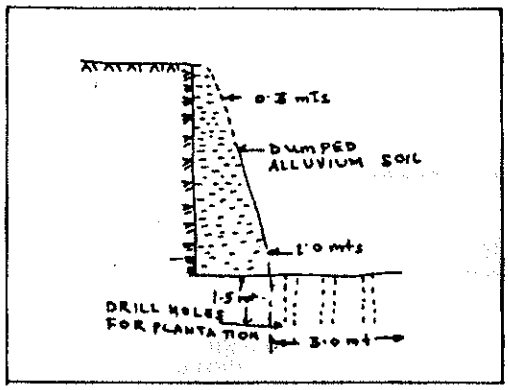


FIG.7.3: PARTIAL RECLAMATION OF FINAL FACES AT PATHARIYA LIMESTONE MINE

In order to make plantation more effective, educative and useful, a tiny garden named as "Aushadhi Udyan" has been developed. About 70 different types of trees, plants, shrub, herb, etc. with medicinal values are planted. The ready information about these plants is displayed in front of each such plant.

Pathariya mine has introduced earthen pitcher system of watering. These pitchers with a water holding capacity of 4 to 5 litres have a 4 mm diameter hole at the bottom and a 15 cm long coir string is inserted through that hole when filled with water this string allow water to drip directly into the roots of plants thus saving a lot of water.

Densely afforested area developed at the north periphery of lease has provided safe, secured and permanent habitat to local wild rabbits, cats, foxes etc, The extensive pond developed has become breeding place for fish and other aquatic creatures. Birds of various species have started coming which include seasonal overseas birds.[24]

(6) Manganese Ore (India) Limited

MOIL produces about 0.6 mt manganese ore annually contributing 30% towards countrywide production and catering upto 65% of requirement of high grade ore for domestic ferro-manganese industry. The following table gives an idea of mining activities of MOIL.

Table 7.5 : Mining activities of MOIL

Location of mines	Total Lease area (hectares)	Form of mining	Area under waste dumps (hectares)
Maharashtra			
Beldongri & Satuk	230.80	Underground & Opencast	18.24
Chikla	282.70	Underground	38.73
Dongribuzurg	170.70	Opencast	50.15
Gumgaon	53.60	Underground	6.38
Kandri	90.90	Underground	27.90
Mansar	149.60	Opencast	17.80
Madhya Pradesh			
Balaghat	183.09	Underground	44.00
Sitapatore & Sukli	153.30	Opencast	46.39
Tirodi	523.80	Opencast	131.91
Ukwa	306.40	Underground	4.90

In 1987, systematic scientific approach was initiated to evaluate the physico-bio-chemical properties of mined lands and spoil dumps along with technological intervention, through an integrated biotechnology to achieve appropriate eco-system restoration. Research indicated need for development of supportive and nutritive rhizosphere through appropriate blending with pressmud, isolation of endomycorhizal fungi and inoculation of plants for profuse root development, development of specialised cultures of biofertilisers and establishment of soil plant microbial ecosystem and also restoration of carbon and nitrogen in degraded lands.[25]

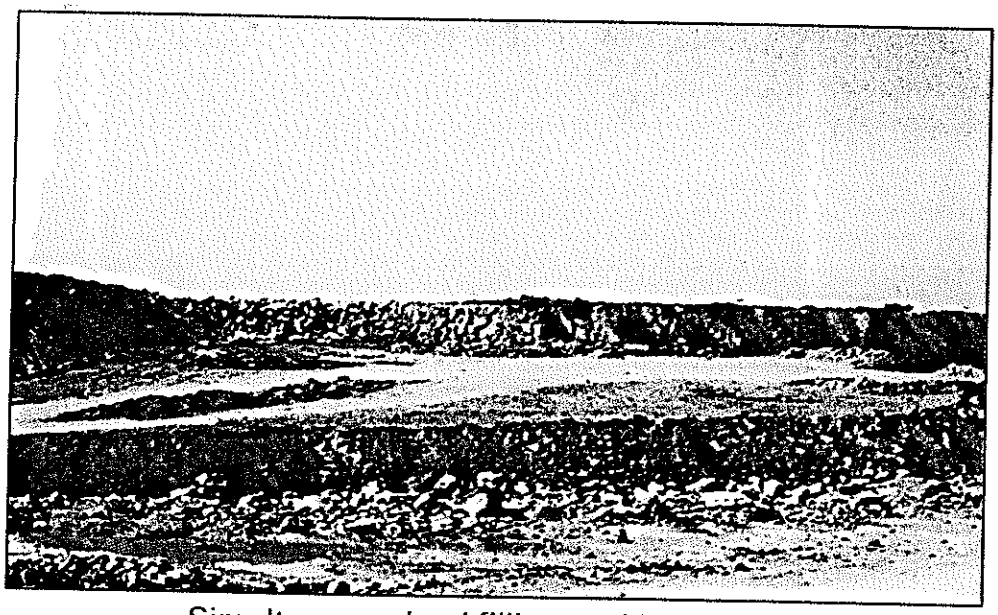
Phytoreclamation

This technology consists of specially blended organic waste in the form of solid waste from industries coupled with inorganic fertilisers like N.P.K on the surface of the dumps. Use of biofertilisers like Rhizobium, Azotobactor, Azospirilium, Phosphate solubilisers and microrrhizae is more beneficial in place of chemical fertilisers. This improved the fertility and water holding capacity of top soil in a very short period of time to sustain the vegetation cover.

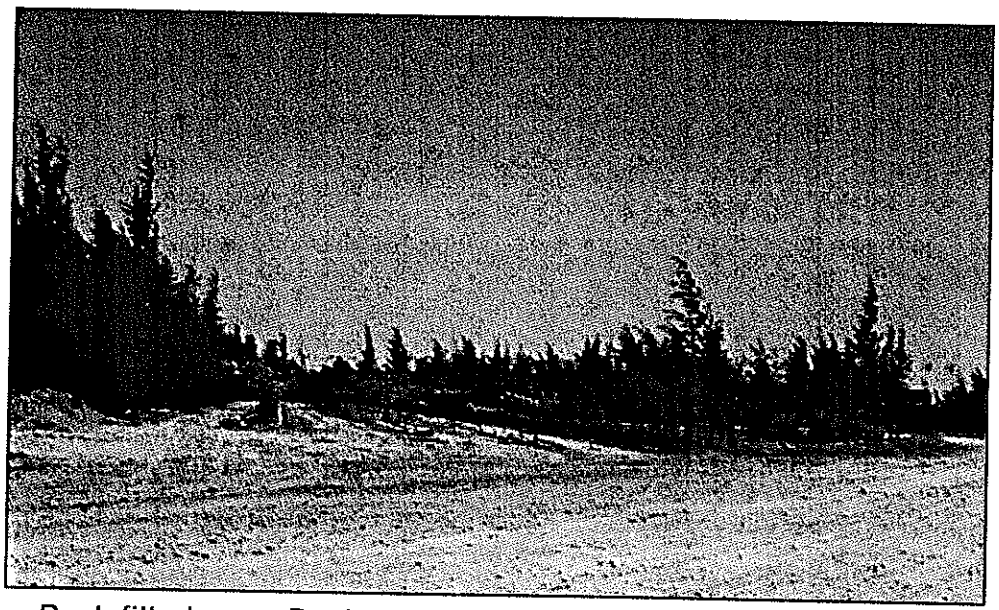
Integrated Biotechnological Approach (IBA)

This approach of IBA is a systematic procedure towards scientific reclamation of mine spoil dumps which includes :

Co-recycling of mine spoil with a sugar mill waste as pressmud. It helps to resolve waste disposal problems and the organic waste provides suitable substance for proliferation of soil microflora.



Simultaneous backfilling and levelling at
Naubasta Limestone Mine of M/s Jaypee Rewa Cement.



Back-filled area. Reclamation and Rehabilitation at Narmada
Cement Limestone Mine of M/s Narmada Cement Co.Ltd.

It involves inoculation of plants with specialised cultures of Endomycorrhizal fungi of Glomus sp. and biofertilisers like Rhizobium and Azotobactor for improving module formation. No ground water pollution was observed due to leaching. The micro organisms secrete hormones, etc. which help to improve plant establishment and growth.

Ecological cycles in rhizosphere are restored in just 18 to 20 months time, which otherwise takes decades. IBA also helps to establish fruit trees like Mango, Sapota and Pomegranate.

Amendment of mine waste with pressmud at the rate of 100 t/ha. showed the improvement in the water holding capacity from 10.6% to 33.95%. Spoil organic matter contents increased from 0.249% to 1.58%. Nitrogen contents improved from 16.9 mg/100 g of spoil to 182 mg/ 100 g. Phosphorous status increased from 14.05 to 116.9 mg/100 g and that of Potassium from 34.95 to 234.65 mg/100 g.

Plants Growth

The addition of pressmud as ameliorative material alongwith top soil boosted the plant growth 8 to 12.6 folds higher side on an average over the mine spoil dumps. The inoculation of shisham and cassia with Endomycorrhizae-Rhizobium and that of Teak, Shivan, Neem, Bamboo with Endomycorrhizae-Azotobacter enhanced the plant growth. A tonne of pressmud along provided 90.7 g NPK besides 420 kgs of organic carbon.

Plant growth response on spoil dumps of Gumgaon and Dongribuzurg mines are as under :

Table 7.6

Plant species	Initial O time during plantation	Plant height (cms) Months					
		6	12	18	24	30	36
Teak	30 cm	108	226	310	408	514	580
Neem	41 cm	123	267	382	456	579	722
Shishum	38 cm	119	214	298	358	465	535
Awala	32 cm	114	196	252	312	416	480
Mango	40 cm	126	181	226	294	373	412
Cassia	36 cm	121	174	258	334	426	485
Acacia	38 cm	122	163	236	318	392	430

Major Achievements

- Plant survival rate gone up from 15% to 87%
- Teak, Shishum, Neem, Shiwan etc. developed lushgreen cover
- Growth rate gone up 7 to 9 times
- Excellent nodulation (250-370) in leguminous plants.
- The IBA gave way to rehabilitation of degraded area through development of agriculture project started in 1989. This enabled socio-economic development of the region at Gumgaon, 1,20,000 mulberry plants variety M5 were planted after inoculation with biofertilisers.
- The IBA promoted 90% survival of plants and enabled profuse plant development compared to earlier mulberry plantation.
- Rearing of silkworm and cocoon development, provided a revenue over Rs.55,000. The commercial plantation and rearing which started during 1994 when 6.09 tonnes of mulberry shoots and 58 kgs of cocoons were sold. Whereas 9.09 tonnes mulberry shoots alongwith 42 kgs of cocoons were sold in 1995.[25]

(7) Narmada Cement Limestone Mine

The mine is situated at Babarkot village, near port town of Jafrabad in a remote area on the southern most point of Saurashtra peninsula and the coast line on either side of it from a nearly east-west area. Before start of the operations the land was originally a waste land and there was no trace of any flora-fauna, plenty of wind blowing sand dunes. The combination of high velocity saline winds and continuous blowing sand didn't even permit the growth of grass for cattles.

As per the figures available till the beginning of 1994 about 1.51 million tonnes of overburden and 10 million tonnes of limestone had been extracted. Overburden sand dumes were systematically removed and dumped at pre-determined places/mined out areas to achieve adjacent ground level and gainful reuse. The mine layout has been designed in such a way that entire rain water of the working pit is collected into an artificial lake created in 2.7 hectares.

The task of plantation and effective aftercare has resulted in regeneration of barren land (North block-1A) and about 92000 plants mainly Ganda Baual and Casurina are surviving in 50 acres area. Diverse species of tree provided congenial conditions and variety of birds, both resident and migratory can be seen here. Even peacocks, partridge and other birds have found it an undisturbed breeding place and made their home here. The plantation has helped in

(a) Transformation of landscape
(b) Checking of blowing sand
(c) Sand transformation into soil and soil binding to support further vegetation
(d) Reduced dust nuisance for regular mining

More than 15 acres have been restored by overburden filling. The area so reclaimed is compacted and levelled with dozer and slopes are covered with low grade footwall clays, produced during the creation of artificial lake (to be used for Pisciculture) in the worked out area. After physical reclamation, a layer of top soil of 0.50 metres is spread over. It is further treated with suitable nutrients like cow dung and other natural manures for generation of microbiota. After bio-reclamation, the area is taken for plantation.

The technique adopted for plantation is based on pot hole plantation on top soil where in pot hole of 30 cm x 30 cm x 30 cm, polypotted saplings reared into nursery are transplanted during monsoon months. The species include non-fruit bearing viz. Cassorana, Bengal-Baual, Ganda-Baual, Neem, Ashoka, etc, and fruit bearing viz. Coconut, Guava, Custard, Apple, Pomegranate, Badam,Chikoo, Lemon, etc.

The plants show good growth and have already survived for three years. All along the haulage road, near Babarkot village a green belt of one kilometer length and twenty metres width (i.e. 2 hectares) is being created. 9240 trees, mainly Casorana and Bagali-Baual (Acacia Auricula fornis) are planted here. This green belt will provide acoustic barrier, and will contain dust pollution near inhabited area of the village.

To ensure proper and complete after care of the plantations a novel concept has been adopted. Local villagers are given contract on survival basis manure and water are provided to them free of cost. This has also helped in creating an environmental awareness among the local masses.[26]

Table 7.7 : Plantation details in reclaimed area

Plot No. & Area	Types of trees	No.of trees	Year of plantation	Rate of survival %
1. 75M X 50M = 3750 M^2	Badam	54		
	Punica Granturn	25		
	Jamun	06		
	Gunda	02		
	Coconut	04		
	Azadirachta Indica	25	1991	90
	Billi Patri	03		
	Mitha Neem	01		
	Amli	01		
	Banyan	01		
	Ashoka	77		
	Cassurand	1280		
	Nerium Elender	33		
	Hibiscus spp.	05		
	Dalbergia Sisoo	15		
	Umra	03		
2. 45M X 30M = 1350 M^2	Coconut	29		
	Punica Granturn	21		
	Cassurand	492	1992	98
	Acacia Auriculac Fornis	167		
3. 35M X 40M = 1400 M^2	Cassurana	301		
	Narium Elender	05	1992	98

(Contd.)

(Table 7.7 Concld.)

Plot No. & Area	Types of trees	No.of trees	Year of plantation	Rate of survival %
	Coconut	41		
	Papaya	28		
	Gunda	01		
4. 55M X 40M = 2200 M^2	Cassurana	514		
	Coconut	48	1992	98
	Guava	04		
	Bor	03		
	Papaya	15		
5. 55M X 40M = 2200 M^2	Acacia Auriculac-Formis	542	1992	98
	Guava	28		
	Chikoo	07		
	Jamun	18		
	Lemon	44		
	Billi Patri	03		
6. 55M X 40M = 2200 M^2	Cassurana	542		
	Coconut	08		
	Chikoo	30		
	Custard Apple	28		
	Bor	11		
	Punica Granturn	07		
	Umra	02	1992	98
	Jamun	01		
	Papaya	02		
	Raj Pipla	09		
	Paras Pipla	02		
	Amla	02		
	Guava	21		
7. 65M X 30M = 1950 M^2	Guava	16		
	Emblic Efficinale	10		
	Custard Apple	16		
	Jamun	10		
	Bor	06	1993	98
	Umra	17		
	Cassurana	340		
	Dalbergia	26		
	Raj Pipla	10		
	Lemon	09		
8. 68M X 20M = 1360 M^2	Cassurana	340		
	Guava	04		
	Emblic Efficinale	33		
	Custard Apple	23	1993	98
	Jamun	8		
	Umra	9		
	Punica Granturn	1		
	Coconut	12		
9. 45M X 50M = 2200 M^2	Cassurana	540		
	Jamun	20		
	Lemon	20		
	Custard Apple	19	1993	98
	Punica Granturn	18		
	Emblica Efficinale	18		
	Guava	3		

(8) Belka Pahar Wollastonite and Calcite Mine

In the Belka Pahar Wollastonite and Calcite mine of M/s Wolkem India Limited in Sirohi district of Rajasthan the waste is dumped in the Valley. The lease area is 46.21 hectare and mine produces over 50,000 tonnes of wollastonite per year along with the almost similar quantity of calcite. The waste consists of pegmatite, very low grade limestone & other associated rocks. Around 3 lakh tonnes of waste is generated per year which is dumped in the nallah systematically as stated above.

Continuous plantation is in progress over it. Before this dumping rocks were exposed in the valley and no plantation was possible. After the systematic filling of the valley followed by plantation, the area has been developed in a lush green belt. Over 50,000 trees of 100 different varieties thrive in 25 hect. of filled land. Whereas there were only about 300 trees before taking up the lease. For further stabilisation, grass has also been grown over the dump surface area. Barring the actual mining area the place has become a sort of forest which has become the home for variety of birds & animals. Since last few years some bears have also come and the number is increasing. The existence of one Tiger is also being reported.[26]

(9) Singrauli Coalfield : NCL

Singrauli Coalfield is one of the largest coal and power companies in the world. It's contribution is 14.5% of CIL's and about 13% of the country's coal production by large mechanised opencast mines using modern technology.

Despite rapid growth of industrialisation in Singrauli Region it has been possible to arrest the environmental deterioration. With the constant efforts of NCL in association with Forest Department it has been possible to increase the forest cover from 27.6% in 1966 to 28.18% in 1991 as established by the Remote Sensing Studies carried out by CMPDI, Ranchi.

Some of the measures adopted for mitigation of adverse effects on land degradations arising out of large scale open pit mining.

(1) Land Use

Presently, the total land involved in 10 mining blocks is 14,873 ha. which includes 6615 ha. (44.4%) for mining excavation, 1820 ha (12.20%) for external OB dumps and 2528 ha (17%) for infrastructures.

Table 7.8

Type of land	Pre-operational	Post-operational
A. Green land (ha.)		
i) Forest land	6,923	418
ii) Reclaimed land	-	7,933
iii) Green belt	-	1,576
Total	6,923	9,927
B. Other land (ha.)		
i) Non forest land	7,950	-
ii) Residential township	-	380
iii) Other infrastructural facilities	-	1,040
iv) Water body	-	1,728
v) Waste land	-	1,798
Total	7,950	4,946
Grand Total	14,873	14,873

It can very well be seen from the above table that the green land as percentage of the total land will increase from 46.55% in pre mining stage to 66.75% in the postmining scenario.

(2) Overburden Dump Management

Over burden dump management constitutes an integral part of the project. Environmental Management Plan for the project is prepared at the planning stage and duly approved by Government. It constitutes :

- The land requirement for external dumping of overburden is kept at minimum.
- The void created by the extraction of coal is filled by OB dumping through dragline. Overburden removed by shovel dumpers is dumped over the internal dumps created by the draglines and subsequently levelled by dozers.
- The peripheral slope of overburden dumps is to be kept at 28 degrees. Benching is to be done and the height of such bench should not exceed 30 m.
- The initial overburden dumps are to be reshaped and levelled before biological reclamation is to be commenced.
- Reclamation of the dump is to be taken up as soon as it becomes inoperative/dead.

(3) Reclamation

The following table 7.9 gives the details of degradation and reclamation done up to March 95 and the proposed programme for the next two years.

Table 7.9

Sl No.	Project	OB Dumps		Reclaimed/vegetated		Plantation in other area	Reclm 95-96 (ha.)	Prog 96-97 (ha.)
		Ext. (ha.)	Int. (ha.)	Ext.(ha.)	Int.(ha.)			
1.	Gorbi	62	120	62	100	8	5	5
2.	Gorbi B	–	–	–	–	–	–	–
3.	Jhingurda	120	–	86	–	133	10	10
4.	Kakri	60	1	40	4	172	5	5
5.	Bina	63	212	63	192	112	20	20
6.	Khadia	90	7	–	–	204	20	20
7.	Dudhichua	108	70	93	24	354	20	20
8.	Jayant	38	254	26	214	104	40	40
9.	Nigahi	48	15	–	–	263	15	15
10.	Amlohri	82	10	7	–	181	20	20
	Total	**671**	**689**	**377**	**534**	**1531**	**155**	**155**

(4) Afforestation

Large scale afforestation programme has been taken up by the NCL since 1986. The following table gives the account of yearwise plantation at NCL.

Table 7.10 : Yearwise Plantation

Sl. No.	Projects	Upto 94-95	Programme		Fig. in Lakhs Total
			95-96	96-97	
1.	Amlohri	7.25	1.00	1.00	2.00
2.	Nigahi	8.74	2.00	1.50	3.50
3.	Jayant	19.76	1.50	0.60	2.10
4.	Jhingurda	6.64	1.00	0.50	1.50
5.	Gorbi	4.99	1.45	0.40	1.85
6.	Gorbi B	–	–	0.25	0.25
7.	Kakri	7.04	1.00	1.00	2.00
8.	Bina	16.7	1.80	1.50	3.30
9.	Khadia	6.11	1.0	0.40	1.40
10.	Dudhichua	12.14	1.70	0.75	2.45
11.	NCL HQ	1.22	–	–	–
	Total	**90.59**	**12.45**	**7.95**	**12.40**

To facilitate the biological reclamation and block plantation, pit head nurseries are maintained in all the projects for providing the desired type of saplings.

The studies of overburden dumps carried out by CMPDI for Biological Reclamation call for the following.

(1) Original dump slope of 37 to 40° is to be regraded to 28° which is favourable for plantation.

(2) To control the soil erosion proper drainage system for dump top and slope to be planned.

(3) The naturally revegetated mine spoil shows growth of Dhak, Shisham, Tendu, Chilbil, Amaltas, Babool, Madar, Grasses and leguminous forbs.

(4) Shrubs, grasses and legumes should be planted on dump slopes.

(5) Initially mine spoil should be covered with grasses, leguminous forbs and later on with suitable trees.

(6) On dump top, two tier plantation with a mixture of leguminous and non-leguminous species should be grown.

(7) Plant species have been selected considering the socio-economic use like fodder, fruits, resin, medicine, timber, fibre, oil etc. and also plant species which can grow on rocks and attract birds.

(8) Waste and vacant land should be brought under plantation to increase the total green cover.[27]

(10) Management of Acidic Dump : PPCL

Mining for base metals has increased manifold in India during the last decade. At different mines/plants of Hindustan Zinc Limited heaps of tailings having sulphur content upto 22% have got accumulated. The tailings of gold and copper mines also contain sizeable amount of pyrites and sulphides. Besides this, the coal mines facing the problem of Acid Mine Drainage (AMD) are at Yellendu area of Singrauli Coal fields. The semi anthracite coals of Jammu & Kashmir also contain 9% sulphur.

However, the most serious problem of AMD in India is being faced at Amjhore Pyrite mine situated at Amjhore, district Rohtas, Bihar. The main ore body contains around 40% sulphur. During the course of mining top and bottom shales are also excavated bringing down the sulphur contents to 22% in the run-of-mine. The top shale contains 10-12% sulphur and is highly liable to spontaneous heating. By coming into contact with moisture or rain-water, it tends to produce weak sulphuric acid.

The shale produced and separated is dumped in the form of 0.3 million tonnes of waste covering an area of around 4000 m^2.

The mine water, before being discharged is being treated with the lime. Extensive studies were carried out using phosphatic waste from lime treatment plant as buffer over acidic waste dumps.

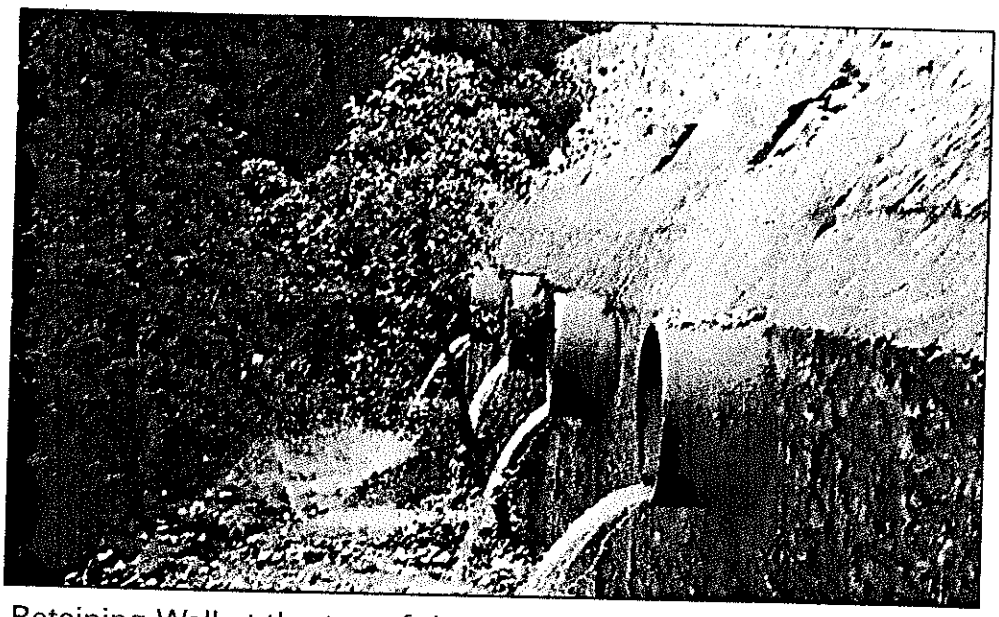
The laboratory analysis of chemical composition of waste and sludge from effluent treatment plant is given in the table below.

Table 7.11 : Chemical composition of pyritic waste, phosphatic waste and sludge of effluent treatment plant (PPCL) ug/g (dry wt. basis) except pH

Sample/ Comp.	Pyritic waste	Sludge of effluent treatment plant (PPCL)
pH	3.30	7.06
Fe	70.31 x 10^0 3	Very high
Mn	588.80	7.2
Cd	2.000	0.125
Cu	128.90	1.217
Zn	233.50	19.395
Pb	83.40	0.700
Co	32.40	4.758
Ni	125.70	6.287

For effective reclamation of the dumps of acidic waste it is necessary to prevent ingress of oxygen and rain water to control further oxidation and weathering of the pyritic waste material and soil erosion. For the experimentation an old dump of about 200 m^2 was selected which was reshaped and terraced to a slope of 1 in 3. A thin layer of dry phosphatic waste from Effluent Treatment Plant was laid. A 30 cms thick layer of cinder (discharge obtain from roasters) was spread over it to fill the voids. 70 to 80 mm of top-soil was provided at the top. A proper water drainage arrangement was made to prevent water going into the dump.

Standard seed of crobalaria juncea (sunhemp, family leguminoceae), Pennisetum typhoids (Bajra, family poaceae), and Ricinus communis (Castor, family euphorbiaceae) were seeded, rinsed with



Retaining Wall at the toe of dumps showing outlet of clear water from waste dump at Belkapahar Calcite and Wollastonite Mine of M/s Wolkem India Ltd.

Reclamation of old mining benches at Noamandi Iron Mine of M/s Tata Steel.

water after being disinfected by dipping into mercuric chloride solution (0.001%) for one minute. Seeds were alternately seeded over the ameliorated terraces leaving one bench for individual species. The lower most bench was seeded with mined flora to monitor the combined growth potential. For monitoring the growth of the biomass, plants of different species were harvested from specified areas after 45 and 78 days.

Table 7.12 : Biomass generated over experimental ameliorated pyritic waste

Name of the plant	Days of growth	Length (cm), max.		Dry biomass, AGP	(wt), BGP
		Root	Shoot	g/plant	g/plant
Crotalaria juncea (Sunhemp)	78	18	182	38.2	29.12
Pennisetum typhoids (Bajra)	78	10	178	36.7	11.32
Ricinus communis (Castor)	78	14	122	47.29	16.32

AGP = Above ground parts BGP = Below ground parts

After 78 days of experimentation, the soil pH level had remained 6.34 against 3.30 of the pyritic waste.

Table 7.13 : Concentration of metals in different parts of the plant (ug/g dry wt.)

Name of the plant	Parts of plant	Cu	Zn	Fe	Mn	Co	Pb	Cr
Castor (Ricinus Communis)	Root	12.27	37.30	332.12	25.49	1.952	5.50	4.294
	Shoot	147.90	31.47	199.03	25.85	1.674	3.44	1.999
	Leaf	258.90	63.13	69707.23	1643.40	8.962	45.80	37.84
Sunhemp (Crotalaria Juncea)	Root	24.79	90.01	1385.86	45.51	17.32	27.17	61.14
	Shoot	16.05	20.67	450.30	14.38	0.638	4.174	1.964
	Leaf	622.09	210.17	55668.60	1686.04	0.034	158.43	263.08
Bajra (Pennisetum typhoids)	Root	17.73	79.87	4978.00	118.08	5.55	0.34	50.00
	Shoot	8.82	48.50	223.43	53.83	20.81	2.17	0.81
	Leaf	35.62	73.94	757.28	51.94	22.94	3.24	5.203

It can be observed from the above table that the three plant species (Castor, Sunhemp and Bajra) do not always show the highest concentration of the heavy metal in the root, rather the actively growing parts of the plant specially leaves, show the highest concentration of heavy metal[28].

(11) Noamundi Iron Ore Mine

At Noamundi, mining is done by opencast benching method adopting shovel-dumper combination in a systematic and scientific manner with a series of 12 m high benches.

When operations in some of the areas were suspended, reclamation on barren open cast benches with pitting and planting method was taken up. The overburden and reject dumps are systematically dumped and at the initial stage grassing is done at the foot of overburden dump to arrest the run-off during rainy season. When the dumps mature and are abandoned, similar method of pitting and planting is adopted for the purpose of afforestation.

During initial years the thrust was on planting hardy and fast growing varieties to green the area. Lately, the emphasis has been shifted to multispecies plantation with native and utility plant species. Over the last decades more than one million seedlings have been planted and a survival rate of more than 85 percent has been attained now. In the leasehold area, more than 400 acres of land has been reclaimed and converted into thick forest so far. Following are some salient features.

* Under the supervision of a Biological Reclamation centre, developed on old mine workings, eight species of trees imported from Amazon Rain Forest of Brazil are under study for their suitability. For the purpose of slope stabilisation grass seeds from Italy with the local varieties are also under investigation.

* Development of the computer based mathematical model for prediction of airborne dust based on data like generation at source, wind speed, direction, distance from the source and elevation of site.

* As a part of the landscape development and reclamation a large barren area of about 45 acres of an old mine has been converted into a Botanical park. The park has a large collection of foliage plants, shrubs and ornamental varieties. There are about 200 varieties of house plants, 250 cultivars of different ornamental shrubs and a large number of annuals, propagated every year. Apart from large scale propagation, many newly derived hybrids are being developed. The rose garden is spread out over 3 acres of land. It has a collection of 150 cultivars / varieties. An orchidarium of about 1500 sq.ft. area houses 65 species / hybrids / cultivars of orchids from wild and other areas.

A rock garden has been developed in a valley, accentuated in depth by old mining excavations. All the plants in the Native Plant garden have been raised by either seeds or cuttings from wild plants, procedure calculated to have minimum effect on the natural populations. The plants are grown to provide propagation material which in turn will be taken and planted in mined out areas. Some plants have been restored to their native locations in numbers prevailing before mining operations were taken up. The Garden for Medicinal and Aromatic Plants maintains 45 species of important drug plants used in traditional medicines. An area of 5 acres have been developed into an orchard.

Vegetation propagation methods make possible the production of exact copies of trees selected for superior characteristics. These methods include conventional techniques such as rooting, cutting, grafting and air layering, as well as newer plant tissue culture methods that include embryo or cotyledon culture, shoot tip culture and cell culture. In contrast to conventional propagation methods, tissue culture produces several copies per copy per culture and the same time requires much less space[29].

Goa Region

As per the information received from the State Government and that available in IBM about 400 mining leases covering total area to the extent of 30450 ha. (which is about 8.2% of total area of the State) are existing. Out of these about 790 ha is forest area which is only 2.6% of total lease area and less than 0.75% of forest cover of Goa State. Thus forest area involved in the mining is insignificant as compared to total forest cover of the State. Most of the leases in Goa State are of iron ore which is 70%, rest are manganese (24%) and bauxite. All these mines (72 working mines) have handled about 84 million tonnes (ROM + OB + waste including mineral rejects) out of which 92% is for iron ore mines. Total lease area of these working mines comes to about 8000 ha, 65% being from iron ore and 20% being from manganese. Forest involved in these mines works out to 9% only. Therefore impact of mining is grab on account of iron ore mining. Out of 48 mines of iron ore, 42 are mechanised-handing over 99.6% of the total. The actual area broken within forest is not available at present. Cause of land degradation due to mining is :

i) Top soil removal
ii) Opencast workings
iii) Formation of dumps on virgin areas.
iv) Siltation of agriculture fields due to wash off from dumps
v) Damage of soil due to dust pollution
vi) Damage of land due to tailings disposal

Concept of removal of top soil separately was not present in the start of mining operations previously (50 yrs. back) and it got mixed with over burden and waste material and become useless.

It is important to note that lease area in most of the case is not able to hold the total quantity of waste generated in mechanised mines and 19 active mines had to acquire area out side the lease

area (964 ha) which works out to about 19% of the total mining lease area. Waste disposal area outside the leases is 435 ha more than that within the lease which is 1.82% of that in the lease area. Therefore effect of mining is immediately being felt even in the area outside the lease. This is worth noting that siltation of agricultural fields has become a regular feature during monsoon which is due to wash off of dumps by rain water.

Reclamation and Rehabilitation in Goan Iron Ore mines :

In about 14 mines working has been discontinued and therefore pits have been abandoned without restoring the area. In addition to this certain erstwhile mineral concessions have not renewed and therefore abandoned due to promulgation of Goan Daman and Diu mining concession (Abolition and declaration as mining leases) Act, 1987. In these cases about 140 mines and total broken area of about 1500 ha and reserves were not completely exhausted under the circumstances there is no other alternative than to leave the pits for water storage.

In working mines it has been observed that area under reclamation is about 9.5% of the broken area and land used for waste disposal is about 11% indicating reclamation lagging behind and not commensurate with the rate of area being broken. Back filling has been started in 10 working mechanised mines out of 42. Total area broken in these mines is about 940 ha. out of which 112 ha area is under reclamation in which about 55 million tonnes of OB / waste has been backfilled.

During 1996-97, OB/waste handling was to the tune of 60 million tonnes with ore to waste ratio of 1 : 3.34 indicating generation of atleast 60 million tonnes of waste every year to be accommodated. Due to scarcity of lead and its exorbitant cost, only remedy is backfilling which would be scientific also. It needs working in a manner to go to the bottom of the deposit as early as possible so that backfilling can be started at the earliest. MCDR, 1988 also requires this. Government of Goa has also made it as conditions in the lease deed in September 1997 as per this :

i) The lessee shall undertake to rehabilitate the land left over after the mining operations are concluded through soil conservation measures to the satisfaction of the Government and within such reasonable time as the Government may order in writing specify.

ii) In the event of the failure on the part of lessee to undertake the aforesaid measures within the stipulated period the Government without prejudice to any other action it may against the lessee to take the requisite steps to rehabilitate the said land and recover the expenses incurred for such work from the lessee as areas of land revenue.

iii) Abandoned mine pits should be backfilled properly and revegetated. Mine area reclamation and afforestation should be carried out concurrently to the maximum extent possible.

A study done in Goa State indicated in annexures shows (I) Mining leases in Goa, (II) Mineral wise breakup, (III) Active leases mineral wise, (IV) Working mines, (V) Iron ore mines analysis (VI) Land use in 42 working mechanised mines (VII) Backfilling analysis and (VIII) Production during 1996-97[30].

Two Cases of back filling proposals are given below :

(12) Deogotimolavoril Dongor (Sangod) Iron Ore Mine of M/s. Lithoferro

The entire area is covered by laterite capping of 5 to 15 m. Iron ore is exposed only in workings. Ore body is folded and plunging at an angle of 10 to 15° towards NW. Strike in NW-SE with a dip of N 10 to 15° E. Area has been established barren below bottom of the pit by boreholes. Bottom is friable silica and / or manganese clay. The volume of the area available for backfilling between two section lines in 6,13,830 cu.m. with an area of 15029 sq.m. The production for next two years proposed was 1,33,000 tonnes and 1,58,620 tonnes, requiring development of 9,73,200 tonnes and 2,35,400 tonnes respectively, making a total of 12,08,640 tonnes. Thus the space available for backfilling is sufficient for waste generated during next two years. This will again create area for backfilling afterward and so on.

Sequence of backfilling

Advance of the dumping has to be according to advance of lower most beach in the pit maintaining a safe distance. If possible backfilling attempt should be made to follow the original order of strata for geo-conservation and in such manner that toxic layer (if any) do not come near the surface.

Rehabilitation

Dumps should be properly drained, compacted and terraced. As loose material swell 10 to 15% backfilling should be 1 to 2 m higher than the original ground level to allow for settlement after its compaction in due course of time. For vegetation all the preparatory work must be completed before the time for seeds, most likely to experience the condition they need for germination and survival. Most appropriate species are having similar growth forms to the original vegetation and that will thrive in the area.

The case was recommended to allow backfilling with following conditions.

i) Limit up to which dumping of reject to be done should be marked on the ground at suitable interval by stone pillars/laterite walls of atleast one metre in height to identify the area earmarked for back filling.

ii) Proper precautions should be taken while dumping keeping in view the aspects of safety of men, machinery and conservation of mineral.

iii) Dumping should start from lower levels in stages of height not exceeding the height of each bench to have proper compaction and to avoid any sliding of dump.

iv) Plantation should be done on the dumps and its sides as soon as reasonable area is available for the same.

v) The density of plantations should be atleast twice the density of the adjoining virgin area having plantation.

vi) As soon as the back filling allowed in this proposal, is completed party has to intimate Indian Bureau of Mines in writing and obtain its permission before dumping further in that area.

Mineral wise break-up

The leases in Goa mainly consist of iron ore, manganese and bauxite. The extent of iron ore constitute 70%, while manganese only 24%. Further analysis of active leases shows that 75% of leases are of iron ore while manganese is 23%. Only two bauxite leases are active. Coming to details of the working mines presently a total number of 72 mines are working. Iron ore mines constitutes 67%, and manganese 31%. All the mines put together have handled about 84 million tonnes (ROM + OB + Waste including mineral rejects). The giant share of 77 million tonnes is from iron ore mines representing over 92% of total handling, while by manganese mines about 8% and bauxite share is negligible. Out of about 800 ha. of lease area, iron ore mines constitute 65% while manganese about 20% and remaining by bauxite mines. The extent of forest involved in all the mines put together works out to 9%.

It is clear from the above that the impacts of mining can be grave on account of iron ore mining. On further analysis of the iron ore mines, out of total 48 mines 42 mines comprise of mechanised category and the total handling from this category is over 99.6% and thus the impacts of mining due to mechanised working mines needs great attention. The extent of forest within the mechanised mines works to about 12%. The actual area broken within forest is not immediately available.

The Impacts of Mining

The impacts of mining on the environment are due to land degradation, air pollution, water pollution, noise pollution, nuisance due to transport, adverse ecological & visual impacts and other socio economic impacts.

We shall analyse the cause of land degradation due to mining.

i) Top soil removal.
ii) Open cast workings.
iii) Formation of dumps on the virgin areas.
iv) Siltation of agricultural fields due to wash off from the dumps.
v) Damage of soil due to dust pollution.
vi) Damage of land due to tailings disposal.

The mining activity has been carrying on for the past 50 years and concept of removal of top soil separately and its utilisation for land scaping was not existing at that point of time. So in the already opened up mines the top soil whatever little was available got mixed up with overburden and waste rendering is useless. However, in the new up-coming mines this aspect needs attention and the relevant provisions made in the MCDR '88 have to be implemented by the mine owners. It may also be noted that the top soil whatever available even on the acquired dumping areas should be removed separately before any spread of dump and utilised for land scaping.

The dumps have been formed within the lease area and also outside the lease area it is to mention here that nineteen active mechanised working mines in Goa have acquired 964 ha. Outside the lease area which works out to about 19% of the total mining lease area. It is pertinent to note that waste disposal are outside the leases is 435 ha more than the waste disposal area within the leases. This shows that for every 1 ha waste disposal area within the lease, 1.82 ha has been acquired outside. Thus the affects of mining are not only felt within the lease area, but also in the acquired areas on a larger scale.

The siltation of agricultural fields has become a regular feature during heavy monsoons of every year due to wash offs from the dumps located in the vicinity.

(13) Tarchan Mol and Cudgaicho Donger Iron Ore Mine of M/s. G.F. De Figueiredo

Tarchen Mol and Cudgaicho Donger are two contiguous erstwhile mining concessions measuring an area of 98.3 and 99.0 hects, respectively, granted during Portuguese regime. Both the leases are being worked as single mine. A beneficiation plant with a capacity of 250 t/hr has also been set up in the mine. Till March 1977, mine has handled 8,66,799 tonnes of ore (ROM) and 15,02,29 tonnes of waste. Topography of area is undulating with few hillocks. General slope of the area is towards a river flowing all along the eastern boundary of the mine. Ore is deep with overburden (laterite and phyllite) thickness upto 20 to 25 m.

There are two pits (pits No. 1 & 2) situated side by side of which pit No. 2 is proposed for backfilling with tailings. Both pits are separated by a dyke. Bore holes has proved that there is either phyllitic clay or manganeferrous clay with silica at the bottom of the ore body.

Goa has been declared as environmentally sensitive and therefore dumping into pit either by solid waste from mine or tailings from the beneficiation plants is to be encouraged. This will help in getting back the land in acceptable form.

In the particular mine filling of pit with tailings has been preferred over that by solid waste from mine due to following :

(1) Quality of waste generated from mine is not sufficient for filling the pit completely.

(2) Present tailing pond is situated very close to the river and is not an ideal location. Water overflowing from the tailing pond has been found polluting the river water and shifting of site for tailings stacking to pit no. 2 will definitely stop this pollution.

(3) Running of beneficiation plant is essential to conserve the mineral by utilising low grade of ore with beneficiation. It is of importance that iron ore mining industry in Goa is fully dependent on global market and for quality control upgradation of ore is a must.

Proposals for rehabilitation

To avoid erosion of fine tailings, pit is to be filled upto a desired level and solid waste from mine is be dumped over it. Case is being forwarded to allow backfilling in pit no.2 with following conditions.

(i) Suitable marking from pit bottom to desired level for filling be made in the pit to identify the level of filling.

(ii) Tailing be discharged into pit with the help of sufficiently large diameter pipe instead of open channel. Also as far as possible discharge end should be at lower level keeping all the safety aspects in view.

(iii) Flocculent should be used for quick settling of fine particles so that water can be utilised for different purposes.

(iv) Falter filling with tailings upto desired level (35 mRL), it should be covered with laterite or suitable material upto suitable height for plantation.

(v) Plantation should be done on the dumps and its sides as soon as reasonable area is available for the same.

(vi) The density of plantation would be atleast twice the density of adjoining virgin area having plantation.

(vii) As soon as the back filling with tailings allowed in this proposal, is completed, an intimation should be made to IBM in writing and obtain its permission before dumping further in that area.

Advantages of backfilling

(i) Reduction of land degradation of virgin ground since additional area to be acquired by the mining industry for waste disposal will be minimal.

(ii) The rehabilitated land can be aimed to bring into use for over all community benefit.

(iii) About 55 million tonnes of waste/tailings has been disposed by backfilling and the industry has already saved over Rs.one crore by avoiding purchase of additional land at the prevailing rates. It is seen that about 60 million tonnes of over burden and rejects needs to be disposed off every year under the present production trend. Even if 50% of it is planned for back filling about Rs.50 to 60 lakhs per year can be recurrently saved by the Goan Mining Industry from additional acquisition of land.

(iv) The litigation cases from the public can be avoided to some extent by adopting progressive reclamation and rehabilitation.

(v) Problems of collapse of benches can be avoided resulting in safety of men and machinery. To achieve this, the workings have to be concentrated in limited stretches in not less than two areas simultaneously so that OB/Waste of ore can be utilised for back filling in the other exhausted pits directly. This enables to exhaust the mineral in a shorter period and well before the benches tend to collapse one exhausted pit is restored by back filling.

The OB/Waste should be used for back filling the exhausted pits and then the most effective treatment is to spread the layer of good soil on top of rocky waste. But, to be really effective a blanket of atleast 10 cms of top soil is required on the waste. If trees and shrubs are to be grown on the reclaimed area a far greater thickness is needed. Because of lack of availability of top soil this treatment is always not possible. In some cases one type of waste material is used to counteract the damaging affects of another for example sewage sludge or peat can be used to improve the fertility of the soil.

Conclusion

1. The mines which were discontinued/ abandoned needs to be reactivated so as to recover completely the balance mineral and at the same time implement progressive reclamation and rehabilitation.

2. Certain abandoned pits can be thought of utilising for dumping of town garbage etc, since now and then complaints are received from public demanding the Government to shift the existing garbage yards located in the outskirts of the towns.

3. Based on the recommendations of the Task Force on Eco development Plan for Goa, Ecological Mining Board was constituted and a committee was set up in July, 1983 for scrutinising the proposals for acquisition and allotment of lands to the mine owners for dumping of mining rejects. Now this committee needs to be activated and a Regulatory Control is necessary to acquire land outside the leases for the purpose of disposal of dumps and tailings. Case by case needs to be examined to establish non availability of exhausted pits and space on the existing dump yard/tailings dam site for waste disposal. Upon issue of certificate to this effect by the competent authority, the committee should grant permission to the mine owner to acquire the land. A law should also be promulgated by the State Government banning the sale of land by private land owners for the purpose of waste disposal unless and until the deal is substatiated by a no objection or clearance certificate issued by the said committee. The said acquired land should also be covered into mining lease for better control.

4. The mining leases shall not be granted in fresh areas which adds to further land degradation. The former mining concessions which have been discontinued and not renewed, only to be granted so as to avoid breaking of fresh land.

5. The restriction of 100 ha per each lease should now be dispensed with and larger areas to be allowed so as to systematically work the mineral deposits and adopt reclamation and rehabilitation properly.

6. Every mine operator shall incorporate proposals of reclamation and rehabilitation in the mining plans/ schemes and ensure to implement the same.

7. The committee set up by the Ecological Mining Board may also be entrusted to thoroughly examine each and every abandoned area and suggest the best possible measures to reactivate or go in for reclamation and rehabilitation. Some mines cannot be worked due to close proximity of habital, public roads, rivers etc.

8. The Mining Industry should embrace the concept of sustainable development. Sustainable development is the development that aims to meet the needs of the society today, soil conserving ecosystems for the benefits of future generations. Rehabilitation is the process by which the impacts of mining on the environment are repaired. It is an essential part of developing mineral resources in accordance with the principles of sustainable development.

This trend is to be continued in all the cases wherever possible. Backfilling will not only reduce in degradation of land (as filling would be done in already degraded land), it will also help in make the degraded land available back with a better land use. As ultimate top of back filled portion in almost all the cases would be level rehabilitation would be easier and it can be put for agriculture use which would properly be best use of reclaimed land. It may be noted that plenty of water is available in iron ore mining belt of Goa State which can be used for irrigation of the land reclaimed and rehabilitated.

(14) DMW mine of INDAL [53]

Indian Aluminium company Ltd. (INDAL) is operating its Durg Man Wadi (DMW) opencast bauxite mine. The entire (110ha) mining area has been fenced with a 3 m high parapet wall. This prevents mine wash-outs going down the natural slopes. This is guided by successive check dams/ siltation tanks and a network of garland drains. This makes physical quality better than the natural conditions. Overburden, which is temporarily stacked is filled back into the mined out areas. Top soil containing micro-nutrients necessary for plant growth, is spread on the restored area and plantation is done thereon. The existing barren lands are also vegetated side by side. This will ensure a better look than the original one at the end of mining operations when area will be handed over back to the society.

(15) Lambidhar Limestone Mine of M/s. U.P.S.M.D.C

Lambhidar Limestone Mine of M/s Uttar Pradesh State Mineral Development Corporation is situated in the environmentally sensitive hills of Massourie. Although the mine was closed in 1996 after expiry of it's mining lease as per Supreme Court's orders, the work done by the management to protect the environment is highly appreciated. The lease area at the time of closure was 78 hects. out of which 11.58 hects. was under forest land. It was a mechanised opencast mine.

Around 20 hectares of the area under lease was degraded under pits and approach roads (with no dumps as limestone was outcroping) and almost all of this has been reclaimed by way of plantation. Retaining walls of stone were erected at all the outer edges of excavated bench. Plantation was also carried out at bench tops in the form of pit-plantation, intermittent space was filled by shrubs and grasses. Screen material was spread over bench slopes, well protected by retaining walls and saplings were planted using coir-met technique. A beautiful nursery was also developed in the mine for raising saplings of local plants & shrub species. The nursery was spread over an area of 2 hect. with a capacity of 1 lakh saplings. The achievements of Lambidhar limestone mine in the area of Environment Management are summarised in the form of table and bar diagram [Fig 7.3(a)][51].

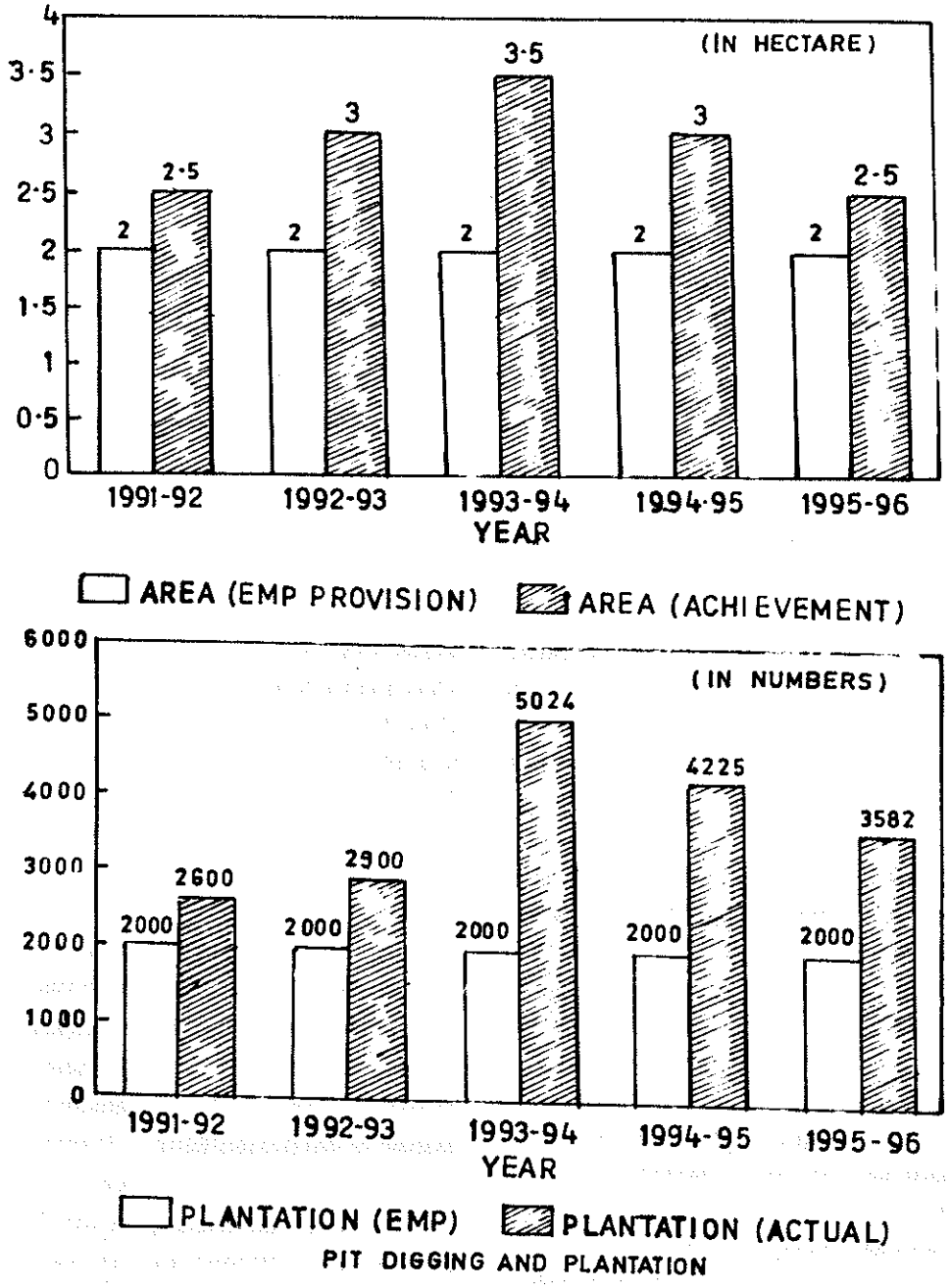


Fig. 7·3 (a) Plantation in mined out area (EMP provision Vs achievement) at lambidhar limestone mine of UPMDC Ltd.

Table 7.14 : Achievement at Lambidhar Limestone Mine

Sl. No.	Item	Target		Achievement		% Achievement
		Area (ha.)	Plantation (Nos.)	Area (ha.)	Plantation (Nos.)	
1.	Plantation in Purukul gaon	3.0	880	3.0	1591	198.87
2.	Plantation around Admn. block	14.0	7500	14.50	8000	106.68
3.	Afforestation of Lambidhar Mine Top	2.5	3000	2.50	3878	129.26
4.	Plantation in Mined out area	10.0	10000	14.50	18331	183.31
5.	Nursery	0.65	25000	1.95	75000	300
6.	Fruit trees	---	1000	---	1200	120

Various species of plants and shrubs used at Lambidhar are as follows

Trees

Cupressus Torulosa
Prunus Puddum
Quercus incana

Shrubs

Artemisia sp.
Arundinaria falcata
Berberis aristata
Cannabis Sativa
Coraria nepalensis
Debreqeasia hypolcuca
Desmodium sp.
Eupatorium sp.
Hypericum sp.
Hamiltonia Suavelones
Lenspedeza gerardina
Pogostemon plectranthoides
Rubus biflorus
Rubus niceus
Rumex hastatus
Rumex nepaleshsis
Rosa moschata
Salix sp.
Virtica sp.

Grasses

Apluda mutica
Chrysopogon sp.
Cymbopogon sp.
Cynodon dactylon
Eulaliopsis binata
Heteropogon Contortus
Saccharum sp.
Themeda anathera

Sedge

Eriophorum comosum

Herbs

Bidens pilosa
Dicliptra roxburghiana
Galium sp.
Micromeria biflora

(16) Ladwakot Limestone Mine of Shri R.K.Oberai, distt. Dehradun, U.P.

(i) Reclamation

The total lease area was 15.81 hects. Reclamation of mined out areas is carried out concurrently with the mining operations. As soon as mining activity on a bench was completed, the bench was prepared for reclamation. After dressing and clearing of all loose rocks, the bench was covered with a 60-70 cm. Layer of top soil which had been obtained during mining is stacked separately. A retaining wall 60 cm x 60 m running all along the outer edge of the bench is constructed to retain the top soil and prevent it from being washed away with the rain water. As an added precaution the finished bench slopes towards the inside to ensure that the water flows along the inner edge of the bench.[52]

(ii) Plantation

Commandable work has also been done at this mine. About 6000 saplings were planted having a survival rate of about 90%. All the mined out benches were reclaimed by way of plantation.

(17) Durmala Rock Phosphate Mine of M/s PPCL, distt. Dehradun, U.P.

At present the mining is carried out by underground method. Earlier it was an opencast mine. The total lease area is 137.48 hects. A total of 15 hects. area has been covered under plantation near office, restored area of 3.062 hects. of old opencast workings near old compressor house and on western flank, and near colony. A total about 66350 saplings of various species were planted so far. The survival rate is about 65 to 80%.[52]

(18) Tata Steel

Tata Steel has done exemplary work to set the ill effects of mining in it's various mines such as Noamundi Iron Mine, Joda East Iron Mine and Joda West Manganese Mine and Gomardih Dolomite Quarry. Tata Steel has prepared a multi-disciplinary team comprising Mining Engineers, Environmental Engineers, Chemists, Botany, Horticulture and Forestry experts. Continuous upgradation of knowledge and best practices are followed by this expert group.

At Noamundi mine strict restrictions are applied on forest tree felling. Effective plant protective measures, coupled with need based reclamation research have resulted in 1.3 million saplings planted in 202 hactares. Recent Landsat Remote Sensing Imagery indicates 70% dense forest cover in 5 km radius zone. The details of this plantation is given in figure 7.4 & 7.5.

As a part of landscape development and reclamation, a mined out area of about 45 acres has been converted into a beautiful green buffer, named after Sir Dorabji Tata. This Botanical Park has various features like foliage plants, shrubs and ornamental ones, a 3 acres of hybrid rose garden, beautifully maintained cacti and succulents, orchids hibiscus, bonsai and medicinal plants. It also consists Amazon forest tree establishment site, Green house, Rock and Pit gardens. Similarly, a degraded forest land of about 4 acres has been converted into a beautiful green Botanical Park at Joda. The uniqueness of this park is that a part of land is left with original vegetation and that development is done without disturbing any of the standing trees.

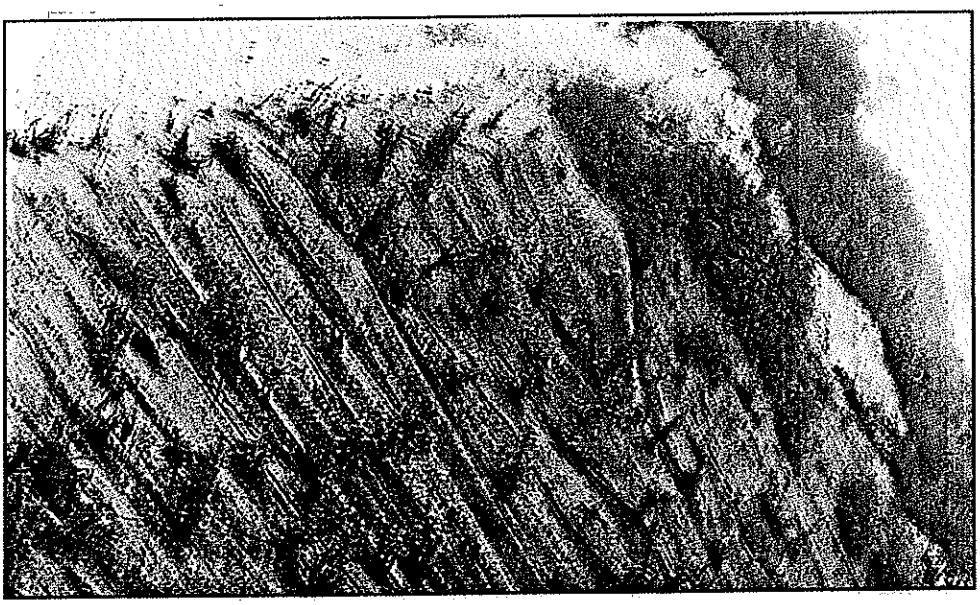
A separate Biological Reclamation Research Centre has been established to understand & employ the soil amendment needs, adaptability and suitability of native plants and bio-edaphic factors. Various species under study are Sal, Teak, Arjun, Sisham, Amla, Mahua, Jamun, Cashewnut, Guvava, Bamboo and Imli under the different parameters like survival, height, canopy spread and diameter at breast height. Some of the research projects in experimental design stage are -

- Tissue culture of naturally regenerating species
- Innoculation of fungi in plant root system
- Beneficiation of slime by bio-leaching.

(19) Vyasanakere Iron Ore Mine of M/s Mineral Sales Pvt.Ltd (MSPL) in Bellary Zone, Karnataka State

Lease area covered is 347.23 ha. since 1962. Float ore mining continued up to 1976.

Top soil removed from reef section is being utilised in reclaimed area of float ore mining. An area of 160 ha. covered with different species has been rehabilitated. Around 8.5 lakhs plants/trees are surveying in the area. Some of the species are Eucalyptus, Simetangadi, Bengal Jali, Feltapar, Acasia, Casurina etc. Due to growth of forest in this area the wild animals like Panther, Jackal, Boar, Wolf etc. are frequently seen in this reclaimed area which come from the nearby forests. The animals come to the area for water which is impounded in the bunds.



Coirmat-Technique employed on Screed-Slopes at
Lambidhar Limestone Mine (now closed) of M/s U.P. State
Mineral Development Corporation Limited.

Plantation over Reclaimed Benches at
Ladwakot Limestone Mine of Shri R.K. Oberai.

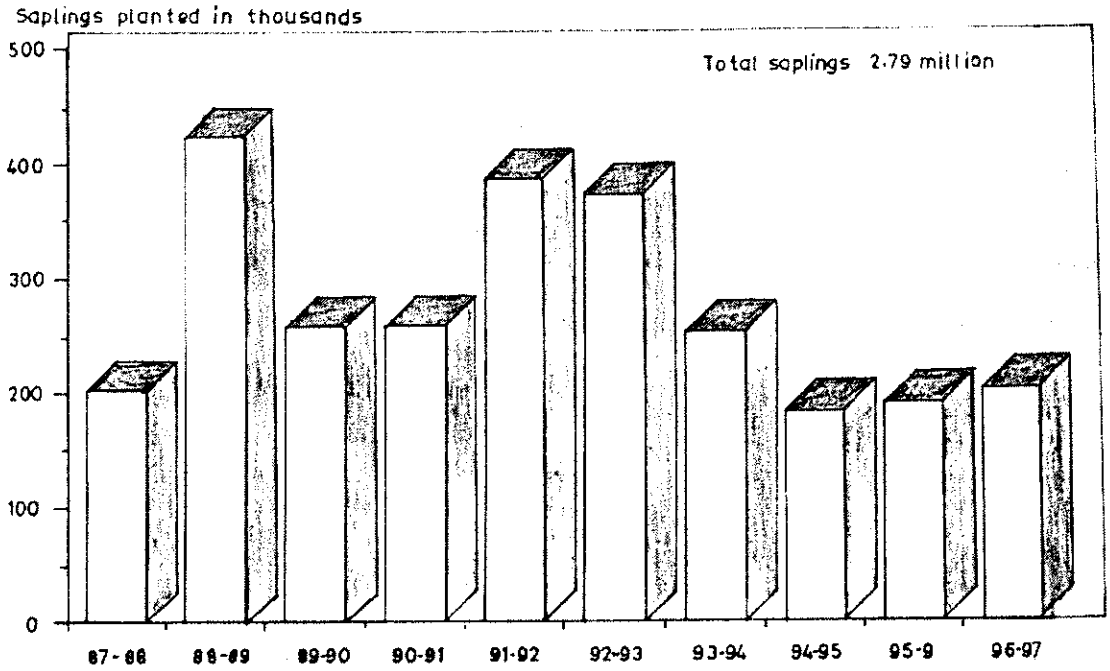


Fig: 7.4 Afforestation in mines division by Tata Steel

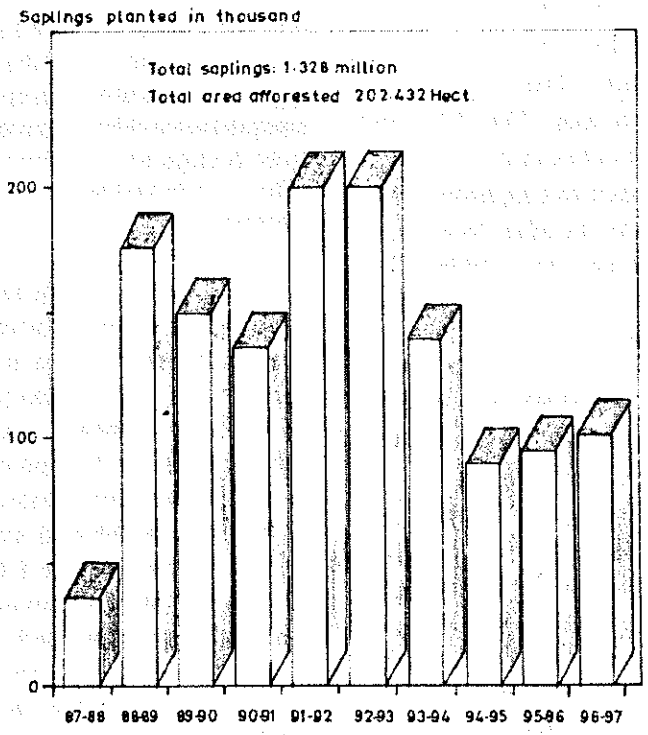


Fig: 7.5 Afforestation within the mining lease by Tata Steel

MSPL has adopted environmental management as per ISO 14001 and is likely to get ISO 14001 certification very shortly.[50]

It is hoped that some of the wild animals visiting the area will migrate permanently at the time when mining and allied operations are completed and area is handed over back to the society after its rehabilitation.

(20) Kodinar Limestone Mine of M/s Gujarat Ambuja Cement Ltd., Gujarat[53].

Entire top soil in the mining area is scraped/ dozed and preserved as stacks within the lease area, but away from the active mining sites. During a span of eight years i.e. 1986 to 1994 about 572 thousand tonnes of top soil was stacked, out of which about 525 thousand tonnes were utilized for plantation purposes. Till 1994 end 21.6 hectares of worked out area has been covered under plantation, which is so dense that wild animals have migrated into this area. A worked out area of about 12.83 ha. has been restored to ground level by filling sand excavated from the floor of adjacent worked out pit (measuring 12 ha.) for expansion by adding another cement plant. This adjacent pit has been converted into a lake. This lake had accumulated about 191 thousand cubic metres of water during 1994 which was collected by diverting several seasonal streams to this lake. In addition to this an area of about 81 ha. and a 15 km long road side belt, both out side the mining lease area have been effectively afforested.

(21) Utterlai Gypsum Mine of M/s. Fertilizer Corporation of India in Barmer district of Rajasthan[54].

A joint Indo US Project (from Oct. '93-Sept., '94) with respect to Germplasam Enhancement for Drought Tolerance and Reclamation & Rehabilitation of Mined Waste - Lands of gypsum mines in Kavas area of Uttarlai Gypsum Mines in Barmer district through Scientific afforestation by CAZRI, Jodhpur was taken up. An exemplary work through scientific approach has been done w.r.t. afforestation/ environmental upgradation which is detailed below:

i) Characteristics of gypsum mined soils of Kavas (Barmer).

Physical and chemical characteristics and nutrient behaviours are very important to plan the rehabilitation of gypsum mine spoil area for quick establishment of plant species in the degraded mine sites. For the detailed characteristics, samples of the mine spoil/debris (muck) and soils underneath the muck were collected from six sites comprising of different treatments. These were analysed for various soil paremeters. Results of the same are reported as follows.

(a) Physico-Chemical Characteristics

Analytical data revealed that there was no significant difference in pH values of the soils which is around 7.8 in most of the cases in various treatment. Total soluble salts (EC) were higher in mine spoil top soil (1.79 to 2.21 mmhos/cm) as compared to subsoil (0.80).

Because the presence of gypsum in the (mine spoil / debris) samples were flocculated as such the exact amount of clay and silt contents could not be determined. Therefore, particle size was determined approximately by sieving, decantation and separating the coarse and fine sand fraction and considering rest of the amount being clay + silt together with a smack proportion of gypsum. Since samples were drawn from a common habitat spread over in large area therefore, there was not much difference in soil texture of the different sites and treatments.

Soils are mainly sandy and comprises of about 90 percent sand of which in most of the cases over 80 percent is fine sand. The clay + silt + gypsum in upper horizon (mine spoil)ranged from 8.5 to 19.5 percent and in sub-soil underneath, the debris from 6.5 to 10.6 percent. Soils of the habitat are calcareous and content in mine spoil of almost all the treatments and sites have more or less identical values (4.6 to 6.0 percent) where as in subsoil the values of amorphous lime are tending towards decreasing side (3 to 4.4 percent) in comparison to top soil (mine spoil). Water holding capacity and moisture equivalent values were significantly higher in minespoil (28 to 32.5, and 6.1 to 9.8 percent, respectively) because of presence of gypsum + clay and silt along with the sand in the mine spoil. While in the underlying aeolian sandy material the values of both these

parameters are much lower (25 to 28 and 3.1 to 4.0 percent, respectively). This indicate that mine spoil has some stability and more strength to retain the soil moisture for a longer period.

(b) Nutrient behaviour

Mine spoil is extremely low in organic carbon (index of available nitrogen). The content mostly found between 0.01 and 0.14 percent. Adequate amount of goat manure (FYM) was applied before transplantation, despite of the fact that it has not shown any apparent response to manure, applied in the soil, Perhaps it could not be decomposed due to inadequate moisture, hardness of the shell and high temperature of the area for most of the period and also oxidation of the organic residue. Therefore, it becomes imperative to apply decomposed manure in the soil and to maintain the optimum moisture level in the soil. Application of nitrogenous fertilizers may be considered beneficial for attaining optimum plant growth.

Available phosphorous (P_2O_5) in mine spoil varied from 12 to 20 kg/ha indicating lower availability whereas in subsoil its content was still low. Halfmoon and ridge and furro treatments have slightly better content than that of microcatchment. However, to attain the adequacy of phosphorous (P_2O_5) in the soil for optimum plant growth, application of diammonium phosphate (DAP) in the soil before transplantation would be beneficial.

As regards available potassium content in minespoil and underlined subsoil; there appeared no apparent deficiency. The values mostly found between a range of 186 to 437 kg/ha exhibiting a medium to high content. Topsoil of mine spoil contained lower values (186 to 292 kg/ha.) as compared to sub-soil stratum (215 + 437 kg/ha.). Similar was the picture of total potassium in sub-soil (0.3 to 0.5 percent). Therefore, it appears that underlying sub-soil is enriched with potassium bearing minerals which on release enhances its content.

Total calcium and magnesium in mine spoil were found of the order of 4.3 to 12.06 and 3.1 to 10.5 percent, respectively where as values in sub-soil were more or less half of the values of the top mine spoil. This may be due to the presence of crystalline gypsum in the topsoil (mine spoil). Ca/Mg ratio for mine spoil and underlying sub-soil was found to be from 0.82 to 3.92 and 0.55 to 2.41 respectively. Data also reflects the dominance of calcium over magnesium in most of the cases in soil materials. There was no significant difference in the content of total sodium within the treatments and also in the mine spoil and underlying sub-soil. The values were mostly around 0.3 percent.

With respect to trace elements, the mine spoil contained an appreciable amount of total manganese, zinc and copper (Mn 172 to 234 ppm, Zn 22.7 to 30.5 ppm and Cu 9.8 to 21.8 ppm). The values are slightly lower in comparison to adjoining original sandy plain soils of the arid region (Barmer district). Further, the content of these elements showed slight declining trend in sub-soils (Mn 131 to 150 ppm, Zn 17.6 to 20.3 ppm and Cu 6.7 to 14.6 ppm) underlying the mine spoil depth of which in most of the cases is around 50 cm. From plant nutrient point of view, the present contents in mine spoil and underlying of sub-soil appears to be sufficient for most of the plant species transplanted at the rehabilitation site of the gypsum mined area. Therefore, there is no need to apply micronutrient elements in the soil.

ii) Gypsum mined wasteland - Kavas

Loss of plants : After the plantation in August 1993 rainfall was 33.6 mm only during September. Thus transplanted plant material could not catch up good growth as compared to excellent growth of 1992 plantation. In summer there was an attack of wildlife especially bluebulls and rabbits. Newly planted material of 1993 was destroyed by rabbits. The damage was to the extent of 33 to 50% in the four treatments. With the onset of next year monsoon, the gap filling was carried out.

In case of1992 plantation, selective species like Caesalpinnia coraria, Cassia strutii and Pithecellibium dulco were target of bluebulls. While Salvadora species were preferred by rabbits. There was 2-7% casualty in 1992 plantation. Loss of C.coraria is compensated by planting Holoptelia integrifolia. In case of other species, new plants of same species have been transplanted.

During the period there was an early break of monsoon in whole of western Rajasthan. This kept all the labourers engaged in crop sowing and other

agricultural operations. The plantation work could be undertaken during August only.

iii) Rehabilitation of Gypsum mined wasteland at Kavas (Uttarlai-Barmer). Plantation during monsoon season (1994).

Like earlier years an additional another patch of four hectare area of gypsum mined wasteland adjoining the last two years was undertaken. The plots were cleared off the weeds,grasses and shrubby growth. The plantation work was carried out from 16th Aug. to 21st August.

(a) Control Plot : As done earlier 3/4 hectare area (75 x 100 m) was utilized for plantation whereas the remaining 1/4 hectare (25 x 100 m) had been left undisturbed for allowing the natural regeneration of species and study the successional trend. 60 cubic cm pits were dug with a spacing of 5 m from plant to plant and row to row distance. Alternate rows have staggered pits with earlier row and accommodate 19 or 20 plants/row like earlier years. Well rotted FYM @ 4 kg/ pit was mixed with the dugout soil. The pits were refilled and plantation carried out. This year 5 species of trees and 4 species of shrub with Prosopis juliflora as control species had been transplanted. The saplings were 6-9 months old attaining 30 to 40 cm height. The soil was compacted after transplantation and each pit was provided with 10 liters of water. The layout of control plot was as follows.

1. Acacia Tortilis
2. Cercidium Floridum
3. Acacia Senegal
4. Colophospermum Mopane
5. Tamarix Aphylla
6. Parkinsonia Aculeata
7. Pithecellobium Dulce
8. Acacia Nubia
9. Prosopis juliflora
10. Acacia Tortilis
11. Cercidium Floridum
12. Acacia Senegal
13. Colophospermum Mopane
14. Tamarix Aphylla
15. Parkinsonia Aculeata
16. Pithecellobium Dulce
17. Acacia Nubica.

(b) Halfmoon Terraces : After minor leveling of one hectare of plot, 60 cubic cm pit at a distance of 5 m were dug in this plot, maintaining 5 m distance from plant to plant and row to row (Fig. 7.6). Half of

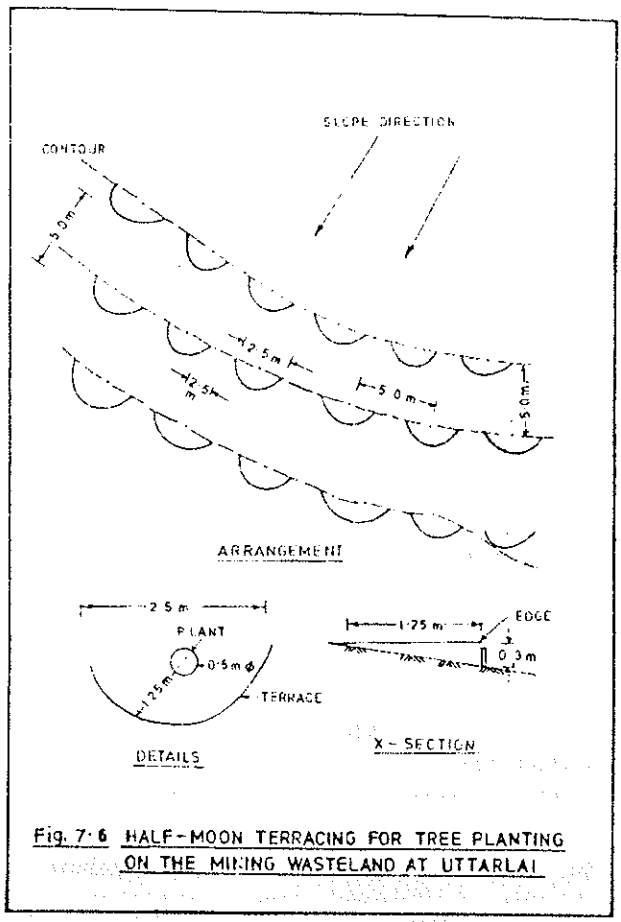


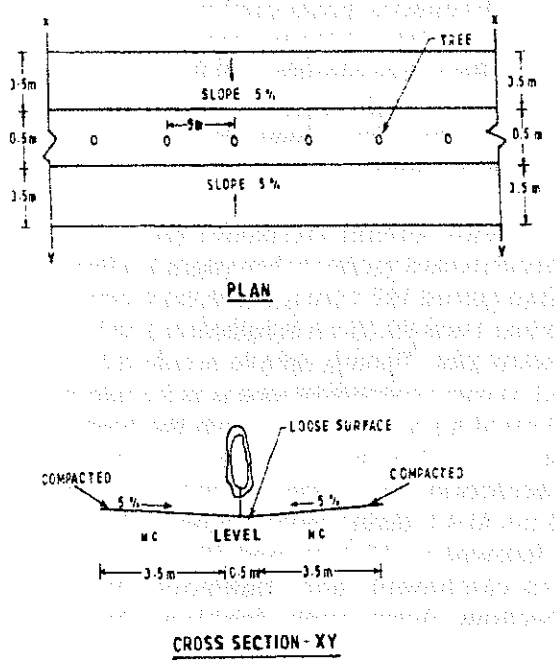
Fig. 7·6 HALF-MOON TERRACING FOR TREE PLANTING ON THE MINING WASTELAND AT UTTARLAI

the dugout soil was utilized to make half moon structure opposite to the direction of immediate slope. Thus the halfmoon structure get scattered in all direction. This allows the harvest of water wihtin the pit after a good shower. Mixing of FYM, filling of pit and transplantation of sapling was similar to control. This plot contains nearly 380 plants. In each row the plant alternate (staggered) with the adjacent row. Here also 5 species of trees and 4 species of shrubs were transplanted. The layout of half moon plot was as follows :

1. Acacia Tortilis
2. Cercidium Floridum
3. Pithecellobium Dulce
4. Parkinsonia Aculeata
5. Tamarix Aphylla
6. Colophospermum Mopane

7. Acacia Senegal
8. Acacia Nubica
9. Albizia Amara
10. Prosopis Juliflora
11. Acacia Tortilis
12. Cercidium Floridum
13. Pithecellobium Dulce
14. Parkinsonia Aculeata
15. Tamarix Aphylla
16. Colophospermum Mopane
17. Acacia Senegal
18. Acacia Nubica
19. Albiza Amara
20. Prosopis Juliflora

(c) Micro-Catchment plot : With the help of tractor and scraper the plot was first brought to the leveled condition. All the shrubby and weedy elements were also removed. Some Prosopis juliflora in the plot were removed and root excavated. The opposite micro-catchment of 3.5 m width on either side with 5% slope were developed. The slopes thus developed will provide the runoff water to the single row of plants. Thirteen such micro-catchments were prepared in the area (Fig. 7.7). Here augor hole planting was carried out in each row. Here 90 cm augor holes of 10 cm width were made, 50% soil and 50% FYM was mixed and the hole were refilled. The sapling were transplanted. Watering was carried out after compaction. In micro-catchment only six species of trees with Prosopis Juliflora as control has been used. Layout of micro-catchment plot was as follows :



MICRO-CATCHMENT

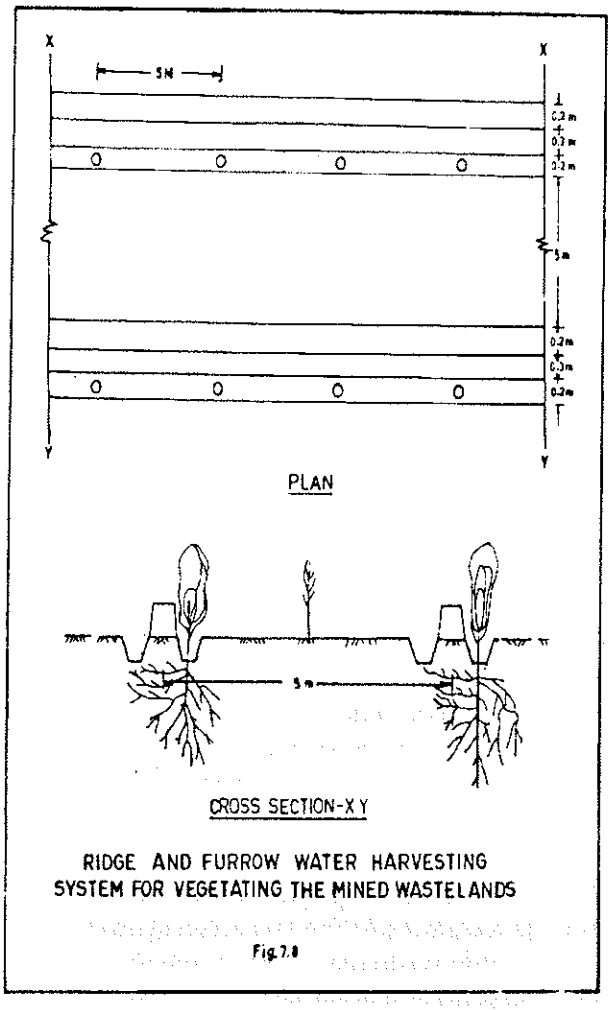
TREE PLANTING ON MINED WASTELAND AT UTTARLAI

Fig-7.7

1. Acacia Senegal
2. Acacia Tortilis
3. Holoptelia Integrifolia
4. Tamarix Aphylla
5. Pithecellobium Dulce
6. Azadirachta Indica
7. Prosopis Juliflora
8. Acacia Senegal
9. Acacia Tortilis
10. Holoptelia Integrifolia
11. Azadirachta Indica
12. Pithecellobium Dulce

(d) Ridge and Furrow Plot : About 25-30 cm high 20 ridges were developed at 5 m distance. On either side of each ridge the furrow gets created to receive the water from the plot and the ridge (Fig. 7.8). Here also the plantation was carried out by augor hole method. 80-90 cm deep augor holes of 10 cm diameter were dugout. Soil and FYM in 1:1 ratio were mixed and the pits were refilled. The saplings were transplanted and watering was carried out like other treatments. Here 5 species of trees and 5 species of shrubs were tried. The layout of Ridge and Furro plot was as follows:

1. Acacia Senegal
2. Mimosa Hamata
3. Albizia Amara
4. Cercidium Floridum
5. Acacia Tortilis
6. Colophosphermum Mopana
7. Pithecellobium Dulce
8. Acacia Nubica
9. Holoptelia Intergrifolia
10. Prosopis Juliflora
11. Acacia Senegal
12. Parkinsonia Aculeate
13. Albizia Amara
14. Cercidium Floridum
15. Acacia Tortilis
16. Colophospermum Mopane
17. Pithecellobium Dulce
18. Acacia Nubica
19. Holoptelia Integrifolia



RIDGE AND FURROW WATER HARVESTING SYSTEM FOR VEGETATING THE MINED WASTELANDS

Fig.7.8

Two years experience has indicated that highly palatable shrub and tree species become the attraction foci for the wildlife especially the bluebull. Cassia struti served as the top feed to rabbits and bluebulls and hence dropped from experiments. Hence some non palatable, thorny and drought hardy species like Acacia nubica,Parkinsonia aculeata, Holoptelia integrifolia etc. have been introduced. A few throny species are nimbled by wild life to some extent destroying the apical part but not damaging much. Present four hectare rehabilitated area was contiguous to last two years plot.

(iv) Thorn Fencing : Prior to planting of any sapling the thorn fencing of Prosopis juliflora was raised around the four hectare area to check the free movement of the sheep and goat. This year hedge could not be put due to shortage of available labour and transport.

(v) Schedule of Cultural Operations

(a) One watering was carried out after planting of saplings.
(b) Watering at two months interval was carried out till Feb., 1995.
(c) Gap filling of casualties undertaken during October, 1994 and Feb., 1995.
(d) One weeding & hoeing was carried out in each pit by the end of Dec., 1994.
(e) Monthly watering carried out from March, 1991 to June 95 in 1994 plantation & bimonthly in old plantation.

(vi) Growth performance of plants at gypsum mined Kavas (Barmer) result and discussion.

A. Two years growth observations were recorded in September 1994. The result obtained for various growth parameters like plant height, crown cover, branch number and their total length etc. were discussed as a comparative account is these treatments.

a. Plant height

Amongst tree species Prosopis juliflora gained maximum height (177.9 cm) in halfmoon terraces followed by micro-catchment (160.1 cm). The height of Pithecellobium dulce (54.7 to 57.4 cm) and Salvadora oleoides (26.8 to 31.8 cm) do not vary much in all treatments due to browsing whereas Tamarix aphylla had better growth in micro-catchment by putting 111.0 cm height.

Mean Annual Increment (M.A.I.) : In microcatchment treatment two years old Prosopis Juliflora gained 107.1 cm M.A.I. in the second year whereas it was 99.25 cm in halfmoon and 59.7 cm in control plot. Tamarix aphylla acquired 35.7 cm M.A.I. in micro-catchment where as it could reach 19.6 cm M.A.I. in control plot, while there was only 13.6 cm M.A.I. in halfmoon turquoises. Pithecellobium dulce, inspite of browsing, gained 19.5 cm M.A.I. during monsoon period in control plot followed by 13.4 cm and 12.6 cm M.A.I. in micro-catchment and halfmoon terraces respectively. Acacia tortilis, tried in two treatment gained 41.0 cm M.A.I. in control and 36.0 cm in halfmoon.

b. Branch number and their length

In micro-catchment Prosopis Juliflora produce 13.5 number of branches whose total

length was 1999.4 cm where as their number in control was 12.5 with 1501.9 cm length followed by halfmoon terraces (10 nos. and 1645.5 cm length). Though Pithecellobium dulce produced higher number of branch (14.8) but their length measured only 443.4 cm. Figures indicated in halfmoon and control were comparatively less.

c. Crown cover

Prosopis Juliflora on an average gained highest crown cover in halfmoon terraces (9.31 sq.m) followed by micro-catchment (8.94 sq.m). Second species in order stands Tamarix aphylla which acquired 0.88 sq.m. crown cover in micro-catchment. Acacia tortilis tried in halfmoon and control did better with halfmoon terraces having 0.918 sq.m. crown cover. Amongst tree species Salvadora exhibited very poor performance.

d. Relative growth performance

Micro-catchment : Five growth characters were recorded in each tree species when each character was pooled and relative values were evaluated, Prosopis Juliflora excelled all the species in the observed characters and RIV providing a distinct look by height, branch length and crown etc. However Tamarix aphylla represent second best species in growth characters and acquiring RIV next to Prosopis Juliflora.

Halfmoon terraces : Six species were compared for their over all growth performance. Here too Prosopis Juliflora provided highest individual growth character value and the RIV, followed by Acacia tortilis. Amongst shrub species Dichrostachys nutans did better.

B. Growth performance of 1993 plantation

In the year 1993 six species of trees and seven species of shrubs were tried in the four treatments. Micro-catchment had only tree species similar to1992 plantation. Other treatment included the trees and the shrub species as well.

a. Plant height

Like earlier years the performance of Prosopis Juliflora showed better height (61.8 cm) in ridge and furrow plot followed by halfmoon terraces (56.2 cm). Tamarix aphylla stood second in gaining height (46.3 cm) in the micro-catchment plot whereas it attained 41.3 cm height in ridge and furrow treatment.

Amongst shrub species. Acacia farnesiana and Parkinsonia aculeata introduced in 1993, gained better plant height 67.1 cm and 56.0 cm respectively in halfmoon terraces.

b. Branch number

Amongst tree species Acacia tortilis produced highest number of branches (10.2 cm) in ridge and furrow treatment followed by 8.7 number in micro-catchment. Dichrostachys nutans produced highest number of branches in ridge and furrow treatment while Mimosa hamata became bushy in halfmoon treatment by producing 9.2 branches.

c. Crown cover

It is Prosopis Juliflora, amongst trees which acquired highest crown cover (2.34 sq.m.) in ridge and furrow treatment followed by Acacia tortilis (3.10 sq.m.) in same treatment. Mimosa hamata, which became bushy, gained 0.47 sq.m. crown cover in halfmoon terraces. Other shrub species remained quite poor in gaining crown cover.

Ideal Reclamation Procedure

Broadly speaking reclamation means returning a de-relect land to a form & level of productivity that can sustain the prior or future land use(s) in ecologically stable state. It is an intricate, complicated site specific ameliorative technique

depending upon the land use (s). There are several reclamation options to land use planning scheme of which Agriculture, Forestry, Industrial, Housing complex, Fish farming water reservoirs are the important ones.

Mine spoils are only matrix of inorganic mineral matters with very poor physical structure, no organic matter and very low amount of plant nutrients, render it incapable of sustaining plant life. The natural process of re-vegetation of spoil dumps through ecological succession takes very long time (80 to 168 yrs.)[2]. If effective steps are taken concurrent to mining with prior knowledge of Physico-chemical characteristics of spoils, it could give a good result within a short period.

The following important parameters have been reckoned as guide lines for re-vegetation of mined out land, spoil dumps and to adopt wherever necessary, depending on the site condition.

Table 7.15 : Guiding Parameters for re-vegetation of mined out land and spoil dumps including backfilled and reclaimed area. [55]

Sl. No.	Parameters	Suggested for re-vegetation
1.0	**Climate**	
1.1	Rainfall (mm)	> 300
1.2	Rainy day (Av.)	> 70
1.3	Temperature (°C)	5 - 50
1.4	Wind speed (KMPH)	< 15
2.0	**Erosion Control**	**< 20%**
3.0	**Physical Reclamation**	
3.1	Soil proportion	
3.1.1	Humid region (%)	20
3.1.2	Arid region (%)	30
3.2	Particle size (mm)	2
3.2.1	Sand (%)	< 70
3.2.2	Silt (%)	< 55
3.2.3	Clay (%)	< 40
3.3	Water holding capacity(%)	+ 42
3.4	Slope (degree)	< 20
3.5	Height (Mt.)	< 10
3.6	Berm width (Mt.)	2-4
3.7	Barm Slope (degree)	0.5 Min
3.8	Terracing	Diamond shape
3.9	Length of slope	Satisfactory
3.10	Compaction (gm/cm²)	1.3 - 1.55
3.11	Rooting depth (cm)	30 - 100
3.12	Soil temperature (°C)	5 - 50
3.13	Top Soil placement (cm)	6 - 8
4.0	**Nutrient Status**	
4.1	Soil pH	5.5 - 7.5 (good) 6 - 7 (optimum)
4.2	Electrical conductivity (mm hos/cm)	4 (good)
4.3	Organic matters (%)	+ 2.4
4.4	Available Nitrogen (ratio)	1:25 (OM:N)
4.5	Available Phosphorous (kg/ha)	+ 45
4.6	Available Potassium (kg/ha)	+224

5.0 Micro Nutrients

Sl No.	Micro nutrients	Good	Poor	Potential Toxic to plant growth
a.	Zinc (Zn)	< 40	40 - 200	> 200
b.	Manganese (Mn)	< 60	60 - 100	> 200
c.	Copper (Cu)	< 40	40 - 100	> 100
d.	Lead (Pb)	< 20	20 - 100	> 100
e.	Molybdenum (Mo)	< 0.3	0.3 - 3.0	3.0

Adityana Limestone Mine of M/s. Saurashtra Cement Ltd. has also done a good work of plantation. Migratory birds have started coming to the water accumulated in the worked out pit. There are number of other mines which has done good work of reclamation and rehabilitations all of which could not be covered in this bulletin.

7.4.0 Mine Reclamation : Innovative Approach

Under the umbrella of stringent environment management regulations and social awareness the subject of mine reclamation has been taken by the global mining community very seriously. Specialists have experimented novel approaches which culminated into successful execution world over. It is believed that in the years to come mining industry will be able to convert the derilicted land for a superior end use. Considerable work is going on in the field of Biotechnology for mine area reclamation. Here we will discuss some of the innovative methods used successfully for mine reclamation.

British Coal Minestone services conducted study on variety of waste products to achieve a good vegetation cover over mining waste lands. The following combinations were used

(1) Sewage sludge

(2) Flue-Gas Desulphurization end-products from coal-fired power stations

(3) Pelletized refuse from urban incinerators.

Where a rapid cover of dense vegetation is required,use of mycorrhizal innoculants of fungi on the roots of young trees during transplantation has yielded higher rate of survival.

There has been a considerable dependence on chemical fertilisers to provide necessary nutrients. Unfortunately leaching of the chemicals and regression of vegetation due to regeneration of acidity called for repetitive use of costly fertilisers. Use of different waste products as outlined above may provide with a solution in the years to come.

The most abundant material is sewage sludge which can be mixed with the top layer of the colliery waste to provide nutrients, moisture retention and raise the pH slightly. As per an estimate only 7% of the sludge disposed off is used for actual land reclamation whereas as large as 30% is wastefully disposed off at sea creating further environmental problems. The benefit of sewage sludge and other waste products is that they give up their nutrients very slowly allowing a well established vegetation cover to form without regression. Colliery waste is on average, an excellent soil-forming material. With the addition of sewage sludge an acceptable soil for most amenity and poor grazing agricultural use can be made. The organic matter in sludge is especially important as it can inhabit the oxidation of pyrites in colliery spoil.

Use of biotechnical products is also beneficial for plant growth. Ectomycorrhirhizac are a symbiotic association between the fungi and plant root. The fungus forms a sheath around the roots of both deciduous and coniferous trees and penetrates between the cells of the root. Shoot from the sheath penetrate the colliery waste thereby extending the root system. This has the following beneficial features

(1) They increase plant nutrient and water absorption from the colliery waste.

(2) They increase the plant's tolerance to draught conditions and to low pH.

(3) They protect the plant from pathogens and toxic metals.

It is estimated that almost all coal-fired power plants will be equipped with flue gas desulpurisation equipment in the near future to overcome the problem of air pollution and acid rain. The end product of this process is variable depending upon the method used

(1) Wet scrubbing using limestone and producing gypsum ($CaSO_4$)

(2) Regenerative systems which produce sulfuric acid as an end product

(3) Spray drying absorption (SDA), producing sulfides, hydroxides, and lime

(4) Sea water washing.

The wet scrubbing and SDA end products are neutral or alkaline and pH vary between 6.5 to 9. The geographical location of these products close to the coalfields makes them suitable for mining with colliery waste in order to reduce its overall acidity when used in land reclamation. The fly ash contents should also help reduce permeability of some of the more granular colliery spoil.

The wet scrubbing process produces commercial gypsum, most of which would be used in the plasterboard industry. A typical 2000 megawatt power station would produce around 500,000 tonnes of gypsum per annum of which 100,000 tonnes may be available for land reclamation as per rough estimates.

The SDA process on a similar sized power station would produce 700,000 tonnes per annum of about 45% $CaSO_3$, 10% $CaSO_4$ and 10% $Ca(OH)_2$ as well as small amounts of CaO and $CaCO_3$, with the remainder composed of fly ash. This material would appear to be more suitable for soil making then the wet scrubbing product.

In recent years it has proved economical to incinerate domestic refuse in urban areas. The pelletized end product has a high pH around 8 as a result of it's high $CaCO_3$ contents. It is also high in organic material and nitrogen. It is therefore an ideal material for blending with colliery waste in the top layers of land reclamation to provide a base for good vegetation cover.[31]

7.4.1 Infilling of Mines with Rock Paste

Rock paste, a mixture of colliery spoil and water has been developed as a proposed infill material for limestone mines. During 1985, a trial was organised by Ove Arup & Partners to use the material to infill a section of the Castle Fields Limestone Mine in Dudley, United Kingdom. Rock Paste was mixed under production conditions and pumped underground where it's performance was monitored and evaluated with remote instrumentation. This included video cameras amongst other techniques.

The Castle Fields Mine was worked by the room and pillar technique. The pillars were rectangular in shape and typically 5 m to 6 m. wide and 4 m to 8 m. long. The area earmarked for infilling was approximately 6600 m^2. The trial was successful as all objectives were realised. During the first phase performance test 600 cubic metres of rock paste was pumped through 159 m of pipeline in nine hours continuous operations.

The infilling of the mine took three months. 29100 m^3 rock paste were injected in 74 days of pumping. The rock paste behaved broadly as anticipated flowing as a plastic material around the mine pillars. The mean pumping rate was 53 cubic metres per hour. In a full scale infilling operation, it was estimated that infilling costs would be around ten pounds per cubic metre. On completion of such an operation 4 ha. site at Coppice was landscaped and developed as a football field and that at Littleton was returned to use for spoil disposal. The infilling site in Dudley was cleared and part has been improved to provide a car park[32], which would have not been possible without infilling.

7.4.2 Rehabilitation of Burning Dump

Zimbutu section of Welgedacht Colliery in South Africa was commissioned in 1965. Around 40% of the total run of mine by mass is discarded owing to it's low calorific value after beneficiation. This discard has a calorific value approximately 3800 kcal/kg. This discard was viewed as a waste product and liability. These dumps were ignited by spontaneous heating and otherwise ignited intentionally to get a reduced volume after burning. This caused considerable air pollution and frequent complaints from the local residents.

The tipping from the top of this dump caused segregation of material with fines remaining near the top and coarse running down to bottom. This coarser material at bottom encouraged the air to let into the dump and due to oxidation, heat generation set the convection currents promoting combustion of the dump.

First of all the tipping was stopped and the dump was started to encapsulate by a 10 m. thick layer of compacted waste/discard. This compacted layer was sufficient dense to cut the ingress of air into the dump. This compacted layer was placed on a solid ground by removing soil and soft material around the dump. This nearly nullified the possibility of air entering through this softer medium and soil was used at a later stage to provide with a 1m. thick surface layer as a growing medium for vegetation. Vegetation was established over it. It was experienced that once tipping at the dump edge was stopped the air pollution decreased by an estimated 80%. This was mainly because of cutting down the air supply. As the compacted skin rose up the remaining burning zones were smoothered progressively. One year after the start of the project Welgedacht was awarded the 1988 National Association of Clean Air trophy.[33]

7.4.3 Superabsorbents

The importance of moisture and temperature for seed germination and plantation has already been discussed along with the practices to exercise control. Super absorbent is a wonderful substance which absorb the water quickly and store it in such

Biological recultivation was adopted at Visonta which took four years and during this period, regular fertilization was of great importance. Recultivation with grain crops means growing of such plants as a monoculture during the recultivation period. The yield of grain crops on the refuse fields had been observed to be higher, year after year. At the end of the recultivation period, the average crop yield of the surrounding fields was matched. Vine stocks and fruits trees have been found to develop similarly to those planted on undisturbed territories and in 4 to 6 years turn into cultivable lands of full value.

In 1981, a recultivated area was selected to establish small gardens. More than 300 small plots, each measuring about 1600-1800 square metres, were provided on 50 years lease to the employees of the lignite mines and of the neighbouring Gargarian Thermal Power Station through local councils. Very good crop results were registered in these small gardens mainly in corn, potato, beans, lemon, cucumber, etc. These results could have competed with those from the best of untouched lands. These encouraging experiences resulted in further demands for such gardens. It was learnt that there were as many as 600 such gardens which had already been leased out and that there were a large number of applicants on the waiting list for such gardens.[43]

(3) Bauxite Mines operated by Alcoa of Australia

Rehabilitation of mined out area to create self sustaining forest has been done where fauna from nearby forest have migrated. This is an example.

Location : Three bauxite mines located in the southwest of Western Australia.

Climate : Mediterranean, mean rainfall 1200-1400 mm, winter maximum.

Nature of Mining: Open cut mines. Shallow pits (average ore depth 4m) ranging from 1-100 ha in area. Mines located in the Jarrah Forest.

Area Rehabilitated : 450 hectares/year.

The rehabilitation is rare within the vicinity of the mines. Number of persons working in the mine are few.

Clearing and Topsoil Management: Commercial timber harvested, some timber retained for rehabilitation, remainder burnt. Topsoil double stripped using scrapers (0-50 mm most valuable as seed resource), then spread directly to the area to be rehabilitated.

Rehabilitation Earthworks: Battering of pit walls, ripping of pit floor prior to spreading with topsoil and further (deep) ripping using 'winged' tyne.

Revegetation : Seed mix of (60) native species (0.9 kg/ha including many leguminous species) and eucalyptus (2.6 kg/ha), and cycads (1.2 kg/ha) is broadcast by hand over pit surface.

Timing : Strip topsoil in summer to maximise seed stores. Seeding was undertaken during January-May. Early seeding after ripping before settlement of soil ensures niches for seeds to lodge into resulting in good germination.

Recalcitrant Species : Research aims to increase number of species that can be established in rehabilitated areas. Range of techniques being trialed including seed treatment and tissue culture.

Fertiliser : 500 kg /ha diammonium phosphate with potassium and micronutrients aerially spread in September.

Nutrient Cycling : Lateritic soils are infertile so nitrogen accumulation is encouraged by use of legume understorey species.

Fauna : Fauna corridors & habitats are created using logs/stumps after earthworks.

Weed and Feral Animal Control : Foxes controlled to assist with native fauna recovery.

Erosion Control : Deep ripping on contour with 'winged' tyne is undertaken to control erosion.

Monitoring : Density of legumes and eucalyptus assessed, 9 months after rehabilitation.

Target is 1300-2000 eucalyptus/ha and 1-2 legumes/m^2. Remedial treatment undertaken if needed. More than 90% of bird species, 78% of reptiles, 80% of mammals, 75% of frog species and 70-90% of invertebrate groups from unmined nearby forests have been found in surveys of rehabilitated areas.

Other Details : Dieback - comprehensive dieback management strategy has been developed with the Department of Conservation and Land Management. Infected and uninfected soils are stripped and stored separately. Drainage control and vehicle hygiene are paramount.[3]

(4) Eneabba Mineral Sands Mine operated by RGC Mineral Sands Limited

Self sustaining ecosystem and sustainable agricultural systems can be established in a mined out areas. Following is an example from Australia.

Location : 300 km north of Perth in Western Australia.

Climate : Mediterranean, mean rainfall 530 mm. Long dry hot summer with temperatures often >40°C.

Nature of Mining : Dry surface mining or wet dredging. In the past in uncleared native heathland, present and future in land cleared for agriculture.

Area Rehabilitated : 1200 ha (total).

Rehabilitation Objective : The rehabilitation objective for heathlands is to establish a self-sustaining ecosystem whilst for other areas it is to establish sustainable agricultural systems.

Clearing and Topsoil Management : Topsoil double-stripped 0-50 mm and 50-150 mm and placed in layers in proper sequence directly onto recontoured areas immediately during January-April or stockpiled (<12 months).

Rehabilitation Earthworks : Sand and clay tailings are pumped to mined-out pits and recontoured to produce similar pre-mining landform.

Revegetation : Species regeneration from topsoil and mulching is augmented by direct seeding of about 100 local species. Cover crop of oats is sown with the native seed to protect germinating native seedlings. Nursery seedlings supplement revegetation. Some established areas are re-mulched and re-sown to increase species richness and diversity.

Timing : January-April topsoil placed and seeding undertaken in May in time for winter rains. Seedlings planted out in June/July.

Recalcitrant Species : Research aims to increase number of species in rehabilitated areas. Investigations have centred on seed biology, seed treatments and vegetative propagation for species producing little or no viable seeds.

Fertiliser : The Cover crop and native seed mix is sown with 200 kg/ha of superphosphate (plus Mo and Zn) to boost early establishment.

Nutrient Cycling : Research has been conducted on nutrient cycling in the heathlands and on soil profile re-development. This has indicated the development of soil profiles which will support the proposed landuses.

Fauna : Provision of food and shelter in successfully rehabilitated areas is the key to fauna recolonisation.

Weed and Feral Animal Control : An extensive ongoing program is conducted for the control of rabbits and foxes. Weed infestations are usually small and localised and are eradicated when found. Native legumes are being substituted for oats as a cover crop to decrease the major source of weeds.

Erosion Control : Wind erosion is a major constraint to establishment of seedlings. Minimised by vegetative mulch and establishment of cover crop(oats). Mulch also provides seed source, as many species in this area are bradysporous.

Monitoring : Late spring monitoring of vegetation has revealed a predictable increase in plant densities from <1 to >7 plants/m^2 since 1981. Older areas are approaching agreed interim completion criteria in terms of species numbers, plant densities and cover values.[40]

(5) Hunter Valley No.1 Mine. Owned by Coal and Allied Industries Limited, a subsidiary of CRA.

Following is a good example in which land surface has been stabilised and sustainable post mining land use achieved at a coal mine in Australia.

Location : 100 km northwest of New castle in NSW.

Climate : Warm temperate, mean rainfall 640 mm.

Nature of Mining: Truck & shovel coal mine, operating in strip configuration. Strip lengths vary. Strip widths are 150-300 m wide.

Area rehabilitated : 380 ha (total).

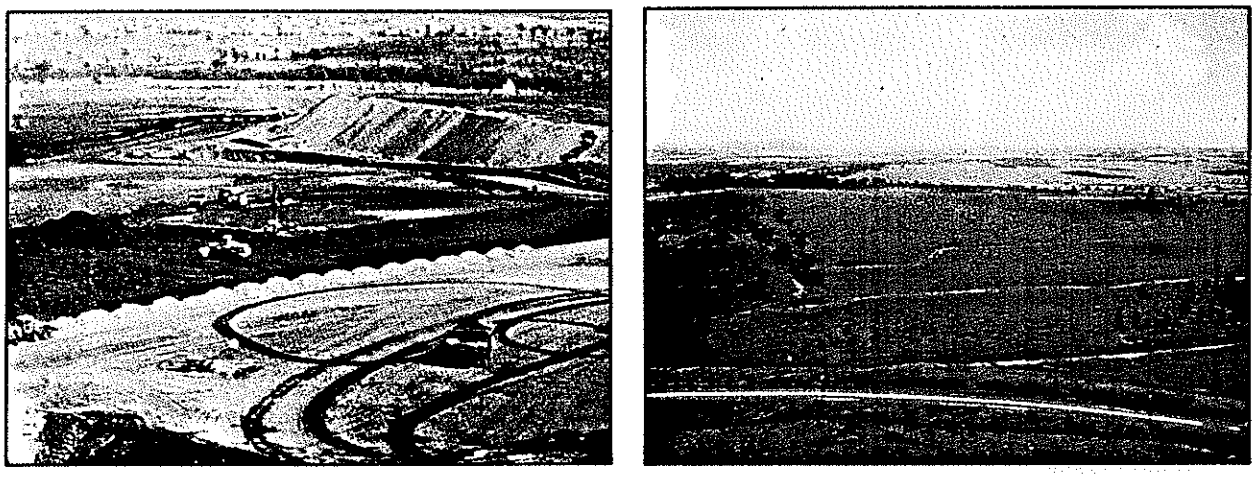
Rehabilitation Objective : Stabilise land surface and to establish a productive and sustainable post-mining landuse incorporating beef cattle grazing and tree shelter belts.

Clearing and Topsoil Management : Topsoil removed with scrapers prior to mining. Where possible placed directly on reshaped areas. Otherwise stored in wedge-shaped stockpiles.

Rehabilitation Earthworks : Drainage, stability and erosion control are primary considerations. Topsoil placed at 100 mm thickness for pasture. No topsoil used where trees are to be planted.

Revegetation : All areas are cultivated using a tyned plough and deep ripped on contour prior to

Before (1981) and after (1989) ' of Rehabilitation at Bauxite Mine operated by Alcao (Australia). *(Both photographs have been taken from same point.)*



Hunter Valley No.1 Mine of M/s Coal and Allied Industries Ltd., (Australia) in operation and same area after Rehabilitation.

Vegetation establishment with woodchip amendments has been found to be equal to that of topsoiled spoils (Dollhopf and Bauman, 1981). From preliminary results, they concluded that woodchips may be a feasible substitute for topsoil where the latter is limited or unavailable. King (1983) observed wood mulch applied to topsoiled spoils to be more effective, after one growing season, than topsoil alone in promoting vegetation establishment.

Manure amendment of bentonite spoils has not proved as effective as wood residue amendment in promoting vegetation establishment. Dollhopf and Bauman (1981) applied 224 ton/ha and 112 ton/ha plus sulfuric acid to spoil material, and achieved variable and poor results. They attributed the poor establishment to increased salt content (1 to 3 mmhos/cm) resulting from the manure. Other research has shown high levels of short chain fatty acids present in manure that are toxic to seedlings (Schuman and MeCalla, 1976). Straw mulch has also been shown to increase vegetation establishment, plant density and cover on bentonite mined lands when applied at the rate of 3.7 ton/ha (King, 1983).

In general, organic amendments have provided the greatest benefit when used on bentonite spoils rather than on areas where topsoil has been replaced. One of the main benefits derived from the organic amendments is improved physical characteristics of the spoil, such as increased water infiltration rates, reduced bulk density and increased aggregation. Such characteristics can provide improved soil water availability and a better rooting growth medium for plants.[44]

(9) Reclamation in Southwestern Wyoming, USA

Bridger Coal Company operates a 5.8 million tpy surface coal mine thirty five miles northeast of Rock Springs, Wyoming. Approximately 20,000 acres are under permit, disturbance over the life of the mine projected to reach on 10,000 acres area. Located on the western rim of the continental divide, the mine receives less than 8.5 inches of precipitation annually. Soils in the area are coarse-textured, and problems associated with elevated salinity and alkalinity are encountered.

A variety of common reclamation techniques have been modified to reflect these conditions. Soil horizons are segregated during salvage operations (the surface six inches as topsoil and the balance as subsoil). Unsuitable materials are not salvaged. Direct application of soil was used (over 130 acres) to maximize native plant regeneration and conserve soil fertility. Inter-seeding (of seeding failures) has proven to be significantly more successful than chisel plowing and reseeding. Broadcast seeding has been ineffective because of strong winds, and a no till - drill has been modified to handle diverse seed mixes and rock conditions. The utility of fertilization under typically xeric moisture regimes is being evaluated. A research project has been initiated to assess establishment of a predominately native, diverse seed mix under irrigation, as well as to determine irrigation rates and duration.[45]

(10) Granville Colliery Land Reclamation, UK

The site of the former Granville Colliery lies in the North Eastern part of Telford and until 1986 it formed the single largest tract of derelict land remaining in the New Town Area, covering in all some 162 hectares. The Colliery was closed in 1979 but the majority of the land remained in the ownership of British Coal Corporation (BCC). It was affected to a substantial extent by various forms of dereliction, ranging from spoil heaps, mineshafts and derelict buildings to areas of ill drained land affected by mining subsidence. Following closure of the Colliery, BCC formulated a proposal in 1981.

A feasibility study was commissioned by Shropshire County Council (SCC) under the control of a Steering Group of officers from SCC, Wrekin District Council (WDC), and Telford District Corporation (TDC). This study considered a wide range of alternatives for the development of the site.

This scheme was the largest single land reclamation contract ever carried out within Telford; reclaiming extensive areas of derelict land for positive end uses complementary to the overall development strategy for Telford. The objectives of all parties were successfully met.

Table 7.19 : Granville Colliery Reclamation Scheme : Salient Features

Item	Estimated	Completed
Coal produced (T)	220,000	176,000
Earth moved (m^3)	2,750,000	3,000,000
Spoil washed (m^3)	900,000	800,000
Shafts treated (no)	153	133
Land reclaimed (ha)	95.1	95.1
- Development (ha)	37.4	37.4
- Open space(ha)	43.7	43.7
- Waste site (ha)	14.0	14.0
Expenditure (million £)	4.8	5.1

Development of land for residential and employment uses, together with associated open space, was created for TDC at a cost some 40 percent less than that normally associated with reclamation schemes in Telford. A major site for future waste disposal has been created for the County Council, which will serve Telford and the surrounding community for the next 15-20 years, at a time when existing facilities were virtually exhausted. Coal mineral in substantial quantities has been recovered from waste tips for the benefit of BCC, without detriment to the ultimate land uses. The project would not have been possible without the close co-operation fostered between British Coal Corporation, Shropshire County Council, Wrekin District Council and Telford Development Corporation, or without the expertise of TDC's Specialist Land Reclamation Engineering Team. It demonstrates how large and complex schemes can be brought to fruition, given sufficient will to succeed, and how the overall community can be benefited from such a venture.[46]

(11) Reclamation of Manners and Pewit Collieries, Ilkeston, Derbyshire (U.K.)

The 54 hectare reclamation scheme included the site of the Pewit Colliery which closed in 1875 and had subsequently been used for household refuse disposal, the Manners Colliery, several old railway embankments, a disused canal, a large number of abandoned allotments built on top of old ironstone spoil and a total of 27 ironstone and coal shafts.

The site had been reclaimed for a mixture of industry and recreation and included a 16 ha industrial site; a five hole extension to an adjacent golf course; an enlarged and deepened subsidence flash to improve the fishing facilities and footpaths alongside and across the cleaned up canal. In addition a 160,000 cubic metre capacity balancing reservoir had been created to serve the industrial estate.[47]

(12) Easton Bing, Scotland

Easton Bing, the site of the former Easton Colliery, covers an area of 30 ha. In the early 1980s it consisted of heaps of unvegetated colliery spoil and lagoons containing fine coal waste and water. A series of fires within the spoil caused air pollution.

Restoration of Easton Bing was considered in conjunction with that of another site 2 km away, near Bathgate Town Centre. This second site, Little Boghead, consisted of 44 ha of low-lying, soggy ground which, despite its poor ground conditions, was the only area within Bathgate designated by the local plan for private housing. An economic assessment of various reclamation options for these two sites was carried out by a firm of chartered accountants. This assessment took into account the costs of various alternatives and the likely financial return from the sale of developable land. All schemes were found to have a net cost, but this was substantially reduced for the option which used material from Easton Bing to create developable land at Little Boghead, compared with options which reclaimed the two sites independently of one another. The Easton Bing scheme was approved by the Board of the Scottish Development Agency, who provided funding in 1984. The Land Engineering Division of the SDA acted as the client/ employer for the scheme and design and supervision was carried out by the Landscape Development Unit of Lothian Regional Council.

On completion of the coal recovery scheme the bing(waste pile) was regarded and treated with processed sewage sludge cake, followed by direct sowing and planting to form grazing land and woodland. The site now resembles a natural hill. The spoil is, however, generating some acid mine drainage water, which can be seen in a stream on the north side of the bing. Despite the compaction achieved at Little Boghead, some acid mine water has appeared in the culvert crossing the site.

The general air of dereliction at Bathgate has largely disappeared since the reclamation of Easton Bing and similar sites. The reopening of the local railway line to Edinburgh has also made the area a

more attractive place to live. Part of the justification for reopening the line was the anticipated increase in population arising from new house building at Little Boghead. As a result of these improvements, prices for development land in Bathgate have risen substantially since the economic appraisal of the reclamation scheme. The revenue that had been anticipated from sale of the whole site has now been received from sale of just one fifth of the area to a private housing developer.[48]

(13) Falquemont, France

Coal was deep mined at Falquemont and provided the major fuel source for a power station 15 km away. The mine was closed in 1974. However, coal dust reclaimed from the settling lagoons continued to provide fuel for the power station.

As the mining company had progressively withdrawn, the local council became involved in promoting new uses of the site for industrial, educational and recreational purposes. A large part of the site is now used as a training college for operators of heavy earth-moving equipment.

The site, which occupied an area of 160 ha, was divided into three parts :

- former mine buildings;
- spoil heaps;
- settling lagoons.

Falquemont provided a good example of a long-term project to reclaim derelict land for a variety of new uses.

The former mine buildings

The main reception building services a double purpose for teaching and student accommodation. Some of the remaining buildings are occupied by small industrial users. However, some of the buildings are in a poor state of repair and only the ground floors are suitable for occupation.

The spoil heaps

The spoil heaps are used as the main driver training ground, and have been found to be ideal for earthmoving operations in all weather conditions. The spoil heap material is continually moved around by the students practicing their driving and operational skills.

The settling lagoons

HBL (Houilliere de Basin Lorraine), the original mining company, was exploiting the settling lagoons for recovery of coal dust and the empty lagoons were being filled with spent ash from the power station. HBL were working in conjunction with the EPML to reclaim the lagoon area, and further studies were to be carried out as to how the alkaline nature of the ash will affect the reclamation proposals :

- upper lagoon - this was to be completely filled with ash and was to serve as an additional training area for machine operators ;
- middle lagoon - this lagoon was to be partially-filled and a fishing pond/wildlife area was to be created;
- lower lagoon - plans to recover coal dust from the lagoon had been halted due to the low coal content. It was likely that the lagoon would be drained to improve the stability and then planted to create woodland. Hope work had been completed successully.

Landscape work

Some initial landscape work has been carried out along the old railway line at the periphery of the site to improve the outlook from the nearby residential area. This has also helped to reduce the noise transmission from the ongoing earthworks operations on the site.

Shafts

There were two shafts on the site, both of which had been capped. Water from the flooded workings is being utilised for local industrial purposes.[48]

(14) Wingles, France

The region of Nord-Pas de Calais in the northern, industrialised corner of France includes a large coal field with many abandoned colliery sites. Reclamation has been carried out in the region for at least 20 years but the proportion reclaimed remains small. As a result, prominent spoil heaps dotted around a flat landscape remain typical of the region. Colliery site has been transformed into a very successful public park. It is located on the edge of Wingles, a small mining town situated centrally in the basin, 20 km south-west of Lille, the regional capital.

The site comprises around 200 ha. of land and water, and is open to the public as a recreation park. Numerous activities are catered for, including sailing, fishing, motor-cross, cycling and jogging. There is also a campsite, an information centre and various play areas. There is a substantial amount of woodland, with large areas reserved for wildlife.

The park has been developed progressively since reclamation. The 12 ha. watersports lake, excavated for the purpose in an area of subsidence, was completed in 1986. The 20 ha. of fishing ponds, formed by mining subsidence, were already in existence when reclamation commenced.

(15) Colard and Acierie L.D., Belgium

The province of Liege is the major coal and steel producing area of Belgium. Since 1961 economic development in the region has been promoted by the Societe Provinciale d'Industralisation (SPI), an association of local authorities and other economic and social institutions in the province. The members of SPI now include 68 of the communes of the province, representing 91.5% of the population.

To help bring the increasing amount of derelict land back into beneficial use, SPI set up an affiliated organisation, SORASI (Societe de Renovation et d'Assainissement des Sites Industriels) in 1988. The objective of SORASI is to reclaim derelict land and then sell it for a suitable after-use.

Colard is the site of a former coal mine which ceased production in 1979.

There are two shafts on the site. Prior to reclamation a colliery spoil tip was present at one end of the site, with a few remaining buildings. The spoil was not acid-producing.

A reclamation scheme has been carried out in which the spoil heap was levelled to provide land suitable for the construction of light industrial units. Access roads have also been provided. No building is allowed within 25 m of the shafts and this restricted area has been fenced. Scrub vegetation is developing within the fenced area. A small trolley from the coal mine has been used as the centrepiece adjacent to the site, as a monument to the coal industry.

Acierie L.D. (14 ha. site) was originally a coal mine, then part of the steelmaking facilities of the local steel company, which still has active blast furnaces adjacent to the site. After closure in 1985 the steelmaking plant was dismantled and transported to China.

The site was covered with several sq. metres of effected ground, consisting of wastes from the coal and steel industries. A site investigation was carried out to determine the ground conditions and contamination status of the waste. It was concluded that the majority of the wastes could remain in situ, but should be covered by soil. One small area of more contaminated material has been removed. Two shafts are present on the site, which have been capped.

The site was in the process of being restored by infilling with imported materials. This infilling was necessary to give a gentle slope from one end of the site to the other, enabling construction of an access road across the site. Currently the site is at a lower level than the surrounding ground.

The site was to be divided into four zones, for housing, commerce, light industry and recreation. The zones were to be separated by green areas and the recreation area. A sports field was to be a buffer between the existing active steelworks and the other zones.[48] It is hoped that this work has been completed successfully.

8. Conclusions

8.0.1 The awareness of the importance of countryside preservation and pollution control has placed greater pressures upon mine operators today than existed in years gone by. Minimisation of environmental impact and the ability to prevent the disfigurement of the landscape are essential if new mining ventures are to be granted planning permission. Till recently "Reclamation" was considered to be a separate exercise in our "Mining Industry". With the introduction of more stringent regulatory laws pertaining to the environmental aspects in mining and mineral industry, ever increasing awareness among the masses and social pressures, reclamation has gained significant importance in our country.

8.0.2 During the course of winning the degradation of the environment through land, water and air is evident. The most significant of all is land degradation which sometimes effects water and air pollution as well. Different mining activities result in several modes of land degradation. Before making a strategy to push effective controlling measures on them an assessment of various causes has been made. In the light of the population explosion, social pressure and availability of land, the issue of land degradation is of paramount importance.

8.0.3 Reclamation is a process, which infact, begins prior to the actual mining operations during planning stage. The days are over when it was considered as an exclusively post mining process. The successful reclamation starts with the planning of a mine and much before the actual execution. A Comprehensive Reclamation Plan as a standard mining practice is required to be chalked out considering pre-mining status, Regulatory Laws, Environmental and Social aspects, Resources and Economics, after-use of landscape alongwith the possible extent of effective concurrent reclamation to keep the cost inputs at minimum possible levels. With a little advance thinking and efforts the damage to the local environment cannot only be minimised but an effective restoration and rehabilitation strategy can also be worked out for best possible use of the damaged land which is very much the need of the time. This calls for an effective all round co-ordination between mine-operators, government and its various concerned departments like mines, forest, P.W.D., agriculture, horticulture and scientific organisations with their latest know-how in the field of mining operations, environment and processing along with that with the community around the mining site.

8.0.4 In the last decade, techniques have been developed that enable revegetation of mine wastes, particularly waste rock dumps and tailings dams, to be undertaken to a very high standard. Research trials have led to solutions that have been deployed successfully on tailings from base and precious metal workings throughout the world.

The essential ingredients of success are commitment, careful development of a specification, scientific objectives and a properly formulated management plan. Different end-points are achievable according to the site specific location and climate. A wide range of land uses is available including various grasslands, woodlands and wild-life habitat.

8.0.5 Selection of the most suitable plants and species is the basic ingredient of a successful revegetation process. Not only the site specific conditions like location, soil quality, topography, nutrient requirement, climate should be taken in account but equally important is the end use of landscape. The whole process of vegetation from selection to the final establishment is required to be organised scientifically and a careful monitoring of the whole process is must. Basic guidelines for the selection procedure have to be incorporated but the approach should have the required flexibility for improvisations based upon the local experience and innovation.

8.0.6 The objective "Total Reclamation" remains far from achieved if the process of vegetation has not been taken to a point of "Self-Sustenance". Often the role of "Aftercare - Management" to

achieve the desired result has not been given a meaningful thought. The aftercare management strategy should be laid down depending on the end use pattern. Based on these lines the strategy is to be worked out for different management components for Grassland, Forestry & Woodland Management.

8.0.7 By the year 2020 land degradation may pose a serious threat to food production and rural livelihoods, particularly in poor and densely populated areas of the developing world. Appropriate policies are required to encourage land improving investments and better land management if developing countries are to sustainably meet the food needs of their populations.

In India also lessons have been learnt and various organisations are putting more emphasis on the effective land reclamation mechanism. Fair amount of research is being carried out by various Government and non-Government organisations and the results are encouraging. Several innovations have been carried out in the field of Bio-technology for quick and rapid rehabilitation. Some of the companies like, TISCO, NLC, Gujarat Ambuja, HZL, MOIL, NMDC, BALCO, PPCL, KIOCL, Wolkem India Ltd., etc. have done remarkably well in the field of environment protection but much is desired to be done as far as Indian Mining Industry as a whole is concerned.

For example, the decline of forest cover in India has been qualitative (crown density) and not quantitative (area under forest) with per capita forest cover declining by 36 percent during the period 1951-1991. Though mining is minor player contributing even below 1%, improvement in mining area would help considerably to the society. Other reasons contribute the rest and also rapid increase in population puts tremendous pressure on environment. In our country the requirement of firewood is nearly six times the sustainable supply, while the requirement of industrial wood is more than twice the sustainable supply. The number of animals grazing in the forest rose from 25 million in 1950-1951 to over 100 million Cow units in 1994-1995. Industrial wood demand has increased by more than six times in the last four decades and is likely to grow even faster in future.

In total, there were 13600 registered factories 30 years ago, compared to 0.1 million factories today. Thermal power constitutes about 72% of the total installed capacity and releases about 45 million tonnes of fly-ash per year. Beneficial uses of this fly ash after desulphurisation to improve the soil characteristics of coal mine spoil and use of end product from desulphurisation as an effective amendment agents have been established.

The municipal solid waste generated in Indian cities increased from 6 million tonnes in 1947 to 48 million tonnes in 1997. This is because of an increase in urban population from 57 million in 1947 to 274 million in 1997 and an increase in per capita generation from about 300 gms per day in 1947 to 500 gms per day in 1997. Currently, 100 million tonnes of solid waste and 2 million tonnes of hazardous waste are generated by the industry. The total urban municipal solid waste generated will increase from 48 million tonnes per annum in 1997 to 300 million tonnes per annum in 2047, almost a six fold. A very effective use of this solid municipal sludge is in mine reclamation. This not only helps quick rehabilitation of various species of plants but the problem related to it's disposal can also be marginalised.

It is no longer appropriate without regard to specific circumstances to argue against mining based upon the inevitability of irreversible damage to the landscape, loss of amenity or natural history values. However, the proper reclamation techniques have to be employed. It is imperative that Scientific Reclamation Plan commensurate to latest technological developments is a must for successful mining venture.

Experiments and research are going on as a continuous process throughout the world for best utilisation of land damaged by mining and allied operations. It is hoped that this will go on and will help the society to live a better life in the affected areas due to mining, by improving at least equal to the original pre-mining environmental conditions, if not to a better environment which may be possible.

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