ASPECTS OF LAND RECLAMATION IN INDIA, SOUTH AFRICA AND SPAIN[1].

by

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Abstract. The reclamation of land disturbed by industrial and construction activities in India, South Africa and Spain provides for many contrasts between each country.

In Spain, land reclamation is a virtually new concept, imposed by the country's recent entry into the European Common Market and the need to conform with the environmental regulations of the EEC. Consequently, there are few examples of actual reclamation in mining and other industries. Much is still at the assessment stage of environmental problems and the planning of land reclamation.

India has long recognised the need for land reclamation but this has been limited by economic, socio-cultural and technical restraints. Industrial development has had catastrophic effects on the nation's forest cover. Recent legislation has recognised the situation, and, as a result, all new mining leases which entail the destruction of reserved forests, must afforest an equivalent area of non-forest land in addition to the reclamation of the mine site itself. Afforestation must begin to take place immediately, not just at some time into the active life of the mine.

Reclamation in South Africa gained worldwide recognition with the development of procedures to establish vegetation on steeply-sloping acidic gold tailings. Less widely known are the subsequent modification of those procedures. Reclamation of other metallic wastes, coal spoils and overburden is common practice. Several intensive reclamation research programmes are underway.

Some of the problems and successes on land reclamation in each of the three countries are described; the legislative status of land reclamation, and the effect of economic, technical and social factors on land reclamation are briefly reviewed.

Introduction

Climatic and edaphic factors primarily determine the type and form of land reclamation programmes. Socio-economic and legislative factors in any one country though, may determine whether or not disturbed lands are actually reclaimed, the rate at which land is reclaimed, and reclamation standards (i.e. permitted level of environmental impact of the industrial activity).

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One of the major obstacles to developing revegetation programmes on mining and industrial wastes and subsoils exposed by construction activity, is the concept held by many in industry and government that a green cover, quickly established, is all that is required for successful reclamation. In South Africa, such a cover would consist entirely of grasses, usually composed of two or more of Cynodon dactylon, Eragrostis curvula, Chloris gayana and various other species. The long term relationship between these species has rarely been considered despite clear evidence that unmaintained stands of such species decline in time and lose their effectiveness for erosion control On occasion, alfalfa would be included as a legume component, but with virtually no chance of success because of interspecific competition.

One research programme (Walmsley, personal communication) is now investigating the use of more balanced grass-legume seed mixtures in order to establish maintenance-free vegetatation and at the same time permit the invasion of local species. As well as evaluating tropical legumes, such as Desmodium inortum and Macroptilium atropurpurium, a number of temperate legumes are being seriously considered for tailings revegetation and elsewhere. Several trials conducted by the agricultural industry have indicated a strong potential for Lotus corniculatus, Coronilla varia, Onobrychis viciaefolia, Ornithopus sativus and O. compressus in certain regions of the country. Greenhouse trials utilising tailings from various sources have given an initial indication of satisfactory adaption but field trials are required for confirmation.

The above approach strongly contrasts with that of another research programme (Wyk, personal communication) which is a evaluating a very large number of ecotypes of Eragrostis curvula for use in land reclamation. Traditionally, E. curvula has been widely used in South Africa as an erosion control species, despite obvious limitations imposed by growth habit and lack of longterm persistence. The programme not only hopes to overcome those characteristics, but to provide sufficient seed of single or bulked ecotypes for use in large scale reclamation programmes.

Although revegetation of gold tailings has dominated the land reclamation scene in South Africa for many years other tailings and wastes are rapidly emerging as major fields of activity. Little publicised, but undertaken with great success over the past decade, has been the restoration of mineral sands at Richards Bay in Natal. The restoration of wastes arising from the mining of platinum, asbestos and coal are now receiving great attention. The number of environmental impact assessments being undertaken by various consulting companies are indicative of this.

One technical aspect of land reclamation that will have to be addressed in the near future is the limited (type and quantity) availability of grasses, legumes and herbs for use in erosion control schemes. Only one perennial legume is widely available at present- alfalfa. There has been no development (and given the apparent lack of a market for such this is understandable) of herbaceous species for use in the arid and semi-arid climates which characterise much of the Iberian Peninsula. Where reclamation schemes have been undertaken on highway and other areas, landscape-type shrubs and trees have mostly been used.

Reclamation Practice in South Africa

The reclamation of land areas disturbed by mining, highway and other construction and industrial activity is widespread and accepted practice in South Africa. There is a large literature base spread between research publications, government documents, institutional magazines and conference proceedings. Because of the enormous importance and influence of mining on the South African economy, descriptions of mined land reclamation, and associated technology, tend to predominate. (e.g. Gowan and Williamson 1987; Smith, Bentel and Robbertze 1987; Walmsley and Jones 1987; Wells 1987; Wrench 1987; Wyk 1979, 1988; Wyk, Wells and Marsden in press)

The success achieved by the gold-mining industry in South Africa during the past 25 years with the establishment of vegetation on acidic gold residue deposits has been considered outstanding by many reclamationists. A history of the technical development and the respective contributions of the various people involved over the years has been compiled by Marsden (1987), while changes to some of the original techniques, leading to an improved ecosystem development on the deposits owned by Rand Mines, have been described by Wells (1987).

Many of the earlier vegetated deposits now exhibit a vegetative cover clearly in a slow decline. No maintenance fertiliser, frequent fires and human activity have largely contributed to the decline. In contrast, on those older deposits subjected to selective fertilisation practices and land management there has developed a diversified plant cover, including invasion by local species, capable of recovering from fire and requiring only minimal maintenance. In addition to newer revegetation techniques, specific close-out procedures for recently completed residue dumps have been devised, especially control of water run-off, which contribute greatly to the success of new reclamation programmes.

Land reclamation in India primarily involves the re-establishment of forest cover, whether on or off the mine site, by the planting of container grown tree stocks. Some of the most commonly used species include Eucalyptus, Cassia, Acacia, Prosopis, Azadirachta, Lucaena and Dalbergia. Given the wide range of climates which occur in the Indian subcontinent, this list of species is by no means exhaustive or wholly typical.

In the arid area of Rajasthan, grasses, Cynodon dactylon and Pennisetum typhoides, have been successfully established on zinc-lead tailings along with several shrubby ornamentals including Lantana species (Chaphekar 1989). This use of grasses, however, appears to an exception to general revegetation practice.

Reclamation Practice in Spain

Land reclamation in Spain has yet to develop as a vigorous activity in academic, government or industrial circles. There are a number of reasons for the current state of affairs.

The relevant legislation is comparatively new, it does not apply to already existing situations (unless having severe impact upon air and water quality in which case government persuasion can be brought to bear), industry is waiting to see what degree of enforcement will be applied by government, and there are few reclamation specialists to provide advice to either industry or government.

There are other reasons as well. For example, in the aggregate industry, many operations are small and individually owned. Although the collective environmental impact of aggregate mining in any one area can be quite large, each of the individual operations cannot afford to undertake either reclamation or EIA studies. Also, Spain at present has high unemployment, and the government appears loath to enforce environmental regulations which may result in a reduction or closure of a mining operation.

There is virtually no published information available and much remains hidden within company or government reports; for example, the extensive reclamation work undertaken by Asturiana de Zinc at its Reocin mine in northern Spain, revegetation trials on old metal mines undertaken by the regional government of Murcia (southern Spain), and an environmental impact assessment of kaolin mining (Minconsult 1988).

reclamation procedures and technologies in other countries. As a result, much of the investigative work undertaken in India is either repetitive or reveals a lack of technical understanding for some of the basic procedures in revegetation work, e.g. legume inoculation, fertiliser requirements, species selection and adaptation trials. [

At present much of the reclamation work in India is descriptive, making assessments of current environmental problems (but often based on minimal air, soil and water data collection) and drawing up environmental management and reclamation plans for the future. This state of affairs is partly due to the requirements of the current legislation. Environmental management and land reclamation plans are required from mining companies if they are to obtain licences to mine; particularly, where the destruction of forested land is involved.

A licence will only be granted if the company can demonstrate that it has an equal amount of non-forested land elswhere that be afforested almost immediately. This is known as compensatory afforestation. If only degraded forest land is available, then twice the number of trees have to be planted on that land. The afforestation policy has been criticised (Rao 1989) on the premise that it has no value in terms of ecological balance, and,"if damage is done to the foot, one does not treat the arm.. damage to nature at place A is not rectified by rehabilitation or afforestation at place B".

After a mining licence has been granted by the regulatory authorities, there is virtually no inspection mechanism to ensure that the environmental and reclamation programmes designed for a mine site are actually carried out, or if so, are of a satisfactory standard. This situation is proposed to be rectified shortly by the establishment of a national environmental monitoring agency.

In the meantime, the degree of land reclamation undertaken by mining companies is dependent upon the environmental ethics of the companies. There are a number of private companies which have undertaken large and elaborate land reclamation schemes. One especially worthy of mention is Sayaji Iron and Engineering in west-central India; where the standard of restoration (to wild-life habitat) is the equal of many elswhere in the western world. Unfortunately, but not altogether suprising, the attitude of some private and government owned mines towards land restoration leaves much to be desired.

A discussion of the many technical problems associated with land reclamation in India cannot be undertaken here for reasons of space. It must be sufficient to say that the problems of controlling surface erosion and sediment runoff, of lack of overburden and tailings characterisation studies and of little attention being given to post-mining landforms in open-cast coal mining, represent only a few of the many problems that have to be resolved within the Indian mining industry.

1. The location of residue deposits and evaporation ponds for liquid wastes;
2. The disposal of wastes in any way other than on residue deposits and in evaporation dams;
3. Safety of residue deposits;
4. Prevention of environmental pollution;
5. Maintenance of abandoned residue deposits;
6. Specific requirements in respect of coal discard or debris;
7. Hazardous waste (non-radioactive and radioactive materials.

Both the above authors have stated that the regulatory structure appears quite complex; yet equally point out that the structure works well in practice. The various acts are supplementary to each other and satisfy the requirements of the relevant controlling authority.

In addition to the various acts and regulations, the mining industry provides self-regulation in environmental protection through its representative body, the Chamber of Mines. That organisation has produced a series of "Handbooks of Guidelines for Environmental Protection" and include recommendations and procedures for the reclamation (revegetation) of gold and coal wastes.

Reclamation Practice in India

Land reclamation in India has traditionally been associated with the reclamation of saline and sodic agricultural soils (e.g. Abrol 1986). Only within the last decade have there been numerous attempts to restore lands disturbed by mining to an acceptable or useful vegetative condition (e.g. Gupta 1979; Mann and Chatterji 1979; Prad and Chadhar 1987).

A recent conference (Federation of Indian Mineral Industries, 1989) revealed the extent of activity in the reclamation of lands disturbed by mining during the last decade but at the same time demonstrated several weaknesses in the land reclamation scene. The results of the above activity have either not been published,or if so, only in government or industry reports to which access is difficult to obtain. Also, many of those active in land reclamation have had little or no opportunity to review or study the development of land

The Mineral Concession (Amendment) Rules, 1960, amended 1987 and 1988, prescribes, among other, the detailed contents of theMining Plan, qualifications of the persons recognised to prepare the mining plan and the obligations of the mining applicant regarding the compensatory afforestation and implementation of the mining plan. In order to encompass the provisions of the Water Act, 1974, the Air Act, 1981 and the Forest Act, 1980 and other constituents of the environment not included in those Acts, the Environmental (Protection) Act, 1986, (and the rules framed under it in 1986 and 1987) was enacted as an umbrella environmental act. The new Act is a more comprehensive piece of legislation than any other legislations enacted earlier which contained only limited provisions regarding the environment.

The Forest (Conservation) Act, 1980, provided for the conservation of forests by controlling the indiscriminate diversion of forest land for non-forest purposes. The amended act was introduced to provide a greater degree of control over the leasing and clearing of forest land for non-forest purposes. In particular, the definition of what constituted non-forest land use was refined to include therein the cultivation of plantation crops, oil-bearing plants, horticultural crops and medicinal plants.

Despite the above legislation, there is still no specific legal requirement that a coal company must reclaim or restore the topography or former ecological values of a mine site (Town and Country Planning Organisation 1987, Annexe V, p.42.). Also, as pointed out by Bannerjee (1988), the coal company has no incentive to restore the disturbed mine site, for, after use, the land reverts to the government, and there is no economic incentive to the company to undertake progressive land reclamation.

Reclamation Related Legislation in South Africa

The regulatory structure for the control of hazardous waste (including mining wastes)in South Africa was briefly reviewed by Malan (1987). Control measures are included in different acts, ordinances and by-laws which control environmental conservation in total. There are presently six Acts of Parliament in force which either directly, or through regulations, control mining waste management (Wyk, Wells and Marsden, in press).

The aspects of mining waste management which are governed by the six acts (with two further acts pending) have been described by Wyk, Wells and Marsden (in press) and are as follows:

TABLE 1. CIRCUMSTANCES REQUIRING OPEN-CAST MINING EXTRACTION INDUSTRIES TO CONDUCT AN ENVIRONMENTAL IMPACT ASSESSMENT.

1. Operations requiring a total earth movement of more than 200.000 cu. m./annum;

2. Operations carried out below a water table, the reference level being the highest level known in in the annual fluctuation cycle;

3. Mining of fluvial, fluvioglacial, coastal or wind dynamic deposits, and marine deposits;

4. Mining operations visible from motorways, divided highways, national and regional roads, from urban centres with more than 1.000 inhabitants, or those which are situated less than 2 km from such centres;

5. Operations located in protected natural spaces or in an area which can be seen from any of its established boundaries;

6. Mining of substances which may be altered by oxidation, hydration, etc., and which may induce limits in excess of those contained in current legislation for acidity, toxicity or other parameters in concentrations which involve risks to human health or the environment, e.g. ores with sulphides, mining of solid fuels, those requiring leaching treatment in situ, and radioactive minerals;

7. Operations which, while not coinciding with any of the above circumstances, are located less than 5 km from the planned limits of any existing open-cast mining claim;

8. Any work, installation or secondary or ancillary activity included in the open-cast mining project.

(Modified from Vadillo et al, 1988)

Reclamation Related Legislation in India

The prevention of environmental degradation by mining activities is governed by several Federal Acts and Regulations. The Mines & Mineral (Regulations and Development) Act, 1957, is the major act dealing with the regulation of mines and development of mineral resources in India. Its extensive amendment through the enactment of the M & M (R and D) Amendment Act, 1986, contained new provisions which relate to the protection of the environment in the mining industry. Of major importance is the provision in it granting powers to the Federal Government to order closure of a mine or prematurely terminate a mining lease if the mining operations in an area are found to cause damage to the environment or if damage to the environment is foreseen.

Interest in the environment in general, and water supply and quality in particular, was raised by the four year drought which affected the country in the mid 1980's. During the last two years there has been a considerable upsurge in studies on environmental impact assessment and environmental management planning.

Reclamation Legislation - General

In all industralised countries today a variety of laws and regulations require that land reclamation be a concomitant component of mining exploration, development, operations and abandonment. The underlying theme of the laws and regulations governing the reclamation aspects of mining is that land disturbed by mining and associated waste disposal practices is restored to a level of biological productivity, equal to, or greater than that which existed prior to mining and that it is non-polluting.

Reclamation Related Legislation in Spain

Environmental control (including land reclamation) of air, land and water affected by mining is subject to a number of different laws and regulations (Vadillo et al 1988). Relevant legislation was introduced in the province of Catalonia in 1981 and 1983. In Castille and Leon provinces, general legislation governing mining was passed in 1983, while further legislation, specific to the reclamation of land disturbed by coal mining was introduced in 1986.

The other provinces in Spain are governed by laws introduced in 1982 (non-coal minerals) and 1984 (coal). Reclamation plans prepared by an operating company are submitted to appropriate ministries in regional or national government. Technical comment on the reclamation plans is then provided by two institutes, IGME (National Geological and Mining Survey) and ICONA (National Institute for Nature Conservation).

Comprehensive legislation requiring all new or expanding open-cast mines to undertake Environmental Impact Asssessments was enacted in 1988. This legislation was introduced in order to comply with environmental directives within the EEC. The EIA's are subject to public scrutiny. An outline of the mining situations where an EIA must be undertaken are presented in Table 1.

The developments in land reclamation which were characteristic of most westernised countries from the mid 1960's to the early 1980's were almost entirely ignored in Spain. Not until Spain was granted entry into the European Common Market and the consequent need to conform with EEC environmental standards and regulations that "environment" including land reclamation has become a prominent factor in mining and construction developments. Spain, being one of the most highly mineralised parts of Europe and with a mining history extending over many centuries, has a large legacy of mined lands in need of reclamation.

Few people question the fact that the major environmental problem in India today is the restoration of degraded forest lands. Since Independence in 1947, the nation's forest cover has declined from 40 to 23 percent; and only 11 percent is actually truly forested. This represents approximately 33 million hectares, which is continuing to decline by 1,5 million hectares per year.

Some 175 to 200 million hectares of land in India have been been classified as degraded or waste land. The destructive effects of floods and siltation is a consequence of deforestation as evidenced in the heavily populated areas of the Ganges and Brahmaputra river belts. Flood prone areas have increased from 25 million hectarès in 1960 to 59 million hectares in 1987. (Rao 1989, Town and Country Planning Organisation 1987).

Legislation, described as "stringent, punitive and comprehensive", was introduced between 1980 and 1987 to rectify the loss of forest lands whether from mining activity or diversion to other non-forest land uses. However, it was not realised, unfortunately, that such enactments would only affect organised sectors of the economy, such as mining and construction. The major factor in forest destruction remains the ever increasing population and its demand for food, fuel and shelter (Thakore 1989).

In South Africa the reclamation of acidic tailings dumps created from gold mining on the Witswaterand is internationally known. Less so, perhaps, are the reclamation activities on other waste dumps and disturbed lands from other mineral and coal mining activities respectively. In general, land reclamation is well integrated with other aspects of environmental control (air and water). During the past three decades, an increasing awareness of the need for improvement in waste management has led to the promulgation of numerous Acts of Parliament and ensuing regulations (Wyk, Wells and Marsden (in press)).

Other areas of emerging interest in land reclamation include, the use of wetlands for attenuation of acid tailings seepage, early treatment of gold tailings dumps so as to allow progressive revegetation to be carried out, shrub and tree plantings and development of waste areas as game refuges to name but a few.

Conclusions

This has been an extremely brief review of land reclamation practices in three countries, each exhibiting widely varied climates and soils, and different economic, social and cultural values. Because of limitations of space, much has been left unsaid as to how each of the above influences land reclamation and associated environmental matters. Perhaps a too simplistic state of affairs has been presented but it is also hoped that some of the flavour of land reclamation in each country has been captured.

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