INTRODUCTION
The mining industry has evolved gradually in response to both availability and depletion of resources, technical and technological progress, economics and diseconomies of scale, energy crisis and substitution threat and growing consciousness of workers and public. However, the basic tenets of this industry include maximisation of production and minimisation of wastage. The production, within an economic framework, is divided into three sectors - primary production of resources, secondary production based on the resources, tertiary services - the intersectoral relations being limited to minor input-output linkage only.

Since most of the mining industry in India is located in the backward areas, the focus is on regional development through employment generation. Contradictory tendencies between the support of production system for a larger economy and the demand for regional development have led to unhealthy relationships between income generation and reinvestment for development. Thus mining has led to the destruction of the resource itself as also of other productive natural resources such as land, water and vegetation. In addition, technological change has often
meant both regional unemployment as well as the import of skilled labour from outside the region. Inter-sectoral linkages, contradiction between maximisation of production, minimisation of waste and welfare of the deprived and the long and short-term implications of the industry, both in terms of its impact on nature as well as its effect on society, would provide the background for analysing the question of the environmental impacts of mining. This essentially means that the environment consists not only of natural resources but also includes men and women and the relationship between different strata of society.

With the increasing demands, land has been constantly exploited for raw materials from the natural environment. Land is not a resource which automatically renews itself like rainfall or sunlight. It is a finite resource, being diminished by the spread of industry and urbanisation (Coleman, 1979). Mining accounts for a substantial proportion of the total loss of land of primary production due to mining activity. In India, 7,85,000 hectares of land is reported to be under mining operations (Baliga, 1985).
IMPACT OF MINING ON ENVIRONMENT:

Modern industrial, economic and commercial activity depend a lot on the exploitation and consumption of minerals. The process of extraction of mineral resources and its use in various ways generates a wide range of environmental changes sometimes having far reaching consequences.

More than 7,85,000 hectares of land of the country are presently under the stresses of mining activities of various kinds. Much larger area is disturbed by other activities associated with mining. The recovery of minerals and construction material requires removal of vegetal cover with underlying soil mantle and excavating overlying rock masses (overburden) which more commonly exceed the volume of material sought. The result is reshaping of the topography, generation of great volumes of debris (waste) and disruption of surface and ground water circulations.

As demands for minerals grow, the area of mining would expand at a faster rate, threatening increasingly larger areas of landscape with scarification, debris dumps,
soil degradation, with widening circle of deforestation and distress to the population affected.

In the strip-mining, the overburden is stripped away to recover the minerals by use of bull dozers, scrapers or by manual operations. The contour-strip mining involves removal of the overburden, starting from the outcrop and proceeding along the hillside so that the cut after another is made and a series of benches formed. The inside walls range in height from a few meters to more than 30m but generally within 10m. On the outer side, debris is dumped on the slopes. The net result is very ugly disfigurement of the landscape.

In the opencast contour-strip mining in the mountains, rich soil together with overburden is scrapped off and pushed downslope. The sliding of the great volume of debris causes great damage to the vegetation and to the springs and streams. Ugly scarifications and drastic reshaping of the landscape and serious destruction of forests have occurred. Picking only the very high grade materials and discarding the rest, the mine-owners had been casting of more than 30% of the valuable ores to slide down the 30° - 50° slope (Valdiya, 1984). When saturated with
heavy rain water, the loose waste material becomes debris flow which descend into the valleys, clog the channels and spread over agriculture fields.

Indiscriminate mining since 1961 has destroyed 50,000 hectares of forests in Goa and against the export of 12 million tonnes/year of high grade iron ores, 30 million tonnes of iron ore rejects are scattered indiscriminately over an area of 10,000 hectares of paddy and coconut groves, thus killing the fertility of the soil. The washing of mineral ores for beneficiation has caused serious water pollution in rivers as well as in wells and springs.

Present Problem:

GOA is situated in the western part of India, lying on 15° 48' 00" N & 14° 53' 54" N Latitude and 74° 20' 13" E & 73° 40' 33" E Longitude. On the Western side is the Arabian Sea, in the North it is bordered by Maharashtra and on the East and South by Karnataka.

Exploitation of mineral deposits of Goa remains the dominant industry, inspite of the various new industrial developments, in diversified fields like small scale cottage
industries, electronics, automobiles, tourism, etc. Mining industry still forms the back bone of the state's economy. The iron and manganese ore belt in the western ghats extends from Maharashtra to Karnataka passing through Bicholim, Sattari, Sanguem and Quepem talukas of Goa. Large chunks of land of these taluka were leased out for mining to the private entrepreneurs by the Portuguese ruler in fifties. Subsequently termination of some of the leases by the Government of India reduced the number of leases to 581; which covered 46.12% of Bicholim, 35.83% of Sanguem, 15.8% of Quepem and 14.7% of Sattari talukas. As with any other large scale industry, the mining industry and particularly the iron ore mining activity, has undeservedly earned the stigma of environmental damage and pollution.

Open cast mining involves deforestation at the mining site, excavation and movement of large volumes of earth's crust. A ton of iron ore mined for instance, produces almost 2/3 tons of rejects. Since 1950, large amount of rejects has accumulated. Dumps of the rejects are spread over hill sides, river sides, and places around other waterbodies, agricultural lands and human habitations. Various mining and processing operations have the potential for pollution and can affect not only the environment but
also ecosystem. Mining operations expose relatively large areas of sub-surface rocks to the action of the atmosphere, with the result that abnormal quantities of water soluble compounds of iron, manganese, etc., may contaminate the drainage system. The ore is transported by open trucks to the river sides to load in the barges. During the transport, trucks spill the ore and dust flies. From the reject dumps, dust is blown adding to the dust pollution. During the monsoon, heavy rains wash down the reject from dumps and the ore materials from the mining areas into the agricultural fields and the waterbodies. As such, agricultural yield was affected. Eventhough, the rice plants can withstand high concentrations of iron, soil may become reducing with the addition of organic matter and the plants may develop symptoms of iron toxicity (Ponnamperuma et al. 1955).

Heavy metals, unlike other pollutants are non-biodegradable. Once released into the environment, they pose danger to life for a very long time. Effects of heavy metals on plants has been studied extensively. Heavy metals cause virtual cessation of root growth and formation of short stumpy laterals and ultimately, although not
immediately, the death of plants (Bradshaw & Chadwick, 1980).

Ernst (1976) has stated that most significant symptom of heavy metal toxicity is stunted growth. Poor root growth can be the cause of retarded root length (Foy et al. 1978). They also suggested that most characteristic symptom of metal toxicity is stunting and chlorosis. The stunting in plants may be due to (1) specific toxicity of the metals (2) antagonism with other nutrients or (3) inhibition of root penetration in the soil.

Nag P. et al. (1981), have studied the heavy metals effects on plant tissues involving chlorophylls and proteins. Metals taken up by plants are incorporated into a tissue depending on its mobility within the plant, i.e. translocation (Ernst, 1980). Surplus of heavy metals can severely reduce growth and biomass production of plants. The expression of a metabolic disorder may be the result of interaction of ion uptake and or transport (Ernst, 1972).

The present work deals with a study wherein establishment of vegetation in a stressed environment is being tried. A huge mining complex at Pale in GOA is one
MAP OF GOA SHOWING PALE
of the mining areas where iron ore is extracted. This mining complex is made up of three mines of which one of the mines is operated by M/s. Chowgule & Co. Ltd., Mormugao, Goa. The area occupied by them for the purpose of mining is 159.638 hectares of which 122.00 hectares are under active mining operations and 42 hectares of the area is occupied by the reject dumps. The mine first started functioning from the year 1954 under non-mechanical sector. Later in the years 1960-61 the mine was fully mechanised. The depth of the mine is 160 meters and the height of the dumps is 30 meters. The slope of the dumps is 40°. The age of the inactive dumps range from 5 - 15 years. The annual production of iron ore is approximately 1 million tonnes. Annually approximately 4 million tonnes of ore including the overburden/reject is handled. In the 1960's & 70's the ore exported was lumpy type of the +57 grade. Later from 1980's onwards powdery ore of the grade +60 was exported. Japanese are the main importers of the iron ore from this region. The labour force employed by the company to run the mines is about 390 people.

Annual rainfall at Pale is in the range of 2,800mm to 3,200mm under normal conditions. The monsoons start
around the last week of May and end in October. Maximum temperature is observed in the months of April & May is 35°C to 37°C. Minimum temperature is in the month of January ranging from 17°C to 21°C. Relative humidity ranges from 70% to 90%.

From the survey of the areas around the mines showed that it was evergreen type of physiognomy with a more or less similar floral composition (Henry Nyabuto, 1989). Evergreen plant species easily noticed are *Alstonia scholaris*, *Mallotus albus*, *Garcinia indica*, *Tamarindus indica*, *Syzygium cumini* & *Mangifera indica* as trees.

However, some deciduous plant species are frequent like, *Sterculia urens*, *Sapium insigne*, *Strychnos nux-vomica*, *Bombax ceiba*, *Careya arborea* and *Terminalia* species. In some places, *Acacia nilotica* is also found growing. Many different types of herbs and shrubs are found growing around the mining sites. One of the genus found growing around the mining areas is *Crotalaria*, a legume.

During mining activity, it is known to leave huge amounts of wastes in the form of enormous reject dumps.
Information available showed that the vegetation was destroyed and lost for good below the huge dumps and that no new vegetation can survive under the conditions of aridity, instability, nutrient deficiency and heavy metal toxicity which is prevalent on the dumps. It was necessary to study the various aspects of plant responses to these stresses. Once the nature of responses to these stresses is well understood, the next step is to improve upon the existing conditions.

In the following chapters efforts in this direction are detailed starting with the preparation and analysis of the reject soil used for studying the response of plants. Morphological and biochemical response of Crotalaria juncea L. (Sunn hemp), a leguminous plant of economic importance was taken up for study in the nursery with different percentage composition of rejects, and also with the addition of seaweeds and different combinations of fertilizers (NPK) to the reject. Chemical analysis of the different parts of the plant viz. leaf, stem and root was carried out to find the amount of iron, manganese & aluminium taken up by the plant from the reject soil.
Also a study of six tree species used for the purpose of revegetation on the reject dumps were made. The species studied were *Acacia nilotica* (Linn.) Delile; *Azadirachta indica* A.Juss.; *Bombax ceiba* Linn.; *Parkia biglandulosa* Wight & Arn.; *Pithecellobium dulce* Benth. and *Tamarindus indica* Linn. Of the above mentioned species taken up for study *Acacia nilotica*, *Bombax ceiba* and *Tamarindus indica* are the native plants and the other three are introduced ones to this region because of their hardy nature and drought resistance.

A survey through the literature showed that no information was available regarding the response of the above mentioned plants to the mining rejects or to the different heavy metals like iron, manganese and aluminium. Hence the present study was taken up to see how they would respond to the mine rejects.