CHAPTER 1

INTRODUCTION
1.1 GENERAL

Growth of energy industry is the key governing factor for the industrial development of any nation. This industry has seen a steady shift in its raw material (fuel) consumption pattern since the time of the industrial development. In the recent times due to heavy banking on the hydrocarbon use; the hydrocarbon reserves are under stress (Fig.1.1). This has created need for the exploitation of other natural energy minerals, e.g., coal and lignite again as coal was the main energy mineral in use during industrial revolution and due to the environmental considerations coal was later replaced by hydrocarbons and other cleaner energy minerals. All the energy mineral need to be mined before putting them in use. Exploitation of natural mineral wealth is not possible without disturbing the fragile environmental equilibrium. The dynamic equilibrium of the environment is governed by the interplay between different components of environmental system, due to the mining or any other anthropogenic activity the dynamic equilibrium gets disturbed and takes time to restore itself to equilibrium again. The magnitude of disturbance in the environmental components, viz. lithosphere, hydrosphere and biosphere is largely dependent on the magnitude of the disturbance imparted either by natural or by anthropogenic agencies.

Geoenvironment, is derived from two words, Geo= geological and Environment = our surrounding, in broad terms geological surroundings are referred as the geoenvironment. One of the aspects in the study of geoenvironmental problems is the understanding of various disturbances arising in the lithosphere on account of human interference while indulging in the activity of winning the natural resources. The study also aims to determine the remedial measures to contain the disturbance in the lithosphere and hydrosphere and associated risk assessment through monitoring and modelling. Geoenvironment is further qualified as the
uppermost parts of the lithosphere, which is directly affected by human activities" (Bobrowsky, 2002).

For any region, the geo-environmental understanding would involve determination of the interrelations of various aspects of the earth system (Fig.1.2) e.g., lithology, climate, flora and fauna, mining, hydrology, etc., which are help in the understanding of the quality and quantum of the impacts.

![Diagram of geo-environmental understanding](image)

**Figure 1.2.- Flow chart showing various aspects of geo-environment**

Mining being an anthropogenic activity greatly contributes to the perturbations in these sub-domains, e.g., social, water, air and soils, etc. of the lithosphere. For understanding the environmental issues involved in the mining industry, one needs to divide entire mining
activity into different thematic attributes as shown in the Fig. 1.2. As mining activity is likely to adversely affect the surrounding environment, it is desired that the adversity is kept to its minimum level to ensure sustainable development.

1.2. SCOPE OF THE STUDY

Globally the coal and lignite mining has resulted in to large scale environmental degradation, however, over a period of time good mining practices have evolved and the question of environmental degradation is adequately addressed. India has also gone through the same cycle of mining problems and has now evolved into a responsible nation by taking care of the environmental impacts due to mining by adopting area specific solutions to contain the adverse impacts, while the progressive mining phase is on and having mandatory provision of land reclamation and restoration for better use.

Western India in general and Gujarat in particular, consumes higher electricity per capita, and to meet the demand of electricity, thermal power plants are set up. Most of the thermal power stations of Gujarat run on lignite as the state bear good deposits of lignite occurring in the Tertiary sedimentaries. Lignite was given priority for its exploration and exploitation however, in due course of time this has posed environmental problems to the fragile ecosystem in the surrounding areas of these mines.

As part of doctoral work, author has attempted to understand the environmental problems arising from lignite exploitation at Panandharo and setting up of thermal power project in the vicinity of the mining area. Gujarat Mineral Development Corporation (GMDC) has been mining lignite at Panandharo since 1974 employing the manual and mechanized mining methods. Kachchh Lignite Thermal Power Plant (KLTP) was commissioned subsequent to the lignite mining in the year 1979. As coal and lignite would cause acid release due to the oxidation of pyretic component present in the mineral and similarly the fly ash is also enriched in the sulphur content, a common problem observed globally is that of the acid mine water, which carries the potential of degrading the soil and water quality of the affected region. Panadharo lignite mining and fly ash from KLTP plant have also caused generation of acidic water ponds threatening the local environment.

Due to the mining and KLTP at Panadharo, on one one hand the area experienced economic boom since 1974, and on other hand experienced a substantially prolonged addition of variety of pollutants as well as landscape disturbance resulting in adverse environmental problems such as;
Land degradation
Overburden disposal/management
Land slide due to slope and face failures
Dust generation due to vehicular and mining operation
Deforestation and change in land use pattern and finally,
Contamination of soil and ground as well as surface water bodies by the lignite dust fly ash which causes acid mine water and drainage

With these in mind, it was aimed to study geo-environmental status of lignite mine operated by GMDC, Ltd. and Kachchh thermal power plant (KLTP) at Panandhro. The author, in the thesis, has endeavoured to deal with the environmental impacts due to the lignite mining and flyash generated from the Thermal Power plant in the study area.

1.3 AIMS AND OBJECTIVES

The main objectives of the study are as under:

- To estimate extent of land degradation due to mining activity.
- To evaluate the toxicity potentials of lignite and flyash.
- To workout the leaching pattern of heavy metals released by lignite and flyash to the sub surface.
- To propose measures to minimize the geoenvironmental degradation on account of these activities.
- To study the contamination of lignite dust, acid mine water and flyash in the soils, groundwater and surface water in the about 10 km radius of the area around the mine and thermal plant site.

1.4 METHODOLOGY

To achieve the aims of the study the following methodology has been adopted:

- Study of the literature related to the various aspects of the geology of the area. A detailed study of structural and geomorphic set up of the area with a view to understand the depositional and morphotectonic evolution of the area.
- Hydrological conditions of the area study based on seasonal fieldwork coupled with the data collection and generation, in the addition metrological records available for the area were also used.
- Geochemical studies to understand the chemistry of the natural system, leaching / contaminants in the soils and mine-water were undertaken.
- To workout the strategy to minimize degradation and to reclaim the damage already caused.

The survey was done in entire mining lease area 10 km radius area surrounding mining lease site. Data collection pertaining to their mode of occurrence of litho-units, distribution, thickness, depositional structures, soils rocks was carried out. The environmental impact of mining on water and soil were critically studied and recorded in the field and was marked directly on the map during the field studies. Evidences of geo-environmental impact were photographed to support the field observations.

1.5. GENERAL INFORMATION OF THE STUDY AREA

1.5.1 Location

The Panandhro lignite mine is an open cast mine. It is situated near village Panandhro of Lakhpat Taluka in Kachchh District (Fig. 1.3, 1.4) and is located between longitudes 68°44'55" to 68°45'00" east and latitudes 23°39'58" to 23°42'03" north, in the SOI, toposheet No.41F/14. Area is 130 km from from Bhuj and is well connected by road. GMDC has been exploiting the lignite available in Panandhro. Due to assured availability of lignite, Gujarat Electricity Board (GEB) has set up a Kachchh Lignite thermal power station (KLTPS) with 2 units of 70 MW each and one unit of 75 MW for which GMDC is supplying lignite from the Panandhro field. The quantum of lignite mined is of the order of 1.2 million tonnes per annum (MTPA).
Physiography and Drainage

The area in this part of Kachchh is hilly. The plains are generally 30 to 40 metres above Mean Sea Level. In study area msl, varies from a minimum of 17.0 m to maximum of 42.0 m. The area has general slope towards NW direction. The Panandhro lignite field is a plain area in the northern extremity of which stands the Babia hill, with an elevation of more that 90 metres above msl.

There are two rivers, Kali and Koravadi, flowing through these plains (Fig. 1.5). The former flows from south to north and the latter flows from east to west. These two rivers meander through the mining area and join together in the northwestern part of the lease area before debouching into the Arabian Sea near Lakhpat. There are numerous minor riverlets flowing through the lignite bearing area. The drainage is seasonal type.
Due to predominant lime content, soils absorb very little water and therefore almost all the rain-water gets drained through these water courses. Due to these factors vegetation growth is very limited.

1.5.3 Climate

The climate in this region is dry and is classified as semi-arid. Extreme summer and winter temperatures are experienced. The maximum recorded temperature is 44°C while a minimum or less than 1°C is sometimes recorded in winters. However, the temperature generally varies between 36°C to 40°C in summer and the winter temperature normally varies from 10°C to 12°C. May is the hottest month and January is the coldest. The humidity in general varies from 25% to 50% during the day, except during monsoon months when it is as high as 60% to 75%.

Rainfall is extremely scanty and does not follow any cyclic pattern. Normally monsoon is from June to September. These months, experience about 75% of the average annual rainfall of 335 mm. The normal range of annual rainfall appears to be from 200 to 400 mm. The maximum recorded rainfall in this region during a 24 hour period is 240 mm.

The region is constantly swept by high velocity winds, which seems to cause most of the soil erosion. The wind direction varies seasonally as follows:
Thus Panandhro lignite field lies in a semi-arid zone, swept by high velocity winds, plagued by perennial shortage of drinking water, barren-hot-terrain having an extreme climate with annual evaporation of about 2.25 m.

The is one meteorological station is at Naliya, which is approximately 70 km. away from Panandhro and another meteorological station has been set-up at Dayapar, which is about 25 km. The records of rainfall made available from these stations are shown in the Fig. 1.6. The average rainfall of lakhpat taluka is 320 mm as per the record of last fifty year.

1.6 THE MINING LEASE AREA

Total lease area for mining is 1719 hectares. The village wise disturbance of land use pattern is shown in Table-1.2, out of which lignite bearing area is around 850 hectares. The total proved minable reserves of lignite in the region are 105 MMT. Out of this, 60 to 65 million MT are already excavated and mining operation is under progress for remaining 40 MMT of lignite. The project has remaining life up to 8 to 9 years based on the
amount rate of 5 MMT/year. The lignite mined at Panandhro is sold as a fuel to replace coal and has found its usage in many big and small industries. Lignite has a good market potential because of its high calorific value ranging from 3300 to 3500 kcal/kg but has a moisture content of 28 to 35 percent. Besides lignite, the other economic minerals found in the area are siderite, limestone, white clay and iron concretions. It is worthwhile to use these minerals in appropriate industries from the mineral conservation point of view.

Table 1.2 Tabular and graphical representation of Land Use Pattern mining lease area.

<table>
<thead>
<tr>
<th>Village</th>
<th>Area wise lease Ha</th>
<th>Net cropped area Ha</th>
<th>Cultivable wastes Ha</th>
<th>Uncultivable area Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Panandhro</td>
<td>1342.25</td>
<td>12.00</td>
<td>0.70</td>
<td>1329.55</td>
</tr>
<tr>
<td>Fulra</td>
<td>220.00</td>
<td>71.00</td>
<td>30.00</td>
<td>119.00</td>
</tr>
<tr>
<td>Khanot</td>
<td>156.75</td>
<td>5.60</td>
<td>2.50</td>
<td>148.65</td>
</tr>
<tr>
<td>Total</td>
<td>1719.00</td>
<td>88.60</td>
<td>33.20</td>
<td>1597.20</td>
</tr>
</tbody>
</table>

1.7 NEED FOR GEOENVIRONMENTAL STUDY OF THE AREA

In the proceeding section details about the geology, geomorphology, mineral reserves and mining have been covered on introductory scale.

Synthesis of geoenvironment of the Panandhro lignite project is essential in order to ensure scientific restoration and reclamation of the area. During progressive mining as well as at the time of mine closure, the observation and findings of the study will be useful in ascertaining a frame work for the sustainable mining of the project area.