CHAPTER - I

# I N T R O D U C T I O N

## 1.1 GENERAL

Economic growth of any country depends on the availability of sufficient energy resources and their judicious and economic exploitation. The per capita energy consumption by the people of a country also indicates the standard of living, thus economic development of a country. The developed country has higher per capita energy consumption than under developed and developing countries. In our country, it is only 0.24 tonnes oil equivalent (toe) against the average world figure of 1.0 toe, which is much less in comparison to developed countries (Table 1.1).

In recent years, India's global economic policy has envisaged fast industrial growth. It is expected to grow at rate of 10-12% against the level of 8% indicated during 1995 (*Bose*, 1995). In such a situation, the energy sector has to play a vital role in economic development and the rate of consumption is bound to increase at a faster rate. The growth rates of consumption of commercial energy of developing countries of Asia has grown at a faster rate than the other regions of the world in last two and a half decades. Worldwide the commercial energy has grown at a rate of approx. 2.5%, while it was 5.3% in China 7.2% in India, 2.7% in U.K. and 1.4 % in U.S.A. (*Chowdhary*, 1995).

The share of commercial energy in total energy use in our country has progressively increased in the past decades from a level of 26% in 1950-51 to about 60% at present. It is expected that in near future with

## Table 1.1 Per Capita Primary Energy Consumption

| S.No | COUNTRIES | TONNE OF OIL EQUIVALENT (toe) |
|---|---|---|
| 1. | U.S.A | 7.77 |
| 2. | Canada | 7.67 |
| 3. | Australia | 5.02 |
| 4. | Russian Federation | 4.52 |
| 5. | Japan | 3.83 |
| 6. | European Union 12 | 3.58 |
| 7. | S. Korea | 3.00 |
| 8. | China | 0.62 |
| 9. | India | 0.23 |
| One-tonne-coal-equivalent (toe) = 0.697 tonne-oil-equivalent (toe). | | |

**Source** : Tata Energy Research Institute **(TERI)**, 1996.

a projected 6% per annum growth rate, the share would go upto 80% of total energy in the next decade (*Sachdeva*, 1996).

The commercial sources of energy available in India are Coal, Lignite, Oil, Natural gas, Hydropower and Nuclear energy. Natural gas is a relatively new entrant in energy sector. In terms of abundance in availability and economy, coal is dominating the whole energy scenario, not only in our country but almost throughout the world and it is expected to continue for few decades to come. Presently, the share of coal in total commercial energy is around 60% in our country.

Hydro and nuclear sources of energy do not hold much promise. Most of the untapped hydel potential is situated in relatively inaccessible location in the extreme northern and north-eastern parts of the country, generally prone to seismic activities. The field of nuclear energy is also stymied because of low sectoral allocation, public fears about the safety of reactors and increased international interference.

The demand for power is steadily increasing and as per the assessment of Planning Commission, by the end of VIIIth (1996-96), IXth (2001-2002) and Xth (2006-2007) plan period, total installed capacity of power generation would be of the tune of 86156 MW, 144168 MW and 207842 MW, respectively. The coal based generation during these periods would be 60%, 57% and 54%, respectively (Table 1.2). Thus the demand for coal will be largest by the power sector.

**Table 1.2 Installed Capacity of Power Generation (MW) during VIIIth, IXth and Xth Plan Period**

| S.No. | TYPE OF FUEL | AT THE END OF VIIIth PLAN 1996-97 | AT THE END OF IX th PLAN 2001-2002 | AT THE END OF Xth PLAN 2006-2007 |
|---|---|---|---|---|
| 1. | Coal | 51276 (59.5%) | 81788 (56.7%) | 111788 (53.8%) |
| 2. | Hydro | 21811 | 30174 | 52719 |
| 3. | Gas | 6706 | 9592 | * |
| 4. | Lignite | 2285 | 2955 | * |
| 5. | Diesel/Wind | 439 | 439 | * |
| 6. | Multi fuel | 1414 | 16115 | * |
| 7. | Nuclear | 2225 | 3105 | 5985 |
| | TOTAL | 86156 | 144168 | 207842 |

** Break-up not available.*

**Source** : Sen and Bhattacharya ,1997.

The coal reserves of India have recently assessed by Geological Survey of India after detailed coal exploration carried out in past years and after due thrust in finding new deposits, proving large deposit and identifying additional areas, reserves are estimated as 204.652 million tonnes upto the depth of 0-1200 metres. The reserves under different categories and depth cut-off are given in Table 1.3.

Total reserves as on 1.1.97 upto 1200 metre depth for seam more than 0.9 metres thickness is about 204.6 billion tonnes against the global reserves of over 14,000 billion tonnes, out of these 99.6% belongs to Gondwana Coal and 00.4% is from Tertiary coal.

## 1.2 COAL MINING AND ENVIRONMENTAL IMPACT

The Coal, being of organic origin from living plants, which flourished hundred of million years ago, lies at various depth and in different geological formations. According to location of seams different mining methods like opencast mining (OCM) and underground mining (UGM) methods are employed. Underground mining is resorted to where coal seams are located very deep. The coal is directly mined by creating access to it through a horizontal, inclined or vertical tunnel. As the coal is removed to the surface, the passages that are tunneled underground have to be provided with roof supports to prevent it from collapsing. These large, blocks of coal have to be left undisturbed to act as pillars to support the roof and sometimes it is possible to recover only 50-60%

## Table 1.3 Coal Reserves Estimated by Geological Survey of India

| S.No | YEAR | DEPTH (in Metres) | RESERVES IN MILLION TONNES | | | TOTAL |
|---|---|---|---|---|---|---|
| | | | PROVED | INDICATED | INFERRED | |
| 1. | 1972 | 0-600 | 21,365 | 30,759 | 28,828 | 80,972 |
| 2. | 1978 | 0-1200 | 26,331 | 40,941 | 44,606 | 111,878 |
| 3. | 1984 | 0-1200 | 34,413 | 58,996 | 53,382 | 148,791 |
| 4. | 1990 | 0-1200 | 52,294 | 81,377 | 48,373 | 186,044 |
| 5. | 1996 | 0-1200 | 70,443 | 89,750 | 41,761 | 201,954 |
| 6. | 1997 | 0-1200 | 72,733 | 89,835 | 42,083 | 204,652 |

**Source** : Sen and Bhattacharya ,1997.

of the coal. The manual board and pillar mining is mostly used to underground coal production with the assimilation of longwall mining technology for a given conditions. Mechanical longwall by sub-level caving and multislicing is applied for extracting thick seam. Hydraulic mining and descending shield methods are also applied to a limited extent in coal mines of Jharia. Opencast mining is another method to extract shallow and surfacial coal deposits. The topsoil, earth, rock and other strata, called overburden are completely removed to provide access to the coal seam. The overburden is stripped away to recover the minerals by use of bulldozers, scrapers, or by manual operation. In case of deep excavation a large amount of overburden is generated in such type of mining. The technology scenario of opencast mine ranges from shovel-dumper combination to draglines, Shove-dumper combinations are used in the mines, where stripping ratio is low, while draglines are applied at OCM with high stripping ratios.

The environment is a complex function of external and internal forces that exists within the lithosphere of earth and that supports favourably the growth and development of life. Any change in the environmental conditions bringing forth adverse effects on life and surroundings may be defined as environmental degradation or hazard. Such environmental degradation may be caused by biotic and/or abiotic factors. However biotic factors may be judiciously tackled to cause least trampling of environmental conditions.

In the coalfield with active mines, the environmental hazards are triggered due to biotic interaction, i.e. mining of coal by man for its economic use. Due to such activities the lands are degraded, water contaminated and air polluted, forests denuded, erosion triggered, cultivable land lost and thus human life and property are endangered. In a nutshell, the pure environment of virgin coalfields are polluted due to exploitation of coal resources. This has a far-reaching adverse effect on the country and society in economics, health and aesthetics. In such a situation it is essential to find out some solutions to make a balance between exploitation of coal and preservation of environment.

Underground mining can lead to subsidence of land. The roof of an underground mine is supported by timber and pillars of the coal. When an underground mine is abandoned, mine operators try to extract as much coal as possible. Excessive depillaring and removal of timber leads to subsidence, making the mined area with big crater like depressions.Vast tracts in the coal mining districts of the mining heartland, threatened by subsidence, have been rendered unsafe for habitation, agriculture and grazing. They have been officially declared as derelict lands and are now permanently unfit for productive purposes. The subsidence of ground over underground mines is a result of unscientific practices. A slow process extending over decades, subsidence eventually leads to drastic accidents such as floods, failure of dams and levees or embankments on the rivers that flow on the ground over the underground mines, collapse of buildings and destruction of sewage, drains and canals.

Various underground coal mining hazards in India have taken a toll of thousands lives since the turn of the century. Following withdrawal of coal at depths of 80-200 m from the underground mines in Jharia, the strata overlying the coal seam subsided 10.6 cm, 5.9 cm and 25 cm in different places (Kumar ***et. al,*** 1975). The subsidence, albeit at a slow rate, over an area of 32 sq km by the end of 1966 had caused damage to buildings leading to the collapse of many. In North Kujam colliery, the sudden collapse in 1979 of a 200x100 m block resting on 14 m high coal pillars caused subsidence of about 2.4 m of the ground surface over 2000 sq km the Jharia-Bilaspur road sinking 1.2-1.6 m (*Banergee*, 1981).

Damage to land can also result from underground and stockyard fires in coal mining areas. Coal is normally accompanied by methane gas which is released when coal is fractured and crushed during production. This gas can ignite spontaneously and it is difficult to stop an underground coal seam from burning once it ignites. The normal practice is to seal off the tunnels where the fire has started so that it is starved of oxygen. This process may take years. In the Jharia coalfield, till 1978 about 10 major fires were reported, destroying 34 m forever, and 79 mines are still smouldering in underground fires (*Valdia*, 1988).

Deeper excavations in the underground mining causes the water table to sink locally, often drastically resulting in the drying up of wells and springs of the neighborhood area or their becoming seasonal. In the hilly terrain, the process of excavation and attendant landslides frequently expose passages of underground water, thus deprives the spring of their content. The spoil banks, likewise contain mineral that weather easily so that production of pollutants take place at a much faster rate. The minerals containing sulphates and oxides produces sulphuric acid and soluble salts, which adversely affect flora and fauna of the area.

Continuous dewatering by underground mines also affects water resources by annually pumping out millions of litres to drain mine galleries and release it into nearby watercourses. This cause flooding, silting, waterlogging and pollution. Besides this lowering of surrounding water table, reduction in available groundwater and natural vegetation is enevitable. The underground coal mines at Birsinghpur in Shahdol district of M.P. pump nearly 3,000 litres of water per minute into the Ganjra nala that runs into Johilla river. As a result, the water table in the surrounding areas has dropped and large tracts are now devoid of vegetation (*Anonymous* 1985).

The land damage is most severe problem in case of surface/opencast mining. A large area is deforested/scrapped off and excavated to reach the mineral deposit. In most cases an equal sometimes even a larger area than the excavated one is needed for locating the external overburden dumps. This overburden originates from the consolidated and unconsolidated material overlying a coal seam and when disturbed and haphazardly mixed during mining is called mine spoil. During dumping the soil profile is altogether disturbed, the top soil being fertile and rich in organic matter lies at the bottom while boulder, sandy soil devoid of nutrients are heaped at the top. Thus opencast mining drastically changes the entire landscape in the area.

In the Indian mining scenario a greater emphasis is being laid on opencast mining than hitherto. During VIth Five Year Plan, the share of opencast coal was 40 percent, which rose to 56 percent in VIIth Plan and it is estimated that by 2000 AD the share will go upto 65 percent. Thus greater area of land damage can be anticipated (*Banerjee*, 1987).

Coal mining operations adversely affect surface and ground water resources and water quality. The surface mining unavoidably disrupts the natural drainage pattern and also the water consumption equilibrium to a large extent. The destruction and removal of vegetation and creation of overburden dumps in the area causes chain reaction of enhanced surface run-off, sedimentation and pollution of water courses. Enhanced surface run-off, in turn reduces ground water recharges. Creation of large surface mines and quarries directly alter the groundwater gradient and flow, affecting the extraction potential of aquifers for other uses. Even if pumped for reuse, the mine water may have harmful particulates and ingredients. In the semi-consolidated formation of Gondwana terrains, there is considerable groundwater movement through the open interstitial spaces of the rocks and their joints, fractures and fault zones. The situation may become more critical where mining areas are fringed by alluvial basins or valleys that have considerable thickness of porous and permeable sandy horizons, often near surfaces. These facilitate transmission of the polluted waters. The surface waterbodies are contaminated with suspended solids as well as soluble chemicals generated from mining and ancillary operations. These may be grouped as (i) discharge of acid mine water which continues even after erosion of mining (ii) addition of elements like Se, Ni, F etc., from coal and associated rocks (iii) coal dust and silts from mines, dumps, coke plants, washeries etc.

The air pollutants, whether gaseous or particulates, are introduced to the atmosphere as a result of mining, dumping, loading, washing and other operations, like blasting and transportation of coal and wastes; smoke generated from coal burning and mine fires; gases like CO, NO, $SO_2$, $CO_2$, $NH_3$ etc., emanated from coke oven plants. These smoke, gases and fine particulates go into the atmosphere in such abundance that they can not be disbursed adequately and the form a thick blanket overhead in the near surface region of the atmosphere.

The Suspended Particulate Matter (SPM) below 5 μm size is a major air pollutant. The fugitive dust arises from mechanical disturbance involving digging, transport and dumping. When undisturbed, this is not discharged and remain as confined flow stream. In case of mine situated on till tops and wind speed is high, the dust generated due to mining is carried far and wide affecting the atmosphere and life of the local workers and people living in the vicinity of the mines. Inhalation of fine dusts results in the development of pulmonary diseases.

Extensive use of mining technologies like blasting, drilling and transportation and heavy machinery cause noise pollution. This affects the workers adversely. The wildlife in the vicinity may also migrate elsewhere. According to World Health Organization (WHO), the threshold limit value for noise should be below 90 dB (A). However in most of the Indian coal mines, operation of Heavy Equipment and Mining Machines (HEMM), coal handling plant, coal washeries etc. generate high noise level of 105-110 dB(A).

Operations of coal mining projects and allied activities have direct and indirect impact on the socio-economic condition of the existing inhabitation. The pre-existing settlements being permanent type are compelled to be abandoned or shifted to safer region. Cultivable land, forest and pasture land are also often lost due to such operation, which necessitate abandoning or shifting villages and settlements. On the other hand new colonies, roads, railways, factories etc., come up which cause change in the demographic pattern and result in change in the landscape. The overall change in the socio-economic condition of the region is thus obvious once the coal mining starts. These operations also invite influx of outsiders for livelihood and other necessities which bear a tremendous impact not only on the physical environment of the area but also on the behavioral pattern of the human beings and the society. As a consequence, the problem of law and order creeps in. The rampant antisocial and mafia activities in Jharia-Raniganj coal belt is not unknown. Needless to say, any inapt handling of such matters triggers social unrest.

The deteriorating environmental condition due to fast industrialisation and habitat transformation affects the health status of the population residing in the area. The workers in mine are affected by respirable diseases causing *Pneumoconiosis, Silicosis* or *Bronchitis* due to inhalation of dust.

## 1.3 THERMAL POWER GENERATION & ENVIRONMENTAL IMPACT

Electricity, the most convenient form of secondary energy, which creates essentially no environmental problems at the point of consumption is irreplaceable by another equivalent form of secondary energy. The capacity for electric generation has risen tremendously around the globe with rapid industrialization and urbanization and about 72% of the electricity generated in the world during 80's was based on the conversion of primary energy into heat in conventional thermal power plants. However, the largest fraction of World's electricity is generated in fossil fueled thermal power plants. As, the world's coal reserves are large, generation of power from coal is very significant. An assessment made during World Coal Study, 1980 revealed that by 2000 AD, the coal share in electricity generation would be 85% in Australia, 50% in North-America, 35% in Europe and 10% in Japan (*Bose*, 1984).

India has made significant development in power generation since independence. The installed generations capacity has risen from 1400 MW in 1947 to 81,164 MW in 1995 and out of that thermal power accounted 58,110 MW which was more than 70% of total power generation capacity (*Sachdeva*, 1996). The National Energy Policy as accepted by Government of India in May 1981 envisages coal as the principal source of energy to the extent that is practicable and economic. However, Government of India had earlier taken a significant decision during mid 1960's to use high ash coals for electricity generation because large reserve of high ash coals in thick seams and within shallow depth were unexploited before as there was no market. Such a wise decision opened a new era in power generation by producing large quantity of coal through large scale opencast mining and establishment of super thermal power stations at pit-head location subject to availability of water.

Although, large scale electricity generated through thermal power stations may boost up our economic and industrial growth, it may also invite the environmental problems. The major environmental problem, associated with thermal power plants is the deterioration of air quality due to bulk coal combustion, ash disposal and thermal discharge into reservoirs, water pollution etc. A large quantity of coal combusted for massive power generation produces large quantities of $SO_2$ and particulate matter as waste. The coal having high ash content after combustion also produces large amount of flyash as waste material and requires large area for disposal in the form of ash ponds or land fill sites. In ash ponds after the settling of ash, the excess water flows and meets natural waterbodies. There is also very threat of ash overflow during monsoon season and seepage from disposal pits. The ash contains heavy metals and toxic compounds, which dissolve in water and pass into natural water system through ash pond discharge.

The most serious threat to aquatic life is from waste heat discharge. It is mostly localised afftecting fish. The fish can not withstand sudden changes in temperature caused by routine shut-down and start up of plants. Thermal plants using the nearby waterbody as cooling pond may increase the surface temperature of entire waterbody/reservoir. Increase in temperature generally increases the growth rate (which increases the oxygen demand) but reduces oxygen diffiusivity (*Shen*, 1980). This may cause the dissolved oxygen level to drop below a critical level. However, the consumptive use of water by the power plants together with waste heat discharge could at periods of low water availability be of serious consequences to ecological resources of area. Air quality deterioration is the most serious impact of power generation plant in a region. The combustion of massive quantities of coal produces large quantities of Sulphur dioxide ($SO_2$), Carbon monoxide (CO), hydrocarbons and polycyclic organic matter and particulate matter as waste. Except $SO_2$ all above said product can be kept minimum by having a more efficient and complete combustion. The problem of large quantities of $SO_2$ emission is of particular importance because of its well known impact as acid rain on surrounding vegetation and health of society. Although, Indian coal having low sulphur content, can still be a problem with large power stations, if no sulphur removing technology is employed. In our country, installation of desulphurisation plant like western countries is cost prohibitive because of heavy expenditure on technology (± 25% of plantcost) as well as power consumption (5% of total output) (*Biswas* and *Pande*, 1983). In such a situation, dispersion of $SO_2$ over larger area through construction of tall stacks are done to minimise ground level concentration. However, adoption of this technology bring an enormously large area under chronic fumigation by flue gases. Low concentrations of $SO_2$ have serious long term negative impact on materials and living organisms, specially on green plants, ultimately leading to sharp changes in the ecosystem. A common experience is loss of yield due to $SO_2$ exposure and coal smokes reducing the biomass. A secondary effect of the gaseous emissions from coal fired plant is acid precipitation with long term ecological consequences. The acidification of environment has major impact on soil. Important plant nutrients such as calcium, magnesium and potassium may progressively leach away from soil by acid water leading to accumulation of potentially toxic elements such as aluminium and zinc.

## 1.4 ABOUT SINGRAULI COALFIELDS

Singrauli coalfields spread over an area of 2120 sq km (Table 1.4), out of which 2040 sq km lies in M.P. and 80 sq km in U.P. At present only a small portion in the north-eastern side of the coal bearing area is being developed which is popularly known as Singrauli coalfields. The coalfield consist of two basin i.e. Mohar half basin (312 sq km) and Singrauli main basin (1808 sq km).

The present mining activity are confined to Mohar half basin. A feasibility study carried out in 1974 have estimates of 9,207 million tonnes of coal of which about 2700 million tonnes could be quarried. (Table1.5).

After detailed exploration upto 300 metres depth coal reserve of Mohar basin has been assessed as 2635 million tonnes. The ash content of coal ranges between 17% to 46% and moisture content varies from 6% to 10%, sulphurs content 0.35 to 0.40%. The colorific value ranges from 3300 to 5500 K.Cal/kg. Because of its ash and moisture content,

**Table 1.4 Salient Feature of Singrauli Coalfields**

| | |
|---|---|
| Total area | 2120 sq km |
| Mohar basin | 312 sq km |
| Singrauli main basin | 1808 sq km |
| Present working | Mohar basin |
| Estimated reserves | 9.207 billion tonnes |
| Proved reserves | 4.158 billion tonnes up to 300 m depth |
| Reserves under exploitation | 1.922 billion tonnes |
| Coal seams | Purewa top - 9 m thick<br>Purewa - 12 m thick<br>Bottom Turra Seam - 20 m thick<br>Jhingurdah - 130 to 138 m thick |
| Coal Quality | C to F Grade<br>Gross CV (6000-4500) K cal/Kg |

**Source** : NCL at a Glance, 1996.

**Table 1.5 Yearwise Coal Production and Overburden Dump (OB) Removal**

| YEAR | COAL PRODUCTION (MT) | OVERBURDEN DUMP REMOVAL (MT) | COMP($MM^3$) | GROWTH IN COAL PRODUCTION(MT) |
|---|---|---|---|---|
| 85-86 | 82.76 | 162.96 | 222.08 | - |
| 86-87 | 13.60 | 42.40 | 52.12 | - |
| 87-88 | 16.50 | 53.67 | 65.45 | 21.32 |
| 88-89 | 219.63 | 69.37 | 83.42 | 18.97 |
| 89-90 | 23.28 | 83.54 | 100.16 | 18.59 |
| 90-91 | 27.89 | 89.44 | 109.75 | 19.80 |
| 91-92 | 30.88 | 89.11 | 111.70 | 10.72 |
| 92-93 | 30.70 | 82.36 | 104.90 | -0.58 |
| 93-94 | 31.41 | 90.53 | 112.70 | 2.31 |
| 94-95 | 32.50 | 93.92 | 117.14 | 3.48 |
| **TOTAL** | 309.15 | 857.32 | 1079.02 | |

**Source** : NCL at a Glance, 1996.

the coal is suitable only for power generation. The coalfield consist of 13 mining blocks namely Gorbi, Jhingurdah, Kakri, Bina, Marrak, Khadia, Dudhichua, Jayant, Nigahi, Amlori and Mehrauli (Table 1.6). Subsequently more blocks namely block "B" and Mohar has been identified. With assured production of coal from these blocks a chain of Super Thermal Power Plant with planned production capacity of 20,000 MW electricity has been envisaged in Singrauli region, which makes it future power capital of India.

Three Super Thermal Power Station (STPS) namely Singrauli STPS (Plate 1.1),Vindhyachal STPS (Plate 1.2),and Rihand STPS of National Thermal Power Corporation Ltd. (NTPC) (Plate 1.3), Obra TPS and Anpara STPS of UP Electricity Board (UPEB) (Plate 1.4), and one captive power house of Renusagar Power company of Birlas have been installed in this region. The generation capacity of these plants is 7335 MW. The tentative expansion Programme by the turn of century is further 5020 MW, (Table 1.6).

## 1.5 REMOTE SENSING OF ENVIRONMENT

Environmental impact due to mining and thermal power generation is cause of concern. As the imbalance caused due to extraction of coal and power generation adversely affects the ecosystem arising due to developmental projects the Ministry of Environment and Forest in its notification has made mandatory to obtain environmental clearance prior to undertaking new projects or projects involving expansion for

Plate 1.1 Panoramic View of Singrauli STPS (NTPC) Sidhi District, M.P.

Plate 1.2 Panoramic View of Vindhyachal STPS (NTPC) Sonbhadra District, U.P.

Plate 1.3 Panoramic View of Rihand STPS (NTPC) Sonbhadra District, U.P.

Plate 1.4 Panoramic View of Anpara STPS (UPEB) Sonbhadra District, U.P.

## Table 1.6 Linkage of Coal Mines with Thermal Power Plant

| S.NO | Coal Mining | | | | | | | | Thermal Power Generation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mining Project | Year of start | Reserve (Mt) | Sanctioned Capacity (Mt) | Operational Capacity (Mt) | Added Capacity (95-96) (Mt) | Stripping Ratio $M^3/t$ | Status | Plant Name | Capacity (MW) | | Linkage |
| | | | | | | | | | | Estimated | Ultimate | |
| 1. | Jhingurdah | 1965 | 121.0 | 3.0 | 3.0 | - | 1.15 | -do- | | | | |
| 2. | Gorbi | 1971 | 36.49 | 1.5 | 1.5 | - | 1.47 | Completed | | | | |
| 3. | Bina | 1975 | 108.34 | 4.5 | 1.8 | 2.7 | 2.20 | -do- | Other | 395 | 395 | Bina/ Jingurdhah/ Gorbi |
| 4. | Jayant | 1975 | 348.93 | 3.0 | 3.0 | - | 2.60 | Operation | Singrauli STPS (NTPC) | 2000 | 2000 | Jayant/ Dudhichua |
| 5. | Kakri | 1980 | 71.93 | 2 5 | 1.0 | 1.5 | 2.25 | -do- | Obra STPS | 1550 | 1550 | Bina |
| 6. | Khadia | 1982 | 80.0 | 4.0 | - | - | 4.08 | -do- | Anpara (STPS) | 1130 | 3130 | Khadia/ Kakri |
| 7. | Amlori | 1982 | 379.25 | 4.0 | 3.0 | 1.0 | 4.30 | -do- | Rihand STPS (NTPC) | 1000 | 3000 | Amlori/ Dudhichua |
| 8. | Didhichua | 1984 | 344.96 | 10 | 5.0 | - | 3.29 | -do- | Vindhyac-hal, STPS (NTPC) | 1260 | 2260 | Nigahi/ Dudhichua |
| 9. | Nigai | 1986 | 91.80 | 4.2 | - | 4.2 | 3.76 | -do- | - | - | - | - |
| 10. | Gorbi-B | 1987 | 47.98 | 3.0 | 0.60 | - | 3.35 | Operation | | | | |
| 11. | Bina II* | - | 33.57 | 1.80 | - | - | 2.49 | Yet to be teken up | | | | |
| 12. | Nigahi* (Exp) | - | 298.63 | 10.0 | - | - | 4.18 | -do- | | | | |
| 13. | Mehrauli** | - | - | - | - | - | - | Not planned | | | | |
| 14. | Marrak** | - | - | - | - | - | - | Not planned | | | | |
| Total | | | 2302.88 | 51.50 | 18.90 | 9.4 | 35.12 | | | 7335 | 12335 | |

* Expension Awaited ** Not planned.

specific activity (Anonymous 1994). This require creation of resource data base like mining block, location, extent and spatial distribution for all such projects. These can be obtained by employing various techniques of conventional and modern survey, the remote sensing technique using aerial photograph and space borne images. Remote Sensing with its unique synoptic perspective is a potential mean of monitoring natural resources and environment. The mining specially opencast being surfacial nature can be more efficiently mapped and analysed by these techniques. A major application of remote sensing involves the characterization of natural resources through measurement of multi-spectral data and this potentiality offers a great improvement over conventional technique, since it allow the researcher to monitor changes in the terrain condition of the same area with time.

Aerial photography was the first method of remote sensing and even today in the age of satellite and electronic scanner, aerial photographs still remain the most widely used type remotely sensed data. (*Curran*, 1985). Applications of aerial photographs have been widely acclaimed for many years in identification and mapping of natural resources. The important factor which contribute significantly to the success studies of aerial photography applied to natural resources studies are three dimension affordable by the stereoscopic coverage. These photographic images have distinct tones and textural variation and superior spatial resolution. The most commonly used films are black and white panchromatic/infrared and colour, colour IR. In most of the cases, generally black and white film are used. Colour and colour IR film are widely used in vegetation damage detection and assessment as subtle tonal changes are best exemplified in these films (*Murtha*, 1978).

Use of aerial photograph started more than sixty years ago as a reconnaissance tool it then acquired a photogrammatic quality and topographic map were generated. An important study on operational use of air borne remote sensing in natural resources was done for the Peace Athabasca Delta in Canada. Multistage and colour infrared (CIR) film were used in the study. (*Dirsch* ***et. al.,*** 1974). In India extensive studies have been carried out in the field of natural resources survey and inventory using aerial photographs by several workers. (*Majumdar* ***et. al.,*** 1994 and *Gautam*, 1995).

The worldwide recognition to remote sensing goes to satellite as it paved the way for modern remote sensing technology. The advent of satellite remote sensing technology has open several new vistas in the field of mapping and monitoring on account of readily available data for most of the world, lack of political, security or copyright restrictral, low cost, repetitive and synoptic multi-spectral coverage and minimal image distortion. Satellite data acquired in the digital form for earth's surface can be analysed through a computer (Image processing system) or it may be visually interpreted after converting the digital data in analogue form. In both the cases ground truth data is required either for making interpretation key in case of visual interpretation or for training sites in case of digital analysis. The greatest advantage of digital analysis is less time required for classification as compared to visual method but greatest disadvantage is diminishing accuracy in case of heterogeneous area with varying topography. However, the advantage of satellite data in temporal change detection and mapping is very significant. Remote sensing satellites, having improved spatial, spectral and temporal resolution i.e. LANDSAT 5 (TM), SPOT 2, IRS-

1C and 1D launched by United State of America, France and India respectively open a new era in the field of natural resources survey and monitoring. Any study pertaining to the dynamics and temporal attributes of the environment can be studied comprehensively by analysing the data obtained through these satellites.

Satellite data have been widely used for study of natural resources in many parts of the world. *Thomson* ***et. al.,*** 1978 applied visual and digital analysis approach with Landsat MSS data. Thematic mapper data has been widely used for environmental monitoring in abroad and India (Kamat ***et. al.,*** 1985, *Anon*, 1988, *Lodwick*, 1981, *Sahai,* 1989, *Chinmaya* ***et. al.,*** 1992). The launch of Indian Remote Sensing Satellite (IRS) in March 1988 and successive satellites of IRS 1C and 1D in coming years, quick impact assessment and periodic monitoring of our natural resources has been possible. IRS LISS II and LISS III data has been widely used for impact assessment (*Garg* ***et.al.*** 1989, *Tamilarasan*, 1989, *Gautam*, 1995).

In the present study magnitude of environmental impacts in Singruali coalfield has been studied through remote sensing technique by analysing temporal satellite data to obtain comprehensive and reliable results. Remotely sensed data has been used effectively to observe some of the key changes i.e. landuse/landcover, degradation of vegetation, air pollution, water pollution etc. in the ecological set-up of the area. The result obtained provides critical inputs for Environmental Management Plant (EMP). Broadly, remote sensing has been used for studying land, air and water the three important facets of ecology and environment.

## 1.6 SIGNIFICANCE AND OBJECTIVES OF THE PRESENT STUDY

Although occurrence of coal in Singrauli area has been known for about 150 years, the coalfield came into prominence only in the early 1960's due to large quantity of non-cooking coal deposit at shallow depths and availability of plenty of water from Govind Ballabh Pant Reservoir, both favorable for large scale power generation. Considering the geo-mining conditions of the coalfield, opencast mining method is being followed in all the mines, which is triggering environmental hazards. On account of mining and allied activities, the land has been degraded, water contaminated and polluted, vegetation and cultivable land lost. The virgin environment of the area is also suffering by air, water and noise pollution. (Table 1.7)

The rapid industrialisation and urbanisation in the area is also aggravating the environmental problems. For mitigating these adverse impacts of coal mining and allied activities and to find out some solutions to restore a balance between exploitation of coal/thermal power generation and conservation of environment, a judicious monitoring of the impacts and adoption of efficient management plan is needed. With the above background an attempt has been made to assess the environmental changes associated with mining and ancillary operations and to draw an appropriate environment management strategy for restoration and conservation of environment. The main objective of the present study are as following :

**Table 1.7 Expected Total Air Pollution Load in Singrauli Region, Generating 20,000 MW Power**

| Pollution in 1MT. Coal burned,Kg. | | Expected daily production,MT |
|---|---|---|
| Particulates (30%) | 300.00 | 72000 |
| $SO_2$ (0.35% S) | 6.65 | 1596 |
| NOx | 9.00 | 2160 |
| CO | 0.50 | 120 |
| CH | 0.15 | 36 |

(i) Evaluation of resources potential of the area in terms of landuse/landcover, hydrogeomorphology, slope, drainage/watershed, soil, transport network and assessment of temporal change in landuse/landcover caused by coal mining and thermal power projects.

(ii) Assessment of environment hazards through preparation of environmental appraisal maps on land, air and water.

(iii) Integration and analysis of all the above studies parameters to suggest Environmental Management Plan of the area.