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Environmental Impact Assessment of Coal Mining: Indian Scenario

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Abstract

Coal mining is a development activity, which is bound to damage the natural ecosystem by all its activities direct and ancillary, starting from land acquisition to coal beneficiation and use of the products. This is so because environmental degradation has affected especially the common property resources such as land and water on which depend the subsistence and well-being of the local community. The study area being the foremost coal producing region of the country also ranked high in the record of environmentally degraded region. Huge areas in the Raniganj and Jharia coalfield in India have become ruined due to abandoned and active mine surface and underground mines. In open cast mines, waste resources are usually stacked as huge dumps in the surroundings. These, coupled with coal dumps, cause noteworthy visual impact. Large vicinity of forest, farming land, and pasture land has been transformed into colliery colonies or into uncultivated land due to rapid expansion of the coal mines. As a result, land use pattern has been changed considerably over last three decades. This study is pursued to assess the impact of coal mining activities on local community and environment.

Keywords: environmental degradation; health hazards; mine fire; pollution; agriculture.

Introduction

Environmental Impact Assessment (EIA) is a concept that evolved in search for ways to render development and protection of the environment. In order to predict and assess the impacts associated with a proposed action, it is essential to explain the environmental setting in which the proposed action takes place. This gives the baseline information against which prediction and assessment can be made. The study tries to mention about the environment which has been degraded by coal mining. Now a day's environmental assessment is widely used to study the impact which is still continuing in the particular region by particular activity. Increasing demand for environmental quality, protection of greenery, clear air and water, minimization of noise congestion and open space for active outdoor recreation have all taken with key importance. An impact can be defined as any change in physical, chemical, biological, cultural and socio-economic environmental system that can be attributed to human activities.

Raniganj and Jharia coal mining region plays an important role in India's overall development. This region has well developed transport and communication and rich in mineral resources. This famous coal bearing region has got very well scope for large industrial development along with other developments of agriculture, livestock, forest, water and other minerals. An integrated approach is very necessary for sustainable development in this region.

It is thus clear that coal mining leads to environmental damage, while economic development and self-reliance call for the increased mining activities of the available mineral resources. Though there is no alternative to the site of mining operations, options as to the location and technology of processing, adaptation of eco-friendly coal mining process and afforestation in the mining site etc can really minimize the damage to the environment.

Methodology

The methodology of the present study includes collection of research material over the field study and observation methods. The present study is based on both Primary and Secondary data. Primary data are collected from a structured interview schedule with the officers and workers of Coal India Ltd, W.B, India and secondary data are collected from CMPDI (Coal Mining Planning And Design Institute) records, journals of IICM (Indian Institute of Coal Management) and books and research paper related to coal mines. The field study was conducted from the Coal India Headquarters in 2012.

Results and discussions

Environment of underground mine working in India has been extremely dangerous because of the constricted geometry, darkness around, suffocating mine atmosphere, heat and humidity. Working under poor light in the past caused miners mustangs, is practically unknown now because of the improved lighting. Heat humidity and thermal stress often extreme under deep mines have been responsible for poor efficiency of the miners.

Air conditioning of the atmosphere in some of the deep underground mines have been realized in the interest of good organization. In this exercise, optimization of the man, machines, and environment system- physical environment in terms of heat, humidity, air movement, illumination noise, vibration, toxic agent, dust and fumes are to be looked into.

The environment of underground mines have been a subject of serious concern to the mine operators because of the liberation of methane with coal cutting, heat and humidity and generation of fumes with the blasting of coal (Wathern, 1988). The opening of the coal seams with interconnecting galleries, coursing for intake and return air, creation of air draught and deployment of auxiliary or forcing fans are some of the conventional means adopted to improve the environment of underground. The suppression of dust or suspended particulate matter is tried by water spraying from the loading or transfer points. In the subsequent years water infusion in the seams and water jet mounting on the cutting edges is tried to minimize dust menace during cutting of the coal.

The auto oxidation of the coal; a slow process is aggravated when large surface area of the fine coal particles come in contact of air. The oxidation of pyrite adds a new dimension to the problem and being an exothermic process causes spontaneous heating and fire underground under favorable conditions. The heating process generates SO₂, CO, CO₂ and higher hydrocarbons (Boliga, 2010). These gases reaching to the atmosphere through cracks and fissures make the underground atmosphere unsuitable for the miners and also pollute the surface atmosphere around the up cast channels. Similarly the blasting underground generates NO_x and other gases in addition to fine particulate matter. The atmosphere underground was affected by a number of mining activities like cutting, blasting, loading and transport and preparation to beneficiation on the surface. The factors responsible for generating and adding different pollutants in the atmosphere underground are shown in the following chart. The most damaging constituent among them were the suspended particulate, impurity attributed to be due to handling, transport and preparation of coal and the methane released from the coal seams.

Some of the pollutants are the natural product of the coal formation while a number of them are produced during the mining operation, preparation and handling. The underground mining technology has been developed in different parts of the world to improve the mine environment and to minimize hazards associated with different activities. Main activities of the underground

mining, their impact over the surface workers, overlying formation and the surface and common remedial measures are summarized in the following table.

Table 1: Environmental problems of underground coal mining in India

Operation	Impact	Remedial Measures
Excavation	Methane Explosion	Effective ventilation Drainage
Drilling/ Cutting	Coal explosion Noise pollution	Dust extractor / Water infusion Earmuffs
Blasting	Fumes and vibration	Improvement in explosive and detonator
Loading Transport	Dust pollution Noise pollution Noise pollution	Water infusion, Séquence control Earmuffs, improved Maintenance Water spray
Ground	Dust pollution Roof and side fall Opening of join/fissures	Effective support system Reinforcement Remote operation of m/
Movement subsidence	Land degradation Damage of surface Features Lowering or water table	Mining with harmless geometry/ Stowing, and reclamation.

Sources: CMPDI, Survey Report, 2013

Underground dust hazard in coalmining areas

The atmosphere of underground is under severe constraint because of the limited geometry of opening, number of simultaneous mining activities, liberation of gases from the coal seams and reaction of air with freshly exposed coal surface and pyrites. Rise in temperature by 1° C/ 22m depth cover made the atmosphere hot while the seepage of water from the roof and walls increases the humidity when the dust particles get segregated.

The dust particles causing harmful effect are divided into inert and proliferate groups. The inert particles-line stone, and smoke soot do not impair lung function unless excessive deposition over years. Proliferate group of dust includes free or crystalline silica and coal dust. The silicosis giving rise to difficulty in breathing, reduction of chest expansion and susceptibility to tuberculosis is because of the silica dust. Coal dust causes focal emphysema and results in marked disability in advance stage. The disturbance in the lung function in the early stage of fibrosis results in reduction in breathing or ventilator capacity and impairment of the process of gas exchange. In either case, the change in function is associated with bronchitis or emphysema.

The dust concentration underground varies with the operation and location, quality of coal and natural moisture content of the mine environment. Typical findings for an Indian mine is summarized in the following table covering different operational sites (CMRS* Annual Report-2012). All the measurements are taken with MRE 113, a Gravimetric Dust Sampler. The dust concentration was high in case of dry, soft coal with high ash content. The dust particles size under suspension varied from 1.5 micron to below 10 microns being most crucial and responsible for pneumoconiosis amongst miners.

* CMRS- Coal Mining Research Standard

Table 2: Dust concentration during different mining operations in India

Operations	Dust concentration mg/m ³ of air
Tub loading	1.93-2.85
Drilling	3.00-10.27
S D Loading*	5.00-6.25
Under cutting	8.00
Transfer points	2.73-2.86
Blasting	10.00-20.00

Sources: CMRS Annual Report, 2012-2013

For every ton of coal mined underground, about 100 gm irrespirable dust is produced, out of which about 1-10% is air borne including 5 and 1 micron particles in the ratio of 1:40. The irrespirable dust generation in high rank coal seams or seams with higher ash content is proportionately more. The dust generation with the blunt cutting bits is also higher when the cutting is more under compression.

Table 3: Irrespirable dust composition from underground mines in India

Operations	Sulfur %	Ash %	Free Silica %
Under cutting	0.49 (0.15-1.05)	20.94 (1.95-57.05)	5.46 (1.56-13.32)
Drilling	0.56 (0.27-1.12)	15.70 (11.64-20.63)	4.05 (2.67-7.71)
Blasting	0.41 (0.31-0.70)	19.0 (13.42-32.67)	4.66 (2.09-12.27)
Loading	0.52 (0.31-0.70)	18.50 (14.81-27.71)	4.37 (1.52-6.89)

Sources: CMRS Annual Report, 2011-12

In the report, nearly 0.56% sulfur, 15.70% ash and 4.05% silica of irrespirable dust is produced per meter of 43 mm diameter hole drilled in coal seams during 2011-2012. The irrespirable dust generated during cutting by different machines is summarized in Table 4. Mechanized cutting of coal, concentrated heavy production, movement of heavy machine and slow velocity of the air are responsible for heavy concentration of air borne coal and silica dust. The problem in case of long wall and continuous mining is being tackled by the use of sharp bits, use of dust extractor and directional clearance of dust by improved air velocity.

Table 4: Irrespirable dust concentration during different mining operations in India

Operation	Dust concentration Average (Range)	Remarks
Development workings Undercutting	2.75 (1.50-4.00)	Face naturally wet
Drilling	2.20 (2.15-2.25)	Face naturally wet

* SDL- Side Discharge Loaders

After blasting	7.13 (7.00-7.25)	Face naturally wet
Manual loading	1.50 (1.25-2.35)	Coal naturally wet
Depillaring operation	2.00 (1.30-2.20)	Air velocity 5.7m/min
Drilling	1.10 (1.05-1.15)	Face naturally wet
Manual loading	5.75 (3.07-8.85)	Face naturally wet
Drilling	5.00 (4.36-5.64)	Coal dry
Chute discharge LHD loading*	1.05 (1.02-1.05)	Wet Dry

Sources: CMRS Annual Report, 2012-2013.

Surface atmospheric pollution in coalmining region in India

Mining below the surface destabilizes the ground, while the process of mining particularly blasting under shallow cover causes vibration of the surface structures and noise menace. The transfer of the raw coal, its beneficiation and handling generates coal dust while open burning of coal for steam or other usage releases gaseous discharge to the surface atmosphere. The movement of coal from the pit head to the loading or consumption points in open leaky trucks or open wagons also adds coal dust to the environment all along the route. The dump from the waste rocks, discharge of effluents from the machines and pumping out of the hard, polluted water to the surface water sources make the water unfit for mass consumption. The surface subsidence due to caving or fire damages the surface structures and endangers the surface dwellers. The underground mines are ventilated by large size fans discharging up to 12,000 m³ /min. through fan evasive of 3m to 5m diameter at over 200 mm pressure (Dhar, 2000). The air absorbing moisture from the underground workings often reduces the suspended particulate matter but the fumes of explosives, methane, SO₂, and Oxides of Carbon are added to the general body of air. The concentration of these hostile gases often creates a little impact over the surface and the population nearby. With the latest realization about the impact of these green house gases over the Ozone layer has drawn the attention of the global community and efforts are made on to drain methane and put it to use as a fuel. The biodiversity and the local populace are also disturbed by the mining activities though they were mostly underground (CMPDI Report, 2012).

Dust concentration in coalmining areas

The dust concentration in the coal mining area is one of the worst menace affecting the common residents and miners alike. The miners from the organized sector get health support and other medical facilities while the common citizens suffer without any such insurance. Major portion of the menace is indirect; associated with open stock burning of coal, dumping, of the waste rock and road transport of coal and sand. The suspended particulate matter in mining atmosphere of Katras coalfield is revealing in this respect. The predominant air emission source in most of the coalfields is road generated dust and vehicular exhaust. In some of the areas road transport is the only mode of coal movement where open, leaky, inefficient trucks and dumpers carry coal on ill maintained roads and pollute the region. In Jharia coalfield, the vehicular movement contributed nearly 47% of total SPM load while the direct contribution of the underground mining was estimated to be 6% only (CMPDI report-2012).

The ambient air quality of the mining area often polluted by the associated activities is of the non mining origin but of public concern and required remedial steps. The vehicular discharge engaged for the transport and handling of the coal within the coalfield is responsible to a large extent in adding suspended particulate pollutants in the general atmosphere. The concentration of suspended particulate matter in ambient air of the coalfield on an average is high and the extreme is up to 1464 mg/1 at *Nirsa colliery*. The trace elements are also reported as pollutant in ambient

* LHD- load-haul-dump

air of Jharia coalfield, including lead, manganese, arsenic chromium and cadmium (CMPDI report-2012).

Table 5: Suspended particulate matter (SPM) in coal mining areas in India

Location	SPM	Level –Microgram/m ³
Mining cum residential area	801	(664-910)
Do (in rainy season)	480	(288-802)
Town residential area	786	(585-1010)
Do (in rainy season)	491	(147-713)
Average	618	-

Sources: CMPDI Survey Report, 2013

Dust concentration in mine fire area

Depillaring or partial extraction of thick coal seams under shallow depth cover has caused cracks traversing the overburden. This has been facilitated breathing of air to the seat of coal resulting in spontaneous heating and fire. The underground coal mine fires are the common picture in Jharia and Raniganj coalfields. The record of coal mine fires are available for Raniganj even before 1869 and Jharia coalfield since 1916. In the process of burning, everything from coal to surface grass is burnt with smoke all around resulting rise in temperature of the whole area. Jharia coalfield alone has over 70 active fires extended over 17.5 sq km emanating huge amount of noxious gases including poisonous CO to the atmosphere.

The occurrence of fire in underground mines in Jharia coal field has devastating impact over the atmosphere due to release of Hydrocarbons, SO₂ and other gases from the coal mass with the rise in temperature. The ambient air pollution near mine fire area of Jharia coalfield is given bellow in the following table.

Trace element pollutants in air surrounding coalmines

The toxicity of trace elements and complexities of biological and chemical interaction and its impact on the health makes the study of trace element in the environment very relevant to the healthy living of the population. Most of these elements are present in soil or rock mass but their concentration increased in the mining areas because of large scale lithosphere disturbance. The metals released with different mining and associated activities get suspended in atmosphere and get easy access to human body. The survey of the ambient atmosphere of Jharia coalfield shows significant concentration of iron, lead, zinc and copper given bellow in the form of table.

Table 6: Trace element in suspended particulate matter in Jharia coalfield in India

SL.No	Element	Area 1	Area 2	Area 3
1	Fe	5.67-13.33	4.38-14.29	5.12-14.92
2	Mn	0.128-.493	0.143-.682	0.148-0.801
3	Pb	0.136-.581	0.148-.623	0.125-.712
4	Cd	0.028-.067	0.018-.073	0.021-.061
5	Cu	0.281-.489	0.362-.521	0.302-.621
6	Zn	1.32-1.52	0.920-1.203	0.822-1.008

Sources: CMRI Report, 2013.

Measures to control dust

The concentration of dust in the presence of moisture underground has shown decreasing trend because of agglomeration of the suspended particulate matter. The use of scrubber at different critical points as such could suppress the dust generation and dispersal. Even in the case

of conventional loading of the blasted coal. Water spraying has been practiced to control the dust in Indian mines. The system is quite popular in case of continuous miners and transfer points of the conveyors. The water infusion in the coal seam and spraying of water during cutting has been practiced for dust suppression.

Plain water or water mixed with surfactants and polymers has been injected into dry low volatile coal seams to reduce the dust generation in the India. The surfactant in very low dilution improved the dust suppression by 15 to 20% compared to plain water. The best arrangement appeared to have one spray behind each cutting bit that provided 4 liters/minute of water at 1-2 MPa*. Hydro jet cutting in shearer has been a common practice to reduce the dust generation during fast cutting of coal at high productive faces.

Noise pollution due to mining activities

The noise is now being recognized as a major health hazard; resulting in annoyance. Cases of Partial hearing loss and even permanent damage to the inner ear after prolonged exposure are noticed. The problems of underground are of special importance because of the acoustics of the confined space. The ambient noise level of the underground mining area is affected by the operation of the cutting machines, tub/conveyor movement and blasting of the coal. The movement of coaling machines and transport units-conveyor, tubs and transfer points caused audible noise which becomes disturbing underground because of the poor absorption by the walls (Singh. 2012).

The most noise generating equipments in underground are the haulage, ventilators-main, auxiliary and forcing fans, conveyor transfer points, cutting and drilling machines. The ambient noise level due to different operations in underground mines varies within 80-1040 dB (A). In Raniganj and Jharia coal field, the noise level near fan house, conveyor system shearer and road headers is reported to be within 92-93 dB (A). The degree of pollution is increased in many Indian mines due to poor maintenance of the machines, which sometimes exceed the permissible limit of 90 dB (A) for 8 hours per day exposure. The transfer points of the coal underground were the main point of the noise menace. The result of a noise survey for a coal mine conducted by DGMS[†] is summarized in the following table, which indicates noise over 90 dB by the drills, breaking and crushing units and transport system underground (Banerjee, 2007).

Table 7: Noise level in underground coal mines in India

Location of survey	Average Noise level (dB) [‡]
Near shearer	96
Transfer point	99
Tail end belt conveyor	89
Power pack pump	91

Sources: CMRS Annual Report, 2012-2013

The mechanized mines have lower noise problem in comparison to the old conventional mines operational mines operating with haulage and coal cutting machines. The results shows that covering wholly manual, partly mechanized with coal cutting machines and partly mechanized with SDL[§] loading has been showed reduction in the noise level in underground.

* MPa- Mega Pascal

† DGMS- Director General Of Mine Safety

‡ Db- The decibel

§ SLD- Side Discharge Loaders

Impact of underground mining on surface domain

Most of the leases acquired for the mining purpose are interior barren land, agricultural farms, or government controlled fallow and forest cover. The development of the underground mining establishments, residential complex and civic amenities required nearly 10% of the total lease area which has to be restored at the cost of forest, farms, or fallow land (Dhar, 2000). These lands are used for the common facility development with the marginal disturbance to the soil cover and green carpet. However the naturalized biological genes of the mining area are driven out or disturbed with the human settlement, noise nuisance has been created by heavy vehicles and construction of jungle of concrete. With the clearing of the exotic plants, the natural plant succession of the area is hindered and the loss of the green cover followed soil erosion.

The concentrated underground mining of coal in and around Jharia, Raniganj town have transferred the underground pollutants to surface atmosphere. The mine exhaust through main ventilators and the return airways added the gaseous and particulate pollutants to the surface atmosphere. Weathering of the coal and rock mass, leachets from the dumps and noise menace from blast wave and movement of surface handling plants pollute the surface environment to variable degrees.

The non mining activities like burning of coal in open stock, active fires and road transport of the coal have added a new dimension to the atmospheric pollution in this region. The sources of pollution associated with underground mining are summarized as follows:

- a) Change in land use pattern and land depredation.
- b) Ground Vibration with blasting.
- c) Suspended particulate in the atmosphere.
- d) Noise and vibration menace due to mining and vehicular movement.
- e) Societal problems due to cultural, economic invasion and displacement.

Change in land use pattern due to mining activity

The underground mining has caused land degradation because of surface subsidence, solid waste and coal dumping, underground fire and silting of the surface. The disturbance of the aquifers and subsurface water table follows loss of green cover and vegetable mass. The subsidence and disturbance of hydraulic regime has been dealt separately because of their importance. The bunker age in Indian coalfields have been very poor when the excavated coal has to be stocked open along the railway siding. In the off seasons the pit head stock varied up to the production level of 15 days in a month covering a large area. The green cover over the patch is lost and the dust pollutes the area under the influence of underground mining and fire, affecting even the local non mining population. The waste rocks are picked and scattered around created severe eye shore. The surface condition of Jharia coalfield is self revealing.

As the size, shape and magnitude of the dumps varied with demand, the land degradation under its influence is variable. Nevertheless, an area once under coal heap remained permanent eye shore unless reclaimed by systematic plantation.

The other factors are responsible for the degradation of land in coalfields of Raniganj and Jharia. The subsidence in normal cases has caused undulation of the surface, damage to the structures and drainage pattern. In case the slope exceeds 15 degrees, erosion of the soil occurs; usually the top soil is removed with torrential rains. This converts the farms to wasteland of low fertility and caused siltation of the dams, streams and ponds. According to estimate, over 5.5 million hectares of land is already converted to waste land in Damodar valley alone (Goswami, 2013).

Land Disturbance due to mining activity

Leaseholds for the underground mines are procured from the land lords who have granted them the right for underground coal. The land for houses, dwellings and the associated activities are purchased piecemeal from different sources while large portion of the surface right remains under the control of farmers and landlords. Underground mining in these areas are conducted with full responsibility of the surface protection by the operators who normally maintains pillars as the natural support to the surface features. Now the condition is very damaging under the Jharia coalfield where thick coal seams are worked under shallow cover. There are some pockets in the coalfield which have subsided by over 10m due to repeat depillaring activities. In geologically

disturbed areas, deep pot holes are formed through which valuable fertile soil is drained to underground and many times surface structures are damaged, distorted or spoiled (Singh, 2006).

The land of Jharia coalfield is under regular threat because of mining operation; failure of pillars and stocks, pillar crushing and advancing fire in adjacent pockets. The story of Raniganj coalfield is in no way different where nearly 4000 He of land subsided up to the year 2010. The impact of underground coal mining in terms of loss of agricultural land is estimated to be nearly 1000 He in *Jamuria*, *Asansol* and *Kulti* blocks of Raniganj coalfield until today.

Water pollution due to mining activity

The hydraulic cycle starting from ocean to sky and ultimately precipitation to the earth is no exception for the coalfield where the rain, natural moisture and surface to subsurface water sustain biodiversity of the region. The infiltrated water is charged to the coal measure aquifers and is retained by the aquiclude or aquifuge. Depending upon the thickness, porosity, permeability and storage coefficient of the rock mass, the capacity of the aquifers varies extensively over *Damodar* valley to *Pench Kanhan* coalfields. The coal seams are known to be impervious, restricted the cross infiltration when different layers charges along the exposure serves as the confined aquifers. The extraction of the coal has followed disturbance of the aquifers and lowering of the water table. In this process mineral leaching occurs, affecting the water quality of underground. The water pollution problems in mining may be broadly classified into the following four major heads (Chadwik, 2007).

- Acid mine drainage due to sulfur content
- Deoxygenating and Eutrophication of coal
- Hardness of water due to leached
- Heavy metal pollution oil, tan and grease mixing in water

The mine effluents have high level of dissolved chlorides, nitrates, phosphates or sulfates of sodium, calcium magnesium and iron. At low levels, nitrates, and phosphates act as nutrients, causing rapid growth of algae and subsequent deoxygenating while at higher level, the character of the water is altered with deleterious effect over the fishes. The bicarbonates, sulfates, chlorides and calcium and magnesium cause hardness of the water and make it unsuitable for industrial and human consumption. The characteristic of the mine water of Jharia coalfield in different seasons is summarized in the following table.

Table 8: Average characteristic of Jharia coalfield mine waste water in India

Parameters	Winter	Summer	Rainy season
Temperature	30.5	26.8	29.5
pH value	8.5	7.4	8.0
Alkalinity:	-	-	-
Phenolphthalein mg/1	32.6	21.3	48.6
Methyl orange mg/1	224.3	256.8	283.8
Total Hardness mg/1	483.6	400.9	487.1
Permanent mg/1	314.2	256.2	413.2
Temporary mg/1	169.4	144.7	74.8
Chlorides mg/1	43.6	60.5	35.5
Sulfates mg/1	180.4	73.1	28.2
Phosphate mg/1	141.7	114.6	87.8
Suspended solids mg/1	119.3	111.8	161.4
Dissolved solids mg/1	558.2	497.7	698.1
Chemical Oxygen Demand mg/1	14.8	21.5	37.7
Iron mg/1	2.1	2.2	2.6

Sources: CMPDI Report, 2013.

Land degradation and its effect on agriculture due to mining activity

The land is non-renewable asset and its degradation therefore has far reaching implications affecting the life of thousands of inhabitants living in the degraded land. Land loss and land degradation due to mining may be due to underground or opencast mining. In underground mining subsidence causes the major loss of land and in Raniganj and Jharia coalfield, extensive area may be considered to be degraded due to instability created by wrong mining procedure (Goswami, 2014). In the surface mining, the excavation and spoil heaps is the major cause of land degradation. There are other causes of land degradation which are associated with mining. Land may become less productive and therefore degraded due to deposits of coal dust and other suspended particulate matter. The extension of urbanization associated with mining also contributes to land loss in many ways. Traditionally, coal production in Raniganj and Jharia coalfield was mostly from underground mines though the scenario has changed significantly in favour of opencast mining after nationalization as has been stated earlier. A number of prestigious underground projects have been undertaken in Raniganj coalfield after nationalization, including one at Jhanjra which is already under implementation with Russian collaboration (Bhengara, 1996). Jhanjra underground project has been planned to be one of the biggest underground mining project in India. The work on an Indo - French project at *Khottadih* has been started recently. The estimate presented in the fore – going paragraphs indicates that approximately 15 to 17 percent of the total land in the coalfields in Raniganj and Jharia would be degraded due to mining and related causes. It is very difficult to assess the quantum of agricultural land involved in the total land degradation. The sample survey presented earlier shows that agricultural land has generally been 18–55 percent of land degraded in a project. The quantum of agricultural land involved increases with mining entering into a relatively new area, whereas when the project is on an area where mining activities are already in full swing, the quantum of agricultural land involved may be smaller. A reasonable estimate may be that 35–40 percent of the total land involved may be agricultural land, which means around 10,000 hector of agricultural land may be involved in the Raniganj coalfield during the process of mining up to 2010. The total land use pattern in the coalfield has never been verified in Raniganj coalfield though some aerial survey data is available for Jharia coalfield.

Conclusions

Mining below the surface destabilizes the ground, while the process of mining particularly blasting causes vibration of the surface structures and noise generation. The transfer of the raw coal, its beneficiation and handling generates coal dust, while open burning of coal for steam or other usage release gaseous discharge to the surface atmosphere. The movements of coal from the pit head to the loading, or consumption points in open trucks or open wagons also add coal dust to the environment all along the routes. The air absorbing moisture from the underground workings often reduces the suspended particulate matter but the fumes of explosives, methane, SO_2 , and Oxides of carbon were added to the general body of air. The concentration of these hostile gases often creates negative impact over the surface and the population nearby. With the latest apprehension about the impact of these green house gasses over the ozone layer has drawn the attention of the global community and efforts are made to drain methane and put it use as a fuel. The bio – diversity and the local people are also disturbed by the mining activities though they are mostly underground mining. The adverse effects of subsidence fissures have made most of the subsided areas barren and unstable. The indirect effect of subsidence has contributed to drying up of many tanks and dug wells in the vicinity. Much of these subsided land may however be put back to productive use with joint effort from coal companies and local administrations, but no concerted and coherent effort has however been taken in this direction. Not much study has been done towards reclamation of subsided land in Indian coalfields. In a few areas of Raniganj coalfield, plantation on subsided land has been tried. The scientists are of the opinion that before starting reclamation of subsided land, the purpose of reclamation in terms of “land-use” should be decided in consultation with the local people. The most important thing is to plug the cracks and it may not be necessary to bring the subsided land to original profile even for use for agriculture, plantation and housing. The human dimensions of these physical impacts have been marginalization of the poor tribal from the mainstream, formal economy, displacement of peasantry and the growth of small scale, informal, illegal coal mining under local initiative. A degraded environment has fore

closed alternative employment opportunities especially in the forestry and agricultural sector, leading the poor people to unlawful activities. This is so because environmental degradation has affected especially the common property resources such as land and water on which the subsistence and well-being of the poor community depends.

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