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Environmental Consequences of a Burning Coal Mine : A Case Study on Jharia Mines

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***Abstract*: Coal mining has always been associated with various environmental consequences. Geo-environmental parameters such as air, water, soil, agricultural lands, vegetation, landforms are affected directly by coal mining activities. Coal fires are an ever-present problem in coal-mines, the world over. In the Jharia coalfield (JCF), it is a well-known fact that subsurface fires, are burning the energy resources, impacting the environment negatively and and rendering mining of coal hazardous. Taking a note of this grave condition, in the present review paper an attempt had been made to identify the environmental parameters which are most effected by mining at (JCF). The reports from EIA studies conducted on the area have been methodically studied for the present work.**

***Keywords:* Coal mining, enviromental impact assesment, effects on air, water, land, Jharia coal-field, AHP**

I. INTRODUCTION

Coal is one of the cheapest, easily available and abundant fossil fuel around the world that meets the major energy requirement of country. It is basically consumed in secondary sector (industries including power, steel and aluminum refineries etc.) and domestic purposes (mostly in villages for cooking and other activities). India ranks third in production (Table 1) of coal, followed by China and USA [1].

Table 1: Geological Survey of India (1st April 2015).

Total reservoir of India	301.5 bn tones
Cooking coal	5.3 bn tones
Medium and semi cooking coal	28.7 bn tones
Non-cooking coal	266 bn tones
Tertiary coal	1.5 bn tones

Out of the total reservoir, Jharkhand has 85 billion tones of coal [2]. The main coal field of Jharkhand are Jharia coal fields (JCF) having about almost 63 bn tons of coal production. Coal accounts for the 60% of the country's energy need and is the major source for power generation in India [2]. A typical coal mining area is generally affected by air, water, soil pollution and changes in topography, land cover and vegetation patterns.

$$\text{Coal} \longrightarrow CO_2 + SO_2 \quad [3]$$

Jharia coalfield (JCF), is well known for the phenomenon of subsurface fires. The fires are burning the precious energy resource as well as impacting the environment negatively.

The objectives of the research presented in this paper are as follows:

i. To have a review on various environmental consequences of coal mining in India and in particular Jharia coal-field (JCF).
ii. A systematic study on environmental Impact Assessment (EIA) is carried out to assess the effects (both positive and negative) of coal mining on the environment.
iii. Sustainable mining approach achieved by developing practices that lower the impacts of mining on the environment [4][5].

II. JHARIA COAL FIELDS (JCF)

JCF located in Jharkahnd, India (Fig. 1), has a long history of mining which started towards the end of the 19th century [6]. The mining activities intensified in Jharia in 1915 and thereafter they have been growing extensively and exponentially. At present, there are around 35 large underground and open cast mines in the JCF. The JCF largely produces bituminous coal which is the only coal- field in India that produces coking coal, which is a prime need for the steel industry.

A. *Environmental Impact Assessment* (EIA)

EIA (Environmental Impact Assessment) is an audit or comity which aims to assess the changes that have occurred in the environment due to a particular activity. EIA aims to understand and assess the impacts, their relationships and also to test policies for pollution control [8].

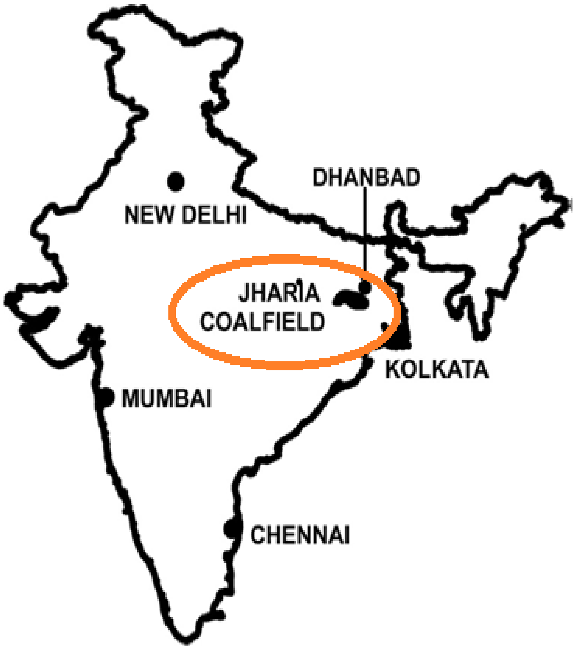


Fig. 1. Location map of Jharia [35]

EIA can be carried out using either field based studies or remote sensing studies or both in a combined manner, depending upon the parameters. Field based studies include collection of data pertaining to various factors such as air, water and soil from ground stations setup at various locations in the field and analysis in the laboratories to determine the extent of pollution in the environment.

The remote sensing studies were typically based on aerial photographic interpretation to study changes in land-use patterns. With the availability of satellite data at varied spectral, spatial and temporal resolutions (Landsat, ASTER, LISS-III/IV, etc.), remote sensing techniques are now being used frequently not only to study the vegetation but to investigate landforms, to detect surface and subsurface fires, to map coal dumps, to study pollution and to estimate surface movements, etc. in the context of coal mining.

III. ENVIRONMENTAL IMPACTS

In the next section, a parameter-wise review to assess the impacts of coal mining on air, water, soil, irrigated lands and vegetation in India has been provided. The studies include field based methods and remote sensing studies both.

A. *Impact on air*

National ambient air quality standards (NAAQS) defined the (CPCB) Central Pollution Control Board (India) to assess the quality of air. Any increase in the concentration of pollutants from the NAAQS (National Ambient Air Quality Standards) point of view then the air is harmful for the local population, flora and fauna (Fig 2a, 2b). Polluted air may lead to various diseases like asthma, bronchitis and respiratory problems etc. During rain fall, oxides of nitrogen (NOx) and sulphur dioxide (SO_2) combine with water droplets and their pH get reduced that results in acid rain. In addition, Oxides of N_2 and S react with volatile organic compounds (released in coal fires) in the presence of sun light to form smog, which in turn leads to a number of harmful effects on humans, plants and animals. Occurrence of acid rain has also been reported in JCF [9]. The comparison with NAAQS does not always depict a true picture of the air quality status of a study area. Therefore, an alternative air quality depreciation index was proposed for more realistic air quality assessment.

Fig. 2 (a) Release of smoke due to mine fires in Jharia [35]

Fig. 2 (b) Dust due to haulage of heavy vehicles in Jharia mine [35]

B. *Impact on water and soil*

Impact of mining activities on water and soil has been reported several years. If the mine water is used for irrigation purposes, toxic heavy metals from it can accumulate in soils and enters the food chain, leading to major health hazards and threatening the long-term sustainability of the local ecosystem [10]. In order to reduce the impacts, the waste water should be treated before discharging in to natural reservoirs and agricultural fields. Studies involving effects of water effluents on aquatic ecosystem, shortage of potable water, changes in natural drainage due to mining and deterioration of surface and ground water quality have also been conducted in JCF (Fig. 3) [11, 12-17].

Fig. 3 Polluted water in a pond at JCF [35]

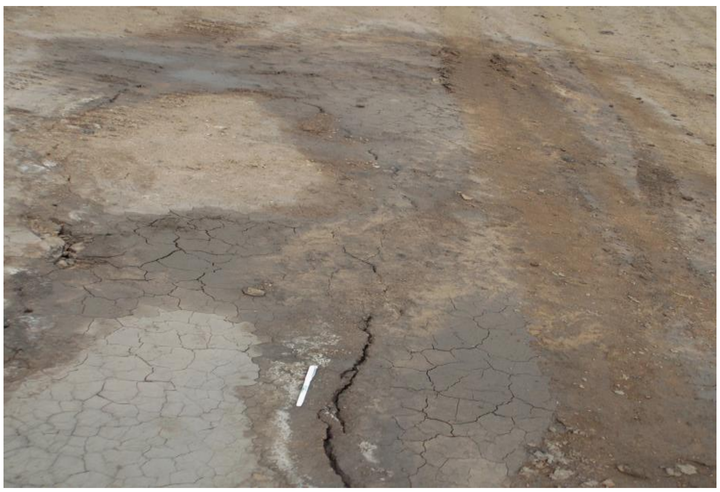


Fig. 4 (a) Desiccation cracks in soil due to fire below [35]

C. Impact on land use and vegetation

Multi-temporal remote sensing data offer an effective way to study changes in land use in mining areas [18]. A uniform classification have been performed, the area was classified into forest, non-forest and water body. Alarming rate of conversion of well forest land to barren land was noticed (Fig 4 (b). The study also assessed the assailability of the dumps and suggested plant species for land reclamation. The use of combine approach combining field based and remote sensing based study for monitoring devastated land over a period of time was also emphasized. Further, the mined area decreased over time but the mined wasteland remains largely unreclaimed. The use of remote sensing for such multi-temporal studies was emphasized.

Fig. 4 (b) Dead and dry vegetation due to heat from underground coal fire; smoke plumes can be seen at places [35]

D. Impact on Topography

Typically OCM results into a significant change in topography. The top soil and vegetation cover are completely removed and replaced by OB dumps and pits. The natural soil profile gets damaged or altered causing a long run impact which may be difficult to restore to the pre-disturbance level. It also has a bad impact on the topography which was once a plain land but later on changes to pits and dumps. As the OCM is becoming large in terms of surface area, topographic deformation is also increasing. This degrades the land/soil and water for long time and turns the region into a derelict land (Fig. 5). Therefore, topographic restoration should be practiced along with biological reclamation to further reduce environmental consequences [19, 20].

Fig. 5 Widespread change in topography due to mining activities; Location: Block II mine JCF. [35]

E. Review of EIA Studies

Several studies have been conducted at JCF. These studies include air environmental impact [21]; impact assessment of land and water resources [22]; environmental impacts of land degradation [23] (Table 2). The implementation of EIA by AHP (Analytic Hierarchy Process) has also been done in many studies. The present section summarizes the results of the EIA studies with respect to environmental impacts and AHP.

IV. ENVIRONMENTAL IMPACTS

1. Air Pollution

a. Aerosol Optical Thickness - Atmospheric turbidity due to aerosol is considered as an indicator of air pollution. It has a detrimental effect on the environment as well as the health of the local inhabitants [24].

b. Greenhouse Gases – In JCF, which has long been associated with coal fires, there is release of large amount of GHGs like CO2, CH4, oxides of nitrogen, etc. Reported GHG emission estimate of GHGs namely CO2, CO and CH4 at about 108 kg/year for JCF. This may cause global warming in the JCF areas [25, 26].

c. Pollution Due To Fire – The soot and particulate matter released from coal mine fires decrease the visibility in the area which causes diseases of the lungs such as asthma and chronic bronchitis. There are documented reports of stroke, pulmonary heart due to air pollution [27, 28, and 29]. Coal fires accumulate a large number of harmful heavy metals like arsenic, selenium, mercury, lead and fluoride. These can condense on dust particles and get inhaled by the people or they may gain entry to water bodies and thus enters the food chain causing severe diseases [30].

2. Water Pollution

Several studies in JCF have indicated severe pollution of water bodies in the area [12-17, 31, 32]. Huge volumes of polluted water from underground mines are channeled into the Damodar River, thus polluting it. Apart from actual mining activities, coal purifying industries also release a large amount of water effluents in the river, which causes a threat to aquatic ecosystem and the prevailing biodiversity (including flora and fauna) [13,16]. The factors responsible for causing water pollution include drainage and runoff from mining areas, oil spills, leaking from tailing ponds/OB dumps and sewage effluents. Mining also has an impact on the groundwater; heavy metals accumulate in water results in the deterioration in the quality of groundwater [32].

3. Soil Pollution

Soil in JCF has poor texture, low organic matter due to heavy metal toxicity. Also, the soil above the fire areas is devoid of moisture. The soil friendly microbes (includes bacteria, nematodes, fungi earthworms, etc.) die under such unfavorable conditions, thus reducing the ability of the soil to support vegetation. The vegetation also dries up and ultimately dies due to the lack of water, nutrients and metabolic activities [33].

4. Landforms and Subsidence

Jharia mine is facing significant changes in subsidence and topography due to OCM and underground mining activities [34-37]. Subsidence is also caused due to the loss of volume as a result of subsurface fires generally; subsidence occurs when mining has cut in an area, but sometimes it occurs when a mine is still working. In such a scenario, it may lead to knocking down of mining infrastructure and lots of mining coal becomes locked and inaccessible due to subsidence. Subsidence also leads to destruction of manmade infrastructure such as houses, industries, pipelines, etc [32]. In rare cases, subsidence could also lead to changes in natural drainage of the area.

Table 2 : Summary of Environmental Impacts and their causes in JCF [35]

Env. parameter	Cause/activity in mining field	Pollutant	Impact of mining activity and pollutants
Air	• Blasting • Drilling • Wind erosion from OB dumps, spoil heaps etc.	• Suspended particulate matter • Respirable particulate matter	• Decrease in amount of sunlight • Decreased photosynthesis as dust settles on leaves • Increase in pulmo-cutaneous problems in local population
	• Loading/unloading of coal • Erosion from coal heaps • Haul roads • Transport through conveyor belts	• Fine coal dust	• Alteration of nutrient content and productive capacity of the soil as it settles on land surface
	• Coal fires • Burning of coal in industries • Heavy vehicular traffic for transportation of coal	• Oxides of nitrogen and sulphur • CO, CO_2 • Polyaromatic hydrocarbons (PAHs) • Greenhouse gases like CH_4 • Heavy metals	• Acid rain • Health problems • Greenhouse effect • Formation of smog due to photochemical reaction between NO and PAHs
Water/drainage	• Erosion from OB dumps	• Sediments and soluble components	• Increase in TDS in local water bodies • Alteration in drainage pattern of local streams
	• Drainage from mining sites • Acid mine drainage	• Acidic waters	• Lowering of regional water table • Drying up of nearby wells • Pollution of local streams with acids, heavy metals and dissolved salts
	• Effluents from coal related industries	• Heated effluents • Effluents containing heavy metals	• Thermal pollution • Threat to aquatic biodiversity
Soil	• Strip mining • Wind erosion from OB dumps, coal heaps, spoil heaps and dried tailing dumps • Use of heavy machinery for extracting coal, loading and unloading of coal, burning of coal	– • Coal dust and fly ash	• Complete loss of topsoil and vegetation • Soil pollution as dust and fly ash settles on land • Baking of soil due to fire below making it biologically sterile
Vegetation	• Both underground (UG) and opencast (OC) mining • Coal fires	–	• Destruction of vegetation for clearing a site for OC mining or for infrastructure related to UG mining • Dry or dead vegetation due to heat from coal fires • Reduction in photosynthesis and thus loss in plant vigour
Landform	• Clearing of surface for installation of mining infrastructure; • Dumping of OB; • Haulage, storage and transport facilities; • Mine fires and subsidence	–	• Change in topography, drainage pattern and land use etc.

5. AHP (analytic hierarchy process) and its implementation for EIA

AHP is a technique which is used to summarize and compare complex correlated factors. It is carried out in steps wherein after the development of hierarchical structure weights are assigned to each criterion and its alternatives. Based on previous studies following Table 2, emphasizes on the major criteria (Environmental Impacts) of JCF and alternatives to each, which help to conduct the EIA studies.

Table 2. Major impacts and their alternatives for JCF [35]

Criterion	Alternatives
	Coal dust
	Vehicular transport
	Blasting and drilling
Air	Gasses released due to fire
	Leaching from tailing pounds
	Heated effluents from industries
Water	Sediments from OB dumps
	Coal dust
	Open cast mining
Soil	Dumping of OB materials
	Coal dumps
	Underground mining
Vegetation	Subsurface fire
	Dumping OB materials
	Industries setup
Agriculture land	Coal dust and fire
	Open cast mining
Topography	Subsidence

V. CONCLUSION

Coal is the fossil fuel that fulfills our energy needs. Due to the increase in demands of energy, there are many efforts to extract more and more coal as it is an economical source of energy. Coal mining has always been associated with negative impacts on environment. Geoenvironmental parameters such as air, water, soil, agricultural lands, vegetation and landforms are affected by coal mining activities. The people living close to the mining areas are the most affected. Thus, in order to quantify the impacts, it is necessary to find the factors/criteria. The present research work has been attempted to review the EIA studies done in JCF. The current review was broadly classified into two parts:

(a) Environmental impacts due to JCF and associated EIA studies done

(b) Identifying the chief criterion and their alternatives.

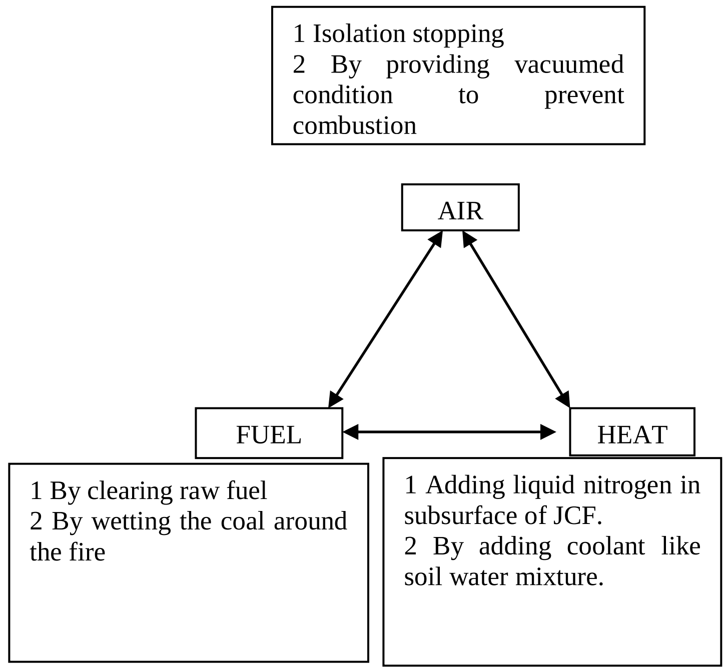
The results indicated that air was the most affected parameter by coal mining activities in the JCF followed by water and other parameters. Studies have also indicated that field based analyses and remote sensing data may be used for carrying out environmental impact assessment of mining areas. Improving environmental performance may lead to sustainable mining practices.

VI. SUGGESTIONS

As subsurface fire is having drastic effect on soil, water, vegetation, and air etc. In order to overcome these problems, we have to stop this subsurface fire. Due to these fires the released gases cause smog, acid rain, global warming causing GHGs. The authors have a few recommendations to arrest the issue.

Sustainable mining is the most environment friendly option.

A fire triangle consists of heat, fuel and air. For reducing the subsurface fire, it is advisable to cut down any one from the aforesaid mentioned factors. Following are few methods to prevent the same:



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