Environmental and socio-economic impacts of fire in Jharia coalfield, Jharkhand, India: an appraisal

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Phenomenon of coal mine fire has a long history on international magnitude in the destruction of valuable natural resources. It dominantly contributes towards adverse impact on environment. Societal influence in terms of health and life hazard is one of the key factors in mine fire areas. This paper focused on socio-economic and environmental impacts of fire in Jharia coalfield (JCF), Jharkhand, India. Issue related to mine fire in various legislations (Mines Act 1952, Coal Mine Regulation 1957, etc.) has been discussed with a view to overcome such situations. A few mitigative measures and proper management of coal mine fire has also been suggested.

Keywords: Coalfields, coal mine fire, safety and environment, subsidence.

COAL, the most used fossil fuel, is a gift of nature to mankind. It contains a high percentage of carbonaceous material along with a number of constituents formed from chemical and bacterial changes of plant remains[1]. Presently, 41% of global and 77% of Indian energy requirements are being fulfiled by coal and it is expected to be the prime source of energy in the foreseeable future[2–5]. Production of coal from the level of about 70 MT (million tonnes) at the time of nationalization of coal mines in the early 1970s reached 565.64 MT in 2013–14, to meet the growing energy requirements of the country[3]. Coal demand is likely to reach up to 1267 MT in the fiscal year 2024–25, with 8% growth in GDP (gross domestic product)[6]. Presently, India is the third largest coal-producing nation in the world and the total coal reserve is estimated to be 301.56 billion tonnes, which is about 7% of the world's total proved coal reserves[7,8]. Jharkhand has the largest proved coal reserve in India and is the only remaining storehouse of prime coking coal (Figure 1), while it shares 20% coal production of the country, i.e. the second largest state in coal production[3,9].

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Exploitation of coal is inherently associated with risk and hazard, which may sometimes lead to disasters[10,11]. A number of disasters have taken place worldwide in the past leading to loss of human life, production and productivity, and affecting the socio-economic conditions and environment[12]. The primary causes for these disasters were coal mine fire and explosion, falling of roofs/sides, and inundation[13,14]. During 1947–2010, around 40% of the total mining disasters and about 50% of the total fatalities of miners were due to coal mine fire and explosion in Indian coal mines (Figure 2)[15]. Coal fires are serious geological hazards in many coal mining regions of the world[16–18]. Coal fires still exist in India, USA, China, Russia, Indonesia, South Africa, Australia, Indonesia, Canada and Germany (Figure 3)[19–23]. The nature

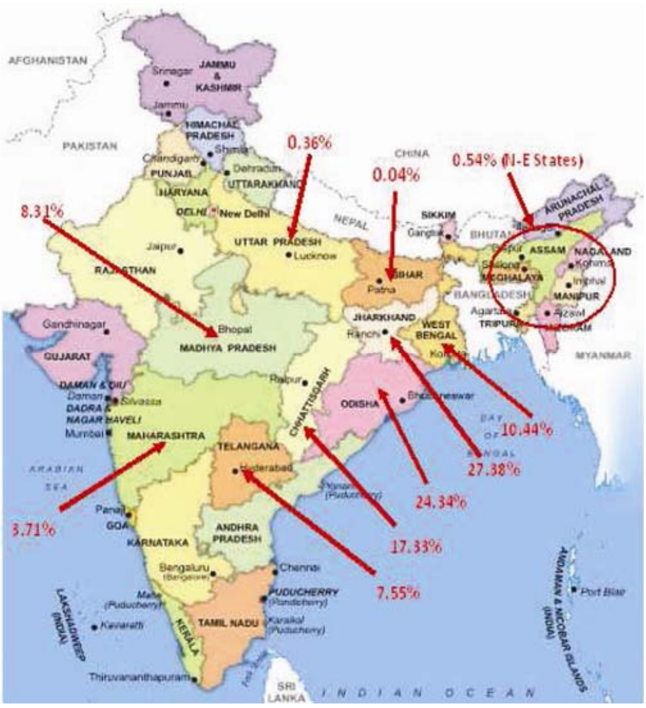

Figure 1. Distribution of coal reserves in India[9,106].

and magnitude of the problem vary depending upon several site-specific circumstances. The coal mine fires in China (Mangolia, North China), USA (Pennsylvania) and India (Jharia and Raniganj coalfields) are still considered to be a major socio-technological problem[24].

Coal mine fire creates both socio-economic and environmental problems[25–27]. It results in the burning of a huge quantity of natural resources, thereby causing economic loss and substantial operational difficulties, including reduction in the productivity[28]. Coal mine fire affects the environment in the form of air pollution, land degradation and desertification[23,29]. The environmental effects of coal fires are serious problems at both local and global levels[21,30]. Coal combustion liberates substantial amount of noxious gases and greenhouse gases (GHGs) along with a large amount of particulate matter[31–38]. The emission of GHGs from coal mine fires is small but significant enough to cause global impact[39–42]. It has been estimated that around 30 MT oxides of carbon are emitted every year due to coal fires alone[22]. Also, coal fire emits 8.719×10^{12} kWh of unproductive heat worldwide and contributes to an increase in the earth's temperature[43]. Subsidence caused by subsurface coal mine fire extensively damages surface structures, thus influencing social activities of the locality[44].

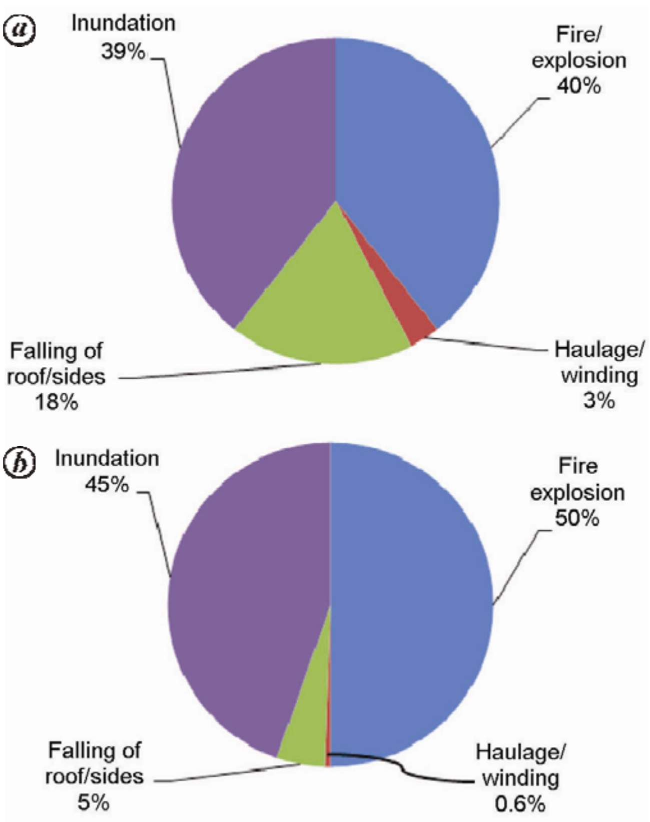

Figure 2. Statistics of disasters in coal mines during 1947–2010 (ref. 15). ***a***, Occurrences of disasters due to different causes (%); ***b***, fatalities of miners due to different cause of disasters (%).

Figure 3. Global scenario of coal mine fires[107].

Coal mine fire in India

The first published reference to the mining of coal in India dates back to the year 1774 at Disergarh seam, Chinakuri in Raniganj coalfield (RCF)[45]. The recorded history of the first coal mine fire in India has been reported in 1865 in RCF[25,46]. Whereas, coal mining in the Jharia coalfiled (JCF) was started in 1894 and the first fire reported in 1916 (refs 46, 47). Mine fire gained widespread attention in India after 1930, with the occurrence of several major fires in JCF and RCF[48]. In 1994, totally 196 coal mine fires were detected in different subsidiaries of Coal India Limited (CIL) (Table 1)[49]. At present coal mine fires are being reported from all Indian coalfields with JCF being the most affected[50,51].

There are several cases of mining accidents due to coal mine fire and explosion in both underground and opencast mine workings resulting in the loss of precious human lives and resources. Over 25 major mine disasters (10 or more fatalities) due to fire and explosion have been recorded in the last ten decades (Table 2). The maximum cases of such events were reported in RCF, JCF and Bokaro and Karanpura (B&K) coalfield. JCF witnessed more than 10 cases of such disasters, causing the death of about 300 miners due to coal fire and explosion from 1901 to 2010 (Figure 4)[15]. Spontaneous heating (endogenous fires) of coal, the prime cause for coal mine fire depends on various mining, geological and environmental factors[52–58]. Moreover, the unscientific exploitation of coal and other exogenous factors makes coal mine fire more catastrophic[51,59,60].

Jharia coalfield fire

JCF is situated in Dhanbad district, Jharkhand, India, in the heart of the Damodar River Valley. It is located about 260 km NW of Kolkata city and about 1150 km SE of Delhi. JCF is confined between 23°38′00″–23°52′00″N lat. and 86°08′00″–86°30′00″E long., extending 38 km from east to west and 19 km from north to south, covering an geological area of 450 sq. km (380 sq. km coal-bearing area)[22,50,61–63]. The rock strata contain mainly sandstone and shale. Several geological structures like folds, faults and fractures are present in the area. There are a number of coal seams present in JCF with thickness ranging from 0.91 to 22.44 m (refs 62–64). It has one of the densely concentrated areas of coal seam in the world, with favourable configuration at relatively shallow depth[65–68].

Coal mining in JCF started in 1894 and first traces of coal fire were observed in 1916 in XII/XIV coal seam at Bhowrah colliery followed by a fire in 1917 XII/XIV seam at Sendra colliery (refs 49, 69–71). However, up to 1928, the JCF basin was deeply forested and had good environmental condition[65]. Coal fire gradually spread over large areas; thus endangering the lives of hundreds of thousands of people residing in the vicinity of the fire area of JCF, with increase in mining activity[72]. The vegetative land of JCF converted into barren land along with undulating topography due to coal mine fire induced subsidence. The fumes, dust and smoke turns ambiance unhealthy[73]. The JCF fire considered as one of the most complicated coal mine fire in the world. It is maintaining its status for more than last ten decades and still spreading over new areas[21,74–76]. Landsat data were used to observe the spread of surface fire throughout JCF between 1985 and 2006 (Table 3)[38,50]. Presently, more than 40 collieries experience active fires at about 80 locations covering around 10 sq. km area (Figure 5)[71,74]. The present scenario of coal mine fires is due to the following

Table 1. Coal mine fire in different subsidiaries of Coal India Limited (estimated in 1994)[49]

Subsidiary	No. of fires detected	Area affected (sq. km)
BCCL	65	17.32
ECL	12	6.6
CCL	30	1.52
WCL	61	1.19
NCL	1	0.06
SECL	9	–
MCL	4	–
NEC	4	–

BCCL, Bharat Coking Coal Limited; ECL, Eastern Coalfield Limited; CCL, Central Coalfield Limited; WCL, Western Coalfield Limited; NCL, Northern Coalfield Limited; SECL, South Eastern Coalfield Limited; MCL, Mahanadi Coalfield Limited and NEC, North East Coalfields.

Table 2. Disasters in Indian coal mines due to fire and explosion (1901–2014)[15]

Date of accident	Mine	Miners killed
16 February 1908	Nadir Khan, ECL	20
7 February 1910	Dishergarh, ECL	11
26 November 1910	Namdaang, ECL	14
9 November 1911	Kendwadih, BCCL	14
22 December 1913	Chowrasi, ECL	27
20 July 1916	Disergarh, ECL	14
18 November 1918	Disergarh, ECL	10
28 February 1921	Amalabad, BCCL	11
9 March 1922	Khoast, Baluchistan	13
4 January 1923	Parbelia, ECL	74
29 June 1935	Bagdigi, BCCL	19
24 July 1935	Kurhurbaree, CCL	62
30 January 1936	Loyabad, BCCL	35
18 December 1936	Poidih, ECL	209
19 March 1946	Begunia, BCCL	13
14 March 1954	Damra, ECL	10
5 February 1955	Amalabad, BCCL	52
19 February 1958	Chinakuri, ECL	175
28 May 1965	Dhori, CCL	268
18 March 1973	Jitpur, IISCO	48
4 October 1976	Sudamdih, BCCL	43
22 October 1979	Baragolai, ECL	16
24 June 1981	Jaganatha, MCL	10
25 January 1994	New Kenda, ECL	55
3 March 1997	New Mogla, J&KMDC	10
6 September 2006	Bhatdih, Nagda, BCCL	54
6 May 2010	Anjana Hill, Chirimiri, SECL	15

J&KMDC, Jammu–Kashmir Mineral Development Corporation and IISCO, Indian Iron and Steel Co Ltd.

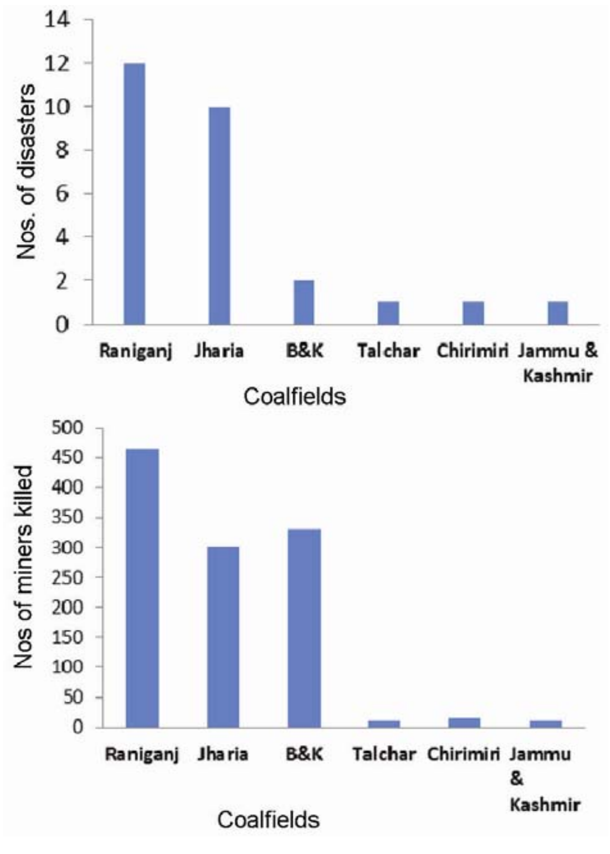

Figure 4. Statistics of disasters and total numbers fatalities of miners due to coal mine fire and explosion in India from 1901 to 2010 (ref. 15).

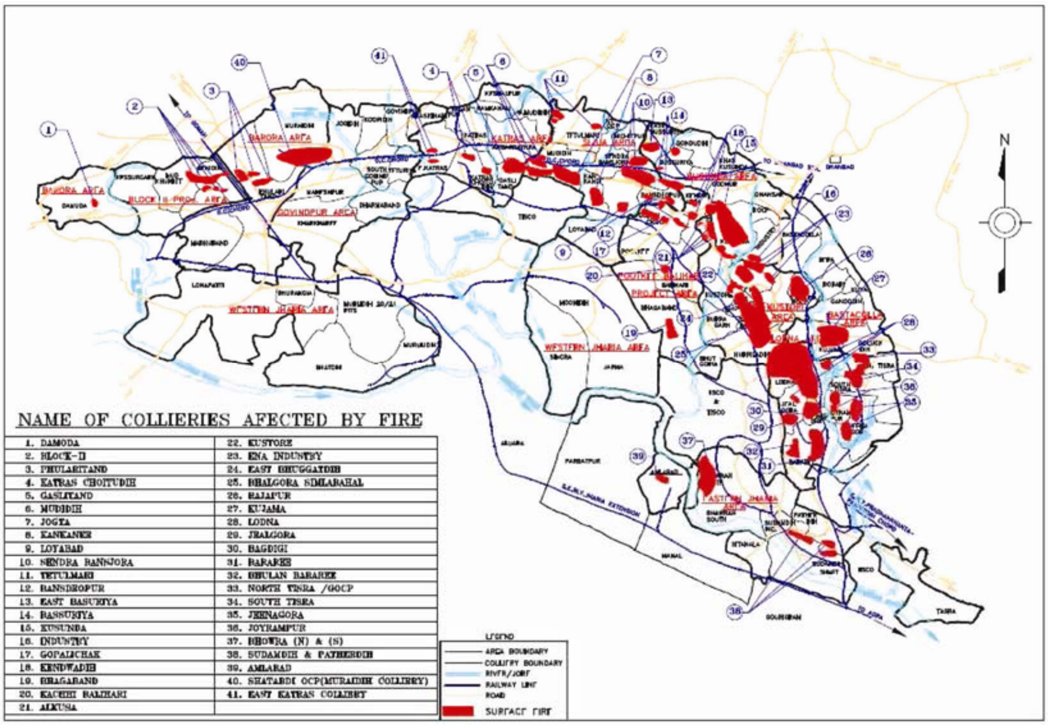

Figure 5. Map of Jharia coalfield (JCF) and showing fire-affected coal mines[74].

Table 3. Total fire area of Jharia coalfield during different years calculated by Landsat data[38,50,108]

Year	Total fire area (sq. km)	Reference
1985	5.57	50
1987	8.82	50
1989	14.50	50
1990	15.87	38
1991	15.92	50
1993	8.79	50
1994	8.48	50
1994	13.67	38
1995	8.92	50
1996	9.39	38
2006	7.18	38
2013	7.63	108

conditions: (a) Underground fires which have become surface fires; (b) Underground fires which have remained underground; (c) Fires in coal benches in opencast mines; (d) Fires in developed galleries standing on pillars; (e) Fires in overburden dumps; (f) Fires in coal stacks.

Mechanism of coal fire

Fuels, whether solid, liquid or gas, may undergo rapid chemical change while interacting with oxygen or oxidants, thus releasing a large amount of energy at a fast rate that manifests in the form of heat and light. This manifestation is known as fire and the process is known as ignition or combustion or burning of fuel[54]. The initiation of such ignition may be exogenous or endogenous depending upon the characteristics of the material and site-specific situations. Coal has the intrinsic property of spontaneous combustion, which starts at a low temperature with a slow rate of propagation without flame[24,77]. The phenomenon of spontaneous combustion of coal is caused by two interrelated process, viz. the interaction between oxygen and coal (oxidation), and the exothermic reaction (heat-shedding process), leading to heat build-up. If the heat produced cannot be dissipated by radiation or conduction or convection, or by all three processes at fast rate, then it produces further rise in temperature, which accelerates the rate of oxygen sorption and production of heat reaching a critical temperature (80–130°C), resulting in smouldering combustion of coal[59]. The oxidation process of coal is aided by catalytic effects of other compounds like pyrite present in the coal matrix, inherent and surrounding atmospheric moisture and bacterial action, etc.[54,78–84]. Anthropogenic causes accelerate the coal mine fire and its spread to larger areas[28,47].

The oxidation of coal starts with exothermic chemical reaction at different stages[85,86]. The general concept of oxidation of coal describes mainly three processes: (a) physical adsorption, (b) chemical adsorption or chemisorptions forming coal–oxygen complexes, and (c) chemical chain reactions. The chemical reaction breaks down less stable coal–oxygen complexes and results in the formation of gaseous products like CO, CO_2 and H_2O vapours followed by generation of heat. The chemical reaction may be represented as follows[87].

$$\text{Coal} + O_2 \rightarrow CO_2 + \Delta H \uparrow . \quad (1)$$

The above reaction is completed in several stages and pathways, which, in turn, depend on presence of substances like water and pyrite. The complete oxidation of coal may be explained as follows[85,86]:

$$C_{100}H_{74}O_{11} + 113O_2 \rightarrow 100CO_2 + 37H_2O + 4.2E8\,J/\text{kmol}O_2. \quad (2)$$

The initial stage of the reaction is chemical absorption or chemisorption at the coal surface, as shown below.

$$C_{100}H_{74}O_{11} + 17.5O_2 \rightarrow C_{100}H_{74}O_{46} + 2.5E8\,J/\text{kmol}O_2. \quad (3)$$

In the presence of catalytic substances like pyrite, the heat-generating reactions take place as shown below[88,89]:

$$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2H_2SO_4 + 2FeSO_4 (+0.37E8\,\text{J/kmol}O_2), \quad (4)$$

$$4FeS_2 + 15O_2 + 2H_2O \rightarrow 2H_2SO_4 + 2Fe_2(SO_4)_3 (+0.56E8\,\text{J/kmol}O_2). \quad (5)$$

Eq. (6) below can be used to calculate the total quantity of air required for combustion of 1 kg of coal considering C_2H as the basic component of coal. About 11.1 kg air is required for complete combustion of 1 kg coal[87].

$$4C_2H + 9O_2 \rightarrow 8CO_2 + 2H_2O + \Delta H. \quad (6)$$

Impact of coal mine fire

Coal mine fires have several major adverse effects on the environment, economy, safety and society. The product of combustion due to coal fire liberates huge amounts of toxic and obnoxious gases as well as GHGs, contributing to global warming and affecting the quality of life in the long run[90]. Besides environmental distress, it results in the economic setback on national non-renewable natural resources and damages surface structures. Mine safety and operational complications is another major ramification of coal mine fire. The major impacts of mine fire in JCF are discussed below.

Environmental impact

Mining adversely affects the ecosystem as a whole and coal mine fire expedites its intensity. The environmental pollution caused by coal mine fire badly affects air, water and land. The combustion of coal releases several gases such as oxides and dioxides of carbon (CO, CO_2), oxides of nitrogen and sulphur (NO_x, SO_x) along with particulate matters (PM_s), which directly affect the health to the local people, while emission of GHGs (CO_2, CH_4, H_2) contributes towards climate change[91]. Seven compounds, viz. benzene, toluene, ethyl benzene, xylene, methane, carbon dioxide and carbon monoxide are predominant in coal fire products; all of them are commonly associated with environmental and human health hazards[40,92,93]. Indian coal contains many radioactive elements, mainly ^{238}U, ^{232}Th, ^{226}Ra, ^{210}Po and 40 K (0.4–1.2 pCi/g) and burning of this coal has a major impacts on the environment[94]. An estimated 650 Gg of methane was released from coal mines in 1994 in India; JCF coal fire was the main contributor[95]. According to the National Center for Atmospheric Research in Boulder, Colorado, USA, coal mine fire in JCF emits atmospheric sulphate aerosols, which absorb or scatter solar radiation, thereby reducing the amount of sunlight that reaches the earth's surface[21,96,97]. A study based on Landsat-5 satellite imagery of 2010 concluded that the eastern part of JCF is more polluted in comparison to the western part due to a large number of coal fires as well as extensive mining activities[98]. According to Pandey *et al.*[37], the concentrations of PM_{10}, $PM_{2.5}$ and $PM_{1.0}$ in the coal fire areas of JCF during winter and summer of 2010 were 1.5 and two times higher than the National Ambient Air Quality Standards (NAAQS) in 2010–11. The concentrations of SO_2 was above and that of NO_2 was below NAAQS (80 μg/m^3) during all the seasons. Mishra *et al.*[36] observed that mean concentration of PM_{10} was around two times higher than NAAQS at three different sites of JCF[36]. The result corroborates that fact that concentration of Cd, Co, Mn, Ni, and Pb in the PM_{10} dust samples was on the higher side and found in the order of Mn > Ni > Co > Cd > Pb.

The coal fire contaminates water and increases its acidity, due to the presence of sulphur in coal. Coal fire and other mining activities adversely affect the water quality by not only lowering the pH of the surrounding water resources, but by also increasing the level of suspended particulate solids (SPS), total dissolved solids (TDS) and some heavy metals especially Fe, Cu, Mn and Ni. Utilization of such water for domestic purposes results in several health hazards[99]. The Damodar River, flowing through JCF, has been classified as a heavily polluted river by CPCB[100]. Other seasonal rivers, jores and ponds are also heavily contaminated. A few ponds and streams have dried-up due to subsidence induced cracks and fissures in the fire-affected areas. Acid mine drainage (AMD) originates from the weathering and leaching of sulphide minerals present in coal and associated strata, including contamination of the water table, and disrupts the growth and reproduction of aquatic plants, flora and fauna in surface water bodies.

Coal mine fire has led to degradation of land in the form of undulating surfaces caused by subsidence and

Figure 6. Field photographs of coal fire-induced pothole, cracks, subsidence and land degradation at Ena colliery, Bastacolla area of JCF.

affects vegetative land by degrading the fertility of the soil (Figure 6). Over 6025 ha of land had degraded due to coal fire and other mining activity in JCF. The forest cover has decreased sharply and native natural vegetation is being replaced by exotic species[101]. Aesthetic look of JCF is drastically damaged due to mass deforestation and subsidence.

Economic impact

Mine fires cause danger to mining operations and loss to substantial coal reserves, thus leading to economical losses. JCF experienced huge loss of prime coking coal due to fire; nearly 38 MT of metallurgical coal has been burnt to ashes. About 1900 MT coal is locked due to coal fire. The extraction of these locked up coal is very difficult some time impossible[20,21,101]. Besides, loss of coal due to burning and sterilization, cost of fire fighting, control system and management result in enormous economical losses to the nation. The other associated economic losses are related to human health, damage to surface structures and disseminate effects. Rehabilitation measures for the displaced population incur substantial expenditure.

Several committees have been formulated to deal with the problem of fire and subsidence in JCF[74,102]. In 1977, the Bharat Coking Coal Limited (BCCL) initiated a project to fight the menace with the help of Soviet experts. The better expressed their 'inability to control the fire' after an expenditure of Rs 215 crore in two years, and thus the project was abandoned. In 1988, the Central Mine Planning and Designing Institute (CMPDI) prepared a integrated fire control plan for JCF. There were altogether 22 sanctioned projects involving an outlay of Rs 114.97 crores for fighting the fire. In April 1993, a diagnostic and exhaustive study of the technology was taken up by BCCL with the assistance of World Bank to deal with the fire at JCF in a comprehensive manner. The study was conducted between 1994 and 1996 by international consultants (USA and Canada) under joint venture for development of a fire-fighting programme and preparation of environmental management plan[48,50]. In 1996, as a consequence of fire-induced subsidence affecting 219 houses in the JCF, Rs 7112.11 crores was released by Planning Commission, Government of India under a master plan to deal with the problems of fire, subsidence, related rehabilitation and diversion/shifting of surface infrastructure[101,103]. Furthermore, numerous R&D and sponsored projects involving large sums of money were also issued by different government agencies to academic and research institutions, national/international consultants to manage this socio-technological problem. In spite of incurring huge expenditure to deal with fire-associated problems, they still persist.

Impacts on society

Coal mine fires in JCF have exerted some direct and cascading impacts on society. In fact, the most common problem associated with coal fire is that of involuntary displacement and unemployment. The present population of JCF is around 1.3 million, and 83% of whom directly or indirectly depend on mining activities, 15% are traders and the rest 2% are farmers. There are 16 urban and 172 rural settlements, and 68% of the total population is living in urban areas[101]. Several residential colonies and miner dwellings in JCF are affected due to fire induced subsidence; people are left homeless and ultimately migrate to safer locations. Recently, Jharia Rehabilitation and Development Agency (JRDA) carried a demographic survey of JCF under a master plan to identify unstable houses. It found 98,314 houses, including private, encroached and BCCL quarters to be underthreat[74]. Jharia town is a business hub for coal/coke and various other trading activities; it is profusely affected by fire and subsidence. Several built-up areas are being affected due to fire (Figure 7). However, numerous notices/appeals have been issued by government agencies and mine managements to residents of fire and subsidence-prone areas. Poverty compels people to reside in unsafe areas in spite of these warnings. Several coal mines are under fire and thus closing down, resulting in the loss of jobs. Degradation of air and water quality critically affects the health of society. Health-related issues, especially lung and respiratory diseases, nervous problems, high blood pressure, heat stroke, etc. are common in the fire-affected areas. Coal fire coupled environmental health hazards are presently giving rise to liver diseases and cancer.

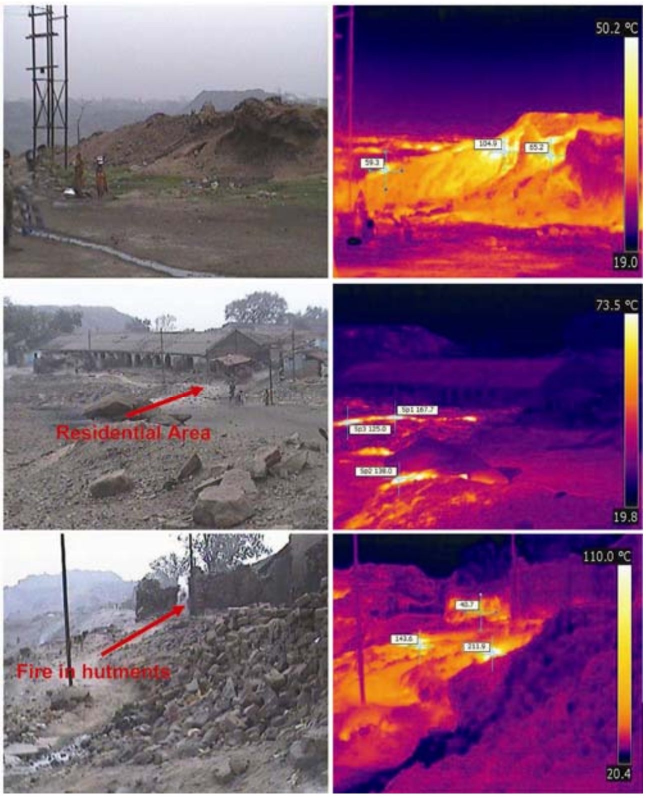

Figure 7. Visual and the respective thermal images illustrating poor quality of life due to smoke, temperature, subsidence, etc. in the coal fire-affected area of JCF.

Impact on surface infrastructure

Coal mine fire and subsequent subsidence drastically affect surface structures. The important surface structures and features, namely roads, rail, schools, colleges, government offices, water supply lines, electric transmission lines, business units, residential areas, jores (streams), religious places and surface monuments are under constant threat. Master plan 2008 identified 532 unstable sites which are under threat for surface collapse/subsidence[74]. As carbonaceous material of underground coal seam is burnt, the natural support to the super incumbent strata is lost and the upper beds cave in. The new cracks develop with head of fire front and smoke, fumes and hot flame emanate through these cracks (Figure 8). Many surface infrastructures like rail, roads, buildings, etc. have caved in with progress of fire in JCF[49]. Many schools, banks, offices, miner's dwellings and colonies have been shifted to safer locations. Dhanbad–Jharia–Sindri via Patherdih railway line has been permanently closed and dismantled. The following important railway lines and roads passing over JCF (Figure 9) under threat of fire are proposed to be diverted considering safety issues[64,71,74,76].

Figure 8. Field photographs of blazing fire in exposed coal seam and subsequent cracks and damage on the surface in the JCF.

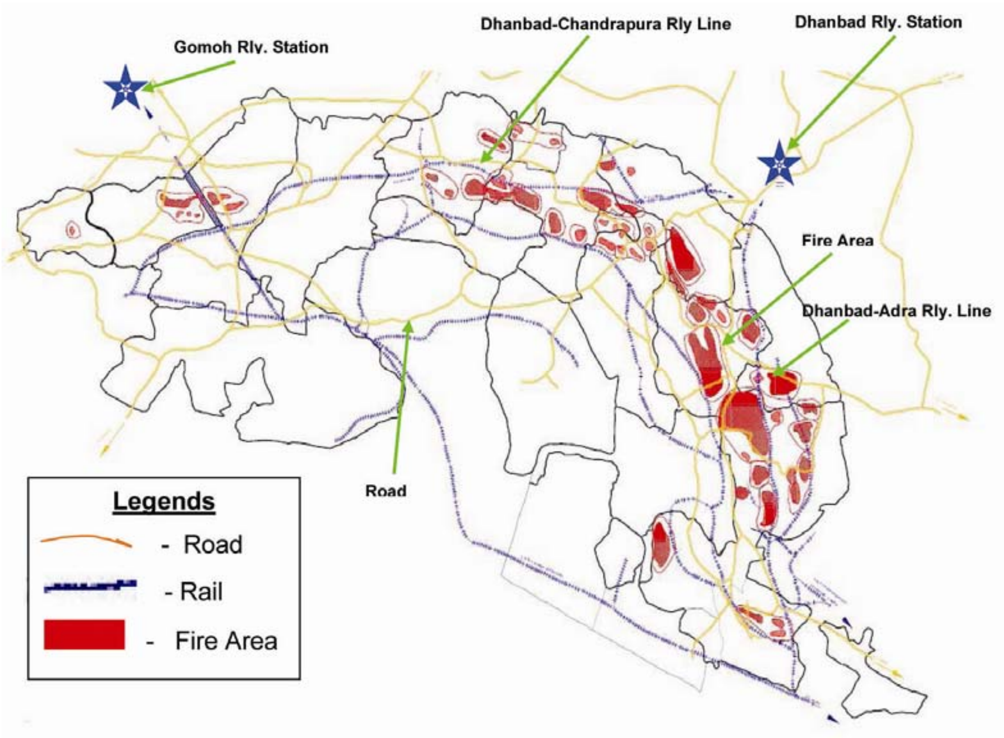

Figure 9. Railway lines and important roads passing over fire areas in the JCF[74].

Railway lines

(i) Adra–Santhaldih railway line (SE Rly) due to Patherdih and Sudamdih coal mine fire.
(ii) Bhaga–Gomoh railway Line (SE Rly) and Khanoodih station due to Bhowra, Phularitand and Kharkharee coal mine fire.
(iii) Patherdih–Bhojudih link line (SE Rly) between Patherdih and Sudamdih stations (part of Dhanbad–Patherdih railway line) due to fires from different coal mine.
(iv) Dhanbad–Chandrapura railway line (SE Rly) due to Basuria and Sendra Bansjora coal mine fire.
(v) Dhanbad–Kusunda–Tetulmari link line (SE Rly) due to East Basuria coal mine fire.

Roads

(i) National Highway 32 passing over the coal-bearing areas of JCF is affected due to fire of Kenduadih colliery between Kedua and Karkend.
(ii) District Board road passing from Jharia to Kendua is under threat due to fire in Alkusa colliery near Kendua Police Station.
(iii) Fire approaching Dhanbad–Jharia road at Bhagatdih and Bastacolla collieries.
(iv) Jharia Sindri road between Indira chauk and Hanuman garhi is under threat due to fire.
(v) Several another link roads in JCF.

Impact on mining operation

In case of mine explosion, huge amounts of noxious and poisonous gases with high temperature and flame are released instantly, resulting in loss of precious life of miners, damage to machines, equipment and coal reserves. Several underground coal mines have been abandoned and expensive shaft sealed permanently as the consequences of fire in JCF[101]. A number of coal seams were developed in the past without stowing and taking any due care regarding safety. Most of these developed seams are under fire and consequently underground mining is practically impossible leading to loss of prime coking coal. Presently, at some locations fire-affected coal seams at shallow depth are being tackled by opencast method. This gives rise to enormous operational difficulties apart from health hazards to miners, viz. sudden collapse of benches on movement of man and machine, explosion during drilling and blasting operation, hot flame burning, heat stroke, etc. (Figure 10). Ekra, Kari, and Chatkari jore (seasonal rivers) flowing over these areas require immediate protection to prevent mine inundation in case of stream bed collapse[49,74,76,101].

Statutory obligations on coal mine fire

Three distinct legislations, namely Mines Act 1952, Mines and Mineral Act 1957, and Forest Conservation Act 1980 govern exploitation of minerals, safety and environment in India. The coal fire-related issue is governed by Mines Act 1952, Coal Mine Regulation 1957 (CMR-1957), along with a number of bye-laws and technical circulars issued by the Directorate General of Mines Safety (DGMS), a statutory body under the Ministry of Labour and Employment, Government of India (GoI)[104]. The Ministry of Environment and Forests (MoEF), GoI, has also issued several instructions (Rules and Advisory) on this issue. The rules, circular and advisory issued on coal fire are outlined below.

Central pollution control board

The Central Pollution Control Board (CPCB; MoEF, GoI) has developed National Environmental Standards and code of practice for coal mines[105]. For new projects and reorganization of projects, after the issuance of the Environmental Impact Assessment (EIA) Notification, 1994 under the Environment (protection) Act, 1986, environmental clearance from MoEF is mandatory. For environmental clearance, the mines are required to prepare environmental management plans. They are also required to submit their environmental statements annually to the MoEF. However, the problems of the coal mine fires are not adequately addressed. Moreover, the air quality standard for coal mines has been formulated by MoEF, based on the age of the mines. The older mines have been leniently dealt with; the average annual standard fixed for them is 1.4 times higher than that of new mines. The justification for this is that old mines/coalfields such as Jharia, Raniganj and Bokaro already have high dust concentration and smoke due to coal fire and therefore, would not be able to meet the stringent standards set for the new mines.

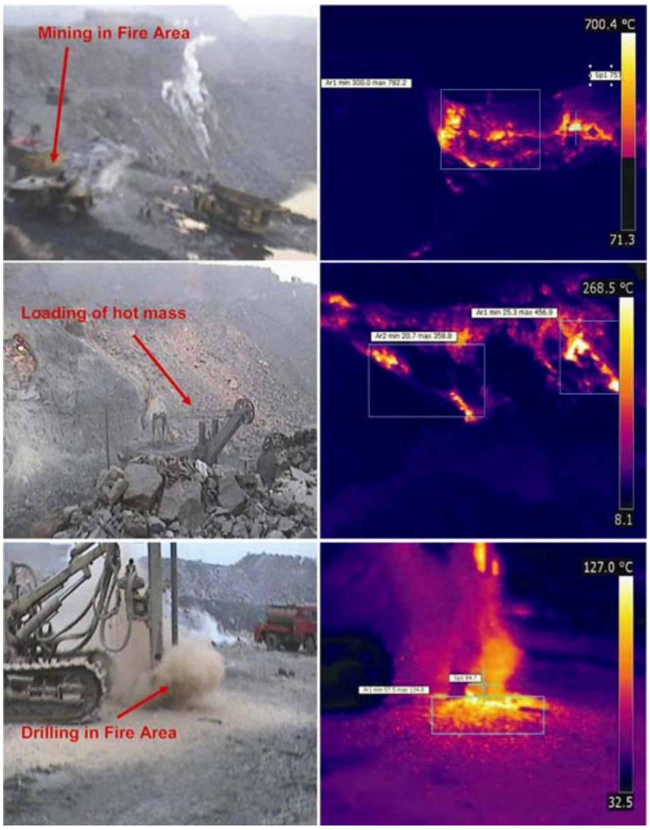

Figure 10. Visual and the respective thermal images of fire-affected coal mines in the JCF illustrating risky mining operations in toxic and high-temperature environment.

Mines Act 1952

Section 57 of the Mines Act 1952 illustrates the power of the Central Government to make regulation related to dust, ventilation, coal fire and explosion. In this section, clause ‘n’ describes the inspection of fire areas and due precautions required to be taken to prevent of outbreak of fire. Clauses ‘o’ and ‘s’ describe actions to be taken in respect of safeguard against dust, inflammable and noxious gases, and precautions against spontaneous combustion, fire and explosion. Clause ‘v’ deals with procedure on occurrence of accidents due to ignition and/or explosion.

CMR-1957 and DGMS circulars

The CMR-1957 and various circulars issued by DGMS from time to time, describe detailed technical instructions to detect, prevent and deal with the occurrences of coal mine fire and explosion. Regulations 116–124 of chapter XI of CMR-1957 instruct the precautions against dangers from fire, dust, inflammables and noxious gases. In addition, regulations 141–149 of chapter XII, regulations 152 and 156 of chapter XIII and regulations 171–175 of chapter XIV standardize the several safety and precautionary measures. Several bye-laws, standing orders and DGMS technical circulars are also issued as safety and guidelines to prevent and mitigate mining-related hazards. Standard environmental dust concentration for coal mines has also been specified in regulation 123 of CMR-1957.

In spite of numerous rules, regulations and advisory, the problem of fire is persistent, with threats to new areas. So, the policymakers have to be stringent towards rules and regulations to overcome such situations.

Conclusion

The coal mining industry is a future prospective for Indian economy to grow up with more rapid rate and being only storehouse of prime coking coal, JCF has immense importance. Coal mine fire in JCF is a serious issue related to the emission of gases that affect the environment, both locally as well as globally. Release of PMs, TDS, heavy metals-polluted water and degraded land lead to health hazards among the locals. Loss of prime coking coal is a huge economic burden for the nation. Damage to surface structures due to fire-induced subsidence is common in JCF. Organized, joint efforts by regulatory and advisory bodies, local and federal governments, researchers and industries are necessary to combat the socio-economic issues. The present study highlights some basic points to prevent any further occurrence of coal mine fire along with safe and effective management of the existing fires:

(a) The industry should prepare a status report of mine fires, surface plan indicating fire in national grid, estimation of brunt and locked-up coal due to fire, and the actions being taken, with both the success and failure stories.
(b) In mine design, prevention and control of mine fire should be taken into account for all the new mining projects and mines undergoing reorganization.
(c) Coal mines should be categorized according to the Coal Mine Fire Liability Index (CMFLI) considering all possible factors for mine fire.
(d) There should be a provision of yearly third-party technical audit of the mines and scheme of reward/punishment may be evolved for prevention, safeguarding and mitigation of mine fires. The carbon credit system can also be included.
(e) The possible hazards and damages due to coal fire like threat to people living in nearby localities, possible subsidence and related safety and health hazards, dangers due to mining operation, and threats to forests and ecology should estimated.
(f) A nominal fire mitigation cess should be imposed to develop a fund to help the industry in combating fires.
(g) Preparation of disaster mitigation and management plan to take care of mine fires and explosion. The necessary preparedness for disasters and steps to mitigate them should be suitably defined.

The above objectives will help to save the valuable coal resources and reduce the adverse impacts on the environment and society.

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