Review

Opencast mines: A subject of major concern for human health

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Presently India ranks third amongst the coal producing countries in the world after China and USA. Sustainability of present growth rate around 9% in the Indian economy depends largely in accelerating growth in mining sector, especially the coal mining. Country's demand of coal has increased manifold requiring adoption of appropriate technology in the industry. Enhancement of combustion fuel / minerals is mainly responsible for the degradation of air quality in mines area. Some activities (i.e. drilling, blasting, loading-unloading of materials, overburden etc.) in mines area created some fine particles which can suspended in air and caused of respiratory diseases. These all effects on human health through particulates matter are follow the time of exposure and quantity of particle in such type of concentration. Here we undertake the simplistic review of particulate matter which is generated due to mining activities and creates adverse impact on human health.

Keywords: Air pollution, Particulate matter, Opencast mines, Modeling, Health effects.

INTRODUCTION

Growth in coal production in India in first 25 years of independence was very slow, from around 30 million tonnes (Mt) in 1947 to 73 Mt in 1970-71. However, post nationalization period experienced a rapid growth in coal production from 81 Mt in 1973-74 to 493.90 Mt in 2008-09 (Table 1). Coal production crossed 100 Mt in 77-78, 200 Mt in 89-90, 300 Mt in 99-2000 and 400 Mt in 05-06 (Dixit, 2009).

Table 1 shows the shift of share of coal production from opencast mines from below 30% until nationalization to above 88% in 2008-09. And this trend is expected to remain heavily tilted towards opencast mines because of higher demand of coal in future to support the growth of the economy. As projected in "Coal Vision 2025" document, based on approach made by The Energy and Research Institute (TERI), demand at 8% Gross Domestic Product (GDP) will be 1267 Mt and at 7% GDP will be 1147 Mt by 2025 (MOC, 2005).

This has resulted in and will continue to result in opening up of huge opencast mines with very high production capacity. Presently Coal India Ltd. has very high capacity opencast mines like Dudhichua, Jayant and

Nigahi in NCL, Gevra in WCL and Rajmahal in ECL, producing more than 10 Mt coal per annum. Similar large capacity mines with high degree of mechanisation are proposed in several areas and some of the existing mines will undergo production capacity enhancement, e.g. ECL is in the final stage of implementing a project to enhance the production of Rajmahal open cast mine from 11.5 Mt to 17.5 Mt high ash thermal coal (E and F grade) in 2012 (Bose, 2009).

Increase in depth of surface mining

The sharp augmentation of coal production through commissioning of large opencast mines is leading the opencast mines to go deeper, i.e. deep opencast mines are going to come up more and more in future. The Rajmahal opencast mine is planned for a depth of up to 150 m. Similar situation, although not as sharp increase of production as coal, is also going to happen in case of opencast non-coal mines. Malanjkhand Copper Project (MCP), the single largest copper deposit of India with nearly 70% of the country's reserve and contributing around 80% to total copper production of Hindustan Copper Limited (HCL), have a reserve of 221 Mt with a grade of 1.31% copper and now have an annual

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Table 1. Coal production in India

	Coal Production (Mt)			% Share	
	Underground (UG)	Opencast (OC)	Total	UG	OC
At the time of Independence (1947)	28.20	7.80	30.00	94	16
At the time of Nationalisation (1970-71)	59.95	21.05	81.00	74	26
2010-11	58.89	529.11	588.00	10.015	89.984

production of 2 Mt (MCP, 2009).

It is proposed to increase the production of mine which will necessitate the opencast mine to go as deep as 300m from the surface (The surface Reinforcement Learning (RL) is 580m, RL of presently working is 200m and extraction of the entire reserve will necessitate the mine to go deep up to a RL of 280m.). Similar is the case with the three big opencast iron ore mines of Steel Authority of India Limited (SAIL) at Kiriburu, Meghahatuburu and Bolani having annual production of about 4.20 Mt. Each of them has been planned to go for higher production with increase of depth of working.

Share of opencast mines increases

Opencast mines and underground mines are the most important and common methods of extraction of minerals / coal from the earth, but choice of methods is totally depends on economic cost of minerals, depth of minerals and quantity of minerals. In India, the quantity of opencast mines has increased because of opencast mines is only methods to extract the minerals with 100% possibility. The results of this scenario, Indian Coal/ Minerals mines sector both have large no. of opencast mines.

Air pollution and Health

"Air pollution may be defined as any atmospheric condition in which certain substances are present in such concentration that they can produce undesirable effects on man and his environment" (Rao, 1998). Some of these pollutants are sulphur dioxide, nitrogen dioxide, carbon monoxide, particulate matter (PM_{10} and $PM_{2.5}$), ozone, lead, ammonia, benzene, arsenic and nickel (NAAQS, 2009). Both indoor and outdoor pollution can have effects not only on human health but also on surrounding environment (Adgate et al., 2003; Chunlei et al., 2005; Kamens et al., 1991; Koponen, et al., 2001; Reshetin and Kazazyan, 2004; Ruth, 2007; Saxena, 1997; Sivacoumar et al., 2001; Smith et al., 2005).

Both developed and developing countries have been facing the air pollution problem (Chan et al., 2001; Kan et al., 2009; Gupta et al., 2006; Kim et al., 2006; Tsai and Chen, 2006). Huge amount of pollutant are emitted by

fossil fuel combustion in vehicles, industries and other production sites (Abdul-Wahab, 2006; Ashbaugha et al., 2003; Kan et al., 2011; Laden et al., 2000; Moreno et al., 2007; Mukhopadhyay and Forssell, 2005). The enhanced concentration of pollutants in the atmosphere due to anthropogenic activity has significant impact on health of human being (Bond et al., 2004; Braun et al., 1992; Maantay, 2002; Ramanathan and Carmichael, 2008; Stieb et al., 2002; Wilson and Spengler, 1996). The emitted particulate matter in the atmosphere leads to the increasing mortality and morbidity through the respiratory disease (Abbey et al., 1998; Anderson et al., 2004; Arbex et al., 2009; Beverland et al., 2002; Brunekreef and Holgate, 2002; Castillejos et al., 2000; Dockery et al., 1993; Dockery and Pope, 1994; Guo et al., 2009; Halliday et al., 1993; Hopke 2009; Kan and Chen, 2004; Kjellstrom et al., 2002; Lebowitz, 1996; O'Neill et al., 2008; Ostro, 2004; Pan et al., 2007; Pope at al., 2002; Pope III et al., 2002; Qian et al., 2007; Salter and Parsons, 1999; Samet et al., 2000; Schwartz et al., 1996; Spix et al., 1993; Vedal, 1995; Wilson and Spengler, 1996).

Among all air pollutant, the impact of particulate matter on health is the most important one (ApSimon et al., 2001; Braun et al., 1992; Brunekreef et al., 1997; Harrison et al., 2001; Kamens et al., 1991; Kulkarni, 2006; Nel, 2005; Pillai et al., 2002; Schwartz et al., 1996; Smith and Jantunen, 2002; Wilson and Suh, 1997). Many studies have shown that the particulate matter generated through urban pollution (vehicle, industries etc.) leads to the adverse impacts on health (Arbex et al., 2009; Cooper et al., 2009; Harrison and Yin, 2000; Kamens et al., 1991).

Air Pollution and Surface Mining

Surface mine is the most important contributors to modern societies. It is a type of mining in which soil and rock materials are removed to get economic minerals. This mining method is applicable to stratified minerals deposit close to the surface. Opencast mines are the most important and common methods of extraction of minerals / coal from the earth, but choice of methods is totally depends on economic cost of minerals, depth of minerals and quantity of minerals. It is totally opposite of underground mining. Surface mining is predominant
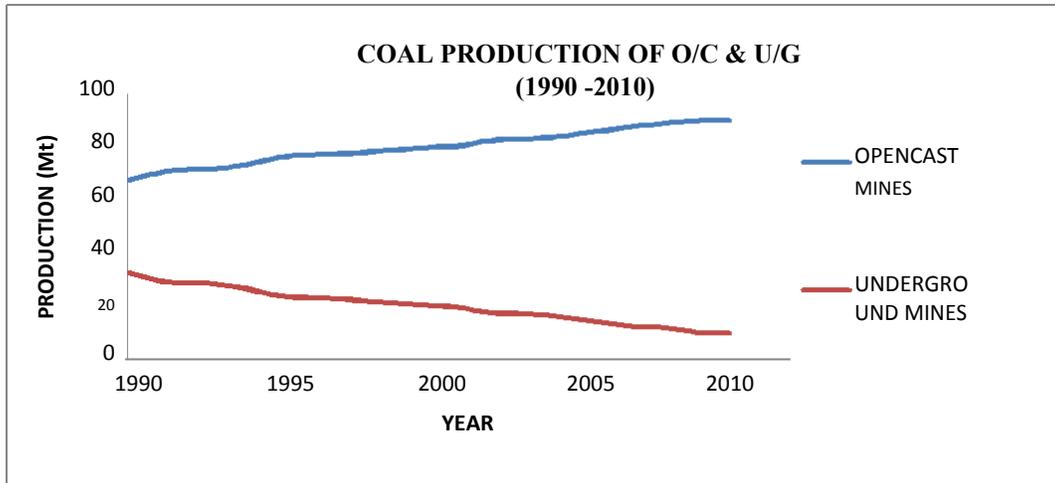
Figure 1. Coal Production in Opencast (OC) and Underground (UG) mines
Source: Ministry of Coal & Mines, Govt. of India

exploitation procedure for minerals. Almost all metallic ore, non-metallic ore and other materials are mined using surface mining. In World, the quantity of opencast mines has increased because of opencast mines is only methods to extract the minerals with 100% possibility. In India, the ratio of underground mining and surface mining is 10% and 80% respectively.

Surface mines generally result in high productivity and low operation cost therefore; deep opencast mines are going to come up more and more in future. Surface mining are among the most economical of all mining methods but can only be applied to limited categories of mineral deposits. Surface mining Therefore, are gradually increasing time by time. In India, several examples are present to indicate that increases the depth of opencast mines for higher production such as Rajmahal opencast coal mines, Malanjkhand Copper Project (MCP) and Steel Authority of India Limited (SAIL) at Kiriburu, Meghahatuburu and Bolani opencast mines. Each of them has been planned to go for higher production with increase of depth of working.

Surface mines is a direly related to surrounding environment. Some unit operation of surface mining (i.e. drilling, blasting, crushing and loading – unloading, etc) are directly emitted pollutant to the atmosphere (Chaulya, 2004; Cowherd, 1979; Ghose, 1989; Ghose and Majee, 2000; Ghose and Majee, 2001; Ghose and Majee, 2007; Jacko, 1983; Kumar et al., 1994; Mirmohammadi et al., 2009; Pandey et al., 2008; Silvester et al., 2009; Sinha and Banerjee, 1994; Sinha, 1995; Soni and Agarwal, 1997; Trivedi et al., 2009; Chengdu et al., 2010). Some other pollutant (gaseous) is concerned to major pollutant in mining areas such as oxide of nitrogen, oxide of sulphur, carbon monoxide and hydrocarbon, etc. (Almbaucer et al., 2001; Chakraborty et al., 2002; Ghose and Majee, 2001; Zhengfu et al., 2010).

A surface mine has been responsible for creating impact on surrounding environment as compare to other mining methods. Mining activities are not only reducing air quality but also disturbing natural environment such as fauna and flora, etc. (Chaudhari and Gajghate, 2000; Chaulya, 2004; Crabbe et al., 2000; Nanda and Tiwary, 2001; Wheeler et al., 2000). However, many environmental impacts are at maximum in surface mining areas including air blast, visual intrusion, noise and vibration, air and water pollution and dereliction.

Modelling of particulate matter

In recent, the particulate matter is the most significant source of air pollution in mega cities (Chan et al., 2001; Kan et al., 2009; Gupta et al., 2006; Kim et al., 2006; Tsai and Chen, 2006). The source of particulate matter are very common either urban areas activities such as factories, chimneys, and exhaust from vehicles, etc. (Abdul-Wahab, 2006; Ashbaugha et al., 2003; Kan et al., 2011; Laden et al., 2000; Moreno et al., 2007; Mukhopadhyay and Forssell, 2005) or mining activities such as drilling, blasting, crushing, transporting of material, loading- unloading point, overburden, and haul rods, etc.(Chaulya, 2004; Cowherd, 1979; Ghose, 1989; Ghose and Majee, 2000; Ghose and Majee, 2001; Ghose and Majee, 2007; Jacko, 1983; Kumar et al., 1994; Mirmohammadi et al., 2009; Pandey et al., 2008; Silvester et al., 2009; Sinha and Banerjee, 1994; Sinha, 1995; Soni and Agarwal, 1997; Trivedi et al., 2009; Zhengfu et al., 2010). Due to these all activities the concentration of particulate matter leads to gradually high in the atmosphere. At this stage, the precaution is the most important not only for human life but also for the surrounding environment (plant, buildings, and natural

habitat, etc.). All mega cities of India are also affected by the increase of air pollution levels as a result of activities from urbanisation and industrial/mining activities (Molina and Molina, 2004; Oanh et al., 2009). The increase rate of pollutant has driven for modelling and measurement of air quality. The modelling of particulate matter is the most important to identify the origin and dispersion behaviour of particulate. Modelling of particulate matter is also provided some information about the particle such as mass concentration with size range. Modelling gives some information about how much concentration of pollutant substances at a particular location but it can not be gives information about the future concentration of pollutant. The pollutant can be controlled by meteorological condition (Pang et al., 2009; Sezer et al., 2005; Silva et al., 2007).

DISCUSSION

The aim of this study was to assess respirable dust exposure in opencast coal mines. Predominant dust types include the ore/mineral mined, exhausts from the mining machineries and dust types in the nearby locality that is carried by wind and tyres of the vehicle to the mine working environment. Dilution and dispersion of PM in a surface mine is a function of design of mine working and local meteorological condition. Several earlier studies have indicated that the pollution due to PM is very high in working areas of opencast mines. With increase in depth of mines, effective vertical movement and final dispersion of PM away from mine working becomes difficult. It is therefore needed to carry out studies to measure and understand the nature of dispersion of PM from deep surface mines. Determination of the respirable dust exposure of coal miners will help to investigate relationships between such exposures and respiratory diseases. This will give an estimate of PM in different horizons of a deep surface mine that the persons working are exposed to. This will serve as an input to the scientists who are working on areas to interpret the impact of workplace environment on the health of a worker.

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