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Management of Mine Dust for Optimum Ambient Air Quality of Suakati Region- A Case Study

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Abstract

Mining is one of the core sectors of the Indian economy. Mining of minerals is inevitable. Simultaneous mining is also associated with the degradation of the environment. Over the years, minerals have been exploited without giving due consideration to environmental degradation. Dust generation is the result of almost all the activities of a mine, which is primarily responsible for various occupational health hazards, environmental pollution, etc. This paper presents various aspects of mine dust, mine air quality, and the impact of such dust on the nearby environment. An attempt has been made to determine the most effective practices for better ambient air quality.

Keywords: *Dust Suppression, Mine Dust, Mist Cannon, PM10, $PM_{2.5}$*

1.0 Introduction

Mine dusts are products of mining activities that are formed when rocks are broken by blasting, crushing, or grinding. The compositions of these dusts are determined by their source region and closely reflect the composition of soil cover[1]. Mine Dusts are the particulate matter that is suspended in the air. Mine dusts could broadly be classified as Inhalable, Respirable, Crystalline silica, and Inhalable lead dust particles. Mine dusts are classified based on the size distributions of the particulates and in terms of physiological effects. The physiological effects of mine dust are further divided into five categories namely; toxic dust, carcinogenic (cancer-causing) dust; fibrogenic (silicosis-causing) dust; explosive dust, and nuisance dust[2]. Particles with a size of 500-1000 μm get dislodged from the rock surface, but only those with an aerodynamic diameter of less than 7.5 μm will get suspended in the atmosphere[3]. Research has shown that when miners are exposed to dust over a certain period of years, there is always the tendency for these miners would develop silicosis, siderosis, lung cancer, and tuberculosis[4]. Research has shown that suspended particulate matter is the major cause of asthma, lung cancer, cardiovascular diseases, and premature deaths in humans[5]. Pulmonary siderosis is a rare occupational lung disease that occurs due to chronic inhalation of iron compounds. It had been believed to be a benign pneumoconiosis because of the absence of significant signs/symptoms or associated fibrosis[6,7].

Apart from adverse health effects, the corrosive effect of dust particles reduces the life of lubricants used in Heavy Earth Moving Machinery (HEMM) and in turn, increases their maintenance cost due to excessive wear and premature failure of the machine components[8]. Dust damages the parts, reduces the efficiency of mine machinery, and degrades the nearby environment. In Odisha, most of the Iron Ore is mined by surface mining method. Surface mining contributes more to environmental degradation than the underground method. Environmental control in surface mines can be broadly divided into two categories: 'Working

Environment' and 'External Environment'. In a mine, all reasonable steps should be taken to minimize exposure to a level well below the exposure limit. In this context, the dust suppression practices of Gandhamardan Iron Ore Mines were analyzed. Air quality monitoring at six places within the mining lease area (working zone), six other places outside the mining lease area (external zone), and nearby important places have been carried out for this case study to determine the amount of particulate matter using a gravimetric method of sampling as per Central Pollution Control Board guidelines. At last, a comparison of all the twelve monitoring stations and various dust suppression methods (carried out in the mine) was made to determine the most effective and economical method of dust suppression to limit the concentration of particulate matter in ambient air and ensure healthy living conditions.

2.0 Study Area

Gandhamardan Iron Ore Mine of OMC Ltd was chosen for our case study. The mine is located at Banspal Tehsil, Suakati, Keonjhar (Figure 1). There are two leases of OMC which are adjacent to each other, Gandhamardan A - 618.5760 Ha and Gandhamardan B - 1590.87 Ha. The leases are located in Gandhamardan Hills of Keonjhar district, which is a pristine forest ecosystem of the state of Odisha. About 90% of the total lease area has forest cover. The two leases are located within the Latitudes- 21˚36'08.58" to 21˚39'41.89" and Longitudes- 85˚29'13.06" and 85˚33'16.78". The Gandhamardan Hills are home to some flagship wildlife species such as the elephants and also cater to river Baitarani through many feeder streams. No rare or endangered flora and fauna are noticed in this area, but the movement of megafauna like elephants is often noticed in the same area. Apart from elephants, sloth beer and spotted deer are also seen in the area. There are two quarries in which mining is being done these days, Putulpani Quarry and Hilltop Quarry.

2.1 Green Belts

Trees act as windbreaks and the leaves as dust filters. Maiti and Banerjee found that an 8m wide green belt between roads and buildings can reduce dust fall by two to three times, and conifers reduce dust fall by up to 42% in temperate urban areas[9]. About 601.782 Ha of virgin forest land apart from the safety zone of 23.48 Ha surrounds the mining area of the lease which acts as a green belt to confine the dust within the lease area. Major vegetation consists of trees like Sal, Bija, Asan, Amla, Kasi, Kumbhi, Kendu, etc.

Figure 1. Gandhamardan iron ore mine, Suakati.

2.2 Dust Suppression Practice

Water sprinkling is done using both fixed and mobile sprinklers in Gandhamardan Iron Ore Mine. Water is sourced from a nearby nallah and a pool (Figure 2). Fixed water sprinklers have been installed along the sidelines of haul roads, which spray water in intervals. Four Tankers having 24kL water carrying capacity are being used for water spraying along the haul roads and other areas of the mine in gaps (Figure 3). Fixed water sprinklers have also been installed along the hoppers of the primary crushers to avoid dust generation while dumping the runoff mine into it. The trucks use the principle of gravity flow for water spraying. Thus, requiring no electrical power for its operation.

2.3 Mist Cannons

The mobile mist cannon works with the principle to bind air-borne dust particles with water particles and force them to settle on the ground. In mist systems, water under high pressure is forced through micro nozzles using powerful fans to form a water mist. Water is broken down into droplets smaller than 50 micrometres using high

Figure 2. Source of water from a nearby nallah.

Figure 3. Conventional water sprinkling resulting in muddy haul roads.

Figure 4. **(a)** Truck-mounted Mist Cannons. **(b)** Fixed water sprinklers along the sidelines of haul roads.

pressure (> 100 Bar) and suitable nozzles. The machine can rotate through up to 330°. Two mobile truck-mounted 24kL water tankers with mist spraying systems have been procured recently to combat dust pollution (Figure 4).

3.0 Results and Discussion

Air quality was monitored at six locations inside the mine known as Working Zones and six locations outside the mine known as External Zones. In the working zone, only PM_{10} monitoring was done using a respirable dust sampler with cyclone (Gravimatric) whereas in the external zone, both PM_{10} and $PM_{2.5}$ monitoring was done using a respirable dust sampler with cyclone (Gravimatric) and fine dust sampler (Gravimatric) respectively (Figure 5). The respirable dust concentration (PM_{10}) was determined by gravimetric analysis. A Glass fibre filter of 20.3×25.4 cm size was used for this purpose. Air was drawn through a size-selective inlet and through a glass fibre filter. The airflow rate was maintained at 1132 L/min. The fine dust concentration ($PM_{2.5}$) was determined by gravimetric analysis. A Polytetrafluoroethylene (PTFE) filter was used

Figure 5. Dust sampler (PM_{10} & $PM_{2.5}$).

Table 1. Working zone monitoring data

Station Code	Location	PM_{10} (µg/m³)
FE1	Near Magazine	726
FE2	Ore Stock Yard Near Jagar Camp	864
FE3	Bolder Face, Putulpani	489
FE4	Near Hill Top	204
FE5	Haul Road near Quarry (V-C)	397
FE6	Near 325TPH Crusher	246

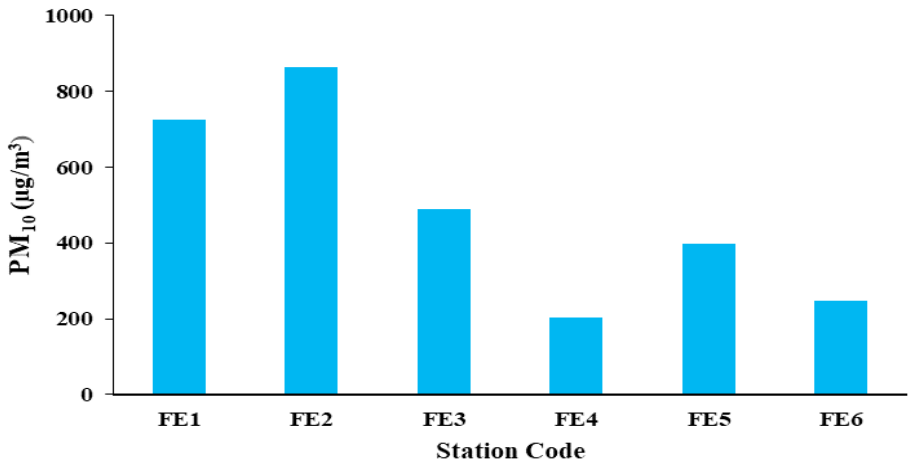

Figure 6. Working zone monitoring data.

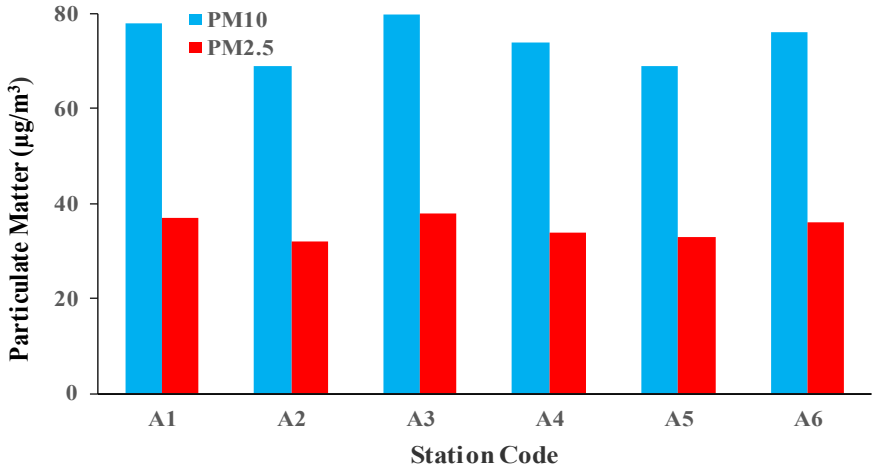

Figure 7. Results of external zone air quality monitoring data.

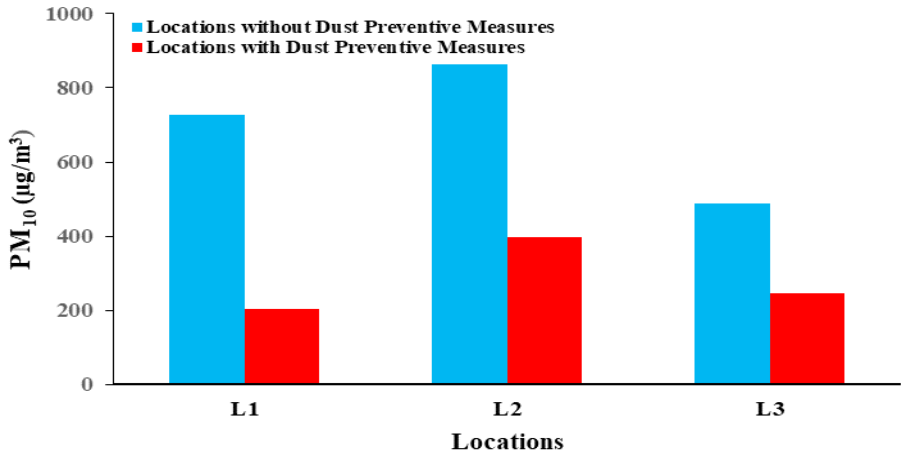

Figure 8. Zones with and without dust preventive measures.

for this purpose. The electrically powered air sampler drew ambient air at a constant volumetric flow rate of 16.67 LMP. The machines were set for twenty-four-hour observation.

The concentration of PM_{10} at the Ore Stock Yard was reported to be the highest among six selected locations (Figure 6). The PM_{10} concentration was 864 (µg/m³). The concentration of PM_{10} at the Near 325TPH Crusher was reported to be the lowest among six selected locations. The PM_{10} concentration was 246 (µg/m³). The concentration of PM_{10} and $PM_{2.5}$ at external zones such as Suakati School, OMC Medical, Guest House, Suakati College, and Daunla Village was very very low compared to working zones (Figure 7; Table 2). Further, it was observed that the concentration of PM_{10} in the zones with dust suppression measures was considerably lower than in the zones without any dust suppression measures (Figure 8).

It was observed that the concentration of PM_{10} in the zones with mist cannon water sprinkling measures was lower than in the zones with conventional water spraying (Figure 9). Water consumption was much less compared to conventional water sprinklers. Efficiency, as well as effectiveness, was more in Mist Cannon. Due to the small

Table 2. External zone air quality monitoring data

Sl. No.	Locations	Station Code	PM_{10} (µg/m³)			$PM_{2.5}$ (µg/m³)		
			Maximum	Minimum	Average	Maximum	Minimum	Average
1	Suakati School	A1	85	71	78	41	33	37
2	Guest House	A2	75	61	69	36	27	32
3	OMC Medical	A3	93	72	80	44	34	38
4	Suakati College	A4	85	63	74	40	28	34
5	Maintenance	A5	76	61	69	37	28	33
6	Daunla Village	A6	81	71	76	40	34	36

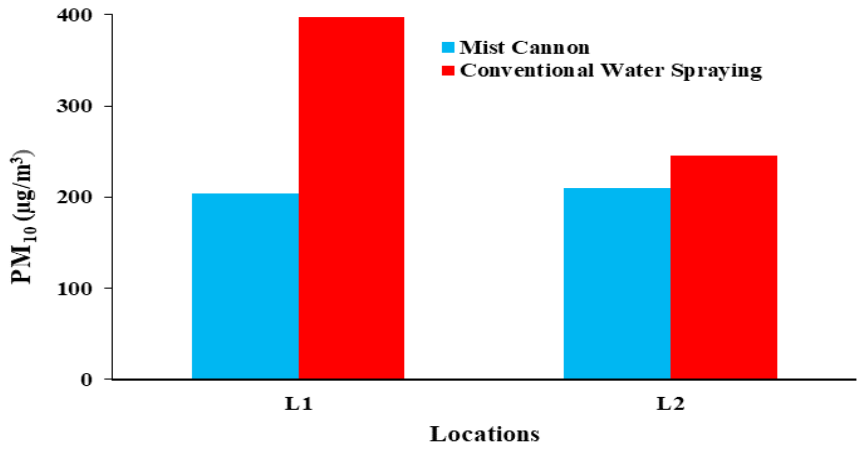

Figure 9. Comparison between mist cannon and conventional water sprinkler.

Table 3. Comparison between conventional water sprinklers and mist cannons.

Factors	Water Sprinkler	Mist Cannon
Water Consumption	More	Less
Effective Area	Less	More
Cost of Operation	Much less	High
Efficiency	Less	More
Effect on Surface	Partially muddy	No muddy effect
Frequency of Water Sprinkled	More	Less

droplet size the total surface area of a specific volume of water introduced as mist into a dust zone, compared to the same volume of conventional water spray, is enlarged by a factor of 100. A much larger area could be covered compared to conventional water spraying. Unlike gravity water sprinkling, no muddy effect was witnessed in Mist Cannon (Table 3).

4.0 Conclusions

Air Quality plays a vital role in the health and safety of mankind and ecology. Mining, more precisely surface mining involves the extraction of the topsoil. Almost every step of it generates dust resulting in various problems. In every mine, all measures should be explored to limit the concentration of dust as per the permissible standards. In the present study, it was found that the air quality within the mine lease area and outside was within the limits of the CPCB. However, at some places like Ore Stock Yard, PM_{10} concentration was 864 ($\mu g/m^3$). Therefore, the company needs to be cautious towards it and try its best to adopt modern recommended technologies of dust suppression and to prevent dust generation from the source itself.

The recently introduced truck-mounted mist cannon system proved to be an effective dust suppression practice with regard to water conservation, area of influence, and conditions of the haul roads. Such cannons could also be installed near the stockpiles. Effective dust control using water at mines and on haul roads requires uniform wetting and monitoring of weather conditions, like air temperature, relative humidity, and wind direction and speed. In this regard, mist sprinkling outweighs conventional water sprinkling practices. Therefore, the use of mist sprinklers results not only in better haul roads and dust suppression but also in conserving water. The presence of a large patch of forest land around the lease area acts as a huge green belt and thus plays a major role in controlling the air quality of the zones outside the lease area and in the nearby zones of Suakati. Hence planting more trees and establishing green belts around the lease area after the existing trees are felled for mining, could help to check the air quality of the nearby zones in the future.

5.0 Acknowledgements

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