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Air Quality Characterization in Coal mines with special reference to existing standard

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Abstract: ***Mining industries in general and coal mining in particular are more concerned to environment and eco – friendly mining in India. Efforts are being made continuously to improve the quality of life of people by enhancing the quality of environmental attributes. Air is an important attribute of the environment and most visible impact is observed in and around mining industry.***
In this paper, a case study of a large opencast coal mining complex has been discussed with special reference to characterization of particulate matter for improving the air quality in and around the mine. The particulate matter characterization in terms of concentration, size, shape, time of exposure and composition is issued. The results were compared with existing standards and guidelines of air quality given by NAAQS, 2009.
The paper concludes that some more parameters may be included in NAAQS for protecting and restoring the ecosystem of the mining area.
Coal mining in India is started more than 150 years back. The production of coal in 1971 – 72 (before nationalization was only 70 million tons mainly (more than 90% from underground mines). During this time also strict environment and safety compliance were there. After nationalization of the coal industry, the coal mining trend has been shifted from underground to open cast mining with huge mechanization by introducing drag lines and surface miners. The scenario has been changed. Now, more than 90 % production is from open cast and less than 10 % from underground mines (Anon., 2011) .
Simultaneously, environmental problems caused by opencast mining has increased many folds and more and more acts, rules, guidelines came into existence after the creation of the ministry of environment in 1984. Step by step with the advancement, awareness and strict compliance with environmental guidelines, there is advancement in monitoring techniques of air quality also. All these aspects are discussed in the subsequent paragraph.
Keywords: Air pollution, Opencast coal mine, SPM

1. INTRODUCTION

The particulate term indicates the size of a particle larger than a single molecule (0.0002 um) but smaller than 500 um. These particles have a lifetime in suspension varying from a few seconds to several months (Kenneth et al 1976). Generation and removal of these particles are continuous and depend on the specific source of pollution in mining areas. Extraction and transportation activities release the huge amount of particulate matter. Air quality status in Indian environment is dominated by SPM causing great concern to environment planners (Ravindra 1991).They can exert the ill effect on plant and animal life, so efforts continue and trends of world wide basis to determine the concentration and trend of SPM in urban, nonurban, and industrial areas (Spirtas et al 1970). It may produce health hazard due to continuous exposure in this zone. In general increase incidences of asthma, stomach and pancreatic cancer, foetal abnormalities and ear disorders may be seen in and around the mining areas (Bate and Coppin, 1991). It is well known that prolonged inhalation of dust containing quartz can cause silicosis – a fibrotic lung disease. The International Agency for Research on Cancer (IARC) has recently revised the classification of silica to Group 1 Human Carcinogen (IARC, 1997). The American Conference also classified silica as a category A2 carcinogen, i.e. a suspected human carcinogen (Bandopadhyay, 2010). These SPM may contain toxic trace metals like Arsenic (As), Cadmium (Cd), Lead (Pb), Zinc (Zn), Chromium (Cr), and Manganese (Mn) and their compounds. It may degrade the quality of land soil if deposited over it and produce various health hazards. The general trend of investigating pollution level is usually based on estimating the concentration of the SPM, but it will not provide information regarding the severity of the dust hazard. Keeping these facts in mind this paper describes the geometrical and mineralogical properties of SPM which are generally produced in open cast coal mines.

2. AIR QUALITY IN OPEN CAST MINES

Air quality monitoring was undertaken in mines of NCL since 1986 but not continuously. The concentration of suspended particulate matter, their size, shape and mineral composition in various source points as well as in surrounding vicinity is observed and given in table 1 to 3.

Concentration of SPM

Table 1(a): SPM concentration at a distance of 10

meters from various mining activities

Activities	Average concentration (ug/m3)		Addition of SPM	Percentage increase of dust ug/m3
	Down wind	Upwind		
Drilling (overburden sand stone)	1820.3	698.6	1121.7	61.6
Drilling (coal)	2187.4	629.2	1558.2	71.2
Drilling (coal, shale, clay)	2106.2	623.3	1482.9	70.4
Blasting (overburden)	1203.8	646.1	557.7	46.3
Blasting (coal)	916.6	603.8	312.8	34.1
Haulage (Dumper)	1801.2	539.6	1261.6	70.0
Haulage (except dumper)	1460.3	724.2	736.1	50.4
Dumping of overburden (Dragline)	1062.6	600.4	462.2	43.5
Dumping of coal (coal yard)	1785.8	721.2	1064.6	59.6
Shovelling of coal (working face)	887.6	692.3	195.3	22.0
Coal handling plant	1833.8	754.7	1079.1	58.8
Grand Total			9832.2	

Table 1 (a) shows the concentration of SPM in terms of mass at different point sources. It may be observed from the above table that dumper movement on haul roads, drilling operation into the coal seam and overburden and coal crushing and coal handling plant (CHP) are the major sources of SPM in the mine environment. The shovelling operation at working face produces comparatively less SPM.

Table 1 (b): SPM concentration in mining and surrounding area.

Table 1 (b) shows the seasonal variation of SPM in mining and residential areas. It may be observed that the concentrations of SPM in mining as well as in residential areas are above permissible limits in pre and post-monsoon seasons as compared withNAAQS,2009 standards. The higher concentration of SPM Particularly in residential area is not only as a result of mining operation but also influenced by the emissions coming from thermal power plants (Dhar et al. 1991; Jamal.1990)

The textural analysis of SPM in terms of geometrical shape and size has been done. The results are tabulated below in Table no 2.

Sites	Concentration (ug/m3)		Average Concentration	Permissible limits as per NAAQS,2009 (ug/m3)
	Max	Mini		
Pre monsoon Season				
Mining site	1892.6	1242.5	1546.3	Yearly 60 Hourly 100
Residential site	673.1	477.2	607.2	
During monsoon season				
Mining site	465.4	328.1	384.9	Yearly 60 Hourly 100
Residential site	283.2	164.5	194.6	
Post monsoon season				
Mining site	1087.2	792.3	934.1	Yearly 60 Hourly 100
Residential site	796.8	467.2	515.8	

Table 2 (a) : Textural analysis of SPM

Sample No	Activities	Particle percentage		
		Angular	Sub-angular	Sub–rounded
SPMD-4	Drilling	31.6	48.4	20.0
SPMD-6	Drilling	33.0	48.2	18.8
SPMD-9	Drilling	41.6	43.4	15.0
SPMD-10	Drilling	43.7	42.7	23.6
SPMD-14	Drilling	43.6	41.0	15.4
SPMH-9	Haulage	21.9	37.7	40.4
SPMH-20	Haulage	18.2	41.2	40.7
SPMH-23	Haulage	21.3	39.4	41.0
SPMH-27	Haulage	18.3	41.3	32.3
SPMH-29	Mining	21.3	48.1	30.6

SPMH-30	Mining	27.4	51.9	20.7
SPMH-31	Mining	30.8	47.6	21.6
SPMH-32	Mining	28.2	47.1	24.7
SPMH-36	Mining	28.3	41.3	30.4
SPMH-40	Mining	29.3	41.4	29.5

It may be seen from above textural analysis of SPM that drilling dust has the higher percentage of angular particles in comparison to haulage dust. In drilling dust, the percentage of angular particles ranged from 31.6 to 43.6, whereas in haulage dust angular SPM ranged from 81.2 to 21.9 percent. These observations also revealed that the shape of Quartz particles in drilling, dumping yard, working face were same as may be found in parent rocks, but probably due to the abrasion of dust by the movement of dumpers, dozers, etc. The quartz particles in haulage SPM were the somewhat different shape.

Table 2 (b): Effects of various sizes of SPM on Human being.

Group	Size range in um	Effects
Super fine	< 0.5	Least effect on respiratory system.
Fine	0.5 to 2.5	Maximum effect on respiratory system.
Medium	2.5 to 5.0	Moderate effect on respiratory system.
Coarse	5.0 to 15.0	Mostly affect the visibility of atmosphere.
Very coarse	15.0 and above	This fraction has fast settling rate usually causes soiling of machineries etc.

Table 2 (b) shows the classification of the various size range of SPM and there effects on human being. Particle size is the equivalent diameter of a spherical particle of unit density having the same falling velocity. The particle size is most important parameter while considering the pulmonary effects of suspended particulate matter.

Table 3: Mineralogical composition of SPM

Specific gravity	Mineral/Coal rock fragments	Coal hand-ling plant	Coal yard	Haulage	Drilling in sand-stone	Mining area	Residential Area
<1.55	Coal fine SPM , pollen grains etc.	69.37	61.83	37.62	6.39	35.59	39.28
1.55-2.40	Rock fragments	12.46	18.09	17.48	8.86	6.88	11.30
2.40-2.70	Quartz and feldspar	13.14	16.10	41.16	73.25	48.24	48.08
2.70-2.80	Muscovite and Biotite	nil	2.83	1.02	2.36	5.20	0.64
>2.80	Heavy minerals (pyrite,magnetite ,hematite)	4.41	0.86	1.93	7.73	3.36	Nil
Weight loss	0.62	0.62	0.29	0.79	1.41	0.83	0.97

Table 3 shows the percentage distribution of various coal and mineral constituents according to their specific gravities. It may be seen from the above table that the mineral constituents present in SPM are fibrogenic in nature. Free silica, silicate (mica, asbestos), iron oxides and coal particles are mostly harmful to the respiratory system. Among them, the free silica is most virulent and coal is least. The observation shows that higher percentage of coal in SPM near coal handling plant, drilling site in overburden shows the higher percentage of free silica and lower at coal drilling sites and at haul roads. In coal handling plant, the silica concentration is highest due to fugitive SPM from sandstone drilling. The other constituents present in these samples have been shown in this table. Though the percentage of mica and iron oxides is small less than 7 % in comparison to silica and coal but due to its higher virulence that coal, they also need attention while formulating standards of SPM for air Quality.

Table 4: Existing NAAQS and need for improvement

Sr.No	Pollutents (ug/m3)	Time weighted average	Concentration in Ambient Air (Industrial, Residencial area)
1	Sulphur Dioxide(SO2)	Annual	50
		24 Hours	80
2	Nitrogen Dioxide(NO2)	Annual	40
		24 Hours	80
3	Particulate Matter (Size<10 um) PM 10	Annual	60
		24 Hours	100
4	Particulate Matter (Size<2.5 um) PM 2.5	Annual	40
		24 Hours	60
5	Ozone (O3)	8 Hours	100
		1 Hours	180
6	Lead (Pb)	Annual	0.5
		24 Hours	1.0
7	Carbon Monoxide (CO)	8 Hours	02
		1 Hours	04
8	Ammonia (NH3)	Annual	100
		24 Hours	400
9	Benzene (C6H6)	Annual	05
10	Benzo(a)Pyrene (BaP)- particulate phase only	Annual	01
11	Arsenic (As)	Annual	06
12	Nickel (Ni)	Annual	20

In this existing NAAQS the pollution criteria are totally based on the concentration of SPM and some gaseous and few metallic contents which are not sufficient enough to assess the severity of dust pollution. Results from the above study show that the characteristics of a particular SPM is totally depends upon the source of production and the mode by which it produced. So some other properties like shape, size, and mineralogical characteristics must be included for getting a complete picture of the severity and the extent up to which the affected person may suffer.

3. Conclusion and recommendation

The observations show that SPM is produced through every activity in mining but the main sources are drilling and dumper haulage system. The coal handling plant also produces the reasonable amount of SPM. Seasonal variation of SPM in the surrounding area shows maximum concentration in Pre-monsoon season, minimum in monsoon season and in-between during Post-monsoon season. The shape and size of mineral particles in SPM show a wide variation in different mining activities. Mineral composition of SPM shows that quartz and feldspar concentration is very high in sandstone drilling sites and more or less equal to other mining and residential sites. The result shows the drilling crew is highly influenced by dust hazards. The results indicate that a proper investigation of SPM must be done to assess the actual severity of dust in mining and the surrounding area like shape, size, mineralogical characteristics etc. Proper treatment methods should be adopted for a particular textural and mineralogical composition of various dust. A similar technique of dust treatment for every dust is not sufficient. More dust suppuration is required at main sources of SPM generation points. Some chemical treatment should be used for neutralizing the effects of some harmful constituents of SPM like silica etc.

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