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ASSESSMENT AND CHARACTERIZATION OF DUST IN SURFACE MINE AT DIFFERENT WORKING CONDITIONS-A CASE STUDY

M.S. BHULLAR[1], DR. A. BHATNAGAR[2]

[1]M.S.Bhullar, Student of Dept. of mining Engineering, C.T.A.E, Udaipur, Rajasthan, India
[2]Dr. A. Bhatnagar, Faculty of Dept. of mining Engineering, C.T.A.E, Udaipur, Rajasthan, India

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Abstract- *Dust pollution is a major problem from opencast mining activities like Drilling, blasting, loading, transportation, crushing and conveying. Basically the dust would be generated in the form airborne and fugitive in which the airborne dust is comparatively dangerous because its expansion is in the form of clouds from the source. The monitoring and assessment of the dust is necessary to know the various impacts of dust at the surrounding environment. In the result these dust particles are the reason of dangerous diseases like lung cancer, silicosis, carcinogen and pneumoconiosis etc. In this project the basic purpose is to monitor the concentration of PM10, PM2.5, SO2, CO, NO2 and to find out the difference of dust exposure between core and buffer zone. So for the monitoring of PM10 and the PM2.5 high volume dust sampler respectively Envirotech APM 460 NL and Envirotech APM 550 is used and for monitoring of SO2 and NO2 U-V Spectrometry (the automatic method of dust monitoring) is used.*

Key Words: Airborne dust, fugitive dust, U-V Spectrometry, carcinogen, pneumoconiosis and silicosis.

1. INTRODUCTION

Mining is a significant practice for industrial and economic development of any country. The development of infrastructure is immediately linked with multiple minerals like dolomite, limestone, iron ore, Bauxite, silica, granite, magnetite and many others which are acquired through the opencast mines. When it comes to dust generation, comparison between the surface mines and the underground mines, then it is obvious that the surface mining operations are more associated with the generation of dust. Surface mining emission of dust and prediction of dispersion is difficult process as there are various factors which are responsible for emission and dispersion. Dust emission and dispersion are difficult to predict through dispersion model due to the wide range of fugitive sources in mining activities. For the safety purpose and workable environment to a miner, it is required to carry out dust monitoring on regular basis for the long term and follow the guidelines of DGMS. The dust dispersion pattern are affected by the Wind speed, Precipitation and the sources of emission itself.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is being connected at limestone mine. The lease area of mine is 390.625 ha. which is 35 km from the Sirohi, Rajasthan. This mine has the limestone production capacity of 8 to 13 million TPA. National highway-14 is 3.5km from the mine in North-West direction.

Fig. 1: Boundary map of studied area, Sirohi (Rajasthan)

In India the limestone is the backbone for infrastructure development as it is major raw material for manufacturing of cement. Thus for the national growth it is essential to mine the limestone.

2.2. Dust Measurement Standards

National Ambient Air Quality Standards (NAAQS) has notified so many versions related to ambient air dust monitoring in which the forth provision was related to the air (Prevention & Control of Pollution Act), 1981. The aim of central pollution control board (CPCB) is to provide the uniform air quality to entire area and irrespective use of land

Patterns across the whole over country.

There are so many parameters in the ambient air which affect the human body, some of those parameters are shown below according to their CPCB limits.

Table 1 National Ambient Air Quality Standards (2009) with CPCB limits

NATIONAL AMBIENT AIR QUALITY STANDARDS (2009)

Pollutants	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)	
Sulphur Dioxide (SO_2), µg/m3	Annual * 24 Hours **	50 80	20 80	-Improved West and Gaeke Method -Ultraviolet Fluorescence
Nitrogen Dioxide (NO_2), µg/m3	Annual * 24 Hours **	40 80	30 80	-Jacob & Hochheiser modified (NaOH-NaAsO2) Method -Gas Phase Chemiluminescence
Particulate Matter (Size less than 10µm) Or PM_{10}, µg/m3	Annual * 24 Hours **	60 100	60 100	-Gravimetric -TEOM -Beta attenuation
Particulate Matter $PM_{2.5}$ (Size less than 2.5µm)	Annual * 24 Hours **	40 60	40 60	-Gravimetric -TEOM -Beta attenuation
Carbon Monoxide(CO), mg/m3	8 Hours * 1 Hour **	02 04	02 04	-Non dispersive Infrared (NDIR) Spectroscopy

The principal of all the methods are different in which the samples are collected on the field and than these samples have to be sent to the laboratory for the analysis.

The strategies prescribed within the notification for various parameters are the combination of physical technique, wet-chemical technique and continuous on-line method.

2.3 Dust Monitoring Methodology and Instruments

2.3.1 Dust Monitoring Methodology

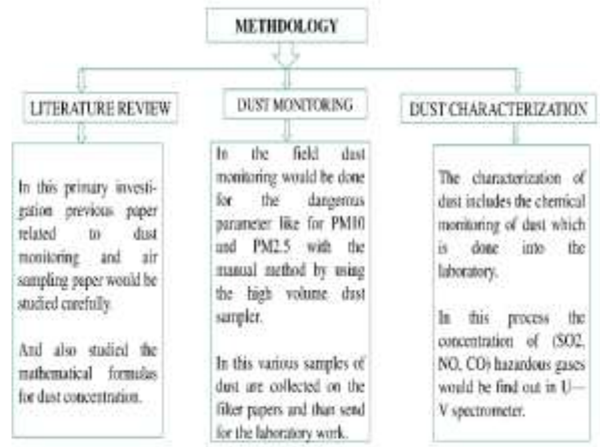

Fig. 2: Methodology of dust monitoring

The plan of work mainly focused on a comprehensive assessment of the impact of dust due to mining activities. The focus of the work is mainly to assess dust generation at different working sources, to minimize the effect of dust and to predict impact of dust generation by mining activities in the surrounding areas.

2.3.2 Dust Monitoring Instruments

Gravimetric method of dust sampling is used to measure the quantitative amount of airborne dust which is collected from the different workplace. These measurement are carried out to estimate occupational exposures to evaluate the efficiency of air pollution control technology. The gravimetric sampling technology is a method in which air is gone through the channel and basically this channel is the filter paper whose initial and final weight would be calculated to analysis the dust concentration. Here some of the sampling instruments are given below:-

2.3.2.1 Envirotech APM 550 NL

In these forms of air samplers the dust particles of $PM_{2.5}$ can be measured. That is also known as the fine dust particle sampler. The dust particle of 2.5 microns and less can be measure by this instrument.

In this the ambient air enters the downward-directional in APM 550 series sampler to provide a clean aerodynamic cut-point for particles which are greater than 10 microns in size. Particles in the air stream which are smaller than 10 microns proceed to a second impactor chamber, which has an aerodynamic cut-point at 2.5 microns where the filter paper of 47mm diameter is placed. The particle which has the diameter of more than 2.5 microns are collected on this and the remaining air stream would come out from the below part. It can be worked with a single individual sampling pump.

Fig. 3: Envirotech APM 550 NL

2.3.2.2 Envirotech APM 460 NL

The Envirotech APM 460 NL is used for the PM_{10} and heavy particular mater in the cyclone. In this at the top a filter paper of (8"x10") is used for the collection of PM_{10} size particle and the larger particles go down into the cyclone bucket. As shown in the given Fig. 4 after proper supply of power through motor the air passes completely through the samplers and the filter system.

Fig. 4: Envirotech APM 460 NL

The filter paper is pre-weighted by the weighing machine and then start the machine. Than after completion of 24 hours the difference in the filter paper weight gives the particular dust mass. In this the difference of mass is divided by the volume of air sampled which gives the concentration of TSP. The upper chamber of the sampler collect airborne particles from 10 to 100 micrometers (μm) in diameter, the PM_{10} Particles are collected on the filter paper and the large particles go down in the cyclone.

high volume dust sampler are also used to measure total suspended particles and the gases or chemical elements present in the atmosphere which are harmful for human health for example the measurement of SO_2, NO_2, CO etc.

3. FIELD MONITORING INVESTIGATIONS AND LABORATORY WORK

3.1 Sampling and the analysis of PM_{10} with Envirotech APM 460 NL

In this methodology first of all a fresh filter paper is selected of the size of 20.3cm x 25.4 cm (8"x10") and the air drawn through a size particular. The ordinary flow rate would be 1132 L/min. Process of sampling would be done for the entire shift or for a day the particles who are less than 10 microns in diameter or equal to them are collected on the filter paper after sampling. The flow rate would be in the range of 1.02-1.24 m^3/min. The mass of PM_{10} concentration can be calculated with the difference of the weight of filter paper before and after of sampling. The flow rate would be in the range of 1.02-1.24 m^3/min. The mass of PM_{10} concentration can be calculated with the difference of the weight of filter paper before and after of sampling. It suggest that as the mass weight increases, the concentration of PM_{10} increases. The concentration of the PM_{10} is calculated by the weight gain in the filter paper to the volume of air sampled.

The concentration of particulate matter 10 can be given by the following formula which shows the presence of dust in μg per cubic meter.

Concentration of PM_{10} (μg/m3) =(Wf - Wi) x 10^6/ V

Where,

PM_{10} = Concentration of PM_{10}, μg/m^3

Wf = Initial weight of filter in gm

Wi = Initial weight of filter in gm

10^6 = Conversion of gm to μg

V = Volume of air sampled, m^3

Table 2 Ambient air quality monitoring for PM10 at core (working) zone

S. NO	LOCATION NAME	AFR PM_{10} (m^3/ min.)	FILTER PAPER WEIGHT		WT. of PM_{10} (gm)	PM_{10} (µg/m³)	Tem (°C)	Humidity (%)
			INTIAL (gm)	FINAL (gm)				
1	Mine Office	1.175	2.7698	2.8882	0.1185	70.5	39.7	34.1
2	View Point Of Crusher Area	1.175	2.4584	2.5827	0.1244	74.01	38.6	36.3
3	Screen Machine Area	1.175	2.1442	2.2707	0.1265	75.31	36.6	35.2
4	New Drilling Area	1.175	2.6358	2.7772	0.1414	84.16	38.6	36.3
5	New Drilling Point	1.175	2.9995	3.1514	0.1519	90.41	37.9	37.6
6	Belt No. 12 Reject Area	1.175	2.6547	2.7949	0.1402	83.43	40.1	35.4
7	Mine Area 435 Mtrs.	1.175	2.6551	2.7946	0.1395	83.5	39.6	37.5
8	Near Crusher	1.175	2.1212	2.2653	0.1441	85.78	38.1	36.4
9	Dump At Waste	1.175	2.6958	2.4787	0.1415	84.27	38.4	33.3
10	Mine Area 453 Mtrs.	1.175	2.4787	2.6089	0.1302	77.53	39.9	37.6

Table 3 Ambient air quality monitoring for PM10 at buffer (Village) zone

S. NO	LOCATION NAME	AFR PM_{10} (m^3/ min.)	FILTER PAPER WEIGHT		WT. OF PM_{10} (gm)	PM_{10} (µg/m³)	TEM (°C)	HUMIDITY (%)
			INTIAL (gm)	FINAL (gm)				
1	Basantgarh village	1.175	2.7698	2.8784	0.1086	64.61	39.7	34.1
2	Adarsh village	1.175	2.4584	2.5655	0.1071	63.72	38.6	36.3
3	Rohida village	1.175	2.1442	2.2518	0.1076	64.03	36.6	35.1
4	Puravto ki phali	1.175	2.6358	2.7384	0.1026	61.05	38.6	36.3
5	Silwa village	1.175	2.9995	3.1066	0.1071	63.75	37.9	37.1
6	Rampura village	1.175	2.6547	2.7714	0.1167	69.44	40.1	35.6

Fig. 5: Working performance of Envirotech APM 460 NL & Envirotech APM 550 NL

3.2 Sampling and the Analysis of $PM_{2.5}$ with Envirotech APM 550 NL

The principle of this method is to measure the dust particle size of 2.5 micrometers and smaller which are very harmful for the human body. In this a electric powered motor is used for the monitoring of the ambient air at the average flow rate of 16.7 lpm which is maintained by a mass flow or volumetric flow controller that is coupled to a microprocessor into initial particle size impactor which is known as the cyclone. The particular size separator separates the particulate matter of 2.5 micrometer size by the collection of 47 mm polytetrafluoroethylene (PTFE) filter over a specified sampling period. The filter paper would be weighted carefully before and after of the sampling to determine the net value of the particulate matter.

Following equation is used to calculate the mass of fine particulate matter on the filter paper:-

$$M_{2.5} = (Mf - Mi) \text{ mg} \times 10^3 \text{ µg}$$

Where,

$M_{2.5}$ = total mass of fine particulate collected during sampling period (µg)

Mf = mass of the filter paper after sample collection (mg)

Mi = initial mass of the filter paper before sample collection (mg)

10^3 = unit conversion factor for milligrams (mg) to micrograms (µg)

Now the volume of air sampled can be calculated according to the given formula below

$$V = Qavg \times t \times 10^{-3} \text{ m}^3$$

Where,

V = total sample value (m^3)

Qavg = average flow rate over the entire duration of the sampling period (L/min)

t = duration of sampling period (min)

10^3= unit conversion factor for liters (L) into cubic meters (m^3)

Now to determine $PM_{2.5}$ mass concentration:-

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$$PM_{2.5} = M_{2.5} / V$$

Where,

$PM_{2.5}$ = mass concentration of $PM_{2.5}$ (μg/m³)

$PM_{2.5}$ = total mass of fine particulate collected at the time sampling period (μg)

V = total volume of air sampled according to the above equation (m³)

Table 4 Ambient air quality monitoring for PM2.5 at core (working) zone

S. NO	LOCATION NAME	AFR $PM_{2.5}$ (lpm)	FILTER PAPER WEIGHT INTIAL (gm)	FILTER PAPER WEIGHT FINAL (gm)	WT. OF $PM_{2.5}$ (gm)	$PM_{2.5}$ (μg/ m³)	Tem (°C)	Hum-Idity (%)
1	Mine office	16.7	0.14896	0.14523	0.00059	24.68	39.7	34.1
2	View point of crusher area	16.7	0.14787	0.14849	0.00062	26.17	38.6	36.4
3	Screen machine area	16.7	0.14523	0.14596	0.00073	30.68	36.6	35.5
4	New drilling area	16.7	0.14523	0.14596	0.00073	30.70	38.6	36.4
5	New drilling point	16.7	0.14879	0.14953	0.00074	30.97	37.9	37.4
6	Belt no. 12 reject area	16.7	0.14698	0.14762	0.00064	26.63	40.1	35.6
7	Mine area 435 metres.	16.7	0.14321	0.14386	0.00065	27.17	39.5	36.5
8	Near crusher	16.7	0.14441	0.14510	0.00069	28.79	37.9	34.3
9	Dump at waste	16.7	0.14789	0.14859	0.00070	29.40	39.9	31.3
10	Mine area 453 metres.	16.7	0.14658	0.14724	0.00066	27.46	40.5	35.5

Table 5 Ambient air quality monitoring for PM2.5 at buffer (Village) zone

S. NO	LOCATION NAME	AFR $PM_{2.5}$ (lpm)	FILTER PAPER WEIGHT INTIAL (gm)	FILTER PAPER WEIGHT FINAL (gm)	WT. OF $PM_{2.5}$ (gm)	$PM_{2.5}$ (μg/ m³)	Tem (°C)	Hum-Idity (%)
1	Basantgarh village	16.7	0.14787	0.14855	0.00068	28.68	39.7	34.1
2	Adarsh village	16.7	0.14444	0.14504	0.00060	24.95	38.6	36.3
3	Rohida village	16.7	0.14514	0.14580	0.00066	27.64	36.6	34.1
4	Puravto ki phali	16.7	0.14784	0.14841	0.00057	23.73	38.6	34.1
5	Silwa village	16.7	0.14783	0.14845	0.00062	25.96	37.9	37.5
6	Rampura village	16.7	0.14556	0.14627	0.00071	29.65	40.1	37.6

4 RESULTS FROM DUST MONITORING

4.1 Results for PM_{10}

According to the objective of project the results are described from the field investigation and laboratory work done at different points of mine for different dust parameters with various of technology.

Fig. 6: Weight monitoring of filter paper for PM_{10} concentration

As according to the object the dust parameters which are measured at the working zone of mine area consider the higher range of dust particles as compare to near environmental baseline condition that mean it is clearly shown from the dust particulate values in the core zone and the buffer zone the dust concentration at the core zone is high compare to the buffer zone.

Table 6 Concentration of PM_{10} particles at core zone

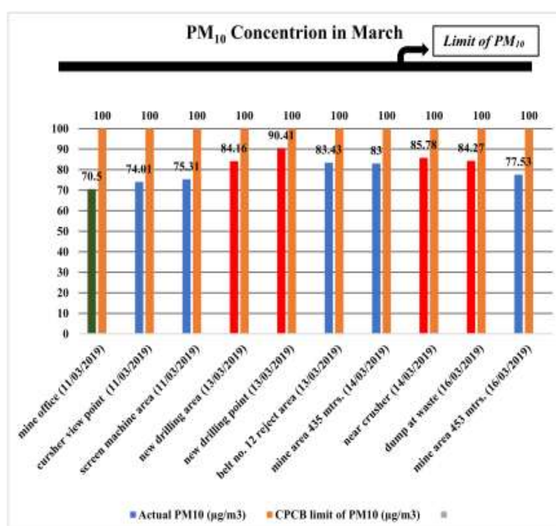
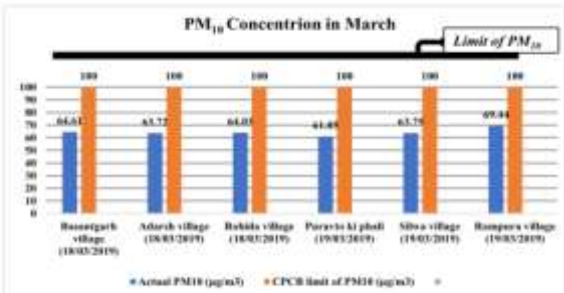


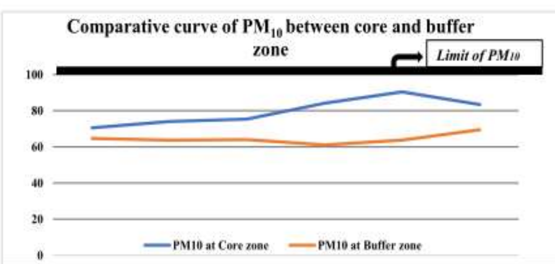
Table 7 Concentration of PM_{10} particles at buffer zone



In the above chart the concentration of dust is high in Rampura and Basantgarh villages because the Rampura village was nearly 1.9 km to the crusher point and Basantgarh village was 3 km from the working face zone where the drilling is going on.

Above two tables resulted the Comparative curve of PM_{10} between core and buffer zone table 8 shows that the concentration of dust PM_{10} at core zone is higher than buffer zone.

Table 8 Comparison curve of PM_{10} between core and buffer zone



4.2 Results for $PM_{2.5}$

Fig. 7: Weight monitoring of filter paper for $PM_{2.5}$ concentration

Table 9 Concentration of $PM_{2.5}$ particles at core zone

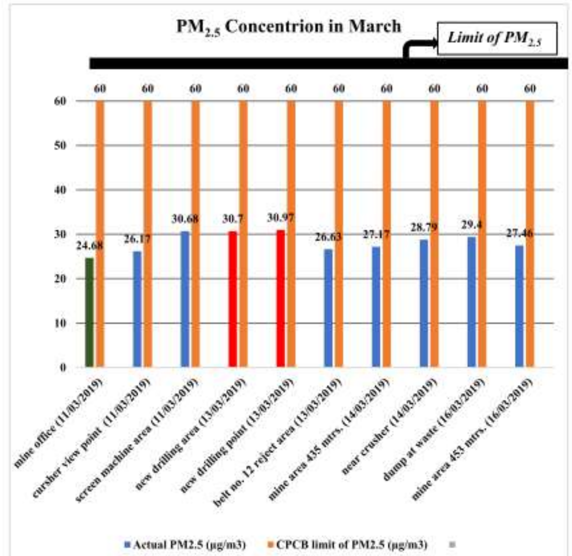
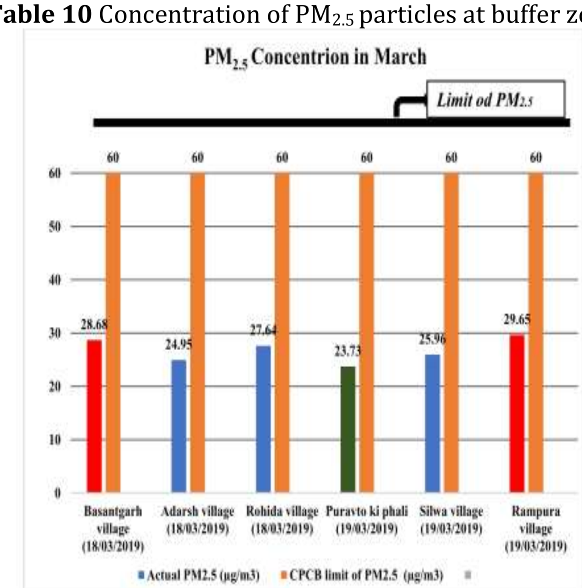
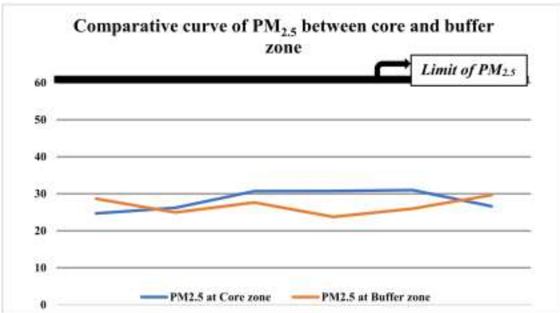


Table 10 Concentration of $PM_{2.5}$ particles at buffer zone



In the Puravto ki phali (23.73) which is 5 km far from the mine boundary so the dust concentration in this village is comparatively less to the other villages so it is shown in the green zone. In the above chart the concentration of dust is high in Rampura and Basantgarh villages because the Rampura village (29.65) was nearly 1.9 km to the crusher point and Basantgarh village (28.68) was 3 km from the working face zone where the drilling is going on.

Table 11 Comparison curve of $PM_{2.5}$ between core and buffer zone



the concentration of dust $PM_{2.5}$ at core zone is higher than buffer zone but in the Basantgarh and Rampura villages the dust concentration is greater than to core zone so that's why graph lines are intersecting each at these two pints below.

5. CONCLUSIONS

In this study many achievements have been made for fighting dust problems viz-a-viz generation, localization and suppression during blasting and haul roads, which are most important sources in dust generation.

In addition to present procedure, the dust expansion can be reduced by effective water spraying technology at haul roads. The dust which is expanded from the drilling is controlled with the new wet drilling technology.

The flyrock, air blast and ground vibrations are the damages from blasting which can be controlled with the proper stemming material and air-decking techniques. At the place of air decking or other filling material water bags can be used as the stemming media, basically the water bags reduce higher flyrock and ground vibrations. This technology minimize the concentration of dust in the surrounding areas.

To prevent/reduce the dust expansion at the site of shovel dumper combination, movable or customized stationary water sprinkler system can be deployed as these sites contribute maximum in dust expansion.

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