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Monitoring and Prediction of Fugitive Dust Concentration in an Opencast Coal Project Using AERMOD

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***Abstract*— This paper focuses on the real time monitoring of dust level at different sources of a mechanised coal mine using DustTrak II and finally prediction of dust concentration at different locations of the mine and nearby areas using AERMOD view software. The paper summarizes the findings of dust measurement at different work places in different size range PM10, < 4 micron, < 2.5 micron and , <1 micron and using meteorological data and AERMOD software dust concentration around the mine were predicted. The predicted value of dust concentrations (PM10) were compared with NAAQS-2009 standard.**

***Keywords*— fugitive dust, coal mine, dusttrak II, AERMOD**

I. Introduction

Dust generation and its dispersion has been the major concern in large opencast coal projects. Airborne dust below 10 micron size can result in significant health risk to miners. Monitoring fugitive dust concentrations from different sources is essential in opencast coal mines and can be done using DustTrak II. Opencast coal mining involves various operations e.g. overburden removal, drilling, blasting, mineral loading, haulage and unloading that generate particulates due to various mechanisms. It has been observed that out of total particulates generated, the PM_{10} constitute one-third to half (Ghose & Majee, 2007; Trivedi et al., 2009). Air dispersion models predict the ambient air concentrations of a compound at specific spatial locations (called receptors) using mathematical equations that represent the numerous and complex meteorological processes responsible for dispersion.

II. Materials and Methods

A. *Study area*

The study area (Lakhanpur OCP) is situated in Jharsuguda district in Orissa. It lies between latitudes 21’43’30” to 21’46’44” and longitudes 83’49’11” to 83’52’38”. The mine was divided into 3 quarries, i.e. quarry1 to quarry 3. The total mines area was about 4.84 km2.In this area as mining operation is the main activity, dust pollution is the dominating factor for air pollution. There are different sources identified in that area for generation of dust like haul road, surface miner, drilling, loading- unloading, and transportation etc.

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B. *Dust Measurement and Dispersion Modelling*

The dust concentration was monitored by using an instrument DustTrakII. Different size selectors like PM10, PM4, PM2.5 and PM1 were used in a sequence for a period of 1hour to determine dust concentration at selected sampling locations with different operational activity. Dispersion modelling is a modern tool for prediction of pollution concentration at different locations within or surrounding the mining area. In this study AERMOD software was used for prediction of dust dispersion.

The emission rate for mining operation was calculated by an empirical formula given by Chaulya et al. (2002):

Emission of SPM for Overall mine is given in Eqn.1

$$E=[u^{0.4} a^{0.2} \{9.7+0.01p+b/(4+0.3b)] \quad (1)$$

Where,

u: wind speed (m/s),

P: coal/mineral production (MT/Annum),

b: OB handling (Mm3/Annum);

E: emission rate (g/s).

The emission rate for the coal mine was calculated as, E =22.284 g/s and was used in the AERMOD view software.

III. Results and discussion

A. *Dust Monitoring*

Monitoring was done by DustTrak II at nearly 9 locations and the result are tabulated in Table 1.The results show that at all the operational points the dust concentration was very high. The drilling

TABLE 1: REAL-TIME AEROSOL MONITORING RESULT AT DIFFERENT LOCATION

Locations		Average dust concentration (mg/m3)				Maximum dust Concentration (mg/m3)			
	Location Code	*1µm*	*2.5µm*	*4µm*	*10µm*	*1µm*	*2.5µm*	*4µm*	*10µm*
Shovel-dumper	A1	1.800	0.958	0.787	0.474	39.400	62.600	13.700	4.350
Surface Miner	A2	13.300	8.350	4.860	2.470	150.000	146.000	103.000	110.000
Drilling	A3	8.730	11.100	30.500	26.800	150.000	150.000	150.000	150.000
Wet Haul Road	A4	0.631	0.487	0.428	0.483	23.100	1.780	3.080	4.080
Transportation Road	A5	1.500	0.642	0.604	0.587	12.300	2.320	14.200	2.830
Office of Colliery Manager	A6	0.456	0.421	0.414	0.480	6.500	1.140	1.360	3.810
OB Bench (Before blasting)	A7	1.550	0.538	0.467	1.420	20.000	5.680	12.100	62.000
OB Bench (After blasting 1)	A8	*	*	*	1.420	*	*	*	10.600
OB Bench (After blasting 2)	A9	*	*	*	1.590	*	*	*	122.000

accounts for maximum values of dust concentration. The blasting point and loading-unloading point shows somehow high concentrations of dust during operation and the average concentration were comparatively lower in those areas. As blasting is an instantaneous operation so to collect values for all size of particles with the instrument is not possible. For that reason only monitoring was done for 10µm only.

B. Meteorological analysis of the area

Meteorological data was collected from the nearby whether station. AERMET file which was used as an input file in the AERMOD. Cloud Cover (tenths), Dry Bulb Temp (°C), Relative Humidity (%),Station Pressure (mbar), Wind Direction (deg), Wind Speed (m/s), Ceiling Height (m), Hourly Precipitation (1/100 th of inch), Global Horizontal Radiation (Wh/m2) were taken as meteorological parameter for the study. Wind rose plot is shown in Fig.1. The result shows that 34.17% time wind was in calm condition.

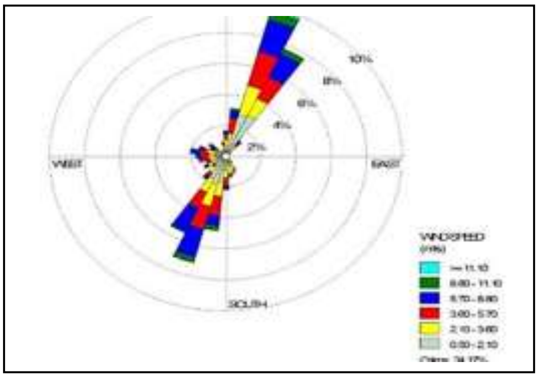

Figure 1: Wind rose

C. Modelling by using AERMOD software

The prediction was done for about 30 different locations for both 24 hour average and annual average value, present near to the mine and the result is shown in the Table 2. The values from the table shows that at some locations like Tringismal, Khuntmahul, Karlajori, Khairkuni the values are far above the standard level for both 24 hour and annual data. Those areas are falling within the mining area. Following those areas Khaliapali and Banjipali showing high values above standard level. Beheramal, Soldia, Banjari, Belpahar, Samra, Piplimal, Kudaloi, Darlipali, Ubuda, Charla areas showing dust level just above the standard level. Apart from those area all other showing values within the norms.

The modelling pictures gives the ideas of dust concentration at different location around mine. Color scale was used to specify the level of dust at different location in that software. The central orange-red color specifies the highest concentration of dust within the mining area. The color gradually changed green and then purple color indication gradual decrease in the dust concentration level. The model also obtained by incorporation of google earth for 24 hour maximum value and annual average value. Figure 2 and Figure 3 shows the 24 hour maximum value and annual average value on google earth map, indicating direct concentration level at specific sources.

TABLE 2. PREDICTION OF CONCENTRATION FOR PM10 AT DIFFERENT AREAS AT AND AROUND LAKHANPUR OPEN CAST PROJECT (LOCP)

Location	Location Code	Predicted Value (µg/m3)						NAAQS Standards (µg/m3)	
		24hr			Annual			*24hr*	*Annual*
		Min.	*Max.*	*Avg.*	*Min.*	*Max*	*Avg.*		
Lakhanpur	C01	23.8	50	36.9	0	0	0	100	60
Mauliberena	C02	23.8	50	36.9	0	0	0	100	60
Beheramal	C03	200	500	350	30	50	40	100	60
Soldia	C04	200	500	350	30	50	40	100	60
Bartap	C05	100	200	150	10	30	20	100	60
Banjari	C06	200	500	350	10	30	20	100	60
Belpahar	C07	200	500	350	30	50	40	100	60
Samra	C08	200	500	350	10	30	20	100	60
Piplimal	C09	200	500	350	30	50	40	100	60
Kudaloi	C10	200	500	350	50	60	55	100	60
Tingismal	C11	1000	2000	1500	300	500	400	100	60
Khuntmahul	C12	1000	2000	1500	600	800	700	100	60
Karlajori	C13	1000	2000	1500	300	500	400	100	60
Khairkuni	C14	1000	2000	1500	100	300	200	100	60
Khaliapali	C15	500	900	700	100	300	200	100	60
Adhapara	C16	70	90	80	0	0	0	100	60
Banjipali	C17	500	900	700	100	300	200	100	60
Darlipali	C18	200	500	350	30	50	40	100	60
Kushraloi	C19	100	200	150	8.6	10	9.3	100	60
Ubuda	C20	200	500	350	30	50	40	100	60
Charla	C21	200	500	350	10	30	20	100	60
Khadam	C22	100	200	150	10	30	20	100	60
Bandhbahal	C23	100	200	150	10	30	20	100	60
Sarandamal	C24	100	200	150	10	30	20	100	60
Dalgaon	C25	100	200	150	0	0	0	100	60
Negipali	C26	50	70	60	0	0	0	100	60
Kirarama	C27	100	200	150	8.6	10	9.3	100	60
Katapali	C28	100	200	150	0	0	0	100	60
Kudopali	C29	90	100	95	0	0	0	100	60
Baliput	C30	70	90	80	0	0	0	100	60

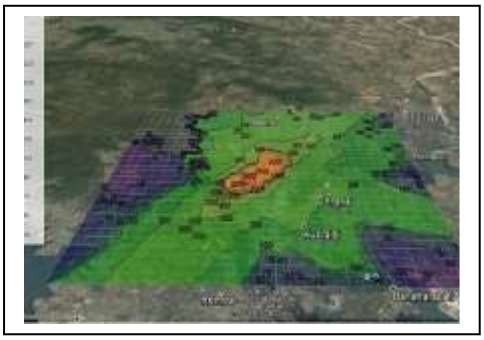

Figure 2: Highest 24 hour dust concentration Isopleths as seen in Google earth

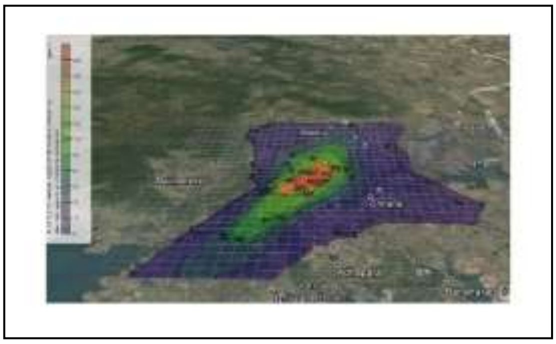

Figure 3: Annual average dust conc. Isopleths as seen in Google earth

IV. Conclusion

The data from above field monitoring of dust concentrations using DustTrak-II at LOCP, it can be suggested that the maximum dust concentration was obtained at drilling point with average concentration of 26.8 mg/m3 and maximum concentration of 150.000mg/m3 in PM10 range. Minimum mean dust concentration was found at loading point at 0.474mg/m3 for ≤ PM10. Drilling and Surface Miner operations were found to be the major sources of dust generation in mining operation.

The dispersion modelling of AERMOD suggest that at most of the places at and around LOCP, the dust concentrations were found to be below NAAQS limit of 100 µg/m3 except at Tingismal, Khuntmahul, Karlajori, Khairkuni, Khaliapali, Banjipali. For 24hr period, dust concentration for PM10 at all other places except at Bartap, Adhapara, Lakhanpur, Mauliberena, Charla, Sarandamal, Dalgaon, Negipali, Kirarama, Katapali, Kudopali and Baliput, were found to be above NAAQS limit of 60 µg/m3.

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Dr. Debi Prasad Tripathy is working as Professor in the Department of Mining Engineering at National Institute of Technology, Rourkela since 2008. He has published more than 150 research and technical papers in reputed International and National Journals/Conferences and authored 6 books. He is an active member of several professional bodies: Chartered Engg. and FIE (I), IRED, FUWA, FISRMTT, LISTE, MMGMI and LMEAI. He has visited USA, Australia, Canada, South Africa, Papua New Guinea, Botswana and Singapore on various academic assignments.