Generation and Dispersion of Total Suspended Particulate Matter Due to Mining Activities in an Indian Opencast Coal Project

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1. Introduction

The knowledge of ambient air quality plays an important role in assessing the environmental scenario of the region. The ambient air quality status in the vicinity of the mining activities forms an indispensable part of the Environmental Impact Assessment Studies. The quality of ambient air depends upon the concentrations of specific contaminants, the emission sources and meteorological conditions. The mining activities contribute to the problem of air pollution directly or indirectly (Trichy ,1996, Corti and Senatore, 2000, Baldauf *et al.*, 2001 and Collins *et al.*, 2001). Coal dust is the major pollutant in the air of open cast coal mining areas. (Kumar *et al.*, 1994, Vallack and Shillito, 1998. and CIMFR, 1998) The primary source of fugitive dust at fully operational surface mine may include overburden (OB) removal, blasting, mineral haulage, mechanical handling operations, minerals stockpiles and site restoration (Appleton *et. al.* 2006). Major air pollutants due to opencast mining are total suspended particulate matter and respirable particulate matter whereas concentration of SO_2 and NO_X is negligible (Sinha and Banerjee, 1997, CIMFR, 1998, Banerjee, 2006, and Trivedi *et. al.*, 2009).
Transportation of materials is the major source of TSPM generation in the mining areas. The vehicle and haul road intersection has been identified as the most critical source producing as much as 70% of total dust emitted from surface coal mines (Muleski and Cowherd, 1987, Sinha and Banerjee, 1997, Ghose and Majee, 2002), while it was accounted to be 80-90% of the PM_{10} emission (Cole and Zapert, 1995). Maximal concentrations of particulate matter are generally occurred during winter and minimal in the rainy season.(Ghose and Majee, 2000, Tayanc, 2000, Reddy and Ruj, 2003). However, in certain urban areas maximal concentrations of particulate matters are also observed in summer season (Crabbe *et al.*, 2000, Almbauer *et al.*, 2001, Triantafyllou *et al.*, 2002 and Triantafyllou, 2003). The dispersion of particulate matter follows the annual predominant wind direction of an area (Corti and Senatore, 2000, Baldauf *et al.*, 2001 and Pandey *et. al.*, 2008).
Such a large amount of dust generated cause safety and health hazards such as poor visibility, failure of mining equipment, increased maintenance cost etc which ultimately lowers the productivity. A prolonged exposure to air borne dust may cause to damage of lung tissues of the miners which may further lead to pneumoconiosis or black lung disease. The maximum tissue damage is caused by the dust of 5 microns lesser sizes since such particles reach the alveoli of the lung (Peavey et. al, 1985). These air pollutants reduce air

quality and this ultimately affects people, flora and fauna in and around mining areas (Crabbe *et al.*, 2000, Wheeler *et al.*, 2000). Implementation of effective air quality control measures by the mining company are needed and green belts development can be devised wherever necessary (Kapoor and Gupta, 1984, Sharma and Roy, 1997, Shannigrahi and Sharma, 2000, Chaulya, 2004).

In the present study, an attempt has been made to generate ambient air quality data, micro-meteorological data, source-wise emission inventory data for an Indian coal mine namely Padampur Opencast Coal Project (O.C.P.) of Western Coalfields Ltd. (W.C.L.), India. The status of TSPM and PM_{10} concentration in ambient air has been monitored through a well defined at monitoring network. In the light of micro-meteorological data such as wind speed, stability class etc, dispersion coefficients of the dust for vertical as well as horizontal direction have been estimated. A correlation between TSPM and PM_{10} concentration has been sought out. Emission inventory data for all point, area and line sources of TSPM at Padampur OCP have been generated for the determination of emission rates. Air Pollution modeling has also been attempted using Fugitive Dust Model (FDM) developed by United States Environment protection Agency (USEPA). FDM has been used for the validation of the study by comparing predicted and observed values. FDM is a computerized Gaussian Plume Air Quality Model, specifically designed for the estimation of the concentration and deposition impacts from fugitive dust sources. FDM employs an advance transfer particle deposition algorithm.(USEPA, 1995). The model gives hourly average, long term concentration and deposition of particulate matters at all user selected receptor locations. FDM represents the behavior of particles in the atmosphere most accurately. Since terrain features are not included in FDM, it can be used only for local scale.

2. Materials and method

2.1 Field settings at OCP

As mentioned earlier that Padampur OCP is selected for the study purpose. Padampur OCP is located at Chandrapur district in Maharastra State of India. The Project is located between latitudes 20^0 2′ N to 20^0 3′ N and Longitudes 79^0 17′ E to 79^0 19′ E and is covered by Survey of India Toposheet No 55 P/8. Geologically the area forms the central part of eastern limb of Regional anticline structure of Wardha Valley Coalfield of Western Coalfields Limited (WCL). The area is undulating with few isolated ridges of Kamthi Sandstone. The area covers two separate and adjoining geological blocks namely Padampur and Motaghat blocks. The net geological reserve of Padampur OCP is about 43.5 Million Tones. The annual production is 1 Million Tones with an average stripping ratio of 3.7 m^3/tones. The coal produced from the mine is of non-coaking type with 'D' and 'E' grade. The shovel dumper combination is being used to excavate the overburden as well as coal. The shovels of 4.6 m^3 bucket capacity and dumpers are of 35 Ton capacities have been deployed in the field. Backfilling is also practiced simultaneously with the production of coal.

Micrometeorological data collection is an indispensable part of any air pollution study. The data collected during air quality survey are used for proper interpretation of existing ambient air quality status. The ambient air quality monitoring was carried out through reconnaissance followed by air quality surveillance program and micrometeorological study of the area. A weather monitoring station and SODAR have been installed at study site. The weather monitoring station measures ambient air temperature in degree centigrade, wind speed in km. per hour and wind direction in degrees from north. It also measures relative humidity, barometric pressure, and total rainfall. Site specific relevant parameters like mixing height and stability class have been accurately measured by SODAR. The amount of

turbulence in the ambient air has a major effect upon the rise and dispersion of air pollutant plumes. The amount of turbulence is categorized into "stability classes". The most commonly used categories are the Pasquill stability classes A, B, C, D, E, and F. Class A denotes the most unstable or most turbulent conditions and Class F denotes the most stable or least turbulent conditions. The most common procedure for estimating the dispersion coefficients was introduced by Pasquill (1961), modified by Gifford (1961) and adopted by the U.S. Public Health Service (Turner, 1970).
Meteorological data has been collected from the nearest Indian Meteorological Department (IMD) station at Nagpur, India. The climate of the area is tropical. Summer is well defined from April to June, followed by rainy season from July to September and winter from December to February. May is the hottest month with temperature rising to a maximum of around 48^{0}C. December is the coldest month when the temperature falls down to about 10^{0}C. The mean annual rainfall is around 1250 mm. Wind direction is generally from North and Northwest, with velocities up to 6-7 Km./hour during monsoon and about 3-4 Km./hour in winter. Relative humidity varies from 74-83% during August and September and is about 15-20% during summer. Wind rose diagram during the study period is illustrated in Fig.1.

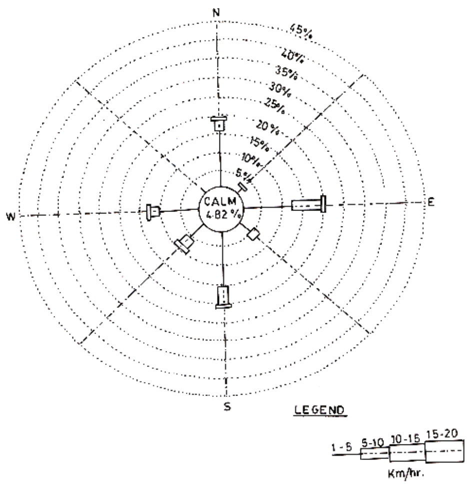

Fig. 1. Wind Rose Diagram of Padampur OCP

2.2 Ambient air quality monitoring

The ambient air quality status in the impact zone was assessed through a network of ambient air quality monitoring locations. The studies on air environment include identification of specific air pollutants for assessing the impacts of proposed mining projects including other activities. Air quality monitoring was carried out in winter season. Among the ambient air quality parameters, Total Suspended Particulate Matter (T.S.P.M.) and Respirable Particulate Matter (PM_{10}.) have been measured at 8 hours interval for 24 hours using the High Volume Sampler with Respiratory Particulate Matter measurement arrangement with the standard methods as shown in Table 1. Other air qualities parameters are not considered because of their concentrations are found much below the threshold value in the study area.
The existing status of air environment was assessed through a systematic air quality surveillance program in which five ambient air quality stations have been selected to know

the air quality of the area. The measured data of TSPM and PM_{10} are shown in Table 2 along with the arithmetic mean and standard deviation (S.D.) of the measured data.

Para meter	Time weighted Avg.	Concentration in Ambient Air	Method	Instruments
TSPM	Annual 24 hours	430 µg/ m^3 600 µg/ m^3	IS-5182 Part XIV	High Volume Sampler with PM_{10} Measurement arrangement (Av. Flow rate not < 1.1 m^3/min)
PM_{10}	Annual 24 hours	215 µg/ m^3 300 µg/ m^3	IS-5182 Part XIV	High Volume Sampler with PM_{10} Measurement arrangement (Av. Flow rate not < 1.1 m^3/min)

(Source: Central Pollution Control Board Notification, 1994)

Table 1. Air Pollutant Analysis Methods: Coal Mine Standards

Sl. No.	Sample Site	TSPM (µg/ m^3)		PM_{10} (µg/ m^3)		PM_{10} (Percent of TSPM
		mean	S.D.	mean	S.D.	
1	Filter Plant	294.30	21.67	120.34	18.90	40.89
2	SAM Office	631.72	58.44	120.03	21.55	19.00
3	Kitadi Village	390.30	32.20	103.03	25.90	26.39
4	Padampur Village	654.38	54.55	130.88	12.15	20.00
5	Manager Office Sec-IV	1078.10	75.56	226.40	35.60	20.99

Table 2. Table Showing Ambient Air Quality of Padmapur OCP

2.3 Source-wise emission inventory details

Emission inventory details have been collected by installing two High Volume Samplers at down wind sides and, to know the back ground concentration, one High Volume Sampler at up wind side of the TSPM source. High Volume Samplers are placed at a distance nearly 100m from the source Emission data have been generated for various mining activities such as overburden loading, coal loading, haul road transportation, unloading of overburden, unloading of coal, stock yard, exposed overburden dumps, coal handling plant, exposed pit face and workshop. Blasting being an instantaneous source was monitored separately which is not included in the present study.

The modified Pasquill and Gifford formula for ground level emission has been used to calculate the emission rate.

$$C(x,0) = \frac{Q}{\Pi u \, \sigma y \, \sigma z}$$

Where, C(x,0) =DN max - UP

C (x, 0), Difference in pollutant concentration , µg/.m; DN max, maximum concentration in down wind direction; UP, back ground concentration in up wind direction; Q, Pollutant emission rate, µg/s; Π, 3.14159; u, Mean wind speed, m/s; σy, Standard deviation of horizontal plume concentration, evaluated in terms of downwind distance x, m (as shown in Fig. 2); σz, Standard deviation of vertical plumes concentration, evaluated in terms of downwind distance x, m (as shown in Fig. 3).

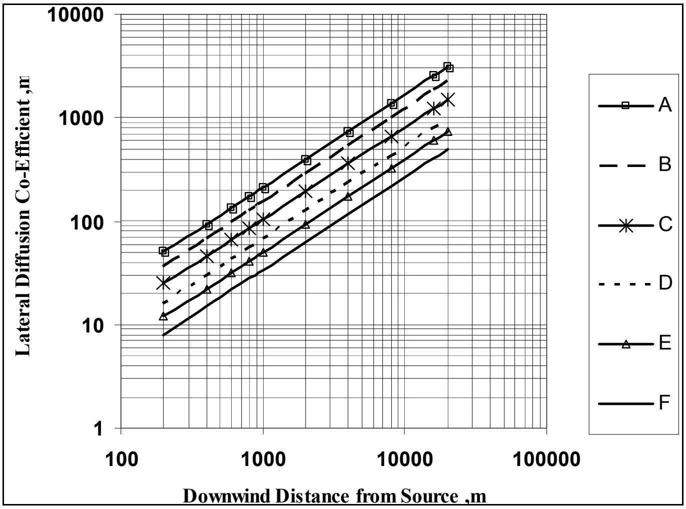

Fig. 2. Lateral Diffusion Co-Efficient Vs Downwind Distance from Source (Source : Turner, 1970).

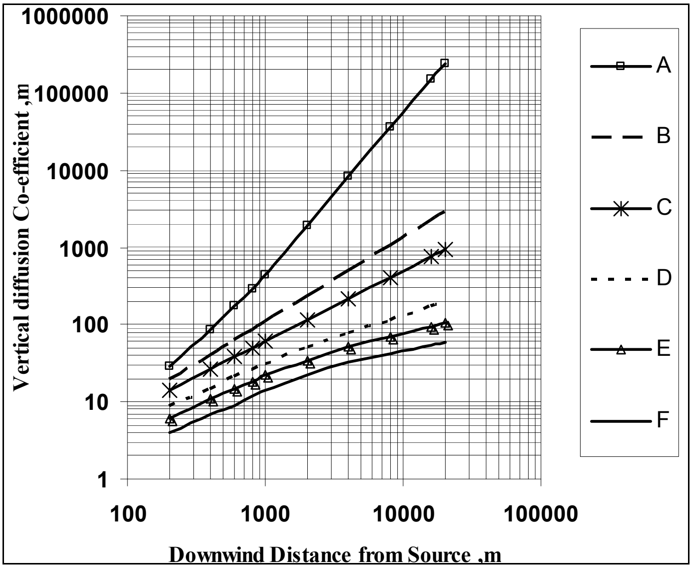

Fig. 3. Vertical diffusion Co-efficient Vs Downwind Distance from Source (Source : Turner, 1970).

Source-wise emission inventory has been shown in Table 3. Source-wise emission properties such as moisture content silt content etc. measured from the samples collected during field study have been placed in Table 4. Secondary data affecting TSPM emission such as frequency of drilling, vehicle movement on the haul road and transport road etc have also been collected as shown in Table 4.

TSPM source	TSPM Concentration (μg/m³)				Wind velocity, m/s	Diffusion coefficient		Emission Rate	
	DN Min	DN Max	UP	DN_{max} -UP		σy, m	σz, m	Unit	Value
Drilling	1340	1758	1233	525	2.1	14	8	g/s	0.3877
Overburden Loading	1234	1660	1108	552	2.4	14	8	g/s	0.4659
Coal Loading	1648	2092	1377	715	2.1	14	8	g/s	0.5218
Haul Road	1963	2498	1336	1162	3.1	14	8	g/ms	0.0127
Transport Road	2015	2605	1387	1218	3.1	14	8	g/ms	0.0132
Overburden Unloading	1195	1605	942	663	1.9	18	12	g/s	0.8544
Coal Unloading	1438	1897	1135	762	2.0	14	8	g/s	0.5360
Exposed Overburden dump	1030	1387	1002	385	2.5	24	16	g/m²s	0.0000363
Stockyard	1482	1872	1027	845	1.8	14	8	g/m²s	0.0001981
Workshop	1062	1478	1040	438	1.7	25	15	g/m²s	0.0000878
Exposed pit surface	1015	1357	985	372	1.0	15	32	g/m²s	0.0000160
Overall mine	469	713	365	348	2.4	95	60	g/m²s	0.0000108

Table 3. Source-Wise TSPM Emission Inventory at Padmapur OCP

TSPM sources	Source type	Moisture content, %	Silt content, %	Emission rate		Remarks
				Unit	Value	
Drilling	Point	7.4	38.0	g/s	0.443	Hole dia 160 mm;12 hole/day
Overburden Loading	Point	7.6	13.6	g/s	0.4867	drop height 1.4 m; frequency 23 no/hr
Coal Loading	Point	8.1	10.9	g/s	0.5783	drop height 0.9 m; frequency 23 no/hr
Haul Road	Line	12.4	34.5	g/ms	0.0144	Frequency 18 no/hr; average speed 2.6m/sec;
Transport Road	Line	9.8%	30.0	g/ms	0.0146	Frequency 27 no/hr; Average speed 10 m/sec.
Unloading of Overburden	Point	7.2	14.2	g/s	1.2740	Frequency 10 no/hr ;drop height 14.3m.
Unloading of coal	Point	8.0	11.2	g/s	0.7333	Frequency 7 no/hr; drop height 2.5 m
Exposed Overburden dump	Area	7.4	8.2	g/m²s	0.00004	dump area 0.029 sq. km
Stock yard	Area	6.0	12.5	g/m²s	0.00024	Unloading freq. 3 No/hr; loading freq. 12.0 No/hr
Work shop	Area	12.4	31.8	g/m²s	0.0001	Area 5000 sq. m
Exposed pit	Area	8.1	7.8	g/m²s	0.00002	Exposed area 0.03 sq.km.

Table 4. Source Wise TSPM Emission Properties

3. Results and discussion

Air pollution modeling has been exercised with the help of Fugitive Dust Model (FDM). The input parameters include source types, dust concentration near sources, hourly meteorological data such as wind speed and direction, temperature atmospheric stability and receptor locations. All data depicted the average value for the study period. Emission source has been demarcated in three categories of sources like point, line and area sources using mine plan. All these sources have been numbered for preparation of data sheet. Emission rate has been assigned to each activity as per the field measurement data in the mine. From the modeling exercise, TSPM concentrations at certain receptor locations have been predicted. The receptor locations have been selected such that these are exactly same of one where ambient air quality measurement was carried out. The predicted values at receptor locations have been added to regional background levels to get the total predicted TSPM concentration. Regional background data are the average of the monitored data in no activity zone. The predicted and observed TSPM concentrations at receptor locations for different mines are listed in Table 5 and Table 6.

Field observations of ambient air quality of Padampur OCP have been placed in the Table 2. The Ambient Air quality at the five sites of Padmapur is well within the limit except Manager Office sec IV The higher value of TSPM and PM_{10} at Manager Office sec IV may be contributed by the presence of main transport road and other industries nearby. The 24-hr average of TSPM concentrations ranged from 294.3 to 1078.1 μg m^{-3} in industrial area i.e. mining area and from 390.3 to 654.38 μg m^{-3} in residential area respectively. The 24-hr average of PM_{10} concentrations ranged from 120.34 to 226.4 μg m^{-3} in industrial area and from 103.03 to 130.88 μg m^{-3} in residential area respectively as shown in Table 2. On average the PM_{10} in the ambient air constituted 19.00 % to 40.89 % of the TSPM in mining area and 20.00 % to 26.39 % of the TSPM in residential area. The concentration of particulate matters vary with the meteorological parameters and a relation also exist between TSPM and PM_{10} (Tayanc, 2000, Jones *et al*., 2002, Triantafyllou *et al*., 2002, Triantafyllou, 2003, Chaulya, 2004). The case under study also reveals that there exists a relationship between TSPM and PM_{10} concentrations. Linear regression correlation coefficient (R^2) between TSPM with PM_{10} has been found to be 0.8116 as shown in Fig. 4. With the help of FDM, TSPM concentration at five monitoring stations has been predicted. The variation between measured and predicted values, as shown in Table 5 and fig. 6 , may be due to non-accountability of emission from various other sources like non-mining area activities, domestic use of fuels, transportation network nearby thermal power plant , cement plant etc. The value of coefficient of correlation between observed values of TSPM Concentration and predicted values by FDM have been calculated to be 0.969

Source-wise emission inventory data placed in Table 3. Stability classes have been found to be B, C & D. It is clearly evident from the Table 3 that among the point sources namely drilling, overburden loading, overburden unloading and coal unloading highest value of emission rates (g/s) has been found in case of unloading of overburden. Among the area sources namely exposed OB dump, stockyard, workshop, exposed pit surface, highest values of emission rate (gm/m^2/s) has been found in case of exposed OB dump. Among the line sources, emission rates have been in case of haul found and transport road to be 0.0127 gm per meter per second and 0.0132 gm per meter per second respectively. In terms of overall TSPM pollution line sources contribute more than other sources because of their lengths and nature of mining operations. This very fact again confirms that the vehicle and haul road intersection is the major source of dust in opencast mines (Muleski and Cowherd, 1987, Sinha and Banerjee, 1997, Ghose and Majee, 2002) Emission rate for whole mine is found 0.0000108 gm per sq. meter per second.

With the help of FDM, TSPM concentration has been predicted at various distances in down wind direction as shown in Table 6. As far as rate of fall in concentration of TSPM with the distance from the source is concerned, an exponential fall in the TSPM concentration with the distance from the source has been observed which can be clearly seen in the Fig. 5. Maximal concentrations of TSPM and PM_{10} have been found to occur within the mine. Again the dust generated due to mining activities does not contribute to ambient air quality in surrounding areas beyond 500 meters in normal meteorological condition as shown in the Table 6. Thus the result matches with the findings of the Several researchers (Hanna *et al*., 1982, Chaulya *et al*., 2001 and Jones *et al*., 2002, Chaulya, 2004) that maximal concentrations of TSPM and PM_{10} are found in a mining area and the concentrations are gradually diminished with increase in distance due to transportation, deposition and dispersion of particles. The value of coefficient of correlation between observed values of TSPM Concentration and predicted values by FDM have been calculated to be 0.9957.

From the emission study, it is quite clear that haul road and transport road were the major contributor to the pollution load of ambient air quality. Therefore proper dust suppression arrangement is to be made. The prevailing practice of water sprinkling does not seem to be adequate. Therefore, the installation of continuous atomized spraying system for haul roads should be used. Exposed overburden dump is another major contributor of pollution load. These dumps not only contribute to air pollution by way of wind erosion but also spread the dump it self. Therefore, judicious, plantation on these dumps is highly recommended. These plantations will not only stabilize the dump but also attenuate the dust emission. Biological reclamation of overburden dumps and wastelands is also essential. Effective control measures at the coal handling plant, excavation area and overburden dumps should also be implemented to mitigate the TSPM emissions at source.

Green belt development around the mining area is highly recommended. The capacity of plants to reduce air pollution is well known (Kapoor and Gupta, 1984, Sharma and Roy, 1997, Shannigrahi and Sharma, 2000, Chaulya, 2004). A Few plant species can be grown around highly polluted areas where dust (TSPM) is the main pollutant as given Table 7. These species not only reduces air pollutants but also retards water and soil pollution.

S. No.	Sample site	Observed value (μg/m³)	Predicted value (μg/m³)
1	Filter plant	294.30	250
2	SAM Office	631.72	540
3	Kitadi Village	390.30	325
4	Padmapur Village	654.38	564
5	Manager Office Sec-IV	1078.10	910

Table 5. Comparison between observed and predicted values of TSPM Concentration

TSPM Source	Predicted values (μg/m³)					
	At source	100 m	200 m	300 m	400 m	500 m
Padampur mine as a whole	698	505	375	260	165	125

Table 6. Predicted values of TSPM Concentration along down Wind Direction

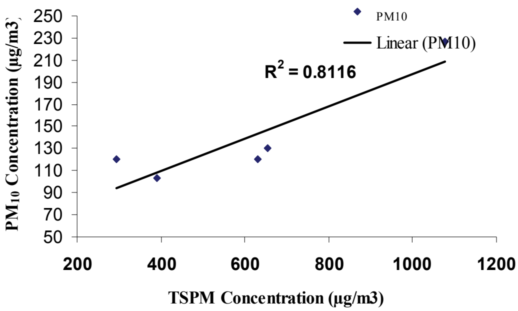

Fig. 4. Correlation between TSPM and PM_{10} Concentration.

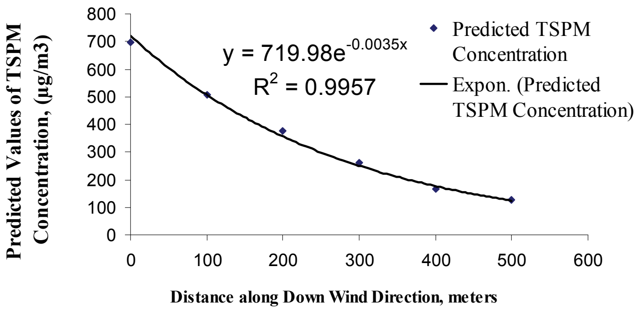

Fig. 5. Relation of TSPM Concetration with Distance from OCP.

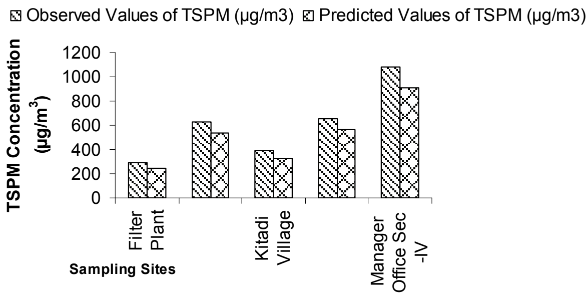

Fig. 6. Comparision between Observedvalues and Predicted Values of TSPM.

Species Name	Family	Local Name of Plants	Evergreen (E) or deciduous
Butea monsperma	Moraceae	Palas	Deciduous
Spathodea companulata	Bignoniaceae	Sapeta	Evergreen
Fiscus infectoria	Moraceae	Pakur	Evergreen
Cassia fistula	Caesalpiniaceae	Amaltas	Deciduous
Anthocephalus cadamba	Rubiaceae	Kadam	Deciduous
Cassia siamea	Caesalpiniaceae	Minjari	Deciduous

Table 7. Recommended pollution retarding plant species for green belt development

4. Conclusions

TSPM and PM_{10} are the major sources of emission from various opencast coal mining activities. The predicted values of TSPM using FDM are 70 percent to 94 percent of observed values. The difference between observed values and predicted values of TSPM indicates that there are non-mining sources of emission viz. domestic transportation network near by mine sites and other industries etc. Fugitive Dust Model (FDM) has been found to be most suitable for modeling of dispersion pattern of fugitive dust at Padampur Opencast Coalmine Project of W.C.L. PM_{10} is the main focus of concern for human health. Correlation between PM_{10} and TSPM would help in predicting the PM_{10} concentration by knowing the concentration of TSPM for a similar mining site. Maximal concentration of TSPM is found in a mining area and the concentrations falls exponentially with increase in distance due to transportation, deposition and dispersion of particles.

Of the various sources of TSPM pollution, line sources contribute more than other sources because of their lengths and nature of mining operations. Among the line sources, emission rates have been in case of haul found and transport road to be 0.0127 gm per meter per second and 0.0132 gm per meter per second respectively. Emission rate for whole mine is found 0.0000108 gm per sq. meter per second. Various management strategies are evaluated for reduction of dust emission at the source and design of green belt with few recommended species is also very effective tool to mitigate air pollution. Proper dust suppression arrangement is to be made including installation of continuous atomized spraying system for haul roads and transport roads. As exposed overburden dump is another major contributor of pollution load, judicious, plantation on these dumps is highly recommended. However, for achieving the effective result to bring down the air pollution level in the mining area a constructive measure at political level is also highly essential. This would lead to an eco-friendly mining and better habitat for all those living in the area.

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6. References

Almbauer, R.A., Piringer, M., Baumann, K., Oettle D., & Sturm P.J. (2001). Analysis of the daily variations of winter time air pollution concentrations in the city of Graz, Austria., *Environmental Monitoring and Assessment,* Vol. 65, pp. 79–87.

Appleton, T.J., Kingman, S.W., Lowndes I.S., & Silvester, S.A. (2006). The development of a modeling strategy for the simulation of fugitive dust emissions from in-pit quarrying activites: a UK case study, International *Journal of Mining, Reclamation and Environment,* Vol. 20, P. 57-82.

Baldauf, R.W., Lane D.D., & Marote, G.A. (2001). Ambient air quality monitoring network design for assessing human health impacts from exposures to air-borne contaminants, *Environmental Monitoring and Assessment,* Vol. 66, pp. 63–76.

Banerjee, S.P (2006). TSP emission factors for different mining activities for air quality impact prediction as collated from different sources, Minetech, Vol. 27, pp. 3-18.

CPCB, *Central Pollution Control Board Notification, India,* (1994).

Chaulya, S.K., Chakraborty, M.K., & Singh R.S.(2001). Air pollution modelling for a proposed limestone quarry. *Water, Air, and Soil Pollution* Vol. 126, pp. 171–191.

Chaulya, S. K. (2004). Assessment and management of air quality for an opencast coal mining area, *Journal of Environmental Management*, Vol. 70, No. 1, pp. 1-14

CIMFR. Central Institute of Mining and Fuel Research (erstwhile Central Mining Research Institute) Report (1998). Determination of Emission Factor for Various Opencast Mining Activities, *GAP/9/EMG/MOEF/97,* Dhanbad, India

Collins, M.J., Williams P.L, & MacIntosh, D.L (2001). Ambient air quality at the site of a former manufactured gas plant. *Environmental Monitoring and Assessment* Vol. 68, pp. 137–152.

Corti, A. & Senatore, A. (2000). Project of an air quality monitoring network for industrial site in Italy. *Environmental Monitoring and Assessment,* Vol. 65, pp. 109–117

Crabbe, H., Beaumont R. & Norton, D. (2000). Assessment of air quality, emissions and management in a local urban environment. *Environmental Monitoring and Assessment,* Vol. 65 , pp. 435–442.

Cole, C.F. & Zapert, J.C. (1995).Air Quality Dispersion Model Validation at Three Stone Quarries, Washington DC, National Stone Association.

Ghose, M.K. & Majee, J. (2000). Assessment of dust generation due to opencast coal mining—an Indian case study. *Environmental Monitoring and Assessment,* Vol. 61, pp. 255–263.

Ghose, M.K. & Majee, S.R. (2000). Assessment of the impact on the air environment due to opencast coal mining -an Indian case study, *Atmospheric Environment* ,Vol. 34, pp. 2791-2796

Gilford, F.A. (1961). Uses of Routine Meteorological Observations for estimating atmospheric Dispersion, *Nuclear Safe*, Vol. 2

Grundnig, P.W., Höflinger, W., Mauschitz, G., Liu, Z., Zhang G., & Wang, Z. (2006). Influence of air humidity on the suppression of fugitive dust by using a water-spraying system, *China Particuology,* Vol. 4, No. 5, pp. 229-233.

Hanna, S.R., Briggs, G.A. &. Hosker, R.P. (1982). Handbook on Atmospheric Diffusion, DOE/TIC-11223, *US Department of Energy, Technical Information Center*

Jones, T. Blackmore, P. Leach, M. Matt, B.K. Sexton K. &. Richards, R. (2002). Characterisation of airborne particles collected within and proximal to an opencast coalmine: South Wales. UK *Environmental Monitoring and Assessment,* Vol. 75, pp. 293–312.

Kapoor, R.K. &. Gupta, V.K., (1984). A pollution attenuation coefficient concept for optimization of green belt. *Atmospheric Environment,* Vol. 18, pp. 1107–1117.

Karaca, M., Tayanc M. &. Toros, H. (1995). The effects of urbanization on climate of Istanbul and Ankara: a first study. *Atmospheric Environment,* Vol. , pp. 3411–3429.

Kumar, C.S.S., Kumar, P., Deshpande, V.P., &. Badrinath S.D. (1994). Fugitive dust emission estimation and validation of air quality model in bauxite mines, *Proceedings of International Conference on Environmental Issues in Minerals and Energy Industry, IME Publications, New Delhi, India,* pp. 77–81.

Muleski G.E. &. Cowherd, C. (1987). Evaluation of the effectiveness of Chemical dust Suppressants on Unpaved Roads, EPA/600/2-87.102. *U.S. Environmental Protection Agency, Research Triangle Park N.C.*, pp-81.

Pandey, S.K., Tripathi, B.D. &. Mishra, V.K. (2008). Dust deposition in a sub-tropical opencast coalmine area, India, *Journal of Environmental Management,* Vol. 86, No. 1, pp. 132-138.

Pasquill, F. (1962). *Atmospheric Diffusion, Van Nostrand Co. Ltd. Londan*

Peavy, H.S., Rowe, D.R. &. Obanoglous, G. Tech (1985). *Environmental Engineering, Megraw Hill, New York*, pp. 668-670.

Reddy, G.S. &. Ruj, B. (2003). Ambient air quality status in Raniganj–Asansol area, India. *Environmental Monitoring and Assessment,* Vol. 189, pp. 153–163.

Roney J. A. &. White, B. R. (2006). Estimating fugitive dust emission rates using an environmental boundary layer wind tunnel, *Atmospheric Environment*, Vol. 40, pp. 7668-7685

Shannigrahi, A.S. &. Sharma, R.C. (2000). Environmental factors in green belt development-an overview. *Indian Journal of Environmental Protection* , Vol. 20, pp. 602–607.

Sharma, S.C. &. Roy, R.K. (1997). Green belt—an effective means of mitigating industrial pollution. *Indian Journal of Environmental Protection* Vol. 17, pp. 724–727.

Sinha, S. &. Banerjee, S.P. (1997). Characterisation of haul road in Indian open cast iron ore mine. *Atmospheric Environment,* Vol. 31, pp. 2809–2814.

Tayanc, M. (2000) An assessment of spatial and temporal variation of sulphur dioxide levels over Istanbul, Turkey. *Environmental Pollution*, Vol. 107, pp. 61–69.

Tichy, J. (1996). Impact of atmospheric deposition on the status of planted Norway space stands: a comparative study between sites in Southern Sweden and the North Eastern Czech Republic. *Environmental Pollution*, Vol. 93, pp. 303–312

Triantafyllou, A.G. (2003). Levels and trends of suspended partcles around large lignite power station. *Environmental Monitoring and Assessment*, Vol. 89, pp. 15–34.

Triantafyllou, A.G., Kyros E.S. &. Evagelopoulos, V.G. (2002). Respirable particulate matter at an urban and nearby industrial location: concentrations and variability, synoptic weather conditions during high pollution episodes. *Journal of Air and Waste Management Association,* Vol. 52, pp. 287–296.

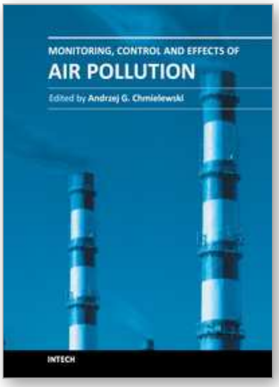
Trivedi, R. Chakraborty M. K., &. Tiwary, B.K. (2009). Dust Dispersion Modeling Using Fugitive Dust Model at an Opencast Coal Project of Western Coalfields Limited, India, *Journal of Scientific and Industrial Research*, Vol. 68, pp71-78

Turner, D.B. (1970).*Workbook of atmospheric Dispersion Estimates*, U.S.E.P.A.,Washington, DC.

USEPA, *United States Environmental Protection Agency* (1995). User's guide for the fugitive dust model (FDM), vol. 1, User Instructions, Region 10, 1200 sixth Avenue, Seattle, Washington, USA.

Vallack, H.W. &. Shillito, D.E. (1998). Suggested guidelines for deposited ambient dust, *Atmospheric Environment*, Vol. 32, No. 16, pp. 2737–2744.

Wheeler, A.J., Williams, I. Beaumont, R.A., &. Manilton, R.S. (2000). Characterisation of particulate matter sampled during a study of children's personal exposure to air borne particulate matter in a UK urban environment. *Environmental Monitoring and Assessment,* Vol. 65, pp. 69–77.



Monitoring, Control and Effects of Air Pollution

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The book addresses the subjects related to the selected aspects of pollutants emission, monitoring and their effects. The most of recent publications concentrated on the review of the pollutants emissions from industry, especially power sector. In this one emissions from opencast mining and transport are addressed as well. Beside of SOx and NOx emissions, small particles and other pollutants (e.g. VOC, ammonia) have adverse effect on environment and human being. The natural emissions (e.g. from volcanoes) has contribution to the pollutants concentration and atmospheric chemistry governs speciation of pollutants, as in the case of secondary acidification. The methods of ambient air pollution monitoring based on modern instrumentation allow the verification of dispersion models and balancing of mass emissions. The comfort of everyday humanâ€™s activity is influenced by indoor and public transport vehicles interior air contamination, which is effected even by the professional appliances operation. The outdoor pollution leads to cultural heritage objects deterioration, the mechanism are studied and the methods of rehabilitation developed. However to prevent emissions the new technologies are being developed, the new class of these technologies are plasma processes, which are briefly reviewed at the final part of the book.