Dispersion Modelling of Air Pollutants of Coal Based Thermal Power Station

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***Abstract*—** The present study was conducted with the objective to assess the cumulative impacts due to air emissions for a coal based thermal power station located in the Eastern part of India. The methodology adopted was to carry out air pollutant dispersion modeling of particulate emissions (PM10), and gaseous emissions viz. SO2 and NOx for all four seasons to enable the understanding of the extent of air pollution around the site due to the stack emissions from the plant. Detailed study was conducted including the measurements of ambient air quality at several stations around the plant and dispersion modelling of stack emissions for all four seasons using site-specific meteorological data. The results of annual averages for ambient air quality showed that except PM10 all the parameters were within the specified limits of ambient air quality as stipulated by the NAAQS, India. The present paper describes the air dispersion modeling results from this study.

***Keywords*—** Coal fired power plant; air dispersion modelling

I. Introduction

Coal based thermal power generation has always been a concern due to the enormous amounts of trace gas emissions in the atmosphere [1]. The Central Pollution Control Board (CPCB) [a statutory organisation under the Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India], has recently introduced revised norms for the emissions from thermal power plants which include stringent emissions norms for particulates and oxides of sulphur and nitrogen along with the addition of limits for emissions of mercury [2].

The main objectives of this study were:

- Collection of data regarding emissions from all the stacks of the plant like rate of emission, flow velocity at exit point, flow volume, diameter of exit points, temperature etc.
- Collection of site specific meteorological data for a minimum of one year.
- Identification of maximum Ground Level Concentrations (GLCs) due to emissions in and around the plant premises using AERMOD air dispersion model [3].
- Interpretation of modelling data both in terms of the NAAQS requirements and correlating with monitored data to establish the present air quality in and around the plant.

II. Methodology

The power plant is located on the southern bank of the river Brahmani in a district of Eastern India. The southern hilly region forms the watershed between river Brahmani and Mahanadi River. The central part of the district in which the project area is located is characterized by undulating plain. The valley portion exposes granites and its variants with hillocks of Khondalites, the remaining including the study area is characterized by considerably flat country. The highest elevation is over 85 m above mean sea level is observed towards southwest and the lowest elevation 56 m above mean sea level is towards east of study area near Brahmani River. The availability of coals in Talcher coalfields and high flow in the river Brahmani are the prime factors for rapid growth of industrial activities in this area.

In order to perform air dispersion modelling, the following was perceived:

- The year was divided in four seasons i.e. winter season (December, January and February); Summer season (March, April, and May); Monsoon season (June, July, and August) and Post-monsoon season (September, October and November).
- The model was applied to determine maximum GLC's for the four seasons for the three parameters (SO_2, NO_x, and PM_{10}).

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- The primary grid size for model runs was 400 m x 400 m in the 10 km radius area from the plant centre.

The AERMOD modelling system requires emission data and meteorological data as its primary input [4] [5].

- Stack Data – The emission data for the three stacks inside the plant are presented in Table 1.
- Site Specific Meteorological Data – The meteorological data for one year (2015) were obtained from Lakes Environmental Inc., Canada (www.weblakes.com). These meteorological data were specific for the plant site location.
- The meteorological data were processed in the AERMET software to generate the wind flow patterns for the four seasons, viz. winter, summer, Monsoon and Post-monsoon.
- The wind rose for the whole year has been presented in Figure 1.

TABLE I:
STACK DATA

S. No.	Data	Stack 1	Stack 2	Stack 3
1	Description of type of stack	MS Flue	MS Flue	MS Flue
2	PM_{10} (g/s)	18.2	16.3	13.4
3	SO_2 (g/s)	177.5	133.5	114.4
4	NO_x (g/s)	84.9	69.4	56.7
5	Stack exit gas temperature (ºK)	121.7	112.7	110.3
6	Stack inside diameter at exit point (m)	4.8	4.8	4.8
7	Stack exit gas flow rate(m^3/sec)	429	401	422
8	Stack height (m)	275	275	275

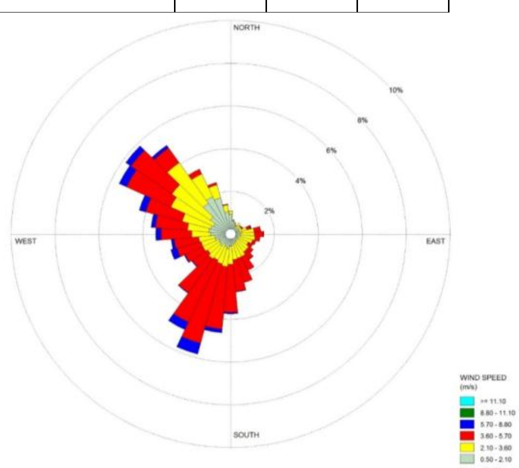

Fig. 1: Wind Rose Plot – Annual

III. Results and Discussion

The dispersion modelling results for 24 Hour maximum (Winter Season) of pollutants have been shown in Figures 2 to 4 and have been tabulated as presented in Table 2. As observed in Table 2, the maximum ground level concentrations of all the parameters were predicted by the model to occur within 1.0 km radius of the plant in three seasons whereas in winter these occur about 4.4 km South-South-East of the plant.

The analysis of results of dispersion modelling for all four seasons revealed that a maximum of 2.53 µg/m^3 in PM_{10} concentrations increases due to the emissions from stacks in the 10 km radius of the plant.

For SO2 and NOx the overall maximum increment is 22.4 and 11.1 µg/m3 in winter season within the 10 km radius of the plant.

TABLE II:
SUMMARY OF MODEL RESULTS – 24 HOUR MAXIMUM GLC'S AND THEIR LOCATION IN DIFFERENT SEASONS

S. No.	Season	PM_{10} (µg/m^3)	SO_2 (µg/m^3)	NO_x (µg/m^3)	Distance and direction from plant center
1	Winter	2.53	22.4	11.10	4.4 km SSE
2	Summer	1.98	17.5	8.70	0.5 km NW
3	Monsoon	2.09	18.5	9.18	0.25 km W
4	Post-Monsoon	2.29	20.3	10.08	0.8 km SSE

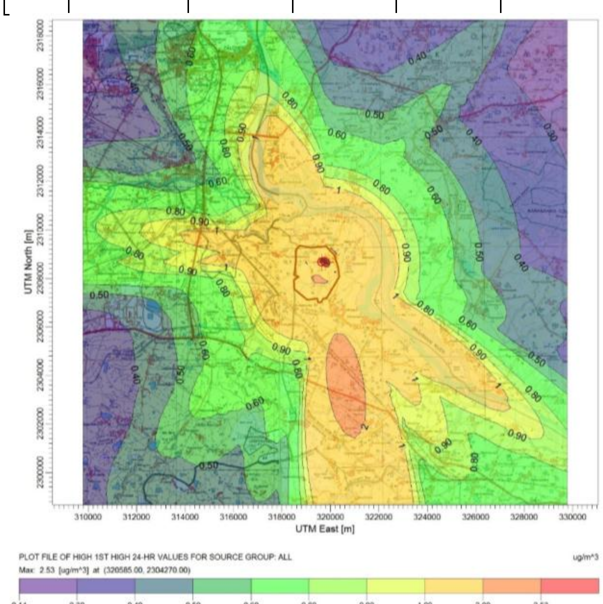

Fig. 2: Contour Plot of 24-Hour Maximum GLC's – Winter (PM10)

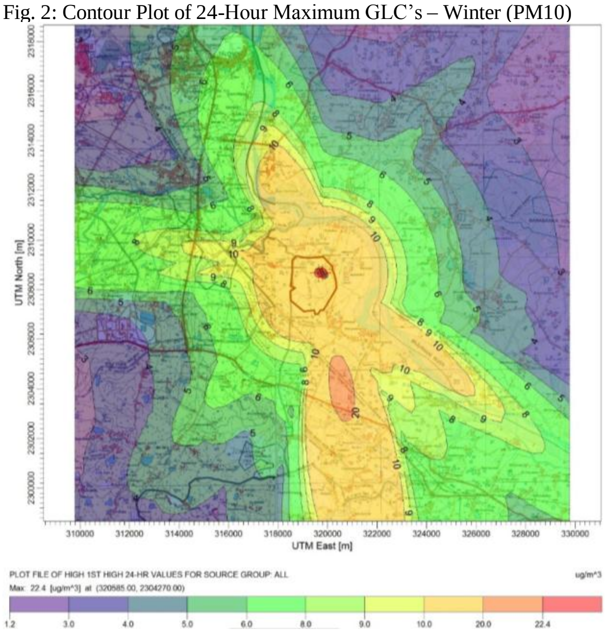

Fig. 2: Contour Plot of 24-Hour Maximum GLC's – Winter (SO2)

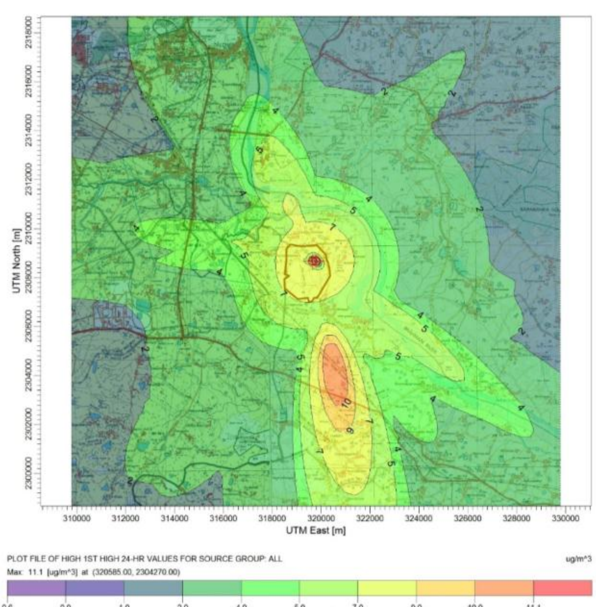

Fig. 3: Contour Plot of 24-Hour Maximum GLC's – Winter (NOx)

IV. Conclusion

The present study was conducted with the objective to assess the cumulative impacts due to air emissions for a coal based thermal power station. The methodology adopted was to carry out air pollutant dispersion modelling of particulate emissions (PM10), and gaseous emissions viz. SO2 and NOx for all four seasons to enable the understanding of the extent of air pollution around the site due to the stack emissions from the plant [6].

The analysis of results of dispersion modelling for all four seasons revealed that a maximum of 2.53 μg/m^3 in PM_{10} concentrations increases due to the emissions from stacks in the 10 km radius of the plant. This increment is just about 2.5% of the stipulated NAAQS value for PM_{10} which is 100 μg/m^3. For SO_2 and NO_x the overall maximum increment is 22.4 and 11.1 μg/m^3 in winter season within the 10 km radius of the plant. These increments in SO_2 and NO_x are acceptable as none of the sites showed exceedances in the concentrations of these parameters as measured during the course of this study.

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