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Application of Meteorological analysis in Urban Air Pollution Modeling using Gaussian Line Source Model

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Abstract: *Severity of Air Pollution in Pune City is growing rapidly due to urbanization, rapid growth of two and four wheelers and industrialization. Respirable Particulate Matter (RSPM) below 10 micron from Urban Transportation in the city is major concern and associating with lungs diseases especially in Infant babies, children and old age people. The present study was carried out at Katraj Chowk at Southern of Pune through out in the month of October 2015 to identify and determine the concentrations of RSPM as well as concentrations at every 100 m on downwind direction with the help of Gaussian Line Source model. PM10 sampler along with Gaussian Line Source model was use to determine and predict the concentrations at Source and Receptor locations at 100m, 200m, 300m, 400m, 500m respectively. The sampling was done in a day for 12 hours and during rush hours at Katraj Chowk. The relationship will be explored in depth here with special emphasis being given to the effect of meteorological elements on the dispersion of RSPM in the atmosphere and conversely, to the influence of atmospheric contaminants on meteorological condition.*

Keywords: *Air Pollution, Aerosols, RSPM, Meteorology, Atmosphere, Gaussian Line source Model, Air Pollution Episodes, Weather Monitoring*

I. Introduction

Recently, it has been noticed in Pune city that there is treamendous increase in patients of Asthma and Lungs Disorder especially in the age group of 1-10 and 40-above. Very fine particles from different sources are observed in city with low atmospheric visibility. Since city is situated in mountainous region, a stable atmospheric condition always prevails. The trapped RSPM in colder layer at surface is affecting residents and animals with severe changes in behaviour pattern. Sudden changes in atmophere have effect on the people with allergy. Humid and stable condtions are observing routinly which has effect on infant babies, childern and old age people. The city's much of transportation consists of two wheelers and four wheelers and industrial sectors are located at Pune city.

The problems of air pollution especially Aerosols, Dust are felt prominently in India. The Concentration levels of SPM are very high when compared with other cities in the world (Clayton, C.A., R.L. Perritt, E.D. Pellizzari, K.W. Thomas, R.W. Whitmore, L.A. Wallace, H. Ozkaynak, and J.D. Spengler, 1993 et al). . Pollution problems arise from the influence of atmospheric contaminants, adverse meteorological condition and at times, certain topographical conditions. Because of the close relationship that exists between air pollution and certain atmospheric conditions, it is necessary to have a thorough understanding of meteorology (Edgerton, E., B. Hartsell, J. Jansen, P. Saxena, and R. Wyzga, 1998 et al). The major air pollution episodes give a fair understanding of cause-effect relationship between meteorological and topographical conditions and air pollution (Ketzel, M., Berkowicz, R. and Lohmeyer, A, 2000 et al).

The present study envisages monitoring and sampling of Respirable Suspended Particulate Matter (RSPM) below 10 micron from all sources like domestic, industrial and automobile in Kolhapur city and determines concentration at every one hour to find maximum concentration at Source and Receptor level using Gaussian Dispersion model for better understanding of RSPM and its behavior in the atmosphere. To support such study, application of meteorological parameters in model is used for better predictions.

The Gaussian Line Source model was used for determination of concentration at various receptor levels. The Gaussian model is perhaps the oldest and perhaps the most commonly used model type (Samet JM, Zeger SL, Dominici F, 2000 et al). It assumes that the air pollutant dispersion has a Gaussian distribution, meaning that the pollutant distribution has a normal probability distribution (EPA U.S. Environmental Protection Agency, 1985). Gaussian models are most often used for predicting the dispersion of continuous, buoyant air pollution plumes originating from ground-level or elevated sources (Sini, J., Anquetin, S., Mestayer, P., 1996 et al) The model is used in this study was for ground level sources and area sources.

$$C_{(x,y,z)} = \frac{2Q}{(2 \times \pi)^{0.5} \times \underline{U} \times \sigma_z}$$

where, $C_{(x,y,z)}$ = Concentration at receptor levels in x, y, z direction, µg/m^3
Q = Source strength, µg/m^3
U = Wind Velocity, m/sec
σ_z = standard Deviation, m
σz can be found out by referring Pasquill's stability table which is govern by wind velocity and day/night time radiation.

Sometimes a high concentration exposure of RSPM to human being due to meteorological parameter changes and continuous exposure to the same may cause serious short and long term problems to human body (Sini, J., Anquetin, S., Mestayer, P., 1996 et al). Use of Gaussian Line source model for computing concentrations was vital step as combination of Domestic, Industrial and Automobile pollutants leads to increase in levels as metrological parameters changes into atmosphere.

II. Materials And Methodology

The study was incorporated with mathematical model to predict best possible RSPM concentrations at source and receptor locations. Use of Gaussian Dispersion model with some modifications was important to validate the actual results. After careful observation and studying wind rose of Katraj Chowk, it was decided to conduct this study in the month of October 2015 and record meteorological parameters like wind velocity & direction, temperature, humidity, stability class etc between 9 am to 9 pm everyday. For better understanding, the data shown here is a sample data for one day in October 2015 on which higher concentrations of RSPM was recorded and observed and subsequently results and observation of such day is mentioned herewith.

III. Results And Discussions

It is seen from Table no. 3.1 and figure no. 3.1 that concentration of RSPM at 9 am to 11 am are very high at source and receptor due to commercial activities like rush to offices, school, colleges, businesses etc. in the city and then sudden decrease in concentration in afternoon. This is, also, due to stable to neutral atmospheric conditions prevailing in the city. As previously mentioned, Pune city is always in stable condition due to its existence in mountainous geography. Maximum concentration of RSPM at Evening period is again, due to commercial activities and less wind velocities. Wind velocities in city are quite low which unable proper dispersion. Meteorology at Pune city is not favorable for proper dispersion. It is obvious that concentration at receptor will get minimize as receptor distance increases. It is seen that concentration at receptor is very less due to dispersion of RSPM in three directions like downwind (x), Crosswind (y) and upwind (z). This is also, due to low wind velocities in city. The results of concentrations of RSPM at Source and Receptor at Katraj Chowk on 12th October 2015 are shown below.

Table 1: RSPM at Source and Receptor location at Katraj Chowk

Time	Concentration in µg/m^{3}at source	Concentrations in µg/m^3 predicted by Gaussian Line Source Model					Downwind Direction and Velocity
		At 100M	At 200M	At 300M	At 400M	At 500M	
9 am	819.2025	29.18409	13.61924	10.21443	5.836818	5.376016	⇦ E 3.1 m/s
10 am	670.8151	23.89779	11.1523	8.364226	4.779558	4.402224	⇦ E 3.6 m/s
11 am	657.4622	24.17764	11.2829	8.462175	4.835528	4.453776	⇦ E 3.1 m/s
12 noon	**581.1966**	14.96112	7.480562	4.987042	3.740281	2.992225	⇦ E 3.1 m/s
1 pm	700.6105	20.70693	10.35347	6.902311	5.176733	4.141387	⇦ ENE 2.7 m/s
2 pm	589.9878	17.43742	8.718708	5.812472	4.359354	3.487483	⇦ NE 2.7 m/s
3 pm	772.6031	28.02442	14.01221	9.341473	7.006105	5.604884	⇦ NE 2.2 m/s
4 pm	1172.412	34.65128	17.32564	10.39538	6.497114	4.158153	⇦ NNE 1.8 m/s
5 pm	1509.818	44.6235	22.31175	13.38705	8.366905	5.354819	⇦ NNE 1.8 m/s
6 pm	**1854.396**	54.80769	27.40385	16.44231	10.27644	6.576923	⇦ NE 1.8 m/s
7 pm	1366.103	55.90516	27.95258	16.77155	10.48222	6.708619	⇦ NE 1.3 m/s
8 pm	1190.809	48.73158	24.36579	14.61947	9.137171	5.847789	⇦ NE 1.3 m/s

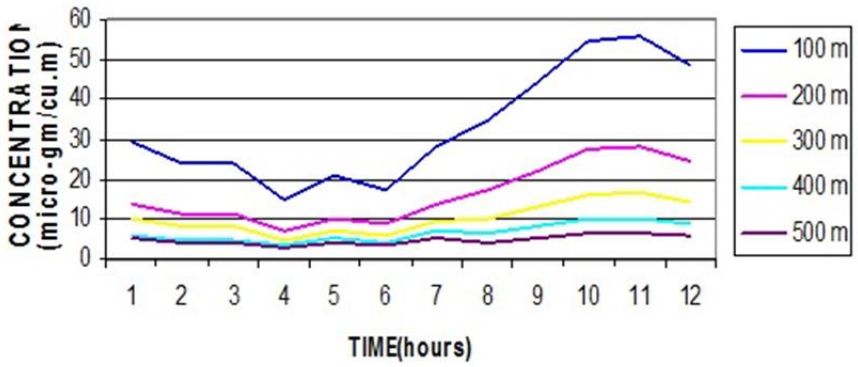

Figure 1: RSPM Concentration at various receptor levels on downwind directions during a day predicted by Gaussian Line Source Model

IV. Conclusion

High concentration like 1854.396 µg/m^3 at 6 pm which is 9 to 10 times higher that ambient air quality standard, can affect people and traffic policemen severely and such concentration always experienced in city which is alarming signal to the children and old age people. Doctors concluded that such concentration may cause severe attacks of asthma and lungs disorders. Average daily concentration of 990.4513 µg/m^{3}is also 4 to 5 times higher the National Ambient Air Quality Standards 2010 which is quite high.

It is recommended to Central and State Pollution Control Board that new National Air Quality Standards (NAAQS) for ambient air as well as motor vehicles to be established on the basis of one hour instead of 24 hours as hourly concentrations can affect human beings severely. A traffic policeman, who is continuously with this exposure, is first and foremost person to suffer maximally. New set of NAAQS will be beneficial to determine concentration at hour basis and urban planners to plan transportation and domestic activities. Use of Remote sensing devices to determine hourly concentration may be useful for traffic planning and such device should be incorporated with weather stations for effective implementations of Urban Environmental planning.

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