International Journal of Science, Environment and Technology, Vol. 4, No 4, 2015, 1119 – 1125

ISSN 2278-3687 (O)
2277-663X (P)

MONITORING AND PREDICTION OF PM10 DISPERSION FROM VEHICULAR POLLUTION IN MYSURU

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Abstract: Traffic-related air pollution is one of the major problems in modern urban agglomerations both in the developed and the developing world despite the recent technological improvements on vehicle emission control and the increasingly stricter rules and regulations. The present study signifies about the modelling air pollutant concentrations for a roadway passing through commercial area in Mysuru city. Particulate matter is monitored over two sampling locations along the roadway. Simultaneously during the sampling period meteorological data and traffic flow data were also collected and windroses were plotted. CALINE4 line source dispersion tool has been applied to model Particulate matter 10 (PM10). It is observed to exhibit better correlation against actually monitored data.
Keywords: Air Pollution, PM10, CALINE4, Vehicular Pollution.

I. INTRODUCTION

Transportation system has contributed significantly to the development of human civilization; on the other hand it has an enormous impact on the ambient air quality in several ways. About 60 per cent of air pollution in Indian cities is due to automobile exhaust emission. The vehicular emission contains more than 450 different organic chemical compounds either in gaseous or in particulate or in the combined forms. The Government of India has enacted Air Act in 1981 (Prevention and Control of Pollution) in order to arrest the deterioration in air quality. Central Pollution Control Board of India recommends limits to primary pollutants for different categories of land use as shown in Table I. To regulate the effect of vehicular emissions on the environment, it is important for us to understand the dispersion of air pollutants in the atmosphere as well as the air pollution models. Air pollution measurements can only describe air quality at specific locations and times, without giving clear guidance on the identification of the causes of the air quality problems. However, they can give important, quantitative information about ambient air quality problems. Air pollution modelling, instead, can give a more complete deterministic description of the

*Received July 17, 2015 * Published Aug 2, 2015 * www.ijset.net*

existing air quality status, including an analysis of factors and causes and some guidance on the implementation of mitigation measures. CALINE4, the latest version of CALINE series models, is most widely used Gaussian based vehicular pollution dispersion model to predict air pollutants concentrations.

Table: National Ambient Air Quality Standards (NAAQS)

Pollutants	Time Weighted Average	Conc. In Ambient Air	
		Indl,Resi,Rural areas	Sensitive area
Sulphur dioxide (SO_2)µg/m3	Annual	50	80
	24 Hours	20	80
Nitrogen Dioxide (NO2), µg/m3	Annual	40	30
	24 Hours	80	80
PM10 (<10µm), µg/m3	Annual	60	60
	24 Hours	100	100
PM2.5 (<2.5µm), µg/m3	Annual	40	40
	24 Hours	60	60
Lead (Pb),µg/m3	Annual	0.5	0.5
	24 Hours	1	1
Carbon Monoxide (CO)mg/m3	8 Hours	2	2
	1 Hour	4	4
Nickel (Ni),ng/m3	Annual	20	20

Source: CPCB (2011)

II. MATERIALS AND METHODOLOGY

A. Study Area

Mysuru is the fastest growing tier 2 cities in India with a total vehicle population of around 6.5 lakhs. Mysuru district is a tourist destination, offering several attractions ranging from the royal splendor of Mysuru City and its fabulous Dasara festival to the exquisite temples, pilgrimage centres and scenic spots. The traffic congestion contributes greater to deteriorating environment in urban communities. In the last few years, about 70% of ambient air quality degradation in Mysuru is affected by transportation activities.

In order to study the air quality in Mysuru a typical city roadway, Devraj Urs Road is selected and is one of the major roadways in the city. Fig. 1 show the sampling stations of the study area considered.

Fig. 1 Sampling stations of the study area

B. Data Collection Methods

Air quality monitoring stations were selected and sampling was conducted twice in a month during January to May 2015 using Envirotech APM 460 BL High Volume Air Sampler. Simultaneously meteorological data collection and traffic monitoring were also carried out. Fig. 2 shows the relative contribution of motorized vehicles in study area.

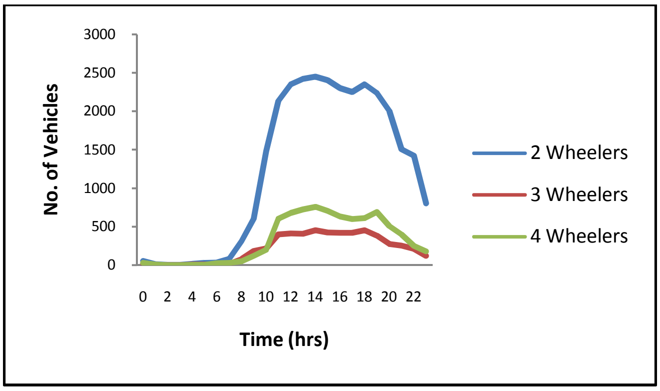

Fig. 2. Contribution of motorized vehicles in study area

C. CALINE4 model description

CALINE4 model is a simple line source Gaussian plume dispersion model which predicts the concentrations of Carbon monoxide (CO), nitrogen dioxide (NO_2) and suspended particulates ($PM_{10}/PM_{2.5}$). It employs a mixing zone concept to characterize pollutant dispersion over the roadway due to vehicles plying on the road corridor. The input parameters required for model include classified traffic volume, meteorological parameters, emission parameters, road geometry, type of terrain, background concentration of pollutants (ppm or µg/m3) and pre-identified receptor locations along the road corridors.

III. RESULTS AND DISCUSSIONS

A. Windroses Plots

Based on the meteorological data collected, windroses are plotted using WRPLOT view during December 2014 to May 2015, as described in "Fig. 3". The wind rose shows that the majority of the wind blows predominantly from East, East-North-East and West- South - West direction.

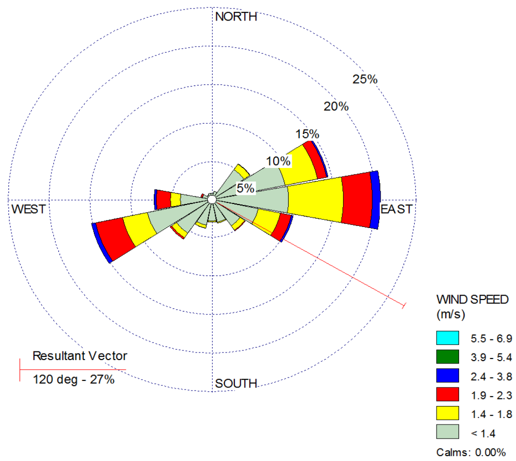

Fig. 3. Average windrose plot for sampling duration

B. Air Quality Monitoring Results

In present work an attempt has been made to study the seasonal variations of air quality for two seasons viz winter and summer. It is observed that the concentration of the PM_{10} is high in winter than in summer season and exeeds the limits as prescribed by NAAQS in both the seasons. "Fig. 4A" and "Fig. 4B," show the concentration PM_{10} observed during winter and summer season at location 1 and 2

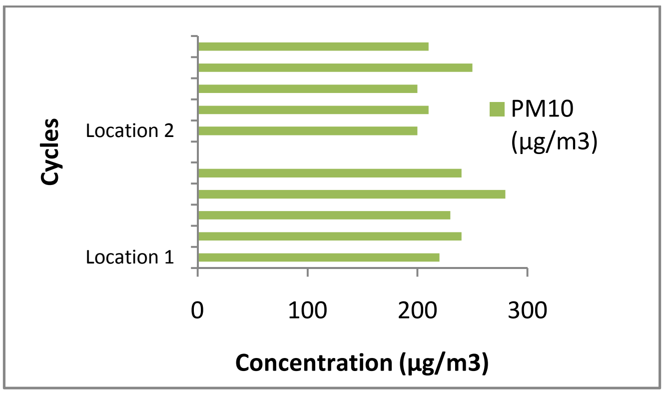

Fig. 4A. Ambient PM_{10} concentration during winter season

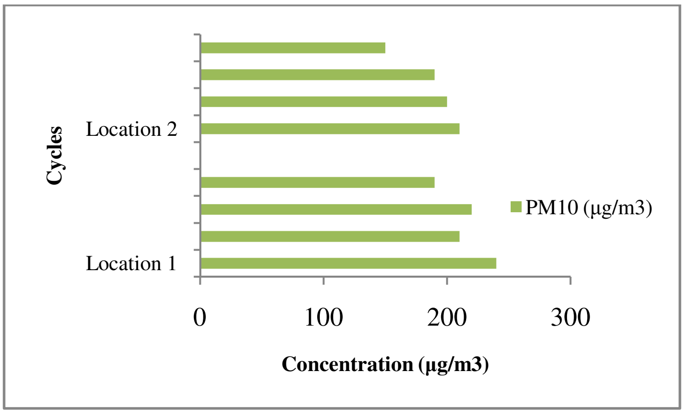

Fig. 4B. Ambient PM_{10} concentration during summer season

C. Modelling using CALINE4 dispersion model

CALINE4 model is calibrated and validated using the monitored PM_{10} values. The traffic flow data obtained by the traffic flow studies and the emission factors given by the Automotive Research Association of India (ARAI) are used to run the model. In the present study, isopleth plots for different days of the study period from December 2014 to May, 2015 for PM_{10} were made. Fig 5 shows the Isopleth plot for the predicted PM_{10} concentrations over the stretch of roadway on one of the monitored day in winter. From the Isopleth plot, it is observed that the pollutant is concentrated at the higher elevation points and it traversed equally on either side of the road. As the elevation of study area decreased, more dispersion of pollutant took place.

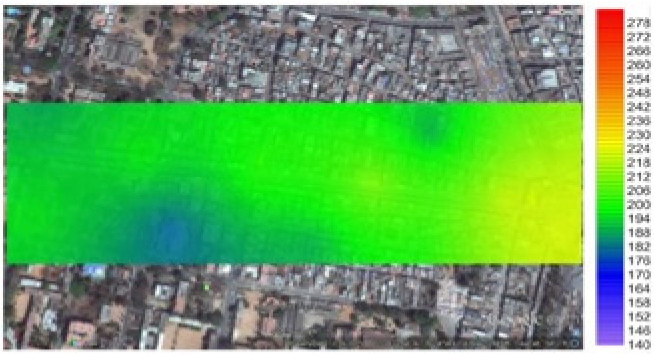

Fig. 5. PM_{10} level isopleth around study area

A plot of correlation between models predicted values against the monitored PM_{10} concentrations have been made and best fit line has been drawn shown in Fig. 6. The best fit straight line between measured PM_{10} concentrations and PM_{10} concentrations predicted by CALINE4 model gives a R^2 value of 0.915 and Pearson's correlation (r)= 0.95. The results of sensitivity analysis of CALINE4 model showed that the lower wind velocity (<2 m/s) had an impact on dispersion of PM_{10}. However, the atmospheric stability class and ambient temperature had no influence on the dispersion of PM_{10}.

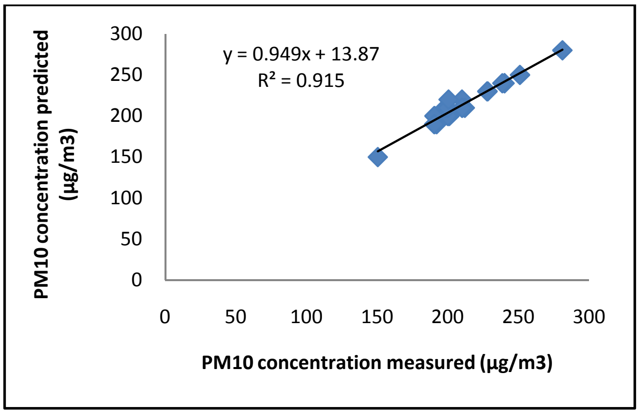

Fig. 6. Best fit straight line between Measured PM10 concentrations and PM10 concentrations predicted by CALINE4 model

IV. CONCLUSION

Vehicular pollution dispersion models have been used for regulatory purpose all over the world. According to the present study the CALINE4 model marginally over-predicted the PM10 pollutant concentrations when compared to field monitored concentration with Pearson's correlation co-efficient of 0.95 indicating that CALINE4 model values are well predicted with the monitored data resembling the real scenario ideally. The problem of vehicular pollution mainly arises due to emissions from plying of vehicles at various road networks. Thus, air quality management is a growing concern. As such, it is quite necessary to have regular assessment and prediction of air quality. This will help in providing database to prevent and minimize the deterioration of air quality

ACKNOWLEDGEMENT

I express my profound gratitude and indebtedness to Dr. B. M. Krishna and Dr. B. Manoj Kumar, Professors, Department of Environmental Engineering, Sri Jayachamarajendra College of Engineering, Mysuru for guiding me throughout my work and helping me whenever required.

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