

Prediction of Air Pollutants Dispersion Emitted from Point and Line Sources along the Highway Passing Through Industrial Area of Mysuru- AERMOD and CALINE4 Models

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ABSTRACT: Highway passing through the industrial area of Mysuru constantly experiences emissions from vehicles and industries situated in close proximity to the highway. Prediction of the seasonal variations on the air pollutants concentrations at three receptor locations along the highway contributed from line source; point sources, and combined line and point sources using CALINE4 and AERMOD air pollutant dispersion models, respectively, have been studied. CALINE4 model predicted PM₁₀ concentration was found to be in good agreement when compared with monitored values showing R² value of 0.943, whereas, the model marginally underpredicted NO_x concentration with R² value of 0.901. Further, CALINE4 model was sensitive to changes in wind speed. At location 2, the measured PM₁₀ concentration of 140.5 µg/m³ was found to be maximum during summer season, which was mainly due to vehicular emission sources. The AERMOD predicted PM₁₀, NO_x and SO₂ pollutants concentration emitted from point sources at different averaging time periods were found to be within the NAAQ Standards. AERMOD was found to be underpredicted the PM₁₀ concentration contributed from combined point and line sources with R² value of 0.260. Maximum contribution of PM₁₀ and NO_x concentration was found to be from vehicular sources when compared to industrial sources at the receptor locations.

KEYWORDS: Particulate matter, Sulfur dioxide, Nitrogen Oxide, Ambient Air Quality Monitoring, CALINE4 model, AERMOD

I. INTRODUCTION

There has been a rising concern over the effects of air pollution in urban areas of many developing countries. Due to increase in industries as well as automobiles, many cities in India are experiencing deteriorated ambient air quality. Exposure to traffic related air pollutants such as Particulate matter of aerodynamic size less than 2.5 µm and 10 µm (PM_{2.5} and PM₁₀) and NO_x (Nitrogen Oxides) will lead to autism disorder in Children [13]. Many process based industries also emits particulate matters and Sulfur-dioxides (SO₂). The other known sources of air pollutants in urban areas are from open burning of solid waste, domestic fire places, resuspension of road dust, etc. This will alter the atmospheric gaseous and particulate matter concentrations and deteriorates urban air quality. In order to minimize the emission of air pollutants such as Particulate matter of aerodynamic size less than 2.5 µm and 10 µm (PM_{2.5} and PM₁₀), Carbon monoxide (CO), Sulfur dioxide (SO₂), Oxides of Nitrogen (NO_x), and Polycyclic aromatic hydrocarbons (PAHs), there should be better urban air quality management plan. Air pollutant dispersion modeling is a simple method of assessing the concentration of pollutants in the ambient air emanating from various sources. Many air quality models have been used in urban air pollution studies, these include : ISCST3 (Industrial source complex short term model3), AERMOD (American meteorological society environmental protection agency regulatory model), CALPUFF (California puff model), ADMS (Atmospheric dispersion modeling system), CALINE4 (California line source model4)

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 8, August 2016

and MOBILE 6.2 (Motor Vehicle Emissions Factor Model).The recent Gaussian based air pollutant dispersion models like AERMOD and CALINE4 are the widely used models for urban air quality studies.

II. RELATED WORK

Ambient air quality is one of the most severe environmental concerns in urban areas around the world, particularly in developing countries such as India, China, Africa etc. To assess the impact on the ecosystem from various emission sources, air quality monitoring and air quality modeling studies are required. In the past, many researchers have conducted ambient air quality monitoring studies of various cities / towns to measure the impact of major air pollutants such as, NO_x , SO_2 , particulate matter, CO, etc. on the environment. Ambient Air Quality Monitoring (AAQM) was carried out in Madurai city, Tamilnadu, India over a period of one year to measure the level of air pollutants such as PM_{10} and lead (Pb) contributed from various sources (vehicles, industries, diesel based electricity generators, burning biomass for cooking) in the city [1]. The results indicated, PM_{10} concentrations found to be maximum during summer season and minimum during monsoon season. It was due to the photochemical reactions in summer season which produced peak PM_{10} concentration. AERMOD was used to predict NO_2 concentration at two places in Delhi wherein four emission sources namely power plants, vehicles, industries and household sectors was chosen. It was stated, as the averaging period increased, predictions of AERMOD became better [10]. Hence, at both stations, predicted and observed values of NO_2 showed a good agreement with 24 hour period than for 1 hour and 8 hour. Further, CALINE4 model was used to predict NO_x and PM_{10} concentrations from vehicular sources along the highway in Mysuru. The results indicated that, model results were found to be in good agreement with monitored data [11]. Dispersion modeling on $\text{PM}_{2.5}$, NO_x and SO_2 from point and major line source emissions was conducted using AERMOD. Model Results showed the validity of using AERMOD to estimate surface impact of major point and line sources in complex terrain, differing land use patterns and large variability in annual meteorology [4]. From the above it is observed that, vehicular and industrial source of emissions are highly contributing to air pollution in urban areas. In the present investigation, it has been proposed to validate the field monitored results with that of CALINE4 (for line source) and AERMOD (for point source and combined point and line source) air quality dispersion model results along the highway passing through the Industrial area of Mysuru, India.

III. METHODOLOGY

Mysuru is an emerging second metropolitan city of Karnataka state, India, with a population of about 10.25 lakhs. On the Contrary, due to increase in the developmental activities, the ambient air quality in Mysuru is gradually getting deteriorated. There will be continuous movement of vehicles in the ring road which represents the outskirts of Mysuru city. The highway (Bengaluru - Mercara) which connects ring road passes through the industrial area in Northwestern part of Mysuru which is about 7 Km from the heart of the city. In the present study, AAQM was carried out at three selected locations along the highway stretch passing through the industrial area of Mysuru shown in Figure 1.

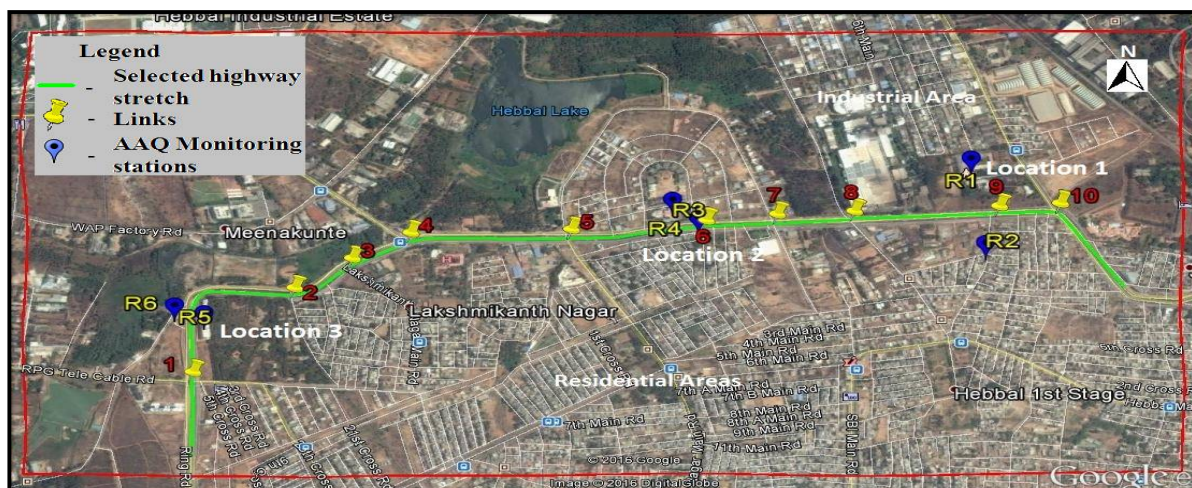


Fig. 1. Study area showing the AAQM locations along the highway passing through the industrial area of Mysuru.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

Airquality modeling using CALINE4 and AERMOD model

In order to predict the ambient air pollutant concentration for PM_{10} and NO_x contributed from vehicular emission along the highway passing through industrial area in Mysuru, CALINE4 Model was used. 8 hour, daily and seasonal variation in the concentration of PM_{10} and NO_x in the atmosphere were estimated and the type of vehicular sources include : 2 wheelers (2w); 3 wheelers (3w); 4 wheelers (4w - Cars) and heavy duty vehicles (HDV). CALINE4 is the fourth generation simple Gaussian dispersion model which predicts the ambient air pollutant concentrations upto 500 m from the roadway [9]. The highway stretch was divided into a series of 10 links (Figure 1). The emission factors specified by Automotive Research Association of India (ARAI) were used to calculate the weighted emission factors [2,12] for predicting the ambient air pollutant concentrations. The vehicular count was taken with the help of a cctv camera footage which was fixed at a commercial building situated along the highway. The other model input parameters include: wind speed, wind direction, mixing height, stability class, road geometry and receptor locations.

AERMOD (American meteorological society Environment protection agency Regulatory dispersion Model) is the recent air pollution dispersion model which is an improved version of ISCST3 (Industrial Source Complex Short Term model 3) model. It can predict pollutant concentration upto 50 Km [6]. In the present study, AERMOD model was used to predict the air pollutant concentrations such as PM_{10} , SO_2 and NO_x and the variation in pollutant concentrations during 8 hr, 24 hr and seasonal averaging time intervals was also studied for point sources. AERMOD was also used to predict PM_{10} concentration from combined point as well as line sources for 8 hr and seasonal averaging time intervals. The emitted pollutant sources were from large scale industries (point sources) which are situated near the highway (Figure 2). Five major industries identified in the study area include: Hindustan Unilever limited (HUL - P1); Mysore Polymers (Mypol - P2); J.K. tyre plant-1 (P3); J.K. tyre plant-2 (P4) and Automotive Axles Pvt. Ltd. (P5). Stack emission characteristics data were collected from Karnataka State Pollution Control Board, Mysuru (KSPCB-Mysuru) shown in Table 1 which have been used as input into the model equation. Emission rate for each pollutant was estimated as a product of flowrate and pollutant concentration [5]. The study area was divided into grids of uniform spacing of 1 km \times 1 km by selecting uniform Cartesian coordinate in the model with a total area of 20 km \times 20 km. The meteorological data for the study area was generated by AERMET (AERMOD's meteorological data preprocessor). AERMAP (AERMOD's terrain data preprocessor) was used to get the topographical elevation data of the study area obtained from U.S. Geological Survey (USGS) digital elevation dataset which have been input to the model.

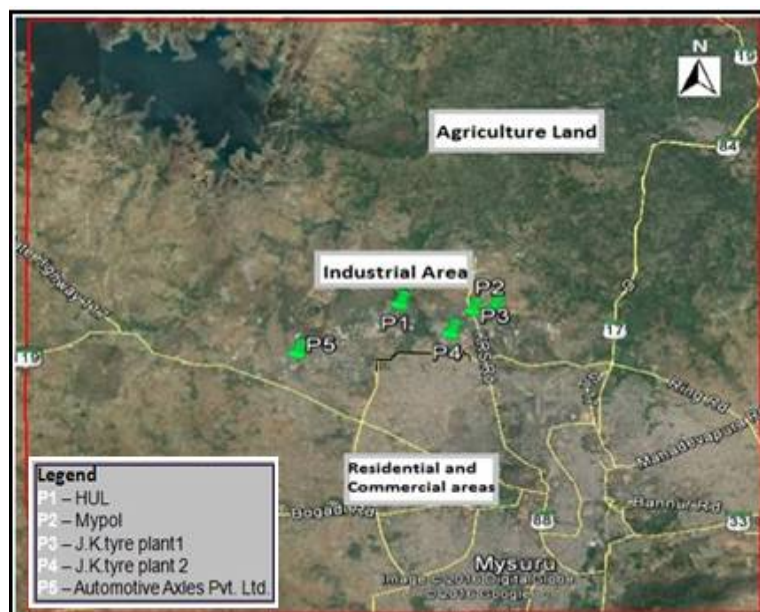


Fig. 2. Study area showing the industrial sources situated along the highway intended for AERMOD dispersion modeling.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

Meteorological data

Daily actual observed meteorological data such as temperature, wind speed, wind direction and relative humidity was obtained from the website www.imdgrimet.gov.in. Hourly wind speed, wind direction and precipitation data was

Stacks	Stack height (m)	Stack internal diameter (m)	Exit gas velocity (m/s)	Exit Temperature (°K)	Emission rate (g/s)		
					PM ₁₀	SO ₂	NO _x
Stack 1 (HUL)	40	1.8	8.83	378.15	5.22	0.367	0.809
Stack 2 (HUL)	16	0.36	6.81	305.15	0.135	-	-
Stack 3 (HUL)	16	0.75	7.76	303.15	0.098	-	-
Stack 4 (HUL)	23	0.45	11.06	533	0.250	0.053	0.164
Stack 5 (HUL)	54	1	9.94	383	0.318	0.116	0.239
Stack 6 (HUL)	23	0.45	12.20	583.15	0.201	0.040	0.124
Stack 7 (HUL)	10	0.3	10.40	303	0.044	-	-
Stack 8(MYPOL)	30	0.8	8.12	338	1.305	0.058	0.141
Stack 9 (J.K. Tyres plant-1)	77.8	3.8	7.94	368	5.025	0.324	0.856
Stack 10 (J.K. Tyres plant-2)	65	1.3	8	375	0.767	0.138	0.368
Stack 11 (Automotive axles)	30	1.2	11	298.15	0.321	-	-

obtained from the website www.wunderground.com and used in plotting monthly wind rose diagrams.

Table 1: Industrial Stacks Characteristics
(Source: KSPCB-Mysuru)

IV. FIELD EXPERIMENTAL RESULTS

Vehicular Traffic Density

Results of vehicular traffic study showed that, the study area majorly comprised of 2w fleet followed by the 4w, HDV and 3w. A plot of daily variation in traffic volume of different category of vehicles against time was made shown in Figure 3. The average number of all the vehicles on a weekday was observed to be 25,000 to 27,000. The daily peak traffic flow was observed between 09:00 am and 11:00 am and, 17:00 pm and 20:00 pm. During morning hours, from 1:00 am to 5:00 am, more number of HDV were observed than other categories of vehicles which is mainly due to supply of raw materials to the industries which are located along the highway [11].

Meteorological Observations

Wind rose plots showed that, the wind direction changed over the study area seasonally. The wind blew from East and Northeast directions during winter season and from West and Southwest in monsoon season. During summer season, wind direction was found to be variable, which changed from East to Southeast and Southwest. The average wind speed during winter, summer and monsoon seasons were found to be 1.87 m/s, 2.62 m/s and 4.17 m/s, respectively. The temperature was maximum during summer season which found to be 39.9°C in the month of April and the minimum temperature of 10.6°C was found to be in the month of January during winter season. Minimum relative humidity of about 22 % was found in winter season whereas, maximum relative humidity of about 97 % was found to be during the warm month of May.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

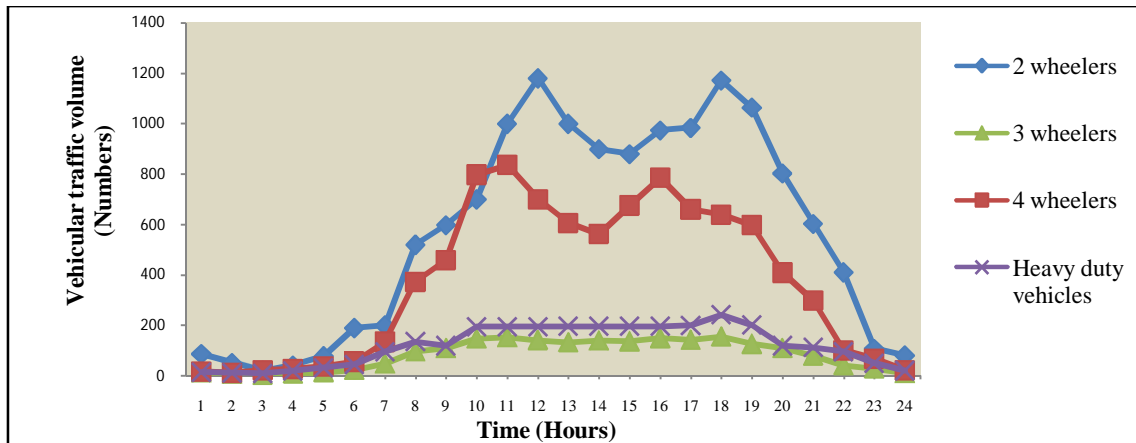


Fig. 3. Daily variations in traffic volume along the highway stretch passing through industrial area of Mysuru.

Field Monitoring

AAQM was carried out for 8 hours on different days during winter, summer and monsoon seasons at all the three identified locations along the highway. At each monitored locations two stations were established across the road to know the lateral dispersion of pollutants in the study area. The concentrations of PM₁₀, PM_{2.5}, SO₂ and NO_x were measured at the three locations viz. location 1 (near CIPET), location 2 (near V-LEAD) and Location 3 (near Sheshadripuram College) shown in the Figures 4, 5 and 6. It was found that, the average pollutant concentrations at all the three locations during winter season were found to be within the National Ambient Air Quality Standards (NAAQS), CPCB, India (Figure 4). However, PM₁₀ concentration was found to be almost nearer to the limiting concentration of 100 µg/m³. This was due to the reduced mixing height observed during winter season which builds the pollutant concentrations near the ground level and thereby increases in the PM₁₀ concentration.

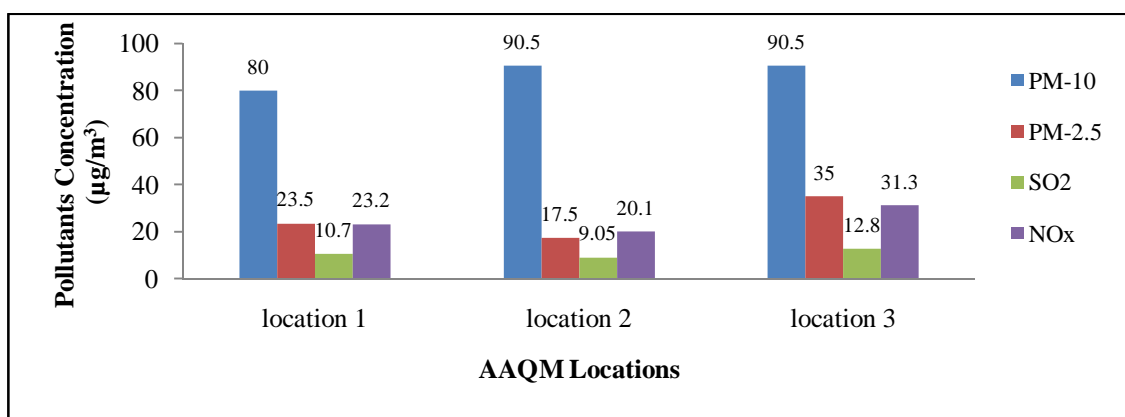


Fig. 4. Graph showing the results of AAQM conducted during winter season.

The PM₁₀ concentration at location 1 and 2 was found to exceed the (NAAQS) during summer season (Figure 5) which may primarily due to photochemical reactions in the atmosphere [1]. Infact, the meteorology and source strength also influenced the pollutant concentrations. Heavy vehicular movement during summer season when compared to other seasons might have added to the pollutant concentration due to vehicular emissions. It was also due to frequent variation in wind direction during summer season which influenced some of the Industrial sources (P2, P3 and P4) emissions located on upwind of all three receptor locations. During monsoon season, less concentrations of

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

PM₁₀ was found at monitoring stations (Figure 6) due to the precipitation which scavenged the particulate matters to the ground and also high wind velocities caused turbulent dispersion leading to lower ground level pollutants concentration.

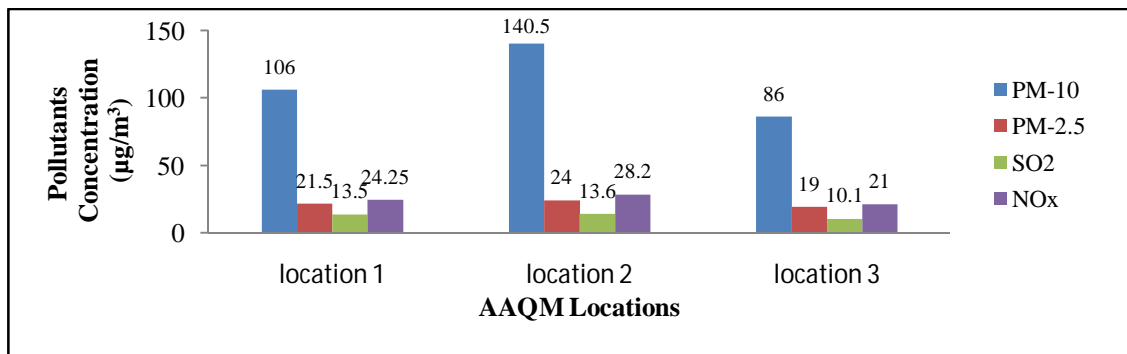


Fig. 5. Graph showing the results of AAQM conducted during summer season.

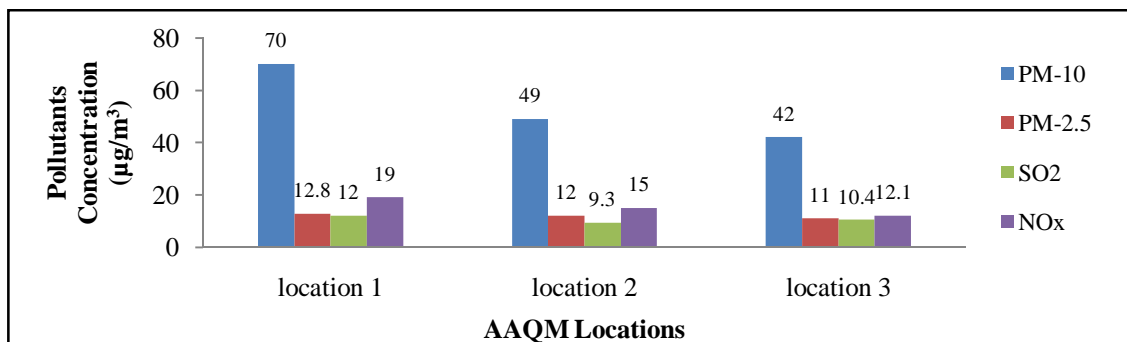


Fig.. 6. Graph showing the results of AAQM conducted during monsoon season.

V. AIR QUALITY DISPERSION MODELS RESULTS

Present study mainly focused on monitoring of ambient air quality for PM₁₀ and NO_x concentrations during winter, summer and monsoon seasons and validated with the CALINE4 model. Results of predicted PM₁₀ concentrations were found to be agreeable, while the predicted NO_x values were found to be marginally underpredicted by the CALINE4 model when compared to the observed values. The averaged PM₁₀ monitored concentration observed was 83.8 µg/m³, whereas the CALINE4 predicted averaged concentration of PM₁₀ was found to be 62.1 µg/m³. The correlation coefficient (R²) for PM₁₀ concentration was found to be 0.943 which indicates that, the model predictions were almost in good agreement with monitored values (Figure 7a). The R² value obtained for NO_x (0.901) shows marginal underprediction by the CALINE4 model (Figure 7b). Infact, the reason for underprediction of CALINE4 model values for NO_x may be due to overlapping of NO_x concentrations from the industrial sources, vehicular emissions and also the presence of atmospheric NO_x which was not being considered in the model. The temperature, wind speed and stability of the atmosphere was also fluctuating in the study area hourly, daily and seasonally. The maximum and minimum wind speed was observed to be varied from 1 m/s to 5.3 m/s, and the temperature in the study area ranged from 10.6°C to 39.9°C. CALINE4 model was run for varied wind speed as well as temperature for different stability class of atmosphere (1 to 7). The sensitivity analysis of CALINE4 model showed that the model predicted PM₁₀ concentration was 132 µg/m³ at location 2 when the wind speed was 1 m/s. Similarly, the predicted PM₁₀ concentration was found to be 37 µg/m³ at location 1 when the wind speed was 5 m/s.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

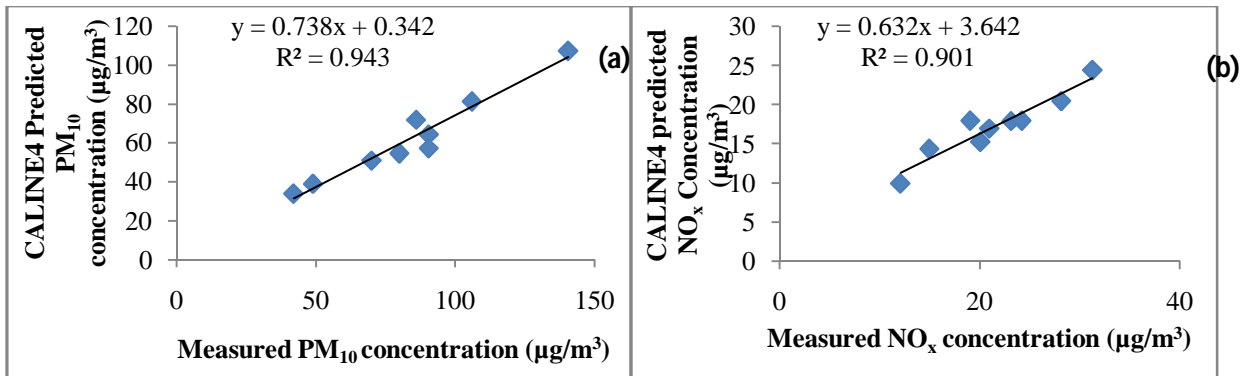


Fig. 7. Plot of correlation coefficient between measured and CALINE4 predicted pollutants concentrations
(a) PM₁₀(b) NO_x

The results of AERMOD predicted for PM₁₀, NO_x and SO₂ concentrations from point emission sources were conformed to NAAQ Standards at all three receptor locations. It was observed that, the predicted concentration of pollutants varied from source to receptor locations. The 8 hr predicted PM₁₀, SO₂ and NO_x concentrations averaged over all three receptor locations during winter, summer and monsoon seasons were found to be 16.67 µg/m³, 17.04 µg/m³ and 11.7 µg/m³; 1.57 µg/m³, 2.93 µg/m³ and 2.25 µg/m³; and 2 µg/m³, 3.31 µg/m³ and 2.05 µg/m³, respectively. Therefore, AERMOD predicted 8 hr average pollutant concentrations was found to be very less at the receptor locations than found at the source (Table 2) and it was also found to be less when compared to the 8-hr monitored values. Similarly, 24 hr and the seasonal average pollutants concentration were found to be less at the receptor locations. The high PM₁₀ concentration (30.8 µg/m³) during monsoon season (Table 2) was due to the shorter averaging time period (i.e., between 1st June and 10th July, 2016) being considered while modeling, whereas three months average time was considered for summer (March, April and May, 2016) and two months average for winter seasons (January and February, 2016).

AERMOD model estimated air pollutant concentrations of PM₁₀, SO₂ and NO_x near the source at different averaging time are presented in Table 2. From Table 2 it is observed that, the predicted pollutants concentrations by AERMOD became accurate when the averaging time period increased from 8 hr to the seasonal averaging.

Table 2: AERMOD model estimated maximum air pollutant concentrations near the source at different averaging time

Averaging time with seasons		AERMOD estimated maximum pollutant concentrations in µg/m ³ found near the source		
		PM ₁₀	SO ₂	NO _x
Winter season	8-hr	71.92	12.87	16.46
	24-hr	42.02	8.64	11.07
	Winter period	16.98	3.68	2.88
Summer season	8-hr	63.76	9.53	12.20
	24-hr	44.69	6.34	8.14
	summer period	20.53	1.66	2.14
Monsoon season	8-hr	55.79	8.66	11.03
	24-hr	41.82	5.38	6.91
	monsoon period	30.8	2.85	3.65

International Journal of Innovative Research in Science, Engineering and Technology

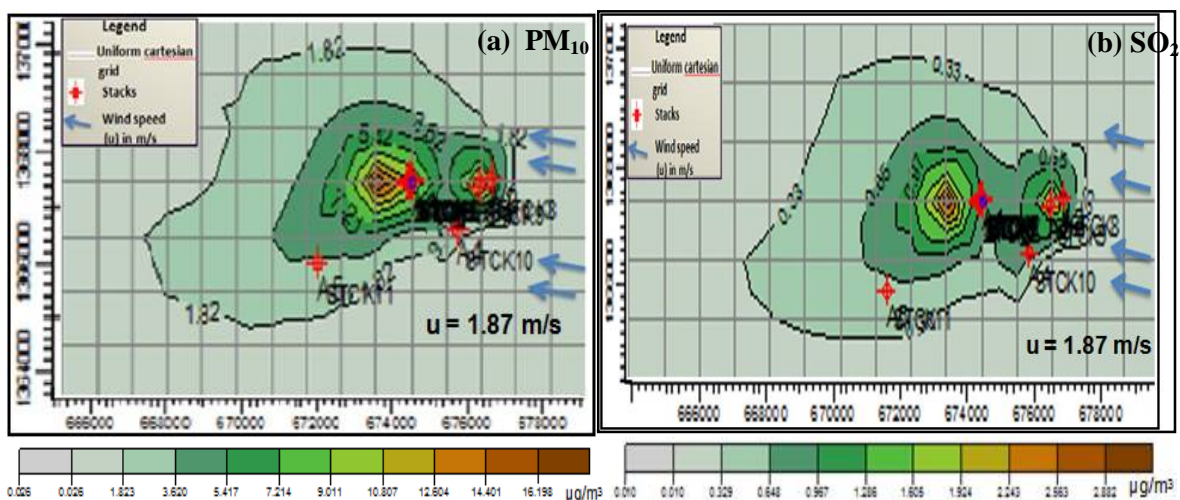
(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

AERMOD predicted surface concentration of PM₁₀, SO₂ and NO_x during winter, summer and monsoon seasons were estimated depicted in Figures 8, 9 and 10. Most of the time as the wind direction was from North-east (NE) and East directions during winter season, the pollutant PM₁₀ dispersed towards west and west-south-west (WSW) directions. The PM₁₀ concentration decreased from 16.98 µg/m³ near HUL industry to about 3.62 µg/m³ at 4 km away from HUL (Figure 8a) as was observed during winter season. Similarly, SO₂ and NO_x were found to disperse towards west direction during winter season (Figures 8(b) and 8(c)). Thus, during winter, some portion of the pollutants was carried towards residential areas located in the South-west (SW) part of the study area.

The average PM₁₀ concentration for the whole summer period was found to disperse towards East-North-East (ENE) over a distance of 3.5 km from HUL and also towards west direction (2 km) of HUL shown in the Figure 8(d). The predicted SO₂ and NO_x concentrations during summer season were also found to get dispersed towards ENE and slightly towards west direction (Figures 9(a) and (b)). This was mainly due to the fluctuations in the wind direction which was observed during summer season. Similar observation has been made by Khare et al. (2012). Further, AERMOD will not process under calm wind conditions [3] which were observed to be more (39.28 %) during winter season. Hence, PM₁₀ concentration during summer season was found to be higher than was observed during winter season.

In monsoon season, the AERMOD predicted values for PM₁₀, NO_x and SO₂ concentrations (Figures 10 (a), (b) and (c)) were found to be very less compared to the predicted pollutants values during winter and summer seasons. This was mainly due to the wet deposition of gaseous and particulate matter [8] emitted from stacks. The average wind speed of 4.17 m/s and the wind which blew from West-South-West (WSW) direction observed in the month of June was also a reason for the less pollutant concentration found during monsoon season. Thereby, the pollutants were carried away from the residential areas and found to get dispersed towards agriculture fields located towards NE direction of the study area during monsoon season. In all the monitored seasons, it was found that, AERMOD predicted maximum concentration of pollutants was found near to the point sources of emissions. As there is not much variation in the terrain elevation, in addition, the building downwash effects were not considered in the model [14], hence, it became favorable for the pollutants to disperse rapidly over large area.



International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

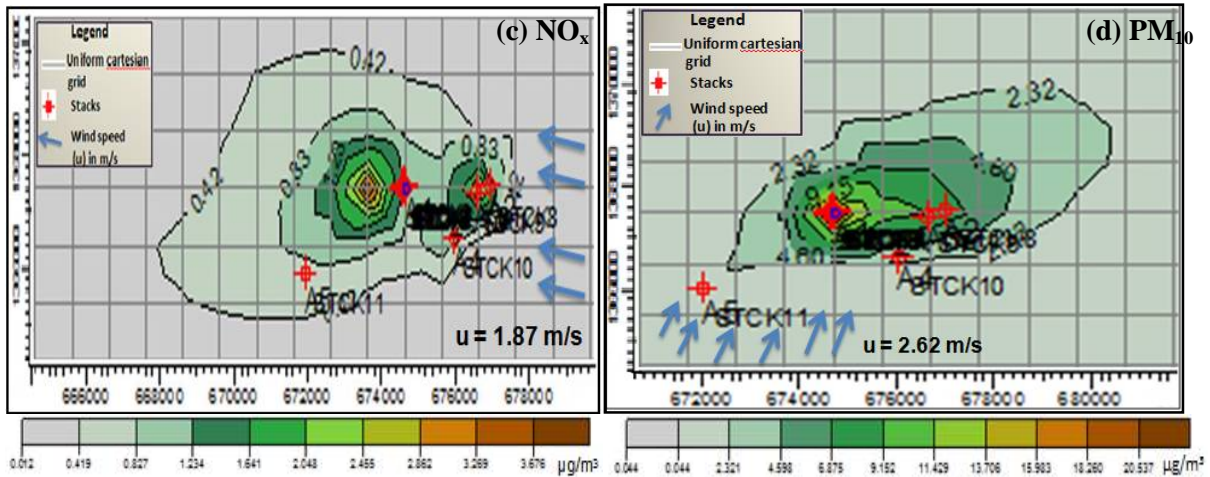


Fig.8. Plots of surface concentration of pollutants estimated by AERMOD during winter season (a) PM₁₀, (b) SO₂ and (c) NO_x; and summer season (d) PM₁₀.

It was found that, the AERMOD underpredicted the pollutants concentration when compared to the monitored concentrations at all the three receptor locations. The correlation coefficient (R^2) for AERMOD predicted PM₁₀, SO₂ and NO_x concentrations (for point source alone) versus the corresponding observed values were found to be 0.309, 0.241 and 0.271, respectively. It is clearly indicated, the model is underpredicting all the pollutants concentration which may be due to not considering the background pollutants concentration in the model equation.

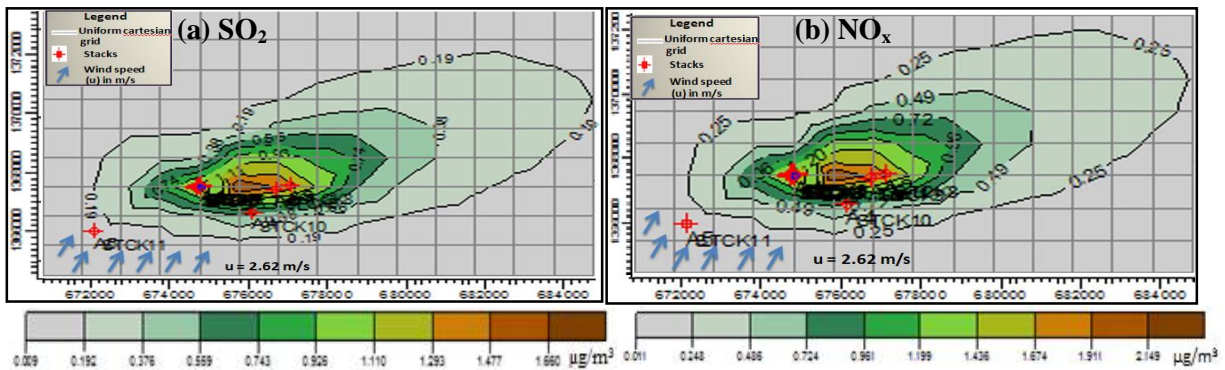
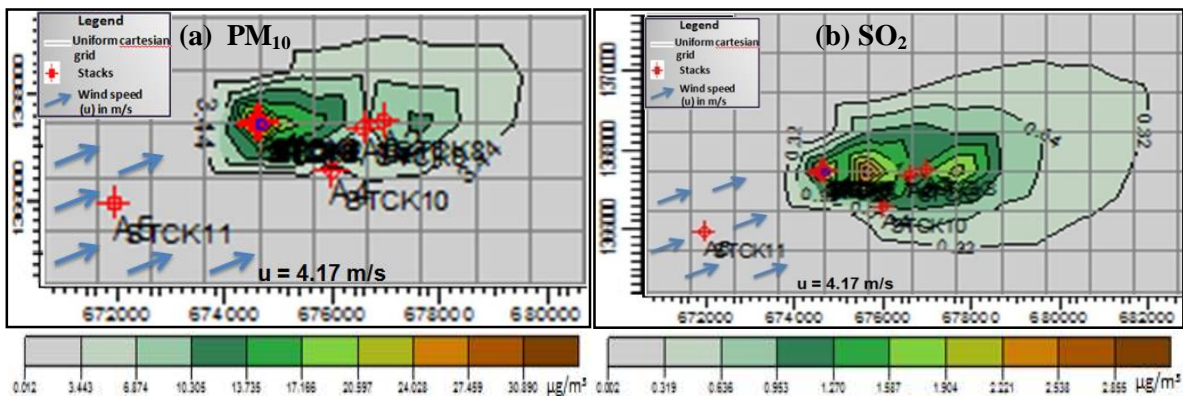


Fig. 9. Plots of surface concentration of pollutants estimated by AERMOD during summer season (a) SO₂ and (b) NO_x over the study area.



International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

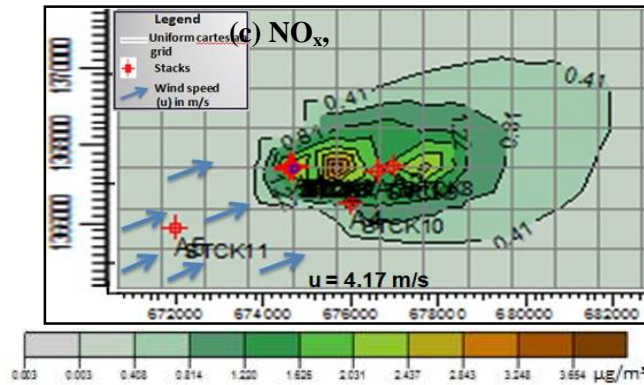


Fig. 10. Plots of surface concentration of pollutants estimated by AERMOD for monsoon season (a) PM₁₀, (b) SO₂ and (c) NO_x

AERMOD was also run to know the effect of combined vehicular and industrial sources on the dispersion of PM₁₀ concentration along the highway for 8 hr and seasonal averaging time periods during winter, summer and monsoon seasons. It was found that, 8 hr predicted PM₁₀ concentrations averaged over all three receptor locations during winter, summer and monsoon periods were found to be 28.69 µg/m³, 53.62 µg/m³ and 13.96 µg/m³, respectively which is well within the NAAQ Standards of 100 µg/m³. It is observed from the Table 3 that, maximum 8 hr predicted PM₁₀ concentration was found to be during summer season, which may be due to the photochemical reactions of the pollutants further leads to more ground level PM₁₀ concentration. During seasonal averaging time period, the predicted maximum PM₁₀ concentration (26.46 µg/m³) during summer season was found to be less when compared to during winter and monsoon seasons. This may be due to longer averaging time of three months (March, April and May) was considered for summer season when compared to winter (two months) and monsoon seasons (1 month and 10 days).

The AERMOD results as indicated in Table 3 showed high PM₁₀ concentration when combined point and line sources are considered. However, PM₁₀ concentration showed lower values when only point sources considered. It indicates that, vehicular emission will have significant impact on the industrial air quality. Further, R² value of the AERMOD model predicted PM₁₀ concentration for combined point and line sources versus the observed value was found to be 0.260, which indicated AERMOD is underpredicting the PM₁₀ concentrations at the receptor locations. This may also be due to not considering the background PM₁₀ concentration in the model equation for the study area.

Table 3: AERMOD estimated maximum pollutant concentrations from combined point and line sources at different averaging time

Averaging time with seasons		AERMOD estimated maximum PM ₁₀ pollutant concentrations in µg/m ³ found near the source
Winter season	8hr	105.37
	Winter period	35.81
Summer season	8hr	151.92
	summer period	26.46
Monsoon season	8hr	94.74
	monsoon period	34.39

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

Further, from the Table 4, it was found that, the dominant source of PM₁₀ contribution over the receptors at the study area is from vehicular source as predicted from CALINE4 model during all the seasons studied and very less contribution was observed from the industrial sources as predicted from AERMOD model which found to be 16.26 %, 15.5 % and 21.80 % during winter, summer and monsoon seasons, respectively. Similarly the vehicles are the dominant source of NO_x emitters in the study area when compared to industrial sources whose percentage contribution from vehicular source and that from industrial sources are presented in Table 5. Therefore, vehicles are considered to be the dominant sources contributing to the PM₁₀ and NO_x concentrations over the study area.

Table4: Seasonal variation in PM₁₀ concentration contributed from vehicular and industrial sources along the study area.

Seasons	PM ₁₀ concentration (µg/m ³) averaged over the study area as estimated by CALINE4 and AERMOD models		Observed PM ₁₀ concentration(µg/m ³) averaged over the study area	Percentage contribution of PM ₁₀ concentration	
	Vehicular source	Industrial source		From vehicular source	From industrial source
Winter	58.71	14.15	87	67.48 %	16.26 %
Summer	86.7	17.18	110.8	78.2 %	15.5 %
monsoon	41.3	11.7	53.6	77.05 %	21.8 %

Table5: Seasonal variation in NO_x concentration contributed from vehicular and industrial sources along the study area.

Seasons	NO _x concentration (µg/m ³) averaged over the study area as estimated by CALINE4 and AERMOD models		Observed NO _x concentration(µg/m ³) averaged over the study area	Percentage contribution of NO _x concentration	
	Vehicular source	Industrial source		From vehicular source	From industrial source
Winter	19.23	2.08	24.85	77.3 %	8 %
Summer	18.5	3.24	24.50	76.19 %	13.28 %
monsoon	14.13	2.06	15.4	91.75	13.37 %

VI. CONCLUSION

Present study mainly focused on the prediction of air pollutant dispersion using AERMOD and CALINE4 models due to vehicular emissions, industrial emissions and combination of both vehicular as well as industrial emissions along the highway passing through industrial area of Mysuru. At all three receptor locations the average pollutants concentrations were found to be within the NAAQ Standards during winter and monsoon seasons. During summer season, PM₁₀ concentration was shown to be 140.5 µg/m³ and 106 µg/m³, which exceeds the NAAQ Standards of 100 µg/m³ at location 2 and 1, respectively. At location 2, PM₁₀ concentration found to be more when compared to at location 1. This may be due to the position of location 2 is in valley, in addition during summer at location 2 heavy traffic volume was observed. As the prevailing wind direction during winter season was from northeast, the pollutants dispersed towards the city. However, during monsoon season pollutants were carried away from the residential areas and tend to reach agricultural field located towards Northeastern part of the study area due to the wind which blew from West (270°) and WSW directions (248°). The CALINE4 model slightly underpredicted NO_x concentration with R² value of 0.901. Results of sensitivity analysis showed CALINE4 model was more sensitive to the changes in wind speed. Results of output of AERMOD model indicate, industrial source emissions are not much contributing to the air pollution in Mysuru city. AERMOD predicted PM₁₀ concentration for combined point and line sources was found to be underpredicted when compared with the monitored values which are due to not considering the background PM₁₀

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Vol. 5, Issue 8, August 2016

concentration in the model equation. Maximum contribution of pollutants such as PM_{10} and NO_x at the receptor locations along the highway was from vehicular emissions in all three seasons.

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