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MODELLING OF VARIATION IN VEHICULAR POLLUTION CONCENTRATION WITH TIME PERIOD AND SEASON

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1. INTRODUCTION

There are different kind of sources of air pollution such as industry, mobile sources like vehicles, ships, train sources and natural sources as biogenic emissions. There is 60 to 70% contribution from vehicles to ambient air quality, in urban cities. These emissions are released in the atmosphere and transported and removed which is a continuous process affected by source strength and meteorological parameters like solar radiation, cloud cover, rain fall, temperature, wind profile and mixing height. The reduction of air pollution can help to mitigate global burden of diseases like respiratory infections, heart disease and lung cancer. World Health Organized (WHO) has estimated that 1.3 million people die by urban outdoor pollution (WHO, 2006). The effect of poor air quality requires rational action for individual sources at national regional and international level. The WHO air quality guidelines represent the most widely and rational assessment of health effects of air pollution, recommending targets for air quality at which the health risks are significantly reduced. The Guidelines indicate that by reducing particulate matter (PM10) pollution from 70 to 20 micrograms per cubic metre, we can cut air quality related deaths by around 15% (WHO, 2006). Most of the metropolitan cities of the world have heavy transportation load to meet needs of the people of the city. This load is increasing with respect to time as the population is increasing. This increasing transportation load is making it difficult to manage the health and safety of societies. There are many kinds of sources of emission like industrial, vehicular and domestic sector in the mega cities but vehicular sources are at ground level, so they disperse less in the atmosphere and have severe effect on human health and environment. It is important to make better and healthy environment, which requires study of vehicular pollution. There are many ways to model the vehicular pollution modeling. The most widely used are Gaussian based, viz. CALINE3 model (Benson, 1979), EPA's HIWAY-2 model (Petersen, 1980) and GM model (Chock, 1978). The modified HIWAY model (called HIWAY-2) and the GM model are applicable to a situation where the upwind segment of the road (measured from the perpendicular line drawn from the receptor) is at least three times the distance between the receptor and the road. Hence, the GM model over predicts the concentration by a considerable amount if the above constraint is not satisfied (Luhar and Patil, 1989). A model was developed (Csanady, 1972) for a finite line source, but it is applicable only when the wind is perpendicular to the roadway. The above constraint can be handled by using the HIWAY-2 model but as mentioned earlier its performance is not as accurate as that of the GM model (Noll et al. 1978). Moreover the HIWAY-2 and CALINE3 models require rigorous computer calculations to estimate the value of integration. All these models require meteorological data, surface characteristics and emission data of vehicles. In this study, hourly onsite meteorological data has been generated using WRF model for whole year 2011. A comparative assessment of vehicular pollution modeling has been carried out with different time scales and seasons for year 2011. A study earlier has been done to see the effect of various time

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scales on air pollution modelling using AERMOD (Zou et al. 2010). The approach in present study is different than the above.

3. STUDY AREA

The main objective of this study was determination of concentration of pollutants by line sources using urban area models through a procedure of forecasting meteorological parameters. The Chembur region of the Mumbai city has been selected for study of vehicular pollution. Chembur represents a highly populated area by industries as well as vehicles. Its latitude and longitude are 19.05^o N and 72.89^o E respectively. The study area is 6.5 kilometres east-to-west and 8.45 kilometres north-to-south as shown in Figure 1. Containers and heavy duty vehicles from this area use Port Trust Road, Mahul Road and Ramakrishna Chemburkar Marg. Due to continuous movement of heavy vehicles, road conditions are getting worse.

Figure 1. Study area of Chembur, Mumbai

3. METHODOLOGY AND INPUT DATA

Vehicle counting was done for six roads of Chembur and emission inventory data was assembled with the help of Air quality monitoring project-Indian clean air programme (ICAP, 2008), ARAI, Pune. Onsite meteorological data was generated using Weather Research and Forecasting (WRF) model, which saved time and resources. These meteorological data from output of WRF model was fed in AERMET with preprocessor of AERMOD. Finally AERMOD model was used for prediction of NOx and PM concentration from traffic emission for the six roads of Chembur. AERMOD was run for one day and one month of winter season and monsoon season of year 2011 and comparison of results was done with day of season, month of season and annual average of concentrations.

Figure 2 shows the wind rose of different periods of time of year 2011. This has been used in air quality modelling of vehicular sources for the study domain for six roads. In one day of winter season, wind is blowing from north-east for maximum time period but maximum wind speed is 3.6 to 5.7 m/sec with 20% frequency from north-west direction. The wind rose of one month of winter shows, wind is blowing from north-east and north-west direction with 8 to 10% frequency. The wind rose of one day of monsoon shows, wind is blowing from south-west direction with around more than 30% frequency and wind rose of one month of monsoon shows, wind is blowing north-east direction for maximum period of time. The annual wind rose shows maximum period of time, wind is blowing from west-south direction with highest speed and also blowing from north-west and east direction. All wind roses are different for different time period.

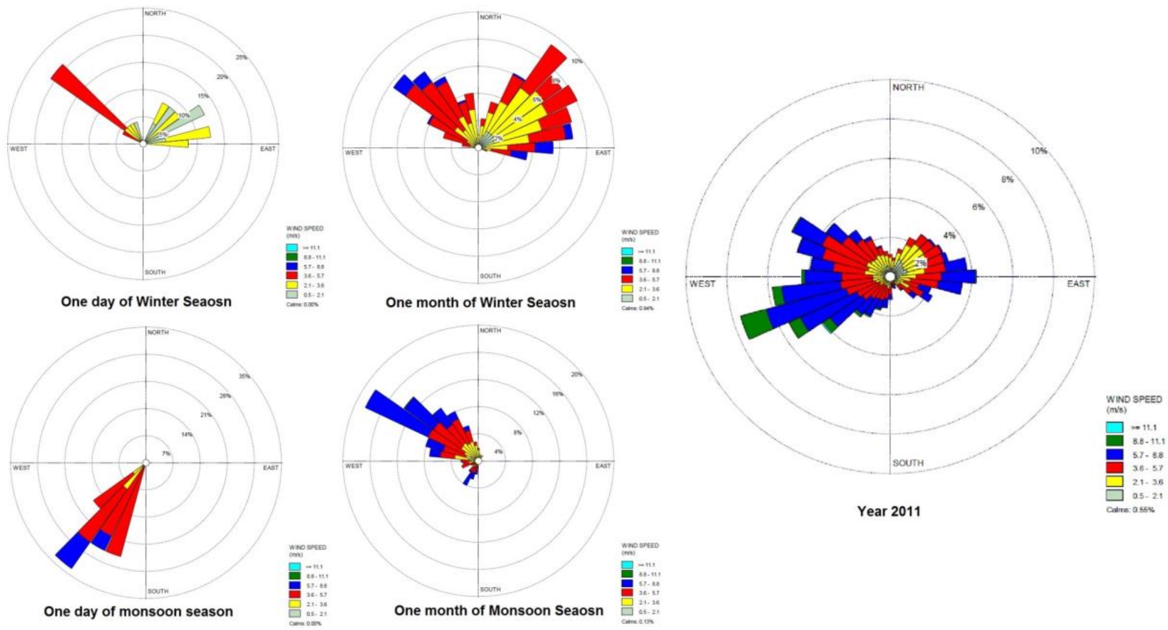

Figure 2. Wind Rose

4. RESULTS AND DISCUSSION

In the present study, NOx and PM emission has been modelled for one day of season, one day of monsoon and year 2011 to figure out the variation of concentration of pollutant with averaging time period and season. Vehicular emission varies with time-period i.e. morning peak, evening peak, off peak and lean peak. So, vehicular emission modelling has been kept constant for the day to see this effect of meteorology.

Figure 3 shows NOx concentration by vehicles for one day, one month of winter and monsoon season and annual average of the year 2011 in the study area. The north part of study area is dominated by vehicular source and high density of vehicles. Maximum concentrations of NOx are 108 µg/m3 for one day of winter season at Chembur Naka, 55 µg/m3 for one month of winter season and 49 µg/m3 for one year 2011at same location. When comparison is done in monsoon season with annual average then it has been found that maximum concentrations are 15 µg/m3 for one day of monsoon, 37 µg/m3 for one month of monsoon and 49 µg/m3 for one year 2011 at Chheda Nagar. Three hot spot have been found in vehicular pollution modelling in each case at Chheda Nagar, Chembur Naka and Chuna Bhatti with high concentration of pollutant. A very interesting result has been observed that when averaging time is increasing then concentration is decreasing in winter season but concentration increases with increasing averaging time of the period in monsoon season.

Figure 4 shows contour plot of PM concentration from vehicles in the study area. Here also, north part of study area is dominated by vehicular sources. In the modelling of PM, background concentration has been estimated as 30 µg/m3 based on the work done earlier (Kumar, 2012) which includes resuspended particulate matter. Maximum concentration of PM is 52 µg/m3 at Chembur Naka and 42 µg/m3 at Chuna Bhatti for one day of winter season. The maximum concentration is 41 µg/m3 at Chembur Naka and 38 µg/m3 at Chheda Nagar and Chuna Bhati for one month of winter season. Modelling of monsoon season shows, the maximum concentration is 32 µg/m3 at Shramjivi Nagar and Chuna Bhatti for one day of monsoon season. Maximum concentration is 36 µg/m3 at Chembur Naka and Chedda Nagar for one month of monsoon season. The maximum concentration of PM is 38 µg/m3 at Chembur Naka and Chedda Nagar for annual average of time period. In PM modelling also, it can be seen that when averaging time increases it decreases concentration of pollutant in winter season but when averaging time increases it increases concentration in monsoon season as compared to annual average of same period.

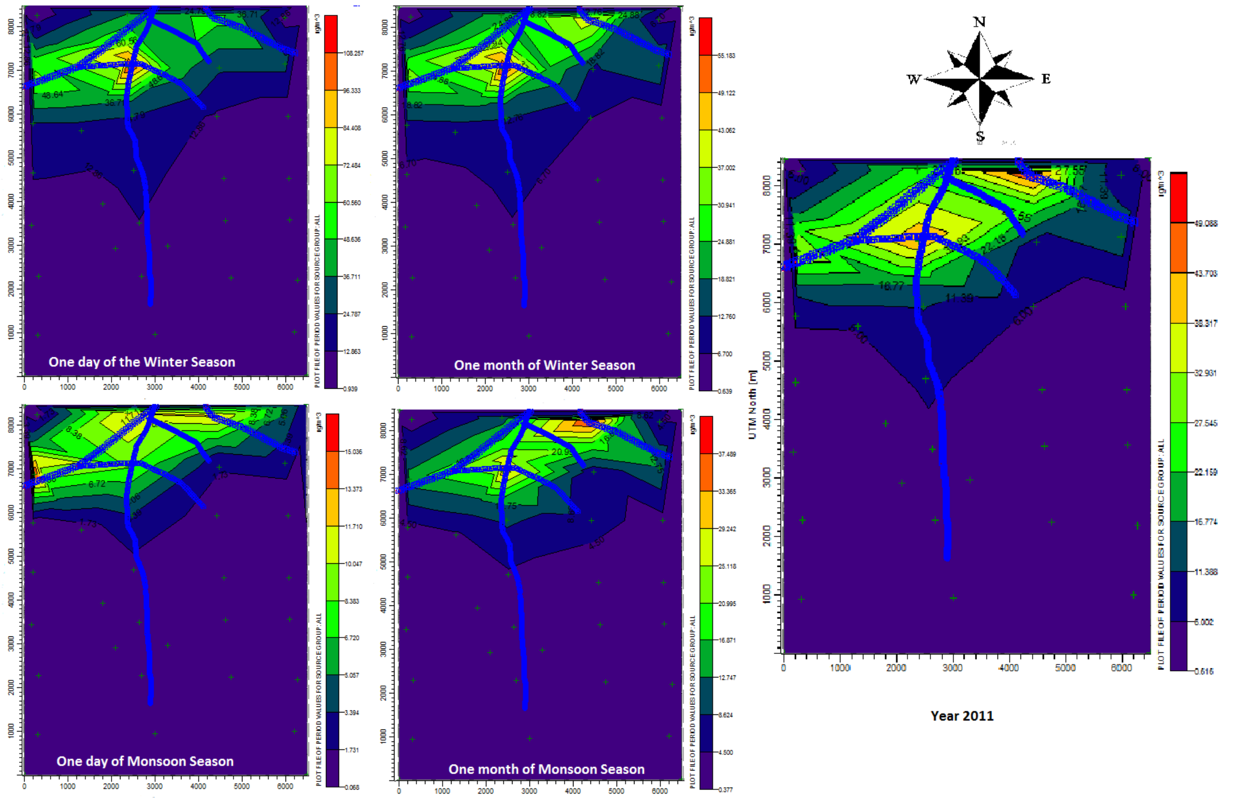

Figure 3. NOx Concentration for Chembur Region

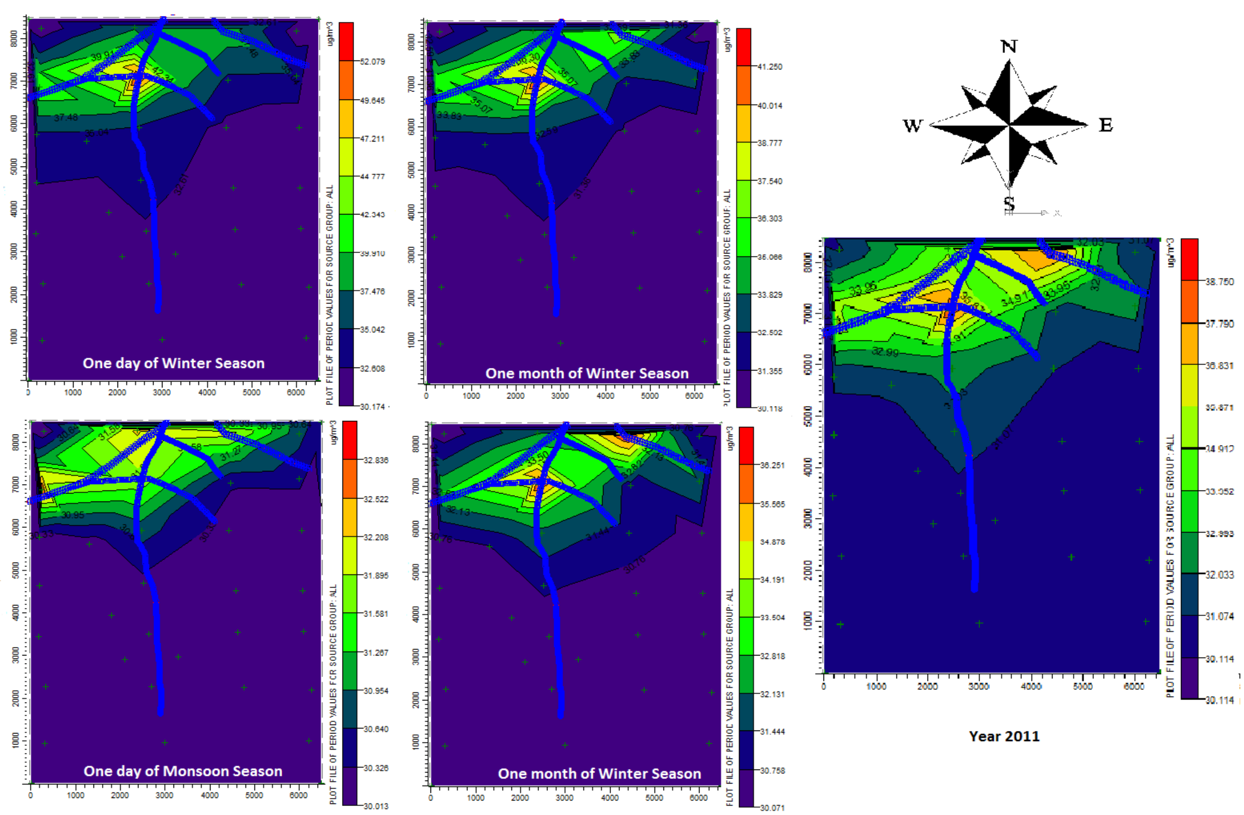

Figure 4. PM Concentration for Chembur Region

5. CONCLUSIONS

The aim of the study was to generate onsite meteorological profiles for using them in vehicular pollution modelling. The advance WRF model was used successfully in this study. It generated onsite and real time meteorological data which was fed in AERMET pre-processor of dispersion model AERMOD. The integrated model was applied one day for all vehicular sources. An emission inventory was compiled using number of vehicles with emission factor for the study area. There is a general understanding in air quality modelling that concentration decrease when averaging time increases. But this study is making a very important observation about effect of averaging period of time on concentration that it is dependent upon season of the period. The concentration is decreasing with increasing of averaging time in winter season while concentration is increasing with increasing of averaging time period in monsoon season. This study also shows that the use of WRF model can save considerable cost and resource for obtaining the data from meteorological station. It also creates on site meteorological data which gives more accurate results.

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