AIR DISPERSION MODELLING FOR VEHICULAR EMISSION IN VADODARA CITY

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ABSTRACT

Vehicular exhaust is one of the important sources of air pollution. As per study 70% air pollution caused by vehicular activity, in India. Vadodara city is a Tehsil, having more than 1.9 million populations. In last decades the vehicular density has dramatically increase, with the increase of populations. In this situation traffic is one of the big problems in this fast generation. Air pollutants from vehicle exhaust like HC, CO, NOx, and PM will cause lots of dieses in human being, like stroke, chronic pulmonary dieses, heart dieses, lung cancer, respiratory infection, etc. & in the city every year more than lacks of vehicles are registered in regional transportation office. This study involves estimation of the vehicular air pollutants in the city by doing traffic survey and air quality modelling using AERMOD (USEPA) software. The result of the study is Isopleths of the various pollutants, which represent the pollution level in the traffic zone and various area of city based on 24 hour maximum ground level concentration µg/m^3 in ambient air quality of Vadodara city.

Keyword: - *AERMOD, Vehicular Air pollution, Air Dispersion Modelling*

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1. INTROCUTION

Vadodara city is situated on both the banks of the river Vishwamistri and is famous as cultural capital of Gujarat and centre of educational activities. The population of the city is as per last census 16, 66,495 and approx. 1.9 million very soon. City is having geographical area of 159.95 m^2 [1].

AMS/EPA Regulatory Model (AERMOD) is a steady-state plume model. It is designed to apply to source releases and meteorological conditions that can be assumed to be steady over individual modelling periods (typically one hour or less). AERMOD has been designed to handle the computation of pollutant impacts in both flat and complex terrain within the same modelling framework. AERMOD having the option for line source point, source as well as area source. This study is for vehicular emission so it has been fall into line source. To successfully run AERMOD line source, need to required meteorological data, details of roads, vehicular population, Map, emission factors, etc.

Meteorological data are essential to run ‘AERMET’ which is one of the bases of the dispersion modelling. The Meteorological data includes various parameters i.e. Temperature (%), Wind Speed (m/s), Wind Direction (degree), Rainfall (mm), Humidity (%) etc. The meteorological data on hourly basis for winter 2018 has been collected for Vadodara city from IMD Ahmedabad. Vehicular density counted by actual traffic survey as well as registered vehicles data collected from regional transport office Vadodara and emission factor consider as BS III as per cpcb vehicular exhaust standard.

1.1 Aim & Objective

Air dispersion modelling for vehicular emission (HC, CO, NOx, PM) in terms of GLC by using AERMOD Software for Vadodara City.

1.2 Scope of the study

Assessment of impact due to vehicle exhausts (HC, CO, NOx, and PM) in the various areas around the roads using AERMOD software and existing land use pattern of the city. Finding the incremental GLC for 24 hour at the various receptors in the city by using (1) Existing ambient air quality condition, (2) Traffic count by actual traffic survey, (3) Meteorological condition by collecting data from IMD & (4) Run AERMOD line source.

2. LITERATURE SURVEY

Increasing air pollution levels due to rapid urbanization and growth in industrial emissions, vehicular emission and transportation activity are now causes of major concern in many large cities of the world. When strategies to protect public health are under consideration, establishing ambient air quality standards and regulations have been introduced in order to set limits on the emissions of pollutant. To achieve these limits, consideration was given to mathematical and computer modelling of air pollution. Therefore, air quality models are indispensable tools for assessing the impact of air pollutants on human health and the urban environment. The necessity for such models has increased tremendously especially with the rising interest in the early warning systems in order to have the opportunity to take emergent and preventive action to reduce pollutants when conditions that encourage high concentrations are predicted. On the other hand, long- term forecasting and controlling of air pollution are also needed in order to prevent the situation from becoming worse in the long run. Air quality protection is a key element in ensuring sustainable livelihoods for both present and future generations. Literature abounds in studies on air quality modelling and the effect of industrial emissions on ambient air quality. Below is presented a selection of works that have dealt with this topic and also the main inferences that emerge from these studies both at national and international levels.

2.1 International Scenario

The dispersion modelling system based on the combined application of an urban dispersion modelling system (UDM-FMI) and a road network dispersion model (CAR-FMI) was developed by (Karppinen et al., 2000) for evaluating traffic volumes, emissions from stationery and vehicular sources and atmospheric dispersion of pollution in an urban area. Similarly, Koracin et al., (2000) performed a comprehensive modelling study of PM_{10} impact in Treasure Valley, Idhao using ISCST3 (Industrial Source Complex Short Term model). The study reported that the input base year meteorology and gridded emissions for mobile sources, point sources and wood burning, generally agreed well with measurements in both temporal patterns and annual averages. Meng et al., (2000) discussed a new statistical framework for estimating carbon monoxide impacts, with the intention of replicating the microscale modelling results achieved with CAL3QHCR (CALINE3 with queuing and hot spot calculations). The results of the study showed that the proposed model can be easily and reliably used by traffic engineers to predict potential carbon monoxide exceedances at the planning stages for transportation projects. Hassid et al., (2000) described their experience in using US EPA Gaussian models for developing environmental impact statements that focused on four different sectors: highway, quarries, airports, and tunnels. The authors encountered several uncertainties associated with the use of dispersion models. The main problems encountered are the uncertainties in the emission factors, the lack of accounting of the complex terrain effects and the fact that the Israeli Standards relate to total NOx concentration rather than NO.

2.2 National Scenario

The increased air pollution levels as a result of concentrated industrial activities in Jamshedpur; the steel city of India was studied by (Sivacoumar et al., 2001). The impact of NO_X emissions resulting from various air pollution sources, viz. industries, vehicles and domestic, was estimated using Industrial Source Complex Short-Term (ISCST) Gaussian dispersion model. The contribution of NOx concentration from industrial, vehicular and domestic sources was found to be 53, 40 and 7% respectively. Further statistical analysis was carried out to evaluate the model performance by comparing measured and predicted NOx concentrations. The model performance was found good with an accuracy of about 68%. Similarly, Reddy et al., (2005) had used the ISCST-3 model to study the impact of an industrial complex, located at Jeedimetla in the outskirts of Hyderabad city, India, on the ambient air quality. The emissions of SO2 from 38 elevated point sources and 11 area sources along with the meteorological data for 2 months (April and May 2000) representing the summer season and for 1 month (January 2001) representing the winter season have been used for computing the ground level concentrations of SO2. Bhati et al., (2009) estimated that the transportation Sector had the greatest contribution (~66.4 %) towards total PM concentration followed by domestic waste (~30.8 %) and power plants (~2.7%) estimated using AERMODE. Mortality assessment revealed that 20% decrease in vehicular emissions leads to five times greater reduction in mortality count as compared to a major shift from coal to natural gas sources in power production sector. Similar studies were done at Patnagar for source contribution of ambient NO2 concentration using models (GFLSM) and (ISCST-3) by (Banerjee et al., 2011). Models simulation indicated that contribution of NO_2 from industrial and vehicular source was in a range of 45– 70% and 9–39% respectively. Further, statistical analysis revealed satisfactory model performance with an aggregate.

3. METHODOLOGY

The methodology is given in flow chart as below:

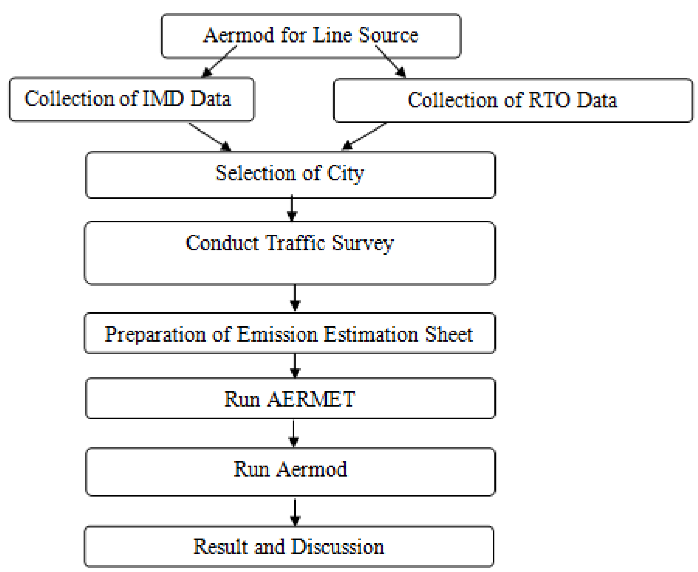

Fig -1: Methodology

3.1 Materials

As discussed above the IMD data of Vadodara City for the Winter Season 2018 (Dec'17 to Feb'18) including various parameters Temperature (%), Wind Speed (m/s), Wind Direction (degree), Rainfall (mm), Humidity (%) are collected from IMD Ahmedabad which is used to run AERMET, the wind rose diagram of the same is given in below fig 2. The traffic count based on the 8 hour and 12 hour as per availability of the resources conducted on the various roads and traffic junction of the city, total 29 roads was surveyed by actual field traffic count. The traffic data is the primary source of the vehicular density in various roads and area of the city. The registered vehicles data including 2wh (scooter, moped), 3wh(auto), 4wh (passenger car, vans, school van, private cars) & 6wh (tractors, buses, trucks) from 2011 to 2018 in the RTO office was collected as secondary data. Emission estimation sheet includes length and width of roads (which was finding by actual road measurement), number of vehicles on each road (find by actual traffic count), and vehicles emission standards (consider BS 3 as per cpcb vehicular exhaust standard) as well as types of vehicles, engine capacity, etc.

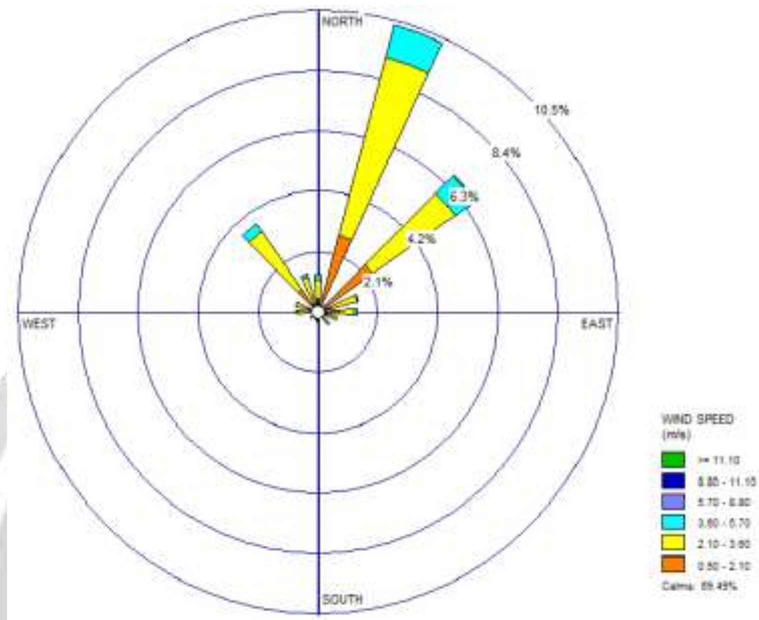

Fig -2: WR Plot Winter 2018 – Vadodara City

3.2 About AERMOD & Assumption

The Aermod is a tool to identify the impact of various air pollutant sources in its surrounding area in terms of GLC. This software also used for the determine the impact of various source for particular period like 24 hour, 8 hour as well as annually. The impact of the vehicular activity on the surrounding area of the roads is given in below. Aermod is divided into two portion first is AERMET which includes input met file and generate SAM file & SFC File, second portion is AERMOD, in which required to input all the data including types of source, emission factor, base map, etc after that, can able to generate isopleths for particular period i.e. 24 hour, 12 hour, annually. The brief procedure to run Aermod is:

- Collection of Meteorological data;
- Preparation of Met-sheet which includes various parameters temperature, wind speed, wind direction, humidity, rainfall;
- Finding out the Latitude and Longitude of the location;
- Run AERMET and generate SAM file & SFC file;
- Input of base map usually land use map of the area;
- Open AERMOD software input latitude and longitude in UTM format;
- Selecting the source and pollutant type;
- Point out the location on map and input the detail of source;
- Run Aermod software;
- Generating the isopleths & Output its Results.

This is the basic consideration & assumption while running the AERMOD software.

- The terrain is considered to be flat;
- The width, length of the roads and number of vehicles are taken as per the actual traffic count and measurement;

- The input of the software is based upon the EES which is prepared using by the RTO Vadodara data, traffic survey data and the emission factors taken from the valid sources;
- The meteorological data includes temperature (%), humidity (%), wind speed km/h, wind direction, rainfall (mm), etc which was taken from the Indian meteorological department for Season winter season (Dec'17 to Feb'18).

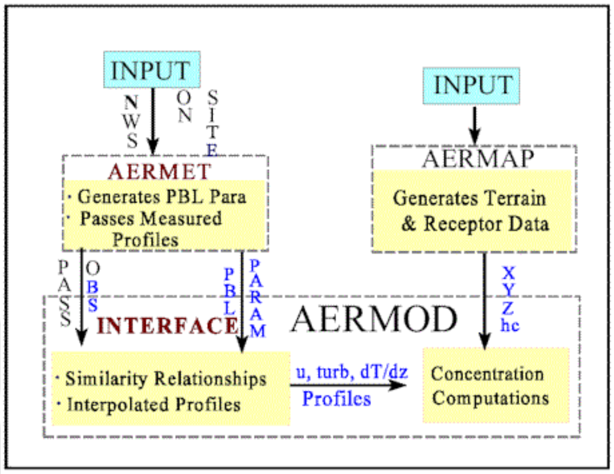

Fig -3: Data flow in AERMOD modelling system

3.3 Conclusion

As per calibration of model, the output is based on 24 hour average results for each road. The Aermod has been run for each roads vehicular emission (pollutants PM_{10}, NOx, HC, CO). Average of 24 hour maximum dispersion in terms of GLC's $\mu g/m^3$ for each road various types of vehicles 2wh, 3wh, 4wh and 6 wh. are given as below.

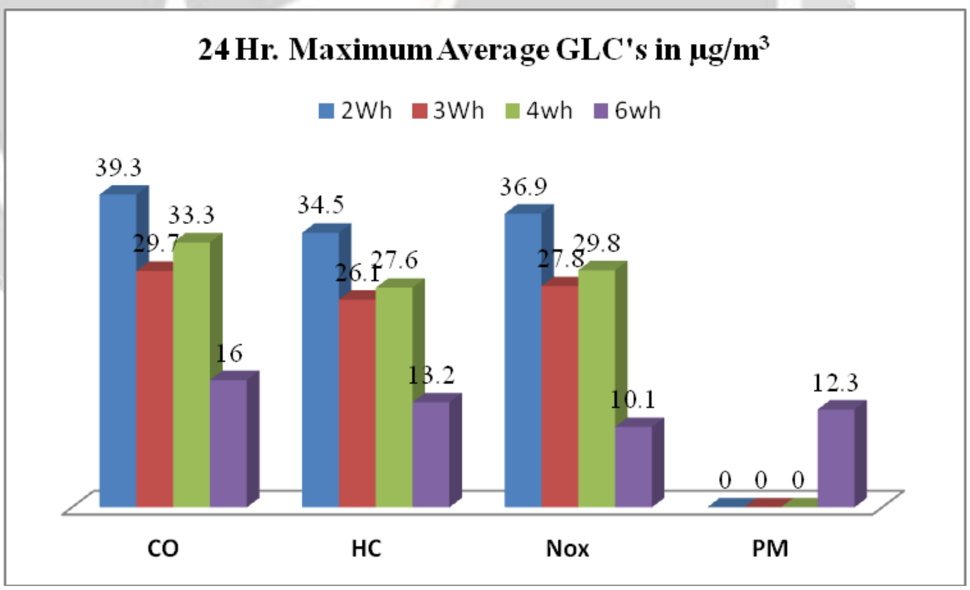

Chart -1: 24 Hr. Maximum Average Value of Aermod line source of all Roads

It is concluded that:

- Heavy vehicles like trucks, buses & tractors are responsible to add 12.3 $\mu g/ m^3$ PM, 16.0 $\mu g/ m^3$ CO, 13.2 $\mu g/ m^3$ HC & 10.1 $\mu g/m^3$ NOx in the ambient air quality of Vadodara city per day.

- Three wheelers like car, jeeps, van and taxi are responsible to add 33.3 µg/ m^3 CO, 27.6 µg/ m^3 HC & 29.8 µg/ m^3 NOx in the ambient air quality of the Vadodara city per day.
- Three wheelers like auto is responsible to add 29.7 µg/m^3CO, 26.1 µg/m^3 HC & 27.8 µg/m^3 NOx in the ambient air quality of the Vadodara city per day.
- Two wheelers like Scooters & Motor Cycles are responsible to add 39.3 µg/m^3 CO, 34.5 µg/m^3 HC & 36.9 µg/m^3 NOx in the ambient air quality of the Vadodara city per day.

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