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Prediction of NOX - GLC'S from Area Source Emissions Using Air Modeling of Ahmedabad city, India

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Abstract* – Air quality evolution by incorporating emission inventory and modeling tools is a decisive element in pollution mitigation. The air dispersion modeling tools are used in the environmental impact assessments, risk analysis, emergency planning, and source apportionment studies. Recent approach towards improving the air quality of cities has led to the opening of wide varieties of mitigation measures and characterization of sources along with understanding the dispersion patents of pollutants in urban area. In order to achieve this various air dispersion models have been developed and used worldwide so far for different applications under different scenarios. The use of Gaussian plume model for studying the advection and transport of pollutants due to turbulent diffusion and advection by the wind is getting momentum. The city planners are incorporating the dispersion studies of city in developing the master plan of city. In this study the AERMOD (the American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee's Dispersion Model,) is used to predict the ground level concentrations (GLC's) of oxides of nitrogen (NOx)- µg/m^3 from area source emissions of different areas of Ahmedabad city. Source emission inventory is prepared for all the areas under study incorporating emissions from Domestic (Slum), Domestic, Hotels and restaurants, Bakeries, Crematorium, Open burning. The secondary data are collected from Ahmedabad Municipal Corporation, Office of Registrar general and respective associations. In the present study 12 areas, two from each zone of Ahmedabad are selected. The maximum GLC of NO_x obtained at Naroda (143 µg/m^3) in the residential cum commercial area. The GLC at Mithakhali cross road, Navrangpura, Mirzapur are exceeding the permissible limit.

***Keywords*- AERMOD, downwind, Gaussian plume model, ground level concentrations (GLC's), Area source emissions, receptor points, NO_X.**

I. INTRODUCTION

Due to rapid urbanization and industrialization of cities led to the development of air pollution problems in urban areas. Furthermore the absence of requisite environment policies has increased the economic and social cost and greater damage to the environment particularly the worsening of air quality. Air-quality management strategies are important for minimizing harmful effects of air pollutants and for reducing the impact of anthropogenic emissions (Ozkurt, 2011). The strategies also have to systematically address the short and long-term causes of air pollution and help cities to achieve a sustainable growth pattern (Elbir et al., 2010). Determination of emissions, air-quality monitoring and modeling are the principal activities involved in air-quality assessment and management (Ying et al., 2007). Since, continuous and long term monitoring of pollutants both temporally and spatially is not always feasible, air quality modeling is widely used as a tool to estimate the pollutants in a desired region (Kumar et al., 1999; Cora and Hung, 2003; Rama Krishna et al., 2005). Therefore the numerical modeling along with monitoring are effective in understanding the air quality of an urban area. For the dispersion of different pollutants, the Gaussian-type air quality models have been studied for different cities, e.g. Delhi (Singh et al., 1990; Goyal and Rama Krishna, 2002; Goyal et al., 2003). The accuracyof air-quality dispersion models depends on many factors, including quality of emission data, quality and representation of meteorological data (Zannetti, 1990). Air quality models have been the topic of discussion and the subject of extensive evaluation to ascertain their performance under an array of meteorological and terrain conditions because they are used to support laws and/or regulations that protect air quality (Kumar et al., 2006). Because these dispersion models are used to support regulatory and/or abatement studies for setting targets for air quality.

II. METHODOLOGY

Study Area

Ahmedabad is located at 23°02′N 72°35′E in the State of Gujarat at an elevation of 53 metres (174 ft). The city is the seventh largest metropolis in India and the largest in the state of Gujarat. In western India, Ahmedabad has been one of the most important centres of trade and commerce. River Sabarmati cuts the city into two parts: eastern walled city and western Ahmedabad on either side of its banks. The Ahmedabad Municipal Corporation (AMC) area is spread over 190.84 sq. km and the Ahmedabad urban agglomeration (AUA) area is about 350 sq. km. Population in AUA has increased from 4.5 million in 2001 to 5.6 million in 2011,(census 2011). The industrial hubs in Ahmedabad city are Narol, Vatva, Naroda, Odhav and other scattered locations which were initially beyond the periphery of city but now very much part of Ahmedabad city. Ahmedabad Municipal Corporation (AMC) area is divided into six zones and 52 wards for administrative purpose.

Metrological Data

Dispersion of air pollutants in the atmosphere are influenced by regional weather patterns (Ying et al., 2007; Al-Azmi et al., 2009). The meteorological conditions play a very important role in pollutant dispersion which affects the ground level concentrations in the residential areas. The meteorological parameters that affect NOx are wind speed, wind direction, mixing height, ambient temperature and inversion layer. Meteorological data of the year 2015 are obtained from meteorological station of Gujarat Environment Management Institute. Meteorological data consist of hourly wind speed, temperature, cloud cover, ceiling height, surface pressure and relative humidity. AERMOD model needs hourly surface data values for wind speed, temperature, relative humidity, wind direction and cloud cover. The surface and upper air data files were then used to generate the meteorological file required by the AERMOD dispersion model using the AERMET meteorological pre-processor. This AERMET programme has three stages to process the data. The first stage extracts meteorological data and assesses data quality through a series of quality assessment checks. The second stage merges all data available for 24-hour periods and writes these data together in a single intermediate file. The third and final stage reads the merged meteorological data and estimates the necessary boundary layer parameters for dispersion calculations by AERMOD.

Table 1: Meteorological data of winter season (0-24 Hours)

Year	**Hour**	**Cld Covr [tenths]**	**Temp. [C]**	**Humi. [%]**	**W DIR [deg]**	**W SPD [m/s]**	**Cei Ht[m]**	**Radn, wh/m2**
2015	1	2	17.6	59	171	1.9	3000	0
2015	2	2	16.6	64	176	1.5	3000	0
2015	3	2	16.9	70	161	2.2	3000	0
2015	4	2	16.9	73	173	1.9	3000	0
2015	5	2	16.6	77	354	3	3000	0
2015	6	2	16	81	175	1.5	3000	0
2015	7	2	15.1	86	173	3.3	3000	0
2015	8	2	15.2	87	172	3.4	3000	6
2015	9	2	16.8	81	36	1.3	3000	60
2015	10	2	20.2	73	157	1.2	3000	223
2015	11	2	20.8	71	130	1.1	3000	341
2015	12	2	21.5	66	59	1.1	3000	261
2015	13	2	22.8	62	20	2.2	3000	159
2015	14	2	22.9	61	46	2.4	3000	122
2015	15	2	22.6	63	359	0.9	3000	63
2015	16	2	23	61	110	1.4	3000	95
2015	17	2	22.7	63	265	0.9	3000	33
2015	18	2	22.1	64	337	1.4	3000	3
2015	19	2	21.4	66	133	1.6	3000	0
2015	20	2	20.5	69	35	2.2	3000	0
2015	21	2	20.2	70	109	2.6	3000	0
2015	22	2	19.8	72	353	1.6	3000	0
2015	23	2	19.6	73	70	2.8	3000	0
2015	24	2	17.7	57	155	1.2	3000	0

The Wind rose shows the prevalent wind direction blows from which the wind blows. It shows that the pollutant will be dispersed in that direction. The wind rose shows that the predominant wind direction is from east to west with 11% wind speed falls in calm conditions.

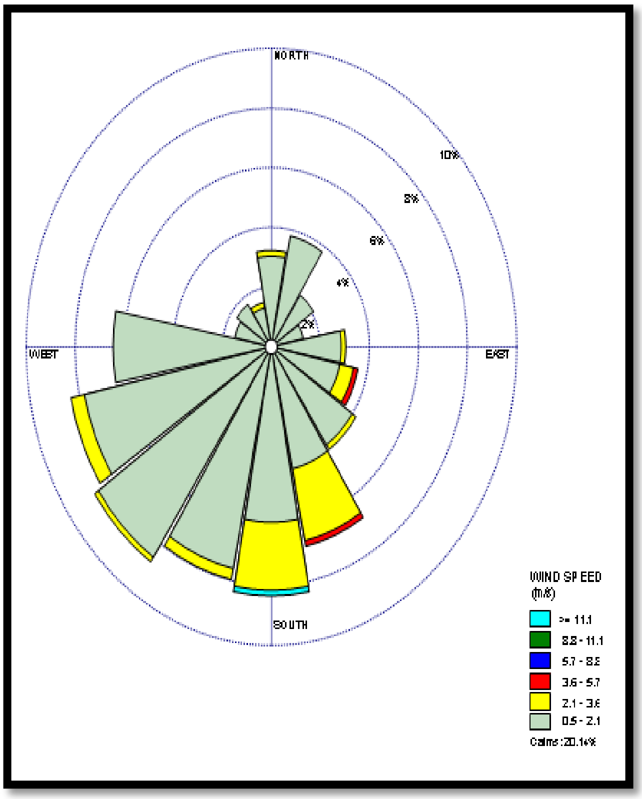

Fig. 1: Wind rose of Winter Season

Emission Inventory:

Table 2: Various Types of Area Sources around Study Zone Locations

Study zones	Population	Slum Population	Hotels & Restaurants	Crematoria	Open Burning	Bakeries	Incinerator
Naroda road	79926	29355	22	-	300 Kg	4	-
Nava Naroda	109922	35976	7	-	315 Kg	-	-
Dariyapur	63664	12732	10	-	-	2	-
Shahpur	68150	17037	6	-	-	1	-
Kankaria	67110	20133	8	-	-	-	-
Maninagar	95481	28644	13	-	-	-	-
Nikol	137840	55136	15	-	-	1	-
Odhav	137543	48140	8	-	-	2	-
Navrangpura	55647	8940	19	-	-	-	-
Paldi	83109	24500	12	-	297 Kg	-	-
Ghatlodiya	206893	-	14	-	-	-	-
Vejalpur	295075	-	9	-	-	-	-

- Hotels/ restaurants are situated in the study zones of almost all the sites.
- No crematorium was observed near any one of the locations. No medical waste incinerator and solid waste disposal facility was found near any one of the sites.
- Open burning was observed during survey at Nava Naroda and Paldi.
- Emission load was calculated using emission factor given by CPCB

Table 3: Ward wise Area Source Emission Load

Ward	Ward Name	Nox (kg/day)
1	Naroda road	246.9
2	Nava Naroda	245.7
3	Dariyapur	82.1
4	Shahpur	122.9
5	Kankaria	167.8
6	Maninagar	172
7	Nikol	338.7
8	Odhav	123.8
9	Navrangpura	365.2
10	Paldi	62.4
11	Ghatlodiya	66.4
12	Vejalpur	55.3

AERMOD Dispersion Modeling

- AERMOD is a steady-state plume model. In the stable boundary layer (SBL), it presumes the concentration distribution to be Gaussian in both the vertical and horizontal. In the convective boundary layer (CBL), the horizontal distribution is also assumed to be Gaussian, but the vertical distribution is described with a bi-Gaussian probability density function (pdf).
- AERMOD incorporates current concepts about flow and dispersion in complex terrain.
- AERMOD develops vertical profiles of needed meteorological variables based on measurements and extrapolations of those measurements using similarity (scaling) relationships.
- Vertical profiles of wind speed, wind direction, turbulence, temperature, and temperature gradient are estimated using all available meteorological observations.
- AERMOD is designed to run with a minimum of observed meteorological parameters.
- Site location involving elevated terrain, the AERMAP terrain pre-processing program is incorporated into the model to generate.
- The model has algorithms for wet and dry deposition.

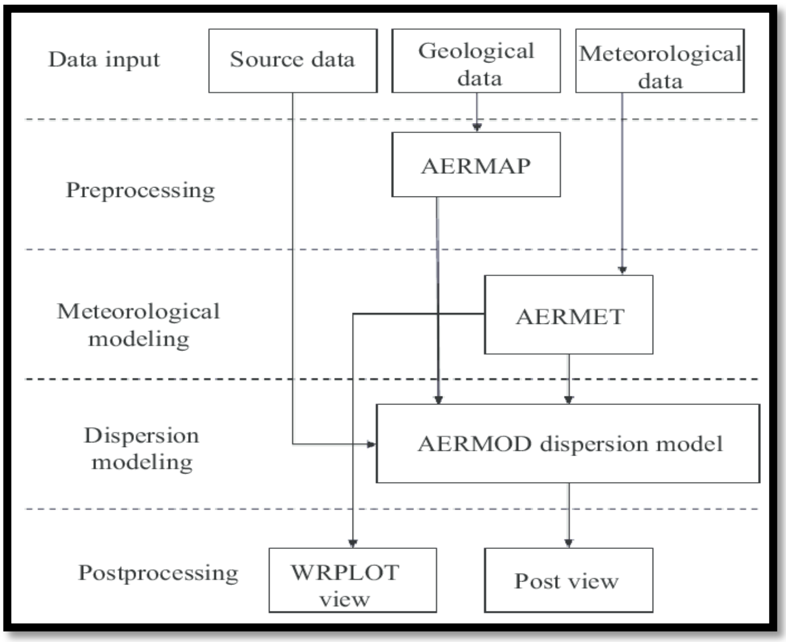

Fig. 2.Data flow in the AERMOD modeling

III. RESULTS AND DISCUSSION

The contour is developed showing the concentration of NO_x in different areas of the city. The maximum concentration obtained at Naroda (143 µg/m^3). The GLC at Mithakhali cross road, Navrangpura, Mirzapur are exceeding the permissible limit. The top ten GLC obtained are given in the table 4.

Table 4: Top Ten GLC across the city (24 h avg)

X	Y	Concentration (AVERAGE CONC) [ug/m^3]
260084	2553126	142.61581
250084	2549126	133.94539
252084	2549126	81.24606
254084	2545126	72.88733
250084	2551126	68.34991
260084	2549126	62.94066
260084	2551126	62.38106
254084	2547126	57.82891
262084	2549126	55.18259
262084	2551126	53.80046

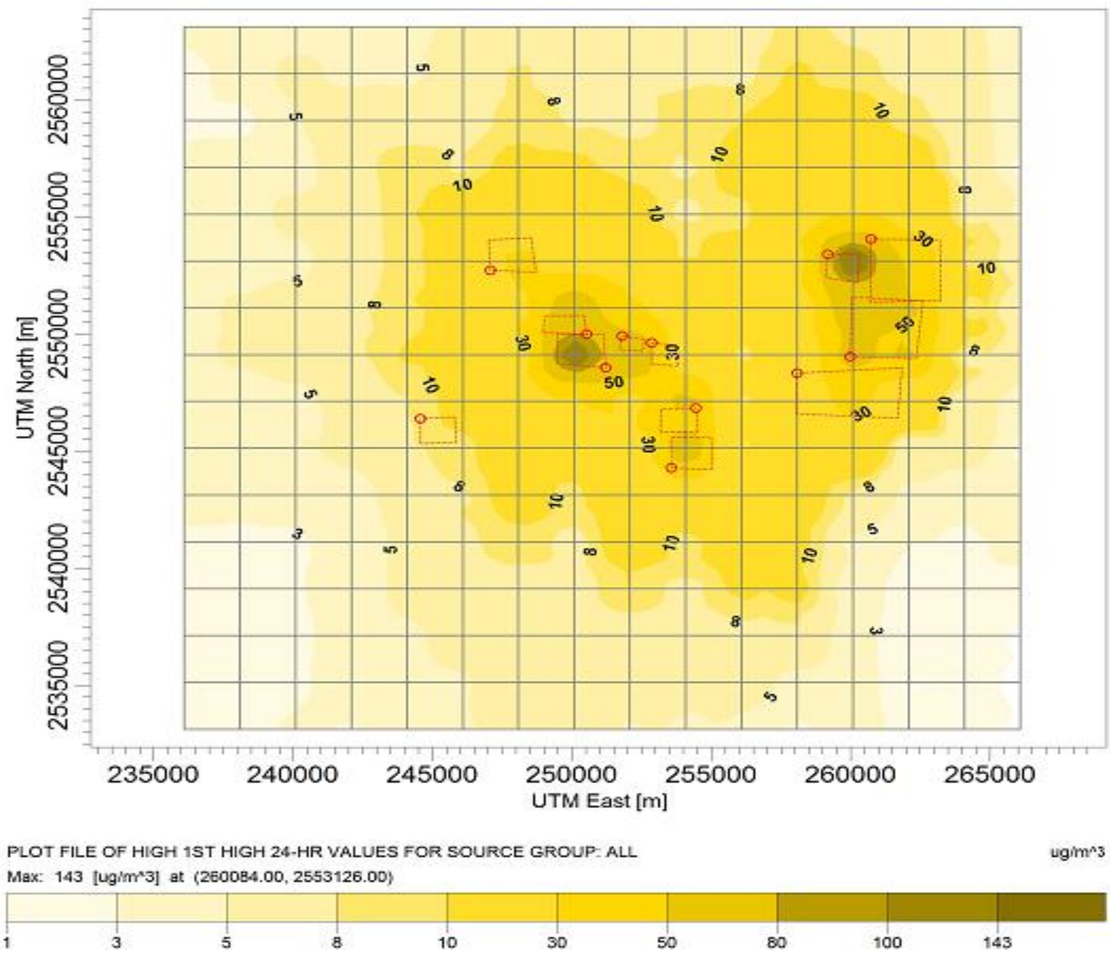

Fig. 3. isoconcentration plot of Oxides of Nitrogen (No_X) (24 h avg)

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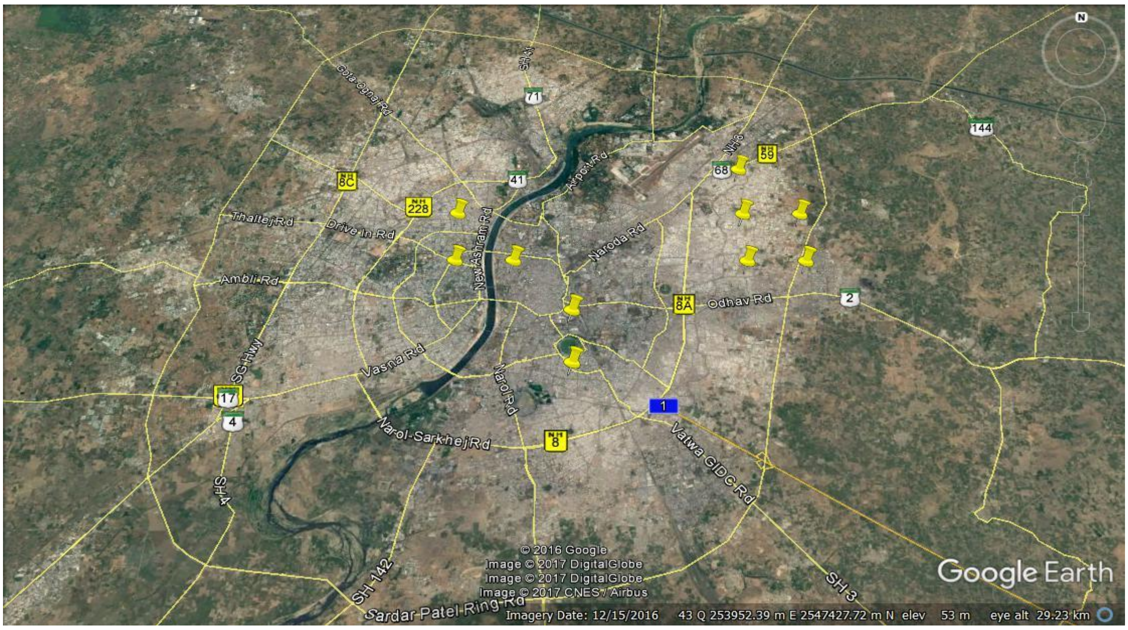

Fig.4. Top Ten GLC depicted in Google Earth Image of Ahmedabad City

IV. CONCLUSION

The AERMOD model is used to obtain the iso concentration profile of the oxides of nitrogen. Model usability in terms of pollutant dispersion prediction was analyzed for the Ahmedabad city. The iso concentration shows that the top ten GLC out of which three exceeds the permissible limit 0f 80 µg/m^3 falls in the residential cum commercial area. The emission inventory showed most of the NO_x was from the domestic slum areas of all the locations. The higher use of Wood, Kerosene, and Coal in the slum results into the increased emission load. The use of clean fuel should be encouraged among the slum habitat. Ahmedabad Municipal Corporation should develop holistic environment policy as part of the master plan.

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