International Journal of Advanced Research in
Civil,Structural,Environmental and Infrastructure Engineering and Developing
Volume: 2 Issue: 2 01-Jun-2014,ISSN_NO: 2320-723X

Air Quality Modeling in Tuticorin City

Joyce Vetha Evelyn. A

PG Student, Environmental Science and Engineering, Department Of Civil Engineering,
Regional Centre of Anna University, Tirunelveli- 627 007, India.
joyceeben@gmail.com

ABSTRACT— *This Air Quality Modeling (AQM) study will provide a quantified analysis and recommendations on how best to improve air quality in the city of Tuticorin and to reduce greenhouse gas (GHG) emissions, while meeting critical health and economic development objectives. To accomplish this, a comprehensive inventory of point, area, and line sources was conducted in the selected study area, primarily aiming to estimate the sectoral emission contributions to ambient air quality. The Industrial Source Complex Short–Term Model, Version 3 (ISCST3) will be used to predict the ambient concentrations of total suspended particulate matter (SPM), Sulphur dioxide (SO_2), and Nitrogen dioxide (NO_2) at seven monitoring sites (receptor locations) three operated by the Central Pollution Control Board (CPCB) and four operated by the Tuticorin Thermal Power Plant (TTPS) for the for Calendar Year (CY)-2012 (as baseline) and for Business as usual (BAU)-2013 and future scenario for 2020.*

Index Terms— Air Quality Modeling, Emissions, Source apportionment (key words)

1, INTRODUCTION

The Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) were set up under the Water Act of 1974 for controlling and monitoring environmental degradation in the country and they function under the Ministry of Environment and Forests (MoEF). The Indian Parliament enacted Air (Prevention and Control of Pollution) Act in 1981, to tackle the challenges posed by air pollution and entrusted the implementation of this law to the State Pollution Control Boards (SPCBs) and the Central Pollution Control Board (CPCB). Environmental clearance has been made mandatory under the Environment Protection (EP) Act-1986, for the expansion or the modernization of any activity or for setting up new projects listed in Schedule-I. CPCB has laid down the ambient air quality standards for different areas and the SPCBs have fixed emission standards for the different industries. The SPCBs are also responsible for the compliance of industrial emissions with the National Ambient Air Quality Standards (NAAQS).

Tuticorin is one of the most polluted cities in Tamilnadu due to its unrestricted growth. Urban transport, cargo freight activities, manufacturing industries, and thermal power plants are the major sources of anthropogenic pollution. As a consequence, the assimilative capacity of atmosphere is being stressed. The ambient air quality of Tuticorin does not comply with National Ambient Air Quality Standards (NAAQS) in selected areas. The situation calls for imposing stringent control measures on the air pollution sources. Such proposed remediation measures primarily, require a detailed understanding of the sectoral emissions (point, area and line sources) and their contri-bution to ambient air pollution (source apportionment) and secondly, to predict the impact of regulatory interventions or to impose stricter emission standards on ambient air quality. Due to time and resource limitations the study has been restricted to the harbor estate. The base year for the study is Calendar year (CY) 2012.

2, DESCRIPTION OF THE STUDY AREA

Tuticorin, also known as Thoothukudi, is a port city and Municipal Corporation and an Industrial city in Thoothukudi district of the Indian state of Tamil Nadu. Thoothukudi is the headquarters of Thoothukudi District. Thoothukudi is located at a latitude of 8.53°N and a longitude of 78.36°E. It is located about 590 kilometres (367 mi) south of Chennai. The city experiences tropical climatic conditions characterized with immensely hot summer, gentle winter and frequent rain showers. Summer extends between March and June when the climate is very humid. Tuticorin registers the maximum temperature of 39°C and the minimum temperature of 32°C. During the months of October and November, the city receives around 444 mm rainfall from the Northeast monsoon, 117.7 mm during summer, 74.6 mm during winter and 63.1 mm during the South-west monsoon season. The city has a very high humidity being in the coastal sector.

According to the Confederation of Indian Industry, Tuticorin has the second highest Human Development Index in Tamil Nadu next to Chennai.Tuticorin city has grown in importance during the last two decades like industry, educational institutions, commercial complexes, tourism etc. Day-by-day population has been increasing; people from rural areas are shifting to the city in search of employment, education etc. The large industries other than infrastructure providers i.e. the Port and the TNEB power plant are Sterlite (copper), SPIC (fertilizers and chemicals), and Kilburn Chemicals (titanium dioxide). There are several textile mills also in the district. The presence of these large industries has led to the establishment of industries that have product synergies with these units. Several medium and small industries, including traditional ones, are situated in Thoothukudi and its neighborhood. The major segments include salt – industrial and domestic, marine products, minerals (Ilmenite, Garnet, etc.), dry flowers exports, edible oil extraction, readymade garments, and senna (medicinal herbs) exports. In the service industry, logistics and port related services industry is a thriving segment whose growth is directly related to the growth of the Port.

3, ANALYSIS METHODS AND INPUTS

3.1 Pollutants Being Modelled

The list of pollutants under consideration in the assessment are as follows:., Sulphur dioxide (SO_2), oxides of nitrogen as (NO_x) and suspended particulate matter (SPM) and respirable suspended particulate matter (RSPM/ PM_{10})

3.2 Ambient / Background Levels

For all pollutants under consideration an appropriate value for background concentration will be determined. This is achieved by the collection of ambient air monitoring data from local authorities. The local authorities referred to in this study are

The Tamilnadu State Pollution Control Board which has three monitoring stations at Tuticorin, namely, Fisheries College, Raja Agency Building and AVM Jewellery Building and the Tuticorin Thermal Power Plant which monitors ambient air data within its premises and at key locations in the vicinity of which four are considered for this study. These stations are operated manually using high volume samplers for PM_{10} and the data is collected 2 to 3 times per week.

3.3 Meteorology / Surface Characteristics

The hourly–average meteorological data for observations such as wind speed and direction, temperature, humidity, cloud cover, mixing and ceiling height have been collected from Indian Meteorological Department (IMD), for the study period. The meteorological data used in the model such as wind speed, wind direction, temperature, relative humidity, precipitation rates have been collected from the Cyclone warning Centre of the Indian Meteorological Department (IMD) located in the Tuticorin Port Trust**.** Wind directions and wind frequency distribution in the major seasons of the year and wind roses have been plotted**.** Relevant data for the monitoring period are converted into daily mean hourly parameters and used for prediction at the respective sites.

3.4 Emission Inventory (EI)

Preparation of detailed emission inventory with estimation of emissions from various activities such as vehicular, industrial, residential, commercial, etc. carried out for the year 2012 based on fuel consumption data for transport, industrial, and domestic sectors. SPM, SO_2, and NO_2 emissions from point, area, and line sources in the study area were computed and compiled for each month during the study period. SO_2, NO_2, and SPM have been selected as criteria pollutants based on the rationale that: a) these are the significant pollutants emitted from the thermal power plants, b) they are the only air pollutants which are subject to current Indian standards c) they are continuously monitored by the regulatory authorities, d) the changes in parameters can be predicted by the modelling process. Only fuel burning industries were covered by this study. Emissions were estimated based on the annual fuel consumption, fuel type and appropriate emissions factor. If stack-test data was available, pollutant loads were estimated based on pollutant concentrations and flow rate of the flue gas. Type of control equipment and its efficiency are also considered while estimating pollutant loads. The domestic fuel consumption and its emission load has been considered to be insignificant, compared to the industrial or vehicular emissions, as the primary domestic fuel for household operations is the liquid petroleum gas (LPG) or kerosene.

3.4.1 Emission Factors

Activity based emission factors (EF) are used to estimate the emissions inventory for SPM, SO_2 and NO_x. Emission factor is defined as the emitted mass per vehicle-km traveled (for transport) or emitted mass per unit of fuel burnt (for industries, power plant, domestic, or waste sectors). Applicable emission factors for transport, industrial, and power sectors and domestic sector for various fuels are available in the 'Air quality monitoring, emission inventory and source apportionment study for Indian cities - National Summary Report' released by the CPCB (2010)- Annexure VII for Vehicular and Annexure VIII for non-Vehicular emission factors.

3.4.2 Spatial Allocation of Emissions

A uniform Cartesian grid system was used to locate and fix sources and receptors in the study area. The southwest point in the system is considered as 'origin' and northeast point in the system is 'the point' of maximum x and y values. Grid wise emission rates for different source groups are worked out for SPM, SO_2 and NO_x from baseline emission inventory of the year 2012.

3.5 Dispersion Modeling

3.5.1 Choice of Model

The Industrial Source Complex Short–Term Model, Version 3 (ISCST3) will be used to predict ambient concentrations of pollutants for the study period. ISCST3 is based on steady–state Gaussian plume algorithm, applicable for estimating ambient concentrations from point, area, and line sources up to a distance of 50 kilometres (http:// www.epa.gov/ scram 001/). The Central Pollution Control Board (CPCB) has accepted ISCST3 as a preferred model for regulatory studies (CPCB, 1998). The inputs and options required for this model are:

- Control options
- Sources data
- Meteorological data
- Receptors information

3.5.2 Model Description

The Industrial Source Complex (ISC) Short Term model provides options to model emissions from a wide range of sources that might be present at a typical industrial source complex. The basis of the model is the straight-line, steady-state Gaussian plume equation, which is used with some modifications to model simple point source emissions from stacks, emissions from stacks that experience the effects of aerodynamic downwash due to nearby buildings, isolated vents, multiple vents, storage piles, conveyor belts, and the like. Emission sources are categorized into four basic types of sources, i.e., point sources, volume sources, area sources, and open pit sources. The volume source option and the area source option may also be used to simulate line sources.

3.5.4 Scenario Analysis for 2020

The emissions, dispersion, calculations will be extended to the year CY 2020, taking into account economic growth and growth in population, industries and number of vehicles.

IV. CONCULSION AND FUTUREWORK

In this paper is presented an Air Quality Modeling (AQM) study which will provide a quantified analysis of the ground level concentrations of pollutants in the coastal city of Tuticorin. SPM has been identified as the major contributor to the deterioration of AQ Standards in the city. The annual average background concentrations are calculated as SO_2 -12 µg/ m^3, NO_2- 14 µg/ m^3 and SPM (RSPM + PM)- 200 µg/ m^3. The annual average ground level concentration of SPM far exceeds the National Ambient Air Quality Standards (NAAQS) in all the stations except the AVM Jewellery station. The annual average ground level concentrations of SO_2 and NO_2 are well within the prescribed NAAQS standard. The uncertainties involved in the use of available emission factors is acknowledged. But calculating and measuring the emission factors for every activity is an expensive and time consuming process. As more information becomes available about emission factors, we can refine the model inputs. The future work of this paper is to analyze the scenario for CY 2013 (BAU) and future scenario for CY 2020.

REFERENCES

[1] Anand Kumar, Ashish Garg and Upender Pandel. (2011), ‘A Study of Ambient Air Quality Status in Jaipur City (Rajasthan, India), Using Air Quality Index.’, Nature and Science;Vol. 9(6), pp. 38-43

[2] Angelika Sharma, Anil K. Raina (2012), ‘Ambient air quality of Jammu City: A study with reference to SO2 and NO2 contents’, International Journal Of Environmental Sciences , Volume 3, No 1, pp. 650-658.

[3] Anikender Kumar, Pramila Goyal (2011) ‘Forecasting of air quality in Delhi using principal component regression technique’ Vol. 2, pp. 436-444

[4] Anne E. Wittig, Natalie Anderson, Andrei Y. Khlystov, Spyros N. Pandis, Cliff Davidson, Allen L. Robinson (2004) ‘Pittsburgh air quality study overview’, Atmospheric Environment, Vol. 38, pp. 3107 -3125

[5] Angelika Sharma, Anil K. Raina (2012), ‘Ambient air quality of Jammu City: A study with reference to SO2 and NO2 contents’, International Journal Of Environmental Sciences , Volume 3, No 1, pp. 650-658.

[6] ‘Air quality monitoring, emission inventory and source apportionment study for Indian cities - National Summary Report’(www.cpcb.nic.in) < moef.nic.in/ downloads/ public.../Rpt-air-monitoring-17-01-2011.pdf >

[7] Arun Kansal , Mukesh Khare , Chandra Shekhar Sharma (2011), ‘Air quality modelling study to analyse the impact of the World Bank emission guidelines for thermal power plants in Delhi’ Atmospheric Pollution Research , Vol.2, pp. 99-105.

[8] CPCB, (2010), 'Air Quality Monitoring, Emission Inventory and Source Apportionment Study for Indian Cities. Central Pollution Control Board, Government of India, New Delhi, India', < cpcb.nic.in >

[9] 'Emission Factors for Locomotives' (2009), USEPA Office of Transportation and Air Quality , < www.epa.gov/otaq/locomotives.htm.>

[10] Goyal. P and Anikender Kumar, (2006) 'Mathematical Modeling of Air Pollutants: An Application to Indian Urban City' Mathematical Modeling of Air Pollutants: An Application to Indian Urban City

[11] Gupta A. K., Karar K., Ayoob S. and John K. (2008), 'Spatio-Temporal Characteristics of Gaseous and Particulate Pollutants in an Urban Region of Kolkata, India.' Atmospheric Research, Vol. 87 Issue 2, pp.103-115

[12] Klingberg.J, Karlsson.P. E, Pihl Karlsson.G, Hu.Y., Chen.D., Pleijel.H. (2012) 'Variation in ozone exposure in the landscape of southern Sweden with consideration of topography and coastal climate', Atmospheric Environment , Vol. 47, pp. 252-260

[13] Paul J. Croft, Belkys V. Melendez (2009), 'Investigation Of The Air Quality Index As Related To Weather Regime' National Weather Digest, Vol. 33(2), pp. 132-153.

[14] Rao, C.S. (1991) 'Environmental Pollution Control Engineering', New Age International (P) Limited, Publishers, New Delhi.

[15] Rao, M.N and Rao H.V.N. (1989) 'Air Pollution', TATA McGraw-Hill Publishing Company, New Delhi.

[16] Sarath K. Guttikunda, Puja Jawahar (2012) 'Application of SIM-air modeling tools to assess air quality in Indian cities' Atmospheric Environment, Vol. 62 pp. 551-561

[17] Sharma, B.K. (2001) 'An Introduction to Environmental Pollution' GOEL Publishing House, Meerut

[18] Srinivas.V. (2001), 'Air Quality Modeling as a Vital Component in IES-India Project', < cleanairinitiative.org/ portal/system/files/59171 _ srinivas _ paper . doc.>