A REVIEW PAPER ON PERFORMANCE OF AERMOD FOR VARIOUS PARAMETERS

[1]Goral Parikh, [2]S. M. Usman
[1] Student of Environmental Engineering Department, Aadishwar College of Technology, Swarrnim Start Up & Innovation University, Gandhinagar, Gujarat, India,
[2]Assistant Professor, Department of Environment Engineering, Aadishwar College of Technology, Swarrnim Start Up & Innovation University, Gandhinagar, Gujarat, India.

Abstract: Air pollution is the major concerned type of pollution amongst all the types of pollutions like water pollution, land pollution, noise pollution, ground water contamination etc. Air pollution may be the result of natural sources or natural occurrences or human activities. Rapid increase and revolution in industrialization and increase in population are major reasons considered for increased air pollution in current era. Diminution of air pollution is the most important because it affects biotic as well as abiotic components present on the planet Earth. To diminish the air pollution, the first step shall be monitoring of air quality. Assessment of air pollutants emitted from industrial activities is necessary. Now-a-days, there are many active Air Pollution Dispersion Models being used widely, like CALPUFF, ISCST 3, SCREEN, AERMOD, Gaussian Plume Dispersion Model etc. However, AERMOD is most widely used Air Pollution Dispersion Model, which can be run with the use of Meteorological parameters as well as Emission data. AERMOD is the most popular and widely used air pollution dispersion model, which works on the concept of steady state Gaussian plume type model. In the country like USA, AERMOD is in widely used for prediction of Ground Level Concentration (GLC) since 2005 and then after countries like India as well as Australia have also recommended the use of AERMOD as air pollution dispersion model. In this paper, the review of various AERMOD run for different parameters for different purposes is studied.

Index Terms **– AERMOD, Dispersion Model, Ground Level Concentration.**

I. INTRODUCTION

Air pollution is the presence of any foreign substances in the ambient atmosphere, mostly due to any human activity, in sufficient concentration, for sufficient time, and with the circumstances of interfering significantly with the comfort, health or welfare or with the full use or enjoyment of the properties for each and every living being, including humans Air pollution may be the result of emerging industrialization and automobiles. Air pollution may be due to natural occurrences or human activities.

As we know, Pollution is the biggest concern of any country, especially developing countries, like ours, amongst all types of pollutions, Air Pollution is said to be a 'Silent Killer'. Thousands of people are trying to be survived from the adverse health effects due to air pollution, which have become a major and global issue now-a-days and people are continuously finding ways for escaping from the jaw of this Silent Killer.

In June, 1972, the United Nations Conference on Human Environment was held at Stockholm, Sweden and was attended by then Prime Minister Hon'ble Smt. Indira Gandhi and she stated that "Poverty is the biggest polluter."

In India, current air quality is at alarming level, all parameters i.e. SO_X, NO_X, PM_{10}, $PM_{2.5}$ etc. are going beyond the limits prescribed by the Ministry of Environment, Forests & Climate Change vide its Notification No. G.S.R. 826(E), dated 16th November, 2009 regarding National Ambient Air Quality Standards (NAAQS), and hence focus on the quality of ambient air shall be the top most priority of the country like ours.

II. AERMOD MODEL DESCRIPTION

AERMOD is one of the popular Gaussian type air dispersion model which is based on Planetary Boundary Layer (PBL) and Similarity relationship theory. AERMOD is regulatory model in USA, since 2005 and recently Australia has also recommended AERMOD as regulatory model for air quality modeling purpose. It is an updated version of the Industrial Source Complex (ISCST3) model being proposed by the USEPA for assessing air quality management purpose. In this study, emission data of flue gas stack of industries located within Kerala GIDC for parameters like exit stack gas velocity, stack gas temperature, stack height, stack inside diameter etc are required to be fed as input to AERMOD. Meteorological data required as input are wind speed, wind direction, dry bulb temperature, solar radiation, % relative humidity, hourly precipitation, cloud cover etc.

About approximately 30 years ago, the establishment of National Ambient Air Quality Standards (NAAQS) was occurred. The impact of any future source or activity on air quality can be easily identified using dispersion modeling. The need to assess and compare the air quality with NAAQS due to existing and future activities was felt by U. S. Environmental Protection Agency (USEPA). In 1991, the formal collaboration between the American Meteorological Society (AMS) and the U.S. Environmental Protection Agency (EPA) was initiated with the designed goal of introducing current planetary boundary layer (PBL) concepts into regulatory dispersion models.

A working group (AMS/EPA Regulatory Model Improvement Committee, AERMIC) comprised of AMS and EPA scientists were formed for this collaborative effort. In most air quality applications one is concerned with dispersion in the PBL, the turbulent

air layer next to the earth's surface that is controlled by the surface heating and friction and the overlying stratification. The PBL typically ranges from a few hundred meters in depth at night to 1 - 2 km during the day time.

In 1991, the American Meteorological Society (AMS) and the U.S. Environmental Protection Agency (EPA initiated a formal collaboration with the designed goal of introducing current planetary boundary layer (PBL) concepts into regulatory dispersion models [3]. Planetary boundary layer is the layer next to the earth's surface, which is controlled by friction and surface heating overlaying the stratification. The range of PBL may extend up to few hundred meters in night to 1-2 km in day. Now-a-days, there are many active Air Pollution Dispersion Models being used widely, like CALPUFF, ISCST 3, SCREEN, AERMOD, Gausian Plume Dispersion Model etc. However, AERMOD is most widely used Air Pollution Dispersion Model, which can be run with the use of Meteorological parameters as well as Emission data.

AERMOD is one of the most popular air dispersion model, which works on the concept of steady-state Gaussian Plume type model. In the country like USA, AERMOD has been a regulatory model since 2005, and then after many other countries like Australia, India etc. have now recommended AERMOD for monitoring air quality. Boundary layer parameters used by AERMOD, which are required as input to the AERMET processor, include albedo, Bowen ratio, and surface roughness [7].

AERMOD modeling system consists of two pre-processors and the dispersion model; the meteorological processor (AERMET), which provides the meteorological information that are needed to characterize the planetary boundary layer (PBL) and the terrain pre-processor (AERMAP), which characterizes the terrain, and generates receptor grids for the dispersion model (AERMOD)[1]. AERMOD simulates five different plume types depending on the atmospheric stability and on the location in and above the boundary layer: (1) direct, (2) indirect, (3) penetrated, (4) injected and (5) stable [2].

In AERMOD, mainly three components are used:

1. AERMET – estimate boundary layer for dispersion
2. AERMAP - used to compute height of receptors & source
3. AERMOD - steady-state Gaussian Plume model

AERMOD model has following mentioned three components:

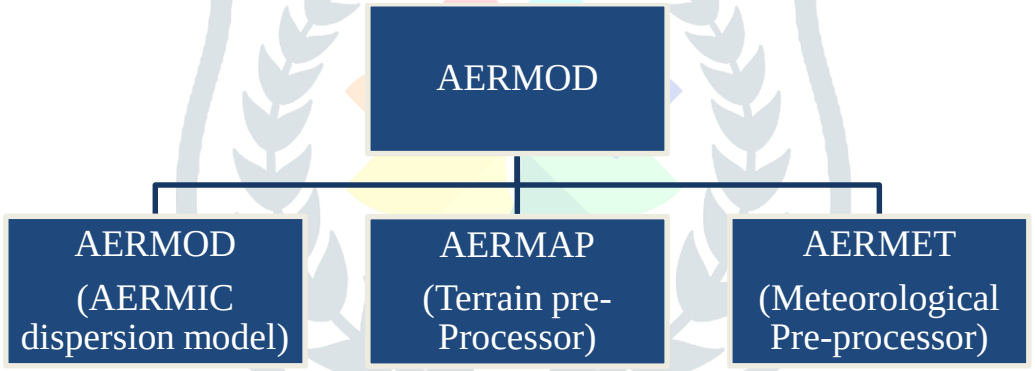

Figure 1: Components of AERMOD

Input to AERMOD is fed through excel sheets in prescribed formats. AERMOD may generate daily, monthly as well as annual concentrations of pollutants in the ambient air.

AERMAP (Terrain Pre-processor):

AERMAP is a terrain pre-processor designed to simplify and standardize the input of terrain data for the AERMOD. AERMAP has high flexibility in the specification of receptor locations. The receptors are specified in the AERMAP terrain pre-processor in a manner identical to the AERMOD dispersion model. Discrete receptors as well as Cartesian and polar grid networks are well specified by AERMAP. The user can specify the receptor coordinates in either universal transverse Mercator (UTM) coordinate system or any other user coordinate system. Output data includes location and height scale for each receptor.

AERMET (Meteorological Pre – processor):

Boundary layer parameters used by AERMOD is calculated mainly by the use of AERMET. AERMET input interims of hourly wind speed, wind direction, dry bulb temperature along with surface characteristics in the form of Albedo , Surface Roughness and Bowen ration which are associated with land use land cover (LULC). Then AERMET calculates other parameters like Friction velocity, Monin Obukhov length, convective velocity scale, surface heat flux which determines the stability of the PBL. The AERMET module is a three stage processing routine. In first stage, extraction of the data from the two sets of data presented and subjecting it to quality assurance checks in the form of acceptable data ranges occurs. In second stage, all data available are merged in to a single data file. The third stage establishes the boundary layer parameters from the merged data and generates the two meteorological files which are read by the AERMOD module.

1. Surface data file
2. Profile data file

Calculations of the boundary layer parameters are dependent on the surface conditions in the vicinity of the facility being modeled. Obstacles to wind flow, surface moisture and reflectivity all affect the calculation and are quantified by the assignment of three variables: surface roughness length, surface albedo, and Bowen ratio. Data flow of AERMOD is as follows:

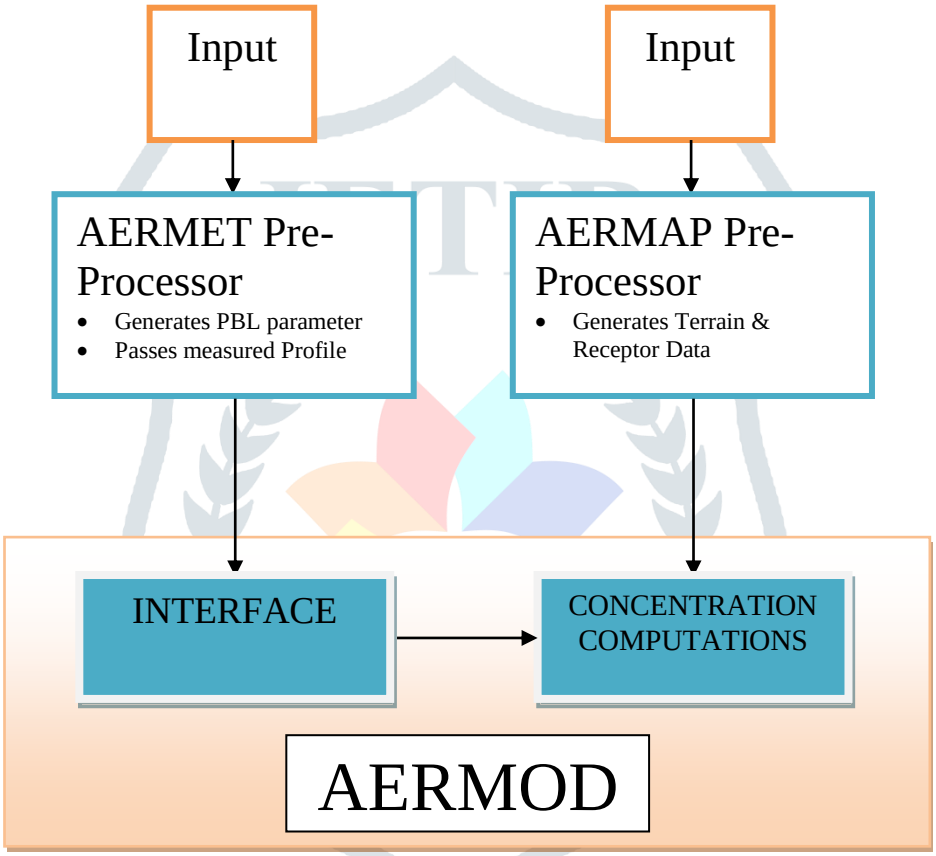

Figure 2: Dataflow of AERMOD

Major inputs required for the assessment of cumulative air pollution of Kerala GIDC are of two types, which are mentioned as under:

Emission Data

- stack gas emission rate (g/s)
- exit stack gas velocity
- stack inside diameter
- stack height
- stack gas temperature

Meteorological Data

- wind speed
- wind direction
- dry bulb temperature
- solar radiation
- % relative humidity
- hourly precipitation
- cloud cover etc

III. LITERATURE REVIEW:

Many research papers related to the studies carried out worldwide by using AERMOD dispersion model for various purposes is studied. The studied papers contain study of various parameters and its impact on health as well as environment by using AERMOD. AERMOD uses a Gaussian and a bi-Gaussian approach in its dispersion models. It generates hourly, daily, monthly as well as annual concentrations of pollutants in ambient air [13]. AERMOD dispersion model is now-a-days widely used in carrying out the study of Environmental Impact Assessment. In the country like India, submission of Environmental Impact Assessment (EIA) Report is mandatory as per EIA Notification, 2006 and amendments thereafter. The US Environmental Protection Agency's short term atmospheric dispersion model (AERMOD) is a good candidate for radiological dose calculations to the general public and Environment [1]. AERMOD gives effective results in the measurement of odor dispersion. To assess the perception of odours using dispersion models such as AERMOD and CALPUFF, a simple averaging time scaling factor can be used to estimate short-term peak concentrations [2]. Surface roughness has the greatest impact on prediction other than albedo and surface roughness [3]. Actual land use parameters shall be measured and its impact on ground level concentration can be evaluated. AERMOD gives effective measurement of PM_{10}. Long term as well as short term impacts can be identified by using AERMOD. A limitation of AERMOD may be the scarcity of air sampling data to compare to exposure estimates [8]. AERMOD can be run successfully for all types of pollutants sources, i.e. point, area and volume sources. Globally, albedo and Bowen ratio have less effects on concentration patterns than the roughness length, this is to be expected since albedo and Bowen ratio only affect the retention of incoming solar radiation, and therefore have no effect at night or just during convective conditions [9]. Concentration contours shows that maximum ground level concentrations may follow or may not follow the predominant wind direction [13].

IV. CONCLUSION:

This study shows that AERMOD can be performed for all types of pollution sources, i.e. point source, area source, volume source etc. AERMOD gives accurate results for all the types of pollution sources. AERMOD can be used as a useful tool to predict pollution potential of a proposed project. With the help of this, impacts on human health as well as Environment can be identified in early stage of any project and hence prevention measures can be implemented in the same in early or planning stage of the project. AERMOD gives prediction as well as accurate results for many parameters successfully under Indian scenario also.

V. REFERENCES:

1. Abubakar Sadiq Aliyu, Ahmad Termizi Ramli, Muneer Aziz Saleh, "Environmental impact assessment of a new nuclear power plant (NPP) based on atmospheric dispersion modeling", Stoch Environ Res Risk Assess (2014) 28:1897–1911, DOI 10.1007/s00477-014-0856-9
2. Andler Magno, Vieira de Melo, Jane Meri Santos, Ilias Mavroidis, Neyval Costa Reis Junior, "Modelling of odour dispersion around a pig farm building complex using AERMOD and CALPUFF. Comparison with wind tunnel results", Building and Environment 56 (2012) 8-20
3. Arasi Dobariya, Prof. Dr. N.S.Varandani, Prof. Huma Syed, "Study of Impact of Surface Characterstics on Ambient Air Concentration by using AERMOD: A Review", Vol-2 Issue-3 2016 IJARIIE-ISSN(O)-2395-4396
4. B. Vijay Bhaskar & R. V. Jeba Rajasekhar & P. Muthusubramanian & Amit P. Kesarkar "Measurement and modeling of respirable particulate (PM10) and lead pollution over Madurai, India", Air Qual Atmos Health (2008) 1:45–55
5. Bin Zoua, F. Benjamin Zhan, J. Gaines Wilsond, Yongnian Zeng, "Performance of AERMOD at different time scales", Volume 18, Issue 5, May 2010, Pages 612–623
6. Kanyanee Seangkiatiyuth, Vanisa Surapipith, Kraichat Tantrakarnapa, Anchaleeporn W. Lothongkum, "Application of the AERMOD modeling system for environmental impact assessment of NO2 emissions from a cement complex", Journal of Environmental Sciences 2011, 23(6) 931–940
7. Mutahharah M. Mokhtar, Mimi H. Hassim, Rozainee M. Taib, "Health risk assessment of emissions from a coal-fired power plant using AERMOD
8. Pamela Funderburg Heckel & Grace K. LeMasters, "The Use of AERMOD Air Pollution Dispersion Models to Estimate Residential Ambient Concentrations of Elemental Mercury", Water Air Soil Pollut (2011) 219:377–388
9. Pascal Moudi Igri, Derbetini Appolinaire Vondou and Francois Mkankam Kamga," Case Study of Pollutants Concentration Sensitivity to Meteorological Fields and Land Use Parameters over Douala (Cameroon) Using AERMOD Dispersion Model ", *Atmosphere* 2011, *2*, 715-741
10. Patrick T. O'Shaughnessy, Ralph Altmaier," Use of AERMOD to determine a hydrogen sulfide emission factor for swine operations by inverse modeling", Atmospheric Environment 45 (2011) 4617- 4625
11. S. Gulia, S. Nagendra and M. Khare," Comparative Evaluation of Air Quality Dispersion Models for PM2.5 at Air Quality Control Regions in Indian and UK Cities " M_APAN-Journal of Metrology Society of India
12. Sunil Gulia, Akarsh Shrivastava, A. K. Nema and Mukesh Khare, "Assessment of Urban Air Quality around a Heritage Site Using AERMOD: A Case Study of Amritsar City, India", Environ Model Assess
13. Vishwa H. Shukla, Prof. Dr. N.S.Varandani and Prof. Huma Syed," Performance Study of AERMOD under Indian Condition ", 2014 IJIRT, Volume 1, Issue 9, ISSN: 2349-6002