Prediction of Air Pollution Concentration Using a Fixed Box Model

Yannawar Vyankatesh B[1], Bhosle Arjun B[2], Yannawar Sonali B[3]

[1,2]School of Earth Sciences, Swami Ramanand Teerth Marathwada University, Vishnupuri, Nanded- 431606, Maharashtra, India

[3] School of Chemical Earth Sciences, Swami Ramanand Teerth Marathwada University, Vishnupuri, Nanded- 431606, Maharashtra, India

Abstract: The main objective of this paper is to present a fixed-box model method easy-to-use for evaluating the presence of air pollutants in Nanded city, and the potential exposure of frequents to that risk. A fixed-box model has been used to compare the burdens, optical depths and direct radioactive forcing from anthropogenic PM2.5 aerosol constituents over the Nanded city. We have developed a modeling system for evaluating the traffic volumes, emissions from stationary and vehicular sources, and atmospheric dispersion of pollution in an urban area. This paper has described a detailed model for studying the urban air pollution. However, the acquired results point out that air pollutant concentration could significantly swerve and, consequentially, the evaluation of results tolerates pollutants attentions towards city. Thus, the described method represents a useful tool for local administrations to plan best practices and the use of the final goal of reducing air pollution in the city. Validation of the results from this study for urban air pollution would be highly beneficial.
[Yannawar Vyankatesh B, Bhosle Arjun B, Yannawar Sonali B. **Prediction of Air Pollution Concentration Using a Fixed Box Model.** *Researcher* 2014;6(5):89-92]. (ISSN: 1553-9865). http://www.sciencepub.net/researcher. 15

Key words: Air quality guidelines, exposure assessment, modeling, road traffic, urban air pollution

1. Introduction

The use of comprehensive air quality models started in the late 1970s Daly A. & Zannetti P. (2007) and since then, their development has increased rapidly, together with the fast increase in computational resources. Today, more and more complex and computationally expensive numerical models are developed by the scientific community, and their results are made available to the environmental authorities dealing with the development of air quality plans and regulations. Models may serve as very useful tools for indirect estimation of human exposure. As already stated, it is not possible to perform monitoring in all the various environments that the population meets. Lifetime exposure cannot be measured directly, and for this kind of study modeling is the only option.

Furthermore, data from air quality models can supplement the monitoring data for performing mapping of pollution concentrations in the various microenvironments in which monitoring is not performed. For model tools to be useful in exposure studies they need to be well tested and they need to describe the dominating physical and chemical processes in the atmosphere at the given location Moussiopoulos N. (1997). Present-day numerical air quality models are seen as important tools for the assessment and forecast of air pollutant concentrations and depositions, contributing to the development of effective strategies for the control and reduction of air pollutant emissions Carnevale et al., (2012).

The forecasting of air quality is one of the topics of air quality research today due to urban air pollution and specifically pollution episodes i.e. high pollutant concentrations causing adverse health effects and even premature deaths among sensitive groups such as asthmatics and elderly people Tiittanen et al., (1999). The impact of air pollution on urban environments has become an important research issue Bitan, A., (1992), leading to numerous modeling studies related to the influence of buildings and other urban structures on pollutant accumulation and dissipation patterns. A wide variety of operational warning systems based on empirical, causal, statistical and hybrid models have been developed in order to start preventive action before and during episodes Schlink et al., (2003).

Modeling approaches to predict pollutant concentrations based on emission sources and environmental conditions are commonly used tools in air pollution and climate studies Bond et al., (2011). The forecasting of air quality is one of the topics of air quality research today due to urban air pollution and specifically pollution episodes i.e. high pollutant concentrations causing adverse health effects and even premature deaths among sensitive groups such as asthmatics and elderly people Tiittanen et al., (1999). Air quality models predict air quality in terms of the concentration of specified pollutants in the air at a certain place. All air quality models need two kinds of input: 1. information about the input from pollutants in the air from one or more sources; and 2.

information about factors that influence the dispersion of pollutants through the air such as wind speed and direction, presence of high buildings, presence of hills around the city, etc. The models use all of this information to mathematically calculate and simulate how pollutants will spread, giving estimates of specific concentrations at specific places. Some models are very simple, while others are more complex, including such data as ground level elevation and chemical reactions taking place in the atmosphere that change the concentration of pollutants in the air. There are many approaches to modeling, each approach having its strengths and weaknesses.

Using different models or, even better, combining modeling with other assessment techniques, significantly improves the reliability of a model UNEP (2005). Fixed-box model is a low cost air pollution modeling method to roughly and quickly estimate the pollutant concentration in urban atmosphere Mahajan S.P. (2009). Air quality models are now used extensively for the purpose of air quality management. Whilst such a model can be used in an operational context, i.e., to predict air pollutant concentrations in advance, more commonly they are used to evaluate pollution control strategies in advance of implementation, so as to ensure maximum cost-effectiveness Skouloudis et al., (1997).

The main objective of this paper is to present a fixed-box model method easy-to-use for evaluating the presence of air pollutants in Nanded city, and the potential exposure of frequents to that risk. These studies were is to compute air pollution concentration in this city using the general material balance equation. The goal of this paper is therefore to review the air pollutants of the approach by discussing studies applying Fixed Box model methods. After listing the studies identified through a systematic review, we structure the review according to the main components of Fixed Box model: monitoring data, geographic predictors and model development and validation.

We will compare the validity of the Fixed Box models to alternative quantitative approaches especially dispersion modeling, and conclude with a discussion of limitations and new developments. A short review of Fixed Box models has been published before Pham Ngoc Ho et al., (2009). Air quality modeling provides a useful support to decision making processes incorporating environmental policies and management process. They generate information that can be used in the decision making process. The main objectives of models are: to integrate observations, to predict the response of the system to the future changes, to make provision for future development without compromising with quality.

2 Material and Methods

2.1 Study Area

Nanded is one of the fastest growing city of Marathwada regions of Maharashtra. For the present study, the Nanded city has been selected. Nanded district is part of Marathwada Region in Maharashtra. For the present study in and around area of Nanded city is selected. Nanded city is situated on the bank of Godavari River. The total area under the Nanded Waghala City Municipal Corporation jurisdiction is 51.76 Sq.km, (5,176.66 Ha). Nanded City is divided in two parts i.e. Old Nanded (20.62 Sq.km) north of the Godavari river (on the left bank) and New Nanded (31.14 Sq.km) comprising of Waghala and six other newly merged villages and CIDCO area, south of the Godavari river (on the right bank). Nanded Waghala City Municipal Corporation (NWCMC) is the local civil body Yannawar V.B. and Bhosle A.B. (2013).

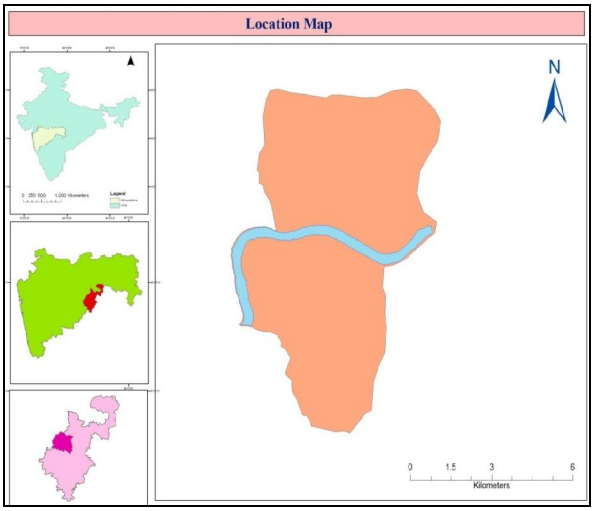

Fig.1. Location of Study Area of Nanded city in Maharashtra and India

3. Result Analysis

2.2 Theoretical background of the fixed-box model

Box models are based on the conservation of mass. The receptor is considered as a box into which pollutants are emitted and undergo chemical and physical processes. Input to the model is simple meteorology. Emissions and the movement of pollutants in and out of the box are allowed.

The air mass is considered as well mixed and concentrations to be uniform throughout. Advantage of the fixed-box model is simple meteorology input and detailed chemical reaction schemes, detailed aerosol dynamics treatment. However, following inputs of the initial conditions a fixed-box model

simulates the formation of pollutants within the box without providing any information on the local concentrations of the pollutants.

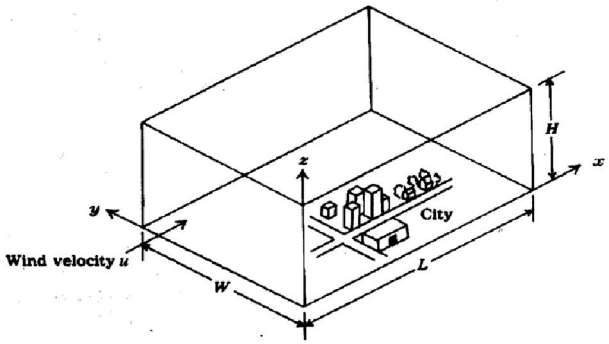

Fig.2. Rectangular city, showing meaning of symbols used in the fixed-box model

The mass balance equations for a given substance in all the boxes can be summarized in a single differential equation. Emission of air pollution is calculated according to the following formula:

Where,

Co = Concentration of the pollutant entering in the town (μ/m3),

q = expressed as flux (g/s.m2),

W = width of area,

L = length of area,

H = height of area,

u = Velocity of air

Equation shows how the flux is calculated using this model.

3 Result & Discussion

We have applied fixed box model on the air pollution data. We have shown that the model is adequate for short-term forecasting of air pollution. The models proposed work even when the numbers of sites are moderately large, although as expected the computations become more intensive as the number of sites increases. The initial result may have impact for studying the application of this fixed box model on evaluating the air quality in districts of Nanded city in particular and urban areas of India in general.

3.1 Computations

Here Co = 100 g/m3

q = 80 g/m2S

L = 30,000

W = 15,000

H = 500 m

Velocity of air μ = 5 m/s

To use the equation

C = 100 + {(80) (30000)} / {(5) (500)}

C = 100 + 960

C = 1060 g/m1060 g/m3

The expected concentration of air pollution in Nanded city is 1060 g/m3was detected. A similar box model has been used by Pham Ngoc Ho et al., (2009) and Schenker U et al., (2007) for pollution analysis. The results from the Fixed Box Model are verified by real data get high accuracy Pham Ngoc Ho et al., (2009). It was found that the box model more accurately calculated the daily variability in London median NOx, CO and PM10 concentration than the Gaussian model Matthew Rigby (2007).

Conclusion

This paper investigates methodologies for evaluating the performance of dispersion air quality models. Dispersion models are used to predict the fate of gases and aerosols after they are released into the atmosphere. The Fixed Box Air Quality Model was used for studying regional air pollution problem in the Nanded city. This paper has described a detailed model for studying the urban air pollution. Mathematical models are needed to optimize air quality monitoring, provide estimates for monitoring purposes, study different street geometries, and finally test prospect emission. Depending on their mathematical principles, they may be more or less suitable for a number of applications. However, validation of the results from this study for urban air pollution would be highly beneficial. The same approach would work fit indoors air pollution

Acknowledgement:

We are thankful to the School of Earth Sciences, Swami Ramanand Teerth Marathwada University, Nanded for providing laboratory and library facilities.

Correspondence to:

Yannawar Vyankatesh Balaji

School of Earth Sciences

SRTM University Nanded 431606, India

Telephone: 02462-229242

Email:vyanky@hotmail.com

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5/16/2014