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Management of Air Pollutants from Point Sources

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Abstract**—**Monitoring is essential to assessing the effectiveness of air pollution control actions. The goal of the air quality information system is through monitoring, to keep authorities, major polluters and the public informed on the short and long-term changes in air quality, thereby helping to raise awareness. Mathematical models are the best tools available for the prediction of the air quality management. The main objective of the work was to apply a Model that predicts the concentration levels of different pollutants at any instant of time. In this study, distribution of air pollutants concentration such as nitrogen dioxides (NO_2), sulphur dioxides (SO_2) and total suspended particulates (TSP) of industries are determined by using Gaussian model. Besides that, the effect of wind speed and its direction on the pollutant concentration within the affected area were evaluated. In order to determine the efficiency and percentage of error in the modeling, validation process of data was done. Sampling of air quality was conducted in getting existing air quality around a factory and the concentrations of pollutants in a plume were inversely proportional to wind velocity. The resultant ground level concentrations were then compared to the quality standards to determine if there could be a negative impact on health. This study concludes that concentration of pollutants can be significantly predicted using Gaussian Model. The data base management is developed for the air data of Hubli-Dharwad region.

Keywords**—** DBMS, NO_2, SO_2, Wind rose plots.

I. Introduction

MANY people nowadays are willing to accept some environmental deterioration for getting a higher standard of living and a greater abundance of consumer goods. High air pollution load in urban cities have been a major contributing factor towards degrading the ambient air quality day by day [1]. Urban air pollution remains as a serious environmental problem, whose solutions must have priority, but also an adequate approach. Air pollution is a global problem, since the pollutants become dispersed throughout the entire atmosphere. It is a phenomenon characteristic of large urban centers and industrialized regions, where the pollutants concentration may reach greater values than ambient background levels. Pollutants are introducing to the atmosphere are subject to numerous impacts that implies the contact of both air components and other pollutants. According to Kovacs [2], reactions between pollutants and air are more frequently taking place than between pollutants themselves.

Unwanted constituents in air can have a detrimental effect on human health, on the health of other creatures, value of properties, and the quality of life. There are many dramatic evidence showing that ambient of air pollution can seriously endanger public health like in Meuse Valley, Belgium in 1930, Donora, Pennsylvania in 1948, and London, England in 1952. The causal role of pollutants in producing adverse health effects normally experienced in industrialized urban environments, where many diseases such as chronic respiratory diseases and upper respiratory infections such as bronchitis and pneumonia, cardiovascular diseases, asthma, and irritation of eyes, nose, and throat [3].

Industrial areas in Hubli-Dharwad have many residential areas therefore, it is important to know the pollutant distribution in this area because it will affect the public health condition if the concentration of pollutants is high. For industrial area, there are several factors that affect the distribution of the pollutants to the nearby area such as stack height, wind direction, and topography. By using Gaussian Plume Dispersion model, the prediction of the pollutants distribution concentration can be identified. Dispersion models can be set up to estimate downwind concentrations of contaminants over varying averaging periods – either short term (three minutes) or long term (annual). Most modern air pollution models calculate the pollutant concentration downwind of a source using information [4].

The objective of the study was to determine the distribution of air pollutants concentration i.e. total suspended particulates (TSP), nitrogen dioxides (NO_2), sulphur dioxides (SO_2), and carbon monoxides (CO), using Gaussian Plume Dispersion Model. To evaluate the effect of wind speed and direction to the pollutants plume concentration within the affected area.

Maintaining of air emission from the industry is a mandatory, as required by the Environmental Quality Act (EQA) [5]. There are many studies that have shown the air quality in the industrial area is highly polluted by the air pollutants. However, there is not enough information on the air pollutants released by individual industries that may increase the level of air pollution. Hence, this study will identify the air quality profile for industrial area, affected by the plume dispersion from the industrial emissions. Besides that, it also useful to predict the future air quality within the affected area. By knowing the profile of air pollutants distribution, this study contributes in planning purposes in locating plants or development of industrial area. By that, proper regulation can be implemented within the area.

The study region, Hubli-Dharwad city (Latitude 15^o 27″ N, Longitude 75^o 12″ E) is one of the fastest developing industrial hub in Karnataka after Bangalore. More than 1000 allied small and medium industries already established basically are located in Gokul Road & Tarihal regions of Hubli and Lakmanahalli and Belur regions of Dharwad.

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Industrial belt covers an area of about 72.78 Sq.kms. There are Machine tools industries, Electrical, Steel furniture's, Ceramic industries, Food products, Rubber and leather industries, Tanning industries, Dairy industries, Coke industries etc. It has gathered momentum in industrial development, whose stack emissions contribute significantly to air pollution.

The most prominent wind direction pattern was observed as south west direction during summer season followed by south east direction during winter season and south west direction during rainy season. Moderate to high wind speed was observed during the month of April-May, with prevalence of low to calm wind during the month of December-February. Moderate to heavy rain occurred during the months of October-November. The value of maximum temperature ranges from 36 to 39°C and the value of minimum temperature ranges from 12 to 16°C. In the case of relative humidity, the mean value ranges from 75 to 80 %.

II. Materials and Method

Vayubhodha Stack Sampler-1 was used in the study for stack sampling and the sampling is restricted to primary pollutants i.e. Suspended Particulate Matter, SOx, NOx.

III. Modeling

An air dispersion model is a series of mathematical equations that describe the behavior of gases/particles emitted into the air and used to calculate the concentration of pollutants at various points surrounding an emissions source. Today most commonly used dispersion models are steady-state Gaussian-plume models, providing an analytical solution to the dispersion equations. These are based on mathematical approximation of plume behavior and are the easiest models to use. They incorporate a simplistic description of the dispersion process and can provide reasonable results when used appropriately [4].

The Gaussian plume equation for the concentration C at any point (x, y, z) in the three – dimensional coordinate system of the plume is

$$C(x,y,z) = [Q/(2*\pi*u*\sigma_y*\sigma_z)]\exp(-y^2/2\sigma^2{}_y)*$$
$$(\exp-(z-H)^2/2\sigma^2{}_z+\exp-(z+H)^2/2\sigma_z{}^2)$$

where;

C(x, y, z) = centre line concentration of pollutant at any point (x, y,z) in space, µg/m^3

Q = Emission rate of pollutants, µg/s

H = Effective stack height, m

u = Average wind speed at the effective height of the stack, m/s

σ_y = Horizontal dispersion coefficient, m

σ_z = Vertical dispersion coefficient, m

IV. Results and Discussion

The distribution of Nitrogen dioxides (NOx), Sulphur dioxides (SOx), Total Suspended Particulates (TSP) concentration were sampled and analyzed for different seasons of NRE coke and Nandu Chemicals. The analysis of the model is carried out depending on the effect of wind speed and its direction for different pollutants and seasons. The data base management of the pollutants for the Hubli- Dharwad region is developed.

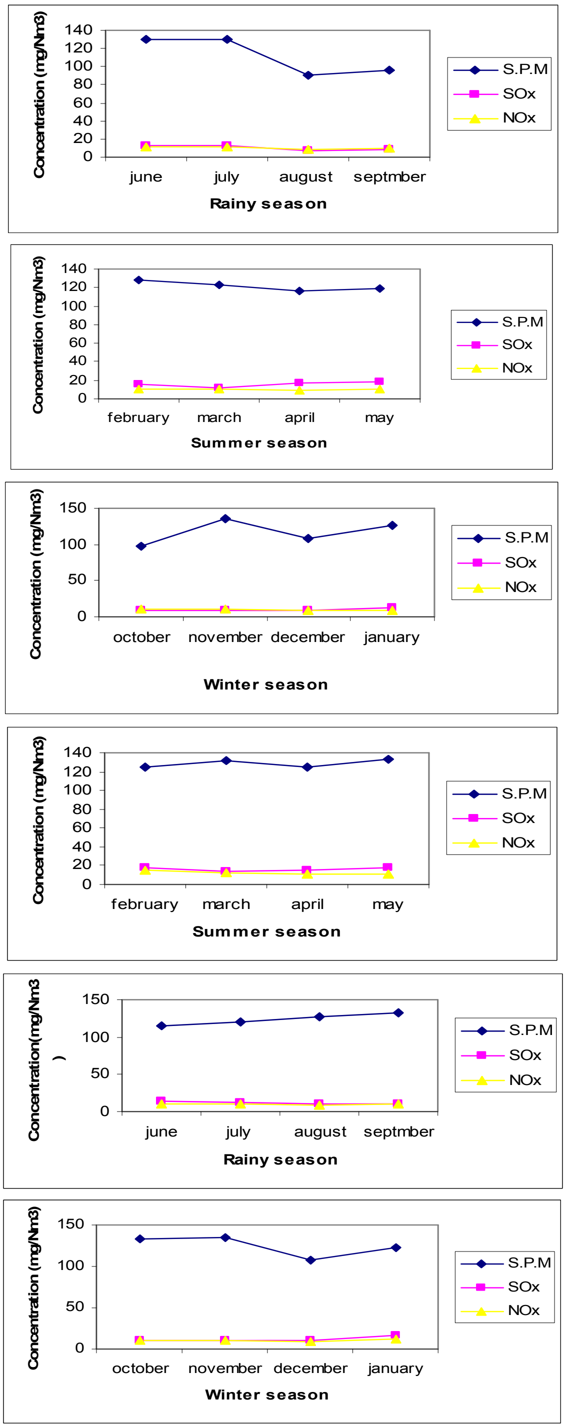

Fig. 1 Stack analysis of NRE coke for different seasons and different stack

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A. NRE Coke Industry

The stack results analyzed of NRE coke (Fig. 1) showed that the suspended particles are in larger concentration compared to NOx and SOx concentration. The concentration of SOx and NOx were very negligible. There was slight variation in concentration of the pollutants for third stack because of the variation of the feed content to the boiler. Even the concentration of pollutants were slightly different for summer season compared to rainy and winter seasons because of the effect of the meteorological parameters like wind speed and direction, rainfall and temperature.

B. Nandu Chemicals

Stack results analyzed for Nandu chemicals showed that the suspended particles are in larger concentration. The concentration of SOx and NOx were very completely negligible as shown in Fig. 2. The concentration of pollutants were slight different for summer season compared to rainy and winter seasons because of the effect of the meteorological parameters like wind speed and direction, rainfall and temperature.

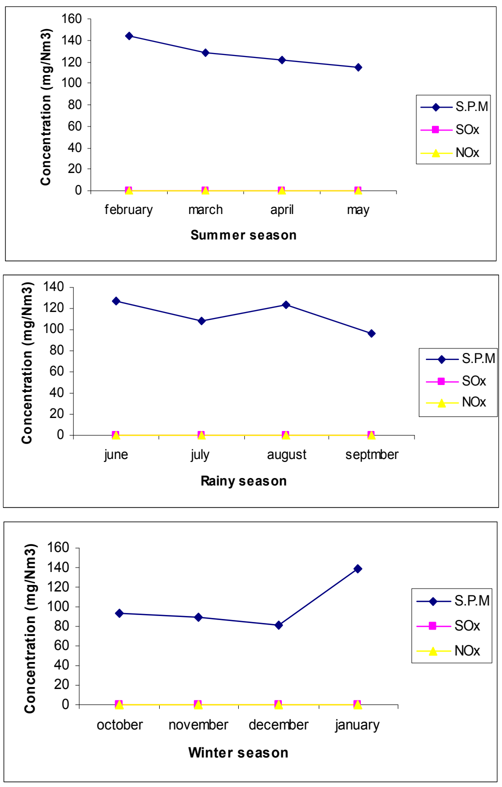

Fig. 2 Stack analysis of Nandu chemical for different seasons

C. Modeling: Gaussian Model

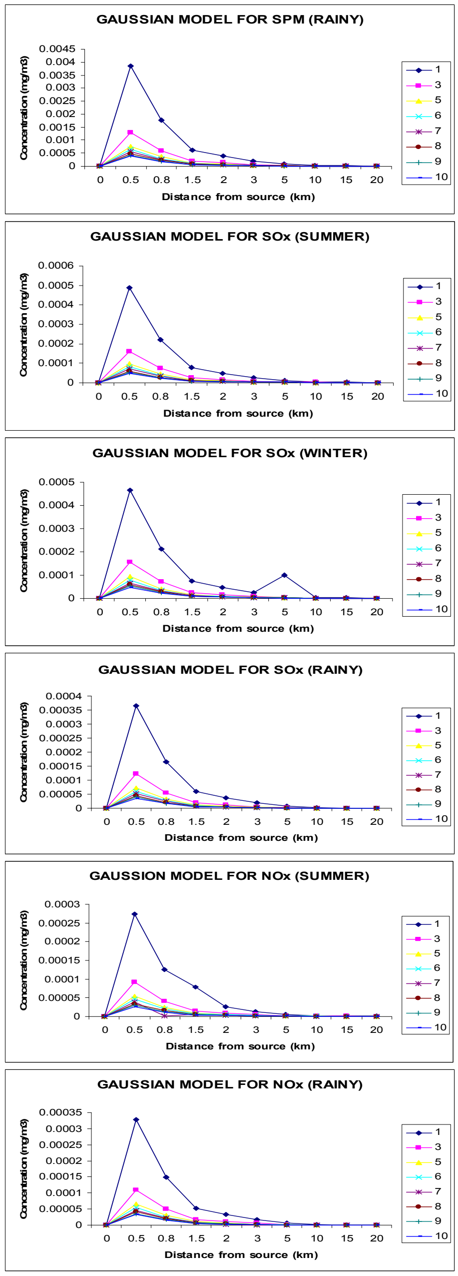

Fig. 3 Gaussian model for different season and pollutants

Calculation for Gaussian model used to calculate ground level concentration and deposition of plume components was obtained by c – program written for Gaussian equation where the profile of air pollutants concentration were sketched as in Fig. 3. Hence, the most affected area resulting by the plume dispersion can be identified easily. After the modeling process is completed, a process of data validation was done. This process is important to make sure that this model is reliable for future prediction of air quality profiling. The results from the sampling were transferred to Microsoft Excel and profile of air pollutants concentration obtained and compared with data sampling. Therefore, efficiency for the air quality profile obtained by using Gaussian Plume Dispersion model can be identified.

D. Wind Rose Plots

The wind rose plots for the different seasons will help in analyzing the variation of pollutant concentration along the distance from the industry in the model for those seasons. Higher the wind speed and in what direction the wind blows the concentration of pollutants change all along the distance from the stack and impact of health effects in that region can be studied. Here throughout the year the wind speed is on an average of 2- 3.5 m/s in all seasons. Different season plots are shown below in Fig. 4. In rainy and summer season the blow of wind direction is in South-West. In winter season the blow of wind direction is in South-East.

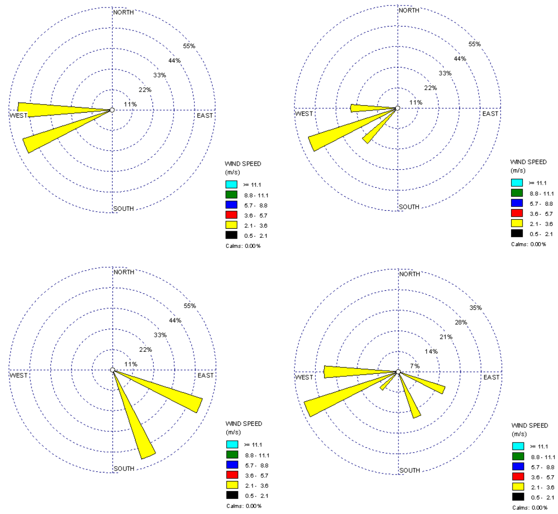

Fig. 4 2009 wind rose of rainy, summer, winter and yearly plots

E. Data Base Management System (DBMS)

DBMS is a set of computer program control for the creation maintenance and the use of data base. It allows a different user application programs to access the same data base. It allows the users and other software to store and retrieve data in a structured way.

A database is a collection of non redundant data between different application programs. A set of application programs acting as a layer between the physical database and its users. Conventional method of handling data is to store data in files. But the disadvantage is that, files may have a lot of redundant data, data not secure, changes in file structure difficult. Hence, need a system specifically for managing database i.e. database management system.

Air quality management require knowledge of the sources of air pollutants in a region, the ability to understand and project the emissions from those sources, and the ability to handle the regulatory processes associated with controlling emissions from those sources. This is an ongoing challenge for regions with ample resources, the challenge is even greater for developing countries with limited information and disparate local planning programs [6].

In this project data base management Fig. 5, will help the regulating authorities to maintain records of various industries and their emissions, national ambient quality standards, geographical conditions, meteorological data, vehicular pollution data in the region.

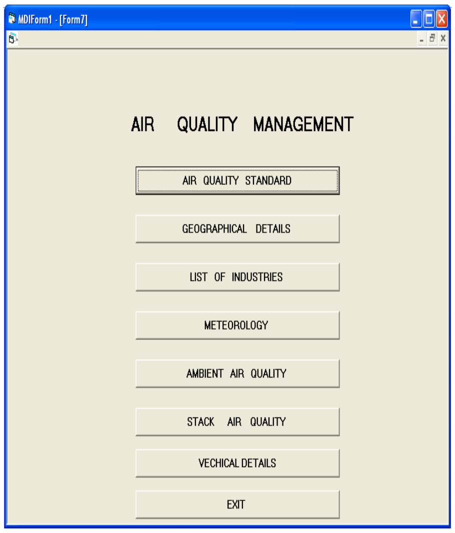

Fig. 5 Data base management system

V. Conclusion

Results that are obtained from analysis processes have provided important information regarding the distribution of air pollutants and factor affecting it. From the air quality profiles that produced in the analysis processes, they show that North and East regions are the most polluted regions compared to the others. This situation occurred because of the wind speed in these regions is lower than South and West region, as concentration of pollutants is inversely proportional to the wind velocity. From the air quality profiles that produced by Gaussian Plume Dispersion Model, they show that wind velocity is the most important factor that affect the concentration of the pollutants while wind direction is affecting its polar distribution. High velocity of wind produced lower pollutants concentration in the atmosphere compared to the low wind velocity. Based on the air quality profile obtained from the modeling, it shows that the difference of pollutants concentration between maximum and minimum wind speed are about 76 to 85%. So, wind velocity and its direction is the main factor that affects the distribution and concentration of air pollutants.

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