"URBAN AIR QUALITY MODELING AND MANAGEMENT IN DEVELOPING CITIES"

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Abstract:Presently many Indian cities are suffering the pressure of a combination of different driving forces like increase in urban population density, industrialization and motorization and without a sufficiently well developed institutional capacity or the financial resources to control them. As a consequence, the ability of many cities in the region to cope with the combined pressure is often exceeded thereby leading to deterioration of environmental quality. Air pollution in India is mainly caused from three sources namely vehicles, industrial and domestic sources. CPCB (2003) enlists following reasons for high air pollution in India:Poor Quality of Fuel, Old Process Technology, Wrong Siting of Industries, No Pollution Preventing Step in Early Stage of Industrialization, Poor Vehicle Design, Uncontrolled Growth of Vehicle Population, No pollution Preventive and Control System in Small/Medium Scale Industry, Poor Compliance of Standard in Small/Medium Scale Industries

Introduction:

Urban air pollution continues to pose a significant threat to human health, the environment and the quality of life of millions of people throughout world. Urbanization in India is mainly caused due to adoption of mixed system of economy by the country which gave rise to the development of private sector. Population residing in urban areas in India, according to 1901 census, was 11.4% (Singh, 1978), this count increased to 28.53% according to 2001 census (Datta, 2006), and crossing 30% as per 2011 census, standing at 31.16% (Business Standard, 2). According to a survey by UN State of the World Population report in 2007, by 2030, 40.76% of country's population is expected to reside in urban areas. The rate of urbanization is growing steadily due to the employment opportunities and declining feasibility of agricultural sector. Urbanization and associated growth in mobility and industrialization have resulted in the intensification of air pollution in densely populated areas, causing deterioration of air quality and air quality management needs immediate attention. Air quality models simulate the physical and chemical processes occurring in the atmosphere to estimate the atmospheric pollutant concentration. A variety of air quality models are available ranging from simple empirical models to complex Computational Fluid Dynamic (CFD) models. Air quality models can be a valuable tool in pollution forecasting, air quality management, traffic management and urban planning.

National Air Quality Policy

Government of India enacted the Air (Prevention and Control of Pollution) Act 1981 to arrest the deterioration in the air quality. The act prescribes various functions for the Central Pollution Control Board (CPCB) at the apex level and State Pollution Control Board at the state level. The ambient air quality objectives/standards are pre-requisite for developing programme for effective management of ambient air quality and to reduce the damaging effects of air pollution. The objectives of air quality standards are:

- To indicate the levels of air quality necessary with an adequate margin of safety to protect the public health, vegetation and property.
- To assist in establishing priorities for abatement and control of pollutant level.
- To provide uniform yardstick for assessing air quality at national level.
- To indicate the need and extent of monitoring programme.

The Central Pollution Control Board had adopted first ambient air quality standards on November 11, 1982 as per section 16 (2) (h) of the Air (Prevention and Control of Pollution) Act,1981. The air quality standards have been revised by the Central Pollution Control Board on April11,1994 and were notified in Gazette of India, Extraordinary Part-II section 3, sub section3, sub section (ii), dated May 20, 1994. The revised National Ambient Air Quality Standards are depicted in table. These standards are based on the land use and other factors of the area.

Air Quality Status in India

Air pollution problems becomes complex due to multiplicity and complexity of air polluting source mix (e.g. industries, automobiles, generator sets, domestic fuel burning, road side dusts, construction activities, etc.). Air quality data generated by the Central Pollution Control Board (CPCB) under the National Air Quality Monitoring Programme (NAMP) presents deadly facts about air pollution levels in Indian cities. The most widely monitored pollutants in India are particulate matter (PM), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and on a limited scale carbon monoxide.

Indian cities are experiencing a heavy particulate pollution with almost 52 percent of cities hitting critical levels (exceeding 1.5 times the standard). RSPM is the most important pollution parameter especially in the urban environment. Especially northern region of India, PM_{10} levels remains persistently high. Coarser fraction (>PM_{10}) of SPM concentrations are primarily irritants and may not have much relevance to direct health consequences as compared to effects of its respirable fractions (PM_{10} and $PM_{2.5}$), which can penetrate the human respiratory systems deeper. Kanpur shows the highest concentrations of RSPM, followed by mega cities like Delhi (CPCB website).

NO_x is emerging as the new national challenge and a growing problem. According to CPCB, although various interventions have taken place to mitigate ambient NO_x levels but at the same time number of vehicles has increased exponentially. The vehicles are one of the major sources of NO_x (CSE, India).

Sulfur dioxide is not considered a problem in India any more. SO_2 levels are within the annual standard (60 $\mu g/m^3$) in most of the cities. Its levels in most cities are already very low and declining at all cities, which is largely attributed to sulfur reduction in diesel. The variation in annual average concentrations during different years may be due to multiple factors including meteorology, neighbourhood, activity pattern or levels during monitored period, etc.

Problem Formulation

Kolhapur city is located in South-Western Maharashtra at 16º42´N 74°13´E/16.7; 74.22. It has an average elevation of 545 meters. The geographical area of the district is 7685 km^2. Kolhapur city is experiencing rapid urbanization, growth in mobility and industrialization, resulting in the intensification of air pollution, causing deterioration of air quality. A recent report published by Motor Transport department of Maharashtra, indicates that there is a phenomenal surge in the number and use of motor vehicles in Kolhapur. As on 31stbMarch, 2011 the total number of vehicles in Kolhapur has reached around 7.09 lakhs, of which 77.64% are two wheelers, 10.34% are four wheelers, and 10.09% are heavy duty vehicles (Motor Transport Statistics of Maharashtra, 2011). The continual traffic growth has raised concerns over the impact of traffic emissions on human health and urban air quality. Considering these aspects there is a need for a coherent regulatory framework for the management of traffic, air quality and emissions at urban level.

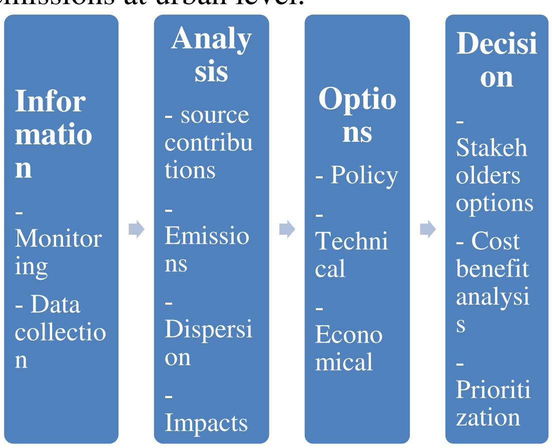


Fig: Air quality management system

Air quality modelling is an inherent part of any regulatory framework for air quality management fig. Air quality models simulate the physical and chemical processes occurring in the atmosphere to estimate the atmospheric pollutant concentration and they can be a valuable tool in pollution forecasting, air quality management, traffic management and urban planning. No such air quality modelling studies have been conducted by far to assess the impact of traffic related air pollution in Kolhapur city. Hence the purpose of this research work is to evaluate several transportation related models to assess the air quality in streets of Kolhapur city.

Applications of the Research

Air quality management is an upcoming field in Kolhapur, and technical expertise available for this purpose is limited. Pollutants from automobile sources are emitted near large number of people. As source- receptor distances are short, resulting concentrations can be high and may affect health of the people adversely. Proposed research work is aimed at a systematic evaluation of the current air pollution scenarios and to identify factors influencing air quality in streets of Kolhapur city. Such research work shall also contribute to identify, develop and demonstrate solutions that will lay the foundation for successful application of urban air quality models and still further to develop policy implications to improve air quality in Kolhapur.

Methodology Adopted

Air quality modeling study is basically divided into two sections i.e. modeling and monitoring.

Air quality models need traffic density and emission factors as input. Manual traffic counts were performed at selected street i.edabholkar corner.

Air quality models also require meterology data such as ambient temperature,windspeed,winddirection.Meterological data were collected using automatic weather station.

Details in street configuration viz. orientation, length, and width of the street, Angle between street and wind direction, and average height of the building were collected using Google map and on site measurements.

Another crucial input required for the air quality modeling is urban background measurements for selected pollutants viz. SPM, PM_{10}, NO_2.Background particulate concentrations were determined following using graviometric method and NO_2 concentrations were determined using spectrophotometric method.

Two models namely: BOX MODEL, and STREET CANYON MODEL to predict the hourly concentration of pollutants in the street. Using the mathematical framework models calculate the pollutant concentrations in the street at desired receptor location.

Second part of the methodology deals with the ambient sampling and analysis to determine the pollutant concentration in the street.

Predicted and observed concentrations were used for statistical analysis of urban models validation. Results of this study can be used for assessing roadside air quality by providing prediction of present and future air pollution levels as well as temporal and spatial variations.

Study Area

City Profile

Kolhapur is located on the Sahyadri mountain range and south western part of the Maharashtra state. Kolhapur city is situated on the bank of Perennial River 'Panchaganga' on the adjoining hill named as 'Bramhapuri'. Kolhapur is known for moderate climate, fertile soil, ample amount of water which has led to flourish agriculture, allied business, industries, cooperatives sectors, etc.Though there recent advancements in the industrial sector, the oldest industrial areas like ShivajiUdyamnagar as well as peripheral industrial areas like ShirolMIDC, GokulShirgaon MIDC and Kolhapur Sugar Mill are having the same importance as before. Bricks kilns, stone quarries and tanneries are also a common feature of the city.

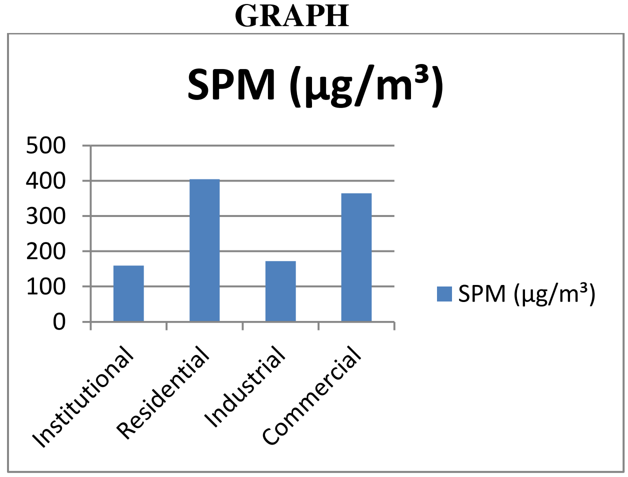
Fig:Google Map showing Kolhpur city

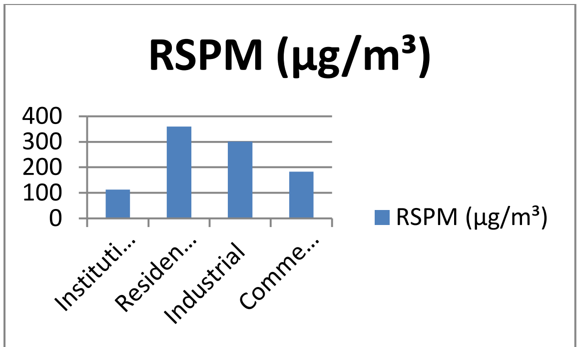
RESULTS AND DISCUSSIONS

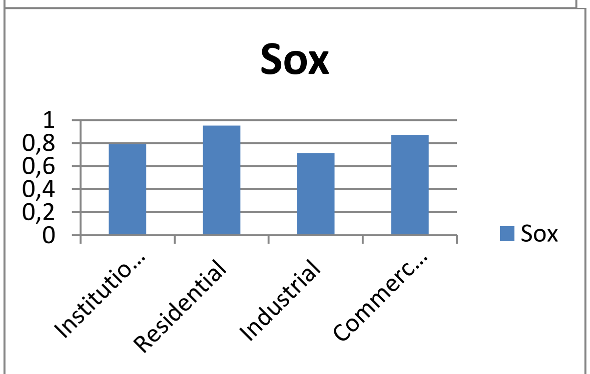
Observed Concentrations

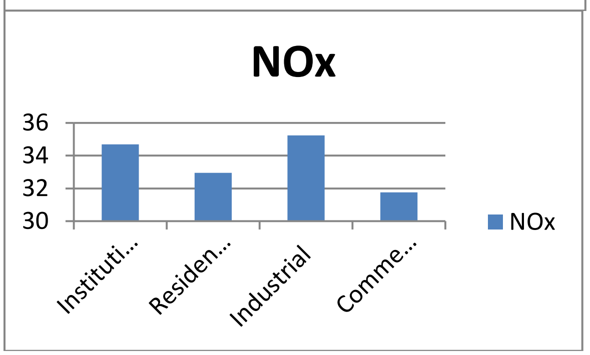
Area of Sampling	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	SO_x (µg/m^3)	NO_x (µg/m^3)
Institutional	159.46	113.16	0.7921	34.69
Residential	404.74	359.78	0.951	32.94
Industrial	171.82	300.68	0.713	35.24
Commercial	364.69	182.34	0.871	31.76

GRAPH









CONCLUSIONS

Considerable efforts have been taken up by various government agencies in recent years to improve the scientific understanding of the dispersion and transformation phenomenon governing urban air quality. Very few studies have been focused on modelling of air quality in street canyons which are considered to be the hotspots for air pollution. Street canyons are complex urban structures where natural ventilation is reduced due to the presence of high rise buildings around the streets. Such a structure create wind vortex which aggregates the deterioration of air quality in street canyons. Worst conditions can occur under perpendicular wind speed ,photochemical reactions speed up the production of secondary pollutants like ozone, and NO_x during winter season.

Air quality modelling study in Kolhapur was carried out with an objective to analyse and validate the performance of street canyon models for simulating concentrations of traffic originated pollutants. The study was conducted at one of the busiest routes in the heart of the Kolhapur city i.e. station road. Study was conducted in two parts viz. Modelling and monitoring. Traffic density was measured manually during the morning and evening peak hours. Meteorological data viz. Temperature, wind speed and wind direction by automatic weather station. The data collected during the study period was then used as input to simulate the hourly concentrations of selected pollutants. 2 models , street canyon and box model were used to simulate the concentrations of selected pollutants. Concentrations of SPM and PM 10 were measured following gravimetric method suggested by CPCB.

Findings Of The Research:

With rapid urbanisation and industrialisation, an exceptional rise in the vehicular population has been observed in recent decades in Kolhapur city.

Due to the proximity to central bus stand and railway station , station road is heavily congested with vehicles. In addition, many academic institutions, private coaching classes and business officers in area attracts more people in this area thereby increasing vehicular congestion and air pollution.

The background pollutant concentration levels of SPM, PM10 and NOx are alarming, most of the times exceeding ambient air quality standards. The industrial estate like gokulshirgaon and shiroli MIDC are located on the upstream side of the

Kolhapur city, which aggravates the air pollution situation in the city.

RECOMMENDATIONS:

In order to improve the air quality within streets following recommendations can be given,

Awareness regarding reducing the air pollution. Educating public on vehicular air pollution and their role in reducing it will help a lot in air pollution.

Traffic management has a crucial role play in urban air quality management. traffic diversion under high air pollution conditions using air pollution sensors and advanced signal systems can surely provide better results than conventional systems.

Advection – diffusion inside and the transfer rate at the roof level of canyon affect the pollution removal inside the street. hence, extreme care shall be taken while planning the road and buildings in traffic prone areas.

A good public transport systems can serve as the catalyst in reducing the vehicular emission.

Road condition also have a role to play in air quality management.

Fuel substitution to CNG for public transport sector can be a good option.

Older vehicles shall be strictly obsolete from the vehicle fleet. Because they pollute more compare to newer vehicles.

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