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Integrating AI and IOT for Smart Air Quality Management in Developing Urban Areas

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Abstract: *The development in urban population density, industry, and motorization are straining many Indian cities, which lack the institutional capacity or financial resources to handle them. The combined pressure sometimes surpasses the capability of many local cities, deteriorating the environment. Indian air pollution comes from household, industrial, and automobile sources. The CPCB (2003) lists India's high air pollution causes: Poor Fuel Quality, Old Process Technology, Wrong Industry Siting, No Pollution Preventing Step in Early Industrialization, Poor Vehicle Design, Uncontrolled Vehicle Population Growth, No Pollution Preventive and Control System in Small/Medium Scale Industry, Poor Standard Compliance.*

Keywords: Air pollution monitoring, Urban pollution sources, Air quality indices

I. INTRODUCTION

The health, environment, and quality of life of millions of people worldwide are threatened by urban air pollution. Indian urbanization is largely induced by its mixed economy, which developed the private sector. The urban population in India has grown from 11.4% in 1901 (Singh, 1978) to 28.53% in 2001 (Datta, 2006) and 31.16% in 2011 (Business Standard, 2). In 2007, the UN State of the World Population Report predicted that 40.76% of the population will live in cities by 2030. Urbanization is rising due to job possibilities and agricultural decline. Urbanization, transportation, and industry have increased air pollution in densely populated places, deteriorating air quality. Air quality control is needed immediately. Air quality models assess pollution concentrations by simulating atmospheric physical and chemical processes. Simple empirical models to complicated CFD models are available for air quality. Air quality models aid pollution forecasting, air quality management, traffic management, and urban planning.

II. NATIONAL AIR QUALITY POLICY

To reduce air pollution, India passed the Air (Prevention and Control of Pollution) Act 1981. The statute specifies the CPCB's and SPCB's duties. Ambient air quality objectives/standards are needed to establish a program to manage air quality and minimize air pollution. Air quality guidelines aim to:

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.

On November 11, 1982, the Central Pollution Control Board adopted the first ambient air quality criteria under section 16 (2) (h) of the Air (Prevention and Control of Pollution) Act,1981. On April 11, 1994, the Central Pollution Control Board modified air quality standards and published them in Gazette of India, Extraordinary Part-II section 3, sub section 3, sub section (ii), dated May 20, 1994. Amended NAAQS are in the table. These rules reflect local land usage and other factors.

III. AIR QUALITY STATUS IN INDIA

Air pollution is compounded by industry, autos, generators, domestic fuel burning, roadside dusts, and construction. The CPCB's National Air Quality Monitoring Programme (NAMP) data demonstrates lethal air pollution in Indian cities. PM, NO_2, SO_2, and CO are India's most monitored pollutants. Critical particle pollution is 1.5 times the standard in 52% of Indian cities. RSPM is the main city pollution measure. PM10 is high in northern India. SPM concentrations over PM10 are irritants and may not directly harm health, unlike its respirable components (PM10 and PM2.5). Kanpur and Delhi have greater RSPM (CPCB website).

Emerging national issue: NO_x. Although many steps have lowered ambient NO_x emissions, CPCB reported a sharp increase in vehicle numbers. Vehicles emit much of NO_x (CSE, India). India no longer worries about SO_2. SO_2 levels in most cities are below the annual threshold (60 $\mu g/m^3$). Due to diesel sulfur reduction, all cities have low and falling levels. Over time, weather, neighborhood, activity pattern, and measurable factors may change annual average concentrations.

IV. PROBLEM FORMULATION

Kolhapur is located in South-Western Maharashtra at 16º42´N 74°13´E/16.7; 74.22. The average altitude is 545m. District size: 7685 km^2. Air pollution in Kolhapur is rising due to urbanization, traffic, and industry. Recently, Maharashtra's Motor Transport Agency found a large growth in Kolhapur's motor vehicle use. Kolhapur had 7.09 lakh vehicles on March 31, 2011, including 77.64% two-wheelers, 10.34% four-wheelers, and 10.09% heavy-duty vehicles (Motor Transport Statistics of Maharashtra, 2011). Traffic emissions affect health and urban air quality as traffic expands. These concerns need coordinated urban traffic, air quality, and emissions management.

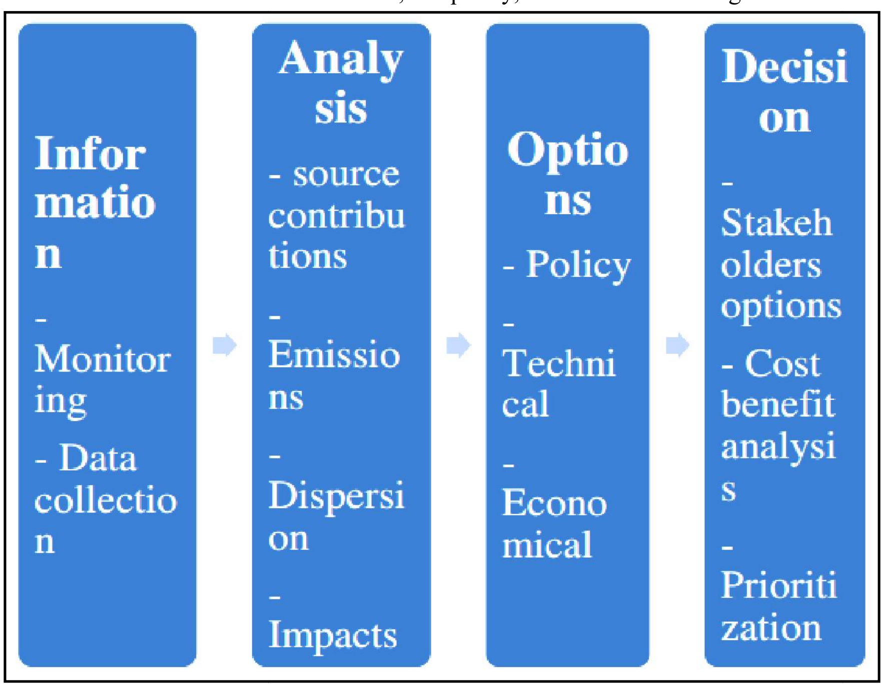

Fig. 1: Air quality management system

Any air quality management regulatory system includes air quality modeling fig. To estimate atmospheric pollutant concentration, air quality models replicate physical and chemical processes in the atmosphere. They may be used in pollution forecasting, air quality management, traffic management, and urban planning. No air quality modeling studies have assessed traffic-related air pollution in Kolhapur. This project aims to analyze numerous transportation-related models to estimate Kolhapur street air quality.

V. APPLICATIONS OF THE RESEARCH

Air quality management is a new area in Kolhapur with insufficient technical skills. Automobile pollution affects many individuals. Short source-receptor distances may lead to high concentrations that harm health. A rigorous study of present air pollution scenarios and identification of variables affecting air quality in Kolhapur city streets is proposed. Such study will also explore, develop, and demonstrate solutions that will establish the groundwork for urban air quality model application and policy implications to enhance Kolhapur air quality.

VI. METHODOLOGY ADOPTED

This research duplicates and monitors air quality. Emission and traffic density statistics are needed for air quality models. Deskholkar corner traffic was manually counted. Wind, direction, and temperature are needed for air quality models. Independent weather data was collected. Google Maps and on-site measurements determined street direction, length, width, wind angle, and average building height. Urban SPM, PM10, and NO3 backdrops are needed for air quality modeling.Gravimetric, spectrophotometric NO3 and background particle readings. Box and Street Canyon models measure hourly street pollution. Mathematical approaches evaluate receptor street pollution. Second-phase ambient sampling and analysis assess street pollution.

Statistics on projected and actual concentrations for urban model validation. This approach forecasts roadside air pollution time and place.

VII. STUDY AREA

City Profile

Kolhapur is in south-western Maharashtra on the Sahyadri mountain range. On ‘Bramhapuri’ hill, Kolhapur is on the perennial river ‘Panchaganga’. Kolhapur's temperate temperature, good soil, and abundant water have boosted agriculture, associated businesses, industries, cooperatives, etc.Even though the industrial sector has advanced, ShivajiUdyamnagar and outlying industrial sites like ShirolMIDC, GokulShirgaon MIDC, and Kolhapur Sugar Mill remain important. Brick kilns, stone quarries, and tanneries dot the city.

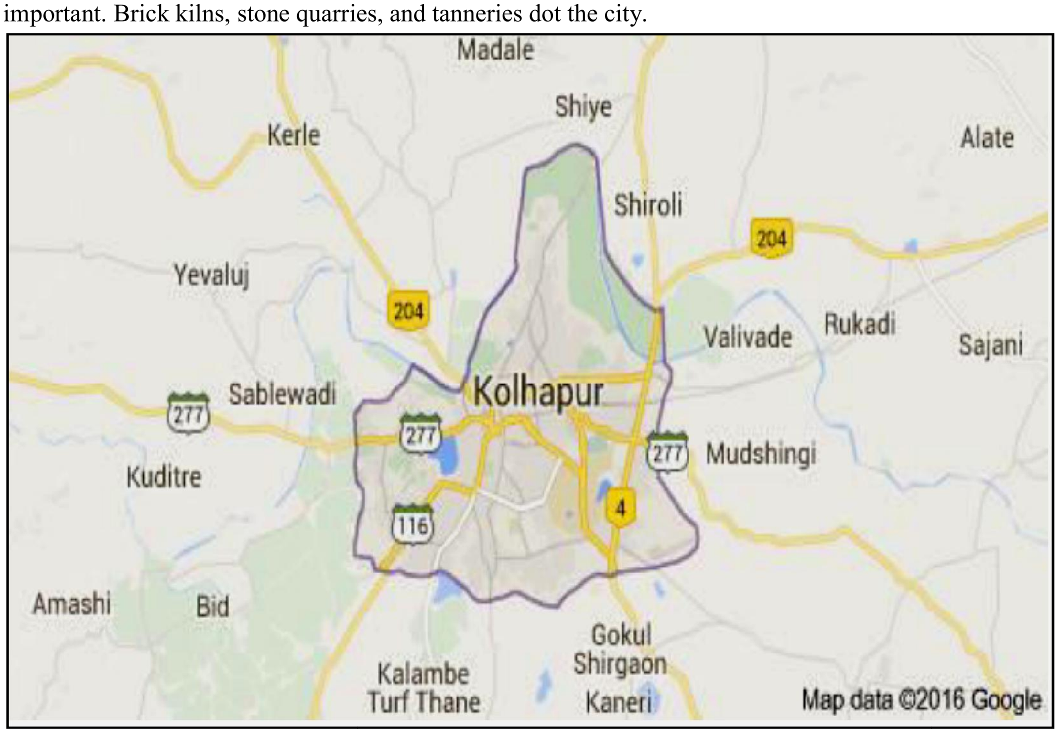

Fig. 2: Google Map showing Kolhpur city

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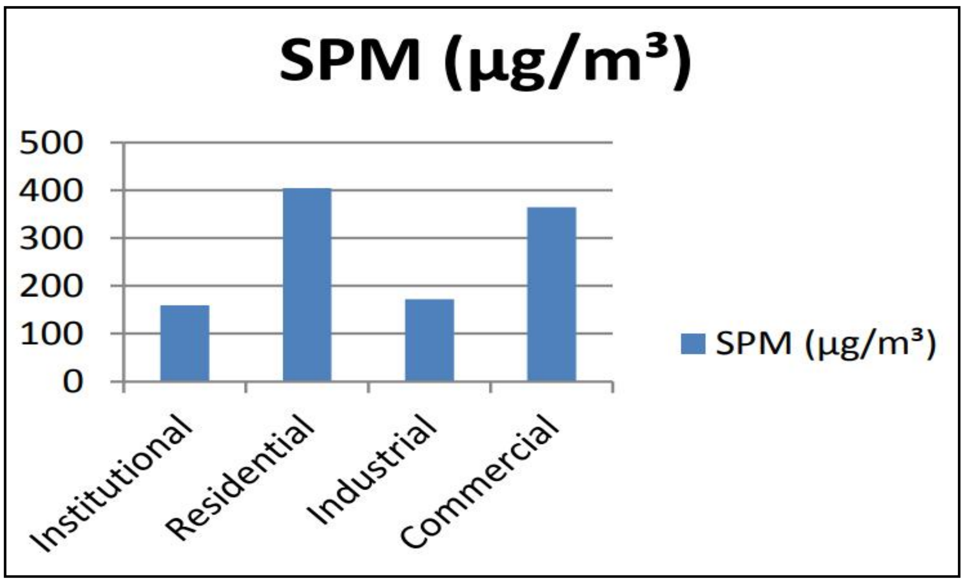
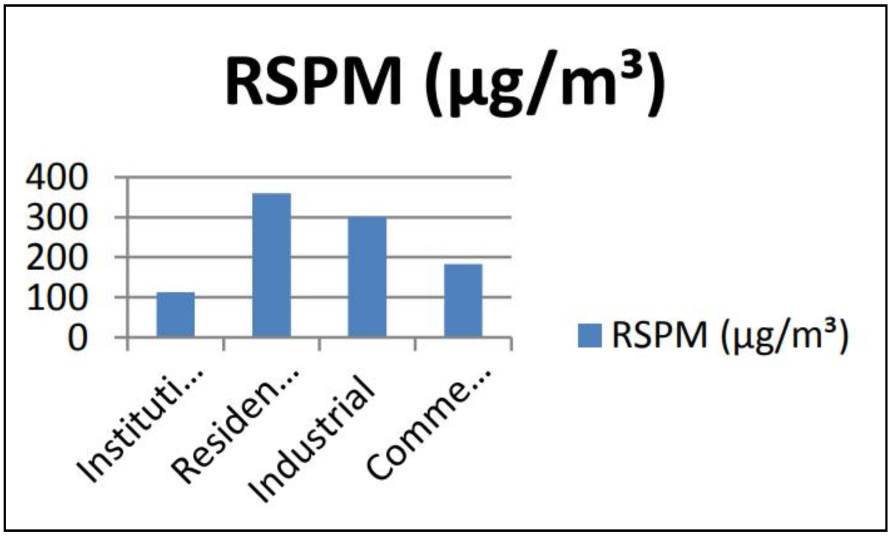
VIII. RESULTS AND DISCUSSIONS

Observed Concentrations

Area of Sampling	PM10 (µg/m S)	PM2.5 (µg/m S)	SOx (µg/m S)	NOx (µg/m S)
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

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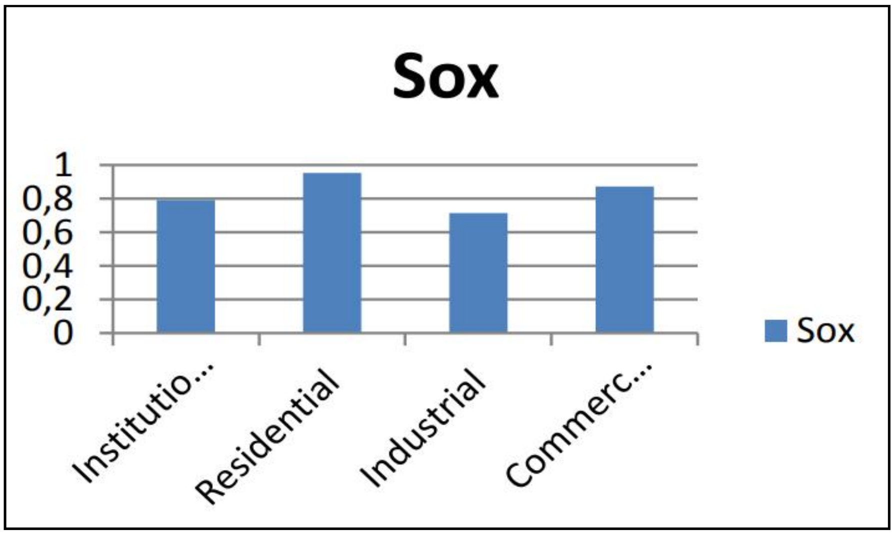
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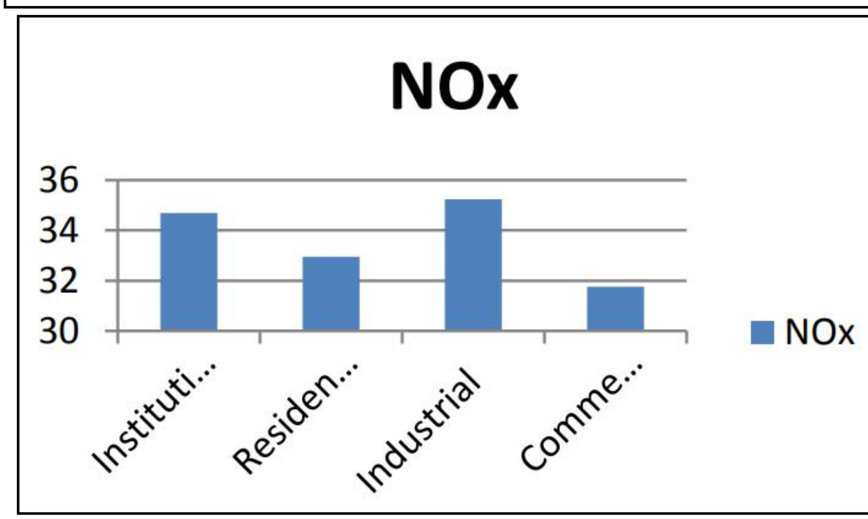
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IX. CONCLUSIONS

In recent years, numerous government agencies have made significant efforts to enhance the scientific comprehension of the dispersion and transformation phenomenon that governs urban air quality. The modeling of air quality in street canyons, which are considered to be the centers for air pollution, has been the subject of very few studies. Street canyons are intricate urban structures that are characterized by the obstruction of natural ventilation by high-rise buildings that encircle the streets. The deterioration of air quality in street canyons is aggregated by the wind vortex generated by such a structure. The air pollution situation in Kolhapur city can be further exacerbated by the occurrence of the most severe conditions.

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