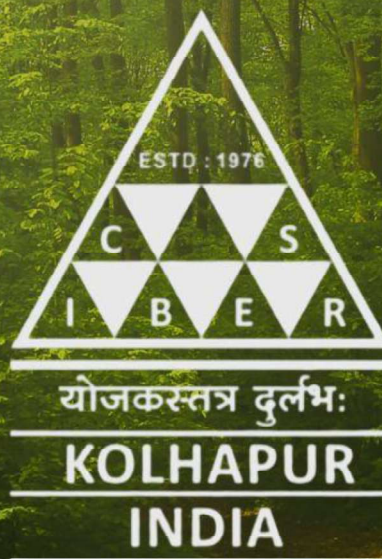




# CSIBER INTERNATIONAL JOURNAL OF ENVIRONMENT(CIJE)

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## Imperial Study of Causes for Deterioration of Air Quality Level of Kolhapur in the Past Five years

**Dr. Varsha Rayanade**

Assistant Professor,

School of Business,

Chhatrapati Shahu Institute of Business Education & Research

### Abstract

The city of Kolhapur has been witnessing a steady decline in its air quality, raising serious concerns for the health of its residents and the environment. This imperial study investigates underlying causes responsible for deterioration of air quality between 2021 and 2025 by analyzing data collected from government air quality monitoring stations, published reports and scientific research studies. The study identifies rising vehicular emissions construction dust, industrial activities and biomass burning as dominant contributors of particulate pollution. Further, seasonal variations and meteorological factors exacerbate pollution wherein lower wind speeds and temperature inversions during winter and post-monsoon months trap pollutants close to ground level, thereby worsening air quality. Despite sustained efforts including implementation of the National Clean Air Programme (NCAP) and localized initiatives focusing on vehicle emission controls and dust suppression, air pollutant concentrations regularly surpass the National Ambient Air Quality Standards (NAAQS), reflecting gaps in enforcement and infrastructure. This study provides a comprehensive empirical narrative with data interpretation, discussions on policy effectiveness and recommendations for sustainable urban air management in Kolhapur.

**Keywords:** Kolhapur, air quality, NCAP, NAAQS, pollution causes, particulate matter, vehicles, construction dust, industrial emissions

### Introduction

Urban air quality has become a significant issue in the recent years, and many Indian cities have been repeatedly placed in the list of the most polluted cities in the world. Even the city of Kolhapur located in the state of Maharashtra, once known for its lush green cover and rich cultural heritage has been struggling to maintain good air quality. Over the past few years, the city has been facing a silent but serious challenge in the form of steady decline in its ambient air quality. The worsening of air quality not only affects the environment, but also poses a serious threat to the health and daily lives of Kolhapur's residents. The residents of city are witnessing increased health issues such as respiratory problems, cardiovascular diseases, and other pollution-related illnesses.

Several interconnected factors such as rapid growth in population, increased vehicular traffic, building construction works, and on-going industrial projects around the city have contributed to the decline in air quality. As a result of which the city of Kolhapur has joined the list of non-attainment cities in India, that are habitually violating national pollution limits. In spite of implementing National and State Policy initiatives such as the National Clean Air Programme (NCAP) by the local administration, the city still struggles in handling the situation. The local authorities are facing pressure from the raising concern from the public to take corrective and preventive measures. This study attempts to empirically investigate the causes responsible for deterioration of air quality in Kolhapur from 2021 to 2025.

### Air Quality Index (AQI)

An air quality index (AQI) is an approximation of how polluted the air currently is or how polluted it is forecast to become. As air pollution levels rise, so does the AQI, along with the associated public health risk (Wikipedia). Computation of the AQI requires an air pollutant concentration over a specified averaging period, obtained from an air monitor or model.

AQI or Air Quality Index is one of the most popular systems of communicating the level of air pollution to the public. It takes the complicated data on air pollution and transforms it into a single value, which reflects the cleanliness or pollution of the air and the associated health consequences that may be of concern. The AQI is given on a scale of 0 and 500, wherein higher number indicates poorer air quality and higher health hazard. The AQI is determined using the level of major air pollutants, such as particulate matter (PM 2.5 and PM 10), ground-level ozone (O<sub>3</sub>), carbon monoxide (CO), sulphur dioxide (SO<sub>2</sub>) and nitrogen dioxide (NO<sub>2</sub>). Each of these pollutants have certain breakpoints, which convert the concentration of the pollutant to AQI values that are assigned to one of the six AQI categories ranging between 'Good' and 'Hazardous'. Each of these category is identified by a particular color and health warning. Different countries have their own air quality indices, associated to different national air quality standards. The Ministry for Environment, Forest and Climate change

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launched the National Air Quality Index (AQI) with ‘One Number – One Color – One Description’ to help the Common Indian Man judge the Air Quality

AQI Category, Pollutants and Health Breakpoints								
AQI Category (Range)	PM <sub>10</sub> 24-hr	PM <sub>2.5</sub> 24-hr	NO <sub>2</sub> 24-hr	O <sub>3</sub> 8-hr	CO 8-hr (mg/m <sup>3</sup> )	SO <sub>2</sub> 24-hr	NH <sub>3</sub> 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5 – 1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe (401-500)	430+	250+	400+	748+*	34+	1600+	1800+	3.5+

*\*One hourly monitoring (for mathematical calculations only)*

(Source: Ministry of Environment, Forest and Climate Change)

#### AQI and Associated Health Impacts

AQI	Associated Health Impacts
Good (0-50)	Minimal Impact
Satisfactory (51-100)	May cause minor breathing discomfort to sensitive people
Moderately polluted (101-200)	May cause breathing discomfort to people with lung disease such as Asthma and discomfort to people with heart disease, children and older adults
Poor (201-300)	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease
Very Poor (301-400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases
Severe (401 -500)	May cause respiratory impact even on healthy people and serious health impacts on people with lung/ heart disease. The health impacts may be experienced even during light physical activity

(Source: Ministry of Environment, Forest and Climate Change)

#### Literature Review

The issue of air pollution in urban India has been widely researched in terms of its impact on human health, environment and sustainability of urban life. Studies have indicated that some of the leading pollutants that cause negative health effects including respiratory illnesses to cardiovascular diseases are particulate matter (PM<sub>10</sub> and PM<sub>2.5</sub>), nitrogen dioxide (NO<sub>2</sub>), and sulfur dioxide (SO<sub>2</sub>) (WHO, 2018). The impact is aggravated in fast growing cities where industrialization, motorization, and construction work content with the lack of regulations and insufficiency of infrastructural systems (Gupta et al., 2020).

#### Ambient Air Quality in Medium-Sized Indian Cities

Researchers have focused their studies on Air Quality of megacities such as Delhi, Mumbai, Bangalore, etc. while cities such as Kolhapur have remained under-researched until recently despite having equally serious or even more problematic pollution issues (Sharma and Kumar, 2021). It is also observed that in such cities, there is often lack of continuous monitoring system and complete emissions inventories, which result in small-scale, single-faceted research instead of coordinated air quality measurements (CPCB, 2023).

### **Early Air Quality Studies in Kolhapur**

One of the first systematic studies of ambient air quality in Kolhapur, by Mangalekar et al. (2015), reported high levels of suspended particulate matter (SPM) and respirable suspended particulate matter (RSPM, which is now synonymous with PM<sub>10</sub> and PM<sub>2.5</sub>) with high levels of suspension suspended particles observed especially in densely populated commercial and traffic-prone regions, including Dabholkar Corner and Mahadwar Road. Their results showed that there were repeated surpassing of the limits set by the Central Pollution Control Board (CPCB), especially in the dry post-monsoon and winter seasons, which highlights seasonal effects on the level of air pollution.

The trends shown by Mangalekar et al. were confirmed in subsequent monitoring done by Bhosale et al. in 2022-23. Further, Bhosale et al. extended their analysis to source apportionment, which revealed that the greatest contributions of PM<sub>10</sub> was attributed to vehicular emissions and road dust. The study mentioned that over 40% of coarse particulate pollution was due to two-wheelers and diesel vehicles, along with significant contribution by road dust arising from unpaved surfaces, construction sites, and loose aggregates. (Bhosale, 2023)

### **Source Apportionment and Emission Inventories**

In the comprehensive source apportionment and emission inventory report published by Maharashtra Pollution Control Board (MPCB) in 2022 helped in providing more clarity about Kolhapur's pollution. This report in a way endorsed the findings of previous studies and also confirmed that pollution by vehicles and suspended road dust particles together contributed more than 70% to the PM<sub>10</sub> levels in major areas in the city. This report also observed that even small and medium scale industries along with burning of bio mass also played a role in polluting the city's air.

The report also highlighted the role of seasonal activities like agricultural residue burning, and open waste burning in the peri-urban regions which are episodic but result in acute pollution spikes that severely deteriorate the quality of air in the winter and post-monsoon months (MPCB, 2022; CPCB, 2023).

### **Meteorological Influences on Air Quality**

Specific studies undertaken in Kolhapur and in the western region of Maharashtra reveal that regional meteorology has some impact on the dispersion of pollutants. The particulate concentrations are reduced due to rainfall in the period June to September, while low speeds and inversion of temperature during November to February restrict vertical mixing, increasing the concentration of pollutants at the ground level (Rao et al., 2019)

### **National Clean Air Programme (NCAP) and Policy Context**

In 2019, the Government of India introduced National Clean Air Programme (NCAP) to address the rising air pollution crisis. The primary goal of this program was to initiate policies to reduce the particulate matter by around 20% to 30% by 2024 as compared to 2017 levels in 131 non-attainment cities, including Kolhapur (MoEFCC, 2019). The focus of the program was on exercising efforts in controlling the sector –specific source by regular monitoring, formulating regulation and creating awareness among the public.

According to the NCAP guidance, the Environment Plan developed for Kolhapur's District identified vehicular emissions, road dust, industrial emissions, and burning practices as priority sectors, for which strategies such as mechanized street sweeping, vehicle fitness programs, and enhanced industrial pollution controls were suggested. However, recent evaluations of NCAP implementation indicated the difficulties in the institutional capacity, the rigour of enforcement, citizen engagement, and monitoring density, which restrict the noticeable improvements in local air quality, including Kolhapur (Singh et al., 2022; CPCB, 2023).

### **Research Gap**

There are limitations in the temporal scope in the existing studies. These studies have concentrated on specific pollutants or sectors without considering the context of spatial, seasonal, and sectoral variability. Further, there is lack of combined multi -year studies specifically for Kolhapur city that could connect the long-term ambient air quality trends along-with emission source dynamics and policy impacts.

The changing landscape of the urban Kolhapur characterized by the rising construction, developing vehicular growth, changing industrial and agricultural practices requires constant updated analysis to inform the relevant policymakers. In addition, there is a dearth of information on PM<sub>2.5</sub> and gaseous pollutants, which restricts the knowledge about the exposure of finer particulate matter and associated health hazards.

## Research Objectives

### General Objective

- To empirically examine and assess the causes of air quality deterioration in Kolhapur city over the past five years (2021–2025).

### Specific Objectives

- To examine recent temporal trends in PM<sub>10</sub>, PM<sub>2.5</sub>, NO<sub>2</sub>, and SO<sub>2</sub> concentrations at key monitoring stations in Kolhapur.
- To combine source apportionment and emission inventory results to measure the proportionate contributions of key sectors (transport, road dust, industry, domestic fuel, biomass burning).
- To investigate the seasonal and spatial differences in pollutant levels across traffic, industrial, and background sites.
- To review NCAP and district-level action plans for Kolhapur and assess their alignment with empirically identified drivers.
- To recommend specific evidence-based measures for improving the quality of air in short to medium term.

## Research Methodology

### Data:

This study is based on secondary data and document analysis.

### Methods

- Descriptive statistics to summarize concentration of pollutant by year, season and location.
- Qualitative analysis of source apportionment data to assign sectoral contributions.
- Comparative analysis between observed exceedances and the sectoral measures outlined in NCAP and district plans.
- Interpretation is contextualized within established knowledge of meteorological effects on the quality of air in Western Maharashtra.

## Data Analysis and Interpretation

### Trend in Particulate Matter (2021–2025)

Recent analyses of MPCB and emission inventory show that PM<sub>10</sub> has been exceeding the National Ambient Air Quality Standards (NAAQS) threshold (annual 100 µg/m<sup>3</sup>) at key urban locations for much of the 2021–2025 period. Locations with high traffic like the Dabholkar Corner and Mahadwar Road continue to record the highest concentration, while comparatively greener areas and less congested areas like Shivaji University show low, but alarming levels of particulates.

Kolhapur is classified as a non - attainment city due to exceedance of PM<sub>10</sub> factor reported in the District Environment Plan, This confirms that PM<sub>10</sub> is not an infrequent phenomenon but a consistent issue. Less spatially-dense PM<sub>2.5</sub> data exhibit similar patterns and emphasize the role of combustion-related sources in driving fine particulates.

### Sectoral Source Contributions

According to the source apportionment conducted by Bhosale and MPCB's study of PM<sub>10</sub> shows that the road dust and exhaust of vehicles are the largest contributors to PM<sub>10</sub> emissions in Kolhapur. The road dust constitutes re-suspension of particles from paved and unpaved roads and construction debris. The findings of the emission inventory suggest that higher percentage of emissions is caused due to re-suspended dust as compared to tailpipe emissions of vehicles highlighting the importance of street sweeping and Construction and Demolition waste management.

Approximately three lakh vehicles with a high proportion of two-wheelers contribute both coarse and fine particulate matter as well as high loads of NO<sub>2</sub>, especially in congested corridors. Further, the industrial sources

contribute the localized yet significant contribution of PM10 and gaseous pollutants released in industrial estates, especially where stack emission controls and fuel quality are inadequate.

Burning of Biomass and open waste in peri-urban and rural suburbs are recognized as important seasonal contributors. Even though their contribution to PM10 per annum may be less than transport and dust, they still cause acute short term spikes and contribute to secondary particulate formation.

### **Seasonal and Spatial Patterns**

The results of the recent data are in line with the previous studies which revealed that pollutant concentrations in Kolhapur are lowest during the monsoon months when wet deposition is high due to rainfall, and when dust re-suspension is suppressed by soil moisture. While in the post monsoon and winter seasons there is increase in PM10 and PM2.5 on account of lower mixing heights and temperature inversions common to the area. Spatially, it is the commercial business areas and traffic junctions that display the highest particulate levels followed by industrial estates and finally the greener residential and suburban and peri-urban areas.

### **Policy Alignment and Gaps**

The District Environment Plan of NCAP and Kolhapur focus on the control of road dust, better Construction and Demolition waste management, better public transport, better traffic management, and industrial emission control. These areas of focus are reasonably aligned with the major sources identified by emission inventories and source apportionment, which implies conceptual compatibility.

Non-compliance with PM10 and non-compliance status in the past five years however reflect weakness in areas of implementation such as limited coverage and frequency of mechanized street sweeping, partial execution of construction dust norms, incomplete Construction and Demolition waste processing infrastructure as well as capacity limitations in enforcing industrial emission standards. Moreover, the limited density of continuous air quality monitoring stations makes it difficult to track intervention effects on a fine scale.

### **Discussion,**

This analysis shows that the decline in air quality in Kolhapur over the past five years is not caused because of one dominant factor, but has arisen due to an interconnected network of sources of emissions and enabling conditions. The accelerated growth of vehicles and the persistent road and construction dust implies that there is a problem with the planning of urban transport and land-use. Additional particulate loads arise due to industrial emissions and burning of biomass, which in unfavorable weather conditions push the level of pollutants beyond NAAQS.

The fact that the sources identified are very close to the sectors targeted under NCAP is an indication that the main policy framework is towards the correct direction. The main difficulty lies in scaling up, coordinating, and sustaining of implementation of these measures at the city level, especially on road dust control, Construction and Demolition waste management, rigorous enforcement of the industrial standards and behavior change to prevent open burning.

From the research perspective the past five years stress the importance of improving monitoring determination (both spatial and temporal) and integration of local health data so as to directly co-relate exposure with outcomes in Kolhapur. The local institutions and technical capacity needs to be strengthened for translating emission inventories and action plans into measurable air quality gains.

### **Conclusion**

The findings of the imperial study reveals that the deterioration of air quality of Kolhapur in the last five years has been primarily driven by PM10 pollution associated with road dust, vehicular emissions, industrial activity, and biomass and waste burning. Persistent exceedance of national standards, particularly at high traffic junctions and commercial hotspots has been confirmed by the ambient monitoring data. Further, emission inventory and source apportionment studies have constantly identified road dust and transport as the leading contributors with industry and seasonal burning playing significant secondary roles.

Despite the fact that NCAP and other district-level plans focus on these areas, the present non-attainment status of Kolhapur has not changed, which indicates that the existing interventions are inadequate in terms of the scope or the enforcement. In order to reverse current trends, Kolhapur will have to focus on intensive management of road dust (mechanized sweeping and construction and demolition waste management), strengthen of public transport, vehicle emissions, modernization of industrial pollution control, and institutionalization of actions to

stop open burning. Further data-driven approach to air quality management will be supported by expanded and high-quality monitoring and integrated health assessments.

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