Comparative Study of Air Quality Index (AQI) in Major Metropolitan Cities of India: The Context of Sustainable Development Goals.

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Abstract:

Air pollution in urban areas has become a major environmental and health concern in India, largely driven by rapid urbanization, industrial growth, and the increasing number of vehicles. This study examines the Air Quality Index (AQI) trends in four major metropolitan cities of India—Delhi, Mumbai, Kolkata, and Chennai—and evaluates their relationship with the United Nations Sustainable Development Goals (SDGs). The research relies on secondary data obtained from reports published by the Central Pollution Control Board (CPCB) and IQAir covering the period **2021–2025**, along with projected estimates for **2026**.

A comparative analysis was conducted using tabular data and descriptive interpretation to examine variations in AQI levels among the selected cities. The findings reveal that Delhi consistently records the highest AQI values, indicating severe air pollution conditions caused by factors such as vehicular emissions, industrial activities, and high population density. Kolkata also experiences relatively high pollution levels, while Mumbai and Chennai generally maintain comparatively moderate AQI levels.

The study highlights that geographical conditions, urban congestion, and industrial development play a significant role in determining air pollution levels in metropolitan regions. The findings emphasize the importance of effective environmental management, sustainable urban planning, and improved air quality monitoring systems to support the achievement of SDG 3 (Good Health and Well-being), SDG 11 (Sustainable Cities and Communities), and SDG 13 (Climate Action).

Introduction:

Urban air pollution has become a serious environmental and health concern in India. Rapid population growth, urban expansion, industrial development, and increasing vehicle usage have significantly affected air quality in many large cities. Pollutants such as PM2.5 and PM10 are commonly found at high levels in metropolitan areas, which can negatively impact human health and the environment.

Reports published by international organizations indicate that several Indian cities frequently record pollution levels above recommended air quality standards. Exposure to polluted air can lead to various health problems, including respiratory disorders and cardiovascular diseases. Therefore, monitoring and controlling air pollution has become an important priority for policymakers and researchers.

The Air Quality Index (AQI) is widely used to represent the overall level of air pollution in a specific location. It combines different pollutant concentrations into a single value that helps people understand the condition of air quality and its potential health effects.

This study examines AQI levels in four major metropolitan cities of India—Delhi, Mumbai, Kolkata, and Chennai—to compare pollution patterns and analyze their implications for sustainable urban development and the United Nations Sustainable Development Goals (SDGs).

Literature Review

Previous research has highlighted the growing problem of air pollution in major Indian cities. Reports by the World Health Organization indicate that rapid urbanization and industrial growth have contributed to increased levels of particulate matter in urban environments.

Shinde (2020) examined AQI trends in several metropolitan cities of India and concluded that traffic congestion, industrial emissions, and population density are major contributors to urban air pollution. The study used comparative analysis to understand differences in pollution levels among cities.

Beig and Guttikunda (2017) discussed the development of India's National Air Quality Index system, which was designed to provide clear information about air pollution levels to the public and policymakers.

Similarly, Kumar and Guttikunda (2015) analyzed air quality patterns in major Indian cities and identified vehicular emissions, industrial activities, and construction dust as key sources of pollution.

These studies emphasize the importance of continuous monitoring and comparative analysis of air quality across cities to support effective environmental management and sustainable urban planning.

Research Gap

Many previous studies have examined air pollution in individual cities or focused on specific pollution sources. However, limited research compares the Air Quality Index across multiple metropolitan cities while linking the findings with Sustainable Development Goals. Therefore, the present study attempts to analyze and compare AQI patterns in major Indian metropolitan cities such as Delhi, Mumbai, Kolkata, and Chennai.

Objectives

To examine the Air Quality Index (AQI) levels of selected

1. metropolitan cities such as Delhi, Mumbai, Kolkata, and Chennai using available secondary data.
2. To compare the variation in air quality among these major metropolitan cities of India.
3. To analyze the overall air pollution pattern in these cities in relation to sustainable urban development and the United Nations Sustainable Development Goals (SDGs).

Limitations of the Study

The study is based on secondary data and limited to selected metropolitan cities. Future research may include more cities and longer time periods to provide a more comprehensive understanding of air pollution trends.

Database and Methodology

This study **is entirely based on** secondary data sources. **Air Quality Index** (AQI) information for the selected cities was obtained from publicly available reports and databases published by the Central Pollution Control Board (CPCB), the World Health Organization (WHO), and IQAir.

The research focuses on four major metropolitan cities of India: Delhi, Mumbai, Kolkata, and Chennai. Annual average AQI values for each city were collected from publicly available environmental monitoring reports.

The projected AQI values for 2026 were estimated using a simple trend projection method based on the average growth pattern observed during the period 2021–2025. Tables and graphical representations were used to examine differences in AQI levels and identify patterns of air pollution among the selected cities.

Delhi

Delhi records some of the highest Air Quality Index (AQI) levels among major metropolitan cities in India. The pattern of air pollution in the city shows significant seasonal variation. AQI levels generally increase during the winter months, particularly from October to January, due to factors such as temperature inversion, vehicular emissions, construction activities, and the burning of crop residues in neighboring regions. During this period, the concentration of particulate matter, especially PM2.5, often exceeds the permissible limits recommended for public health.

In contrast, air quality conditions tend to improve during the monsoon season, as rainfall and stronger wind circulation help disperse air pollutants. Despite these

seasonal improvements, Delhi continues to experience severe air pollution challenges throughout the year. These conditions highlight the urgent need for effective environmental management policies, stricter emission control measures, and sustainable urban planning. Addressing air pollution in Delhi is also closely related to achieving **Sustainable Development Goal (SDG) 13 – Climate Action**, which emphasizes the importance of mitigating environmental degradation and reducing climate-related risks.

Mumbai

Mumbai generally experiences moderate air pollution compared with northern cities like Delhi. Temporal analysis shows that AQI levels tend to increase during the **winter and pre-summer months** due to vehicular traffic, construction activities, and industrial emissions. However, Mumbai's **coastal location** allows better air circulation, which helps in dispersing pollutants. During the **monsoon period**, air quality generally improves due to rainfall that reduces airborne particulate matter **(Central Pollution Control Board, 2023).**

Kolkata

Kolkata also experiences noticeable seasonal variations in air quality. AQI levels generally rise during the **winter months** because of low wind speeds, increased vehicular emissions, and industrial activities. The dense population and urban congestion further contribute to pollution accumulation. However, the **monsoon season** typically results in improved air quality due to rainfall and atmospheric cleansing processes **(World Health Organization, 2024).**

Chennai

Compared with other metropolitan cities such as Delhi and Kolkata, Chennai generally records **relatively lower AQI levels**. The city's coastal location and favorable wind patterns help reduce pollutant concentration in the atmosphere. Nevertheless, temporal changes in AQI can occur due to urban growth, industrial development, and vehicular emissions. Similar to other cities, monsoon rainfall often improves air quality by removing particulate matter from the air (Central Pollution Control Board, 2023). Overall, Chennai maintains relatively better air quality conditions due to its coastal geographical location and favorable atmospheric circulation.

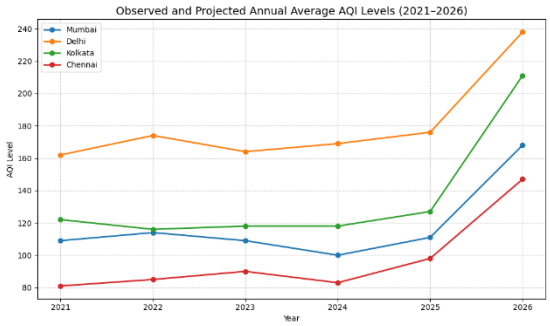
Data Analysis and Interpretation

Graphical representations were used to analyze pollution trends and compare AQI levels across the selected metropolitan cities.

Table 1: Observed and Projected Annual Average AQI Levels (2021–2026)

Year	Mumbai	Delhi	Kolkata	Chennai
2021	109	162	122	81
2022	114	174	116	85
2023	109	164	118	90
2024	100	169	118	83
2025	111	176	127	98
2026	168	238	211	147

Source: Central Pollution Control Board (CPCB), National Air Quality Index Database; IQAir World Air Quality Report; AQI.in Historical and Forecast Air Quality Database.



The data in Table 1 shows the annual average Air Quality Index (AQI) levels of four major metropolitan cities in India from 2021 to 2026. Among the selected cities, **Delhi consistently records the highest AQI levels**, indicating severe air pollution conditions. **Kolkata also shows relatively high AQI values**, reflecting increasing urban pollution. In contrast, **Mumbai and Chennai maintain comparatively moderate AQI levels**, possibly due to their coastal location and better air circulation. The projected values for 2026 indicate a significant rise in AQI levels across all cities, suggesting worsening air quality if effective pollution control measures are not implemented. These trends highlight the urgent need for improved environmental policies and sustainable urban management.

Table 2: Comparative AQI Levels of Cities

The average AQI values for the selected cities were calculated using the **Arithmetic Mean method**.

Formula:

Average AQI = ΣAQIi / n

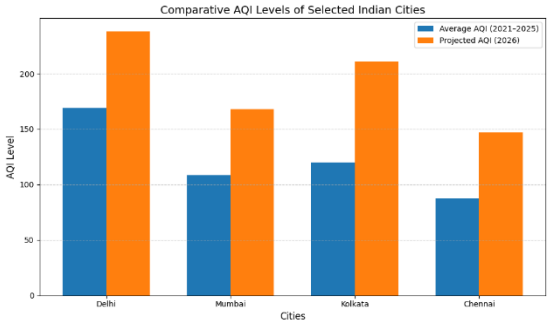
Where:

AQIi = AQI value for each year

n = Number of years

City	Average AQI (2021–2025)	Projected AQI (2026)	Change (%)
Delhi	169.0	238	+40.8%
Mumbai	108.6	168	+54.7%
Kolkata	120.2	211	+75.5%
Chennai	87.4	147	+68.2%

Source: Central Pollution Control Board (CPCB), National Air Quality Index Database; IQAir World Air Quality Report; AQI.in Historical and Forecast Air Quality Database.

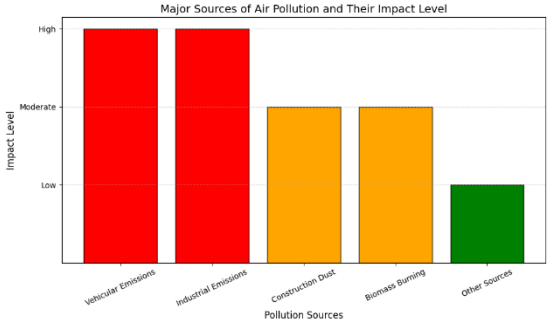


The comparative analysis of AQI levels indicates a significant increase in projected air pollution across all selected cities by 2026. Delhi records the highest average AQI (169.0) during 2021–2025 and is projected to reach 238, reflecting severe air quality concerns. Kolkata and Chennai show the highest percentage increases, suggesting **a rapid deterioration in environmental conditions.** Mumbai also demonstrates a notable rise in projected AQI levels. Overall, the results highlight an urgent need for stronger air pollution control and sustainable urban environmental policies in major Indian cities.

Table 3: Major Sources of Air Pollution

Major Pollution Sources	**Impact Level**
Vehicular Emissions	High
Industrial Emissions	High
Construction Dust	Moderate
Biomass Burning	Moderate
Other Sources	Low

Source: Central Pollution Control Board (CPCB), National Air Quality Index Database; IQAir World Air Quality Report; AQI.in Historical and Forecast Air Quality Database.



The analysis indicates that vehicular emissions and industrial activities are the most significant contributors to urban air pollution, showing a high impact on air quality. Construction activities and dust from urban development contribute moderately to particulate pollution levels. Biomass burning also plays a moderate role in increasing air pollutants in metropolitan regions. Other minor sources have relatively lower impacts but still contribute to overall air quality degradation. These findings highlight the importance of controlling transportation and industrial emissions to improve urban air quality.

Result

The analysis reveals noticeable differences in air quality among the selected metropolitan cities. Delhi records the highest AQI levels, indicating severe air pollution conditions. Kolkata also experiences relatively high pollution levels. In contrast, Mumbai and Chennai generally report moderate AQI levels, which may be attributed to their coastal locations and better atmospheric circulation.

The findings suggest that factors such as population density, industrial growth, transportation activities, and geographical conditions significantly influence air pollution patterns in major metropolitan regions.

Suggestions / Recommendations

1. Metropolitan cities such as **Delhi, Mumbai, Kolkata, and Chennai** should introduce **urban pollution budgets**, where annual limits are set for emissions from transport, industries, and construction activities. This can contribute to achieving the **SDG 11 (Sustainable Cities and Communities)**
2. A **city-level carbon credit or pollution trading system** should be implemented to encourage industries to reduce emissions and
3. promote cleaner production methods. Such initiatives can support the objectives of **SDG 13 (Climate Action)**
4. The adoption of **AI-based air quality monitoring and forecasting systems** can help authorities provide early warnings about hazardous pollution levels and protect public health, contributing to SDG 3 (**Good Health and Well-being**)

Conclusion

The study examined the Air Quality Index (AQI) levels in four major metropolitan cities of India—Delhi, Mumbai, Kolkata, and Chennai—to understand variations in urban air quality. The findings show that Delhi experiences the highest pollution levels among the selected cities, while Kolkata also records relatively high AQI values. In contrast, Mumbai and Chennai generally maintain moderate air quality conditions due to their coastal location and better atmospheric circulation.

The results indicate that factors such as population growth, industrial development, vehicular emissions, and urban expansion significantly influence air pollution levels in metropolitan areas. Effective environmental policies, improved monitoring systems, and sustainable urban planning are necessary to reduce pollution and support the achievement of the Sustainable Development Goals.

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