# A Data-Driven Assessment of Air Pollution Trends in Major Indian Cities Using AQI (2018–2024)

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***Abstract*—Air pollution remains a major environmental and public health concern in India, primarily driven by rapid urbanization, industrialization, and vehicular emissions. This study presents a comprehensive data-driven analysis of air quality trends across major Indian cities using the Air Quality Index (AQI) and key pollutants, including Nitrogen Dioxide ($NO_2$), Nitric Oxide (NO), Ammonia ($NH_3$), and Carbon Monoxide (CO), over the period 2018–2024.**

**The dataset, obtained from an open-source platform, was analyzed using statistical and visualization techniques in Microsoft Excel, including trend analysis and comparative evaluation. The findings reveal that AQI levels in most cities fall within the moderate to poor categories, with Delhi consistently exhibiting the highest pollution levels. Nitrogen-based pollutants, particularly $NO_2$, are identified as dominant contributors. Seasonal analysis indicates significantly higher pollution levels during winter due to atmospheric inversion conditions.**

**The study emphasizes the need for stricter emission regulations, sustainable urban planning, and enhanced public awareness to mitigate air pollution and its health impacts.**

***Index Terms*—Air Pollution, AQI, $NO_2$, Environmental Analysis, Urban Pollution, India**

## I. Introduction

Air pollution has become one of the most critical environmental challenges worldwide, particularly in developing countries like India (World Health Organization, 2022).particularly in developing countries such as India. Rapid economic growth, urban expansion, and increased energy consumption have significantly contributed to the deterioration of air quality. According to environmental studies, prolonged exposure to polluted air can lead to respiratory and cardiovascular diseases (World Health Organization, 2022)The Air Quality Index (AQI) is a standardized indicator used to measure and communicate air quality levels. It converts complex pollutant data into a single value, making it easier to understand the level of pollution and its potential health impact.

This study focuses on analysing air pollution data across major Indian cities to identify patterns, trends, and key contributing pollutants. By leveraging data analysis techniques, the study aims to provide insights that can support environmental management and policy-making.

### Research Gap

Most existing studies focus on short-term analysis, whereas this study provides a multi-year (2018–2024) comparative evaluation across major Indian cities.

## II. Objectives

The primary objectives of this study are:

1. To analyse AQI levels across major Indian cities
2. To compare air pollution levels between cities
3. To identify key pollutants contributing to AQI
4. To examine temporal variations in air quality
5. To assess potential health implications

## III. Literature Review

Previous studies have highlighted the rapid increase in air pollution in urban India (Central Pollution Control Board, 2023).According to the World Health Organization, air pollution is one of the leading environmental risk factors contributing to premature mortality worldwide.

Research by Central Pollution Control Board indicates that vehicular emissions, industrial activities, and construction dust are the primary sources of urban air pollution. Kumar and Gulia (2021) demonstrated that nitrogen oxides (NOx) and particulate matter significantly influence AQI levels in metropolitan cities.

Furthermore, seasonal variations—particularly winter inversion—have been shown to intensify pollution levels by trapping pollutants near the ground. This study extends existing research by applying a data-driven analytical approach to evaluate recent trends (2018–2024).

## IV. Data and Methodology

### 1. Data Source

The dataset includes the following variables:

- City
- Date
- AQI
- NO (Nitric Oxide)
- $NO_2$ (Nitrogen Dioxide)
- $NH_3$ (Ammonia)
- CO (Carbon Monoxide)

### 2. Data Description

The dataset was preprocessed using the following steps:

- Removal of missing and null values
- Elimination of duplicate records
- Verification of data consistency

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4. **Data Transformation**
   Additional variables were created:
   - Month (derived from Date)
   - Year (derived from Date)

5. **Analytical Techniques**
   The following tools and techniques were used:
   - Pivot tables for data aggregation
   - Line charts for trend analysis
   - Bar charts for comparative analysis
   - Filtering techniques for city-wise evaluation

## V. Results and Analysis

1. **Overall AQI Analysis**

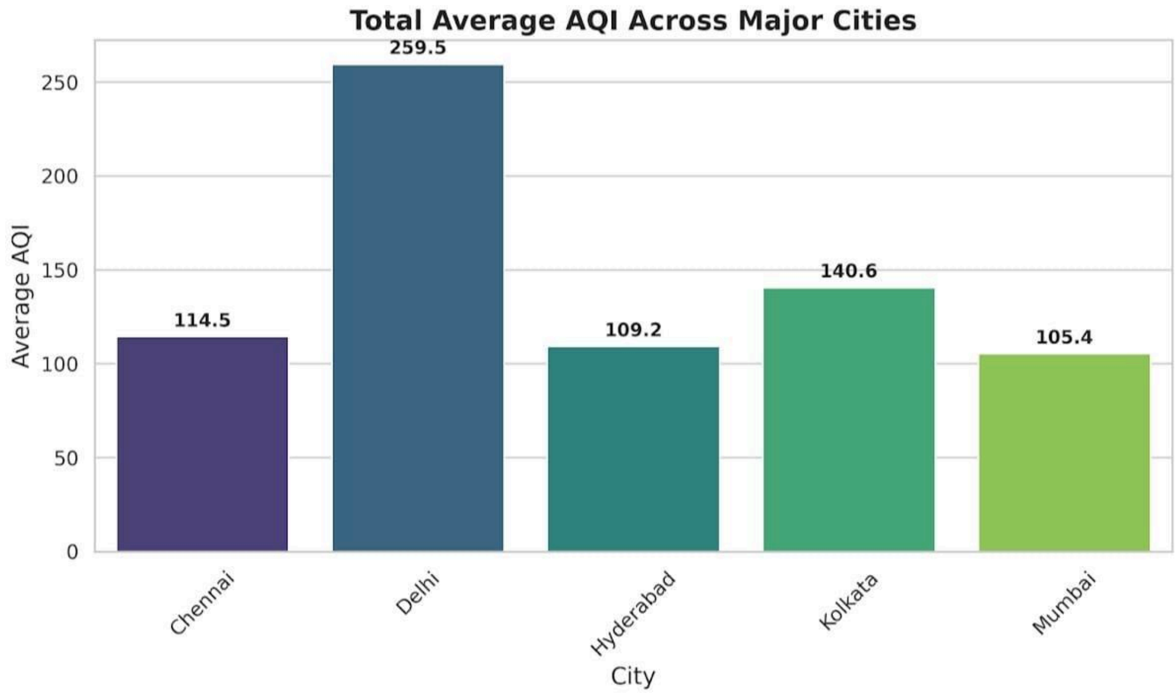


**Figure 1: Trend of Air Quality Index (AQI) across major Indian cities (2018–2024)**

The analysis reveals that AQI values across cities predominantly range between 130 and 150, indicating moderate to poor air quality. This suggests that air pollution is a persistent issue in urban areas. The overall AQI trend across major Indian cities is illustrated in Figure 1.

2. **City-wise Comparison**

The comparison of AQI levels shows

- Delhi exhibits the highest pollution levels
- Mumbai and Kolkata show moderate pollution
- Chennai and Hyderabad show relatively lower AQI

This variation reflects differences in industrial activity, traffic density, and geographical fact

The comparison of AQI levels shows that Delhi exhibits the highest pollution levels, followed by Mumbai and Kolkata, while Chennai and Hyderabad show relatively lower AQI values. A comparative analysis of AQI levels among cities is presented in Figure 2.

**City-wise Observations**

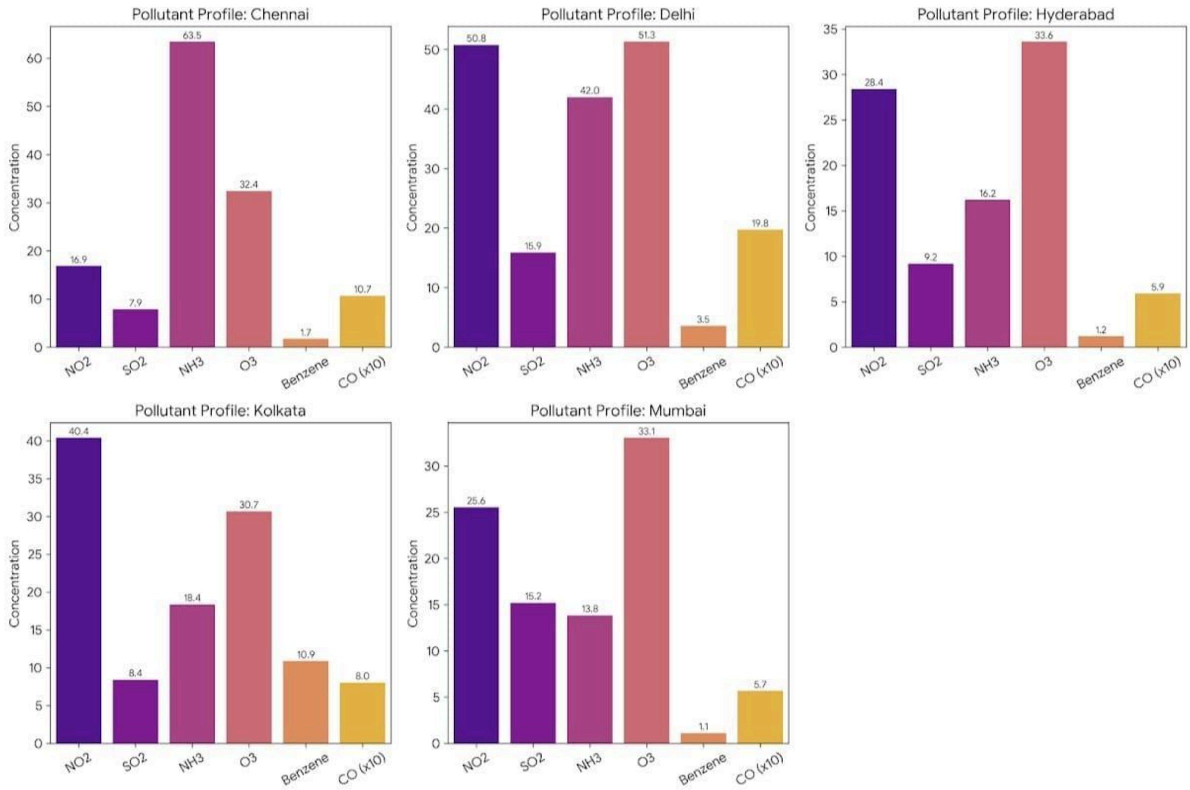


**Figure 2: City-wise comparison of average AQI levels**

Chennai exhibits a notably high concentration of $PM_{10}$ (~63.9 µg/m³), indicating a significant contribution from dust and vehicular emissions. $O_3$ levels (~32.8 µg/m³) are also moderately elevated, suggesting active photochemical reactions. However, gaseous pollutants such as $NO_2$ (~16.4 µg/m³) and $SO_2$ (~7.8 µg/m³) remain comparatively low, reflecting relatively better industrial emission control.

Delhi shows consistently high concentrations across multiple pollutants, particularly $NO_2$ (~50.8 µg/m³) and $O_3$ (~52.3 µg/m³). $PM_{10}$ (~42.2 µg/m³) is also substantially elevated. These levels indicate a combination of vehicular emissions, industrial activity, and secondary pollutant formation, making Delhi the most polluted city among those analyzed.

Hyderabad presents moderate $NO_2$ (~28.8 µg/m³) and $PM_{10}$ (~16.2 µg/m³) levels, but relatively high $O_3$ (~33.8 µg/m³). This suggests that while primary emissions are moderate, photochemical smog formation contributes significantly to air pollution.

Kolkata is characterized by high $NO_2$ (~40.4 µg/m³) and $O_3$ (~32.7 µg/m³) concentrations, along with moderate $PM_{10}$ (~18.4 µg/m³). Benzene levels (~10.3 µg/m³) are comparatively higher than in other cities, indicating a possible influence of fuel combustion and industrial emissions.

Mumbai demonstrates relatively balanced pollutant levels, with moderate $NO_2$ (~25.4 µg/m³) and $O_3$ (~33.1 µg/m³). $PM_{10}$ (~13.8 µg/m³) is lower compared to other metropolitan areas, possibly due to coastal dispersion effects. However, the presence of $O_3$ indicates ongoing secondary pollutant formation.

Comparative Insights

Across all cities, ozone ($O_3$) emerges as a consistently high pollutant, highlighting the importance of secondary atmospheric reactions driven by sunlight and precursor gases. Delhi stands out as the most polluted city due to its high levels of $NO_2$, $PM_{10}$, and $O_3$. In contrast, Mumbai and Hyderabad show relatively moderate pollution levels, while Chennai is primarily affected by particulate matter.

Benzene concentrations are generally low across cities, though slightly elevated in Kolkata, suggesting localized industrial or traffic-related sources. Carbon monoxide (CO) levels remain within a moderate range in all cities, indicating incomplete combustion processes but not at critically high levels.

3. **Pollutant Contribution**

The analysis of pollutant levels indicates that $NO_2$ is the major contributor to AQI, followed by other nitrogen oxides. The contribution of individual pollutants is shown in Figure 3.

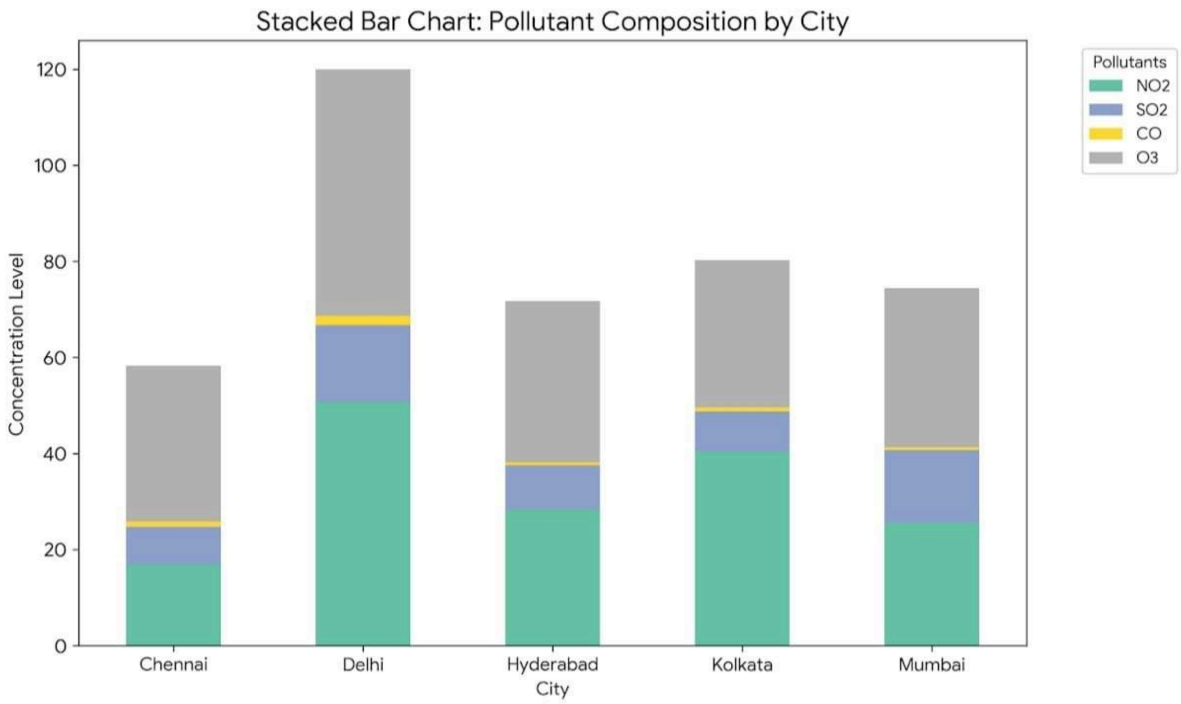


**Figure 3: Contribution of major pollutants to AQI levels**

The analysis of pollutant levels indicates:

- $NO_2$ is the major contributor to AQI
- Nitrogen oxides significantly impact air quality
- CO has relatively lower influence
- $NH_3$ shows moderate contribution

These findings highlight the role of vehicular and industrial emissions in air pollution.

4. Temporal Trends

Seasonal analysis shows:

- Higher AQI levels during winter months
- Lower AQI levels during monsoon season

This is due to atmospheric conditions such as temperature inversion and rainfall patterns.

**Result**

- AQI values ranged between **130–150**, indicating **consistent moderate-to-poor air quality**
- Delhi recorded the highest pollution levels due to:
    - High traffic density
    - Industrial emissions
    - Meteorological conditions
- $NO_2$ identified as **dominant pollutant**
- Winter AQI ↑ due to **temperature inversion**
- Monsoon AQI ↓ due to **rainfall washout effect**

**Delhi shows highest pollution levels, consistent with national reports (CPCB, 2023)**

## VI. Discussion

The dominance of nitrogen oxides suggests that vehicular emissions are the primary drivers of urban air pollution. This aligns with findings from global environmental agencies.

The variation among cities indicates that **localized policies** are essential rather than a one-size-fits-all approach. Additionally, the increasing concentration of secondary pollutants such as ozone highlights the need for integrated air quality management strategies. These findings align with global environmental studies (World Health Organization, 2022)

**Policy Recommendations**

- Implementation of stricter emission standards
- Promotion of electric vehicles
- Improved public transportation systems
- Urban green infrastructure development

## VII. Conclusion

This study demonstrates that air pollution remains a significant environmental challenge in major Indian cities, with AQI levels predominantly in the moderate to poor range. Delhi emerges as the most polluted city, while southern cities exhibit comparatively better air quality.

Nitrogen-based pollutants, particularly $NO_2$, are identified as key contributors, emphasizing the impact of vehicular and industrial emissions. Seasonal variations further influence pollution levels, with winter months showing higher concentrations.

Addressing this issue requires coordinated efforts involving policy interventions, technological advancements, and increased public awareness.

## VIII. Limitations

- Limited pollutant coverage (PM2.5 not included)
- Analysis performed using basic tools (Excel)
- Limited geographical scope

## IX. Future Work

Future studies can explore:

- Machine learning-based AQI prediction models
- Inclusion of additional pollutants
- Real-time data analysis
- Policy impact assessment

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