Trend Analysis of Air Quality Index Using MATLAB

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Abstract — Air pollution remains a critical challenge in urban areas, especially in rapidly developing countries like India. This study conducts a comprehensive trend analysis of the Air Quality Index (AQI) from 2017 to 2024 for Delhi, Bangalore, and Hyderabad. Utilizing MATLAB's advanced computational tools, this research integrates AQI data with meteorological parameters such as temperature, precipitation, wind speed, and atmospheric pressure to elucidate their collective impact on urban air quality. The study reveals distinct city-specific pollution patterns and establishes significant correlations between AQI and various meteorological factors. The analytical framework developed provides a replicable methodology for urban air quality management and policymaking.

Keywords: Air Quality Index, MATLAB, Trend Analysis, Meteorological Parameters, Urban Air Pollution

I. Introduction

Air quality significantly influences public health and environmental sustainability, particularly in densely populated urban centers. Cities like Delhi, Bangalore, and Hyderabad face complex air pollution dynamics driven by anthropogenic activities and meteorological variations. Understanding these trends is vital for effective policy formulation and pollution mitigation. This research focuses on analyzing AQI trends from 2017 to 2024 using MATLAB, integrating meteorological data to uncover relationships that can inform targeted interventions.

II. Literature Review

Previous studies have examined air quality trends and their meteorological dependencies. For instance, Singh and Gupta (2020) analyzed seasonal trends in Delhi's AQI, highlighting winter pollution peaks due to temperature inversions. Kumar et al. (2019) used statistical models to forecast air pollutant behaviors, demonstrating the effectiveness of regression techniques in environmental studies. However, comprehensive comparative analyses across major Indian cities integrating multiple meteorological factors remain limited. This study aims to fill this gap by employing a multi-parameter approach with MATLAB's computational capabilities.

III. Methodology

A. Data Collection

Air quality data (AQI) from 2017 to 2024 were gathered from government and environmental monitoring agencies across Delhi, Bangalore, and Hyderabad. Concurrently, meteorological datasets comprising temperature, precipitation, wind speed, and atmospheric pressure were sourced from respective meteorological departments.

B. Data Preprocessing

Data underwent preprocessing to handle missing values, correct biases using the Rolling Change Method, and ensure temporal alignment between AQI and meteorological parameters.

C. Analytical Methods

- Time Series Analysis: To identify temporal trends and seasonal patterns in AQI.
- Correlation Analysis: Assessed statistical relationships between AQI and meteorological variables.
- Regression Analysis: Developed models quantifying the influence of meteorological factors on AQI variations.
- Visualization: MATLAB's graphical tools generated interactive visualizations to illustrate trends and correlations.

D. City-wise Comparative Analysis

Comparative assessments highlighted differing pollution dynamics and meteorological influences across the three cities.

E. Tools

MATLAB served as the primary analytical platform, leveraging its data processing, statistical, and visualization toolboxes.

IV. Results and Discussion

A. AQI Trends 2017-2024

- Delhi: Consistently hazardous AQI levels with seasonal spikes during winter due to temperature inversions and post-harvest biomass burning.
- Bangalore: Generally better air quality but a slight upward trend correlates with increased urbanization.
- Hyderabad: Moderate AQI with evident seasonal variations linked to meteorological changes.

B. Impact of Meteorological Factors

- Temperature: High temperatures sometimes associated with pollutant accumulation due to atmospheric stability.
- Precipitation: Acts as a natural cleansing agent, reducing airborne pollutants.
- Wind Speed: Higher speeds facilitate pollutant dispersion, improving AQI.
- Atmospheric Pressure: Elevated pressure conditions contribute to pollutant entrapment.

C. Statistical Relationships

Regression models revealed significant inverse relationships between AQI and wind speed/precipitation, while positive correlations existed with high atmospheric pressure and temperature inversions.

V. CONCLUSION

The study confirms that air quality trends in major Indian cities are intricately linked with meteorological factors. MATLAB-based analysis facilitated a robust understanding of these multidimensional relationships. The findings underscore the necessity for localized air quality management strategies that incorporate meteorological insights to effectively mitigate pollution. Furthermore, the research outlines a replicable analytical framework for future environmental studies and policymaking aimed at sustainable urban development.

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