

Cognitive Air Quality Systems: Quantifying AQI Levels Through AI and Time Series Modelling

Dr. M Sindhana Devi ^[1]

*Department of Data Science
Kumaraguru College of Liberal Arts and Science
Coimbatore, India
sindhanadevi.m.dsc@kclas.ac.in*

Dr. L Mary Louis ^[2]

*Department of Mathematics
Kumaraguru College of Liberal Arts and Science
Coimbatore, India
marylouis@kclas.ac.in*

Dr. K S Narayanan ^[3]

*Department of Data Science
Kumaraguru College of Liberal Arts and Science
Coimbatore, India
narayanan.ks.dsc@kclas.ac.in*

Jeyanth Varma A ^[4]

*Department of Data Science
Kumaraguru College of Liberal Arts and Science
Coimbatore, India
jeyanth.22bds@kclas.ac.in*

Abstract – Air, vital for life and Earth's climate regulation, faces escalating threats from pollution. Prioritizing air quality is imperative for human health, environmental protection, and climate change mitigation. Achieving cleaner air requires global collaboration and sustainable practices. India's diverse landscapes, from the Himalayas to beaches, influence air quality, with forests serving as crucial carbon sinks. Rapid urbanization and deforestation present challenges, harming nature and public health. Combating pollution is strengthened through conservation and afforestation initiatives. This study employs artificial intelligence, machine learning, and IoT, providing an enhanced Air Quality Index (AQI) via a user-friendly interface, ensuring a disease-free future for younger generations. Government policies, stringent emissions norms, and cleaner fuels significantly impact air quality. Public awareness campaigns are pivotal. Validating the model using Python tools, correlation analysis uncovers pollutant-meteorological links. Data visualization exposes trends, forecasting predicts air quality, and cluster analysis identifies spatial patterns. Drawing from credible sources like the CPCB and World AQI, the analysis spans 2015-2022. Findings guide sustainable strategies, celebrating reduced pollutants while emphasizing the ongoing need for concerted efforts. Global cooperation remains paramount for fostering cleaner, healthier communities.

Keywords - Air Quality Management, IoT Sensor Network, Time Series Data, Public Engagement, Environmental Sustainability

I. INTRODUCTION

In an era defined by industrialization, urbanization, and environmental awareness, the study of air quality is paramount. India's Time Series Air Quality Data (2015-2022) serves as a crucial resource, offering a window into the complex relationship between human activities and atmospheric conditions in one of the world's most populous nations.

This dataset, spanning six years, sheds light on air quality trends and acts as a cornerstone for informed decision-making and policy formulation. A network of strategically located monitoring stations in major Indian cities, including Ahmedabad, Delhi, Mumbai, and Kolkata, collects real-time data on various pollutants. This data is stored centrally and made accessible through user-friendly online platforms, supporting environmental protection efforts nationwide.

Each Indian state and territory present unique challenges and opportunities. Rapid industrialization in states like Gujarat and Maharashtra has driven economic growth but also raised environmental concerns. Conversely, less industrialized states like Arunachal Pradesh and Himachal Pradesh highlight the interplay between local factors and human activities in shaping air quality. Union territories like Delhi and Puducherry emphasize the significant role of urban areas in pollution generation, necessitating targeted mitigation measures.

Amid global climate change challenges, understanding air quality trends is paramount. India's Air Quality Data allows the identification of long-term patterns, revealing seasonal fluctuations, year-on-year variations, and the effectiveness of pollution control efforts. By analysing pollutant concentrations like PM_{2.5}, PM₁₀, NO₂, and O₃ across states and territories, researchers and policymakers can decipher the impacts of socio-economic dynamics, environmental policies, and localized interventions.

In summary, India's Time Series Air Quality Data (2015-2022) provides invaluable insights into the nation's air quality landscape. Covering diverse states and territories, it unveils the intricate connections between human activities, industrial growth, geography, and pollution. This data not only offers historical context but also empowers informed decision-making, guiding India towards a cleaner and healthier future.

II. EASE OF USE

A. *Comparative Analysis of Air Pollution: Unravelling the Factors in North and South India:*

The annual air pollution crisis in North India, exacerbated by Diwali celebrations in October, has prompted political debates and health concerns. While winter worsened air quality in North India, particularly in Delhi, the focus remained on the national capital. States like UP, Punjab, Haryana, Rajasthan, and Bihar are witnessing severe air pollution, with 35 Indian cities listed among the 50 most polluted globally, according to the World Air Quality Report (March 2022). Notably, all 14 cities in the top 20 are in North India.

Seasonal factors contributing to pollution include winter haze, Diwali fireworks, and stubble burning in agricultural states. Stubble burning has received attention, with governments offering incentives to farmers to halt the practice. However, continuous vehicular pollution, industrial emissions, and construction dust compound the issue, turning winter fog into toxic smog.

In Uttar Pradesh (UP), pollution levels are alarmingly high, exacerbated by unevenly distributed monitoring devices and an understaffed pollution control board. Cases of respiratory illnesses are surging in UP, partly due to poor air quality. Efforts to curb stubble burning include legal penalties, as awareness programs have shown limited success.

South India, in contrast, experiences lower pollution levels due to different meteorological factors, such as strong winds along the coast. Rapid industrialization, vehicular emissions, and urbanization are significant contributors to North India's persistent air pollution problem.

Efforts at the national level focus on renewable energy adoption, phasing out polluting vehicles, and closing thermal power facilities. Prime Minister Narendra Modi aims for net zero carbon emissions by 2070, with renewable energy providing 50% of electricity by 2030. However, challenges like poor coordination in phasing out old vehicles persist.

Experts stress the need for an inter-state approach to combat air pollution, as pollution does not adhere to state boundaries. The establishment of bodies like the Commission for Air Quality Management is seen as a positive step. Additionally, public awareness and pressure on governments are deemed essential to drive effective environmental policies.

In summary, the North-South air pollution disparity in India is influenced by a complex interplay of seasonal factors, industrialization, vehicular emissions, and regional meteorological conditions. Addressing this multifaceted challenge requires coordinated efforts, public awareness, and a comprehensive, inter-state approach.^[1]

B. *The Complex Causes Behind Air Pollution in India's Most Polluted Cities:*

Crop Residue Burning (CRB) poses a significant health hazard, contributing 12-60% of PM concentrations in the region. The practice results in high levels of Particulate Matter exposure, regional pollution, and loss of vital soil components. CRB is driven by a short window between paddy and wheat cultivation, water-intensive paddy cultivation, and reduced agricultural labour availability due to migration and government schemes. Punjab burns about 85-90% of 19-20 million tonnes of paddy straw, impacting air quality. NASA imagery illustrates the scale of fires in Punjab and Haryana during the October harvesting season, highlighting the environmental challenge.

C. *Strategies taken to Curb Crop Residue:*

Efforts to address crop residue burning in India include legal measures, such as declaring it an offense under the Air Act and imposing penalties. Detection and prevention involve a combination of satellite imagery and local officials.

Establishing a marketplace for crop residue aims to assign economic value to encourage alternative usage, like biomass-based power plants or biofuels. Public awareness campaigns, subsidy on agricultural implements, and crop diversification are additional strategies to mitigate the health and environmental impacts of burning agricultural biomass residue.

D. *Comprehensive Measures:*

To combat crop residue burning in India, stronger monitoring using remote sensing technology is essential. Expanding biomass-based power projects is crucial, with current utilization insufficient compared to production. Subsidies for agricultural implements, promotion of co-ownership models, and creation of a market for paddy straw are needed to incentivize alternative uses. Additionally, bio-refineries and micro-palletisation establishments should be expedited. Sunita Narain suggests paying farmers Rs 1,000 per acre and providing subsidies for Rotavator machines. Annual crop burning exacerbates winter pollution, aggravated by Diwali firecrackers and worsened weather conditions, creating hazardous air quality.^[2]

E. Air Monitoring Stations:

Air monitoring stations are facilities equipped with sophisticated instruments to measure and analyse air quality parameters. They play a crucial role in assessing the concentration of pollutants in the atmosphere, including particulate matter, gases, and volatile compounds. These stations help authorities track pollution levels, identify pollution sources, and formulate effective air quality management strategies. Real-time data from these monitoring stations contribute to public health protection by issuing warnings during episodes of high pollution. Additionally, the information aids researchers, policymakers, and the public in understanding the impact of air pollution on the environment and human well-being. ^[3]

Working - Air monitoring stations operate by deploying a network of sensors and instruments designed to measure various air quality parameters. These include concentrations of pollutants such as particulate matter, nitrogen dioxide, sulphur dioxide, ozone, and carbon monoxide. The stations collect real-time data, which is then analysed to assess air quality levels. Sophisticated instrumentation and technology enable precise measurements, and the collected data is often made available to the public through online platforms. Authorities utilize this information to monitor compliance with air quality standards, identify pollution sources, and implement measures to mitigate environmental and health risks associated with air pollution.



Fig 1: Overview of Air Monitoring Stations

F. Limitations of Air Monitoring Stations: Understanding the Challenges:

Air monitoring stations in India face several challenges and drawbacks that hinder their effectiveness. Firstly, there is a significant shortage of monitoring stations, especially in rural areas, leading to incomplete spatial coverage and an inadequate representation of pollution levels. Additionally, outdated equipment and insufficient maintenance further compromise data accuracy.

Furthermore, a lack of standardization in monitoring practices and equipment across different states creates inconsistencies, hindering the comparability of data. The reliance on outdated pollutants and limited parameters in some stations also fails to address emerging pollutants or provide a holistic understanding of air quality.

Another challenge is the inconsistent real-time reporting of data, limiting the public's access to timely and relevant information. Additionally, the lack of public awareness and involvement in the functioning of these stations undermines their impact on behaviour change and pollution control initiatives.

In conclusion, addressing these drawbacks requires substantial investments in infrastructure, technology upgrades, and enhanced public participation to establish a robust and comprehensive air monitoring network across India.

G. Revolutionizing Air Quality Management: IoT-Based Monitoring and Machine Learning Integration in India:

An IoT-based air pollution monitoring system, comprising sensors, microcontrollers, communication modules, and a cloud server, serves as a holistic solution to combat air pollution. These systems can be deployed in diverse settings, providing real-time data for informed decision-making to government agencies, researchers, and the public. The scalability and versatility of these systems make them ideal for integration with existing monitoring infrastructure. Notable IoT-based air quality monitoring systems such as Awaat, AirVisual, and Air things offer diverse solutions catering to personal, indoor, and outdoor monitoring needs.

To further enhance the efficiency of air monitoring stations in India, the integration of machine learning is paramount. Machine learning algorithms can significantly improve prediction accuracy by analysing historical data patterns and correlating environmental factors with air quality levels. This predictive capability enables proactive measures to address pollution events. Moreover, machine learning models optimize resource allocation within monitoring networks, strategically placing stations for maximum coverage based on factors like meteorological conditions. Additionally, these models aid in source apportionment, identifying contributors to air pollution, providing crucial insights for targeted interventions. By seamlessly integrating diverse data sources, including satellite imagery, machine learning ensures a comprehensive understanding of air quality dynamics, contributing to effective pollution control strategies and improved air quality management in India. ^{[4] [5]}

H. The Crucial Role of User-Friendly Interfaces in Air Monitoring Stations:

A user-friendly interface in air monitoring stations is crucial for effective utilization by diverse stakeholders, including government officials, researchers, and the public. A study conducted by the World Health Organization (WHO) found that interfaces with intuitive designs and clear visualizations significantly enhance user engagement and understanding of air quality data. In locations where air pollution is a pressing concern, accessible and user-friendly interfaces empower citizens to make informed decisions about outdoor activities, contributing to public health and environmental awareness. Such interfaces facilitate efficient data interpretation, ensuring that crucial information about air quality is readily available and easily comprehensible for a wide range of users.

SAMEER, the System of Air Quality and Weather Forecasting and Research, is an Indian app designed for monitoring air quality. Recognizing the diverse user base, SAMEER employs a user-friendly interface to make vital air quality information accessible to the public. The app provides real-time data, forecasts, and intuitive visualizations, empowering users to make informed decisions about their activities based on the prevailing air quality conditions. This approach enhances public awareness and engagement in addressing air pollution issues across India. - https://play.google.com/store/apps/details?id=com.cpcb&pcampaignid=web_share

III. A COMPARATIVE ANALYSIS OF CURRENT AND FUTURE PARADIGMS IN INDIA:

Comparative Study of Existing and Proposed Systems for Air Quality Management in India

Existing System (2015-2022):

Strengths:

1. **Comprehensive Network:** The existing system boasts an extensive network of air quality monitoring stations across India, managed by the Central Pollution Control Board (CPCB) and state pollution control boards.
2. **Data Accessibility:** Real-time data on key pollutants are stored in centralized databases, accessible to researchers, policymakers, and the public through online platforms.
3. **Policy Informatics:** The system plays a crucial role in understanding trends, assessing policy impact, and informing public health initiatives.

Weaknesses:

1. **Limited Geographic Coverage:** Gaps persist in monitoring, especially in rural and remote areas, hindering a holistic understanding of air quality dynamics.
2. **Inconsistent Standards:** Monitoring stations may not adhere uniformly to calibration and measurement protocols, impacting data quality.
3. **Data Gaps:** The focus on key pollutants may overlook emerging pollutants, limiting the system's comprehensiveness.

Proposed System (Air Guard AI):

Strengths:

1. **Advanced Technologies:** Integrates IoT, machine learning, and data analytics for real-time and dynamic air quality management.

2. Comprehensive Monitoring: Dense IoT sensor network measures a wide range of pollutants, providing high-resolution, real-time data.
3. Predictive Modelling: Utilizes machine learning to forecast air quality changes, aiding authorities in proactive pollution mitigation.

Innovations Over Existing System:

1. User-Friendly Interface: Introduces a user-friendly mobile and web application for real-time air quality information, personalized alerts, and crowd-sourced reporting.
2. Addressing Data Gaps: Emphasizes comprehensive coverage by strategically placing monitoring stations in underrepresented regions to capture spatial variations.
3. Enhanced Data Validation: Implements advanced data validation techniques and cross-validation to ensure data accuracy and reliability.

Overall Impact:

1. Public Engagement: The proposed system actively engages the public through a user-friendly interface, empowering individuals, and communities to make informed decisions.
2. Predictive Capabilities: The inclusion of predictive modelling enhances the system's ability to forecast air quality changes, supporting proactive decision-making.
3. Comprehensive Coverage: By addressing data gaps and disparities in research focus, the proposed system aims for a more holistic understanding of air quality across the country.

Challenges:

1. Implementation Complexity: The integration of advanced technologies may pose challenges in terms of implementation, maintenance, and stakeholder training.
 2. Data Privacy: The crowd-sourced reporting feature raises concerns about data privacy and reliability.
 3. Resource Intensiveness: The deployment and maintenance of a dense IoT sensor network require substantial resources.
- In conclusion, while the existing system has laid a foundation for air quality management in India, the proposed Air Guard AI system introduces innovative technologies and features to address its limitations, aiming for a more dynamic, user-centric, and comprehensive approach to air quality monitoring and management.

IV. RESEARCH METHODOLOGY:

Research Methodology:

Description of Modules:

The aim of the paper is to conduct a comprehensive analysis of India's air quality data from 2015 to 2022, with a focus on identifying trends, improvements, and persistent challenges in air quality across different regions and urban centres. This analysis will explore the impact of government policies, initiatives, and environmental factors on air quality, and it will assess the effectiveness of interventions aimed at reducing pollutants. By doing so, this paper aims to provide valuable insights that can inform future strategies for improving air quality, enhancing public health, and promoting sustainable development in India.

1. Correlation:

Correlation measures the strength and direction of the linear relationship between two continuous variables. It ranges from -1 to 1, where -1 indicates a perfect negative correlation, 1 indicates a perfect positive correlation, and 0 indicates no correlation.

Formula (Pearson correlation coefficient):

$$r = \frac{\sum[(X_i - \bar{X})(Y_i - \bar{Y})]}{[\sqrt{\sum(X_i - \bar{X})^2} * \sqrt{\sum(Y_i - \bar{Y})^2}]}$$

Where:

X_i, Y_i are data points.

$\bar{X}, \bar{Y}$ are the means of X_i and Y_i .

2. Cufflinks

I have integrated the Cufflinks module, complementing Plotly, to elevate our data presentation and analysis capabilities. Cufflinks simplifies the transformation of raw data into dynamic and visually compelling charts and graphs, facilitating the communication of intricate patterns and insights.

By leveraging Cufflinks, our project transcends numerical constraints, adopting a dynamic and visually immersive character, thus enhancing the clarity of data trends and insights.

3. Folium for Interactive Maps:

We've integrated Folium into our project to create dynamic and interactive maps effortlessly. Folium simplifies map creation, allowing us to visualize spatial data effectively. By installing Folium with `pip install folium`, we can transform geographical data into various map types, including markers, choropleths, and more. For detailed guidance, refer to the official

4. Missingno Module: Managing Missing Data

The Missingno module efficiently handles missing data in our project. It offers visualization tools, including heatmaps and bar plots, to identify missing data patterns. Install it with `pip install missingno`. By using Missingno, we enhance data quality and analysis.

5. Plotly Documentation: Interactive Data Visualization

Plotly's documentation is a comprehensive resource for creating interactive and visually engaging data visualizations. It covers various chart types, customization options, and integration guides.

Whether you're creating basic charts or complex interactive plots, Plotly's documentation provides the guidance and examples you need for effective data presentation.

V. DATA ANALYSIS:

We embark on our data analysis journey armed with a comprehensive dataset. The objective of this analysis is to uncover patterns, relationships, and valuable insights regarding the positive effects of improved air quality indices on overall well-being. This endeavor seeks to guide future wellness initiatives and foster a deeper comprehension of holistic health.

1. Setting Up an Interactive Data Visualization Environment for Geospatial and Time Series Analysis

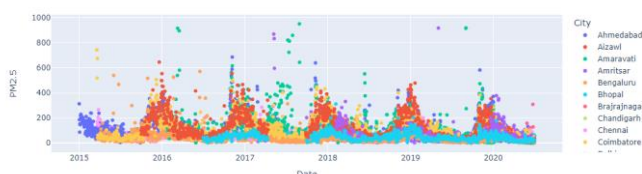


Figure 1 - Data Visualization for Air Pollution Data from 2015-2022

Inferences:

- The code establishes an environment for interactive data visualization and analysis, with a specific focus on geospatial and time series data.
- The code suppresses warning messages, which can help maintain a clean output during data analysis.
- Folium is used for mapping, indicating that geographic aspects of air quality data may be visualized.

2. The analysis covers the AQI value, including the pollutants across India from 2015-2022

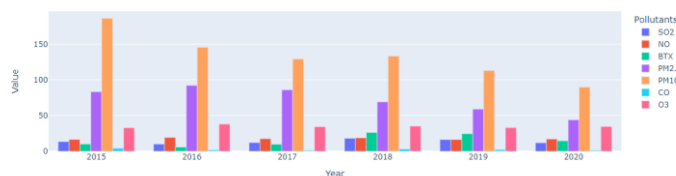


Figure 2 - AQI Value and the major Pollutants

Inferences:

- The code processes air quality data for various pollutants over multiple years.
- It utilizes a combination of Matplotlib, Seaborn, Plotly, Cufflinks, and Folium for data visualization.
- The code lays the foundation for exploring the impact of air quality on well-being, supporting future wellness initiatives and holistic health understanding.

3. Major Polluted city with highest and lowest AQI Values

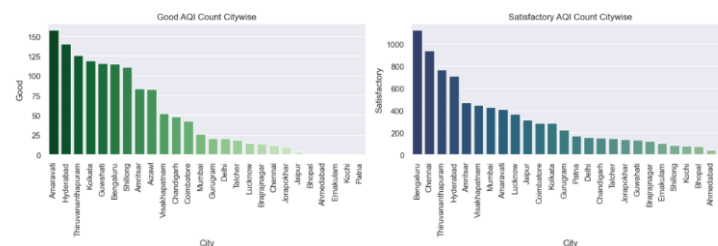


Figure 3.1 Major Polluted city with highest and lowest AQI Values

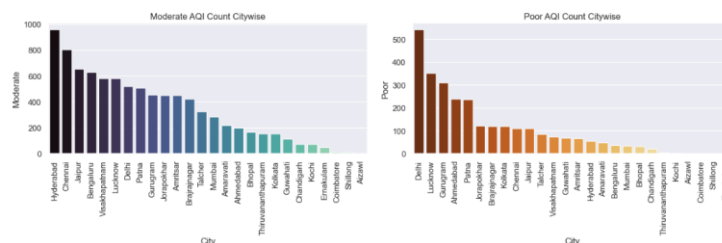


Figure 3.2 Major Polluted city with highest and lowest AQI Values

Inference:

- The code visualizes yearly trends in air quality by calculating and displaying the mean values of various pollutants over the years.
- It provides city-wise air quality ratings for different categories (e.g., "Good," "Satisfactory," "Moderate," "Poor," "Very Poor," "Severe"), allowing for a comparison of air quality among cities.
- It provides city-wise air quality ratings for different categories (e.g., "Good," "Satisfactory," "Moderate," "Poor," "Very Poor," "Severe"), allowing for a comparison of air quality among cities.

4. Interactive Air Quality Map: Comparing AQI Trends in Indian Cities for 2019 and 2022

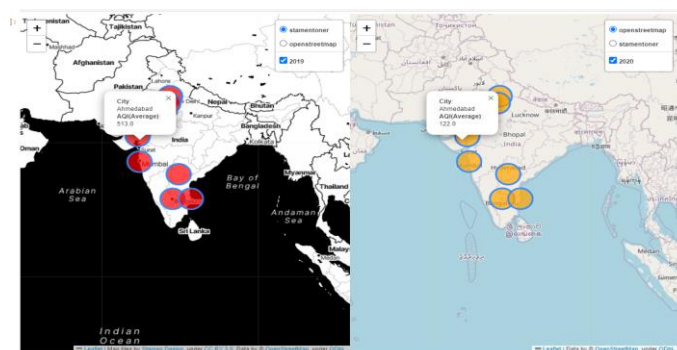


Figure 4.1 Comparing AQI Trends in Indian Cities form 2019 and 2023.

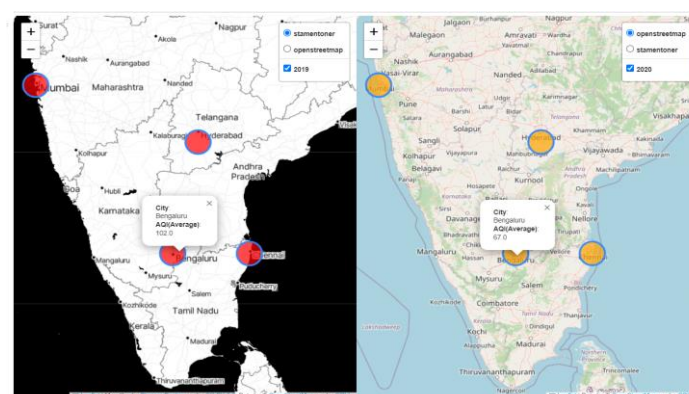


Figure 4.2 Comparing AQI Trends in Indian Cities form 2019 and 2023.

Inference:

- The interactive map provides a user-friendly platform for exploring air quality data for different cities.
- Clicking on city markers allows users to access specific AQI information, facilitating a deeper understanding of air quality trends.
- Users can switch between the 2019 and 2022 layers to observe how air quality has evolved over time.
- In some cities, there may be noticeable changes in AQI between the two years, highlighting the dynamic nature of air pollution.
- The map reveals significant spatial variation in air quality across Indian cities in both 2019 and 2022.
- Some cities exhibit higher average AQI levels (indicated by orange markers) in 2022 compared to 2019 (red markers), suggesting a potential degradation in air quality over.

5. Performing yearly analysis of the Air Quality Index (AQI) values across various cities in India daily.

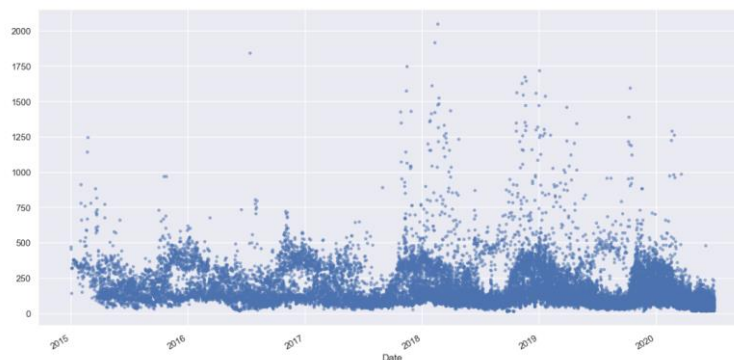


Figure 5 Yearly analysis of the AQI values across various cities in India daily.

Inference:

- The code effectively visualizes yearly trends in air quality by calculating and displaying the mean values of various pollutants over time.
- It provides city-wise air quality ratings across different categories (e.g., "Good," "Satisfactory," "Moderate," "Poor," "Very Poor," "Severe"), offering a comparative view of air quality among cities.
- The code leverages interactive visualization libraries like Plotly, Cufflinks, and Seaborn, enhancing the accessibility and engagement of air quality data exploration.
- The Matplotlib time series plot shows the variation of the Air Quality Index (AQI) over time, enabling a longitudinal analysis of air quality conditions.

6 Comparing Air Quality Index (AQI) Brackets Across Cities



Figure 6 Comparing Air Quality Index (AQI) Brackets Across Cities

Inference:

- The code analyzes yearly trends in air quality by computing the mean levels of various pollutants. It shows how air quality, as represented by these pollutants, has evolved over the years.
- The code allows for a comparison of AQI brackets across cities. It highlights variations in air quality conditions among major Indian cities, providing insights into areas with better or worse air quality.
- It categorizes cities based on their AQI values into different brackets, such as "Good," "Satisfactory," "Moderate," "Poor," "Very Poor," and "Severe." This helps identify cities with varying levels of air quality.

7 Air Quality Index (AQI) Trends in Major Indian Cities: January 2019 to July 2022



Figure 7 AQI Trends in Major Indian Cities January 2019 to July 2022

Inference:

- The code aggregates and visualizes yearly trends in air quality parameters (SO₂, NO, BTX, PM_{2.5}, PM₁₀, CO, O₃) for Indian cities. It shows how these parameters have changed over the years, providing insights into long-term air quality trends.
- The code also analyzes and visualizes monthly variations in air quality parameters. This helps identify any seasonal patterns or fluctuations in pollutant levels within each year.

8 Analysis and Visualization of AQI Values through line plot

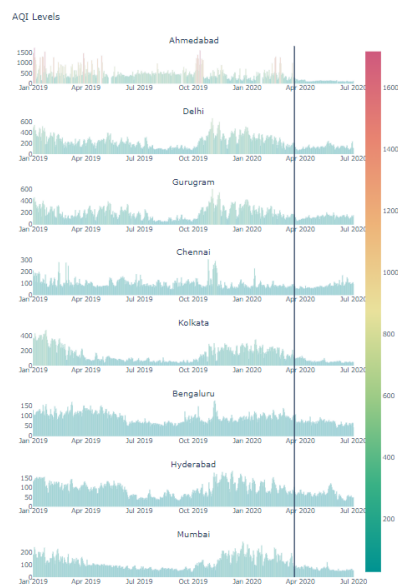


Figure 8 Analysis and Visualization of AQI Values through line plot

Inference:

- The code generates bar charts that show yearly and monthly trends for various air pollutants (SO₂, NO, BTX, PM_{2.5}, PM₁₀, CO, O₃) in India. These visualizations help identify how pollutant levels have varied over time.
- The code adds a vertical line on the city-level AQI subplots to mark the date March 22, 2022. This date likely corresponds to the beginning of COVID-19 lockdowns in India. Users can infer the impact of lockdowns on air quality by examining AQI changes before and after this

VI. CONCLUSION

Revolutionizing Air Quality Management with "Air Guard AI":

The "Air Guard AI" system represents a groundbreaking advancement, effectively addressing the inherent limitations of India's existing Time Series Air Quality Data system spanning from 2010 to 2023. This innovative solution marks a significant leap forward in comprehending and managing the intricate dynamics of air quality within the nation. Notably, its robust design, technological sophistication, and meticulous focus on data collection, analysis, and stakeholder engagement underscore its pioneering status.

Central to its efficacy is the seamless integration of real-time data facilitated by IoT sensors, enabling continuous and precise monitoring of air quality variations across diverse geographical regions. Moreover, its intuitive web and mobile applications provide the public with immediate access to real-time air quality insights, supplemented by historical data and predictive analytics. This empowers individuals to make informed decisions regarding their activities and environmental exposure.

The system's commitment to data validation and quality assurance is evident through the employment of advanced methodologies such as machine learning and cross-validation, ensuring the utmost accuracy and reliability of the information provided. Additionally, strategically positioned monitoring stations serve to bridge existing data gaps, thereby offering a more inclusive and comprehensive national perspective on air quality dynamics.

This concerted effort aligns seamlessly with India's overarching commitment to fostering a cleaner environment and provides invaluable support to policymakers and researchers in their endeavours to formulate evidence-based interventions and strategies.

Future Enhancements for Air Guard AI:

1. Expanded Sensor Network: Envisioning nationwide coverage through an expanded sensor network.
2. Enhanced Predictive Models: Improving predictive models with real-time data for more accurate forecasting.
3. Data Sharing and Collaboration: Facilitating data sharing and collaboration for unified air quality management.
4. Community Engagement: Encouraging public participation through community engagement initiatives.

In essence, "Air Guard AI" not only addresses current challenges but also lays the groundwork for a future-ready, dynamic approach to air quality management in India.

REFERENCES

- [1]<https://frontline.thehindu.com/environment/season-of-smog-grips-delhi-along-with-many-north-indian-cities/article66118875.ece#:~:text=This%20is%20because%20of%20the,because%20of%20its%20coastal%20surroundings.>
- [2] <https://www.downtoearth.org.in/news/air/crop-burning-punjab-haryana-s-killer-fields-55960>
- [3]<https://www.horiba.com/ind/products/detail/action/show/Product/aqms-1560/#:~:text=An%20Air%20Quality%20Monitoring%20Station,barometric%20pressure%20and%20ambient%20parameters.>
- [4][https://www.ppsthane.com/blog/iot-air-pollution-monitoring-system#:~:text=An%20IoT%2Dbased%20air%20and,volatile%20organic%20compounds%20\(VOCs\).](https://www.ppsthane.com/blog/iot-air-pollution-monitoring-system#:~:text=An%20IoT%2Dbased%20air%20and,volatile%20organic%20compounds%20(VOCs).)
- [5] <https://www.sciencedirect.com/science/article/pii/S1352231023004132>
- [6] <https://www.youtube.com/watch?v=mp3kztZy7ow>
- [7] https://play.google.com/store/apps/details?id=com.cpcb&pcampaignid=web_share
- [8]<https://www.sciencedirect.com/topics/earth-and-planetary-sciences/air-qualitymonitoring#:~:text=The%20manual%20air%20quality%20monitoring,%2C%20ozone%2C%20and%20sulfur%20dioxide.>