Air Quality Index (AQI) Report

Data Source: West Bengal Pollution Control Board
Station: Bhasa,2nd Campus of Asutosh College
(April 2023-April 2024)

Introduction to AQI Measurement

The Air Quality Index (AQI) serves as a critical metric to inform the public about daily air quality levels and associated health impacts. It is designed to offer a straightforward, understandable way for the public to comprehend the quality of the air they breathe and its potential effects on health. The AQI is calculated based on the concentrations of major air pollutants regulated by environmental laws, including particulate matter ($PM_{2.5}$, PM_{10}), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3), and lead (Pb). Each pollutant's concentration is converted into a sub-index value, and the highest of these sub-index values determines the overall AQI at a given location and time.

Description of the Data

The dataset analyzed consists of measurements of various air pollutants and ambient temperature, captured over a period with a total count of 193 observations for each variable. The AQI values exhibit a mean of 129.94 with a standard deviation (SD) of 52.38, ranging from a minimum of 33.84 to a maximum of 347.92, indicating periods of significantly poor air quality. Nitrogen dioxide (NO_2) has a mean concentration of 65.10 $\mu g/m^3$ (SD = 21.25), sulfur dioxide (SO_2) averages at 111.32 $\mu g/m^3$ (SD = 34.46), and fine particulate matter ($PM_{2.5}$) maintains a mean level of 73.70 $\mu g/m^3$ (SD = 8.69). The temperature throughout the dataset period averages at 25.65°C with variability (SD = 5.02), spanning from 15.51°C to 37.16°C, which might influence the dispersion and reaction rates of pollutants in the atmosphere (Table 1)

Table 1 Description of the data

Statistic	**AQI**	**NO_2**	**SO_2**	**$PM_{2.5}$**	**Temperature**
count	193	193	193	193	193
mean	129.9418	65.10339	111.3208	73.7044	25.64975
std	52.37565	21.24558	34.4641	8.693206	5.016498
min	33.84211	20.31263	30.84737	39.215	15.505
25%	90.04167	48.63	86.02125	68.30125	21.44733

50%	118.7647	63.12917	108.37	74.49125	25.57583
75%	165.7083	79.12125	138.2117	78.77083	29.61273
max	347.9231	182.5531	194.8146	93.79429	37.16188

Source: PCB (Station: Bhasa ,2nd Campus of Asutosh College)

Distribution of the Data

The distribution of air quality data and temperature shows significant variability and patterns across different pollutants:

- **AQI** is characterized by a mean of 129.94 with a standard deviation of 52.38, indicating a broad range of air quality conditions from clean to hazardous. The highest recorded AQI peaks at 347.92, underscoring episodic severe pollution events.
- **NO_2** levels have a mean of 65.10 µg/m^3 and a standard deviation of 21.25 µg/m^3, with extreme values peaking at 182.55 µg/m^3, reflecting both usual urban background levels and high pollution episodes likely linked to traffic and industrial emissions.
- **SO_2** shows a mean of 111.32 µg/m^3 and a standard deviation of 34.46 µg/m^3, with values ranging up to 194.81 µg/m^3, indicative of variable emission sources, possibly including industrial processes.
- **$PM_{2.5}$** remains comparatively stable with a mean of 73.70 µg/m^3 and a lower standard deviation of 8.69 µg/m^3, suggesting a consistent presence of particulate matter, potentially from both local and regional sources.
- **Temperature** records a mean of 25.65°C with a range from 15.51°C to 37.16°C, reflecting the influence of seasonal variations which could affect air pollutant levels through changes in atmospheric chemistry and mixing heights.

The data suggests strong correlations among specific pollutants, particularly between AQI, NO_2, and SO_2, indicating common sources or conditions that increase these pollutants simultaneously. The stable yet high levels of $PM_{2.5}$ could be contributing consistently to the AQI, while the inverse relationship with temperature suggests higher temperatures might help in reducing pollution levels through enhanced dispersion.

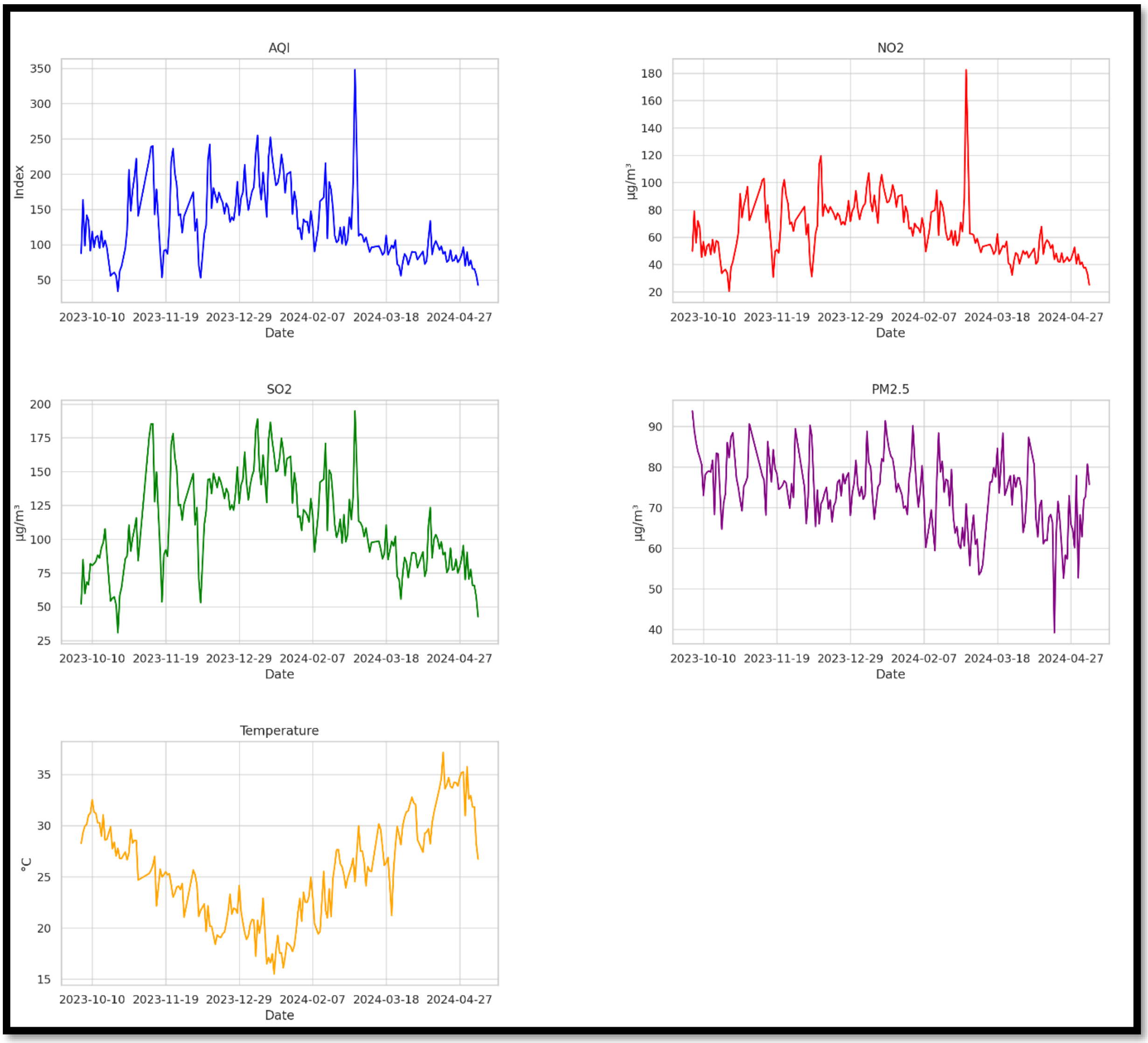


Figure 1 Time-series plots displaying the variation in AQI, NO_2, SO_2, $PM_{2.5}$, and temperature over several months, highlighting significant spikes in pollution levels and their correlation with temperature fluctuations.

Correlation Analysis

The correlation analysis of the dataset highlights strong associations among several air pollutants and an inverse relationship with temperature. AQI shows a very high correlation with NO_2 ($r = 0.98$) and SO_2 ($r = 0.92$), suggesting that these gases significantly influence the air quality index, often emanating from similar pollution sources such as traffic and industrial emissions. SO_2 and NO_2 themselves are highly correlated ($r = 0.90$), reinforcing the idea of shared emission sources. On the other hand, correlations between these pollutants and $PM_{2.5}$ are relatively weak ($r = 0.17$ for AQI and $PM_{2.5}$, $r = 0.15$ for NO_2 and $PM_{2.5}$), indicating that particulate matter may have different or additional sources such as construction and natural dust. Temperature inversely correlates with AQI (r = -0.62), NO_2 (r = -0.61), and SO_2 (r = -0.69), demonstrating that higher temperatures potentially aid in the dispersion of these pollutants, thereby improving air quality.

This correlation pattern underscores the intertwined nature of NO_2 and SO_2 emissions in influencing air quality and their common source attributes. The negative correlation with temperature supports meteorological impacts on pollution concentration, suggesting that warmer conditions could be beneficial in mitigating pollution levels.

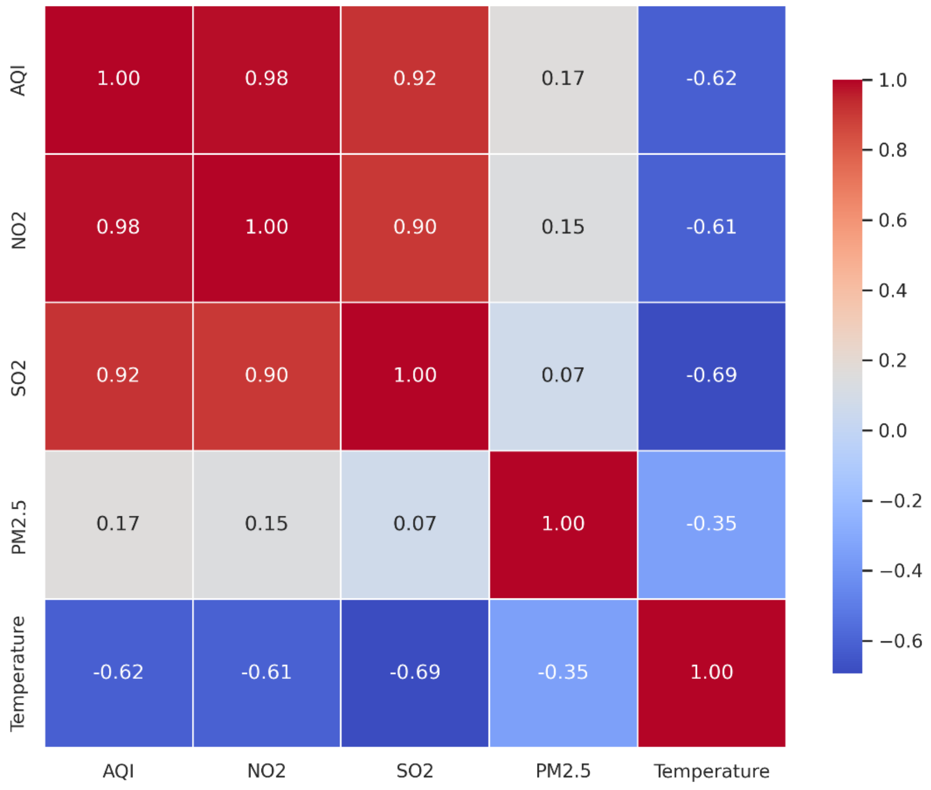


Figure 2 Correlation heatmap illustrating the strong positive correlations between AQI, NO_2, and SO_2, and their negative correlation with temperature, highlighting the impact of meteorological conditions on air pollutant concentrations.

Regression Analysis for finding the influential parameters responsible for AQI

The regression model developed to predict AQI based on inputs of NO_2, SO_2, $PM_{2.5}$, and temperature yields substantial insights into the relationship between these pollutants and air quality. The coefficients from the regression provide quantified measures of how each pollutant impacts AQI:

- NO_2 shows the strongest impact with a coefficient of 1.97, suggesting a nearly two-point increase in the AQI for each one-unit increase in NO2 concentration.
- SO_2 contributes with a coefficient of 0.34, indicating a more moderate influence on AQI compared to NO2.
- $PM_{2.5}$ has a similar effect to SO2, with a coefficient of 0.30.
- Temperature also shows a positive association with AQI, with a coefficient of 0.35, revealing that higher temperatures slightly increase AQI levels.

The model's Mean Squared Error (MSE) of 45.81 indicates the average squared difference between the predicted and actual AQI values, which is relatively low, suggesting good model accuracy. Moreover, the Coefficient of Determination (R^2) of 0.976 confirms that the model explains 97.6% of the variance in AQI, demonstrating a very good fit.

The regression analysis illustrates that NO_2 is the predominant predictor of AQI among the studied factors, implying that efforts to manage and reduce NO_2 emissions could be particularly effective in improving air quality. The positive coefficients for all variables suggest that increases in these pollutants are associated with worse air quality, while the high R^2 value indicates that these factors together provide a reliable basis for predicting AQI changes.

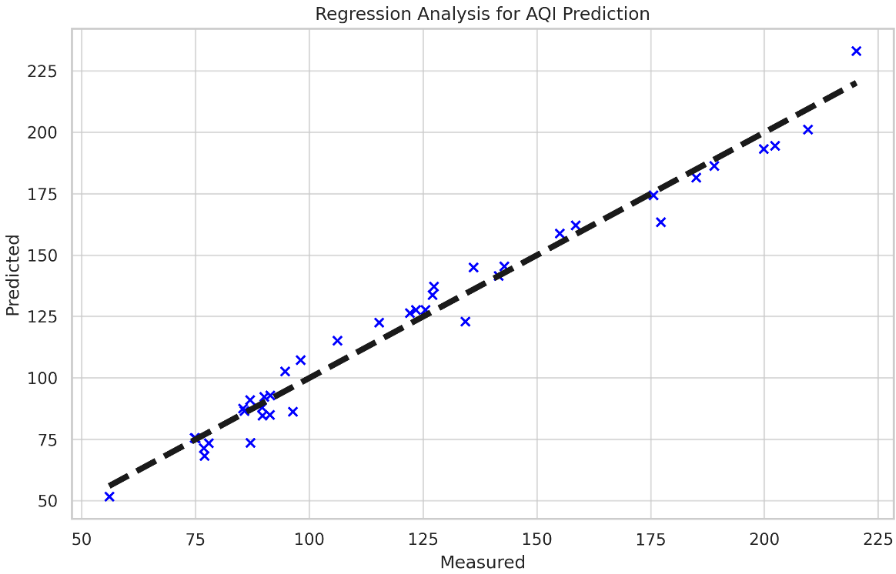
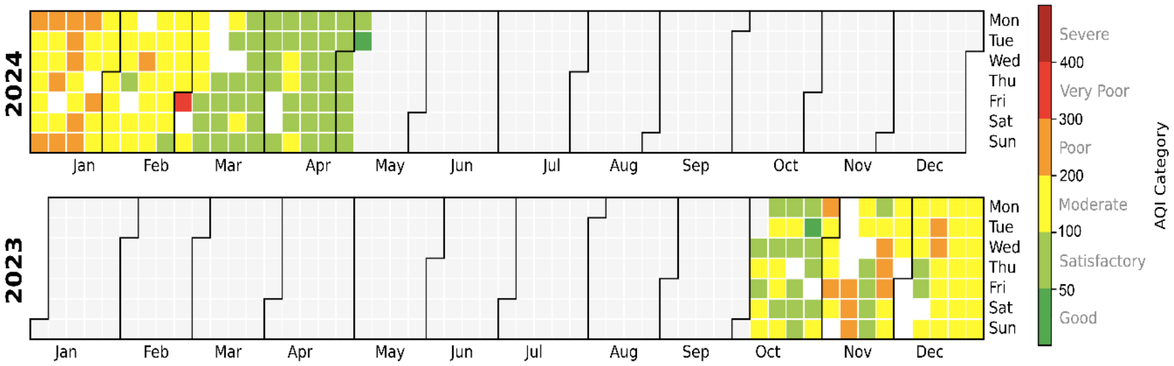
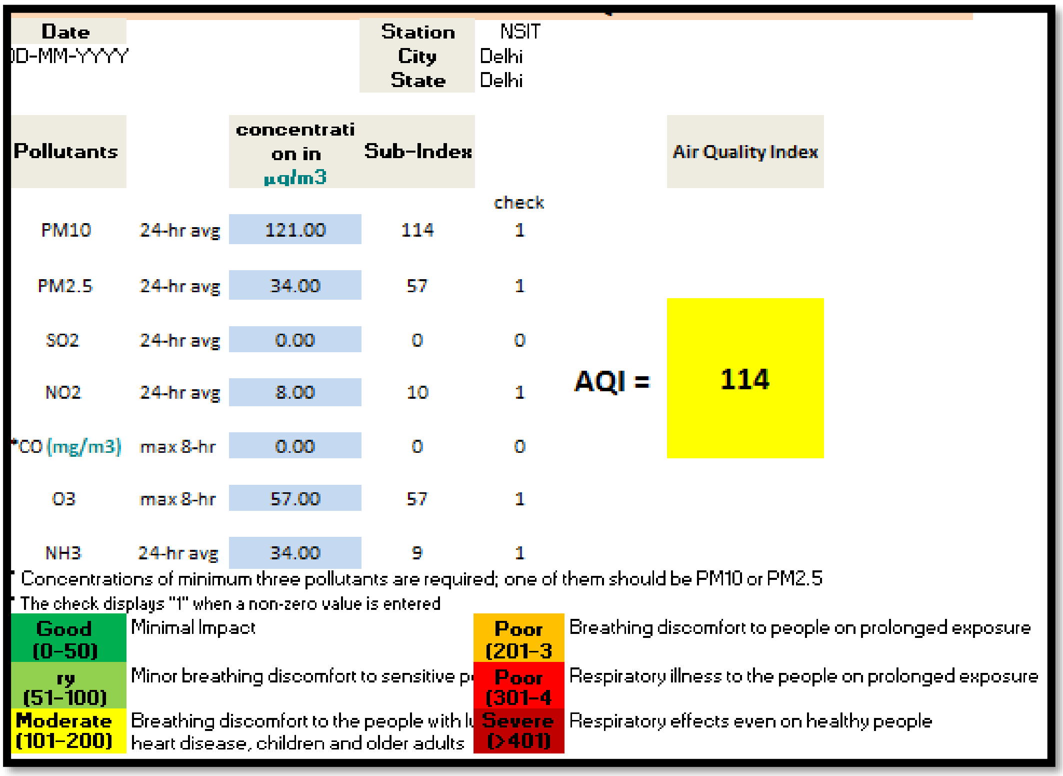


Figure 3: Scatter plot with a regression line illustrating the strong predictive relationship between measured and predicted AQI, based on regression analysis incorporating NO_2, SO_2, $PM_{2.5}$, and temperature, showing a very high model accuracy with R^2 of 0.976.





Date			**Station**	NSIT		
D-MM-YYYY			**City**	Delhi		
			State	Delhi		
Pollutants		**concentration in µg/m3**	**Sub-Index**			**Air Quality Index**
				check		
PM10	24-hr avg	121.00	114	1		
PM2.5	24-hr avg	34.00	57	1		
SO2	24-hr avg	0.00	0	0		
NO2	24-hr avg	8.00	10	1	**AQI =**	**114**
*CO (mg/m3)	max 8-hr	0.00	0	0		
O3	max 8-hr	57.00	57	1		
NH3	24-hr avg	34.00	9	1		

* Concentrations of minimum three pollutants are required; one of them should be PM10 or PM2.5

* The check displays "1" when a non-zero value is entered

Good (0-50)	Minimal Impact	**Poor (201-3**	Breathing discomfort to people on prolonged exposure
ry (51-100)	Minor breathing discomfort to sensitive p	**Poor (301-4**	Respiratory illness to the people on prolonged exposure
Moderate (101-200)	Breathing discomfort to the people with l heart disease, children and older adults	**Severe (>401)**	Respiratory effects even on healthy people

Concluding remarks

The analysis of AQI and associated pollutants over the period shows significant variations, with episodes where air quality reaches hazardous levels. These instances of elevated AQI, particularly influenced by high concentrations of NO_2, SO_2, and $PM_{2.5}$, underscore the critical need for ongoing monitoring and proactive management of air quality.

AQI Status Relative to WHO Guidelines

According to the World Health Organization (WHO), the recommended safe level for $PM_{2.5}$ is an annual mean of 5 $\mu g/m^3$ and a 24-hour mean of 15 $\mu g/m^3$, which are significantly lower than observed levels in our data, where $PM_{2.5}$ averages 73.70 $\mu g/m^3$. This discrepancy indicates that air quality often exceeds WHO recommended limits, posing potential health risks to the population, especially in densely populated or industrial areas.

Recommendations for Awareness and Action

1. Enhanced Public Awareness: There should be initiatives to educate the public about the sources and risks of air pollution through workshops, seminars, and informational campaigns. These efforts could explain the components of AQI and the health implications of each pollutant.

2. Engagement in Mitigation Practices: Recommendations from the analysis can be integrated into public health advisories, encouraging residents to adopt behaviors that reduce pollution exposure. For example, using public transportation, carpooling, and reducing the use of heavy-duty vehicles can decrease NO_2 levels.

3. Installation of Monitoring Instruments in Academic Institutions: Placing air quality monitors in academic institutions not only provides real-time data for further research but also raises awareness among students and staff. These stakeholders can learn from direct observation and analysis of air quality data, fostering a culture of environmental consciousness within the academic community.

4. Policy Development: Local governments should consider the insights from the AQI and pollutant analysis to form policies aimed at reducing emissions from key sources, such as traffic, industrial emissions, and waste management. Policies could include stricter emission standards, promotion of cleaner technologies, and incentives for pollution reduction measures.

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Final Note

The status of air quality, as reflected by the AQI data and its comparison with WHO guidelines, highlights a pressing need for immediate and effective actions to mitigate air pollution. Both public awareness and structural policy changes are crucial in improving air quality, thus safeguarding public health and enhancing the quality of life.

Note: Report produced by Air Quality Monitoring System Committee.

Committee Members

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