Air Quality Index (AQI) Report

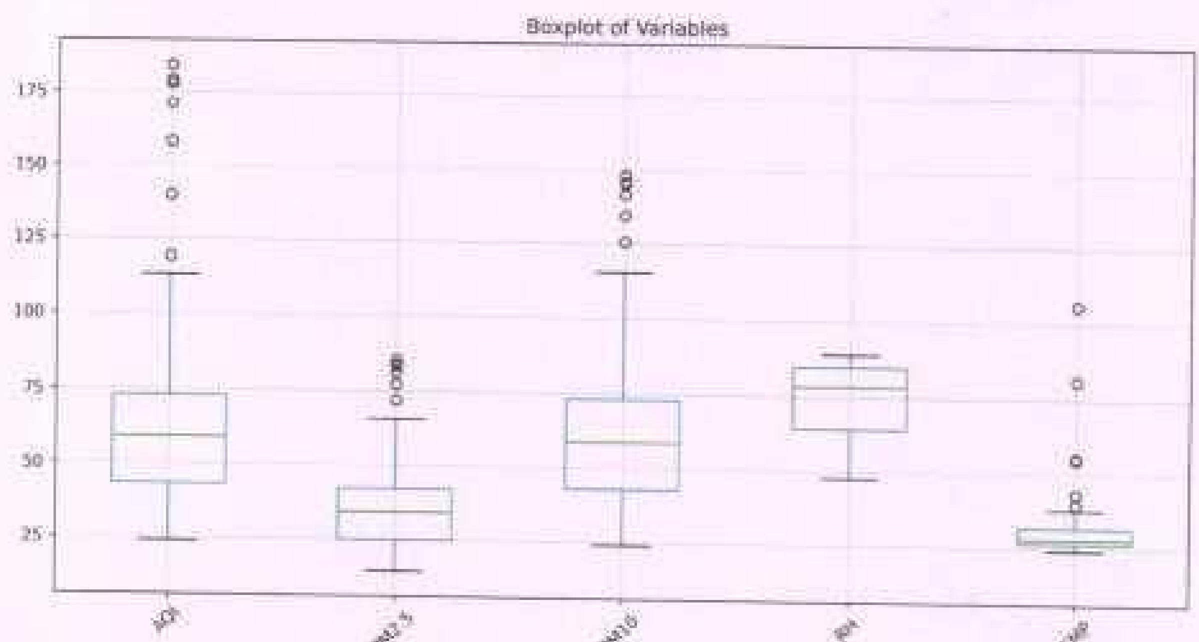
Data Source: West Bengal Pollution Control Board
Station: Bhasa,2nd Campus of Asutosh College
(October_2025)

Introduction

The Air Quality Index (AQI) is a standardized numerical scale that indicates the level of air pollution in a given area. It translates complex pollutant concentration data into an easy-to-understand value, showing how clean or polluted the air is at present or is expected to be. The AQI is derived from the measured concentrations of key pollutants, including PM2.5, PM10, ground-level ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2). Each pollutant is compared with established national or international standards, and the pollutant with the highest index value determines the overall AQI.

The scale generally ranges from 0 to 500, where values between 0 and 50 represent good air quality with negligible health impacts, while values above 300 indicate hazardous conditions that can pose severe health risks, especially to sensitive groups such as children, the elderly, and people with respiratory or cardiac issues. AQI is widely used by governments and environmental agencies to inform the public, guide outdoor activities, and support policy decisions related to air pollution management.

Analysis and Discussion of the Data



The boxplot compares the distribution and variability of five variables: **AQI, PM2.5, PM10, Relative Humidity (RH), and Temperature (TEMP)**. Each variable shows its median, interquartile range (IQR), spread, and the presence of outliers.

1. AQI (Air Quality Index)

- The median AQI lies around the mid-50s, indicating generally *moderate* air quality.
- The IQR is fairly wide, showing noticeable variability in AQI values.
- Several high outliers (above 150–180) indicate occasional episodes of significantly poor air quality.
- Lower whisker extends close to 25, showing some days with very good air quality.

2. PM2.5

- Median is around 30–35 µg/m³.
- IQR is relatively narrow, suggesting that PM2.5 levels are more consistent compared to AQI and PM10.
- Multiple outliers appear above 70–85 µg/m³, showing that pollution spikes do occur.
- Lower whisker near 15 suggests some days with clean air.

3. PM10

- Median is around 55–60 µg/m³, higher than PM2.5.
- Larger IQR indicates more variability in PM10 concentrations.
- Several high outliers (130–150 µg/m³) indicate severe particulate pollution events.
- Lower values go down to around 25 µg/m³.

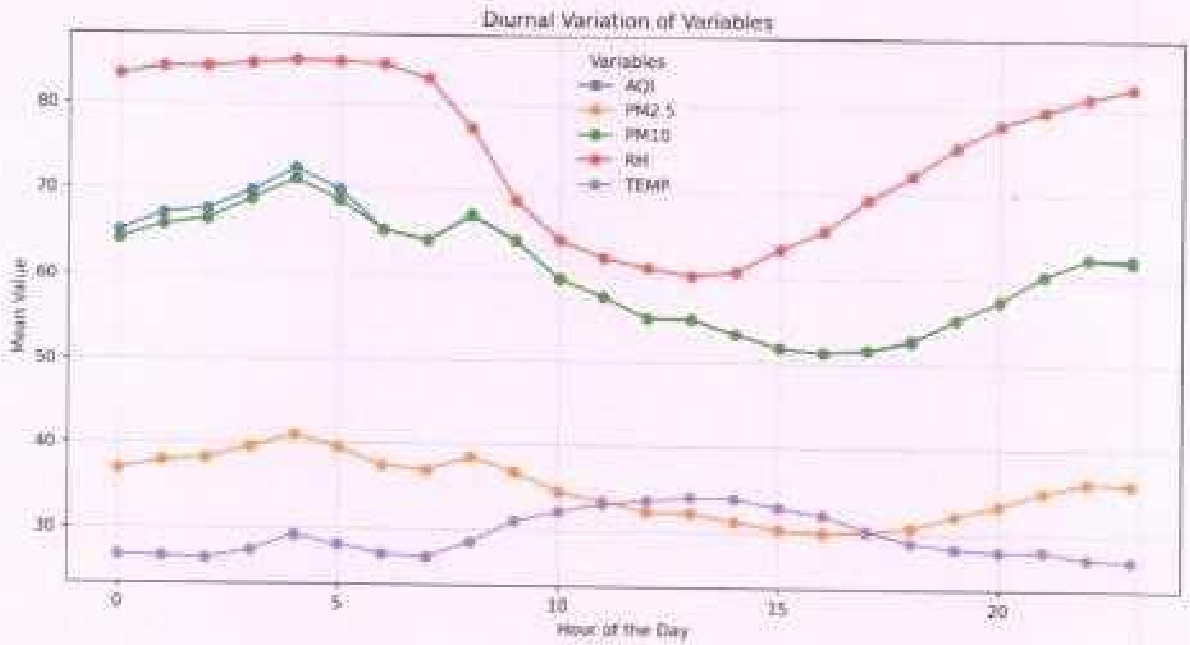
4. Relative Humidity (RH)

- RH exhibits the **least variability** among all variables.
- Median lies around 78–80%.
- The IQR is small, meaning humidity levels are largely stable.
- A few mild low outliers appear (around 48%), but no extreme highs.
- Conditions are predominantly humid.

5. Temperature (TEMP)

- Median temperature is around 27–30°C.
- The IQR is narrow, showing stable temperature trends.

- Multiple upper outliers (40–50°C, and one above 100°C likely erroneous or extreme) indicate occasional heat spikes or potential sensor anomalies.
- Lower whisker around 24–25°C.



The plot shows how air quality parameters and meteorological variables change throughout a 24-hour cycle. The patterns reflect human activities, atmospheric processes, and natural environmental conditions.

1. AQI (Air Quality Index)

- AQI starts around **65 at midnight**, gradually rising and peaking around **72–73 between 4:00–6:00 AM**
- This early-morning peak is typical because:
  - Temperature is low and atmospheric mixing is weak, trapping pollutants near the surface.
  - Early traffic movement begins around this period.
- After sunrise, AQI gradually decreases and stabilizes around **60–63** in the afternoon due to:
  - Enhanced solar heating
  - Stronger vertical mixing
  - Dispersion of accumulated pollutants
- AQI again increases slightly after **7–8 PM**, likely due to:
  - Evening traffic
  - Reduced atmospheric dispersion at night

2. PM2.5

- PM2.5 shows a similar pattern to AQI, reflecting its strong contribution to overall air quality.
- It rises from **37 µg/m³ at midnight** to a peak of **~41 µg/m³ around 4–5 AM**, likely from:
  - Vehicular emissions
  - Household heating/cooking
  - Stable atmospheric conditions
- After 6 AM, PM2.5 moves downward, reaching a daytime low around **30–31 µg/m³ (14–16 hrs)**.
- In the evening, it increases again to **36 µg/m³** as dispersion weakens and emissions rise.

3. PM10

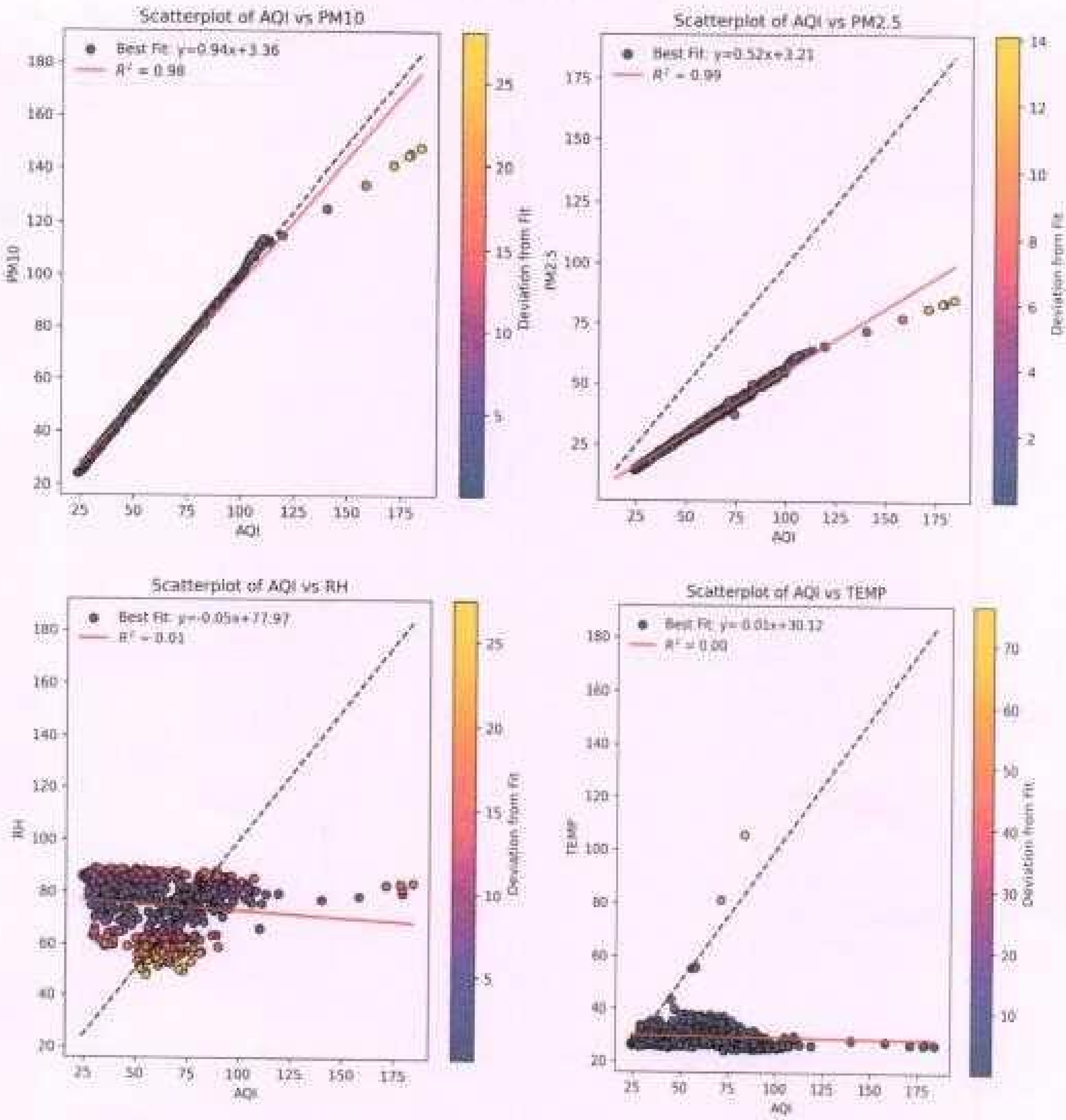
- PM10 begins at **65 µg/m³ midnight**, rising slightly to **~68–70 µg/m³** by early morning.
- Peaks around **6–7 AM**, similar to PM2.5, due to:
  - Morning traffic
  - Dust resuspension
- After sunrise, PM10 falls steadily, reaching its lowest values (**~51 µg/m³**) around **15–16 hrs**.
- In the late evening, PM10 increases again to around **62–63 µg/m³**, consistent with human activities and atmospheric stability.

4. Relative Humidity (RH)

- RH begins **high (83–85%) at midnight** and remains high until **5–6 AM**.
- After sunrise, RH drops sharply, reaching its lowest levels (**60–62%**) around **noon to 2 PM** due to:
  - Increase in temperature
  - Enhancement of evaporation
- After afternoon, RH gradually increases again, reaching **80–85% by late night**, following the natural diurnal humidity cycle.

5. Temperature (TEMP)

- Temperature begins **low (27–28°C) around midnight**, remaining steady until early morning.
- Starts rising after **7 AM**, peaking around **34–35°C** at **11:00 AM–12:00 PM**.
- Declines gradually through the afternoon and evening, returning to **27–28°C at night**.
- This typical diurnal temperature cycle directly influences pollutant dispersion:
  - Higher temperatures → better mixing → lower pollutant concentrations
  - Lower temperatures → poor dispersion → higher pollutant concentrations



These four scatterplots show the statistical relationship between AQI and key environmental variables using linear regression lines, R^2 values, and deviation color maps. The dashed line represents the 1:1 reference, while the red line shows the actual best-fit regression.

1. AQI vs PM10

Very Strong Positive Correlation

- **R^2 = 0.98**, indicating an almost perfect linear relationship.
- The regression line (y = 0.94x + 3.36) is nearly parallel to the 1:1 line.
- This suggests that PM10 levels closely track AQI values.
- Points are tightly clustered around the regression line with minimal deviation (mostly between 0–10).
- **Interpretation:**
  PM10 is one of the dominant contributors to AQI. As PM10 increases, AQI rises almost proportionally. This strong coupling indicates that AQI heavily depends on PM10 concentrations.

2. AQI vs PM2.5

Extremely Strong Positive Correlation

- **R^2 = 0.99**, the strongest relationship among all variables.
- Regression equation: **y = 0.52x + 3.21**.
  - Indicates AQI increases at nearly *twice the rate* of PM2.5.
- Points fall very close to the regression line with low deviations (0–12).
- **Interpretation:**
  PM2.5 is another key pollutant driving AQI changes. Since fine particulate matter (PM2.5) has high health risk, its strong correlation with AQI is expected. AQI increases consistently with PM2.5 levels, confirming PM2.5 as a major determinant of air quality status.

3. AQI vs Relative Humidity

No Significant Relationship

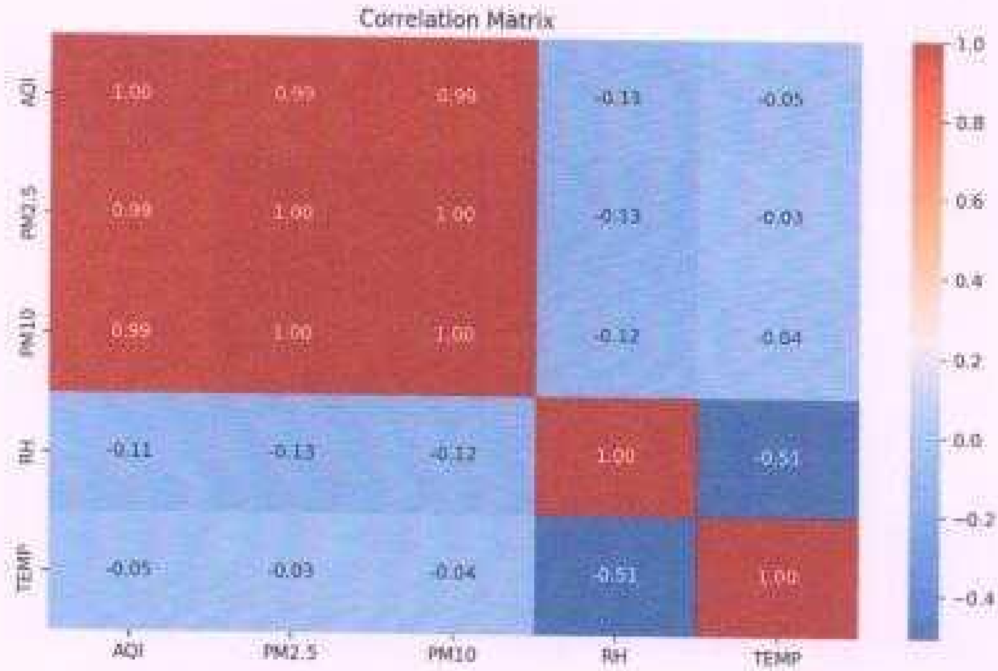
- **R^2 = 0.01**, indicating almost *no correlation*.
- Regression line: **y = -0.05x + 77.97** (slightly negative slope).
- Points are widely scattered with no visible pattern.
- Deviations from the fit are large (up to ~25).
- **Interpretation:**
  RH does not influence AQI directly. Although humidity can affect pollutant dispersion and secondary aerosol formation, this dataset shows **no linear dependence**. RH remains relatively constant irrespective of air quality levels.

4. AQI vs Temperature

No Meaningful Correlation

- **R^2 = 0.00**, meaning *zero linear relationship*.
- Regression equation: **y = -0.01x + 30.12**, almost a flat line.
- Most temperature values cluster around 27–35°C, regardless of AQI.

- Some high outliers exist but still do not form any pattern.
- **Interpretation:**
  Temperature does not directly correlate with AQI. Although temperature can influence atmospheric mixing and pollutant dispersion, the relationship is not linear in this dataset. AQI variations are largely independent of temperature changes.



The correlation matrix visualizes the strength and direction of linear relationships among AQI, PM2.5, PM10, RH, and temperature. Values range from **-1 to +1**, where:

- **+1** = perfect positive correlation
- **0** = no correlation
- **−1** = perfect negative correlation

1. Relationship Between AQI and Particulate Matter (PM2.5 & PM10)

Extremely Strong Positive Correlations

- **AQI & PM2.5: 0.99**
- **AQI & PM10: 0.99**

These nearly perfect positive correlations mean:

- Increases in PM2.5 or PM10 are directly and strongly associated with increases in AQI.
- PM2.5 and PM10 are the **dominant contributors** to AQI values.
- AQI is almost completely determined by particulate concentrations in this dataset.

This matches the scatterplots and diurnal patterns, confirming that aerosol pollutants are the primary drivers of air pollution.

2. Relationship Between PM2.5 and PM10

Perfect Positive Correlation (1.00)

- PM2.5 and PM10 show an **exact linear relationship** (correlation of 1.00).

This indicates that:

- Both pollutants exhibit identical temporal variation—when one increases, the other does so proportionally.
- They likely originate from common sources (traffic, resuspended dust, combustion, etc.).
- Their simultaneous rise strongly influences overall AQI behavior.

3. Relationship Between AQI and Meteorological Variables (RH & TEMP)

Weak Negative Correlations

- **AQI & RH: −0.11**
- **AQI & TEMP: −0.05**

Interpretation:

- These values are **very close to zero**, indicating negligible linear influence.
- Slight negative tendencies suggest:
    - Higher humidity may slightly reduce AQI, possibly due to particle settling or hygroscopic growth effects.
    - Higher temperature may help dilute pollutants via enhanced vertical mixing.
- However, the relationships are **too weak** to be meaningful.

Thus, meteorological parameters do **not** significantly determine AQI in this dataset.

4. Relationship Between RH and Temperature

Moderate Negative Correlation (−0.51)

- Indicates a strong inverse relationship:
    - As temperature rises, relative humidity drops.
    - As temperature falls (nighttime), RH increases.

This is expected due to natural atmospheric thermodynamics.

- Warm air holds more moisture → relative humidity decreases.
- Cool air holds less moisture → relative humidity increases.

Summary of Key Insights

1. **AQI is almost perfectly correlated with PM2.5 and PM10**, showing these pollutants are the primary drivers of air quality degradation.
2. **PM2.5 and PM10 exhibit perfect correlation**, showing identical diurnal and seasonal behavior.
3. **Meteorological factors (RH, temperature) have very weak correlations with AQI**, indicating limited direct influence.
4. **RH and temperature show a moderate negative correlation** due to natural climatic cycles.

Conclusion

The overall analysis clearly demonstrates that particulate pollutants—**PM2.5 and PM10**—are the primary determinants of air quality in the study area. Both pollutants show strong diurnal patterns, with peak concentrations during the early morning hours when atmospheric mixing is minimal, and lower values during the afternoon when enhanced solar heating promotes dispersion. Their exceptionally high correlations with AQI (0.99 for both) and the nearly perfect inter-correlation (1.00) confirm that fluctuations in AQI are almost entirely governed by variations in particulate matter.

In contrast, meteorological parameters such as **relative humidity and temperature** exhibit weak or negligible correlations with AQI, indicating that their direct influence on air quality is minimal within this dataset. RH and temperature themselves show an expected moderate negative relationship due to natural thermodynamic processes, but these factors do not significantly modulate pollutant levels.

Overall, the results underscore that **AQI variability is overwhelmingly driven by particulate pollution**, with meteorological factors playing only a secondary or indirect role. Effective air quality management in the region should therefore prioritize controlling sources of PM2.5 and PM10, particularly during early morning hours when pollution accumulation is highest.

Note:

Report produced by Air Quality Monitoring System Committee

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