Air Quality Index (AQI) Report

Data Source: West Bengal Pollution Control Board
Station- Bhasa 2nd Campus of Asutosh College
(April 2025)

The Bhasa region, situated along the rapidly urbanising Diamond Harbour Road corridor on the south-western fringe of Kolkata, faces growing concerns over air quality due to the combined impacts of urban sprawl, traffic congestion, and semi-rural land-use practices. As a peri-urban zone, Bhasa serves as a transition area between densely populated city centres and agricultural hinterlands, making it particularly susceptible to diverse pollution sources. Emissions from an increasing number of vehicles, ongoing road expansion and construction projects, brick kilns, diesel generators, and seasonal biomass burning all contribute to elevated levels of air pollutants, especially fine particulate matter such as $PM_{2.5}$ and PM_{10}.

Air Quality Index (AQI) levels in and around Bhasa typically range from "Moderate" to "Poor" across much of the year, with the worst conditions occurring during the winter and post-monsoon months when atmospheric inversion layers trap pollutants close to the ground. The proximity of air quality monitoring stations at Joka and Diamond Harbour Road helps in estimating real-time pollution trends for Bhasa, often showing rapid fluctuations in response to traffic peaks, local burning, or changing weather patterns. During the pre-monsoon and monsoon seasons, wind and rainfall generally help to disperse airborne pollutants, resulting in temporary improvement in air quality.

However, even during relatively cleaner periods, the presence of background pollution levels exceeding national health-based standards poses long-term health risks to residents, particularly children, the elderly, and those with respiratory or cardiovascular issues. The region's mixed-use landscape—comprising educational institutions, housing, small-scale industries, and agricultural plots—further complicates pollution dynamics. As Bhasa continues to develop, it becomes crucial to implement targeted mitigation strategies such as stricter vehicle emission control, regulated construction practices, improved public transportation, and community-level awareness to reduce pollutant loads and safeguard public health

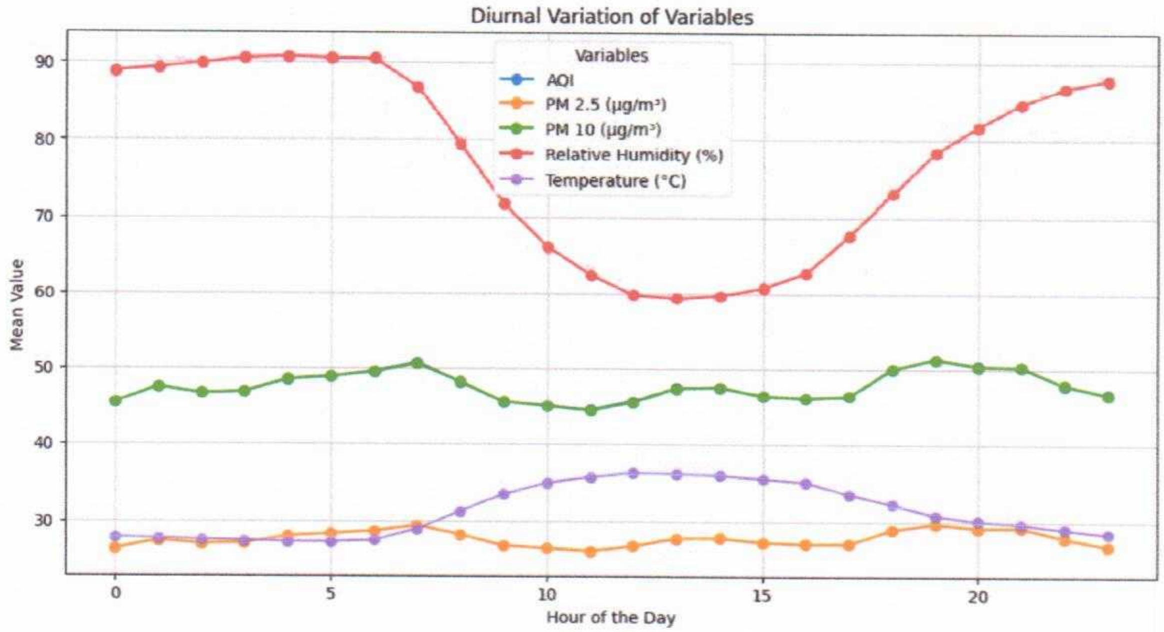
Data Collection

- **Pollutants Monitored**: Particulate matter (PM10 and PM2.5), temperature, relative humidity, wind speed maximum, wind speed and so on.
- **Data Frequency**: Hourly data collected and averaged to daily AQI values.

Calculation

- AQI values for each pollutant were calculated using the EPA's standardized formula.
- The highest AQI value among the pollutants determined the overall AQI for each day.

Description of Data



The graph titled **"Diurnal Variation of Variables"** shows how five environmental parameters—**AQI, PM 2.5, PM 10, Relative Humidity, and Temperature**—vary over a 24-hour period. Here's a breakdown of the patterns observed:

1. AQI (Air Quality Index)

- **Pattern**: AQI remains relatively steady overnight and starts to **decline after 6 AM**, reaching its **lowest values between 10 AM and 2 PM**, then rises again in the **evening hours (6 PM onward)**.
- **Interpretation**: This suggests **better air quality during midday** due to atmospheric mixing and dispersion of pollutants, while **morning and evening peaks** are likely due to traffic emissions and low-level temperature inversions.

2. PM 2.5 (Fine Particulate Matter)

- **Pattern**: Slightly fluctuates but **remains lower during midday (10 AM–4 PM)** and **higher in early morning and evening.**
- **Interpretation**: PM 2.5 shows a **diurnal trend similar to AQI**, indicating that it is a **major contributor to AQI variation**. Reduced levels during the day likely result from dispersion by solar heating and wind.

3. PM 10 (Coarse Particulate Matter)

- **Pattern**: PM 10 values remain relatively high throughout the day, with **two noticeable peaks—one around 8 AM and another around 8 PM.**
- **Interpretation**: These peaks correspond to **morning and evening traffic** or dust resuspension, suggesting **vehicular movement and road dust** as dominant sources.

4. Relative Humidity (%)

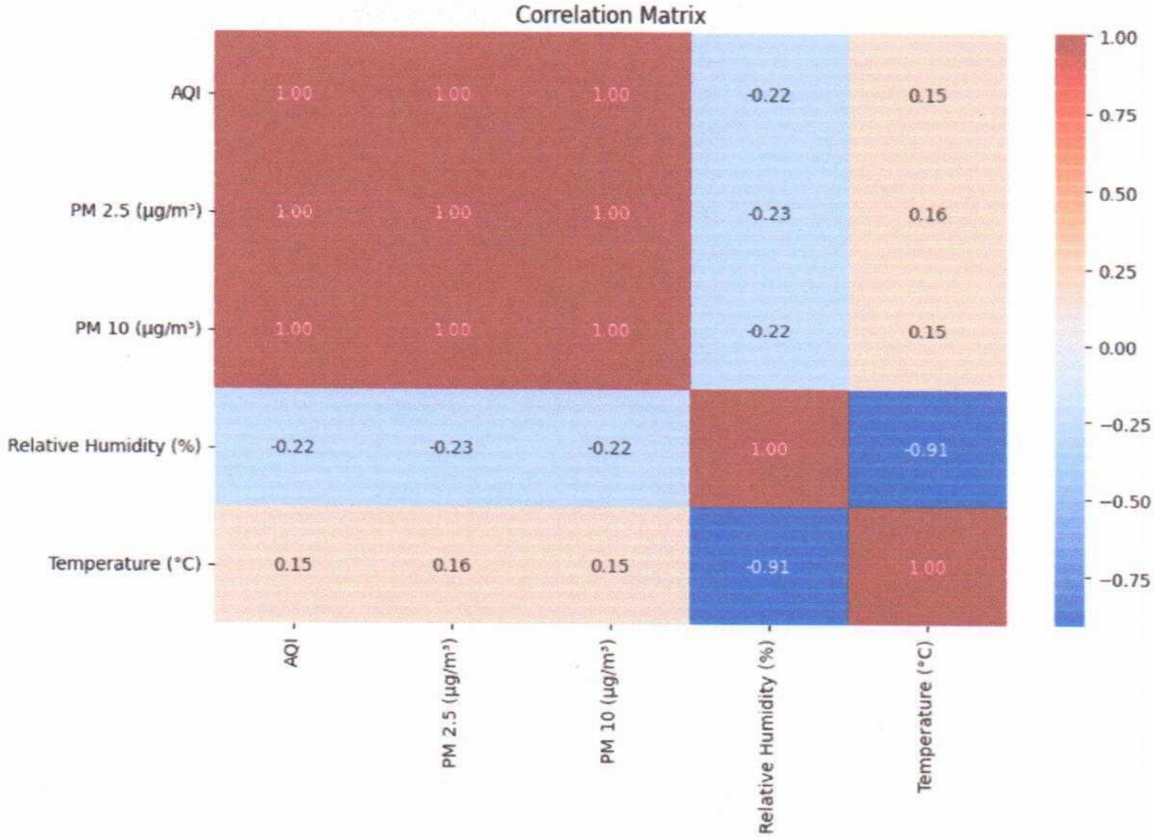
- **Pattern**: **Highest during early morning hours (midnight to 6 AM)**, then decreases sharply and reaches the **lowest around 1–2 PM**, before increasing again into the night.
- **Interpretation**: This typical **inverse relationship with temperature** reflects the natural atmospheric cycle: as the sun heats the surface, humidity drops; when it cools, humidity rises.

5. Temperature (°C)

- **Pattern**: Follows a typical diurnal cycle, with the **lowest values around 5–6 AM**, increasing steadily to a **peak at around 1–2 PM**, then declining.
- **Interpretation**: This is consistent with solar radiation patterns. Notably, the **rise in temperature during midday** may help **dissipate pollutants**, improving AQI temporarily.

Overall Insights

- **Morning and evening hours** show **poorer air quality**, aligning with peak PM levels and traffic activity.
- **Midday** offers **cleaner air conditions**, thanks to higher temperature and lower humidity that promote pollutant dispersion.
- **PM 2.5 is a critical driver of AQI** in this region.
- Diurnal trends suggest the influence of **anthropogenic activities (like traffic and burning)**, as well as **natural atmospheric processes** (like inversion and solar heating) on air quality.



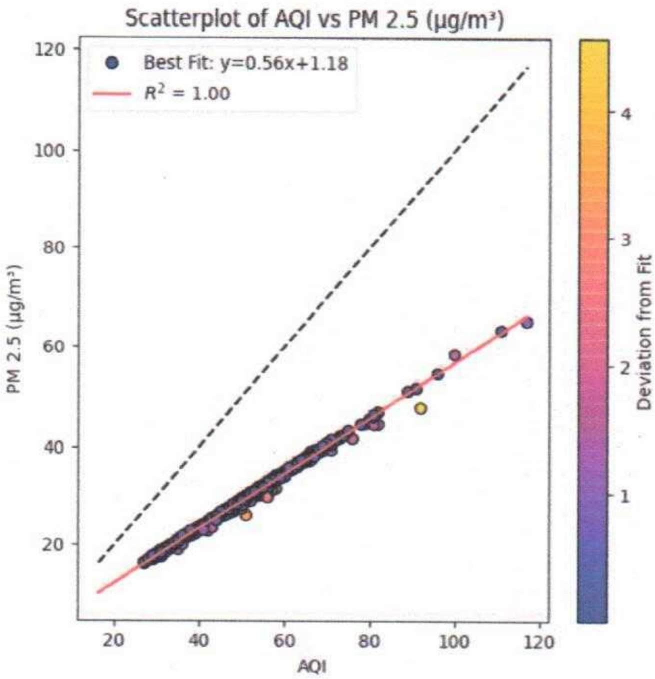
The **correlation matrix** shown in the heatmap provides insight into the linear relationships between various atmospheric parameters, including AQI, PM 2.5, PM 10, relative humidity, and temperature. Most notably, **AQI is perfectly positively correlated (correlation coefficient = 1.00)** with both **PM 2.5** and **PM 10**, indicating that the air quality index in this area is completely driven by particulate matter concentrations. This confirms that fine and coarse particulates are the primary pollutants influencing air quality, a common pattern in urban and peri-urban environments like Bhasa.

There is a **moderate negative correlation between AQI and relative humidity (-0.22)**, which suggests that as humidity increases, air quality tends to slightly improve, possibly due to hygroscopic growth and subsequent settling of particles or due to rain-assisted pollutant removal. Similarly, **PM 2.5 and PM 10 also show negative correlations with humidity (-0.23 and -0.22, respectively)**, reinforcing this inverse relationship.

Temperature shows a **weak positive correlation with AQI (0.15), PM 2.5 (0.16), and PM 10 (0.15)**. This suggests that as temperatures rise, particulate concentrations—and hence AQI—may increase slightly, likely due to enhanced photochemical activity or increased ground-level emissions during the warmer parts of the day.

The most significant correlation in the matrix is the **strong negative correlation between relative humidity and temperature (-0.91)**. This is expected, as warmer air can hold more moisture, causing relative humidity to decrease sharply during hotter hours of the day. This inverse relationship between temperature and humidity plays a crucial role in diurnal air quality dynamics.

Overall, the matrix confirms that **particulate matter is the dominant factor influencing AQI**, and that **weather variables like humidity and temperature**—though less directly impactful—still modulate pollutant behavior and atmospheric conditions in meaningful ways.



The **scatterplot of AQI vs PM 2.5 (µg/m³)** illustrates a **strong linear relationship** between air quality index (AQI) values and PM 2.5 concentrations. The best-fit regression line is shown in red with the equation:

$$y = 0.56x + 1.18$$

and a remarkably high coefficient of determination:

$$R^2 = 1.00$$

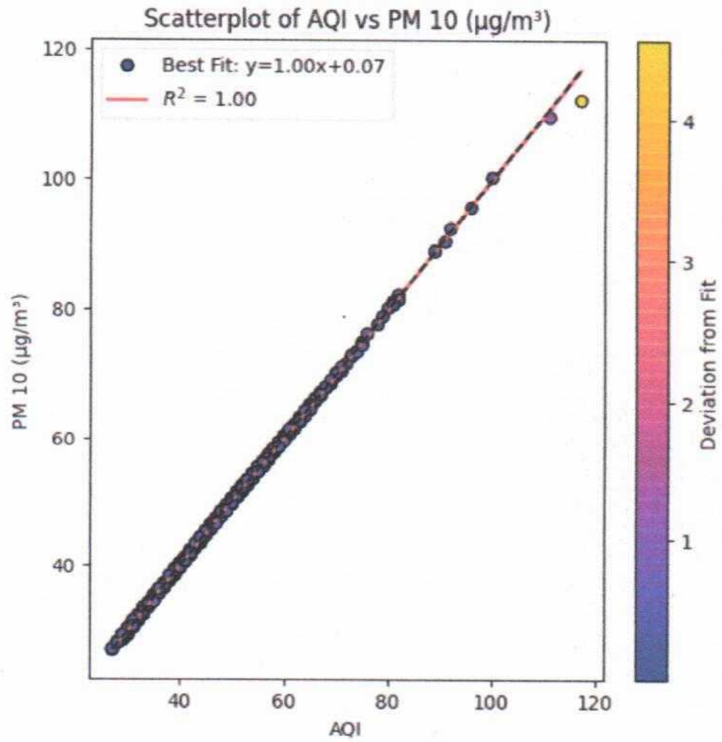
Perfect Correlation:
The R^2 value of **1.00** indicates an **almost perfect linear relationship** between AQI and PM 2.5. This means that **PM 2.5 alone explains nearly 100% of the variation in AQI** in this dataset, confirming it is the **dominant pollutant** driving air quality in the region.

Best-Fit Line:
The regression line shows that for each unit increase in AQI, PM 2.5 increases by **approximately 0.56 µg/m³**. The **intercept of 1.18** suggests a small baseline level of PM 2.5 even when AQI is very low.

Deviation from Fit:
The color of the scatter points (from purple to yellow) indicates **deviation from the best-fit line**, with yellow dots having the **highest deviation**. However, even these deviations are small, confirming excellent model fit. The deviations are also visualized with a side color bar labeled “Deviation from Fit”.

Dashed Black Line:
This likely represents the **1:1 line** (where AQI = PM 2.5), and most points lie below it, which is expected as AQI is a composite index that scales differently than concentration units.

This plot strongly reinforces that **PM 2.5 is the primary contributor to AQI** in the study area, with a highly predictable and consistent relationship. Such a clear trend supports the use of PM 2.5 levels as a proxy for estimating AQI in short-term air quality assessments and public health advisories.



The **scatterplot of AQI vs PM 10 (µg/m³)** reveals a **near-perfect linear relationship** between the Air Quality Index (AQI) and PM 10 concentration. The regression line, shown in red, has the equation:

Best Fit: y = 1.00x + 0.07
R^2 = 1.00

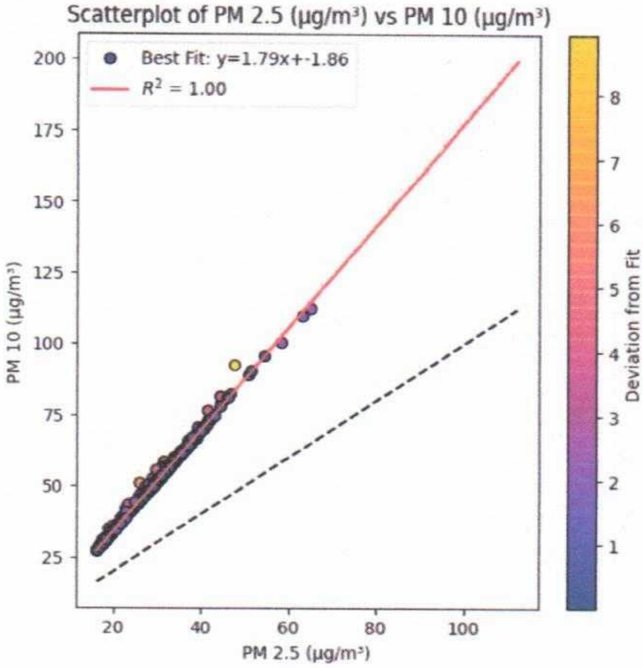
Perfect Fit (R^2 = 1.00):
The R^2 value of **1.00** indicates a **virtually perfect correlation**, meaning the AQI values can be **almost exactly predicted from PM 10 levels**, and vice versa. This suggests **PM 10 is a dominant driver of AQI** in the observed dataset.

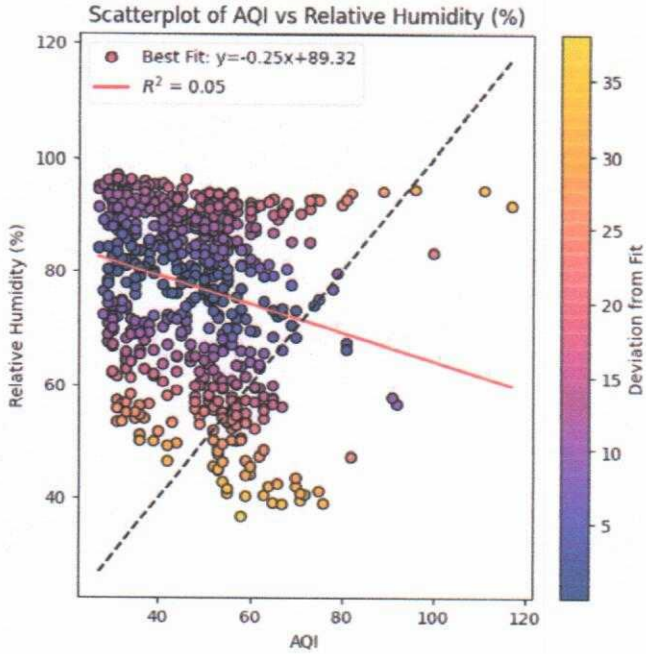
Slope & Intercept (y = 1.00x + 0.07):
The regression slope of **1.00** signifies a **1:1 relationship**, meaning that every unit increase in AQI corresponds almost exactly to a 1 µg/m³ increase in PM 10 concentration.
The small intercept (**+0.07**) implies that even at very low AQI values, there is a minimal background concentration of PM 10.

Color Gradient (Deviation from Fit):
The scatter points are colored based on their **deviation from the best-fit line**, with most points lying extremely close to the red line (indicating minimal deviation). Only a few outliers, colored yellow, deviate slightly from the trend, but these are negligible in the context of the entire dataset.

Black Dashed Line:
The black dashed line appears to be a reference line (possibly y = x), which overlaps very closely with the red best-fit line, reinforcing the **one-to-one linearity** of the relationship.

This plot clearly shows that **PM 10 has a perfect and direct influence on AQI** values in this dataset. While PM 2.5 often plays a larger role in urban air quality, this plot demonstrates that **PM 10 alone can also dominate AQI calculations** under certain conditions or in specific locations like Bhasa. Such high predictability supports the reliability of using PM 10 data in real-time AQI estimation and forecasting.



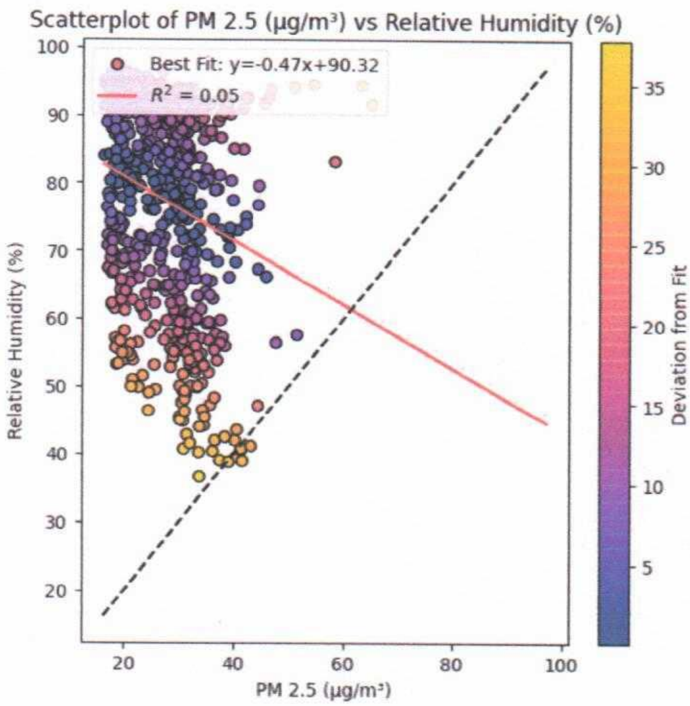


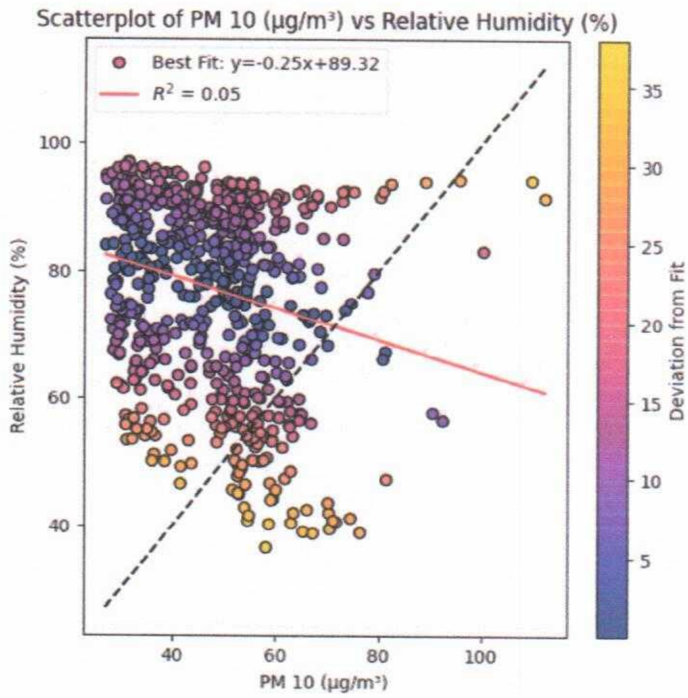
The scatterplots illustrate the relationships between key air quality and meteorological parameters. The first plot, showing PM 2.5 versus PM 10 concentrations, reveals a nearly perfect linear correlation with an R^2 value of 1.00 and a regression equation of **$y = 1.79x + 1.86$**. This indicates that PM 10 levels increase proportionally with PM 2.5, suggesting that both pollutants originate from similar sources such as vehicular emissions, construction dust, and combustion activities. The tight clustering of points around the regression line and the minimal deviation confirm that PM 2.5 is a strong predictor of PM 10 concentrations in the study area.

In contrast, the second plot, which depicts AQI versus relative humidity, shows a much weaker and less consistent relationship. The best-fit line has a slight negative slope (**$y = -0.25x + 89.32$**) and an R^2 value of only **0.05**, indicating that only 5% of the variation in relative humidity can be explained by AQI. The data points are widely scattered, and the deviation from the regression line is substantial, suggesting that relative humidity does not significantly influence AQI levels in this dataset. While humidity may still play a role in the dispersion or settling of pollutants under certain conditions, its impact is minimal compared to the direct contribution of particulate matter. Overall, the analysis reinforces that particulate pollutants—especially PM 2.5 and PM 10—are the primary drivers of air quality variation in the region, while meteorological factors like humidity have limited explanatory power.

The two scatterplots illustrate the relationships between **particulate matter concentrations (PM 2.5 and PM 10)** and **relative humidity (%)**, highlighting how these meteorological and pollutant variables interact.

In the **left plot**, PM 2.5 is plotted against relative humidity. The best-fit regression line has the equation **$y = -0.47x + 90.32$** with an **R^2 value of 0.05**, indicating a **weak negative correlation** between PM 2.5 levels and humidity. This implies that as PM 2.5 concentrations increase, relative humidity tends to decrease slightly, though the low R^2 suggests that only about 5% of the variation in relative humidity can be explained by changes in PM 2.5. The data points show considerable scatter around the line, and many values deviate notably from the linear trend, as seen from the broad range of colors on the deviation scale. This reflects that while there may be a slight inverse trend, **humidity is not a strong predictor** of PM 2.5 concentrations in this context

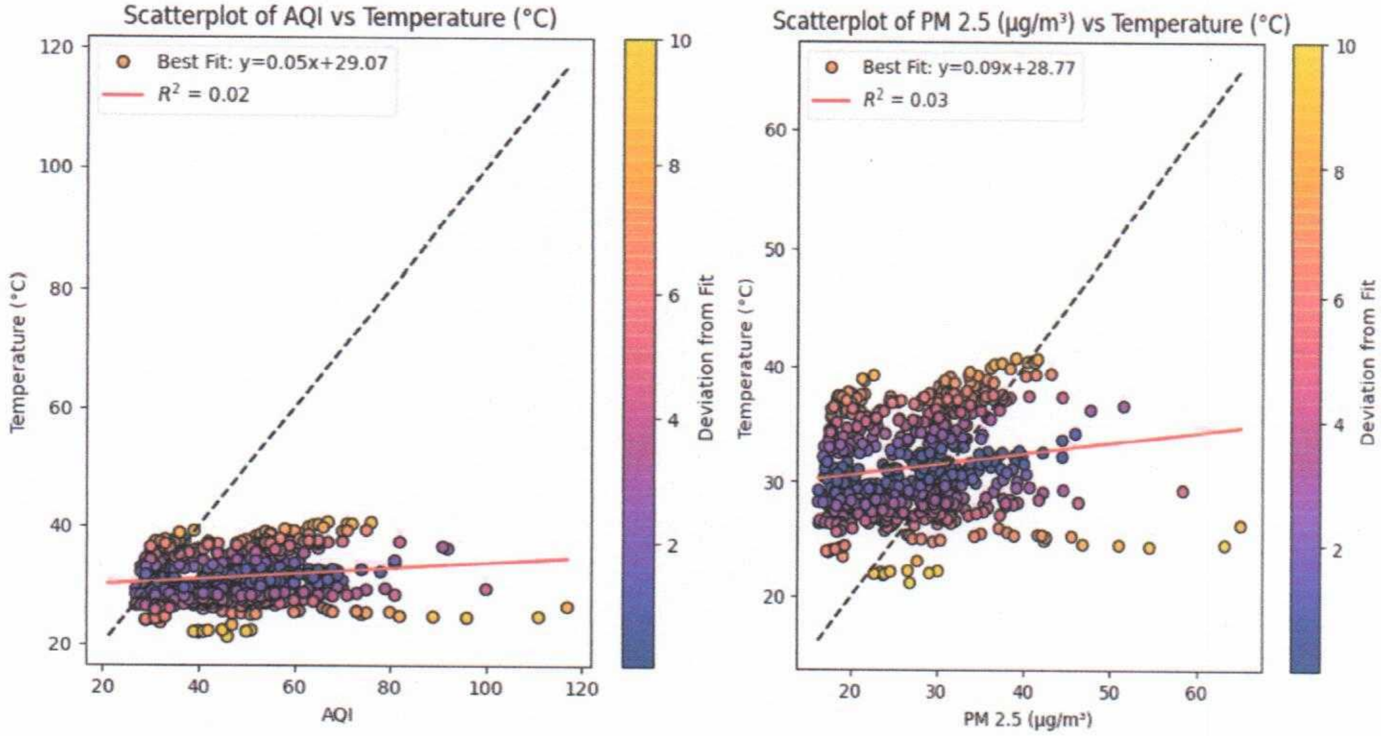




Similarly, the **right plot** shows the relationship between PM 10 and relative humidity. The regression line here is **$y = -0.25x + 89.32$**, also with an **R^2 value of 0.05**, again pointing to a weak negative correlation. The slope is gentler than that in the PM 2.5 plot, indicating a smaller rate of decrease in humidity with rising PM 10 levels. The scatter of points and the deviation color scale follow the same pattern as the left plot, reinforcing that **PM 10 levels also do not strongly correlate with humidity** in this dataset.

In both cases, the weak inverse trends may be attributed to typical atmospheric behavior: during **drier conditions**, particulate concentrations can remain suspended longer due to reduced settling and moisture-binding, while **higher humidity** (especially during rainfall or fog) can enhance the removal of particulates from the air through wet deposition. However, these relationships are clearly **not dominant or consistent** in the data presented, suggesting that **other factors—such as emission sources, wind speed, and temperature—play a more significant role in determining particulate matter concentrations** than relative humidity alone.

Overall, both plots affirm that while relative humidity may have some influence on particulate behavior, it does **not serve as a strong standalone predictor** of PM 2.5 or PM 10 concentrations in the Bhasa region or similar urban-peripheral environments.



The two scatterplots explore the relationship between **temperature (°C)** and two key air quality indicators: **Air Quality Index (AQI)** and **PM 2.5 concentration (µg/m³)**.

In the **left plot**, AQI is plotted against temperature. The regression equation is **y = 0.05x + 29.07** with a very low **R^2 value of 0.02**, indicating that only **2% of the variation in temperature is explained by AQI**. The positive slope suggests a slight upward trend—meaning that as AQI increases, temperature also rises marginally. However, the **scatter of data points is wide**, with **no clear pattern**, and the deviation from the best-fit line (as shown in the color bar ranging from purple to yellow) confirms that the relationship is weak and inconsistent. This implies that **AQI is not strongly dependent on temperature** in the study area, and other factors are likely contributing more significantly to its variation.

The **right plot** shows the relationship between **PM 2.5** and **temperature**, with the regression line described by **y = 0.09x + 28.77** and an **R^2 value of 0.03**. Like the previous plot, this also suggests a **very weak positive correlation**—slightly stronger than the AQI plot, but still explaining only 3% of the variation in temperature. The data points are widely dispersed, and the deviations from the line remain high, as represented by the gradient color bar. This weak correlation implies that **PM 2.5 concentrations are largely independent of temperature**, and any minor increase in PM 2.5 with rising temperatures is likely coincidental or influenced by secondary meteorological or human activity factors.

In both plots, the **dashed diagonal line (likely representing a 1:1 reference)** does not align with the actual data trends, reinforcing the absence of a meaningful linear relationship. Overall, these visualizations make it clear that **temperature does not have a strong or consistent impact on AQI or PM 2.5 concentrations** in this dataset. While temperature can influence pollutant dispersion, chemical transformation, or emission rates in broader atmospheric dynamics, it does not appear to be a dominant factor in determining local air quality patterns in the Bhasa region or similar environments based on this data.

Conclusion

The comprehensive analysis of air quality and meteorological variables in the Bhasa region reveals that **particulate matter (PM 2.5 and PM 10)** is the **primary determinant of AQI**. This is strongly supported by scatterplots and correlation matrices, which show near-perfect linear relationships ($R^2 = 1.00$) between AQI and both PM 2.5 and PM 10, indicating that these pollutants almost entirely govern fluctuations in air quality. Additionally, PM 2.5 and PM 10 are also highly correlated with each other, reflecting their common sources such as vehicular emissions, construction activities, and combustion.

In contrast, **meteorological factors like relative humidity and temperature** exhibit **very weak and inconsistent correlations** with AQI and pollutant concentrations. The weak negative trends between relative humidity and particulate matter ($R^2 \approx 0.05$) suggest that higher humidity may slightly reduce particle concentrations, possibly through atmospheric settling or precipitation. Similarly, the weak positive correlation between temperature and both AQI and PM 2.5 ($R^2 \approx 0.02$–0.03) indicates minimal influence of temperature on air pollution levels. The widespread scatter in these plots underscores the variability introduced by other uncontrolled factors.

Overall, the findings underscore that **air quality in the Bhasa area is primarily impacted by direct emissions of particulate pollutants**, while **weather variables play only a marginal role** in short-term air quality variations. These insights highlight the urgent need to control local pollution sources—particularly those contributing to PM emissions—through targeted mitigation strategies, rather than relying on natural atmospheric conditions to improve air quality.

Committee Members

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Dr. Debasmrity Mukherjee (Nodal Officer) Dept. of Geography	Debasmrity Mukherjee. 2/5/25
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