Analysis of PM10 and PM2.5 Air Quality Levels in Marylebone and Rochester

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I. ABSTRACT

This study shows the impact that location and weather properties can have on air quality. The result indicates that the average PM10 from 2018-01-01 to 2021-02-28 of Marylebone (urban) is higher than that of Rochesther (rural). In Marylebone, both wind speed and wind gust shows negative correlation with PM10 and PM2.5 concentrations. Additionally, atmospheric pressure is positively correlated with PM10 and PM2.5 levels.

II. INTRODUCTION

In this report, we compare the level of PM10 concentration in Marylebone (urban area) and Rochester (rural area). Additionally, we look at the difference in PM10 concentrations in the morning (6:00 AM) and evening (6:00 PM) in both locations. Furthermore, we investigate which weather variables may have an impact on PM10 measurements.

Air pollution (PM2.5 and PM10) can cause serious health risks. Understanding how weather, location, and time affect these pollutants can help improve air quality monitoring.

This analysis consists of three key components: (1) a comparison of PM10 levels between urban and rural locations; (2) an evaluation of how PM10 varies at different times of day; and (3) an investigation of which weather drivers could have an impact on both PM10 and PM2.5 concentrations.

The report is structured as follows: the methodology is first described, followed by the results of the analysis, and finally a conclusion.

III. METHODOLOGY

The aims of this analysis are to explore how weather drivers could have an impact on the air quality measurements and investigate the air quality between the urban and rural sites. The hypotheses are

- **H1:** PM10 and PM2.5 concentrations are higher in Marylebone (urban) than in Rochester (rural).
- **H2:** Wind speed and wind gust are negatively correlated with PM10 and PM2.5 concentrations.
- **H3:** Atmospheric pressure is positively correlated with PM10 and PM2.5 concentrations.

The datasets used in this analysis are as follows:

- Marylebone_AirQualityDataHourly_2018-2021_clean.csv
- Rochester_AirQualityDataHourly_2018-2021_clean.csv
- Weather_data_hourly_Heathrow-Airport.csv

Python was used in the analysis, with the following libraries:

- `numpy` [1]
- `pandas` [2]
- `matplotlib` [3]

The air quality indicators measured in this study are PM10 and PM2.5. These are measured in (µg/m^3).

The meteorological variables considered include:

- **Wind Speed** (km/h)
- **Wind Gust** (km/h)
- **Atmospheric Pressure** (hPa)

Scatter plots were used to explore the correlation between weather variables and particulate matters (PM10 and PM2.5). Line plots were used to visualise and compare trends in pollutant levels over time between Marylebone and Rochester.

This analysis uses the equation

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i, \quad (1)$$

where $x_{i,}$ is the sample of the data, to find the mean value.

To find the average difference we use the equation

$$\bar{x}_1 - \bar{x}_2 \quad (2)$$

Also, we can find the sample standard deviation using the equation

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n} (x_{i,} - \bar{x})^2} \quad (3)$$

IV. RESULTS

A. Comparison of PM10 Concentration: Marylebone vs Rochester

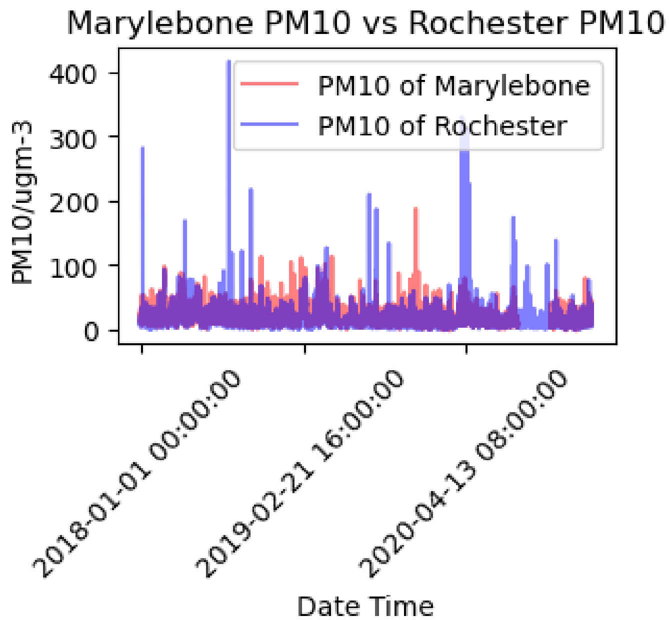

FIG. 1. PM10 concentrations (µg/m³) in Marylebone and Rochester over the entire study period (2018–2021).

Figure 1 compares PM10 concentrations in Marylebone (urban) and Rochester (rural) from 2018-01-01 to 2021-02-28. Although Rochester exhibited a higher peak value of PM10 during the time period, the average concentration was higher in Marylebone.

Using equation (1), the average PM10 concentrations were found to be $\bar{x}_{\text{Marylebone}} = 20.94\ \mu\text{g/m}^3$ and $\bar{x}_{\text{Rochester}} = 15.66\ \mu\text{g/m}^3$. The average difference between the two locations, calculated using equation (2), is $x_{\text{Average\_difference}} = 5.28\ \mu\text{g/m}^3$.

This suggests that Marylebone generally experienced worse PM10 pollution than Rochester, despite the rural site having higher occasional spikes. From the equation (3) we can calculate the standard deviation. The standard deviation of PM_{10} in Marylebone was $\sigma_{\text{Marylebone}} = 11.82$, while in Rochester it was $\sigma_{\text{Rochester}} = 13.40$. This indicates greater variability in PM10 levels at the rural site.

B. Comparision of PM10 at 6am and 6pm in Marylebone

We use the equation (1) to calculate the mean of Marylebone at 6am and 6pm. We get $\bar{x}_{6\text{am}} = 18.66\ \mu\text{g/m}^3$ and $\bar{x}_{6\text{pm}} = 21.39\ \mu\text{g/m}^3$. We can clearly see that the average PM10 at 6pm which is in the evening is higher than the average PM10 at 6am which is in the morning.

C. Impact of Wind Speed on PM10 and PM2.5 in Marylebone

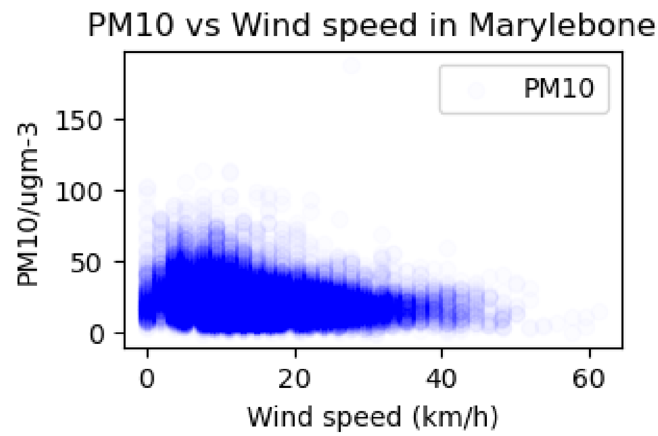

FIG. 2. Scatter plot of PM10 concentrations (µg/m³) against wind speed in Marylebone.

As shown in Figure 2, there is a negative correlation between wind speed and PM10 concentrations. The correlation coefficient between PM10 and wind speed is -0.203 . Higher wind speeds are generally associated with lower PM10 levels.

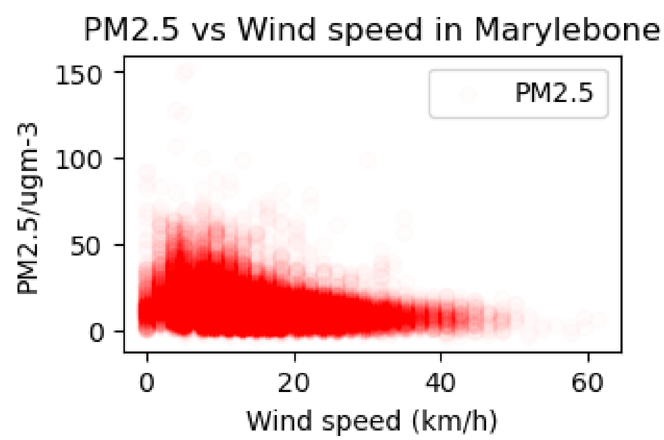

FIG. 3. Scatter plot of PM2.5 concentrations (µg/m³) against wind speed in Marylebone.

Similarly, Figure 3 shows that wind speed is also negatively correlated with PM2.5 concentrations. The correlation coefficient between PM2.5 and wind speed is -0.295. The pattern is consistent with the behaviour observed for PM10. This shows that increased wind speed helps reduce both PM10 and PM2.5 levels in the urban atmosphere.

D. Impact of Pressure on PM10 and PM2.5 in Marylebone

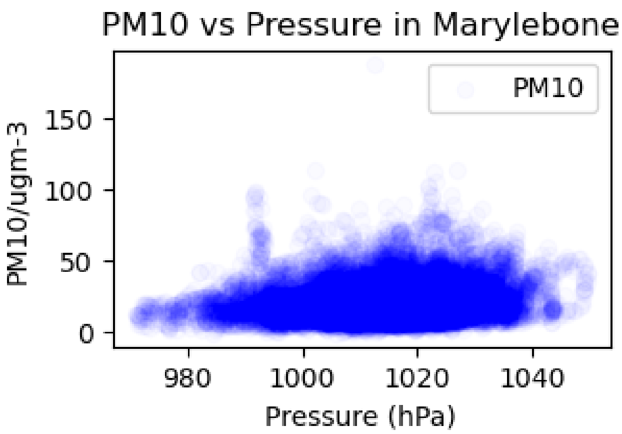

FIG. 4. Scatter plot of PM10 concentrations (µg/m^3) against atmospheric pressure (hPa) in Marylebone.

Figure 4 shows a scatter plot of PM10 concentrations versus atmospheric pressure in Marylebone. The plot suggests a positive correlation between the two variables. The correlation coefficient between PM10 and pressure is 0.143. This shows that PM10 concentrations tend to increase with higher pressure levels, although the relationship is not particularly strong.

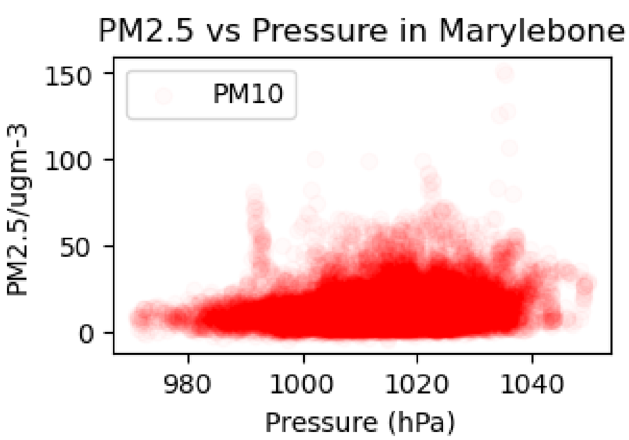

FIG. 5. Scatter plot of PM2.5 concentrations (µg/m^3) against atmospheric pressure (hPa) in Marylebone.

Similarly, Figure 5 shows that PM2.5 concentrations also tend to rise with increasing pressure. The correlation between PM2.5 and wind speed is 0.169. This indicates that atmospheric pressure has a comparable positive effect on both PM10 and PM2.5 levels, despite a relatively low correlation coefficient.

E. Impact of Wind Gust on PM10 and PM2.5 in Marylebone

Figure 6 shows a scatter plot of PM10 concentrations versus wind gust in Marylebone. The plot indicates a negative correlation. The correlation between PM10 and wind gust is -0.214. This suggest that higher wind gusts are generally associated with lower PM10 levels.

Similarly, Figure 7 shows a negative relationship between wind gust and PM2.5 concentrations. The correlation between PM2.5 and wind gust is -0.303. Both PM10 and PM2.5 demonstrate a comparable negative trend with increasing wind gusts. This shows that stronger gusts may help reduce the concentration of particulate matter in the air.

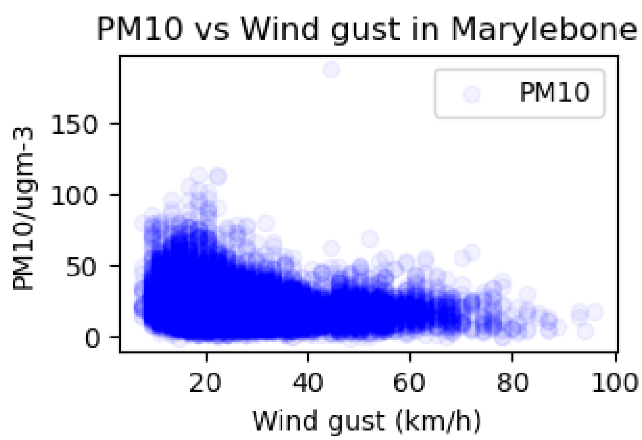

FIG. 6. Scatter plot of PM10 concentrations (µg/m^3) against wind gust (km/h) in Marylebone.

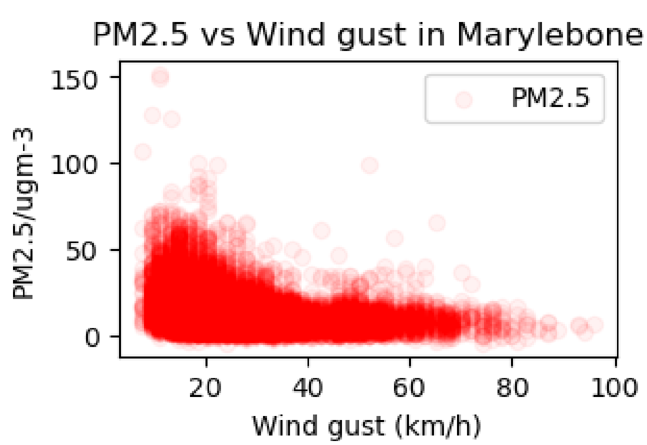

FIG. 7. Scatter plot of PM2.5 concentrations (µg/m^3) against wind gust (km/h) in Marylebone.

CONCLUSION

This report investigates the relationship between air pollution (PM10 and PM2.5) and meteorological variables (wind speed, wind gust, and atmospheric pressure) in Marylebone. In addition, the report compares PM10 concentrations between an urban site (Marylebone) and a rural site (Rochester), and pollutant levels at 6:00 AM and 6:00 PM in Marylebone.

The results showed that Marylebone had a higher PM10 level compared to Rochester, despite Rochester occasionally having higher peak PM10 concentrations. Scatter plots shows a consistent strong negative correlation between wind variables (wind speed and wind gust) and particulate matter (PM10 and PM2.5). This means that higher wind speed and gusts may help reduce air pollution. Atmospheric pressure showed a weak positive correlation with PM10 and PM2.5. This shows that that high-pressure may reduce the air quality.

[1] C. R. Harris, K. J. Millman, S. J. van der Walt, R. Gommers, P. Virtanen, D. Cournapeau, E. Wieser, J. Taylor, S. Berg, N. J. Smith, R. Kern, M. Picus, S. Hoyer, M. H. van Kerkwijk, M. Brett, A. Haldane, J. F. del Río, M. Wiebe, P. Peterson, P. Gérard-Marchant, K. Sheppard, T. Reddy, W. Weckesser, H. Abbasi, C. Gohlke, and T. E. Oliphant, Array programming with NumPy, Nature **585**, 357 (2020).

[2] T. pandas development team, pandas-dev/pandas: Pandas (2020).

[3] J. D. Hunter, Matplotlib: A 2d graphics environment, Computing in Science & Engineering **9**, 90 (2007).