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Project 4

Option 2: *Pollution and Meteorological Data Analysis*

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Abstract

This investigation is an insight into how weather and location data impact air quality. Data was taken from an urban traffic site within London and a rural background site from the east of London. This data consisted of measurements of different pollutants as well as measurements of gases in the air. To briefly sum up the results of the analysis, the data suggest that aspects of the weather data have a mild correlation with measurements of the pollutants and that the level of nitrogen oxide has a fairly positive correlation with the measurements of the pollutants.

Introduction

Background Information

Three files were provided that spanned from the beginning of 2018 to the beginning of 2021. Two of the files contained area data on hourly measurements of PM10 and PM2.5 particulate matter as well as a measurement of nitrogen dioxide. PM10 particulate matter is caused by dust from construction sites, industrial sources and burning whereas PM2.5 particulate matter is caused by combustion of fuel and wood.

The data in the files was collected from a rural area and an urban area within London. The third file contained weather data for London with dates that overlapped those of the previous two files. The premise of this investigation was to take a look at the measurements of PM10 particulate matter and compare the data between the two locations, while also investigating the effects of meteorological conditions and gas levels on these measurements.

Questions Being Asked

The questions I set out to investigate were as follows:

- How does the amount of air pollution in urban and rural areas differ?
- Are there any trends in the amount of air pollution between the two areas?
    - i.e. certain times of year/day or certain events like the pandemic
- What if any is the correlation between particulate matter and nitrogen dioxide in the air?
- What if any is the correlation between particulate matter and the meteorological data?
- Are the impacts for PM10 and PM2.5 similar?

Hypotheses

My Hypotheses for this investigation are as follows:

1) *I believe that urban areas will have far lower pollutant levels than rural areas due to there being a much higher likelihood of there being construction sites and a much higher rate of people driving cars which leads to fuel combustion.*
2) *I believe that COVID-19 will have a huge impact on the pollutant levels in urban areas but not so big of an impact on urban areas.*
3) *I believe that there will be a strong positive correlation between air pollutant measurements and nitrogen oxide levels in the air.*
4) *I believe that temperature will have a positive correlation. I believe precipitation will have a negative correlation as an increase in humidity combats dust. I believe air pressure will have a positive correlation, and I believe that wind speed and gust will have a negative correlation as wind will cause the pollution to disperse.*
5) *I believe the impacts on PM10 and PM2.5 will be similar for certain things but not all since they are pollutants that come from different sources.*

Analysis and Discussion

Comparing Measurements of PM10 in Rural and Urban Areas

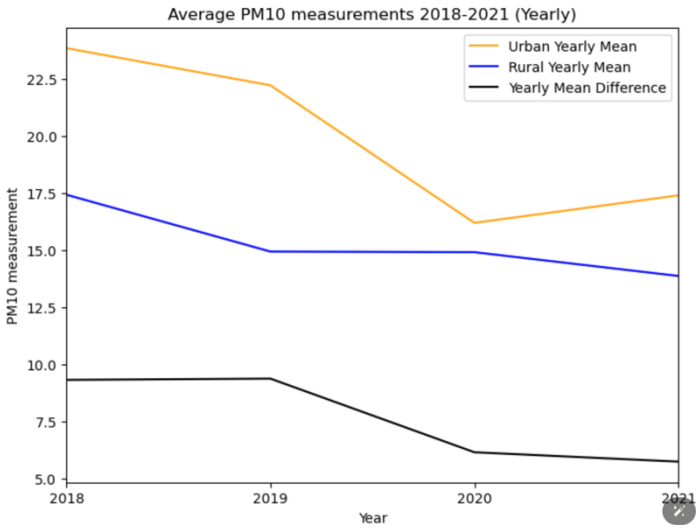

Figure 1

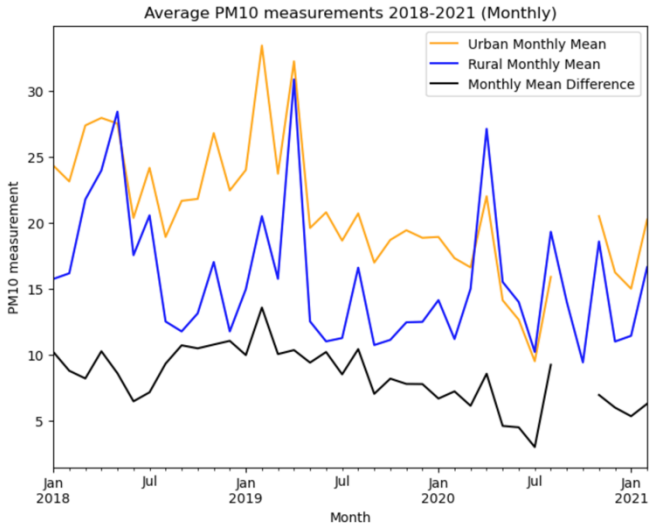

Figure 2

Analysis of Plots

This data alone does not reveal much information. It highlights the fact that Rural areas have less particulate matter than Urban areas. This makes sense as rural areas will not have nearly as many people, cars or building sites. The effect of COVID-19 is noticeable in Figure 2 as around March 2020 we saw a huge drop in air pollution, due to lockdown, and then saw a spike around July 2020, when restrictions were eased. Data is not available from August 2020 - October 2020. The period in which the second lockdown ("fire break") took place. This persisted until November 2020 when we can see the reading for spikes up compared to where August left off. We can also see the dip in December when the third national lockdown took place.

Analysing the Measurements of PM10 Throughout the Day

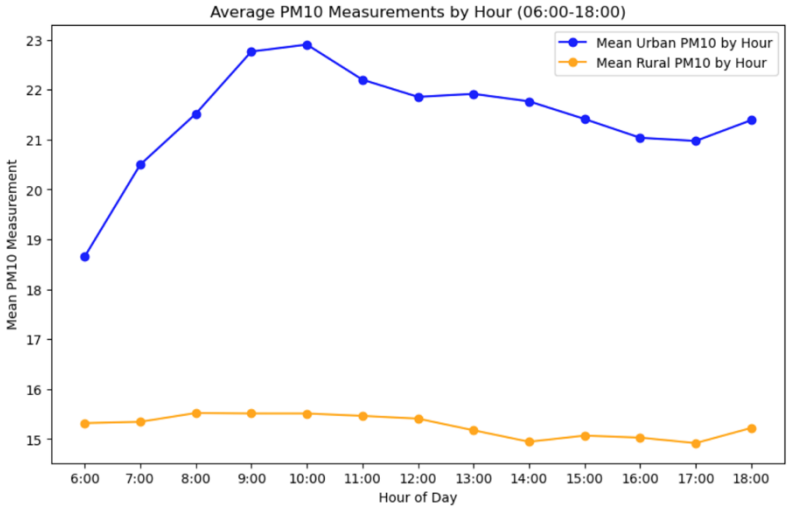

Figure 3

Analysis of Plot

Figure 3 shows that in urban areas air pollution has a noticeable increase from 06:00 and 18:00, the peak of this being 09:00 – 10:00 before steadily decreasing. It shows that the PM10 measurement goes from an index 1 to an index 2 (according to uk air defra) throughout the day. On the other hand, the rural area seems to be quite steady throughout the day, even decreasing slightly, while staying at around an index 1.

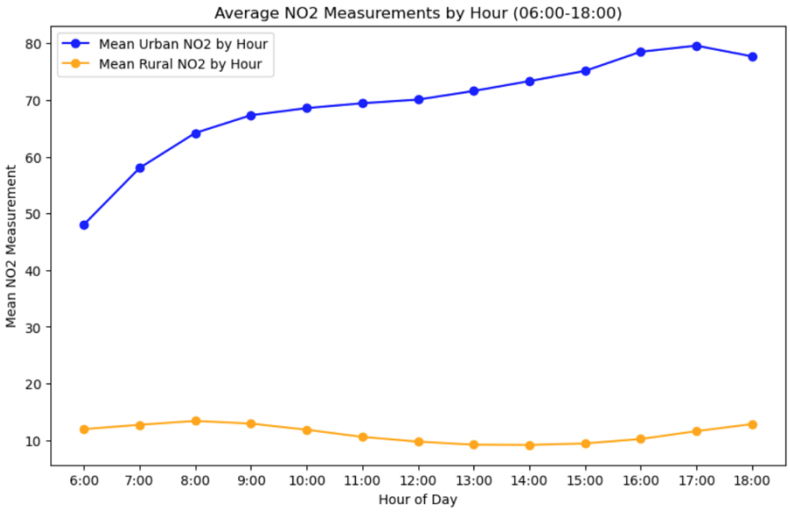

Figure 4

Analysis of Plot

Figure 4 depicts the changes in nitrogen dioxide levels over the same time frame as *Figure 3*. This plot clearly shows that there is a positive correlation between the PM10 measurements and nitrogen dioxide measurements. It also suggests that the rural area has a stronger positive correlation with the nitrogen dioxide level than the urban area, as both nitrogen dioxide levels and PM10 measurements in the rural area change very little. These changes seem very consistent with one another. On the other hand, the urban location has quite a gradual change in nitrogen dioxide levels but a far more pronounced change in PM10 measurements. Again rural remains at index 1 throughout the time frame while urban starts at index 1 and ends at index 2.

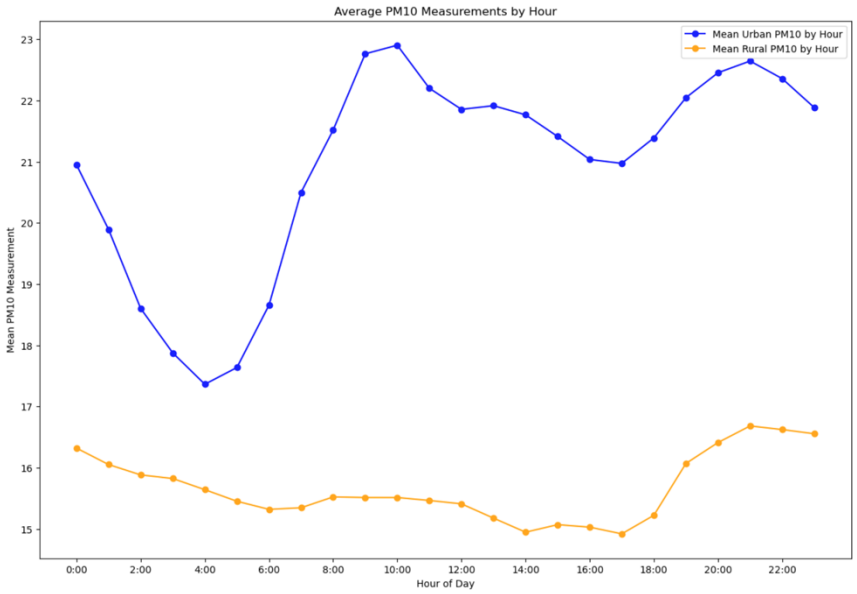

Figure 5

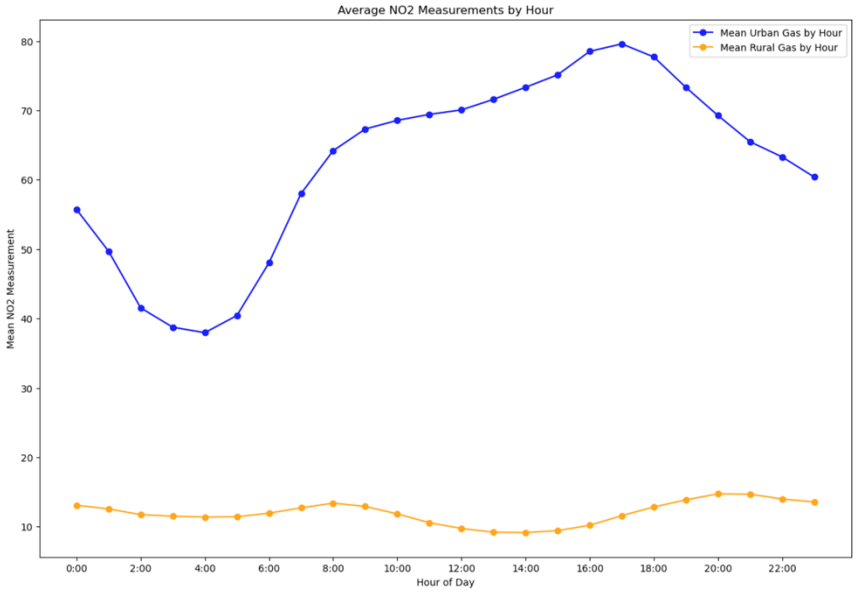

Figure 6

Analysis of Plots

Figures 5 and 6 again show that there seems to be a positive correlation between nitrogen dioxide and PM10 levels in both locations. Changes in nitrogen dioxide levels very clearly impact levels of PM10 particulate matter. Again, it is very clear that the level of both PM10 particulate matter and nitrogen dioxide is far lower in rural areas, this pattern is especially pronounced during the daytime and evening hours. This could be due to several factors, such as lower traffic volumes, less industrial activity, and generally lower energy usage, all of which contribute to nitrogen dioxide emissions and air pollution. From these figures: in urban areas, the trends in nitrogen dioxide levels somewhat follow the trends in PM10 levels throughout the day, though there are times during early morning hours when nitrogen dioxide levels drop more significantly than PM10 and in the rural area, it shows less dramatic variation in nitrogen dioxide levels compared to urban areas and a generally lower level of nitrogen dioxide. This time, the trends between PM10 and nitrogen dioxide in rural areas appear less synchronized in rural areas compared to urban. Hence, this suggests that there may be a stronger correlation between PM10 and nitrogen dioxide levels due to more emissions from traffic, construction, and industrial sources, which contribute to both PM10 and nitrogen dioxide levels. The fluctuations in PM10 seem to coincide more closely with the changes in NO2 levels in urban areas, especially during the daytime.

Analysing the Correlation Between Meteorological Data and Air Pollutant Data

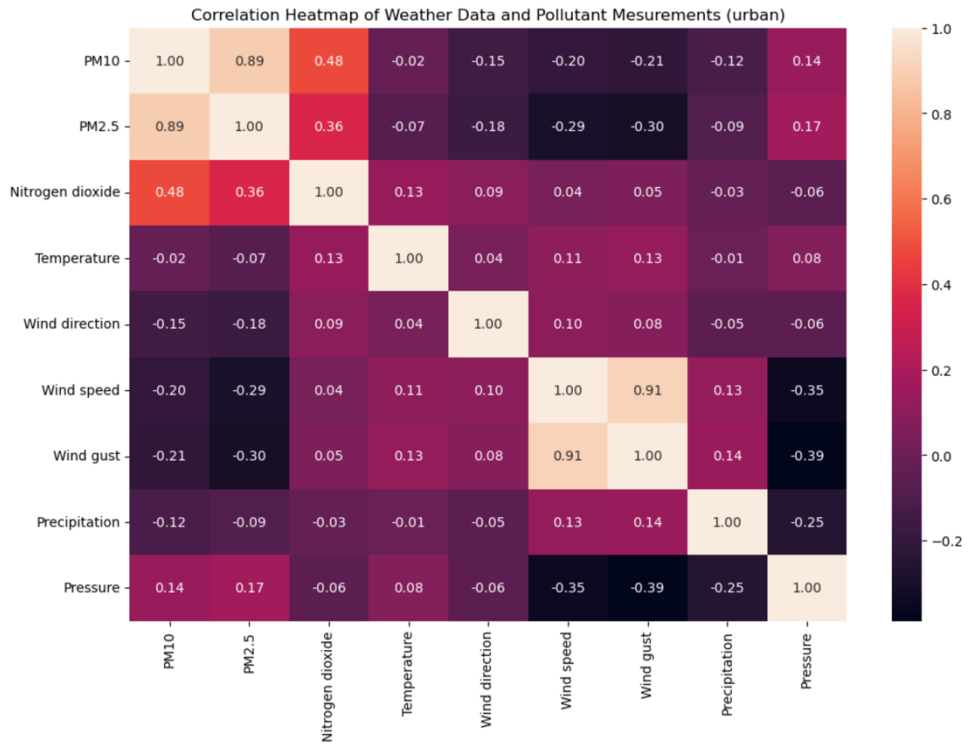

Figure 7

Analysis of Plot

For the remainder of the investigation, I chose to investigate the urban area as the higher levels of PM10 and nitrogen dioxide seemed like it would be more interesting to investigate. From the correlation heatmap, the following observations can be made:

- **Nitrogen dioxide and PM10**: The correlation coefficient is 0.48, indicating a moderate positive correlation. This suggests that as nitrogen dioxide levels increase, PM10 levels also tend to increase. This could be due to the fact that both pollutants can be emitted from similar sources, such as motor vehicles and industrial processes.
- **Nitrogen dioxide and PM2.5**: The correlation coefficient is 0.36, which is also positive but slightly weaker compared to PM10. This indicates a similar relationship where higher nitrogen dioxide levels could be associated with higher PM2.5 levels, but the relationship is less strong compared to PM10. This could suggest that the majority of nitrogen dioxide comes from industrial and construction sites rather than fuel combustion, hence the higher correlation.
- **Temperature**: Shows very low correlations with PM10 and PM2.5 (−0.02 and −0.07, respectively), suggesting that temperature changes have little direct impact on concentrations of these particulates in this urban setting.
- **Wind direction and speed**: Both have negative correlations with PM10 and PM2.5, with wind speed showing slightly stronger negative correlations (−0.20 for PM10 and −0.29 for PM2.5). This implies that higher wind speeds, which often disperse air pollutants, tend to lower concentrations of particulate matter.
- **Wind Gust**: Similar to wind speed, wind gusts show a negative correlation with PM10 and PM2.5, supporting the idea that stronger winds help to disperse particulate pollutants.
- **Precipitation**: Has negligible correlation with PM10 (−0.12) and PM2.5 (−0.09), indicating that rainfall does not significantly impact these particulate levels, possibly due to the urban setting where rain washout effects are less pronounced. This is surprising as precipitation leads to an increase in humidity which traps air pollution in the ground.
- **Pressure**: Displays very weak correlations with PM10 (0.14) and PM2.5 (0.17), suggesting minimal influence on particulate concentrations. It does however make sense for this to be positive as higher air pressure makes tends to make the air more stiff allowing greater concentrations of air pollution to build up.

Conclusions

From this investigation, the following conclusions can be made based off my analysis:

Firstly, rural areas have far less PM10 levels compared to urban areas. This is most likely due to the lack of industrial sites and construction sites in rural areas compared to urban areas. This also could be linked to lower levels of nitrogen dioxide in rural areas. Looking at *Figure 1* and *Figure 2*, not a huge amount can be said as there are many fluctuations that do not seem to be consistent with anything, however, I do believe that the impact of COVID-19 can be seen from the general decrease in measurements of PM10 around the times of our lockdown.

Second, I believe there to be a strong correlation between nitrogen dioxide levels and PM10 levels as *Figures 3-6* show that higher levels of nitrogen dioxide seem to correlate with higher levels of PM10. I believe that overall urban areas, the areas with a higher nitrogen dioxide emission, have a stronger correlation between PM10 and nitrogen dioxide. This is because looking at the levels throughout the day, the fluctuations in each graph seem to be more consistent than in the rural area. This may simply be because urban areas have higher emissions causing a stronger link.

Finally, looking at *Figure 7* we can see that nitrogen dioxide has a moderately strong correlation with both particulate matters, however slightly less strong with PM2.5 likely due to the source of nitrogen dioxide. We can also see that temperature, precipitation, and pressure have a negligible correlation with either of the particulate matters, whereas the wind factors all have some moderate negative correlation. This is most likely because stronger and more extreme winds will cause the air pollution to disperse. Impacts on PM10 generally have the same effect on PM2.5, however, the amount they correlate with each factor varies. This is likely due to the difference in where each particulate matter comes from. I believe that PM2.5 has a less positive correlation with nitrogen dioxide because there is not as much nitrogen dioxide being released from combustion as there is from construction/industrial sites in urban areas. I also believe that PM2.5 has a stronger negative correlation with wind factors due to the fact that they are smaller and lighter and will disperse much easier.

References

Index Data: *uk-air_defra.gov.uk*

Covid dates: *Wikipedia*

Effect of air pressure on air pollution: *Clarity Movement Co.*

Effect of humidity on air pollution: *Airly*