Mini Project Report

S18809

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1 Introduction

Hourly measurements of air quality parameters, including $NO, NO_2, NO_x, O_3, SO_2, PM_{10}, and PM_{2.5}$, were collected for London city from January 1, 2022, to December 31, 2022. Notably, not all gases are present at every site, and missing values exist in our data collection. The primary objective of this study is to **systematically examine and identify patterns in London's air quality**.

With a focus on analyzing the maximum concentration of each gas, our investigation extends to identifying the regions, periods of time, and days characterized by high measurements. The report encompasses thorough evaluations in the results, discussion, and literature review sections. In the discussion section, we explore the connections between each variable and London's overall gas percentage distribution. Additionally, a detailed examination of each gas's pattern, considering variations by month, day, and hour, provides insights into the temporal dynamics over the year.

The report concludes with final thoughts, bearing in mind that null values in the dataset are assumed to have no bearing on the results section and are treated as zero. Furthermore, it is essential to acknowledge the study's limitation to highly observable data.

2 Literature Review

The examination of air quality parameters, including Nitric Oxide (No), Nitrogen Dioxide (No2), Nitrogen Oxides (Nox), Ozone (O3), Sulfur Dioxide (SO2), Particulate Matter with a diameter of 10 micrometers or less (PM10), and Particulate Matter with a diameter of 2.5 micrometers or less (PM2_5), has been a subject of increasing importance in environmental research. Studies across various regions and time frames have contributed to a collective understanding of the dynamic nature of air quality and its impact on public health. This literature review seeks to contextualize the study's goals by exploring existing research on the measurement and patterns of air pollutants, with a particular focus on urban environments like London

(Luis A.Gill-Alana, October 2020) According to this article, there is a great deal of variation among contaminants, and almost always, persistent behavior based on a lengthy memory pattern is seen. In certain instances, seasonality and declining linear tendencies are also observed.

(De et al. 2021),This article demonstrates how the analysis yields spatio-temporal patterns, or patterns across several place categories and time periods. It also demonstrates how urban factors, such human commuter behavior and the built environment, interact with the patterns of air quality that are observed.

While the literature analysis outlines the patterns of changes in air gases, this report demonstrates the locations and times of high concentrations of air pollution. Graphs allow us to quickly determine the London air pattern.

3 Results and Discussion

3.1 Summary of the data Sets

Our data set has 289,069 rows and 14 columns. columns contains code,site,date,nox,no2,no,pm10,o3,pm2_5,so2, dateocc (measurement occurance of the date),timeocc (what time measured),latitude, and longitude .Summary statistics for each gas are given below..

	Nox	No2	No2	Pm10	O3	Pm2_5	So2
Min	-4.50	-7.20	-3.30	-6.50	-2.00	-3.0	-4.90
1st quartile	22.50	16.70	2.60	11.10	32.20	6.0	1.80
Median	40.80	27.70	7.99	16.40	49.30	8.0	3.00
Mean	62.81	33.15	19.34	19.47	49.61	10.6	3.08
3rd quartile	75.70	44.00	21.10	23.90	65.70	13.6	4.20
Max	1111.10	285.10	631.50	300.8	189.60	685.0	11.10

Table 1: Summary statistics for 7 gases

Table 1,illustrates the summary statistics for each gas. Among the 7 gases, the minimum amount is measured in sulfur dioxide (So2), while the maximum amount of gas is measured in nitrogen oxide (Nox). When we compare the average measurements of the gases nitrogen oxide (62.81) and ozone (49.61), they are highly measured, and at the same time, ozone has a higher median value than nitrogen oxide.

3.2 Relation Ship between Variables

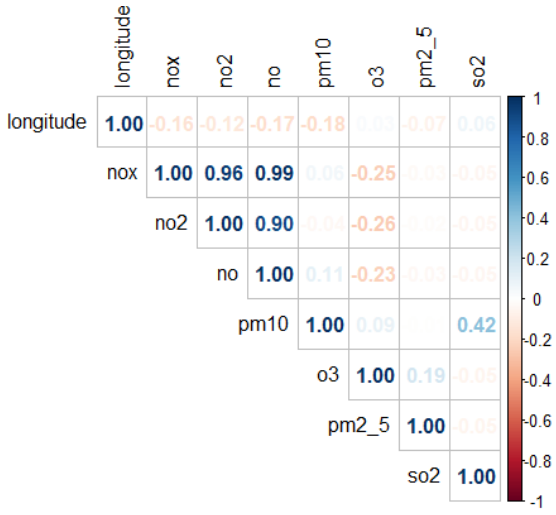

Figure 1: Relation between variables

A correlation between variables can be shown in this graphic. Because there is only a slight association between gases and longitude in this case, all gases are independent of longitude. Additionally, nitrogen groups depend on one another due to their strong correlation. Other than the nitrogen group, there isn't much of a correlation.

3.3 Compare all of gases measurements made during a single year

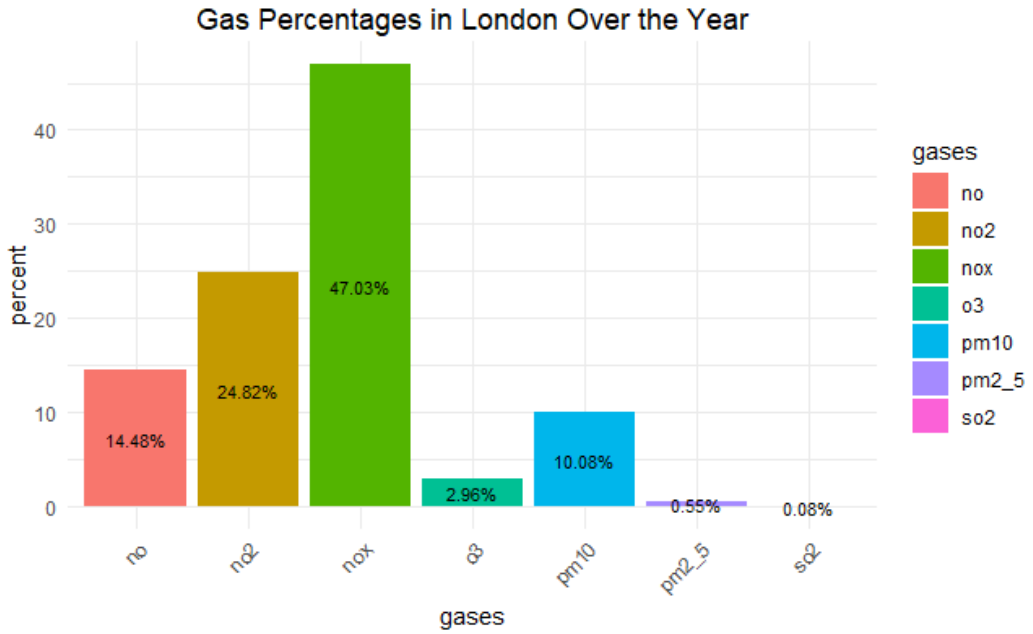

Figure 2: Percentages between the air gases

This bar chart illustrates the gas percentage in London over a one-year period. Among the gases, 47.03 percent of Nitrogen oxide is highly measured, and at the same time, a very small percentage measures Sulfur dioxide. When we compare other gases, the nitrogen group is highly affected in London. About 3 percent of the measured ozone gas.

3.4 Average air measurement for each month

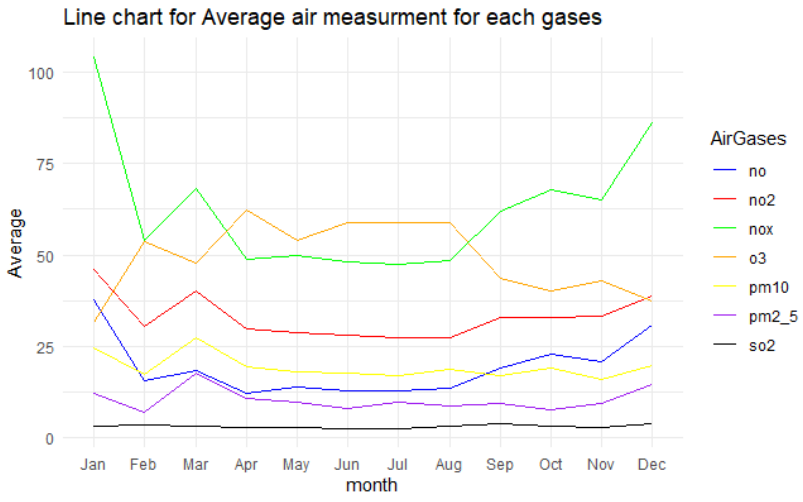

Figure 3: Average Measurements for each gases trend each month

The line chart illustrates significant variations in gas concentrations from January to December. The x-axis represents the months, while the y-axis displays the average measurements for each gas.

Within the nitrogen group(Nox,No2,No), a consistent trend is observed across the months. Except O3 and So2, the average measurement experiences a slight decrease from January to February,

followed by a significant and rapid increase from February to March.

Following April, PM2.5 concentrations exhibit a gradual decrease until June, followed by an increase in July. Conversely, PM10 levels experience a slight decline from April to July, followed by a gradual increase until August. Subsequently, from November onwards, there is a notable increase in PM10 concentrations.

The ozone levels exhibited a slight increase from January to March, followed by a dramatic surge in average measurements from March to April. From April to August, ozone concentrations consistently remained higher than those of nitrogen oxide (NOx). Across all months, both NO2 and O3 emerged as the gases with the highest average measurements. In contrast, sulfur dioxide (SO2) levels remained relatively stable throughout all months.

3.5 Nitrogen Group

Based on the table 1, Within the nitrogen group, comprising NO, NO2, and NOx, a comparison of average measurements and medians reveals that nitrogen oxide (NOx) consistently exhibits higher values than the other two gases.

3.5.1 Nitrogen oxide(Nox)

Month	Site	Average Measure
January	Ealing - Hanger Lane Gyrator	236.2448
Febuary	Wandsworth - Putney High Street	164.5615
March	City of London - Walbrook Wharf	152.3541
April	Lambeth - Brixton Road	113.4241
May	Ealing - Hanger Lane Gyrator	143.0711
June	Ealing - Hanger Lane Gyrator	122.9278
July	Lambeth - Brixton Road	119.1022
Augest	Lewisham - Loampit Vale	166.4022
September	Lambeth - Brixton Road	162.6655
October	Lewisham - Loampit Vale	214.4912
November	Ealing - Hanger Lane Gyrator	162.0470
December	Lambeth - Brixton Road	190.4439

Table 2: Maximum Average measurement for each month

Table 2 shows that each month, which site has the maximum measurement?. Based on the table for Ealing-Hanger Lane Gyrator,Lambeth-Brixton Road, and Lewisham-Loampit Vale, these areas are highly affected by nox gas in January, August, September, October, November, and December.

boxplots for air measurements in January, August, September, October, November, and December at sites EA6, LB4, and LW4 based on weeks

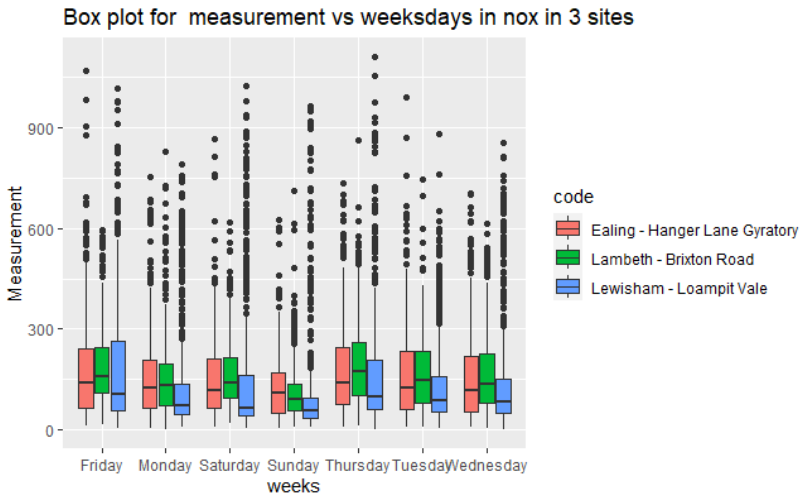

Figure 4: Box plot for air measurement based on the weeks

The box plot shows how the nox spreads each week. In Lambeth, Brixton Road has a high median measurement all week compared to the other two sites. Friday and Thursday are highly measured, while Sunday is low measured.

Scatter plot for the average measurement of nitrogen oxide on Thursday and Friday in January and October based on hours

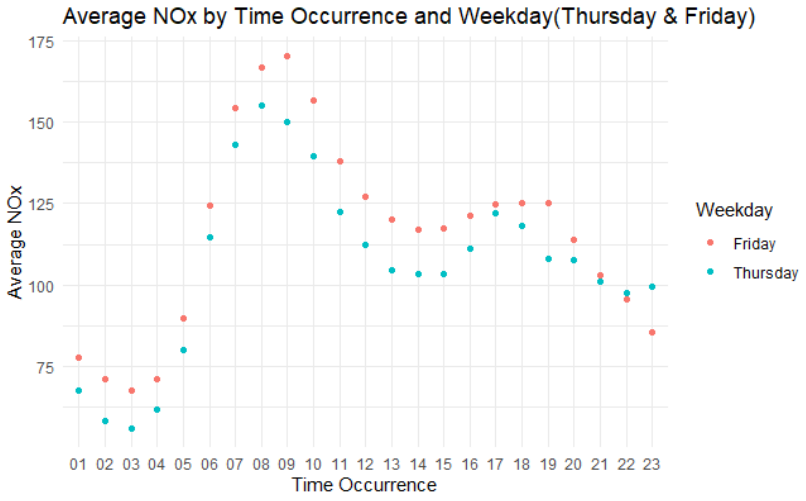

Figure 5: Hourly measurement in Thurday and Friday

The figure 5 illustrates the trend for nox gas measurement on Thursday and Friday based on hours. These two-day trends are approximately the same. Both days, at 8 a.m., nox was highly measured, then decreased until 2 p.m.; after that, gas increased to 5 p.m., but this measurement was less than the previous value measured at 8 am.

3.5.2 Nitrogen dioxide(No2)

This gas was highly measured in January, March, and December. January and December were highly measured in Lambeth—Brixton Road, while the City of London—Walbrook Wharf was highly mea-

sured in March. This data is based on an average measurement.

3.5.3 Nitric oxide(No)

There were Nitic oxide highly measured gases in January and December. This gas has a significant impact on Ealing-Hanger Lane Gyratory, but Wandsworth-Putney had low measurements in January. Richmond Upon Thames_Barnes Wetlands, had the minimum measurement in December, while Lambeth, Brixton Road, recorded the maximum.

3.5.4 Trend for nitrogen gases for each site

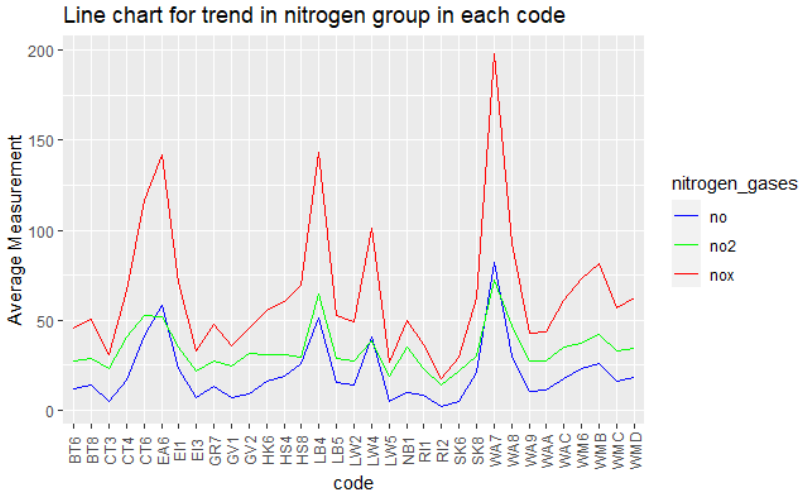

Figure 6: Trend For Nitrogen Group

The chart depicts the trend for each gas across different sites. Notably, all three gases exhibit a similar trend across the various sites. Among the sites, Wandsworth-Putney High Street consistently registers the highest measurements for all three gases, while Richmond Upon Thames and Barnes Wetlands consistently show lower measurements. Additionally, other areas with elevated measurements include Ealing - Hanger Lane Gyratory, Lambeth - Brixton Road, Lewisham - Loampit Vale, and Westminster - Oxford Street East.

3.6 Ozone(O3)

When we considered the ozone gas, it was highly measured in February, April, and August. This 3-month period is highly affected in Richmond Upon Thames - Barnes Wetlands. On August 13, the maximum ozone level was measured, which was 189.6.

3.6.1 pie chart for ozone measurements each week in Richmond Upon Thames - Barnes Wetlands

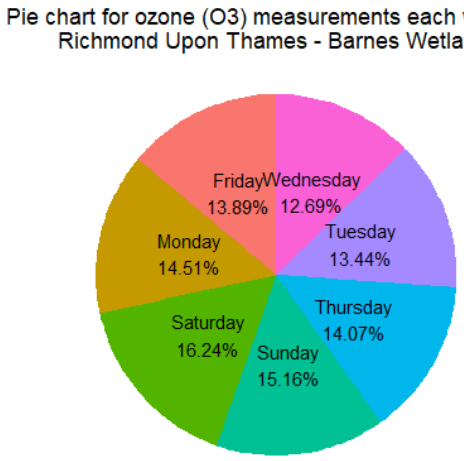

Figure 7: Percentage of ozone in each weeks

The pie chart illustrates ozone measurements each week in Richmond Upon Thaandes - Barnes Wetlands.All days, percentage levels greater than 10. On Saturday, 16.24 percent of the total measurement was measured, which was highly measured, and on Sunday, 15.16 percent was measured. Based on the percentage, from Monday to Wednesday, the measurement level was decreasing, then on Thursday, the measurement level suddenly increased, then decreased on Friday, reaching 13.89 percent. Then Saturday suddenly increased.

3.6.2 Trends for hourly measurements on Saturday in Richmond Upon Thames - Barnes Wetlands

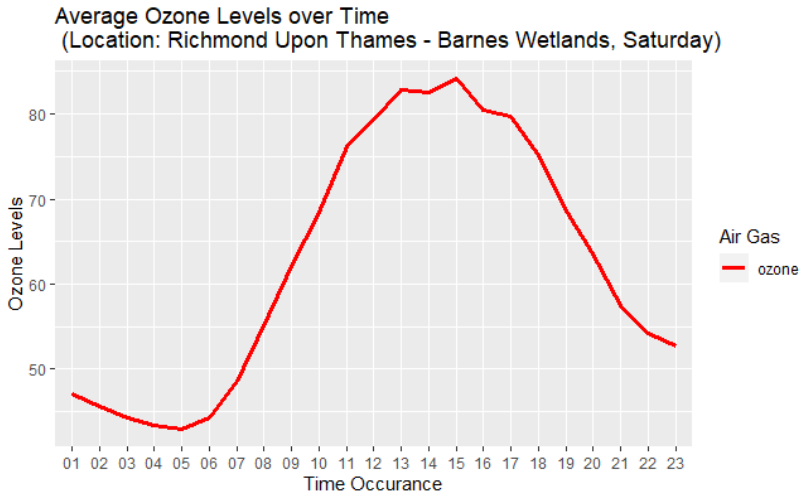

Figure 8: Hourly Measured on Saturday

After 5 a.m., ozone levels suddenly increased until 12 p.m. after a slight decline until 1 p.m., then increased up to 3 p.m., then decreased up to 11 p.m. At 3 p.m., it was highly measured on Saturday.

3.7 pm10

The below table shows top 10 areas with the spread of PM10 in London within one year.

Site	Measurement
Lambeth - Bondway Interchange	306785.0
Ealing - Western Avenue	213899.3
Hounslow Gunnersbury	183995.2
Wandsworth - Battersea	175535.4
Lewisham - Loampit Vale	169640.0
Wandsworth - Putney High Street	162901.5
Lambeth - Brixton Road	159325.5
Wandsworth - Lavender Hill (Clapham Jct)	156128.8
Hounslow Chiswick	153551.4
Ealing - Hanger Lane Gyratory	1465350

Table 3: top 10 areas with total measurement

3.7.1 Bar chart for the spread levels of PM10 in the top 5 areas, organized by month

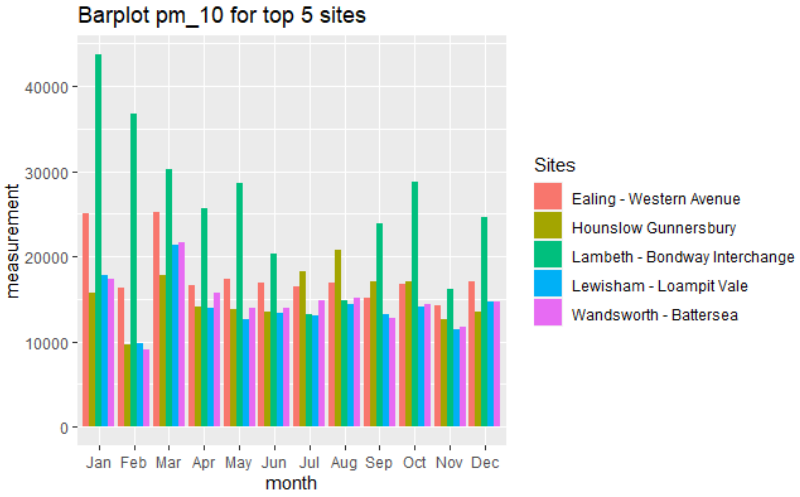

Figure 9: Barchart for spread levels in top5 months

The bar chart highlights the measurement trends in the top 5 areas for each month. Notably, Lambeth-Bondway Interchange consistently recorded the highest measurements over the past 12 months, with identical measurements observed in March and October. Ealing and Western Avenue exhibited consistent air gas measurements in January and March, while measurements across other months remained relatively stable. Conversely, Lewisham-Loampit Vale consistently registered lower values compared to the other sites in most months.

3.8 Pm2_5

Hackney - Old Street, Hounslow - Chiswick, and Westminster - Elizabeth Bridge were measured for PM2.5 gas. These areas showed elevated measurements, particularly in January and March. In January, Hackney - Old Street recorded an average air temperature of 10.04211. In March, Hounslow - Chiswick and Westminster - Elizabeth Bridge reported temperatures of 17.99203 and 17.09194, respectively.

3.8.1 Trend for pm2_5 gases on January and March in 3 sites

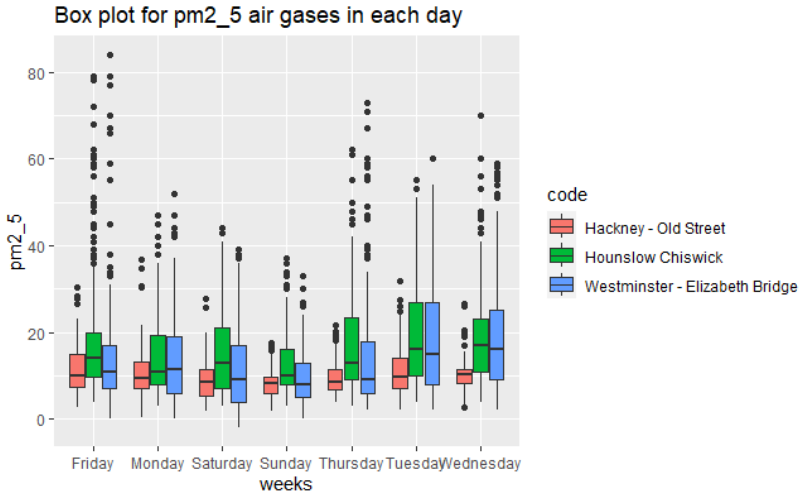

Figure 10: Trend for pm2.5 each weeks

The graph illustrates the trend of PM2.5 gas measurements for each weekday in January and March. According to the plot, Hounslow-Chiswick consistently registers higher measurements compared to Hackney-Old Street, which exhibits lower measurements. Notably, Thursday emerges as the day with the highest measurements among the weekdays.

3.8.2 line chart for measure level in pm2_5 on Tuesday

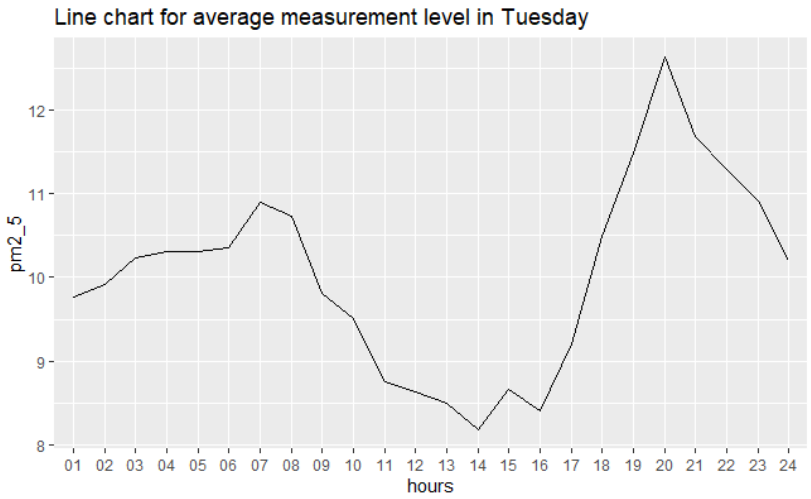

Figure 11: Treand over Thursday

The chart depicts the hourly average measurements on Tuesday. From 1 a.m. to 8 a.m., there is a slight increase, followed by a decrease until 2 p.m. At 2 p.m., there is a dip in measurements, which is succeeded by an increase at 3 p.m. and a subsequent decrease at 4 p.m. After 4 p.m., measurements steadily increase until 8 p.m., after which there is a decline. When comparing day and night, higher levels are measured during the night.

3.9 Sulfer dioxide(So2)

3.9.1 Line chart to illustrate the spread of SO2 levels each month in Lambeth - Bondway Interchange

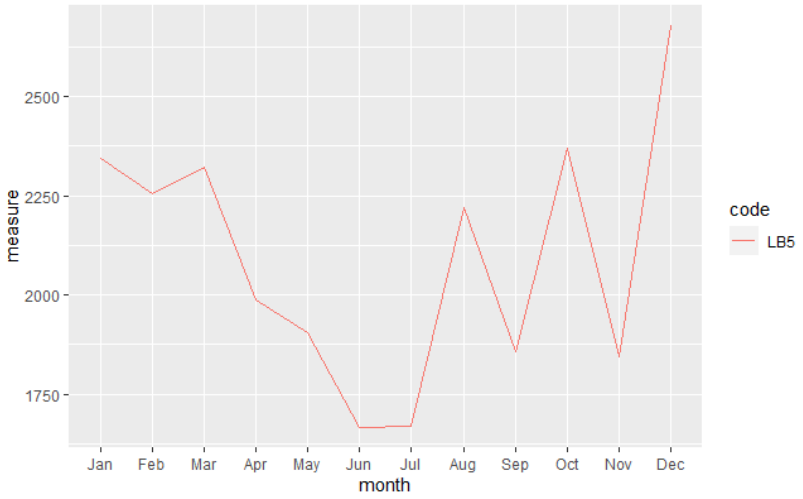

Figure 12: Spread of So2 each month in Lambeth

Sulfur dioxide is primarily concentrated in the Lambeth-Bondway Interchange area. The chart illustrates its dispersion each month. Following March, the measurement levels steadily decreased until June. Subsequently, the measurements remained consistent until July, after which fluctuations were observed between months

4 conclusion

In conclusion, our study aimed to analyze air quality trends across London, focusing on pollutants like NO, NO2, NOx, O3, SO2, PM10, and PM2.5. As we delve into our findings, it's evident that this research significantly enhances our understanding of London's air quality dynamics.

Our analysis reveals that air quality is not tied to the specific location of monitoring sites in London. Regardless of longitude, nitrogen oxide (NOx) consistently dominates overall gas measurements, indicating its central role in shaping air quality trends. Monthly evaluations consistently show elevated levels for both ozone (O3) and nitrogen oxide (NOx), highlighting the intricate dynamics governing air quality in London.

The nitrogen group's three gases exhibit a consistent trend. Additionally, significantly elevated measures are observed across monitored sites in January and December, particularly on Thursdays and Fridays around 8 a.m. This suggests a potential weekly pattern where air quality peaks at specific times.

Ozone (O3) consistently records high measurements in February, April, and August. Richmond Upon Thames reports elevated ozone levels on Saturdays at 3 p.m. For PM10, Lambeth - Bondway Interchange and Ealing - Western Avenue are notably affected. PM2.5 peaks on Tuesday nights, revealing a distinct nightly trend. Nighttime measurements across various gases are notably higher when compared to daytime levels. SO2 primarily impacts Lambeth - Bondway Interchange, while NOx has a higher influence in this area compared to SO2. SO2 maintains consistent levels throughout all months. Remarkably, Hackney - Old Street is the only site where all six gases appear, with NOx being highly affected and PM2.5 showing lower impact.