Methods of Advance Data Engineering – Data Report

How does the concentration of pollutants NO2 and O3 change throughout the day in Cuxhavener Straße, and what could be the possible reasons for it?

Introduction

Understanding the dynamics of NO2 and O3 pollutants in urban environments is crucial for addressing air quality issues. Nitrogen dioxide (NO2), primarily emitted from vehicles and industrial activities, is a harmful pollutant known to cause respiratory problems. Its concentration typically peaks during morning and evening rush hours due to increased traffic. In contrast, ozone (O3) is formed through the reaction of NO2 and volatile organic compounds (VOCs) in the presence of sunlight. While beneficial in the upper atmosphere, ground-level ozone is harmful, leading to respiratory issues. O3 concentrations generally peak in the afternoon with the highest sunlight intensity and decrease at night. Several factors influence these patterns: traffic emissions, photochemical reactions driven by sunlight, weather conditions like wind and temperature inversions, and industrial activities. By examining how NO2 and O3 levels change throughout the day in areas like Cuxhavener Straße, we can better understand their interplay and develop effective air quality management strategies. This knowledge is vital for reducing health risks and creating healthier, more sustainable urban environments.

Data Sources

Two data sources have been used from www.govdata.de.
In order to protect human health and vegetation from the effects of excessive air pollution, air quality is continuously monitored and assessed in accordance with legal regulations.

For this purpose, the State Office for the Environment (LfU) in Schleswig-Holstein operates a network of measuring stations at which air pollutants are measured using various methods.

The measurement data from Schleswig-Holstein and a lot of additional information on the measurements are forwarded to the Federal Environment Agency and from there reported to the European Commission together with the data from all federal states.
The data links are mentioned below:

1. https://www.umweltbundesamt.de/api/air_data/v2/measures/csv?data%5B0%5D%5Bst%5D=1562&data%5B0%5D%5Bco%5D=3&data%5B0%5D%5Bsc%5D=2&date_from=2024-01-01&time_from=1&date_to=2024-12-31&time_to=24&lang=en
2. https://www.umweltbundesamt.de/api/air_data/v2/measures/csv?data%5B0%5D%5Bst%5D=1562&data%5B0%5D%5Bco%5D=5&data%5B0%5D%5Bsc%5D=2&date_from=2024-01-01&time_from=1&date_to=2024-12-31&time_to=24&lang=en

Get to Know the Data

The data sources that have been used contains data of concentration of pollutants NO2 and O3 in µg/m^3 throughout the day for every hour for the year 2024.
The data contains information about state, measuring station, time of the day when measurement has been made, the concentration of pollutant at specific time interval and the unit used.

Data Format

There are two data formats available:

1. CSV
2. JSON

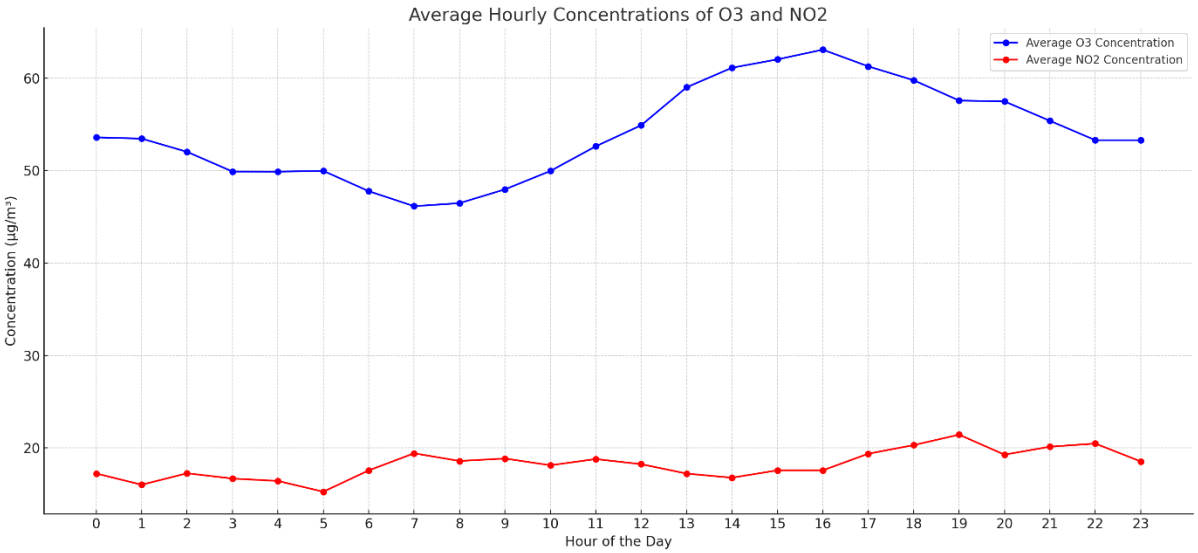
Both the data formats fall under the structured data category.

Data Pipeline

The technology being used for data pipeline are Python and sqlite. The data is being read from the data sources mentioned above and then the data is being cleaned and written to the sqlite file. In the sqlite file, two tables are created one for each pollutant i.e NO2 and O3.
The data cleaning steps involves removing rows against which there was missing value of pollutant concentration. Furthermore, a few columns were dropped because they contain data that is of no use for our analysis and pipeline. The data is continuously being updated after every hourly time interval and the implemented data pipeline takes care of it.

Analysis

Here's the combined graph showing the average hourly concentrations of O_3 and NO_2. This visualization allows you to compare the typical daily patterns of both pollutants side by side



The combined graph of average hourly concentrations for O_3 (ozone) and NO_2 (nitrogen dioxide) displays distinct daily patterns for each pollutant, which can be influenced by various environmental and human factors:

O_3 (Ozone)

Ozone typically shows higher concentrations during the day. This is because O_3 is formed through photochemical reactions involving sunlight, nitrogen oxides (NOx), and volatile organic compounds. As sunlight intensity increases, more O_3 is produced. The peak often occurs in the early afternoon when sunlight and temperatures are highest, aiding the chemical reactions that produce ozone.

Concentrations drop towards the evening and during the night because the photochemical reactions that produce ozone are not emitted in the absence of sunlight.

NO_2 (Nitrogen Dioxide)

NO_2 concentrations typically peak during early morning and late afternoon or early evening. These peaks align with rush hour traffic times, suggesting a strong link to vehicular emissions, as cars are major sources of nitrogen oxides.

The dip in NO_2 levels around midday might be partly due to increased atmospheric mixing which disperses pollutants more effectively and also due to a shift in the chemical balance between NO and NO_2 catalyzed by sunlight, converting NO_2 to other nitrogen species.

Interaction Between O_3 and NO_2

There's an interesting interplay between O_3 and NO_2: NO_2 can lead to the formation of O_3, but O_3 itself can react with NO to convert back to NO_2, showing a dynamic balance influenced by sunlight and traffic patterns.

Conclusion

To conclude with, we can say that the concentration of pollutants O3 and NO2 are being caused by various human activities and environmental phenomena. Urban planning and traffic management can have significant impacts on these pollutants' levels, as can regulations aimed at reducing emissions from vehicles and industrial sources.