Final Project Report

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Vehicular Activities and its Contribution to Particulate Matter Levels: An Analysis of Air Quality Index and AQI Bucket in Delhi

Abstract

This project entails an exploratory analysis of two datasets: one containing daily Air Quality Index (AQI) readings for major air pollutants in Delhi, India, and the other comprising vehicle data spanning from 2015 to 2020. Utilizing the Pandas library for data analysis and manipulation, the study establishes a correlation between particulate matter (PM2.5 and PM10) concentrations and AQI values, demonstrating a strong dependence of AQI values on particulate matter concentrations, particularly PM10. Notably, particulate matter AQI values consistently surpassed those of other air pollutants, emerging as the primary contributor to elevated AQI levels in Delhi. A longitudinal examination revealed a parallel trend between average particulate matter AQI and the percentage increase in vehicles within Delhi, indicating vehicular activity as the predominant factor driving heightened particulate matter levels. This encompasses emissions from vehicles as well as the dispersion of road dust into the atmosphere, largely attributable to the substantial volume of vehicles traversing unpaved roads across Delhi.

Keywords: Air Quality Index (AQI), Particulate Matter (PM2.5 and PM10), Vehicles, Emissions

Introduction

"The AQI is a yardstick that runs from 0 to 500. The higher the AQI value, the greater the level of air pollution and the greater the health concern" (*AQI Basics | AirNow.gov*, 2024). It was seen that for the majority of the days for five years the AQI values fell into the AQI bucket of 'Moderate', 'Poor', and 'Very Poor'.

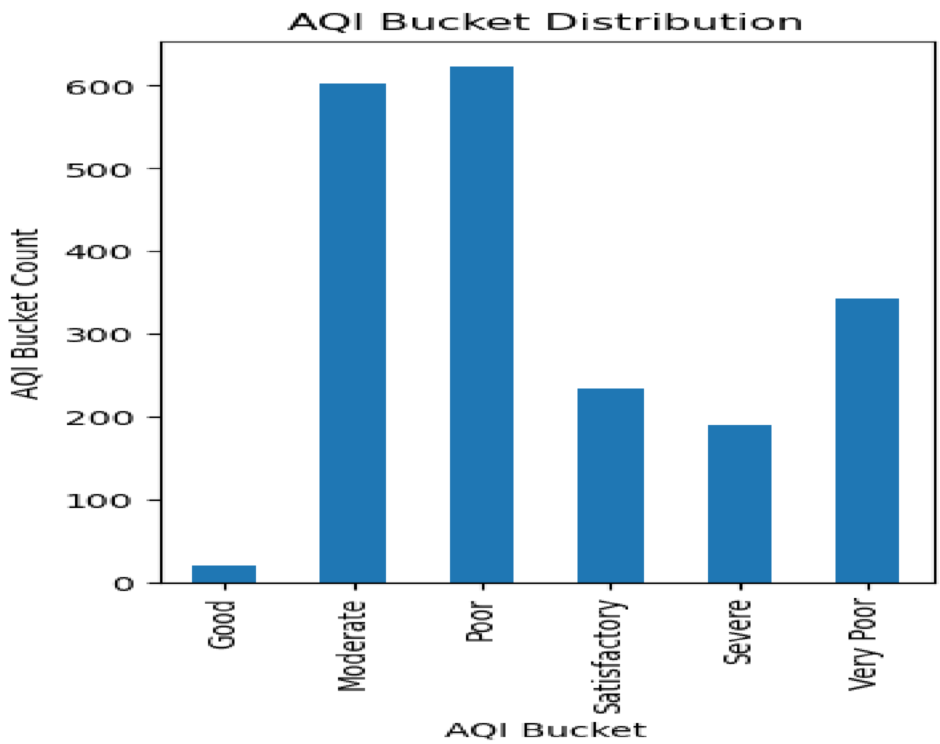

Figure 1: AQI Bucket Distribution

AIR QUALITY INDEX (AQI)	CATEGORY
0-50	Good
51-100	Satisfactory
101-200	Moderate
201-300	Poor
301-400	Very Poor
401-500	Severe

Figure 2: Air Quality Standards

Source: (Ahuja, 2019)

The AQI value for a given day is determined by identifying the highest among all AQI values attributed to various pollutants present in the air. Upon analyzing the AQI values for each day, it became evident that they consistently skewed towards the upper end of the spectrum, as illustrated by the distribution depicted in Figure 1.

This project aims to delve into the underlying reasons behind the persistently high AQI values and ascertain the factors contributing to these elevated levels. This inquiry holds significant importance as it offers valuable insights into strategies for mitigating air pollution, a pressing concern that ranks as the second-largest public health threat in India, trailing only child and maternal malnutrition (None Chetna et al., 2023).

Methods (Acquisition of Data and Analysis)

The Air Quality Index dataset was sourced from Kaggle, while the vehicle dataset was acquired from Open City Urban Data Portal. Upon loading both datasets into data frames and filtering them to align with the project's scope, it was discovered that the AQI value column had been inaccurately computed, leading to incorrect AQI bucket assignments. To rectify this, the AQI and AQI bucket columns were initially dropped and then recalculated using custom functions and conditional statements.

Within the AQI dataset, twelve pollutants are identified, including PM2.5, PM10, NO, NO2, NOx, NH3, CO, SO2, O3, Benzene, Toluene, and Xylene. The initial step involved determining the pollutant(s) with the highest values in each row, as this information dictates the AQI value and subsequently determines the AQI bucket. This process unfolded in two phases: firstly, by generating a correlation heatmap of the numeric columns to pinpoint pollutants with the strongest correlation to AQI values. Secondly, by visually assessing the influence of particulate matter and other pollutants on the distribution of AQI buckets.

The overarching objective was to diminish particulate matter (PM2.5 and PM10) by 50% while preserving the original values of other pollutants, and conversely, to reduce other pollutants by 50% while retaining the particulate matter values. This approach allowed for an exploration of the resultant effects on the distribution of AQI buckets.

Furthermore, to examine the impact of vehicle emissions on particulate matter, the average PM2.5 and PM10 values were calculated for each year and grouped accordingly. These metrics were then juxtaposed with the percentage increase in vehicles observed year by year.

Results and Discussion

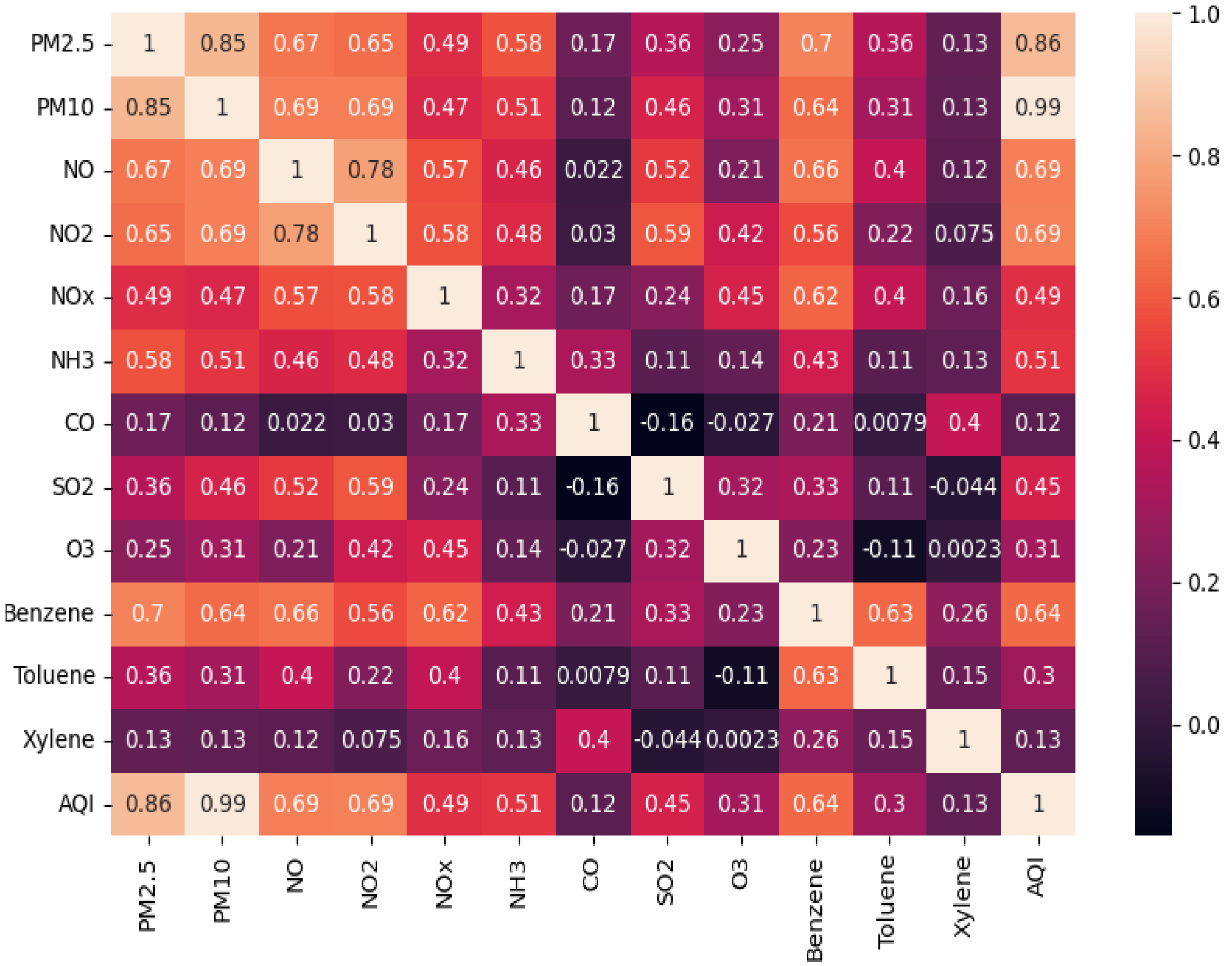

Figure 3: Correlation Heatmap

Figure 3 illustrates a strong correlation between AQI values and both PM2.5 and PM10, with PM10 exhibiting the highest correlation coefficient of 0.99.

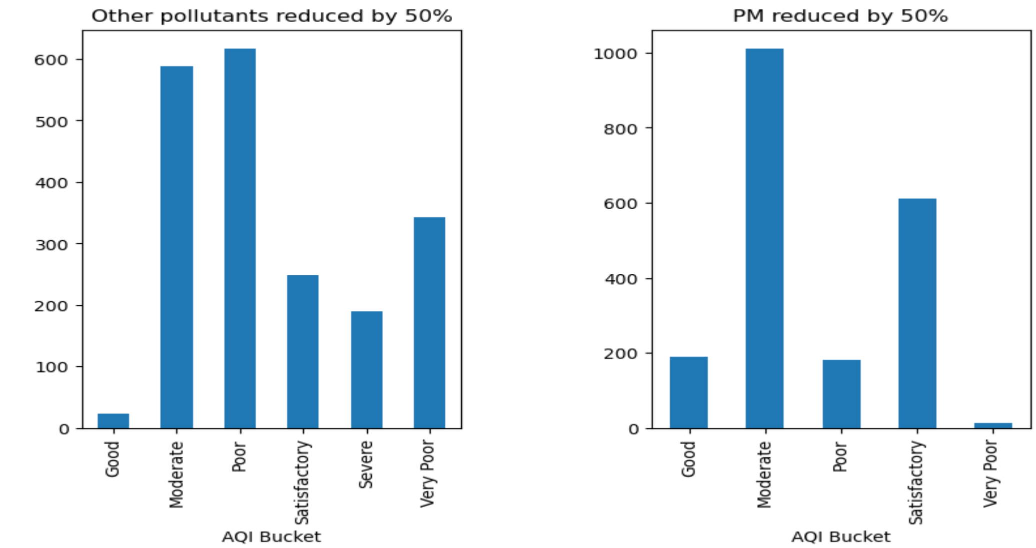

Figure 4: Impact of Particulate Matter on AQI Bucket

Figure 4 demonstrates that particulate matter consistently contributes the highest AQI values across all rows in the dataset. Following its reduction, the AQI bucket distribution shifts towards healthier categories, effectively eliminating the 'Severe' category. Conversely, reducing other pollutants does not alter the AQI bucket distribution, which remains unchanged from that depicted in Figure 1.

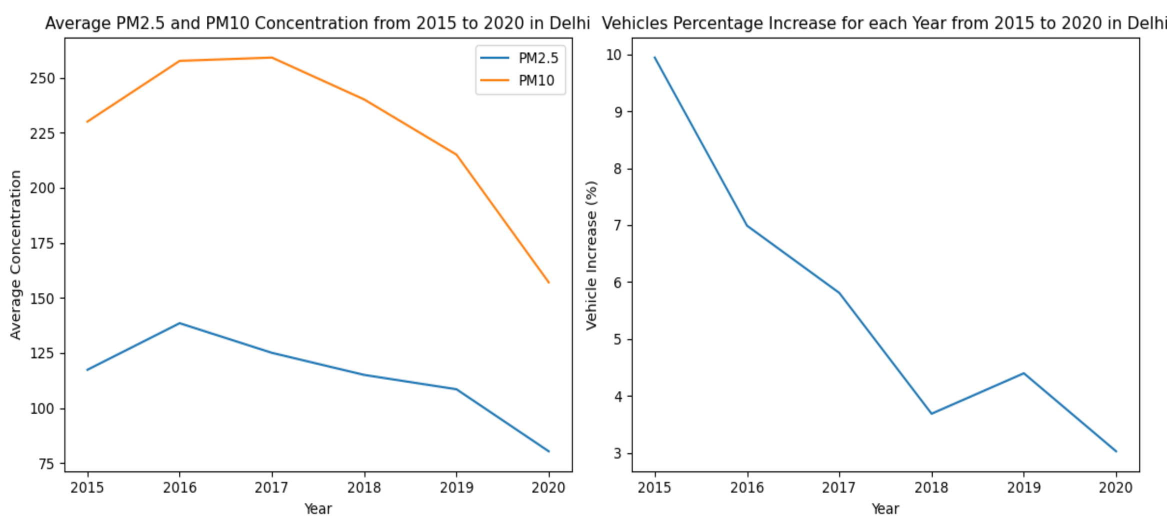

Figure 5: Particulate Matter Levels and Vehicle (%) Increase Trend from 2015 to 2020 in Delhi, India

The preceding visualizations reveal a consistent trend between the average particulate matter and the percentage increase in automobiles from 2015 to 2020, both showing a gradual decrease over the years. However, it's noteworthy that the sharp decline in both plots observed in 2020 can be attributed to the global COVID-19 pandemic. Despite the declining trend in average particulate matter concentration (AQI) over the years, the AQI values remain elevated, reaching their lowest average value in 2019 (excluding 2020) at 215, categorized as 'Poor'.

A study published in the Indian Journal of Community Medicine in 2013 reported that Delhi emitted approximately 3000 metric tons of air pollutants daily, with vehicular pollution contributing significantly (67%) (Rizwan et al., 2013). Another investigation conducted in 2016 analyzed the sources and average levels of various air pollutants in Delhi. It revealed that 38% of PM2.5 pollution originated from road dust, 20% from vehicles, 12% from domestic fuel burning, and 11% from industrial point sources (Mukesh & Dikshit, 2016).

Conclusion

In conclusion, the analysis conducted on the data from 2015 to 2020 and other credible sourced articles from the same period underscores the significant impact of vehicular activities on the levels of particulate matter in the air of Delhi. These activities encompass not only emissions but also the dispersion of road dust into the atmosphere, particularly exacerbated by the substantial volume of vehicles navigating unpaved roads within the city. This finding highlights the urgent need for comprehensive measures to mitigate vehicular pollution and improve air quality in Delhi Enforcing stringent emissions regulations, bolstering road infrastructure, and advocating for sustainable transportation solutions, including the adoption of electric vehicles, are pivotal measures in combating this urgent environmental challenge and protecting public health.

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