

Is the world dying? Are pollutants responsible for temperature change and Global Warming?

A report to understand the relationship between the increased amounts of pollutants and the temperature change in Indian cities.

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1. Introduction

This report answers our main question “Does temperature changes with the increase/decrease in pollutants in the air?”. In this report we will perform exploratory data analysis on the pollution and temperature data gathered from six main cities in India. India is country with appx 1.4 billion people residing. The large amount of people can be result in release of high amounts of the pollutants in the air. With each day passing, we can see adverse weather conditions that could be a consequence of the increased amounts of pollutants.

2. Data

Data sourced from Kaggle was processed using a custom pipeline ('pipeline.sh') to import two datasets: one containing temperature and precipitation data (including columns like 'date', 'tavg', 'tmin', 'tmax', 'prcp') for six Indian cities, and another with daily average pollutant levels (PM2.5, PM10, NO, NO2, NOx, NH3, SO2, CO, Ozone, Benzene). The datasets were merged post-preprocessing in 'preprocessing.ipynb' for detailed analysis, with statistical summaries available for 'delhi_merged.csv' and 'mumbai_merged.csv'.

Data columns (total 15 columns):				RangeIndex: 4589 entries, 0 to 4588			
#	Column	Non-Null Count	Dtype	#	Column	Non-Null Count	Dtype
0	date	4589 non-null	datetime64[ns]	0	date	4589 non-null	datetime64[ns]
1	tavg	4587 non-null	float64	1	tavg	4589 non-null	float64
2	tmin	4348 non-null	float64	2	tmin	3940 non-null	float64
3	tmax	4540 non-null	float64	3	tmax	4286 non-null	float64
4	prcp	1250 non-null	float64	4	prcp	1943 non-null	float64
5	PM2.5 (ug/m3)	3208 non-null	float64	5	PM2.5 (ug/m3)	1231 non-null	float64
6	PM10 (ug/m3)	1755 non-null	float64	6	PM10 (ug/m3)	1104 non-null	float64
7	NO (ug/m3)	3549 non-null	float64	7	NO (ug/m3)	1158 non-null	float64
8	NO2 (ug/m3)	3547 non-null	float64	8	NO2 (ug/m3)	1169 non-null	float64
9	NOx (ppb)	3581 non-null	float64	9	NOx (ppb)	2519 non-null	float64
10	NH3 (ug/m3)	2519 non-null	float64	10	SO2 (ug/m3)	1245 non-null	float64
11	SO2 (ug/m3)	3038 non-null	float64	11	CO (mg/m3)	2984 non-null	float64
12	CO (mg/m3)	2921 non-null	float64	12	Ozone (ug/m3)	1193 non-null	float64
13	Ozone (ug/m3)	3096 non-null	float64	13	Benzene (ug/m3)	3011 non-null	float64
14	Benzene (ug/m3)	1379 non-null	float64	14	Toluene (ug/m3)	2530 non-null	float64

dtypes: datetime64[ns](1), float64(14)
memory usage: 537.9 KB

Figure 1: A brief description of the data and the datatypes of Delhi and Mumbai dataset

3. Licences

- The dataset 1 holds a [CC0: Public Domain](#) licence that has no copyrights it is available in public domain.
- The dataset 2 hold the [CC BY-NC-SA 4.0](#) licence that allows us to freely copy and share it.

In order to comply with these restrictions, our project will lie under the ‘Open Data Licence’ so that it can be further used and improved by anyone.

4. Analysis

This analysis explores the relationships between air pollutants and temperature using data collected over a 4 year from 2019 to 2022. Through statistical methods and visualizations, we aim to uncover potential correlations and trends that may illuminate how various pollutants interact with local temperature patterns.

4.1. Correlation Analysis

A heatmap displaying correlation coefficients visually illustrates the relationships between average temperature and different pollutants, where color intensity signifies the strength of correlation. Analysis of the correlation matrix (Figure 2) indicates pollutants impact temperature, notably affecting cities like Mumbai and Bangalore. Notably, ozone consistently emerges as a significant pollutant across all plots, positively correlating with temperature suggesting that higher ozone levels correspond to increased temperatures.

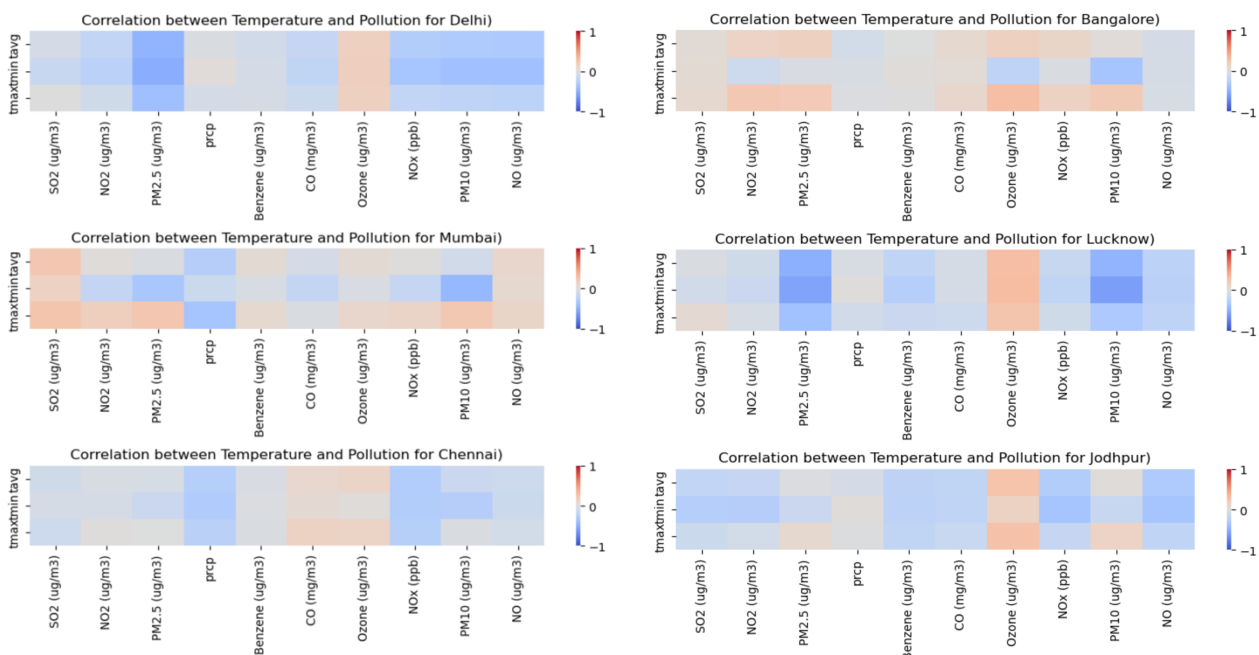


Figure 2: Coorelation Maxtrix showing the coorelation of pollutants wrt Temperature

4.2. Time Series Line Plots

The line plot shows a consistent upward trend in pollutant levels over time, specifically depicting increasing concentrations of PM_{2.5} and PM₁₀ and the change in temperature over time.

4.2.1. Pollutants Line Plots

As we can depict from the pollutants graph, the PM_{2.5} and PM₁₀ concentration has been increased over time and we inferred from the coorelation matrix that they are interlinked. However there was some lack of the data in some graphs. PM₁₀ is a major pollutant with higher concentration in each and every graph. We also see that Delhi is the most polluted city in terms of PM_{2.5} and PM₁₀ levels as it has the highest values of these pollutants.

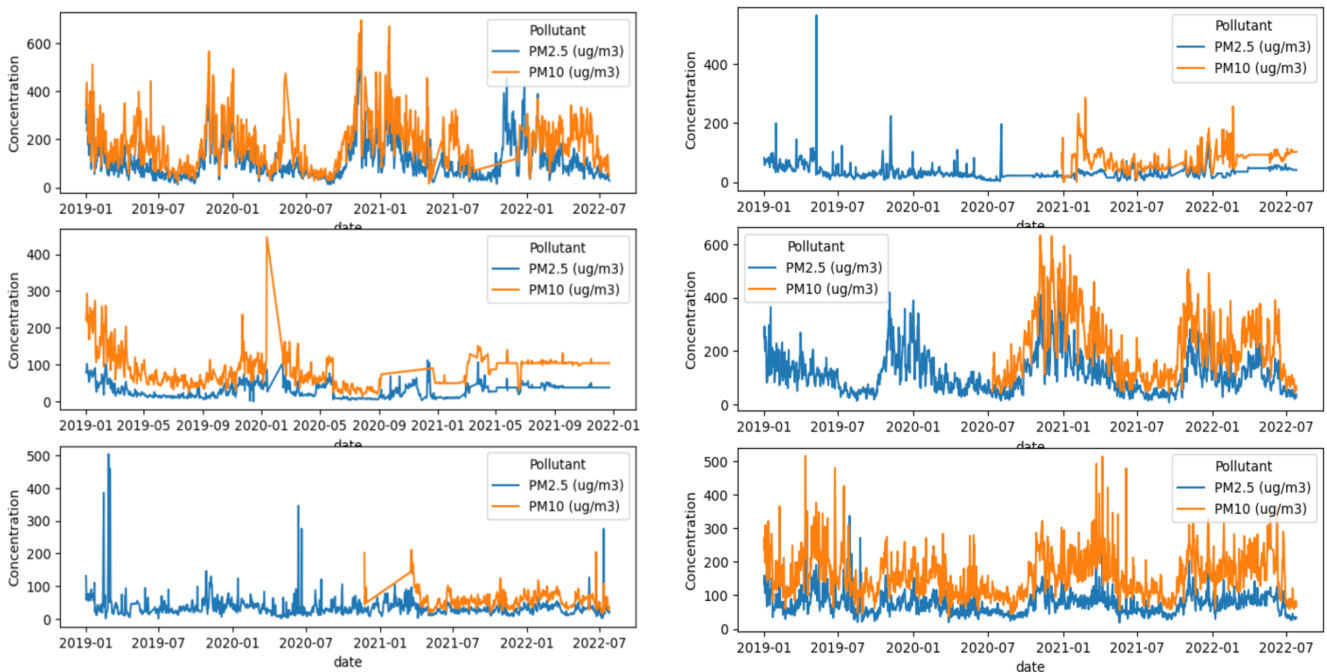


Figure 3. Line Plots showing the increase in pollutants over time in 6 different cities (Delhi, Mumbai, Chennai, Bangalore, Lucknow, Jodhpur) in top-down order.

4.2.2. Temperature Line Plots

As we can depict from the temperature graph (figure 4), temperature has slightly increased over time. However with the drastic increase in the pollutants did not show a clear trend line for the temperature but there was a slight increase in temperature and these slight increases will take us to a a big problem in the upcoming years. Once again, the capital city, Delhi recorded the highest temperature of 48.1 degrees surpassing all other cities. Surprisingly, Jodhpur being close to the desserts still had the maximum of 39.2 degrees. This can easily be inferred from the amount of pollutants in Delhi.

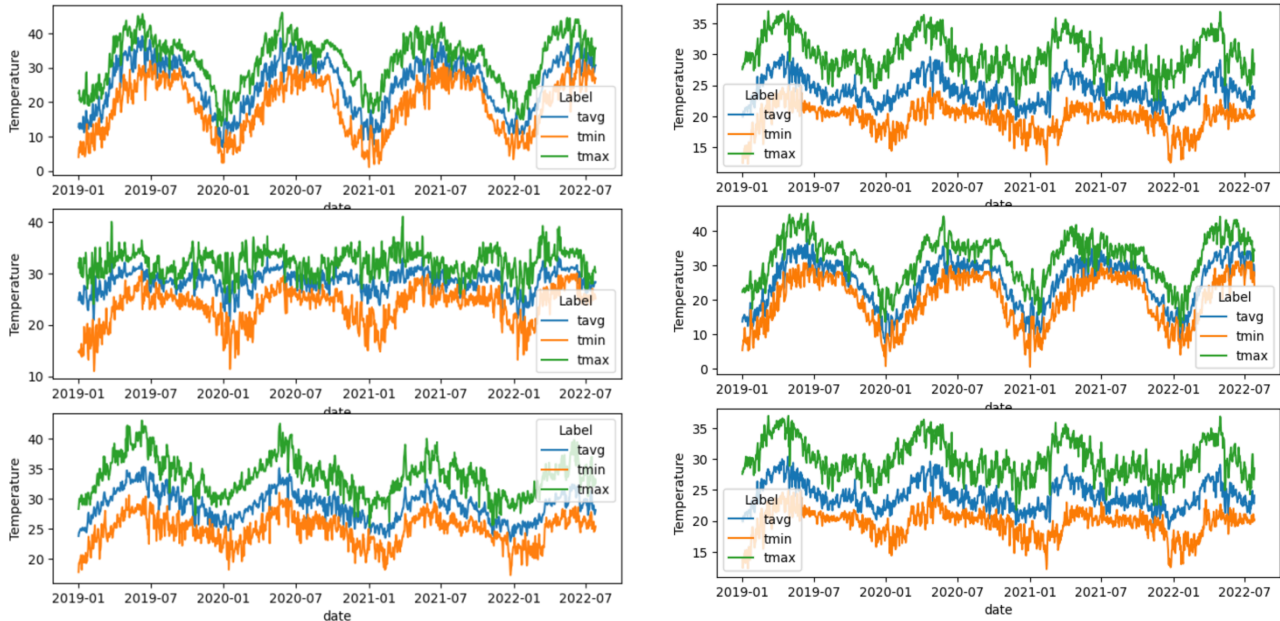


Figure 4. Line Plots showing the temperature over time in 6 different cities (Delhi, Mumbai, Chennai, Bangalore, Lucknow, Jodhpur) in top-down order.

5. Conclusion

Based on the analysis of pollution and temperature data from six major cities in India, it is evident that there is a significant correlation between increased pollutant levels, particularly PM_{2.5} and PM₁₀, and rising temperatures over the studied period from 2019 to 2022. The data shows a consistent upward trend in pollutant concentrations, especially in Delhi, which correlates with higher temperatures observed across all cities. While the analysis provides valuable insights into these relationships, uncertainties remain regarding the precise causative mechanisms and the long-term implications of these trends. Further research and monitoring are crucial to fully understand and mitigate the environmental impacts highlighted in this study.

6. Future Work

- Conduct deeper statistical modeling to elucidate causal relationships between pollutants and temperature variations.
- Expand data collection to include more cities and longer time periods for a comprehensive nationwide analysis.
- Integrate meteorological factors like wind patterns and humidity to refine the understanding of local climate impacts.
- Study how factors like people's activities and economic conditions impact pollution levels and how policies can address them.