Modeling the stubble burning generated airborne contamination with air pollution components through MATLAB

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Abstract

Air pollution is one of the significant environmental issues. It can cause adverse health effects such as cancer, cardiovascular diseases, and high mortality rates. High population density is a huge contributory factor of air pollution in cities and urbanized areas. Other sources of air pollution are transport, local heating, and possibly a pollution transfer from neighboring industrial regions. Information about the opening and closing of industrial plants, stubble burning, and fireworks can be considered an added value to this work. In recent past years, among the Delhi/National Capital Region. The pollution level has been raised multiple times during November and March months. The most significant root cause of this trouble is stubble-burning air pollution in the neighboring cities like Punjab and Haryana. Another concern is the burning of fireworks in these months due to Diwali and other festivals in the cities. This research paper aims to perform a data-based analysis on the PM2.5 and PM10 concentration levels of the past six years month-wise from the authenticated sources to find out the causes of extreme air pollution levels. This research paper deals mainly with long-term time series, including air pollutants PM2.5, PM10, and other meteorological variables. It models and analyzes the PM2.5 and PM10 values for 2014–2018. The present research work also deals with the facts and methods to handle the high air pollution rate in Delhi/NCR caused by stubble burning and analysis the effect on the environment by the call of Honorable Prime Minister of India Shri Narendra Modi Ji for the illusion of candles as a symbolic fight against COVID 19.

Keywords Urban area · Emission · Stubble burning · PM2.5 · PM10 · Industry · Burning of fireworks · Air pollution

Introduction

Air pollution has been a serious concern for the Delhi/NCR. Various studies and research have been conducted to find out the root cause of high API (Air Pollution Index) in the region. This research work discussed how stubble burning and crackers affect the API factors rapidly and produce dangerous smog all over the region. ISR Report consists of API data collected of Delhi (NCR) which brings to analysis of API factors of every two months across the year. The present research work analysis the records of the past six years API factors which affected badly and continuously by stubble burning and crackers. API is divided into seven factors: PM2.5, NO2, NH3, SO2, OZONE, PM10 Table 1 represents the AQI pollution index standards in India. The major factors which affected directly by stubbled burning and burning of Diwali crackers are PM2.5 and PM10. They directly contribute to the high range of pollution in API (World Bank and Institute for Health Metrics and Evaluation 2016; Menon 1988). In the current research work, Matlab has been used to generate comparative graphs to analysis the PM2.5 and PM10 values with stubble burning data for the six years.

Stubble burning

Stubble burning is intentionally setting fire to the straw that remains after grains, like paddy, wheat, etc., mostly found in Punjab and Haryana in the month of January or sometimes in the month of November, depending upon farmer to farmer. The burning of stubble, contrasted with alternatives such as plowing the stubble back into the ground or collecting it for
industrial uses, has several consequences and effects on the environment. The pollutants that emit are the burning of straw directly affects the two most important pollutants of API factors that are PM2.5 & PM10 (Massey et al. 2009; Sharma and Mathur 2020; Sharma et al. 1998).

Generally helpful effects are

- Kills slugs and other pests.
- Can reduce nitrogen tie-up
- Loss of nutrients.
- Pollution from smoke.
- Damage to electrical and electronic equipment’s from floating threads of conducting waste (Rastogi et al. 2020; Gautam et al. n.d.).

Results and discussions

Analysis of January & February for PM2.5

Figure 1 is the graph of PM2.5 for the past six years. This graph analysis the data of consecutive two months, that is, JANUARY & February for the last six years of one of the factors of air pollution that is PM2.5. So in this graph, we can see that in 2019 years in the month of January the highest pollution is measured in last six years, and the major reason behind that is stubble burning which is mostly seen in the month of January, and that is the most major reason for increasing pollution nowadays. We can see that easily that in the month of February there is not much increase in pollution as compared to the month of January there are slightly up and down in the range of pollution. We can also analysis that there is a continuous increase in pollution from 2014 to 2019 and a slight down in the year 2017 the month January. Using correlation formula, has derived the following graph, which depicts the monthly comparison of PM2.5 and PM10 values in a year.

The formula for correlation analysis:

\[
r = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}}
\]

where 
\( \bar{x} \) and \( \bar{y} \) are the sample means average of quantity 1 and average of quantity 2.

Analysis of January & February for PM10

Figure 2 indicates the graph of PM10 for the past six years. This graph analysis the data of two consecutive months is January & February, for the last six years of one of the factors of air pollution that is PM10. So, in this graph, we can see that in 2019 years in the month of January, the highest pollution is measured in the last six years, and the major reason behind that is stubble burning which is mostly seen in the month of January, and that is the most major reason for increasing pollution nowadays. We can see that easily that in the month of February there is not much increase in pollution as compared to the month of January there are slightly up and down in the range of pollution. We can also analysis that there is a continuous increase in pollution from 2014 to 2019 and a slight down in the year of 2017 for the month of January.

Analysis of March & April for PM2.5

Figure 3 shows the graph of PM2.5 for past 6 years. This graph analysis the data of consecutive two months that is March and April for last 6 years of one of the factors of air pollution index (API) that is PM2.5. So, in this graph we can see that in year 2014 in the month of April the highest pollution is measured and even in year 2015 a high pollution is measured in the month of April only as compared to other years. Also, in last 6 years and the major reason behind that is pollution emanating from factories and the vehicle’s which
is mostly seen in the month of April. We can see that easily that in the month of March there is not much increase in pollution as compared to month of April but there is slightly increment in the range of pollution from 2015.

**Analysis of March & April for PM10**

So below is the graph of PM10 for the past six years shown in Fig. 4. This graph analysis the data of two consecutive months that is March and April, for the last six years of one of the factors of API that is PM10. So, in this graph, we can see that in the year 2014, in the month of April, the highest pollution is measured, and even in the year 2017, high pollution is measured in the month of April as compared to other years. In the last six years and the major reason behind that is pollution emanating from factories and vehicles, which is mostly seen in the month of April. We can see that in the month of March for the year 2019, there is a high increment in pollution is measured, and the reason is same which is for April too that pollutants that emitted from factories and vehicles.
Analysis of May & June for PM2.5

Figure 5 is the graph of PM2.5 for the past six years. This graph analysis the data of two consecutive months, that is, May and June, for the last six years of one of the factors of air pollution index (API) that is PM2.5. So in this graph, we can see that in the year 2019, in the month of June, the highest pollution is measured, and even in the year 2018 a high pollution is measured in the month of June only as compared to other years, and there is a rapid increment of air pollution from 2014 to 2019 which contributes 2019 the most in last six years, and the major reason behind that is heat and different pollutants emanating from factories, consumption of AC is increased, and that causes an increment of heat which is the major contribution in pm2.5, and that causes the increment in pollution which is mostly seen in the month of June. We can see that easily that in the month of May there is up and down in pollution year by year in the month of May and the reasons are excessive exposure of heat.

Analysis of May & June for PM10

Figure 6 is the graph of PM10 for the past 6 years. This graph analysis the data of consecutive two months that is May and June for the last 6 years of one of the factors of API which is PM10. So in this graph we can see that in year 2019 in the
month of June the highest pollution is measured and even in year 2018 a high pollution is measured in the month of June only as compared to other years and there is a rapid increment of air pollution from 2014 to 2019 which contributes 2019 the most in last 6 years and the major reason behind that is heat and different pollutants emanating from factories, consumption of AC is increased and that causes an increment of heat which is the major contribution in pm2.5 and that causes the increment in pollution which is mostly seen in the month of June. We can see that easily in the month of May there is a downfall in pollution after the year 2016 in the month of May and the reason is change in weather but after May month there is the high increment in pollution.

**Analysis of July & August for PM2.5**

Figure 7 is the graph of PM2.5 for the past six years. This graph analysis the data of consecutive two months that is July and August for the last 6 years of one of the factors of API that is PM2.5. In this graph we can see that in year 2014 in the month of July the highest pollution is measured and it is continuous up and down in pollution from 2015 to 2019 which and the major reason behind that it is less compared to different months is change in weather the API for the month of July & August is good in range that specifies that the air is a bit free from pollution and we can see that for the month of August only in the year 2014 has high pollution from other years.

**Analysis of July & August for PM10**

Figure 8 is the graph of PM10 for the past six years. This graph analysis the data of two consecutive months, that is, July and August, for the last six years of one of the factors of air pollution index (API) that is PM10. In this graph, we can see that in the year 2014 in the month of July the highest pollution is measured and it is continuous up and down in pollution from 2015 to 2019 which and the major reason behind that it is less compared to different months is a change in
weather the API for the month of July & August is good in a range that specifies that the air is a bit free from pollution and we can see that for the month of August only in the year 2014 has high pollution from other years.

**Analysis of September & October for PM2.5**

Figure 9 is the graph of PM2.5 for past six years. This graph analysis the data of consecutive two months that is September and October for the last six years of one of the factors of API that is PM2.5. In this graph, we can see that in year 2018 in the month of October the highest pollution is measured and even in the year 2019 a high pollution is measured in the month of October and if we compare pollution range from September then there is not much pollution increment over the last six years as compare to month of October in PM2.5 and the major reason behind that is heat and different harmful particles emanating from factories, vehicles have been increased and cause an increment of heat which is the significant contribution in PM2.5 and that causes the increment in pollution which is primarily seen in the month of September.

**Analysis of September & October for PM10**

So below is the graph of PM10 for the past six years. This graph analysis the data of two consecutive months, that is, September & October, for the last six years of one of the factors of API, that is PM10. So in this graph, we can see that in the year 2014, in the month of September, the highest pollution is measured, and even in the year 2017 a high pollution
is measured in the month of September only, and after that, there is a downfall in air pollution after 2017 in last six years, and the major reason behind that is heat and different harmful particles emanating from factories, vehicles are increased, and that causes an increment of heat which is the major contribution in PM10 and that causes the increment in pollution which is mostly seen in the month of September. We can see that in the month of October to there is a high range of pollution in the year 2018 & 2019 and the reason is heat and different harmful particles emanating from factories, vehicles are increased and that causes an increment of heat which is the major contribution in pollution (Massey et al. 2009) (Fig. 10).

**Analysis of November & December for PM2.5**

Figure 11 is the graph of PM10 for past six years. This graph analysis the data of two consecutive months that is November and December for last six years of one of the factors of API that is PM10. Hence in this graph we can see that in all the years in the month of November as well as the December has the highest pollution measured and the major reason behind that is burning of Diwali crackers and while burning the Diwali crackers it emits a lots of smog in the air sometimes it also included the stubble burning factors too because in some stated they cut the stubble burning twice in the year which causes the breathing problem and contributes the high amount of pollution in the air. As we all know that October and November are the Diwali month so due to burning of crackers it leaves its impact on December too that is why the month of December is also counted as one of the most polluted months from past 6 years’ record. And the most factor which is affected by this burning is PM2.5 as compared to PM10.

Regression analysis on two variables can be done with the help of correlation and Pearson coefficients. Table 4 shows the correlation and Pearson coefficient values between the annual, monthly average temperature data and PM2.5 average monthly data of ITO, Delhi center of pollution control board (Verma et al. 2019). The table indicates that the correlation coefficient is closer to +1 or -1. It indicates a positive (+1) or negative (-1) correlation between the two quantities. A positive correlation means that if the values in one quantity increase, the values in the other quantity increase. A correlation coefficient closer to 0 indicates no or weak correlation. The results in Tables 2 and 3 indicate that even in the increase of stubble burning percentage contributing to the total level of PM2.5 in the air pollution still, there is no direct linkage of the stubble burning with the rise of temperature in the region. Hence the current investigation results are against the general conventional assumption that stubble burning contributes to the temperature rising in the region. Another Statically measurement R squared values are shown in Table 4. The formula of R squared regression fit tool is mentioned below.

**Analysis of November & December for PM10**

Figure 12 is the graph of PM2.5 for past 6 years. This graph analysis the data of consecutive two months that is November and December for last 6 years of one of the factors of air pollution index (API) that is PM10. So in this graph we can see that in all the years in the month of November as well as the December has the highest pollution measured and major reason behind that is burning of Diwali crackers and while burning the Diwali crackers it emits a lots of smog in the air which causes the breathing problem and contributes the high amount of pollution in air. As we all know that October and November are the Diwali month so due to burning of crackers it leaves its impact on December too that is why the month of December is also counted as one of the most polluted months from past 6 years’ record. And the most factor which is affected by this burning is PM2.5 as compared to PM10.
**Table 2** Buring of stubble percentage PM2.5 (Central Pollution Control Board n.d.)

| YEAR | 2019 | 2018 | 2017 | 2016 | 2015 | 2014 |
|------|------|------|------|------|------|------|
| PERCENTAGE | 197% | 181% | 143% | 171% | 151% | 145% |

**Table 3** Buring of fireworks percentage PM10 (Central Pollution Control Board n.d.)

| YEAR | 2019 | 2018 | 2017 | 2016 | 2015 | 2014 |
|------|------|------|------|------|------|------|
| PERCENTAGE | 196% | 174% | 156% | 168% | 158% | 138% |
Table 4  Regression analysis between temperature and PM2.5

| Years | Correlation coefficient | Pearson coefficient | R Squared |
|-------|-------------------------|---------------------|-----------|
| 2014  | 0.9013437956           | 0.9013437956       | 0.812420638 |
| 2015  | -0.578310694           | -0.578310694       | 0.334524661 |
| 2016  | -0.8985714087          | -0.8985714087      | 0.807430577 |
| 2017  | -0.6831840385          | -0.6831840385      | 0.343688508 |
| 2018  | -0.7063514274          | -0.7063514274      | 0.009051676 |

$r = n \frac{(\sum xy) - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2} \cdot \sqrt{n\sum y^2 - (\sum y)^2}}$

Where,
- $r$ = The Correlation coefficient
- $n$ = number in the given dataset
- $x$ = first variable in the context
- $y$ = second variable

**Conclusion**

In the present research work analyses, it has been proved that the major reasons which are contributing to the increment of air pollution are stubble burning, and after that, the smog arises from Diwali crackers. These two factors are the most responsible factors for air pollution or adversely affecting the API. Stubble burning and pollutants that emits after the burning of Diwali crater directly affect the API factors that is PM2.5 & PM10, and these both factors cause a high rate of increment in pollution every year. These findings are unlike...
the current trends and popular myth that only stubble burning from neighboring states of Delhi causes severe air pollution during this period of the year. This snapshot is the latest API Index of date 05/04/2020. On this day, our honorable Prime Minister of India, Shri Narendra Modi Ji, said to light the divas and the public of India light Diya, as well as the fireworks too and the API index, which is going well in snapshot one that is 90 with color green, rises immediately to 120 with yellow color shows moderate to rapid increment in PM10 shows that while burning fireworks rapidly affects the PM10. Figures 13 and 14 are the screenshots pollution control board data verifies the above conclusion.

未来的研究工作

在未来的研究工作中，我将继续在同一个问题域中工作，考虑到更大的数据集，并将它们应用于多个参数以获得更准确的结果。这将导致我们开发出能够解决这些问题（空气污染）的大问题的方法。在未来，我们将开发一个软件工具来监测和评估。一个软件工具可以自动化整个过程并提供进一步的管理信息。

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