IJBPAS, September, 2021, 10(9): 3204-3220

ISSN: 2277–4998

International Journal of Biology, Pharmacy and Allied Sciences (IJBPAS)

'A Bridge Between Laboratory and Reader'

www.ijbpas.com

ROLE OF AIR POLLUTION IN SPREAD OF COVID-19: A DELHI-GURUGRAM CITY CASE STUDY

RAJENDRA K[1], YADAV P[1], YADAV D[2] AND SHARMA L[3*]

1: Amity School of Earth and Environmental Science, Amity University Haryana

2: Department of Environmental Science, IBSBT, CSJM University Kanpur

3: Amity Medical School, Amity University Haryana

***Corresponding Author: Dr. Luxita Sharma: E Mail:** lakshita1982@gmail.com

Received 26th Oct. 2020; Revised 28th Nov. 2020; Accepted 12th Dec. 2020; Available online 1st Sept. 2021

https://doi.org/10.31032/IJBPAS/2021/10.9.5634A

ABSTRACT

BACKGROUND AND OBJECTIVES: Corona virus was highly uncertain and complex in space and time and nature. Atmospheric parameters such AQI, NO_2, $PM_{2.5}$ and PM_{10} etc and local weather played an important role in COVID-19 cases and its spread. Therefore, the need of whether Air pollution induced the spread of COVID-19 or not is necessary to find out. This paper aims to examine whether the air pollution parameters influenced the spread of COVID-19 or not.

METHODS: The pollution parameters like AQI, $PM_{2.5}$, PM_{10}, NO_2 data were collected from a trusted source for both the cities. And the data for COVID-19 was also collected from the online trusted sources for daily deaths and daily new cases, for both the cities. And these were plotted against each other in separate graphs to find the relation between them.

FINDINGS: The results revealed that the gaseous pollutants and COVID-19 daily cases and daily deaths for the period of Sept'2020 till 25th Nov'2020, were positively correlated. And the concerned pollution parameters when increased depicted the rise of COVID-19 daily deaths and daily new cases in the graphs for both the cities. Thus, by all analysis done from data, we can conclude that somehow "Air pollution was a factor which should be considered to relate to the spread of Covid-19 in case of Delhi-Gurugram City".

CONCLUSION: These findings may provide policy-makers with crucial information for better understanding about the effect of Air pollution on COVID-19 spread globally for

various polluted cities which suffered high wave of increased number of COVID-19 cases and deaths related to it.

Keywords: Air health; Air pollution; AQI; COVID-19

INTRODUCTION

Coronavirus disease 2019 or COVID-19, caused by Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus which is responsible for this pandemic infectious. It was first identified in December 2019 in a market in Wuhan, Hubei Province, China. Since then, COVID-19 had rapidly spread from Wuhan to the whole world through global travel and affected every-one **[1]**. On 11th March 2020, The World Health Organization (WHO) declared the COVID-19 outbreak as a global pandemic. And SARS-CoV-2 is supposed to be mainly transmitted from human-to-human through close contact, respiratory droplets, fomites, and contaminated surfaces **[1]**. Air pollution has been an on-going research focus as it is a major environmental threat to human health. And it has been demonstrated that long-term exposure to air pollution is associated with an increased prevalence of many respiratory diseases and deaths related to them **[2]**. As we all know that the exposure to air pollution is considered as the major environmental cause of several diseases and premature death around the globe. Sufficient shreds of evidence have tightly linked air pollution to the occurrence of numerous respiratory diseases, such as COPD, SARS and asthma. For example, worse air quality has also been shown to increase SARS fatality as well as to increase influenza incidence **[3]**. The hypothesis that air pollution, resulting from a combination of factors can act both as a carrier of the infection and as a worsening factor of COVID-19 disease, has been raised recently. Also, in the laboratory environment, SARS-CoV-2 showed stability in ambient aerosols, which may be a considerable source for transmission of COVID-19 **[4]**. By seeing the relationship between air pollution parameters and adverse COVID-19 health outcomes it is crucial for developing solutions to this global crisis. However, whether ambient air pollutants are associated with increased incidence of COVID-19 in realistic situations remains largely unknown. This underlying hypothesis works on whether the pre-determined particulate matter concentration can foster COVID-19 and make the respiratory system more susceptible to this infection. Preliminary findings from a study in Italy suggested that if weather conditions are stable and concentrations of particulate matter (PM) are high, the virus could create clusters with PM. In Lombardy (Italy), the

research team conducted their studies on 34 PM10 samples from an industrial area in Bergamo collected over a period of three weeks from February 21 to March 13. The study found several samples were tested positive for SARS-CoV-2 gene markers **[5]**. A study collected data from 25 cities in India, reported a direct relationship between the concentration of $PM_{2.5}$ and COVID-19 mortality **[6, 7]**.

In one of the research papers they aimed to fill the gap in the literature and proposes the first empirical assessment on the relationship between air pollution and COVID-19-related-deaths in France. To do so, they collected different sets of unique data on Particulate Matter (PM_{10} and $PM_{2.5}$) and COVID-19-related-deaths over the largest and most recent available period (from March 18th to April 27th 2020 for three major French cities (Paris, Lyon and Marseille) **[8]**.

Air Pollution & Public Health

According to WHO, air pollution is considered as the grave risk to the health of people across the globe. According to Cohen et al, 2017, air pollution is one of the major risk factor both for mortality and morbidity. From research findings by it has been recorded that air pollution directly or indirectly affects almost all the organs of the body leading to various ailments. It was recorded that with elevation in the NO_x concenteration in the atmosphere, there is an 8 per cent hike in the mortality risk **[9]**.

Air pollution is considered as the potential risk factor for many diseases and thus reducing the immunity. In the hard times of COVID-19, immunity has a major role in maintaining good health and keeping diseases at bay. Air pollution can be prevented to a major extend. This paper investigates the depth of co-relation between air pollution and mortality rate because of COVID-19 infections **[10]**.

Yaron Ogen (postdoctoral researcher at the Martin-Luther-University Halle-Wittenberg in Halle, Germany) in a DW News interview explained that he examined the environmental parameters and the region with the higher number of deaths and noticed a pattern in fatalities in China, Tehran, Northern Italy, and Madrid because these regions were surrounded by mountains so didn't allow the air pollutants to disperse and they remained closed to the ground and caused a higher number of deaths. He also said if the environment is clean, we will be healthy but if the environment is polluted, we will suffer more, and in this case because of the COVID-19 pandemic **[11]**.

Based at the Harvard T.H. Chan School of Public Health, and a leading researcher in her field, Dr. Francesca Dominici's work has been instrumental in helping the scientific community and policy makers

understand the adverse health effects of air pollution and climate change. When COVID-19 emerged as a global pandemic, she became interested in how air pollution might be connected to the pandemic. And She conducted a national study in the United States to determine the link between long-term exposure to air pollution — specifically fine particulate matter, also known as $PM_{2.5}$ — and the increased risk of death from COVID-19. Their study included 3,087 counties and 98% of the population. We found that long-term exposure to $PM_{2.5}$ increases the number of deaths due to COVID-19 by 8% after accounting for many confounding factors. However, there is no evidence to suggest that the virus is airborne, there are viruses such as chickenpox that can easily be transported via air current and do not require droplets to get in contact with the eyes or nose and thus the novel coronavirus is not considered in this category of viruses **[12]**.

Many of study evidences indicates that both short and long-term exposures to air pollutants are associated with a wide range of adverse health effects, such as higher fatality rates, increased hospital admissions and increased outpatient visits **[13]**. Some of the many reviews highlighted the links between air pollution and COVID-19 **[10, 11]**. However, up to now a limited number of data-dependent studies have been conducted to investigate the association between air pollution and COVID-19 infection and mortality. Also, The Harvard study is one of several that suggest air pollution is affecting COVID-19 mortality **[10, 11]**.

Researchers analyzing 120 cities in China found a significant relationship between air pollution and COVID-19 infection, and of the coronavirus deaths across 66 regions in Italy, Spain, France and Germany, 78% of them occurred in five of the most polluted regions. There's also evidence from previous outbreaks like SARS, which was also a coronavirus, as well as many other respiratory infections including influenza, that breathing more polluted air increased risks of death **[12]**.

Evidences from various countries where studies have been conducted are listed below individually-

Air pollution & Covid-19 in China

Zheng *et al.* found that patients with severe Covid-19 infections requiring, for instance intensive care, were two times as likely to have had pre-existing diseases, especially heart disease, strokes, chronic lung diseases and diabetes—all of which are known to be caused by air pollution **[12]**.

Xie *et al.,* analysed 120 cities in China and found a significant relationship between air pollution and COVID-19 infection after controlling for confounding factors **[13]**.

Liu *et al.,* found that places with higher levels of nitrogen dioxide pollution (10 micrograms per cubic metre) in the five years before the pandemic had 22% more Covid-19 cases, while higher levels of small particle pollution saw a 15% rise in infection rates **[15]**.

Zhou *et al.*, found that particulate matter pollution was positively associated with increased cases of COVID-19 **[16]**.

Meng *et al.,* found that air pollution was positively associated with higher fatality rates from COVID-19 **[17]**.

Pan *et al.,* found that NO2 concentration was positively associated with the transmission ability of COVID-19 **[18]**.

Air pollution & Covid-19 in Europe

The United Kingdom's Office for National Statistics found that without controlling for ethnicity, long-term exposure to fine particulate matter could increase the risk of contracting and dying from COVID-19 by up to 7% **[19]**

Ozgen*et al.* found that in the Netherlands, a municipality with 1 µg/m3 more PM2.5 concentrations will have 9.4 more COVID-19 cases, 3 more hospital admissions, and 2.3 more deaths **[20]**.

- Ogen found that of the coronavirus deaths across 66 administrative regions in Italy, Spain, France and Germany, 78% of them occurred in just five regions, and these were the most polluted **[21]**.
- Frediani *et al.,* found high death rates seen in the north of Italy correlated with the highest levels of air pollution **[22]**.
- Popovic *et al.,* found air pollution levels in England are associated with COVID-19 cases and deaths **[23]**.
- Passarini *et al.,* detected Coronavirus on particles of air pollution while investigating whether this could enable it to be carried over longer distances and increase the number of people infected **[24]**.
- Barbieri *et al.* found that higher levels of particle pollution could explain higher rates of infection in parts of northern Italy before a lockdown was imposed.**[24]**
- Coccia found that the rapid spread of COVID-19 in North Italy has been strongly associated with air pollution **[24]**.

Air pollution & Covid-19 in United States

- Hill *et al.,* found an increase in exposure to hazardous air pollutants (HAPs) is associated with a 9% increase in COVID-19 mortality **[25]**.
- Nethery *et al.,* found an association between air pollution over many years with an 11% increase in mortality from COVID-19 infection for every 1 microgram/cubic meter increase in air pollution **[26]**.
- people living in communities with more long-term exposure to tailpipe emissions were associated with higher rates of dying from COVID-19, with a 4.6ppb increase in NO_2 exposure (which primarily comes from

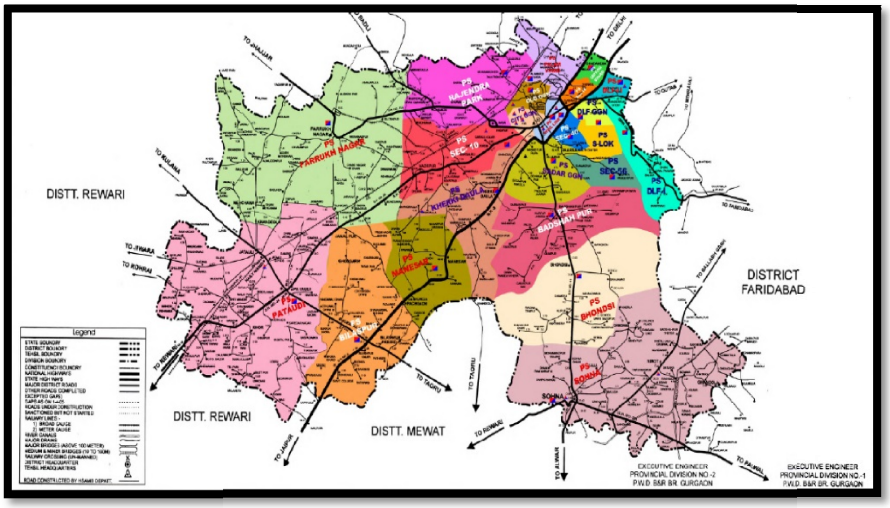
urban traffic) resulting in an 11% increase in the case fatality rate after controlling for other factors that may increase risk of dying from the disease **[27]**.

Thus, with this review I want to provide an updated state of the art relating the role of air pollution, in particular AQI, $PM_{2.5}$, PM_{10}, and NO_2, in COVID-19 daily active cases and daily deaths. Many studies have been conducted across the globe mainly in the worst COVID-19 affected countries to understand the impact of various parameters of air pollution on COVID-19 mortality and the number of cases. Therefore, it is essential to find out whether air pollution-induced the spread of Covid-19 in India also in the case of Delhi and Gurugram city in terms of the considered pollution parameters for the study.

MATERIALS AND METHODS

The proposed study considered the data for the Delhi region (National Capital of India) and for Gurugram city (Haryana State) for the period of 1stSept'2020 till 25th November'2020. The pollution parameters that were considered for the study were collected from online trusted sources and application. And the data related to Covid-19 daily new cases and daily deaths were also considered from trusted and government provided data sources. Pollution parameters considered for the study were plotted against the Covid-19 daily new cases and daily deaths for both the cities through Ms-Excel graphs with proper data of AQI, $PM_{2.5}$, PM_{10}, NO_2 and proper graphs were plotted for the conclusion of the respective case study.

(a)



(b)

Figure 1: Geographiclocation of the study area; (a) Delhi, (b) Gurugram city

RESULTS AND DISCUSSION

Data for the AQI were plotted against the daily COVID-19 daily cases and daily deaths for both Delhi and Gurugram Cities from 1st July'2020 till 25th November'2020. I chose this period because of the comparison between the air quality of Delhi and Gurugram in 2019 and 2020. So, the experts said the average AQI of September was better in 2019 mainly due to weather conditions. As per CPCB's air laboratory, said, "As there was low pressure formation in Bay of Bengal, the air didn't flow from south to north. The stagnation in the air increased the concentration of pollutants in the air and hence, AQI level went up this year in September." Also, the Officials at Centre for Science and Environment (CSE), said, "September is a transition phase between monsoon and winter and weather has a role to play. The air was cleaner in September 2019 and 2018 as the city received better rain as compared with this time." Also, it was added that, "The pollution level is rising due to unlocking phases. Though public vehicles are limited, locals are using private vehicles. Waste burning has also been observed."However, the city this year recorded a better AQI from January to August as compared with 2019. Delhi saw more polluted air in November 2020 than in 2019 **[28, 29]**. Delhi's air pollution saw an uptick due to lesser rainfall and rampant stubble burning. A major factor was large-scale stubble burning due to early harvesting this year by farmers in the neighbouring states.

Punjab alone had witnessed 76,590 incidents of stubble burning this season, which were 55,210 in 2019. Maximum incidents of stubble burning were recorded between November 4 and November 7, according to the Indian Agricultural Research Institute (IARI). Delhi's annual

problem of choking in bad air just got worse a little earlier than expected. This is the second time that the AQI crossed the 300 mark. This was also for the first time in the last four years that the quality of air in Delhi became very poor by mid-October **[30]**. Because the monsoon withdrawal happened on September 30 this year, Delhi did not receive rainfall since September 8. In 2019, the capital received moderate showers of 47.3 mm on October 4 and trace rainfall on October 1, while extended monsoon till October 10 last year. And the moderate to high rainfall helps in settling down pollutants while light rain could make air quality worse. And, the air was more contaminated this year as it only rained one day in November compared to two and three days in November 2018 and 2019, respectively **[31]**. **A**nd the Pollution crossed the emergency level twice in November this year. Despite the ban on sale and use of firecrackers by the Delhi government and National Green Tribunal, pollution levels on Diwali and the day after were at its maximum in the last four years.

As for the Gurugram City, the sharp increase in recorded instances of farm fires around Delhi-NCR this year has corresponded with the first half of November, which is seeing the highest number of 'severe' AQI days (five) in the past five years. This year, till November 12, there has only been one 'good' air day. Farm fires alone, though, do not determine AQI. Meteorological factors, wind direction and local sources also play an important part. According to the Haryana State Pollution Control Board (HSPCB), the city witnessed the worst AQI in the past five years as it had only witnessed one 'good' air day since September 1. A senior HSPCB official said. "There is not a single 'satisfactory' day in October and in November it has already witnessed five 'severe' AQI days". An official at Centre for Science and Environment, Delhi said that Deepavali being in November this year and higher number of farm fires in the end of October in neighbouring states and low temperature are the possible reasons for the high pollution in 2020 compared to 2019 **[31]**. And "Air quality was predicted to get worsen in north India due to cold waves and low temperatures said a statement by the government-run monitoring agency SAFAR.

Also, the period was just the period when cases increased on a visible scale and the pollution started to rise due to the just reopened industries and with no traffic in lockdown to people back on roads for important work and the nearby time for the Diwali. As from the above stated evidences from different sources, it is confirmed that the air quality between the period which we considered degraded on a visible scale with sufficient evidences and proofs. So, this

was the main reason, we selected that particular time of span (1st September till 25th November) for our research. And the average results of the considered parameters are discussed below in detail with comparison.

1) DELHI- NATIONAL CAPITAL

i) DAILY CASES VS AQI: [29]

The graphs plotted for Daily cases VS AQI for Delhi- National Capital depicted that the daily cases rose visibly with the change in AQI values. And by the graph it can be concluded easily that Daily Cases and AQI were positively related to visible extent, but many other factors are also there which impacted COVID-19 spread **(Figure 1)**.

ii) DAILY DEATHS VS AQI:

The graphs plotted for Daily Deaths VS AQI for Delhi- National Capital depicted that the daily deaths were already increasing at higher rate but it didn't show any co-relation with increasing deaths as such. With 6511 Deaths on 1st Nov'20 to 7060 deaths on 10thNov'20 to 7423 Deaths on 14th Nov'20 (i.e. Diwali). So, we can say that Daily Deaths and AQI were not visibly related to each other, because many other factors are also there which would have also impacted COVID-19 spread on a much larger scale **(Figure 2)**.

iii) PM10, PM2.5, NO2 VS DAILY CASES AND DAILY DEATHS: [31]

In the early period i.e. from 1st Sept'2020 till 2nd Oct'2020, the parameters didn't show the relation with daily cases. And after that the graph clearly depicts that with increasing $PM_{2.5}$, PM_{10}, NO_2 values the cases rose accordingly with highest peaks during 9th -14th Nov'2020 which was the period near Diwali Festival **(Figure 3)**.

2) GURUGRAM CITY [31-33]

i) DAILY CASES VS AQI:

The graphs plotted for Daily cases VS AQI for Gurugram City depicted that whenever there was a slight difference noted in AQI, the Daily Cases also rose and decrease accordingly as clearly seen in the graph. And data for daily cases for 11th Oct' 2020 was not provided by the official site. So, we can say that somehow the Daily Cases for Gurugram city were positively co-related to the AQI values as per the graph plotted **(Figure 4)**.

ii) DAILY DEATHS VS AQI: [32, 33]

The graphs plotted for Daily deaths VS AQI for Gurugram City depicted that the deaths didn't showed any positive relation with the AQI values. Because the daily deaths cases were very less for Gurugram City i.e. from 0 deaths at minimum and 4 deaths at maximum. And data for daily deaths for 11th Oct'2020 was not provided by the official site. So, I conclude with the help of the graph plotted that the deaths were not really co-related with AQI values for Gurugram city **(Figure 5)**.

iii) PM10, PM2.5, NO_2 VS DAILY CASES AND DAILY DEATHS: [30, 31, 33]

The daily cases showed slight positive co-relation at some points with increasing PM_{10}, $PM_{2.5}$, NO_2 values. In the early period i.e. from 1st Sept'2020 till 26th Sept'2020, the parameters didn't show the visible relation with daily cases in this period. And after that the graph clearly depicts that with increasing $PM_{2.5}$, PM_{10} values the cases rose accordingly with highest peaks during 6th -16th Nov'2020 which was the period near Diwali Festival, but the PM_{10}, $PM_{2.5}$ values showed a decrease in values but cases rose in that period, so we can't just say that the parameters were solely responsible for the increasing cases, many other factors are there which would have impacted the spread after the parameters value decreased **(Figure 6)**.

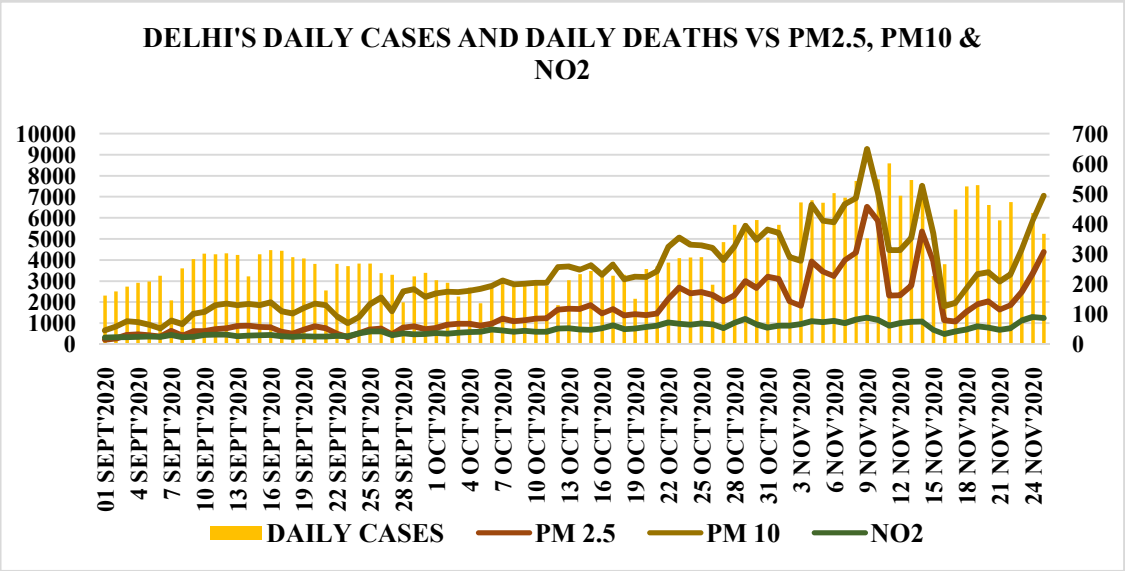


Figure 1

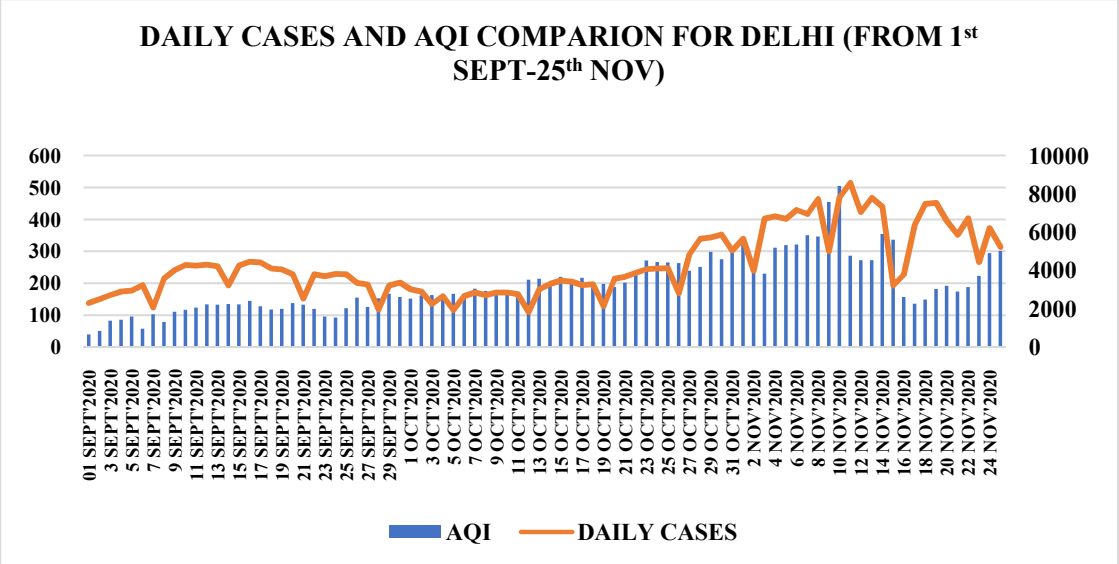


Figure 2

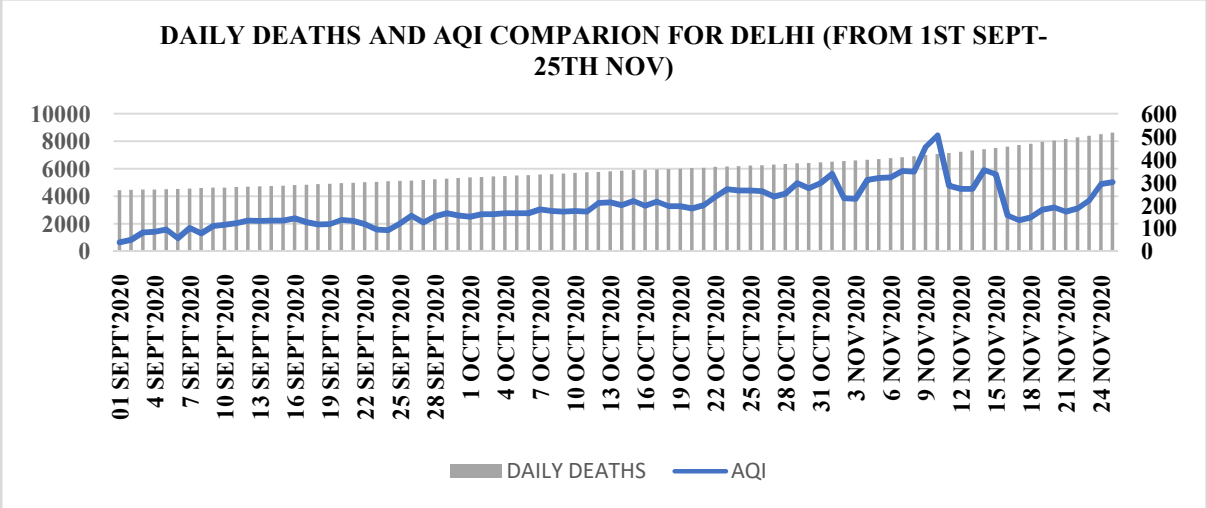


Figure 3

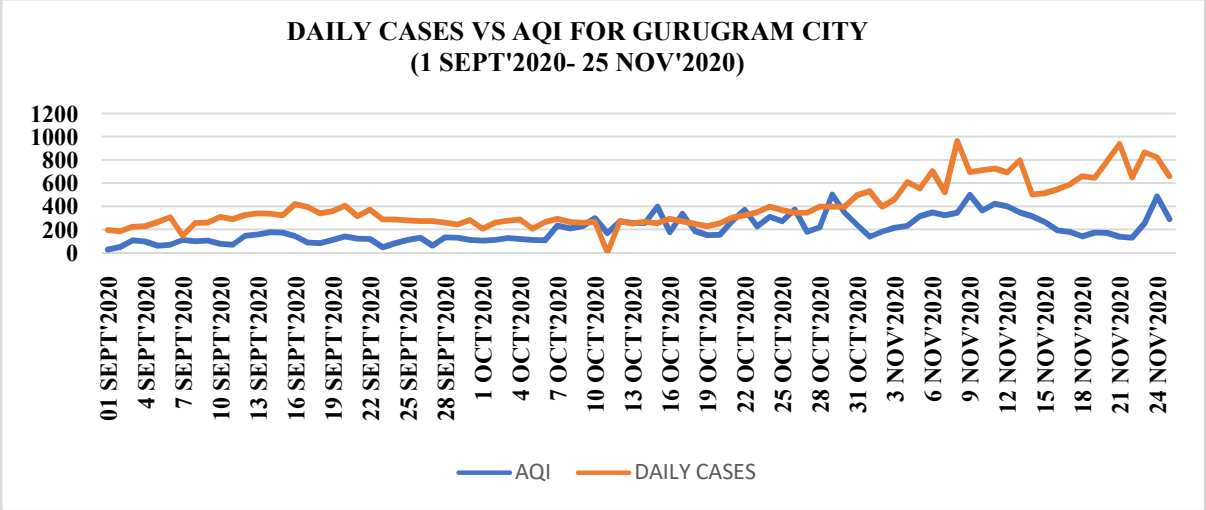


Figure 4

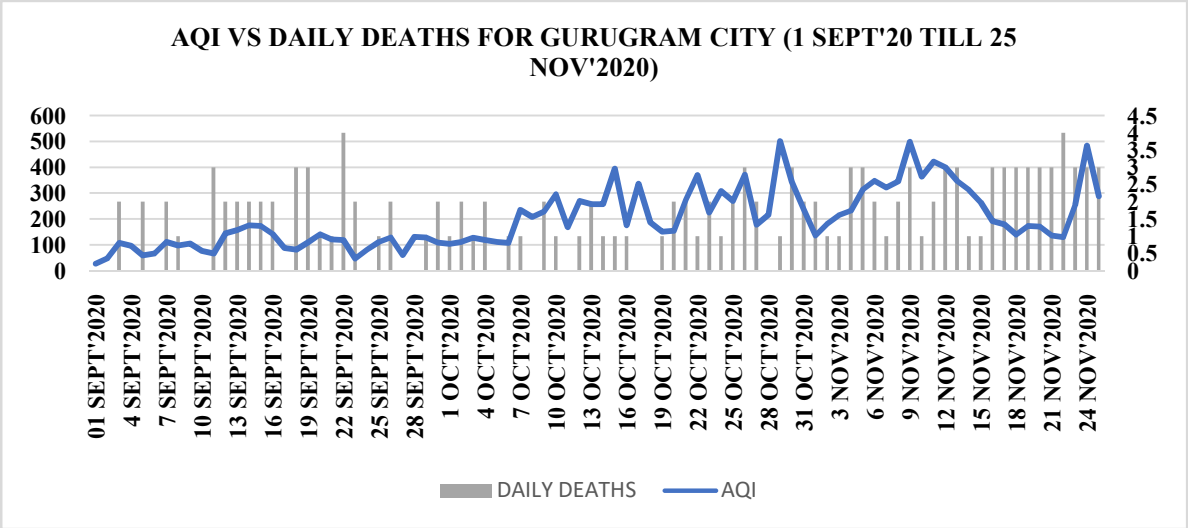


Figure 5

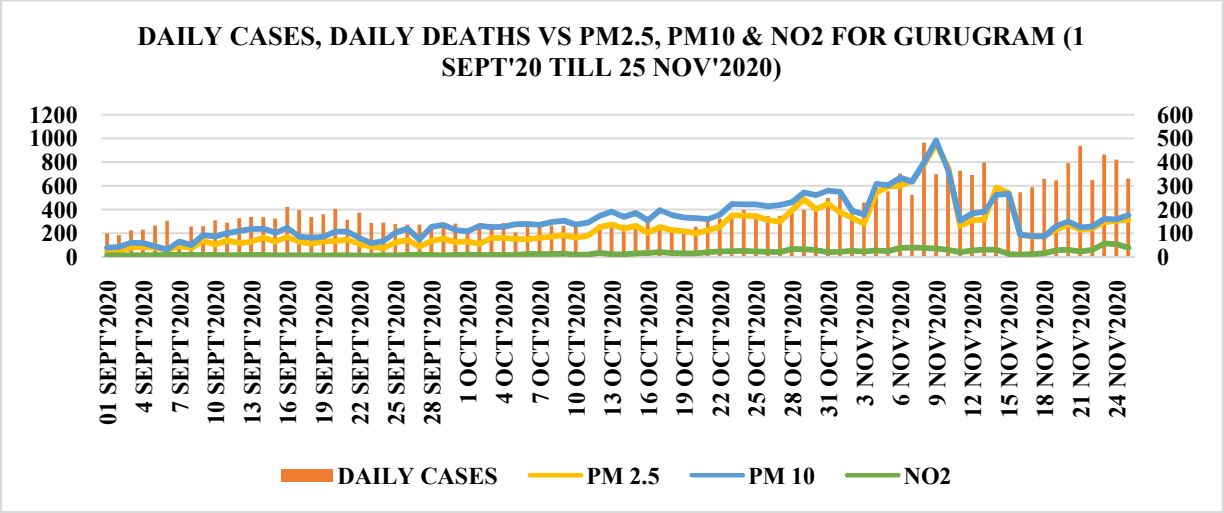


Figure 6

CONCLUSION

This study investigated the pollution parameters affecting spread of COVID-19 for Delhi and Gurugram city. And I observed a positive association between COVID-19 daily cases and AQI data for both the cities. However, the daily deaths didn't show much of a correlation with increasing AQI values and other pollution parameters in general. The association was larger in magnitude and significant in the more polluted cities of India like Delhi and Gurugram City. In conclusion, exposure to air pollution especially PM_{10} and $PM_{2.5}$ may increase the susceptibility of infection and mortality from COVID-19. The available data also indicate that exposure to air pollution may influence COVID-19 transmission. Moreover, air pollution can cause adverse effects on the prognosis of patients affected by SARS-CoV-2 infection. By the results, it is clearly visible that we need to implement environmental strategies that will reduce the exposure to poor air quality and air pollution and may help the epidemiologists to select a proper measure to prevent such an outbreak in the future. Also, as we don't know that when this COVID-19 pandemic will completely stop, due to its reoccurrence as a new modified strain. And the fact that the results are in general consistent with other studies on relation between air pollution and COVID-19 daily cases gives us the greater confidence that the findings of this case study are somewhat valid and true (-at least to some extent). Overall, the case study can somewhat serve as a supplement to encourage the regulatory bodies to take action or promote changes in environmental policies to control and reduce the harmful effects of environmental pollutants, in this case for COVID-19 Pandemic.

AUTHOR CONTRIBUTIONS

Pooja Y performed the literature review, experimental design, analysed and interpreted the data, prepared the literature review, compiled that data. **Droupti Y** and **Luxita S** helped in literature review, manuscript text, and manuscript edition, and manuscript preparation. Dr. **Kushagra R** and **Luxita S** co-authored and supervised the study.

ACKNOWLEDGEMENT

This study was supervised by **Dr. Kushagra Rajendra**.

CONFLICT OF INTEREST

The author declares no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the author.

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