Impact of COVID-19 on PM$_{2.5}$ Pollution in Fastest-growing Megacity Dhaka, Bangladesh

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Abstract

Objective: The purpose of the research was to investigate and identify the impact of COVID-19 lockdown on fine particulate matter (PM$_{2.5}$) pollution in Dhaka, Bangladesh by using ground-based observation data.

Methods: The research assessed air quality during the COVID-19 pandemic for PM$_{2.5}$ from 1 January 2017 to 1 August 2020. The research considered pollution in pre-COVID-19 (1 January-23 March), during COVID-19 (24 March-30 May), and post-COVID-19 (31 May-1 August) lockdown periods with current (2020) and historical (2017-2019) data.

Results: PM$_{2.5}$ pollution followed a similar yearly trend in year 2017-2020. The average concentration for PM$_{2.5}$ was found 87.47 μg/m$^3$ in the study period. Significant PM$_{2.5}$ declines were observed in the current COVID-19 lockdown period compared to historical data: 11.31% reduction with an absolute decrease of 7.15 μg/m$^3$.

Conclusion: The findings of the research provide an overview of how the COVID-19 pandemic affects air pollution. The results will provide initial evidence regarding human behavioral changes and emission controls. This research will also suggest avenues for further study to link the findings with health outcomes.

Keywords: Novel coronavirus; pandemic; particulate matter; air pollution; South-Asia
Introduction

Fine particulate matter (PM$_{2.5}$) is a major indicator of air pollution that poses the greatest risk to people’s health. Research shows that historical PM$_{2.5}$ exposure is proportional to COVID-19 mortality rates $^1$. Most of the direct (i.e., construction sites and fire) and indirect (i.e., power plants, industries and automobiles) sources of PM$_{2.5}$ pollutants were shut down during the COVID-19 lockdown period. For this reason, a decline in PM$_{2.5}$ pollution has been observed in nations responding to the COVID-19 pandemic $^2$.

Bangladesh is the world’s most polluted country for PM$_{2.5}$ exposure $^3$. Every year a number of patients with cardiovascular and respiratory difficulties die due to unhealthy and hazardous PM$_{2.5}$ pollution $^4$. Dhaka (the capital of Bangladesh) is the most vulnerable city to both PM$_{2.5}$ pollution $^5$ and COVID-19 transmission in Bangladesh $^6$. High population density combined with poor air quality makes the city risky for COVID-19 patients. Governments have taken different policies and initiatives regarding PM$_{2.5}$ pollution control, but enormous constructions and developments have hampered the government initiatives. As a result, the spending of government funds might have increased but the PM$_{2.5}$ pollution remains the same.

The first COVID-19-positive case was found in Dhaka on March 8, 2020 and like many other countries, the Bangladesh government declared a countywide lockdown from March 24, 2020. The lockdown resulted in not only in reducing the rate of new COVID-19 cases but also in reducing the air pollutants $^7$. But the identification of PM$_{2.5}$ pollution change has not yet been clarified, so it is not obvious how much the PM$_{2.5}$ pollution has decreased in Dhaka due to COVID-19 lockdown. In this situation, ground-based measurements and observation of PM$_{2.5}$ pollutant concentrations might be an important tool for detecting and reducing pollution through regulatory compliance.

This research included investigating the PM$_{2.5}$ scenarios and identifying changes during COVID-19 lockdown based on time series datasets. This study delineates the trend of PM$_{2.5}$ along with the summary statistics for pre-COVID-19, during COVID-19 and post-COVID-19 lockdown periods for the study period (2017-2020). The research might help decision-makers to make effective policies to reduce the PM$_{2.5}$ pollution based on the behavioral changes of the communities due to COVID-19. The specific objective of the research was to identify the impacts of COVID-19 on PM$_{2.5}$ pollution change in the study area.
Methods

Dhaka, the capital of Bangladesh was selected as the study area. It is the ninth-largest and the sixth-most densely populated city in the world with a population of over 21 million. The city is known as the world’s second least livable city in terms of PM$_{2.5}$ pollution. The research used hourly PM$_{2.5}$ concentration of Dhaka from 1 January 2017 to 1 August 2020 which was collected from AirNOW data. The statistical software R was used for data preparation, visualization, and analysis. The collected hourly PM$_{2.5}$ concentration data was converted to 24-hours mean concentration. The trend of PM$_{2.5}$ was investigated for the study period (2017-2020). The first three COVID-19 positive patients were confirmed in Bangladesh on March 8, 2020. The Bangladesh government declared a countrywide lockdown from March 24, 2020 and extended it to May 30, 2020. Based on the duration of the lockdown, the research classified the PM$_{2.5}$ concentration data into pre-COVID-19 lockdown, during COVID-19 lockdown, and post-COVID-19 lockdown periods. For change detection, these three time periods were further subclassified into two classes as current (data from 2020) and historical (data averaged from 2017 to 2019) data. Month-wise distribution of PM$_{2.5}$ concentration for current and historical periods were investigated. Comparisons between historical versus current periods of PM$_{2.5}$ concentrations were done using two-sided t-tests. The research also reports both absolute differences and percentage change in pollution from historical to current periods.

Results

The PM$_{2.5}$ concentration showed a similar trend (i.e., a sinusoidal pattern) for each of the year during the study period (2017-2020). The 24-hours mean of PM$_{2.5}$ was higher than the WHO standard (i.e., 25 μg/m$^3$) for the majority time in a year. Literature also shows that PM$_{2.5}$ concentration is gradually increasing in Dhaka city. Rapid development, industrialization and pollution were the major catalysts for the increase of PM$_{2.5}$ concentration in the densely populated city. In recent years, a large number of mega projects like the metro rail, flyover, elevated expressway etc. were taken in the city. Regular road construction and repair, and other construction for fulfilling the faster-growing population needs such as housing and utility services have also increased in recent years. PM$_{2.5}$ concentrations were higher in the starting and the end of the year (i.e., winter season) whereas relatively lower values were observed in the middle of the year (i.e., rainy season). In the dry season (beginning and end of the year), the
concentration of PM$_{2.5}$ was higher than the other times of the year. Limited rainfall during this period allows pollutants to roam around in the air freely, which is one of the major reason for higher PM$_{2.5}$ concentration. Furthermore, development projects such as the construction of road and drainage facilities run in full swing at this time which results in an increase in the concentration of PM$_{2.5}$. On the contrary, the value was found low in the rainy season (i.e., middle of the year) as raindrops clean the air. The maximum, average and minimum values for PM$_{2.5}$ (μg/m$^3$) concentrations were found to be 324.96μg/m$^3$, 87.47μg/m$^3$, and 7.94μg/m$^3$ respectively for the study period.
**Table 1** 24-hours mean concentration of PM$_{2.5}$ (μg/m$^3$) in Dhaka city relative to COVID-19 lockdown periods

|                      | Historical (2017–2019) Mean (sd) | Current (2020) Mean (sd) | Difference between Current and Historical Means (% change) |
|----------------------|----------------------------------|--------------------------|----------------------------------------------------------|
| Pre-COVID-19 Lockdown (January 1 – March 23) | 161.88 (58.12) | 151.56 (54.14) | -10.32 (-6.38%) |
| During COVID-19 Lockdown (March 24 – May 30)   | 63.23 (30.26) | 56.07 (27.53) | -7.15 (-11.31%) |
| Post COVID-19 Lockdown (Mar 31 – August 1)    | 32.13 (13.23) | 32.25 (10.87) | 0.12 (0.40%) |

Table 1 illustrates the mean concentration of PM$_{2.5}$ for both historical (2017-2019) and current (2020) period. In pre-COVID-19 lockdown period, historical mean of PM$_{2.5}$ was 161.84 μg/m$^3$, which has declined by 6.38% in current period compared to the historical average (p = 0.15; 95% CI [-24.36; 3.4]). The declining trend continued to the lockdown period when the mean concentration of PM$_{2.5}$ declined by 11.31% (p = 0.10; 95% CI [-15.72; 1.4]). However, in post-COVID-19 lockdown period, the mean concentration stayed almost the same and no statistically significant differences was found for this period (p = 0.94; 95% CI [-3.51; 3.76]).
Fig. 1 Summary statistics for 24-hours mean values of PM$_{2.5}$ (μg/m$^3$) in current (2020) and historical (2017-2019) periods
According to Fig. 1, in the lockdown period, the median value of PM$_{2.5}$ concentration declined at a higher rate than pre- and post-lockdown periods. During the lockdown, the median value of PM$_{2.5}$ decreased by 17% in 2020 with respect to the historical median (2017-2019); the percentage change for the median was 15% and 3% in the pre-lockdown and post-lockdown period, respectively. If the median line is extended to the next chart within the group, it seems that there is unlikely to be a significant difference between historical data and current data as the extended median lines lie inside the interquartile range (IRQ) range for all three periods.

**Discussion**

In the pre-COVID-19 lockdown period, the concentration of PM$_{2.5}$ was higher at the start of the year. But the current period has a lower concentration than the historical period. It can be said that COVID-19 impact on PM$_{2.5}$ started at the beginning of 2020. In this year, some of the mega projects were stopped or minimized due to a lack of foreign technology and manpower. The global impacts of COVID-19 also influenced industrial production. The majority of industries like garments industries product orders were canceled during early 2020, as a result of which, the industrial source of PM$_{2.5}$ might have been minimized. People were in fear of the pandemic; as a result, private vehicles on road were limited during this period. In Dhaka, the decline of vehicles on roads might have affected the amount of PM$_{2.5}$ concentration.

During the COVID-19 lockdown period, the amount of PM$_{2.5}$ concentration declined in 2020 from the historical period. The government was forced to stop all offices, industries and public transport, which might be the main cause of this decline. Electricity consumption was reduced during this period that might have an influence on the concentration of PM$_{2.5}$. Literature also shows that the amount of PM$_{2.5}$ in the air have reduced at a higher rate during COVID-19 lockdown period $^{14}$. The country’s economic structure was one of the major barriers to less amount of PM$_{2.5}$ decline$^{15}$. During the middle and late lockdown period, daily earner people went to their work and small factories were restarted, violating the government restrictions. Due to the miscommunication between Bangladesh Garment Manufacturers and Exporters Association (BGMEA) and government bodies, some industries were reopened during the national lockdown. The industrial reopening might influence the amount of PM$_{2.5}$ concentration in the city. Closing and reopening of industries, and major festivals like Eid, forced the local transport to start; as a result, the decline might be reduced in reference to the historical period. Some emergency
repairing of roads and other utility facilities were done before the rainy season. Most of the mega projects were in unfinished condition during this period. These might have an impact on the PM$_{2.5}$ of the city.

In the post-COVID-19 lockdown period, all of the industries, office and construction work were reopened as previous years. In this period, the concentration of PM$_{2.5}$ was higher than the historical period. The unfinished construction work and pending orders in industries might have influenced the amount the PM$_{2.5}$ in this period.

**Conclusion**
COVID-19 lockdown has a significant impact on PM$_{2.5}$ concentration as well as overall air quality. The mean PM$_{2.5}$ concentration declined by 11.31% in current period compared to historical average. Community behavioral change and shut-down of PM$_{2.5}$ pollutant sources played a vital role in reducing PM$_{2.5}$ concentration during the COVID-19 lockdown. The research provide an overview of how the COVID-19 pandemic affected air pollution. The results will provide initial evidence regarding human behavioral changes and emission controls. The pandemic has already affected people’s lives in many ways. Researchers’ interest around the world regarding the pandemic and its associated impacts is increasing continuously. This research creates potential avenues for further study to link the findings with the health outcomes. However, there are some limitations to this research. First, the research used only three years of data for calculating the historical trend. More historical data can provide a more accurate historical trend. Second, there could be other catalysts that can influence the PM$_{2.5}$ concentration, which was not considered in this research. Future research should address these issues.
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