International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048
Volume 9, Issue 8, pp 107-112, August-2025
https://doi.org/10.47001/IRJIET/2025.908014

Comparative Analysis of Particulate Matter Levels Before, During, and After the COVID-19 Pandemic in Gazipur, Bangladesh

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Abstract **- This study investigates the variation in particulate matter ($PM_{2.5}$ and PM_{10}) concentrations in Gazipur, Bangladesh during three distinct phases: before, during, and after the COVID-19 pandemic by utilizing secondary data from the Continuous Air Monitoring Stations situated in Gazipur. Gazipur is one of the major urban cities and a hub for the garments industry in Bangladesh. Since the establishment of Gazipur City Corporation in 2013, a number of large-scale construction and development projects have been initiated there which eventually deteriorated the air quality. The findings indicated consistently high pollution levels before the COVID-19 pandemic, especially during winter months. Seasonal factors, like low temperatures and stagnant air, lead to increased PM levels, although monsoon rains temporarily improved air quality. During the COVID-19 lockdown in 2020, $PM_{2.5}$ and PM_{10} levels decreased by 6.5% and 53.7% respectively, based on annual average compared to 2019 because of reduced industrial and transportation activities. Nevertheless, levels immediately returned to pre-pandemic figures following the lifting of major restrictions. Even during the lockdown, PM concentrations were above Bangladesh's National Ambient Air Quality Standards and World Health Organization's Air Quality Guidelines as evidenced by the annual average value of 235 µg/m³ for PM_{10} in 2021. The peak $PM_{2.5}$ and PM_{10} levels post COVID-19 were recorded as 307.1 and 339 µg/m³ respectively. These findings emphasize the necessity of adopting long-term measures to improve air quality. Measures must encompass more stringent emissions regulations, additional CAMS establishment, sustainable urban development, and improved public awareness to safeguard public health and ensure clean air in Gazipur.**

Keywords: Air pollution; $PM_{2.5}$; PM_{10}; COVID-19; Temporal variation, Gazipur.

I. INTRODUCTION

Good air quality is essential for maintaining human health, environmental sustainability, and overall quality of life. Clean air reduces the risk of respiratory and cardiovascular diseases, including asthma, bronchitis, lung cancer, and heart attacks [1]. Furthermore, good air quality is crucial for climate regulation, as it limits the concentration of greenhouse gases and short-lived climate pollutants, which contribute to global warming and extreme weather events. Air pollution has become a global concern that has drawn attention to recent years, especially since the situation is worsening in urban areas. Approximately 80% of urban residents are exposed to air pollution levels that surpass the standards established by the World Health Organization (WHO) [2]. Air pollution in Bangladesh results from several anthropogenic activities and natural sources that significantly impact the environment and public health. The rapid growth in the number of motor vehicles, particularly in bigger cities like Dhaka and Gazipur is a major cause of air pollution. Poorly maintained vehicles that use low-quality fuel emit pollutants such as particulate matter (PM), nitrogen oxides (NO_x), and sulfur dioxide (SO_2). It was estimated that traffic-related emissions constitute more than 50% of the total particulate air pollution [3]. Bangladesh is home to thousands of traditional brick kilns that burn coal, wood, and other materials, releasing large amounts of PM and black carbon into the atmosphere [4]. These emissions contribute significantly to air pollution, particularly during the dry season, when brick kiln activity is at its peak. Rapid urbanization and construction activities generate dust, increasing the concentration of PM in the air [5]. Additionally, unpaved roads and inadequate dust control measures contribute to the problem, particularly during the dry season [6].

In Bangladesh, several key air quality parameters are affected by environmental pollution. The most common air pollutants include PM ($PM_{2.5}$ and PM_{10}), NO_x, SO_2, carbon monoxide (CO), ozone (O_3), and volatile organic compounds

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(VOCs). Particulate matter pollution is a significant concern in the large cities of Bangladesh. They are primarily emitted from vehicle exhausts, brick kilns, diesel generators, and industrial activities [3]. These fine particulate matters, with diameters less than 2.5 micrometers ($PM_{2.5}$) and 10 micrometers (PM_{10}), are considered the most harmful pollutants in urban air because they can penetrate deep into the body and lungs via the bloodstream [7]. The concentration of $PM_{2.5}$ in major cities like Dhaka has been observed to be significantly higher than global air quality standards, contributing to severe health issues like respiratory and cardiovascular diseases [8].

At the beginning of 2020, the world confronted the COVID-19 outbreak caused by a new virus from the corona virus family, known as SARS-CoV-2. The COVID-19 pandemic had a significant impact on various aspects of society, including health, economy, and environment. Health wise, it led to roughly 2.05 billion confirmed cases and 29.5 million deaths globally as of April 2025 [9]. Bangladesh has recorded 20,51,201 verified COVID-19 cases and 29,499 deaths till April 2025 [10]. Economically, it caused widespread job losses, business closures, and a global recession. However, there were some positive environmental impacts, such as temporary reductions in air pollution due to decreased human movement, less traffic, and industrial activities during strict lockdowns [11].

Exposure to air pollution is a major environmental threat to human health in large cities such as Gazipur [12]. To understand an area's air quality, measurement and analysis of air quality parameters are required. Choosing $PM_{2.5}$ and PM_{10} is highly relevant due to their significant impact on human health and the environment. According to the World Air Quality Report 2024, Sreepur, an upazila of Gazipur district, had an average $PM_{2.5}$ concentration of 77.7 µg/m³, which exceeded by more than 15 times the WHO's annual guideline [13]. Mukta et al. (2020) reported highest concentrations of $PM_{2.5}$ and PM_{10} in the winter as opposed to the other seasons after analyzing the CAMS-4 data in Gazipur for one year ranging from October 2017 to September 2018 [3]. It was also suggested that the higher pollutant load in the winter was associated with large-scale polluted air transported from the nearby brick kiln. Islam et al. (2023) investigated the concentration of $PM_{2.5}$ and PM_{10} from 56 different locations in Gazipur city including industrial, commercial, and residential areas [14]. The average concentrations of $PM_{2.5}$ and PM_{10} were 263.53 and 340.17 µg/m³ respectively. Previous studies were conducted within a very limited timeframe and did not include the Covid-19 pandemic to compare its impact with other time periods. The objective of this study is to evaluate the change in the concentrations of $PM_{2.5}$ and PM_{10} in Gazipur from pre-to post-COVID-19 and look into the particulate matter pollution scenario of Gazipur. Monitoring these pollutants is essential for understanding the scope of air pollution and its long-term effects on public health.

II. MATERIALS AND METHODS

2.1 Study Area

Gazipur is one of the major cities and a hub for the garments industry in Bangladesh. Since the establishment of Gazipur City Corporation in 2013, this industrial city has been dealing with a tremendous increase in population and physical expansion [15]. There is one Continuous Air Monitoring Stations (CAMS) located near the Gazipur area: CAMS-4 having latitude 23°99'41.28"N and longitude 90°42'23.15"E. This location is also characterized as high traffic area due to a large number of vehicles move around Gazipur city. Figure 1 illustrates the selected CAMS location for this study.

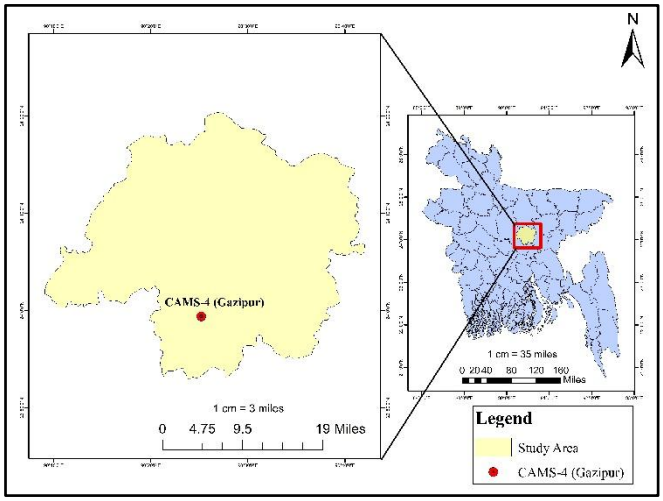

Figure 1: ArcMap of the study area showing the location of the CAMS-4

2.2 Data Collection

The Department of Environment (DoE), situated at Agargaon in Dhaka, provided the historical data for $PM_{2.5}$ and PM_{10} generated by CAMS-4. This dataset included $PM_{2.5}$ and PM_{10} hourly concentrations for the selected CAMS that were chosen between January 2017 and December 2023. The data was selected in such a way that three distinct time periods before COVID-19 (2017-2019), during COVID-19 (2020-2021), and after COVID-19 (2022-2023) could be compared.

2.3 Statistical Analysis

Microsoft Excel was used to analyze the data. The hourly data from the CAMS were converted into daily, monthly, and annual averages to investigate the temporal pattern and short-time fluctuations in air quality. The daily average of the data

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was determined by averaging hourly data obtained every day. The monthly averages were then calculated using these daily averages. For investigating seasonal variation, four prominent seasons in a year were considered. Winter season comprised of the months of December, January, and February; summer season included the months of March, April, and May; monsoon season consisted of the months of June, July, August, and September; and the months of October and November were considered the post-monsoon season. To visualize the monthly, seasonal and annual trends, the data were plotted in Origin 2024.

2.4 Air Quality Monitoring

Department of Environment (DoE), Bangladesh has established a countrywide air quality monitoring (AQM) network. The continuous monitoring of six criteria pollutants including $PM_{2.5}$, PM_{10}, SO_2, NO_x, CO, and O_3 is being executed by 16 Continuous Air Monitoring Stations (CAMS) and 15 Compact Continuous Air Monitoring Stations (C-CAMS) located in the divisional and industrial districts of the country [16]. The data and information generated from these stations are automatically collected on the central server and then shared as per need.

2.5 Air Quality Standards

The Air Pollution (Control) Rules-2022, which set ambient air quality standards, was put into effect by the Government of Bangladesh [17]. To improve public health by reducing air pollution, national, regional, and local authorities can follow the WHO's Air Quality Guidelines (AQG) as a global standard [18]. In Bangladesh, the DoE under the ministry of Environment Forest and Climate Change has declared National Ambient Air Quality Standards (NAAQS) for certain pollutants. The WHOAQG and NAAQS for $PM_{2.5}$ and PM_{10} in micrograms per cubic meter (µg/m³) are shown in Table 1.

Table 1: National Ambient Air Quality Standards (NAAQS) and WHO Air Quality Guidelines (AQG) for $PM_{2.5}$ and PM_{10}

NAAQS for Bangladesh			WHO AQG	
Pollutant	**Averaging time**	**Limit Value**	**Averaging time**	**AQG Level**
$PM_{2.5}$ (µg/m³)	Annual	35	Annual	5
	24 hours	65	24 hours	15
PM_{10} (µg/m³)	Annual	50	Annual	15
	24 hours	150	24 hours	45

III. RESULTS AND DISCUSSION

3.1 Before the COVID-19 Pandemic (2017-2019)

Before COVID-19, concentrations of both $PM_{2.5}$ and PM_{10} often exceeded the NAAQS limits. The highest $PM_{2.5}$ concentration was recorded in January 2018 at 206.3 µg/m³, while the lowest was 9.4 µg/m³ in July 2019 (Figure 2). Monthly data showed lower concentrations during the monsoon (June to September) and higher levels in the winter (December to February). A similar trend was observed for PM_{10}, with the highest concentration of 326.7 µg/m³ was observed in January 2019 and the lowest at 39.3 µg/m³ in July 2017 (Figure 3).

3.2 During the COVID-19 Pandemic (2020-2021)

During the first phase of COVID-19 (March to May 2020), concentrations of both $PM_{2.5}$ and PM_{10} decreased significantly compared to the same period in 2019. For example, $PM_{2.5}$ levels fell from 62.3 µg/m³ in April 2019 to 51.0 µg/m³ in April 2020. The reduction in PM_{10} was even higher, dropping from 115.5 µg/m³ to 69.2 µg/m³ over the same period. On a yearly average, $PM_{2.5}$ and PM_{10} levels declined by 6.5% and 53.7% respectively, in 2020 compared to 2019. However, concentrations still frequently exceeded NAAQS limits. Moreover, the annual average value of $PM_{2.5}$ and PM_{10} in 2021 was higher than their corresponding values in 2020. Covid-19 major lockdown restrictions were lifted and gradually scaled back to normal towards the end of 2021. Seasonal patterns remained consistent with those observed before the COVID-19 period.

3.3 After the COVID-19 Pandemic (2022-2023)

Following the COVID-19 period, $PM_{2.5}$ and PM_{10} levels increased gradually. By 2022, concentrations had nearly returned to pre-pandemic levels and continued to rise in 2023, indicating that earlier improvements were temporary (Figure 4 and 5). The seasonal pattern remained consistent, with higher values in the winter and lower values during the rainy season. The peak values of $PM_{2.5}$ and PM_{10} were recorded as 307.1 µg/m³ (December 2022) and 339 µg/m³ (January 2023) respectively (Figure 2 and 3).

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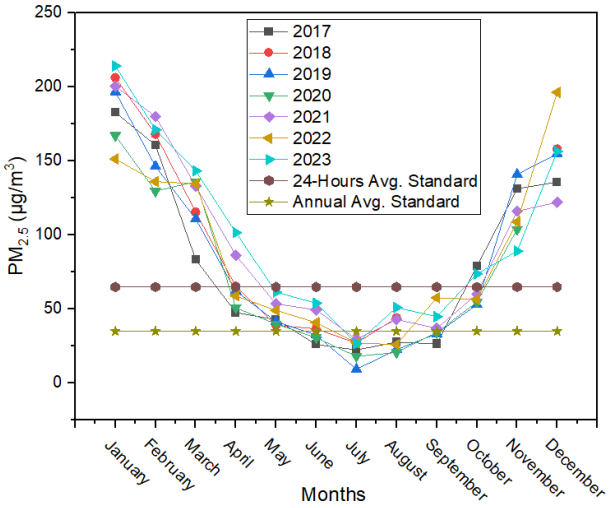

Figure 2: Monthly average concentrations of $PM_{2.5}$ from January 2017 to December 2023

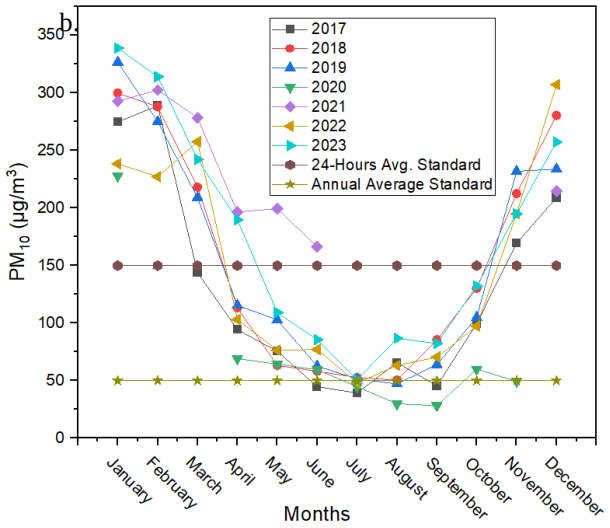

Figure 3: Monthly average concentrations of PM_{10} from January 2017 to December 2023

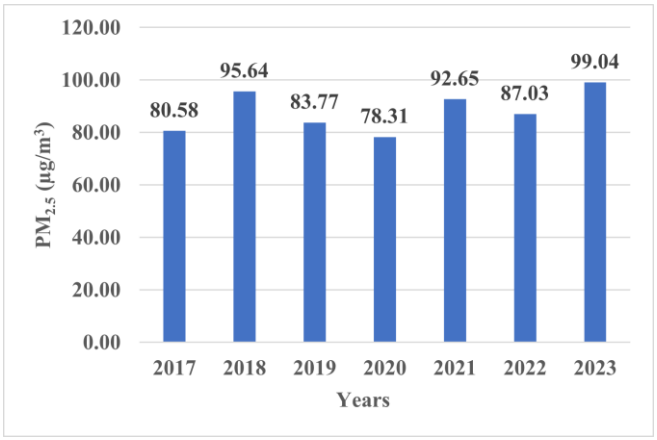

Figure 4: Yearly average concentrations of $PM_{2.5}$ from 2017 to 2023

Figure 5: Yearly average concentrations of PM_{10} from 2017 to 2023

IV. CONCLUSION

This study investigated the impact of the COVID-19 lockdown on particulate matter ($PM_{2.5}$ and PM_{10}) concentrations in Gazipur using secondary data. Our findings indicate that Gazipur consistently faced high levels of air pollution before the pandemic, particularly during the winter months. While the lockdown led to a temporary reduction in PM concentrations due to decreased human activities, air quality quickly returned to pre-pandemic levels once the restrictions were lifted, as $PM_{2.5}$ and PM_{10} levels remain elevated, consistently exceeding the Bangladesh NAAQS and WHO AQG limits. Presently, a single CAMS is placed in Gazipur district which is insufficient by all means as the area consists of Gazipur City Corporation which is the largest city corporation of Bangladesh in terms of area. Therefore, increasing the number of monitoring stations in the Gazipur area and improving air quality monitoring structure would enable easy access to more real-time data and strengthen the ability to track and respond quickly to air pollution. Future research should focus on advanced monitoring technologies, longer monitoring periods and comprehensive data sets for other significant pollutants to provide a better understanding of Gazipur's air quality dynamics.

ACKNOWLEDGEMENT

The authors would like to take this opportunity to express sincere appreciation to the DoE, Bangladesh for their support in providing data for this study.

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Citation of this Article:

Md. Sultanul Islam, & Md. Hasibul Hassan. (2025). Comparative Analysis of Particulate Matter Levels Before, During, and After the COVID-19 Pandemic in Gazipur, Bangladesh. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(8), 107-112. Article DOI https://doi.org/10.47001/IRJIET/2025.908014

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