M. Alamgir, S.M.T. Islam and J. A. Saju (Eds.)
ISBN: 978-984-35-4034-8

Proceedings of the Waste Safe 2023 – 8th International Conference on Integrated Solid Waste and Faecal Sludge Management
25-26 February 2023, Khulna, Bangladesh

MONITORING AND ASSESSMENT OF $PM_{2.5}$ AND PM_{10} IN GAZIPUR SADAR, BANGLADESH

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ABSTRACT

Anthropogenic emissions into the atmosphere alter the chemical composition of the natural air. The increase in the country's economic growth patterns, use of resources, the density of population, and geographical formations change the atmospheric environment by emitting various air pollutants. Particulate matter (PM) causes approximately 800,000 premature deaths each year, ranking it the 13th leading cause of mortality worldwide according to World Health Organization. Air quality (AQ) in Gazipur has been becoming polluted day by day due to the increase in development projects. To assess the air quality of Gazipur city, this research monitored the concentration of particulate matter $PM_{2.5}$ and PM_{10} from fifty-six locations. The covered areas are Residential areas, Industrial areas, Mixed use areas, Commercial areas, Road intersections, Village areas, and Bazar areas. The air pollutants were measured by various automated portable instruments. The average concentrations of $PM_{2.5}$ and PM_{10} in Gazipur City were 263.53, and 340.17 µg/m^3 respectively. Results showed that the concentration of $PM_{2.5}$ (263.53 µg/m^3) in different land use was four times higher than the standard level. A strong correlation coefficient was estimated between $PM_{2.5}$ and PM_{10} as R^2=0.9802. It was also observed that the changes in the PM concentrations within different land use patterns were significant. The studied land uses are arranged in descending order based on average concentration PM which follows as village area > industrial area > road intersection area > sensitive area >commercial area > mixed area > residential area.

***Key words**: Air Pollution, $PM_{2.5}$, PM_{10}, Gazipur city*

INTRODUCTION

Air pollution has recently become a major concern all over the world. With the rapid expansion of industrialization and urbanization, the global air pollution situation has been deteriorating around urban areas. Approximately 80% of people in urban areas are vulnerable to air pollution that exceeds the World Health Organization (WHO) air quality standard value, and 98% of cities in low-middle-income countries and 56% in high-income countries don't really meet the WHO guidelines (WHO, 2016). According to Masum and Pal (2020), every year, an estimated 4.2 million people die as a result of exposure to ambient (outdoor) air pollution, including cancer, brain stroke, cardiac arrest, and various types of chronic respiratory infections. Globally it causes 9% of lung cancer deaths, 17% of chronic pulmonary disease deaths, 30% of ischemic heart and stroke deaths, and 9% of respiratory

deaths (Mukta et al. 2020).

Air pollution is one of the major man-made environmental problems in Bangladesh (Hoque et al., 2020). According to the Environmental Performance Index (2020), Bangladesh has a low environmental performance index (rank: 162/180 countries) as a result of the poor air quality index (Islam et al. 2021). Human activities are deteriorating air quality. In Bangladesh, brick kilns, vehicular emissions, open-air burning, coal and biomass burning, and industrial emissions are major sources of air pollution (Masum et al. 2020). Dust pollution from road construction, building constructions, and other development activities exacerbates the city's air pollution problem. Poor air quality endangers human health, structures, and vegetation, reduces visibility, and increases greenhouse gas emissions. The World Bank (WB) estimates that by reducing air pollution in Dhaka, Chittagong, Rajshahi, and Khulna, the country could avoid 15,000 deaths and save $200 million to $800 million per year (UNEP, UNICEF & WHO (2002). According to Rahman and Al-Muyeed (2005), the yearly costs of health maintenance due to air pollution in Dhaka city have been estimated in excess of US$ 100 million and cause more than 8,000 excess deaths in the city. Concerns about particulate pollution in urban areas are growing in importance around the world. Urban areas are primarily affected by suspended matter, which poses a number of health risks (Wahid, 2006). Aerosol particulate matter is known to have a link to toxic trace metals and to have an impact on human health in both urban and rural settings (Begum et al., 2013). Previous studies have signposted that the severe $PM_{2.5}$ pollution resulted in more than 3 million premature deaths worldwide in 2010 (Lim et al., 2012).

When a particle enters the human body, it goes through several removal processes. Nostril hair filters out larger (>10μm) particles (e.g., coarse dust, ash, etc.) in the head region. The smaller size (2 to 10 μm) particles (e.g., fume, dust, smoke) can be removed by the sweeping action of cilia in the tracheobronchial region. Much smaller particles (< 1.0 μm) penetrate the lungs and reach the alveoli. Some particles retained in the alveoli are absorbed into the bloodstream. The extent of the effect of particulates depends on concentration, presence of other contaminants, and length of exposure. Exposure to particulate matter is associated with increased incidence of respiratory illness, chronic bronchitis, bronchoconstriction, decrement in pulmonary function, and increased mortality rates. Adverse effects associated with short-term exposure to particulate matter include an increase in the rate of asthma attacks (Leslie et al. 2022).

Exposure to air pollution is a major environmental threat to human health in large cities such as Gazipur city (Hasan et al. 2020). Hence estimation and understanding of the status and level of air pollution are necessary. The effect of air pollution can be estimated only when the quality of air in a particular region is available. To understand an area’s air quality, measurements of air quality parameters are required. This study measured the concentration of $PM_{2.5}$ and PM_{10} to find out the particulate air pollution scenario of Gazipur city. However, it is not feasible to measure PM concentration all over the area. Therefore, sometimes forecasting future air quality is essential. The aim of the study is to determine ambient PM concentration in the study area and to assess air quality according to the Bangladesh National Ambient Air Quality Standards (BNAAQS).

METHODOLOGY

Study Area

Gazipur is one of the major cities in Bangladesh. It is 31 km away from the capital city Dhaka and is a hub for the Garments Industry of Bangladesh. Gazipur Sadar Upazila (Gazipur district) area is 446.38 sq.km, located between 23°53' and 24°11' north latitudes and between 90°20' and 92°30' east longitudes. It is bounded by Sreepur (gazipur) upazila on the north; Savar and Rupganj upazila and Uttara thana on the south; Kaliganj (gazipur) and Rupganj upazila on the east; Kaliakair and Savar upazilas on the west. Gazipur upazila

was established in 1983 consisting of Joydebpur and Tongi police stations. Gazipur was turned into a City Corporation on 13 January 2013. The city consists of 9 Wards and 31 Mahallas. The area of the town is 49.32 km^2. It lays on Latitude: 23° 59′ 20″ N and Longitude: 90° 22′ 30″ E. Fifty-six locations were selected on basis of the land use pattern to monitor the air quality. Afterward, locations were divided into seven types, which are Commercial, Industrial, Mixed-use, Residential, Road Intersection, Sensitive, and Village Area. The 56 monitoring locations are exhibited in Figure 1 and categorized in Table 1.

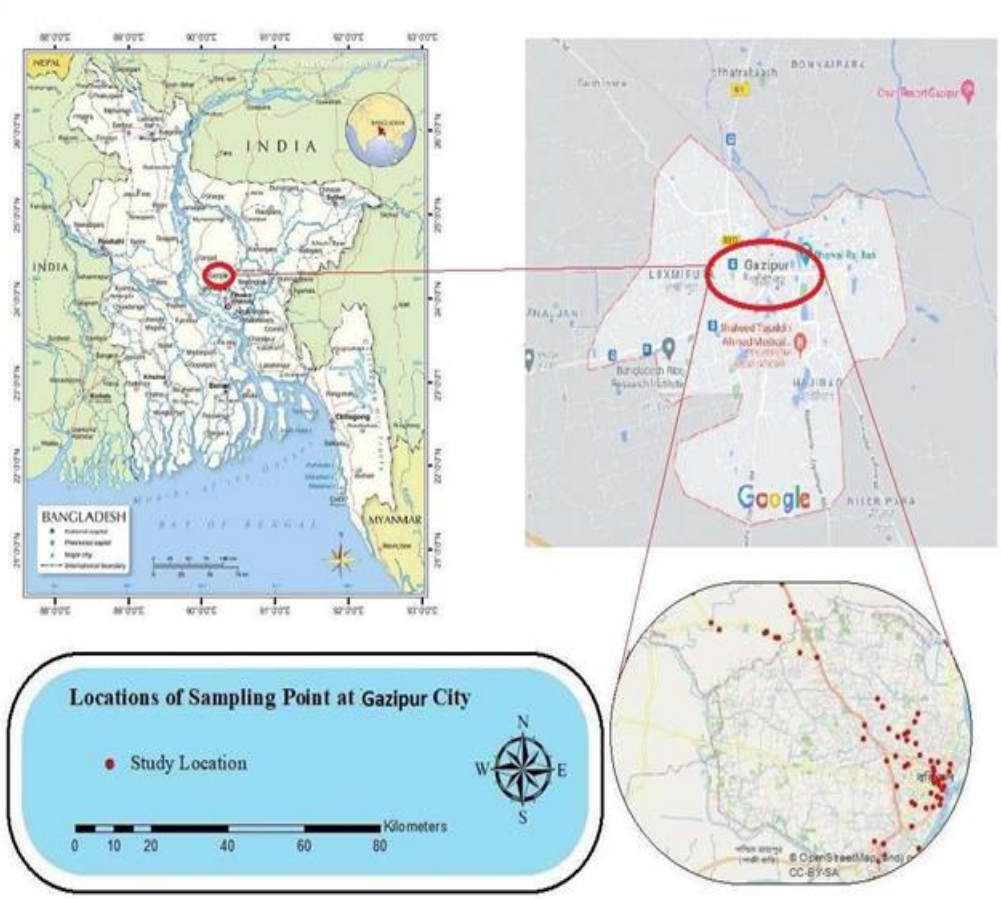

Figure 1 Selected locations for monitoring the air quality of Gazipur city in the context of Bangladesh

Table 1 PM monitoring locations according to each category

Location Types	Monitoring Frequency
Commercial Area	9 Locations
Industrial Area	7 Locations
Mixed-use Area	8 Locations
Residential Area	8 Locations
Road Intersections	8 Locations
Sensitive Area	8 Locations
Village Area	8 Locations

Air Quality Monitoring

Exposure to Particulate Matter can affect both lungs and the heart. Particle pollution exposure to a variety of health problems, including premature death in people with heart or lung disease, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, increased, respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing, etc. On the other side, Particulate Matter can be carried over long distances by wind and then settle on the ground or water. Depending on their chemical composition, the effects of this settling may include making lakes and streams acidic, changing the nutrient balance in coastal waters and large river basins, depleting the nutrients in the soil, damaging sensitive forests and farm crops, and affecting the diversity of ecosystems. PM can stain and damage stone and other materials, including culturally important objects such as buildings and other historical places. Particulate matter ($PM_{2.5}$, and PM_{10}), Nitrogen oxides (NOx), Sulfur dioxide (SO_2), Carbon Monoxide (CO), and Ozone (O_3) has been considered criteria air pollutants in Bangladesh. However, in this study, based on the availability of air quality monitoring equipment $PM_{2.5}$ and PM_{10} were selected to be measured in the concerned area. PM Quality was measured in fifty-six locations of Gazipur City with the help of PM monitoring equipment: Model: B07SCM4YN3.

Air Quality Index

The air quality index (AQI) is a value representing the status of air quality in an area. AQI is the communication vehicle to express the air quality of an area and to make people concerned in that specific area about how is the quality of the air they are going to face. AQI value tells how much clean or polluted the air is and focuses on health effects. The air quality index formula according to EPA, NSW-Australia (NSW Government, 2019) is presented in equation 1. The AQI standard for Bangladesh according to (CASE, 2018) is given in Table 2.

$$AQI = \frac{Measured\ Concentration}{Standard\ Concentration} X100 \dots\dots\dots\dots\dots\dots\dots (1)$$

Table 2 Air Quality Index for Bangladesh

Air quality index (AQI)	Category	Color
0–50	Good	Green
51–100	Moderate	Yellow Green
101–150	Caution	Yellow
151–200	Unhealthy	Orange
201–300	Very unhealthy	Red
301–500	Extremely unhealthy	Purple

Source: CASE (2018)

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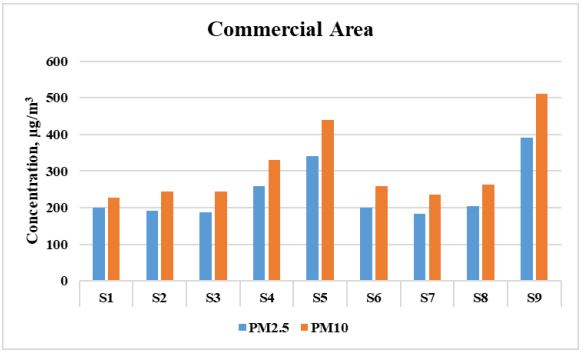
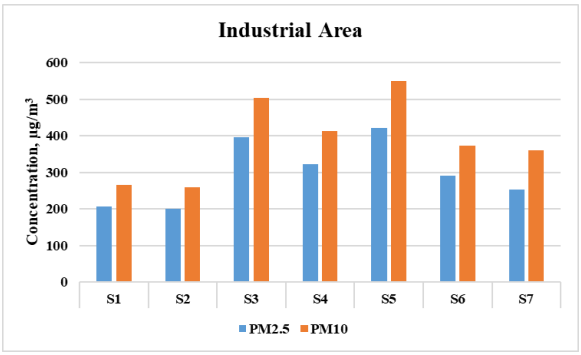
RESULTS AND DISCUSSION

Concentration of PM at different locations of Gazipur city

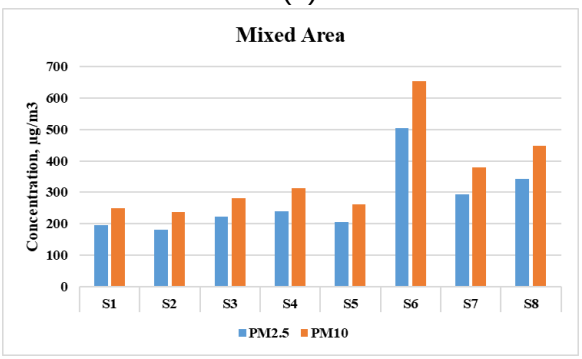
PM concentration at several locations of Gazipur city is presented in Figure 2 (a-g). The maximum PM concentration was observed in location S4 of the sensitive area which is DUET Joydeppur. The environment of DUET has been polluted by the surrounding activities. At S4 the $PM_{2.5}$ and PM_{10} were found 388 and 497 µg/m^3. Minimum concentrations of $PM_{2.5}$ and PM_{10} were counted at location S7 of the sensitive area which is called Kumun, Baria union Porisod, Baria, and the concentration were 154 and 201 µg/m^3, respectively for The surrounding environment of that Kuman area has comparatively less pollutant than other's area. However, all the other locations failed to meet the standard value of $PM_{2.5}$ and PM_{10} according to BNAAQS as $PM_{2.5}$ and PM_{10} should not exceed 65 and 150 µg/m^3. It can be observed from the figure that most of the monitored locations exceeded the WHO and BNAAQS guidelines for particulate matter. The people living in the respective locations should use protective measures to keep their own bodies healthy. Moreover, the government-mandated body should plan and implement pollution mitigating strategies for keeping humans and the environment safe from the polluting atmosphere.



(a)



(b)



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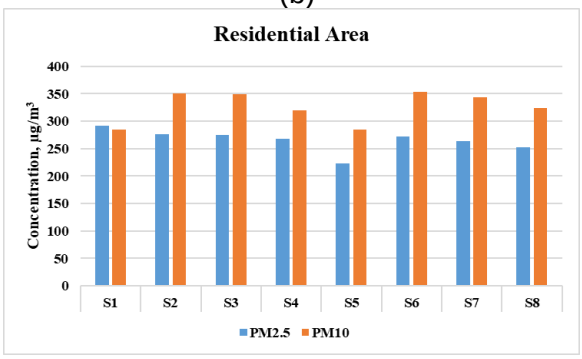

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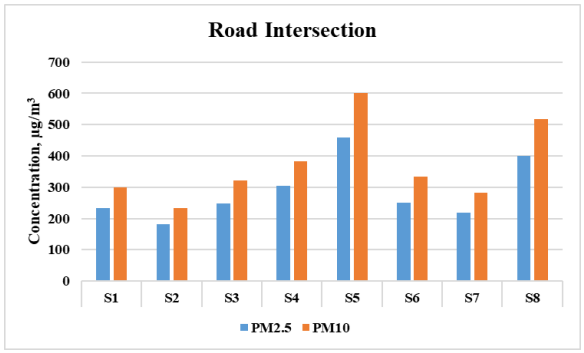

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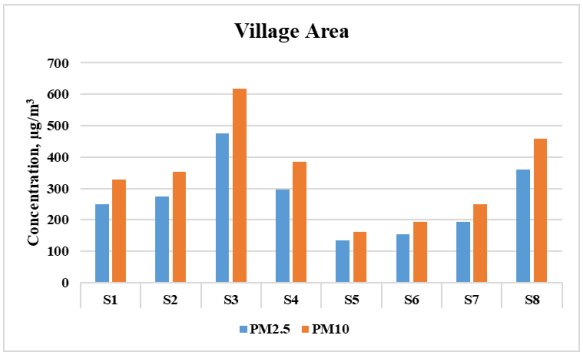

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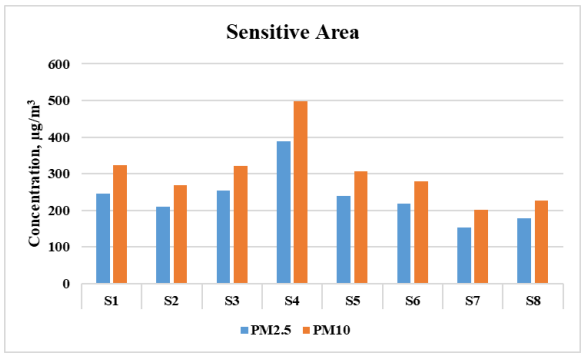

(g)

Figure 2 Concentration of $PM_{2.5}$ and PM_{10} in Gazipur city, (a) Commercial Area; (b) Industrial Area; (c) Mixed Area; (d) Residential Area; (e) Road Intersection; (f) Village Area; (g) Sensitive Area

Correlation of $PM_{2.5}$ and PM_{10}

The ratio of $PM_{2.5}$ and PM_{10} at various locations of Gazipur city is displayed in Figure 3. The ratio of $PM_{2.5}$ and PM_{10} means the contribution of $PM_{2.5}$ to the total concentration of PM_{10}. The maximum ratio was found in residential area as 0.814. This ratio reflects that more than 81% of $PM_{2.5}$ contributed to the total concentration of PM_{10}. However, the minimum ratio appeared in the industrial area as 0.766. Figure 4 represents the correlation coefficient between $PM_{2.5}$ and PM_{10}. It was observed that $PM_{2.5}$ and PM_{10} were strongly correlated with a correlation coefficient of 0.9802.

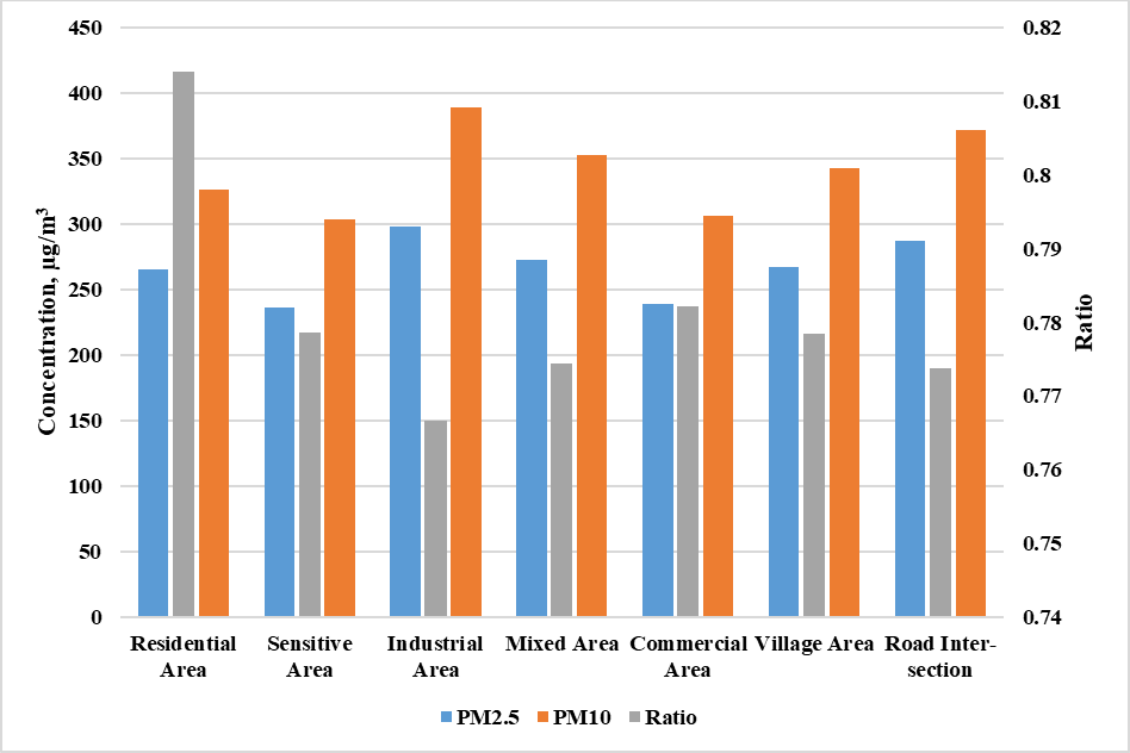

Figure 3 Ratio of $PM_{2.5}$ and PM_{10} at various locations of Gazipur city

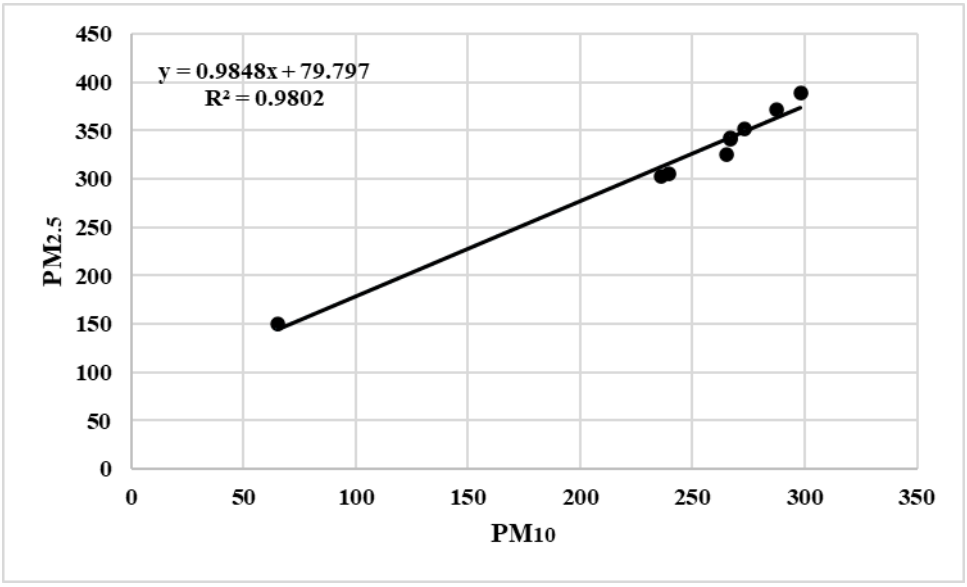

Figure 4 Correlation between $PM_{2.5}$ and PM_{10}

Air Quality Index (AQI) of PM

Air quality index of Particulate matter measured in this study is presented in Table 3 and calculated with the help of above depicted Equation 1. Maximum AQI found in the range of 301-500 for $PM_{2.5}$ at all locations indicating extremely unhealthy condition for human health. AQI for PM_{10} ranged in 201-300 in all locations also indicating very unhealthy condition for human health. Maximum AQI value of $PM_{2.5}$ and PM_{10} appeared at Industrial Areas as 459 and 259 consecutively. However, the minimum AQI value of $PM_{2.5}$ and PM_{10} appeared in

sensitive areas like hospitals, clinics, etc.

Table 3 AQI values of $PM_{2.5}$ and PM_{10} at different locations of Gazipur city

Location	AQI of $PM_{2.5}$	AQI of PM_{10}
Residential Area	408	217
Sensitive Area	363	202
Industrial Area	459	259
Mixed Area	420	235
Commercial Area	368	204
Village Area	411	229
Road Inter-section	442	248

CONCLUSIONS

The maximum concentration of $PM_{2.5}$ (298 ug/m^3) and PM_{10} (389 ug/m^3) in industrial area is higher than Bangladesh National Ambient Air Quality Standard (BNAAQS). The ratio of $PM_{2.5}$ and PM_{10} showed the abundance of fine particles in the monitoring locations. The ratio of $PM_{2.5}$ and PM_{10} varied from 0.766 to 0.814. This indicates the abundance of finer particles present in the air of Gazipur city. According to the air quality index, particulate matter is very much unhealthy at all the monitoring locations. It reveals that the people who are living in the city of Gazipur are at high risk for health issues such as heart disease, stroke, chronic obstructive pulmonary disease (COPD), lung cancer, acute lower respiratory infections, etc.

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