"Seasonal Air Quality Dynamics in Urban Slums of Dhaka Metropolitan Area"

Md. Maksudur Rahman[1]*, Asmaul Husna Siddique

Student, Jahangirnagar University

[1]ORCHID ID: 0009-0005-8284-4585

***Corresponding Author**

DOI: https://doi.org/10.47772/IJRISS.2026.100700093

Received: 10 July 2026; Accepted: 15 July 2026; Published: 25 July 2026

ABSTRACT

Bangladesh being a developing country in South Asia, is facing the challenge of air pollution for a long time now. The capital city Dhaka stands out within top 3 polluted cities in the entire earth. Inside Dhaka metropolitan area, the slums are often regarded as the most polluted locations. Still these areas are not explored properly in terms of slum-specific air pollution state. Thus, this study measures air pollution at 5 major slum areas of the Dhaka metropolitan area i.e. Shagufta, Bauniabadh, Bhasantek, Korail and Ceramic Bazar through an air quality monitoring system (AQMS) installed in each site for 2025. The collected data include values of particulate matter ((PM_1, $PM_{2.5}$, PM_4, PM_{10}), gaseous substances (CO_2, NO_2, SO_2) and atmospheric variables (temperature and relative humidity). The collected data was taken into Microsoft excel and cleaning process was performed. Then the data for these variables were grouped by four seasons i.e., summer, monsoon, post-monsoon and winter and after analysis using RStudio, these were compared among the slum locations. This revealed that Korail, Bhasantek and Ceramic bazar are comparatively more polluted in terms of particulate matter, whereas Shagufta is more polluted by other gaseous traces. The analysis indicates winter as the most polluted season and monsoon as the least. Pearson's correlation analysis revealed the interconnectedness among these variables, where particulate matter exhibited high positive correlation with one another. Principal component analysis revealed particulate matter as the dominant pollutant. Under these circumstances, the study provides slum-specific recommendations e.g., awareness campaign, waste management etc.

Keywords: Particulate matter, CO_2, NO_2, SO_2, Pearson's correlation, slum, Dhaka.

INTRODUCTION

Urban residency is attracting more people than ever around the world due to comparatively better economic opportunities (Wang et al., 2019). People are moving to big cities horrendously, but the later part is hard to coup up for most of the low-income migrants. They cannot afford any well livable house or apartments and pushed to settle in informal overcrowded setting known as slum areas. These areas normally are devoid of major basic human needs like good food, health, finance and overall environment. These slum areas are increasing and as one out of every four people live in slums (Patel et al., 2019). The phenomenon is very common in Bangladesh's case, especially for the capital city Dhaka (Streatfield & Karar, 2008). With rapid development in the area, different types of harmful dust, particles and gases are exceeding all the limits set by different international and national organizations and governing bodies (Rahman et al., 2019). This is impacting the relatively more vulnerable slum dwellers of the city. These people often find themselves having respiratory problems and other major health concerns (Alam et al., 2018). Considering the city as a whole, different scholars have tried to understand Dhaka city's air quality and failed to solve real world issues at hand. Here, some scholars have worked on how air pollution affects human health in Bangladesh, diurnal variation of air pollution using artificial intelligence, machine learning, statistical analysis (Islam, 2025; Haque et al., 2025). In the meantime, others have focused about Bayesian modeling for air quality analysis, Dhaka city's air pollution distribution using Google Earth Engine and satellite image processing (Dey & Al Mamun, 2026; Howlader et al., 2026; Rahman et al., 2025; Lee et al., 2025). Considering the working range regarding slum area's air quality, it is found that there has not been any comparative site-specific analysis of air quality of different slum areas inside the Dhaka

City Corporation (DCC). To add on, the correlation of the meteorological parameters i.e., temperature and humidity has not been analyzed with slum area's air pollution level. To address these major gaps, this study aims to investigate air quality variation in selected urban slums of Dhaka. The specific objectives include - To compare spatial differences in air pollutant concentrations among the selected slum settlements in 2025, to identify trend of seasonal air pollution and correlation with atmospheric factors and finally to provide recommendations for improving air quality exposure in vulnerable urban slum communities. This study uses in field continuous monitoring data for this entire period of time which makes the analysis robust and realistic than other researches which are solely leaned on secondary sources. Another aspect is that, these slum areas being always underprivileged, this work will identify the situations of air quality in these areas, which will later work as a foundation for providing necessary recommendations to tackle the vulnerable state of the slum community and for enhancing the overall environmental management in these slum areas. The work will directly contribute to the SDG 11 of Sustainable Cities and Communities, along with SDG 13 of Climate Action.

Study Area

The study is mainly focused on primary database and thus selecting major slums was mandatory for understanding the actual situation of air quality and seasonal variations there (Gruebner et al., 2014). Thus, five slums were selected i.e., Shagufta, Bauniabadh, Bhasantek, Korail and Ceramic Bazar (Table 1).

Table 1. Selected Slum Areas.

Name of the Area (Slum)	Latitude	Longitude
Shagufta	23°49'38.78"N	90°22'27.01"E
Bauniabadh	23°49'16.60"N	90°22'53.21"E
Bhasantek	23°48'17.35"N	90°23'10.58"E
Korail	23°47'4.60"N	90°24'17.01"E
Ceramic Bazar	23°44'9.60"N	90°21'43.87"E

*Note: every selected slum is displaying latitude and longitude.

Shagufta area is located in Mirpur DOHS and near Mirpur 12. It's located in Dhaka North City Corporation's (DNCC) ward no. 02 (Figure 1). Under Shagufta point, there lies another slum area i.e., Bauniabadh. It's located in DNCC's ward no. 05 and the area was previously wetland that's been filled up by waste materials. Finally migrated and homeless people started settling at one portion of the area. Meanwhile, Bhasantek slum is located in DNCC's ward no. 15. People here faces serious water shortage and use illegal electric supply. To solve the housing crisis in this neighborhood, a project of 'Bhasantek Rehabilitation Project (BRP)' in 1998 (Kabir, 2011). The project remained unfinished till now. Then, Korail is considered the largest slum of Dhaka city and is located near Mohakhali and Gulshan-Banani area. The slum is located in DNCC's 20 no. ward and spread over 160 acres of landmass. On the contrary, Ceramic bazar area is located in Dhaka South City Corporation's (DSCC) ward no. 14 (Figure 1). This dense area is located near Hazaribagh.

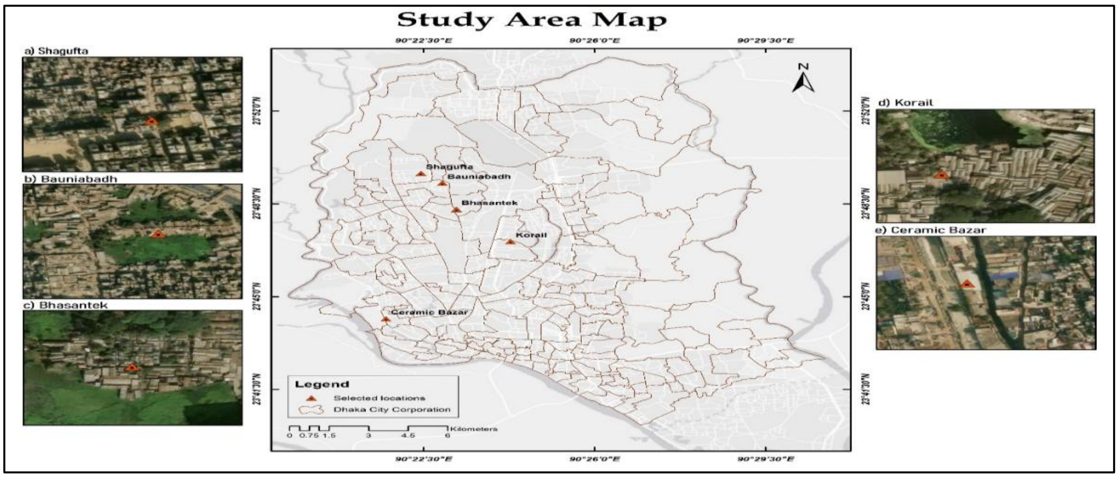


Figure 1. Study Area Map showing the five selected locations for the analysis – a) Shagufta, b) Bauniabadh, c) Bhasantek, d) Korail and e) Ceramic Bazar.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

METHODOLOGY

For the data collection, 5 air quality monitoring systems (Model: CS-AQMS) were deployed at the selected slum areas to continuously measure these area's different variables i.e., Meteorological variables (temperature, humidity), Particulate Matter (PM_1, $PM_{2.5}$, PM_4, PM_{10}) and gaseous pollutants (CO_2, NO_2, SO_2). This monitoring system used laser scattering for PM and electrochemical sensors for detecting the gaseous trace present. Meanwhile, the temperature sensor holds an accuracy of ±0.1°C (typical) and ±0.3°C (maximum), with the relative humidity sensor shows an accuracy of ±1% RH and a maximum accuracy of ±2% RH (0 - 90% RH). Prior to deployment, all the sensor performance was checked through a comparison among the devices at a similar location and routine inspection during field operation. Raw datasets were screened for missing values, duplicate records and anomalous observations before analysis. As optical particulate matter sensors can be affected by ambient humidity and sensor response drift under varying environmental conditions, post-processing corrections were performed in RStudio. Relative humidity effects were adjusted using a humidity correction factor, while temperature drift was minimized through normalization. The corrected particulate matter concentrations were calculated as:

$PM_{corrected} = \frac{PM_{raw}}{1+\alpha(RH-\beta)}$ .... (Equation 1)

Here,

PM_{raw} = Measured concentration of particulate matter

RH = Relative humidity in percentage

α and β = Correlation coefficients (empirically derived)

Particulate matters are tiny solid or liquid particles, with diameter ranging from less than 1 µm to not more than 10 µm. These can create major pollutions and lead to environmental degradation (Gieré & Querol, 2010). Meanwhile, the gaseous pollutants are majorly noticed where different type of burning activities took place. Thus, slum becomes a hotspot for these pollutants and it is rising with time (Dewan et al., 2012). For correlation of these pollutants to atmospheric state, temperature and humidity data were also collected through the AQMS. Data was collected from January 1, 2025 to December 31, 2025. The collected data were downloaded and organized using Microsoft Excel. Quality control procedures were performed to identify and remove erroneous, duplicate or incomplete readings from the system. After cleaning the data, the time-series records were aggregated into four climatic seasons commonly recognized in Bangladesh:

Table 2. Seasonal details used in the analysis.

Season name	Temporal Period	Key Characteristics
Summer	March, April, May	High temperatures (30 - 42°C), dry to moderately humid conditions in early summer which increasing toward May. Characterized by frequent thunderstorms (Kalbaishakhi or Nor'westers).
Monsoon	June July	Heavy and frequent rainfall, very high humidity (often >80%), over casted skies, occasional flooding and waterlogging.
Post-monsoon	August, September, October	Gradual decline in rainfall, warm and humid weather, clearer skies toward October, transition to drier conditions.
Winter	November, December, January, February	Cool and dry weather (average 12 - 29°C), low rainfall, lower humidity, frequent morning fog or mist.

For each of the slum site, the collected data for all the variables were calculated. This is basically is to understand the seasonal variations of pollutants and meteorological parameters across these 5 locations. Furthermore, it helped to reduce the bias and fluctuations. Seasonal mean concentrations of PM_1, $PM_{2.5}$, PM_4, PM_{10}, CO_2, NO_2, and SO_2, along with temperature and humidity, were compared among the five study sites. The results were taken into RStudio and presented through different graphs to illustrate spatial (slum areas) and temporal trends.

To investigate the influence of meteorological conditions on air pollutant concentrations, Pearson correlation analysis was performed. Two separate correlation assessments were conducted for this i.e., correlation between particulate matter (PM_1, $PM_{2.5}$, PM_4 and PM_{10}) and meteorological variables (temperature and relative humidity) and correlations between gaseous pollutants (CO_2, NO_2 and SO_2) and meteorological variables (temperature and relative humidity). The correlation analysis has been completed using Equation 2.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n(\sum x^2 - (\sum x)^2] \, [n(\sum y^2 - (\sum y)^2]}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation 2)}$$

Here,

r = Pearson's correlation coefficient

n = Number of paired observations (sample size)

x = Values of the first variable

y = Values of the second variable

$\sum$ = Summation (sum of all values)

$\sum x$ = Sum of all x values

$\sum y$ = Sum of all y values

$\sum xy$ = Sum of the products of corresponding x and y values

$(\sum x)^2$ = Sum of the squared x values

$(\sum y)^2$ = Sum of the squared y values

Seasonal average observations from all monitoring locations were used in the correlation analysis. Correlation coefficients were computed to determine the direction and strength of relationships between air quality parameters, air pollutants and meteorological conditions. Although detailed chemical speciation data were unavailable, Principal Component Analysis (PCA) served as an exploratory source apportionment technique by grouping pollutants with similar temporal and spatial behaviors into common source-related factors. The factor loading matrix was used to infer the likely origin of pollutants and distinguish between particulate matter dominated and combustion related emission sources. Factor scores were analyzed across the monitoring locations to evaluate the relative contribution of each source category to local air quality conditions.

PCA was performed using seasonal average concentrations of PM_1, $PM_{2.5}$, PM_4, PM_{10}, CO_2, NO_2, SO_2, temperature and relative humidity. Prior to analysis, all variables were standardized using z-score transformation to eliminate unit biases. PCA was conducted in RStudio using the specific function (procomp), and components with eigenvalues greater than one were retained. Variables with loading values greater than 0.7 were considered significant contributors to each component. The extracted components were interpreted as potential emission source categories based on pollutant associations and known source characteristics. This approach enabled identification of dominant particulate and gaseous emission signatures across the monitored slum environments. To improve interpretability, a varimax rotation was applied to the retained principal components, maximizing the separation among pollutant groups and facilitating source characterization. The percentage of variance explained by each component was calculated to assess its relative contribution to overall air quality variability. The resulting component structure was used to explain the observed spatial heterogeneity in pollutant concentrations and to infer the dominant sources influencing air quality across the selected urban slum environments.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

Finally, based on the observed seasonal trends, comparison data, spatial differences in particulate matter, pollutant concentrations and correlation analysis results, a synchronization has been created and these were analyzed for understanding which slums are more vulnerable to air quality degradation (Figure 2). Using this, the study provides site-specific recommendations to tackle the air quality scenario of the slum areas. After that, these recommendations were also compared with previously formed policies, laws or regulations to understand the credibility and applicability.

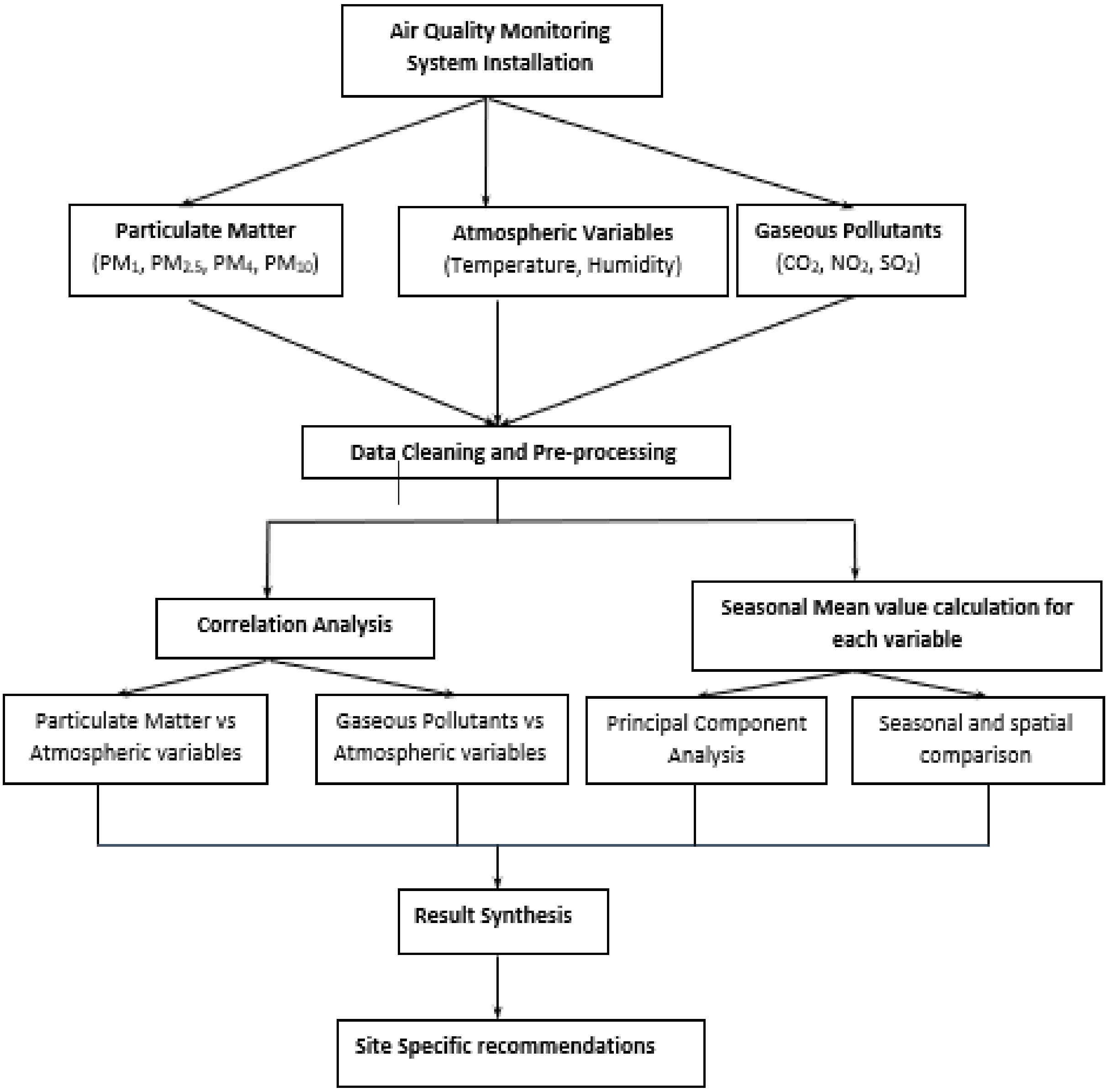


Figure 2. Methodological flow diagram of the study.

RESULT AND DISCUSSION

After the execution of the methodology in an orderly manner, there comes out some important findings. Initially, the distribution of particulate matter can be seen in Figure 3.

The highest PM_1 concentrations were consistently observed during winter, whereas the lowest concentrations occurred during the monsoon season, indicating a strong seasonal influence on fine particulate matter levels. During summer, PM_1 concentrations ranged from 60.06 µg/m³ at Shagufta to 97.30 µg/m³ at Ceramic Bazar. Bhasantek (81.76 µg/m³), Korail (68.40 µg/m³), and Bauniabadh (65.62 µg/m³) also exhibited relatively high PM_1 levels, reflecting increased dust resuspension, vehicular emissions and dry atmospheric conditions. In the monsoon season, PM_1 concentrations decreased substantially across all locations, with values ranging from 26.57 µg/m³ at Korail to 43.58 µg/m³ at Ceramic Bazar. Shagufta, Bauniabadh, and Bhasantek recorded concentrations

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

of 37.07, 28.45, and 30.67 µg/m³, respectively. During the post-monsoon season, PM_1 concentrations increased compared to the monsoon, ranging from 31.40 µg/m³ at Bhasantek to 63.53 µg/m³ at Bauniabadh. Shagufta, Korail, and Ceramic Bazar recorded 46.63, 42.22, and 52.97 µg/m³, respectively (Figure 3.a). This increase reflects the gradual reduction in rainfall and the resumption of anthropogenic activities, leading to the accumulation of particulate matter. The winter season recorded the highest PM_1 concentrations at all monitoring sites, varying between 136.09 µg/m³ at Shagufta and 209.69 µg/m³ at Ceramic Bazar. Bhasantek (200.62 µg/m³), Korail (198.76 µg/m³) and Bauniabadh (178.19 µg/m³) also exhibited exceptionally high concentrations compared to other seasons.

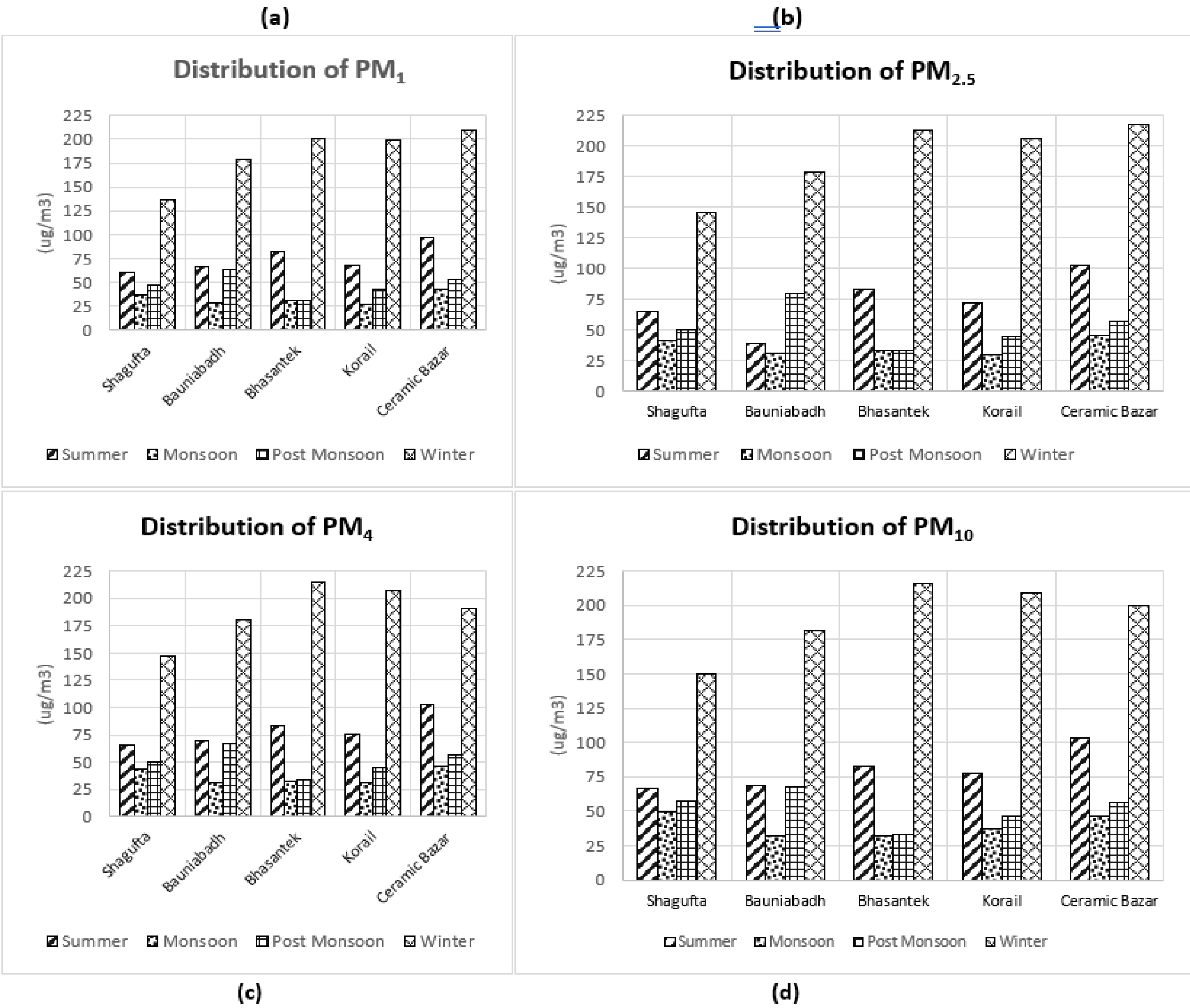


Figure 3. Distribution of particulate matter across the five slum locations - (a) PM_1 distribution, (b) $PM_{2.5}$ distribution, (c) PM_4 distribution; (d) PM_{10} distribution.

As for $PM_{2.5}$, it's concentrations ranged from 38.91 µg/m³ at Bauniabadh to 102.62 µg/m³ at Ceramic Bazar. Concentrations declined markedly during the monsoon, varying between 28.99 µg/m³ at Korail and 45.76 µg/m³ at Ceramic Bazar, mainly due to the washout effect of frequent rainfall. In the post-monsoon season, $PM_{2.5}$ levels increased, ranging from 33.24 µg/m³ at Bhasantek to 79.58 µg/m³ at Bauniabadh, as rainfall decreased and atmospheric conditions became drier. The winter season exhibited the highest concentrations at all sites, ranging from 145.39 µg/m³ at Shagufta to 217.71 µg/m³ at Ceramic Bazar, reflecting poor atmospheric dispersion, lower mixing heights, and increased emissions from traffic, brick kilns, and biomass burning.

In summer, PM_4 concentrations ranges from 65.99 µg/m³ at Shagufta to 103.05 µg/m³ at Ceramic Bazar. With the onset of the monsoon, concentrations declined to 31.11 µg/m³ at Bauniabadh and 45.92 µg/m³ at Ceramic Bazar. Following the monsoon, PM_4 concentrations increased during the post-monsoon period, with values ranging from 33.41 µg/m³ at Bhasantek to 67.21 µg/m³ at Bauniabadh. The winter season showed a sharp rise

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

in PM_4 levels, reaching 146.71–214.83 µg/m³, with the highest concentration measured at Bhasantek and the lowest at Shagufta.

PM_{10} concentrations showed clear seasonal variation across all thee slums, with the highest levels reaching in winter and the lowest during the monsoon season. Winter concentrations ranged from 150.37 µg/m³ (Shagufta) to 215.65 µg/m³ (Bhasantek), indicating severe particulate pollution. In contrast, monsoon values were substantially lower. Among the sites, Bhasantek, Korail and Ceramic Bazar consistently recorded higher PM_{10} levels, while Shagufta exhibited comparatively lower concentrations.

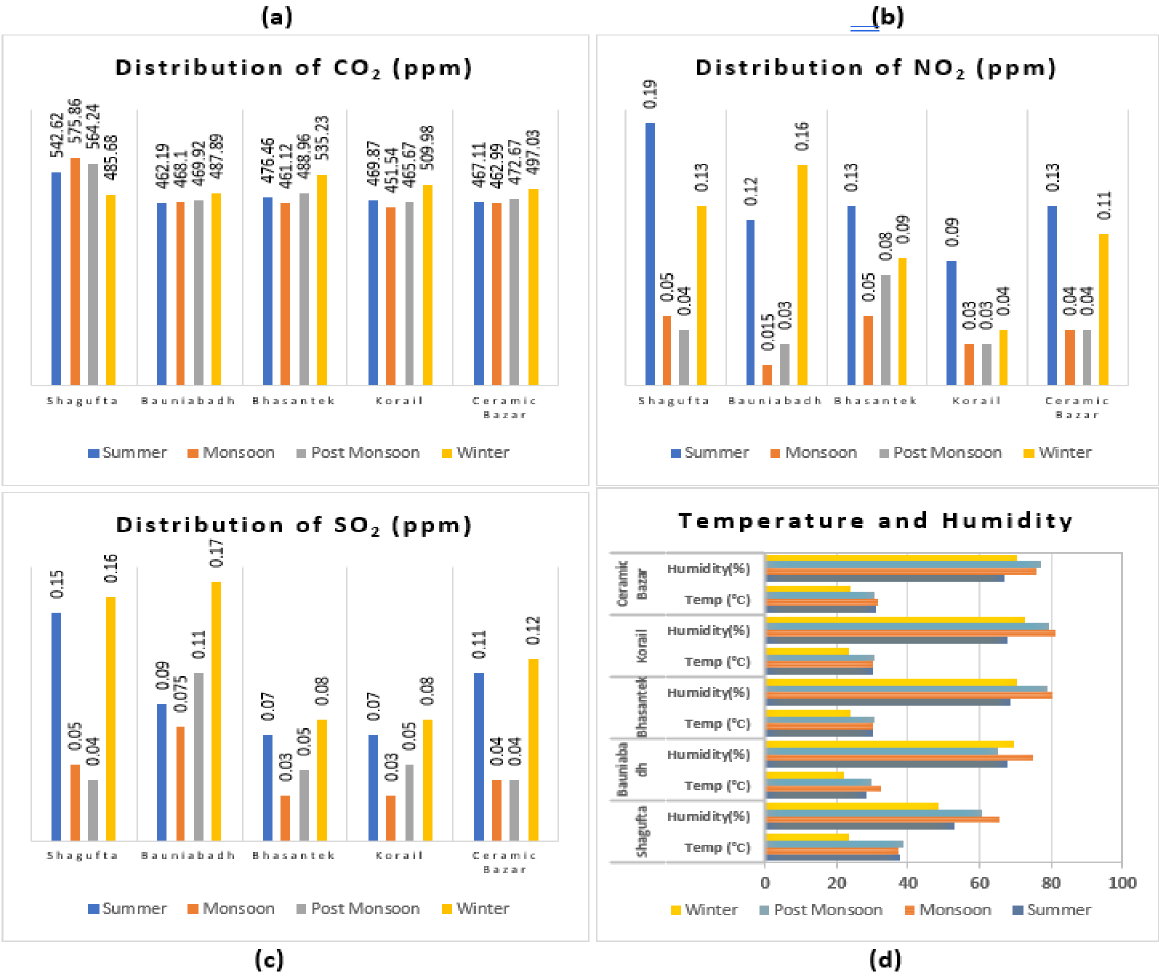


Figure 4. Distribution of gaseous pollutants across the five slum locations – (a) CO_2 distribution, (b) NO_2 distribution, (c) SO_2 distribution and (d) Temperature and Humidity distribution.

According to the figure 4.a, Shagufta area exhibits the highest amount of CO_2 concentration during summer, monsoon and post-monsoon period which is 542.62 ppm, 575.86 ppm and 564.24 ppm respectively. Meanwhile in winter, the highest value is recorded at Bhasantek area which is 535.23 ppm. During these four seasons, near similar trend can be observed for Bauniabadh, Korail and Ceramic Bazar slums.

NO_2 concentrations showed that the highest levels generally occur during summer, followed by winter, while the lowest concentrations were observed during the monsoon and post-monsoon seasons (Figure 4.b). The seasonal decline during the monsoon is primarily associated with rainfall, enhanced atmospheric mixing, and wet removal of pollutants. Here, Shagufta and Bauniabadh tended to exhibit relatively higher NO_2 concentrations, whereas Korail generally recorded the lowest levels.

Sulphur di-oxide (SO_2) concentrations in ranged from 0.08 ppm at Bhasantek and Korail to 0.17 ppm at Bauniabadh (Figure 4.c). During summer, SO_2 concentrations varied between 0.07 and 0.15 ppm, with the highest value observed at Shagufta and the lowest at Bhasantek and Korail. Concentrations declined during the monsoon (0.03 to 0.075 ppm). In the post-monsoon season, SO_2 levels showed a slight increase up to 0.11 ppm,

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

with Bauniabadh recording the highest concentration. Overall, Bauniabadh and Shagufta generally exhibited comparatively higher SO_2 concentrations, whereas Bhasantek and Korail consistently recorded lower levels.

Temperature and relative humidity varied considerably across seasons and monitoring locations (Figure 4.d). During summer, temperatures was the lowest (28.37°C) at Bauniabadh and highest (37.88°C) at Shagufta, while relative humidity varied between 53.14% and 68.60%. Ceramic Bazar, Korail and Bhasantek recorded temperatures of 30.89°C, 30.12°C and 30.40°C, respectively. In the monsoon season, temperatures ranged from 30.28°C at Bhasantek to 37.36°C at Shagufta. Relative humidity increased substantially, ranging from 65.42% at Shagufta to 81.48% at Korail, with Bhasantek (80.41%) and Ceramic Bazar (75.78%) also experiencing high humidity. During the post-monsoon period, temperatures ranged between 29.90°C at Bauniabadh and 38.61°C at Shagufta. Relative humidity varied from 60.77% at Shagufta to 79.26% at Korail, while Bhasantek and Ceramic Bazar recorded 78.89% and 77.20%, respectively. The winter season recorded the lowest temperatures across all sites, lowest at Bauniabadh and highest at Ceramic Bazar. Relative humidity ranged from 48.56% at Shagufta to 72.54% at Korail. In summary, Shagufta consistently recorded the highest temperatures and the lowest relative humidity, whereas Korail and Bhasantek generally experienced the highest humidity levels, particularly during the monsoon and post-monsoon seasons.

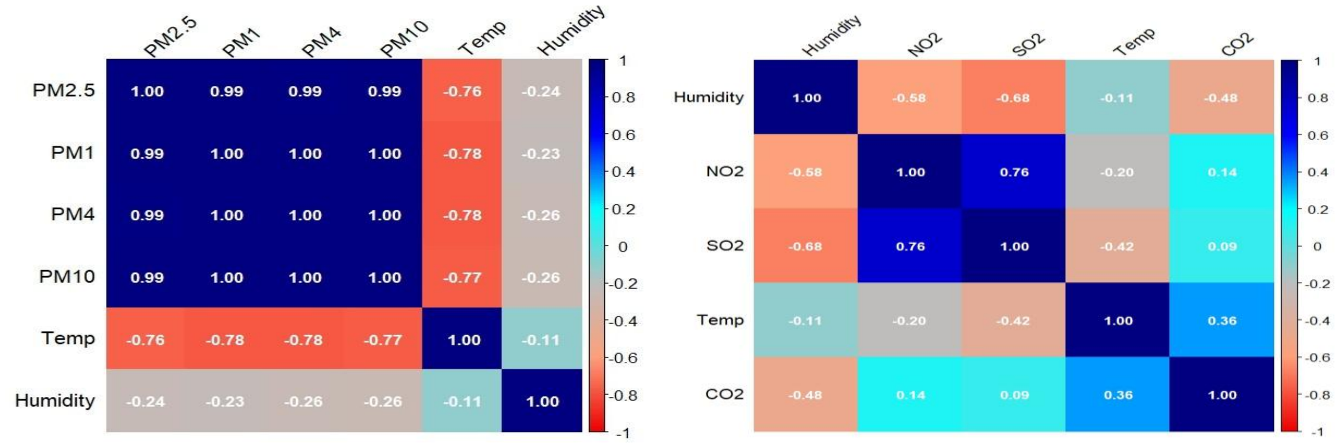
Table 3 presents a comparative overview of the seasonal averages of particulate matter, gaseous pollutants and meteorological variables across the five selected slum locations in Dhaka. A consistent seasonal pattern was observed for particulate matter (PM_1, $PM_{2.5}$, PM_4 and PM_{10}), with concentrations peaking during winter and reaching their minimum during the monsoon season at all monitoring sites. Among the locations, Bhasantek, Korail and Ceramic Bazar generally experienced the highest particulate matter concentrations, whereas Shagufta consistently recorded the lowest values. For instance, winter PM_{10} concentrations ranged from 150.37 µg/m³ at Shagufta to 215.65 µg/m³ at Bhasantek, while winter $PM_{2.5}$ varied from 145.39 µg/m³ at Shagufta to 212.94 µg/m³ at Bhasantek. Similarly, PM_1 concentrations reached 209.69 µg/m³ at Ceramic Bazar but remained comparatively lower (136.09 µg/m³) at Shagufta. During the monsoon, all particulate fractions declined substantially, reflecting the effective removal of airborne particles through rainfall and enhanced atmospheric mixing. The gaseous pollutants exhibited comparatively lower seasonal variability than particulate matter. SO_2 concentrations ranged from 0.03 to 0.17 ppm, with the highest values generally occurring during winter and summer, particularly at Bauniabadh and Shagufta, while the lowest concentrations were observed during the monsoon. NO_2 showed a similar pattern, with concentrations ranging between 0.015 and 0.19 ppm, where Shagufta and Bauniabadh frequently recorded higher levels than the remaining locations. These elevated concentrations are likely associated with greater traffic density and combustion-related activities surrounding these sites.

Atmospheric CO_2 concentrations varied from 451.54 to 575.86 ppm across the study locations and seasons. The highest concentration was observed at Shagufta during the monsoon (575.86 ppm), whereas the lowest concentration (451.54 ppm) was recorded at Korail during the monsoon. Seasonal fluctuations in CO_2 were relatively modest compared with particulate matter, indicating the influence of continuous anthropogenic emissions rather than strong seasonal meteorological controls. Meteorological conditions also showed distinct spatial and seasonal differences. Shagufta consistently recorded the highest temperatures, ranging from 23.37°C in winter to 38.61°C in the post-monsoon season, whereas the remaining sites generally experienced temperatures between 22.21°C and 32.40°C. Relative humidity was highest during the monsoon, ranging from 65.42% to 81.48%, with Korail and Bhasantek exhibiting the greatest humidity levels. Conversely, winter was characterized by relatively low humidity, particularly at Shagufta (48.56%), creating favorable conditions for pollutant accumulation. Overall, the findings indicate that meteorological conditions strongly influenced seasonal air quality across the study locations. High humidity and frequent rainfall during the monsoon make the air at these slum locations the best among all these seasons. In contrast, the dry atmosphere, lower temperatures and reduced atmospheric mixing during winter favored pollutant accumulation, producing the highest particulate matter levels. Spatially, Bhasantek, Korail and Ceramic Bazar emerged as the most polluted locations in terms of particulate matter, while Shagufta generally experienced higher temperatures, lower humidity and relatively lower particulate concentrations but comparatively elevated gaseous pollutant levels.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

Table 3. Average seasonal particulate matter, gaseous pollutant and atmospheric variable data across the five slum locations (at a glance).

	Season	PM1 (µg/m³)	PM2.5 (µg/m³)	PM4 (µg/m³)	PM10 (µg/m³)	CO2 (ppm)	NO2 (ppm)	SO2 (ppm)	Temp (°C)	Hum (%)
Shagufta	Winter	136.09	145.39	146.71	150.37	485.68	0.13	0.16	23.37	23.37
	Summer	60.06	64.79	65.99	66.69	542.62	0.19	0.15	37.88	53.14
	Monsoon	37.07	41.32	43.39	49.35	575.86	0.05	0.05	37.36	65.42
	Post Monsoon	46.63	49.8	50.22	57.22	564.24	0.04	0.04	38.61	60.77
Bauniabadh	Winter	178.19	145.39	180.61	181.89	487.89	0.16	0.17	22.21	69.57
	Summer	65.62	64.79	69.19	69.22	462.19	0.12	0.09	28.37	67.64
	Monsoon	28.45	41.32	31.11	31.11	468.1	0.015	0..075	32.4	74.85
	Post Monsoon	63.53	49.8	67.21	67.21	469.12	0.03	0.11	29.9	65.21
Bhasantek	Winter	200.62	178.21	214.83	215.65	525.23	0.09	0.08	23.83	70.7
	Summer	81.76	79.58	83.04	83.19	476.46	0.13	0.07	30.4	68.6
	Monsoon	30.67	30.49	32.58	32.67	461.12	0.05	0.03	30.28	80.41
	Post Monsoon	31.4	38.91	33.41	33.49	488.96	0.08	0.05	30.51	78.89
Korail	Winter	198.76	212.94	207.29	208.87	509.98	0.04	0.08	23.35	72.54
	Summer	68.4	82.69	75.77	77.99	469.87	0.09	0.07	30.12	67.75
	Monsoon	26.57	32.39	31.22	36.78	451.54	0.03	0.3	30.32	81.48
	Post Monsoon	42.22	33.24	44.98	46.86	465.67	0.03	0.05	30.51	79.26
Ceramic Bazar	Winter	209.69	71.84	190.77	200.23	497.03	0.11	0.12	23.88	70.5
	Summer	97.3	28.99	103.05	103.31	467.11	0.13	0.11	30.89	67.06
	Monsoon	43.58	44.37	45.92	45.92	462.99	0.04	0.04	31.33	75.78
	Post Monsoon	52.97	206.1	56.5	56.67	472.67	0.04	0.04	30.66	77.2



(a) (b)

Figure 5. Pearson correlation matrix of the variables – (a) Particulate matter and Atmospheric variables, (b) Gaseous pollutants and Atmospheric variables.

Figure 5.a presents the Pearson correlation matrix illustrating the relationships among particulate matter (PM_1, $PM_{2.5}$, PM_4 and PM_{10}), temperature and relative humidity. The results reveal very strong positive correlations among all particulate matter fractions, with correlation coefficients ranging from 0.99 to 1.00. Specifically, $PM_{2.5}$ showed a correlation of 0.99 with PM_1, PM_4, and PM_{10}. These results indicate that the different particulate size fractions are more likely to originate from similar emission sources and display comparable temporal and spatial variations. Temperature exhibited a strong negative correlation with all particulate matter fractions, with correlation coefficients ranging from −0.76 to −0.78. This inverse relationship suggests that higher temperatures are associated with lower particulate matter concentrations. Relative humidity showed weak negative correlations with particulate matter, with coefficients ranging from −0.23 to −0.26. The weak correlations suggest that humidity alone had a limited influence on particulate matter levels. The relationship between temperature and relative humidity was also weakly negative ($r = -0.11$), indicating little linear association between these two meteorological variables during the study period.

Meanwhile, Figure 5.b illustrates the correlation matrix showing the relationships among gaseous pollutants (NO_2, SO_2 and CO_2) and meteorological variables (temperature and relative humidity).

A strong positive correlation was observed between NO_2 and SO_2 ($r = 0.76$). In contrast, CO_2 exhibited weak positive correlations with both NO_2 ($r = 0.14$) and SO_2 ($r = 0.09$), indicating only a limited linear relationship between CO_2 concentrations and these gaseous pollutants. Relative humidity showed moderate negative correlations with NO_2 ($r = -0.58$) and SO_2 ($r = -0.68$), implying that higher humidity levels were associated with lower concentrations of these. Humidity also displayed a moderate negative correlation with CO_2 ($r = -0.48$), whereas its relationship with temperature was weakly negative ($r = -0.11$). Temperature exhibited negative correlations with NO_2 ($r = -0.20$) and SO_2 ($r = -0.42$), indicating that increasing temperatures were generally associated with lower concentrations of these pollutants. Conversely, CO_2 showed a weak positive correlation with temperature ($r = 0.36$), suggesting a slight increase in CO_2 concentrations with rising temperature, although the relationship was not particularly strong.

Meanwhile, the Principal Component Analysis (PCA) identified three major source factors that collectively explained 82.54% of the total variance in air quality parameters across the selected slum settlements. From the table 4, the first principal component (PC1) accounted for 50.34% of the total variance and exhibited strong positive loadings for PM_1 (0.465), $PM_{2.5}$ (0.416), PM_4 (0.467) and PM_{10} (0.464). The simultaneous loading of all particulate matter fractions suggests a common origin and indicates that particulate pollution is the primary factor controlling air quality variability among the study sites. The negative association with temperature (-0.415) further suggests that particulate concentrations tend to accumulate during cooler seasons, particularly winter, when atmospheric mixing is reduced and pollutant dispersion is limited. The dominance of PC1 indicates that particulate matter is the most significant air quality concern in the investigated slum environments (Table 4). The second principal component (PC2) explained 17.59% of the total variance and was primarily characterized by a strong positive loading of CO_2 (0.750), accompanied by moderate positive loading of

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VII July 2026

temperature (0.389). This component appears to represent residential combustion and human activity related emissions. Elevated The relationship with temperature may reflect increased energy demand and intensified human activities during warmer periods. The emergence of this factor highlights the contribution of everyday residential practices to gaseous pollution within the settlements.

Finally, the third principal component (PC3) accounted for 14.61% of the total variance and was dominated by NO_2 (0.591) and SO_2 (0.564), while relative humidity showed a moderate negative loading (-0.546). The co-occurrence of NO_2 and SO_2 suggests that these pollutants originate from similar combustion sources. The negative relationship with humidity indicates that atmospheric moisture may facilitate pollutant removal through wet deposition and dilution processes, particularly during the monsoon season. The presence of this factor demonstrates that traffic and fuel combustion activities contribute substantially to the spatial variability of gaseous pollutants among the monitored slums.

Overall, the PCA results reveal that air quality in the selected slum settlements is influenced by three major source categories i.e., particulate emissions from dust and biomass-related activities, (ii) residential combustion and human activities, (iii) traffic and sulfur-containing fuel combustion sources.

Table 4. Principal Component Analysis (PCA) result for air quality parameters across the slums.

Variable	PC1 (PM)	PC2 (CO_2, NO_2)	PC3 (SO_2)
PM_1	**0.465**	0.035	0.044
$PM_{2.5}$	**0.416**	0.110	-0.161
PM_4	**0.467**	0.051	0.048
PM_{10}	**0.464**	0.060	0.053
CO_2	0.038	**0.750**	0.034
NO_2	0.047	0.080	**0.591**
SO_2	-0.036	-0.414	**0.564**
Temperature	-0.415	0.389	0.021
Relative Humidity	0.001	-0.298	-0.546
Eigenvalue	**4.77**	**1.67**	**1.38**
Variance Explained (%)	**50.34**	**17.59**	**14.61**
Cumulative Variance (%)	**50.34**	**67.93**	**82.54**
Interpreted Source	Dust resuspension, biomass burning, waste burning and construction activities	Household fuel combustion, cooking activities, population density and generator use	Vehicular emissions, diesel generators and sulfur-containing fuel combustion

***Note:** Bold values indicate the dominant loadings used for source interpretation. Principal components with eigenvalues > 1 were retained following the Kaiser criterion.

Considering the overall outcome, there are some important recommendations to be made. These are specifically important to mitigate the current pollution scenario. In this part, site-specific recommendations are provided first, which will be more impactful for the one slum area only (Table 5). After that, based on the overall improvement and refurbishment of the deadly air quality state, common solutions are pointed. These solutions are linked to one another and works as a matrix of a complex system. If one solution becomes negatively impactful rather than being positive, all in all, it hampers the overall harmony of the eradication mechanism of air pollution. Thus, before the beginning of implementing each recommendation, proper feasibility test is needed to be executed in reality. Future works can be extended based on this aspect.

Table 5. Site-specific and common recommendations for the selected slum areas.

Slum Location	Specific Recommendation	Common recommendations
Shagufta	Roadside vehicle emission control and regular traffic management to reduce exposure to traffic-related NO_2 and SO_2 emissions.	

Bauniabadh	Emission control of nearby small industries and carbon burning in the slum area.	- Conduction of awareness campaign among the slum dwellers about the negative sides of air pollution. - Integration of air quality improvement as a major part of every development project inside Dhaka City Corporation boundary. - Setting up air quality monitoring device that gets continuous data always. This will be impactful in assessing air quality of the slums and to act accordingly. - Tree plantation campaign and urban green space creation through vertical gardening, free seed providing, roadside plantation, terrace gardening, 'one house one tree' policy etc. - Promote the use of clean cooking fuels (e.g., LPG or electricity) instead of biomass and solid fuels in slum households. - Regularly clean and sprinkle water on dusty roads, particularly during the dry season. - Phase out older, high-emitting vehicles.
Bhasantek	Implement strict dust control measures at nearby construction sites through regular water spraying and covering of construction materials.	
Korail	Suspended dust removal from construction sites using water spray, efficient waste management and burning ban inside the slum area.	
Ceramic Bazar	Installation of particulate emission control systems (e.g., bag filters) in nearby small industries, eco-friendly infrastructure development.	

CONCLUSION

Dhaka city being home to more than 20 million people, occupies some major slum areas majorly on the middle areas of the city. In these slums, the study found that pollution level varies significantly from one place to another all the time. Here, some slums exhibited comparatively more concern in terms of particulate matter concentration i.e., Bhasantek, Korail and Ceramic Bazar areas due to being occupied by comparatively more slum dwellers and passive pollutions from vehicles, constructions and nearby small industries. As of the gaseous pollution, Shagufta area normally exhibited the highest pollution level. The correlation analysis also illustrated the pollution connection with temperature and humidity. So, it can be inferred that, all these slum area's air quality is way out of national and international clean air quality threshold level. In this current scenario, different measures are mandatory to cover for the slum areas, but its also important to determine which area to cover first or start working simultaneously. These measures, if taken accurately, will definitely upgrade the current toxic air of these areas and reduce the amount of health issues formed by air pollution.

REFERENCES

1. Wang, J., Long, R., Chen, H., & Li, Q. (2019). Measuring the psychological security of urban residents: Construction and validation of a new scale. Frontiers in Psychology, 10, Article 2423. https://doi.org/10.3389/fpsyg.2019.02423
2. Patel, A., Joseph, G., Shrestha, A., & Foint, Y. (2019). Measuring deprivations in the slums of Bangladesh: Implications for achieving sustainable development goals. Housing and Society, 46(2), 81–109. https://doi.org/10.1080/08882746.2019.1622346
3. Rahman, M. M., Mahamud, S., & Thurston, G. D. (2019). Recent spatial gradients and time trends in Dhaka, Bangladesh, air pollution and their human health implications. Journal of the Air & Waste Management Association, 69(4), 478–501. https://doi.org/10.1080/10962247.2018.1548388
4. Alam, M. Z., Armin, E., Haque, M. M., Halsey, J., & Qayum, M. A. (2018). Air pollutants and their possible health effects at different locations in Dhaka city. Journal of Current Chemical and Pharmaceutical Sciences, 8(1), 111.
5. Islam, F. A. S. (2025). A comprehensive analysis of air pollution in Dhaka City, Bangladesh, and the application of artificial intelligence and machine learning for enhanced management and forecasting. International Journal of Applied and Natural Sciences.

6. Hoque, M. M. M., Mizan, M. M. R., Hossain, M. N., Sarker, M. E., Pranto, N. A. N., Khan, M. M. H., Ali, M. A., Islam, M. S., & Yesmin, R. (2025). Spatial distribution and diurnal variation of particulate matters and gaseous air pollutants of Dhaka city, Bangladesh. Discover Atmospheres, 3, Article 10. https://doi.org/10.1007/s44292-025-00031-z
7. Dey, A. K., & Al Mamun, A. (2026). Modeling air pollution in Dhaka with Bayesian generalized additive mixed model and quantile regression. Environmental and Ecological Statistics, 33, 653–675. https://doi.org/10.1007/s10651-026-00720-x
8. Howlader, M. K. A., Zaman, S. U., Hossen, M. A. A., Kiber, M. A., & Salam, A. (2026). Traffic-induced air pollution at traffic intersections in Dhaka: Seasonal patterns and associated health implications. Environmental Science: Atmospheres.
9. Rahman, M. M., Kamruzzaman, M., Faridatul, M. I., & Szabó, G.. (2025). Spatiotemporal dynamics of urban air pollution in Dhaka City (2020–2024) using time-series Sentinel-5P satellite images and Google Earth Engine (GEE). Environments, 12(8), Article 274. https://doi.org/10.3390/environments12080274
10. Lee, M., Bayazid, A. R., Rosenthal, L., Khan, R. H., Arku, R., Barratt, B., Quayyum, Z., & Baumgartner, J. (2025). Spatiotemporal patterns in air pollution and sound in Dhaka, Bangladesh. Scientific Reports, 15, Article 32852. https://doi.org/10.1038/s41598-025-32852-0
11. Streatfield, P. K., & Karar, Z. A. (2008). Population challenges for Bangladesh in the coming decades. Journal of health, population, and nutrition, 26(3), 261.
12. Gruebner, O., Sachs, J., Nockert, A., Frings, M., Khan, M. M. H., Lakes, T., & Hostert, P. (2014). Mapping the Slums of Dhaka from 2006 to 2010. Dataset Papers in Science, 2014(1), 172182.
13. Kabir, T. (2011). Factors affecting slum resettlement projects in Bangladesh: A case study of Bhasantek Rehabilitation Project, Dhaka [Master's thesis, Erasmus University Rotterdam]. Academia.edu. https://www.academia.edu/92496444/A_case_study_of_Bhasantek_Rehabilitation_Project_Dhaka
14. Gieré, R., & Querol, X. (2010). Solid particulate matter in the atmosphere. Elements, 6(4), 215–222. https://doi.org/10.2113/gselements.6.4.215
15. Dewan, A. M., Kabir, M. H., Nahar, K., & Rahman, M. Z. (2012). Urbanisation and environmental degradation in Dhaka Metropolitan Area of Bangladesh. International Journal of Environment and Sustainable Development, 11(2), 118-147.