BILINGUAL PUBLISHING GROUP

Journal of Atmospheric Science Research

https://journals.bilpubgroup.com/index.php/jasr

ARTICLE

Investigating the Impact of Meteorological Parameters on PM2.5 Concentrations and Air Quality Index Using Regression Analysis

Neelam Tanwar [1], *Satish Bhagwatrao Aher* [1*], *Dharma Raj* [2], *Subroto Nandi* [1]

[1] *Department of Environmental Monitoring and Exposure Assessment (Air), ICMR-National Institute for Research in Environmental Health, Bhopal 462030, India*

[2] *Department of Biostatistics and Bioinformatics, ICMR-National Institute for Research in Environmental Health, Bhopal 462030, India*

ABSTRACT

Air pollution from fine particulate matter (PM2.5) poses a serious health risk in rapidly urbanizing areas like Bhopal, India. This study investigates the influence of meteorological factors temperature, humidity, rainfall, and wind speed on PM2.5 concentrations and the Air Quality Index (AQI) from January 2022 to December 2023. PM2.5 levels ranged from 1.0 µg/m³ to 938.0 µg/m³, with an average AQI of 119, indicating moderate pollution. Correlation analysis indicated that higher temperatures were sometimes associated with elevated PM2.5 episodes due to enhanced photochemical activity, but regression analysis revealed an overall negative association, suggesting stronger atmospheric dispersion at higher temperatures. Wind speed consistently reduced PM2.5, while humidity and rainfall supported pollutant removal. Regression models explained 18.1% of PM2.5 and 29.7% of AQI variability. Ridge regression reinforced the dominant influence of temperature and humidity. AQI was modelled alongside PM2.5 to align with its practical role in public communication and policy, despite being largely driven by PM2.5. These findings highlight the role of meteorological conditions in shaping urban air quality and emphasize the need for targeted interventions during stagnant, high-pressure episodes. By focusing on Bhopal, this study contributes valuable city-specific knowledge to the broader discourse on air pollution in rapidly developing regions of India. The study reinforces the need to incorporate meteorological forecasting into urban air quality

*CORRESPONDING AUTHOR:

Satish Bhagwatrao Aher, Department of Environmental Monitoring and Exposure Assessment (Air), ICMR-National Institute for Research in Environmental Health, Bhopal 462030, India; Email: aher.satish@icmr.gov.in

ARTICLE INFO

Received: 27 June 2025 | Revised:23 August 2025 | Accepted: 30 August 2025 | Published Online: 7 September 2025

DOI: https://doi.org/10.30564/jasr.v8i4.11242

CITATION

Tanwar, N., Aher, S.B., Raj, D., 2025. Investigating the Impact of Meteorological Parameters on PM2.5 Concentrations and Air Quality Index Using Regression Analysis. Journal of Atmospheric Science Research. 8(4): 10–18. DOI: https://doi.org/10.30564/jasr.v8i4.11242

management strategies.

Keywords: PM2.5; Air Quality Index (AQI); Meteorological Parameters; Regression Analysis; Urban Air Pollution

1. Introduction

Clean air is fundamental to human health and environmental sustainability, yet air pollution driven by rapid industrialization, urban expansion, and increased energy demand remains one of the most pressing global health challenges. According to the World Health Organization (WHO), ambient air pollution is responsible for approximately 4.2 million premature deaths annually worldwide, with fine particulate matter (PM2.5) identified as a major contributor to cardiovascular, respiratory, and other chronic diseases [1–5]. In countries like India, where urban populations and industrial activity are growing rapidly, air quality has continued to deteriorate [6–9]. Current estimates suggest that approximately 1800 deaths per day are attributable to air pollution in Indian cities, with nearly 90% of air pollution-related mortality occurring in low- and middle-income countries [10].

The Air Quality Index (AQI), a composite indicator used globally to communicate air pollution levels, often reflects PM2.5 as the dominant pollutant in urban settings across India [11,12]. Due to their microscopic size, PM2.5 particles can bypass the body's natural defence, penetrate deep into the lungs, and cause severe health impacts [13].

Meteorological conditions including temperature, relative humidity, wind speed, and rainfall play a critical role in influencing the formation, dispersion, and concentration of air pollutants. For instance, higher temperatures can accelerate photochemical reactions, increasing pollutant levels, while wind and rainfall can facilitate pollutant dispersion or removal from the atmosphere [14–16]. While previous studies have acknowledged the role of meteorological factors in shaping air quality, many have focused on short-term datasets, lacked seasonal resolution, or generalized findings without accounting for local climatic and urban characteristics.

Despite the growing body of research, key knowledge gaps remain, particularly in understanding how meteorological variability interacts with urban air pollution at the city scale in rapidly developing regions like central India. Unlike megacities such as Delhi or Mumbai, Bhopal represents a tier-2 urban centre with a unique emissions profile (mixed industrial–residential), irregular urban morphology (lakeside settlements vs. industrial belts), and marked seasonal shifts (humid monsoon, dry summer, stagnant winter). These characteristics make it a distinctive case for assessing meteorology–pollution interactions beyond metro-centric studies.

This study aims to address these gaps by focusing on the following objectives:

1. To analyze the relationship between key meteorological parameters (temperature, rainfall, relative humidity, and wind speed) and PM2.5 concentrations in Bhopal over a two-year period (2022–2023),
2. To assess the impact of meteorological variability on the Air Quality Index (AQI), with attention to seasonal differences,
3. To explore how local weather dynamics influence pollutant behaviour in a mid-sized urban setting, offering insights distinct from those based on megacities.

The novelty of this study lies in its city-specific perspective, the use of continuous hourly data across multiple seasons, and the integration of both PM2.5 and AQI as response variables for enhanced public health relevance.

2. Materials and Methods

2.1. Study Area

Bhopal, located in central India at 23°25′ N latitude and 77°25′ E longitude, with an altitude of 550–600 meters above sea level, was chosen for this study (**Figure 1**). The city experiences a humid subtropical climate with four distinct seasons: winter (mid-November to February), summer (March to early June), monsoon (mid-June to September), and autumn (October to mid-November). These seasonal shifts create diverse meteorological conditions, which are ideal for studying the impact of weather patterns on air quality.

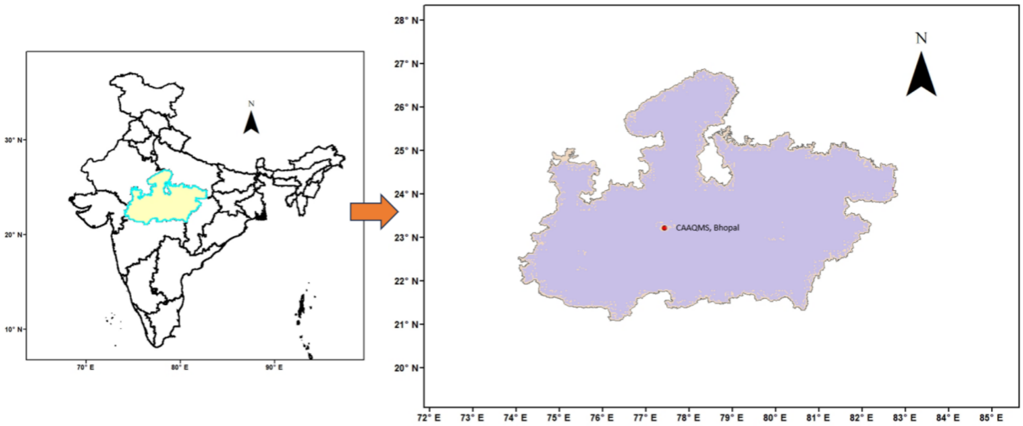

Figure 1. Study area.

2.2. Data Collection

This study employed hourly data spanning from January 1, 2022, to December 31, 2023, covering PM2.5 concentrations, Air Quality Index (AQI), and key meteorological variables including temperature, relative humidity, wind speed, atmospheric pressure, solar radiation, and rainfall. These datasets were sourced from the Continuous Ambient Air Quality Monitoring System (CAAQMS), operated by the Madhya Pradesh Pollution Control Board (MPPCB), and are publicly accessible via the Central Pollution Control Board (CPCB) portal (https://cpcb.nic.in/). The data were collected from fixed ambient monitoring stations equipped with standardized instrumentation following CPCB protocols. For this study, data were extracted from monitoring stations located in Bhopal, Madhya Pradesh. A map showing the geographic locations of the monitoring station used is provided in **Figure 1**. To ensure reliability, the data underwent a preliminary quality control process. Outliers and missing values were handled by the concerned agency. All stations follow CPCB's standard operating procedures for calibration, maintenance, and data validation, ensuring a high degree of accuracy and consistency across the dataset. Nevertheless, any limitations related to data completeness or potential measurement uncertainties have been addressed.

2.3. Statistical Analysis

The data underwent preprocessing to eliminate inconsistencies and missing values, resulting in 16,524 observations suitable for analysis. Pearson correlation analysis was conducted to investigate the relationships between PM2.5 concentration, AQI, and meteorological parameters [16]. Multiple Linear Regression (MLR) was then applied to model the relationships between air quality and meteorological factors, as outlined in the regression equation below:

$$y = a + bx1 + cx2 + dx3 + \ldots$$

where y represents the dependent variable (either PM2.5 concentration or AQI), x1, x2, … are the meteorological parameters, and a is the intercept term. To address multicollinearity, Ridge Regression was employed to refine the model's robustness by introducing a penalty term to minimize coefficient variance [17–19]. Although AQI is strongly influenced by PM2.5, it was included as a dependent variable because it is the public-facing metric used in advisories and policymaking.

2.4. Statistical Evaluation

Model performance was initially assessed using the coefficient of determination (R-squared), which measures the proportion of variance in the dependent variable that can be explained by the independent variables [19]. While higher R-squared values can indicate a stronger statistical association between meteorological parameters and air quality indicators such as PM2.5 and AQI, it is important to note that R-squared alone does not imply causality. To address this limitation and provide more robust insights into potential causal relationships, additional statistical technique was considered. The correlation analysis was included to identify the strength and direction of individual relationships as this study focuses primarily on identifying significant associations and patterns rather than asserting direct causality.

3. Results and Discussion

3.1. Descriptive Statistics

The descriptive statistics for PM2.5 concentrations and meteorological parameters reveal significant variability in air quality over the study period (**Table 1** and **Figure 2**). PM2.5 concentrations ranged from 1.0 µg/m³ to 938.0 µg/m³, with an average concentration of 47.9 µg/m³. This substantial variability points to the influence of both natural and anthropogenic factors. For example, periods of elevated PM2.5 are typically associated with increased vehicular emissions, industrial activities, and seasonal changes [20–22]. The average PM2.5 concentration exceeds the World Health Organization's (WHO) recommended daily limit of 25 µg/m³, which is indicative of the potential adverse health effects on the population, particularly in urban environments where pollution levels often peak.

The AQI varied between 23 (good) and 413 (hazardous), with an average value of 119, reflecting moderate air quality, but with frequent hazardous air quality events. These fluctuations suggest that PM2.5 is a major contributor to the AQI, with peaks in AQI aligning closely with high PM2.5 concentrations. The high pollution levels, particularly during the summer months, are consistent with findings by Mohan and Kandya [23], who highlighted the exacerbation of particulate pollution in tropical climates due to elevated temperatures and reduced precipitation.

Table 1. Descriptive statistics.

Parameter	Count	Mean	Minimum	Maximum	SD (±)
PM2.5 (µg/m³)	16,524	47.9	1	938	42.2
AQI	16,524	119	23	413	56
Temperature (°C)	16,524	25.1	6.8	44.3	6.4
Humidity (%)	16,524	57.5	7.5	98	23
Wind Speed (m/s)	16,524	0.79	0.3	4.63	0.46
Rainfall (mm)	16,524	0.13	0	55	1.45
Solar Radiation (W/m²)	16,524	201.9	32	640	189.5
Barometric Pressure (mmHg)	16,524	709.9	703	719.8	3.5

Meteorological conditions also exhibited considerable variability, with temperature ranging from 6.8 °C to 44.3 °C (mean = 25.1 °C), relative humidity between 7.5% and 98% (mean = 57.5%), and wind speed from 0.30 m/s to 4.63 m/s (mean = 0.79 m/s). These meteorological fluctuations strongly influence air pollution levels by affecting pollutant formation, dispersion, and removal [16]. For example, higher temperatures are known to increase the formation of secondary pollutants, such as ground-level ozone, which indirectly contributes to PM2.5 concentrations [24,25].

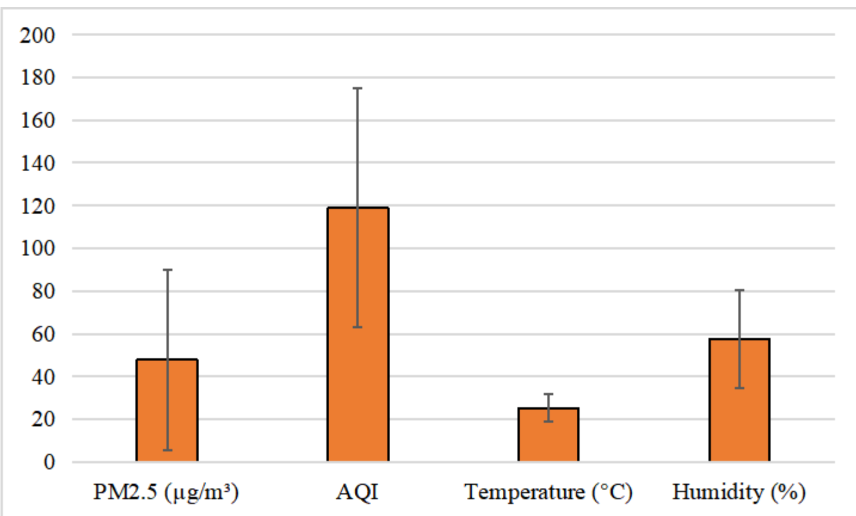

Figure 2. Mean values of environmental indicators (PM2.5, AQI, temperature, and humidity) observed during the study period, with corresponding standard deviations.

3.2. Correlation Analysis

The correlation analysis revealed significant relationships between PM2.5 concentrations, AQI, and meteorological parameters (**Table 2**). The strong positive correlation between PM2.5 and AQI (r = 0.622) is consistent with earlier studies that have identified PM2.5 as the primary driver of air quality deterioration [11,26]. This finding reinforces the importance of monitoring fine particulate matter, especially in regions with high population densities and industrial activities. Temperature and relative humidity exhibited a significant negative correlation (r = −0.580) with each other [27]. This inverse relationship is important because temperature plays a significant role in controlling the atmospheric dispersion and secondary aerosol formation, which directly impacts PM2.5 concentrations. A positive correlation between temperature and solar radiation (r = 0.412) further supports the role of temperature in the formation of secondary pollutants, which can contribute to higher PM2.5 levels [28].

Table 2. The correlation between PM2.5, air quality index and meteorological parameters.

Parameter	PM2.5	AQI	T	RH	WS	RF	SR	BP
PM2.5	1.000							
AQI	0.622*	1.000						
T	−0.318	−0.180	1.000					
RH	−0.029	−0.320	−0.580*	1.000				
WS	−0.192	−0.070	0.293	−0.155	1.000			
RF	−0.063	−0.090	−0.029	0.125	0.065	1.000		
SR	−0.128	−0.010	0.412*	−0.331	0.364	−0.054	1.000	
BP	0.000	−0.060	−0.103	0.236	−0.241	−0.039	−0.197	1.000

(AQI—Air quality index; T—ambient temperature; RH—Relative humidity; WS—Wind speed; RF—Rainfall; SR—Solar radiation; BP—Barometric pressure; * indicates statistically significant.)

Wind speed was negatively correlated with PM2.5 (r = −0.192), a result that aligns with previous studies showing that lower wind speeds often lead to stagnant air conditions, which inhibit the dispersion of pollutants, thus allowing particulate matter to accumulate in the atmosphere [29]. Similarly, low wind speeds contribute to the persistence of high PM2.5 concentrations, especially in urban settings with significant vehicular emissions. The weak negative correlation between rainfall and PM2.5 (−0.063) indicates that the limited rainfall observed during the study period had little effect on reducing particulate matter concentrations. This finding is consistent with earlier studies [29–31], who suggested that while rainfall can assist in the wet deposition of particles, its effect is often limited during dry seasons or in regions with low precipitation.

3.3. Multiple Linear Regression and Ridge Regression

The multiple linear regression model for PM2.5 concentration explained 18.1% of the variability in the data (R^2 = 0.181). Among the meteorological parameters, wind speed showed a significant negative relationship with PM2.5 concentration (−9.1193). This finding suggests that increased wind speeds help disperse particulate matter, thus lowering its concentration in the atmosphere. This result is supported by findings from Bose and Roy Chowdhury [29], who found that high wind speeds contribute to the dilution and dispersion of air pollutants, leading to reduced particulate concentrations in the atmosphere.

Temperature, rainfall, and relative humidity all showed negative associations with PM2.5 concentrations (**Tables 3** and **4**). Higher temperatures promote atmospheric mixing, facilitating the dispersion of pollutants, which may explain the negative association with PM2.5 concentrations observed in this study [32]. Rainfall, though minimal in this study (mean = 0.13 mm), also showed a negative relationship with PM2.5, which may be attributed to wet deposition removing particulate matter from the atmosphere. Relative humidity, another key meteorological factor, can influence the formation of secondary aerosols, which in turn affects PM2.5 levels [18]. However, the low levels of rainfall in this study may have limited the impact of this parameter.

Table 3. Multiple Linear Regression and Ridge regression Coefficients of PM2.5 and Air Quality Index.

Parameter	Multiple Linear Regression		Ridge Regression	
	PM2.5	**AQI**	**PM2.5**	**AQI**
Constant	165.8	−96.83	47.8932	118.7936
Temperature	−3.0910*	−4.7949*	−19.8743*	−30.8288*
Humidity	−0.5791*	−1.5522*	−13.3082*	−35.6731*
Wind Speed	−9.1193*	−0.1962	−4.1742*	−0.0906
Rainfall	−0.8976*	−0.8330*	−1.3027*	−1.2092*
Solar Radiation	0.0007	0.0042	−0.1699	0.8005
Barometric Pressure	0.0006	0.5982*	0.0017	2.0774*

(* indicates statistically significant.)

Table 4. Multiple Linear Regression equations and Ridge regression equations for PM2.5 and Air Quality Index.

Multiple Linear Regression Equation
PM2.5 = [165.80 – (3.0910 × Temperature) – (0.5791 × Relative Humidity) – (9.1193 × Wind Speed) – (0.8976 × Rainfall) + (0.0007 × Solar Radiation) + (0.0006 × Barometric Pressure)] **AQI** = [−96.8295 – (4.7949 × Temperature) – (1.5522 × Relative Humidity) – (0.1962 × Wind Speed) – (0.8330 × Rainfall) + (0.0042 × Solar Radiation) + (0.5982 × Barometric Pressure)]
Ridge Regression Equation
PM2.5 = [47.8932 – (19.8743 × Temperature) – (13.3082 × Relative Humidity) – (4.1742 × Wind Speed) – (1.3027 × Rainfall) – (0.1699 × Solar Radiation) + (0.0017 × Barometric Pressure)] **AQI** = [118.7936 – (30.8288 × Temperature) – (35.6731 × Relative Humidity) – (0.0906 × Wind Speed) – (1.2092 × Rainfall) + (0.8005 × Solar Radiation) + (2.0774 × Barometric Pressure)]

For AQI, the regression model explained 29.7% of its variability ($R^2 = 0.297$), indicating that meteorological factors such as temperature and humidity play a crucial role in determining air quality (**Table 4**). The negative relationship between temperature and AQI (−4.7949) is consistent with the findings of Sangeetha and Manjunath [33], who demonstrated that higher temperatures are linked to deteriorating air quality due to increased pollutant formation. Similarly, relative humidity had a negative association with AQI (−1.5522), further supporting the role of humidity in influencing air quality, with higher humidity levels generally improving air quality by promoting the removal of particulate matter via wet deposition.

Rainfall also showed a negative relationship with AQI (−0.8330), suggesting that increased precipitation can improve air quality by removing particulate matter and pollutants from the atmosphere. However, wind speed and solar radiation did not significantly impact AQI, indicating that their role in influencing air quality in Bhopal may be secondary to temperature, humidity, and rainfall.

3.4. Ridge Regression

The ridge regression analysis reinforced the findings from the multiple linear regression model, with temperature, relative humidity, wind speed, and rainfall showing consistent negative relationships with both PM2.5 and AQI (**Tables 3** and **4**). This further supports the idea that meteorological factors such as temperature and humidity are key drivers of particulate matter levels in the atmosphere. The effect of barometric pressure on AQI was more pronounced in the ridge regression model, suggesting that high-pressure systems may create atmospheric stability that traps pollutants near the surface, contributing to poor air quality. This result is consistent with previous studies, which have suggested that high-pressure systems limit the vertical mixing of air and prevent the dispersion of pollutants, thus exacerbating air pollution [32,34].

4. Limitations

This study has several limitations that should be acknowledged. The analysis relied mainly on surface-level meteorological parameters such as temperature, humidity, rainfall, wind speed, solar radiation, and barometric pressure, without incorporating synoptic-scale conditions (e.g., surface synoptic charts or baric topography maps) that could better substantiate the physical processes influencing pollutant accumulation. For example, anticyclonic regimes marked by high pressure, elevated temperatures, low humidity, and weak winds are known to trap pollutants, yet these dynamics were not explicitly assessed. Similarly, the study did not account for urban morphology and land-use effects such as street orientation, canyon effects, and heterogeneous emission sources, which strongly affect pollutant dispersion. In addition, the regression models used here explained only a modest portion of the variance in PM2.5 ($R^2 = 0.181$) and AQI ($R^2 = 0.297$), indicating that linear approaches capture only part of the variability and that unmodeled factors such as emission inventories and traffic density are also important. Finally, the statistical methods applied were limited to correlation, multiple linear regression, and ridge regression; future research should consider time-series analyses, non-linear approaches, and advanced machine learning techniques to better capture the complex and potentially non-linear interactions between meteorology and air quality.

5. Conclusions

This study examined the influence of meteorological parameters temperature, relative humidity, wind speed, rainfall, solar radiation, and barometric pressure on PM2.5 concentrations and the Air Quality Index (AQI) in Bhopal, India, using two years of hourly data (2022–2023). Through the application of Pearson correlation, multiple linear regression, and ridge regression techniques, the study provided a quantitative assessment of how weather conditions modulate urban air pollution levels in a tier-2 Indian city context. The findings confirm that meteorological factors play a significant role in influencing PM2.5 and AQI. Notably, temperature, relative humidity, wind speed, and rainfall all showed negative associations with both air quality indicators, suggesting that cooler, more humid, windier, and wetter conditions generally help reduce particulate concentrations. Ridge regression further validated these relationships, especially reinforcing the suppressive effect of barometric pressure on AQI likely due to its role in atmospheric stability and pollutant accumulation.

Despite these insights, the regression models explained only a moderate portion of the variance in PM2.5 ($R^2 = 0.181$) and AQI ($R^2 = 0.297$), indicating that while meteorological conditions are influential, they are not the sole determinants of air quality. This highlights the presence of other critical factors such as localized emission sources, urban morphology, land use patterns, and human activities that were not explicitly modelled in this study. Moreover, the analysis emphasized association rather than causation an important distinction that future studies should address using more advanced causal inference techniques (e.g., time-series modelling, structural equation modelling, or machine learning-based feature attribution methods). The novelty of this research lies in its localized, high-resolution dataset, the integration of both PM2.5 and AQI as dependent variables, and the seasonal exploration of meteorological impacts in an under-studied urban area. By focusing on Bhopal, this study contributes valuable city-specific knowledge to the broader discourse on air pollution in rapidly developing regions of India. The study reinforces the need to incorporate meteorological forecasting into urban air quality management strategies. The findings can support early warning systems and inform policy interventions, especially during seasons of heightened pollution risk. Future research should aim to integrate emission inventory data, land use variables, and high-resolution satellite observations to develop more comprehensive and causally robust air quality models tailored to mid-sized Indian cities.

Author Contributions

Conceptualization, S.B.A.; methodology, S.B.A. and N.T.; software, N.T. and D.R.; validation, N.T. and D.R.; formal analysis, N.T. and D.R.; investigation, S.B.A., N.T. and D.R.; resources, S.B.A., D.R. and S.N.; data curation, N.T.; writing—original draft preparation, S.B.A. and N.T.; writing—review and editing, S.B.A., N.T., D.R. and S.N.; visualization, S.B.A. and N.T.; supervision, S.B.A. and S.N. All authors have read and agreed to the published version of the manuscript.

Funding

This work received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The data set associated with the study is available with the authors and will be made available upon request.

Acknowledgments

The authors express their sincere gratitude to the Director of ICMR–National Institute for Research in Environmental Health, Bhopal, for their invaluable guidance and support.

Conflicts of Interest

The authors declare no conflict of interest.

References

[1] Chen, B., Kan, H., 2008. Air Pollution and Population Health: A Global Challenge. Environmental Health and Preventive Medicine. 13(2), 94–101. DOI: https://doi.org/10.1007/s12199-007-0018-5

[2] Landrigan, P.J., 2017. Air Pollution and Health. Lancet Public Health. 2(1), e4–e5. DOI: https://doi.org/10.1016/S2468-2667(16)30023-8

[3] Kelly, F.J., 2014. Influence of Air Pollution on Respiratory Disease. EMJ Respiratory. 2, 96–103.

[4] Turner, M.C., Andersen, Z.J., Baccarelli, A., et al., 2020. Outdoor Air Pollution and Cancer: An Overview of the Current Evidence and Public Health Recommendations. CA: A Cancer Journal for Clinicians. 70(6), 460–479. DOI: https://doi.org/10.3322/caac.21632

[5] de Bont, J., Jaganathan, S., Dahlquist, M., et al., 2022. Ambient Air Pollution and Cardiovascular Diseases: An Umbrella Review of Systematic Reviews and Meta-Analyses. Journal of Internal Medicine. 291(6), 779–800. DOI: https://doi.org/10.1111/joim.13467

[6] Kempaiah, B.U., Charan, B., Mampilli, R.J., 2020. Data Analysis of Air Pollutant Levels in India. In Proceedings of the 2020 IEEE International Conference for Innovation in Technology (INOCON), Bangaluru, India, 6–8 November 2020. DOI: https://doi.org/10.1109/INOCON50539.2020.9298391

[7] Sharma, D., Mauzerall, D., 2022. Analysis of Air Pollution Data in India between 2015 and 2019. Aerosol and Air Quality Research. 22, 210204. DOI: https://doi.org/10.4209/aaqr.210204

[8] Swarna Priya, R.M., Sathya, P., 2019. Statistical Analysis of Air Pollutants in Ambient Air, Reality of Sensors and Corrective Measures in India. In Proceedings of the 2019 Innovations in Power and Advanced Computing Technologies (i-PACT), Vellore, India, 22–23 March 2019. DOI: https://doi.org/10.1109/I-PACT44901.2019.8960010

[9] Nasir, H., Goyal, K., Prabhakar, D., 2016. Review of Air Quality Monitoring: Case Study of India. Indian Journal of Science and Technology. 9(44). DOI: https://doi.org/10.17485/ijst/2016/v9i44/105255

[10] Remoundou, K., Koundouri, P., 2009. Environmental Effects on Public Health: An Economic Perspective. International Journal of Environmental Research and Public Health. 6(8), 2160–2178. DOI: https://doi.org/10.3390/ijerph6082160

[11] Kumar, S., Mehra, S., Jha, H., et al., 2024. Statistical Modeling of Air Pollutants for Predicting AQI Levels. In Proceedings of the 2024 IEEE International Conference on Big Data (BigData), Washington, DC, USA, 15–18 December 2024; pp. 4334–4341. DOI: https://doi.org/10.1109/BigData62323.2024.10825033

[12] Sahu, S.K., Kota, S.H., 2017. Significance of PM2.5 Air Quality at the Indian Capital. Aerosol and Air Quality Research. 17(3), 588–597. DOI: https://doi.org/10.4209/aaqr.2016.06.0262

[13] Navinya, C.D., Vinoj, V., Pandey, S.K., 2020. Evaluation of PM2.5 Surface Concentrations Simulated by NASA's MERRA Version 2 Aerosol Reanalysis over India and Its Relation to the Air Quality Index. Aerosol and Air Quality Research. 20(6), 1329–1339. DOI: https://doi.org/10.4209/aaqr.2019.12.0615

[14] Squizzato, S., Masiol, M., 2015. Application of Meteorology-Based Methods to Determine Local and External Contributions to Particulate Matter Pollution: A Case Study in Venice (Italy). Atmospheric Environment. 119, 69–81. DOI: https://doi.org/10.1016/j.atmosenv.2015.08.026

[15] Oji, S., Adamu, H., 2020. Correlation between Air Pollutants Concentration and Meteorological Factors on Seasonal Air Quality Variation. Journal of Air Pollution and Health. 5(1), 11–32. DOI: https://doi.org/10.18502/japh.v5i1.2856

[16] Khedekar, S., Thakare, S., 2023. Correlation Analysis of Atmospheric Pollutants and Meteorological Factors Using Statistical Tools in Pune, Maharashtra. E3S Web of Conferences. 391, 01190. DOI: https://doi.org/10.1051/e3sconf/202339101190

[17] Samad, A., Garuda, S., Vogt, U., et al., 2023. Air Pollution Prediction Using Machine Learning Techniques – An Approach to Replace Existing Monitoring Stations with Virtual Monitoring Stations. Atmospheric Environment. 310, 119987. DOI: https://doi.org/10.1016/j.atmosenv.2023.119987

[18] Prasad, N.V.K., Sarma, M.S.S.R.K.N., Sasikala, P.,

et al., 2020. Regression Model to Analyse Air Pollutants Over a Coastal Industrial Station Visakhapatnam (India). International Journal of Data Science. 1(2), 107–113. DOI: https://doi.org/10.18517/ijods.1.2.107-113.2020

[19] Gulati, S., Bansal, A., Pal, A., et al., 2023. Estimating PM2.5 Utilizing Multiple Linear Regression and ANN Techniques. Scientific Reports. 13, 49717. DOI: https://doi.org/10.1038/s41598-023-49717-7

[20] Chen, H., Yan, Y., Hu, D., et al., 2023. High Contribution of Vehicular Exhaust and Coal Combustion to PM2.5-Bound Pb Pollution in an Industrial City in North China: An Insight from Isotope. Atmospheric Environment. 294, 119503. DOI: https://doi.org/10.1016/j.atmosenv.2022.119503

[21] Aher, S.B., Dobhal, B.S., Awasthi, R.S., 2014. Spatial and Temporal Variations of SO2, NOx, PM10 and TSPM Concentration in Ambient Air of Jalna City, India. International Journal of Agriculture, Environment and Biotechnology. 7(3), 571–576. DOI: https://doi.org/10.5958/2230-732x.2014.01362.x

[22] Chaudhry, S.K., Tripathi, S.N., Ramesh Reddy, T.V., et al., 2025. Assessment of Seasonal Variation in PM2.5 Concentration Using Low-Cost Sensors: A Case Study of Jaipur City, India. Atmospheric Environment. 345, 121067. DOI: https://doi.org/10.1016/j.atmosenv.2025.121067

[23] Mohan, M., Kandya, A., 2007. An Analysis of the Annual and Seasonal Trends of Air Quality Index of Delhi. Environmental Monitoring and Assessment. 131(1–3), 267–277. DOI: https://doi.org/10.1007/s10661-006-9474-4

[24] Ebi, K.L., McGregor, G., 2008. Climate Change, Tropospheric Ozone and Particulate Matter, and Health Impacts. Environmental Health Perspectives. 116(11), 1449–1455. DOI: https://doi.org/10.1289/ehp.11463

[25] Orru, H., Ebi, K.L., Forsberg, B., 2017. The Interplay of Climate Change and Air Pollution on Health. Current Environmental Health Reports. 4, 504–513. DOI: https://doi.org/10.1007/s40572-017-0168-6

[26] Maltare, N.N., Vahora, S., 2023. Air Quality Index Prediction Using Machine Learning for Ahmedabad City. Digital Chemical Engineering. 7, 100093. DOI: https://doi.org/10.1016/j.dche.2023.100093

[27] García Arias, L.F., Espinosa, D., Hernández-Leal, E., et al., 2022. Correlations and Cross-Correlations in Temperature and Relative Humidity Temporal Series From Manizales, Colombia. Communications in Computer and Information Science. 1594, 65–80. DOI: https://doi.org/10.1007/978-3-031-19951-6_5

[28] Wu, Y., Liu, D., Tian, P., et al., 2022. Tracing the Formation of Secondary Aerosols Influenced by Solar Radiation and Relative Humidity in Suburban Environment. Journal of Geophysical Research: Atmospheres. 127(19), e2022JD036913. DOI: https://doi.org/10.1029/2022JD036913

[29] Bose, A., Roy Chowdhury, I., 2023. Investigating the Association between Air Pollutants' Concentration and Meteorological Parameters in a Rapidly Growing Urban Center of West Bengal, India: A Statistical Modeling-Based Approach. Modeling Earth Systems and Environment. 9(3), 2877–2892. DOI: https://doi.org/10.1007/s40808-022-01670-6

[30] Sharma, R.C., Sharma, N., 2018. Statistical Investigation of Effect of Rainfall on Air Pollutants in the Atmosphere, Haryana State, Northern India. American Journal of Environmental Protection. 6(1), 14–21.

[31] Shukla, J.B., Misra, A.K., Sundar, S., et al., 2008. Effect of Rain on Removal of a Gaseous Pollutant and Two Different Particulate Matters from the Atmosphere of a City. Mathematical and Computer Modelling. 48(5–6), 832–844. DOI: https://doi.org/10.1016/j.mcm.2007.10.016

[32] Parra, J.C., Gómez, M., Salas, H.D., et al., 2024. Linking Meteorological Variables and Particulate Matter PM2.5 in the Aburrá Valley, Colombia. Sustainability. 16(23), 10250. DOI: https://doi.org/10.3390/su162310250

[33] Sangeetha, N., Manjunath, D., 2024. A Study on Air Quality Analysis and the Impact of Pollutants and Climatic Factors. International Journal of Advanced Research in Science, Communication and Technology (IJARSCT). 4(1).

[34] Yao, L., Chu, B., Wang, J., et al., 2023. Editorial: Atmospheric Chemistry in the Urban Air. Frontiers in Environmental Science. 11, 1166400. DOI: https://doi.org/10.3389/fenvs.2023.1166400