Review Study on Evaluation of Air Pollution in Selected Cities of West Bengal

Rizwanul Islam

Research Scholar, Department of Environmental Education Studies, RKDF University, Ranchi, India.

ABSTRACT

This review study assesses the condition, origins, and effects of air pollution in several cities of West Bengal. The fast urbanisation, industrialisation, escalating automobile traffic, and heightened energy use have markedly exacerbated the decline of air quality in metropolitan areas throughout the state. The study integrates information from published research publications, government reports, air quality monitoring data, and environmental evaluations to deliver a thorough knowledge of pollution patterns and related dangers. The review examines primary air pollutants, such as particulate matter (PM2.5 and PM10), sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and ground-level ozone (O_3). It analyses disparities in pollutant concentrations among specific cities, emphasising the impact of industrial operations, vehicular emissions, construction methodologies, and seasonal weather patterns. The study evaluates the effects of extended exposure to dirty air on public health, specifically concerning respiratory and cardiovascular disorders, and examines the environmental repercussions, including diminished visibility, harm to flora, and deterioration of urban ecosystems. The results demonstrate that multiple cities in West Bengal have pollutant concentrations beyond both national and international air quality requirements, particularly during winter and times of heightened human activity. The evaluation highlights the necessity for enhanced air quality monitoring, more rigorous implementation of emission control regulations, the promotion of greener transportation and energy options, and heightened public awareness concerning pollution reduction. This study presents a comprehensive assessment of air pollution in certain cities of West Bengal and offers insights that may assist policymakers, researchers, and urban planners in formulating effective measures to enhance air quality and protect public health.

Keywords: *Urban Air Quality, Particulate Matter (PM2.5 and PM10), Sulfur Dioxide (SO_2), Nitrogen Oxides (NO_x), Industrial Pollution, Environmental Degradation.*

INTRODUCTION

Air pollution has become one of the most significant environmental concerns confronting urban regions globally. In India, swift industrialisation, urban growth, escalating motor traffic, and rising energy consumption have markedly exacerbated air quality degradation. West Bengal, as one of the most densely inhabited and industrially advanced states, has seen significant environmental strain in its metropolitan areas. Cities like Kolkata, Howrah, Kalyani, Durgapur, and Barrackpore are especially susceptible to air pollution owing to industrial concentration, transit systems, commercial enterprises, and high population density.

Air pollution denotes the existence of deleterious compounds in the atmosphere at levels that might negatively impact human health, ecosystems, and the environment. Commonly reported major pollutants in urban areas encompass particulate matter (PM2.5 and PM10), sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and ground-level ozone (O_3). These pollutants emanate from several anthropogenic sources, including vehicular emissions, industrial discharges, fossil fuel combustion, construction operations, and waste incineration. Seasonal weather conditions, particularly in winter, frequently exacerbate pollution levels by restricting atmospheric dispersion.

The health consequences of extended exposure to contaminated air are significant and thoroughly documented. Respiratory infections, cardiovascular diseases, asthma, bronchitis, and diminished lung function are significant health issues linked to inadequate air quality. At-risk populations, such as youngsters, the elderly, and those with pre-existing medical disorders, are more vulnerable. Besides health repercussions, air pollution exacerbates environmental deterioration by impacting plants, diminishing visibility, and modifying atmospheric processes.

This review study seeks to assess the status and trends of air pollution in specific cities of West Bengal by integrating findings from published research, government reports, and air quality monitoring data. It aims to identify primary pollution sources, compare pollutant concentrations among urban centers, evaluate related health and environmental effects, and analyse current pollution management strategies. The study aims to synthesise existing evidence to offer a thorough picture of the air pollution situation in West Bengal and aid in the development of effective policies and strategies for enhancing urban air quality.

REVIEW OF LITERATURE

Karmakar Joy (2024). Delhi and Kolkata have been classified as the two most polluted cities in terms of exposure to harmful fine particulate matter (PM2.5), according to research that was generated by the Health Effects Institute (HEI), which is based in the United States. Regulations were put into place in Kolkata in 2018 in order to meet the National Ambient Air Quality Standards. This was done in order to address the problem. NAAQS stands for." The purpose of this study is to investigate the levels of particulate matter 2.5 (PM2.5) in the Kolkata Metropolitan Area (KMA) between the years 2021 and 2023. Based on the findings, it can be concluded that the primary contributors to PM2.5 are transportation, households, and industry; however, the extent to which these three sources exert their influence varies within the metropolitan region. It is in Kolkata and the places surrounding it, such as Bidhannagore and New Town Kolkata, that the mean and median concentrations of PM2.5 are found to be high. As an additional point of interest, it has been noticed that the levels of PM2.5 stay high during the winter as well as the summer seasons.

Das Mainak, Kundu Aditi (2024). West Bengal has serious problems with air quality, especially in cities and industrial areas during the winter. This detailed study talks about those problems. These results show that air quality is getting worse across schools, highlighting Kolkata as the world's second-most polluted city and highlighting how quickly natural conditions can change. This report uses information from a large group of separate air quality monitoring systems to stress the need for ongoing monitoring and strategies that are tailored to each area. It is suggested that the government get involved, educational programs be run, the community be involved, people work together to protect the earth, and businesses be responsible. Strict controls on industrial emissions should be put in place right away, air quality should be taught in schools, communities should be involved in reducing pollution, tracking programs should be made bigger, and companies should be urged to be responsible. To stop the worsening air pollution problem in West Bengal and make the environment healthier for people and kids, these steps must be taken together.

Paul D, Mukherjee K et al. (2023). Unplanned urbanisation that is growing quickly is invariably linked to environmental deterioration, which has an immediate impact on people's quality of life. Cancer, early mortality, chronic harm to the cardiovascular and pulmonary systems, and other conditions are all associated with poor environmental quality. Using an example urban greenery, NO2, SO2, PM 2.5, PM 10, road-induced pollution, land surface temperature, built-up area, and noise, followed by an examination of its spatial pattern. The Urban Environmental Quality (UEQ) index was developed using a

geoinformatics platform in the aspects of the built environment and physical environment of the Kolkata Metropolitan Area (KMA). KMA has 13.2 million residents, making it the largest urban agglomeration in eastern India and the second largest in all of India, according to the 2001 census. Through multi-criteria analysis in KMA, this study attempted to identify the areas with poor environmental quality using the Urban Environmental Quality (UEQ) index. Nine parameters have criteria weights that have been determined using the analytical hierarchy process (AHP) based on the relative importance of controlling the outdoor environment. The rating and matching weight of the factors were combined to create the UEQ index. Low environmental quality results from the polycentric growth of urban centres, which causes appropriate spatial matching. Although suburbanization occasionally lowers the UEQ in the peripheries, most of the places have higher environmental quality.

El-Magd, A. et al. (2023). The difficulties in predicting and evaluating air pollution, which result from the interaction of many pollution sources, different land uses, and regulatory factors. In this work, we used a time series of particulate matter pollution records and the machine learning technique of random forest to anticipate and generate a particulate matter pollution susceptibility map. The adopted strategies include stricter laws and enhanced particulate matter pollution control, with Ras Garib City, Egypt, serving as a case study. For the years 2018–2021, data on air pollution was collected from five air quality stations. Many of these stations are in close proximity to densely populated areas, and with the current rate of development, they may eventually become crowded. Using the random forest technique, the relationships between the particulate matter and a number of independent factors were verified and shown. The Landsat OLI 8 imaginary spectrum bands as well as the land cover and land use indices were used to build the independent variables. The analysis's findings demonstrate that having the appropriate air quality distribution monitoring stations would enable researchers to fully comprehend the dispersion of pollution in the study area. The distribution of air quality is significantly influenced by location with respect to roadways and land surface temperature. The probability and classification maps obtained were assessed using the area under the receiver's operating characteristic curve. The outcome prediction maps are valuable for future monitoring and improvement of air quality, and they are practicable. Furthermore, applying the suggested method for predicting pollutant concentrations can improve judgment and provide appropriate answers.

Bose A, Roy Chowdhury I. (2023). Meteorological conditions significantly influence ambient air quality in urban environments. Siliguri, known as the "Gateway of Northeast India," is a major contributor to air pollution in West Bengal. However, the effects of meteorological variables on criteria air pollutants in this rapidly growing city have received limited scientific investigation. This study aimed to determine the relationships between concentrations of criteria air pollutants (PM2.5, PM10, NO2, SO2, CO, O3, and NH3) and meteorological variables, including daily mean temperature (°C), relative humidity (%), rainfall (mm), and wind speed (m/s), from March 2018 to September 2022. The research also examined historical trends in air contaminant levels. Spearman correlation analysis was used to assess the association between air pollution concentrations and meteorological factors. Multiple linear regression (MLR) and non-linear regression (MLNR) models were compared to evaluate the influence of climatic variables on pollutant concentrations. Trend analysis revealed that, while concentrations of most pollutants are declining, NH3 levels in Siliguri are increasing. Most pollutants showed a negative correlation with meteorological variables, although their responses varied seasonally. The comparative regression analysis indicated that both linear and non-linear models effectively forecast particulate matter concentrations but are less successful in predicting gaseous pollutant levels. Considering seasonal variations and meteorological influences, these findings are expected to enhance the accuracy of air pollution forecasting in the near future.

Mohammad Ahmad, Weihu Cheng, Zhao Xu, Abdul Kalam (2023). Air quality is a multifaceted issue influenced by numerous factors. It refers to the degree of cleanliness of the air in a specific location. The considerable variability in air quality data, driven by climate change and environmental conditions, poses challenges for traditional methods in accurately identifying anomalies or outliers. In Kolkata City, air pollution has been steadily increasing due to rapid industrialization and rising population density. To evaluate the effectiveness of an outlier identification methodology for working and nonworking days using the variables NO2, SO2, and O3 over a one-year period in Kolkata, India, this study is structured in two phases. The first phase addresses the imputation of missing values, while the second phase focuses on outlier detection using Statistical Process Control (SPC) and Functional Data Analysis (FDA). The findings indicate that the functional data approach outperforms conventional outlier detection techniques. Furthermore, after imputation, functional data analysis exhibits greater sensitivity compared to the other methods, and the proposed outlier detector is well-suited for accurately identifying outliers in highly volatile data.

Gouri, Sankar & Bhunia, Gouri & Ghosh, Anitabha & Pravat, · & Shit, Pravat. (2022). In Kolkata, air pollution is steadily rising due to the city's rapid industrial development and growing population. The goal of the current study is to comprehend how particulate matter (PM) 2.5, PM 10, sulfur dioxide (SO 2), and nitrogen dioxide (NO 2) vary over time and space in the City of Kolkata between 2017 and 2020. PM 2.5, PM 10, SO 2, and NO 2 were gathered from the Central Pollution Control Board (CPCB) and West Bengal Pollution Control Board at eight sample locations in order to analyze the temporal and spatial distribution of the ambient air quality data. To enable temporal analysis of pollution fluctuation, the Geographic Information System (GIS) was given the spatial positions of each chosen monitoring station. The distance between two data series observations represents the time difference between them. For every sample location, the geographical distribution of pollutant levels was estimated using the radial basis function (RBF) approach. The model fit that estimates the distribution of air contaminants was chosen using mean standardized error (MSE) and root mean square standard error (RMSSE). The Cossipore Police Station on B.T. Road has the greatest SO2 concentration. The Moulali and Salt Lake regions have the highest PM 2.5 readings. NO 2 is significantly correlated with rainfall ($R^2 = 0.459$; $P < 0.015$), maximum temperature ($R^2 = 0.916$; $P < 0.0002$), and minimum temperature ($R^2 = 0.759$; $P < 0.0002$). In the minor areas east of Kolkata Municipal Corporation (KMC), the NO2 content is higher than what is allowed by the National Ambient Air Quality Standards (NAAQS). The KMC located to the north and east of the KMC had the highest concentration levels. The southeast region showed the lowest concentration, which also spread to the few areas west of the KMC. The study's findings may offer a scientific foundation for logical choices about industrial urban development, enhancing air quality, and taking proactive measures to combat pollution.

Gulia, S. et al. (2022). Air pollution has long been a major concern, but stakeholders have only recently become aware of it. The detrimental effects of air pollution are still being felt, and these findings have brought attention to the weaknesses and deficiencies in the management and control methods that are in place right now. Therefore, it is essential that technological advancements be coupled with tougher rules to handle the situation in order to decrease the bad impacts of air pollution. It's critical to identify the gaps in the available research in order to regulate air quality effectively and efficiently. The article seeks to give information about the evolution of air quality management policy in India by gathering data from earlier studies and keeping it in a virtual repository called the Indian Air Quality Studies Interactive Repository (IndAIR). Geographic Information Systems (GIS) are used in the study to visually represent the geographical distribution across the country map and pinpoint areas where previous research has fallen short. The gap analysis shows that the Indo-Gangetic Plains (IGPs) and urban areas have both seen a

significant amount of research on air pollution. In contrast, the Eastern, Southern, and Central States are the least studied regions in the country. Furthermore, the analysis of the spatial distribution of PM2.5 and NOx concentrations reveals that more research is conducted in highly polluted cities and vice versa. Among the various categories of air quality, the socioeconomic effects of air pollution are among the least studied. Therefore, in order to understand location-specific difficulties related to air pollution, these places and domains should be thoroughly explored. The current assessment found inadequacies in three areas: research, policies, and economics.

Rana S (2022). The Air Quality Index (AQI) that is used in different countries doesn't clearly show how much air pollution affects the normal life expectancy (LE). This study clearly shows how much air pollutants, especially fine particles in the air, lower a person's average LE in a certain place over the course of a year. The Air Quality Life Index (AQLI) was found, and it shows that the average LE of every person living in Medinipur city will go down in 2019 and 2020. The lower level of lung function in humans caused by particulate matter pollution comes from two semi-experimental variation studies that were done in China. The studies looked at how coarse particles (PM10: particle size ranges between 2.5 micrometres and 10 micrometres) affected people living on the northern and southern borders of the China Huai River. "An extra 10 micrograms per cubic meter of PM10 exposure lowers LE by 0.64 years," the data showed. The study used the University of Chicago Energy Policy Institute's (EPIC) epidemiological estimates to find the best way to figure out global AQLI. They used PM2.5 to PM10 ratios because global PM10 data wasn't available and said that "additional sustainable exposure to fine particles or PM2.5 (particle size less than or equal to 2.5 micrometres) reduces LE by 0.98 years per 10 micrograms per cubic meter." This was followed by two studies by Chen et al. (2013) and Ebenstein et al. (2017) that looked at the effects of long-term PM pollution on permanent residents of both the north and south sides of the China Huai River. Previous fine particle (PM2.5) densities are measured at a certain resolution using an integrated geophysical-statistical method that gives the global fine particulate or PM2.5 data3 used to find out the AQLI of a country or city. PM2.5 concentrations are also looked at for world atmospheric pollution because PM2.5 particles get into deeper parts of the respiratory tract and are more harmful or toxic to humans than coarse particles (PM10).4,5 We use the most recent annual PM2.5 data from the ground-based measure of PM2.5 concentration to find the AQLI for each city in this study. The study found that the current annual concentration of PM2.5 from Breezo Meter and PMS3003 at four chosen stations (S1 to S4) in Medinipur city ranged from 23 to 29 μg/m³. The average LE loss in Medinipur ranged from 1.3 years to 1.87 years per person, which could be due to heart disease and lung cancer.

Verma, M. et al. (2021). The goal of the current study is to evaluate Lucknow's ambient air quality and look into seasonal variations in the city's air pollution levels. It also illustrates how the primary pollutants in the city affected people's health between 2010 and 2019. The effect of particulate matter on health was also assessed using Air Q+. Long-term exposure to PM2.5 was thought to be responsible for around 19 to 28% of the mortality from all causes, and long-term exposure to PM10 was thought to be responsible for between 37 and 48% of the post-neonatal (age 1–12 months) mortality rate. It has also been attempted to evaluate how the lockdown affected Lucknow's ambient air quality during COVID-19. During the lockdown, PM2.5 levels dropped by 65% at Gomti Nagar, 23% at Central School, 79% at Lalbagh, and 35% at Talkatora. Gomti Nagar's air quality index thus fell to 43, which is far lower than 50, which is within the healthy range. In addition, NO2 levels dropped. But there was no appreciable decrease in SO2 levels. Using Pearson correlation analysis, a strong positive link ($r = 0.65$, $P < 0.001$) was found between the data about Angstrom exponent and aerosol optical depth.

CONCLUSION

This review study emphasises that air pollution remains a significant environmental and public health issue across several cities in West Bengal. The examination of existing literature, governmental reports, and air quality monitoring data reveals that urban areas including Kolkata, Howrah, Asansol, Durgapur, and Siliguri consistently encounter heightened levels of primary pollutants, notably particulate matter (PM2.5 and PM10), sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and ground-level ozone (O_3). The results indicate that traffic emissions, industrial operations, fossil fuel combustion, construction dust, and waste incineration are the principal factors degrading air quality in these cities. Seasonal influences, particularly winter conditions, exacerbate pollution levels by diminishing air dispersion and enhancing pollutant buildup. These conditions not only deteriorate the urban environment but also provide substantial dangers to public health, including respiratory and cardiovascular diseases, diminished lung function, and other chronic health issues.

The review study emphasizes West Bengal's need for an integrated air pollution management strategy. Reduce pollution via improving air quality monitoring networks, implementing tougher emission regulations, encouraging cleaner fuels and transportation systems, controlling industrial emissions, and improving urban planning. Long-term air quality improvements require public knowledge and community cooperation. The study concludes that policymakers, regulatory agencies, industry, researchers, and citizens must work together to reduce air pollution in selected West Bengal cities. Pollution control and sustainable urban development can improve air quality, public health, and future generations' environment.

REFERENCES

1. Ahmad, M., Cheng, W., Xu, Z. and Kalam, A. (2023) A Study of Detection of Outliers for Working and Non-Working Days Air Quality in Kolkata, India: A Case Study. Journal of Environmental Protection, 14, pp-685-709. doi: 10.4236/jep.2023.148039.
2. Bhunia, Gouri & Ghosh, Anitabha & Shit, Pravat. (2022). Comprehensive spatio-temporal analysis of ambient air quality of Kolkata Municipal Corporation, Kolkata (West Bengal, India) during 2017–2020. Arabian Journal of Geosciences. 15. 1782. 10.1007/s12517-022-11081-7.
3. Bose A, Roy Chowdhury I. Investigating the association between air pollutants' concentration and meteorological parameters in a rapidly growing urban centre of West Bengal, India: a statistical modelling-based approach. Model Earth Syst Environ. 2023;9(2):2877-2892. doi: 10.1007/s40808-022-01670-6. Epub 2023 Jan 5. PMID: 36624780; PMCID: PMC9812750.
4. D Paul, K Mukherjee, J K Pandey, A Dutta Roy (2023), Assessing the Urban Environmental Quality: A Case Study of Kolkata Metropolitan Area, India, IOP Conf. Series: Earth and Environmental Science 1164 (2023) 012001 doi:10.1088/1755-1315/1164/1/012001
5. Das Mainak, Kundu Dr Aditi (2024) Unveiling Air Pollution dynamics in West Bengal, Switch On Foundation, January 2024, pp1-17
6. El-Magd, A., Soliman, G., Morsy, M. et al. (2023). Environmental hazard assessment and monitoring for air pollution using machine learning and remote sensing. *Int. J. Environ. Sci. Technol.*, 20, 6103–6116.
7. Gulia, S. et al. (2022). Evolution of air pollution management policies and related research in India. *Environmental Challenges*, 6, 100431.
8. Karmakar Dr. Joy (2024), Air Pollution and Particulate Matter in the Kolkata Metropolitan Area, India, Journal of Indian Association for Environmental Management, Vol. 44, No. 1 (2024), 52-59.

9. Rana, S. (2021). Evaluating the Disease Burden Linked with Short-term Exposure to Atmospheric Coarse Particles (PM_{10}) in the City of Midnapore in West Bengal, India from 2019 to 2020: A Case Study. *Applied Ecology and Environmental Sciences*, *9*(12), 1018-1023.
10. Verma, M., Mishra, P.K. et al. (2021). Spatio-temporal assessment of ambient air quality, their health effects and improvement during COVID-19 lockdown in one of the most polluted cities of India. *Environ Sci Pollut. Res.*, 28, 10536–10551.