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Environmental Risk Factors for Air Pollution in Lucknow City

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ABSTRACT:

Air pollution stands as a critical environmental and public health concern, particularly in rapidly developing nations. The sharp rise in vehicular traffic, industrial operations, and manufacturing activities has significantly contributed to the accumulation of pollutants in the atmosphere. Lucknow, a city undergoing swift urban expansion, has been the focus of numerous studies over the years investigating various dimensions of air pollution. These studies consistently highlight particulate matter as a predominant air contaminant within the region. The purpose of this review is to examine the current status of ambient air quality in Lucknow, assess its environmental and health implications, and explore potential mitigation strategies discussed in existing research. Findings suggest that pollution levels at reference sites, such as rural areas or zones with minimal traffic, are notably lower compared to those in urbanized sectors of the city. In particular, particulate matter—along with hazardous constituents like heavy metals, polycyclic aromatic hydrocarbons (PAHs), and gaseous emissions—has been identified as a major contributor to deteriorating air quality.

Key Words : Air pollution, Concentration of the pollutants, Health effect, Control measures.

1. INTRODUCTION

quality has increasingly become a matter of public and social concern, particularly in light of ongoing urban development and industrial expansion. While assessing air pollution is inherently complex, regulatory authorities focus on a set of key pollutants through systematic monitoring efforts. Among the most closely tracked are particulate matter (PM), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). In the context of Lucknow, several short-term studies have been conducted to evaluate ambient air pollution levels. These investigations primarily focus on pollutants such as PM_{10}, $PM_{2.5}$, suspended particulate matter (SPM), SO_2, NO_x, and various trace metals, offering valuable insights into the city's air quality status.

2. STUDY AREA

Lucknow, with a population of approximately 3.3 million within its municipal and cantonment boundaries, spans an area of 310 km². Geographically, the city is situated at 26°52'N latitude and 80°56'E longitude, with an elevation of 128 meters above sea level. The city's rapid urbanization, driven by its growth as a manufacturing, commercial, and retail hub, has intensified environmental challenges—particularly ambient air pollution.

A significant number of small-scale industries are scattered across various parts of the city, contributing to the degradation of air quality. In particular, studies conducted in the Trans-Gomti area—an urban zone on one side of the river Gomti—have highlighted the severity of the issue. For example, a survey carried out during moderate traffic hours (11:00 AM to 1:00 PM) across twelve locations near road crossings in 2000–01 found extremely elevated levels of particulate matter (PM_{10}). The average PM_{10} concentration was 499.4 µg/m³—far exceeding the National Ambient Air Quality Standards (NAAQS) limit of 100 µg/m³. At the busiest intersection with a traffic density of 6,723 vehicles per hour, the PM_{10} concentration peaked at 995 µg/m³, while the lowest level (150 µg/m³) was recorded at a site with minimal traffic (52 vehicles/hour). Gaseous pollutants such as sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) also showed variability, with maximum readings of 41.92 µg/m³ and 38.24 µg/m³ respectively, and minimum values of non-detectable SO_2 and 4.29 µg/m³ of NO_2.

Further research from 1999–2000, conducted across seven sites in residential, commercial, and industrial zones, revealed that both PM_{10} and suspended particulate matter (SPM) levels varied seasonally. PM_{10} concentrations ranged from 216.5 to 261.5 µg/m³ across summer, winter, and monsoon seasons, while SPM levels fluctuated between 522.3 and 918.4 µg/m³—well above the permissible limits. These studies also pointed to a significant influence of meteorological conditions on pollutant levels, and attributed elevated particulate concentrations to high volumes of diesel-powered vehicles near sampling sites (Pradhan et al., 2004).

The Air Quality Index (AQI) at different locations varied dramatically: clean air (AQI ~9.89) was observed in forest-covered, low-traffic areas, while areas like busy crossings exhibited AQI values around 68.42—bordering on the "polluted" category. This highlighted the disproportionate exposure of the urban population to poor air quality.

An especially concerning finding was the prevalence of polycyclic aromatic hydrocarbons (PAHs), toxic compounds often associated with vehicular emissions and industrial activities. A study estimated that nearly 1.64 million residents were at risk of developing short-term health issues—including cardiovascular, respiratory, eye, and ear problems—due to PAH exposure. The associated economic burden was significant, with an estimated annual health damage cost of Rs. 900 million in Lucknow (Bhargava et al., 2003).

During the post-monsoon period of October 2001, the SPM levels measured in residential, commercial, and industrial zones were 342.0 µg/m³, 547.5 µg/m³, and higher in some instances—each surpassing the NAAQS thresholds. Additionally, emissions from a growing fleet of two-wheelers, three-wheelers, and older four-wheeled vehicles were identified as major contributors to air pollution in the city. These emissions, exacerbated by inefficient traffic regulation and inadequate urban infrastructure, release high levels of PM, NO_x, and volatile organic compounds (VOCs) into the air.

Monitoring data from across the city also revealed that air pollutants exhibit seasonal and spatial variations. PM_{10} levels were found to fluctuate between 111.24 and 240.89 µg/m³, while SO_2 concentrations remained relatively low (6.96 to 11.50 µg/m³). In contrast, NO_2 levels varied more significantly—from 25.28 to 44.41 µg/m³—often higher in commercial hubs such as Hazratganj and Ansal T.C., compared to residential areas like Mahanagar and Aliganj.

These studies collectively underline that Lucknow's air quality is influenced by a range of factors, including traffic volume, vehicle types, meteorological conditions, urban planning inefficiencies, and localized industrial emissions. A multi-pronged strategy involving stricter emissions regulations, modernization of public transportation, green infrastructure development, and continuous air quality monitoring is essential to mitigate health risks and environmental degradation.

- **PM10:**

The annual average concentration of PM10 can range from 178.09 µg/m³ with a range of 111.24 to 240.89 µg/m³.

- **SO2:**

SO2 levels typically range from 7.11 to 8.94 µg/m³, according to a study on Lucknow air quality.

- **NO2:**

NO2 concentrations can vary significantly, with some areas like industrial zones showing higher average levels than residential areas. For example, in residential areas, the 24-hour average NO2 concentrations can range from 15.18 to 43.82 µg/m³, while commercial areas might see concentrations between 17.37 and 45.59 µg/m³(Genral data).

In Lucknow, air pollution tends to be more severe during winter months due to denser, cooler air trapping pollutants near the ground. Summer months, while still experiencing pollution, generally have slightly lower concentrations of some pollutants due to increased ventilation.

Seasonal Air Pollutant Concentrations in Lucknow:

- **Winter:**

Studies show that PM10, SO2, and NO2 levels tend to be highest during the winter months, reaching maximum values of 218.20, 10.32, and 41.43 µg/m3, respectively.

- **Summer:**

The monsoon season (July-October) often sees the lowest concentrations of PM10, SO2, and NO2, with values of 123.47, 7.19, and 28.31 µg/m3, respectively.

- **SO2 and NO2 Ranges:**

SO2 concentrations are typically in the range of 6.96 to 11.50 µg/m3, while NO2 ranges from 25.28 to 44.41 µg/m3.

3. CONCLUSION

It has been found Factors Influencing Air Pollution in Lucknow:

- **Climate:**

Lucknow has a subtropical climate with cool, dry winters and hot, humid summers.

- **Vegetation:**

The presence of trees and vegetation can help mitigate air pollution by absorbing pollutants and improving air quality.

- **Human Activities:**

Vehicular emissions, industrial activities, construction, and biomass burning contribute significantly to air pollution.

- **Vehicular emissions:** Lucknow's large number of vehicles, particularly diesel-powered ones, contribute significantly to air pollution.
- **Road dust and construction:** These activities can also contribute to elevated PM10 levels.
- **Industrial activity:** Industries in and around Lucknow release pollutants into the atmosphere.
- **Fuel burning:** Burning of biofuels can also contribute to air pollution.
- **Seasonal variations:** Pollutant concentrations tend to be higher during winter months and lower during monsoon seasons.

The above factors are responsible for ;

- **Respiratory issues:** Exposure to air pollutants, particularly PM2.5, can lead to respiratory problems like bronchitis and emphysema.
- **Cardiovascular problems:** Air pollution can also exacerbate existing heart conditions.
- **Other health complications:** Long-term exposure to air pollutants can lead to various other health issues, including neurological problems.
- **Poor Air Quality:**

Studies indicate that Lucknow's air quality is often unhealthy, with AQI values exceeding recommended levels, especially during winter.

- **Health Concerns:**

Poor air quality can lead to respiratory issues, cardiovascular problems, and other health complications, according to research.

Air pollution in Lucknow remains a persistent, year-round challenge, with seasonal variations influencing the intensity and composition of airborne pollutants. During winter, pollutant concentrations tend to rise due to adverse atmospheric conditions such as low wind speeds and temperature inversions that hinder dispersion. In contrast, the monsoon season provides temporary relief, largely owing to enhanced ventilation and wet deposition of particulates.

Monitoring data indicate that annual concentrations of PM_{10} consistently exceed the permissible limits set by the National Ambient Air Quality (NAAQ) standards. However, the levels of sulfur dioxide (SO_2) and nitrogen dioxide (NO_2) have generally remained within acceptable ranges throughout the year, with the lowest values typically observed during the monsoon period and higher levels recorded in the summer and winter months.

Indoor air quality has also emerged as a growing concern. Pollutant concentrations within indoor environments tend to escalate from well-planned residential colonies to more densely populated urban zones, with the highest values recorded near roadside dwellings. In these high-density and roadside areas, both $PM_{2.5}$ and PM_{10} levels were found to exceed safe limits, posing significant health risks. The elevated presence of fine and coarse particulate matter is a major factor contributing to poor indoor air quality, which is closely linked to respiratory illnesses and other health issues among urban populations.

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