



## AMBIENT AIR QUALITY STATUS OF LUCKNOW: A REVIEW

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### Abstract

The ambient air quality of Lucknow, the capital city of Uttar Pradesh in India, is known to be poor and has some of the worst pollution levels in the world. The city consistently experiences high levels of particulate matter, specifically PM<sub>2.5</sub> and PM<sub>10</sub>, as well as toxic gases such as nitrogen dioxide and sulfur dioxide. Observing the data from recent years, Lucknow has had yearly PM<sub>2.5</sub> readings that exceed the healthy threshold. In 2019, the city had a yearly PM<sub>2.5</sub> reading of 90.3 µg/m<sup>3</sup>, which is classified as unhealthy and poses severe health risks. The pollution levels in Lucknow are particularly high during certain months, with January and November being the worst months. Breathing polluted air in Lucknow can lead to various health issues, including respiratory and pulmonary diseases, cardiovascular problems, and adverse effects on the reproductive system. It is important for individuals, especially those with respiratory diseases, to take precautions and limit outdoor exertion during times of high pollution levels. Efforts to monitor and improve air quality in Lucknow are ongoing. There are air quality monitoring stations in the city that use laser particle sensors to measure PM<sub>2.5</sub> pollution in real-time. The data from these stations provides valuable information on the current air quality index (AQI) and helps in understanding the health implications of different air quality levels.

**Keywords:** PM<sub>2.5</sub>, CPCB, Lucknow, WHO, transport

### Introduction

Lucknow, the capital city of Uttar Pradesh, is situated on the northwestern bank of the Gomti River. It is not only the largest city in the state but also serves as its administrative and cultural center (Sharma et al., 2016). Lucknow is surrounded by various neighboring districts, with Barabanki to the east, Unnao to the west, Raebareli to the south, and Sitapur and Hardoi to the north (Kanaujia et al., 2015). The city of Lucknow is spread out on both sides of the River Gomti, although it was originally situated only along the right bank. In recent times, the city has been rapidly expanding in all directions, particularly on the left side of the river (Singh et al., 2023). Lucknow experiences a humid subtropical climate. The winters, from mid-November to February, are generally cool and dry. The summer season in Lucknow starts from late March and lasts until June. It is characterized by hot and dry weather. The maximum temperatures during this period can reach up to 45 degrees Celsius or higher (Singh, 2015). The city experiences scorching heat during the summer months. The city covers an approximate area of 470.7 square kilometers, resulting in a population density of 5981 individuals per square kilometer (Sharma, 2023a). Lucknow, like many other cities in India, is experiencing rapid development driven by factors such as urbanization, industrialization, and population growth. The population density of Lucknow in 2011 was approximately 5981 individuals per square kilometer (Sharma, 2023b). These areas house a variety of industries, including 10 large, 15 medium, and 15 small industries classified under the Red category. Additionally, there are three large, four medium, and 65 small-scale industries categorized under the Orange category. Furthermore, one medium-scale industry and 131 small-scale industries fall under the Green category. Apart from these, various other industries, including 255 brick kilns, are also operational in the vicinity of Lucknow City (Mishra et al., 2023). Lucknow offers a range of public transportation options to its residents and visitors. These include taxis, city buses, auto-rickshaws, tempos, cycle-rickshaws, jeeps, cars, and other modes of transport. These options ensure



that people can travel conveniently within the city (Transport Department, Government of Uttar Pradesh, 2022.). The Regional Transport Office (R.T.O) in Lucknow has a significant number of vehicles registered under its jurisdiction. As of March 31, 2016, the total number of registered vehicles with R.T.O, Lucknow, was 1,864,556. This indicates the high level of vehicular ownership and usage in the city (Davis and Davis, 2021). The Uttar Pradesh State Road Transport Corporation (UPSRTC) also operates bus services in Lucknow under the banner of "Lucknow Parivahan Seva." These bus services cover different routes within the city, providing an additional mode of public transportation for the residents (Saini et al.,2022). In terms of fuel availability, Lucknow has 125 petrol/diesel filling stations and six filling stations for Compressed Natural Gas (CNG) as of 2015-16. These fuel stations cater to the demands of vehicles in the city (Mishra et al., 2023).

Currently, Lucknow has more than 1.8 million vehicles, and this number is increasing at an average annual rate of about 9%. The rising number of vehicles contributes significantly to air pollution in the city, along with other sources such as ongoing construction activities, metro rail construction, road and flyover construction, and multistory apartment construction (Singh,2012). These activities release pollutants into the air, adding to the pollution from domestic, commercial, industrial, and vehicular sources. To monitor the ambient air quality in Lucknow, the Board has established monitoring stations at seven locations through manual methods (Saxena et al., 2022). Additionally, one location is monitored using Continuous Ambient Air Quality Monitoring Stations (CAAQMS). These monitoring stations measure various parameters, including PM10 (particulate matter with a diameter of 10 micrometers or less), PM2.5 (particulate matter with a diameter of 2.5 micrometers or less), SO<sub>2</sub> (sulfur dioxide), NO<sub>2</sub> (nitrogen dioxide), and other relevant parameters (Spandana, 2021). Monitoring the ambient air quality is crucial for assessing the level of pollution and its impact on public health and the environment. By tracking these parameters, authorities can identify areas of concern and implement measures to mitigate pollution levels and improve air quality in Lucknow (Gulia et al., 2022).

Air pollution in Lucknow can be attributed to emissions from transportation, including vehicles on roads. The combustion of fossil fuels in vehicles releases pollutants such as particulate matter, nitrogen dioxide, and sulfur dioxide. Domestic activities, such as cooking and heating, also release pollutants into the air (Pate, 2014). These emissions can come from burning solid fuels, biomass, or crop residues. Improper waste management practices, including the burning of municipal solid waste and garbage, further worsen air quality (Adami, 2020). Resuspension of road dust is another significant contributor to air pollution in urban areas. Dust particles from unpaved roads, construction sites, and other sources can become suspended in the air and contribute to the overall pollution levels (Gulia et al., 2022). Construction activities, including excavation, building demolition, and the use of construction machinery, generate dust and emissions that contribute to air pollution. Additionally, the operation of diesel generator sets during power failures can release pollutants into the air, especially if these generators are not equipped with proper emission control mechanisms (Akorede et al., 2010). All of these sources and activities contribute to the poor urban air quality in Lucknow. Addressing air pollution requires a multi-faceted approach that includes implementing stricter emission standards, promoting sustainable transportation, improving waste management practices, adopting cleaner energy sources, and raising awareness about the importance of reducing pollution for public health and the environment (El Badry, 2021).

The CPCB provides guidelines and technical assistance to the state pollution control boards and authorities for effective pollution control measures. The combined efforts and directions from these institutions highlight the commitment to improving air quality and addressing the challenges posed by air pollution in cities like Lucknow (Guttikunda et al., 2014). It emphasizes the need for strong enforcement, regular monitoring, and implementation of measures to control and reduce air pollution levels.



## 2. Action taken by the Central Pollution Control Board

Central Pollution Control Board has issued directions to various government officials and managing directors of gas companies regarding the prevention and control of air pollution in Lucknow city (Chand, 2018). The directions were issued under Section 31(A) of the Air (Prevention and Control of Pollution) Act, 1981, which pertains to the powers of the Board to issue directions for preventing and controlling air pollution. The specific officials who received the directions include:

- (i) Principal Secretary Urban Development
- (ii) Principal Secretary Forests
- (iii) Principal Secretary Transport
- (iv) Principal Secretary Agriculture
- (v) Managing Director Central U.P. Gas Ltd.
- (vi) Managing Director Indraprastha Gas Ltd.
- (vii) Managing Director Green Gas Ltd.

According to the information, the Board regularly monitors the ambient air quality in Lucknow city. Additionally, source emission monitoring, specifically stack monitoring of industries, is conducted on a regular basis. Based on the analysis report of these monitoring activities, appropriate actions are taken. If an industry is found to be violating the air quality standards, the Board follows a specific procedure (Jahnke, 2022). Firstly, a show-cause notice is issued to the industry, allowing them an opportunity to explain their actions or rectify the violations. Following the show-cause notice, if the industry fails to comply with the standards or adequately address the concerns raised, closure action is taken against them under the provisions of the Air (Prevention and Control of Pollution) Act, 1981 (Paliwal, 2006). The closure action refers to the temporary or permanent shutdown of the industry's operations in order to prevent further air pollution and ensure compliance with the air quality standards (Rocky, 1996). It's important to note that the specific details of the violations, actions taken, and the process followed may vary in each case based on the severity of the violations and the applicable laws and regulations.

## 3. Sources of air pollution in Lucknow

Based on the Spatial and Temporal GIS Based Emission Inventory of Air Pollutants and Greenhouse Gases in three major cities of Uttar Pradesh, including Lucknow, the main sources of air pollution in Lucknow city are as follows:

*Vehicular emissions:* Vehicular pollution contributes to approximately 5% of the air pollution in Lucknow. This includes emissions from cars, buses, trucks, motorcycles, and other vehicles.

*Road dust:* Road dust is a significant contributor, accounting for approximately 87% of the air pollution in Lucknow. It refers to the particulate matter (dust and dirt) that is generated from the movement of vehicles, construction activities, and other sources on the city's roads.

*Construction and demolition activities:* Construction and demolition activities also contribute to air pollution in the city. These activities can release dust and other pollutants into the air, affecting air quality.

*Industries (Point source and Area source):* Industrial emissions, both from point sources (individual industrial units) and area sources (industrial areas as a whole), are a source of air pollution in Lucknow. These emissions can include various pollutants depending on the type of industry.

*Garbage burning:* Open burning of garbage contributes to approximately 2% of the air pollution in Lucknow. When waste is burned openly, it releases pollutants into the air, including particulate matter and harmful gases.

*Agriculture waste burning:* Burning of agricultural waste, such as crop residues, also contributes to approximately 2% of the air pollution in Lucknow. This practice is prevalent in rural areas surrounding the city.



#### **4. Health issues associated with breathing polluted air in Lucknow**

Breathing polluted air in Lucknow, particularly with high levels of particulate matter (such as PM<sub>2.5</sub>), can pose several health risks. Some of the health issues associated with breathing polluted air in Lucknow or any other highly polluted city include, inhalation of polluted air can lead to respiratory issues such as coughing, wheezing, shortness of breath, and exacerbation of asthma and other respiratory conditions. The fine particles in the air, including PM<sub>2.5</sub>, can penetrate deep into the lungs and irritate the respiratory system. Long-term exposure to air pollution has been linked to an increased risk of cardiovascular diseases. Fine particulate matter can enter the bloodstream, leading to inflammation, oxidative stress, and the development or worsening of heart conditions, including heart attacks, strokes, and high blood pressure. Prolonged exposure to polluted air can have a negative impact on lung health and lead to a decline in lung function over time. This can make individuals more susceptible to respiratory infections and decrease their overall quality of life. Pollutants in the air, such as pollen, dust, and pollutants from industrial sources, can trigger allergies and allergic reactions in sensitive individuals. This can manifest as nasal congestion, sneezing, itching, and watery eyes. Breathing polluted air can weaken the respiratory system and make individuals more vulnerable to respiratory infections such as bronchitis, pneumonia, and other respiratory illnesses. Children are particularly susceptible to the harmful effects of air pollution due to their developing respiratory systems. Exposure to polluted air can contribute to long-term respiratory problems and impair lung development in children. Long-term exposure to air pollution has been associated with a range of health issues beyond respiratory and cardiovascular problems. It has been linked to an increased risk of cancer, neurological disorders, adverse birth outcomes, and even premature death.

It is important for individuals living in areas with high levels of PM<sub>2.5</sub> pollution to take necessary precautions, such as minimizing outdoor activities during peak pollution periods, using air purifiers indoors, and wearing appropriate masks when necessary. Additionally, efforts to reduce and control PM<sub>2.5</sub> emissions at the source, such as improving air quality regulations, implementing cleaner technologies, and promoting sustainable practices, are crucial for protecting public health and mitigating the risks associated with air pollution.

#### **5. Current air quality in Lucknow**

The report states that pollution levels in all the observed cities were dangerously and persistently higher than the latest World Health Organisation's (WHO) guidelines. Lucknow Air pollution levels in 11 cities of the country, including Lucknow, are well over the danger mark, reveals the latest Greenpeace India report. The report, titled 'Spare the Air', was compiled after a year-long study between September 2021 and September 2022. The report states that pollution levels in all the observed cities were dangerously and persistently higher than the latest World Health Organisation's (WHO) guidelines. In particular, Lucknow's air was found to have an annual PM<sub>2.5</sub> concentration of 79.24 µg/m<sup>3</sup>, which is 15.8 times higher than the safe levels (5 µg/m<sup>3</sup>) set by the WHO. This alarming level of PM<sub>2.5</sub> concentration was recorded on all 366 days of the study period. Similarly, the state capital's annual PM<sub>10</sub> concentration was recorded at 140.9 µg/m<sup>3</sup>, which is 9.3 times higher than the safe levels (10 µg/m<sup>3</sup>). Again, these alarming levels were recorded on all 366 days of the study period. The city's annual NO<sub>2</sub> concentration was also found 3.3 times higher than the safe levels at 32.95 µg/m<sup>3</sup>. These high levels of NO<sub>2</sub> concentration were recorded on 341 of the 366 days. Speaking on the findings, Avinash Chanchal from Greenpeace said, "The findings of this report should serve as a resounding wake-up call for our government. The analysis of air quality data emphasises the need for a regional airshed management approach to address the crisis effectively. The revision of national ambient air quality standards based on regional context should be the crucial first step in this process. It is concerning that over one year and ten months have passed since the WHO updated its air quality standards, while our own national standards remain stagnant." He added, "It is for the government to



prioritise clean energy sources like wind and solar, while actively promoting low-cost, carbon-neutral, and accessible transportation alternatives.” The current air quality in Lucknow can be seen in Table 1.

**Table 1.** Current status of air quality in lucknow (<https://www.aqi.in/in/dashboard/india/uttar-pradesh/lucknow>)

LOCATIONS	STATUS	AQI-US	PM2.5	PM10	Temp	Humid
BR Ambedkar University	Poor	144	53	73	30	89
Central School	Poor	117	42	71	30	95
Charbagh	Poor	129	47	62	30	93
Gomti Nagar	Poor	139	51	83	30	71
Haibat Mau Mawaiya	Poor	129	47	55	30	91
Kukrail Picnic Spot 1	Poor	137	50	71	30	100
Lalbagh	Poor	134	49	45	30	88
Nishat Ganj	Poor	127	46	59	30	92
Talkatora	Poor	137	50	71	30	95
Vijay Khand	Poor	127	46	71	30	86

Earlier, in 2021, the WHO conducted a systematic review, adjusting all the Air Quality Guidelines levels downwards. This was done due to the increasing evidence of air pollution affecting different aspects of health. The WHO had then warned that exceeding the new air quality guideline levels is associated with significant health risks. Studies have revealed that exposure to severe air pollution increases the likelihood of premature death and many medical conditions -- including asthma, preterm birth, low birth weight, depression, schizophrenia, diabetes, stroke, and lung cancer. Dr CM Nautiyal, noted environmentalist and former scientist at Birbal Sahni Institute of Palaeosciences, said, “Sub 2.5-micron pollution cannot be filtered out by our bodies. Pollutants like PM2.5 are mainly related to coal. Switching to solar power is a possible solution. Protection of the planted vegetation is as important as planting saplings. Also, public transport infrastructure must be improved. Activities like walking and cycling should be promoted. Considering the cost of treatment and loss of productive hours later on, making attempts to prevent pollution may prove to be cheaper in the long term.” In a similar vein, environmentalist VK Joshi said, “Greenpeace report is certainly an eye opener. It talks of air-shed management. If government checks rampant construction activity with an iron hand in Lucknow, we may be able to bring down pollution levels. We also need to protect life-saving trees. The role of the development authority is quite important in all this. It must be made sure that developers are following all norms. Dust, along with other elements, reaches Lucknow easily in the absence of trees. IIT Delhi has done some pioneering work in the field of airshed management and their opinion can be sought regarding its feasibility on Lucknow’s air.”

## 6. Conclusion

The city has been experiencing high levels of air pollution, primarily due to factors such as vehicular emissions, industrial activities, construction dust, and biomass burning. These pollutants, including particulate matter (PM2.5 and PM10), nitrogen oxides (NOx), sulfur dioxide (SO2), and volatile organic compounds (VOCs), have severe implications for public health and the environment. The deteriorating air quality in Lucknow has led to various health issues, including respiratory problems, cardiovascular diseases, allergies, and reduced lung function. Vulnerable populations such as children, the elderly, and individuals with pre-existing respiratory conditions are particularly at risk. The



pollution levels often exceed the National Ambient Air Quality Standards, and Lucknow is considered to have some of the worst pollution levels in the world. Efforts to monitor and improve air quality are ongoing, but significant challenges remain. It is important for residents to stay informed about the air quality and take necessary measures to protect their health.

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