# Assessment of Ambient Air Quality of Lucknow City

## Post Monsoon 2023

Vishvigyan Bhawan Campus

Dr. C.R. Krishnamurti Campus


सीएसआईआर-भारतीय विषविज्ञान अनुसंधान संस्थान

**CSIR-INDIAN INSTITUTE OF TOXICOLOGY RESEARCH**

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# Contents

# Salient Features of the Study Area: LucknowCity

| | | |
|---|---|---|
| ❖ **Geographical Position** | : | 26° 52' N Latitude<br>80° 56' E Longitude<br>128 m above Sea Level |
| ❖ **Area** | : | 631 sq. km. |
| ❖ **Population** | : | 2815033 as per 2011 Census |
| ❖ **Projected Population** | : | 65 Lakhs as per Master Plan 2031 |
| ❖ **Climatic Condition** | : | Subtropical climate, cool dry winter (Dec-Feb) & summer (Mar-Jun). Temperature about 45°C in summer to 3°C in winter. The average annual rainfall is about 100 cm. |
| ❖ **Total Vehicular Number as on 01/06/2023** | : | 2816291 |
| ❖ **Growth of Vehicles Over 2022-2023** | : | 6.3% |
| ❖ **Total No. of Fuel Filling Stations (Petrol/Diesel/CNG)** | : | 230 |
| ❖ **Consumption of Fuel:** | | |
| • **Petrol** | : | 262701 kL |
| • **Diesel** | : | 202293 kL |
| • **CNG** | : | 69926513.8 kg |
| ❖ **Major Sources of Pollution** | : | Automobiles, D.G. Sets<br>Biomass burning<br>Construction activities<br>Dry sweeping and<br>Resuspension of road dust |
| ❖ **Parameters Monitored** | : | $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$, Pb, Ni and Noise Levels |
| ❖ **Study Conducted by** | : | Environmental Monitoring Division |

## Executive Summary

Rapid urban development and increased activities have added many air emission sources, and influenced the air quality of Lucknow city. Understanding the latest status of air pollution in the city is important. To address air pollution in Lucknow city, CSIR-IITR has been conducting air quality surveys (pre-monsoon and post-monsoon seasons) at 9-locations across Lucknow city since 1997, and regularly identifying the updated sources, developing their inventory of emissions and generating air pollution data in the city for public awareness and to support in government policy making. In this connection, during the month of September-October 2023, CSIR-IITR has monitored air pollutants such as $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$, and toxic heavy metals Lead (Pb) and Nickel (Ni), and noise levels at 9 locations for the assessment of ambient air quality.

The average particulate pollution levels (i.e., $PM_{10}$ and $PM_{2.5}$) in Lucknow breached national standards, whereas the concentration of gaseous pollutants (i.e., $SO_2$ and $NO_2$) was found below their limits. Among all the monitoring sites in Lucknow, the average concentration exceedance was observed as 49% in $PM_{10}$ and 14% in $PM_{2.5}$ than the prescribed NAAQS limits of 100 $\mu g/m^3$ and 60 $\mu g/m^3$ respectively.

The comparison of concentration trend analysis with post-monsoon 2022 showed that the levels of $PM_{10}$ decreased in residential and commercial sites by 20% and 51%, but increased by 29% at industrial sites. Whereas the levels of $PM_{2.5}$ decreased by 44%, 58%, and 32% from post-monsoon 2022 to post-monsoon 2023. Similarly, overall, in the city, the levels of $SO_2$ decreased by 18% and 22% in residential and commercial areas, whereas in the industrial area increased by 81% from 2022 to 2023 during post-monsoon. The levels of $NO_2$ increased in the residential, commercial, and industrial sites by 22%, 20%, and 98% respectively.

In the initial part of the study during September 2023 frequent rainfall was observed in the city. In the later part, slight rains were further observed for a few days during October 2023 which can suppress the dust entrainment from roads significantly. Therefore, in most locations of the city, there is a decreased trend in particulate matter when compared with the previous year post-monsoon, 2022. However, at the Indiranagar (residential) and Amausi (industrial) sites, $PM_{10}$ observed an increased trend. Near the Indiranagar site, due to the impact of ongoing flyover road construction has resulted in increased $PM_{10}$. Near the Amausi industrial site, activities related to the elevated road construction and highway expansion are in progress. The site-specific construction activities induced traffic congestion and the diversion of vehicles on the road, particularly that routed through Amausi industrial area where the sampling site exists, have also been observed. However, overall, in the city, the air quality trend has decreased compared to 2022 of the same season except at Indiranagar and Amausi for $PM_{10}$.

The measured noise levels were above their respective daytime and nighttime national standards for residential areas and commercial areas. The analysis results of noise levels revealed that the residential sites recorded higher noise during day times than at night time, whereas in commercial areas, the noise levels were found higher during night-time than day-time. This variation between the intra-city sites is due to the impact of different near and on-road noise sources due to traffic, market, and other commercial activities over the city.

## 1.0 Introduction

Air pollution is an ever-growing phenomenon. It is directly governed by industrialization, urbanization, infrastructure, and population growth. To meet the demands of huge public gatherings for cultural and musical celebrations, sports events, and other events, air pollution sources also come into existence, which emit a mixture of pollutants, and finally, humans and other living creatures are exposed to these air pollutants. As per the Air (Prevention and Control of Pollution) Act of 1981 air pollution has been defined as "any solid, liquid, or gaseous substance present in the atmosphere in such concentration as may be or tend to be harmful to humans or other living creatures or plants, or to property or environment." This definition also includes ambient noise. While pollutants are defined as anthropogenically-introduced substances that pollute water or the atmosphere or those that have negative effects on the environment, contaminants are defined as inputs of alien and potentially toxic substances into the environment, such as chemical or microbial contaminants. However, there are a variety of gases in the Earth's atmosphere that help to support life. Major gases like nitrogen and oxygen comprise most of the volume of dry air, while other gases together account for around 1% including argon, carbon dioxide ($CO_2$), and many more. The atmosphere protects us from a majority of the Sun's damaging ultraviolet (UV) radiation and also provides us air to breathe for our life.

Particulate aerosols (Suspended Particulate Matter >10µm, Respirable Particulate Matter (RSPM)≤10µm, and Nano-particles ≤0.1µm) are the major air pollutants present in the urban environment. Particles ≤2.5µm are considered to be more hazardous and pose a greater health risk because of their small size and comparatively higher surface area than larger-size particles. They enter the alveolar sac and induce a variety of respiratory and cardiovascular conditions, such as bronchitis, asthma, and other conditions. The primary causes of harm to the environment, human health, and climate are the principal pollutants, including $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$, $O_3$, CO, HC, and PAHs. A major contributor to these principal pollutants is the local sources that introduce pollutants into the surrounding environment.

Our regulatory agencies working for a better environment have taken several steps to curb and control the detrimental effects of air pollution and climate change. Scientists, decision-makers, and the general public are also aware of the environmental changes and the related impacts. There has been an increasing level of fine particulate matter from various sources in most cities. The National Clean Air Programme (NCAP) of MoEF & CC has identified 131 non-attainment cities in 23 states, including Lucknow, to reduce the predominant ambient air pollutants, particularly fine particulate matter concentration by 2024.

Therefore, regular monitoring and survey of seasonal air quality status is needed to determine the city's current load of different pollutants, whether it is within its allowable limits or still needs appropriate abatement approaches, to be put into effect in order to meet the regulations. In this connection, CSIR-Indian Institute of Toxicology Research (IITR), Lucknow has been conducting air quality surveys in Lucknow city since 1997 for the pre-monsoon (April-May) and post-monsoon (September-October) seasons to determine the concentration status of ambient particulate ($PM_{10}$ and $PM_{2.5}$), gaseous ($SO_2$ and $NO_x$), Trace metals (Pb and Ni) and ambient Noise pollution levels in city environment.

**1.1 Layout of Lucknow City**

Lucknow is the capital and the largest city of the Indian state of Uttar Pradesh and the city's area and urban population are growing at a very rapid pace. The present population is anticipated to be about 35 lakhs. Lucknow is the eleventh-most and the twelfth-most populous urban agglomeration in India. Bounded on the east by Barabanki, on the west by Unnao, on the south by Raebareli , and in the north by Sitapur and Hardoi, Lucknow sits on the northwestern shore of the river Gomti, The river flows across the city and divides it into two parts viz., Cis and Trans Gomti areas. The city stands at an elevation of 123 meters (404 ft) above sea level. Lucknow city had an area of 402 $km^2$ till December 2019, when 88 villages were added to the municipal limits and the area increased to 631 $km^2$. Lucknow has always been a multicultural city that flourished as a North Indian cultural and artistic hub and the seat of power of Nawabs in the 18th and 19th centuries. It continues to be an important center of

governance, administration, education, commerce, aerospace, finance, pharmaceuticals, technology, design, culture, tourism, music and poetry.

**1.2 Vehicular Inventory and Fuel Consumption in the City**

Vehicular and fuel consumption inventory for Lucknow city were carried out and primary information collected from RTO as on June 01, 2023 (Table 1). The total registered vehicle numbers are increased 6.3% by 2023 in comparison with the vehicle data of 2022. The total number of CNG (compressed natural gas) & electricity buses of UPSRTC operational is 68 & 196 respectively by 2023 (Table 2 & 3). Different oil and gas companies have provided total number of fuel outlets (i.e., petrol, diesel & CNG) in Lucknow are 230 (Table 4). Consumption of fuel between years 2022 and 2023 is presented in Table 5, and it is found that the consumption of petrol, diesel and CNG increased by 23.7%, 24.9 and 22.2% respectively, while LPG consumption decreased by 32.4% by 2022-23. Besides, CNG vehicle number by 2023 in the city is presented in Table 6.

**1.3 Study Rationale**

Like many Indian cities air pollution problem is increasing in Lucknow. Over the years particulate matter contributed from multiple sources is responsible for the poor air quality of the city. Air pollution abatement measures and introduction of BS-VI compliant vehicles, CNG and e-vehicles on city roads could have some impact on air quality of city. Installation of proper traffic signals to control vehicle movements has also been taken up by the authorities. However, the idle mode of vehicles, as well as traffic jams at multiple signals, has affected the air quality. Further, increase in urban population and economic activities has resulted in demands for open cooking and street food stall activities, which in turn has increased the cooking combustion-related emission load to ambient air. The problem is often compounded by the predominance of widely distributed area (fugitive) sources in the city, and also the lack of understanding of the sources of secondary aerosol, their formation, and transport.

In different areas of Lucknow, old buildings are demolished and also excavation takes place for new foundations/construction and this becomes a major source of dust. The unpaved and damaged roads are also the sources of soil and road dusts. Although the

State Govt. has taken many initiatives like cleaning programs under the Swachh Bharat Abhiyan, and yet many off-side localities/areas of the city have huge garbage and waste dumps, which are also a source of air pollution. The fugitive sources along the road sides are also contributing to the air pollution.

Therefore, it is extremely important to be aware of the latest status of air pollution in the city to understand the sources and receptor linkages and implement cost-effective strategies for emission reduction. To address air pollution of Lucknow city, CSIR-IITR has been conducting air quality surveys at 9-locations across Lucknow city since 1997, and regularly identifying the sources, developing their inventory of emissions and generating air pollution data for public awareness and to support in government policy making. Post-monsoon 2023 (September to October) air quality survey at 9 locations in Lucknow covering industrial, residential and commercial areas has been carried out with respect to $PM_{10}$, $PM_{2.5}$ $SO_2$, $NO_2$, trace metals (Pb and Ni), and noise pollution and this report illustrate the results with a scientific discussion and recommendations.

**1.4 Objectives**

The following objectives are delineated for the post-monsoon 2023 study:

- *To study the air quality status of post-monsoon season at different locations*
- *To ascertain the concentration of $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_2$, and trace metals (Pb and Ni) associated with $PM_{10}$*
- *To study the trend of air pollution in Lucknow city over the years*
- *To find out the day and night-time noise levels of the current season at different locations*
- *To provide awareness on the current air pollution status*
- *To develop the scientific database and recommendations to assist regulatory agencies in remedial measures for the city*

**Table 1:** Comparison of Registered Vehicle Numbers in Lucknow

| S. No. | Type of Vehicles | No. of Registered Vehicles | | Increase in % |
|---|---|---|---|---|
| | | 2021-2022 | 2022-2023 | |
| 1. | Multi Articulated | 7537 | 7879 | 4.5 |
| 2. | Light, Medium & Heavy Weight Vehicles (Four Wheelers) | 56908 | 61273 | 7.7 |
| 3. | Light Commercial Vehicles (Three-Wheeler) | 3921 | 4072 | 3.9 |
| 4. | Buses | 4794 | 5076 | 5.9 |
| 5. | Omni Buses | 547 | 551 | 0.7 |
| 6. | Taxi | 51165 | 63648 | 24.4 |
| 7. | Light Motor Vehicles (Passenger) | 11139 | 11250 | 1.0 |
| 8. | Two Wheelers | 1931469 | 2012386 | 4.2 |
| 9. | Motor Cycle on Hire | 409 | 409 | 0.0 |
| 10. | Car | 353100 | 394333 | 11.7 |
| 11. | Jeep | 126222 | 150365 | 19.1 |
| 12. | Tractors | 29169 | 30899 | 6.0 |
| 13. | Trailers | 2103 | 2174 | 3.4 |
| 14. | Others | 71803 | 71976 | 0.2 |
| **Increase in total number of vehicles** | | **2650286** | **2812737** | **6.3** |

***Source:*** *RTO, Lucknow, 2023*

**Table 2:** Details of CNG City Bus Service (Gomti Nagar Depot), Lucknow for 2023

| Sl. No. | Route No. | To and Fro | No. of Buses | Frequency (minutes) |
|---|---|---|---|---|
| 1 | 101 | BBD to Charbagh via PatrakaarPuram and Parivartan Park | 9 | 10 |
| 2 | 202 | Industrial area Scooter India to Gomtinagar high court via Ramabaimaidaan and Utretia | 38 | 03 |
| 3 | 402 | Baheta to RajnikhandNishatganj via GPO and Charbagh | 21 | 07 |
| | | **Total** | **68** | -- |

**Table 3:** Details of Electric City Bus Service (Dubagga Depot), Lucknow for 2023

| Sl. No. | Route No. | To and Fro | No. of Buses |
|---|---|---|---|
| 1 | PMI-01 | Stating and end trip: From Dubagga to BadduPur via Parivartan | 08 |
| 2 | PMI-01 | After first trip: Ram Ram bank to BadduPur via Integral University | |
| 3 | PMI-02 | Dubagga to Gangaganj via Charbagh and Gosainganj | 10 |
| 4 | PMI-03 | SGPGI to BhawaniKhera via Charbagh and Atal Chowk | 03 |
| 5 | PMI-03A | Charbagh to Nigohan via SGPGI and Mohanlalganj | 03 |
| 6 | PMI-05 | Ghantaghar to Sandila via Chowk and Dubagga | 20 |
| 7 | PMI-06 | BalaganjChauraha to GudwaChauraha via Maal | 09 |
| 8 | PMI-07 | Rajajipuram bus terminus to Dewa via Charbagh and Polytechnic | 10 |
| 9 | PMI-07A | Rajajipuram bus terminus to Dewa via Charbagh and Kamta-Matiyari | 10 |
| 10 | PMI-08 | Scooter India to AKTU via Charbagh and Kapoorthala | 06 |
| 11 | PMI-11 | GhantaGhar to Maal via Balaganj and Dubagga | 08 |
| 12 | PMI-12 | Scooter India to High Court via RamabaiMaidaan and Suda Office | 12 |
| 13 | PMI-13 | Charbagh to Chandrika Devi Mandir via Engg College | 01 |
| 14 | 801E | Balaganj to VirajKhand via Polytechnic | 14 |
| 15 | 1201E | Dubagga to Bindhaua via Sitapur Bypass and SGPGI | 20 |
| 16 | 105 | Rajajipuram to BBD via Charbagh and Chinhat | 12 |
| 17 | 301 | Scooter India to Engg. College via Awadh Hospital and Charbagh | 15 |
| 18 | 502 | Scooter India to Goel Institute via Utrathia and Ekana Stadium | 10 |
| 19 | 801 | Balaganj to VirajKhand via Dubagga | 14 |
| 20 | 902 | Charbagh to Chandrawal via Bangla Bazaar | 09 |
| 21 | 1001 | GhantaGhar to Naimisharanya via Sandila | 02 |
| | | **Total** | **196** |

**Table 4:** Fuel Outlets in Lucknow City

| Sl.No. | Agency | Number of outlets as on 31st March 2023 |
|---|---|---|
| 1 | Indian Oil Corporation (IOC) | 61 |
| 2 | Bharat Petroleum Corporation Ltd. (BPCL) | 34 |
| 3 | Hindustan Petroleum Corporation Ltd. (HPCL) | 76 |
| 4 | Compressed Natural Gas Stations (CNG) | 59 |
| **Total** | | **230** |

***Source:*** *Indian Oil Corporation (IOC), Bharat Petroleum Corporation (BPCL); Hindustan Petroleum Corporation (HPCL); Green Gas Limited located in Lucknow.*

**Table 5:** Fuel Consumption in Lucknow City

| Sl. No. | Agency | Petrol in kL | | | High Speed Diesel in kL | | | CNG in Kg | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Apr. 22 to Mar. 23 | Apr. 21 to Mar. 22 | % Change | Apr. 22 to Mar. 23 | Apr. 21 to Mar. 22 | % Change | Apr. 22 to Mar. 23 | Apr. 21 to Mar. 22 | % Change |
| 1. | IOC | 128699 | 103343 | 24.5 | 97617 | 75775 | 28.8 | 14786685 | 13629521 | 8.5 |
| 2. | BPCL | 78502 | 64139 | 22.4 | 51276 | 42769 | 19.9 | 120000 | 90000 | 33.3 |
| 3. | HPCL | 55500 | 44845.5 | 23.8 | 53400 | 43424 | 23.0 | 4018000 | 3075300 | 30.7 |
| 4. | Green Gas | - | - | - | - | - | - | 51001828.8 | 40395998 | 26.3 |
| **Total** | | **262701** | **212327.5** | **23.7** | **202293** | **161968** | **24.9** | **69926513.8** | **57190819** | **22.2** |
| | | **LPG in Ton** | | | | | | | | |
| **5.** | **IOC** | **Apr. 22 to Mar. 23** | **Apr. 21 to Mar. 22** | **% Change** | - | - | - | - | - | - |
| | | 662 | 980 | -32.4 | - | - | - | - | - | - |

***Source:*** *Indian Oil Corporation (IOC), Lucknow, Bharat Petroleum Corporation (BPCL), Lucknow, Hindustan Petroleum Corporation (HPCL), Lucknow, Green Gas Limited, Lucknow, Lucknow, 2023*

**Table 6:** Distribution of CNG Vehicles in Lucknow city

| S. No. | Vehicles | Number | | % of Change |
|---|---|---|---|---|
| | | 2021-22 | 2022-23 | |
| 1 | Auto Rickshaws | 4343 | 4343 | - |
| 2 | Tempo Taxi | 2575 | 2575 | - |
| 3 | Buses (UPSRTC) | 260 | 260 | - |
| 4 | Buses (Private) | 40 | 42 | - |
| 5 | School Buses | 1745 | 1974 | 13.1 |
| 6 | School Van | 3117 | 3546 | 13.8 |
| 7 | Private Cars | 30015 | 34711 | 15.6 |
| | **Total** | **42095** | **47451** | **12.7** |

***Source:*** *RTO, Lucknow; Green Gas Limited, Lucknow, 2023*

## 2.0 Monitoring Locations and Methodology

Nine air quality monitoring locations that represents different activities and covering residential, commercial and industrial areas were selected for the post-monsoon 2023 (September-October) study as summarized in Table7 and Figure 1 and methodologies are given in Table 8.

**Table 7:** Monitoring Locations

| Sl.No. | Locations | Activities |
|---|---|---|
| 1 | Aliganj | Residential |
| 2 | Vikas Nagar | Residential |
| 3 | Indira Nagar | Residential |
| 4 | Gomti Nagar | Residential |
| 5 | Charbagh | Commercial cum traffic |
| 6 | Alambagh | Commercial cum traffic |
| 7 | Aminabad | Commercial cum traffic |
| 8 | Chowk | Commercial cum traffic |
| 9 | Amausi | Industrial |

**Table 8:** Parameters and Methodology for Air Quality Monitoring

| Sl. No. | Parameters | Time Weighted Average | Methods of Measurement |
|---|---|---|---|
| 1 | Particulate Matter ($PM_{10}$) | 24 hours | Gravimetric |
| 2 | Fine Particles ($PM_{2.5}$) | 24 hours | Gravimetric |
| 3 | Sulphur Dioxide ($SO_2$) | 24 hours | Improved West and Gaeke |
| 4 | Nitrogen Dioxide($NO_2$) | 24 hours | Modified Jacob &Hochhesier (Na-Arsenite) |
| 5 | Noise Level | Day time (6AM to 10PM) and night time (10PM to 6AM) | Real-time Noise Level Meter |
| 6 | Trace metals in PM (Pb and Ni) | 24 hours | AAS analytical method after sampling on EPM 2000 |


**Figure1:** Ambient air pollution monitoring locations in Lucknow city

## 3.0 Results

The detailed results of air quality monitoring during the post-monsoon period are presented in Table 9 and Figure 2-3.

### 3.1 Respirable Suspended Particulate Matter (RSPM or $PM_{10}$)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar), the 24 hours concentrations of $PM_{10}$ were in the range of 58.5 to 310.9 µg/m$^3$ with an average of 155.7 µg/m$^3$. The average concentration of $PM_{10}$ was observed highest at Indira Nagar among the residential areas.

In commercial areas (Charbagh, Alambagh, Aminabad, and Chowk) the concentrations were in the range of 66.4 to 194.9 µg/m$^3$ with an average of 131.0 µg/m$^3$ respectively. The average concentration of $PM_{10}$ was observed highest at Aminabad among the commercial areas.

In industrial area (Amausi), the average concentration of $PM_{10}$ was 192.9 µg/m$^3$. However, in all locations $PM_{10}$ levels were exceeded the prescribed National Ambient Air Quality Standard (NAAQS) of 100 µg/m$^3$.

### 3.2 Fine Particulate Matter ($PM_{2.5}$)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar, and Gomti Nagar), the 24 hours concentrations of $PM_{2.5}$ were in the range of 32.5 to 118.4 µg/m$^3$ with an average of 70.5 µg/m$^3$. The average concentration of $PM_{2.5}$ was observed highest at Indira Nagar among the residential areas.

In commercial areas (Charbagh, Alambagh, Aminabad, and Chowk) the concentration was in the range of 33.8 to 117.7 µg/m$^3$ with an average of 70.4 µg/m$^3$ respectively. The average concentration of $PM_{2.5}$ was observed highest at Charbagh among the commercial areas.

In industrial area (Amausi), the average concentration of $PM_{2.5}$ was 71.1 µg/m$^3$. Among all locations, $PM_{2.5}$ levels were exceeded the prescribed NAAQS of 60 µg/m$^3$ except the residential areas: Aliganj and Vikas Nagar, and the commercial area: Chowk.

### 3.3 Sulphur Dioxide ($SO_2$)

In residential area (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar), the levels of $SO_2$ were in the range of 8.7 to 29.2 µg/m$^3$ with an average of 16.2 µg/m$^3$. In commercial areas (Charbagh, Alambagh, Aminabad, and Chowk) the concentrations were in the range of 7.9 to 40.8 µg/m$^3$ with an average of 24.3 µg/m$^3$. In industrial area (Amausi), the mean level was 25.5 µg/m$^3$. However, all the values of $SO_2$ were well below the prescribed NAAQS of 80 µg/m$^3$ for all the locations.

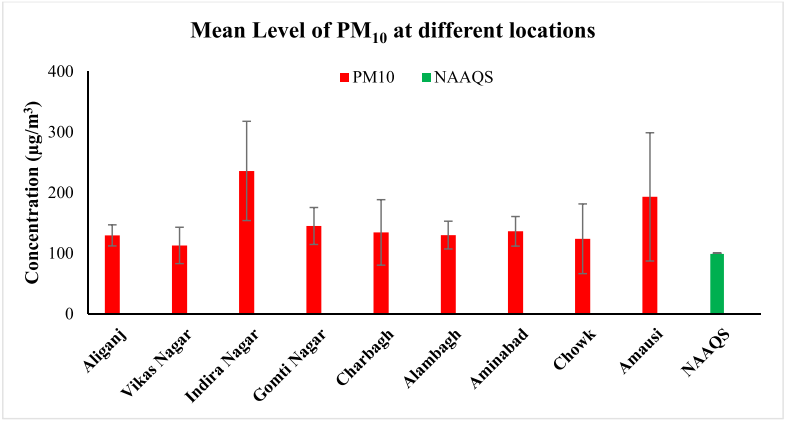
### 3.4 Nitrogen Dioxide ($NO_2$)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the 24 hours concentration of $NO_2$ was in the range of 9.3 to 59.1 µg/m$^3$ with an average of 34.5 µg/m$^3$. In commercial areas (Charbagh, Alambagh, Aminabad, and Chowk) the concentration of $NO_2$ was in the range of 14.1 to 89.0 µg/m$^3$ with an average of 38.8 µg/m$^3$. In industrial areas (Amausi), the average concentration was 47.3 µg/m$^3$. However, all the values of $NO_2$ were within the prescribed NAAQS of 80 µg/m$^3$ for all the monitoring locations.

**Table 9:** Concentration (µg/m$^3$) of $PM_{10}$, $PM_{2.5}$, $SO_2$ and $NO_2$ during post-monsoon 2023

| Location | $PM_{10}$ (RSPM) | | | $PM_{2.5}$ | | | $SO_2$ | | | $NO_2$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Residential** | | | | | | | | | | | | |
| | **Min** | **Max** | **Avg** | **Min** | **Max** | **Avg** | **Min** | **Max** | **Avg** | **Min** | **Max** | **Avg** |
| Aliganj | 102.0 | 148.4 | 129.4±17.4 | 45.6 | 72.6 | 55.1±11.3 | 9.9 | 23.8 | 13.8±5.1 | 19.6 | 35.4 | 25.4±5.7 |
| Vikas Nagar | 58.5 | 141.5 | 112.8±30.0 | 34.0 | 94.2 | 59.4±20.8 | 8.7 | 17.3 | 12.7±3.0 | 23.6 | 59.1 | 37.6±11.4 |
| Indira Nagar | 111.3 | 310.9 | 235.7±81.9 | 66.9 | 118.4 | 88.8±19.3 | 17.2 | 29.2 | 23.2±5.0 | 19.4 | 58.6 | 37.1±16.5 |
| Gomti Nagar | 101.1 | 213.0 | 144.9±30.5 | 32.5 | 110.6 | 78.7±18.8 | 9.2 | 29.1 | 15.3±6.2 | 9.3 | 56.7 | 38.0±12.7 |
| **Commercial** | | | | | | | | | | | | |
| Charbagh | 71.3 | 187.5 | 134.3±54.0 | 51.1 | 117.7 | 75.7±25.3 | 18.7 | 38.8 | 28.1±8.5 | 16.6 | 56.5 | 39.4±15.9 |
| Alambagh | 100.9 | 180.7 | 129.9±22.9 | 38.6 | 97.1 | 71.7±17.5 | 13.0 | 28.9 | 18.2±6.8 | 29.4 | 55.7 | 41.5±8.8 |
| Aminabad | 88.5 | 164.3 | 136.1±24.4 | 33.8 | 97.7 | 75.2±25.6 | 7.9 | 35.5 | 23.6±10.0 | 14.1 | 89.0 | 31.2±25.4 |
| Chowk | 66.4 | 194.9 | 123.8±57.5 | 34.4 | 86.5 | 58.9±18.6 | 9.2 | 40.8 | 27.1±11.1 | 15.7 | 84.8 | 43.4±24.4 |
| **Industrial** | | | | | | | | | | | | |
| Amausi | 84.3 | 337.8 | 192.9±105.8 | 52.9 | 109.9 | 71.1±21.3 | 10.6 | 57.7 | 25.5±16.0 | 27.4 | 70.4 | 47.3±17.1 |
| NAAQS | 100 | | | 60 | | | 80 | | | 80 | | |
| WHO Guidelines | 50 | | | 25 | | | 20 | | | 40* | | |

*=Annual Average, NAAQS=National Ambient Air Quality Standard



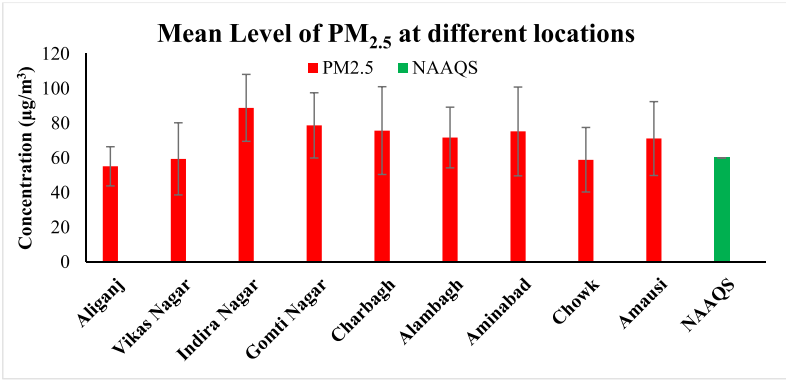
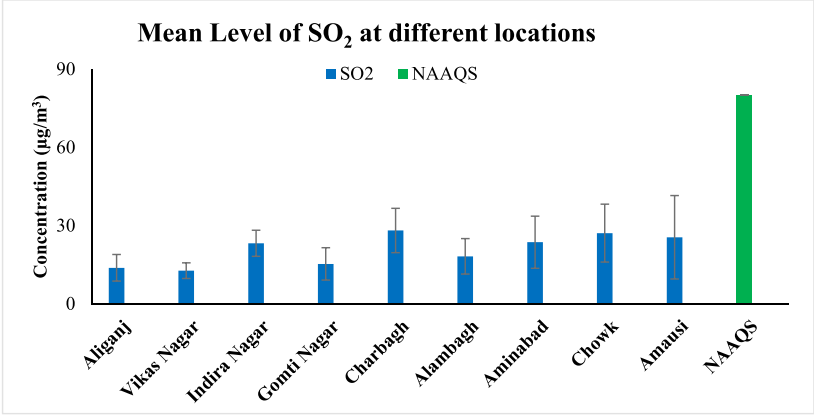




**Figure 2:** Concentration (µg/m$^3$) of $PM_{10}$ and $PM_{2.5}$ in different areas of Lucknow city during Post-monsoon Season (2023) compared with prescribed National Ambient Air Quality Standard (NAAQS)



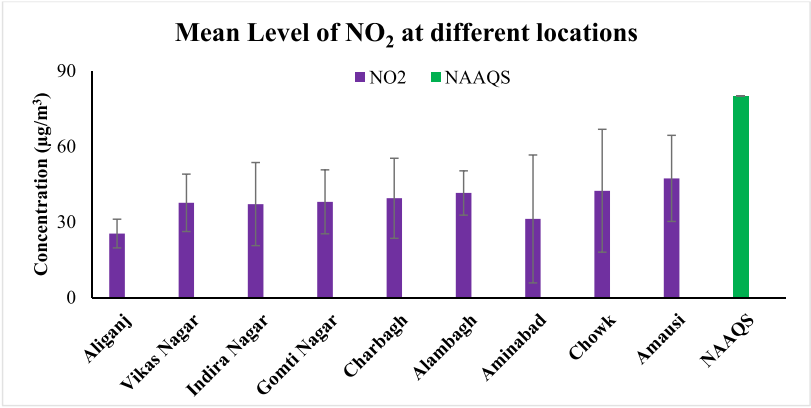




**Figure 3:** Concentration (µg/m$^3$) of $SO_2$ and $NO_2$ in different areas of Lucknow city during Post-monsoon season (2023) compared with prescribed National Ambient Air Quality Standard (NAAQS)

### 3.5 Trace Elements

Metal concentration associated with $PM_{10}$ are presented in Table 10. The average Pb concentration in residential areas was observed 0.0101µg/m$^3$. However, in commercial areas, the values ranged between 0.0028 to 0.0370 µg/m$^3$ with an average of 0.0205 µg/m$^3$. In the industrial area Amausi**,** the value of Pb was 0.0100 µg/m$^3$.

Besides, the concentration of Ni in residential areas ranged between 1.30 ng/m$^3$ (Aliganj) to 8.97 (Gomti Nagar) ng/m$^3$ with an average of 5.08 ng/m$^3$. However, in commercial areas, the values ranged between 3.19 to 11.63 ng/m$^3$ for Charbagh and Aminabad respectively, with an average of 6.83 ng/m$^3$. In industrial area Amausi**,** the value of Ni was found 11.75 ng/m$^3$.

**Table 10:** Metal Concentration of Pb and Ni associated with $PM_{10}$

| **S.No.** | **Location** | **Pb (µg/m$^3$)** | **Ni (ng/m$^3$)** |
|---|---|---|---|
| 1 | Aliganj | 0.0062 | 1.30 |
| 2 | Vikas Nagar | 0.0087 | 1.44 |
| 3 | Indira Nagar | 0.0146 | 8.79 |
| 4 | Gomti Nagar | 0.0109 | 8.97 |
| **Average** | | **0.0101** | **5.08** |
| 5 | Charbagh | 0.0203 | 3.19 |
| 6 | Alambagh | 0.0370 | 3.31 |
| 7 | Aminabad | 0.0028 | 11.63 |
| 8 | Chowk | 0.0221 | 9.19 |
| **Average** | | **0.0205** | **6.83** |
| 9 | Amausi | 0.0100 | 11.75 |
| **NAAQS (National Ambient Air Quality Standards (2009))** | | **1 µg/m$^3$** | **20 ng/m$^3$** |

N=1, *= Annual Average

### 3.6 Noise Level

The noise monitoring data recorded during the post-monsoon period (September-October, 2023) is presented in Table 11. In residential areas, the day and night time noise levels were recorded in the range of 51.9 to 88.6 and 45.2 to 83.6 dB(A) respectively. All the average values were significantly higher than the prescribed national limits of 55 and 45 dB (A) for day and night time respectively.

In commercial and traffic areas, the day and night time noise levels were recorded in the range of 57.9 to 107.3 and 52.8 to 90.1 dB(A) respectively. The average values of noise levels at all the commercial sites were significantly higher than the prescribed national limits of 65 dB (A) and 55 dB (A) for day and night time respectively. In the industrial area Amausi, the day and night time mean noise levels were recorded 79.8 and 72.7 dB(A) respectively. Noise levels at industrial area were recorded higher than the NAAQS of 75.0 and 70.0 dB(A) respectively.

**Table 11:** Noise level dB(A) during day and night time

| Location | Post-Monsoon 2023 | | |
|---|---|---|---|
| | | Day | Night |
| Aliganj | Min | 51.9 | 45.2 |
| | Max | 86.9 | 79.3 |
| | Avg (Leq) | 61.8 | 57.3 |
| Vikas Nagar | Min | 56.0 | 47.9 |
| | Max | 84.2 | 74.4 |
| | Avg (Leq) | 68.8 | 55.7 |
| Indira Nagar | Min | 52.3 | 46.4 |
| | Max | 88.6 | 83.6 |
| | Avg (Leq) | 73.5 | 61.5 |
| Gomti Nagar | Min | 54.9 | 49.3 |
| | Max | 85.4 | 82.8 |
| | Avg (Leq) | 72.1 | 64.2 |
| Charbagh | Min | 60.0 | 58.7 |
| | Max | 107.3 | 90.1 |
| | Avg (Leq) | 77.0 | 73.6 |
| Alambagh | Min | 60.5 | 55.4 |
| | Max | 91.8 | 86.6 |
| | Avg (Leq) | 78.4 | 74.1 |
| Aminabad | Min | 57.9 | 52.8 |
| | Max | 88.4 | 79.9 |
| | Avg (Leq) | 72.7 | 68.6 |
| Chowk | Min | 64.5 | 62.7 |
| | Max | 90.7 | 84.5 |
| | Avg (Leq) | 80.3 | 72.8 |
| Amausi | Min | 59.6 | 54.6 |
| | Max | 92.3 | 80.7 |
| | Avg (Leq) | 79.8 | 72.7 |
| Minimum | | 51.9 | 45.2 |
| Maximum | | 107.3 | 90.1 |
| Mean of 9 Averages | | 73.8 | 66.7 |
| SD of 9 Averages | | 5.9 | 7.3 |

## 4.0 Trends of Ambient Air Quality in Lucknow City

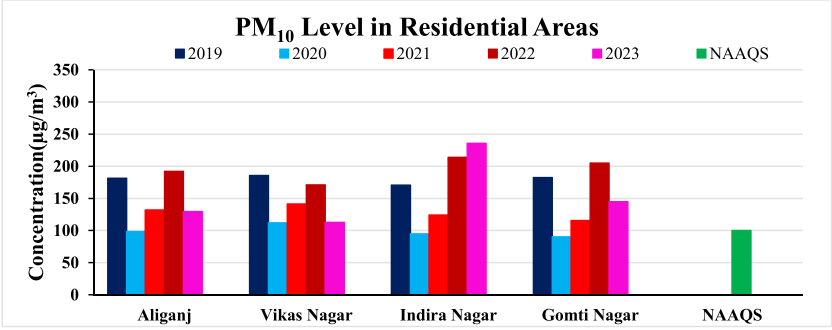
The observed parameters $PM_{10}$, $PM_{2.5}$, $SO_2$, and $NO_2$ for 5 years Post-monsoon data have been compared to find out the prevailing trend of air pollution in Lucknow city (Figures 4-7). Slight changes in the values are attributed due to some local environmental, urban development, and climatic factors.

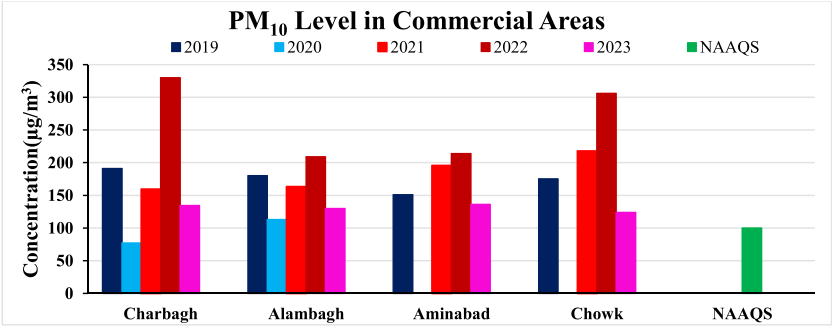
### 4.1 Trend of $PM_{10}$ and $PM_{2.5}$

Figure 4 and Figure 5 indicate that the $PM_{10}$ and $PM_{2.5}$ concentration is in a decreasing trend till 2020 and started increasing from 2021 to 2022 followed by a decrease in 2023 except for two locations for $PM_{10}$, i.e., Indira Nagar and Amausi sites. During post-monsoon 2023 there is intermittent scattered rainfall in different areas of the city. The levels of $PM_{10}$ and $PM_{2.5}$ in all the residential, commercial, and industrial areas were relatively lower as compared to monitoring data of the previous year 2022. However, the concentration of $PM_{10}$ exceeded NAAQS limits for all sites, whereas $PM_{2.5}$ exceeded NAAQS except Aliganj, Vikas Nagar and Chowk sites.

### 4.2 Trend of $SO_2$ and $NO_2$

The level of $SO_2$ and $NO_2$ during Post-monsoon since 2019 is presented in Figure 6 and Figure 7 for all the locations. $SO_2$ concentration is in decreasing trend till 2020 and started increasing from 2021 to 2022, however, decreased in 2023 except Amausi site. $NO_2$ concentration in all the sampling sites shows an increase from 2022 to 2023 except Aliganj site. In residential, commercial, and industrial areas, concentrations of $SO_2$ were found to decrease to that of the previous year 2022, however, $NO_2$ concentration was found to increase from the year 2022. All the values of $SO_2$ and $NO_2$ for the present study were found to be lower than the NAAQS limits.



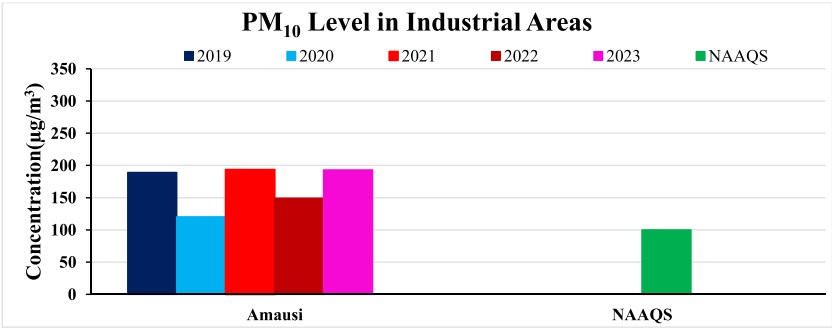
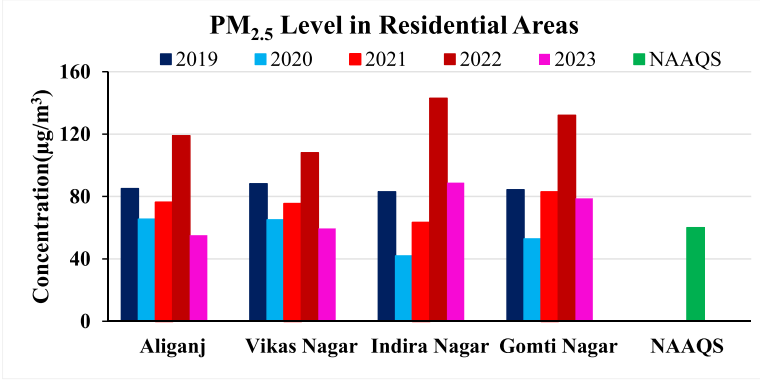
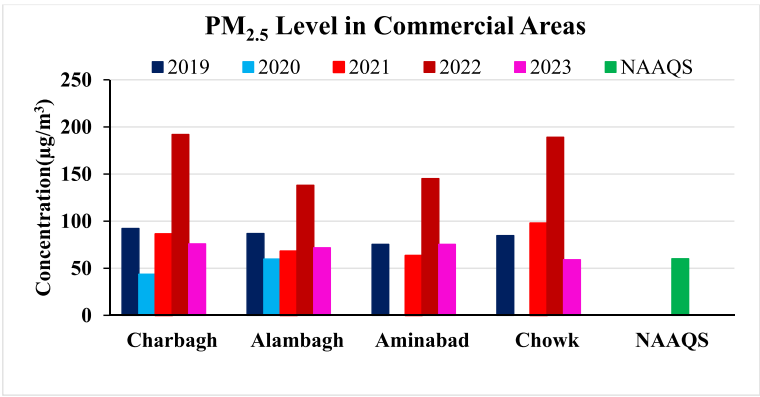




**Figure 4:** Concentration (µg/m$^3$) of $PM_{10}$ **(**RSPM**)** in residential, commercial and industrial areas of Lucknow city during 2019 to 2023 (Post-monsoon) and compared with prescribed National Ambient Air Quality Standard (NAAQS)



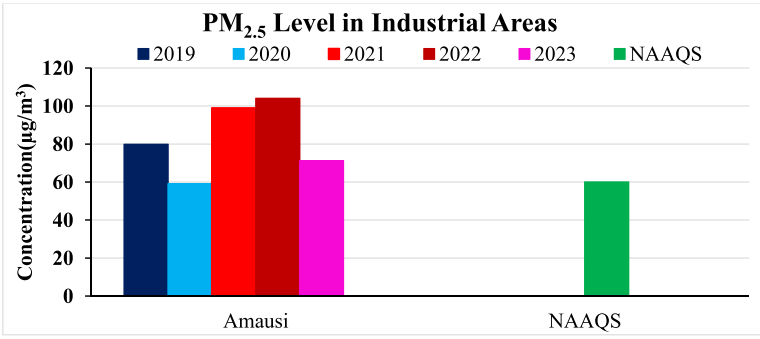
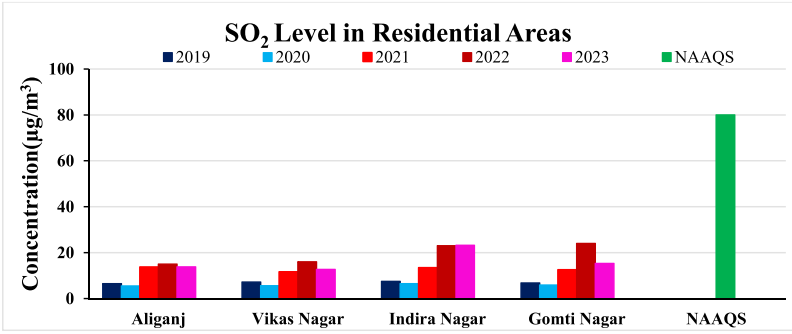
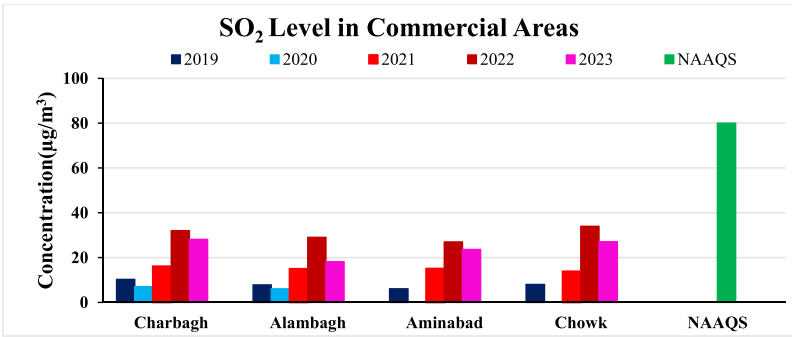




**Figure 5:** Concentration (µg/m$^3$) of $PM_{2.5}$ in residential, commercial and industrial areas of Lucknow city during 2019 to 2023 (Post-monsoon) and compared with prescribed National Ambient Air Quality Standard (NAAQS)



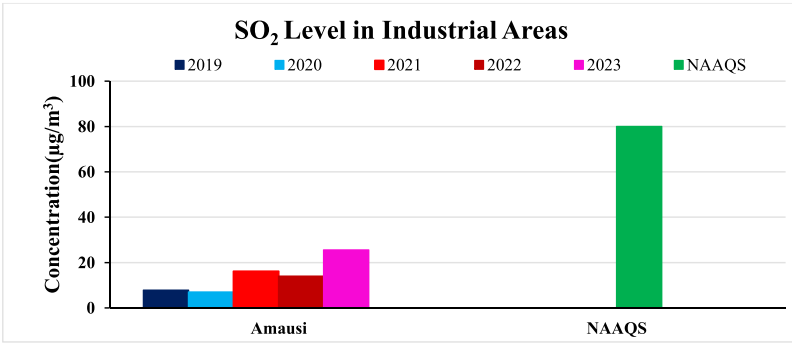




**Figure 6:** Concentration (µg/m$^3$) of $SO_2$ in residential, commercial and industrial areas of Lucknow city during 2019 to 2023 (Post-monsoon) and compared with prescribed National Ambient Air Quality Standard (NAAQS)

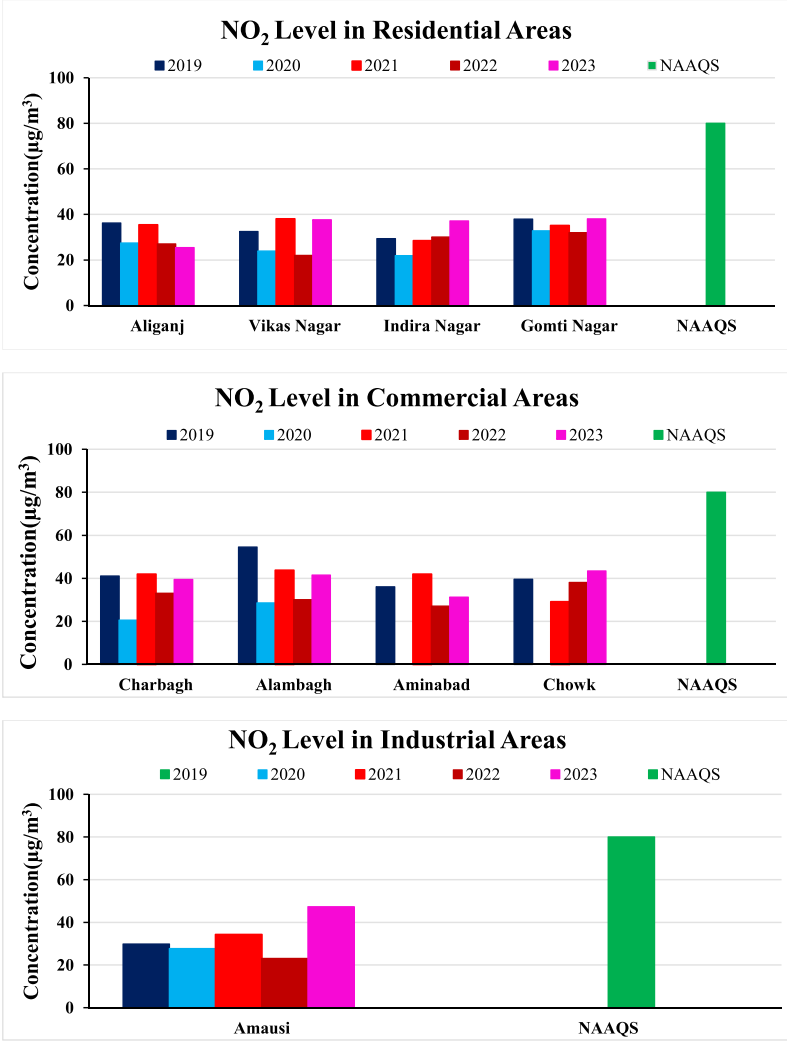



**Figure 7:** Concentration (µg/m$^3$) of $NO_2$ in residential, commercial and industrial areas of Lucknow city during 2019 to 2023 (Post-monsoon) and compared with prescribed National Ambient Air Quality Standard (NAAQS)

### 4.3 Trend of Noise Level

The current year's Post-monsoon noise data was compared with the corresponding data of the previous four years i.e. 2019 to 2022 and results are presented in Figure8 and 9. The higher noise levels adversely affect the lives of millions of urban people. Studies have shown that there are direct links between noise and health.

#### 4.3.1 Day Time Noise Level

All residential, commercial cum traffic, and industrial areas showed a slightly increased trend in Alambagh, Chowk, and Amausi sites, however, a slightly decreased trend was observed for all other locations. The comparative data are presented in Figure 8.

#### 4.3.2 Night Time Noise Level

All residential, commercial cum traffic, and industrial areas showed a slightly increased trend in Alambagh, and Chowk sites, however, a slightly decreased trend was observed for all other locations. The comparative data are presented in Figure 9.

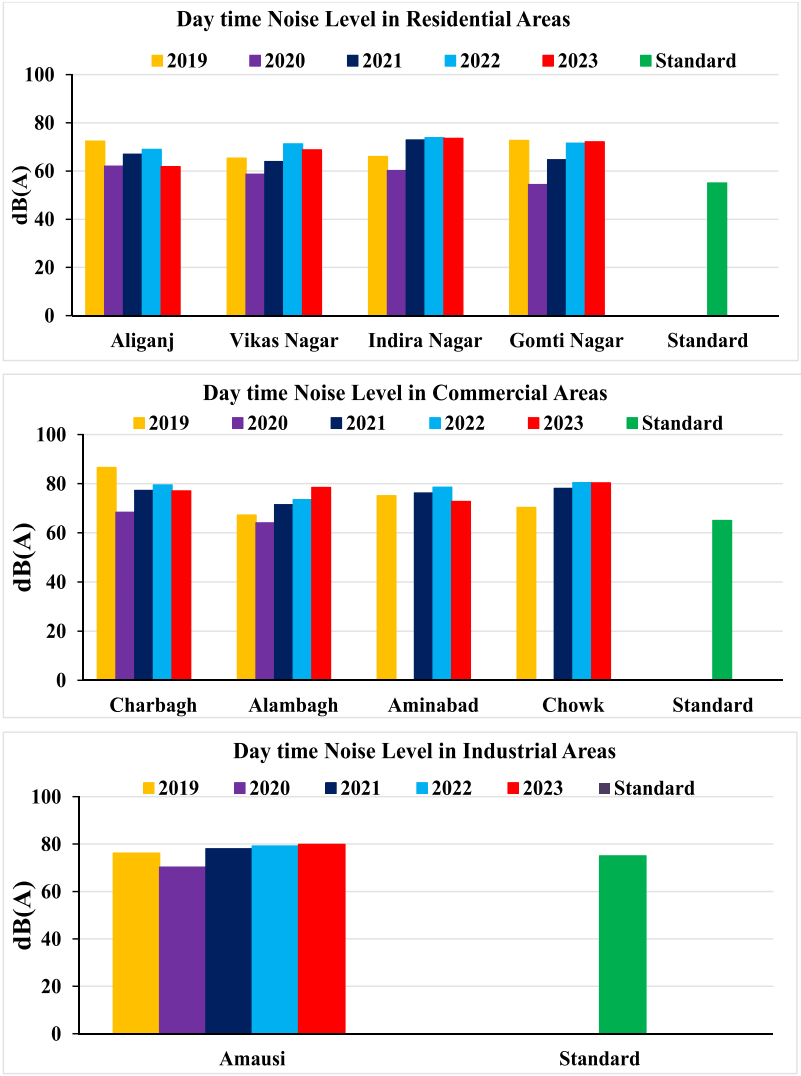
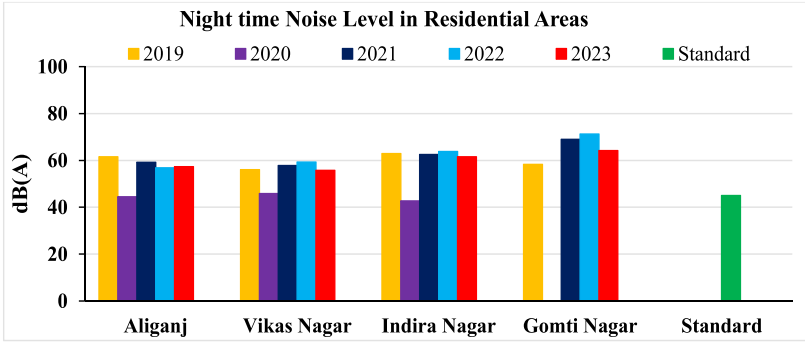
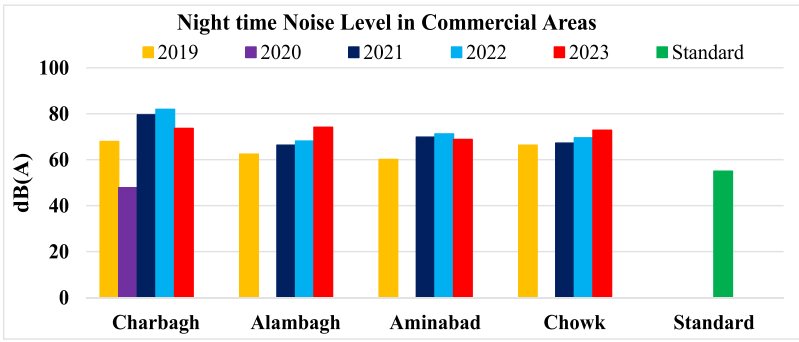



**Figure 8:** Comparison of day time Noise Level in dB(A) for different areas of Lucknow city (Post-monsoon 2019-2023)



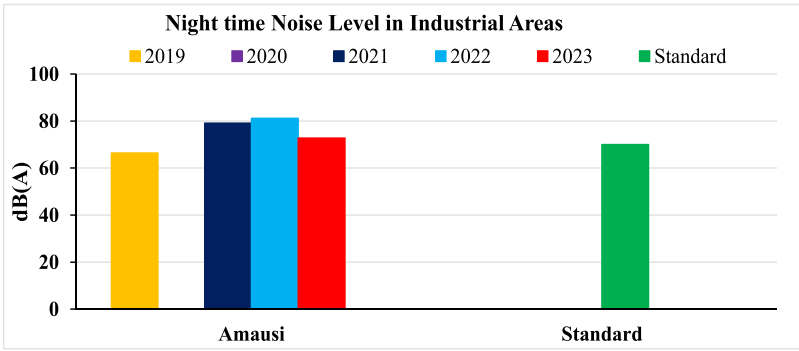




**Figure 9:** Comparison of night time Noise Level in dB(A) for different areas of Lucknow city (Post-monsoon 2019-2023)

## 5.0 Conclusions/ Major Findings

The Post-monsoon ambient air quality assessment of Lucknow city was carried out by the Environmental Monitoring Division, CSIR Indian Institute of Toxicology Research, Lucknow during the months of September-October, 2023. Air quality status was evaluated by monitoring and assessing air pollutants such as 1. Respirable Suspended Particulate Matter: $PM_{10}$, and Fine Particulate Matter: $PM_{2.5,}$ 2. Gases: Sulphur dioxide ($SO_2$) and Nitrogen dioxide ($NO_2$); 3. Trace Metals: Lead and Nickel; and 4. Noise levels at 9 locations which grouped into 3 categories; Residential, Commercial, and Industrial areas.

The 24-hour concentrations of $PM_{10}$ ranged from 58.5 µg/m$^3$ to 337.8 µg/m$^3$ with an average of 148.9 µg/m$^3$ while in the case of $PM_{2.5}$, the 24-hour concentrations ranged from 32.5 µg/m$^3$ to 118.4 µg/m$^3$ with an average of 70.5 µg/m$^3$. The average values of $PM_{10}$ breached at all the sites than the permissible limits of 100 µg/m$^3$. Whereas $PM_{2.5}$ exceeded the national limit 60 µg/m$^3$ except for Aliganj, Vikas Nagar, and Chowk. Trace metals of $PM_{10}$ (i.e. Pb and Ni) are found in the range of 0.0028 to 0.0370 µg/m$^3$, avg. 0.0147 µg/m$^3$ for Pb and 1.30 to 11.75 ng/m$^3$, avg. 6.62 ng/m$^3$ for Ni.

The 24-hour concentrations of $SO_2$ ranged from 7.9 to 57.7 µg/m$^3$ with an average of 20.8 µg/m$^3$ while the 24-hour concentrations of $NO_2$ ranged from 9.3 to 89.0 µg/m$^3$ with an average of 37.8 µg/m$^3$. The values of $SO_2$ decreased by 16.0 % and $NO_2$ increased by 22.0 %, respectively, from post-monsoon of 2022 to 2023. However, average values of $SO_2$ and $NO_2$ were well below the permissible limits of 80 µg/m$^3$ that prescribed by CPCB (NAAQS-2009).

The particulate matter concentration was recorded as highest in Indira Nagar compared to all other residential locations because of highway construction (i.e. flyover) works happening throughout the sampling period. The activities resulted in to increase in traffic congestion, on-road vehicle density due to traffic diversions at nearby roads and dust entrainment from the vicinity activities. The second-highest concentration was recorded at Amausi, and the reason can be the ongoing construction of roads/ flyovers near the sampling site such that traffic congestion and diversions occurred. These two locations show higher dust entrainment as the roads near the locations are not fully paved and construction dust is also added as the extra load of particles in the ambient air. Alambagh, Amausi and Chowk reported the highest $SO_2$ and $NO_2$ concentrations as vehicular movements and various commercial activities dominantly prevailed near the sites of these sampling locations.

The day time and night time noise levels ranged from 51.9 to 88.6 dB(A) and 45.2 to 83.6 dB(A) in residential areas and from 57.9 to 107.3 dB(A) and 52.8 to 90.1 dB(A) in commercial areas respectively. These measured values were above their respective day time standard of 55 dB(A) and night time standard of 45 dB(A) for residential areas and

65 dB(A) and 55 dB(A) for commercial areas respectively as per national standards. At Amausi industrial area, the day time and night time noise levels were 79.8 dB(A) and 72.7 dB(A) respectively. The values are above the national standard of 75 dB(A) for day time and 70 dB(A) for night time recommended for Industrial areas.

The overall trend analysis results revealed that air pollution levels decreased in Lucknow city in comparison to 2022. This may be attributed to intermittent and scattered rainfall during the survey in many parts of the city. Weather in the city was hot and dry on some days whereas windy with rain-showers and humid air on other days which may have contributed to fluctuating pollutant concentrations within the city region. Site-specific sources and variations in diurnal urban activities over the city also influenced the noise levels in the city. The meteorological conditions of the city are likely better (favorable) during the survey period in terms of air pollution dispersion and dilution in the city, which is also a factor for the decreased trend of air quality.

**6.0 Health Impacts of Air and Noise Pollution**

Researchers have focused more attention on exploring and establishing the association of air pollution with respiratory diseases. Epidemiology and toxicology studies have demonstrated that repairable particles are closely related to the incidence of human diseases and mortality rate.

**Particulate Matter ($PM_{10}$& $PM_{2.5}$)**

- Fine airborne particulate matter of diameter ≤ 2.5, ($PM_{2.5}$) when inhaled would penetrate beyond the larynx.
- $PM_{2.5}$ can penetrate deep into the lungs, irritate and corrode the alveolar wall, impair lung function, cause emphysema and bronchitis, and aggravate existing heart disease.
- Ultrafine particles ranging from 0.001 to 0.1 µm in diameter are able to penetrate deep into the lungs and to alveolar sacs where gaseous exchange occurs.

**Sulfur Dioxide ($SO_2$)**

- Increased $SO_2$ may cause irritation of the eyes, nose, and throat, and increases choking and coughing.
- Repeated or prolonged exposure to moderate concentrations may cause inflammation of the respiratory tract, wheezing, and lung damage.

**Oxides of Nitrogen ($NO_x$)**

- Long-term exposure to $NO_2$ may affect lung function and lower the resistance to diseases such as pneumonia and influenza.
- Exposure to low levels of NOx in smog can irritate the eyes, nose, throat, and lungs. It can cause coughing, shortness of breath, fatigue, and nausea.

**Trace element-Lead (Pb)**

- Lead is a neuro-toxin causing impairment of neuro-development in children, affecting the development of the brain of the fetus.
- Decreased nerve conduction velocity, cognitive development and instinctual performance, hearing loss, jaundice, and anemia in children

**Trace element-Nickel (Ni)**

- The harmful human health effects of nickel could be an allergic reaction, chronic bronchitis, reduced lung function, lung cancer, and nasal sinus cancer.
- Animal studies have found an increase in newborn deaths and a decrease in newborn weight after ingesting Nickel.

**Noise**

Noise pollution is the spread of unwanted sounds into the environment that have a range of mental health effects. The brain is always monitoring sounds for signs of danger, even during sleep. Continued exposure to noise pollution can trigger anxiety or stress. Problems related to noise include stress-related illnesses, high blood pressure, speech interference, hearing loss, sleep disruption, and lost productivity. People living with noise pollution may feel irritable, on edge, frustrated, or angry. If a person feels they cannot control the level of noise in their environment, its impact on their mental health intensifies.

## 7.0 Recommendations for Mitigation of Air Pollution

1. Vehicular emission reduction by permitting only BS-VI complaint and electric, biodiesel, CNG, or hybrid-based vehicles.
2. Removal of more than ten years old vehicles from city roads.
3. Avoid frequent cutting and digging of roads.
4. Reduce resuspension of soil and silt from roads by maintaining road surface and regular vacuum-assisted sweeping and watering of roads.
5. Synchronize consecutive traffic signals to facilitate smooth traffic on crossing and strict control of roadside parking.
6. Encouragement to use public transport for daily commute.
7. Installation of more electric vehicle charging stations.
8. Plantation along roadsides to absorb air pollutants and enhance scenic beauty.
9. Regular fogging on roads with a higher load of pollution in the environment.
10. Installation of effective particulate control equipment such as bag filters/scrubbers/ ESPs in the industries.
11. Restrict fugitive dust spread from building construction and demolition activities by installing proper HDPE construction nets/meshes.
12. Proper covering of trucks carrying garbage/solid wastes/sand/cement/concrete/loose materials etc., avoid overloading.
13. Avoid burning of crop residues in the field, and implementation of in-situ technologies to use/ recycle crop residues.
14. Avoid burning of plastic, garbage, trash, and other materials in an open environment.
15. Electrical or gas-based crematorium practices shall be encouraged.
16. More awareness programs to sensitize public about the clean air practices.
17. Restrict haphazard development to avoid hotspots emitting high air pollution.
18. Use energy-efficient equipment to reduce carbon emissions in sectors such as transport, manufacturing, production and agriculture, etc.
19. Ban loudspeakers and horns with high decibel noise levels.
20. Dense tree coverage particularly for arterial roads, public places, and silent zones can help reduce noise pollution
21. Avoid vehicle horns when not necessary to reduce noise pollution

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**Contributors:**

The survey, data analysis, and report preparation are done by the following staff of the Environmental Monitoring Division:

Scientists: Er A H Khan, Dr B Sreekanth

Technical Staff: Mr Pradeep Shukla, Mr Sushil Kumar Saroj

PhD Scholars: Ms Priya Saxena, Mr SS Kalikinkar Mahanta, Mr Hari Om Prasad

Project Associates: Mr Abdul Atiq Siddiqui, Mr Ravi Singh, Mr Mohd. Muzammil, Mr Satyendra Singh

Project Assistants: Mr Murshid Khan, Mr Anuj Kumar, Mr Ashok Kumar, Mr Suresh Kumar Vishwakarma

Head of Division, FEST: Dr N. Manickam

# सीएसआईआर-भारतीय विषविज्ञान अनुसंधान संस्थान
# CSIR-INDIAN INSTITUTE OF TOXICOLOGY RESEARCH

*"सामूहिक सफलता में ही प्रत्येक व्यक्ति की सफलता निहित है।"*
*"Until all of us have succeeded, none of us have"*


"सुरक्षा पर्यावरण और स्वास्थ्य
और उद्योग के लिये सेवा"
**"safety to environment &
health and service to industry"**


## R & D Areas
- Food, Drug & Chemical Toxicology
- Environmental Toxicology
- Regulatory Toxicology
- Toxicoinformatics & Industrial Research
- Systems Toxicology & Health Risk Assessment

## R & D Partnership for Industries & Startup
- Centre for Innovation and Transnational Research (CITAR)
- DSIR-IITR-CRTDH Environmental Monitoring and Intervention Hub

## Services Offered
- GLP certified pre-clinical toxicity studies
- NABL (ISO/IEC 17025:2017) accredited Safety/ toxicity evaluation of NCEs
- Water quality assessment and monitoring
- Analytical services
- Environmental monitoring and impact assessment
- Information on chemicals/ products
- Computational predictive toxicity assessment

## Recognitions
- Scientific & Industrial Research Organizations (SIROs)
- UP Pollution Control Board (Water & Air)
- Indian Factories Act (Drinking water)
- Bureau of Indian Standards (Synthetic detergents)
- Food Safety & Standards Authority of India (FSSAI)

## Technologies Developed/ Available
- Oneer- A novel solution for safe drinking water
- Portable Water Analysis Kit
- Mobile Laboratory for environment and human health
- AO Kit for rapid screening of Argemone in mustard oil
- MO Check for detection of Butter Yellow, an adulterant, in edible oils

## अनुसंधान एवं विकास क्षेत्र
- खाद्य, औषधि और रासायनिक विषविज्ञान
- पर्यावरण विषविज्ञान
- नियामक विषविज्ञान
- टॉक्सिकोइंफॉर्मेटिक्स एवं औद्योगिक अनुसंधान
- प्रणाली विषविज्ञान एवं स्वास्थ्य आपदा मूल्यांकन

## उद्योग और स्टार्टअप के लिए आर एंड डी साझेदारी
- सेंटर फॉर इनोवेशन एंड ट्रांसनैशनल रिसर्च (सिटार)
- डीएसआईआर–आईआईटीआर–सीआरटीडीएच पर्यावरण निगरानी और हस्तक्षेप हब

## सेवाएं दी गईं
- जीएलपी प्रमाणित पूर्व–नैदानिक विषाक्तता अध्ययन
- एनएबीएल (आईएसओ/आईईसी 17025:2017) मान्यता प्राप्त एनसीई की सुरक्षा/विषाक्तता मूल्यांकन
- जल गुणवत्ता मूल्यांकन और निगरानी
- विश्लेषणात्मक सेवाएं
- पर्यावरण निगरानी और प्रभाव मूल्यांकन
- रसायनों/उत्पादों के बारे में जानकारी
- कम्प्यूटेशनल भविष्य कहनेवाला विषाक्तता मूल्यांकन

## मान्यताएं
- वैज्ञानिक और औद्योगिक अनुसंधान संगठन (एसआईआरओ)
- यूपी प्रदूषण नियंत्रण बोर्ड (जल और वायु)
- भारतीय कारखाना अधिनियम (पीने का पानी)
- भारतीय मानक ब्यूरो (सिंथेटिक डिटर्जेंट)
- भारतीय खाद्य सुरक्षा और मानक प्राधिकरण (ै.।.)

## विकसित/उपलब्ध प्रौद्योगिकियां
- ओनीर– सुरक्षित पेयजल के लिए एक नया समाधान
- पोर्टेबल जल विश्लेषण किट
- पर्यावरण और मानव स्वास्थ्य के लिए मोबाइल प्रयोगशाला
- सरसों के तेल में आर्जीमोन की त्वरित जांच के लिए एओ किट
- मक्खन पीले रंग का पता लगाने के लिए एमओ जांच, एक मिलावटी, खाद्य तेलों में

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विषविज्ञान भवन, 31, महात्मा गाँधी मार्ग
लखनऊ-226001, उ.प्र., भारत

VISHVIGYAN BHAWAN, 31, MAHATMA GANDHI MARG
LUCKNOW-226001, U.P., INDIA

Phone:+91-522-2627586, 2614118, 2628228 Fax:+91-522-2628227, 2611547 director@iitrindia.org www.iitrindia.org