Assessment of Ambient Air Quality of Lucknow City

Pre-Monsoon 2021

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

Salient Features of the Study

- **Geographical Position** : 26^{o} 52' N Latitude
  80^{o} 56' E Longitude
  128 m above Sea Level
- **Area** : 310 sq. km.
- **Population** : 2815033 as per 2011 Census
- **Projected Population** : 65 lakhs as per Master Plan 2031
- **General Climate of Lucknow City** : Subtropical climate, cool dry winter (Dec-Feb) & summer (Mar-Jun). Temperature about 45°C in summer to 3°C in winter. Average annual rainfall about 100 cm.
- **Total Vehicular number Of Lucknow city as on 31/03/2021** : 2514461
- **Growth of Vehicles over 2019-2020** : 4.5%
- **Total No. of Fuel Filling Stations (Petrol/Diesel/CNG)** : 149
- **Consumption of Petrol** : 191149 kL
- **Consumption of Diesel** : 176660 kL
- **Consumption of CNG** : 26860650 kg
- **Major Sources of Pollution** : Automobiles, D.G. Sets, biomass burning, Construction activities, dry Sweeping of roads
- **Parameters Monitored** : PM_{10}, $PM_{2.5}$, SO_2, NO_2 And Noise Levels
- **Study Conducted by** : Environmental Monitoring Division CSIR-IITR, Lucknow

ASSESSMENT OF AMBIENT AIR QUALITY OF LUCKNOW CITY DURING PRE-MONSOON, 2021

1.0 SUMMARY

The Pre-Monsoon ambient air quality assessment of Lucknow city was carried out by the Environmental Monitoring Division of CSIR Indian Institute of Toxicology Research, Lucknow during the months of April-May, 2021. Air quality status was evaluated through monitoring and assessment of some of critical and health affecting air pollutants like 1. ***Respirable Suspended Particulate Matter:*** *(PM_{10}, cut off size ≤10 µm, and* ***Fine Particulate Matter:*** *($PM_{2.5}$, cut off size ≤ 2.5 µm);* ***2. Indicator Gases:*** *Sulphur dioxide (SO_2) and Nitrogen dioxide (NO_2); and* ***3. Noise levels*** *at 9 representative locations which are grouped into 3 categories viz.,* ***i. Residential area, ii. Commercial area*** *and* ***iii. Industrial area.***

The 24 hr concentrations of PM_{10} ranged from 109.8 µg/m^3 to 152.5 µg/m^3 with an average of 127.1 µg/m^3 while in case of $PM_{2.5}$, the 24 hr concentrations ranged from 60.7 µg/m^3 to 71.1 µg/m^3 with an average of 64.5 µg/m^3. Irrespective of the locations, the average values of PM_{10} and $PM_{2.5}$ were found to be above the permissible limits of 100 µg/m^3 for PM_{10} and 60 µg/m^3 for $PM_{2.5}$ prescribed by Central Pollution Control Board, New Delhi. However, the values of PM_{10} and $PM_{2.5}$ increased by 26.1 % and 16.6 % compared to the levels measured during Pre-Monsoon 2020 (Lockdown) period (i.e. April-May 2020). Similarly, the values of SO_2 and NO_2 increased by 113.9 % and 23.1 %.

The 24 hr concentrations of SO_2 ranged from 10.1 to 18.5 µg/m^3 with an average of 13.4 µg/m^3 while the 24 hr concentrations of NO_2 ranged from 28.7 to 33.4 µg/m^3 with an average of 31.8 µg/m^3. The average values of SO_2 and NO_2 were well below the permissible limits of 80 µg/m^3 for both SO_2 and NO_2 prescribed by CPCB, New Delhi (NAAQS-2009).

The day time and night time noise levels ranged from 67.0 to 70.7 dB(A) and 55.4 to 60.0 dB(A) in residential areas and from 67.2 to 79.0 dB(A) and 52.3 to 61.3 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. At Amausi Industrial area, the day time and night time noise levels were 73.6 dB(A) and 60.1 dB(A) respectively. The values are below the standard of 75 dB(A) for day time and 70 dB(A) for night time recommended for Industrial areas.

The present study reveals that the levels of pollutants like inhalable particulate matter, gases, and noise are gradually increasing due to the fact that air quality monitoring of Pre-Monsoon 2021 coincided with some periods of partial to complete lockdowns to

control of second wave of COVID-19 while the Pre-Monsoon 2020 study was held completely in lockdown period to control the first wave of COVID-19. More vehicles were permitted to ply on the road, domestic cooking, baking/firing in hotels, near field crop combustion and some industries were allowed to operate, Crematorium fires also increased as number of deaths were high during the Corona second wave pandemic period which also had an effect on the air pollution levels of Lucknow in Pre-Monsoon 2021. The overall trend reveals that all pollutants are increasing in Lucknow city.

1.1 INTRODUCTION

Air pollutants present in the atmosphere, harmful to the health of humans and other living beings, also cause damage to the climate and environment. There are different types of air pollutants in the atmosphere, viz. particulates PM_{10} $PM_{2.5}$ (both organic and inorganic); gases such as sulphur dioxide (SO_2), nitrous oxides (NOx), carbon monoxide (CO), carbon dioxide (CO_2), ammonia (NH_3), methane (CH_4) and chlorofluorocarbons (CFCs), ammonium and nitrate salts and biological molecules. Air pollution is considered to be the prime cause of diseases like asthma, chronic obstructive pulmonary disease (COPD), lower respiratory infections (LRI), allergies and even death in extreme cases. It may also cause harm to other living organisms such as animals and food crops and may damage the natural environment (causing climate change, ozone depletion and/or habitat degradation, acid rain formation etc). A recent study reported that atmospheric particulate matter may also act as a medium to disseminate viruses and keep them in the atmosphere for a certain period of time (Kumbhalgarh, 2020).

Millions of people live in cities with severe air pollution, one of the key risk factors and leading cause of mortality (WHO, 2018). Polluted air holds many toxic pollutants which are specifically emitted by enhanced human activities. The issue of air pollution is a major concern since pollution levels are ever-increasing. Among the 12 criteria that determine air quality, pollutants (PM_{10}/ particulate matter with cut off size 10 µm, $PM_{2.5}$/ particulate matter with cut off size 2.5 µm), SO_2, NO_2, CO, NH_3, O_3 (ozone), C_6H_6 (benzene), BaP (Benzo-a-pyrene, a carcinogenic polyaromatic hydrocarbon) and particle phase metals of Pb (lead), Ni (nickel) and As (arsenic), the concentration of fine particulate matter i.e. $PM_{2.5}$ is of utmost concern due to its size and consequently greater interactive surface area with respect to its mass. These

particulate matters, $PM_{2.5}$ can reach deep into lungs, up to the alveoli sac from where it may get transported to other organs through systemic blood circulation resulting in systemic poisoning. PM_{10} and $PM_{2.5}$ are both inhalable and their concentrations (pre-COVID-19) in most urban cities were often found to be 4 to 6 times higher as compared to the National Ambient Air Quality Standards (NAAQS). The gaseous pollutants i.e. SO_2 and NO_2 were found in moderate concentration and within the permissible limits. Extremely high concentration of these pollutants causes physical discomfort, disruption in life with fear of illness and even death. Regulatory measures have resulted in little success in management of air pollution because the characteristics of the source of pollutants are often complex to understand and their respective pollution loads in the atmosphere, difficult to estimate. However, real time air quality monitoring data has always played a significant role in identifying the changes in the source strength and also in enforcing upgraded air pollution control measures for cleaner air.

Lucknow being the capital of Uttar Pradesh state has been reeling under severe air pollution, particularly from past two decades as the city has expanded rapidly with an ever increasing population. Consequently there is steady demand for increased transportation, better infrastructure, greater industrial production and other anthropogenic activities to meet the aspirations of the growing public in the city. The people of the city are consequently exposed to polluted air that has a detrimental impact on their health and well being. Air pollution levels in the city vary spatially and temporally with respect to the varying localized sources strength and unstable meteorological conditions. Hence, air quality survey/ monitoring in Lucknow is essential to assess the episodic/seasonal pollution load as well as for a comparative understanding of current versus previous pollution data. The assessment further helps in identifying the variations in the impact caused by short- and long-term exposure to pollutants. The seasonal air quality survey is an endeavour to understand whether the current pollution load in the city has crossed its permissible limits and what suitable abatement policies are required to be enforced so as to remain within the permissible standards.

With this view, CSIR-Indian Institute of Toxicology Research, Lucknow, under the aegis of Council of Scientific and Industrial Research, New Delhi, Government of

India, has been continuing air quality survey in Lucknow during May-June (Pre-Monsoon) and October-November (Post-Monsoon) seasons, every year since 1997 for assessing ambient particulate (PM_{10} and $PM_{2.5}$) and gaseous (SO_2 and NO_x) pollution levels in Lucknow.

Uttar Pradesh government has imposed partial (weekend) complete lockdown from 16th April to 31st May 2021 to control the 2nd wave of the COVID-19 pandemic. However, plying of vehicles during recent partial lockdown 2021 were more than that seen during last year (2020) strict and complete Lockdowns.

Vehicular traffic has been considered to be the major source of air pollution in Lucknow. Hence, vehicular and fuel consumption inventory for Lucknow city were carried out. The number of different categories of vehicles registered with RTO Lucknow as on March 31, 2021 are presented in Table 1. UPSRTC introduced bus services as on 31.03.2021 are given in Table 2 and also presented the details of eclectic city buses as public transport are given in Table 3. Filling stations for petrol, diesel and CNG operated by different oil and gas companies are presented in Table 4. Further, the fuel consumption details are illustrated in Table 5. Distribution and number of CNG vehicles in Lucknow is summarized in Table 6.

Environmental Monitoring Division, CSIR-IITR Lucknow has carried out air quality monitoring at 9 locations with respect to PM_{10}, $PM_{2.5}$ SO_2, NO_2 and noise level during April-May-2021 (Pre-Monsoon), with the following aims and objectives;

- *to determine the concentrations of ambient air quality parameters with respect to particulate matter (PM_{10}, $PM_{2.5}$) and gases (SO_2 and NO_2),*
- *to find out the trends of pollutants over a period of time,*
- *to measure the day and night time noise levels,*
- *to create public awareness about environmental pollution and to find abatement for air pollution at individual and community level and,*
- *to create a competency like database for future use.*

Table 1
Comparison of Vehicular Numbers in Lucknow

S. No.	Type of Vehicles	No. of Registered Vehicles as on 31st March		Increase in %
		2020-21	2019-20	
1.	Multi Articulated	6648	6144	8.2
2.	Light, Medium & Heavy Weight Vehicles (Four Wheelers)	51603	47745	8.08
3.	Light Commercial Vehicles (Three Wheeler)	3798	3652	3.99
4.	Buses	4383	4291	2.49
5.	Omni Buses	489	489	0
6.	Taxi	37993	30362	20.08
7.	Light Moto Vehicles (Passenger)	10557	10157	3.93
8.	Two Wheelers	1860778	1804077	3.14
9.	Motor Cycle on Hire	384	384	0
10.	Car	330596	313597	5.14
11.	Jeep	105707	85689	23.36
12.	Tractors	28022	27136	3.26
13.	Trailers	1989	1961	1.4
14.	Others	71514	71506	0.01
	TOTAL	**2514461**	**2407190**	**4.45**

Source: RTO, Lucknow

Table 2
Details of Lucknow CNG City Bus Service, 2021

S. No.	Route No.	To and Fro	No. of Buses	Frequency (minutes)
1	105	Raja ji Puram – Mawaiyya – Charbagh – GPO – Sikanderbagh – Nishatganj – Polytechnic – Awadh Bus Station (Kamta) – BBD	11	17
2	301	Scooter India – Krishna Nagar – Awadh Hospital – Alambagh – Mawaiyya – Charbagh – GPO – Sikanderbagh – Nishatganj – Badshah Nagar – Ram Ram Bank – Engg. College	9	18
3	401	Kashiram Yojna – Para Chowki - Awadh Hospital – Alambagh – Mawaiyya – Charbagh – GPO – Sikanderbagh – Nishatganj – Badshah Nagar – Gol Market – PS Gudmba – Integral University	6	30
4	502	Charbagh- Hussanganj - GPO – Sikanderbagh - Gol Market – Bhoothnath – HAL - Polytechnic – Awadh Bus Station (Kamta)	15	09
5	601	Dubagga – Balaganj – Chowk – Medical College – Kaiserbagh- Hussanganj – Charbagh – Mawaiyya – Alambagh – Awadh Hospital	12	10
6	701	Dubagga – Faridipur – Buddheshwar- Para – Manak Nagar – Awadh Hospital – Pakri Pul – Telibagh – Utrathia – SGPGI	19	06
7	801	Balaganj - Dubagga – Bhitauli – Tedhi Puliya – Khurram Nagar – Sector 25 – Munshi Puliya – Polytechnic – Kamta – Virajkhand Bus Station	19	08
8	901	Charbagh – Mawaiyya – Tedhi Puliya Alambagh – Jail Road – Pasi Qila – Jyoti Gas – CRPF Chouraha – Azad Engg. College	1	120
		Total	**92**	

Table 3
Details of Lucknow Electric City Bus Service, 2021

S. No.	Route No.	To and Fro	No. of Buses	Frequency (minutes)
1	301-E	Dubagga – Buddheshwar – Awadh Hospital - Alambagh – Mawaiyya – Charbagh – GPO – Sikanderbagh – Gol Market – Engg. College – Madiyawo – Bhitauli – I.I.M. College	10	30
2	701-E	Dubagga – Faridipur – Buddheshwar- Para – Manak Nagar – Awadh Hospital – Pakri Pul – Telibagh – Utrathia – SGPGI	12	30
3	801-E	Balaganj - Dubagga – Bhitauli – Tedhi Puliya – Khurram Nagar – Sector 25 – Munshi Puliya – Polytechnic – Kamta – Virajkhand Bus Station	8	35
4	1001-E	Dubagga – Buddheswer – Awadh Hospital – Charbagh – Sikanderbagh – Balu Adda – Fun Cinema – Lohiya Park – CMS – Dayal Paradise – Manoj Pandey Chauraha – Husariya – Virajkhand Bus Station	10	25
		Total	**40**	

Table 4
Fuel Outlets in Lucknow City

S.No.	Agency	Number of outlets as on 31st March 2021
1	Indian Oil Corporation (IOC)	51
2	Bharat Petroleum Corporation Ltd. (BPCL)	32
3	Hindustan Petroleum Corporation Ltd. (HPCL)	33
4	Compressed Natural Gas Stations (CNG)	33
Total		**149**

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

Table 5
Fuel Consumption in Lucknow City

S. No.	Agency	Petrol in kL			High Speed Diesel in kL			CNG in Kg		
		Apr. 20 to Mar. 21	Apr.19 to Mar. 20	% Change	Apr. 20 to Mar. 21	Apr.19 to Mar. 20	% Change	Apr. 20 to Mar. 21	Apr.19 to Mar. 20	% Change
1.	IOC	85316	102547	-16.8	66726	79137	-15.7	11563212	15700482	-26.4
2.	BPCL	48883	56657	-13.7	33984	37800	-10.1	918151	158682	478.6
3.	HPCL	56950	39403	44.5	75950	38746	96.0	1840921	1860688	-1.1
4.	Green Gas	-	-	-	-	-	-	12538366	42359025	-70.4
Total		**191149**	**198607**	**-3.8**	**176660**	**155683**	**13.5**	**26860650**	**77798729**	**-65.5**
		LPG in Ton								
5.	**IOC**	**Apr. 20 to Mar. 21**	**Apr.19 to Mar. 20**	**% Change**	-	-	-	-	-	-
		1737	1954	-11.1						

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

Table 6
Distribution of CNG Vehicles

S. No.	Vehicles	Number		% of Change
		2020-21	2019-20	
1	Auto Rickshaws	4343	4343	-
2	Tempo Taxi	2575	2575	-
3	Buses (UPSRTC)	260	260	-
4	Buses (Private)	40	40	-
5	School Buses	1557	1557	-
6	School Van	2231	2231	-
7	Private Vehicles	472	472	-
8	Private Cars	24539	21168	15.92
	Total	**36017**	**32646**	**10.32**

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

1.2 MONITORING LOCATIONS AND METHODOLOGY

Nine air quality monitoring locations representing different activities/ areas i.e., four in residential, four in commercial cum traffic and one industrial area were selected for the Pre-Monsoon 2021 study as summarized in Table 7 and Figure 1 and adopted methodologies are given in Table 8.

Table 7
Monitoring Locations

S .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 Gaeke
4	Nitrogen Dioxide (NO_2)	24 hours	Modified Jacob & Hochhesier (Na-Arsenite)
5	Noise Level	1 hour	The measurement of noise level was carried out during the day (6 AM to 10 PM) and night time (10 PM to 6 AM) by Noise Level Meter

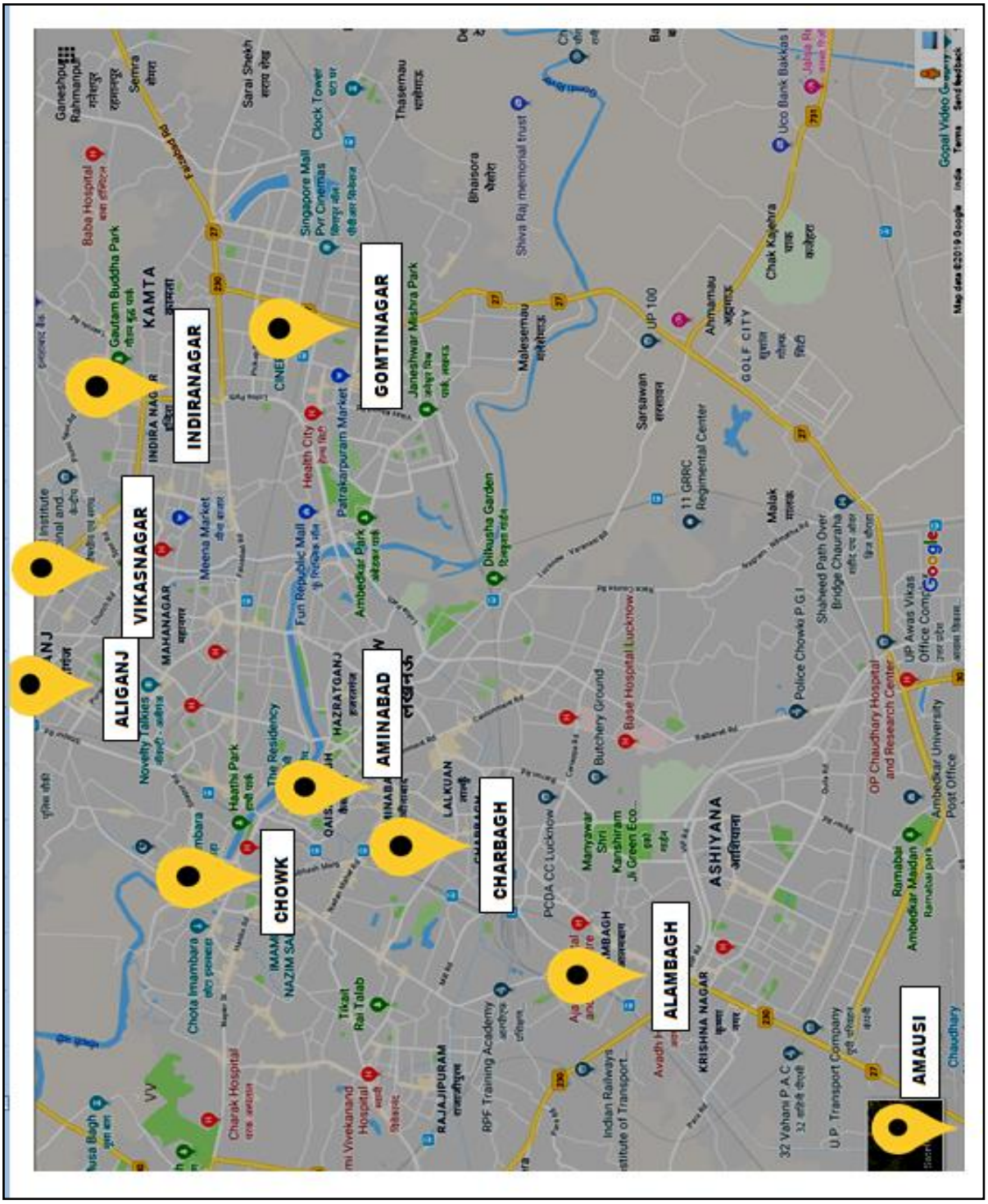


Figure 1: Ambient Air Pollution Monitoring Locations in Lucknow City

1.3 RESULTS

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

1.3.1 Respirable Suspended Particulate Matter (RSPM or PM_{10})

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar), the 24 hours average concentrations of PM_{10} were in the range of 59.6 to 162.0 µg/m^3 with an average of 120.6 µg/m^3. In commercial areas (Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of PM_{10} were in the range of 78.6 to 221.8 µg/m^3 with an average of 127.2 µg/m^3 respectively. In industrial area (Amausi), the average concentration of PM_{10} was 152.5 µg/m^3.

The maximum 24 hours mean concentration of PM_{10} was observed in Gomti Nagar (128.7 µg/m^3) in residential area and Charbagh (143.8 µg/m^3) in commercial areas. All the values of PM_{10} were above the prescribed National Ambient Air Quality Standard (NAAQS) of 100 µg/m^3 for industrial, residential, rural and other areas respectively.

1.3.2 Fine Particulate Matter ($PM_{2.5}$)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar), the 24 hours average concentrations of $PM_{2.5}$ were in the range of 32.7 to 112.7 µg/m^3 with an average of 64.8 µg/m^3. In commercial areas (Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of $PM_{2,5}$ were in the range of 31.2 to 140.9 µg/m^3 with an average of 65.0 µg/m^3 respectively. In industrial area (Amausi), the average concentration of $PM_{2.5}$ was 61.5 µg/m^3.

The maximum 24 hours mean concentration of $PM_{2.5}$ was observed in Gomti Nagar (68.2 µg/m^3) residential area and Charbagh (71.1 µg/m^3) in commercial area. All the values of $PM_{2.5}$ were above the prescribed NAAQS of 60 µg/m^3 for industrial, residential, rural and other areas.

1.3.3 Sulphur dioxide (SO_2)

In residential area (Aliganj) the mean levels of SO_2 was in the range of 8.8 to 15.4 µg/m^3 with an average of 12.5 µg/m^3. In commercial areas (Charbagh, Alambagh and Aminabad) the average concentrations of SO_2 were in the range of 5.9 to 22.0 µg/m^3 with an average of 13.3 µg/m^3. In industrial area (Amausi), the mean level of SO_2 was 14.6 µg/m^3.

All the values of SO_2 were well below the prescribed NAAQS of 80 µg/m^3 for all the locations.

1.3.4 Nitrogen dioxide (NO_2)

In residential areas (Aliganj) the 24 hours average concentrations of NO_2 was in the range of 27.6 to 42.6 µg/m^3 with an average of 33.4 µg/m^3. In commercial areas (Charbagh, Alambagh and Aminabad) the average concentrations of NO_2 were in the range of 16.1 to 58.0 µg/m^3 with an average of 31.1 µg/m^3. In industrial areas (Amausi), the average concentration was 32.4 µg/m^3.

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 Pre-Monsoon 2021

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	79.9	150.7	111.9	53.2	66.6	60.7	8.8	15.4	12.5	27.6	42.6	33.4
Vikas Nagar	71.5	142.7	117.3	43.7	86.3	62.5	ND	ND	ND	ND	ND	ND
Indira Nagar	65.9	156.9	124.5	35.3	112.7	67.6	ND	ND	ND	ND	ND	ND
Gomti Nagar	59.6	162.0	128.7	32.7	94.6	68.2	ND	ND	ND	ND	ND	ND
Commercial												
Charbagh	107.5	167.8	143.8	59.6	89.2	71.1	13.8	22.0	18.5	21.0	48.1	32.8
Alambagh	97.1	201.0	133.9	32.2	112.8	64.5	5.9	14.8	10.1	15.1	58.0	31.8
Aminabad	85.6	167.6	109.8	31.2	138.5	62.0	6.0	19.3	11.2	19.8	43.1	28.7
Chowk	78.6	221.8	121.1	44.6	140.9	62.5	ND	ND	ND	ND	ND	ND
Industrial												
Amausi	108.0	181.8	152.5	32.4	123.5	61.5	10.7	20.8	14.6	23.7	42.0	32.4
NAAQS	100			60			80			80		
WHO Guidelines	50			25			20			40*		

N=8, *= Annual Average, NAAQS=National Ambient Air Quality Standard

ND= Not Done

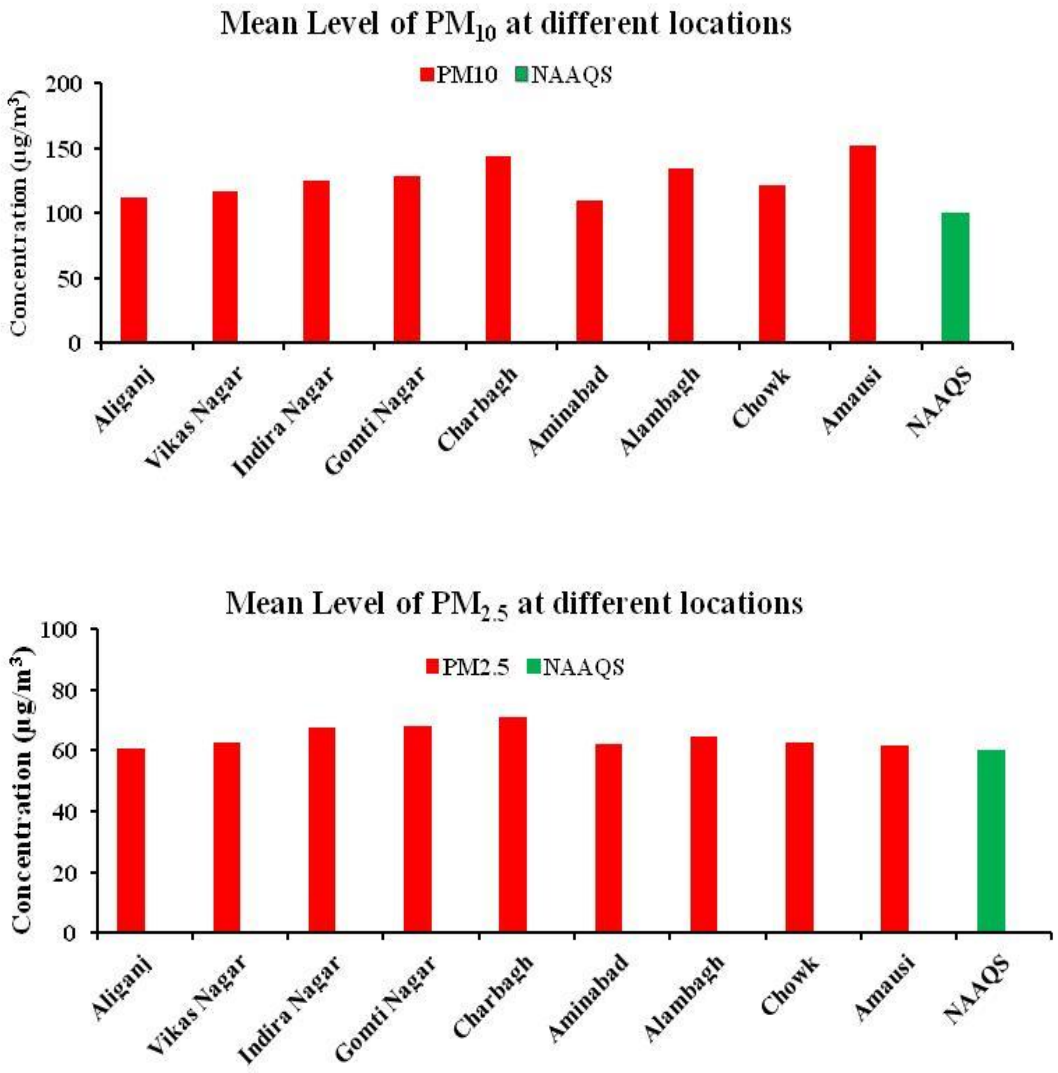


Figure 2: Concentration (µg/m^3) of PM_{10} and $PM_{2.5}$ in different areas of Lucknow city during Pre-Monsoon Season (2021) compared with prescribed National Ambient Air Quality Standard (NAAQS)

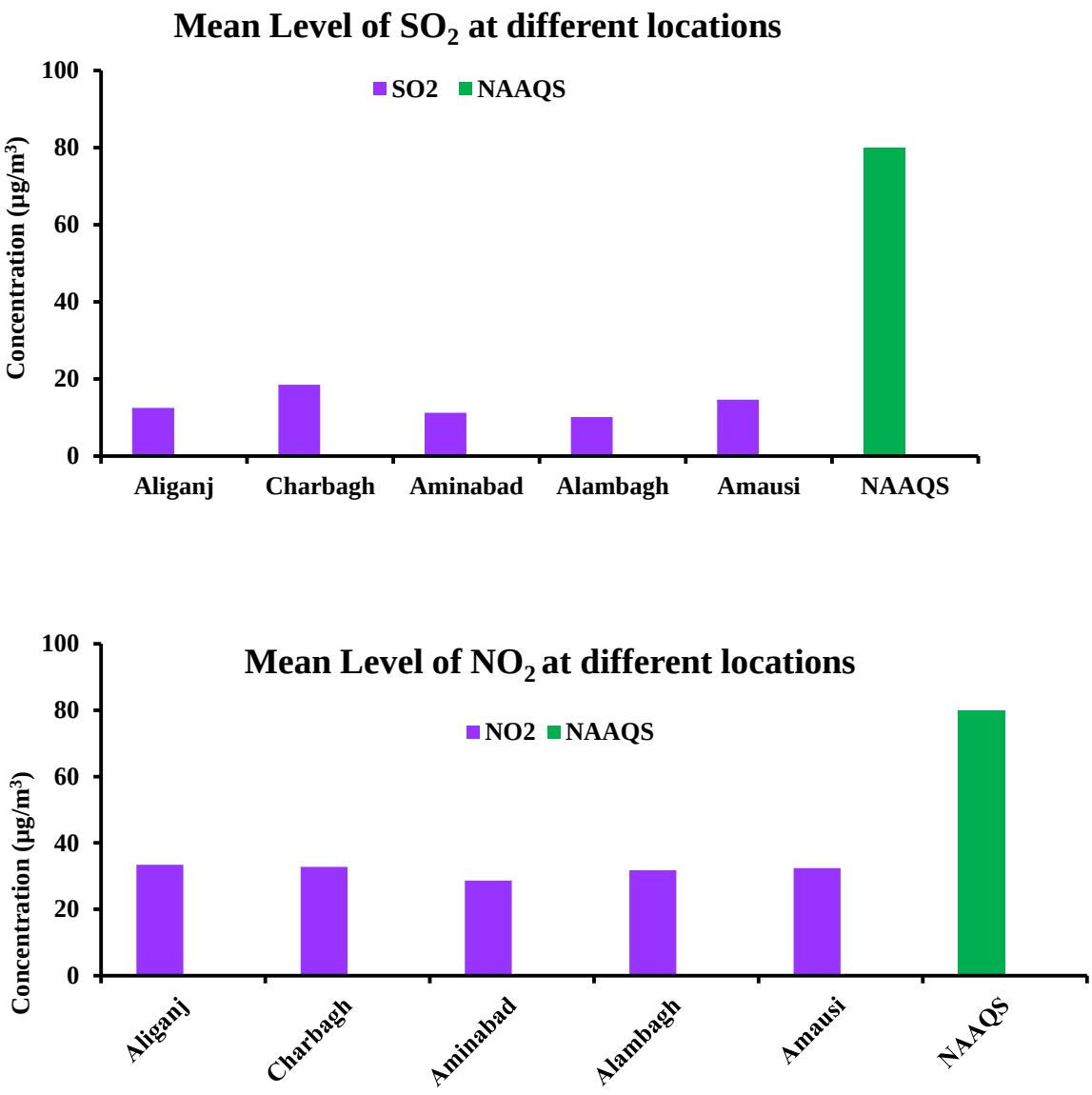


Figure 3: Concentration (µg/m^3) of SO_2 and NO_2 in different areas of Lucknow city during Pre-Monsoon season (2021) compared with prescribed National Ambient Air Quality Standard (NAAQS)

1.3.5 Noise Level

The noise monitoring data recorded during the Pre-Monson period (May, 2021) is presented in Table 10. In residential areas, the day and night time noise levels were recorded between 67.0 to 70.7 and 55.4 to 60.0 dB(A) respectively. All the values were higher than the prescribed limits of 55 and 45 dB (A) for day and night time respectively.

In commercial and traffic area, the day and night time noise levels were recorded between 67.2 to 79.0 and 52.3 to 61.3 dB(A) respectively. Noise level at all the commercial sites during day time were above the prescribed limits of 65 dB (A). However night time noise was below prescribed standard of 55 dB (A) at two locations and above the standard at two other locations respectively. In industrial area Amausi, the day and night time noise levels were recorded 73.6 and 60.1 dB(A) respectively. Noise levels at industrial area were recorded lower than the prescribed limits of 75.0 and 70.0 dB(A) respectively.

Table 10
Noise Level dB(A) during Day and Night Time

S. No.	Area	Location	Noise level dB(A) 2021		Noise level dB(A) 2020	
			Day	Night	Day	Night
1	**Residential**	Aliganj	67.6	58.1	62	44.5
		Vikas Nagar	70.5	60.0	58.6	45.8
		Indira Nagar	67.0	55.4	60.2	42.7
		Gomti Nagar	70.7	56.9	54.4	NA
		Standard	**55**	**45**	**55**	**45**
2	**Commercial**	Charbagh	72.2	61.3	68.3	47.8
		Alambagh	67.2	52.3	60.1	NA
		Aminabad	71.6	53.1	NA	NA
		Chowk	79.0	57.4	NA	NA
		Standard	**65**	**55**	**65**	**55**
3	**Industrial**	Amausi	73.6	60.1	70.2	NA
		Standard	**75**	**70**	**75**	**70**

1.4 TRENDS OF AMBIENT AIR QUALITY IN LUCKNOW CITY

The observed PM_{10}, $PM_{2.5}$, SO_2 and NO_2 for 5 years Pre-Monsoon data have been compared to find out the prevailing trend of air pollution in Lucknow city (Figures 4-7). A slight change in the values may be attributed to some local environmental and climatic factors and Lockdown restrictions imposed by the Government.

1.4.1 Respirable Suspended Particulate Matter (RSPM or PM_{10})

The level of PM_{10} at all the residential, commercial and industrial areas were relatively higher as compared to monitoring data of previous year. All the values of the present study were found to be higher than the NAAQS (Figure 4).

1.4.2 Fine Particulate Matter ($PM_{2.5}$)

The level of $PM_{2.5}$ has been compared with last four year data and all the values of residential, commercial and industrial areas were higher than the previous year. All the values of the present study were found to be higher than the NAAQS (Figure 5).

Overall Trend of PM_{10} and $PM_{2.5}$

Figure 4 and 5 indicate that the PM_{10} concentration is in decreasing trend from 2017 to 2020 in the ambient air of Lucknow city which means that earlier city's air pollution level was more than that of today. This decreasing trend may be due to partial/ complete lockdown during 2020 and 2021 which may be attributed to lowered vehicular density on road, less consumption of petrol/ diesel fuel and complete/ partial closure of industrial establishments during lockdown periods.

Besides, there were significant improvements in traffic management like installation of traffic signals, widening and making paved/ concrete road, sweeping of road dust, avoidance of trash burning and proper disposal of municipal solid waste. Overall traffic management has improved tremendously leading to fewer traffic jams and hence improved ambient air quality.

1.4.3 Sulphur dioxide (SO_2)

The level of SO_2 during Pre-Monsoon since 2017 is presented in Figure 5 for all the locations. In residential, commercial and industrial areas, higher concentrations of SO_2 were found at all locations compared to that of the previous year. All the values of the present study were found to be lower than the NAAQS (Figure 6).

1.4.4 Oxides of Nitrogen (NO_2)

The level of NO_2 during Pre-Monsoon since 2017 is presented in Figure 5 for all the locations. All monitored locations showed increasing trend of nitrogen dioxide when compared to last year values. All the values of the present study were found to be lower than the NAAQS (Figure 7).

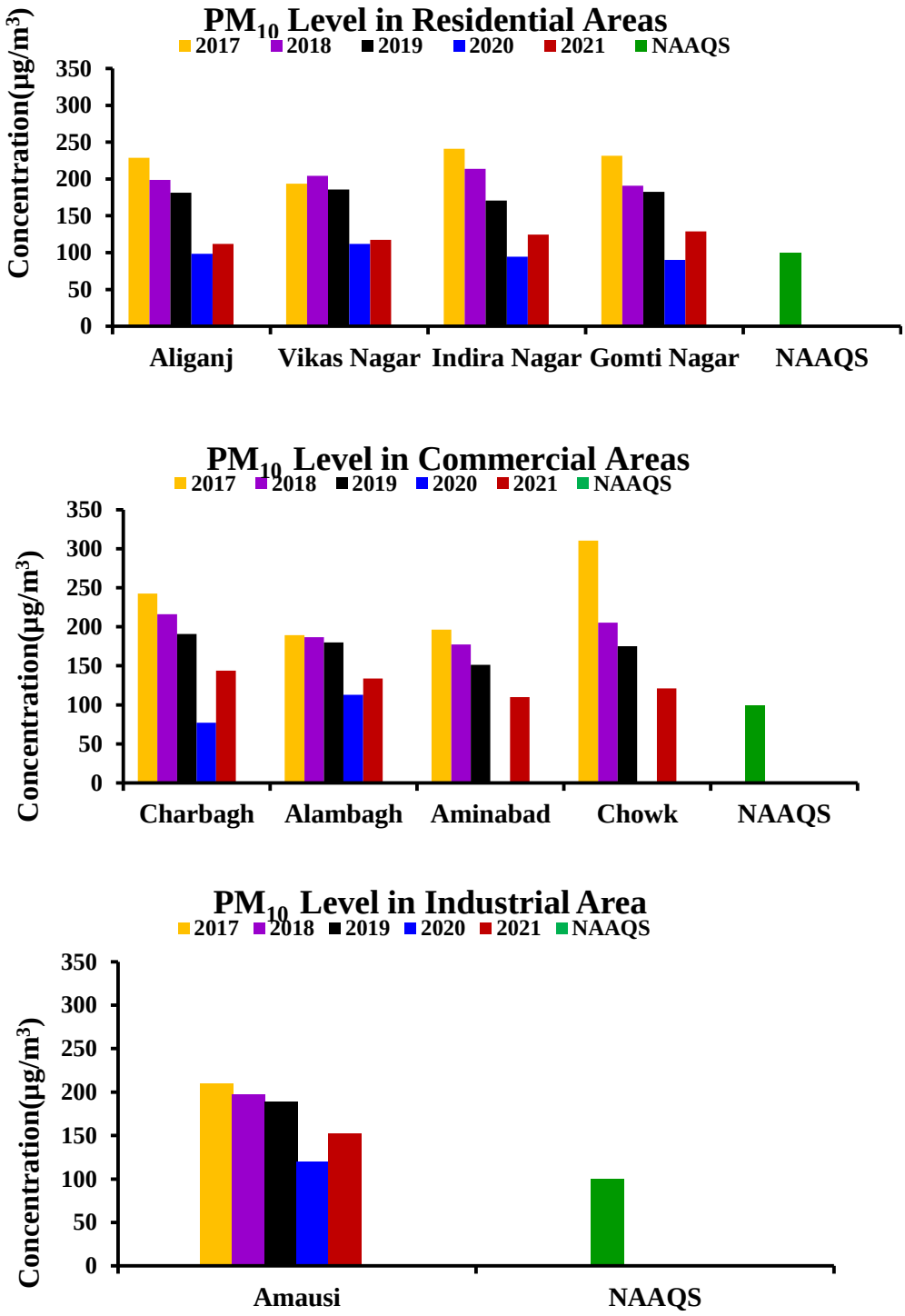


Figure 4: Concentration (µg/m^3) of PM_{10} **(**RSPM**)** in Residential, Commercial and Industrial areas of Lucknow city during 2017 to 2021 (Pre-Monsoon) and compared with prescribed National Ambient Air Quality Standard (NAAQS)

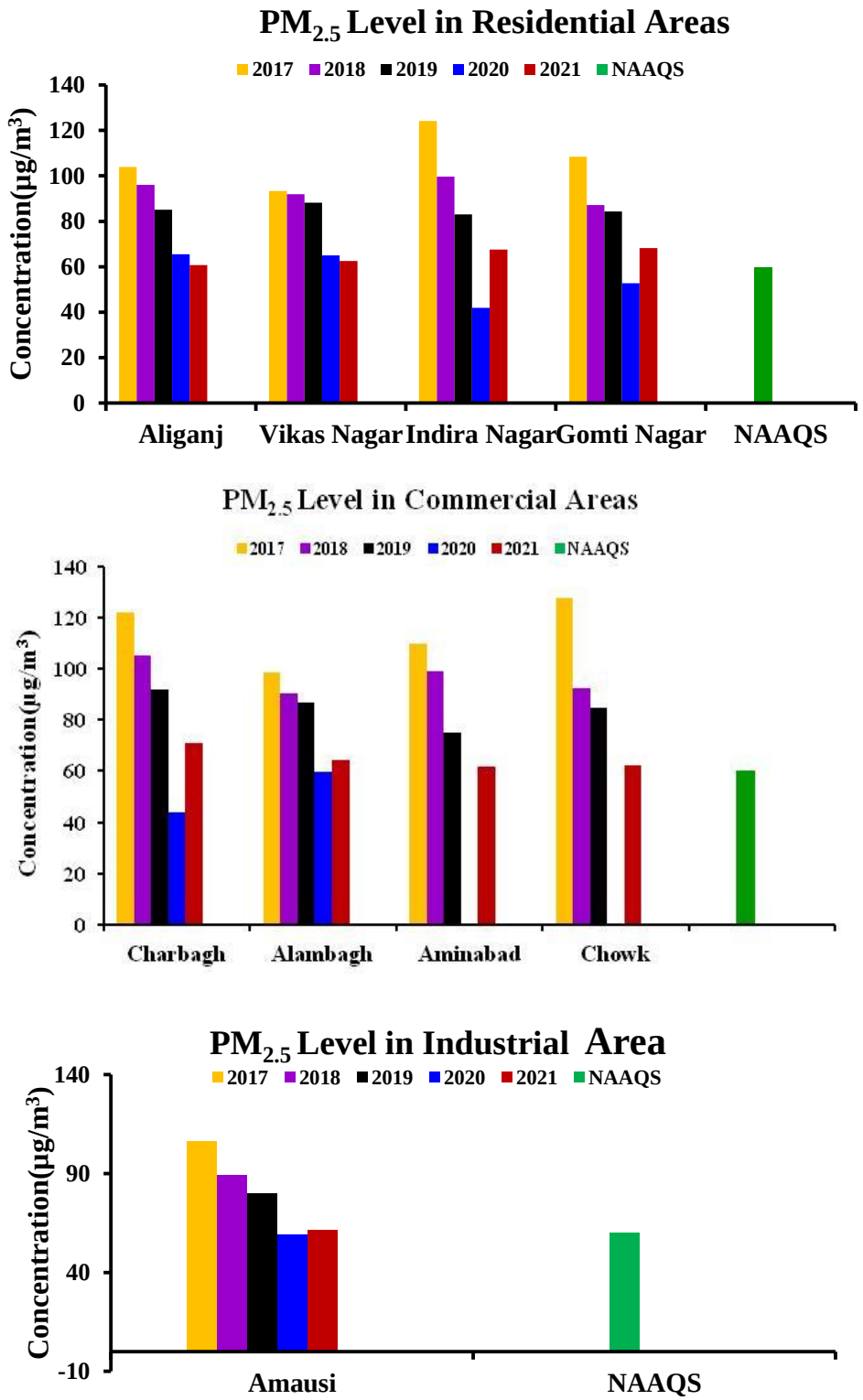


Figure 5: Concentration (µg/m^3) of $PM_{2.5}$ in Residential, Commercial and Industrial areas of Lucknow city during 2017 to 2021 (Pre-Monsoon) and compared with prescribed National Ambient Air Quality Standard (NAAQS)

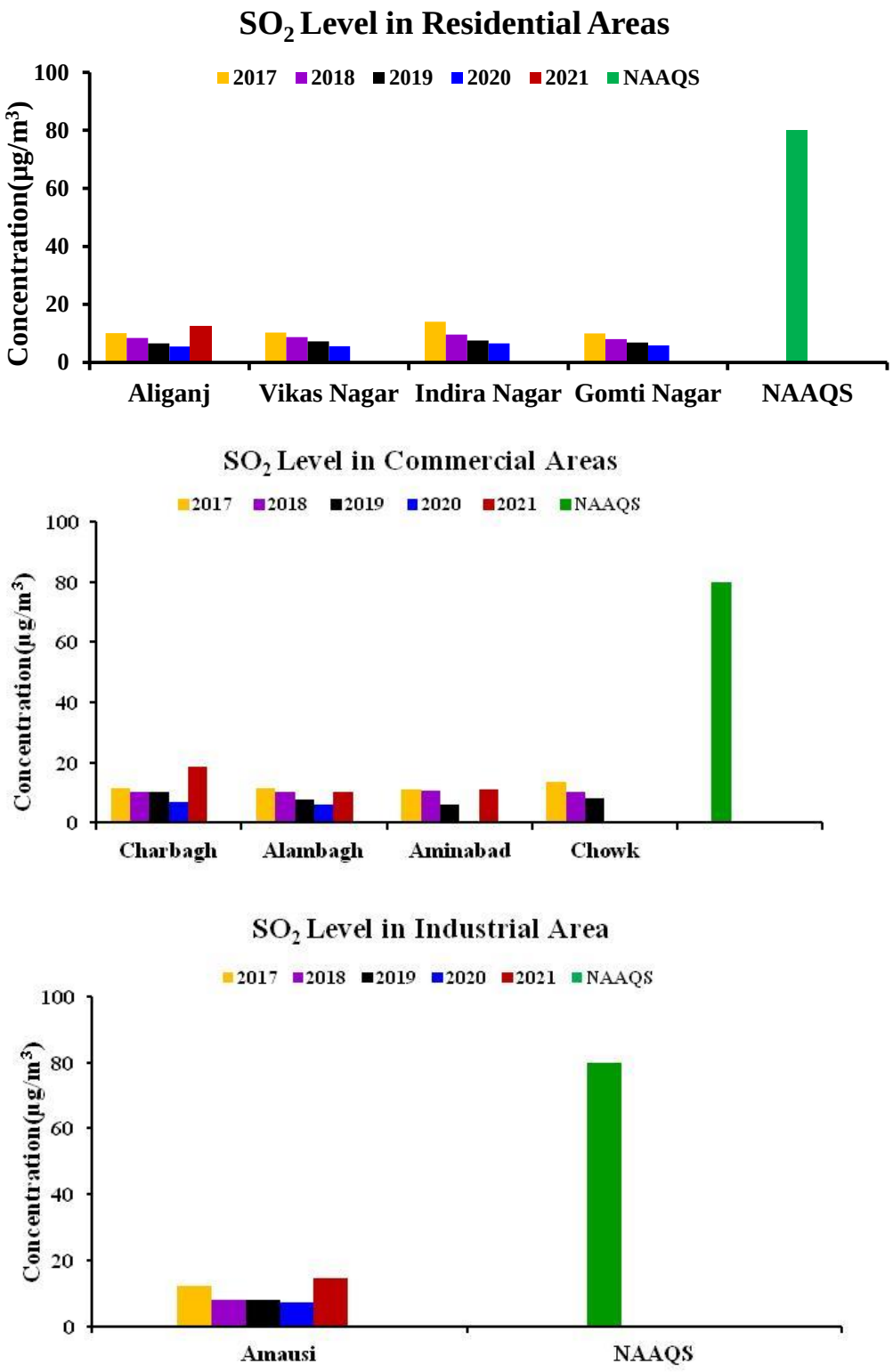


Figure 6: Concentration (µg/m^3) of SO_2 in Residential, Commercial and Industrial areas of Lucknow city during 2017 to 2021 (Pre-Monsoon) and compared with prescribed National Ambient Air Quality Standard (NAAQS)

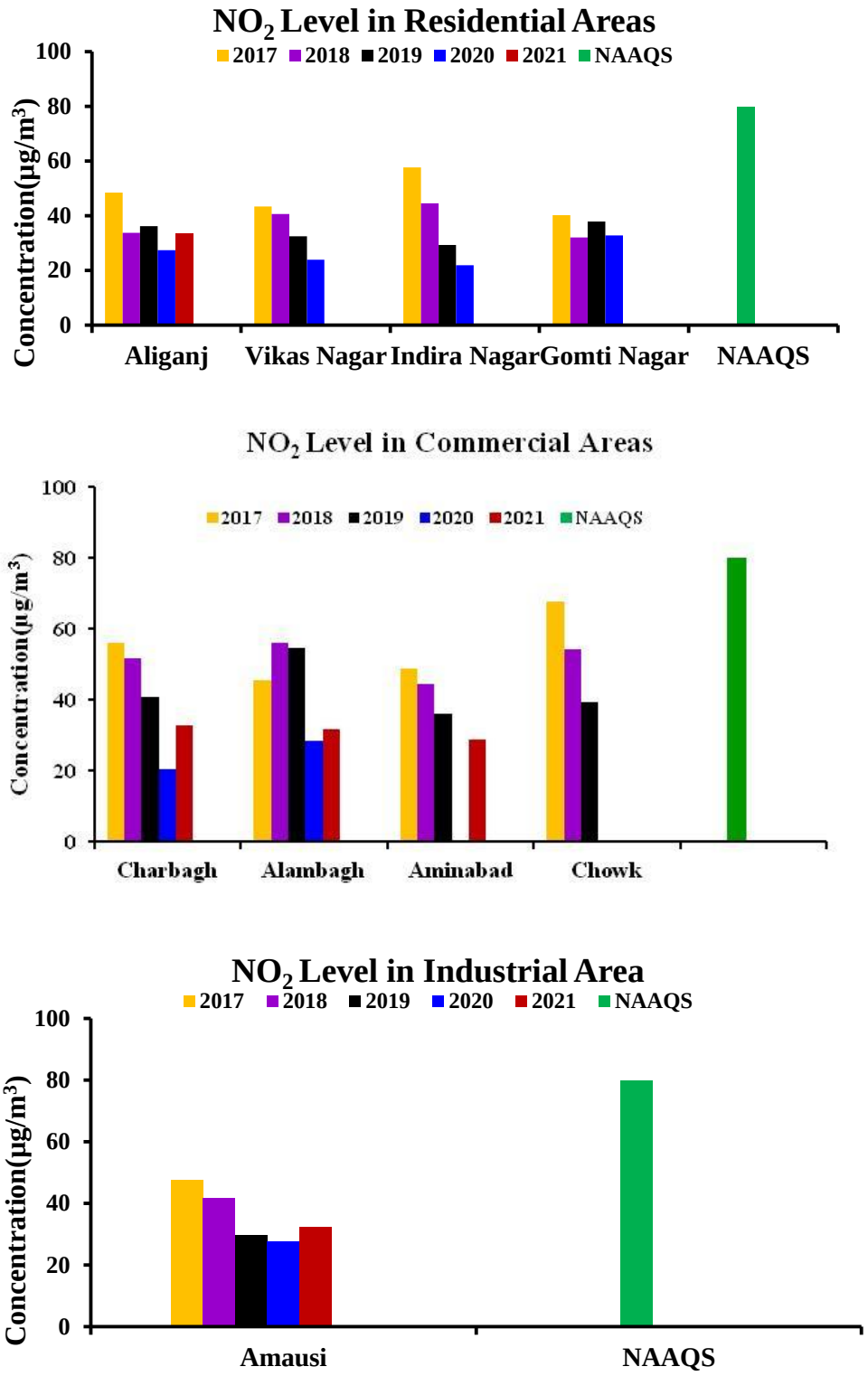


Figure 7: Concentration (µg/m^3) of NO_2 in Residential, Commercial and Industrial areas of Lucknow city during 2017 to 2021 (Pre-Monsoon) and compared with prescribed National Ambient Air Quality Standard (NAAQS)

1.4.5 Noise Level

Current year's Pre-Monsoon noise data was compared with the corresponding data of the previous four years (2017 to 2021) and presented in Figure 8 and 9. The comparative noise levels in residential, commercial and industrial areas are described below:

1.4.5.1 Day time Noise Level

All residential, commercial cum traffic and industrial areas showed slightly increasing trend over that of the previous year. The comparative data are presented in Figure 8.

1.4.5.2 Night time Noise Level

All residential, commercial cum traffic and industrial areas showed slightly increasing trend over that of the previous year. The comparative data are presented in Figure 9.

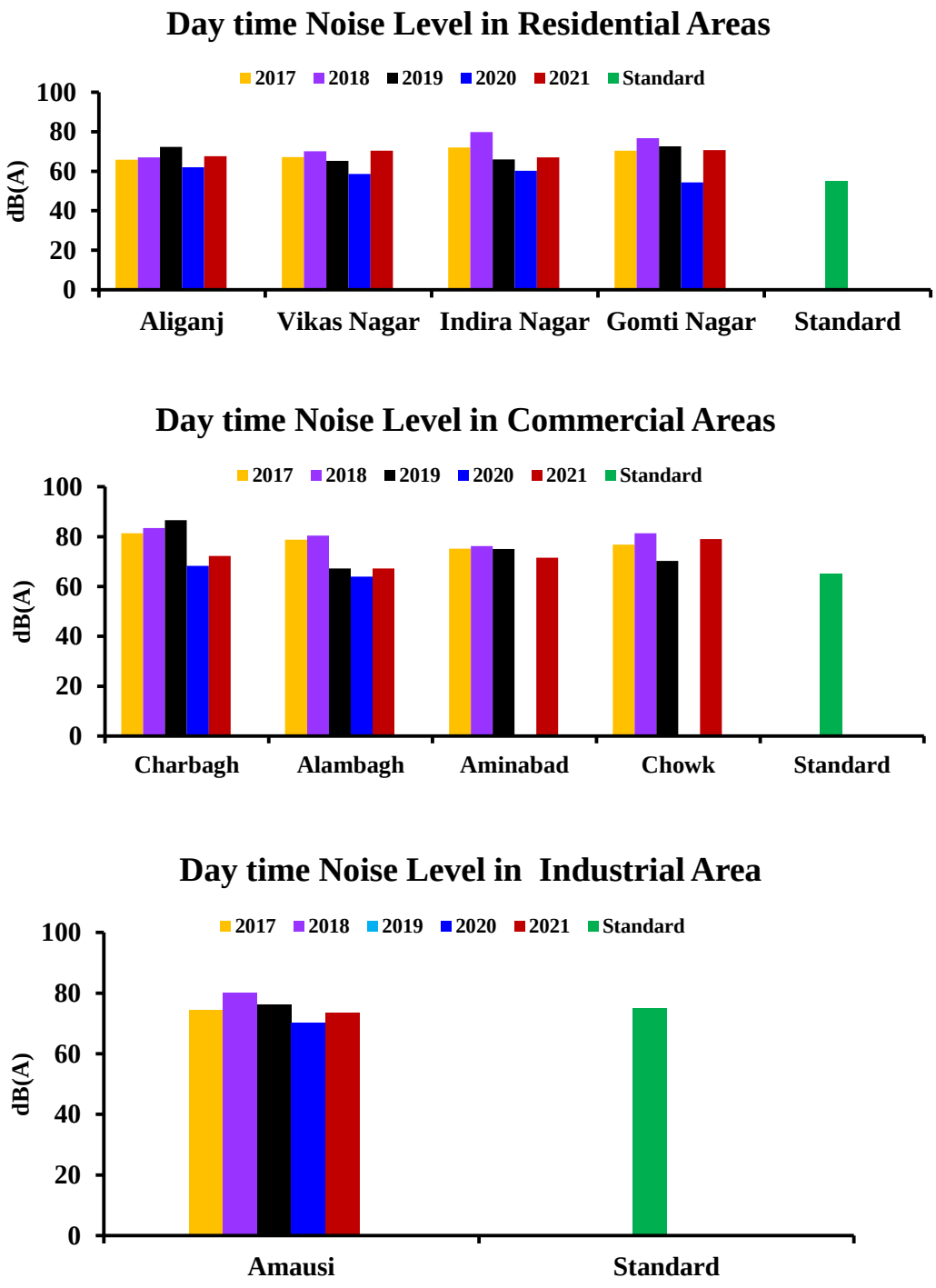
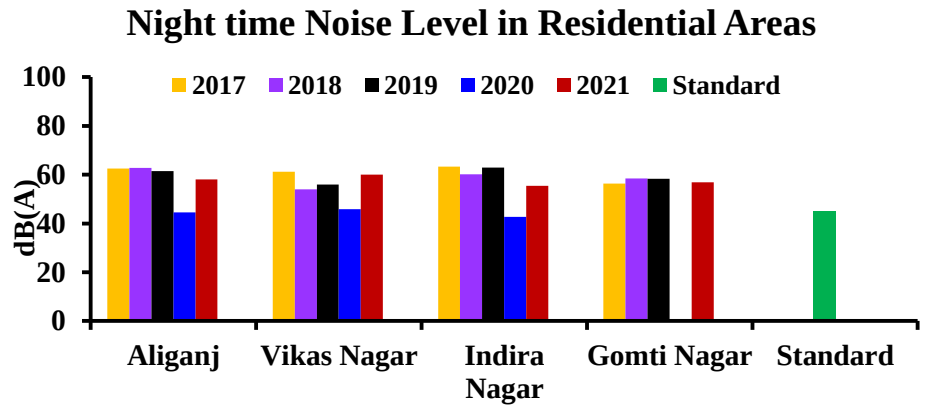
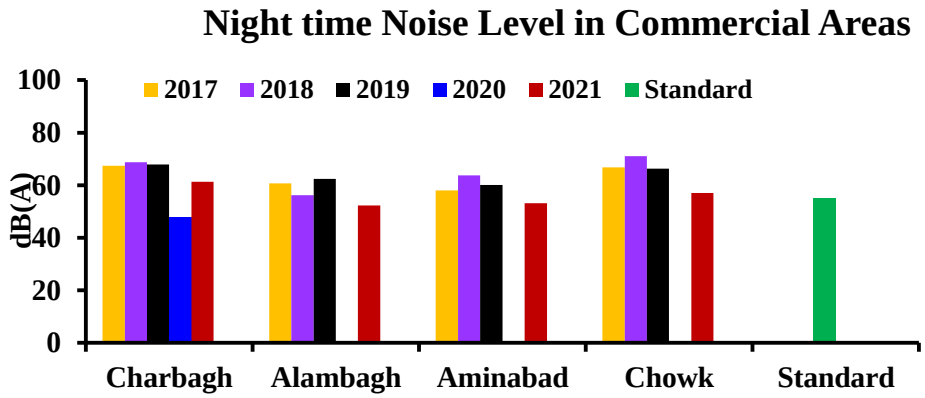


Figure 8: Comparison of day time Noise Level dB(A) in different areas of Lucknow city (Pre-Monsoon 2017-2021)





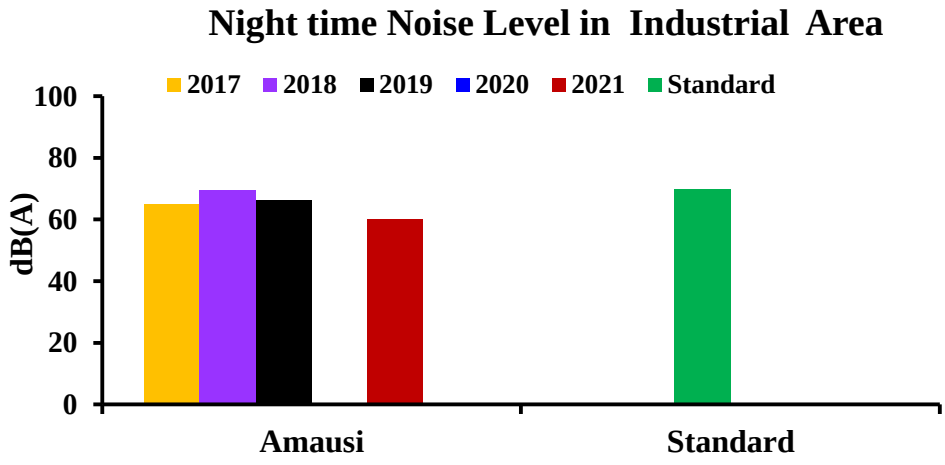


Figure 9: Comparison of night time Noise Level dB(A) in different areas of Lucknow city (Pre-Monsoon 2017-2021)

1.5 CONCLUSIONS

CSIR-IITR has monitored air pollutants such as PM_{10}, $PM_{2.5}$, SO_2, NO_2 at 9 locations for the assessment of ambient air quality during the month of April-May 2021. Besides, day and night time noise levels were also monitored at the same locations. The main findings of the study are as follows:

- The mean levels of PM_{10} (127.1 µg/m^3) and $PM_{2.5}$ (64.5 µg/m^3) at all the monitoring locations of residential, commercial and industrial areas were higher than their respective NAAQS of 100 µg/m^3 for PM_{10} and 60 µg/m^3 for $PM_{2.5}$.

- The Pre-Monsoon, 2021 PM_{10} concentration has increased by 26.10 % w.r.t. Pre-Monsoon 2020 (lockdown) while the $PM_{2.5}$ concentration has increased by 16.57% as compared to Pre-Monsoon 2020.

- The concentration of gaseous pollutants, SO_2 and NO_2 were well below the prescribed NAAQS (80 µg/m^3) at all the locations but Pre-Monsoon 2021 gaseous pollutant concentrations were higher at all locations w.r.t. Pre-Monsoon 2020 (lockdown). The average values of SO_2 and NO_2 has increased by 113.90 % and 23.13 %.

- The day and night time noise levels at residential and commercial areas have exceeded about 17.2 %, 12.92% during day times and 29.94%, 17.19% during night times respectively in comparison with the prescribed standards (55 dB(A) for day and 45 dB(A) for night times). However, the noise levels of Pre-Monsoon 2021 were found increased marginally at all the locations w.r.t. Pre-Monsoon 2020 (lockdown).

- Overall results indicate that all the parameters monitored showed slightly increasing trend compared to previous year which may be attributed to relaxation in Lockdown restrictions from full curfew to partial curfew format from 2020 to 2021. District administration / Lucknow authority has taken many control measures to minimize air pollution which helped to improve air quality of the city.

- Higher levels of air pollutants and their effects on human health is a serious issue. To resolve the issue, a comprehensive study is required in respect of present status of different pollutants and their trends, sources of pollutants, public health risk assessment for future planning on more safer urban areas.

- Regulatory authorities, national institutes, academicians and NGOs should take this issue seriously with authentic research, formation of viable rules and their proper implementation as well as mass awareness amongst public.

1.6 RECOMMENDATIONS FOR MITIGATION OF AIR POLLUTION

A. Reduction of Vehicle Emission

1. Dense foliage is required along roadsides, especially air pollution tolerant/ resistant ornamental plants to quench environmental pollutants. These plants will also enhance the scenic beauty along the roads and overall city land spaces.
2. Synchronize consecutive traffic signals to facilitate smooth traffic flow and thus prevent frequent traffic bottlenecks at signals.
3. Maintaining and retrofitting of particulate matter filter in vehicles, enforcement of BS-VI standards, phase out older vehicles and encourage timely improvement in vehicle standards.
4. Encourage car pooling and public transport for daily commute.

B. Use Energy Efficient Gadgets/ Equipment's and Techniques

5. Energy efficient policies to be introduced beyond the industries, to include households, domestic sanitation and local transport sectors.
6. Effective particulate pollution reduction equipment such as bag filter/ scrubbers/ ESPs are to be installed in all factories and industries located in city area.
7. Switch to greener air conditioning so as to reduce the greenhouse gas emissions.
8. Conserve the energy at home, at work place and everywhere.

C. Reduce Fugitive Emission

9. Use energy efficient equipment to reduce carbon emissions in a wide range of sectors such as transport, manufacturing, production, agriculture etc.
10. Install proper HDPE construction nets/ meshes at construction and demolition sites to prevent and restrict fugitive dust particles generated at the project site from mixing with ambient air.
11. Avoid burning of crop residues in the field which could be managed by using in-situ technologies such as crop diversification.
12. Avoid trash burning and other material. Prevent and minimize open air burning of plastic/ garbage.

D. Other Measures

13. Need to improve the policy of transport sector as to minimize/ avoid frequent digging/ cutting road and construction activities.
14. Loudspeakers with high decibels should be discouraged through legal/ administrative measures.
15. Increase numbers of electric vehicles and charging stations to encourage their use

ACKNOWLEDGEMENT

We, (CSIR-IITR, Lucknow) express our sincere thanks and gratitude to those who provided required data with respect to vehicular population, transport, fuel consumption (Petrol/Diesel/CNG/LPG/Green Gas). Their Names and Designation are mentioned below:

Mr. R P Dwivedi, RTO, **Mr. Akhilesh Kumar Dwivedi ARTO** (Administration), **Mr. Sanjai Tiwari ARTO** (Enforcement), **Mr. P.V. Shukla** (DBA) Lucknow,
Mr. Vinod Kumar, Assistant Regional Manager, City Transport Services Ltd. Gomtinagar, Lucknow,
Mr. Manoj Sharma, Assistant Regional Manager, **Mr. Amir Najir Station Incharge,** City Transport Services Ltd, Dubagga Depot, Lucknow,
Mr. Mukesh Bharadwaj, Sr. Manager, Retail Sales, IOC, Lucknow,
Mr. Pravir Muttu, Chief Manager, Business Planning (Retails), U.P., BPCL **Mr. Shantanu Singh, Sales Office**r, BPCL, Lucknow
Mr. Sanjai Srivastava, Dy. Gen. Manager, HPCL, Lucknow, **Mr. Ashutosh, Manager** (RE & Analytic), HPCL, Lucknow
Mr. Sharat Kumar, Director Commercial, Green Gas Ltd, Lucknow and **Mr. Surya Prakash Gupta, Chief Manager** (Marketing), Green Gas Ltd, Lucknow.

We also express our sincere thanks and gratitude to those who provided necessary facilities and support to our field team at different monitoring localities.

सीएसआईआर-भारतीय विषविज्ञान अनुसंधान संस्थान
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- Nanomaterial Toxicology
- Systems Toxicology & Health Risk Assessment
- Computational Toxicology

R&D Partnership for Industries & Startup

- Centre for Innovation and Translational Research (CITAR)

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 Adulterant Butter Yellow in Edible Oils

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- 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)

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