ASSESSMENT OF ENVIRONMENTAL STATUS OF LUCKNOW CITY

(Post -Monsoon)

FINDINGS OF A RANDOM SURVEY for 43rd IITR FOUNDATION DAY

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Select Features of Lucknow city at a Glance

❖ **Geographical Position**	:	26^{o} 52' N Latitude 80^{o} 56' E Longitude 128 m above Sea Level
❖ **Area**	:	310 sq. km.
❖ **Population**	:	22.45 lakhs as per 2001 Census
❖ **Projected Population**	:	45 lakhs as per *Master Plan 2021*
❖ **Climate**	:	Subtropical climate, cool dry winter (Dec. - Feb.) & summer (Mar - Jun.). Temperature about 45^{0}C in summer to 3^{0}C in winter. Average annual rainfall about 100 cm.
❖ **Total Vehicle Population In the Lucknow city as on 31/03/2008**	:	9,68,915
❖ **Growth of Vehicle over 2007-2008**	:	7.08%
❖ **Road Transportation**	:	Two Wheelers (79.66%) Three Wheelers (1.36%) Car (12.00%) Bus (0.45%)
❖ **Total Number of Petrol Pumps**	:	89
❖ **Consumption of Petrol**	:	90,187 KL
❖ **Consumption of Diesel**	:	83,618 KL
❖ **Major Source of Pollution**	:	Automobiles, D. G. sets, Civil Constructions
❖ **Parameters Monitored**	:	SPM, RSPM, SO_2, NO_X and Noise
❖ **Pollution Level**	:	SPM & RSPM levels are above and SO_2 & NO_x are below the national standards
❖ **Study Conducted by**	:	Environmental Monitoring Section IITR, Lucknow

1.1 INTRODUCTION

Urban atmospheric pollution is amongst the major problems of environmental health. Distinct link between air pollutants and many types of health problems including those of respiratory, cardiovascular, immunological, hematological, neurological and reproductive/developmental systems has been demonstrated (Curtis et al. 2006; Maitre et al. 2006; CPCB 2008). Health of people of urban area is a major concern especially in developing countries, because they are exposed to high level of air pollutants due to vehicular pollution.

It is a well established fact that the vehicular pollution is responsible for the higher level of air pollutants like Suspended Particulate matter (SPM), Sulphur dioxide (SO_2) and Oxides of nitrogen (NOx), Carbon monoxide (CO) and other organic and inorganic pollutants including metals(Caselles et al. 2001; Kaushik et al. 2006; Maitre et al. 2006; Curtis et al. 2006; Sharma et al. 2006; Jayaraman 2007; Bono et al. 2007). Technological upgradation and scientific knowhow has reduced the pollution, especially the gaseous pollutants but increase in number of vehicles causes more emission of pollutants and also changes the composition ratio of the pollutants especially the particulate matter which includes the fine and ultrafine particles (Zanini et al. 2006) . Vehicular exhaust is one of the most important sources of fine particles. In urban area the major source of air pollutants are wood combustion, diesel and gasoline powered exhaust and road dust. Besides that, various types of vehicles and their different operating modes such as idling, stop and start flow of vehicles, accelerating and decelerating, combined with a high density of vehicles lead to a pollution source problem (Kumar et al. 2001) and many trace metals are present in leaded and unleaded petrol, diesel oil, antiwear substances which added to lubricants, brake pads and tyres and are emitted by vehicles exhaust pipe (Monacci and Bargagli 1997).

The effect of these pollutants depends mainly on the concentration, composition and the receptor especially for the gaseous pollutants but in case of particulate matter (PM) which besides concentration and composition, also depends on size, shape and number. Over all the concentration of pollutants depends on the meteorological properties of the atmosphere, topographical influence, emission sources. Besides these pollutants, plying of vehicles on the road is also responsible for higher level of noise which may cause adverse health problem.

There are a number of countries and organizations which have developed standards/permissible limits for concentration of common pollutants (SPM, RSPM, SO_2, NOx CO, Pb etc). It has also been reported that concentration of these pollutants exceeds these limits in many part of the world especially in large cities of developing countries. The adverse health effects have been documented at levels well below standards. Generally, these standards ignore the synergistic effects of combination of toxic air pollutants.

In view of above facts, it is need of the hour to have a look at our city Lucknow the capital of Uttar Pradesh with a population of 22,45,509 (Municipal corporation + Cantonment) as per 2001 census and an area of 310 sq. km.

Vehicular traffic is the main source of air pollution in Lucknow city and earlier reported by us higher level of SPM, RSPM (Kisku et al. 2003; Sharma et al. 2006) and fine particles ($PM_{2.5}$)(Barman et al. 2008). Continuous emission of pollutants from vehicular traffic is a matter of concern because of adverse effects on ambient air quality as well as on the health of human beings. The number of vehicles registered with RTO (Regional Transport Office) Lucknow is 9,68,915 as on 31.03.2008 which is 7.08% higher than previous year (Table 1). The details of vehicles plying as public transport on different routes in Lucknow are shown in Table 2.

Table 1: Registered Vehicles with R.T.O. Lucknow during 2006 - 07 and 2007- 08

Sl. No.	Type of Vehicle	Number of Registered Vehicles On 31st March		% Change
		2007	2008	
1	Multi Axial	1365	1611	48.85
2	Light, Medium and Heavy weight Vehicles (Four wheeler)	8232	11193	35.97
3	Light commercial vehicles(Three wheeler)	3362	3526	6.36
4	Light commercial Vehicles (Four wheeler)	6217	6738	8.38
5	Buses	4198	4364	3.95
6	Taxi	8012	7474	-6.71
7	Three Wheelers and Auto Rickshaw	15154	13224	-12.74
8	Two wheelers	720378	771846	7.14
9	Car	105674	116285	9.99
10	Jeep	13000	13705	5.144
11	Tractor	13923	14582	4.73
12	Trailers	1062	1082	1.88
13	Others	4254	3285	32.97
Total		904831	968915	7.08

Source: RTO, Lucknow

Table 2: Status of Public Transport Available on Different Routes (31.03.08)

Sl. No.	Type of vehicles		Number
1	Buses (LMPS)	Total	43
		CNG Bus	43
2	Tempo/Taxi	Total	2116
		Diesel	214
		CNG	1902
3	Auto Rickshaw	Total	3377
		Diesel	353
		CNG	3024

Source: RTO, Lucknow

Uttar Pradesh State Road Transport Corporation (UPSRTC) introduced bus services under the banner “Lucknow Mahanagar Parivahan Sewa” on different routes of Lucknow city. The details of bus routes and number of buses plying as on 31.03.2008 are given in Table 3.

Table 3: Details of Lucknow city bus service

Sl. No.	Route No.	To and Fro	No. of Buses
1	11	Chinhat-Gomti Nagar-Alambagh	18
	11 A	Chinhat-Gomtinagar-Dalibagh-Charbagh	02
	11B	Chinhat-Gomtinagar-Charbagh-SGPGI	02
	11C	Charbagh-Uttaria-Sardar Patel Dental college	01
	11D	Charbagh-Babasaheb Bhimrao Ambedkar -BB	01
	11E	Charbagh-Telibagh-Ganesh Kunj	01
2	12	Chinhat-Scooter India	10
3	23	Rajinikhand-Gudamba thana	13
4	24	Charbagh - Engineering College	13
5	25	Charbagh-Bijnor	02
6	31	Alambagh – IIM	02
7	33	Alambagh- Engineering College	15
8	34	Alambagh-Charbagh-Hazratganj-Kapoorthala-Keshavnagar	01
9	44	Charbagh-Andhi Chowki	09
10	45	Parag Dairy – Polytechnic Chowraha	10
11	66	GPO- Hazratganj-Rajajipuram	02
12	Shuttle service	Charbagh-Alambagh	03
		Total	105

Source: UPSRTC, Lucknow

In Lucknow city there are 89 petrol pumps operated by four oil companies. The break-up of these petrol pumps are given in Table 4. As per Indian Oil Corporation (IOC), the consumption/sale of diesel and petrol was 83,618 and 90,187 KL as on 31-03-2008. It is observed that petroleum sale has increased marginally by 3.39% whereas sale of diesel has increased by 6.26%. (Table 5).

Table 4: Petrol Pumps in Lucknow City

Sl. No.	Agency	Number of outlets 31st March 2008
1	Indian Oil Corporation. (IOC)	46
2	Bharat Petroleum Corporation Ltd. (BPCL)	18
3	Hindustan Petroleum Corporation Ltd. (HPCL)	22
4	Compressed Natural Gas Stations.(CNG)	3
	Total	89

Source: Indian Oil Corporation (IOC), Lucknow

Table 5: Consumption of Fuel* in Lucknow

Sl. No.	Agency	Petrol (Unleaded)			High Speed Diesel		
		Apr., 06 to Mar., 07	Apr., 07 to Mar., 08	% Change	Apr., 06 to Mar., 07	Apr., 07 to Mar., 08	% Change
1	IOC	45506	49410	8.58	47335	52248	10.38
2	BPCL	26440	25524	-3.46	17199	16318	-5.12
3	HPCL	15283	15253	-0.20	14157	15052	6.32
Total		87229	90187	3.39	78691	83618	6.26

**KL (1 KL = 1000 litres). Source: Indian Oil Corporation (IOC), Lucknow*

Considering the above, assessment of ambient air quality of Lucknow city was carried out at 10 locations during September-October, 2008 with respect to SPM, RSPM, SO_2 and NO_x and Noise level. Monitoring of Environmental Status of Lucknow city with respect to air and noise is being conducted by IITR, since 1997 twice in a year (pre monsoon and post monsoon in the month of May and October respectively) to assess the environmental quality and its trends. The study was conducted with the following aims and objectives.

- ✓ *To assess the ambient air quality with respect to SPM, RSPM, SO_2 and NOx.*
- ✓ *To study trends of pollutants over a period of time.*
- ✓ *To assess day and night time noise to ensure compliance of permissible noise levels.*
- ✓ *To create a database for future use.*
- ✓ *To create public awareness about environmental pollution.*

1.2 MONITORING LOCATIONS AND METHODOLOGY

1.2.1 AIR QUALITY

Ten air quality monitoring locations (Table 6) representing different activities/areas i.e., four in residential, five in commercial cum traffic and one industrial area were selected for the study. Methodology for air quality measurements is summarized in Table 7.

Table 6: Air Quality Monitoring Locations

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

The brief description of each sampling site is given below:-

I. Aliganj

Earlier, Aliganj was a residential area, now it has become a semi commercial area. In this locality, the main source of air pollution is vehicular emission. Most of the people are using LPG gas for cooking. Aliganj has a traffic route from Engineering College to Power House LDA Colony Kanpur Road via Charbagh railway station. In this route means of mass public transportation is by jeep, city buses, three wheeler (Vikram and tempo) which are run on diesel and CNG. Monitoring location was at CSIR Scientist Apartments; sector K, near main road. The main vehicle was two wheeler, passenger car and maxi cab (Jeep).

II. Vikas Nagar

Like Aliganj, Vikas Nagar was earlier a purely residential area and now it has become a semi commercial area. On the main route public transport is by Vikram tempo, minibuses and buses. In Vikas Nagar, vehicular emission is mainly dominated by two wheelers, passenger cars and pubic transport. The monitoring location was at a residential area, which is about 500 metres away from the Vikas Nagar main road.

III. Indira Nagar

Indira Nagar is now a semi commercial area. In this area the means of public transport is by Jeep and buses running on diesel. In day time, main source of vehicular emission is public transport, two wheelers and passenger cars. The main Ring Road passing through Indira Nagar is carrying high volume of mixed vehicular traffic. During night time large volume of different capacity of commercial trucks pass though this route, generating high level of air and noise pollution. Monitoring was carried out 30 m away from the main Ring Road.

IV. Gomti Nagar

Gomti Nagar is a residential area, dominated by middle and upper class families, using LPG gas for cooking. Source of air pollution is public transport (tempo, jeep and mini buses), two wheelers and passenger cars. Night time traffic flow is low. The monitoring location was in Vinay Khand, near Jaipuria crossing about 25 metres away from the main road

V. Hussainganj

In Hussainganj, the monitoring location was 40 metres away from the main road. It is a purely commercial place and during day time traffic flow are city buses, jeeps, two wheelers and passenger cars. Night time commercial vehicles were the main source of pollution.

VI. Charbagh

The place is congested with roadside make shift shops/hawkers and having a high traffic flow. The major source of pollution is auto exhaust from mixed type of vehicles including buses and trucks during night hours. One of the important sources is diesel locomotive. It is one of the busiest places in Lucknow city. The monitoring location was near the main traffic junction.

VII. Alambagh

In Alambagh, monitoring location was 100 m away from the Alambagh crossing on the main Lucknow – Kanpur road. The main source of pollution is vehicular exhaust. In day time, source of pollution is from city as well as from inter city buses, tempos, two wheelers and passenger cars. In night time trucks and long distance buses are the main sources of pollution. Major source of pollution in the area is diesel engine driven vehicular traffic.

VIII. Aminabad

The monitoring location was situated in the central place of Aminabad. This is purely commercial area mainly consisting of shopping complexes. Aminabad serves as major shopping area for upper middle class and middle class families. The whole area is congested having narrow lanes and mixed traffic ranging from bicycles, rickshaws to two wheelers and passenger cars. Sampling site was located adjacent to the Jhandewala Park.

IX. Chowk

The monitoring location was 100 m away from the main road. Area is residential cum commercial. Source of pollution is mainly from tempo, two wheelers and passenger cars. During night time commercial vehicles pass through the main road.

X. Amausi

Amausi is an industrial area. There are a number of small-scale industries. In this area, main source of pollution is from vehicular as well as industrial. The monitoring location was about 300 metres away from the main Lucknow - Kanpur road.

Table 7: Methodology for Air Quality Monitoring

Particulars	SPM	RSPM	SO_2	NOx
Sampling equipment	HVS	RDS	HVS/RDS with gaseous sampling attachment	
Collection media	Glass Fibre		*TCM	NaOH
Flow rate	1.0-1.3 m^3/min		0.5 L/min	
Analytical method	Gravimetric		Spectrophotometry	
Frequency	24 hourly		8 hourly	
Sampling duration	Continuous for 24 hours			
No. of days of sampling at each location	6 days (Twice in a week)			

HVS: High Volume Sampler, RDS: Respirable Dust Sampler, *TCM: Tetra chloro-mercurate

1.2.2 NOISE LEVEL MEASUREMENTS

The measurement of noise level was carried out at twelve locations (Table 8) for 30 minutes at each location during the day time (6 AM to 10 PM) and night time (10 PM to 6 AM). All measurements were made with the “A” weighing filter at a height of receptor organ, i.e., ~1.5 metres above the ground level. The location for the noise level measurement is given in Table 8.

Table 8: Noise Monitoring Location

Sl. No.	Locations	Activity
1	Aliganj	Residential
2	Vikas Nagar	
3	Indira Nagar	
4	Gomti Nagar	
5	Hussainganj	Commercial cum traffic
6	Hazratganj	
7	Charbagh	
8	Alambagh	
9	Aminabad	
10	Chowk	
11	Amausi	Industrial
12	Talkatora	

1.3 RESULTS

1.3.1 AIR QUALITY

The detailed results of air quality monitoring are presented in Table 9 &10 and Fig. 1.

1.3.1.1 PARTICULATE MATTER (RSPM and SPM)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the average concentration of RSPM and SPM were in the range of 144.5 to 170.7 and 330.8 to 368.5 µg/m^3 respectively.

In commercial areas (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the average concentration of RSPM and SPM were in the range of 163.5 to 201.5 and 367.2 to 406.8 µg/m^3 respectively.

In industrial area (Amausi), the average concentration of RSPM and SPM were found to be 127.3 and 321.3 µg/m^3 respectively.

The details of SPM & RSPM levels are presented in Table 9 and average of SPM and RSPM in Table 10 and Fig. 1.

All the values of RSPM and SPM, except in Amausi under industrial area were above the prescribed National Ambient Air Quality Standards (NAAQS) 100 and 150 µg/m^3 for RSPM and 200, and 500 µg/m^3 for SPM in residential, rural and other area and 1ndustrial areas respectively.

1.3.1.2 SULPHUR DIOXIDE (SO_2)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the average concentrations of SO_2 were in the range of 22.2 to 30.1 µg/m^3.

In commercial area (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of SO_2 were in the range of 26.1 to 32.4 µg/m^3.

In industrial area (Amausi) the average concentrations of SO_2 was found to be 28.5 µg/m^3.

All the values are within the prescribed limit of the NAAQS of 80 µg/m^3 for residential, rural and other areas and 120 µg/m^3 for industrial area. The details of 8 hourly SO_2 levels at different locations are presented in Table 9 and average concentration of SO_2 in Table 10 and Fig. 1.

1.3.1.3 OXIDES OF NITROGEN (NO_x)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the average concentrations of NO_X were found in the range of 35.4 to 39.4 µg/m^3.

In commercial areas (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of NO_X were found in the range of 40.5 to 47.1 µg/m^3.

In industrial areas (Amausi) the average concentrations of NO_x was 38.5 µg/m^3.

All the values of NO_x were within the prescribed NAAQS of 80 for residential, rural and other areas and 120 µg/m^3 for industrial area. The details of 8 hourly NO_X levels at different locations are presented in Table 9 and average concentration in Table 10 and Fig. 1.

Table 9: Concnetration (µg/m^3) of SPM, RSPM, SO_2 and NOx

Location	Monitoring Date	SPM	RSPM		SO_2			NOx			
				A	B	C	Mean	A	B	C	Mean
Aliganj	30/09/08	358	162	10.9	16.3	16.3	14.5	28.8	41.5	37.4	35.9
	02/10/08	345	150	31.4	19.5	27.2	26.0	28.8	35.7	49.9	38.1
	08/10/08	356	156	16.7	18.9	25.3	20.3	30.6	23	18.5	24.0
	10/10/08	385	162	20	24.7	34	26.2	36.6	27.1	44.5	36.1
	17/10/08	292	130	15.4	19.5	28.6	21.2	43.9	44.5	55.9	48.1
	19/10/08	270	107	27.5	27.1	21.1	25.2	36.3	46.3	45.1	42.6
	Mean	334.3	144.5				22.2				37.5
Vikas Nagar	4/10/08/	298	135	22.3	27.4	25.6	25.1	38.8	40.1	33.8	37.6
	06/10/08	372	150	29.1	23.2	29	27.1	29.8	39	35.3	34.7
	13/10/08	355	185	25.2	19.5	23.6	22.8	27.7	29.8	43.2	33.6
	15/10/08	321	162	20.6	32.4	32.8	28.6	30.1	43.4	40	37.8
	21/10/08	318	157	26	22.4	25.8	24.7	26.4	40.9	37.7	35.0
	23/10/08	321	168	24.9	24.9	27.7	25.8	30.4	36.4	33.8	33.5
	Mean	330.8	159.5				25.7				35.4
Indira Nagar	24/09/08	339	168	36.6	35.9	23.4	32.0	35.1	45.6	42.8	41.2
	26/09/08	395	177	35	26.7	38.7	33.5	27.4	44.2	47.2	39.6
	02/10/08	398	183	27.8	35.7	27.4	30.3	25.5	36.3	40.1	34.0
	04/10/08	375	167	29.5	33.1	23.7	28.8	43.2	47.1	38.5	42.9
	10/10/08	301	141	24.1	32.5	29.9	28.8	38.3	43.8	43.8	42.0
	12/10/08	403	188	31.8	26.1	24.6	27.5	32.3	41.4	36	36.6
	Mean	368.5	170.7				30.1				39.4
Gomti Nagar	30/09/08	397	150	34.3	32.6	19.8	28.9	29.9	39.8	27.3	32.3
	01/10/08	339	146	26.5	25.7	25.9	26.0	38.8	41.8	31.8	37.5
	07/10/08	335	164	23.2	29.9	22.9	25.3	31.9	42.5	28.9	34.4
	09/10/08	350	142	26.3	26.7	24	25.7	34.8	42.7	37.3	38.3
	16/10/08	344	128	25.5	23	21.3	23.3	31.1	34.5	34.7	33.4
	19/10/08	373	178	21.9	28.7	23.8	24.8	33.4	37.9	24.5	31.9
	Mean	356.3	151.3				25.7				34.6
Huaasinganj	23/09/08	343	165	21.8	34	19..0	27.9	26.8	43.5	24.3	31.5
	26/09/08	366	185	29.3	26	22	25.8	37.4	42.5	36.7	38.9
	01/10/08	355	127	19.2	24.8	28.9	24.3	37.9	49.4	45.8	44.4
	03/10/08	344	153	25.3	28.5	32.8	28.9	40	41.5	37.7	39.7
	10/10/08	403	175	25.6	32.1	30.1	29.3	47.6	47.6	45.8	47.0
	13/10/08	400	176	33.5	32.4	23.8	29.8	35.2	45.4	49.3	43.3
	Mean	368.5	163.5				27.7				40.8

Monitoring twice in a week during September - October 2008. Contd…..

A = 06:00-14:00 hr., B = 14:00-22:00 hr, C = 22:00-06:00 hr

SPM & RSPM values given are mean of 24 hrs.

Table 9 [Contd..] : Concnetration (µg/m^3) of SPM, RSPM, SO_2 and NOx

Location	Monitoring Date	SPM	RSPM		SO_2			NOx			
				A	B	C	Mean	A	B	C	Mean
Charbagh	27/09/08	460	159	36.3	27.2	28.2	30.6	31.6	35.9	34.4	34.0
	29/09/08	415	180	30.2	27.2	25.6	27.7	36.8	38.7	40.6	38.7
	03/10/08	427	182	33	28.2	22.6	27.9	43.6	40.2	35.9	39.9
	05/10/08	370	161	23.1	29.4	36.1	29.5	39.4	44.8	44.1	42.8
	09/10/08	393	173	33	33	30.1	32.0	40.2	43.6	45.9	43.2
	12/10/08	376	176	29.2	27.3	26.2	27.6	41.6	47.2	44.8	44.5
	Avg	406.8	171.8				29.2				40.5
Alambagh	23/09/08	403	223	30.9	40.5	27.5	33.0	48.1	57.6	45.1	50.3
	25/09/08	360	194	43	32.2	30.5	35.2	49.3	41.2	35.4	42.0
	27/09/08	401	191	32	36.2	34.9	34.4	47.7	48.9	43.3	46.6
	01/10/08	360	175	32.9	30	28.8	30.6	46.8	52.9	47.2	49.0
	15/10/08	414	206	32.2	23.4	32.4	29.3	49.2	51.3	46.9	49.1
	18/10/08	462	220	32.7	32.8	30.8	32.1	48.6	50.6	38.2	45.8
	Avg	400.0	201.5				32.4				47.1
Aminabad	27/09/08	392	180	39.6	30.6	40.4	36.9	36.2	34.7	45.8	38.9
	29/09/08	398	195	36.4	34.4	34.8	35.2	44.4	45.4	39.4	43.1
	05/10/08	319	146	31.1	24.5	31.8	29.1	41	41.9	48.4	43.8
	07/10/08	363	165	19.9	28.8	33	27.2	39.4	41	43.6	41.3
	15/10/08	357	141	38.2	27	33.2	32.8	46.6	35.7	47.2	43.2
	17/10/08	374	159	33.7	30.3	26.4	30.1	44.5	48.1	42.9	45.2
	Avg	367.2	164.3				31.9				42.6
Chowk	25/09/08	386	188	18.7	25.7	18.2	20.9	28.5	31.4	38.9	32.9
	27/09/08	410	190	25.8	27.3	30.4	27.8	44.1	36.0	49.5	43.2
	03/10/08	438	177	28.6	23	22.6	24.7	45.3	42.1	48.2	45.2
	05/10/08	330	155	23.2	21.5	28.6	24.4	39.7	40.8	34.8	38.4
	11/10/08	387	161	34.4	24.3	24.3	27.7	49	41.4	38.5	43.0
	13/10/08	404	176	25.7	29.1	38	30.9	47	47.3	46.3	46.9
	Avg	392.5	174.5				26.1				41.6
Amausi	28/09/08	308	123	29.2	28.3	29.1	28.9	42.8	37.4	35	38.4
	30/09/08	281	114	24.3	32.1	24.6	27.0	40.4	48.9	37.6	42.3
	06/10/08	373	170	31.4	28.3	35.2	31.6	47.8	40.3	34.8	41.0
	08/10/08	321	130	32.3	27.0	34.7	31.3	42.4	39.1	32.3	37.9
	15/10/08	322	114	25.3	26.8	24.8	25.6	37	38.3	31	35.4
	17/10/08	323	113	24.5	30.9	25.1	26.8	39	38.7	30.6	36.1
	Avg	321.3	127.3				28.5				38.5

Monitoring twice in a week during September - October 2008.

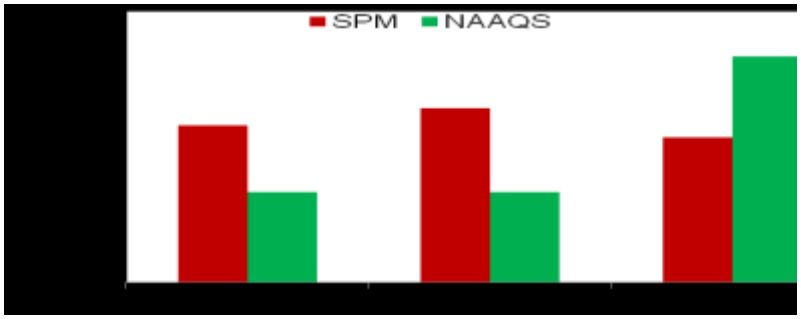
A = 06:00-14:00 hr., B = 14:00-22:00 hr, C = 22:00-06:00 hr

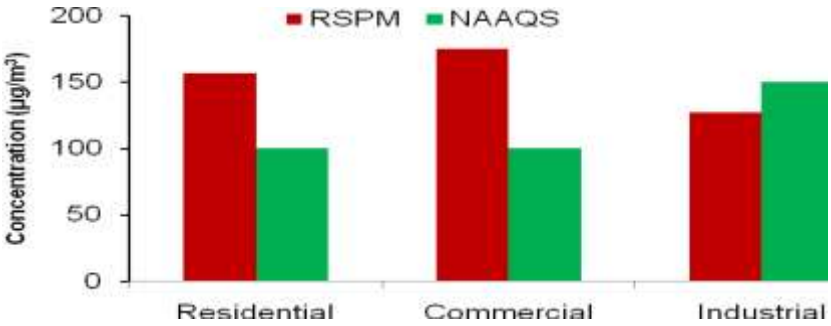
SPM & RSPM values given are mean of 24 hrs.

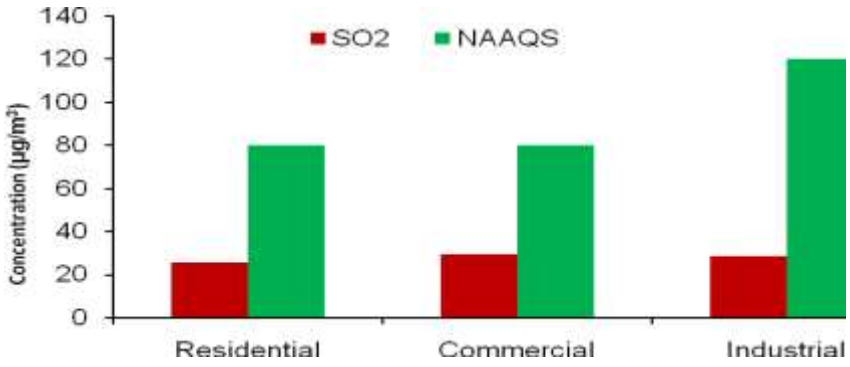
Table 10: Average Concentration (µg/m^3) of SPM, RSPM, SO_2 and NO_x

Area	Location	SPM	RSPM	SO_2	NOx
Residential	Aliganj	334.3	144.5	22.2	37.5
	Vikas nagar	330.8	159.5	25.7	35.4
	Indiranagar	368.5	170.7	30.1	39.4
	Gomti nagar	356.3	151.3	25.7	34.6
	Average	347.5	156.5	25.9	36.7
	NAAQS	**200**	**100**	**80**	**80**
Commercial	Hussainganj	368.5	163.5	27.7	40.8
	Charbagh	406.8	171.8	29.2	40.5
	Alambagh	400.0	201.5	32.4	47.1
	Aminabad	367.2	164.3	31.9	42.6
	Chowk	392.5	174.5	26.1	41.6
	Average	387.0	175.1	29.6	42.5
	NAAQS	**200**	**100**	**80**	**80**
Industrial	Amausi	321.3	127.3	28.5	38.5
	NAAQS	**500**	**150**	**120**	**120**

NAAQS=National Ambient Air Quality Standards







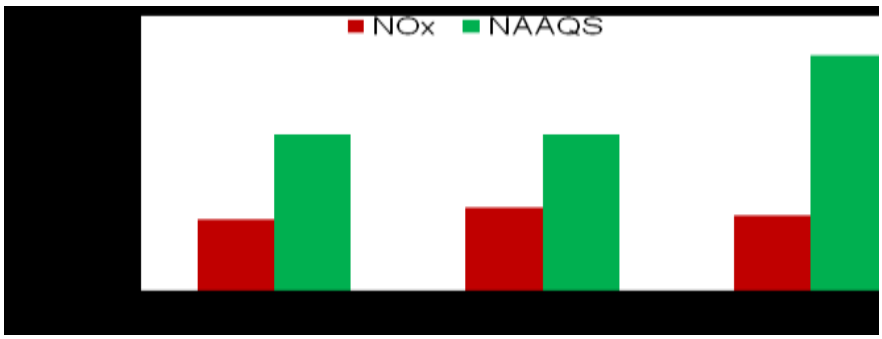


Fig. 1. Average concentration (µg/m^3) of SPM, RSPM, SO_2 and NO_x in different areas of Lucknow city during post monsoon season (2008) and compared with prescribed National Ambient Air Quality Standard (NAAQS).

1.3.2 SEASONAL VARIATION (PRE AND POST MONSOON, 2008) OF AIR POLLUTATS

The concentration of air pollutants (SPM, RSPM, SO_2 and NOx) at any given place depends on various factors like source, meteorological properties as well as the topographical influence. The meteorological properties like wind speed, wind direction, temperature, relative humidity, rainfall etc, also changes with season. A comparative data of pre and post monsoon, 2008 study of all the locations is presented in Fig. 2 and described below.

1.3.2.1 PARTICULATE MATTER (SPM)

All the locations of residential areas, the SPM level during post monsoon were found to be lower than the pre monsoon level, which were in the range of 0.4 to 10.8% with an average of 8.0% .

In commercial areas, during post monsoon the SPM level were found to be lower than the pre monsoon level at all the locations which were in the range of 5.5 to 13.3% with an average of 4.3% except one location, Alambagh which showed little higher value (0.2%).

In industrial area, the SPM level during post monsoon was found to be 18.9% lower than the pre monsoon.

1.3.2.2 RESPIRATBLE PARTICULATE MATTER (RSPM)

All the locations of residential areas, during post monsoon the RSPM level were found to be lower than the pre monsoon level, which were in the range of 7.0 to 23.3% with an average of 15.3% .

In Commercial areas, during post monsoon the RSPM level were found to be lower than the pre monsoon level at all the locations which were in the range of 5.1 to 24.4% with an average of 12.3% except one location, Alambagh which showed little higher (1.8%).

In industrial area, during post monsoon the RSPM level was found to be 23.8% lower than the pre monsoon.

1.3.2.3 SULPHUR DIOXIDE (SO_2)

All the locations of residential areas, during post monsoon the SO_2 level were

found to be higher than the pre monsoon level, which were in the range of 27.8 to 59.4% with an average of 21.7% except one location, Vikas Nagar which showed 14.9% lower concnetration.

Among the five commercial locations, during post monsoon the SO_2 level were found to be higher than the pre monsoon level at three locations, which were in the range of 23.6 to 53.3%. Whereas the rest two locations i.e. Hussainganj and Charbagh, SO2 levels were found to be 2.0 and 18.2% lower value respectively. Overall in commercial areas the mean SO_2 level was found to be 11.6% higher than the pre monsoon reason.

In industrial area, the SO_2 level during post monsoon was found to be 32.5% higher value than the pre monsoon.

1.3.2.3 OXIDES OF NITROGEN (NO_x)

In residential areas, during post monsoon, the NO_x level were found to be higher than the pre monsoon, which were in the range of 19.0 to 44.2% with an average of 17.3% except one location, Vikas Nagar which showed 6.2% lower value.

Among the five commercial locations, during post monsoon the NOx level were found to be higher than the pre monsoon level at three locations namely Alambagh, Aminabad and Chowk which were 15.8, 40.0 and 17.5% respectively. whereas the rest two locations i.e. Hussainganj and Charbagh, NO_x levels were found to be 4.7 and 1.2% lower value respectively. Overall in commercial areas the mean NO_x level were found to be 11.9% higher than the pre monsoon reason.

In industrial area, the NO_x level during post monsoon was found to be 40.0% higher than the pre monsoon.

The higher level of SPM and RSPM during Pre monsoon season (summer) might be due to the windblown dust which is common in northern India, whereas, the gaseous pollutants (SO_2 & NOx) were found comparatively lower level because of well dispersion of these pollutants due to relatively higher wind speed and temperature.

During monsoon, rain washes the suspended and settled pollutants from environment and minimize it's re suspension especially particulate matter which might be one of the cause of lower values during post monsoon.

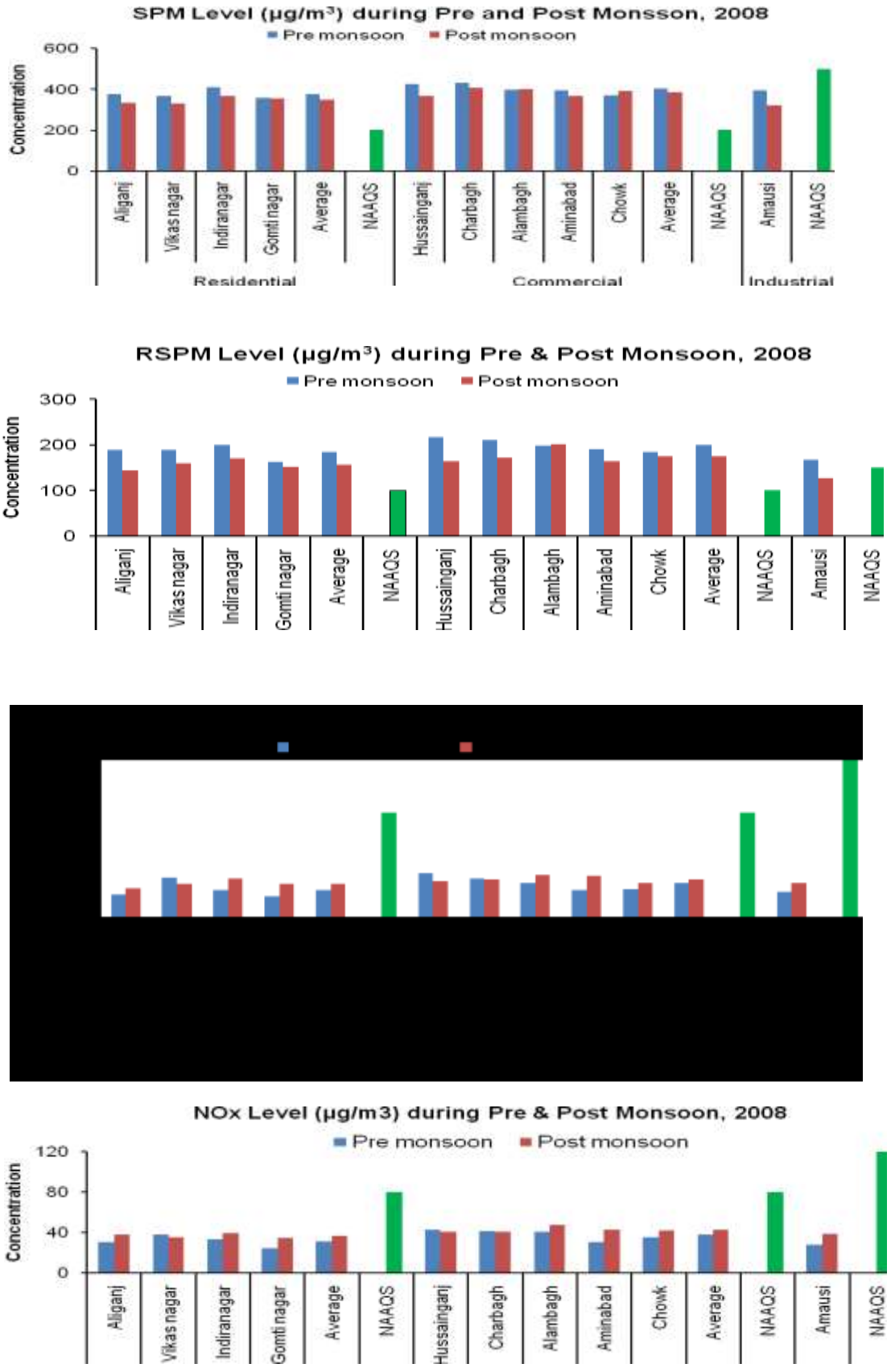


Fig. 2. Average concentration (µg/m^3) of SPM, RSPM, SO_2 and NO_x in different areas of Lucknow city during Pre & Post monsoon seasons (2008) and compared with prescribed National Ambient Air Quality Standard (NAAQS).

1.3.3 NOISE

Elevated noise levels have been associated with adverse impact on human health, ranging from minor annoyance to physiological damage. As such, traffic noise has become a major environmental concern and a source of an ever-increasing level of discomfort particularly in urban areas with high traffic congestion. The sources of noise in the urban settings are primarily vehicular engines; exhaust systems, aerodynamic friction, and tyre-pavement interaction. Traffic noise is affected by factors such as traffic volume and speed, vehicle mix, pavement type, and vehicle conditions. In general, from small vehicles the major part of noise emitted is at the pavement-tyre interface, heavy vehicles emit much of their noise at the engine/exhaust. The monitoring data recorded during the post monsoon period (October, 2008) is presented in Table 11.

In residential areas, the day and night time noise level were recorded between 65.1 to 71.8 and 54.6 to 65.7 dB(A) respectively. All the values are higher than the prescribed limit of 55 and 45 dB (A) for day and night time respectively.

In commercial and traffic areas the day and night time noise level were recorded between 70.7 to 78.7 and 56.8 to 71.9 dB (A) respectively. Noise level at all the commercial sites during day and night time were found above the prescribed limit of 65 and 55 dB (A) respectively.

In industrial areas, Amausi and Talkotora the day and night time noise level were recorded between 73.7 to 77.5 and 62.9 to 66.3 dB(A) respectively. Noise level at Amausi in the day time was higher than the prescribed limit of 75 dB (A) respectively.

Table 11: Noise Level dB(A) during Day and Night Time (October, 2008)

Sl. No.	Area	Location	Day	Night
1	**Residential**	Aliganj	71.3	55.7
		Vikas Nagar	70.7	57.2
		Indira Nagar	71.8	65.7
		Gomti Nagar	65.1	54.6
		Standard	**55.0**	**45.0**
2	**Commercial**	Hazratganj	78.7	58.9
		Hussainganj	71.2	64.9
		Charbagh	72.9	71.9
		Alambagh	70.7	70.7
		Aminabad	71.5	56.8
		Chowk	73.4	61.1
		Standard	**65.0**	**55.0**
3	**Industrial**	Amausi	77.5	62.9
		Talkatora	73.7	66.3
		Standard	**75.0**	**70.0**

1.4 TRENDS

1.4.1 AMBIENT AIR QUALITY

The observed SPM, RSPM, SO_2 and NO_x for 5 years (2002-2006 & 2008) data have been compared to find out the prevailing trend of air pollution in Lucknow city Fig. 3-6).

Suspended Particulate Matter (SPM)

In residential areas namely Vikas Nagar and Indira Nagar showed slightly higher value than last monitoring value in 2006) and all the values are higher than the NAAQS (Fig. 3).

Among the commercial areas, SPM values showed decreasing trend at all the locations since 2004 and all the values are higher than the NAAQS (Fig 3).

Amausi under industrial area showed almost same trend over the previous year and but lower than the NAAQS (Fig. 3).

Respirable Suspended Particulate Matter (RSPM)

In all the locations in residential areas, showed increasing trend and all the values are higher than the NAAQS (Fig. 4).

Among the commercial areas, RSPM values showed increasing trend at all the locations except only in Hussainganj which showed slightly lower value than the last recorded value. All the values are higher than the NAAQS (Fig 4).

Amausi under industrial area showed increasing trend over the last recorded value and marginally lower than the NAAQS (Fig. 4).

Sulphur Dioxide (SO_2)

SO_2 level in residential areas namely Vikas Nagar registered slightly increasing trend in comparison to previous years (Fig. 5).

In the commercial areas, SO_2 registered a decreasing trend at all the locations except in Hussainganj and Aminabad which shows slightly lower level when compared with the last recorded value during post monsoon (Fig. 5).

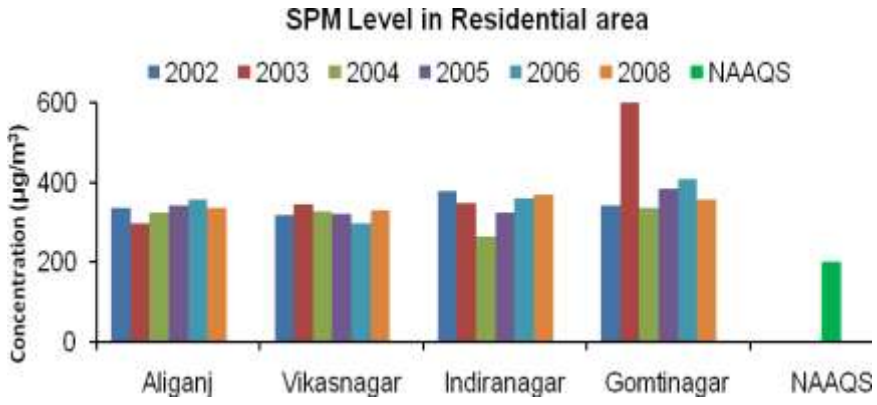
The industrial area Amausi showed also increasing value than the last recorded value during pre monsoon (Fig. 5).

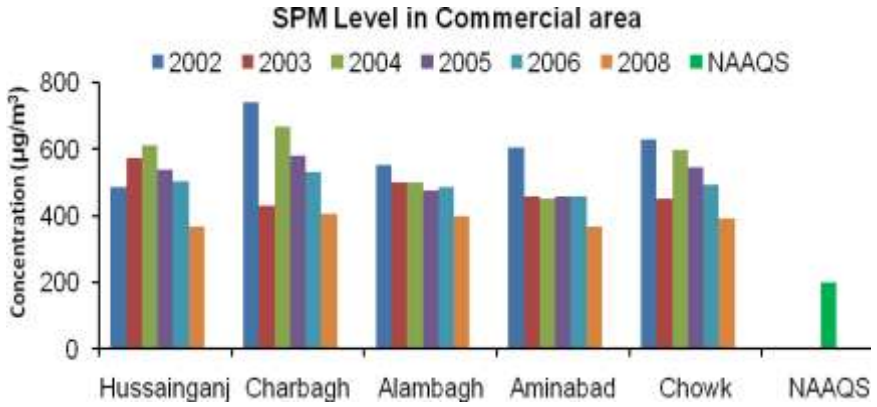
Oxides of Nitrogen (NO_x)

Among the residential areas all the locations showed slightly higher values in comparison to last year (Fig.6).

Among commercial areas, NOx registered decreasing trend at all the locations when compared with the last year data (Fig. 6).

The industrial area Amausi showed lower value trend when compared with the last year data (Fig. 6).





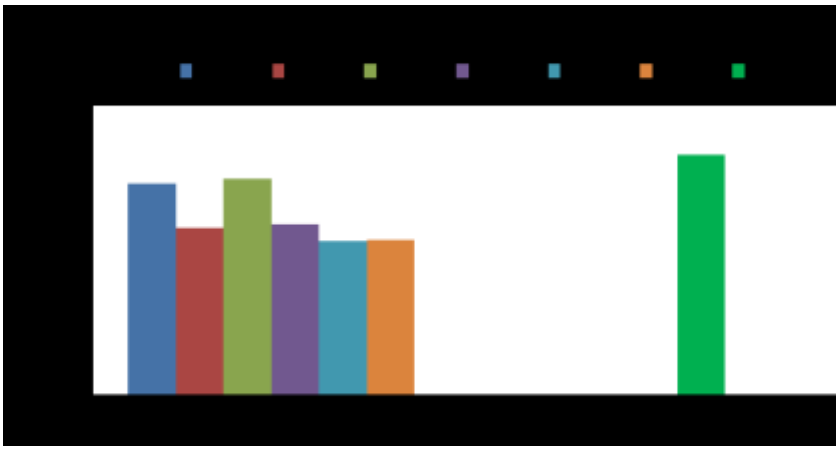
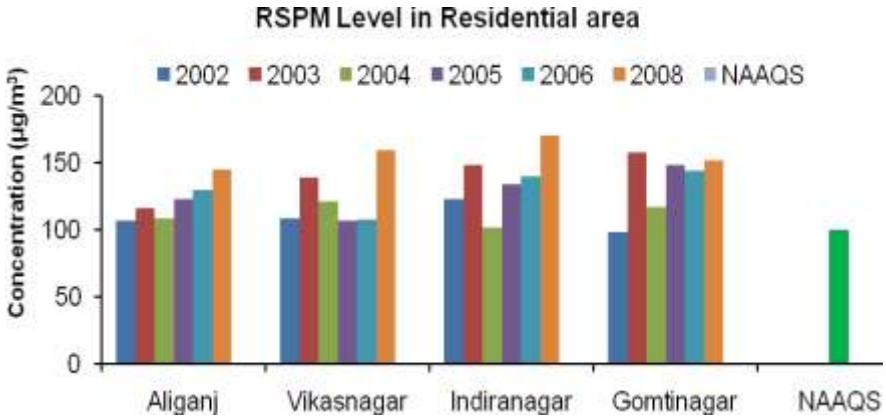
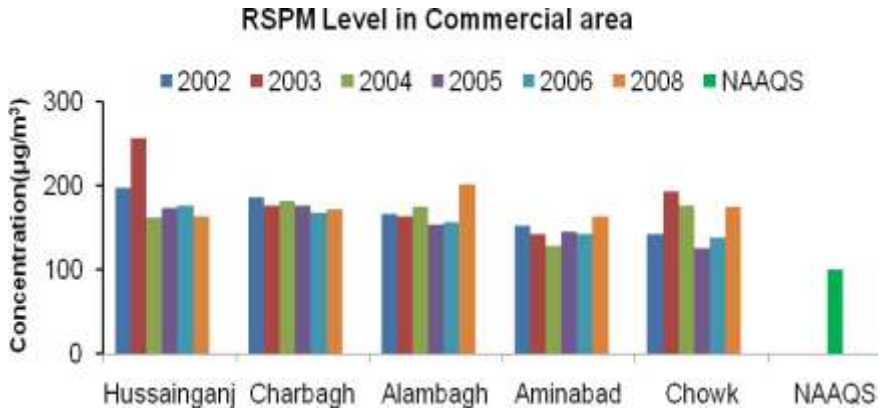


Fig. 3. Concentration (µg/m^3) of SPM in Residential, Commercial and Industrial areas of Lucknow city during 2002 to 2008 and compared with prescribed National Ambient Air Quality Standard (NAAQS).





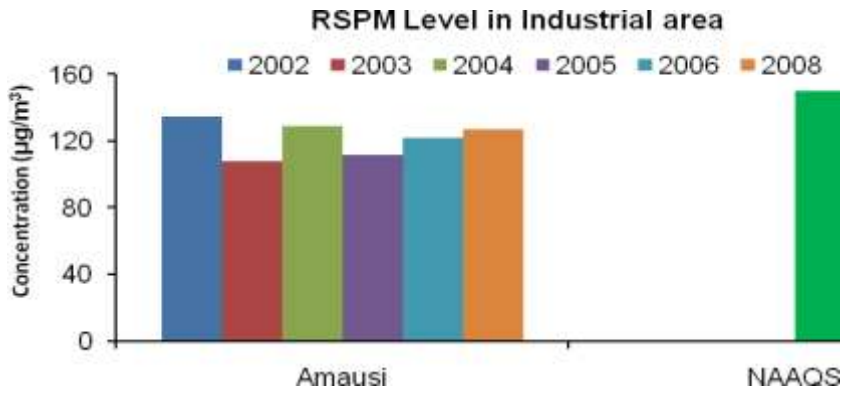


Fig.4. Concentration (µg/m^3) of RSPM in Residential, Commercial and Industrial areas of Lucknow city during 2002 to 2008 and compared with prescribed National Ambient Air Quality Standard (NAAQS).

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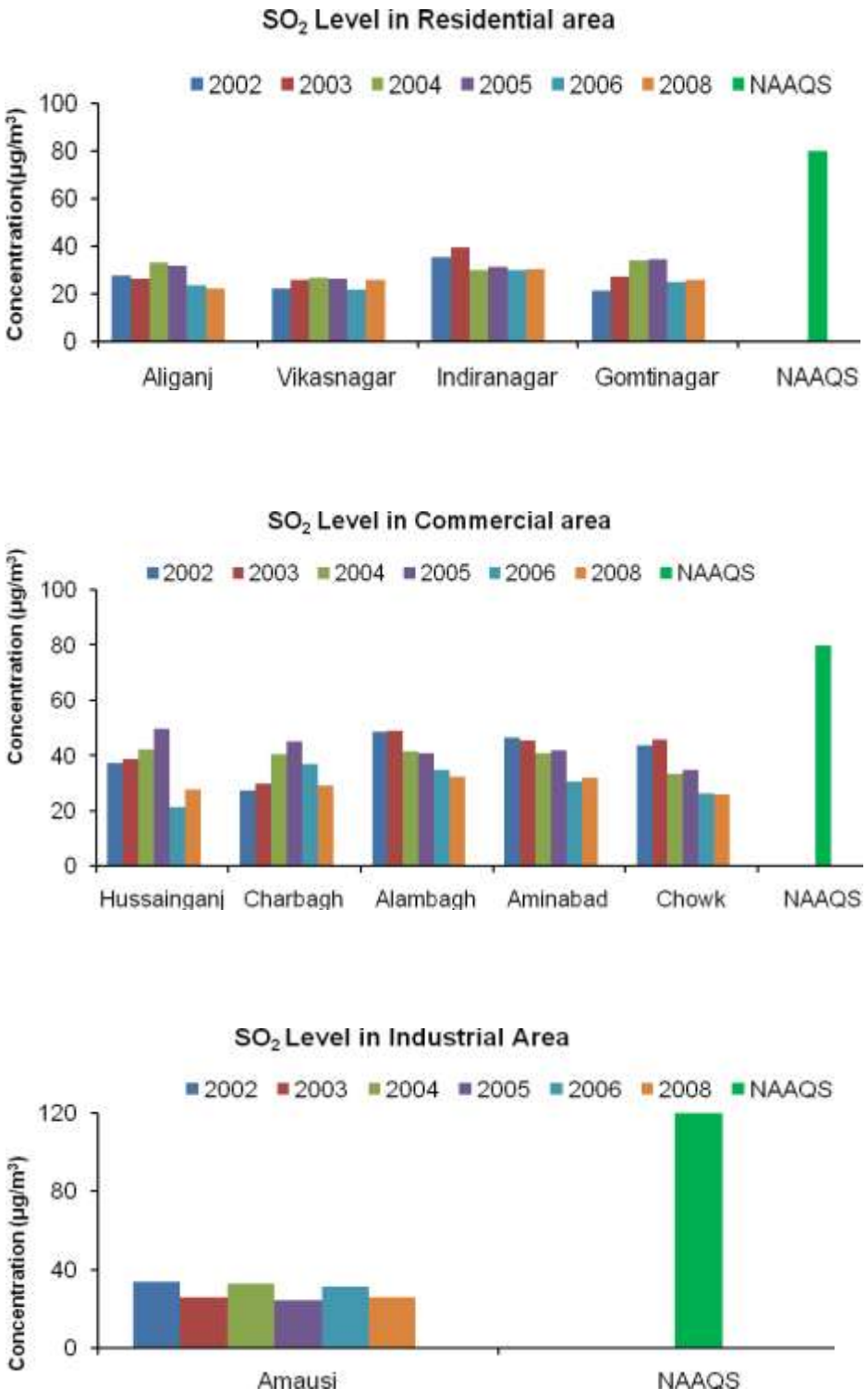


Fig. 5. Concentration (µg/m^3) of SO_2 in Residential, Commercial and Industrial areas of Lucknow city during 2002 to 2008 and compared with prescribed National Ambient Air Quality Standard (NAAQS).

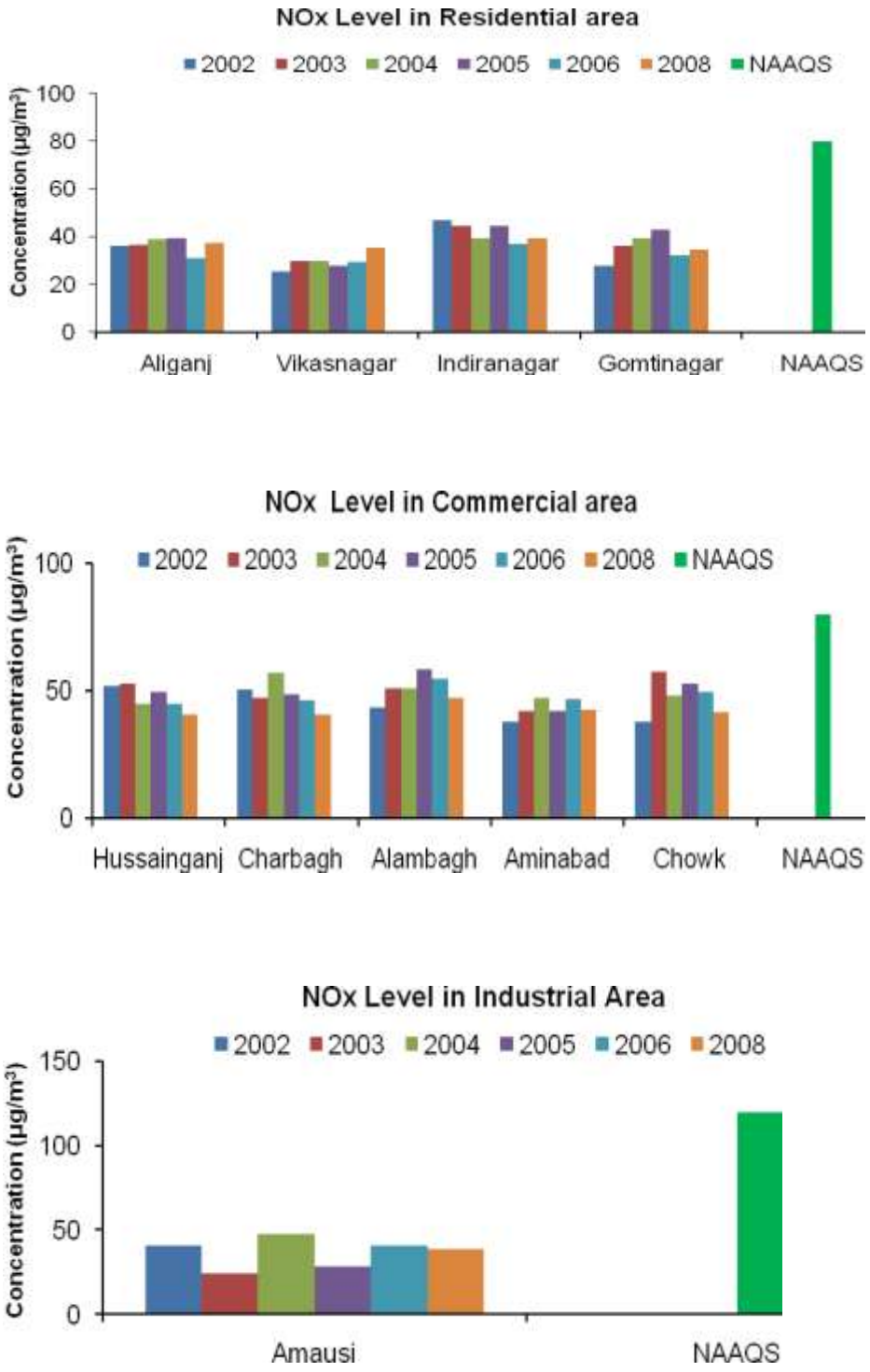


Fig. 6. Concentration (µg/m^3) of NO_x in Residential, Commercial and Industrial areas of Lucknow city during 2002 to 2008 and compared with prescribed National Ambient Air Quality Standard (NAAQS).

1.4.2 NOISE LEVEL

Current year's noise data has been compared with the corresponding data of previous years and are presented in Fig. 7 and 8. The comparative noise level in residential, commercial and Industrial areas is described below:

Day Time Noise Level

In residential areas all the locations show slightly decreasing trend over the last year level. (Fig. 7).

In commercial cum traffic areas show decreasing trends except Hussainganj (Fig.7).

In industrial area, Amausi the noise level was recorded higher and the other location show lower level than last year data. The comparative data are presented in (Fig. 7).

Night Time Noise Level

All four residential areas show slightly lower trend was recorded over the last year level (Fig. 8).

Among commercial areas, all the locations showed lower values than the previous year (Fig. 8).

In both the locations of industrial area, registered a slight decrease in the noise level during nighttime over last year data (Fig. 8).

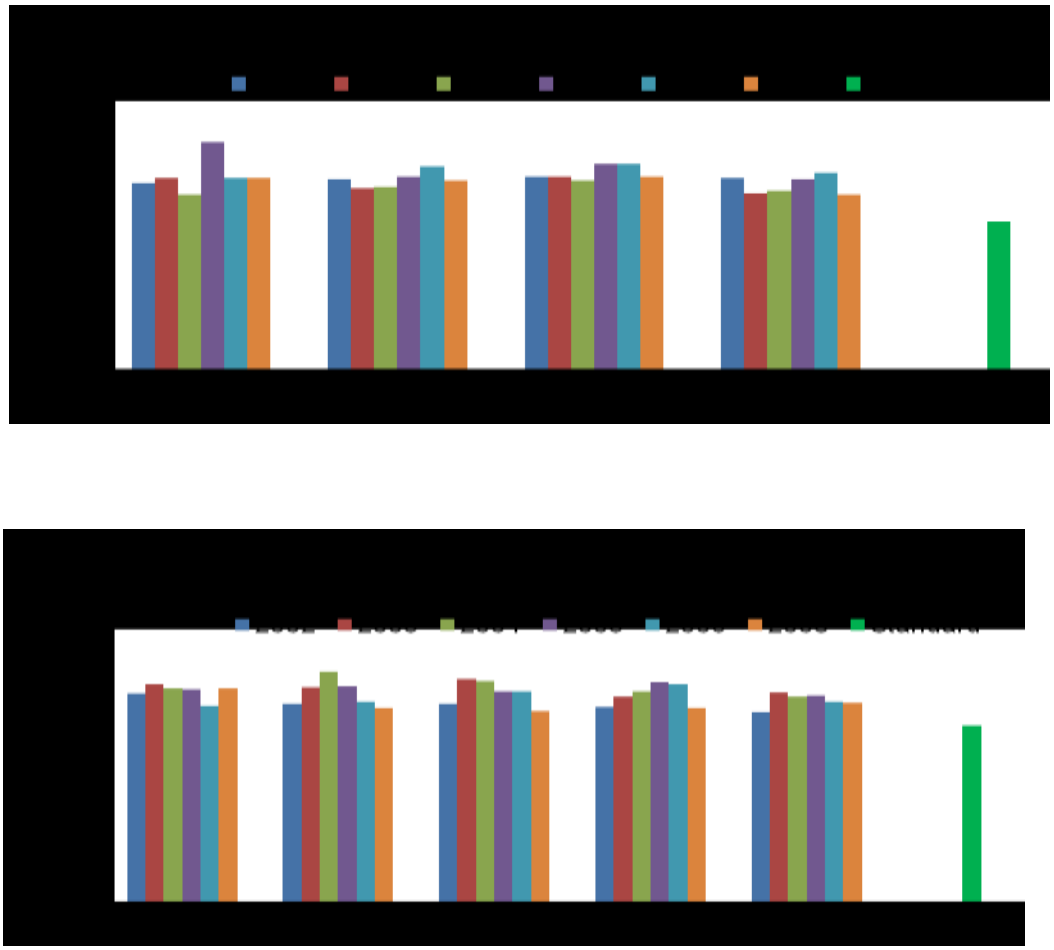
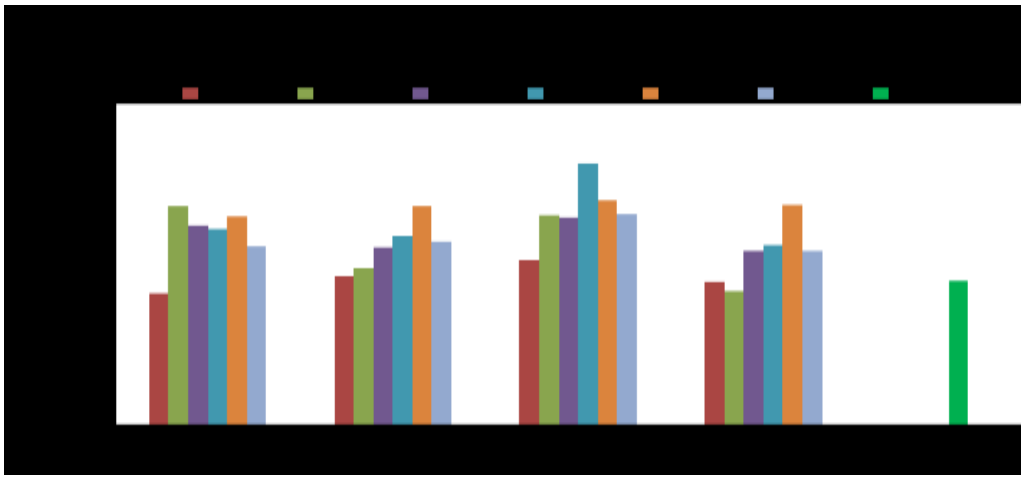
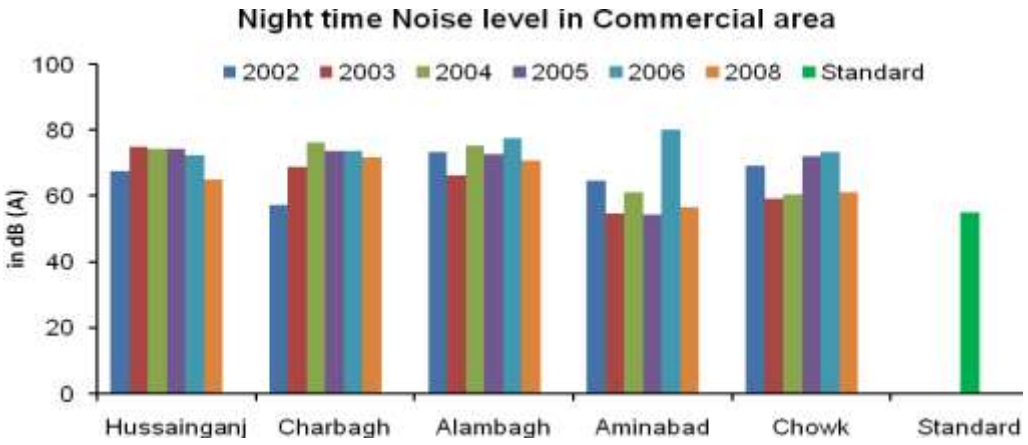


Fig. 7. Yearly (2002 to 2008) comparison of day time Noise Level dB(A) in different areas of Lucknow city.





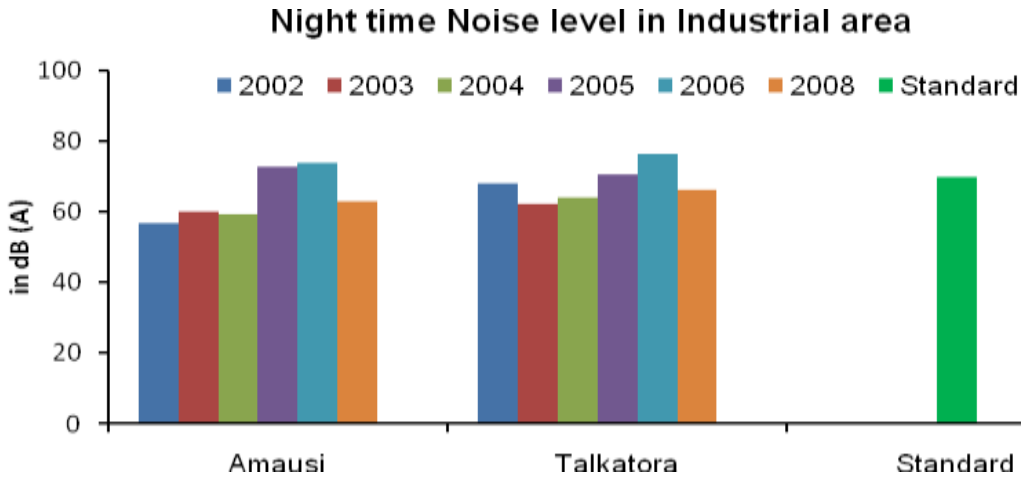


Fig. 8. Yearly (2002 to 2008) comparison of night time Noise Level dB(A) in different areas of Lucknow city.

1.5 DISCUSSION

The automobile exhaust directly influences ambient air quality in urban area. Overall the pollution levels show a mixed trend when compared with previous year's data. The SPM and RSPM at all the locations except industrial area were estimated higher than the prescribed limit, whereas, SO_2 and NOx showed well below the prescribed limit recommended by MoEF, New Delhi.

The study revealed that concentration of the pollutants in residential, commercial and industrial areas showed little variations, indicating that pollutants are well dispersed within the urban area. The variation of the different locations also depends on the traffic congestion, cleanliness of the road which lead to the re-suspension of road dust, composition of vehicle type on the road, topographical influence of the area and also the construction activity in nearby area. The major concern is the particulate matter which is much higher than the permissible limit and affects the human health.

At elevated level all the pollutants have adverse effects on human and environmental health. Accumulation of pollutants in the body through inhalation of air is an important route. Results of the present study revealed that higher level of particulate matter especially the RSPM, which is more dangerous for human health and responsible for several cardiovascular and respiratory diseases such as asthma, bronchitis, reproductive development, increased risk of mortality and morbidity rate (Curtis et al. 2006; Brook et al. 2004; CPCB 2008). Lippmann (1998) estimated that the total daily mortality increased by approximately 1% for every 10 $\mu g/m^3$ increase in RSPM concentration. Researches have suggested that the smaller the particle the greater severity. The effect of PM depends on the mass and number concentration, shape and size and the composition and concentration of other inorganic and organic pollutants associated with it.

In the present study, the concentration of SO_2 and NOx were found to be below permissible limit of NAAQS (80 $\mu g/m^3$), but there are several reports that gaseous pollutants are related with respiratory diseases and reproductive and developmental effects even at low concentrations (Curtis et al 2006). It is reported that 32.5% increases of hospital admissions in Delhi were associated with SO_2 level below NAAQS (CPCB 2008).

Generally, people think that air pollution means higher levels of air pollutants and its adverse effects on human heath as well as on environment and over look the economic effect. The economic cost of air pollution is difficult to estimate accurately. Exposure to various air pollutants and combination of air pollutants create major economic costs by increasing mortality, mobility and increased absenteeism and lost productivity. Air pollution related adverse health effects also cause a lot of human suffering which is hard to measure in terms of money. In addition, air pollution also creates a large amount of non-human health related economic costs including reduced visibility, global warming, building and material damage, and harm to many types of

plants and animals.

Thus it is necessary to monitor the air quality as well as the health effects on regular interval at strategic locations. Our post monsoon monitoring survey might be of help to focus on the pollution level in Lucknow city and its probable consequences. Our database since 1997 will also help the planners for sustainable development of the city.

1.6 CONCLUSIONS

Monitoring results of air pollutants such as SPM, RSPM, SO_2 and NO_x at 10 locations and noise level at 12 locations during post monsoon, 2008 revealed that-

- The SPM and RSPM level at all the monitoring locations of residential and commercial areas showed higher than the NAAQS.
- The concentration of gaseous pollutants, SO_2 & NO_x were within the prescribed NAAQS at all the locations.
- Increasing trend for the RSPM was found at all the locations over the 2006 data except at Hussainganj.
- The noise level at all the locations during day and night time showed much higher level than the respective permissible limits except one industrial area.
- Overall results indicate that vehicular pollution in the urban area is one of the major causes for deterioration of ambient air quality and high noise level.

1.7 RECOMMENDATIONS

- Public mass transport must be strengthened to minimize use of personal vehicle.
- Improve traffic management & remove encroachment for smooth flow of traffic.
- Increase use of alternative fuel e.g., CNG.
- Engine efficiency & improve fuel quality
- Public awareness programme for automobile pollution.
- Pressure horns to be removed from all vehicles.
- Road sides green cover to control dust.

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