ASSESSMENT OF ENVIRONMENTAL STATUS

OF LUCKNOW CITY

(PRE-MONSOON)

FINDINGS OF A RANDOM SURVEY

Presented on

WORLD ENVIRONMENT DAY, 2008

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Select Features of the Study 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**	:	968915
❖ **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**	:	93,476 KL
❖ **Consumption of Diesel**	:	1,59,193 KL
❖ **Major Source of Pollution**	:	Automobiles, D. G. sets, Civil Constructions
❖ **Parameters Monitored**	:	SPM, RSPM, SO_2, NO_X, and Noise
❖ **Study Conducted by**	:	Environmental Monitoring Section IITR, Lucknow

1.1 INTRODUCTION

Urban population is exposed to high level of air pollutants as well as noise due to motor vehicle pollution. It is world wide phenomena and problem is more acute especially in developing countries because of fast growth rate, slow adaptability of upgrade technology and other socio economical factors. There are several reports regarding the vehicular emission is responsible for higher level of air pollutants like SPM, RSPM, SO_2, NOx and other organic and inorganic pollutants including trace metals and their adverse effects on human and environmental health.

Technological upgradation, scientific knowhow, and gradually increase use of green fuel (CNG) has changed the pollutant level and their composition ratio, especially reduction of the gaseous pollutants but increase in number of vehicles causes more emission of pollutants especially the particulate matter, which includes the fine and ultrafine particles. Besides tailpipe emission from vehicle exhaust, the other source of pollutants are secondary sulphates, wood combustion, diesel and gasoline genets exhaust and road dust are responsible for the higher level of air pollutants in urban area especially the PM. 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 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.

Several scientific studies especially the epidemiological studies in different parts of the worlds indicates the higher level of urban pollutants due to vehicular pollution especially the respirable particles (PM10 $\leq$ 10 µm) are responsible for the cardiovascular as well as respiratory diseases including cancer of human being because these particles can penetrate deep into the respiratory system, and studies also indicates that the smaller the particle, severe the health impacts. Ambient particulate matter may be carriers of acidic or toxic species (e.g., heavy metals, acids and carcinogenic organic compounds) and may have detrimental effects on human health and ecosystems. Besides particulate matter, literature also suggests that there is a strong relationship between higher concentration of SO_2 & NO_x and several health effects, like cardiovascular diseases, respiratory health effects such as asthma and bronchitis, reproductive and developmental effects such as increased risk of preterm birth.

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.

Total vehicle of different categories registered with RTO, Lucknow during 2007-2008 were 968,915 as against 904,831 during 2006-2007. The overall growth registered is 7.08 % during 2007-2008 (Table 1).

Table 1: Registered Vehicle 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

The details of vehicles plying as public transport (non government) on different routes in Lucknow are shown in Table 2.

.

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

Sl. No.	Type of vehicles		Number
1	Buses (LMPS)	Total	105
		CNG Bus	43
2	Tempo/Taxi	Total	2116
		Diesel	214
		CNG	1902
3	Auto Rickshaw	Total	4177
		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-Kapporthala-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

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 aim 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.*

The present study is conducted during the month of March to May, 2008 representing the pre monsoon (summer) period.

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.

Table 4: Petrol Pumps in Lucknow City

Sl. No.	Agency	Number of outlet 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

The sales figure of oil companies for the year (2007-08) has been compared with sale figure of 2006-07 (Table 5). It is observed that petroleum sale have been increased marginally by 3.39% whereas sale of diesel has increased by 6.26%.

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*

1.2 MONITORING LOCATIONS AND METHODOLOGY

1.2.1 AIR QUALITY

Ten air quality monitoring locations representing different activities/areas i.e., four in residential, five in commercial cum traffic and one industrial area were selected for the study as summarized in Table 6 and methodology is given 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 by 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 meter 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 pass 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 wheeler and passenger car. Night time traffic flow is low. The monitoring location was in Vinay Khand, near Jaipuria crossing about 25 meter away from the main road

V. Hussainganj

In Hussainganj, the monitoring location was 40 meter 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 mainly of shopping complexes. Aminabad serves as major shopping area for upper middle class and middle class family. The whole area is congested having narrow lanes and mixed traffic ranging from bicycles, rickshaws to two wheeler 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 wheeler and passenger car. During night time commercial vehicles passes 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 meter 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	8 days (Once 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 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 162.7 to 199.2 and 357.6 to 410.5 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 183.8 to 216.2 and 371.8 to 425.1 µg/m^3 respectively.

In industrial area (Amausi), the average concentration of RSPM and SPM were found to be 167.2 and 396.1 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 Industrial areas respectively.

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

Location	Week*	SPM	RSPM	SO_2				NO_x			
				A	B	C	Mean	A	B	C	Mean
Aliganj	I	364.5	194.8	25.8	20.1	17.0	18.7	26.8	33.1	31.1	30.3
	II	374.6	174.2	10.3	29.4	16.0	20.2	26.5	44.8	28.6	33.3
	III	372.1	191.9	17.1	22.3	16.5	21.0	27.9	37.5	30.2	31.8
	IV	370.8	180.8	20.6	24.1	16.0	18.6	33.5	44.1	26.0	34.5
	V	410.0	213.4	15.7	16.8	11.4	14.6	25.5	41.0	37.9	34.8
	VI	381.9	204.6	12.4	22.4	13.8	16.2	26.4	34.2	20.5	27.0
	VII	370.5	169.6	15.7	22.0	11.7	16.5	16.0	30.2	21.5	22.5
	VIII	355.3	176.9	11.4	16.0	12.4	13.3	27.8	29.2	22.7	26.6
	Avg	**375.0**	**188.3**	**17.4**				**30.1**			
Vikas Nagar	I	347.8	186.3	34.5	49.9	24.7	36.4	35.5	52.4	36.2	41.3
	II	323.7	171.5	25.8	47.1	32.2	35.1	35.3	57.5	39.3	44.0
	III	344.3	194.8	36.1	38.8	21.2	32.0	44.0	54.0	31.1	43.1
	IV	379.9	182.4	31.7	43.3	39.4	38.1	35.4	56.1	41.2	44.2
	V	375.9	192.0	20.2	23.4	28.8	24.1	38.1	38.7	32.2	36.3
	VI	395.6	165.9	25.8	28.4	26.2	26.8	31.1	23.0	36.2	30.1
	VII	428.9	216.8	25.6	20.6	26.7	24.3	30.7	26.6	32.8	30.0
	VIII	342.3	197.8	21.2	29.5	23.1	24.6	32.5	32.4	39.7	32.9
	Avg	**367.3**	**188.4**	**30.2**				**37.7**			
Indira Nagar	I	407.5	192.5	17.9	19.0	18.8	18.6	23.0	35.6	37.5	32.1
	II	433.2	188.6	18.5	21.4	20.0	20.0	33.3	29.7	35.0	32.6
	III	382.4	188.2	20.8	21.4	18.5	20.2	33.8	29.5	39.4	34.2
	IV	395.2	201.5	19.0	18.7	17.7	18.5	33.3	30.4	35.5	33.0
	V	411.8	222.2	19.9	22.9	17.1	20.0	24.2	35.0	31.3	30.2
	VI	395.4	183.2	22.0	27.8	26.8	25.5	33.6	44.1	29.4	35.7
	VII	453.1	194.3	17.1	23.5	21.8	28.8	38.2	39.5	26.6	34.8
	VIII	405.3	223.3	21.5	23.4	11.0	18.7	22.9	42.9	30.3	32.0
	Avg	**410.5**	**199.2**	**21.3**				**33.1**			
Gomti Nagar	I	335.2	178.4	10.6	18.8	13.3	14.2	25.8	38.2	20.2	28.1
	II	343.9	149.9	14.1	21.4	9.9	15.1	17.2	29.3	18.2	21.6
	III	382.9	164.8	16.3	22.7	16.0	18.3	19.9	24.2	16.3	20.1
	IV	368.1	157.6	16.8	16.4	16.9	16.7	27.4	30.0	20.6	26.0
	V	335.2	178.4	10.6	18.8	13.3	14.2	25.8	38.2	20.2	28.1
	VI	343.9	149.9	14.1	21.4	9.9	15.1	17.2	29.3	18.2	21.6
	VII	382.9	164.8	16.8	22.7	16.0	18.3	19.9	24.2	16.3	20.1
	VIII	368.9	157.6	16.3	16.4	16.9	16.7	27.4	30.0	20.6	26.0
	Avg	**357.6**	**162.7**	**16.1**				**24.0**			

*Once a week during 24 March-25 May 2008.

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

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

Location	Week*	SPM	RSPM	SO_2				NO_x			
				A	B	C	Mean	A	B	C	Mean
Hussainganj	I	459.3	226.7	44.3	34.6	38.6	39.2	52.7	46.2	38.3	45.7
	II	487.3	223.7	31.4	44.7	50.2	42.1	46.3	61.4	44.3	50.7
	III	454.0	245.6	36.1	42.8	48.2	42.4	58.7	55.5	47.7	54.0
	IV	409.4	205.4	33.3	39.5	44.4	39.1	49.3	60.9	39.2	49.8
	V	422.5	223.4	28.5	33.3	23.7	28.5	34.8	44.7	28.9	36.1
	VI	422.2	221.2	21.9	32.6	24.7	26.4	36.8	51.8	18.8	35.8
	VII	351.3	171.4	28.1	36.9	17.1	27.4	37.7	57.9	17.4	37.7
	VIII	394.5	212.4	20.8	32.9	21.4	25.1	35.0	46.8	16.3	32.7
	Avg	**425.1**	**216.2**	**33.8**				**42.8**			
Charbagh	I	456.3	212.5	30.8	38.0	38.0	35.6	41.1	50.7	42.5	44.7
	II	433.7	193.6	33.2	30.1	31.3	31.5	35.7	33.6	33.5	34.3
	III	445.7	230.3	32.9	35.5	29.1	32.5	40.5	38.0	35.8	38.1
	IV	463.2	204.9	30.8	30.9	39.2	33.6	33.4	33.3	36.8	34.5
	V	442.9	212.0	28.8	28.6	18.5	22.7	31.7	38.4	19.8	30.0
	VI	416.0	193.9	23.7	32.3	29.6	28.5	40.5	49.2	43.3	44.3
	VII	409.5	233.3	24.9	29.4	25.1	26.5	53.1	53.8	45.9	50.9
	VIII	378.5	204.9	26.5	32.8	22.6	27.3	56.7	59.9	36.7	51.1
	Avg	**430.7**	**210.7**				**29.8**				**41.0**
Alambagh	I	375.8	190.7	25.0	39.3	26.8	30.4	37.5	40.5	34.6	37.6
	II	400.2	205.3	28.5	29.2	31.0	29.6	35.6	38.0	41.7	38.4
	III	388.9	182.6	30.8	27.9	29.1	29.2	38.5	45.6	42.5	42.2
	IV	378.5	196.6	28.5	28.5	23.1	26.7	38.0	40.4	46.2	41.5
	V	393.1	185.5	15.0	28.4	23.6	22.3	42.7	55.5	43.1	47.1
	VI	364.4	178.8	17.0	31.1	21.2	23.1	27.6	53.2	29.1	36.6
	VII	438.1	217.8	19.8	26.4	17.9	21.4	38.0	56.3	36.3	43.5
	VIII	455.1	226.5	22.7	25.9	28.5	25.7	48.4	44.2	23.1	38.6
	Avg	**399.3**	**198.0**	**26.1**				**40.7**			
Aminabad	I	401.3	189.6	20.0	22.8	20.9	21.2	30.0	25.3	30.5	28.6
	II	396.6	213.6	18.3	21.4	26.1	21.9	32.8	35.6	38.0	35.5
	III	423.5	185.6	25.7	30.4	24.6	26.9	38.5	43.1	40.2	40.6
	IV	428.7	178.3	35.6	33.4	28.5	32.5	38.0	39.8	33.3	37.0
	V	377.1	191.7	10.8	16.0	12.5	13.1	19.7	19.2	19.0	22.7
	VI	361.3	171.0	16.1	19.5	14.1	16.6	26.2	38.7	22.9	29.3
	VII	334.6	176.4	15.4	20.0	12.9	16.1	23.0	36.5	10.5	23.0
	VIII	444.1	210.0	16.8	21.5	15.4	17.9	27.3	39.3	12.5	26.4
	Avg	**395.9**	**189.5**	**20.8**				**30.4**			

*Once a week during 24 March-25 May 2008.

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

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

Location	Week*	SPM	RSPM	SO_2				NO_x			
				A	B	C	Mean	A	B	C	Mean
Chowk	I	389.6	185.1	18.7	21.0	20.9	20.2	37.3	35.0	37.5	36.6
	II	376.5	166.9	18.5	21.4	26.1	22.0	39.2	41.6	38.0	39.6
	III	355.9	170.2	25.3	30.4	25.5	27.1	44.3	43.1	37.1	41.5
	IV	346.3	188.4	29.7	32.6	26.1	29.5	45.6	46.4	40.4	44.1
	V	397.0	194.6	17.0	22.8	17.7	19.2	24.1	41.7	36.0	34.0
	VI	374.8	181.1	16.6	23.2	15.1	18.3	27.0	39.0	18.4	28.1
	VII	327.5	175.0	17.7	20.2	15.4	17.8	28.8	34.0	28.2	30.3
	VIII	406.9	209.3	16.8	28.7	11.0	18.8	27.4	39.3	20.2	29.0
	Avg	**371.8**	**183.8**	**21.6**				**35.4**			
Amausi	I	445.0	162.3	17.7	20.1	22.5	20.1	22.8	31.3	40.5	31.5
	II	425.6	161.7	18.5	21.4	26.1	22.0	35.6	40.4	33.3	36.4
	III	390.3	170.2	22.4	30.4	27.6	26.8	33.5	32.9	31.4	32.6
	IV	373.5	188.4	28.5	29.9	26.1	28.2	41.6	34.9	35.6	37.4
	V	328.8	159.1	15.0	16.8	10.0	13.9	15.2	27.4	15.2	19.3
	VI	432.5	171.1	13.8	22.4	11.1	15.8	16.9	27.3	17.0	20.4
	VII	379.4	143.4	14.1	19.7	15.8	16.5	17.2	24.1	19.2	20.2
	VIII	393.6	181.4	15.8	16.7	11.0	14.5	19.3	27.1	20.1	22.2
	Avg	**396.1**	**167.2**	**19.7**				**27.5**			

*Once a week during 24 March-25 May 2008.

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

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

Area	Location	SPM	RSPM	SO_2	NOx
Residential	Aliganj	375.0	188.3	17.4	30.1
	Vikas nagar	367.3	188.4	30.2	37.7
	Indiranagar	410.5	199.2	21.3	33.1
	Gomti nagar	357.6	162.7	16.1	24.0
	Average	377.6	184.7	21.3	31.3
	NAAQS	**200**	**100**	**80**	**80**
Commercial	Hussainganj	425.1	216.2	33.8	42.8
	Charbagh	430.7	210.7	29.8	41.0
	Alambagh	399.3	198.0	26.1	40.7
	Aminabad	395.9	189.5	20.8	30.4
	Chowk	371.8	183.8	21.6	35.4
	Average	404.6	199.6	26.4	38.0
	NAAQS	**200**	**100**	**80**	**80**
Industrial	Amausi	396.1	167.2	19.7	27.5
	NAAQS	**500**	**150**	**120**	**120**

NAAQS=National Ambient Air Quality Standards

1.3.1.2 SULPHUR DIOXIDE (SO_2)

In residential area (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the average concentrations of SO_2 were in the range of 16.1 to 25.7 µg/m^3.

In commercial area (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of SO_2 were in the range of 20.8 to 33.8 µg/m^3.

In industrial area (Amausi) the average concentrations of SO_2 was found to be 19.7 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 24.0 to 37.7 µg/m^3.

In commercial areas (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of NO_X were found in the range of 30.4 to 42.8 µg/m^3.

In industrial areas (Amausi) the average concentrations of NO_x was 27.5 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.

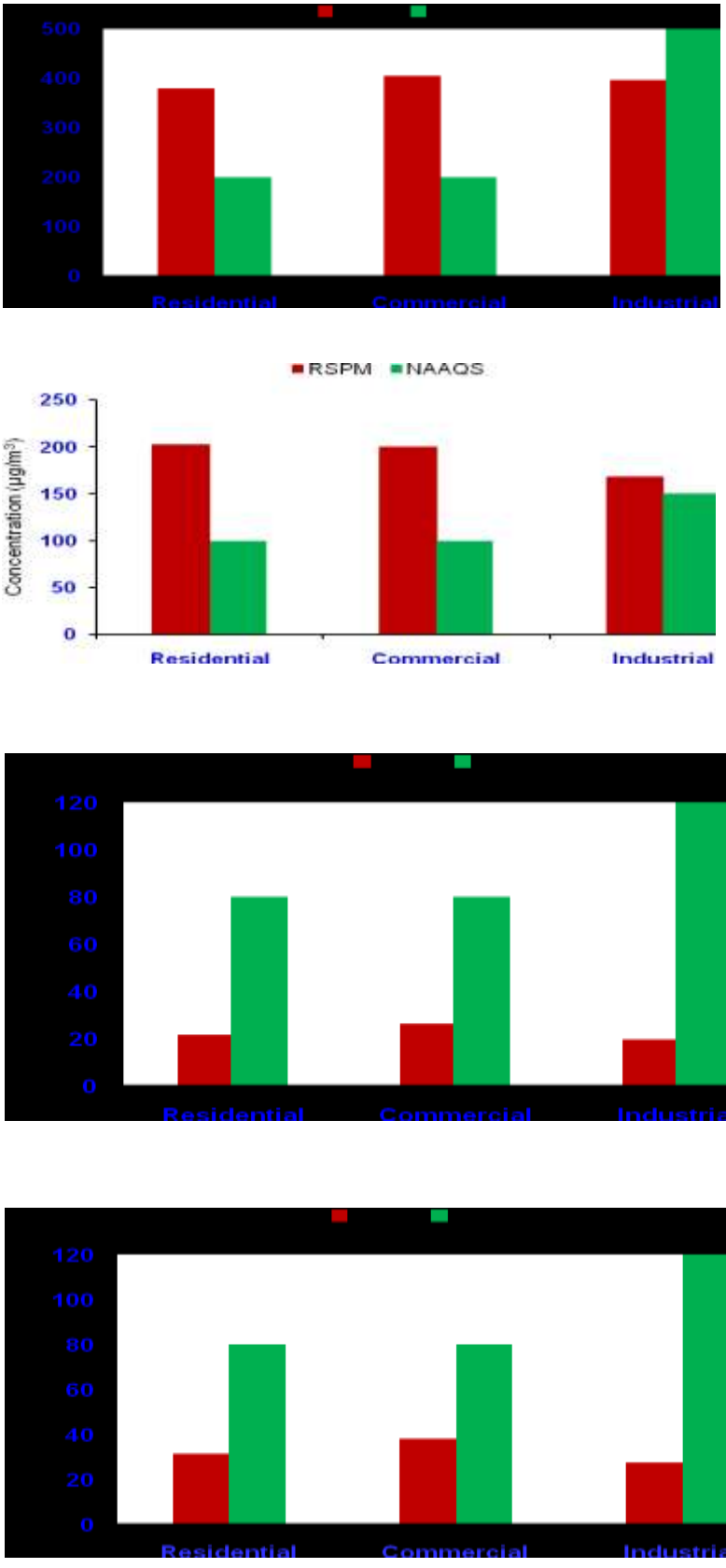


Fig. 1: Average concentration (µg/m^3) of SPM, RSPM, SO_2 and NO_x in different areas of Lucknow city during pre monsoon season (2008) and compared with prescribed National Ambient Air Quality Standard (NAAQS).

1.3.2 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 pre monsoon period (May, 2008) is presented in Table 11.

In residential areas, the day and night time noise level were recorded between 63.4 to 75.3 and 54.1 to 61.0 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 area the day and night time noise level were recorded between 67.1 to 75.3 and 59.5 to 71.2 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 70.4 to 78.5 and 62.8 to 68.9 dB(A) respectively. Noise level at Talkatora 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 (May, 2008)

Sl. No.	Area	Location	Day	Night
1	**Residential**	Aliganj	63.4	54.1
		Vikas Nagar	67.8	55.8
		Indira Nagar	75.3	61.0
		Gomti Nagar	64.9	59.3
		Standard	**55.0**	**45.0**
2	**Commercial**	Hazratganj	67.1	60.8
		Hussainganj	73.5	69.8
		Charbagh	75.3	70.5
		Alambagh	72.6	71.2
		Aminabad	73.7	59.8
		Chowk	74.2	59.5
		Standard	**65.0**	**55.0**
3	**Industrial**	Amausi	70.4	62.8
		Talkatora	78.5	68.9
		Standard	**75.0**	**70.0**

1.4 TRENDS

1.4.1 AMBIENT AIR QUALITY

The observed SPM, RSPM, SO_2 and NO_x for 3 years data have been compared to find out the prevailing trend of air pollution in Lucknow city Fig. 2- 4)

1.4.1.1 Suspended Particulate Matter (SPM)

At all the locations in residential areas, slight increase was recorded over previous year and all the values are higher than the NAAQS (Fig. 2).

Among the commercial areas, RSPM values showed increasing trend at all the locations than the previous year and are higher than the NAAQS (Fig 2).

Amausi under industrial area showed increasing trend over the previous year and but lower than the NAAQS (Fig. 2).

1.4.1.1 Respirable Suspended Particulate Matter (RSPM)

In all the locations in residential areas, slight increase was recorded over previous year except Gomti Nagar and all the values are higher than the NAAQS (Fig. 3).

Among the commercial areas, RSPM values showed increasing trend at all the locations except only in Hussainganj which showed slightly lower value than the previous year. All the values are higher than the NAAQS (Fig 3).

Amausi under industrial area showed increasing trend over the previous year and marginally higher than the NAAQS (Fig. 3).

1.4.1.2 Sulphur Dioxide (SO_2)

SO_2 level in residential areas namely Vikas Nagar registered slightly increasing trend in comparison to last years (Fig. 4).

In the commercial areas, SO_2 registered an increasing trend at all the locations except in Hussainganj which shows slightly lower level when compared with the last year values (Fig. 4).

The industrial area Amausi showed also increasing trend since 2005 (Fig. 4).

1.4.1.3 Oxides of Nitrogen (NO_x)

Among the Residential areas all the locations showed slightly higher values in comparison to last year (Fig.5).

Among commercial areas, NOx registered increasing trend at all the locations when compared with the last year data (Fig. 5).

The industrial area Amausi showed increasing trend when compared with the last year data (Fig.5).

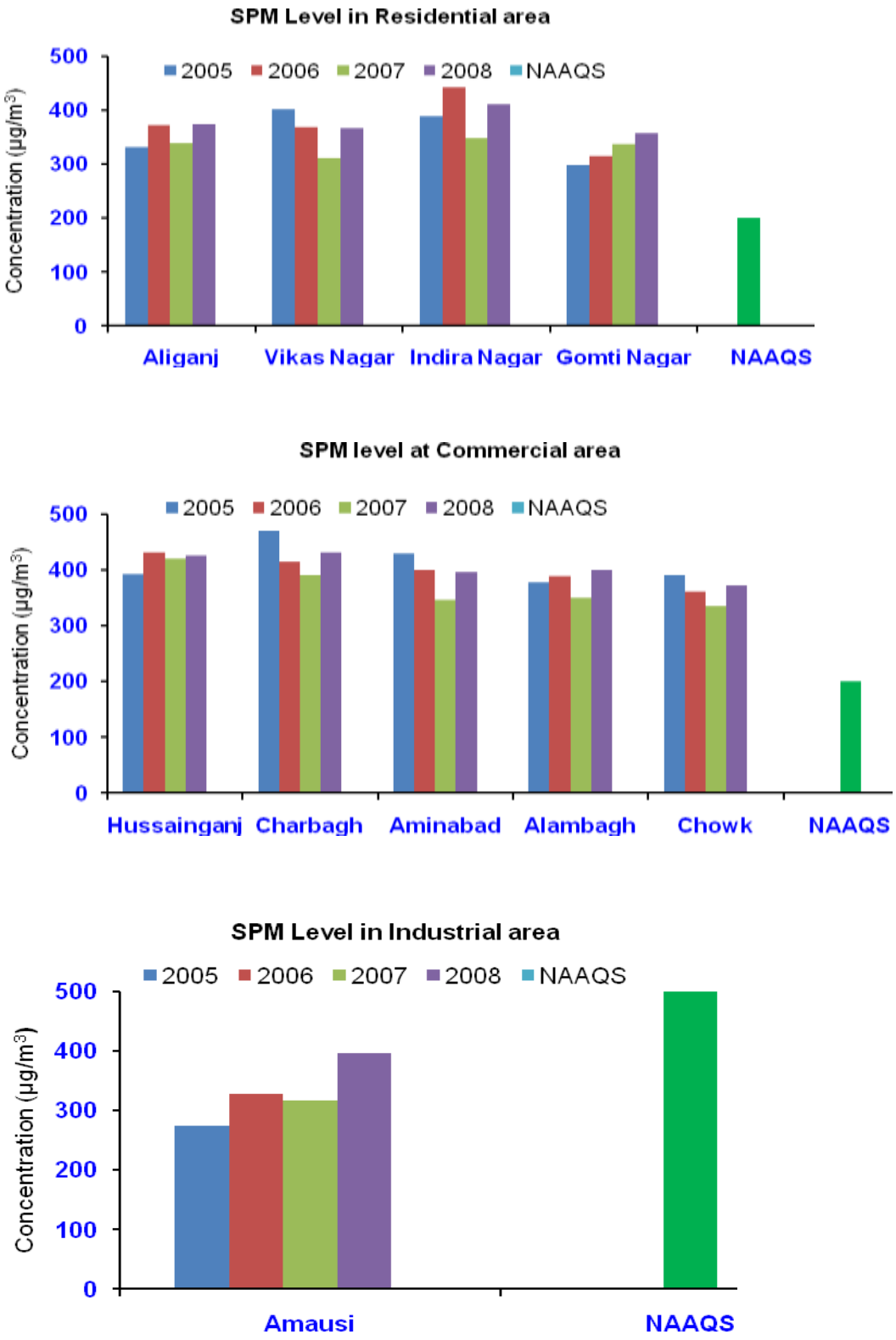
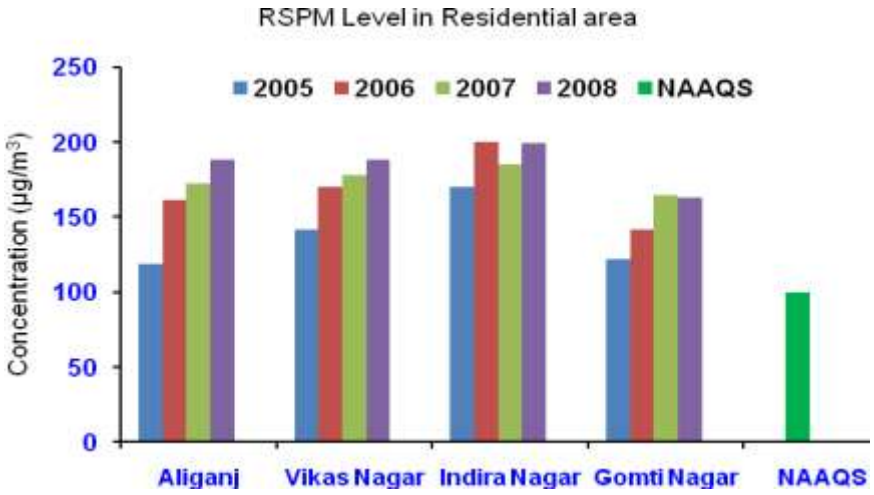
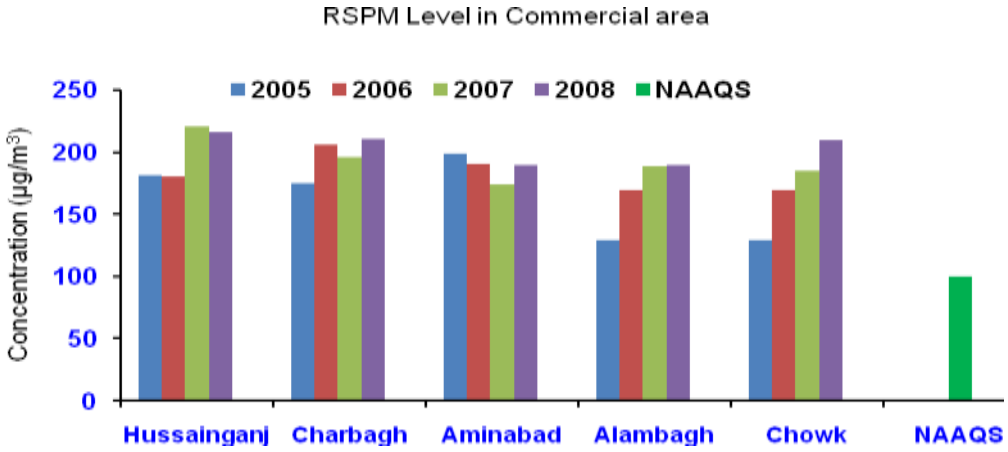


Fig. 2: Concentration (µg/m^3) of SPM in Residential, Commercial and Industrial areas of Lucknow city during 2005 to 2008 and compared with prescribed National Ambient Air Quality Standard (NAAQS).





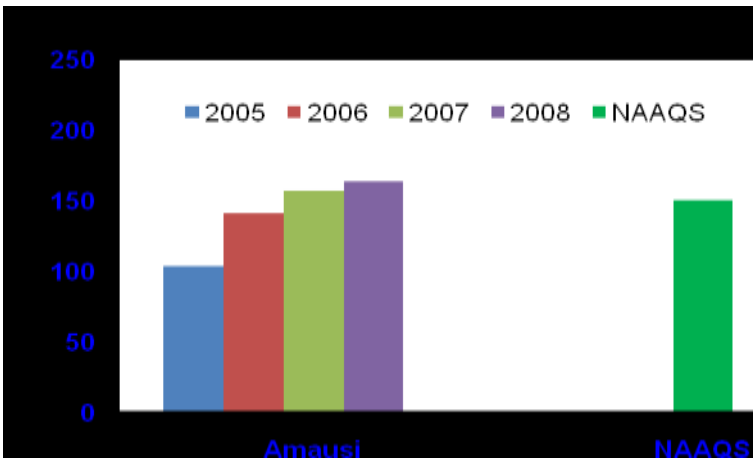
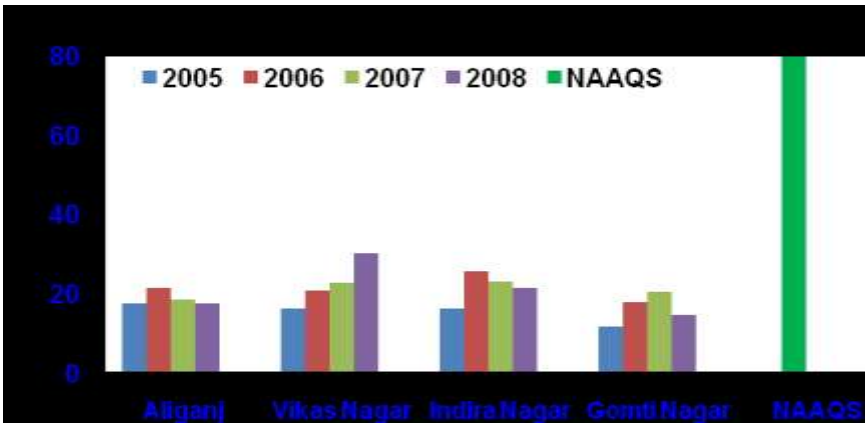


Fig. 3: Concentration (µg/m^3) of RSPM in Residential, Commercial and Industrial areas of Lucknow city during 2005 to 2008 and compared with prescribed National Ambient Air Quality Standard (NAAQS).



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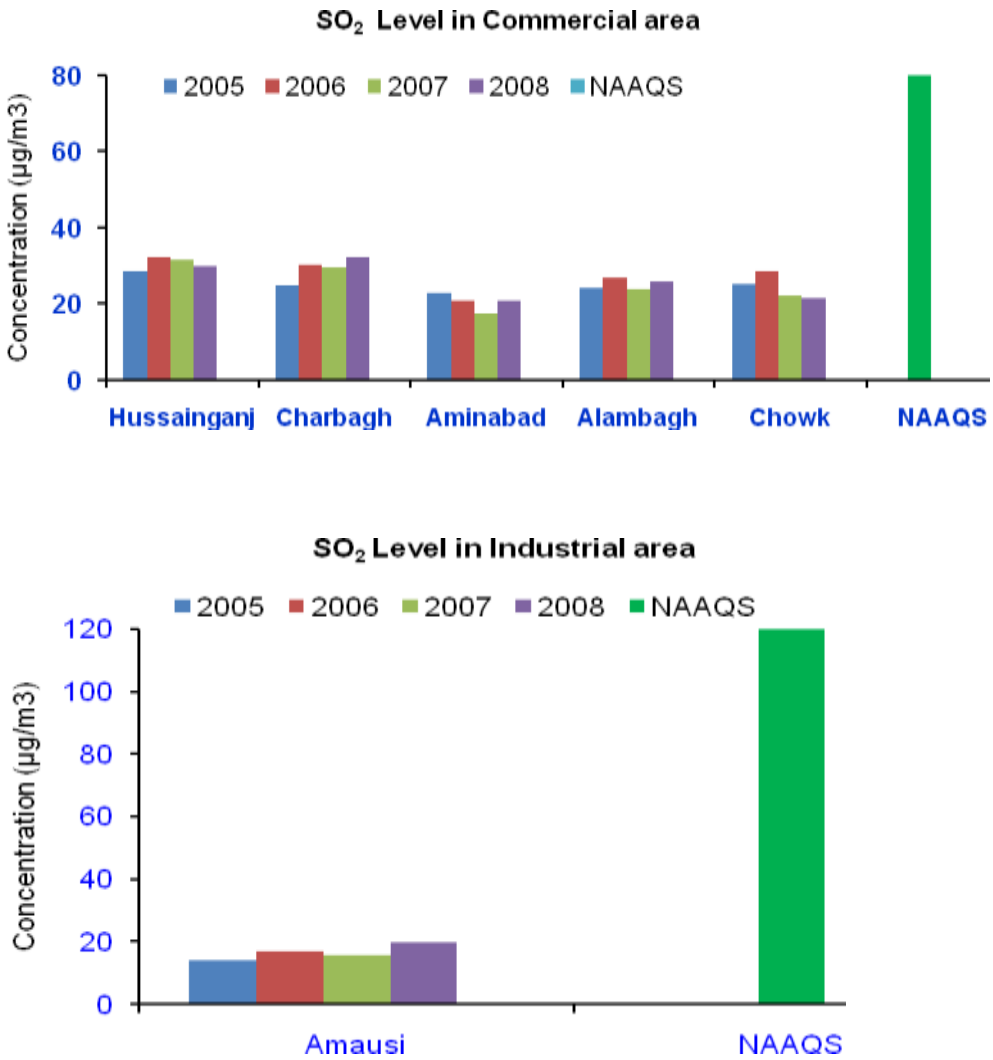


Fig. 4: Concentration (µg/m^3) of SO_2 in Residential, Commercial and Industrial areas of Lucknow city during 2005 to 2008 and compared with prescribed National Ambient Air Quality Standard (NAAQS).

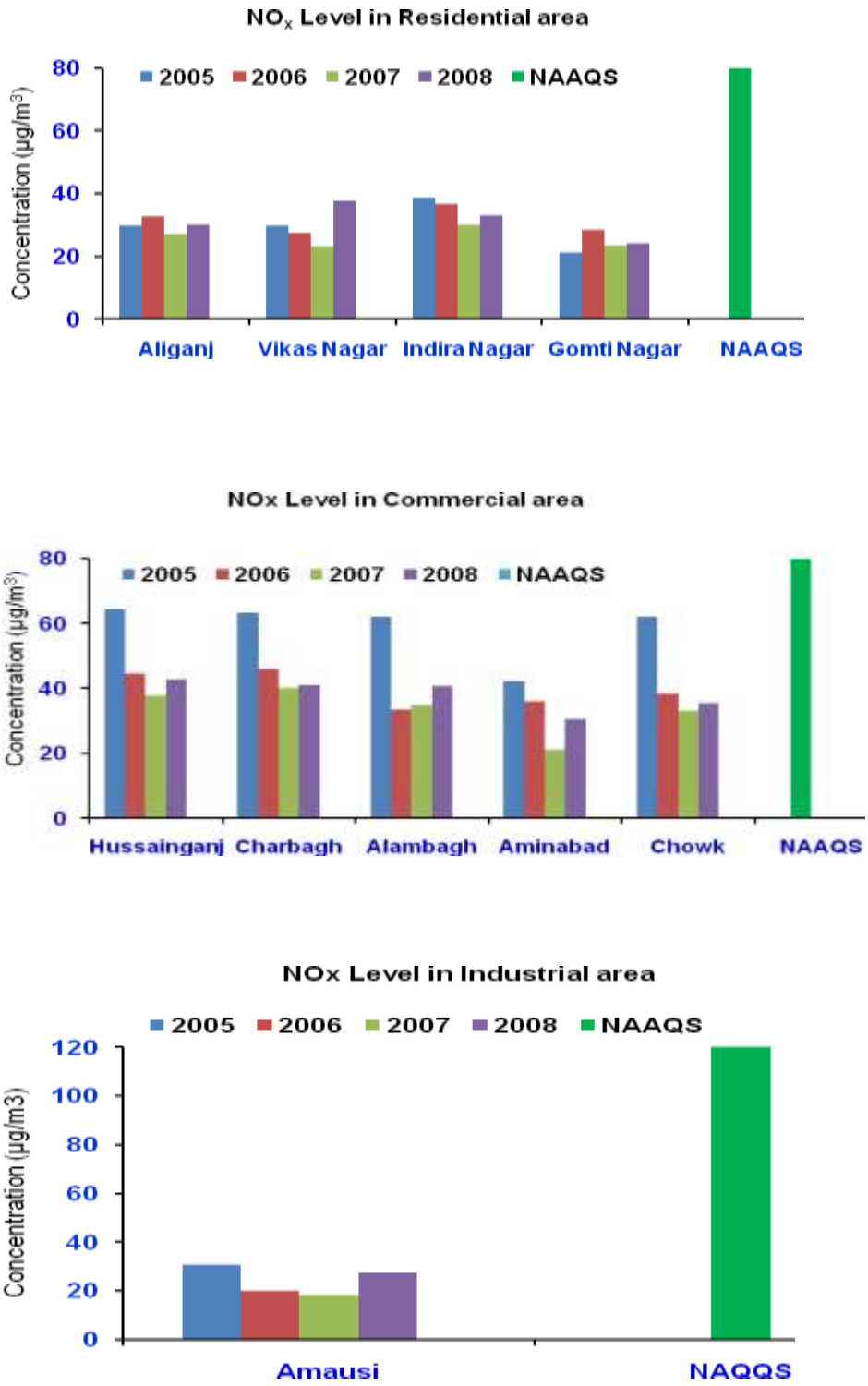


Fig. 5: Concentration (µg/m^3) of NO_x in Residential, Commercial and Industrial areas of Lucknow city during 2005 to 2008 and compared with prescribed National Ambient Air Quality Standard (NAAQS).

1.4.2 TRENDS OF NOISE LEVEL

Current year's noise data has been compared with the corresponding data of previous years and are presented in Fig. 6 and 7. The comparative noise level in residential, commercial and Industrial areas is described below:

1.4.2.1 Day Time Noise Level

In residential areas all the locations shows slightly decreasing trend except Indra Nagar which shows almost equal trend over the last year level. (Fig. 6).

In commercial cum traffic areas slightly lower levels were recorded except Chowk slightly increasing trends was recorded over the last year (Fig.6).

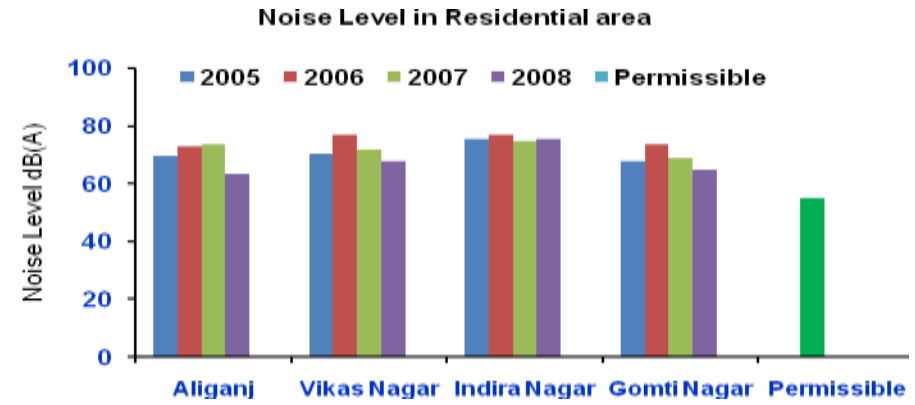
In industrial area, in both the locations the noise level was recorded higher over last year data. The comparative data are presented in (Fig. 6).

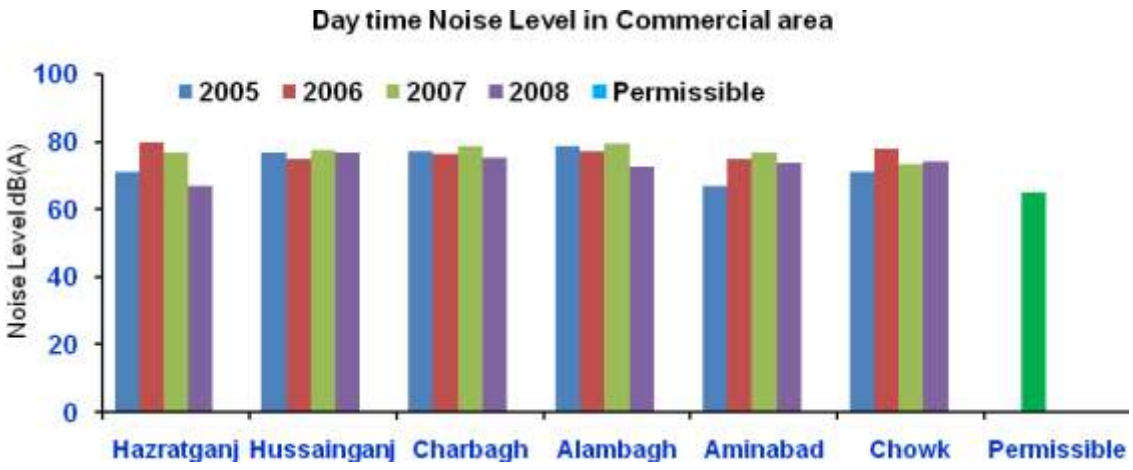
1.4.2.2 Night Time Noise Level

All four residential areas shows slightly lower trend was recorded over the last year level (Fig. 7).

Among commercial areas, all the locations showed almost showed slightly higher values than the previous year (Fig. 7).

In both the locations of industrial area, registered a slight decrease in the noise level during nighttime over last year data (Fig. 7).





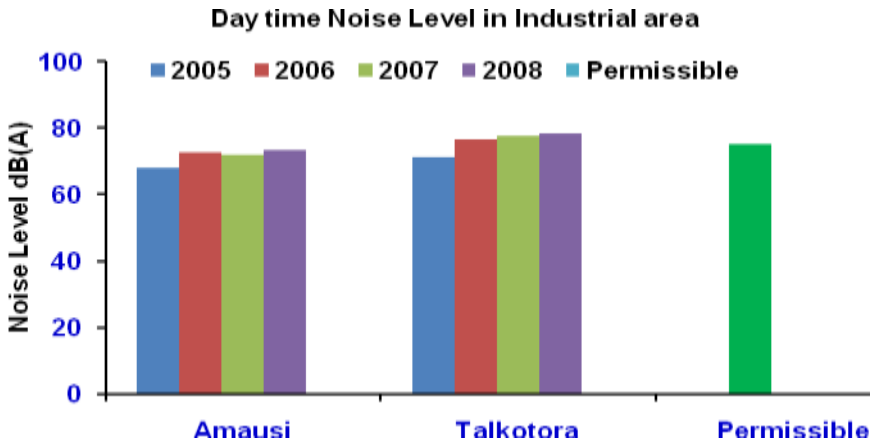


Fig. 6: Yearly (2005 to 2008) comparison of day time Noise Level dB(A) in different areas of Lucknow city.

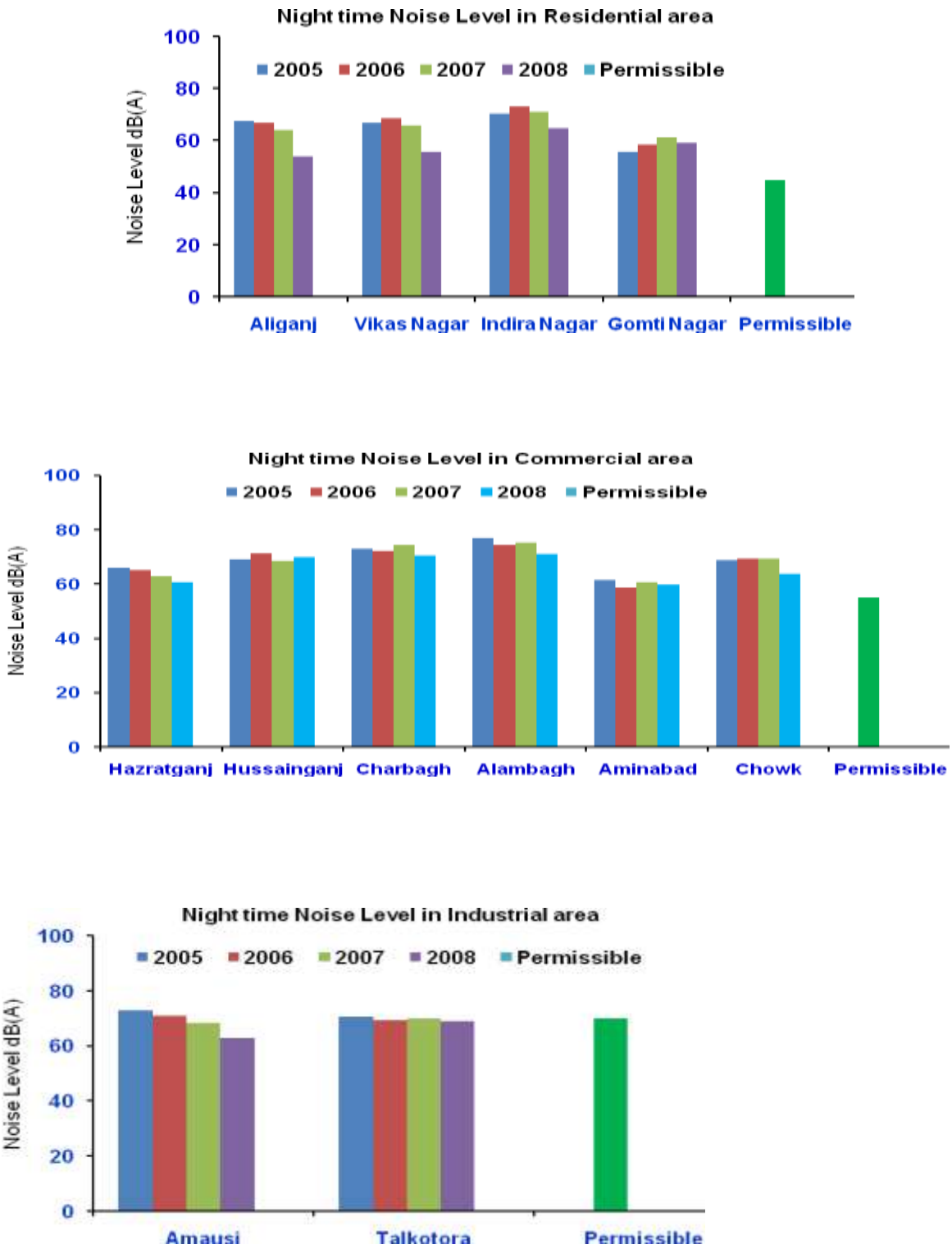


Fig. 7: Yearly (2005 to 2008) comparison of night time Noise Level dB(A) in different areas of Lucknow city.

1.5 HEALTH HAZARDS OF AIR POLUTANTS

1.5.1 Particulate Matter

The respirable particles known as PM_{10} have a diameter less than 10 μm and when inhaled would penetrate beyond the larynx.

Particulate air pollution is associated with a range of effects on health including effects on the respiratory and cardiovascular systems, asthma and mortality. In addition, constituents of particulate matter, such as acid sulphates, may irritate the upper airway and deep lung, reduce bronchial clearance, and modify the lung's resistance to infection.

Effects:

- Small particles can penetrate deeply into the lung and result in bronco-constriction and an alteration in respiratory mechanisms.
- Ultra fine particles ranging from 0.001 to 0.1 micron in diameter are able to penetrate deep into the lung and to the alveolar sacs where gaseous exchange occurs.
- Small particles penetrate deeply into sensitive parts of the lungs and can cause or worsen respiratory disease such as emphysema and bronchitis, and aggravate existing heart disease.
- They work by increasing both the rates of blood flow and vascular permeability to white blood cells, elevating clotting activity, constriction of the airways and fever induction.

1.5.2 Sulfur Dioxide (SO_2)

SO_2 is a colorless water-soluble gas. It smells like burnt matches. It can be oxidized to sulphur trioxide, which in the presence of water vapour is readily transformed to sulphuric acid mist. Sulphur dioxide is detectable to the human nose at concentrations of around 0.5–0.8 parts per million (1400–2240 $\mu g/m^3$).

- Exposure to concentrations of 10 to 50 parts per million for 5 to 15 minutes causes irritation of the eyes, nose and throat, choking and coughing.
- This causes a reflex cough, irritation, and a feeling of chest tightness, which may lead to narrowing of the airways, particularly likely to occur in people suffering from asthma and chronic lung disease, whose airways are often inflamed and easily irritated
- For nasal breathing with low to moderate volumes the penetration into the lungs is negligible.

- For oral inhalation and larger volumes, doses may reach the segmental bronchi
- Exposure of the eyes to liquid sulfur dioxide, (from, for example an industrial accident) can cause severe burns, resulting in the loss of vision.
- Repeated or prolonged exposure to moderate concentrations may cause inflammation of the respiratory tract, wheezing and lung damage
- Other health effects include headache, general discomfort and anxiety.

1.5.3 Oxides of Nitrogen (NO_x)

NOx causes a wide variety of health and environmental impacts because of various compounds and derivatives in the family of nitrogen oxides, including nitrogen dioxide, nitric acid, nitrous oxide, nitrates, and nitric oxide.

NO_2 is a reddish-brown gas with a pungent and irritating odour. It transforms in the air to form gaseous nitric acid and toxic organic nitrates.

Nitrogen Dioxide (NO_2) can have both acute (short term) and chronic (long-term) effects on health, particularly in people with asthma. Its toxicity relates to its ability to form nitric acid with water in the eye, lung, mucus membrane and skin.

Effects

- Eye, nose, and throat irritation
- NO_2 causes inflammation of the airways.
- Long term exposure to NO_2 may affect lung function
- May increase the level of respiratory infections in children
- Enhance the response to allergens in sensitised individuals.
- Lowering the resistance to diseases such as pneumonia and influenza.
- Extremely high-dose exposure (as in a building fire) to NO_2 may result in pulmonary edema and diffuse lung injury.
- Continued exposure to high NO_2 levels can contribute to the development of acute or chronic bronchitis.
- It can cause collapse, rapid burning and swelling of tissues in the throat and upper respiratory tract, difficult breathing, throat spasms, and fluid build-up in the lungs.
- It can interfere with the blood's ability to carry oxygen through the body, causing headache, fatigue, dizziness, and a blue color to the skin and lips.
- Industrial exposure to nitrogen dioxide may cause genetic mutations, damage a developing fetus, and decrease fertility in women.
- Industrial exposure to nitric oxide can cause unconsciousness, vomiting, mental confusion, and damage to the teeth.

- Exposure to low levels of nitrogen oxides in smog can irritate the eyes, nose, throat, and lungs and can cause coughing, shortness of breath, fatigue, and nausea.

1.5.4 Noise

Elevated levels of noise have

- Adverse effects varying from hearing loss to annoyance.
- Noise produces both temporary and permanent hearing loss. Noise can range from the bursting of the eardrum to permanent hearing loss,
- Cardiac and cardiovascular changes, stress, fatigue, dizziness, lack of concentration,
- Cause of accident, irritation, inefficiency, deterioration in motor and psychomotor functions, nausea, interference with work tasks and speech communication, headaches, insomnia and loss of appetite and many others.
- Continuous noise causes an increase in cholesterol level resulting in constriction of blood vessel making prone to heart attack and stress.

1.6 DISCUSSION

The emissions from vehicles exhaust are usually an outcome of several factors: population density, congestion, weather, type of fuel and vehicle used, driving habits, road conditions and maintenance schedule.

Similarly, weather, climate and topography of a region determine the ambient conditions. However, exposure to emissions is mainly a function of socio-economic status of an individual and the location-both house and office.

The automobile exhaust directly influences ambient air quality in urban area. Overall the pollution levels show an increasing trend with respect to SPM and RSPM, at most of the locations and also higher than the prescribed limit, whereas SO_2 and NOx also showed increasing trend with compared with previous year results except few locations in residential area but well below the prescribed limit recommended by MoEF, New Delhi.

The study revealed that concentration of the pollutants in residential, commercial and industrial area showed little variations indicates that pollutants are well dispersed within the urban area. The major concern is the particulate matter which is much higher than the permission limit and affects the human health. The effect of pollutant especially the particulate matter in urban areas depends on several factors like number of concentration, size composition, time of exposure, and lastly the receptor (in case of humans these factors depend on age, health conditions etc.).

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

1.7 CONCLUSIONS

Monitoring of air pollutants such as SPM, RSPM, SO_2 and NO_x at 10 locations during pre 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 2007 data except at Gomti Nagar and Hussainganj.
- The noise level at all the locations during day and night time showed much higher level than the respective permissible limits.
- 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.

1.8 RECOMMENDATIONS

- Public mass transport must be strengthened to minimize use of personal vehicle.
- Improve traffic management
- Encroachment should be removed for smooth flow of traffic.
- Check on fuel adulteration.
- Regular sweeping of roads to avoid re-suspension of soil dust
- Increase use of alternative fuel e.g., CNG.
- Public awareness programme for automobile pollution.
- Pressure horns to be removed from all vehicles.