ASSESSMENT OF ENVIRONMENTAL STATUS OF LUCKNOW CITY

(POST-MONSOON)

FINDINGS OF A RANDOM SURVEY

Presented on

41st FOUNDATION DAY OF

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Lucknow City

Lucknow is the capital of India's most populous state Uttar Pradesh and Lucknow's population is 2,541,101. The city probably derives its name from the legend that Lord Rama gave away this part of the country to Lakshamana, his younger brother. It is situated at the heart of the Uttar Pradesh. Its Geographical position is $26^0$52'N latitude and $80^0$56'E longitude and 128 meter above sea level. The city is surrounded on the eastern side by Barabanki district, on the western side by Unnao District, on the southern side by Raebareli and on the northern side by Sitapur and Hardoi districts.

It has warm subtropical climate with cool dry winter from December to February and dry hot summer from April to June. The temperature in summer and winter ranges between 29-44^{0}C and 5.1-30^{0}C respectively. It receives approximate 101 cm of annual rainfall mostly from southwest monsoon winds between July-September.

Total vehicle population as on 31st March, 2006 is 8,24,003. Annual growth of vehicle population is 9.91% while it is 3 times higher than the annual growth of human population i.e., 3.28%. Road transportation includes Two-Wheelers (11.24%), Three-Wheelers (43.34%), Car (10.6%) and Bus (8.88%). There are 125 number of petrol pumps in the city and the consumption of petrol and diesel is 9609 and 115480 KL respectively. There are some industries in Lucknow city which compound the problems with vehicular emission, D.G. Set, burning of street garbage, domestic waste etc.

1.3 AIR POLLUTION

1.4 OVERVIEW

Atmosphere (complex interplay linked with biological, chemical and physical process) is a dynamic system having the capacity to absorb continuously a wide range of solids, liquids and gaseous pollution both from natural and anthropogenic sources. Air pollution has emerged in the past few decades as a most challenging mankind problem. The urban population is choked with combined onslaught of smoke spewing industries and automobiles. According to **American Medical Association**, ***"Air pollution is the excessive concentration of foreign matter in air which adversely affects the well being to the individual or cause of damage of the property."***

In urban areas - both developing and developed countries, it is dominated by vehicular pollution that contributes 40-60% to air quality problems. The worst thing about vehicular pollution is that it cannot be avoided as the vehicular emissions are emitted at the near-ground level where we breathe. Pollution from vehicles gets revealed through symptoms like cough, headache, nausea, irritation of eyes, various bronchial problems and visibility and are due to discharges like CO, unburned HC, Pb compounds, NO_x, soot and aldehydes, among others, from the tail pipes of vehicles. Mainly vehicle pollution due to high vehicle density in Indian urban centres, older vehicles predominant in vehicle vintage, inadequate inspection and maintenance facilities, predominance of two stroke two wheelers, adulteration of fuel and fuel products, improper traffic management system and road conditions, high levels of pollution at traffic intersections, absence of effective mass rapid transport system and intra-city railway networks, high population exodus to the urban centres. Lucknow city is not an exception to these issues.

Petrol and diesel fuelled vehicles have a strong track record and a very strong popularity because of the cheap and flexible fuel characteristics. Air pollution from motor vehicles also includes emissions of a variety of toxic organic compounds such as benzene. Benzene has been linked to increased risk of leukaemia in workers who were occupationally exposed to benzene in various manufacturing processes. The particles emitted from motor vehicles are mostly black carbon soot size range from 0.002-0.13 μm (micrometer) from diesel engine and from petrol engine is 0.004-0.06 micrometer. Gasoline and diesel powered engines exhaust consist of particulate matter, SO_2, NO_X, CO, HC, aldehydes etc. All these air pollutants which are emitted through motor exhaust are harmful not only to human health but also adversely affect plants. Air pollution, noise pollution, road congestion etc. are environmental hazards due to transport. The mixture and growth in motor vehicles population in any city determines the contribution of the auto emission to the overall air pollution in that city.

Though it is not sufficient but at least some pollution abatement measures have already been taken up by the concerned authorities to control the increasing pollution level in our green city. Lucknowites are leading better quality of life with the supply of CNG/LPG (to fewer auto rickshaws and Vikram tempos at 2 filling stations, Nadarganj and Jankipuram, battery operated tempos, public mass transport system, improvement of the trunk road, divider in the main routes, one way traffic, fly over at congested traffic replacement of old tempos from main routes, supply of low sulfur diesel, unleaded and high powered petrol and technological development.

1.5 OBJECTIVES

Monitoring of air quality of Lucknow city is being conducted by ITRC, by random sampling since 1997 twice in a year (pre monsoon and post monsoon in the month of May and October respectively). This study is conducted during the month of October, 2006 representing the post monsoon season. The following are the aims and objectives of the survey:

- to assess the current status of air and noise pollution in Lucknow city;
- to create and to increase the public awareness regarding the threat posed by the increasing pollution;
- to find out the trend of pollution level with regard to previous years data;
- to suggest simple and effective measures that could be implemented at individual level and
- To draw the attention of decision makers.

1.3 VEHICULAR POPULATION AND FUEL DEMAND

The number of automobiles is increasing day by day. Total vehicle registered with RTO, Lucknow during April 2005 to 31st March, 2006 were 8,24,003 as against the 7,49,830 vehicle number during 2004-2005. The overall growth of the vehicle number is 9.89% during 2005-2006.

Number of registered vehicles with RTO Lucknow under different categories during last two years is given in **Table-1** and details of vehicles plying as public transport on different routes in Lucknow as on 31.03.2006 are shown in **Table-2**.

Table-1: Registered Vehicles with R.T.O. Lucknow during 2004-05 and 2005-06

Sl. No.	Type of Vehicle	Number of Vehicles		% Rise
		On 31st March, 2005	On 31st March, 2006	
1	Multi Axial	567	917	61.73
2	Medium and Heavy weight Vehicles	7925	8014	1.12
3	Light Commercial Vehicles (Three Wheelers)	2525	2930	16.04
4	Light commercial Vehicles (Four wheeler)	4994	5365	7.43
5	Buses	3678	3978	8.16
6	Taxi	5477	5979	9.17
7	Three Wheelers and Auto Rickshaw	8751	12502	42.86
8	Two wheelers	601737	660093	9.70
9	Car	85309	94222	10.45
10	Jeep	11959	12428	3.92
11	Tractor	12309	12821	4.40
12	Trailers	914	991	8.42
13	Others	3173	3199	0.82
Total		**7,49,830**	**8,24,003**	**9.89**

Source: RTO, Lucknow

Table-2: Status of Public Transport on Different Routes as on 31-03-06

Sl. No.	Routes	Number
Buses on Different Routes		
1	Sarojini Nagar to Chinhat	113
2	Charbagh to Tehripulia via Munshipulia	53
3	Rajajipuram to PGI	48
4	Gomti Nagar to Dubagga	73
5	Power House LDA Colony to Engineering College	2
6	Ramram Bank Chowraha to Charbagh	14
	Total	**303**
Maxi cabs on Different Routes		
1	Rajajipuram to PGI	34
2	Gomti Nagar to Dubagga	38
3	Power House LDA Colony to Engineering College	103
	Total	**175**
Auto rickshaws and Battery Operated Vikram (Tempo)		
1	Auto Rickshaws (with catalytic converter)	1490
2	Vikram (with Scrubber)	2200
3	Vikram (Battery Operated)	75
	Total	**3765**

Source: RTO, Lucknow

In Lucknow city, there are 125 petrol pumps of four oil companies (**Table-3).** Consumption of fuel during the year, April 2004 to March 2005 and April 2005 to March 2006 are shown in **Table 4**. The data showed that that petroleum sale has been increased substantially by 0.16% whereas sale of diesel has decreased by 6.49%. 2 CNG/LPG filling stations, Nadarganj and Jankipuram have been opened in Lucknow city.

Table-3: Petrol Pumps in Lucknow City

Sl. No.	Company	Number of outlet
1	Indian Oil Corporation (IOC)	44
2	Bharat Petroleum Corporation Limited (BPCL)	25
3	Hindustan Petroleum Corporation Limited (HPCL)	30
4	Indo Burma Petroleum (IBP)	26
	Total	**125**

Source: Indian Oil Corporation (IOC), Lucknow

Table-4: Consumption of Fuel* in Lucknow

Sl. No.	Agency	Motor Spirit (Unleaded)			High Speed Diesel		
		Apr., 04 to Mar., 05	Apr., 05 to Mar., 06	% Change	Apr., 04 to Mar., 05	Apr., 05 to Mar., 06	% Change
1	IOC	35476	36186	2.0	46710	43116	-7.69
2	BPCL	24849	26727	7.56	23077	24221	4.96
3	HPCL	20165	19853	-1.55	29466	28778	-2.33
4	IBP	15363	13243	-13.80	24237	19365	-20.10
	Total	95853	96009	0.16	123490	115480	-6.49

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

1.4 MONITORING LOCATIONS AND METHODOLOGY

1.4.1 AIR QUALITY

Ten locations representing different activities/areas (four residential, five commercial cum traffic and one industrial) were selected for the study and are summarised in **Table-5**. The brief description of each site is given below:

Table-5: Air 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

► **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. Habitat of this locality is dominated by middle class families. 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. The mass public transportation in this route is by diesel jeep (Sumo/Marshal). Monitoring location was at CSIR Scientist Apartments, Sector K, near main road. The main vehicles are two wheelers, passenger car and maxi cab (Jeep).

► **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 and minibuses. 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.

► **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 daytime, 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.

► **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. At night hours traffic flow is low. The monitoring location was in Vinay khand, near Jaipuria crossing about 25 meter away from the main road.

► **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. At night hours commercial vehicles were the main source of pollution.

► **Charbagh**

The place is congested with road side make shift shops/hawkers and having a high traffic flow. It is also a starting/terminating point for tempo, auto rickshaw, buses etc and lot of vehicles are parked to get passengers. The major source of pollution is auto exhaust from mixed type of vehicles including buses and trucks during night hours. One of the important source is diesel locomotive. It is one of the busiest places in Lucknow city. The monitoring location was near the main traffic junction.

► **Alambagh**

In Alambagh monitoring location was 10 meter away from Alambagh crossing on the main Lucknow - Kanpur road. The main source of pollution is vehicular exhaust. At day hours, source of pollution is from city as well as from inter city buses, tempos, two wheelers and passenger cars. Beside diesel generating sets are also used during power break down. At night hours trucks and long distance buses are the main sources of pollution. Major source of pollution in the area is diesel engine driven vehicular traffic.

► **Aminabad**

The monitoring location was situated in the central place adjacent to Jhandewala Park. This is purely commercial area mainly consisting of shopping complexes. The whole area is congested having narrow lanes and mixed traffic ranging from bicycles, rickshaws to two and three wheelers and passenger cars. The monitoring location was 100 meter away from the main road. Area is residential cum commercial. Source of pollution is mainly from tempo,

two wheeler and passenger car. Beside diesel generating sets are also used during power break down. During night time commercial vehicles passes through the main road.

► **Chowk**

In Chowk, the monitoring location was 200 meter away from the main chowraha. It is a residential cum commercial place and during day hours traffic flow are city buses, jeeps, two wheelers and passenger cars. At night hours commercial vehicles were the main source of pollution.

► **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.

The major source of pollution in Lucknow city is vehicular emissions, use of diesel generating sets during power failure and industries such as Mohan Meakins, Eveready Flash Lights, Scooter India Ltd., Hindustan Aeronautic Ltd., Swaroop Chemicals etc. The monitoring of Ambient Air Quality was carried out as per standard procedures given in **Table-6.**

Table-6: Methodology for Air Quality Monitoring

Particulars	**SPM / RSPM**	**Lead**	**SO_2**	**NOx**
Sampling equipment	Respirable Dust Sampler (RDS)	RDS	RDS with gaseous sampling attachment	
Collection Media	GF/A	EPM-2000	TCM	NaOH
Flow rate	1.0-1.3 m^3/min		0.5 l/min	
Analytical Method	Gravimetric	AAS	Spectrophotometer	
Frequency	24 hour		8 hourly	
Sampling Duration	Continuous for 24 hours			
No. of days of sampling at each location	2 days			

1.4.2 NOISE LEVEL MEASUREMENTS

The measurement of noise levels were carried out for 30 minutes at all the 12 locations (**Table- 7)** 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.

Table-7: Noise Monitoring Location

Sl. No.	Area	Location
1	Residential	Aliganj
		Vikas Nagar
		Indira Nagar
		Gomti Nagar
2	Commercial	Hazratganj
		Hussainganj
		Charbagh
		Alambagh
		Aminabad
		Chowk
3	Industrial	Amausi
		Talkatora

1.5 RESULTS

1.5.1 AIR QUALITY

The results of air quality monitoring are presented in **Tables 8, 9 and Exhibit 1 to 5.**

Table 8: Concentration (µg/m3) of SPM, SO_2, NO_x, and Pb in Lucknow City during October-2006

Location	Day	RSPM 24 hr	SPM 24 hr	SO_2				NO_x				Pb 24 hr
				06-14 hr	14-22 hr	22-06 hr	Mean	06-14 hr	14-22 hr	22-06 hr	Mean	
Aliganj (R)	I	117	328	23.9	24.6	20.5	23.0	31.4	32.9	25.2	29.8	0.023
	II	142	383	23.5	22.5	25.6	23.8	32.8	34.4	29.2	32.2	
	Avg	130	356				**23.4**				31.0	
Vikas Nagar (R)	I	102	287	22.6	21.3	20.2	21.4	34.4	30.8	26.9	30.7	0.036
	II	113	305	21.5	22.0	22.5	22.0	29.4	33.6	20.2	27.7	
	Avg	108	296				21.7				29.2	
Indira Nagar (R)	I	134	365	35.4	25.6	29.6	30.2	41.8	42.2	32.0	38.7	0.034
	II	147	352	30.2	29.0	30.5	29.9	35.1	35.0	36.4	35.5	
	Avg	140	359				30.0				37.1	
Gomti Nagar (R)	I	146	405	42.3	27.5	21.0	30.3	30.0	25.6	37.4	31.0	0.169
	II	142	410	22.1	16.8	20.4	19.8	37.8	36.4	26.3	33.5	
	Avg	144	407				25.0				32.2	
Hussainganj (C)	I	177	490	29.0	20.7	17.9	22.5	47.0	43.0	35.3	41.8	0.024
	II	168	514	25.5	18.8	16.3	20.2	53.5	54.0	37.5	48.4	
	Avg	173.0	502				21.3				45.1	
Charbagh (C)	I	158	515	42.4	46.2	20.0	36.2	44.5	48.5	33.2	42.1	0.219
	II	179	548	41.9	47.1	25.4	38.1	53.0	54.3	43.2	50.3	
	Avg	168.0	531				37.1				46.2	
Alambagh (C)	I	148	473	41.4	43.0	22.3	35.6	59.8	57.7	43.8	53.8	0.234
	II	166	493	39.4	42.4	19.6	33.8	60.9	53.1	41.4	55.2	
	Avg	157.0	484				34.7				54.5	
Aminabad (C)	I	136	438	27.2	33.9	26.0	29.0	46.0	45.0	44.6	45.2	0.522
	II	149	478	31.9	41.6	23.1	32.2	50.3	53.3	40.4	48.0	
	Avg	143.0	458				30.6				46.6	
Chowk (C)	I	144	540	22.2	24.3	15.9	20.8	51.2	42.6	41.8	45.2	0.021
	II	132	438	34.8	36.3	25.4	32.1	68.4	47.6	46.6	54.2	
	Avg	138.0	492				26.4				49.7	
Amausi (I)	I	130	308	40.2	31.9	33.4	35.2	42.2	37.7	35.7	38.5	0.562
	II	115	332	26.4	21.9	34.2	27.5	43.6	39.3	46.0	43.0	
	Avg	122.0	320				31.3				40.7	

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

Area	Location	SPM	RSPM	SO_2	NOx	Pb
Residential	Aliganj	356	130	23.4	31.0	0.023
	Vikas Nagar	296	108	21.7	29.2	0.036
	Indira Nagar	359	140	30.0	37.1	0.034
	Gomti Nagar	407	144	25.0	32.2	0.169
	Average	**354.5**	**130.5**	**25.1**	**32.4**	**0.066**
Commercial	Hussainganj	502	173	21.3	45.1	0.024
	Charbagh	531	168	37.1	46.2	0.219
	Alambagh	484	157	34.7	54.5	0.234
	Aminabad	458	143	30.6	46.6	0.522
	Chowk	492	138	26.4	49.7	0.021
	Average	**493.4**	**171.4**	**30.0**	**48.4**	**0.204**
Industrial	Amausi	320	122	31.3	40.8	0.562

1.5.1.1 PARTICULATE MATTER (RSPM and SPM)

Residential Area

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the concentration of RSPM and SPM were in the range of 95 to 144 (avg. 354.5) and 296 to 407 (avg. 130.5) µg/m^3 respectively.

Commercial Area

In commercial areas (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the concentration of RSPM and SPM were in the range of 138.0 to 173.0 (avg. 155.8) and 458 to 531 (avg. 439.4) µg/m^3 respectively.

Industrial Area

In industrial area (Amausi), the concentration of RSPM and SPM were 104 and 320 µg/m^3 respectively.

The summary of concentration of pollutants studied is presented in **Table 8, 9** and SPM and RSPM level are graphically presented in **Exhibits 1 & 2.**

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

(Tables 8 & 9 and Exhibits 1 & 2).

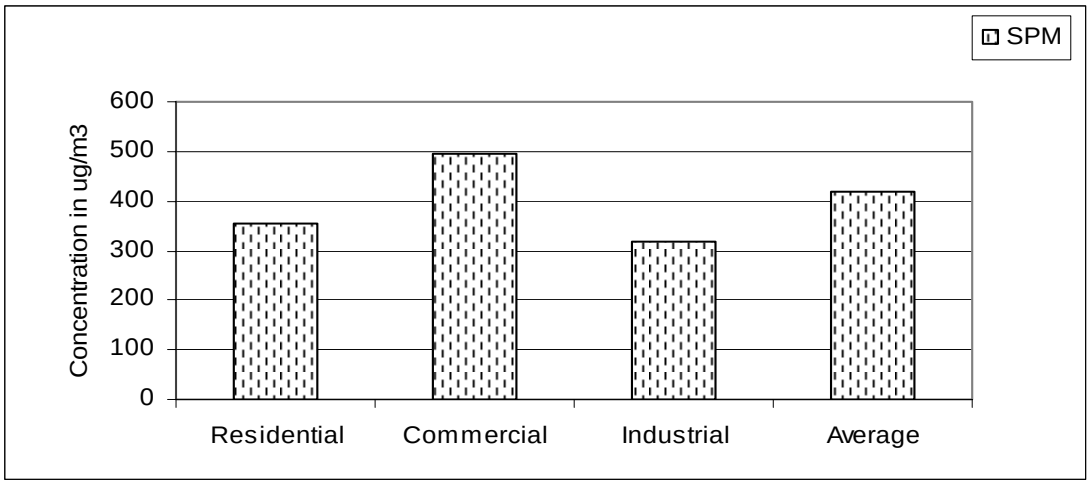

Exhibit 1: Concentration and Average Values of SPM at Different Types of Locations

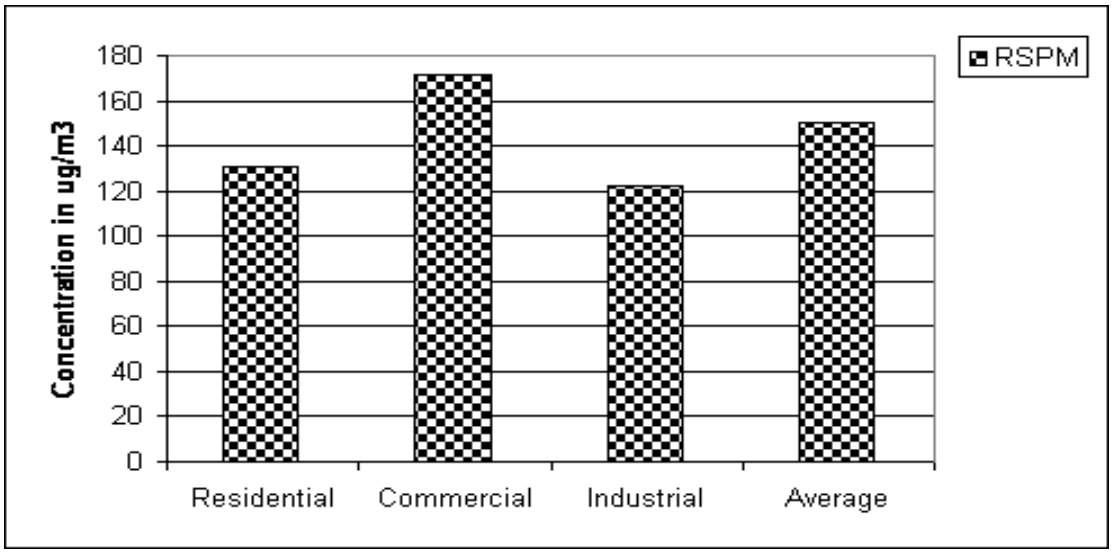

Exhibit 2: Concentration and Average Values of RSPM at Different Types of Locations

1.5.1.2 SULPHUR DIOXIDE (SO_2)

Residential Area

In residential area (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the concentrations of SO_2 were in the range of 21.7 to 30.0 (avg. 25.1) µg/m^3.

Commercial Area

In commercial area (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the concentrations of SO_2 were in the range of 21.3 to 37.1 (avg. 30.0) µg/m^3.

Industrial Area

In industrial area (Amausi) the average concentrations of SO_2 was to be 31.3 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 (**Tables 8, 9** and **Exhibit 3).** The main source of SO_2 is the sulphur content in diesel fuel, which is normally present at 0.2%. At present all oil refineries are trying to reduce it to 0.05 to 0.02% level. The level of SO_2 depends on the engine efficiency as well as on the quality and quantity of fuel used. Redesigning of the engine to follow the Bharat -I & II norm reduced the SO_2 level in urban areas to some extent, but levels may increase due to day by day increase in number of vehicle, especially diesel engine driven in the long run.

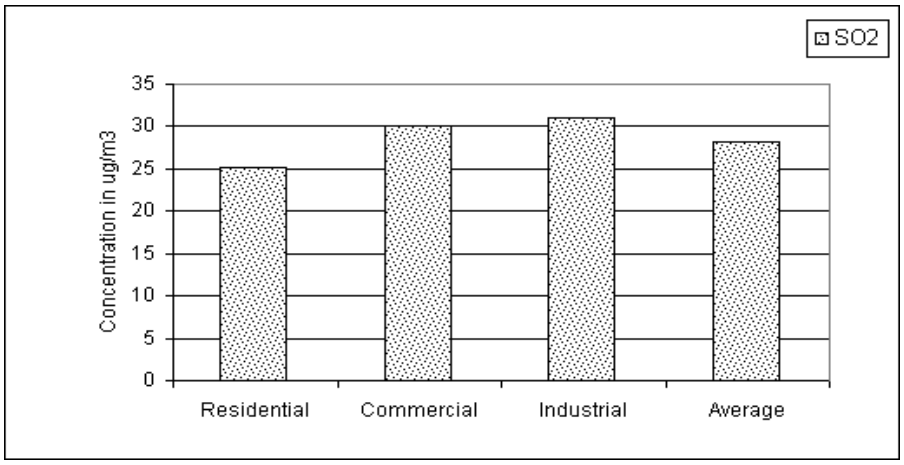

Exhibit 3: Concentration and Average Values of SO_2 at Different Types of Locations

1.5.1.3 OXIDES OF NITROGEN (NO_x)

Residential Area

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the concentrations of NO_X were in the range of 29.2 to 37.1, (avg. 32.4) µg/m^3.

Commercial Area

In commercial areas (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the concentrations of NO_X were in the range of 45.1 to 54.5 (avg. 48.4) µg/m^3.

Industrial Area

In industrial areas (Amausi) the average concentration of NO_x was 40.8 µg/m^3.

All the values of NO_x were within the prescribed limit of the NAAQS of 80 for residential, rural and other areas and 120 µg/m^3 for industrial area (**Table-8, 9** and **Exhibit-4).**

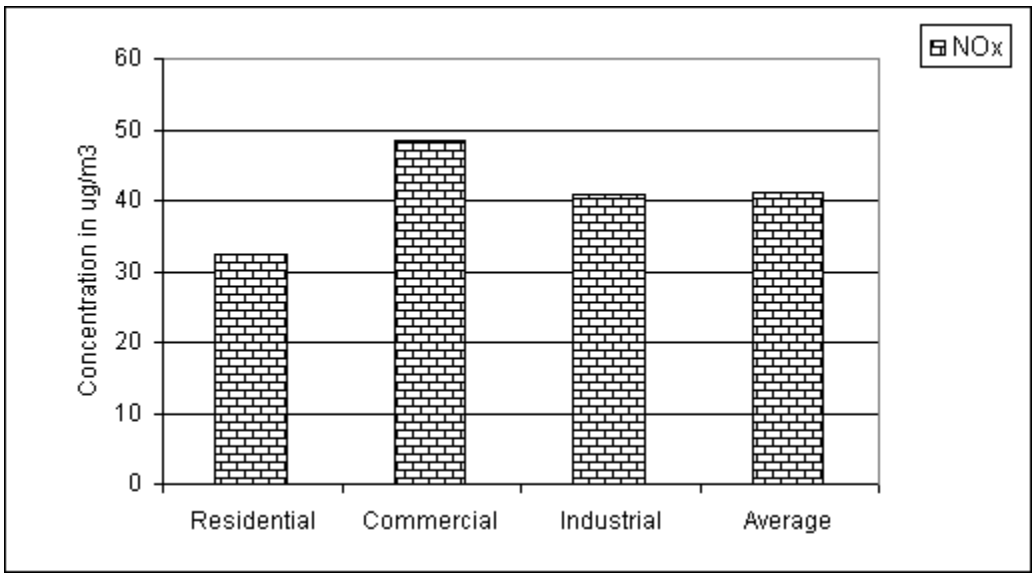

Exhibit 4: Concentration and Average Values of NOx at Different Types of Locations

1.5.1.4 LEAD (Pb)

While leaded petrol was in use, automobile exhaust was considered to be a significant contributor to the total atmospheric lead. With the supply of the total unleaded petrol in the city, this source of lead emission was gradually phased out. However other sources of lead emissions still exists and is therefore reflected in our measurements as summarised in **Tables 8, 9 and Exhibit 5.**

The results revealed that the concentration of Pb in residential area ranged 0.023 to 0.169, (avg. 0.066) µg/m^3. At commercial and traffic junctions it ranged between 0.021 to 0.522, (avg. 0.204) µg/m^3 and in industrial area it was 0.562 µg/m^3. All the values are within NAAQS of 1.0 and 1.5 µg/m^3 for Residential, Rural and Other areas and industrial area respectively.

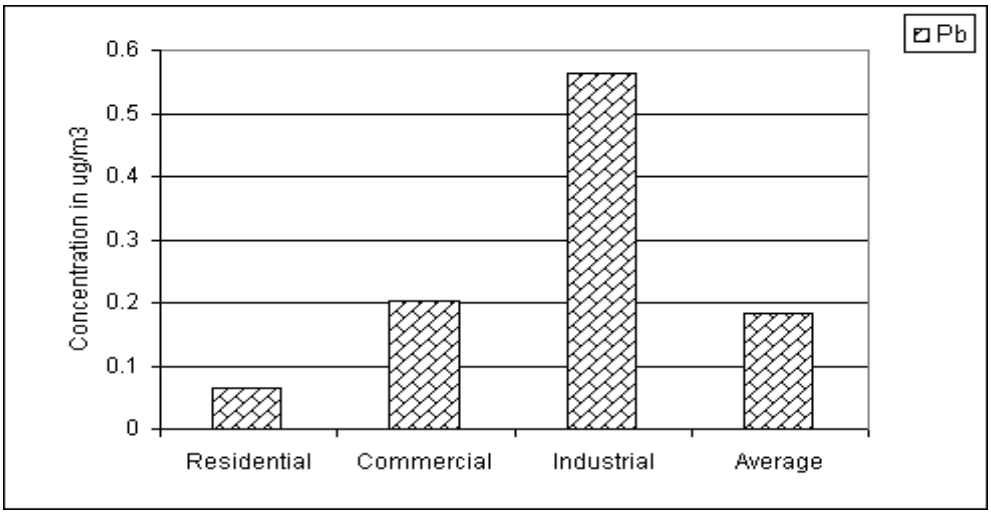

Exhibit 5: Concentration and Average Values of Pb at Different Types of Location

1.5.2 NOISE

Elevated noise levels have been associated with adverse impact on human health, ranging from minor annoyance to physiological damage. Traffic noise has become a major environmental concern and a source of an ever-increasing noise level. 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, 2006) is presented in **Table 9 Exhibit- 6.**

Table-9: Noise Level dB(A) during Day and Night Time

Sl. No.	Area	Location	Day	Night
1	Residential	Aliganj	71.6	65.3
		Vikas Nagar	75.5	68.2
		Indira Nagar	76.9	70.3
		Gomti Nagar	73.4	68.8
2	Commercial	Hussainganj	72.3	73.3
		Charbagh	73.7	71.2
		Alambagh	77.5	69.4
		Aminabad	80.1	78.1
		Chowk	73.5	68.9
3	Industrial	Amausi	74.0	66.1
		Talkatora	76.3	69.2

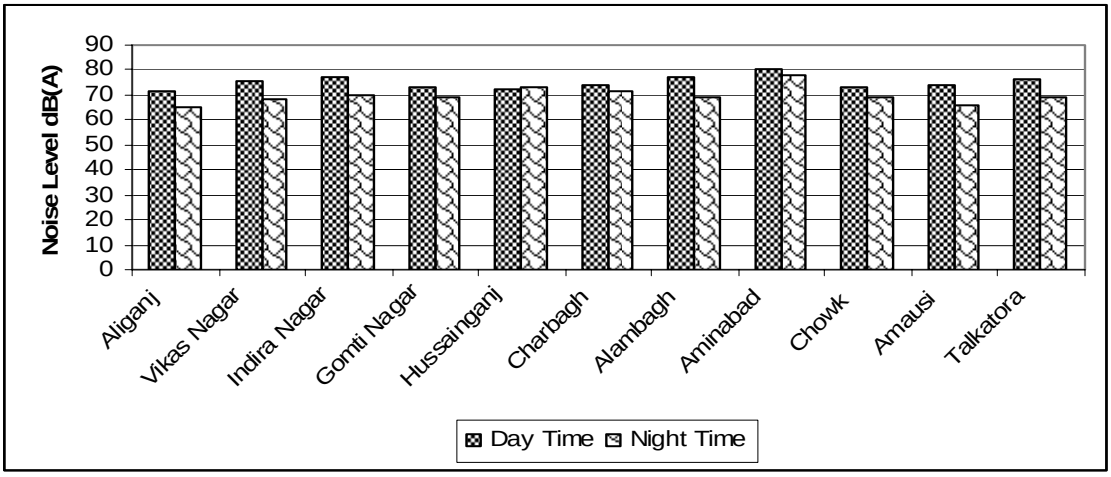

Exhibit 6: Day and Night Time Noise Levels dB(A) in Lucknow City

In residential areas, the day and night time noise level were recorded between 71.6 to 76.9 and 65.3 to 70.3 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 72.3 to 80.1 and 68.9 to 78.1 dB(A) respectively. Noise level at all the commercial sites during day and night time are above the prescribed limit of 65 and 55 dB(A).

In industrial areas, Amausi and Talkatora the day and night time noise level were recorded between 74.0 to 76.3 and 66.1 to 69.2 dB(A) respectively.

1.7 TRENDS

1.6.1 AMBIENT AIR QUALITY

The observed SPM for 8 years (1999 - 2006), SO_2 and NO_x for 9 years (1998 - 2006) data have been compared to know the prevailing trend of air pollution in Lucknow city.

1.7.1.1 Suspended Particulate Matter (SPM)

Among the residential areas, Vikas Nagar shows decreasing trend while Gomti Nagar shows increasing trend, this may be attributed to more commercial and developmental activities of the area. Indira Nagar and Aliganj shows almost similar pattern **(Exhibit 7).**

Among the commercial areas, SPM values showed decreasing trend at all the locations except in Aminabad which showed similar pattern with the previous year value. All the values are higher than the NAAQS. **(Exhibit 8).** Amausi the industrial areas showed a decreasing trend over the previous years and were also within the NAAQS **(Exhibit 9)**.

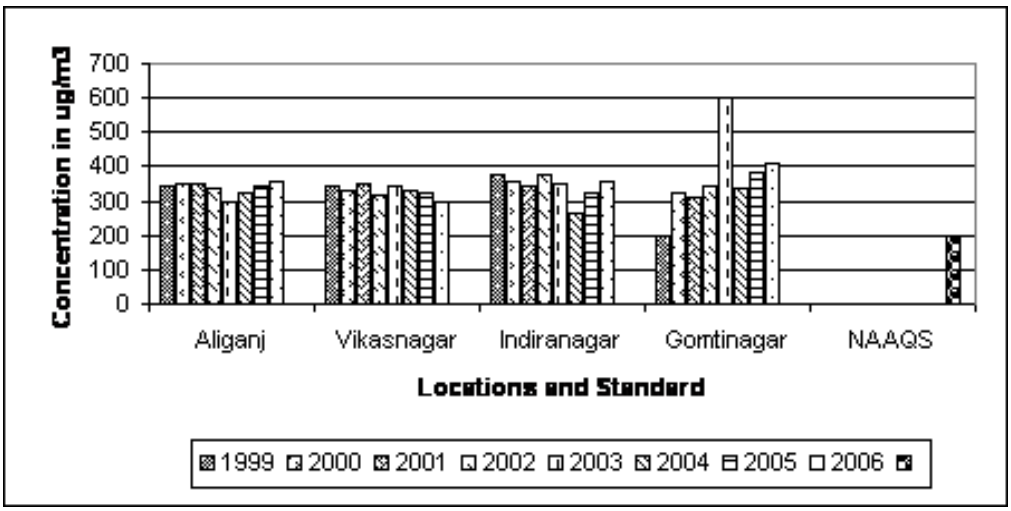

Exhibit- 7: Trend of SPM During 1999-2006 at Residential Areas

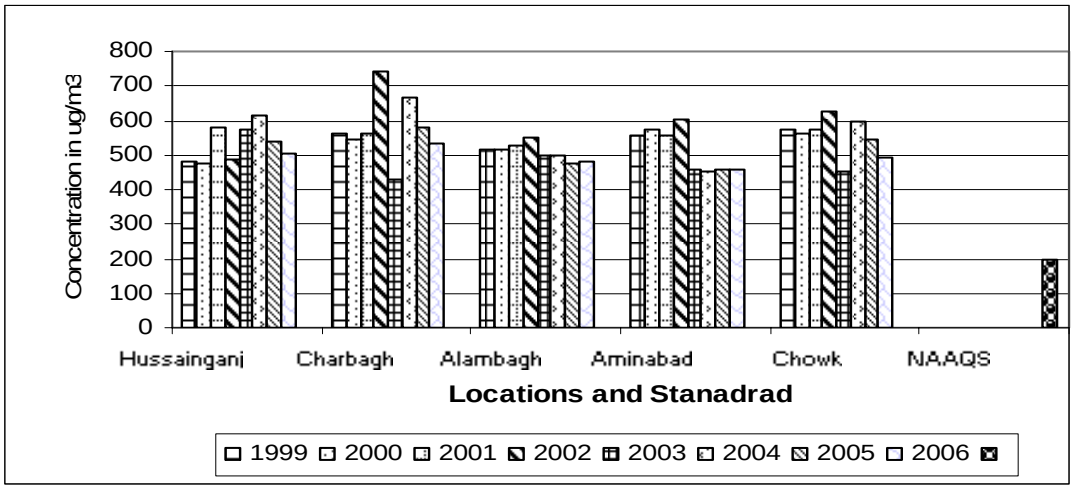

Exhibit- 8: Trend of SPM During 1999-2006 at Commercial Areas

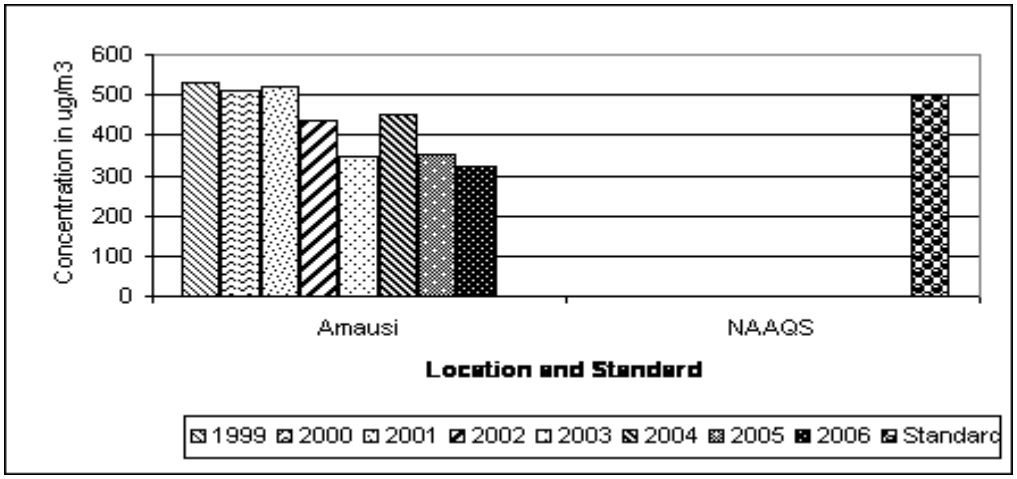

Exhibit- 9: Trend of SPM During 1999-2006at Industrial Areas

1.6.1.2 Sulphur Dioxide (SO_2)

SO_2 level in residential areas registered decreasing trend with comparison to last years values **(Exhibit-10)**.

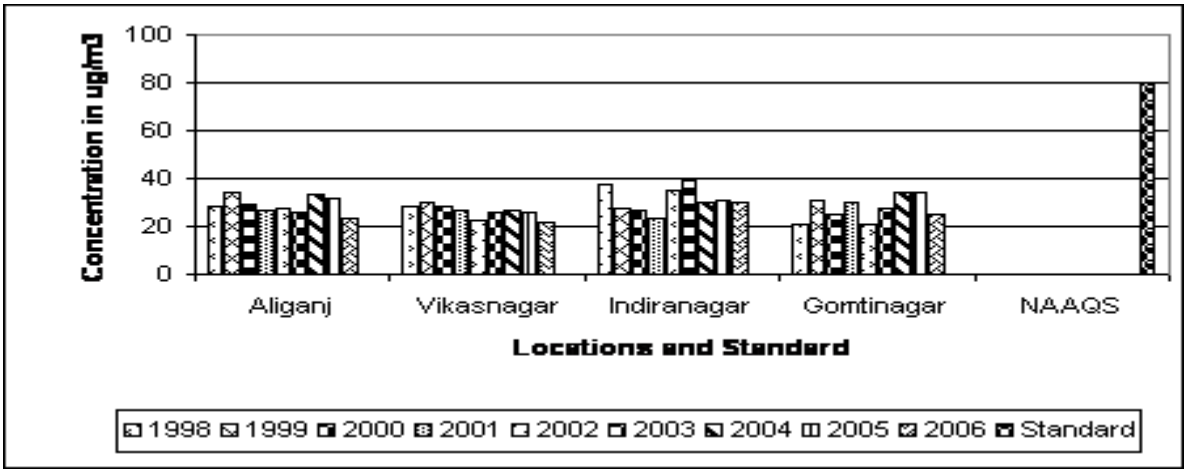

Exhibit- 10: Trend of SO_2 During 1998-2006 at Residential Areas

Among five commercial areas, SO_2 registered a decreasing trend when compared with the last year values **(Exhibit-11)**.

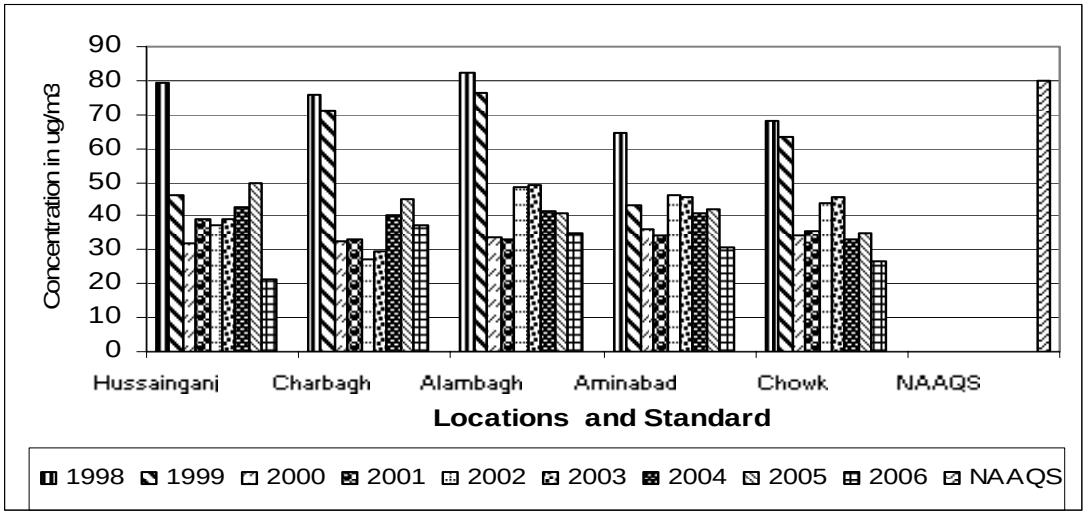

Exhibit- 11: Trend of SO_2 During 1998-2006 at Commercial Areas

The only industrial area Amausi showed decreasing trend when compared with the last year values **(Exhibit-12)**.

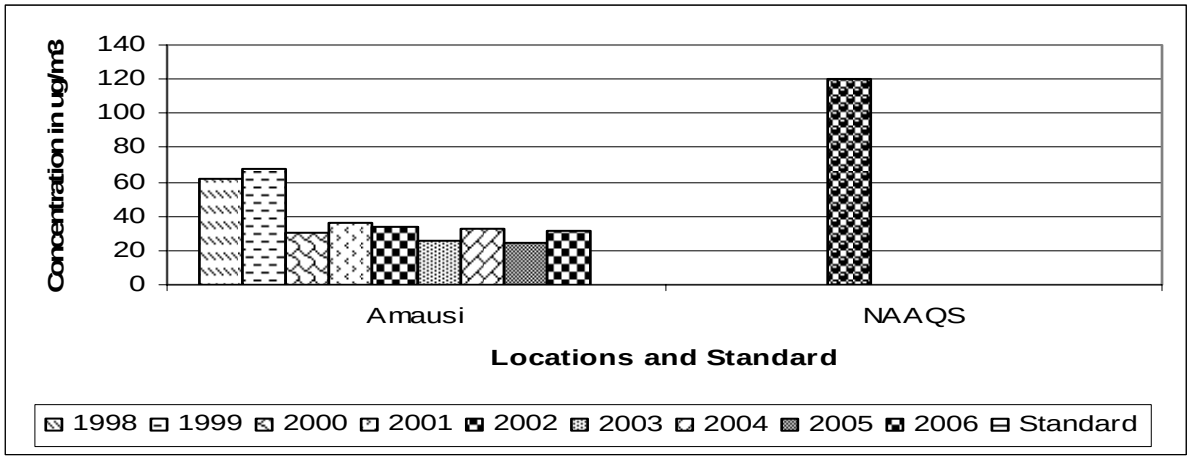

Exhibit-12: Trend of SO_2 During 1998-2006 at Industrial Areas

1.6.1.3 Oxides of Nitrogen (NO_x)

NOx level in residential areas registered increasing trend at Indira Nagar and Gomti Nagar while Aliganj and Vikas Nagar showed more or less same level when compared with last previous years data **(Exhibit-13)**.

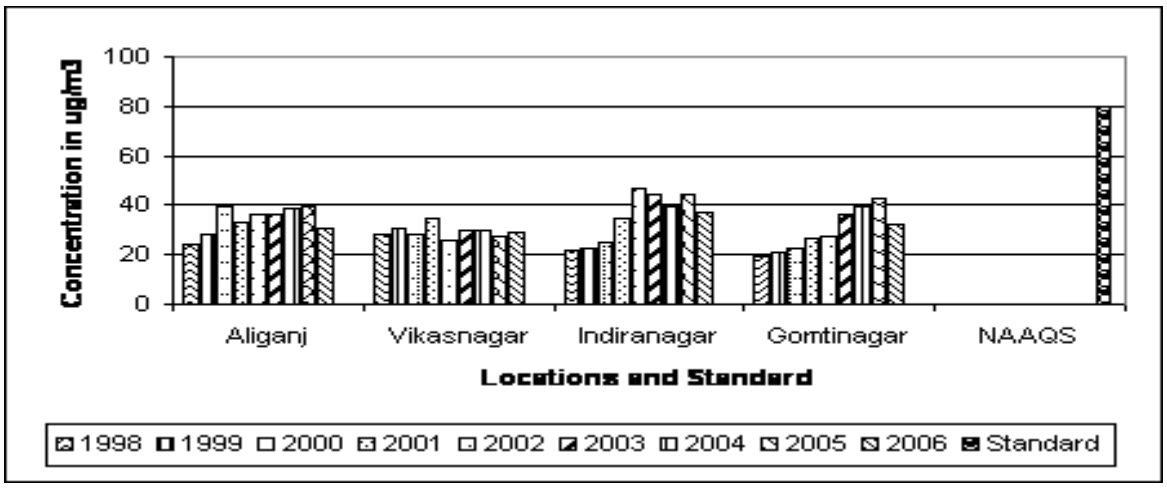

Exhibit- 13: Trend of NO_X During 1998-2006 at Residential Areas

Among commercial areas, NOx registered decreasing trend except at Aminabad, when compared with the last year's data **(Exhibit-14)**.

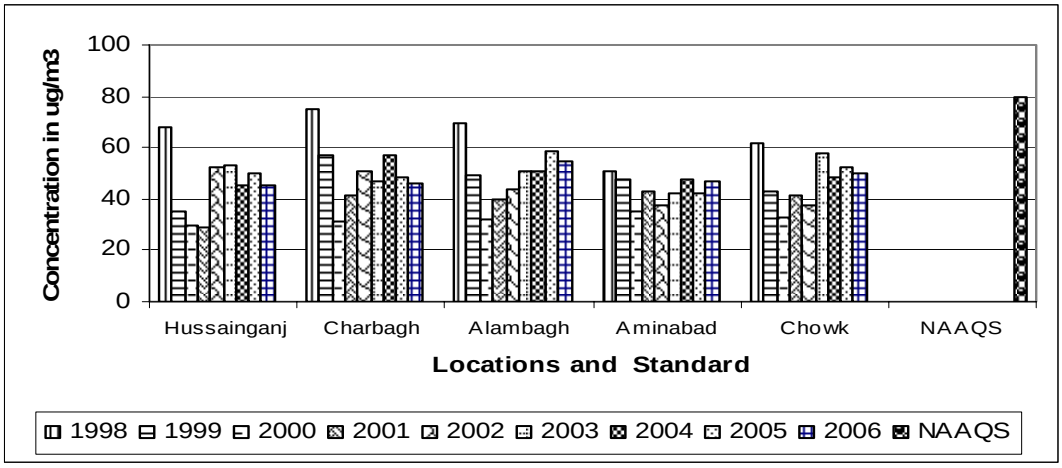

Exhibit- 14: Trend of NO_X During 1998-2006 at commercial Areas

The only industrial area Amausi showed decreasing trend with last year's data but did not show much variation with previous years data **(Exhibit-15)**.

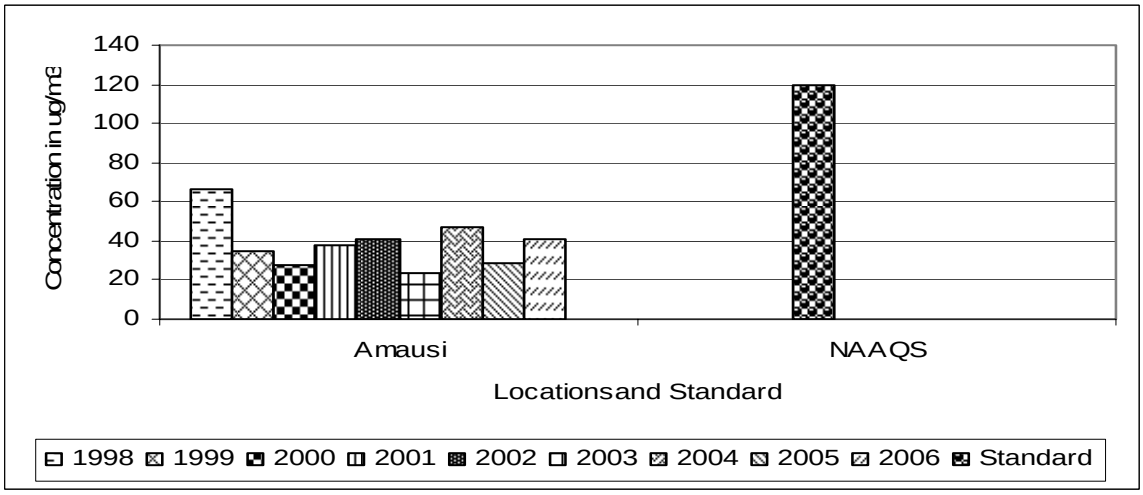

Exhibit- 15: Trend of NO_X During 1998-2006 at Industrial Areas

1.6.2 TRENDS OF NOISE LEVEL

Current year's noise data has been compared with the corresponding data of 2001 to 2005 and presented in **Exhibits 16A, 16B, 16C and 17A, 17B, 17C**. The comparative noise level in residential, commercial and industrial areas are described below:

1.6.2.1 Day Time Noise Level

In residential area, all locations showed higher values than last year **(Exhibit 16A)**.

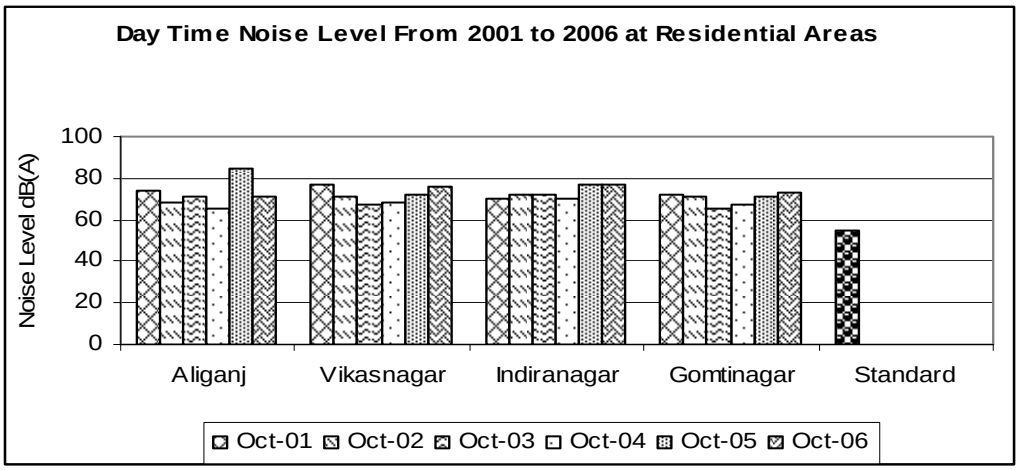

Exhibit-16A: Trend of Day Time Noise Level during 2001 to 2006 at Residential Areas

In commercial cum traffic areas, the noise levels was recorded nearly in the same range as that of last year at Hussainganj and Chowk and in other locations like Charbagh showed slightly lower values and Aminabad showed slightly similar value **(Exhibit 16B)**.

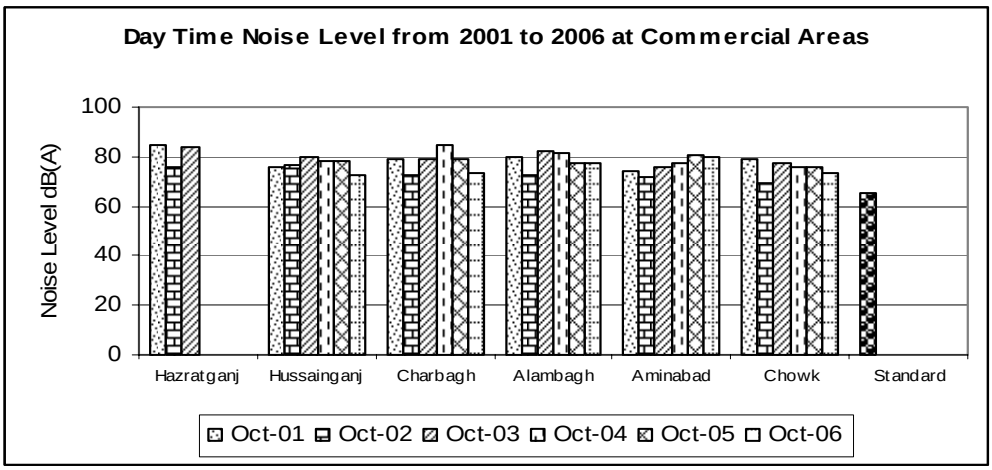

Exhibit-16A: Trend of Day Time Noise Level during 2001 to 2006 at Residential Areas

In Industrial areas Talkatora showed higher value over last year data. The comparative data are presented in **Exhibit 16C.**

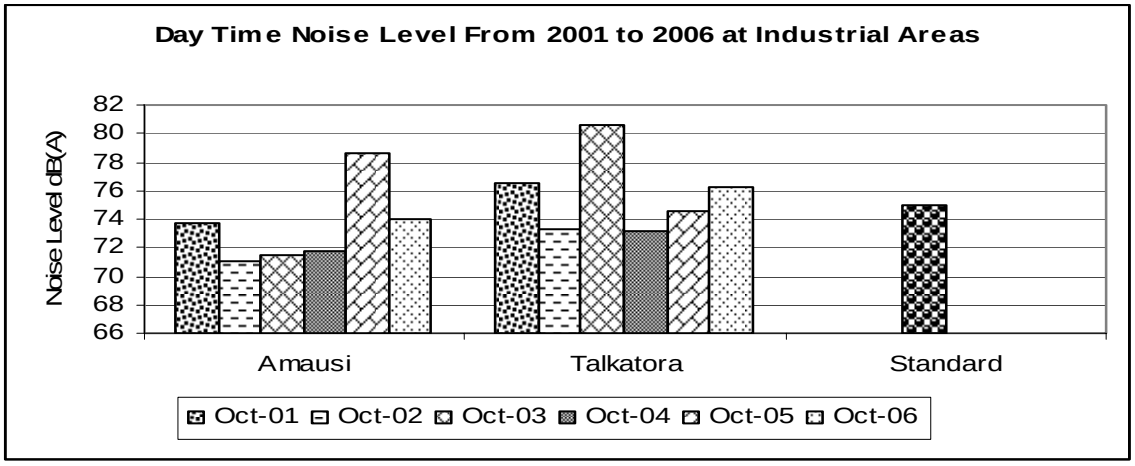

Exhibit-16C: Trend of Day Time Noise Level during 2001 to 2006 at Industrial Areas

1.6.2.2 Night Time Noise Level

In residential area, Indira Nagar registered reducing trend with last year data while Aliganj Vikas Nagar and Gomti Nagar recorded slightly higher values when compared with last year's data **(Exhibit 17A)**.

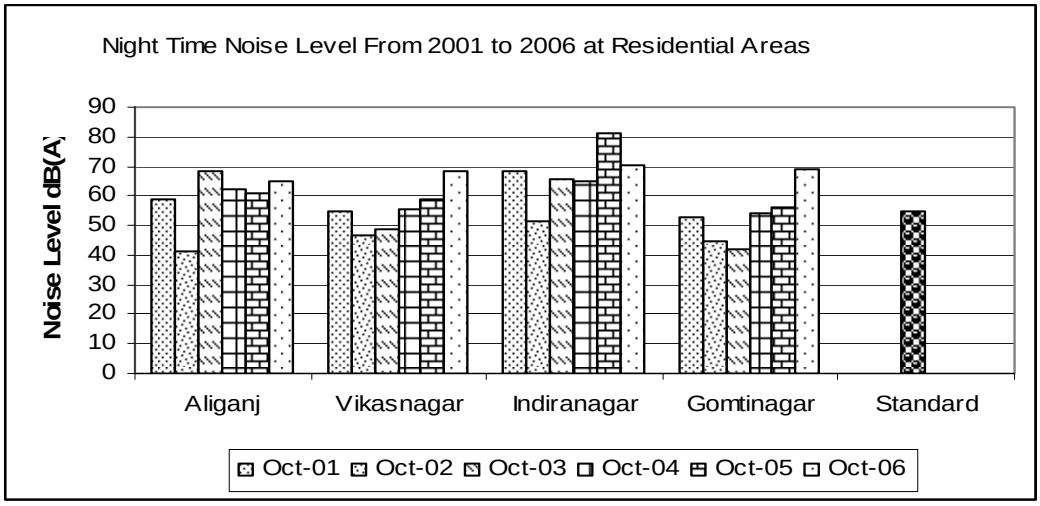

Exhibit-17A: Trend of Night Time Noise Level during 2001 to 2006 at Residential Areas

All the commercial cum traffic areas except Aminabad showed lower values than the last year's data **(Exhibit 17B)**.

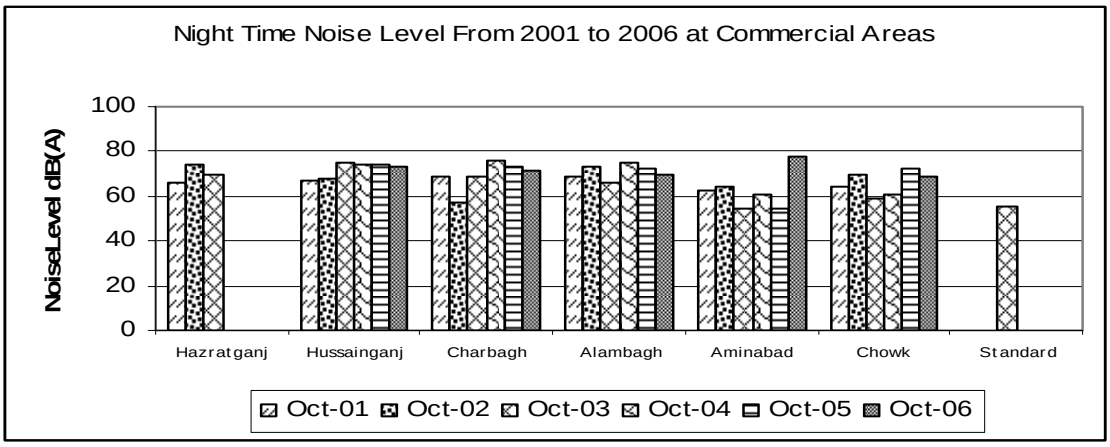

Exhibit-17B: Trend of Night Time Noise Level during 2001 to 2006 at Commercial Areas

In Amausi and Talkatora, the industrial areas did not show significant variation with previous years data in Exhibit **17C.**

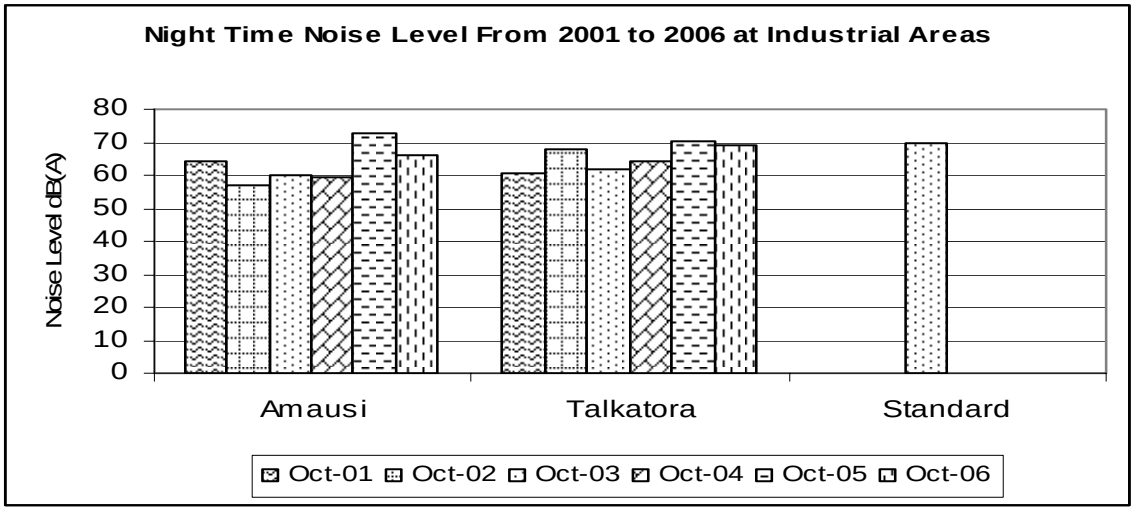

Exhibit-17C: Trend of Night Time Noise Level during 2001 to 2006 at Industrial Areas

1.7 EFFECTS OF POLLUION ON ENVIRONMENT AND HEALTH

Air Pollution creates series of significant health problems including (1) premature death (2) aggravated asthma (3) acute respiratory symptoms (4) decreased lung function in the form of shortness of breath and Chronic bronchitis etc. Particulate matter is also a major cause of visibility impairment enhancing coefficient of haze (COH) in many parts of Asian countries and United States because these particles can scatter and absorb light. Further fine particles can remain suspended in air and travel long distances across regional and international borders without sinking and settling.

Numerous epidemiological studies indicate that an increase in particulate matter concentration is associated with increase mortality, increased hospitalization for respiratory and cardio vascular diseases, increased respiratory symptoms and decreased lung functions. A 10 $\mu g/m^3$ increase in PM_{10} concentration was found to be associated with 1% increase in daily mortality and a 3% increase in asthma attacks, bronchodilator use and lower respiratory symptoms. In England, a 10 $\mu g/m^3$ increase in PM_{10} has been found associated with 2-6% increase in hospital admissions for asthma, bronchitis, pneumonia, all respiratory causes and cerebro-vascular diseases.

1.8 DISCUSSION

All the residential and commercial sampling locations exceeded the National Ambient Air Quality Standard (NAAQS) prescribed threshold limit of 200 and 100 $\mu g/m^3$ for SPM and RSPM respectively which may pose serious health hazards to urban citizens. The observed concentrations for SO_2, NOx, and Pb are within their respective limits (80 $\mu g/m^3$ for SO_2 and NO_X in residential/ commercial areas, 120 $\mu g/m^3$ for SO_2 and NO_X in industrial areas, 1 $\mu g/m^3$ for Pb in residential/ commercial areas, 1.5 $\mu g/m^3$ for Pb in industrial areas).

1.9 RECOMMENDATION

1- Phasing out of grossly polluting vehicles.
2- Public mass transport must be more strengthened to reduce personal vehicles.
3- Improving fuel quality by reducing diesel sulphur and reducing gasoline benzene etc.
4- Regulating agencies have been directed to enforce the standard for control and regulate noise pollution.
5- Implementation of regular ambient air and noise quality monitoring.
6- Complete ban on pressure horns.
7- A loud speaker or public address system shall not be used accept after obtaining written permission from the authority.

1.10 CONCLUSION

Pollution is involved with the growth and development of the city. Pollution level is directly proportional to the population as well as vehicular population of that city. Population is the root cause of all problems. Hence, to control the pollution/population of the city, the reduction of birth rate is necessary and migration/ influx of people has to be checked though the overall growth and development of the rural areas, because each city has its own carrying capacity. Most of the roads are rapidly loosing the smooth flow of vehicles at an optimum speed (40 - 45 km/hr) due to overcrowding. Due to the use of CNG (Compressed Natural Gas), fine particles are also expected to be found in the atmosphere from excessive emissions

of SO_2, NO_x and Volatile compounds. There is need to correlate environmental pollution vis a vis health risk morbidity due to seasonal variation. Thus it is necessary to monitor the air quality as well as health effects at regular interval of Lucknow city.

2.0 BACTERIOLOGICAL QUALITY OF DRINKING WATER IN LUCKNOW CITY, OCTOBER 2006: POST- MONSOON

2.1 INTRODUCTION

Drinking water is one of the basic needs of life and essential for survival. According to the World Health Organization (WHO) report, approximately 2.5 billion people in developing world and about 80% disease world wide are associated with contaminated drinking water. Several water born diseases are due to consumption of contaminated drinking water, particularly in undeveloped and developing countries.

In Lucknow city the prime source of municipal water supply is Gomti River flowing through the middle of city and booster pumps getting ground water through tube wells to supplement the piped supply in different areas of the city. The major source of water contamination is the faecal wastes of sewage. Apart from this, broken pipes and loose joints in the distribution system are also responsible for water contamination through seepage and back suction of sewage. More often improper cleaning and maintenance of overhead tanks and water reservoirs in water works as well as unhygienic conditions at consumer's level have been found to be responsible for water contamination. In addition to these, inadequate chlorination at the source of supply is also responsible for improper disinfection of supplied drinking water at consumers end.

2.2 MICROBIAL AGENTS OF WATER BORNE DISEASES

The pathogenic bacteria causes several water borne diseases like diarrhoea, gastroenteritis, cholera, dysentery, typhoid, amoebiasis, giardiasis, meningitis, poliomyelitis, encephalitis, hepatitis, schistosomiasis etc. Gastroenteritis, cholera, dysentery and typhoid are the most common in tropical as well as subtropical countries particularly in warmer months. The causative bacteria of these diseases are *Escherichia coli*, *Vibrio cholerae*, *Shigella dysentriae* and *Salmonella typhimurium***,** respectively.

2.3 WATER SAMPLING

Water quality surveillance (post-monsoon) of drinking water from piped water supplies and ground water sources (hand pumps and tube wells) in Lucknow city has been conducted during October 2006. On the basis of usage, whole city has been divided in three areas viz. residential (11), commercial (6) and industrial (3) areas based on the population and social activities. The localities identified for the survey are: Aliganj, Vikas Nagar, Indira Nagar, Gomti Nagar, Paper Mill Colony, Nirala Nagar,

Triveni Nagar, Rajajipuram, Model House, Ashiana and Sadar Cantt. in residential area, Charbagh, Alambagh, Chowk, Hazratganj, Hussainganj and Aminabad in commercial area along with Aishbagh, Amausi and Talkatora in industrial area. Fifty-five samples from residential area, thirty from commercial area and fifteen from industrial area were collected. All the hundred water samples were collected in sterilized glass bottles and analysed for their bacteriological quality assessment by determining the most probable number (MPN) of coliforms and faecal coliforms per 100 ml of sample according to standard methods BIS and APHA.

2.4 CONCLUSION AND RECOMMENDATIONS

In residential area 33% samples (18 / 55), in commercial area 40% sample (12 / 30) and in industrial area 47% sample (07 / 15) were found to be contaminated with ≥10 coliforms and /or >1faecal coliforms / 100 ml as per Indian standard for drinking water (BIS, 2003). The analysis shows that bacterial contamination is more in samples from industrial areas than those from remaining two areas (Table–1). Source-wise observations revealed that 48% piped supply and 26% of ground water samples from hand pumps were found bacteriologically unsafe for drinking purpose in the Lucknow city (Table -2 & Fig. 1). Therefore, it requires periodic water quality monitoring with special emphasis on proper disinfection and maintenance of drinking water sources.

Table - 1: Bacteriological Quality of Drinking Water in Lucknow City, October 2006 (Post-monsoon survey)

Sl. No.	Areas	Locations	Total No. of Sample	Coliform* contamin-ated samples	Faecal coliform* contamin-ated samples	Total No. samples with ≥ 10 coliform and/or ≥ faecal coliform	Source of contami-nated sample	Total contamin-ated samples
1	RESIDENTIAL	Aliganj	5	2	2	2	PS&HP	18/55 (33%)
2		Vikas Nagar	5	2	1	2	PS&HP	
3		Indira Nagar	5	3	3	3	PS&HP	
4		Gomti Nagar	5	4	3	4	PS&HP	
5		Paper Mill Colony	5	0	0	0	-	
6		Nirala Nagar	5	1	0	1	PS	
7		Triveni Nagar	5	2	1	2	PS	
8		Rajajipuram	5	1	1	1	PS	
9		Model House	5	1	0	1	PS	
10		Ashiana	5	2	2	2	PS	
11		Sadar Cantt.	5	0	0	0	-	
12	COMMERCIAL	Charbagh	5	2	1	2	PS&HP	12/30 (40%)
13		Alambagh	5	2	1	2	PS	
14		Chowk	5	2	2	2	PS&HP	
15		Hazratganj	5	1	0	1	PS	
16		Hussainganj	5	1	0	1	PS	
17		Aminabad	5	3	3	4	PS&HP	
18	INDUST-RIAL	Amausi	5	2	0	2	PS&HP	07/15 (47%)
19		Talkatora	5	3	1	3	PS	
20		Aishbagh	5	2	1	2	PS & HP	
	TOTAL		100	36	22	37	PS – 24 HP– 13	37/100 (37%)

* Samples with >10 coliform/100 ml and / or > 1 faecal coliform/100 ml as per Indian Standard for Drinking Water Specifications of Bureau of Indian Standard (BIS, 2003).

Table– 2: Contamination profile of drinking water in Lucknow city in post- monsoon, 2006

Area	Piped supply water (PS)		Ground water (GW)		Total samples	
	No. of sample analyzed	No. of Contaminated samples (%)	No. of sample analyzed	No. of Contaminated samples (%)	No. of sample analyzed	No. of Contaminated samples (%)
Residential	26	11 (42.31)	29	07 (24.14)	55	18 (32.73)
Commercial	16	08 (50.00)	14	04 (28.57)	30	12 (40.00)
Industrial	08	05 (62.50)	07	02 (28.57)	15	07 (46.67)
Total	50	24 (48.00)	50	13 (26.00)	100	37 (37.00)