

# **ASSESSMENT OF AMBIENT AIR QUALITY OF LUCKNOW CITY**

**(POST- MONSOON 2014)**

**FINDINGS OF A RANDOM SURVEY**

**PRESENTED ON 49<sup>th</sup> IITR FOUNDATION DAY**



**CSIR- INDIAN INSTITUTE OF TOXICOLOGY RESEARCH**

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## **Salient Features of the Study**

- ❖ **Geographical Position** : 26° 52' N Latitude  
80° 56' E Longitude  
128 m above Sea Level
- ❖ **Area** : 310 sq. km.
- ❖ **Population** : 28,15033 as per 2011 Census
- ❖ **Climate** : Subtropical climate, cool dry winter (Dec. - Feb.) & summer (Mar - Jun.).  
Temperature about 45<sup>0</sup>C in summer to 3<sup>0</sup>C in winter. Average annual rainfall about 100 cm.
- ❖ **Total Vehicular Population in Lucknow city as on 31/03/2014** : 15,52,695
- ❖ **Growth of Vehicle over 2012-2013** : 9.0%
- ❖ **Total No. of Filling Stations (Petrol/Diesel/CNG)** : 100
- ❖ **Consumption of Petrol** : 1,38,755 KL
- ❖ **Consumption of Diesel** : 1,55,226 KL
- ❖ **Consumption of CNG** : 2,62,55,742 Kg
- ❖ **Major Source of Pollution** : Automobiles, D. G. sets, Civil Constructions
- ❖ **Parameters Monitored** : PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>x</sub>, Trace metals and Noise
- ❖ **Study Conducted by** : Environmental Monitoring Division  
CSIR-IITR, Lucknow

# ASSESSMENT OF AMBIENT AIR QUALITY OF LUCKNOW CITY DURING POST-MONSOON, 2014

Environmental Monitoring Division  
CSIR- Indian Institute of Toxicology Research  
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## 1.0 SUMMARY

*The study was carried out during the month of October, 2014 to see the status of air quality by monitoring and assessment of some selected air pollutants namely Respirable Particulate Matter (RSPM or  $PM_{10}$ ), Sulphur dioxide ( $SO_2$ ), Oxide of Nitrogen ( $NO_x$ ) and noise level at 9 representative locations, categorized as residential (four), commercial (four) and industrial (one) areas in Lucknow city. The results revealed the 24 hours concentration of  $PM_{10}$  to be in the range of 123.5 to 342.7  $\mu\text{g}/\text{m}^3$  with an average of 202.9  $\mu\text{g}/\text{m}^3$ . The average values of  $PM_{10}$  irrespective of the locations were found to be above the permissible limit ( $PM_{10}=100 \mu\text{g}/\text{m}^3$ ) prescribed by MoEF. 24 hours concentration of  $SO_2$  and  $NO_x$  were found in the range of 8.4 to 25.5 and 39.9 to 108.3  $\mu\text{g}/\text{m}^3$  with an average concentration of 17.3 and 61.2  $\mu\text{g}/\text{m}^3$  respectively and all the values were below the permissible limits ( $80 \mu\text{g}/\text{m}^3$ ) except for one location. The trace metals Ni & Pb which are associated with  $PM_{10}$ , 24 hours concentration were found to be in the range of 20.6 to 68.2 with an average of 31.1  $\text{ng}/\text{m}^3$  for Ni and all the Ni values were found to be above the permissible limit of annual average ( $20 \text{ng}/\text{m}^3$ ) and 48.4 to 1161.5 with an average of 298.5  $\text{ng}/\text{m}^3$  for Pb and was found to be within the permissible limit ( $1000 \text{ng}/\text{m}^3$ ) except for one location. Noise levels during day and night time were found in the range of 66.1 to 78.8 dB(A) and 54.6 to 72.5 dB(A) which were above the respective permissible limits (day and night time noise levels in residential area are 55 and 45 dB(A) and corresponding values for commercial area are 65 and 55 dB(A) respectively except in industrial area which is 67.6 and 66.7 dB(A) during day and night time respectively. .*

## 1.1 INTRODUCTION

Today, adverse health effect of air pollution is a serious issue in urban areas particularly in developing countries like India. In general, some criteria pollutants like particulate matter, SO<sub>2</sub>, NO<sub>x</sub> are quantified for the assessment of ambient air quality and the major source of these pollutants are burning of fossil fuels. In urban areas, mainly gasoline, diesel and CNG are used by vehicles which are the major sources of air pollutants. Epidemiological studies suggest that air pollutants like Particulate matter, SO<sub>2</sub> and NO<sub>x</sub> are significantly co related with cardiovascular morbidity and mortality. The effect of air pollutants depends on the concentration, chemical and physical characters of pollutants. The particulate matter (PM) is a carrier of number of pollutants like trace elements, Poly aromatic hydrocarbons etc. Inhalation of these pollutants with particulate matter is a matter of serious concern as most of the big cities particularly in India including Lucknow reported higher than permissible limit of PM specified by Ministry of Environment & Forests, Govt. India.

Violation of traffic rules and unnecessary use of vehicle horn is responsible for elevated noise levels in urban area. The 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 vehicular engines, exhaust systems, aerodynamic friction, and tyre-pavement interaction. Traffic noise is affected by factors such as traffic volume and speed, pavement type and vehicle conditions.

Lucknow, the capital city of Uttar Pradesh, also figures in the list of most polluted cities and presently, faces the twin challenge of managing the demands of a growing city while still maintaining the quality of the environment. As per records, the area of the city is about 310 km<sup>2</sup>, which is projected to be increased up to 1000 km<sup>2</sup> as per planned development of the city. Lucknow has witnessed rapid development during the last decade. Large monument such as Ambedkar Park, Ramabai Smriti Sthal, Ambedkar Maidan, Jyotiba Phule Park, Janeshwar Mishra Park etc. have come up in the city. The construction work has continued for over the years. The approach roads these places are either newly built or has been widened. Real estate development in the outskirts, and vacant area was taken up in a big way. These areas are connected to

the old city by new roads. A number of flyovers have also been constructed on existing as well as new roads. Under JNNURM yojna, sewage pipe lines were laid down across the city for which roads were dug-up and remained unpaved for quite some time before it was again re-constructed. LDA and private developers have built a number of multi storied apartments across the city.

The extensive construction activity generated a lot of dust across the city. The increased vehicular movement for supply of material and other commercial activities has also contributed to the particulates and gaseous pollutants. The average growth rate (near about 10%) in registered vehicles clearly indicates that the vehicular pollution is the major cause of air pollution in the city.

Some studies on air pollution sources in Lucknow have estimated about 60-70% contribution from transport sector in air pollution load of city. Every year on Dhanteras/Diwali large number of vehicles are purchased by residents of Lucknow city. More vehicles per unit area on road results in crawling traffic jams on most of the major crossings of the city which also adds to the city air pollution.

The areas developed in the outskirts have four lane roads. In the absence of suitable public transport systems in newly developed areas, people staying there mostly use their own vehicles (car/bikes). This also adds vehicular load on the main city roads, as well as adding more air pollution to the city levels.

In view of the above facts, it is the need of the hour to look into the air quality of our city Lucknow, the capital of Uttar Pradesh which has a population of 28.15 Lakh (Municipal corporation + Cantonment) as per 2011 census and an area of 310 sq. km. Vehicular traffic is the main source of particulate air pollution in Lucknow city. Continuous emission of pollutants from vehicular traffic adversely affects the ambient air quality as well as the health of human being. The number of different categories of vehicles registered with RTO (Regional Transport Office) Lucknow is 15,52,695 as on 31.03.2014 which is 9.0% higher over the last year (Table 1). 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 31.03.2014 are given

in Table 2. In Lucknow city there are 100 filling stations for petrol, diesel and CNG operated by different oil companies (Table 3).

As per Indian Oil Corporation (IOC), the consumption/sale of petrol and diesel was 1,38,755 and 1, 55,226 KL as on 31-03-2014. It is observed that petroleum sale has increased by 8.03% whereas sale of diesel has increased by 13.41%. (Table 4). In Lucknow there are six CNG filling stations and consumption of CNG during last year was approximately 2,62,55,742 Kg (2013-14) which was 10.26% higher than the previous year (2012-13) (Green Gas Limited, Lucknow). Distribution and number of CNG vehicles in Lucknow is summarized in Table 5. Considering the above, assessment of ambient air quality of Lucknow city was carried out at 9 locations during post monsoon (October), 2014 with respect to PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>x</sub> and Noise level with the following aims and objectives.

- To assess the ambient air quality with respect to PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>x</sub>. Trace metals and Noise.
- 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

**Table 1. Vehicles registered with R.T.O. Lucknow during 2012-13 and 2013-14**

Sl. No.	Type of Vehicle	Number of Registered Vehicles on 31 <sup>st</sup> March		% Change
		2012-13	2013-14	
1	Multi Articulated	2770	2974	7.36
2	Light, Medium and Heavy weight Vehicles (Four wheeler)	17142	18430	7.51
3	Light commercial vehicles (Three wheeler)	3170	3225	1.73
4	Buses	3181	3249	2.13
5	Taxi	7089	7797	9.98
6	Light Motor Vehicles (Passenger)	7246	7743	6.85
7	Two wheelers	1136822	1238691	8.96
8	Car	201628	221019	9.61
9	Jeep	19612	22175	13.06
10	Tractor	20417	22010	7.80
11	Trailors	1421	1469	3.37
12	Others	3980	3913	-1.68
<b>Total</b>		<b>1424478</b>	<b>1552695</b>	<b>9.0</b>

Source: RTO, Lucknow



**Table 2. Details of Lucknow City Bus Service, 2014**

Sl. No.	Route No.	To and From	No. of Buses	Frequency
1	11	BBD -Chinhat-Gomti Nagar-Lohiya Park- Tikonia park- Dainik Jagran – Sikendrabagh Jaharbhavan – GPO- Hussainganj- KKC-Charbagh	19	10 minutes interval
2	12	BBD- Chinhat- Polytechnic-Bhoothnath –Badshanagar- Nioshatganj- Sikendrabagh- G.P.O- Hussainganj- Charbagh- Alambagh- Avadh hospital.	9	15 minutes interval
3	13	Charbagh –Mobaiya-Alambagh thana-Teriphulia- Alambagh-bus stand-Awadth Hospital-Krishnagarthana- Natherganj –Sccoter India-Koti Bagia.	10	12 minutes interval
4	23	Behta- Integral University-Gudamba – Vikasnagar- Nishatganj-Sikendrabagh-G.P.O.-Hussainganj-Chargbagh Alambagh- Avadh hospital-Rajnikhand	21	10 minutes interval
5	24	Munshiphulia-Bhoothnath Indiranagar – Nishatganj- Hazratganj-Hussainganj –Charbagh-Alambagh- Krishnagar-Parag diary- Paasi Kila	10	15 minutes interval
6	31	IIM - P &T - Purania- Kapoorthala - Goal Market- Nishatganj_ Sikendrabagh-Shakti Bhavan - Hussainganj- Charbagh-Alambagh	2	60 minutes interval
7	33	Engineering College- Purania- Kapoorthala - Goal Market-Nishatganj-Sikendrabagh-Shakti Bhavan - Hussainganj-Charbagh-Alambagh-Avadh hospital.	20	10 minutes interval
8	45	Virajkhand-Gomtinagar- Lohiya hospital-Polytechnic – Lekraj-Nishatganj- Sikendrabagh-Shakti Bhavan - Hussainganj-Charbagh-Alambagh-Avadh hospital Krishnagar –Parag diary- Passi Kila-Shahid path	16	15 minutes interval
		Total	107	

Source: UPSRTC, Lucknow

**Table 3. Fuel Outlets in Lucknow City**

Sl. No.	Agency	Number of outlets
		31 <sup>st</sup> March 2014
1	Indian Oil Corporation (IOC)	47
2	Bharat Petroleum Corporation Ltd. (BPCL)	22
3	Hindustan Petroleum Corporation Ltd. (HPCL)	25
4	Compressed Natural Gas Stations (CNG)	6
	Total	100

Source: Indian Oil Corporation (IOC), Lucknow

**Table 4. Consumption of Fuel (in KL) in Lucknow**

Sl. No.	Agency	Petrol (Unleaded)			High Speed Diesel			*CNG		% Change
		Apr. 12 to Mar. 13	Apr. 13 to Mar. 14	% Change	Apr. 12 to Mar. 13	Apr. 13 to Mar. 14	% Change	Apr. 12 to Mar. 13	Apr. 13 to Mar. 14	
1	IOC	71217	77693	9.09	75456	88234	16.93	--	---	
2	BPCL	33172	34178	3.03	28234	31497	11.56	--	---	
3	HPCL	24051	26884	11.77	33180	35495	6.97	--	---	
4	Green Gas	--	--	--	--	--	--	2,38,11,473	2,62,55,742	10.26
<b>Total</b>		<b>128440</b>	<b>138755</b>	<b>8.03</b>	<b>136870</b>	<b>155226</b>	<b>13.41</b>	<b>23811473</b>	<b>26255742</b>	<b>10.26</b>

Source: Indian Oil Corporation (IOC), Lucknow, \* CNG in Kg, CNG Source: Green Gas Limited, Lucknow

**Table 5. Distribution of CNG vehicles**

Sl. No.	Vehicles	Number		% of change
		2012-2013	2013-14	
1	Auto Rickshaws	4343	4343	0.0
2	Tempo Taxi	2534	2575	1.61
3	Buses (UPSRTC)	260	260	0.0
4	Buses (Private)	36	36	0.0
5	School Buses	878	985	12.18
6	School Van	753	962	27.75
7	Private Vehicles	83	205	146.98
8	Private Cars	5788	7943	37.23
	<b>Total</b>	<b>14675</b>	<b>17309</b>	<b>17.94</b>

Source: Green Gas Limited, Lucknow

## 1.2 MONITORING LOCATIONS AND METHODOLOGY

Nine air quality monitoring locations representing different activities/areas i.e., four in residential, four in commercial cum traffic and one industrial area were selected for the study as summarized in Table 6 ( brief description of each location is given in our earlier reports (Pre and Post monsoon, 2010) and parameters along with methodology is given in Table 7.

**Table 6. Monitoring Locations**

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

**Table 7. Parameters and Methodology for Air Quality Monitoring**

Sl. No.	Parameters	Time Weighted average	Methods of Measurement
1	Particulate Matter-PM <sub>10</sub>	24 hours	Gravimetric
2	Sulphur dioxide (SO <sub>2</sub> )	24 hours	Improved West Gaeke
3	Nitrogen Dioxide(NO <sub>2</sub> )	24 hours	Modified Jacob & Hochhesier (Na-Arsenite)
4.	Noise Level	1 hour	The measurement of noise level was carried out during the day (6 AM to 10 PM) and night time (10 PM to 6 AM) by Noise level Meter

### 1.3 RESULTS

The detailed results of air quality monitoring are presented in Table 8 and Fig. 1.

#### 1.3.1 Respirable Suspended Particulate Matter (RSPM or PM<sub>10</sub>)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar), the 24 hours average concentrations of PM<sub>10</sub> were in the range of 169.2 to 234.2 µg/m<sup>3</sup> with an average of 192.4 µg/m<sup>3</sup>. In commercial areas (Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of PM<sub>10</sub> were in the range of 177.1 to 260.6 µg/m<sup>3</sup> with an average of 217.5µg/m<sup>3</sup> respectively. In industrial area (Amausi), the average concentrations of PM<sub>10</sub> were 186.6 µg/m<sup>3</sup>.

The maximum 24 hours mean concentration of PM<sub>10</sub> was observed in Indira Nagar (234.2 µg/m<sup>3</sup>) in residential area and Chowk (260.6 µg/m<sup>3</sup>) in commercial area.

All the values of PM<sub>10</sub> were above the prescribed National Ambient Air Quality Standard (NAAQS) of 100 µg/m<sup>3</sup> for industrial, residential, rural and other area respectively.

### **1.3.2 Sulphur dioxide (SO<sub>2</sub>)**

In residential area (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the mean levels of SO<sub>2</sub> were in the range of 13.8 to 17.9 µg/m<sup>3</sup> with an average of 16.0 µg/m<sup>3</sup>. In commercial area (Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of SO<sub>2</sub> were in the range of 15.5 to 20.8 µg/m<sup>3</sup> with an average of 18.5 µg/m<sup>3</sup>. In industrial area (Amausi) the average concentration of SO<sub>2</sub> was 17.3 µg/m<sup>3</sup>.

All the values of SO<sub>2</sub> were well below the prescribed NAAQS of 80 µg/m<sup>3</sup> for all the locations.

### **1.3.3 Oxides of Nitrogen (NO<sub>x</sub>)**

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the 24 hours average concentrations of NO<sub>x</sub> were found in the range of 50.9 to 56.2 µg/m<sup>3</sup> with an average of 53.3 µg/m<sup>3</sup>. In commercial areas (Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of NO<sub>x</sub> were found in the range of 42.3 to 86.4 µg/m<sup>3</sup> with an average of 66.8 µg/m<sup>3</sup>. In industrial areas (Amausi) the average concentration was 70.6 µg/m<sup>3</sup>.

All the values of NO<sub>x</sub> were within the prescribed NAAQS of 80 µg/m<sup>3</sup> for all the monitoring locations except one commercial (Charbagh).

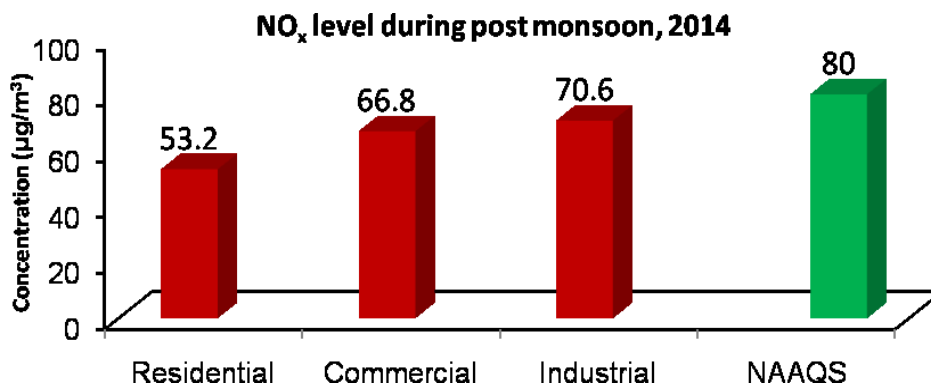
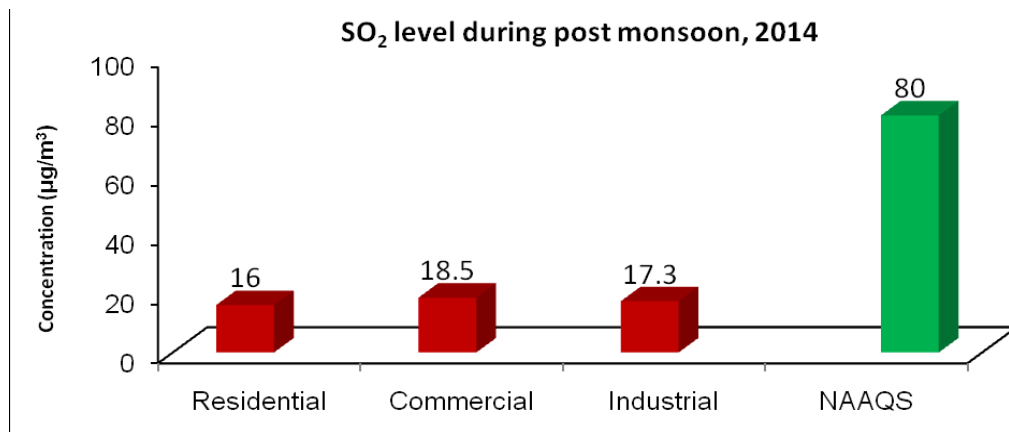
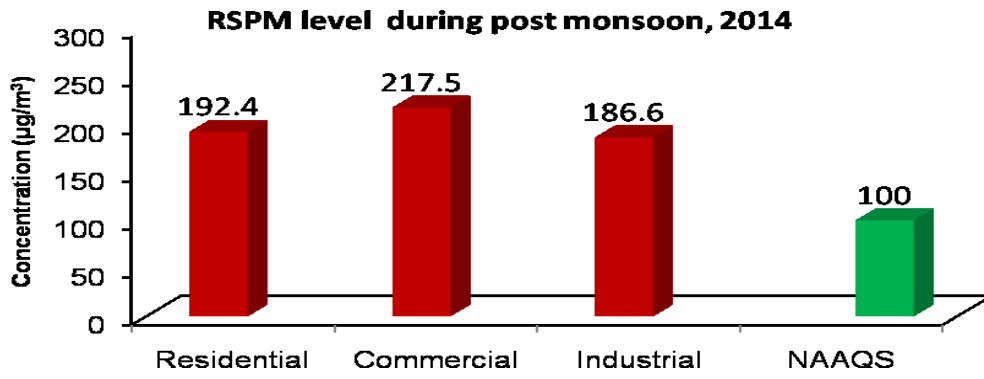
### **1.3.4 Trace Metals in Ambient Air (RSPM or PM<sub>10</sub>)**

The trace metals (Ni and Pb) were estimated in ambient air associated with PM<sub>10</sub> at 9 monitoring locations. The results are present in Table 9. The 24 hr mean concentration of metals were found to be Ni = 31.14, (20.63-68.22) ng/m<sup>3</sup> and Pb = 298.52 (48.43- 1161.53) ng/m<sup>3</sup>.

**Table 8. Concentration ( $\mu\text{g}/\text{m}^3$ ) of RSPM,  $\text{SO}_2$  and  $\text{NO}_x$  during Post monsoon 2014**

Location	RSPM ( $\text{PM}_{10}$ )			$\text{SO}_2$			$\text{NO}_x$		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
<b>Residential</b>									
Aliganj	123.5	296.6	169.2	8.4	17.6	13.8	43.7	63.1	50.9
Vikas Nagar	128.5	252.4	193.9	8.6	21.4	15.8	46.4	62.4	52.3
Indira Nagar	169.0	289.0	234.2	13.6	21.3	17.9	46.5	66.5	56.2
Gomti Nagar	149.2	210.4	172.3	12.8	17.8	16.5	44.8	65.6	53.6
<b>Commercial</b>									
Charbagh	169.2	302.8	221.7	14.8	24.7	20.0	51.8	108.3	86.4
Alambagh	130.8	224.7	177.1	11.9	24.1	17.8	64.5	80.3	69.1
Aminabad	146.9	274.6	210.5	10.5	20.0	15.5	39.9	48.2	42.3
Chowk	172.9	342.7	260.6	16.0	25.5	20.8	55.7	79.4	69.5
<b>Industrial</b>									
Amausi	141.1	245.4	186.6	10.1	21.4	17.3	58.3	95.7	70.6
NAAQS	100			80			80		
WHO Guidelines	50			20			40*		

N=4, \*= Annual average and rest 24 hours, NAAQS=National Ambient Air Quality Standards



**Fig 1:** Concentration ( $\mu\text{g}/\text{m}^3$ ) of PM<sub>10</sub>, SO<sub>2</sub> and NO<sub>x</sub> in different areas of Lucknow city during post monsoon season (2014) and compared with prescribed National Ambient Air Quality Standard (NAAQS)

**Table 9. Metal Concentration in ng/m<sup>3</sup> associated with PM<sub>10</sub>**

<b>Location</b>	<b>Pb</b>	<b>Ni</b>
<b>Residential Area</b>		
Aliganj	95.13	27.70
Vikas Nagar	185.29	36.79
Indira Nagar	48.43	33.72
Gomti Nagar	68.33	29.59
<b>Average</b>	<b>99.29</b>	<b>31.95</b>
<b>Commercial Area</b>		
Charbagh	1161.53	40.71
Alambagh	218.95	22.36
Aminabad	203.03	21.27
Chowk	556.21	68.22
<b>Average</b>	<b>534.93</b>	<b>38.14</b>
<b>Industrial Area</b>		
Amausi	149.78	20.63
NAAQS	<b>*1000.0</b>	<b>** 20</b>

N= 1, NAAQS \*\*Ni=Annual Average; \*Pb=24 hrs Average

### 1.3.5 Noise

The monitoring data recorded during the post monsoon period (October, 2014) is presented in Table 10.

In residential areas, the day and night time noise levels were recorded between 66.1 to 69.6 and 54.6 to 61.2 dB(A) respectively. All the values were higher than the prescribed limit of 55 and 45 dB (A) for day and night time respectively.

In commercial and heavy traffic area, the day and night time noise level were recorded between 72.5 to 78.8 and 55.9 to 72.5 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 area, Amausi the day and night time noise levels were recorded 67.6 and 66.7 dB (A) respectively. Noise levels at all industrial locations in the day and night time was found below the prescribed limit of 75.0 and 70.0 dB(A) respectively.

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

Sl. No.	Area	Location	Noise level dB(A)	
			Day	Night
1	<b>Residential</b>	Aliganj	66.5	57.2
		Vikas Nagar	66.3	54.6
		Indira Nagar	69.6	61.2
		Gomti Nagar	66.1	55.6
		<b>Standard</b>	<b>55.0</b>	<b>45.0</b>
2	<b>Commercial and Traffic</b>	Charbagh	78.8	72.5
		Alambagh	74.4	66.2
		Aminabad	72.5	55.9
		Chowk	73.8	60.2
		<b>Standard</b>	<b>65.0</b>	<b>55.0</b>
3.	<b>Industrial</b>	Amausi	67.6	66.7
		<b>Standard</b>	<b>75.0</b>	<b>70.0</b>

#### 1.4 TRENDS OF AMBIENT AIR QUALITY IN LUCKNOW CITY

The observed PM<sub>10</sub>, SO<sub>2</sub> and NO<sub>x</sub> for 3 years data have been compared to find out the prevailing trend of air pollution in Lucknow city (Fig.2-4). The slight decrease or increase in the values may be attributed to some local environmental and climatic factors.

##### 1.4.1 Respirable Suspended Particulate Matter (RSPM or PM<sub>10</sub>)

In all the locations in residential areas, higher values were found compared to the previous year except Gomti Nagar. Among the commercial areas, PM<sub>10</sub> values were found to be higher than the previous year except Alambagh. Amausi under industrial area showed lower value over the last year. All the values are higher than the NAAQS (Fig. 2).

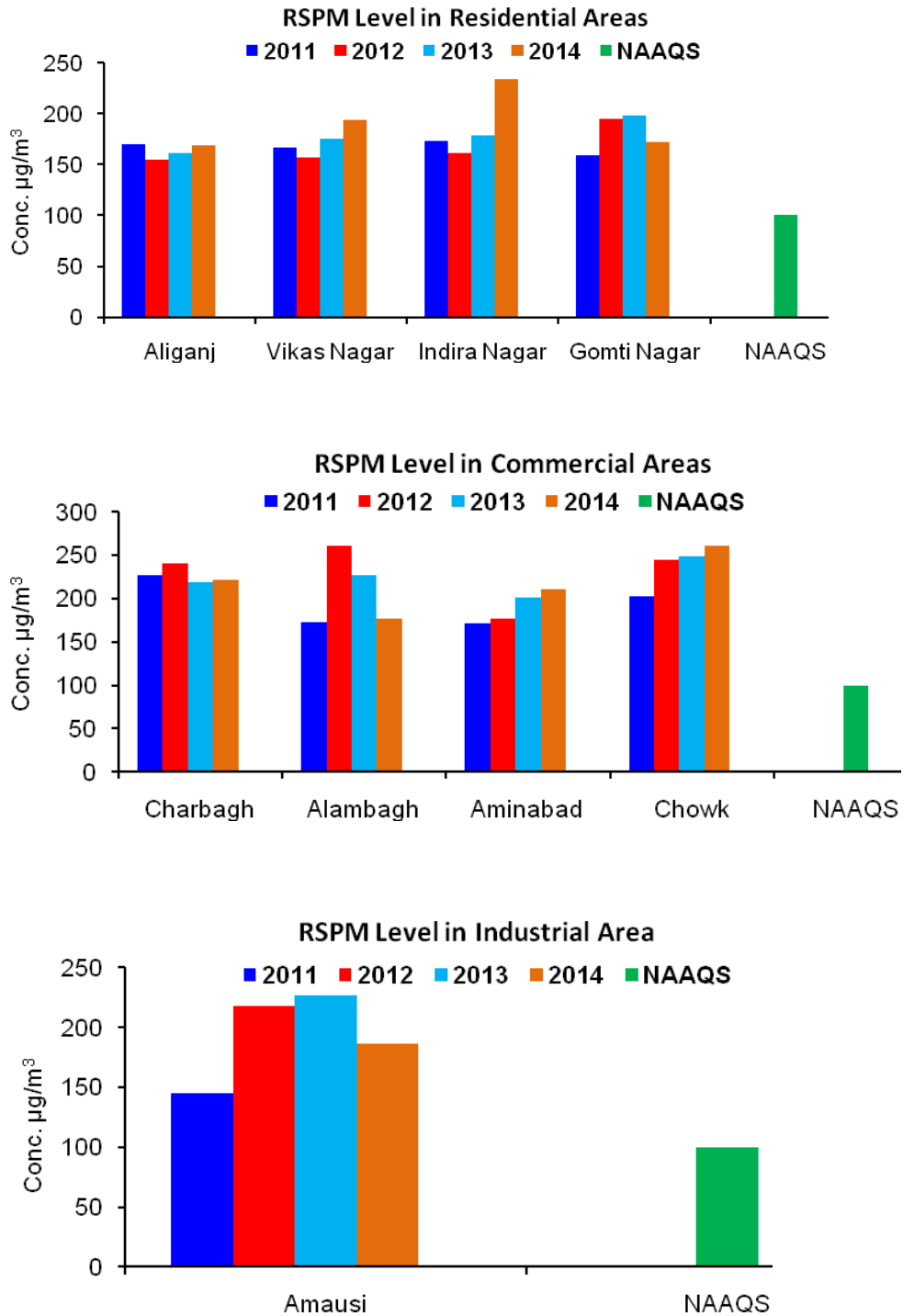
##### 1.4.2 Sulphur dioxide (SO<sub>2</sub>)

Lower concentration was found compared to the previous year at all the residential commercial and industrial areas except Aminabad and Chowk in commercial. All the values were found to be lower than the NAAQS (Fig. 3).

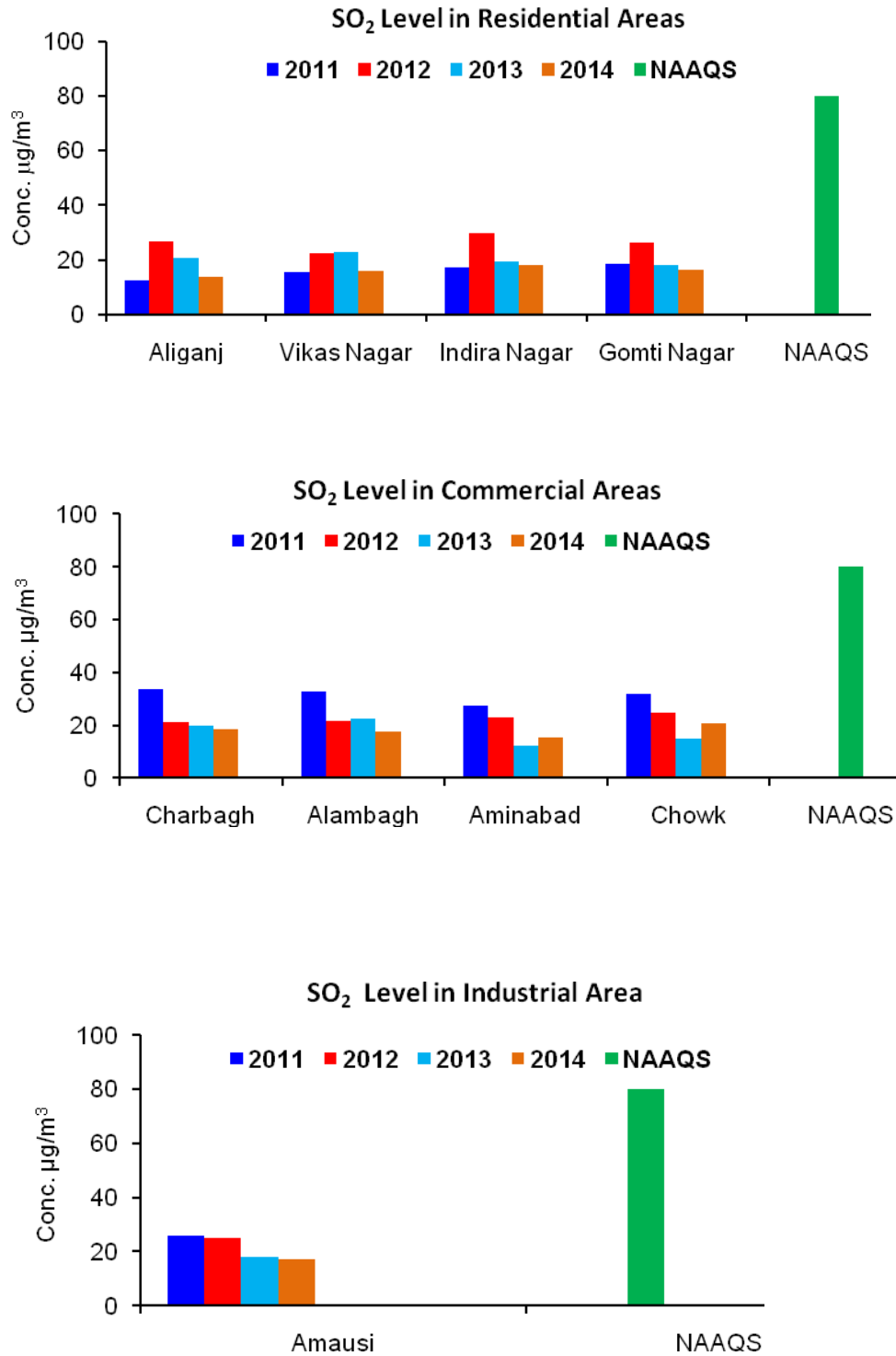
##### 1.4.3 Oxides of Nitrogen (NO<sub>x</sub>)

The level of NO<sub>x</sub> during post monsoon since 2011 is presented in Fig. 4. In residential area showed higher values than the previous year except Vikas Nagar and Indira Nagar. In commercial and industrial areas all the values showed higher values except Aminabad in commercial area. All the values of the present study were found to be lower than the NAAQS (Fig.4) except Charbagh .

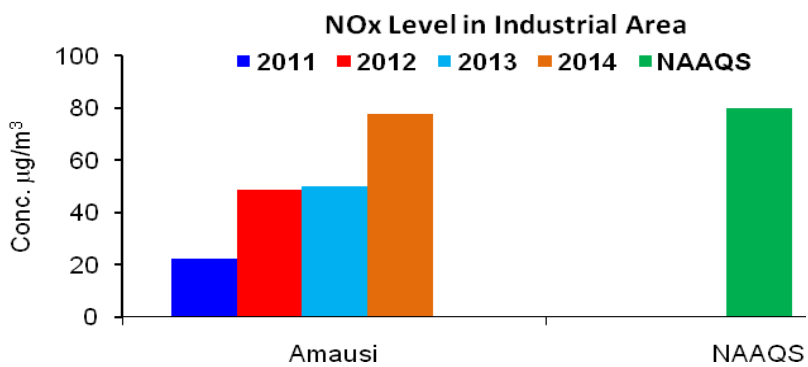
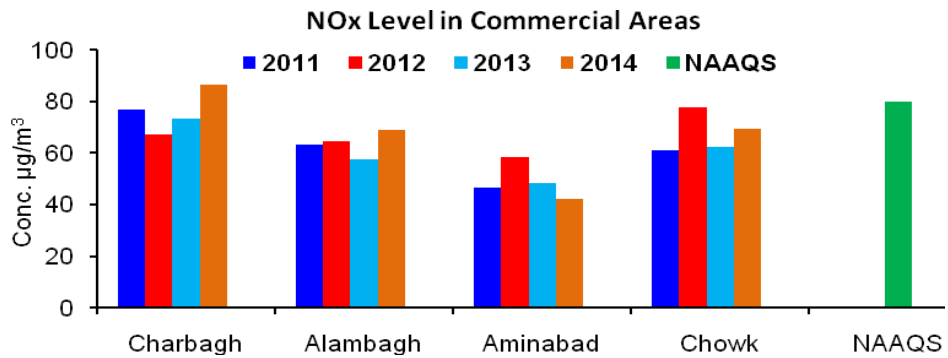
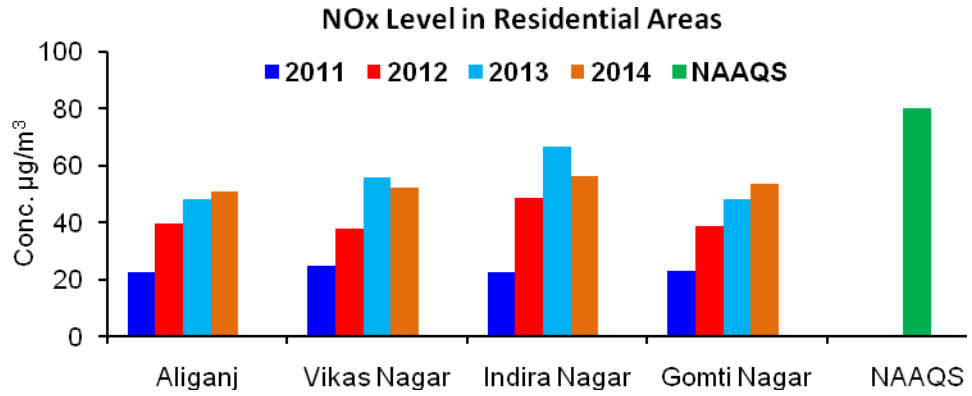




**Fig 2:** Concentration ( $\mu\text{g}/\text{m}^3$ ) of  $\text{PM}_{10}$  (RSPM) in Residential, Commercial and Industrial areas of Lucknow city during 2011 to 2014 and compared with prescribed National Ambient Air Quality Standard (NAAQS)



**Fig 3:** Concentration ( $\mu\text{g}/\text{m}^3$ ) of SO<sub>2</sub> in Residential, Commercial and Industrial areas of Lucknow city during 2011 to 2014 and compared with prescribed National Ambient Air Quality Standard (NAAQS)



**Fig 4:** Concentration ( $\mu\text{g}/\text{m}^3$ ) of NO<sub>x</sub> in Residential, Commercial and Industrial areas of Lucknow city during 2011 to 2014 and compared with prescribed National Ambient Air Quality Standard (NAAQS)

#### **1.4.4 Noise Level**

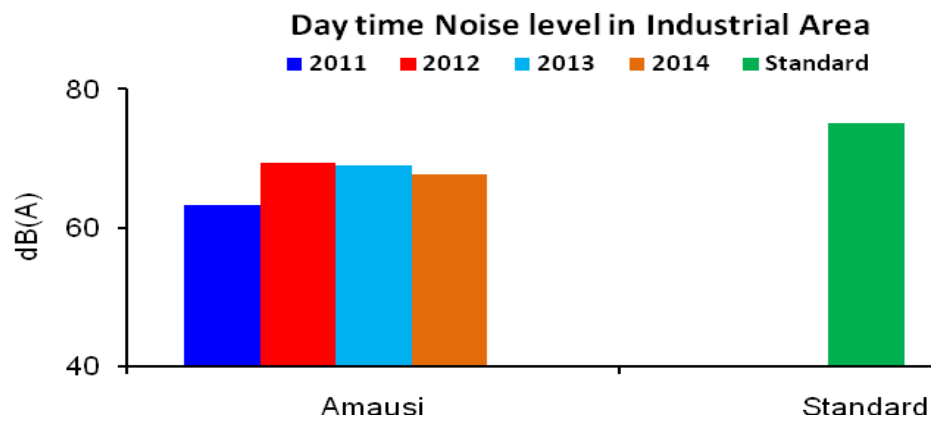
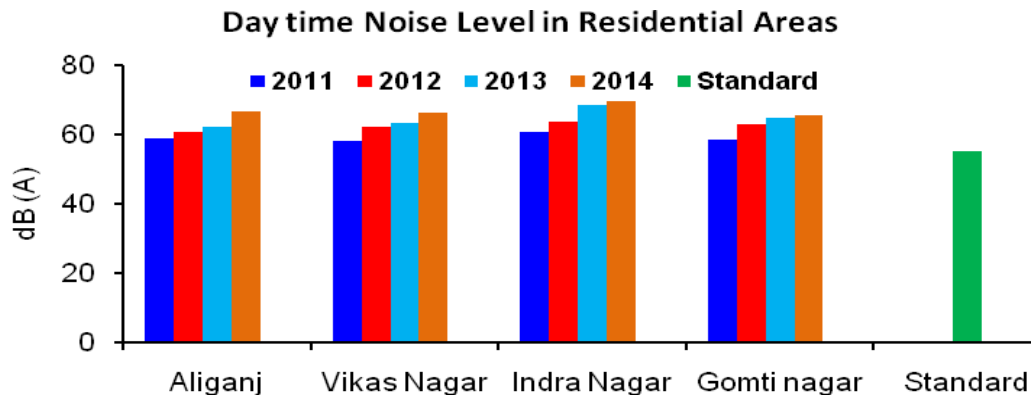
Current year's noise data has been compared with the corresponding data of the previous three years and is presented in Fig. 5 and 6. The comparative noise level in residential, commercial and industrial areas are described below:

##### **1.4.4.1 Day time Noise Level**

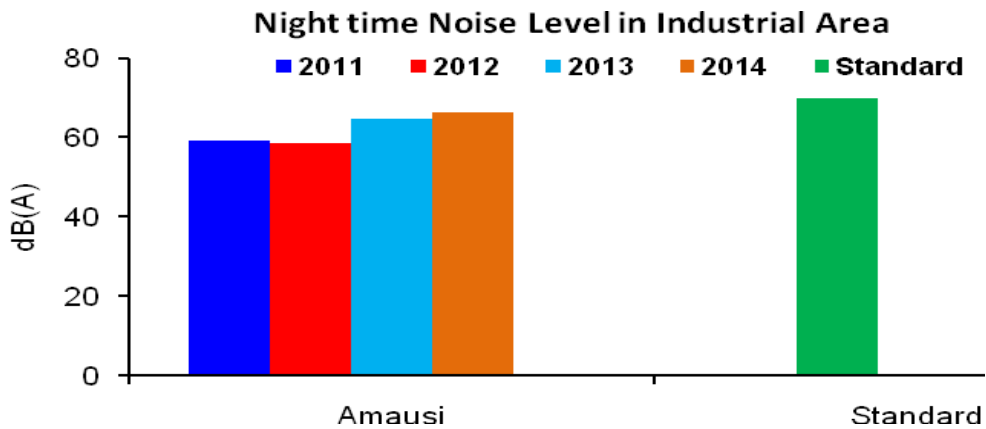
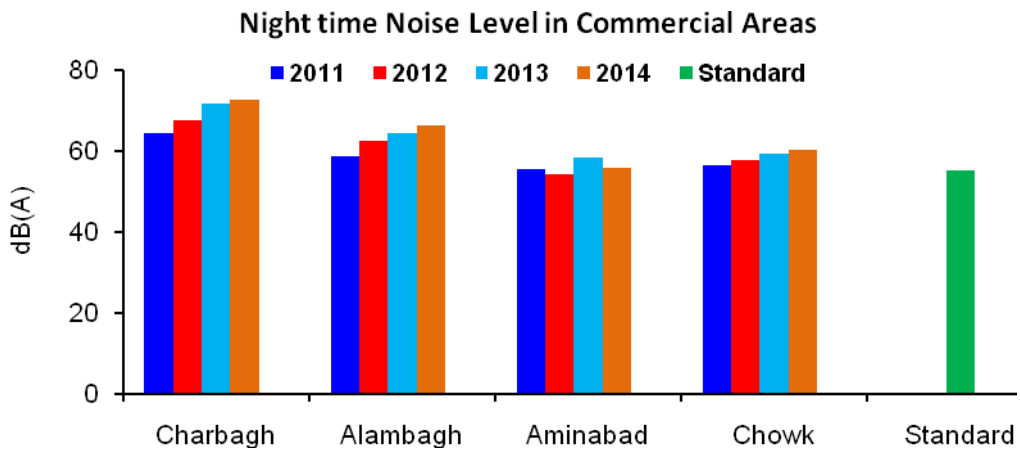
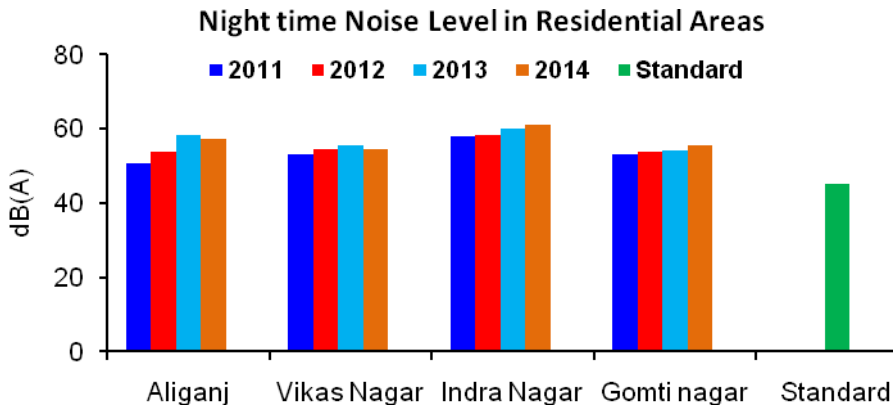
In residential areas all the locations showed slightly increasing trend over the previous year. In commercial cum traffic areas, noise level was slightly on the higher side at all the locations compared to the previous year. In industrial area, Amausi the noise level was slightly lower than the previous year. The comparative data are presented in (Fig.5.).

##### **1.4.4.2 Night time Noise Level**

Residential and Commercial areas showed slightly higher trend than the last year level except Aliganj and Vikas Nagar in residential area and Aminabad in commercial area. The industrial areas also showed slightly higher than the previous year. The comparative data is presented in (Fig. 6).



**Fig 5:** Comparison of day time Noise Level dB (A) in different areas of Lucknow city (2011-2014)



**Fig 6:** Comparison of night time Noise Level dB (A) in different areas of Lucknow city (2011-2014)

## 1.5 HEALTH EFFECTS

At elevated levels, all the pollutants including metals have adverse effects on human and environmental health. Accumulation of pollutants in the human body through inhalation of air is an important route. Results of the present study revealed that higher level of particulate matter especially the PM<sub>10</sub> at all the monitoring locations are more dangerous for human health and responsible for several cardiovascular and respiratory diseases such as asthma, bronchitis, reproductive development, increased risk of preterm birth and even mortality and morbidity rate. It is reported that the total daily mortality increased by approximately 1% for every 10 µg/m<sup>3</sup> increase in PM<sub>10</sub> concentration.

Human exposure to particulate air pollution has been identified as a risk factor for human mortality and morbidity and many countries have revised the limits for PM<sub>10</sub> as previously defined and set up new quantitative standards for PM<sub>2.5</sub>. Nevertheless, PM threshold levels to which exposure does not lead to adverse effects on human health have not yet been clearly identified and hence there is a substantial inter-individual variability in exposure and in the response and it difficult to establish a standard or guideline value that will lead to complete protection of every individual against all possible adverse health effects of particulate matter.

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<sub>2</sub> and NO<sub>x</sub> were found to be below permissible limit (80 µg/m<sup>3</sup>) of NAAQS (MoEF 2009), but there are several reports that gaseous pollutants are related with respiratory diseases and reproductive and developmental effect even at low concentration. Vehicular traffic and NO<sub>2</sub> are associated with significantly higher risk of lung cancer.

Noise pollution is now worldwide recognized as a major problem for the quality of life in urban areas. Noise pollution can have adverse effects varying from hearing loss to annoyance. Noise produces both temporary (short period) and permanent

hearing loss (long period). Damages caused by noise pollution can range from the bursting of the eardrum, permanent hearing loss, cardiac and cardiovascular changes, stress fatigue, dizziness, lack of concentration, cause of accident, irritation, inefficiency, nausea, interference with tasks, headaches, insomnia and loss of appetite etc. It also adversely affects future generations and has sociocultural, aesthetic, and economic effects.

## 1.6 CONCLUSION

We have monitored air pollutants such as PM<sub>10</sub>, SO<sub>2</sub> and NO<sub>x</sub> for assessment of ambient air quality. Besides, we also monitored noise level during day and night time at 9 locations during post monsoon (October), 2014 and our data revealed the following salient points

- The RSPM (PM<sub>10</sub>) level at all the monitoring locations of residential, commercial and industrial areas were higher than the National Ambient Air Quality Standard (NAAQS).
- The concentration of gaseous pollutants, SO<sub>2</sub> and NO<sub>x</sub> were well below the prescribed NAAQS (80 µg/m<sup>3</sup>) at all the locations.
- Increasing trend for the PM<sub>10</sub> was found at all the commercial and industrial areas when compared to the previous year data post monsoon
- The noise level at all the locations except in industrial area during day and night time showed higher level than the respective permissible limits.

Rapid growth of number of vehicles, their technological development and release of invisible tailpipe pollutants emission are serious debatable issues even for the policy makers. Use of different types of fuels namely petrol, diesel and CNG make the environment more complex regarding the air quality and their possible synergistic effects on the human health. Overall, continuous accumulation of different types of pollutants and their exposure to human being needs emergency attention of the policy maker, researchers and regulatory agencies.

The latest development, introduction of metro rail in the city in the near future, is a positive step towards reducing the air pollution, through the decrease in the vehicular density is a clear indication of the severity of the traffic and air pollution. The state



government has a plan to start the Lucknow metro in 2017. The necessary official procedures are under progress, Lucknow Metro Rail Company (LMRC) has come in to existence and construction of one segment from Alambagh to Charbagh is under progress. LMRC has counted the number of vehicles and studied the transport pattern. Accordingly diversion for traffic has been may last for a year or two. During this period the dust and gaseous pollutant in this segment may remain at a higher level. This will add to the air pollution level of the segment and nearby locality. As the construction of metro rail progresses further, other areas may also be affected. Thus there is a possibility of increase in existing air pollution of city for the time being.

The present study suggests that it is necessary to monitor the air quality as well as the health effects at regular intervals 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 help the planners for sustainable development of the city.

## **1.7 RECOMMENDATIONS**

- Subsidized public mass transport must be strengthened to minimize use of personal vehicles.
- Improvement in the traffic management.
- Encroachment should be removed for smooth flow of traffic.
- Public awareness programme for harmful effects of vehicular/ air pollution
- Pressure horns to be removed from all vehicles and avoid use of horn.
- Government should increase the parking charges on hourly basis to discourage the use of personal vehicles.
- Restore foot path for pedestrians.

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