# ASSESSMENT OF AMBIENT AIR QUALITY OF LUCKNOW CITY DURING PRE-MONSOON, 2012

## FINDINGS OF A RANDOM SURVEY

*Presented on*

*WORLD ENVIRONMENT DAY, 2012*


**CSIR-INDIAN INSTITUTE OF TOXICOLOGY RESEARCH**
**Post Box 80, Mahatma Gandhi Marg**
**Lucknow - 226 001**


**5th June, 2012**

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# ***Salient Features of the Study***

- **Geographical Position** : $26^o$ 52' N Latitude
  $80^o$ 56' E Longitude
  128 m above Sea Level
- **Area** : 310 sq. km.
- **Population** : 28,15033 as per 2011 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 Vehicular Population in Lucknow city as on 31/03/2012** : 13,14,705
- **Growth of Vehicle over 2010-2011** : 8.68%
- **Total No. of Filling Stations (Petrol/Diesel/CNG)** : 100
- **Consumption of Petrol** : 1,24,805 KL
- **Consumption of Diesel** : 1,30,372 KL
- **Consumption of CNG** : 2,14,39,460 Kg
- **Major Source of Pollution** : Automobiles, D. G. sets, Civil Constructions
- **Parameters Monitored** : $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_X$, and trace metals
- **Study Conducted by** : Environmental Monitoring Division IITR, Lucknow

**ASSESSMENT OF AMBIENT AIR QUALITY OF LUCKNOW CITY DURING PRE-MONSOON, 2012**

**Environmental Monitoring Division**
**CSIR- Indian Institute of Toxicology Research**
**M.G. Marg, Lucknow**

## 1.0 SUMMARY

*The study was carried out during the months of March-May, 2012 to see the status of air quality by monitoring and assessment of some selected air pollutants namely Respirable Particulate Matter (RSPM or $PM_{10}$), Fine Particulates ($PM_{2.5}$), Sulphur dioxide($SO_2$), Nitrogen dioxide ($NO_2$), and Trace metals- Iron (Fe ), Nickel (Ni), Chromium (Cr), Zinc (Zn), Lead (Pb), Manganese (Mn) and Cobalt (Co) 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 $PM_{10}$ in the range of 113.0 to 396.2 µg/m$^3$ with an average of 231.9µg/m$^3$. The corresponding 24 hours values of $PM_{2.5}$ ranged between 59.8 to 175.4µg/m$^3$ with an average of 89.3 µg/m$^3$. The average values of $PM_{10}$ and $PM_{2.5}$ irrespective of locations were found to be above the permissible limit ($PM_{10}$= 100 µg/m$^3$ and $PM_{2.5}$= 60 µg/m$^3$) prescribed by MoEF. 24 hours concentration of $SO_2$ and NOx were found in the range of 9.8 to 24.9 and 21.6 to 61.5 µg/m$^3$ with an average concentration of 17.5 and 37.3 µg/m$^3$ respectively and all the values were below the permissible limits (80 µg/m$^3$). The mean level of trace metals were found* Fe = 1502.92, Ni = 14.00, Cr = 39.39, Pb = 34.45, Zn =150.11, Mn =113.34 and Co = 4.15 ng/m$^3$. *Noise levels during day and night time were found in the range of 62.5 to 73.7 dB (A) and 52.6 to 66.9 dB (A) which was above the respective permissible limits except in industrial area.*

## 1.1 INTRODUCTION

Exposure of humans to invisible air pollutants is unavoidable in today's perspective especially in the urban area in most of developing countries including India. There are criteria air pollutants like $SO_2$ (Sulphur dioxide), Oxides of Nitrogen (NOx), Particulate Matter (PM), etc. which are common for the assessment of air quality in a particular area. Technological growth and change of fuel consumption/pattern impacts on the composition of vehicular tailpipe emission and now it is a challenge to quantify the threshold limits of these pollutants to assess the effects on human health of each pollutant for their synergistic effects.

It is need of the hour, for the awareness of common people especially in the urban area regarding vehicular pollution and human health and it's consequences in the short and long term. Unlimited growth of number of vehicles and human being which severely affecting the sustainable development and gradually becoming unbearable.

Several scientific studies are going on in the different parts of the world and in India; studies revealed that all most all major cities including Lucknow are polluted. Some criteria pollutants are above the prescribed permissible limit, especially the Particulate Matter (PM).

PM, an ambient air criteria pollutant, has size ranging from nanometer to 10 μm and can be aspirated into the lung airways. Smaller PM cause severe adverse effects on human health. PM is a complex mixture of chemical agents of different shapes and sizes. Studies reveal that the effect of PM on human health will depend on the chemical composition of PM, besides its number and mass concentration. At present PM standard in ambient air is limited to the mass concentration within two specified size ranges $PM_{2.5}$ (< 2.5 μm) and $PM_{10}$ (< 10 μm,). At elevated levels at both size ranges, mortality and morbidity of humans have been reported. The routine air monitoring data on components of the PM mass is essential for epidemiological studies which may identify the chemical constituents of PM which cause health effects and also the source.

Nitrogen dioxide ($NO_2$) and carbon monoxide (CO) are good indicators of traffic exhaust emissions as they contribute most to the total emission. Epidemiological studies have shown that short-term exposure to $NO_2$ and CO is associated with increased cardiovascular mortality, including cerebrovascular diseases and ischemic heart disease.

The sources of heavy metals in urbanized areas, includes vehicle emissions, industrial discharges, street dust and other activities. At elevated concentrations, all the metals are harmful to living beings. Exposure can occur through a variety of routes; among which inhalation of particles (< 10 μm) is one of the important routes. The inorganic components constitute a small portion by mass of the particulates; however, it contains some trace elements which are human or animal carcinogens even in trace amounts.

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, pavement type, and vehicle conditions.

In view of above facts, it is 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 on the health of human being. The number of different category of vehicles registered with RTO (Regional Transport Office) Lucknow is 13,14,705 as on 31.03.2012 which is 8.68% 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 31.03.2012 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 1,24,805 and 1, 30,372 KL as on 31-03-2012. It is observed that petroleum sale have been increased by 3.95% whereas sale of diesel has increased by 3.73%. (Table 4). In

Lucknow there are six CNG filling stations and consumption of CNG in last year was approximately 2,14,39,460.18 Kg (2011-12) which was 12.15% higher than the previous year (2010-11) (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 pre monsoon (March- May), 2012 with respect to $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_x$, Trace metals and Noise level with the following aims and objectives.

- *To assess the ambient air quality with respect to $PM_{10}$, $PM_{2.5}$, $SO_2$, NOx, and trace metals (Fe, Ni, Cr, Pb, Zn, Mn and Co) associated with $PM_{10}$.*
- *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 2010-11 and 2011-12**

| Sl. No. | Type of Vehicle | Number of Registered Vehicles on 31st March | | % Change |
|---|---|---|---|---|
| | | 2010-11 | 2011-12 | |
| 1 | Multi Articulated | 2288 | 2520 | 10.14 |
| 2 | Light, Medium and Heavy weight Vehicles (Four wheeler) | 14268 | 15593 | 9.29 |
| 3 | Light commercial vehicles (Three wheeler) | 2859 | 3022 | 5.70 |
| 4 | Buses | 2935 | 3098 | 5.55 |
| 5 | Taxi | 5354 | 6195 | 15.71 |
| 6 | Three Wheelers and Auto Rickshaws | 7318 | 7195 | 11.71 |
| 7 | Two wheelers | 970897 | 1052717 | 8.43 |
| 8 | Car | 165589 | 183288 | 10.69 |
| 9 | Jeep | 15513 | 16932 | 9.15 |
| 10 | Tractor | 17809 | 19012 | 6.76 |
| 11 | Trailers | 1318 | 1361 | 3.26 |
| 12 | Others | 3597 | 3772 | 4.87 |
| Total | | **12,09,745** | **13,14,705** | **8.68** |

*Source: RTO, Lucknow*

**Table 2. Details of Lucknow city bus service, 2012**

| Sl. No. | Route No. | To and Fro | No. of Buses |
|---|---|---|---|
| 1 | 11 | BBD -Chinhat-Gomti Nagar-Alambagh | 42 |
| | 11 A | Malhaur railway station-Gomtinagar-Dalibagh-Charbagh | |
| | 11B | Charbagh-Alambagh-Avadh hospital-SGPGI | |
| | 11C | Charbagh- Alambagh -Sardar Patel Dental college | |
| | 11D | Charbagh- Alambagh- BBAU | |
| | 11E | Charbagh-Alambagh- Gopal Kunj-Kalindi Park | |
| 2 | 12 | BBD- Chinhat- Charbagh- Alambagh-Scooter India | 24 |
| | 12 A | Samarpan college- Chinhat-Charbagh- Alambagh- Scooter India | |
| | 12 B | BBD-Charbagh- Alambagh- Paasi Kila | |
| 3 | 23 | Gudamba – Vikasnagar- Alambagh- Rajnikhand | 32 |
| | 23B | Rajnikhand-Gudamba | |
| 4 | 24 | Engineering College-Indiranagar-Charbagh-Alambag-Paasi Kila | 24 |
| | 24 A | Alambagh-Manas Bihar colony | |
| 5 | 25 | Charbagh-Alambagh-Chandraval | 7 |
| | 25 A | Charbagh-Aurangabad-Maati | |
| 6 | 31 | Alambagh – IIM | 2 |
| 7 | 33 | Engineering College-Charbagh-Alambagh-Scooter India | 27 |
| | 33 A | Alambagh-Goal chauraha | |
| | 33 C | Engineering College-Charbagh-Alambagh-Scooter India | |
| 10 | 45 | Virajkhand-Gomtinagar-Charbagh-Alambagh-Paasi Kila | 16 |
| 11 | Paryatak Sewa | Charbagh- Parivartan -Hazratganj-Charbagh | 2 |
| | | Total | 176 |

*Source: UPSRTC, Lucknow*

**Table 3. Petrol Pumps in Lucknow City**

| Sl. No. | Agency | Number of outlets |
|---|---|---|
| | | 31st March 2012 |
| 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 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Apr. 10 to Mar. 11 | Apr. 11 to Mar. 12 | % Change | Apr. 10 to Mar. 11 | Apr. 11 to Mar. 12 | % Change | Apr. 10 to Mar. 11 | Apr. 11 to Mar. 12 | % Change |
| 1 | IOC | 65961 | 67849 | | 70179 | 71351 | | -- | --- | |
| 2 | BPCL | 31272 | 32456 | | 25944 | 27121 | | -- | --- | |
| 3 | HPCL | 22828 | 24500 | | 29565 | 31900 | | -- | --- | |
| 4. | Green Gas | -- | -- | -- | -- | -- | -- | 19,117542 | 21439460 | |
| **Total** | | **120061** | **124805** | **3.95** | **125688** | **130372** | **3.73** | **1,91,17,542** | **2,14,39,460** | **12.15** |

*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 | |
|---|---|---|---|
| | | 2010-11 | 2011-12 |
| 1 | Auto Rickshaws | 4213 | 4343 |
| 2 | Tempo Taxi | 2534 | 2534 |
| 3 | Buses (UPSRTC) | 247 | 260 |
| 4 | Buses (Private) | 26 | 34 |
| 5 | School Buses | 363 | --- |
| 6 | School Van | 295 | --- |
| 7 | Private Vehicles | 80 | --- |

*Source: UPSRTC, 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- $PM_{10}$ and $PM_{2.5}$ | 24 hours | Gravimetric |
| 2 | Sulphur dioxide ($SO_2$) | 24 hours | Improved West Gaeke |
| 3 | Nitrogen Dioxide($NO_2$) | 24 hours | Modified Jacob & Hochhesier (Na-Arsenite) |
| 4. | Trace Metals - | 24 hour | AAS method after sampling on EPM 2000. |
| 5. | Noise Level | 1 hour | The measurement of noise level was carried out during the day (6 AM to 10 PM) and night time (10 PM to 6 AM) by Noise level Meter. |

## 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 $PM_{10}$)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar), the 24 hours average concentrations of $PM_{10}$ were in the range of 188.7 to 241.0 µg/$m^3$ with an average of 216.3 µg/$m^3$. In commercial areas (Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of $PM_{10}$ were in the range of 197.8 to 296.7µg/$m^3$ with an average of 248.2 µg/$m^3$ respectively. In industrial area (Amausi), the average concentrations of $PM_{10}$ was 227.2 µg/$m^3$ .

The maximum 24 hours mean concentration of $PM_{10}$ was observed in Gomti Nagar (241.0 µg/$m^3$) in residential area and Charbagh (296.7 µg/$m^3$) in commercial area.

All the values of $PM_{10}$ were above the prescribed National Ambient Air Quality Standard (NAAQS) of 100 µg/$m^3$ for industrial, residential, rural and other area respectively.

### 1.3.2 Fine Particles ($PM_{2.5}$)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the 24 hours level of $PM_{2.5}$ were in the range of 86.3 – 91.8 µg/$m^3$ with an average of 88.4 µg/$m^3$. In commercial areas (Charbagh, Alambagh, Aminabad and Chowk), 24 hours mean concentrations of $PM_{2.5}$ were in the range of 73.3 to 111.3 with an average of 90.6 µg/$m^3$ respectively. In industrial area (Amausi), the average concentration of $PM_{2.5}$ was 87.1 µg/$m^3$.

The maximum 24 hours mean concentration of fine particles was in Indira Nagar (91.8 µg/$m^3$ ) in residential area and Charbagh (111.3 µg/$m^3$) in commercial area.

All the mean values of $PM_{2.5}$ were above the prescribed National Ambient Air Quality Standard (NAAQS) of 60 µg/$m^3$ at all nine monitoring locations.

### 1.3.3 Sulphur dioxide ($SO_2$)

In residential area (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the mean levels of $SO_2$ were in the range of 13.9 to 17.9 µg/$m^3$ with an average of 15.5 µg/$m^3$. In commercial area (Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of $SO_2$ were in the range of 16.3 to 24.2 µg/$m^3$ with an average of 19.5 µg/$m^3$. In industrial area (Amausi) the average concentration of $SO_2$ was 17.1 µg/$m^3$.

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

### 1.3.4 Oxides of Nitrogen ( NOx)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the 24 hours average concentrations of $NO_X$ were found in the range of 28.9 to 37.8 µg/$m^3$ with an average of 32.8 µg/$m^3$. In commercial areas (Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of $NO_X$ were found in the range of 37.3 to 43.0 µg/$m^3$ with an average of 39.2 µg/$m^3$. In industrial areas (Amausi) the average concentration was 46.8 µg/$m^3$

All the values of $NO_x$ were within the prescribed NAAQS of 80 µg/$m^3$ for all the monitoring locations.

**Table 8: Concentration (µg/$m^3$) of $PM_{10}$, $PM_{2.5}$, $SO_2$ and NOx during Pre monsoon 2012**

| Location | RSPM | | | $PM_{2.5}$ | | | $SO_2$ | | | NOx | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Residential** | Min | Max | Avg | Min | Max | Avg | Min | Max | Avg | Min | Max | Avg |
| Aliganj | 124.9 | 317.1 | 203.1 | 72.9 | 100.2 | 87.4 | 10.8 | 16.9 | 13.9 | 28.7 | 37.2 | 32.8 |
| Vikas Nagar | 145.0 | 272.4 | 232.5 | 76.6 | 102.4 | 88.2 | 9.8 | 19.5 | 14.6 | 21.9 | 41.2 | 31.5 |
| Indira Nagar | 113.0 | 263.0 | 188.7 | 62.5 | 133.4 | 91.8 | 12.8 | 22.8 | 17.9 | 22.9 | 49.1 | 37.8 |
| Gomti Nagar | 197.5 | 285.1 | 241.0 | 59.8 | 104.7 | 86.3 | 9.8 | 19.2 | 15.4 | 21.4 | 39.5 | 28.9 |
| **Commercial** | | | | | | | | | | | | |
| Charbagh | 178.3 | 393.1 | 296.7 | 76.9 | 175.4 | 111.3 | 13.8 | 24.9 | 18.5 | 32.4 | 61.5 | 43.0 |
| Alambagh | 151.3 | 396.2 | 207.0 | 71.9 | 111.0 | 95.2 | 11.7 | 18.0 | 24.2 | 32.5 | 45.6 | 39.0 |
| Aminabad | 133.7 | 273.1 | 197.8 | 61.3 | 101.3 | 73.3 | 14.3 | 18.6 | 16.3 | 21.6 | 48.3 | 37.3 |
| Chowk | 168.1 | 361.2 | 293.9 | 61.2 | 100.4 | 82.8 | 9.8 | 14.9 | 19.2 | 28.2 | 48.8 | 38.4 |
| **Industrial** | | | | | | | | | | | | |
| Amausi | 193.3 | 261.7 | 227.2 | 65.3 | 123.9 | 87.1 | 13.9 | 21.5 | 17.1 | 29.9 | 38.2 | 46.8 |
| NAAQS | 100 | | | 60 | | | 80 | | | 80 | | |
| WHO Guidelines | 50 | | | 25 | | | 20 | | | 40* | | |

N=6, *= Annual Average, NAAQS=National Ambient Air Quality Standards

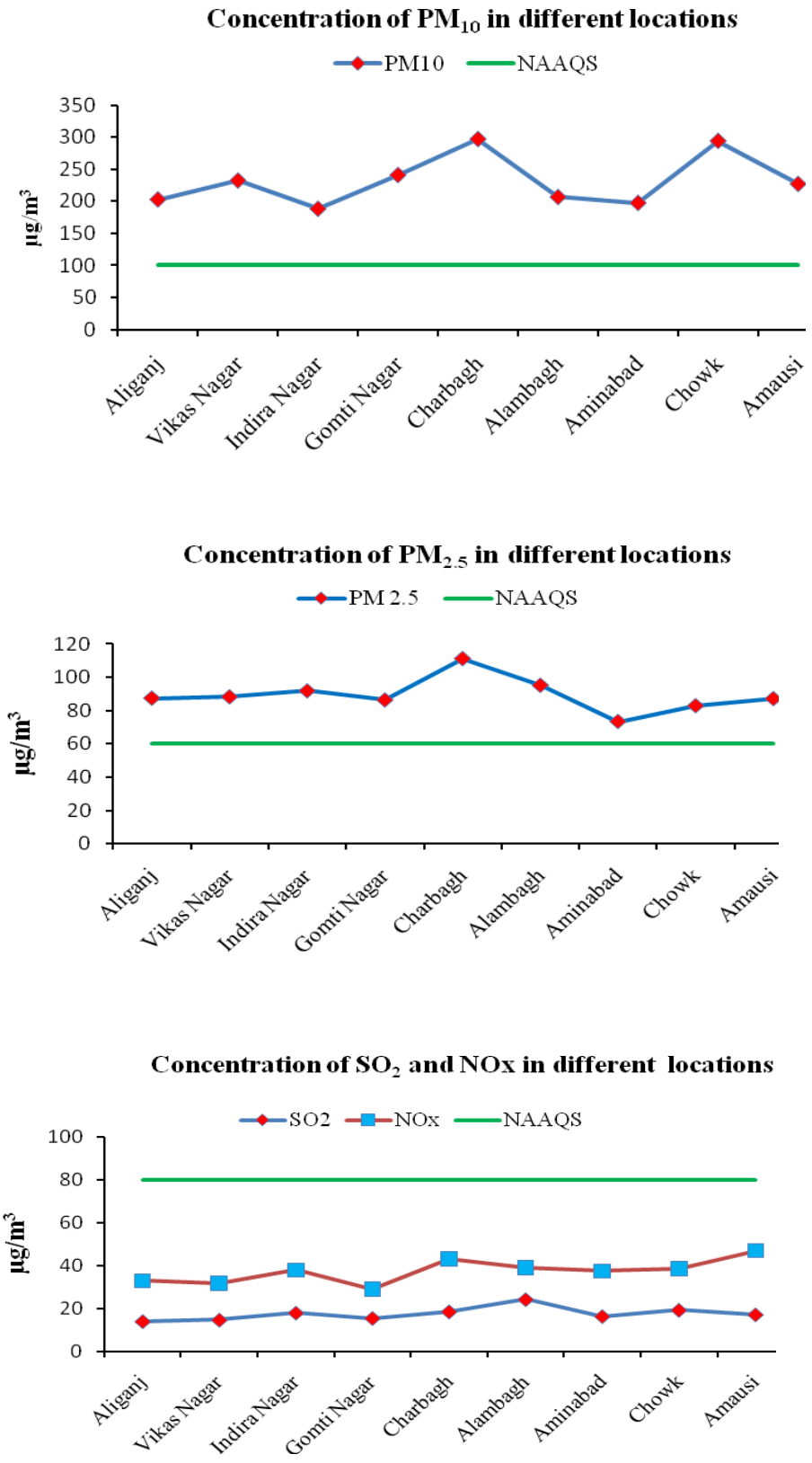



**Fig 1:** Concentration (µg/m$^3$) of $PM_{10}$, $PM_{2.5}$, $SO_2$ and $NO_x$ in different areas of Lucknow city during pre monsoon season (2012) and compared with prescribed National Ambient Air Quality Standard (NAAQS)

### 1.3.5 Trace Metals in Ambient Air (RSPM)

The trace metals (Fe, Ni, Cr, Pb, Zn, Mn and Co) were estimated in ambient air associated with $PM_{10}$ at 9 monitoring locations. The results are present in Table 9.

The 24 hr mean concentration of metals were found to be Fe = 1502.92 (677.24-3645.50), Ni = 14.00, (3.36-36.09), Cr = 39.39 (24.44 – 88.84), Pb = 34.45 (8.73-86.70), Zn =150.11 (58.77 – 286.29), Mn =113.54 (50.35 -321.15), Co = 4.15 (0.95-9.18) ng/$m^3$ . The maximum total concentrations of all metals estimated were found at Vikas Nagar (4082.01 ng/$m^3$) and minimum at Gomti Nagar (964.29 ng/$m^3$). The hierarchies of metals were arranged in descending order of their mean concentrations as given below.

Metals: Fe > Zn > Mn> Cr> Pb > Ni > Co

**Table 9. Concentration of Trace Metals associated with $PM_{10}$**

| | **Concentration in ng/m3** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Location** | **Fe** | **Ni** | **Cr** | **Pb** | **Zn** | **Mn** | **Co** | **Total** |
| **Residential Area** | | | | | | | | |
| Aliganj | 1277.26 | 7.79 | 28.77 | 37.52 | 116.71 | 48.20 | 3.71 | **1546.06** |
| Vikas Nagar | 3645.50 | 36.09 | 30.41 | 8.73 | 225.27 | 101.81 | 8.40 | **4082.01** |
| Indira Nagar | 1170.90 | 3.36 | 26.79 | 32.31 | 68.46 | 55.98 | 0.96 | **1377.76** |
| Gomti Nagar | 677.24 | 8.22 | 43.01 | 44.49 | 58.77 | 112.51 | 3.55 | **964.29** |
| **Commercial Area** | | | | | | | | |
| Charbagh | 2658.09 | 25.01 | 88.84 | 86.70 | 130.11 | 160.10 | 3.86 | **3177.72** |
| Alambagh | 1158.16 | 20.1 | 40.84 | 45.87 | 87.28 | 50.35 | 9.18 | **1413.79** |
| Aminabad | 721.15 | 9.94 | 28.85 | 28.84 | 91.82 | 321.15 | 4.13 | **1205.88** |
| Chowk | 995.30 | 3.45 | 24.44 | 11.172 | 286.29 | 86.33 | 0.95 | **1411.38** |
| **Industrial Area** | | | | | | | | |
| Amausi | 1222.68 | 12.01 | 42.55 | 14.43 | 286.29 | 85.49 | 2.62 | **1678.08** |
| **Mean (N=9)** | **1502.92** | **13.99** | **39.38** | **34.45** | **150.11** | **113.54** | **4.15** | |

N=1

### 1.3.6 Noise

The monitoring data recorded during the pre monsoon period (May, 2012) is presented in Table 10.

In residential areas, the day and night time noise levels were recorded between 62.5 to 66.8 and 52.6 to 58.3 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 traffic area, the day and night time noise level were recorded between 68.5 to 72.8 and 54.6 to 66.9 dB(A) respectively. Noise level at all the commercial sites during day and night time were found above the prescribed limit of 65 and 55 dB (A) respectively.

In industrial area, Amausi the day and night time noise levels were recorded 73.7 and 65.2 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. | Residential | Aliganj | 62.5 | 54.8 |
| | | Vikas Nagar | 64.3 | 56.1 |
| | | Indira Nagar | 66.8 | 58.3 |
| | | Gomti Nagar | 63.4 | 52.6 |
| | | **Standard** | **55.0** | **45.0** |
| 2. | | Charbagh | 72.8 | 66.9 |
| | | Alambagh | 68.5 | 61.5 |
| | | Aminabad | 70.1 | 54.6 |
| | | Chowk | 71.2 | 58.8 |
| | | **Standard** | **65.0** | **55.0** |
| 3. | **Industrial** | Amausi | 73.7 | 65.2 |
| | | **Standard** | **75.0** | **70.0** |

## 1.5 TRENDS OF AMBIENT AIR QUALITY IN LUCKNOW CITY

The observed $PM_{10}$, $SO_2$ 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). 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 $PM_{10}$)

In all the locations in residential areas, higher values were found compared to the previous year except in Indira Nagar. Among the commercial areas, $PM_{10}$ values showed increasing trend except at Alambagh than the last year. Amausi under industrial area showed higher value over the last year. All the values are higher than the NAAQS (Fig. 2).

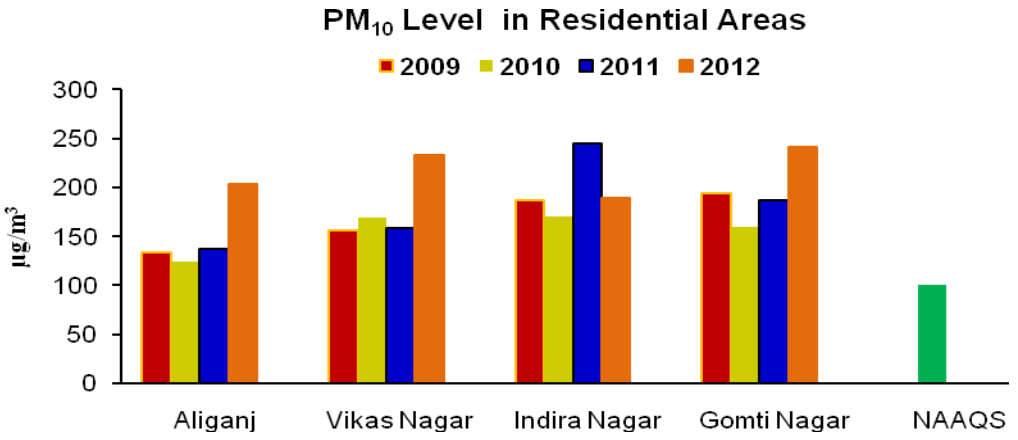
### 1.4.2 Sulphur dioxide ($SO_2$)

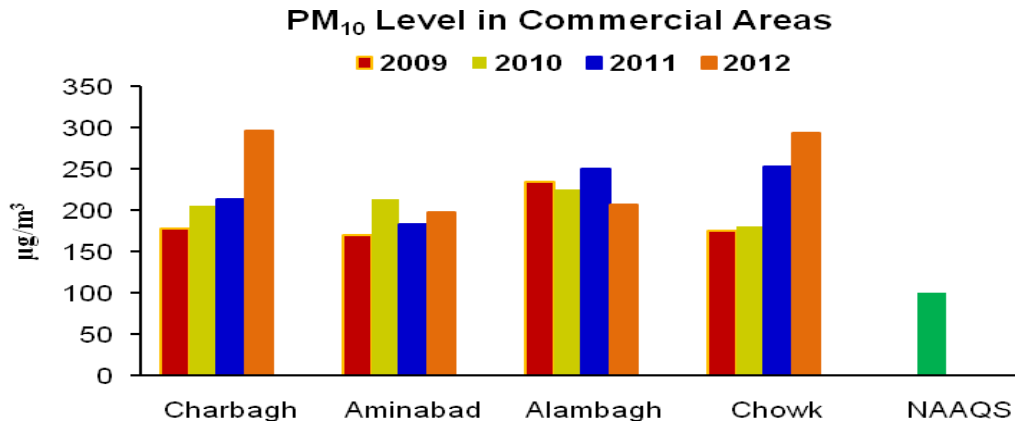
The level of $SO_2$ during pre monsoon since 2009 is presented in Fig. 3 for all the locations.

In residential areas, higher concentration was found compared to the previous year except Indira Nagar. Among the commercial areas, $SO_2$ values showed increasing trend except at Aminabad than the last year. Amausi under industrial area showed increasing trend over the last year. All the values of the present study were found to be lower than the NAAQS (Fig. 3).

### 1.4.3 Oxides of Nitrogen ($NO_x$)

The level of NOx during pre monsoon since 2009 is presented in Fig. 4 for all the locations. Among the residential, commercial and industrial areas all the locations showed increasing trend at all the locations when compared with the previous year data. All the values of the present study were found to be lower than the NAAQS (Fig. 4).



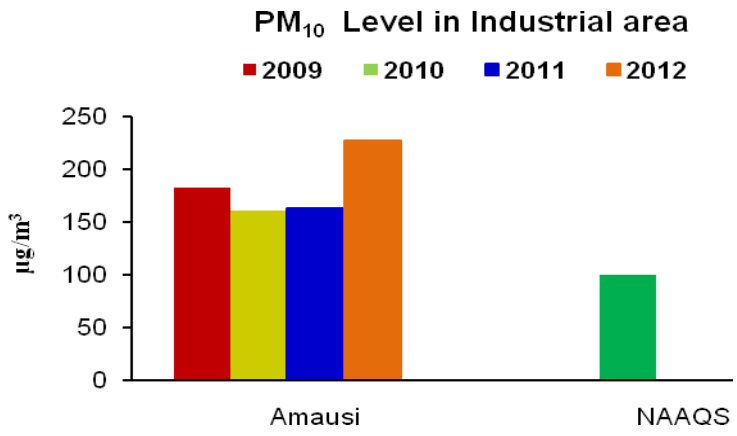




**Fig 2:** Concentration (µg/m$^3$) of $PM_{10}$ **(**RSPM**)** in Residential, Commercial and Industrial areas of Lucknow city during 2009 to 2012 and compared with prescribed National Ambient Air Quality Standard (NAAQS)

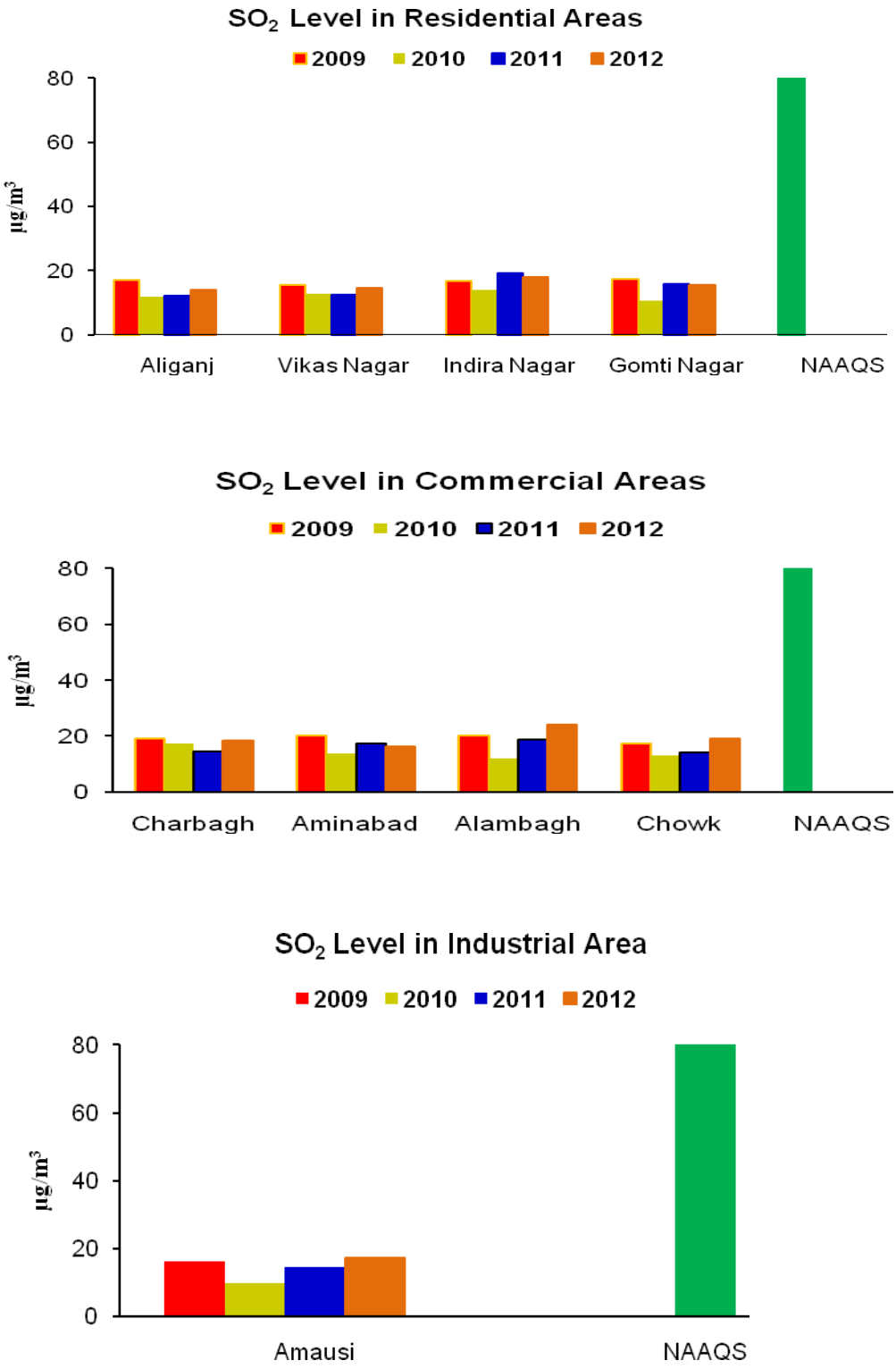



**Fig 3:** Concentration (µg/m$^3$) of $SO_2$ in Residential, Commercial and Industrial areas of Lucknow city during 2009 to 2012 and compared with prescribed National Ambient Air Quality Standard (NAAQS)

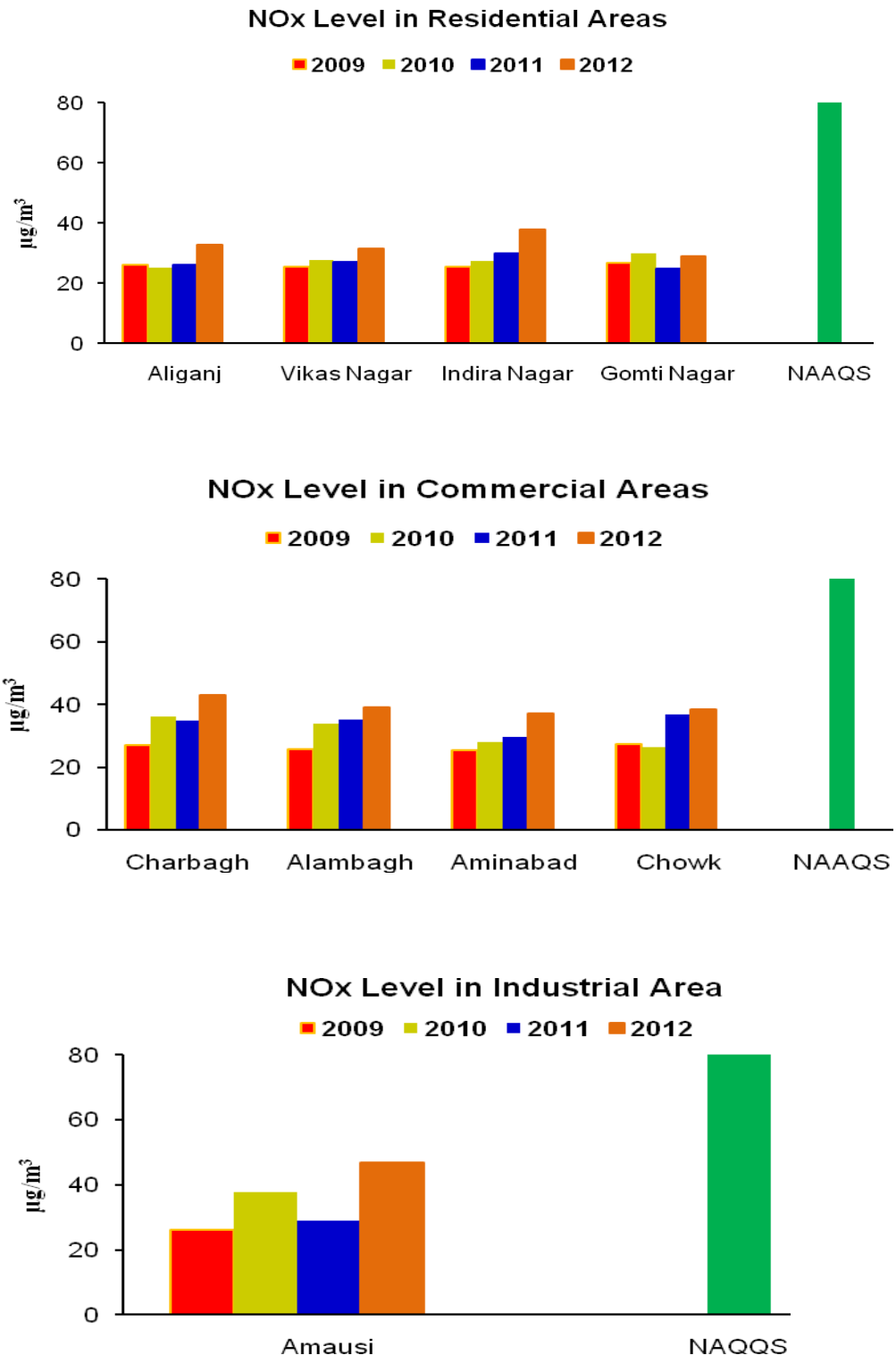



**Fig 4:** Concentration (µg/m$^3$) of $NO_x$ in Residential, Commercial and Industrial areas of Lucknow city during 2009 to 2012 and compared with prescribed National Ambient Air Quality Standard (NAAQS)

### 1.4.4 Noise Level

Current year's noise data has been compared with the corresponding data of the previous three years and are 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 locations were recorded compared to the previous year. In industrial area, Amausi the noise level was higher than the previous year. The comparative data are presented in (Fig.5).

#### 1.4.4.2 Night time Noise Level

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

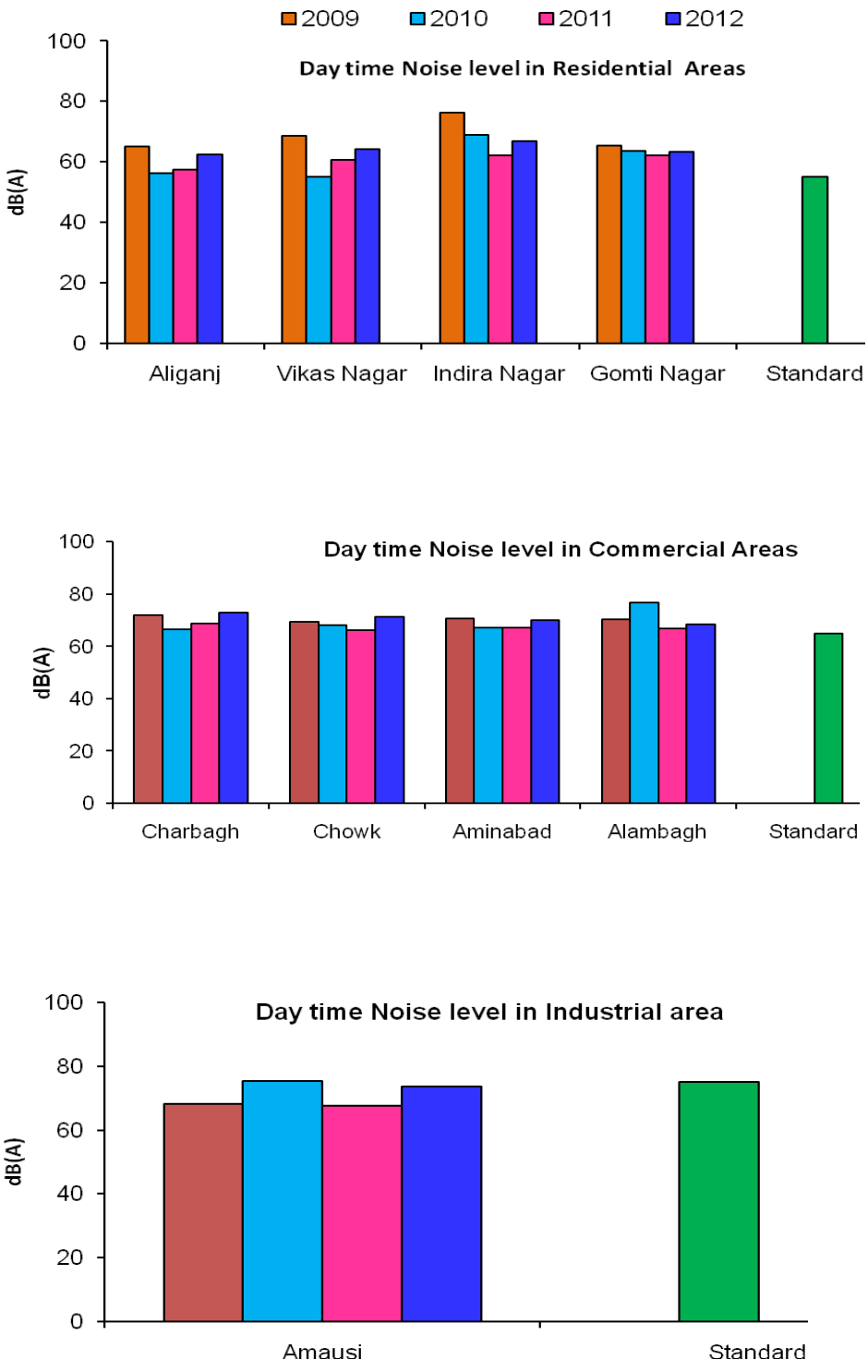



**Fig 5:** Comparison of day time Noise Level dB(A) in different areas of Lucknow city (2009-2012)

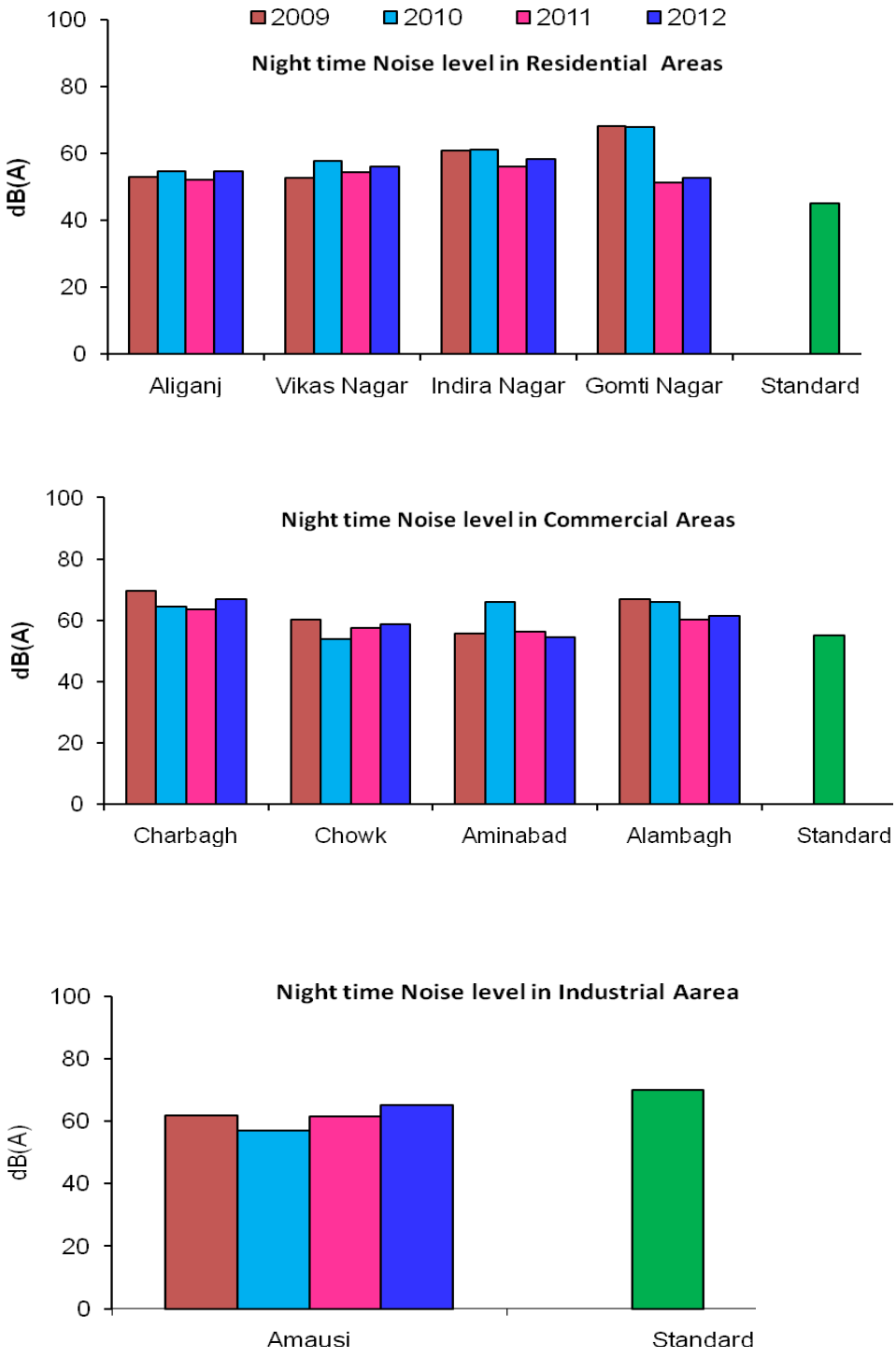



**Fig 6:** Comparison of night time Noise Level dB(A) in different areas of Lucknow city (2009-2012)

## 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 $PM_{10}$ and $PM_{2.5}$ 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 $ug/m^3$ increase in $PM_{10}$ 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 $PM_{10}$ as previously defined and set up new quantitative standards for $PM_{2.5}$. Nevertheless, PM thresholds levels to which exposure does not lead to adverse effects on human health have not yet been clearly identified and there is a substantial inter-individual variability in exposure and in the response and it difficult to established a standard or guideline value that will lead to a 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. We also estimated the trace metals associated with $PM_{10}$. The inorganic components constitute a small portion by mass of the particulates; however, it contains some trace elements such as As, Cd, Co, Cr, Ni, Pb and Se which are human or animal carcinogens even in trace amounts. The high level of Pb can induce severe neurological and hematological effects on the exposed population especially children, whereas Cd and Ni are known for inducing carcinogenic effects in humans through inhalation. Occupational exposure to Cd is a risk factor for chronic lung diseases. Cr (VI) is known to have toxic and carcinogenic effects on the bronchial tree. Mn exposure leads to increased neurotoxic impairments.

In the present study, the concentration of $SO_2$ and NOx were found to be below permissible limit (80 µg/$m^3$) 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 $NO_2$ are associated with significantly higher risk of lung cancer.

## 1.6 CONCLUSIONS

We have monitored air pollutants such as $PM_{10}$, $PM_{2.5}$, $SO_2$, NOx and trace metals for assessment of ambient air quality. Besides, we also monitored noise level during day and night time at 9 locations during pre monsoon (March-May), 2012 and our data showed the following-

- The RSPM ($PM_{10}$) level at all the monitoring locations of residential, commercial and industrial areas were higher than the NAAQS.
- Fine Particle ($PM_{2.5}$) level at all the monitoring locations of residential, commercial and industrial areas were higher than the NAAQS (60 µg/$m^3$)
- The concentration of gaseous pollutants, $SO_2$ and $NO_x$ were well below the prescribed NAAQS (80 µg/$m^3$) at all the locations.
- Increasing trend for the $PM_{10}$ was found at all the locations compared to the 2009 data till the previous year with some exceptions.
- The noise level at all the locations except in industrial area during day and night time showed higher level than the respective permissible limits.
- Overall results indicate that RSPM and associated metals are one of the major causes for deterioration of ambient air quality.

Unlimited growth of number of vehicles, their technological development and release of invisible tailpipe pollutants emission are serious debatable issues even for the policy maker. Use of different types of fuels namely petrol, diesel and CNG make the environment more complex regarding the air quality and their 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 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 pre 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 automobile 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 pedestrian

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