ASSESSMENT OF AMBIENT AIR QUALITY OF LUCKNOW CITY DURING PRE-MONSOON, 2011

FINDINGS OF A RANDOM SURVEY

Presented on

WORLD ENVIRONMENT DAY, 2011

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

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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 45^0C in summer to 3^0C in winter. Average annual rainfall about 100 cm.
- **Total Vehicle Population in the Lucknow city as on 31/03/2011** : 12,09,745
- **Growth of Vehicle over 2009-2010** : 9.23%
- **Total No. of Filling Station (Petrol/Diesel/CNG)** : 98
- **Consumption of Petrol** : 1,20,061 KL
- **Consumption of Diesel** : 1,25,688 KL
- **Major Source of Pollution** : Automobiles, D. G. sets, Civil Constructions
- **Parameters Monitored** : PM_{10}, $PM_{2.5}$, SO_2, NO_X, CO, O_3, and trace metals (Pb and Ni)
- **Study Conducted by** : Environmental Monitoring Division IITR, Lucknow

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

Summary

The study was carried out during the months of April-May, 2011 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), Oxides of Nitrogen (NO_X), Ozone (O_3), Carbon monoxide (CO) and Trace metals, Nickel (Ni) and Lead (Pb) and noise level at 10 representative locations, categorized as residential (four), commercial (five) and industrial (one) areas in Lucknow city. The results revealed the 24 hours concentration of RSPM in the range of 107.3 to 342.5µg/m^3 with a maximum 24 hours average concentration in Chowk (252.9 µg/m^3). The corresponding 24 hours values of $PM_{2.5}$ ranged between 53.4 to 108.9 µg/m^3 with a maximum 24 hours average concentration in Charbagh (95.0 µg/m^3). The values of RSPM 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 (with only two exceptions for $PM_{2.5}$). 24 hours average concentration of SO_2 and NOx were found in the range of 10.7 to 22.4 and 20.5 to 41.6 µg/m^3 respectively and all the values were well below the permissible limits (80 µg/m^3). The one hour mean concentration of CO was in the range of 349.5 to 1130 µg/m^3 and the maximum concentration was found in Hussainganj. All the values were well below the permissible limit (4000 µg/m^3). The one hour mean concentration of O_3 was found in the range of 66.7 to 131.4 µg/m^3 with the maximum concentration in Chowk. All the values were well below the permissible limit (180 µg/m^3). The trace metals Pb and Ni were found in the range of 92.4 to 1506 and 11.3 to 39.1 ng/m^3 respectively. Noise levels during day and night time were found in the range of 57.3 to 66.9 dB (A) and 51.3 to 63.5 dB (A)) which was above the respective permissible limits except in industrial area.

1.1 INTRODUCTION

Rapid increase of vehicular as well as human population is the major concern, because both are responsible for environment and human health especially in urban area. Burning of fuel in any form releases various kinds of unburned or waste product in the environments. Development of technology and recent scientific research changes the pollution scenario gradually. Changing of socioeconomic conditions and modern lifestyle, change the number games and ultimately aggravates pollution.

At present urban air quality draws much attention because large number of people is exposed to it. The tail pipe emission from vehicle is one of the important source of air pollutants namely Particulate Matters, SO_2, NOx, CO and other organic and inorganic pollutants including trace metals in urban area. The quantity and types of pollutants released in the ambient air depends on the quality and quantity of combustion of fuels and running condition of vehicles. Besides that, resuspension of road dust is also responsible for the higher level of air pollutants. Accumulation of these pollutants in the air adversely affects the air quality, health of living beings including human and environment.

The scientific reports suggest that particulate pollution in urban area is a major problem. The respirable particles are responsible for the cardiovascular as well as respiratory diseases of human being because these particles can penetrate deep into the respiratory system, and studies indicate that smaller the particle, more severe the health impacts. Ambient particulate matters are reported to be carriers of acidic or toxic species (e.g., heavy metals, acids and carcinogenic organic compounds) and may have detrimental effects on human health and ecosystems. Besides particulate matter, literature also suggests that there is a strong relationship between higher concentration of SO_2 and NOx and several health effects, like cardiovascular diseases, respiratory health effects such as asthma and bronchitis, reproductive and developmental effects such as increased risk of preterm birth. An elevated level of ozone in ambient air is reported to influence the frequency of emergency departments visits not only for asthma and cardio respiratory conditions but also for headache and migraine.

Nitrogen dioxide (NO_2) and carbon monoxide (CO) are good indicators of traffic exhaust emissions as they contribute most of the total emission. Epidemiologic 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 including humans. 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 such as As, Cd, Co, Cr, Ni, Pb and Se which are human or animal carcinogens even in trace amounts. There are several reports that high level of Pb can induce severe neurological and hematological affects on the exposed population especially children, whereas Ni is known for inducing carcinogenic effects in humans through inhalation.

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.

Monitoring and assessment of air pollution is an important step in determining the levels and its impact on the nearby environment. 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 is a matter of concern because of adverse effects on 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 12, 09,745 as on 31.03.2011 which is 9.23% 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 31.03.2011 are given in Table 2. In Lucknow city there are 98 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 1,20,061 and 1, 25,688 KL as on 31-03-2011. It is observed that petroleum sale have been increased by 10.1% whereas sale of diesel has increased by 10.4%. (Table 4). In Lucknow there are six CNG filling stations and consumption of CNG in last year was approximately 19,117542.14 Kg (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 10 locations during pre monsoon (April-May), 2011 with respect to RSPM, $PM_{2.5}$, SO_2 , NO_x , CO, O_3, Trace metals (Ni and Pb) 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, O_3, CO and trace metals (lead and nickel).*
- ✓ *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: Registered Vehicle with R.T.O. Lucknow during 2009-10 and 2010-11

Sl. No.	Type of Vehicle	Number of Registered Vehicles on 31st March		% Change
		2009-2010	2010-2011	
1	Multi Articulated	2134	2288	7
2	Light, Medium and Heavy weight Vehicles (Four wheeler)	8631	9966	15
3	Light commercial vehicles (Three wheeler)	3702	2859	-22
4	Light commercial Vehicles (Four wheeler)	4532	4302	-5
5	Buses	2930	2935	0.17
6	Taxi	5055	5354	5.0
7	Three Wheelers and Auto Rickshaw	7410	7318	-1.24
8	Two wheelers	890442	970897	9.04
9	Car	145996	165589	13.42
10	Jeep	14910	15513	4.04
11	Tractor	16464	17809	8.86
12	Trailers	1182	1318	11.5
13	Others	4067	3597	10.2
Total		**11,07,455**	**12,09,745**	**9.23**

Source: RTO, Lucknow

Table 2: Details of Lucknow city bus service, 2011

Sl. No.	Route No.	To and Fro	No. of Buses
1	11	BBD -Chinhat-Gomti Nagar-Alambagh	39
	11 A	Malhaur railway station-Gomtinagar-Dalibagh-Charbagh	
	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	
	12 C	Samarpan college-Chinhat-Gomtinagar-Charbagh- Alambagh	
3	23	Gudamba – Vikasnagar- Alambagh- Rajnikhand	32
	23B	Rajnikhand-Gudamba	
4	24	Engineering College-Indiranagar-Charbagh-Alambag-Paasi Kila	25
	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	17
11	Paryatak Sewa	Charbagh- Parivartan -Hazratganj-Charbagh	2
		Total	175

Source: UPSRTC, Lucknow

Table 3: Petrol Pumps in Lucknow City

Sl. No.	Agency	Number of outlets
		31st March 2011
1	Indian Oil Corporation (IOC)	45
2	Bharat Petroleum Corporation Ltd. (BPCL)	22
3	Hindustan Petroleum Corporation Ltd. (HPCL)	25
4	Compressed Natural Gas Stations (CNG)	6
	Total	98

Source: Indian Oil Corporation (IOC), Lucknow

Table 4: Consumption of Fuel (in KL) in Lucknow

Sl. No.	Agency	Petrol (Unleaded)			High Speed Diesel		
		Apr. 09 to Mar. 10	Apr. 10 to Mar. 11	% increase in consumption	Apr. 09 to Mar. 10	Apr. 10 to Mar. 11	% increase in consumption
1	IOC	60163	65961	9.6	66719	70179	5.1
2	BPCL	28828	31272	8.5	22252	25944	16.5
3	HPCL	19968	22828	14.3	24808	29565	19.1
Total		108959	120061	10.1	113779	125688	10.4

Source: Indian Oil Corporation (IOC), Lucknow

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Table 5: Distribution of CNG vehicles

Sl. No.	Vehicles	Number
1	Auto Rickshaw	4213
2	Tempo Taxi	2534
3	Buses (UPSRTC)	247
4	Buses (Private)	26
5	School Buses	363
6	School Van	295
7	Private Vehicles	80
	Total	7758

Source : UPSRTC, Lucknow

1.2 MONITORING LOCATIONS AND METHODOLOGY

Ten air quality monitoring locations representing different activities/areas i.e., four in residential, five in commercial cum traffic and one industrial area were selected for the study as summarized in Table 6 (brief description of each locations 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	Hussainganj	Commercial cum traffic
6	Charbagh	Commercial cum traffic
7	Alambagh	Commercial cum traffic
8	Aminabad	Commercial cum traffic
9	Chowk	Commercial cum traffic
10	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
4	Nitrogen Dioxide(NO_2)	24 hours	Modified Jacob & Hochhesier (Na-arsenite)
3	Ozone (O_3)	1 hours	UV Photometric
4.	Carbon monoxide (CO)	1 hours	Non Dispersive Infrared (NDIR) Spectroscopy
5..	Lead (Pb) and Nickel (Ni)	24 hour	AAS method after sampling on EPM 2000.
6.	Noise Level	1 hour	The measurement of noise level was carried out 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), 24 hours the average concentration of RSPM were in the range of 136.8 to 244.8 $\mu g/m^3$ with an average of 181.7 $\mu g/m^3$. In commercial areas (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of RSPM were in the range of 183.9 to 252.9 $\mu g/m^3$ with an average of 217.8 $\mu g/m^3$ respectively.In industrial area (Amausi), the average concentrations of PM_{10} was 163.0 $\mu g/m^3$.

The maximum 24 hours mean concentration of RSPM was in Indira Nagar (244.8 $\mu g/m^3$) in residential area and Chowk (252.9 $\mu g/m^3$) in commercial area.

All the values of PM_{10} were above the prescribed National Ambient Air Quality Standard (NAAQS) of 100 $\mu g/m^3$ 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 63.0 – 78.9 $\mu g/m^3$ with an average of 69.6 $\mu g/m^3$. In commercial areas (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk), 24 hours mean concentrations of $PM_{2.5}$ were in the range of 73.1 to 95.0 with an average of 81.7 $\mu g/m^3$ respectively. In industrial area (Amausi), the average concentration of $PM_{2.5}$ was 67.6 $\mu g/m^3$.

The maximum 24 hours mean concentration of fine particles was in Indira Nagar (78.9 $\mu g/m^3$) in residential area and Charbagh (95.0 $\mu g/m^3$) in commercial area.

All the values of $PM_{2.5}$ were above the prescribed National Ambient Air Quality Standard (NAAQS) of 60 $\mu g/m^3$ at all ten 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 12.2 to 19.2 $\mu g/m^3$ with an average of 14.9 $\mu g/m^3$. In commercial area (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of SO_2 were in the range of 14.5 to 18.6 $\mu g/m^3$ with an average of 16.9 $\mu g/m^3$. In industrial area (Amausi) the average concentration of SO_2 was 14.3 $\mu g/m^3$.

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

1.3.4 Oxides of Nitrogen (NOx)

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the average concentrations of NO_X were found in the range of 24.9 to 30.1µg/m^3 with an average of 27.0 µg/m^3. In commercial areas (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of NO_X were found in the range of 29.6 to 37.4 µg/m^3 with an average of 34.8 µg/m^3. In industrial areas (Amausi) the average concentration was 29.0 µg/m^3

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

1.3.5 Carbon Monoxide (CO)

The monitoring was conducted for one hour during 12 noon to 5 PM and the avarage results are presented in Table 8.

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the average concentrations of CO were found in the range of 349.5 to 978.6 µg/m^3 with an average of 567.9 µg/m^3. In commercial areas (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of CO were found in the range of 862.1 to 1130 µg/m^3. with an average of 1018.2 µg/m^3. In industrial areas (Amausi) the average concentration of CO was 803.8 µg/m^3.

All the values of CO were within the prescribed NAAQS of 4000 µg/m^3 for all the monitoring locations.

1.3.6 Ozone (O_3)

The monitoring was conducted for one hour during 12 noon to 5 PM and the avarage results are presented in Table 8.

In residential areas (Aliganj, Vikas Nagar, Indira Nagar and Gomti Nagar) the average concentrations of O_3 were found in the range of 79.5 to 97.8 µg/m^3 with an average of 87.5 µg/m^3. In commercial areas (Hussainganj, Charbagh, Alambagh, Aminabad and Chowk) the average concentrations of O_3 were found in the range of 95.6 to 131.4 µg/m^3 with an average of 116.3 µg/m^3. In industrial areas (Amausi) the average concentrations of O_3 was 66.7 µg/m^3.

All the values of O_3 were within the prescribed NAAQS of 180 µg/m^3 for all the monitoring locations.

Table 8: Concentration (µg/m^3) of PM_{10}, $PM_{2.5}$, SO_2 NOx, CO and O_3 during Pre monsoon 2011

Location	RSPM			$PM_{2.5}$			SO_2			NOx			CO			O_3		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Residential Area																		
Aliganj	107.3	158.1	136.8	53.4	71.3	63.0	10.7	14.5	12.2	20.5	32.1	26.1	198.0	803.8	477.6	55.2	135.9	83.7
Vikas Nagar	140.2	168.7	158.9	62.4	77.3	69.5	11.4	13.2	12.5	23.6	30.1	27.0	128.2	733.9	349.5	62.2	125.6	97.8
Indira Nagar	140.5	342.5	244.8	68.5	85.3	78.9	15.4	22.4	19.2	27.4	34.2	30.1	454.4	1339.7	978.6	50.3	145.0	88.8
Gomti Nagar	136.7	276.0	186.4	58.8	79.3	67.1	11.9	22.4	15.8	22.9	27.5	24.9	326.2	932.0	466.0	45.6	135.6	79.5
Commercial Area																		
Hussainganj	169.3	224.2	187.6	66.2	78.4	73.1	15.3	19.2	17.2	33.1	38.9	37.4	466.0	1328.1	1130.0	51.3	175.9	105.8
Charbagh	177.1	288.9	214.1	82.9	108.9	95.0	11.7	18.5	14.5	30.1	39.7	34.8	349.5	1770.8	1001.9	55.3	168.9	126.3
Alambagh	189.7	291.4	250.4	78.4	89.3	83.4	13.7	20.4	18.6	30.4	38.3	35.1	337.8	1374.7	1071.8	65.8	159.6	122.3
Aminabad	138.2	224.4	183.9	66.8	83.1	75.8	12.6	20.6	17.4	27.2	32.0	29.6	244.6	1316.5	862.1	75.3	115.5	95.6
Chowk	149.8	303.7	252.9	78.6	90.4	81.3	14.0	19.9	16.8	31.2	41.6	36.9	267.0	1339.7	1025.2	62.9	172.1	131.4
Industrial Area																		
Amausi	129.3	217.4	163.0	64.7	71.5	67.6	11.9	17.5	14.3	26.5	31.0	29.0	233.0	1165.0	803.8	35.2	102.1	66.7
NAAQS	100			60			80			80			4000			180		
WHO Guidelines	50			25			20			40*			-----			10**		

RSPM, SO_2, NOx (N=6), $PM_{2.5}$ (N=4), CO and O_3 = One hour Average, *= Annual Average, **= 8 Hours Average,

NAAQS=National Ambient Air Quality Standards

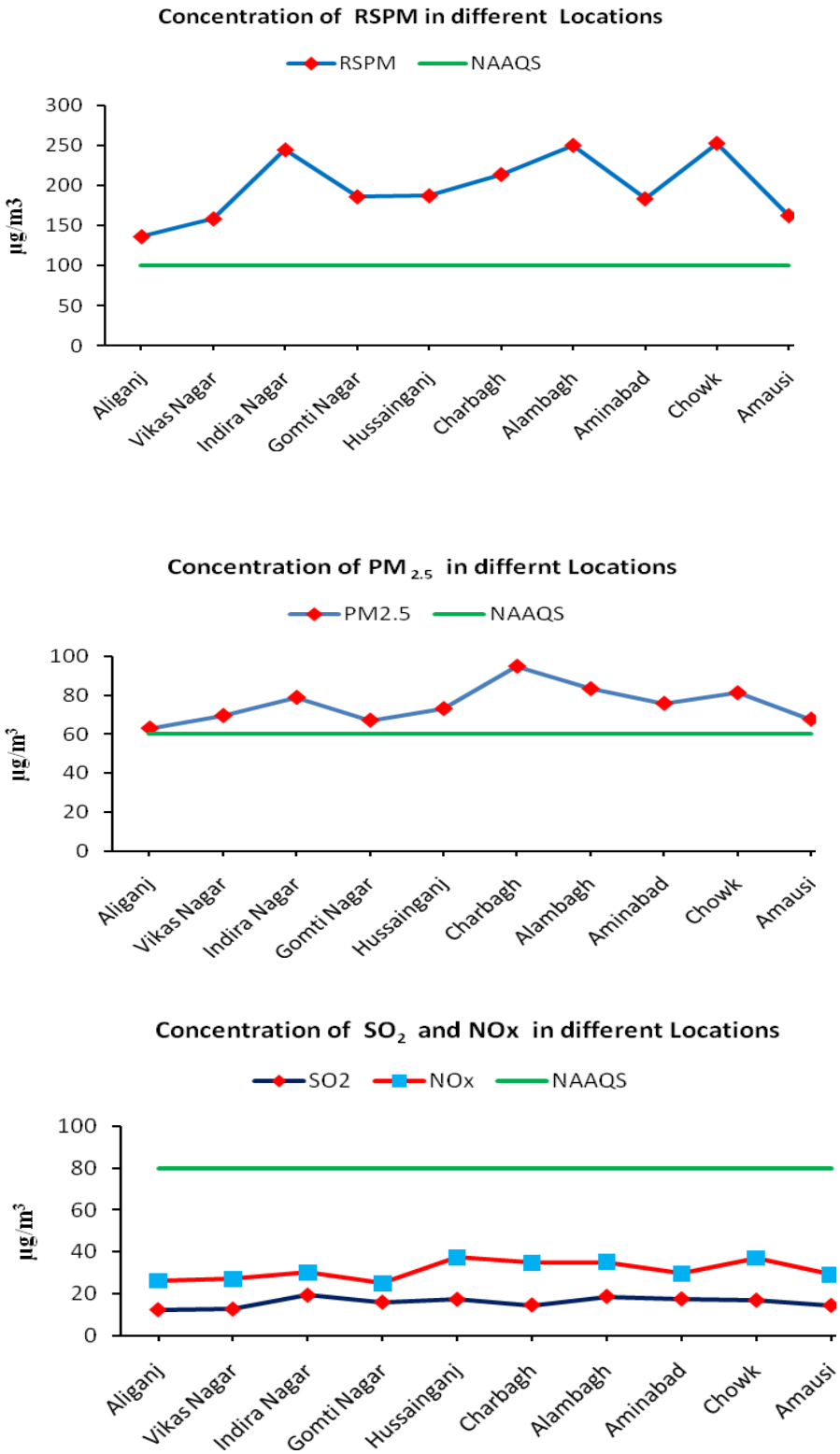

Fig 1: Concentration (µg/m^3) of RSPM, $PM_{2.5}$, SO_2 and NO_x in different areas of Lucknow city during pre monsoon season (2011) and compared with prescribed National Ambient Air Quality Standard (NAAQS)

1.3.7 Trace Metal (Ni and Pb) in Ambient Air (RSPM)

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

The 24 hr concentration of Pb was found to be maximum in Indira Nagar 134.2 and minimum in Vikas Nagar 92.4 ng/m^3 with an average of 112.8 ng/m^3 in residential area. In case of commercial locations, minimum in Alambagh 205.6 and maximum in Aminabad 1506.0 ng/m^3 with an average of 705.2 ng/m^3. In Amausi it was found 405.1 ng/m^3. All the values of lead were found below the prescribed limit of NAAQS 1000 ng/m^3 except Aminabad.

The hierachy of locations for Lead were arranged in descending order of their average concentrations as given below.

Aminabad >Hussainganj >Chowk >Charbagh >Amausi> Alambagh>Gomti Nagar>Indira Nagar>Aliganj>Vikas Nagar

The 24 hr concentration of Ni was found to be minimum in Gomtinagar 16.5 ng/m^3 and maximum in Aliganj 26.1 in residential area. In case of commercial area, minimum in Alambagh 11.3 and maximum in Chowk 39.1 ng/m^3. In Amausi it was found 15.7 ng/m^3.

All the values of Nickel were found below the prescribed limit of NAAQS 20 ng/m^3 except in Aliganj, Vikasnagar, Charbagh, and Chowk.

The hierachy of locations for Nickel were arranged in descending order of their average concentrations as given below.

Chowk>Aliganj>Vikas Nagar >Charbagh> Indira Nagar >Hussainganj > Gomti Nagar>Amausi>Aminabad>Alambagh

There might be an influence of the prevailing meteorological conditions which are responsible for the dispersion of fugitive emissions of road side soil dust.

Table 9: Average value (ng/m^3) of Lead (Pb) and Nickel (Ni)

Location	Pb	Ni
Residential Area		
Aliganj	113.4	26.1
Vikas Nagar	92.4	25.8
Indira Nagar	134.2	19.0
Gomti Nagar	151.3	16.5
Average	**112.8**	**21.8**
Commercial Area		
Hussainganj	898.9	19.0
Charbagh	434.5	20.7
Alambagh	205.6	11.3
Aminabad	1506.0	12.7
Chowk	480.8	39.1
Average	**705.2**	**20.6**
Industrial Area		
Amausi	405.1	15.7
NAAQS	**1000.0**	**20.0**

1.3.8 NOISE

The monitoring data recorded during the pre monsoon period (May, 2011) is presented in Table 10.

In residential areas, the day and night time noise level were recorded between 57.3 to 62.1 and 51.3 to 56.2 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 64.8 to 66.9 and 56.3 to 63.5 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 between 64.6 and 61.4 dB (A) respectively. Noise level 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	57.3	52.1
		Vikas Nagar	60.6	54.3
		Indira Nagar	62.0	56.2
		Gomti Nagar	62.1	51.3
		Standard	**55.0**	**45.0**
	Commercial	Hussainganj	64.8	62.1
		Charbagh	66.5	63.5
		Alambagh	66.9	60.2
		Aminabad	65.1	56.3
		Chowk	66.2	57.6
		Standard	**65.0**	**55.0**
3	**Industrial**	Amausi	64.6	61.4
		Standard	**75.0**	**70.0**

1.4 TRENDS OF AMBIENT AIR QUALITY IN LUCKNOW CITY

The observed RSPM, SO_2 and NO_x for 5 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 estimated over last year except in Vikas Nagar. Among the commercial areas, RSPM values showed increasing trend except at Aminabad and Hussainganj than the last year. Amausi under industrial area showed more or less same 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 2006 is presented in Fig. 3 for all the locations.

In residential areas, higher concentration was found over last year except Vikas Nagar. Among the commercial areas, SO_2 values showed increasing trend except at Charbagh 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 2006 is presented in Fig. 4 for all the locations. Among the Residential areas all the locations showed slightly increasing trend except Gomti Nagar and Vikas Nagar. Among commercial areas, NOx registered increasing trend at all the locations except Charbagh when compared with the last year data. The industrial area Amausi showed lower value when compared with the last year data. All the values of the present study were found to be lower than the NAAQS (Fig. 4).

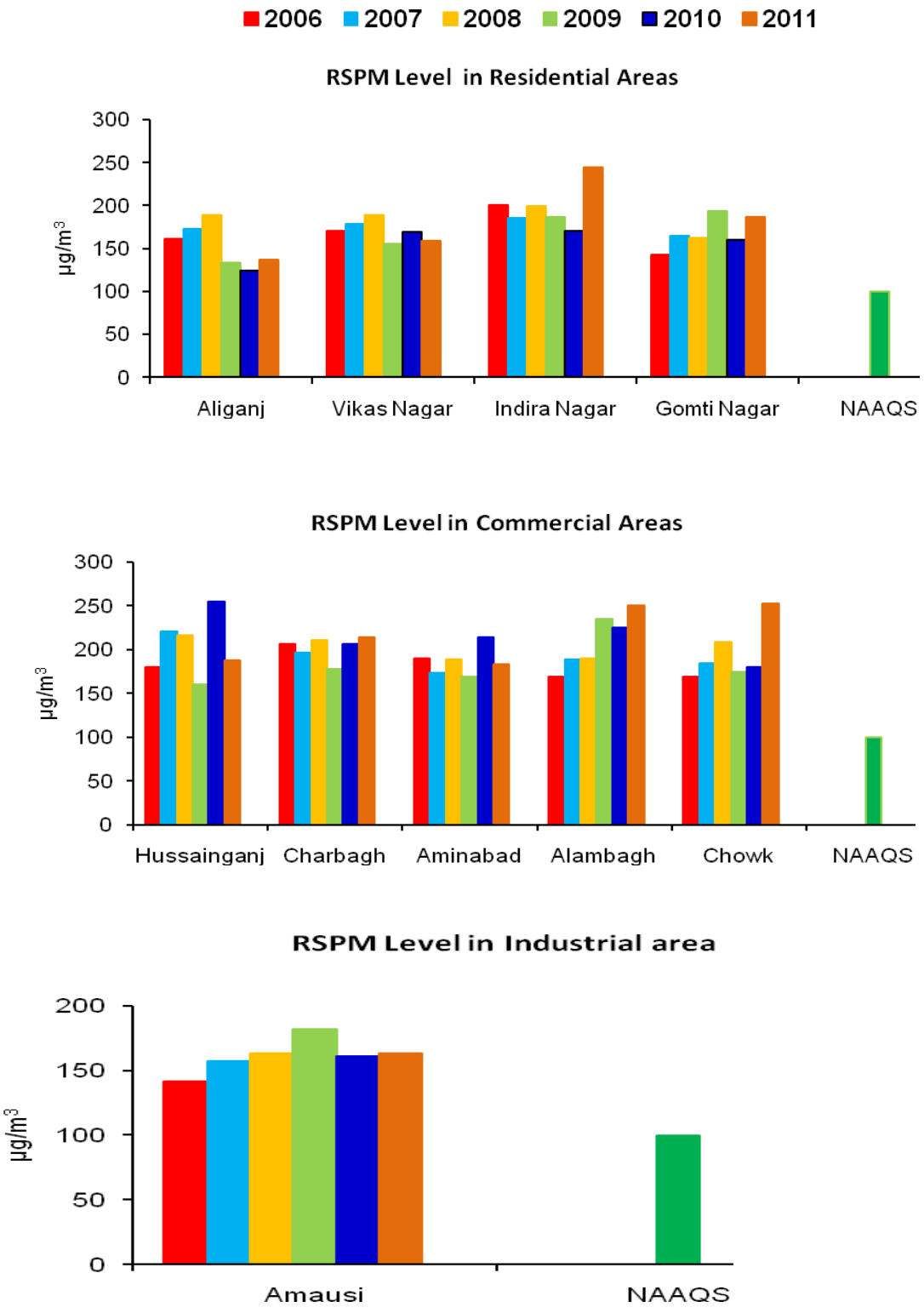

Fig 2: Concentration (µg/m^3) of RSPM in Residential, Commercial and Industrial areas of Lucknow city during 2006 to 2011 and compared with prescribed National Ambient Air Quality Standard (NAAQS)

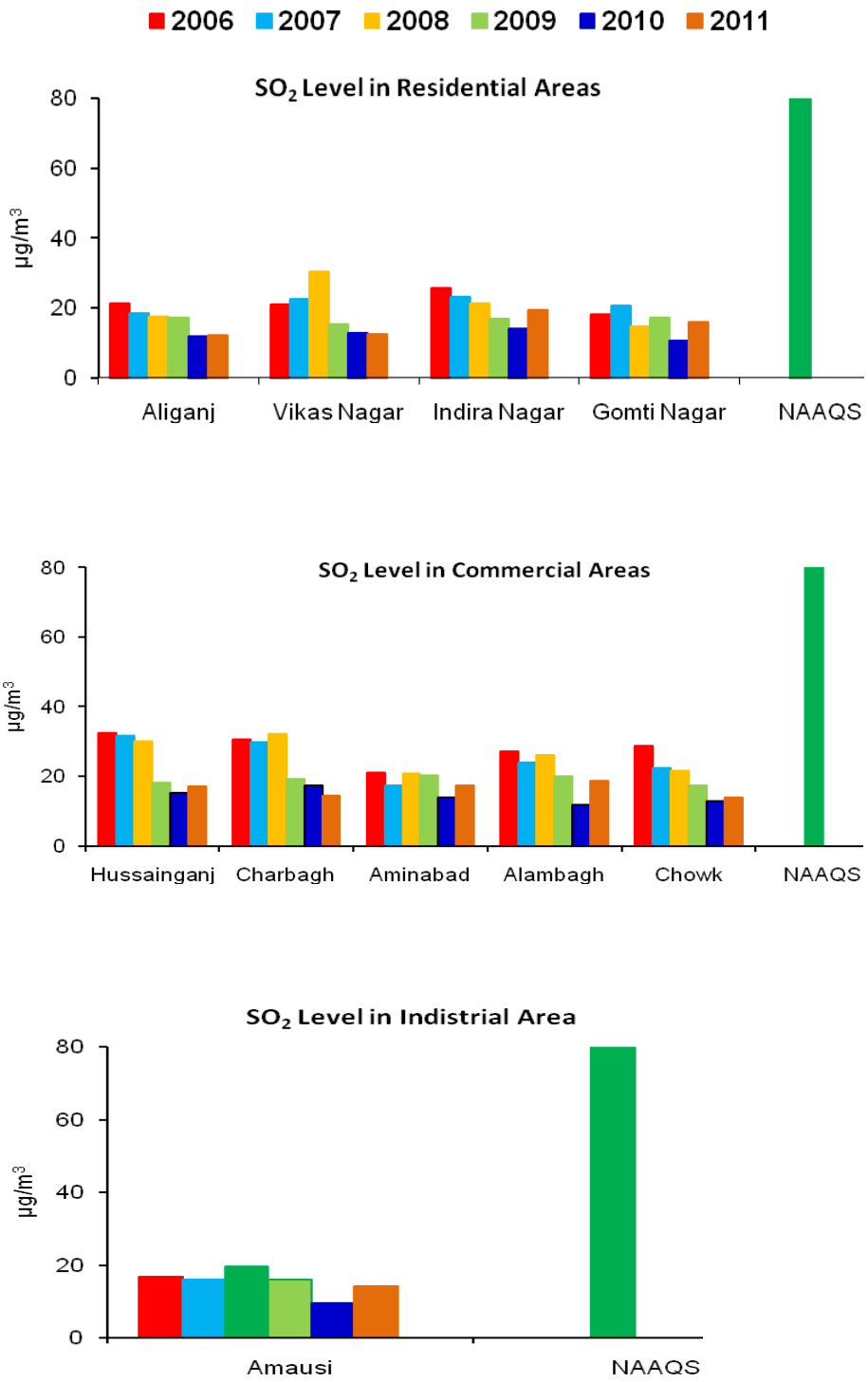

Fig 3: Concentration (µg/m^3) of SO_2 in Residential, Commercial and Industrial areas of Lucknow city during 2006 to 2011 and compared with prescribed National Ambient Air Quality Standard (NAAQS)

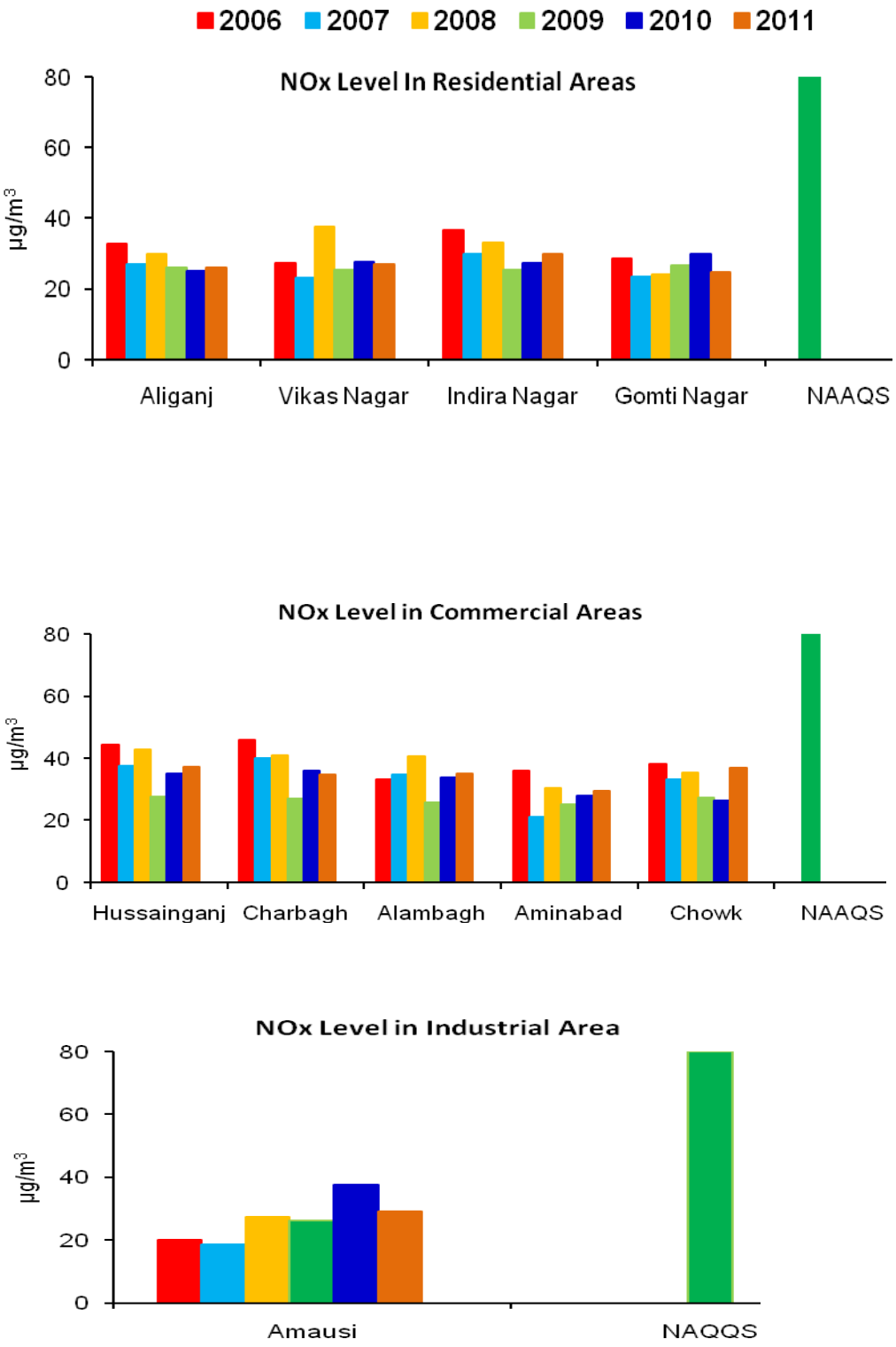

Fig 4: Concentration (µg/m^3) of NO_x in Residential, Commercial and Industrial areas of Lucknow city during 2006 to 2011 and compared with prescribed National Ambient Air Quality Standard (NAAQS)

1.4.4 Trends of Noise Level

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

1.4.4.1 Day time Noise Level

In residential areas all the locations showed slightly decreasing trend over the last year level except Vikas Nagar and Aliganj. In commercial cum traffic areas slightly lower levels at all locations were recorded over the last year except Charbagh. In industrial area, Amausi the noise level was recorded lower value over last year data. The comparative data are presented in (Fig. 5).

1.4.4.2 Night time Noise Level

All four residential areas showed slightly lower trend was recorded over the last year level. Among commercial areas, all the locations showed almost lower values except Hussainganj and Chowk than the last year. In industrial area, registered slightly higher values during night time over last year data. The comparative data are presented in (Fig. 6).

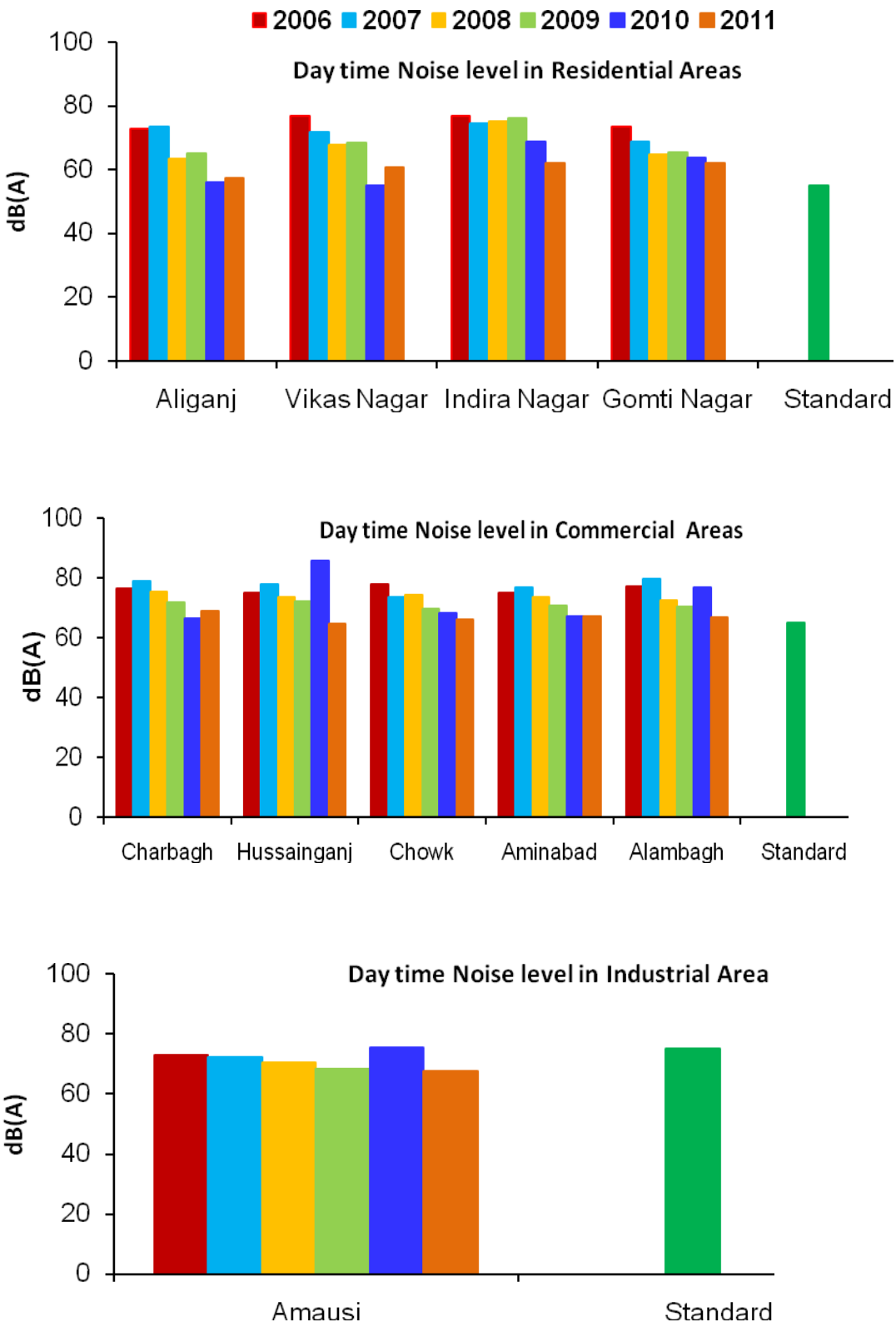

Fig 5: Comparison of day time Noise Level dB(A) in different areas of Lucknow city (2006-2011)

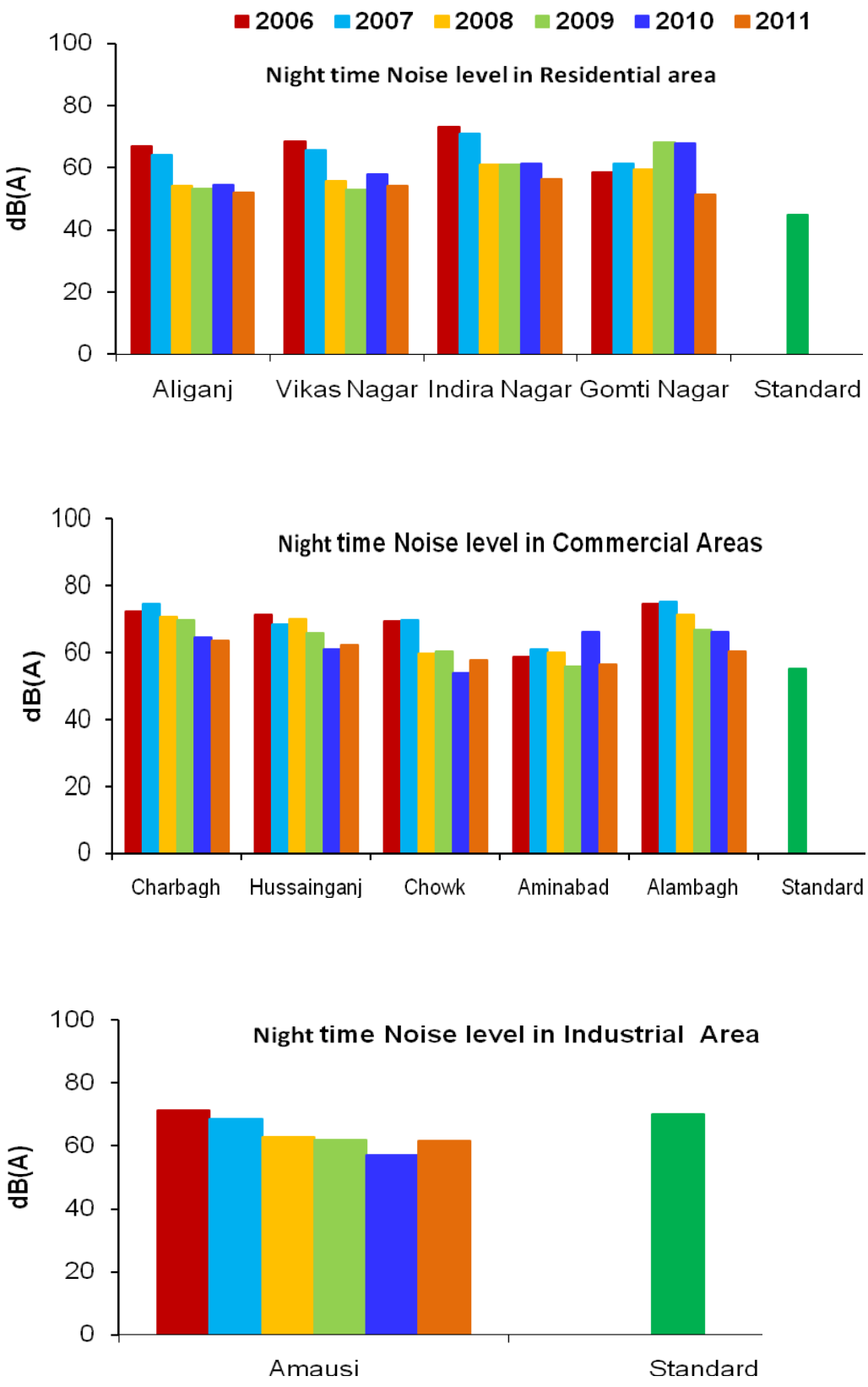

Fig 6: Comparison of night time Noise Level dB (A) in different areas of Lucknow city (2006-2011)

1.5 HEALTH EFFECTS OF AIR POLLUTANTS

1.5.1 Respirable Suspended Particulate Matter (RSPM or PM_{10})

Sources - Construction, abrasion, burning of fuels and also form secondarily.

Effects- Irritation to eyes, skin, throat, upper respiratory system. Particle pollution contains microscopic solids or liquid droplets that are so small that they can get deep into the lungs and cause serious health problems. The size of particles is directly linked to their potential for causing health problems. Small particles less than 10 micrometers in diameter pose the greatest problems, because they can get deep into lungs, and some may even get into bloodstream.

Occupational standard-TWA 15 mg/m^3 (total) TWA 5 mg/m^3. World Health Organization (WHO) air-quality guidelines of 50 $\mu g/m^3$ 24 hrs basis.

1.5.2 Fine Particles ($PM_{2.5}$)

Those particulates which have aerodynamic diameter ≤ 2.5 μm ($PM_{2.5}$)

Sources - Combustion of fuels, metal processing units.

Effects - Carriers of toxic air pollutants including heavy metals and organic compounds, chronic exposure may lead to lung cancer.

Occupational standard -World Health Organization (WHO) air-quality guidelines of 25 $\mu g/m^3$, 24 hrs basis.

1.5.3 Sulfur dioxide (SO_2)

Sources - It is produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulfur compounds, their combustion generates sulfur dioxide unless the sulfur compounds are removed before burning the fuel.

Effects- Irritation to eyes, nose, throat; rhinorrhea (discharge of thin nasal mucus); choking, cough; reflex bronchoconstriction; liquid: frostbite.

Occupational Standard- Time Weighted Average (TWA) 2 ppm (5 mg/m^3).

1.5.4 Nitrogen Dioxide (NO_2)

Sources- Combustion of automobile fuels, coal, which have significant nitrogen content, particularly when burned in combustors.

Effects- Decrease lung function and increase the risk of respiratory symptoms such as acute bronchitis and cough and phlegm, particularly in children.

Occupational Standard- The current WHO guideline values for NO_2 are: a 1-hour level of 200 $\mu g/m^3$ and an annual average of 40 $\mu g/m^3$.

1.5.5 Lead (Pb)

Sources - Paint, urban dust, and folk remedies, use of heat guns, battery making, smelter work, plastic manufacturers.

Effects- It damages the nervous system and causes brain disorders. Excessive lead also causes blood disorders in mammals including human being.

Occupational Standards- > 50 $\mu g/m^3$ (Permissible Exposure Limit) (OSHA)

1.5.6 Nickel (Ni)

Sources - Coal burning units in utility, industrial, and residential use sectors, and municipal and sewage sludge incinerators, high temperature metallurgical operations (steel and nickel alloy manufacturing, secondary metals smelting, and co-product nickel recovery), chemical and catalyst sources (nickel chemical manufacturing, electroplating, nickel-cadmium battery manufacturing, and catalyst production, use, and reclamation).

Effects- Sensitization dermatitis, allergic asthma, cough, shortness of breath, pneumonitis; decreased sense of smell, Nickel sulfide fume and dust is believed to be carcinogenic, and various other nickel compounds may be as well. Nickel carbonyl, $[Ni(CO)_4]$, is an extremely toxic gas. Sensitized individuals may show an allergy to nickel affecting their skin, also known as dermatitis.

Occupational standards- TWA 0.015 mg/m^3

1.5.7 Carbon Mono Oxide (CO)

Sources - Coal, oil and gas-fired furnaces, space heaters, and water heaters (watch especially for cracks in the chimney liner or flue) as well as wood-burning fireplaces.

Effects- Weakness and dizziness may be the only symptoms preceding collapse. The amount of carboxyhemoglobin formed in the blood is dependent on concentration and duration of exposure, ambient temperature, physical exertion, health, and individual metabolism. Symptoms are usually not noticeable until the carboxyhemoglobin level reaches 10%. At 10-40%, symptoms may include increasingly severe headache, dyspnea on exertion, decreased manual dexterity, impaired judgement and memory, irritability, emotional instability, dizziness, fatigue, drowsiness, confusion, nausea, vomiting, palpitations, and impaired vision and hearing.

Occupational standard- The current Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) for carbon monoxide is 50 parts per million (ppm) parts of air (55 milligrams per cubic meter (mg/m^3) as an 8-hour time-weighted average (TWA) concentration.

1.5.8 Ozone (O_3)

Sources- Ground-level or "bad" ozone is not emitted directly into the air, but is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight.

Effects- Breathing ozone, a primary component of smog, can trigger a variety of health problems including chest pain, coughing, throat irritation, and congestion. It can worsen bronchitis, emphysema, and asthma. Ground-level ozone also can reduce lung function and inflame the linings of the lungs. Repeated exposure may permanently scar lung tissue.

Occupational Standard- the Food and Drug Administration (FDA) requires ozone output of indoor medical devices to be no more than 0.05 ppm. The Occupational Safety and Health Administration (OSHA) require that workers not be exposed to an average concentration of more than 0.10 ppm for 8 hours. The National Institute of Occupational Safety and Health (NIOSH) recommend an upper limit of 0.10 ppm, not to be exceeded at any time.

1.6 CONCLUSIONS

We have monitored air pollutants such as PM_{10}, $PM_{2.5}$, CO, O_3, SO_2, NOx, Ni and Pb as recommended by Ministry of Environment and Forest (MoEF), New Delhi for assessment of ambient air quality. Besides, we also monitored noise level during Day and Night Time at 10 locations during pre monsoon (April-May), 2011 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 $\mu g/m^3$)

- The concentration of gaseous pollutants, SO_2 and NO_x were well below the prescribed NAAQS (80 $\mu g/m^3$) at all the locations.

- Decreasing trend for the RSPM was found at all the locations over the 2006 data till last year except at Vikas Nagar, Hussainganj, Charbagh and Aminabad. The present values showed higher level in most of locations .It may be due to local construction activity.

- The noise level at all the locations except in industrial areas during day and night time showed lower level than the respective permissible limits.

- Level of lead at all the locations found to be under permissible limit (1000 ng/m^3) except in Aminabad.

- Level of nickel at all the locations found to be under permissible limit when compared with annual average (20 ng/m^3) except Aliganj, Vikas Nagar, Charbag and Chowk.

- Overall results indicate that RSPM and associated metals are one of the major causes for deterioration of ambient air quality.

The results of the present study revealed that the level of PM_{10} and $PM_{2.5}$ are the major concern because their level is higher than the permissible limit. Results also indicate the presence of other pollutants like carbon monoxide (CO), ozone (O_3), and metals like lead,

nickel in the urban area of Lucknow city. Some of these pollutants are carcinogenic but present in comparatively low level. Continuous exposure is a matter of concern with respect to health of Lucnowites in the long run.

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

1.7 RECOMMENDATIONS

- Public mass transport must be strengthened to minimize use of personal vehicle.
- Improvement in the traffic management.
- Encroachment should be removed for smooth flow of traffic.
- Check on fuel adulteration.
- 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 vehicle.
- Congestions charges for certain area for peak hours.
- Restore foot path for pedestrian

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