NATIONAL AMBIENT AIR QUALITY STATUS 2009

CENTRAL POLLUTION CONTROL BOARD
MINISTRY OF ENVIRONMENT & FORESTS
Website: http://www.cpcb.nic.in/
e-mail: cpcb@nic.in
January 2011

प्रो० स. प्र. गौतम
अध्यक्ष
Prof. S. P. Gautam
Chairman

केन्द्रीय प्रदूषण नियंत्रण बोर्ड
(भारत सरकार का संगठन)
पर्यावरण एवं वन मंत्रलय
Central Pollution Control Board
(A Govt. of India Organisation)
Ministry of Environment & Forests
Phone : 22304948 / 22307233

FOREWORD

The Central Pollution Control Board (CPCB) has established the National Ambient Air Quality Monitoring (NAMP) Network, covering 365 cities/towns of the country in compliance with the mandate under the Air (Prevention and Control of Pollution) Act, 1981 to collect compile and disseminate information on air quality.

The ambient air quality is monitored collectively by Central Pollution Control Board (CPCB), State Pollution Control Boards (SPCBs), Pollution Control Committees (PCCs), and National Environmental Engineering Research Institute (NEERI). The data, thus generated, is transmitted to CPCB for scrutiny, analysis, compilation and its publication. The present Report contains ambient air quality data for the calendar year 2009 and trend analysis of major urban centres such as metropolitan cities since 2000. Air pollution status of various pollutants is described in terms of Low, Moderate, High and Critical category, vis-a-vis the notified ambient air standards. The status is depicted in the form of tables and figures as well.

The contributions made by my colleague Dr. Sanjeev Agrawal, Scientist 'C', Sh. Tarun Darbari, Scientist 'B', Dr. Sanghita Roychoudhury, RA, Ms. Abida Khatoon, JRF, Ms. Pramila Gupta, SRF for compiling the data, under the supervision of Dr. D.D. Basu, Scientist 'E' and Sh. J.S. Kamyotra, Member Secretary is appreciable. Efforts made by CPCB Head Office / ZO'sCPCB / SPCB's / PCC's and other collaborating agencies are acknowledged.

The co-operation of all the monitoring agencies is gratefully acknowledged in successfully achieving this major task. Hopefully, the report will be useful to all concerned.

(S. P. GAUTAM)

20th January 2011

'Parivesh Bhawan' C.B.D.-cum-Office Complex, East Arjun Nagar, Delhi-110 032
Fax : 22304948 / 22307078 email : cpcb@alpha.nic.in
Website : http://www.cpcb.nic.in

PERSONNEL INVOLVED

Principal Coordinator	**Shri J. S. Kamyotra,** **Member Secretary** **Dr. D. D. Basu,** **Scientist 'E' & I/C** **PAMS Division**
Data Collection, Compilation, Securitization, Storage and Report Preparation	**Dr. Sanjeev Agrawal** **Sh. Tarun Darbari** **Dr. Sanghita Roychoudhury** **Ms. Pramila Gupta** **Ms. Abida Khatoon**
Data entry (Online)	**SPCBs/PCCs/NEERI/Universities and other agencies**
Data Storage in EDB (Online)	**Dr. P. Gargava** **Ms. Smriti Upadhyay** **Ms. Sashi Goel** **Sh. Yatindra N. Mishra**
Monitoring agencies involved in NAMP Network	**Air laboratory CPCB/ZOs/SPCBs/ PCCs, NEERI/Universities and other agencies**

CONTENTS

ABBREVIATION

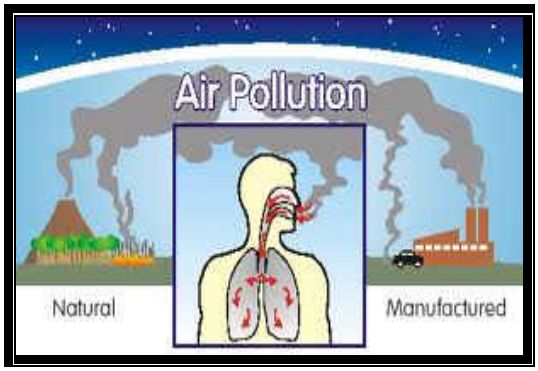
As	Arsenic
B(a)P	Benzo (a) Pyrene
C_6H_6	Benzene
CO	Carbon monoxide
CPCB	Central Pollution Control Board
CPCB ZO	CPCB Zonal Offices
EDB	Environmental Data Bank
H_2S	Hydrogen Sulphide
NAAQS	National Ambient Air Quality Standards
NAMP	National Air Quality Monitoring Programme
NEERI	National Environmental Engineering Research Institute
NH_3	Ammonia
Ni	Nickel
NO_2	Nitrogen Dioxide
O_3	Ozone
PAHs	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCC	Pollution Control Committees
PM_{10}	Particulate matter of size ≤ 10μm
$PM_{2.5}$	Particulate matter of size ≤ 2.5μm
QA/QC	Quality assurance and Quality control
RSPM	Respiratory Suspended Particulate Matter
SO_2	Sulphur dioxide
SPCB	State Pollution Control Boards
SPM	Suspended Particulate Matter

TABLES

FIGURES & PLATES

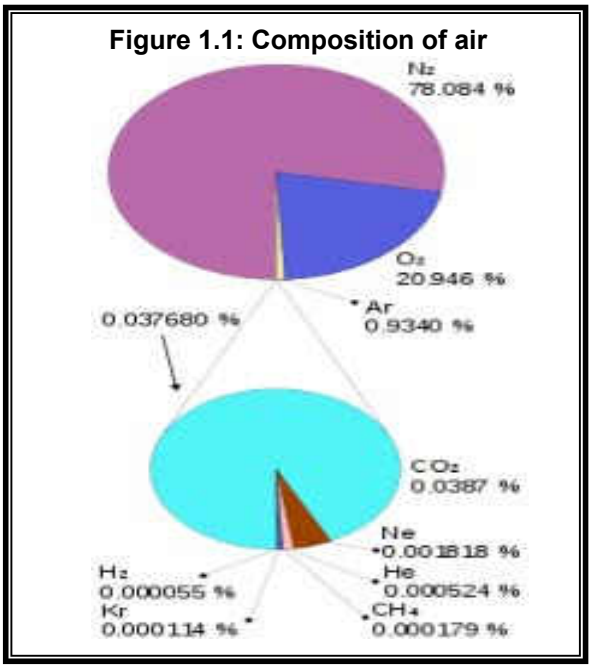
CHAPTER 1

INTRODUCTION



The atmosphere of Earth is a layer of gases surrounding the planet Earth that is retained by Earth's gravity. **Pure air** consists of roughly 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide, and small amounts of other gases (by volume). Air also contains a variable amount of water vapor, on average around 1% (Figure 1.1). But with growth of urbanization and industrialization a lot of other elements has been added to pure air. This resulted in the increase of pollution. In order to prevent, control and abate air pollution, the Air (Prevention and Control of Pollution) Act was enacted in 1981. According to Section 2(b) of Air (Prevention and control of pollution) Act, 1981 '**air pollution**' has been defined as 'the presence in the atmosphere of any air pollutant.' As per Section 2(a) of Air (Prevention and control of pollution) Act, 1981 '**air pollutant**' has been defined as 'any solid, liquid or gaseous substance [(including noise)] present in the atmosphere in such concentration as may be or tend to be injurious to human beings or other living creatures or plants or property or environment'. Therefore **ambient air quality standard** is developed as a policy guideline that regulates the effect of human activity upon the environment so that pollutant emission into the air can be regulated. Standards may specify a desired state or limit alterations.

Figure 1.1: Composition of air



1.1 National Ambient Air Quality Standards (NAAQS)

The objectives of air quality standards are:

- To indicate the levels of air quality necessary with an adequate margin of safety to protect the public health, vegetation and property;
- To assist in establishing priorities for abatement and control of pollutant level;
- To provide uniform yardstick for assessing air quality at national level;
- To indicate the need and extent of monitoring programme.

The revised National Ambient Air Quality Standards notified on November 2009 is depicted below (Table 1.1).

Table 1.1: Revised National Ambient Air Quality Standards (NAAQS)

[NAAQS Notification dated 18th November, 2009]

S. No.	Pollutants	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
			Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (notified by Central Government)	
1	Sulphur Dioxide (SO_2), µg/m^3	Annual*	50	20	1. Improved West and Gaeke 2. Ultraviolet Fluorescence
		24 Hours**	80	80	
2	Nitrogen Dioxide (NO_2), µg/m^3	Annual*	40	30	1. Modified Jacob & Hochheiser (Na-Arsenite) 2. Chemiluminescence
		24 Hours**	80	80	
3	Particulate Matter (Size <10µm) or PM_{10} µg/m^3	Annual*	60	60	1. Gravimetric 2. TOEM 3. Beta attenuation
		24 Hours**	100	100	
4	Particulate Matter (Size <2.5 µm) or $PM_{2.5}$ µg/m^3	Annual*	40	40	1. Gravimetric 2. TOEM 3. Beta attenuation
		24 Hours **	60	60	
5	Ozone (O_3), µg/m^3	8 hours**	100	100	1. UV photometric 2. Chemiluminescence 3. Chemical Method
		1 hours **	180	180	
6	Lead (Pb), µg/m^3	Annual *	0.50	0.50	1. AAS/ICP Method after sampling using EPM 2000 or equivalent filter paper 2. ED-XRF using Teflon filter
		24 Hour**	1.0	1.0	
7	Carbon Monoxide (CO), mg/m^3	8 Hours **	02	02	Non dispersive Infra Red (NDIR) Spectroscopy
		1 Hour**	04	04	
8	Ammonia (NH_3), µg/m^3	Annual*	100	100	1. Chemiluminescence 2. Indophernol blue method
		24 Hour**	400	400	
9	Benzene (C_6H_6) , µg/m^3	Annual *	05	05	1. Gas chromatography based continuous analyzer 2. Adsorption and Desorption followed by GC analysis
10	Benzo(a)Pyrene (BaP)-particulate phase only, ng/m^3	Annual*	01	01	Solvent extraction followed by HPLC/GC analysis
11	Arsenic (As), ng/m^3	Annual*	06	06	AAS/ICP method after sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni), ng/m^3	Annual*	20	20	AAS/ICP method after sampling on EPM 2000 or equivalent filter paper

** Annual Arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform interval.*

*** 24 hourly 08 hourly or 01 hourly monitored values, as applicable shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.*

NOTE: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

1.2 Air Pollutants, their sources and effects

In order to combat air pollution it is required to identify the pollutants, its source of emission and investigate the effects of living and the environment. The Central Pollution Control Board has therefore identified and revised the National Ambient Air Quality Standards on April 11, 1994 which was notified in Gazette of India, Extra-ordinary Part-II Section 3, sub section (ii), dated May 20, 1994 (Table 1.1). The pollutants enlisted in the National Ambient Air Quality Standards and their sources and effects are summarized in Annexure 1

Close examination to Annexure 1 reveals the following information:

- All the pollutants listed in National Ambient Air Quality Standards are generated both from natural and anthropogenic sourced
- Pollutants can be classified in three groups i.e. aerosols, gases and metals
- Combustion of fossil fuel is the major man made activity that leads to generate major air pollutants
- Ozone is the secondary pollutant
- Benzene and benzo(a)pyrene are known carcinogenic compounds
- Respiratory problems, lung and heart diseases mostly correlated with the air pollutants
- Lead effects kidney whereas carbon monoxide creates carboxy hemoglobin

1.3 National Air Quality Monitoring Programme (N.A.M.P.)

1.3.1. Present status of NAMP: Central Pollution Control Board initiated National Ambient Air Quality Monitoring (NAAQM) programme in the year 1984 with 7 stations at Agra and Anpara. Subsequently the programme was renamed as National Air Quality Monitoring Programme (NAMP).

The air quality monitoring network strengthened by increasing the number of monitoring stations from 28 stations in 1985 to 290 stations in 2002. Recently, in this financial year (2009-2010) 147 stations added in the network and the operating stations were became 365 covering 141 cities in 26 states and 5 Union Territories as on 31st March 2010 (The growth of operating Ambient Air Quality monitoring station under NAMP is depicted in Figure 1.2. State and city wise air quality monitoring stations are summarized in Table 1.2 Figure 1.3 shows the number of sanctioned and operating air quality monitoring station in states and Figure 1.4 presents the status stated above in the union territories in India till March 31st, 2010. By 31st October 2010 the operating stations increased to 439 in 178 cities, 26 states and 5 UTs.

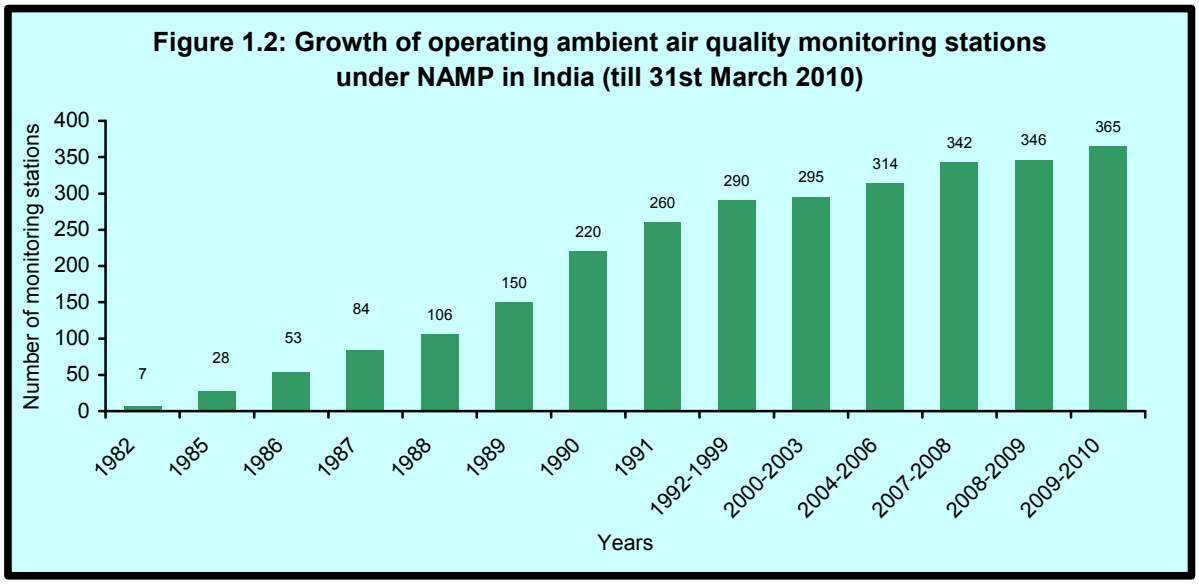


Table 1.2. Operating Air Quality Stations in India as on 31st March 2010

S. No.	State/Union territory	City	Number of operating stations
1	Andhra Pradesh (27)	Hyderabad	9
		Visakhapatnam	8
		Tirupati	1
		Vijayawada	2
		Kurnool	1
		Ramagundum	1
		Patencheru	1
		Nalgonda	1
		Guntur	1
		Warangal	1
		Nellore, Nellore	1
2	Assam (13)	Bongaigaon	3
		Gawahati	4
		Tezpur	1
		Sibasagar	1
		Dibrugarh	1
		Golaghat	1
		Hailakandi	1
		Daranga	1
3	Bihar (2)	Patna	2
4	Chandigarh (5)	Chandigarh	5
5	Chattisgarh (9)	Korba	3
		Bhilai	3
		Raipur	3
6	Delhi (11)	Delhi	11
7	Dadara & Nagar Haveli (2)	Silvasa	2
8	Daman Diu (2)	Daman	2
9	Goa (3)	Ponda	1
		Vasco	1
		Marmagao	1
10	Gujarat (20)	Ahmedabad	6
		Ankaleshwar	2

		Jamnagar	1
		Rajkot	2
		Surat	3
		Vadodara	4
		Vapi	2
11	Haryana (5)	Faridabad	2
		Hissar	2
		Yamuna Nagar	1
12	Himachal Pradesh (14)	Damtal	2
		Parwanoo	2
		Poanta Sahib	2
		Shimla	2
		Kala Amb	2
		Baddi-Barotiwala	3
		Nalagarh	1
13	Jammu& Kashmir (3)	Jammu	3
14	Jharkand (6)	Dhanbad	1
		Jharia	1
		Sindri	1
		Jamshedpur	2
		Ranchi	1
15	Karnataka (14)	Bangalore	6
		Dharwar, Hubli	2
		Mangalore	1
		Hassan	1
		Mysore	2
		Gulbarga	1
		Belgaum	1
16	Kerala (16)	Kozhikode	2
		Kottayam	2
		Cochin	7
		Thiruvanantapuram	4
		Palakkad	1
17	Madhya Pradesh (26)	Bhopal	4
		Indore	3
		Jabalpur	1
		Nagda	3
		Gwalior	2
		Sagar	2
		Satna	2
		Singrauli	3
		Ujjain	3
		Dewas	3
18	Maharashtra (50)	Aurangabad	3
		Lote	2
		Tarapur	3
		Kolhapur	3
		Mumbai	3
		Ambernath	2
		Chandrapur	3
		Nagpur	6
		Nasik	3
		Solapur	2
		Pune	3
		Thane	3
		Navi Mumbai (incl TTC Ind. Area, Taloja Ind Area)	6
		Mahad	3

		Roha	2
		Sangli	3
19	Meghalaya (3)	Shillong	2
		Dwaki	1
20	Mizoram (3)	Aizwal	3
21	Manipur (1)	Imphal	1
22	Nagaland (2)	Dimapur	2
23	Orissa (12)	Rayagada	2
		Rourkela	2
		Talcher	2
		Angul	2
		Bhubaneshwar	1
		Cuttack	1
		Sambalpur	1
		Berhampur	1
24	Punjab (16)	Gobindgarh	3
		Jalandhar	4
		Ludhiana	4
		Naya Nangal	2
		Khanna	2
		Pathankot(Dera baba)	1
25	Pondicherry (3)	Pondicherry	3
26	Rajasthan (18)	Alwar	3
		Jaipur	6
		Jodhpur	3
		Kota	3
		Udaipur	3
27	Sikkim (2)	Gangtok	2
28	Tamilnadu (16)	Chennai	6
		Tuticorin	3
		Coimbatore	3
		Madurai	3
		Salem	1
29	Uttar Pradesh (38)	Agra	6
		Allahabad	2
		Anpara	2
		Firozabad	3
		Gajroula	2
		Ghaziabad	2
		Kanpur	6
		Lucknow	5
		Noida	2
		Varanasi	2
		Jhansi	2
		Khurja	2
		Meerut	2
30	Uttarakhand (2)	Dehradun	2
31	West Bengal (21)	Kolkata	10
		Durgapur	3
		Haldia	3
		Howrah	4
		Asansol	1
Total	**26 states, 5UTs**	**141**	**365**

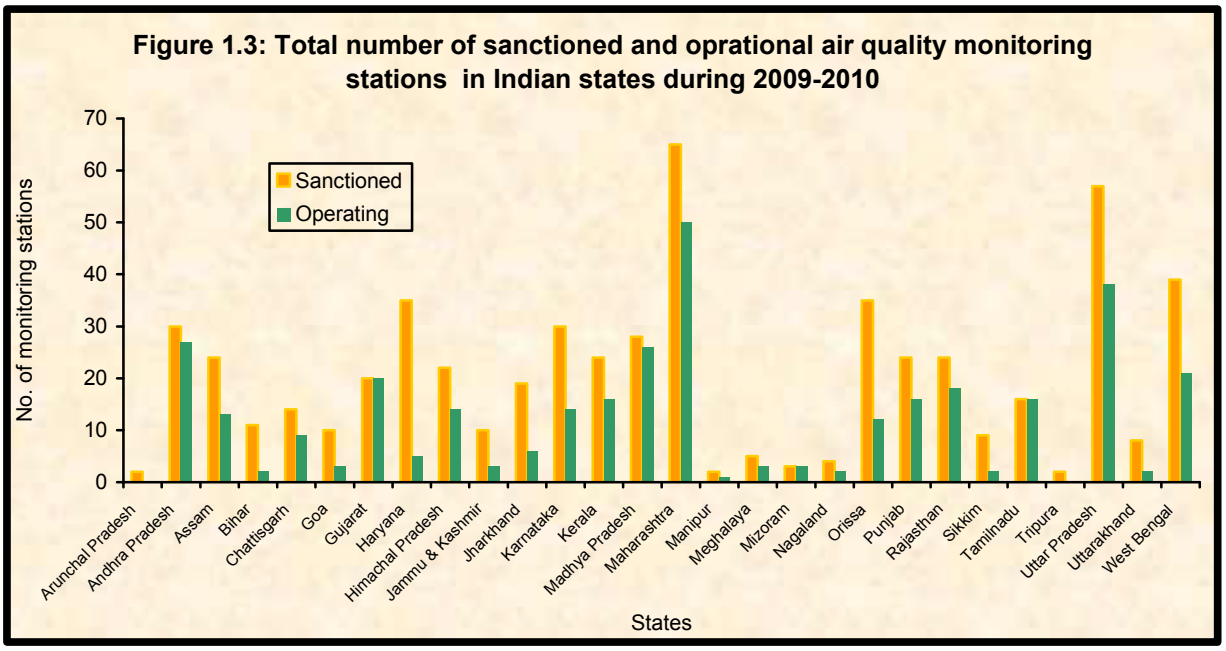


Figure 1.3: Total number of sanctioned and oprational air quality monitoring stations in Indian states during 2009-2010
No. of monitoring stations
70
60
50
40
30
20
10
0
Sanctioned
Operating
Arunchal Pradesh
Andhra Pradesh
Assam
Bihar
Chattisgarh
Goa
Gujarat
Haryana
Himachal Pradesh
Jammu & Kashmir
Jharkhand
Karnataka
Kerala
Madhya Pradesh
Maharashtra
Manipur
Meghalaya
Mizoram
Nagaland
Orissa
Punjab
Rajasthan
Sikkim
Tamilnadu
Tripura
Uttar Pradesh
Uttarakhand
West Bengal
States

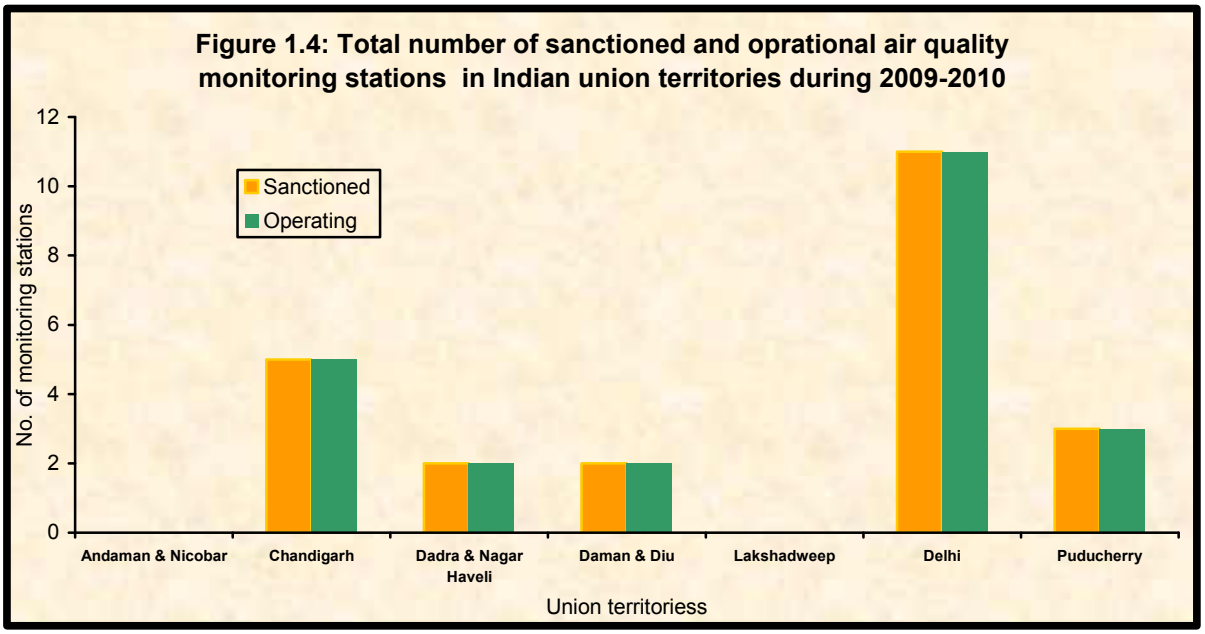


Figure 1.4: Total number of sanctioned and oprational air quality monitoring stations in Indian union territories during 2009-2010
No. of monitoring stations
12
10
8
6
4
2
0
Sanctioned
Operating
Andaman & Nicobar
Chandigarh
Dadra & Nagar Haveli
Daman & Diu
Lakshadweep
Delhi
Puducherry
Union territoriess

1.3.2. Objectives of NAMP

The objectives of the NAMP are as follows:

- To determine status and trends of ambient air quality;
- To ascertain whether the prescribed ambient air quality standards are violated;
- To Identify Non-attainment Cities;
- To obtain the knowledge and understanding necessary for developing preventive and corrective measures;
- To understand the natural cleansing process undergoing in the environment through pollution dilution, dispersion, wind based movement, dry deposition, precipitation and chemical transformation of pollutants generated.

1.3.3. Parameters monitored under NAMP

Under NAMP, four air pollutants *viz*., Suspended Particulate Matter (SPM), Particulate Matter with size less than 10µg (PM_{10}), Sulphur Dioxide (SO_2) and Nitrogen Dioxide (NO_2) were identified for regular monitoring at all the locations and additional parameters such as Carbon monoxide (CO), Particulate Matter with size less than 2.5µg ($PM_{2.5}$), Ozone (O_3) and Ammonia (NH_3) are being monitored at selected locations by methods adopted by CPCB (Annexure 2).

The monitoring of meteorological parameters such as wind speed and direction, relative humidity and temperature were also integrated with the monitoring of air quality.

The monitoring of pollutants is carried out for 24 hours (4-hourly sampling for gaseous pollutants and 8-hourly sampling for particulate matter) with a frequency of twice a week, to have 104 observations in a year.

The monitoring under the NAMP is being carried out with the help of State Pollution Control Boards (SPCB), Pollution Control Committees (PCC) and National Environmental Engineering Research Institute (NEERI), Nagpur and Central Pollution Control Board (CPCB) head and Zonal Offices. CPCB co-ordinates with these agencies to ensure uniformity, consistency of air quality data and provides technical and financial support to them for operating the monitoring station (Plate 1.1).

Plate 1.1. Different monitoring modes a. Mobile van monitoring, b. cabin for monitoring, c. Continuous analysers and d. analysis facility under NAMP

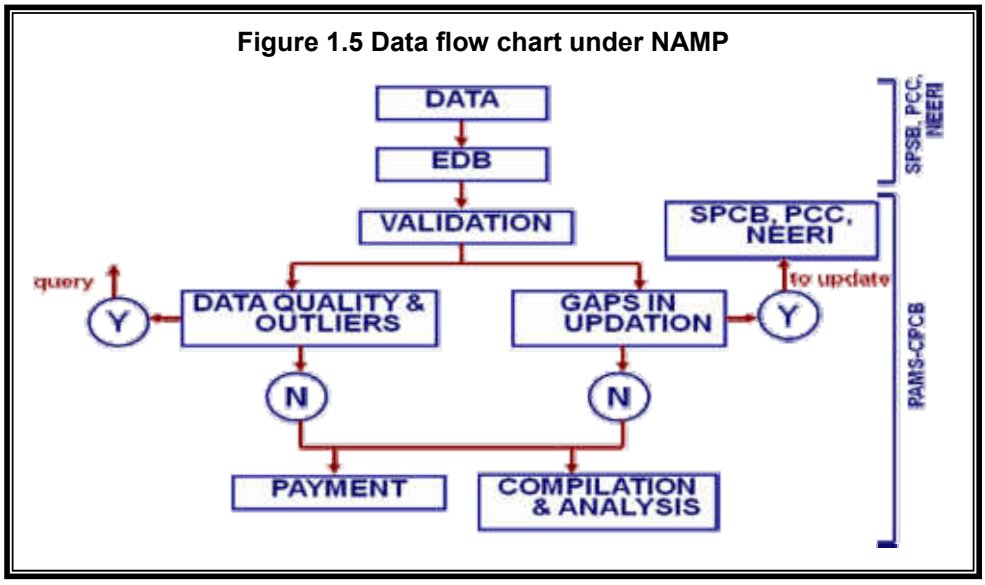
1.3.4. Data Analysis and Limitations

The air quality data generated at the monitoring stations are input into Environmental Data Bank (EDB) by respective SPCBs and PCCs and are transmitted to CPCB where the data is scrutinized for outliers and gaps in input of data. In case of any gaps the matter is discussed with the respective agencies and late the data is checked, scrutinized, compiled, processed and analyzed statistically to get the information on the annual mean, standard deviation etc. of the pollutants and payment is also made to the respective agencies. Figure 1.5 shows the data flow in NAMP. In the present report, results of SPM, PM_{10}, SO_2 and NO_2, for the year 2009 are presented.

While presenting the air quality data in this report following conventions have been followed:

i. If the 24 hours sampling in a day could not be fulfilled at all the locations due to force majeure like power failure, rainfall etc, and the values monitored for 16 hours and more are considered as the representative values for assessing the ambient air quality for that day;
ii. In case no data is available in a particular month with respect to all the three parameters, the month has been excluded;
iii. In case, no data is reported for a particular station with respect to all the three parameters, during entire year, that station has been excluded; and
iv. The frequency of monitoring twice a week, 104 days in a year could not be met in some of the locations. In such cases, 50 days of monitoring in a year is considered adequate for the purpose of data analysis.

Figure 1.5 Data flow chart under NAMP



As NAMP is being operated through various monitoring agencies, a large number of personnel and equipments are involved in the sampling, chemical analyses, data reporting etc.. This increases the probability of personal biases reflecting in the data. Hence it is pertinent to mention that this document be referred keeping in view the above facts and the data be considered more as indicative rather than absolute. The data presented in this report is average over the entire year as available.

1.3.5. Quality Assurance/Quality Control of Data and Management

Quality assurance and Quality control (QA/QC) is an essential part of any monitoring system. QA/QC is a programme of activities that ensures that measurements meet defined standards of quality, with a stated level of confidence. In order to ensure the quality of data the CPCB is carrying out various exercises as follows:

i) Calibration, Servicing and Repair of Instruments and Evaluation of Ambient Air Quality Monitoring Stations

CPCB is carrying out a project on calibration, servicing and repair of instruments/equipments and evaluation of ambient air quality monitoring stations under NAMP. Servicing and repair of respirable dust sampler and high volume sampler is carried out and they are also calibrated using top loading calibrator (Plate 1.2). The location of monitoring stations is evaluated as per CPCB guidelines so as to ensure quality of data.

ii) Training Program on Ambient Air Quality Monitoring

CPCB carries out training program on ambient air quality monitoring with an objective to improve quality of data generated under National Air Quality Monitoring Programme (NAMP). Training is provided to field and laboratory staff involved in NAMP. The training is provided on measurement methods of air pollutants i.e. sulphur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter of size less than 10µg (PM_{10}) and suspended particulate matter (SPM) etc.

iii) Guidelines for Ambient Air Quality Monitoring

CPCB has developed guidelines for carrying out ambient air quality monitoring. The Guidelines for Ambient Air Quality Monitoring include site selection criteria, quality assurance and quality control in air quality monitoring, type of pollutants to be monitored in a city, frequency and duration of monitoring, data reporting and compilation procedures and measurement methods of various air pollutants etc.

iv) Regular Inspection of Monitoring stations and monitoring laboratories are regularly inspected by CPCB officials to ensure proper and uniform methodology for sampling and analysis.

v) Review meetings of NAMP are regularly conducted with monitoring agencies to discuss various problems related to monitoring activities and sort out the remedial measures.

vi) Analytical quality control exercises using Ring Test Facility are regularly conducted to evaluate the performance of different laboratories.

Vii) NB. In this report data has been taken from 1st January 2009 to 31st December 2009. Operating stations has been listed as numbers reported till 31st March 2010 (financial year wise). However, there are cases where data has been given on October 2010 which has been included during data analysis.

Plate 1.2. Field calibration a, b.Top loading calibration of Respirable Dust Sampler c. Use of dry gas meter for gaseous calibration d. Calibration of mettle balance

CHAPTER 2

AIR QUALITY ASSESSMENT & MAJOR FINDINGS

Air Quality Assessment and major findings of the ambient air quality monitoring carried out countrywide during the year 2009 are presented in this chapter. The air quality of different cities/towns has been compared with the respective NAAQS.

2.1 Air Quality Assessment

The air quality of different cities/towns has been compared with the respective NAAQS. The air quality has been categorized into four broad categories based on an Exceedence Factor (the ratio of annual mean concentration of a pollutant with that of a respective standard). The Exceedence Factor (EF) is calculated as follows:

$$\text{Exceedence Factor} = \frac{\text{Observed annual mean concentration of criteria pollutant}}{\text{Annual standard for the respective pollutant and area class}}$$

The four air quality categories are:

- Critical pollution (C) : when EF is > 1.5;
- High pollution (H) : when the EF is between 1.0 - <1.5;
- Moderate pollution (M) : when the EF between 0.5 - <1.0; and
- Low pollution (L): when the EF is < 0.5.

It is obvious from the above categorization, that the locations in either of the first two categories are actually not meeting the standards, although, with varying magnitude. Those, falling in the third category are meeting the standards as of now but likely to exceed the standards in future if pollution continues to increase and is not controlled. However, the locations in Low pollution category have a rather clean air quality and such areas are to be maintained at low pollution level by way of adopting preventive and control measures of air pollution. The pollution control classification is given in Table 2.1.

Table 2.1: Pollution Level Classification

Pollution level	Annual Mean Concentration Range (µg/m^3)					
	Industrial, Residential,Rural & others areas			Ecologically Sensitive Area		
	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}
Low (L)	0-25	0-20	0-30	0-10	0-15	0-30
Moderate (M)	26-50	21-40	31-60	11-20	16-30	31-60
High (H)	51-75	41-60	61-90	21-30	31-45	61-90
Critical (C)	>75	>60	>90	>30	>45	>90

This report represent the air quality scenario with air quality data from January – December 2009 of 357 stations from residential / commercial / industrial / rural area and 14 stations from sensitive area ie a total of 371 stations. Adequate data for annual average concentration (with 50 and more day of monitoring) for SO_2 was received for 292 stations and adequate data for NO_2 was received for 291 stations. Adequate data for PM_{10} was received for 289 stations and for SPM was received for 280 monitoring stations for residential / commercial / industrial / rural area. For sensitive area all the data was adequate. The detail of number of stations for which data was adequate or inadequate is given in Table 2.2.

Table 2.2: Details of data generated during 2009

Data type	Number of monitoring stations							
	Residential / industrial / rural / commercial areas				Sensitive area			
	SO_2	NO_2	PM_{10}	SPM	SO_2	NO_2	PM_{10}	SPM
Adequate data	292	291	289	280	14	14	14	14
Inadequate data	62	63	65	60	0	0	0	0
No data	3	3	3	17	0	0	0	0
Total monitoring stations	357	357	357	357	14	14	14	14

Key: Adequate data: locations where ≥50 days of monitoring was done in a year; Indequate data: locations < 50 days of monitoring was done in a year; No data: Monitoring not done or data not received for the particular parameter

2.2 Number of locations / monitoring stations with low, moderate, high and critical pollution level of air pollution

The analysis of four criteria pollutants with respect to National Ambient Air Quality Standards (NAAQS) during 2009 revealed that out of a total of 357 residential / industrial / commercial / rural and other areas from which data was received, SO_2 mainly showed low concentration in most of the locations (282 locations) and moderate in 10 locations. With respect to NO_2, 112 locations were in low category, 140 in moderate, 25 in high and 14 in critical category. With respect to PM_{10} only 2 locations showed low PM_{10} level. 46 locations showed moderate, 83 high and 158 location were in critical category. Table 2.3, Figure 2.1 shows categorization of locations according to low, moderate, high and critical level of pollutants in residential / industrial / commercial / rural and other areas .

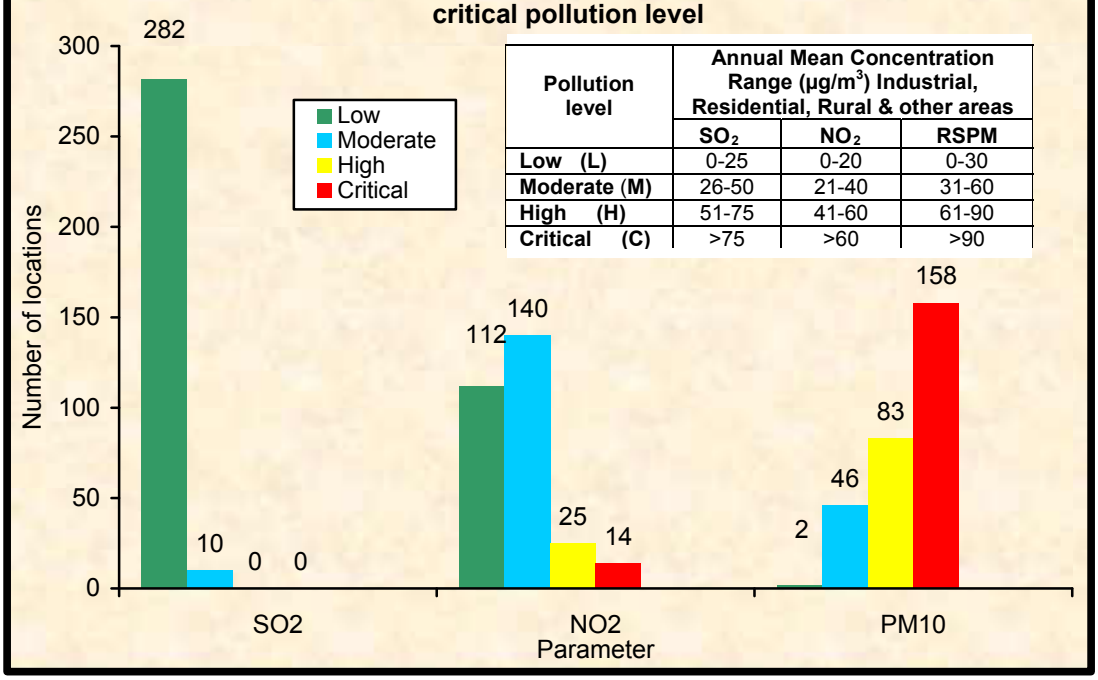
Locations at sensitive zones also showed more or less a similar picture. SO_2 mainly showed low concentration in most of the locations (12 locations) and moderate in 2 locations. The were no cities in high or critical range. For NO_2, 7 locations were in low category, 5 in moderate and 2 in high. For PM_{10} no location showed low PM_{10} level. 2 locations showed moderate and 6 locations each were in high and critical category. Table 2.3, Figure 2.2 gives a picture of the categorization of locations according to low, moderate, high and critical level of pollutants in sensitive areas.

Table 2.3: Number of locations with low, moderate, high & critical air quality (residential/industrial/commercial/rural and sensitive)

Category	Number of monitoring stations					
	Residential / industrial / rural / commercial areas			Sensitive area		
	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}
Low	282	112	2	12	7	0
Moderate	10	140	46	2	5	2
High	0	25	83	0	2	6
Critical	0	14	158	0	0	6
Total	292	291	289	14	14	14

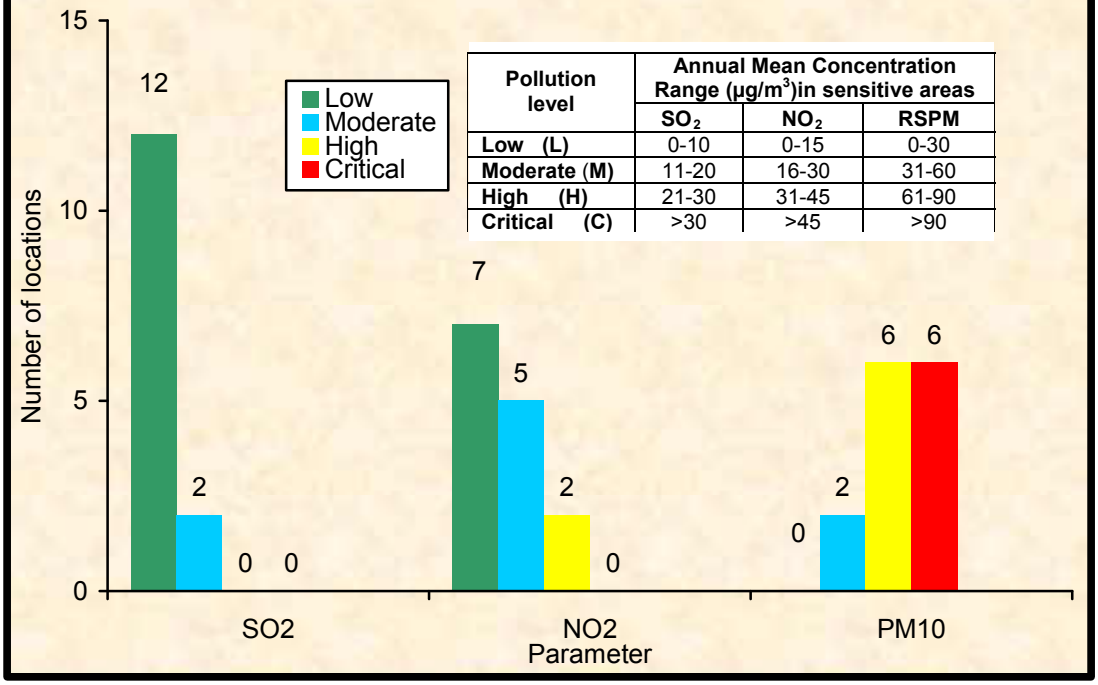
NB. Low, moderate, high, critical classification based on Pollution Level Classification,Chapter 2,Table 2.1

Figure 2.1: Number of locations (residential/industrial/commercial/rural) with low, moderate, high & critical pollution level



Pollution level	Annual Mean Concentration Range (µg/m³) Industrial, Residential, Rural & other areas		
	SO_2	NO_2	RSPM
Low (L)	0-25	0-20	0-30
Moderate (M)	26-50	21-40	31-60
High (H)	51-75	41-60	61-90
Critical (C)	>75	>60	>90

Figure 2.2: Number of locations (sensitive) with low, moderate, high & critical pollution level



Pollution level	Annual Mean Concentration Range (µg/m³)in sensitive areas		
	SO_2	NO_2	RSPM
Low (L)	0-10	0-15	0-30
Moderate (M)	11-20	16-30	31-60
High (H)	21-30	31-45	61-90
Critical (C)	>30	>45	>90

2.3 Number of cities with low, moderate, high and critical pollution levels in the country

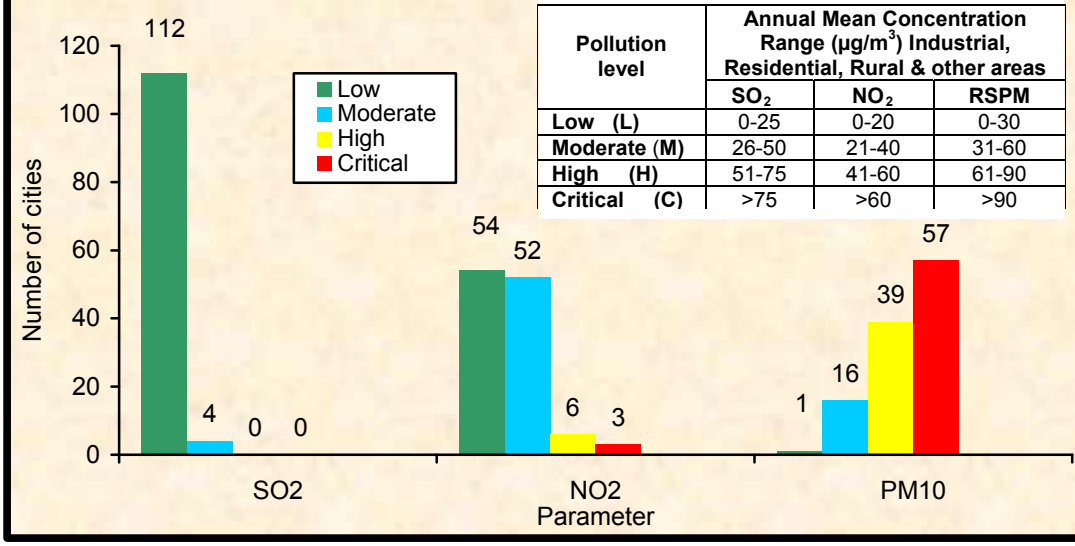
The analysis of four pollutants with respect to National Ambient Air Quality Standards (NAAQS) during 2009 revealed that out of 142 cities (taking residential / industrial / commercial / rural and other areas) from which data was received, 112 cities fall uner low category and 4 under moderate category with respect to Sulphur dioxide (SO_2). No cities show high or critical level. NO_2 pollution levels if considered time weighted annual average concentrations indicated that 54 cities are under the low category, 52 under moderate, 6 under high and 4 cities in the critical category. The PM_{10} in indicated that 1 city fall under low category, 16 cities in moderate category, 39 cities in high pollution levels category and 57 cities in critical category. Data has been inadequate for 26 (18%) cities for SO_2, 27 (19%) for NO_2 and 29 (20%) cities for RSPM. The number of cities with low, moderate, high and critical categories are depicted in Table 2.4, Figure 2.3. Figure 2.4 shows the percentage of cities in low, moderate, high and critical categories

Table 2.4: Number of cities with low, moderate, high & critical air quality

Category	Number of cities					
	Cities with Residential / industrial / rural / commercial areas			Cities with sensitive area		
	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}
Low	112	54	1	7	5	0
Moderate	4	52	16	2	3	3
High	0	6	39	0	1	5
Critical	0	3	57	0	0	1
Indequate data	26	27	29	0	0	0
Total cities	142	142	142	9	9	9

NB. Low, moderate, high, critical classification based on Pollution Level Classification,Chapter 2,Table 2.1

Figure 2.3: Number of cities with low, moderate, high & critical pollution level (residential / industrial / rural / other area)



Pollution level	Annual Mean Concentration Range (µg/m³) Industrial, Residential, Rural & other areas		
	SO_2	NO_2	RSPM
Low (L)	0-25	0-20	0-30
Moderate (M)	26-50	21-40	31-60
High (H)	51-75	41-60	61-90
Critical (C)	>75	>60	>90

Figure 2.4: Percentage of cities showing low, moderate, high and critical level of SO_2, NO_2 and PM_{10} (residential / industrial / rural / other area)

Figure 2.4a: Percentage of cities showing low, moderate, high and critical level of SO2

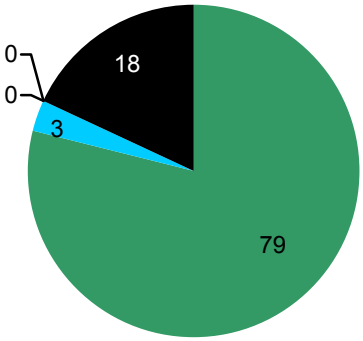


Figure 2.4b: Percentage of cities showing low, moderate, high and critical level of NO2

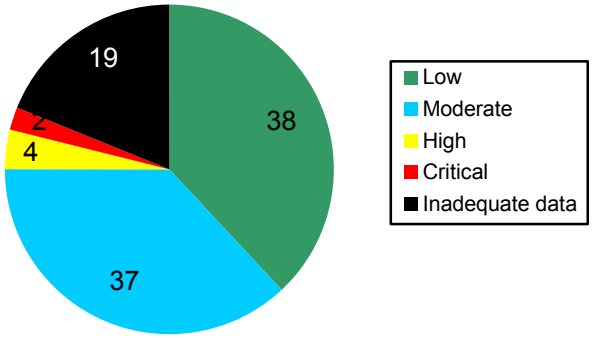
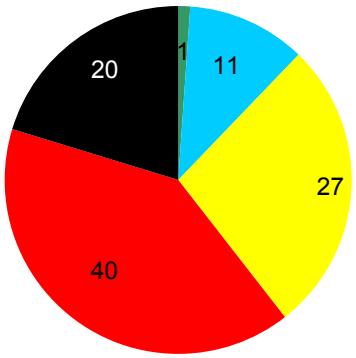


Figure 2.4c: Percentage of cities showing low, moderate, high and critical level PM10



Pollution level	Annual Mean Concentration Range (µg/m^3) Industrial, Residential, Rural & other areas		
	SO_2	NO_2	RSPM
Low (L)	0-25	0-20	0-30
Moderate (M)	26-50	21-40	31-60
High (H)	51-75	41-60	61-90
Critical (C)	>75	>60	>90

Annual average in each city and its catagorization for different pollutant is represented in Table 2.5 represent the. Close examination of Table 2.5 indicates that:

- No city is critical with respect to SO_2
- Cities like Kolkata, Howrah and Durgapur are critical with respect to NO_2
- State capital cities like Patna, Ranchi, Bangalore, Mumbai, Bhopal, Jaipur, Lucknow, and Kolkata are critical with respect to PM_{10}
- Industrial cities like Vishakhapatnam, Ahmedabad, Bhilai, Korba, Dhanbad, Jharia, Jamshedpur, Chandrapur, Dewas, Indore, Rourkela, Kota, Kanpur, Ghaziabad, Howrah, Asansol and Durgapur are critical with respect to PM_{10}
- Durgapur, Howrah and Kolkata , are critical with respect to both PM_{10} and NO_2

Table 2.5: Ambient Air Quality in different cities for the year 2009 (residential / industrial / rural / others)

State	City	SO_2		NO_2		PM_{10}	
		Annual average ($\mu g/m^3$)	Air quality	Annual average ($\mu g/m^3$)	Air quality	Annual average ($\mu g/m^3$)	Air quality
Andhra Pradesh	Guntur	4	-	9	-	85	-
	Hydrabad	5	L	23	M	81	H
	Kakinada	4	-	9	-	48	-
	Kurnool	4	L	9	L	81	H
	Nalgonda	5	-	24	-	101	-
	Nellore	6	-	14	-	118	-
	Patencheru	16	L	25	M	87	H
	Ramagundam	4	L	14	L	104	C
	Vijaywada	6	L	15	L	87	H
	Visakhapatnam	11	L	26	M	93	C
	Warangal	4	-	10	-	69	-
Assam	Bongaigaon	6	L	15	L	84	H
	Daranga	5	L	13	L	77	H
	Dibrugarh	5	L	13	L	41	M
	Golaghat	6	L	14	L	65	H
	Guwahati	8	L	16	L	122	C
	Hailakandi	6	-	13	-	88	-
	Mergherita	12	-	22	-	42	-
	Nagaon	7	-	18	-	161	-
	North Lakhimpur Town	6	-	15	-	73	-
	Sibsagar	5	L	13	L	100	C
	Silchar	6	L	15	L	58	M
	Tezpur	6	L	13	L	90	C
	Tinsukhia	6	-	14	-	81	-
Bihar	Patna	5	L	37	M	146	C
Chandigarh	Chandigarh	2	L	15	L	81	H
Chattisgarh	Bhilai Nagar	15	L	25	M	112	C
	Korba	13	L	21	M	117	C
Dadra & Nagar Haveli	Silvassa	9	L	17	L	71	H
Daman & Diu	Daman	7	L	19	L	57	M
Delhi	Delhi	6	L	50	H	252	C
Goa	Mormugao	4	L	10	L	72	H
	Panaji	3	L	13	L	74	H
	Vasco	4	L	18	L	76	H

Gujarat	Ahmedabad	16	L	21	M	94	C
	Anklesvar	19	L	27	M	89	H
	Jamnagar	14	L	27	M	106	C
	Rajkot	11	L	15	L	105	C
	Surat	19	L	26	M	90	H
	Vadodara	16	L	30	M	86	H
	Vapi	16	L	24	M	79	H
Haryana	Hisar	8	-	5	-	88	-
	Yamunanagar	13	-	27	-	275	-
Himachal Pradesh	Baddi	4	L	12	L	66	H
	Damtal	2	L	12	L	68	H
	Nahan	2	L	17	L	143	C
	Nalagarh	4	L	13	L	70	H
	Paonta Sahib	2	L	16	L	120	C
	Parwanoo	3	L	11	L	82	H
	Shimla	3	L	12	L	68	H
Jammu & Kashmir	Jammu	9	L	13	-	116	-
Jharkhand	Dhanbad	17	-	41	-	164	C
	Jamshedpur	36	M	49	H	172	C
	Jharia	17	L	41	H	261	C
	Ranchi	18	L	32	M	179	C
	Sindri	16	L	40	M	166	C
Karnataka	Bangalore	14	L	37	M	112	C
	Belgaum	2	L	15	L	30	L
	Hassan	4	L	22	M	46	M
	Hubli-Dharwad	3	L	12	L	110	C
	Mangalore	7	L	6	L	41	M
	Mysore	14	L	30	M	48	M
Kerala	Kochi	4	L	12	L	42	M
	Kottayam	6	L	19	L	45	M
	Kozhikode	2	L	9	L	32	M
	Palakkad	3	L	7	L	50	M
	Trivandrum	9	L	21	M	61	H
Maharashtra	Amravati	11	L	13	L	90	H
	Aurangabad (MS)	7	L	25	M	86	H
	Chandrapur	38	M	35	M	115	C
	Kolhapur	12	L	14	L	82	H
	Mahad	12	-	33	-	163	-
	Mumbai	6	L	41	H	117	C
	Nagpur	6	L	31	M	101	C
	Nashik	23	L	29	M	89	H

	Navi Mumbai	15	L	42	H	112	C
	Pune	25	L	40	M	88	H
	Solapur	18	L	36	M	72	H
	Thane	12	L	18	L	58	M
Meghalaya	Byrnihat	18	-	12	-	139	-
	Dawki	3	-	5	-	57	-
	Shillong	2	L	9	L	78	H
Mizoram	Aizawl	2	L	6	L	40	M
Madhya Pradesh	Bhopal	7	L	17	L	119	C
	Dewas	12	L	19	L	113	C
	Gwalior	10	-	17	-	187	-
	Indore	9	L	17	L	183	C
	Jabalpur	2	L	24	M	136	C
	Nagda	17	L	24	M	113	C
	Satna	3	L	10	L	175	-
	Singrauli	-	-	-	-	62	-
	Ujjain	11	L	12	L	86	H
Nagaland	Dimapur	2	-	16	-	80	-
Orissa	Angul	7	L	20	L	117	C
	Balasore	2	L	12	L	85	H
	Berhampur	2	L	14	L	60	M
	Bhubaneshwar	2	L	19	L	88	H
	Cuttack	2	L	20	L	81	H
	Rayagada	3	L	21	M	61	H
	Rourkela	6	L	11	L	108	C
	Sambalpur	4	L	16	L	54	M
	Talcher	12	L	23	M	107	C
Pondicherry	Pondicherry	3	L	11	L	42	M
Punjab	Amritsar	15	L	35	M	190	C
	Bathinda	8	L	21	M	-	-
	Dera Bassi	8	L	21	M	-	-
	Gobindgarh	11	L	29	M	201	C
	Jalandhar	13	L	30	M	143	C
	Khanna	9	L	36	M	248	C
	Ludhiana	9	L	37	M	253	C
	Naya Nangal	8	L	20	L	161	C
Rajasthan	Alwar	8	L	23	M	153	C
	Jaipur	6	L	36	M	151	C
	Jodhpur	6	L	23	M	140	C
	Kota	7	L	24	M	91	C
	Udaipur	5	L	26	M	81	H

Tamil Nadu	Chennai	9	L	17	L	73	H
	Coimbatore	6	L	27	M	77	H
	Madurai	10	L	25	M	42	M
	Salem	8	L	24	M	80	H
	Thoothukudi	21	L	14	L	96	C
Uttar Pradesh	Allahabad	3	L	24	M	160	C
	Anpara	18	L	29	M	135	C
	Firozabad	22	L	32	M	195	C
	Ghaziabad	29	M	31	M	239	C
	Jhansi	9	L	27	M	127	C
	Kanpur	8	L	31	M	212	C
	Khurja	31	M	26	M	179	C
	Lucknow	8	L	36	M	197	C
	Meerut	8	-	44	-	119	-
	Noida	9	L	33	M	133	C
	Varanasi	17	L	20	L	125	C
Uttarakhand	Dehradoon	28	-	30	-	130	-
West Bengal	Asansol	8	L	55	H	154	C
	Durgapur (WB)	10	L	61	C	162	C
	Haldia	10	-	67	-	137	-
	Howrah	12	L	74	C	114	C
	Kolkata	11	L	68	C	126	C
	Barrackpore	10	-	71	-	125	-
	Raniganj	9	-	83	-	215	-
	Sankrail	10	-	68	-	127	-
	South suburban	7	-	60	-	83	-

L: Low, M: Moderate, H: High, C: Critical; Low, moderate, high, critical classification based on Pollution Level Classification, Chapter 2,Table 2.1

'-' Indequate data: locations < 50 days of monitoring was done in a year therefore air quality not calculated

2.4 Number of states with low, moderate, high and critical pollution levels in the country

The analysis of four pollutants with respect to National Ambient Air Quality Standards (NAAQS) during 2009 revealed that out of 29 states and union terrtories (taking residential / industrial / commercial / rural and other areas) from which data was received, 26 states fall uner low category with respect to Sulphur dioxide (SO_2). No states show moderate, high or critical level. NO_2 pollution levels if considered time weighted annual average concentrations indicated that 14 states are under the low category, 8 under moderate, 2 under high and 1 state in the critical category. The PM_{10} in indicated that no state fall under low category, 4 states in moderate category, 10 states in high pollution levels category and 12 in the critical category. Data has been inadequate for 3 (10%) states for SO_2 and PM_{10}, 4 (14%) for NO_2. The number of states with low, moderate, high and critical categories are depicted in Table 2.6, Figure 2.5. Data was inadequate

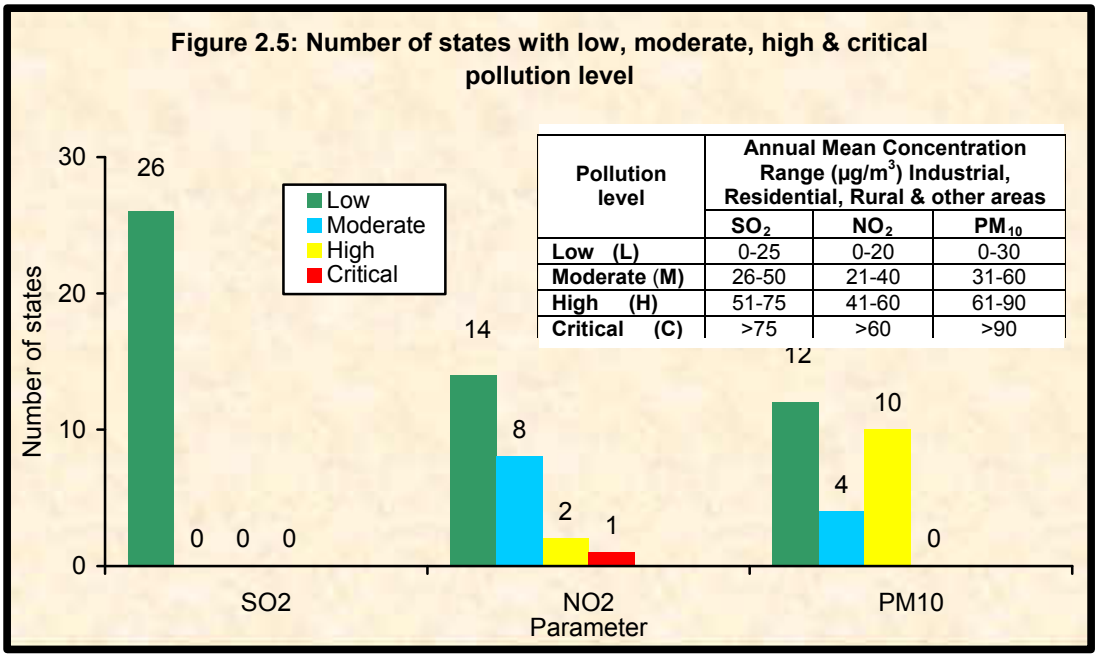
for 3 states for SO_2 and PM_{10} and 4 states for NO_2. Table 2.8 represent the annual average in each state and its catagorization for different pollutant.

Table 2.6: Number of states with low, moderate, high & critical air quality

Category	Number of states with Residential / industrial / rural / commercial areas		
	SO_2	NO_2	PM_{10}
Low	26	14	0
Moderate	0	8	4
High	0	2	10
Critical	0	1	12
Total	26	25	26

NB. Low, moderate, high, critical classification based on Pollution Level Classification,Chapter 2,Table 2.1

Figure 2.5: Number of states with low, moderate, high & critical pollution level



Pollution level	Annual Mean Concentration Range (µg/m³) Industrial, Residential, Rural & other areas		
	SO_2	NO_2	PM_{10}
Low (L)	0-25	0-20	0-30
Moderate (M)	26-50	21-40	31-60
High (H)	51-75	41-60	61-90
Critical (C)	>75	>60	>90

Table 2.7 Ambient Air Quality in different states for the year 2009 (residential / industrial / rural / others)

States	SO_2		NO_2		PM_{10}	
	Annual average ($\mu g/m^3$)	Air quality	Annual average ($\mu g/m^3$)	Air quality	Annual average ($\mu g/m^3$)	Air quality
Andhra Pradesh	7	L	20	L	86	H
Assam	7	L	15	L	88	H
Bihar	5	L	37	M	146	C
Chandigarh	2	L	15	L	81	H
Chhattisgarh	16	L	31	M	164	C
Dadra & Nagar Haveli	9	L	17	L	71	H
Daman & Diu	7	L	19	L	57	M
Delhi	6	L	50	H	252	C
Goa	3	L	14	L	74	H
Gujarat	16	L	24	M	92	C
Haryana	13	-	20	-	168	-
Himachal Pradesh	3	L	13	L	89	H
Jammu & Kashmir	9	L	13	-	116	C
Jharkhand	23	L	42	H	186	C
Karnataka	10	L	27	M	85	H
Kerala	5	L	15	L	46	M
Maharashtra	15	L	31	M	100	C
Meghalaya	6	L	9	L	88	H
Mizoram	2	L	6	L	40	M
Madhya Pradesh	10	L	17	L	129	C
Nagaland	2	-	16	-	80	-
Orissa	5	L	18	L	88	H
Pondicherry	3	L	11	L	42	M
Punjab	10	L	30	M	199	C
Rajasthan	6	L	27	M	129	C
Tamil Nadu	11	L	20	L	72	H
Uttar Pradesh	14	L	31	M	174	C
Uttarakhand	28	-	30	-	130	-
West Bengal	10	L	68	C	136	C

NB. Low, moderate, high, critical classification based on Pollution Level Classification,Chapter 2,Table 2.1

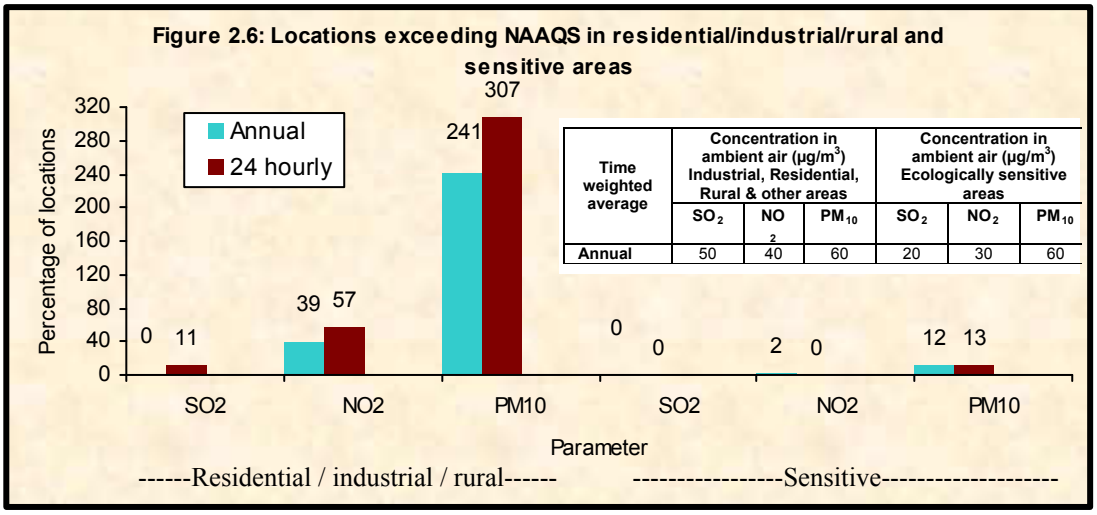
2.5 Exceedence of pollutants from National ambient Air Quality Standard

2.5.1. Locations exceeding NAAQS

Number of monitoring stations exceeding NAAQS is presented in Table 2.8, Figure 2.6. For residential/industrial/rural area, taking annual average into considerration, 39 stations (for NO_2) and 241 stations (for PM_{10}) exceed NAAQS. SO_2 does not exceed the standard. Considering 24-hourly average data into consideration, 11 stations (for SO_2), 57 stations (for NO_2) and 241 stations (for PM_{10}) exceed NAAQS. For sensitive area, considering annual average into considerration, 2 stations (for NO_2) and 13 stations (for PM_{10}) stations exceed NAAQS. Considering 24-hourly average data into considerration, 13 stations (for PM_{10}) exceed NAAQS. SO_2 does not exceed the standard for both annual average and 24-hourly data and NO_2 does not exceed for 24-hourly data.

Table 2.8. Number of locations exceeding the NAAQS (Based on annual average data and 24-hourly data)

	Residential/Industrial/Rural area						Sensitive area					
	SO_2		NO_2		PM_{10}		SO_2		NO_2		PM_{10}	
	Annual	24 hourly	Annual	24 hourly	Annual	24 hourly	Annual	24 hourly	Annual	24 hourly	Annual	24 hourly
Not exceeding NAAQS	292	340	252	294	48	44	14	14	12	14	2	1
Exceeding NAAQS	0	11	39	57	241	307	0	0	2	0	12	13
Inadequate data	65	6	66	6	68	6	0	0	0	0	0	0
Total stations	357	357	357	357	357	357	14	14	14	14	14	14

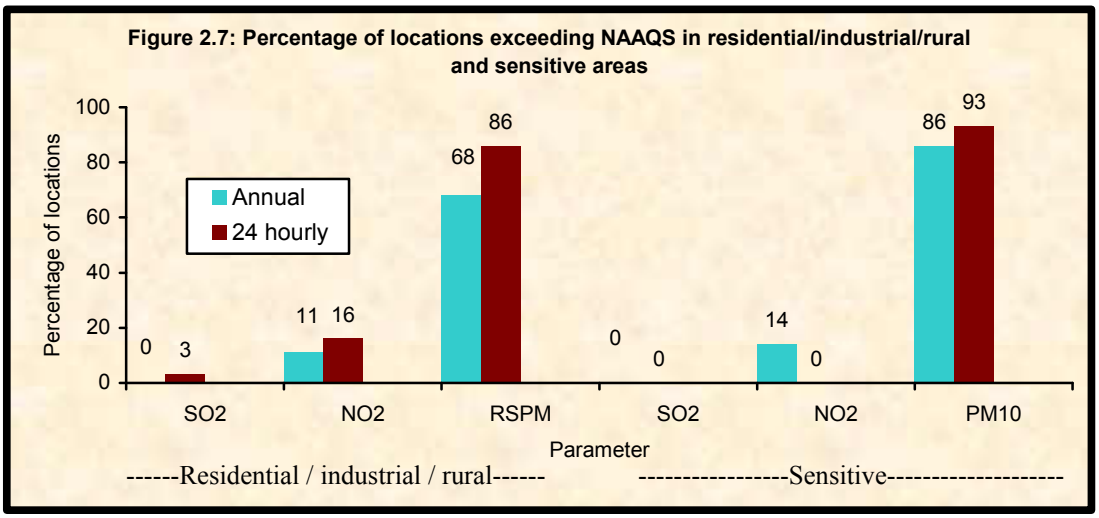


The percentage of locations exceeding national standards with respect to NO_2, SO_2 and PM_{10} is depicted in Table 2.9, Figure 2.7. For residential/industrial/rural area, considering

annual average 11% station (for NO_2) and 68% (PM_{10}) stations exceed NAAQS. SO_2 does not exceed the standard. Taking 24-hourly average data into consideration, 3% station (for SO_2), 16% (NO_2) stations and 85% stations (PM_{10}) exceed NAAQS. For sensitive area considering annual average into 14% station (for NO_2) and 86% (PM_{10}) stations exceed NAAQS. Taking 24-hourly average data into considerration, 93% station (PM_{10}) exceed NAAQS. SO_2 does not exceed the standard for both annual average and 24-hourly data and NO_2 does not exceed taking 24-hourly data into consideration.

Table 2.9: Percentage of locations exceeding the NAAQS (Based on annual average data and 24-hourly data)

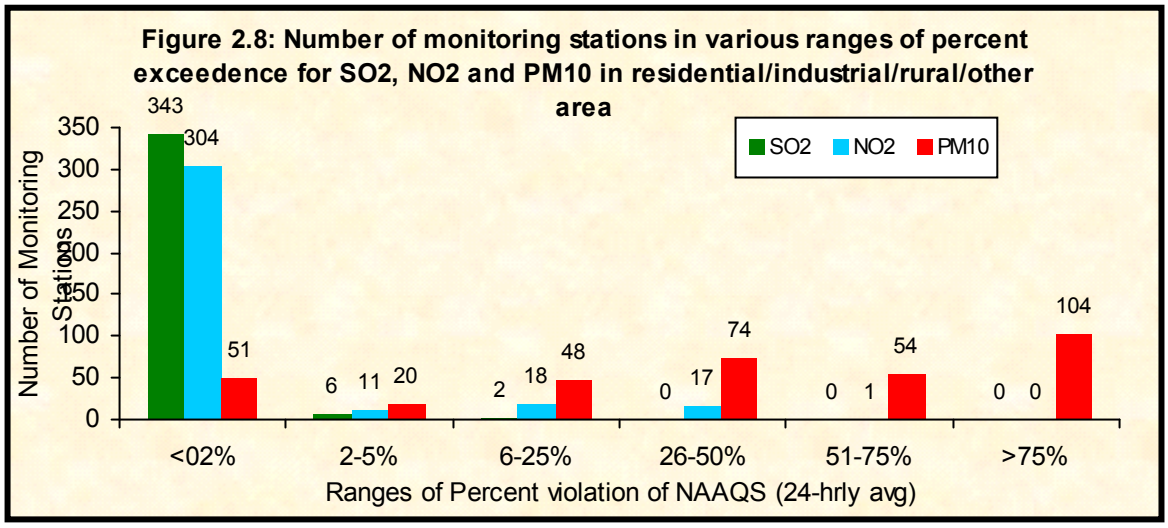
% of locations	Residential/Industrial/Rural area						Sensitive area					
	SO_2		NO_2		PM_{10}		SO_2		NO_2		PM_{10}	
	Annual	24 hourly	Annual	24 hourly	Annual	24 hourly	Annual	24 hourly	Annual	24 hourly	Annual	24 hourly
Not exceeding NAAQS	82	95	71	82	13	12	100	100	86	100	14	7
Exceeding NAAQS	0	3	11	16	68	86	0	0	14	0	86	93
Inadequate data	18	2	18	2	19	2	0	0	0	0	0	0

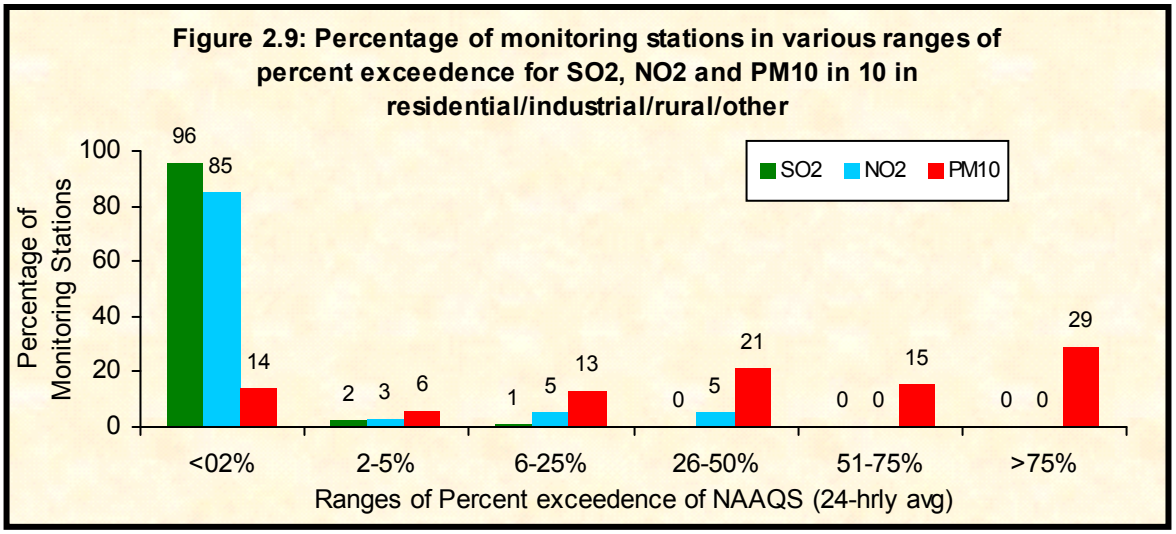


Number and percentage of monitoring stations in various ranges of percentage exceedence of NAAQS (24 hourly average) of PM_{10} is depicted in Table 2.10. The percentage exceedence of NAAQS for residential/industrial/rural/other area was less than 2% at 343 (96%) monitoring stations for SO_2, 304 (85%) monitoring stations for NO_2 and 51 (14%) monitoring stations for PM_{10} out of 357 stations. Therefore it can be mentioned that taking daily average values the exceedence from NAAQS for SO_2 was minimum followed by NO_2 and was maximum for PM_{10}. (Figure 2.8). As for sensitive areas was less than 2% at 14 (100%) monitoring stations for SO_2 and NO_2 and 1 (7%) monitoring stations for PM_{10} out of 14 stations (Figure 2.9).

Table 2.10: Number and percentage of locations in different ranges of percent exceedance

Ranges of percent exceedence	Residential/Industrial/rural/other area						Sensitive area					
	SO_2		NO_2		PM_{10}		SO_2		NO_2		PM_{10}	
	no.of station	% of station	no.of station	% of station	no.of station	% of station	no.of station	% of station	no.of station	% of station	no.of station	% of station
<2	343	96	304	85	51	14	14	100	14	100	1	7
2-5	6	2	11	3	20	6	0	0	0	0	1	7
6-25	2	1	18	5	48	13	0	0	0	0	5	36
26-50	0	0	17	5	74	21	0	0	0	0	1	7
51-75	0	0	1	0	54	15	0	0	0	0	3	21
>75	0	0	0	0	104	29	0	0	0	0	3	21
Inadequate data	6	2	6	2	6	2	0	0	0	0	0	0
Total stations	357	100	357	100	357	100	14	100	14	100	14	100





2.5.2. Cities exceeding NAAQS

Number and percentage of cities exceeding NAAQS is presented in Table 2.11, Figure 2.10 and 2.11. Taking residential/industrial/rural area into consideration, 9 cities (6% for NO_2) and 96 cities (68% for PM_{10}) exceed NAAQS. SO_2 does not exceed the standard in any city. Taking sensitive area, 1 (11%) and 6 (67%) cities exceed NAAQS NO_2 and PM_{10} respectively. SO2 lie withing standard.

Table 2.11. Number of cities exceeding the NAAQS (Based on annual average data)

	Residential/Industrial/Rural area			Sensitive area		
	SO_2	NO_2	PM_{10}	SO_2	NO_2	PM_{10}
Not exceeding NAAQS	16	106	17	9	8	3
Exceeding NAAQS	0	9	96	0	1	6
Inadequate data	26	27	29	0	0	0
Total cities	142	142	142	9	9	9

Figure 2.10: Cities exceeding NAAQS considering residential/industrial/rural areas

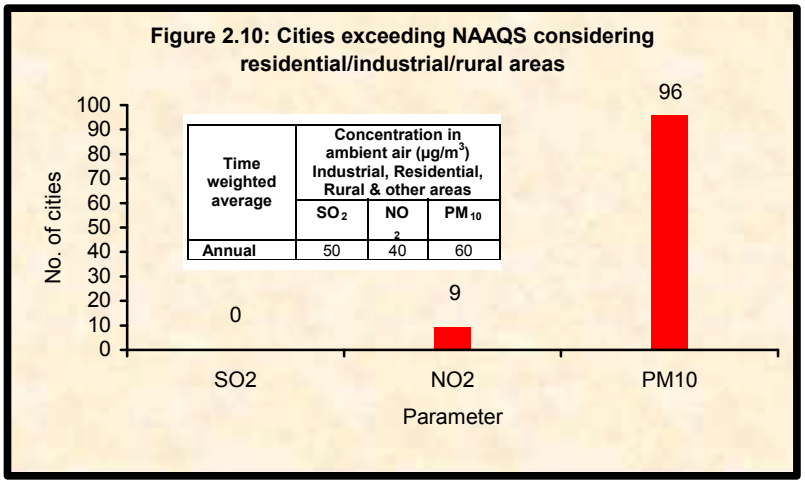
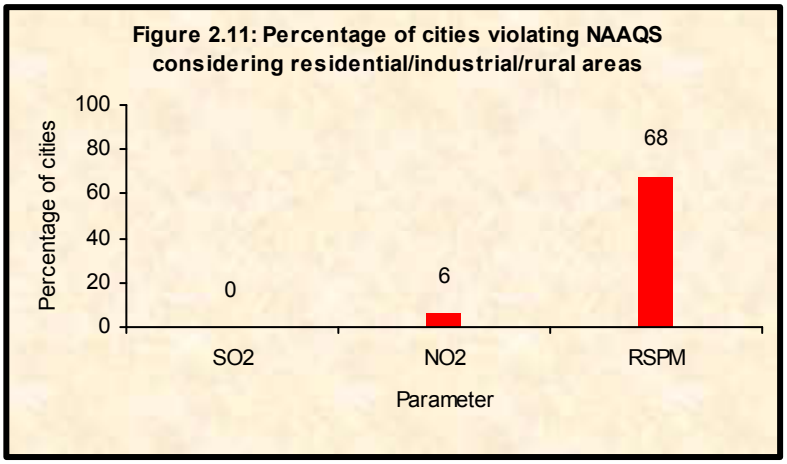


Figure 2.11: Percentage of cities violating NAAQS considering residential/industrial/rural areas



2.5.3. States exceeding NAAQS

Number and percentage of states exceeding NAAQS is presented in Table 2.12. Taking residential/industrial/rural area into consideration, 3 cities (10% for NO_2) and 22 states (76% for PM_{10}) exceed NAAQS. SO_2 does not exceed the standard in any state.

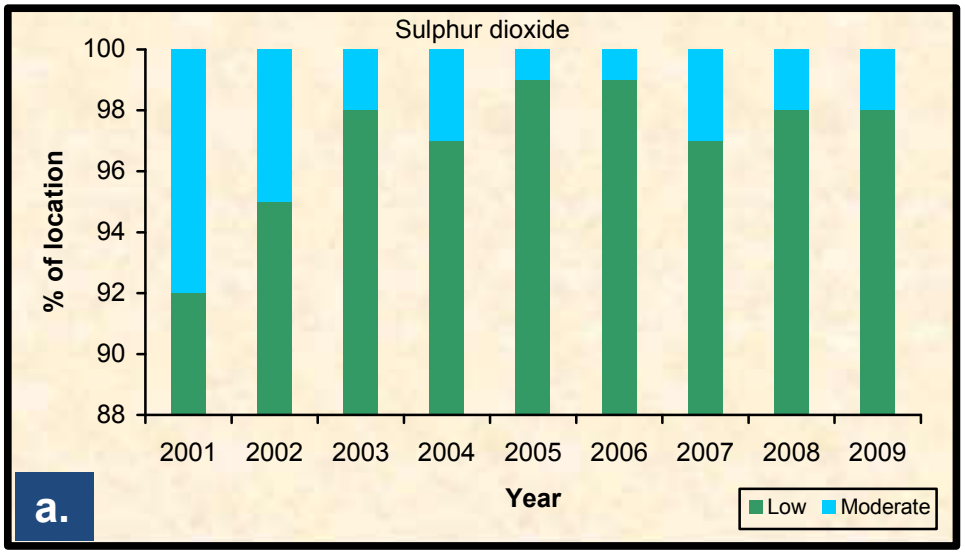
Table 2.12. Number of states exceeding the NAAQS (Based on annual average data of residential / industrial / rural / others areas)

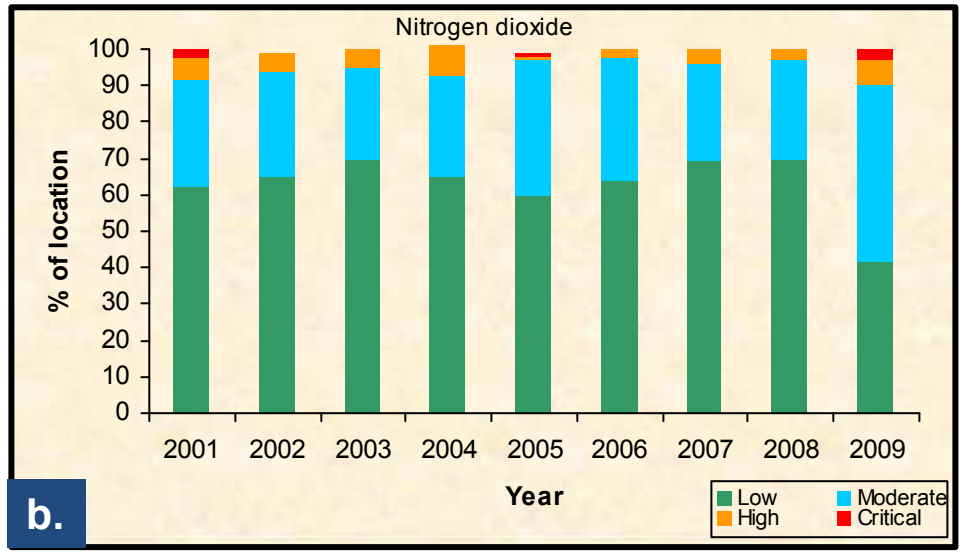
	Number of states		
	SO_2	NO_2	PM_{10}
Not exceeding NAAQS	26	22	4
Exceeding NAAQS	0	3	22
Inadequate data	3	4	3
Total states	29	29	29

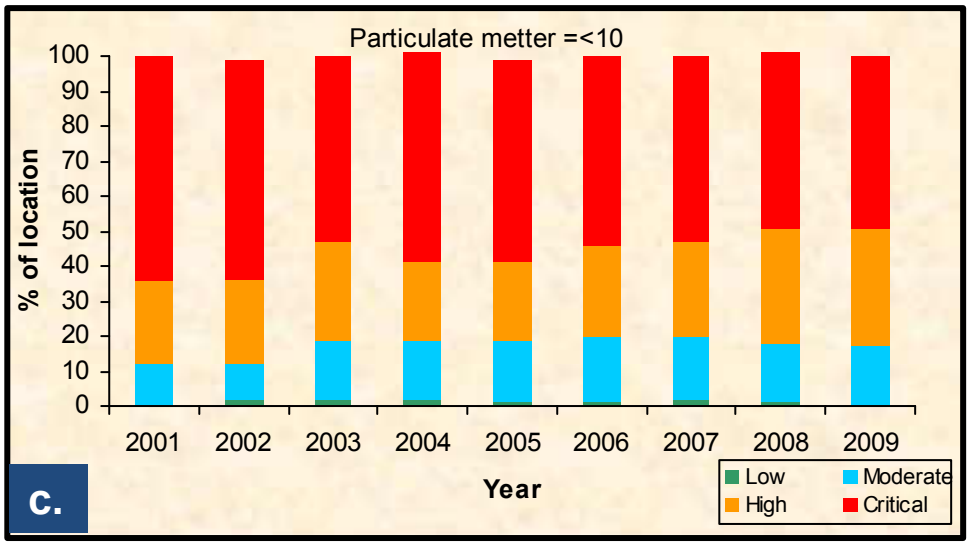
2.6 Percentage of residential location in different pollution categories

Trend in percentage of locations (Residential areas) with low, moderate, high and critical levels of SO_2, NO_2, PM_{10} is depicted in Figure 2.10. With respect to SO_2, percentage of locations are limited to low and moderate category though fluctuating over the years. This indicates a low SO_2 pollution level (Figure 12.10a). NO_2 levels showed an reduction in the low category and an increase in moderate, high and critical level indicating an increase in the pollution level (Figure 12.10b). Location with in respect to PM_{10} showed similar trend in 2009 with a reduction in the low category (Figure 12.10c)

Figure 2.12: Trends of Low, Moderate, High and Critical levels of SO_2, NO_2 and PM_{10} (Residential areas; percentage of location)



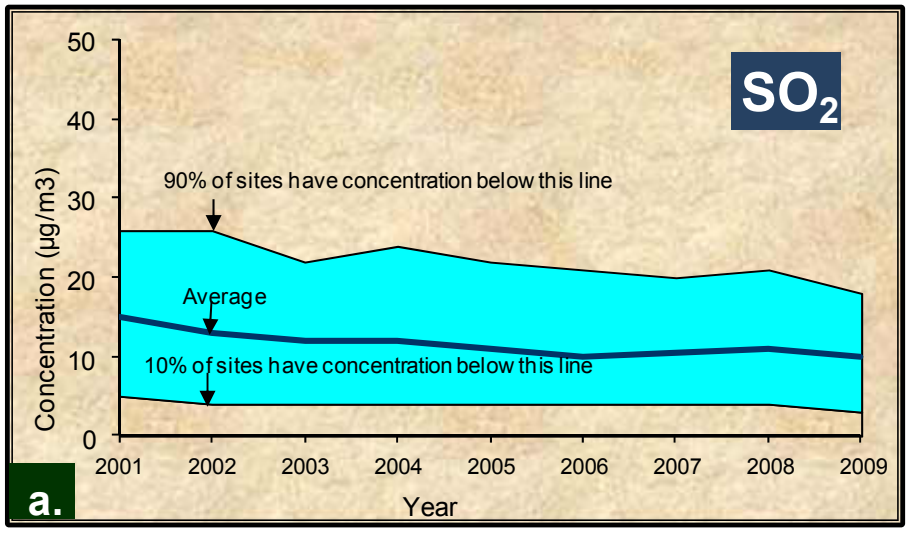


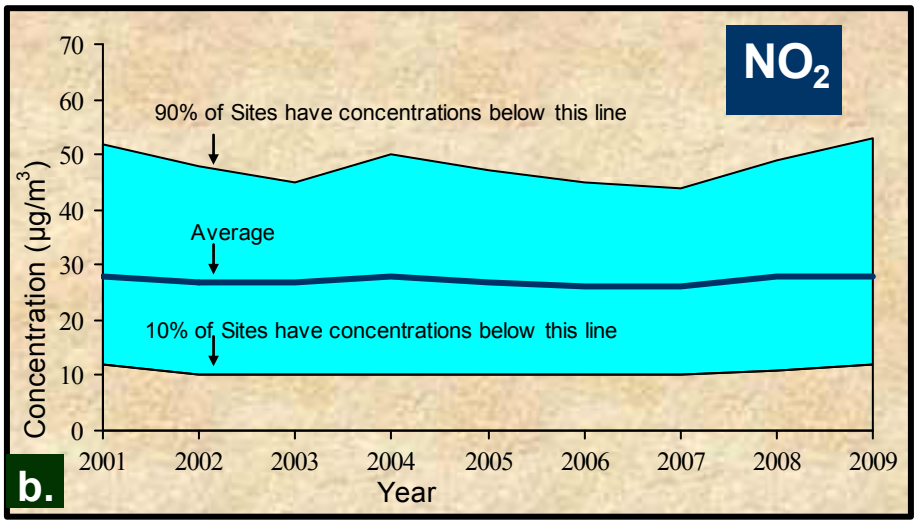


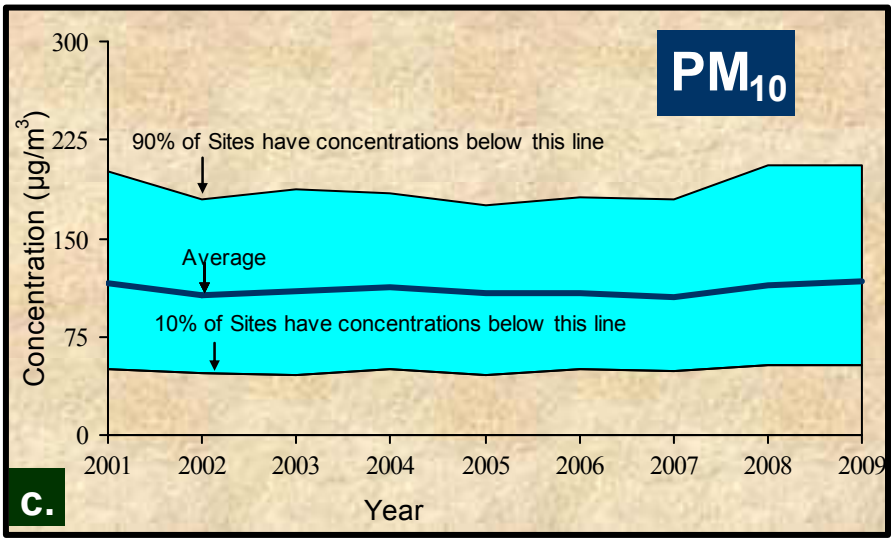
2.7 National Mean Concentration

National mean concentration with 90th percentile and 10th percentile for SO_2, NO_2 and PM_{10} is depicted in Figure 2.13. National mean of SO_2 concentration has decreased over the years indicating that there has been a decline in SO_2 levels (Figure 2.13a). Decreasing trend may be due to various intervention that have taken place in recent years such as reduction in sulphur in diesel, use of cleaner fuel such as CNG in metro cities, change in domestic fuel from coal to LPG etc. National mean of NO_2 concentration has remained stable over the years despite increase in sources like vehicles (Figure 2.13b). The reason for this may be various intervention measures that have taken place such as improvement in vehicle technology and other vehicular pollution control measures like alternate fuel etc. National mean of PM_{10} concentration shows fluctuating trend (Figure 2.13b). Vehicular emission are a major source of PM_{10}. Increasing number of vehicles may be a reason for this trend. The other reasons being emission from gensets, small scale industries, biomass incineration, suspension of traffic dust, natural dust, commercial and domestic use of fuel etc.

Figure 2.13: National mean concentration of different locations that fall under 10th and 90th percentile for SO_2, NO_2 and PM_{10}







CHAPTER 3

AIR QUALITY WITH RESPECT TO SULPHUR DIOXIDE (SO_2)

Sulphur dioxide (SO_2) is a colourless, soluble gas with a characteristic pungent smell. It is the chemical compound produced by volcanoes and in various industrial processes and are also a precursor to particulates in the atmosphere. Its natural source is volcanin eruptions (67%) and anthropogenic sources are combustion of fossil fuel (coal, heavy fuel oil in thermal power plants, office, factories), paper Industry, extravtion & distribution of fossil fuels, smelting of metals (sulfide ores to produce copper, lead and zinc), petroleum refining, combustion process in diesel, petrol, natural gas driven vehicles. SO_2 in ambient air can also affect human health, particularly in those suffering from asthma and chronic lung diseases and exacerbates respiratory symptoms and impaired breathing in sensitive individuals. It also causes visibility impairment. It is considered more harmful when particulate and other pollution concentrations are high. SO_2 also causes acid rain and aesthetic damage. A compilation of sources and effects of SO_2 are given in Annexure 1.

In this chapter a detailed summary of SO_2 levels in the country is furnished. The air quality of different cities/towns has been compared with the respective NAAQS. The air quality has been categorized into four broad categories based on an Exceedence Factor (the ratio of annual mean concentration of a pollutant with that of a respective standard. The four categories are low, moderate, high and critical levels. The top 10 location, cities and states with maximum SO_2 pollution is given.

3.1 Locations and cities with highest SO_2 values during 2009

Table 3.1 shows top ten locations in terms of annual average concentration of SO_2 for residential / industrial / rural / other area in which highest concentration was observed at monitoring station located at MIDC, Chandrapur, Maharashtra and Table 3.2 shows sensitive area in which the highest concentration was observed at Victoria Hospital, Bangalore, Karnataka. Among the cities Chandrapur, Maharashtra, tops the list with 38 $\mu g/m^3$ SO_2 (Table 3.3). Among the states Jharkhand shows highest SO_2 values 23 $\mu g/m^3$ (Table 3.4) At all the locations, cities and states SO_2 values lie within the NAAQS.

Table 3.1: Ten locations with highest SO_2 values (annual average) during 2009 (residential / industrial / rural / other area)

Sl. No.	State	City	Location	Type of area (I / R / O)	Annual average ($\mu g/m^3$)	Standard deviation	No. of days monitored	% exceedence	Air quality
1	Maharashtra	Chandrapur	M.I.D.C.	I	44	27	77	12	M
2	Maharashtra	Chandrapur	SRO, Bapat Nagar	R	37	19	75	4	M
3	Jharkhand	Jamshedpur	Bistupur Vehicle TC	I	36	2	103	0	M
4	Jharkhand	Jamshedpur	Golmuri Vehical TC	I	36	2	99	0	M
5	Uttar Pradesh	Khurja	CGCRI	I	35	6	81	0	M
6	Maharashtra	Chandrapur	Nagar Parishad	R	34	20	69	4	M
7	Uttar Pradesh	Ghaziabad	Atlas Cycles Ltd	I	32	6	78	0	M
8	Maharashtra	Pune	Bhosari	I	30	18	106	3	M
9	Uttarakhand	Dehradoon	Clock Tower	R	29	2	51	0	M
10	Uttar Pradesh	Ghaziabad	Bulandshahar R.I.A.	I	27	6	74	0	M

Key: I:industrial, R:residential, O: other; Low, moderate, high, critical classification based on Pollution Level Classification, Chapter 2, Table 2.1

Table 3.2: Ten locations with highest SO_2 values (annual average) during 2009 (sensitive area)

Sl. No.	State	City		Annual average (µg/m³)	Standard deviation	No. of days monitored	% exceedence	Air quality
1	Karnataka	Bangalore	Victoria Hospital	14	2	98	0	M
2	Andhra Pradesh	Visakhapatnam	INS-VIRBAHU	11	6	108	0	M
3	Madhya Pradesh	Ujjain	Mahakal Temple	10	2	80	0	L
4	Uttar Pradesh	Agra	Nunhai	10	1	90	0	L
5	Uttar Pradesh	Agra	Regional Office	10	1	95	0	L
6	Maharashtra	Aurangabad (MS)	Bibi-Ka-Maqbara	6	2	97	0	L
7	Andhra Pradesh	Hydrabad	Zoo Park	5	1	108	0	L
8	Uttar Pradesh	Agra	Taj Mahal	4	3	266	0	L
9	Andhra Pradesh	Tirupati	Reg.Science Center	4	0	96	0	L
10	Uttar Pradesh	Agra	DIC, Nunhai	4	2	104	0	L

NB. Low, moderate, high, critical classification based on Pollution Level Classification, Chapter 2, Table 2.1

Table 3.3: Ten cities with highest SO_2 values (annual average) during 2009 (residential / industrial / rural / other area)

Sl. No.	State	City	Annual average (µg/m³)	No. of days of monitoring	Air Quality
1	Maharashtra	Chandrapur	38	74	M
2	Jharkhand	Jamshedpur	36	101	M
3	Uttar Pradesh	Khurja	31	80	M
4	Uttar Pradesh	Ghaziabad	29	76	M
5	Maharashtra	Pune	25	106	L
6	Maharashtra	Nashik	23	103	L
7	Uttar Pradesh	Firozabad	22	96	L
8	Tamil Nadu	Thoothukudi	21	92	L
9	Gujarat	Anklesvar	19	105	L
10	Gujarat	Surat	19	104	L

NB. Low, moderate, high, critical classification based on Pollution Level Classification, Chapter 2, Table 2.1

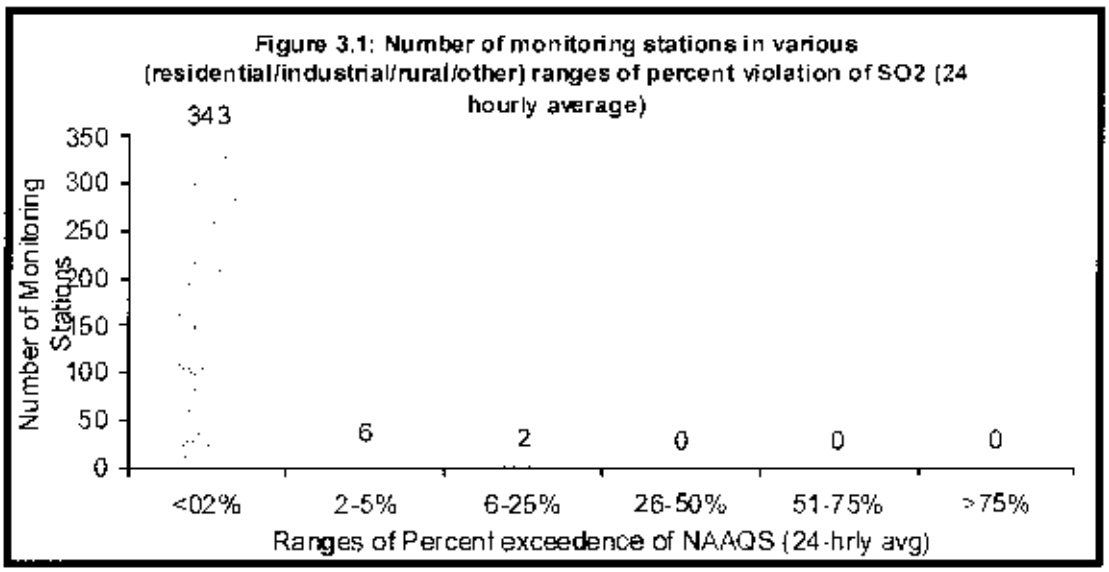
Table 3.4: Ten states with highest SO_2 values (annual average) during 2009 (residential / industrial / rural / other area)

Sl. No.	State	Annual average ($\mu g/m^3$)	No. of days of monitoring	Air Quality
1	Jharkhand	23	79	L
2	Gujarat	16	103	L
3	Chhattisgarh	16	79	L
4	Maharashtra	15	94	L
5	Uttar Pradesh	14	86	L
6	Tamil Nadu	11	94	L
7	Karnataka	10	89	L
8	Punjab	10	99	L
9	Madhya Pradesh	10	65	L
10	West Bengal	10	68	L

NB. Low, moderate, high, critical classification based on Pollution Level Classification,Chapter 2,Table 2.1

3.2 Percentage exceedence of NAAQS (24 Hourly Average)

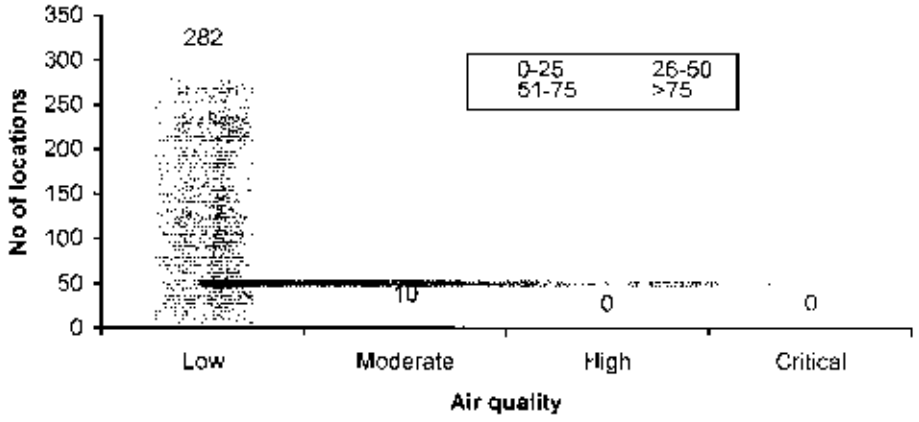
Number of monitoring stations in various ranges of percentage exceedence of NAAQS (24 hourly average) of SO_2 is depicted in Figure 3.1. The percentage exceedence of NAAQS (24 hourly Average) was less than 2% at 343 monitoring stations out of 357 stations. In the remaining stations (14 stations), the percentage exceedence of NAAQS (24 hourly avg.) was 2% or more.



3.3 Air Quality (Low, Moderate, High & Critical)

Number of monitoring stations with low, moderate, high and critical levels of SO_2 is depicted in Figure 3.2. 282 locations showed low SO_2 level, 10 locations showed moderate. None of the location were in the high and critical category.

Figure 3.2: Number of monitoring stations in various ranges of SO2 in residential/industrial/rural/other area (annual average)



The annual average concentration of SO_2 at various monitoring stations is given in Table 3.5. The data given is annual average concentration and number of observations with 16 and more hours of monitoring a day. Also, described in the table is air quality in terms of low, moderate, high and critical.

Table 3.5: SO_2 levels (Annual average) in Ambient Air Quality Stations under NAMP during 2009

State	City	Station	Type	Annual average (µg/m3)	Std. Dev.	No. of mon. days (n)	% exceedence (24 hourly)	Air Quality
Andhra Pradesh	Guntur	Hindu College Guntur	R	4	0	48	0	-
	Hydrabad	C.I.T.D. Balanagar	I	5	3	109	0	L
		Nacharam	I	3	1	94	0	L
		Uppal	I	5	3	108	0	L
		ABIDS Circle	R	5	2	95	0	L
		Charminar	R	5	1	107	0	L
		Jubilee Hills	R	5	2	108	0	L
		Paradise	R	5	4	108	0	L
		Tarnaka	R	4	1	96	0	L
		Zoo Park	S	5	1	108	0	L
	Kakinada	OB Ramanyapeta	R	4	0	16	0	-
	Kurnool	Mourya Inn	R	4	0	99	0	L
	Nalgonda	RO APPCB	R	5	2	42	0	-
	Nellore	Venkatreddy Nagar	R	6	-	1	0	-
	Patencheru	Police Station	R	16	3	107	0	L
	Ramagundam	RTC Bus Depot	R	4	0	84	0	L
	Tirupati	Reg.Science Center	S	4	0	96	0	L
	Vijaywada	Autonagar	I	5	1	114	0	L
		Benz Circle	R	5	0	114	0	L
	Visakhapatnam	CWMP, RAMKY	I	5	2	27	0	-
		Industrial Estate	I	17	27	105	5	L
		Pedagantyada V	I	7	4	27	0	-
		Ganapuram Area	R	14	8	107	0	L
		Panchayat Raj Office	R	9	8	101	0	L
		Police Barracks	R	14	8	106	0	L
		Seethammadhara	R	8	4	107	0	L
		INS-VIRBAHU	S	11	6	108	0	M
	Warangal	KUDA Office	R	4	0	28	0	-
Assam	Bongaigaon	Barpara Office Bldg	R	6	2	110	0	L
		Campus of Oil India	R	6	2	109	0	L
	Daranga	BATAD	R	5	3	92	0	L
	Dibrugarh	Dibrugarh Off. Bldg	R	5	1	103	0	L
	Golaghat	Golaghat Off. Bldg.	R	6	2	104	0	L
	Guwahati	Gopinath Nagar	R	7	2	234	0	L
		Head Office	R	9	4	244	0	L
		Santipur	R	8	3	241	0	L
	Hailakandi	CISF Campus	R	6	2	37	0	-
	Mergherita	Coal India Office	R	12	3	45	0	-
	Nagaon	Water resource Div.	R	7	1	7	0	-

	North Lakhimpur Town	Bazarpatti lakhimpur	R	6	2	40	0	-
	Sibsagar	Sibasagar Off. Bldg	R	5	2	102	0	I.
	Silchar	Office Building RLO	R	6	2	93	0	L
	Tezpur	Tezpur Office Bldg	R	6	1	99	0	L
	Tinsukhia	Digboi carbon factor	R	6	1	18	0	
Bihar	Patna	Beltron Bhawan	R	4	2	72	0	L
		Gandhi Maidan T C	R	7	4	40	0	-
Chandigarh	Chandigarh	Industrial Area	I	2	0	139	0	I.
		Kaimbwala Village	R	2	0	145	0	I
		Punjab Eng College	R	2	0	140	0	L
		Sector-17 C	R	2	0	145	0	L
		Sector-39	R	2	0	144	0	I.
Chattisgarh	Bhilai Nagar	M.P.L.U. Nigam	I	22	7	95	0	I.
		Regional Office	R	5	1	93	0	L
		Visak Hostel	R	18	5	92	0	L
	Korba	I.T.I. Rampur	R	14	1	101	0	I.
		Near Ghantaghar	R	13	1	104	0	I
		Pragati Nagar	R	13	0	102	0	I
	Raipur	Wool Worth I.Pvt.Ltd	I	20	3	35	0	-
		New HIG - 9, Hirapur	R	18	4	46	0	
		Yatayat Thana	R	17	3	40	0	-
Dadra & Nagar Haveli	Silvassa	Khadoli Ind. Area	I	9	2	78	0	L
Daman & Diu	Daman	Kadaiya Ind. Area	I	7	0	76	0	L
Delhi	Delhi	Mayapuri Indl. Area	I	10	6	96	0	I.
		Shahdara	I	4	1	74	0	L
		Shahzada Bagh	I	5	1	77	0	L
		Janakpuri	R	6	1	77	0	I.
		N.Y. School	R	5	4	96	0	I.
		Nizamuddin	R	6	1	75	0	I.
		Pritampura	R	4	0	74	0	L
		Siri Fort	R	6	1	74	0	L
		Town Hall	R	8	7	96	0	L
Goa	Mormugao	Mormugao Port Trust	I	4	2	102	0	L
	Panaji	Near Old GSPCB	R	3	2	98	0	L
	Vasco	Electricity Deptt.	I	4	3	78	0	I.
Gujarat	Ahmedabad	Naroda	I	18	4	104	0	I.
		Shardaban Hospital	I	14	2	96	0	L
		Behrampura	R	16	3	103	0	I.
		Cadilla Bridge Narol	R	19	4	101	0	I.
		I .D. Eng. College	R	13	2	98	0	L
		R.C. High School	R	15	2	105	0	L
	Anklesvar	Rallies India Ltd	I	21	2	105	0	I.
		Durga Traders	R	17	1	105	0	I.
	Jamnagar	Fisheries Office	R	14	3	105	0	I
	Rajkot	Sardhara Indl.Corp.	I	12	2	104	0	L

		Regional Office	R	10	2	100	0	L
	Surat	B.R.C. High School	I	23	2	103	0	L
		Near A.I. Office	R	17	2	103	0	L
		S.V.R. Eng. College	R	15	2	106	0	L
	Vadodara	CETP	I	22	4	105	0	L
		Dandia Bazar	R	16	4	110	0	L
		GPCB Office	R	11	2	110	0	L
	Vapi	GEB	I	18	1	98	0	L
		Vapi Nagar Palika	R	15	2	104	0	L
Haryana	Faridabad	M/s Shivalik Global, Mathura Road, Faridabad	I	15	-	-	-	
		HSPCB office, Ballabgard, Faridabad	R	15	-	-	-	
	Hisar	Urban Estate-II	R	8	1	11	0	-
	Yamunanagar	Ballarpur Industries	I	13	3	34	0	-
Himachal Pradesh	Baddi	AHC	I	4	1	59	0	L
		Industry Department	I	4	1	84	0	L
		Housing Board	R	3	1	31	0	
	Damtal	Old Road	R	2	0	92	0	L
		Regional Office	R	2	2	106	0	L
	Nahan	Industrial Area	I	3	1	150	0	L
		Trilok Pur	R	2	0	160	0	L
	Nalagarh	M.C.	R	4	1	63	0	L
	Paonta Sahib	Gondpur Indl. Area	I	2	1	134	0	L
		Paonta Sahib	R	2	0	133	0	L
	Parwanoo	AC Office Bldg.	I	4	1	126	0	L
		Central Laboratory	R	3	1	117	0	L
	Shimla	Bus Stand	R	3	2	132	0	L
		Tekka Bench Ridge	S	3	1	127	0	L
Jammu & Kashmir	Jammu	B.Brahmana	I	14	4	38	0	-
		M.A.Stadium	R	6	3	54	0	L
		Regional Office	R	6	2	60	0	L
Jharkhand	Dhanbad	Regional Office	R	17	4	48	0	-
	Jamshedpur	Bistupur Vehicle TC	I	36	2	103	0	M
		Golmuri Vehical TC	I	36	2	99	0	M
	Jharia	M.A.D.A.	I	17	3	72	0	L
	Ranchi	Albert Ekka Chowk	R	18	2	84	0	L
	Sindri	BIT	I	16	3	66	0	L
Karnataka	Bangalore	Graphite India	I	17	3	97	0	L
		KHB Indl Area	I	15	2	95	0	L
		Peenya Indl. Area	I	16	2	63	0	L
		AMCO Batteries	R	15	2	101	0	L
		R.V.College	R	6	3	6	-	
		Yeshwanthpura	R	17	3	106	0	L
		Victoria Hospital	S	14	2	98	0	M
	Belgaum	Karnataka SPCB	I	2	0	78	0	L
	Gulbarga	Govt. Hospital	S	3	0	99	0	L
	Hassan	N.R. Circle	R	4	1	107	0	L

	Hubli-dharwad	L. Industrial Area	I	4	1	88	0	L
		Rani C. Circle	R	3	1	96	0	L
	Mangalore	Stides Premises	I	7	2	104	0	L
	Mysore	K.R. Circle	R	15	5	103	0	L
		KSPCB Building	I	14	4	107	0	L
	Kochi	Eloor	I	2	0	90	0	L
		FACT Udyogmandal	I	2	0	92	0	L
		Irumpanam	I	4	2	107	0	L
		CSIR Complex	I	5	3	107	0	L
		Ernakulum South	R	4	2	108	0	L
		FCI, OEN C. O. Bldg	R	5	2	108	0	L
		M.G. Road	R	4	2	108	0	L
	Kottayam	Vadavathoor	I	5	0	96	0	L
		Kottayam	R	6	1	96	0	L
	Kozhikode	Nallalam	I	2	0	108	0	L
		Kozhikode City	R	2	0	105	0	L
	Palakkad	Carboradum/SEPR	I	3	2	118	0	L
	Trivandrum	Hi Tech Chackai	I	18	3	108	0	L
		Sasthamangalam	R	7	1	110	0	L
		SMV School	R	7	2	106	0	L
Maharashtra	Amravati	Apurva Oil and Ind.	I	11	1	104	0	L
		Govt. Coll. of Engg.	r	10	1	102	0	L
		Rajkamal Square	r	13	2	104	0	L
	Aurangabad (MS)	C.A.D.A. Office	R	7	2	96	0	L
		S.B.E.S. College	R	8	2	96	0	L
		Bibi-Ka-Maqbara	S	6	2	97	0	L
	Chandrapur	M.I.D.C.	I	44	27	77	12	M
		Nagar Parishad	R	34	20	69	4	M
		SRO, Bapat Nagar	R	37	19	75	4	M
	Kolhapur	Mahadwar Road	R	12	3	101	0	L
		S.T. Stand	R	15	3	103	0	L
		Shivaji University	R	8	1	103	0	L
	Mahad	EHS mahad	I	12	1	45	0	-
		MNP, Phulle Hall	R	11	1	38	0	-
		WTP, Bhirwadi	R	12	2	44	0	
	Mumbai	Parel	I	5	4	93	0	L
		Kalbadevi	R	6	6	87	0	L
		Worli	R	6	6	96	0	L
	Nagpur	MIDC Industrial Area/Hingana	I	3	3	94	0	L
		MIDC Office	I	10	1	105	0	L
		Govt. Poly. College	R	10	1	94	0	L
		Institution of Eng.	R	10	2	104	0	L
		Maskasath	R	3	2	98	0	L
		NEERI Lab	R	2	1	97	0	L
	Nashik	VIP Industrial Area	I	24	5	102	0	L
		NMC Building	R	23	5	103	0	L
		RTO Colony Tank	R	23	5	103	0	L

	Navi Mumbai	MIDC Taloja	I	25	20	105	4	L
		MPCB Central Lab	I	15	11	104	1	L
		Airoli	R	13	11	101	0	L
		Kharghar	R	10	8	100	0	L
		Nerul	R	14	17	107	4	L
		Panvel Water Works	R	12	4	103	0	L
	Pune	Bhosari	I	30	18	106	3	M
		Nalstop	R	22	8	103	0	L
		Swargate	R	23	9	110	0	L
	Solapur	WIT Campus	I	18	2	104	0	L
		Chitale Clinic	R	18	2	105	0	L
	Thane	Balkum/Kolshet	I	14	3	87	0	L
		Kopri	R	10	2	98	0	L
		Naupada	R	13	2	100	0	L
Meghalaya	Byrnihat	EPIP	I	18	26	44	7	-
	Dawki	Terrance Building	R	3	3	14	0	-
	Shillong	Boards Office	R	2	0	82	0	L
		Tuberculosis Hosp.	R	2	0	88	0	L
Mizoram	Aizawl	Bawngkawn	R	2	0	104	0	L
		Khatla	R	2	0	103	0	L
		Laipuitlang	R	2	0	104	0	L
Madhya Pradesh	Bhopal	Govindpura	I	7	2	45	0	-
		Hamidia Road	R	8	3	58	0	L
		T.T.Nagar	R	5	2	59	0	L
	Dewas	EID Perry (I) Ltd.	I	13	4	95	0	L
		Vikas Nagar	R	12	3	94	0	L
	Gwalior	Dindayal Nagar	R	8	1	46	0	-
		Maharaj Bada	R	11	2	14	0	
	Indore	M.P. Laghu Udyog	I	11	4	43	0	
		Kothari Market	R	11	4	43	0	-
		Telephone Nagar	R	6	2	83	0	L
	Jabalpur	Vijay Nagar	R	2	0	94	0	L
	Nagda	Chem. D. Labour Club	I	26	7	62	0	L
		BCI Labour Club	R	17	4	86	0	L
		Grasim Kalyan Kendra	R	23	5	95	0	L
	Sagar	Pt. Deendayal Nagar	R	4	1	86	0	L
	Satna	Sub-Divisional Off.	I	3	1	41	0	-
		Regional Office	R	3	1	26	0	
	Ujjain	District Office	I	14	2	74	0	L
		Regional Office	R	8	3	83	0	L
		Mahakal Temple	S	10	2	80	0	L
Nagaland	Dimapur	Bank Colony	R	2	0	45	0	
		Dhobinala	R	2	0	45	0	
Orissa	Angul	Industrial Estate	I	6	1	104	0	L
		NALCO Township	R	8	2	84	0	L
	Balasore	Sahadevkhunta	R	2	0	51	0	L
	Berhampur	Regional Office	R	2	0	105	0	L
	Bhubaneshwa	Capital Police Stn.	R	2	0	105	0	L

	r	IRC	R	2	0	104	0	L
		OSPCB Bldg	R	2	2	112	0	L
	Cuttack	Badambi, Cuttack	R	2	0	104	0	L
		R.O. Cuttack	R	2	0	105	0	L
	Rayagada	LPS H. School	I	3	0	105	0	L
		Regional Office	R	3	2	111	0	L
	Rourkela	IDL Police Out-post	R	5	2	105	0	L
		Regional Office	R	6	2	106	0	L
	Sambalpur	PHD Ofice, Sambalpur	R	4	1	125	0	L
	Talcher	Coal Field Area	I	14	3	95	0	L
		T.T.P.S Colony	I	10	2	104	0	L
Pondich erry	Pondicherry	PIPDIC	I	4	1	63	0	L
		Chamber of Commerce	R	3	1	100	0	L
		DSTC Office	R	4	1	59	0	L
Punjab	Amritsar	Nagina Soap Factory	I	15	3	65	0	L
		A-1 Platters	R	15	1	81	0	L
	Bathinda	Bathinda Milk Plant	I	8	1	113	0	L
	Dera Bassi	Bhanakarpur Road	I	8	3	132	0	L
		Winsome Yarns Ltd	I	8	1	124	0	L
	Gobindgarh	Raj Steel	I	10	3	120	0	L
		Modi oil & GM	R	11	4	44	0	
		United Rolling Mills	R	11	4	137	0	L
	Jalandhar	Focal Point	I	14	4	23	0	-
		Punjab Maltex	I	13	1	62	0	L
		MC Tube Well No.27	R	12	1	107	0	L
		Regional Office	R	11	3	116	0	L
	Khanna	Markfed Vanaspati	I	9	2	136	0	L
		A S School	R	9	2	135	0	L
	Ludhiana	Milk Plant	I	8	2	105	0	L
		Rita Sewing Machines	I	9	2	91	0	L
		Bharat Nagar Chowk	R	10	1	31	0	-
		PPCB Office Bldg.	R	9	2	124	0	L
	Naya Nangal	NFL Guest House	R	8	1	129	0	I
		Punjab Alkalies	R	8	1	109	0	L
Rajastha n	Alwar	Gaurav Solvex Ltd.	I	8	1	99	0	I
		RIICO Pump House	I	8	1	100	0	L
		Regional Office	R	8	2	106	0	L
	Jaipur	MIA	I	5	1	105	0	L
		VKIA	I	7	1	107	0	L
		Ajmeri Gate	R	6	1	105	0	L
		Chandpole	R	6	1	103	0	I
		RSPCB Office	R	5	1	106	0	L
		Vidyadhar Nagar	R	6	1	103	0	L
	Jodhpur	Basni Indl. Area	I	6	1	87	0	L
		DIC	I	6	1	99	0	L
		Housing Board	R	5	0	83	0	L
		M M Police Thane	R	5	0	102	0	L
		Shashtri Nagar	R	6	1	84	0	I

		Sojati Gate	R	7	1	83	0	I
	Kota	Regional Office	I	9	4	104	0	L
		Municipal C. Bldg	R	7	1	103	0	L
		Samcore Glass	R	6	1	105	0	L
	Udaipur	Regional Office, MIA	I	5	1	101	0	I
		Ambamata	R	4	2	97	0	I
		Town Hall	R	5	1	102	0	I
Tamilnadu	Chennai	Govt. High School	I	12	3	94	0	L
		Kathivakkam	I	12	3	93	0	I
		M C Thiruvottiyur	I	5	3	94	0	L
		Thiruvottiyur	I	13	3	93	0	L
		Madras Med. College	R	5	3	90	0	L
		NEERI CSIR Campus	R	4	2	96	0	I
	Coimbatore	SIDCO Office	I	7	3	82	0	I
		Dist. Coll. Office	R	6	3	90	0	L
		Ponniyarajapuram	R	5	2	74	0	L
	Madurai	Fenners (I) Ltd.	I	11	3	98	0	L
		Highway Bldg.	R	10	2	97	0	I
		Kunnathur Chatram	R	10	3	93	0	L
	Salem	Sowdeswari College	R	8	1	129	0	L
	Thoothukudi	Raja Agencies	I	21	10	88	0	L
		AVM Jewellery Bldg.	R	20	11	95	0	I
		Fisheries College	R	22	10	94	0	L
Uttar Pradesh	Agra	Nunhai	S	10	1	90	0	L
		Regional Office	S	10	1	95	0	L
		DIC, Nunhai	S	4	2	104	0	L
		Itmad-ud-daulah	S	3	2	104	0	L
		Rambagh	S	3	3	102	0	I
		Taj Mahal	S	4	3	266	0	L
	Allahabad	Bharat Yantra Nigam	R	3	1	102	0	L
		Square Crossing	R	4	1	103	0	L
	Anpara	Renusagar Colony	I	18	2	89	0	I
		Anpara Colony	I	18	2	87	0	L
	Firozabad	CDGI	I	24	5	101	0	L
		Raza Ka Tal	R	22	5	95	0	L
		Tilak Nagar	R	20	4	93	0	I
	Ghaziabad	Atlas Cycles Ltd	I	32	6	78	0	M
		Bulandshahar R.I.A.	I	27	6	74	0	M
	Jhansi	Jail Chauraha	R	9	1	115	0	I
		Veeranga Nagar	R	8	1	104	0	L
	Kanpur	Fazal Ganj	I	8	1	80	0	L
		Jajmau	I	7	1	82	0	I
		Dabauli	R	8	1	77	0	L
		Deputy Ka Parao	R	7	1	84	0	L
		Kidwai nagar	R	8	1	89	0	I
	Khurja	CGCRI	I	35	6	81	0	M
		Ahirpara	R	26	9	78	0	L
	Lucknow	Talkatora	I	9	1	93	0	I

		Aminabad	R	9	1	94	0	I
		Chandganj Nagar	R	8	1	96	0	I
		Kapoor Hotel	R	8	1	90	0	L
		Mahanagar	R	8	1	77	0	I
	Meerut	Begum Bridge	R	9	2	41	0	-
		Thana Railway Road	R	8	2	29	0	-
	Noida	GEE-PEE	I	9	1	98	0	L
		R.O, UPPB	R	9	1	92	0	L
	Varanasi	Regional Office	R	17	1	89	0	I
		Sigra	R	17	1	94	0	I
Uttarakhand	Dehradoon	Raipur Road	I	28	2	33	0	-
		Clock Tower	R	29	2	51	0	M
West Bengal	Asansol	Asansol M.C.	I	9	3	102	0	I
		Kangsabati Spinning Mill, Barjora	I	8	2	43	0	-
		Burnpur Town Department, Burnpur	I	7	2	43	0	-
	Durgapur	Dew India Ltd., Dr. B. C. Roy Avenue, Durgapur	I	12	3	102	0	I
		Kwality Hotel, Bhiringi More, benachiti	I	11	9	102	1	I
		PCBL Club, Muchipara, Bidhannagar	R	8	2	102	0	L
		DMC Water Works, Angadpur	R	8	1	43	0	
	Haldia	Super Market	I	9	1	9	0	
		WBIIDC	I	10	1	9	0	
	Howrah	Bandhaghat	I	16	11	104	0	I
		Howrah MC	I	10	5	104	0	I
		Bator	R	8	3	104	0	L
		Naskarpara	R	13	10	104	0	I
	Kolkata	Traffic Guard Building, Behala Chowrasta	I	9	3	105	0	I
		Cossipore Police Stn	I	22	16	97	1	I
		National Sample Survey Building, Dunlop Bridge	I	8	3	104	0	I
		Upanagari Sporting Club, Baishnabghata	R	6	2	105	0	L
		Kasba	R	14	9	95	0	L
		Lal Bazar	R	17	10	96	0	I
		A.J.C Bose Road, Minto Park	R	7	2	104	0	I
		KMC Office Building, Moulali	R	9	3	105	0	L
		CK Market, Salt Lake	R	7	2	105	0	L
	Barrackpore	Barrackpore Police Station	R	8	2	44	0	
		Dum Dum Telephone Exchange	R	10	3	44	0	-
		Khardah Municipality	R	13	4	44	0	-
	Raniganj	Jamuria Municipality	R	9	1	17	0	
		SKS Public School, Mangalpur	R	8	1	43	0	

		Raniganj Municipality, Raniganj	R	9	2	43	0	-
	Sankrail	P. Mukherjee's House, (Near SBI)	R	6	1	31	0	-
		Bagnan Police Station	R	11	3	31	0	-
		Dhulagarh Gram Panchayet Office	R	12	3	31	0	-
		Bharat Co-operative Housing Society, Sankrail	R	10	2	31	0	-
	South suburban	P. Roy Industrial Training Institute, Amtala	R	7	7	43	0	-
		Baruipur Police Station	R	7	2	43	0	-
		Chanditala Water Supply Pump House, Tollygunge	R	8	3	42	0	-

Note:

** - Locations where annual mean concentration of SO_2 exceeded the NAAQS of 50 µg/m^3 for Residential/ industrial / other area and 20 µg/m^3 for sensitive area. R – Residential and other areas, I – Industrial area, S – Sensitive Areas, Std dev Standard deviation, Mon:monitoring, n – number of days monitored for 16 and more hours a day I - Ivr, M- Moderate, H – High and C – Critical levels of pollution based on exceedence factor (calculated for n > 50 days) classification based on Pollution Level Classification,Chapter 2,Table 2.1, % violation – percentage violation of NAAQS (24 hourly average) BDL – Below Detection Limit (Concentration less than 4 µg/m^3 for SO_2).*

CHAPTER 4

AIR QUALITY WITH RESPECT TO NITROGEN DIOXIDE (NO_2)

Oxides of nitrogen are a generic term for a group of highly reactive gases that contain nitrogen and oxygen in varying amounts. Oxides of nitrogen are formed during combustion processes at high temperatures from the oxidation of nitrogen in air. NOx are emitted as nitrogen oxide (NO) which is rapidly oxidized to more toxic nitrogen dioxide (NO_2) Nitrogen dioxide (NO_2) is a reddish-brown toxic gas with a characteristic sharp, biting odor and is a prominent air pollutant. Sources of nitrogen oxides includes lightning, forest fires, bacterial activity of soil as natural source and vehicles, industrial processes that burn, high temperature combustion (internal combustion engines, fossil fuel-fired power stations, industrial, burning of bio-mass and fossil fuels are anthropogenic sources. NO_2 irritates the nose and throat increase susceptibility to respiratory infections. In addition, NO_x is a potent and selective vasodilator in pulmonary arterial hypertension. Oxides of nitrogen react with Volatile Organic Compounds (VOCs) to form ground level ozone. They also react to form nitrates, acid aerosols. Almost all NO_x is emitted as NO, which is rapidly oxidized to more toxic NO_2. They also contribute to nutrient overload that deteriorates water quality.

In this chapter the a detailed summary of NO_2 levels in the country is furnished. The air quality of different cities/towns has been compared with the respective NAAQS. The air quality has been categorized into four broad categories based on an Exceedence Factor (the ratio of annual mean concentration of a pollutant with that of a respective standard. The four categories are low, moderate, high and critical levels. The top 10 location, cities and states with maximum NO_2 pollution is given.

4.1 Locations and cities with highest NO_2 values during 2009

Table 4.1 shows top ten locations in terms of annual average concentration of NO_2 for residential / industrial / rural / other area in which highest concentration was observed at monitoring station located at Bandhabghat, Howrah, West Bengal. In sensitive area highest concentration was observed at Victoria Hospital, Bangalore, Karnataka (Table 4.2). Among the cities Howrah West Bengal tops the list with 74 $\mu g/m^3$ NO_2 (Table 4.3). Among the states West Bengal shows highest NO_2 values 68 $\mu g/m^3$ (Table 4.4)

Table 4.1: Ten locations with highest NO_2 values (annual average) during 2009 (residential / industrial / rural / other area)

Sl. No.	State	City	Location	Type of area (I/R/O)	Annual average ($\mu g/m^3$)	Std. dev.	No. of days mon. (n)	% excee dence	Air quality
1	West Bengal	Howrah	Bandhaghat	I	85*	35	104	41	C
2	West Bengal	Howrah	Howrah MC	I	81*	37	104	38	C
3	West Bengal	Kolkata	KMC Office Moulali	R	79*	33	105	40	C
4	West Bengal	Kolkata	Behala Chowrasta	I	77*	31	105	39	C
5	West Bengal	Kolkata	Baishnabghata	R	76*	16	105	7	C
6	West Bengal	Kolkata	Cossipore Police Stn	I	73*	30	97	39	C
7	West Bengal	Durgapur (WB)	Dew India Ltd., Durgapur	I	73*	19	102	14	C
8	West Bengal	Howrah	Naskarpara	R	70*	33	104	39	C
9	West Bengal	Kolkata	CK Market, Salt Lake	R	67*	27	105	30	C
10	West Bengal	Kolkata	Dunlop Bridge	I	67*	27	104	34	C

** - Locations where annual mean concentration of NO_2 exceeded the NAAQS of 40 $\mu g/m^3$ for Residential/ industrial / other area. R:residential, I:industrial, O:others, Std.dev:standard deviation, mon:monitoring, n:number of monitoring days; L:Low, M:moderate, H:high, C:critical classification based on Pollution Level Classification,Chapter 2,Table 2.1*

Table 4.2: Ten locations with highest NO_2 values (annual average) during 2009 (sensitive area)

Sl. No.	State	City	Location	Annual average ($\mu g/m^3$)	Std. dev.	No. of days mon. (n)	% exceedence	Air quality
1	Karnataka	Bangalore	Victoria Hospital	37*	5	98	0	H
2	Uttar Pradesh	Agra	DIC, Nunhai	35*	12	104	0	H
3	Andhra Pradesh	Visakhapatnam	INS-VIRBAHU	28	11	108	0	M
4	Uttar Pradesh	Agra	Rambagh	25	12	103	0	M
5	Uttar Pradesh	Agra	Itmad-ud-daulah	24	11	104	0	M
6	Maharashtra	Aurangabad (MS)	Bibi-Ka-Maqbara	23	3	97	0	M
7	Uttar Pradesh	Agra	Taj Mahal	19	11	265	0	M
8	Andhra Pradesh	Hydrabad	Zoo Park	15	2	108	0	L
9	Karnataka	Gulbarga	Govt. Hospital	14	3	99	0	L
10	Madhya Pradesh	Ujjain	Mahakal Temple	11	2	80	0	L

** - Locations where annual mean concentration of NO_2 exceeded the NAAQS of 30 $\mu g/m^3$ for sensitive areas. R:residential, I:industrial, O:others, Std.dev:standard deviation, mon:monitoring, n:number of monitoring days; L:Low, M:moderate, H:high, C:critical classification based on Pollution Level Classification,Chapter 2,Table 2.1*

Table 4.3: Ten cities with highest NO_2 values (annual average) during 2009 (residential / industrial / rural / other area)

Sl. No.	State	City	Annual average ($\mu g/m^3$)	No. of days of monitoring	Air Quality
1	West Bengal	Howrah	74*	104	C
2	West Bengal	Kolkata	68*	102	C
3	West Bengal	Durgapur	61*	87	C
4	West Bengal	Asansol	55*	63	H
5	Delhi	Delhi	50*	82	H
6	Jharkhand	Jamshedpur	49*	101	H
7	Maharashtra	Navi Mumbai	42*	104	H
8	Maharashtra	Mumbai	41*	92	H
9	Jharkhand	Jharia	41*	72	H
10	Maharashtra	Pune	40	106	M

** - Cities where annual mean concentration of NO_2 exceeded the NAAQS of 40 $\mu g/m^3$ for Residential/ industrial / other area. L:Low, M:moderate, H:high, C:critical classification based on Pollution Level Classification, Chapter 2,Table 2.1*

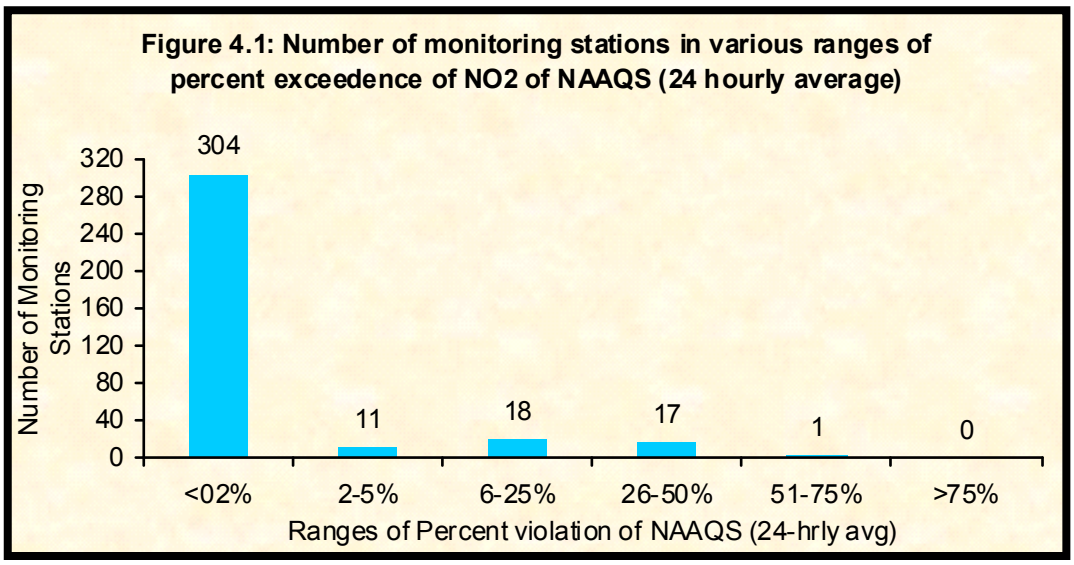
Table 4.4: Ten states with highest NO_2 values (annual average) during 2009 (residential / industrial / rural / other area)

Sl. No.	State	Annual average ($\mu g/m^3$)	No. of days of monitoring	Air Quality
1	West Bengal	68*	68	C
2	Delhi	50*	82	H
3	Jharkhand	42*	79	H
4	Bihar	37	62	M
5	Uttar Pradesh	31	86	M
6	Maharashtra	31	94	M
7	Chhattisgarh	31	79	M
8	Punjab	30	99	M
9	Rajasthan	27	99	M
10	Karnataka	27	89	M

** - States where annual mean concentration of NO_2 exceeded the NAAQS of 40 $\mu g/m^3$ for Residential/ industrial / other area. L:Low, M:moderate, H:high, C:critical classification based on Pollution Level Classification, Chapter 2,Table 2.1*

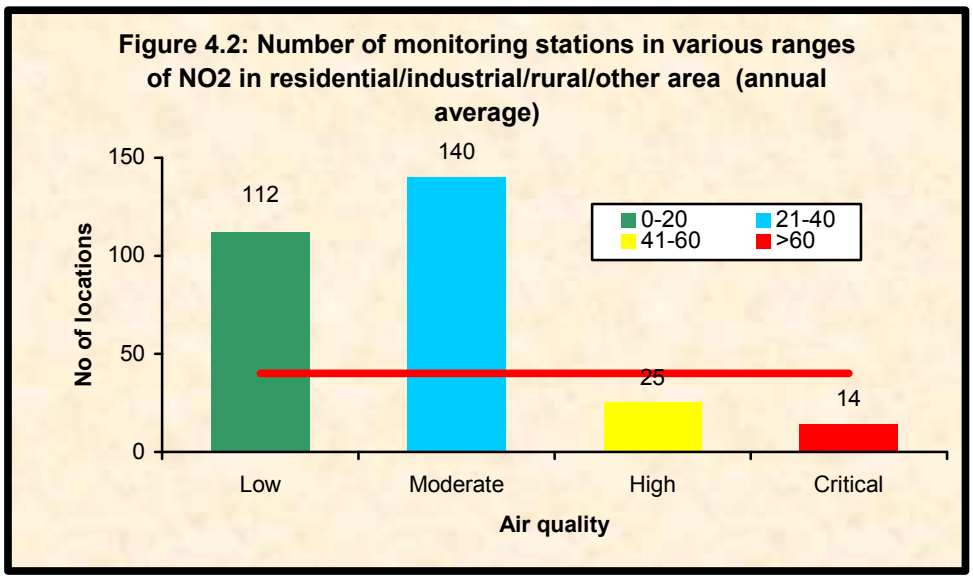
4.2 Percentage exceedence of NAAQS (24 Hourly Average)

Number of monitoring stations in various ranges of percentage exceedence of NAAQS (24 hourly average) of NO_2 is depicted in Figure 4.1. The percentage exceedence of NAAQS (24 hourly Average) was less than 2% at 304 monitoring stations out of 357 stations. In the remaining stations (53 stations), the percentage exceedence of NAAQS (24 hourly avg.) was 2% or more.



4.3 Air Quality (Low, Moderate, High & Critical)

Number of monitoring stations with low, moderate, high and critical levels of NO_2 is depicted in Figure 4.2. 112 locations showed low NO_2 level, 140 locations showed moderate, 25 high and 14 location were in critical category. Therefore, 39 (11%) locations out of 357 exceeded the NAAQS.



The annual average concentration of NO_2 at various monitoring stations is given in Table 4.5. The data given is annual average concentration and number of observations with 16 and more hours of monitoring a day. Also, described in the table is air quality in terms of low, moderate, high and critical. NO_2 levels at many monitoring stations (with high and critical air quality) exceeded the prescribed limit. Standard deviation value indicates that there is not much variation in observation except in cities lik Vishakhapatnam, Patna, Delhi, Chandrapur, Mumbai, Nagpur, Navi Mumbai, Asansol, Durgapur, Howrah, Kolkata, Raniganj, Sankrail and South suburban.

	Sibsagar	Sibasagar Off. Bldg	R	13	3	102	0	L
	Silchar	Office Building RLO	R	15	3	93	0	L
	Tezpur	Tezpur Office Bldg	R	13	3	99	0	L
	Tinsukhia	Digboi carbon factor	R	14	1	18	0	-
Bihar	Patna	Beltron Bhawan	R	23	9	79	0	M
		Gandhi Maidan T C	R	51	20	44	7	-
Chandigarh	Chandigarh	Industrial Area	I	19	10	138	0	L
		Kaimbwala Village	R	12	6	145	0	L
		Punjab Eng College	R	12	7	140	0	L
		Sector-17 C	R	17	7	145	0	L
		Sector-39	R	15	8	144	0	L
Chattisgarh	Bhilai Nagar	M.P.L.U. Nigam	I	32	1	95	0	M
		Regional Office	R	17	1	93	0	L
		Visak Hostel	R	26	1	92	0	M
	Korba	I.T.I, Rampur	R	22	1	101	0	M
		Near Ghantaghar	R	21	1	104	0	M
		Pragati Nagar	R	21	1	102	0	M
	Raipur	Wool Worth I.Pvt.Ltd	I	48	2	35	0	-
		New HIG – 9, Hirapur	R	46	2	46	0	-
		Yatayat Thana	R	45	2	40	0	-
Dadra & Nagar Haveli	Silvassa	Khadoli Ind. Area	I	17	1	78	0	L
Daman & Diu	Daman	Kadaiya Ind. Area	I	19	4	76	0	L
Delhi	Delhi	Mayapuri Indl. Area	I	55*	22	96	15	H
		Shahdara	I	43*	12	74	0	H
		Shahzada Bagh	I	44*	14	77	1	H
		Janakpuri	R	56*	6	77	0	H
		N.Y. School	R	51*	22	96	18	H
		Nizamuddin	R	54*	5	75	0	H
		Pritampura	R	33	7	74	0	M
		Siri Fort	R	54*	5	74	0	H
		Town Hall	R	57*	24	96	22	H
Goa	Mormugao	Mormugao Port Trust	I	10	6	102	0	L
	Panaji	Near Old GSPCB	R	13	8	99	0	L
	Vasco	Electricity Deptt.	I	18	9	78	0	L
Gujarat	Ahmedabad	Naroda	I	23	4	104	0	M
		Shardaban Hospital	I	20	3	96	0	L
		Behrampura	R	21	3	103	0	M
		Cadilla Bridge Narol	R	24	5	101	0	M
		L.D. Eng. College	R	18	2	98	0	L
		R.C. High School	R	20	4	105	0	L
	Anklesvar	Rallies India Ltd	I	28	5	105	0	M
		Durga Traders	R	25	2	105	0	M
	Jamnagar	Fisheries Office	R	27	4	105	0	M
	Rajkot	Sardhara Indl.Corp.	I	17	3	104	0	L
		Regional Office	R	14	2	100	0	L
	Surat	B.R.C. High School	I	29	3	103	0	M
	Town		R	19	3	48	0	

	Mangalore	Stides Premises	I	6	1	104	0	L
	Mysore	K.R. Circle	R	31	7	103	0	M
		KSPCB Building	I	28	6	107	0	M
Kerala	Kochi	Eloor	I	7	2	90	0	L
		FACT Udyogmandal	I	7	2	92	0	L
		Irumpanam	I	11	3	107	0	L
		CSIR Complex	I	13	4	107	0	L
		Ernakulum South	R	19	7	108	0	L
		FCI, OEN C. O. Bldg	R	14	5	108	0	L
		M.G. Road	R	16	5	108	0	L
	Kottayam	Vadavathoor	I	16	1	96	0	L
		Kottayam	R	23	1	96	0	M
	Kozhikode	Nallalam	I	9	3	108	0	L
		Kozhikode City	R	9	3	105	0	L
	Palakkad	Carboradum/SEPR	I	7	3	118	0	L
	Trivandrum	Hi Tech Chackai	I	19	2	108	0	L
		Sasthamangalam	R	27	4	110	0	M
		SMV School	R	30	4	106	0	M
Maharashtra	Amravati	Apurva Oil and Ind.	I	14	2	104	0	L
		Govt. Coll. of Engg.	R	12	2	102	0	L
		Rajkamal Square	R	15	2	104	0	L
	Aurangabad (MS)	C.A.D.A. Office	R	24	4	96	0	M
		S.B.E.S. College	R	27	5	96	0	M
		Bibi-Ka-Maqbara	S	23	3	97	0	M
	Chandrapur	M.I.D.C.	I	35	13	77	0	M
		Nagar Parishad	R	33	12	69	0	M
		SRO, Bapat Nagar	R	35	14	75	0	M
	Kolhapur	Mahadwar Road	R	14	5	101	0	L
		S.T. Stand	R	20	5	103	0	L
		Shivaji University	R	8	3	103	0	L
	Mahad	EHS mahad	I	35	4	45	0	-
		MNP, Phulle Hall	R	29	6	38	0	-
		WTP, Bhirwadi	R	34	5	44	0	-
	Mumbai	Parel	I	41*	22	93	6	H
		Kalbadevi	R	43*	20	87	7	H
		Worli	R	39	20	95	3	M
	Nagpur	MIDC Industrial Area/Hingana	I	30	20	94	5	M
		MIDC Office	I	36	8	105	0	M
		Govt. Poly. College	R	33	5	93	0	M
		Institution of Eng.	R	36	9	105	1	M
		Maskasath	R	26	18	98	2	M
		NEERI Lab	R	28	21	97	3	M
	Nashik	VIP Industrial Area	I	29	5	102	0	M
		NMC Building	R	29	5	103	0	M
		RTO Colony Tank	R	29	5	103	0	M
	Navi Mumbai	MIDC Taloja	I	54*	15	105	0	H
		MPCB Central Lab	I	42*	16	104	3	H
		Kurla C. Circle	R	12	2	96	0	L

	Cuttack	Badambi, Cuttack	R	24	5	104	0	M
		R.O. Cuttack	R	16	2	105	0	L
	Rayagada	LPS H. School	I	22	4	105	0	M
		Regional Office	R	21	4	111	0	M
	Rourkela	IDL Police Out-post	R	11	1	105	0	L
		Regional Office	R	11	2	106	0	L
	Sambalpur	PHD Ofice, Sambalpur	R	16	2	125	0	L
	Talcher	Coal Field Area	I	27	2	95	0	M
		T.T.P.S Colony	I	19	2	104	0	L
Pondicherry	Pondicherry	PIPDIC	I	13	3	63	0	L
		Chamber of Commerce	R	7	2	100	0	L
		DSTC Office	R	12	2	59	0	L
Punjab	Amritsar	Nagina Soap Factory	I	35	4	65	0	M
		A-1 Platters	R	35	3	81	0	M
	Bathinda	Bathinda Milk Plant	I	21	4	113	0	M
	Dera Bassi	Bhanakarpur Road	I	21	4	132	0	M
		Winsome Yarns Ltd	I	21	4	124	0	M
	Gobindgarh	Raj Steel	I	29	6	120	0	M
		Modi oil & GM	R	29	8	44	0	-
		United Rolling Mills	R	30	6	137	0	M
	Jalandhar	Focal Point	I	32	5	23	0	-
		Punjab Maltex	I	32	2	62	0	M
		MC Tube Well No.27	R	31	2	107	0	M
		Regional Office	R	26	2	116	0	M
	Khanna	Markfed Vanaspati	I	36	7	136	0	M
		A S School	R	36	7	135	0	M
	Ludhiana	Milk Plant	I	36	7	105	0	M
		Rita Sewing Machines	I	38	7	91	0	M
		Bharat Nagar Chowk	R	39	5	31	0	-
		PPCB Office Bldg.	R	38	7	124	0	M
	Naya Nangal	NFL Guest House	R	20	2	129	0	L
		Punjab Alkalies	R	20	4	109	0	L
Rajasthan	Alwar	Gaurav Solvex Ltd.	I	23	5	99	0	M
		RIICO Pump House	I	23	6	100	0	M
		Regional Office	R	23	6	106	0	M
	Jaipur	MIA	I	35	4	105	0	M
		VKIA	I	42*	5	107	0	H
		Ajmeri Gate	R	38	4	105	0	M
		Chandpole	R	40	10	103	1	M
		RSPCB Office	R	26	5	106	0	M
		Vidyadhar Nagar	R	36	5	103	0	M
	Jodhpur	Basni Indl. Area	I	24	4	87	0	M
		DIC	I	24	6	99	0	M
		Housing Board	R	21	3	83	0	M
		M M Police Thane	R	21	4	102	0	M
		Shashtri Nagar	R	24	1	84	0	M
		Sojati Gate	R	24	1	83	0	M
	Kota	Regional Office	I	27	13	104	0	M
		[illegible]	R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

		Kapoor Hotel	R	35	2	90	0	M
		Mahanagar	R	35	2	77	0	M
	Meerut	Begum Bridge	R	46	7	41	0	-
		Thana Railway Road	R	43	5	29	0	-
	Noida	GEE-PEE	I	33	6	98	0	M
		R.O, UPPB	R	33	5	92	0	M
	Varanasi	Regional Office	R	20	1	89	0	L
		Sigra	R	20	1	94	0	L
Uttarakhand	Dehradoon	Raipur Road	I	29	2	33	0	-
		Clock Tower	R	31	3	51	0	M
West Bengal	Asansol	Asansol M.C.	I	62*	19	102	26	C
		Kangsabati Spinning Mill, Barjora	I	55	15	43	12	-
		Burnpur Town Department, Burnpur	I	49	13	43	0	-
	Durgapur	Dew India Ltd., Dr. B. C. Roy Avenue, Durgapur	I	73*	19	102	14	C
		Kwality Hotel, Bhiringi More, benachiti	I	64*	18	102	1	C
		PCBL Club, Muchipara, Bidhannagar	R	55*	15	102	6	H
		DMC Water Works, Angadpur	R	53	12	43	7	-
	Haldia	Super Market	I	67	2	9	0	-
		WBIIDC	I	67	2	9	0	-
	Howrah	Bandhaghat	I	85*	35	104	41	C
		Howrah MC	I	81*	37	104	38	C
		Bator	R	59*	24	104	23	H
		Naskarpara	R	70*	33	104	39	C
	Kolkata	Traffic Guard Building, Behala Chowrasta	I	77*	31	105	39	C
		Cossipore Police Stn	I	73*	30	97	39	C
		National Sample Survey Building, Dunlop Bridge	I	67*	27	104	34	C
		Upanagari Sporting Club, Baishnabghata	R	76*	16	105	7	C
		Kasba	R	47*	23	95	13	H
		Lal Bazar	R	63*	28	96	26	C
		A.J.C Bose Road, Minto Park	R	66*	24	104	26	C
		KMC Office Building, Moulali	R	79*	33	105	40	C
		CK Market, Salt Lake	R	67*	27	105	30	C
	Barrackpore	Barrackpore Police Station	R	58	15	44	16	-
		Dum Dum Telephone Exchange	R	77	25	44	34	-
		Khardah Municipality	R	78	29	44	34	-
	Raniganj	Jamuria Municipality	R	62	11	17	0	-
		SKS Public School, Mangalpur	R	114	70	43	58	-
		Chandganj Nagar	R	36	2	96	0	M

		Raniganj Municipality, Raniganj	R	73	12	43	16	-
	Sankrail	P. Mukherjee's House, (Near SBI)	R	42	13	31	3	-
		Bagnan Police Station	R	81	29	31	42	-
		Dhulagarh Gram Panchayet Office	R	80	21	31	48	-
		Bharat Co-operative Housing Society, Sankrail	R	68	17	31	26	-
	South suburban	P. Roy Industrial Training Institute, Amtala	R	58	58	43	21	-
		Baruipur Police Station	R	56	20	43	19	-
		Chanditala Water Supply Pump House, Tollygunge	R	64	29	42	29	-

*Note: * - Locations where annual mean concentration of NO_2 exceeded the NAAQS of 40 µg/m^3 for Residential/ industrial / other area and 30 µg/m^3 for sensitive area. R – Residential and other areas, I – Industrial area, S – Sensitive Areas, R:residential, I:industrial, O:others, mon:monitoring Std dev. – Standard deviation, n – number of days monitored for 16 and more hours a day L- Low, M- Moderate, H – High and C – Critical levels of pollution based on exceedence factor (calculated for n ≥ 50 days) classification based on Pollution Level Classification, Chapter 2,Table 2.1; % violation – percentage violation of NAAQS (24 hourly average) BDL = Below Detection Limit (Concentration less than 4 µg/m^3 for SO_2).*

CHAPTER 5

AIR QUALITY WITH RESPECT TO PARTICULATE MATTER OF SIZE LESS THAN 10µg (PM_{10})

Particulate matter (PM) is a complex mixture of suspended solid and liquid particle in semi equilibrium with surrounding gases. It is classified in different ways:

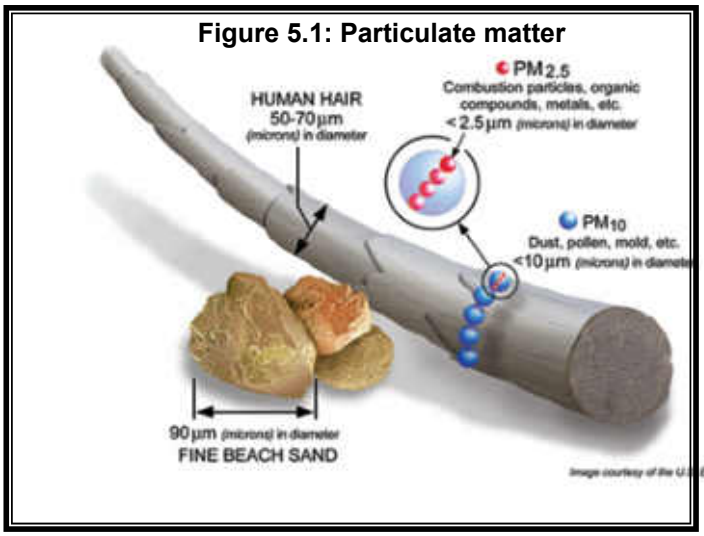
a. Classification on emission:
   - Primary PM: Particulate matter is called primary if it is in the same chemical term in which it is emitted into the atmosphere. The primary particulate matter includes wind blown dust such as road dust, fly ash, soot etc.
   - Secondary PM: Particulate matter is called secondary if it is formed by chemical reactions in the atmosphere. Secondary particulate matter include sulphates, nitrates etc.

b. Classification on size: Table 5.1, Figure 5.1 shows the classification and size of particulate matter

Table 5.1 Classification of particulate matter

Fraction	Size range
Respirable suspended particulate metter (RSPM) or PM_{10} (thoracic fraction)	<=10 µm diameter produced by mechanical attrition of industrial dusts lung deposition principally by impaction 2.5 µm – 10 µm is called coarse fraction
Accumulation mode or Fine particles or $PM_{2.5}$ (respirable fraction)	<=2.5 µm in diameter composed mainly of carbonaceous materials (organic and elemental), inorganic compounds (sulfate, nitrate, and ammonium), and trace metal compounds (iron, aluminium, nickel, copper, zinc, and lead) penetrates deeper into the lungs increases respiratory symptoms, causes irritation of the airways, coughing, or difficulty breathing, decreases lung function; aggravates asthma, chronic bronchitis, irregular heartbeat, nonfatal heart attacks, premature death in people with heart or lung disease
Ultrafine particles (UFP)	<=0.1 µm large surface area to mass ratio making them potential carriers of harmful gaseous compounds cause severe pulmonary inflammation and hemorrhage, high degree of alveolar and interstitial edema, disruption of epithelial and endothelial cell layers and even death

Figure 5.1: Particulate matter



c. Based on the generation mechanism PM are categorized into
   - Dispersion Originated - the particulate originated from wind generated movement in nature as well as man made or from the breakdown from liquid or solid bulk materials, i.e. by grinding,

atomization, natural dispersion, wind erosion etc. Eg. Dust (Dispersion Originated) is produced by subdivision of solid material through mechanical actions or in nature. Anthropogenic emissions are generated during grinding or milling of materials, during transfer of finely divided material as well as from agriculture, forestry and construction activities. The larger the particle diameter, they tend to settle faster. The rate of settling also depends on density and shape of particles. Particles larger than 50 µm settle rapidly.

- Condensation Originated - build up from molecular dimension after heating and cooling. Eg. Fumes (Condensation Originated) areroduced from hot solid substances by vaporization and condensation usually industrial process originated, combustion originated or from metallurgical processes.
  Mist (Dispersion & Condensation Originated) is generated from liquid by mechanical actions, evaporation and/or condensation of vapors generated from Industrial processes, spraying, electroplating etc.

Respirable Suspended Particulate Matter or PM_{10} are the particles with upper size limited by a 50% cut at 10 µm aerodynamic diameter (USEPA, 1996). Ie they consist of particles with a diameter up to 10 µm. The major constituents of RSPM are organic and elemental carbon, metals/elements +like silicon, magnesium, iron, ions like*sulphates, nitrates, ammonium etc. PM_{10} can be formed by physical processes of crushing, grinding and abrasion of surfaces. Mining and agricultural activities are some of the sources of large size particles. The anthropogenic source are coarse particles are produced by the mechanical break-up of larger solid particles, wind blown dust such as road dust, fly ash, soot, agricultural processes, physical processes of crushing, grinding and abrasion of surfaces, photochemically produced particles, such as those found in urban haze, pollen grains, mould spores, and plant and insect parts and anthropogenic sources are combustion of fossil fuel (coal, heavy fuel oil in thermal power plants, office, factories), paper Industry, extraction & distribution of fossil fuels, smelting of metals (sulfide ores to produce copper, lead and zinc), Petroleum refining. combustion process in diesel, petrol, natural gas driven vehicles PM10 can settle in the bronchi and lungs and cause health problems like respiratory illness, visibility impairment, aggravate existing heart and lung diseases. It also causes visibility reduction. A compilation of sources and effects of PM_{10} are given in Annexure 1.

In this chapter the a detailed summary of PM_{10} levels in the country is furnished. The air quality of different cities/towns has been compared with the respective standard.The air quality has been categorized into four broad categories based on an Exceedence Factor (the ratio of annual mean concentration of a pollutant with that of a respective standard. The four categories are low, moderate, high and critical levels. The top 10 location, cities and states with maximum PM_{10} pollution is furnished.

5.1 Locations and cities with highest PM_{10} values during 2009

Table 5.2 shows top ten locations in terms of annual average concentration of PM_{10} for residential / industrial / rural / other area in which highest concentration was observed at monitoring station located at Town Hall, Delhi and Table 5.3 shows sensitive area in highest concentration was observed at DIC Nunhai, Agra. Among the cities Jharia, Jharkhand tops the list with 261 $\mu g/m^3$ $PM_{10.}$(Table 5.4). Among the states Delhi shows highest PM_{10} values 252 $\mu g/m^3$.(Table 5.5)

Table 5.2: Ten locations with highest PM_{10} values (annual average) during 2009 (residential / industrial / rural / other area)

Sl. No.	State	City	Location	Type of area (Indistrial/ Residential/ other)	Annual average ($\mu g/m^3$)	Std dev	No. of days mon (n)	% exceed ence	Air quality
1	Delhi	Delhi	Town Hall	R	317*	155	96	92	C
2	Delhi	Delhi	Janakpuri	R	309*	125	72	100	C
3	Delhi	Delhi	Nizamuddin	R	292*	120	74	96	C
4	Delhi	Delhi	Mayapuri Indl. Area	I	274*	121	96	94	C
5	Delhi	Delhi	Siri Fort	R	269*	97	74	96	C
6	Rajasthan	Jaipur	VKIA	I	269*	127	107	94	C
7	Punjab	Ludhiana	Rita Sewing Machines	I	265*	31	91	100	C
8	Jharkhand	Jharia	M.A.D.A.	I	261*	88	78	99	C
9	Punjab	Ludhiana	PPCB Office Bldg.	R	251*	18	124	100	C
10	Punjab	Khanna	A S School	R	249*	16	135	100	C

** - Locations where annual mean concentration of PM_{10} exceeded the NAAQS of 60 $\mu g/m^3$ for Residential/ industrial / other area. R:residential, I:industrial, O:others, Std.dev:standard deviation, mon:monitoring, n:number of monitoring days; L:Low, M:moderate, H:high, C:critical classification based on Pollution Level Classification,Chapter 2,Table 2.1*

Table 5.3: Ten locations with highest PM_{10} values (annual average) during 2009 (sensitive area)

Sl. No	State	City	Location	Annual average ($\mu g/m^3$)	Std dev	No. of days mon (n)	% exceed ence	Air quality
1	Uttar Pradesh	Agra	DIC, Nunhai	243*	125	104	88	C
2	Uttar Pradesh	Agra	Nunhai	211*	39	95	99	C
3	Uttar Pradesh	Agra	Regional Office	185*	46	99	98	C
4	Uttar Pradesh	Agra	Itmad-ud-daulah	167*	99	103	68	C
5	Uttar Pradesh	Agra	Taj Mahal	154*	102	266	68	C
6	Uttar Pradesh	Agra	Rambagh	147*	92	102	63	C
7	Maharashtra	Aurangabad	Bibi-Ka-Maqbara	90*	32	101	33	H
8	Karnataka	Gulbarga	Govt. Hospital	74*	23	99	12	H
9	Andhra Pradesh	Visakhapatnam	INS-VIRBAHU	66*	21	108	6	H
10	Himachal Pradesh	Shimla	Tekka Bench Ridge	62*	29	131	9	H

** - Locations where annual mean concentration of PM_{10} exceeded the NAAQS of 60 $\mu g/m^3$ for sensitive areas. Std.dev:standard deviation, mon:monitoring, n:number of monitoring days; L:Low, M:moderate, H:high, C:critical classification based on Pollution Level Classification,Chapter 2,Table 2.1*

Table 5.4: Ten cities with highest PM_{10} values (annual average) during 2009 (residential / industrial / rural / other area)

Sl. No.	State	City	Annual average ($\mu g/m^3$)	No. of days of monitoring	Air Quality
1	Jharkhand	Jharia	261*	78	C
2	Punjab	Ludhiana	253*	88	C
3	Delhi	Delhi	252*	80	C
4	Punjab	Khanna	248*	136	C
5	Uttar Pradesh	Ghaziabad	239*	76	C
6	Uttar Pradesh	Kanpur	212*	87	C
7	Punjab	Gobindgarh	201*	102	C
8	Uttar Pradesh	Lucknow	197*	90	C
9	Uttar Pradesh	Firozabad	195*	96	C
10	Punjab	Amritsar	190*	54	C

** - Cities where annual mean concentration of PM_{10} exceeded the NAAQS of 60 $\mu g/m^3$ for Residential/ industrial / other area. L:Low, M:moderate, H:high, C:critical classification based on Pollution Level Classification,Chapter 2,Table 2.1*

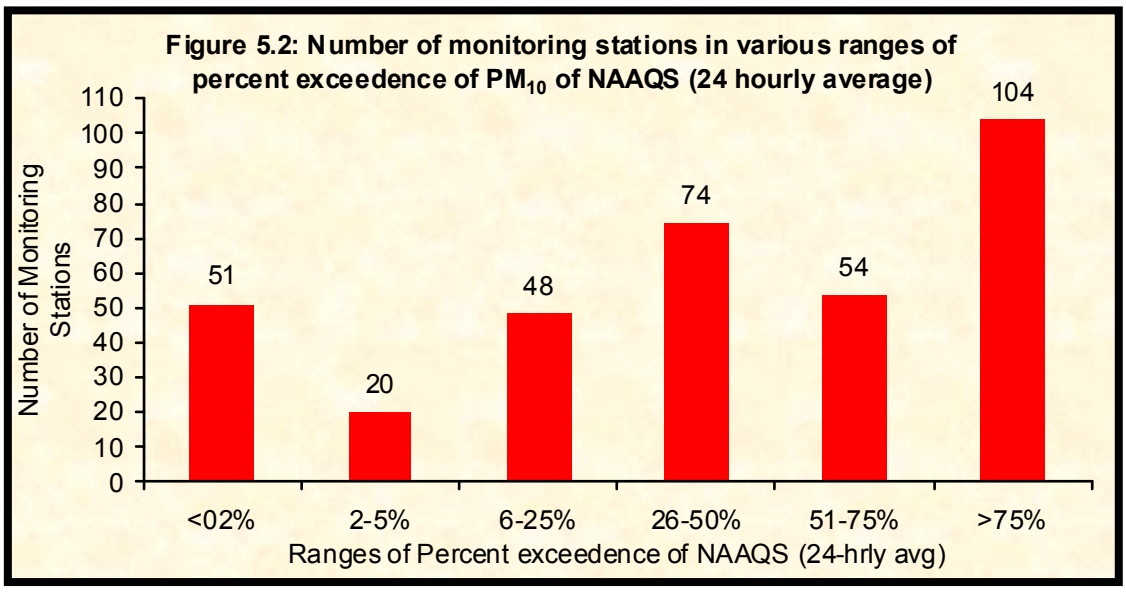
Table 5.5: Ten states with highest PM_{10} values (annual average) during 2009 (residential / industrial / rural / other area)

Sl. No.	State	Annual average ($\mu g/m^3$)	No. of days of monitoring	Air Quality
1	Delhi	252*	80	C
2	Punjab	199*	85	C
3	Jharkhand	186*	81	C
4	Uttar Pradesh	174*	87	C
5	Chhattisgarh	164*	75	C
6	Bihar	146*	66	C
7	West Bengal	136*	67	C
8	Rajasthan	129*	99	C
9	Madhya Pradesh	129*	57	C
10	Jammu & Kashmir	116*	50	C

** - States where annual mean concentration of PM_{10} exceeded the NAAQS of 60 $\mu g/m^3$ for Residential/ industrial / other area. L:Low, M:moderate, H:high, C:critical classification based on Pollution Level Classification,Chapter 2,Table 2.1*

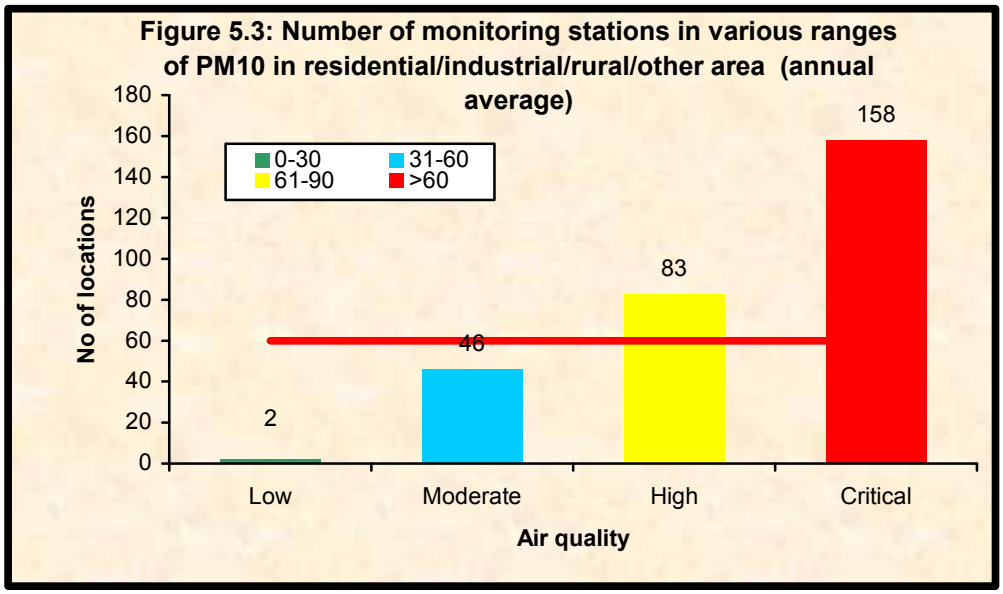
5.2 Percentage exceedence of NAAQS (24 Hourly Average)

Number of monitoring stations in various ranges of percentage of exceeding limit of NAAQS (24 hourly average) of PM_{10} is depicted in Figure 5.2. The percentage exceedence of NAAQS (24 hourly Average) was less than 2% at 51 monitoring stations out of 357 stations. In the remaining stations (306 stations), the percentage exceedence of NAAQS (24 hourly avg.) was 2% or more.



5.3 Air Quality (Low, Moderate, High & Critical)

Number of monitoring stations with low, moderate, high and critical levels of PM_{10} is depicted in Figure 5.3. 2 locations showed low PM_{10} level, 46 locations showed moderate, 83 high and 158 location were in critical category. Therefore, 241 (68%) locations out of 357 exceeded the NAAQS.



The annual average concentration of PM_{10} at various monitoring stations is given in Table 5.6. The data given is annual average concentration and number of observations with 16 and more hours of monitoring a day. Also, described in the table is air quality in terms of low, moderate, high and critical. PM_{10} levels at many monitoring stations (with high and critical air quality) exceeded the prescribed NAAQS. Standard deviation value indicate that there is variation at Guwahati, Patna, Delhi, Bangalore, Mumbai, Satna, Alwar, Jaipur, Agra and Asansol.

	Sibsagar	Sibasagar Off. Bldg	R	100*	56	102	42	C
	Silchar	Office Building RLO	R	58	31	93	8	M
	Tezpur	Tezpur Office Bldg	R	90*	70	99	32	H
	Tinsukhia	Digboi carbon factor	R	81	33	18	28	-
Bihar	Patna	Beltron Bhawan	R	110*	58	85	58	C
		Gandhi Maidan T C	R	182	109	46	83	-
Chandigarh	Chandigarh	Industrial Area	I	93*	37	148	39	C
		Kaimbwala Village	R	76*	30	154	20	H
		Punjab Eng College	R	78*	32	150	22	H
		Sector-17 C	R	77*	29	154	20	H
		Sector-39	R	80*	30	153	20	H
Chattisgarh	Bhilai Nagar	M.P.L.U. Nigam	I	159*	14	96	100	C
		Regional Office	R	82*	8	94	3	H
		Visak Hostel	R	96*	12	92	30	C
	Korba	I.T.I, Rampur	R	125*	20	101	96	C
		Near Ghantaghar	R	119*	15	104	88	C
		Pragati Nagar	R	108*	14	102	76	C
	Raipur	Wool Worth I.Pvt.Ltd	I	265	24	25	100	-
		New HIG - 9, Hirapur	R	275	43	14	100	-
		Yatayat Thana	R	250	36	45	100	-
Dadra & Nagar Haveli	Silvassa	Khadoli Ind. Area	I	71*	8	78	0	H
Daman & Diu	Daman	Kadaiya Ind. Area	I	57	9	76	0	M
Delhi	Delhi	Mayapuri Indl. Area	I	274*	121	96	94	C
		Shahdara	I	204*	59	61	93	C
		Shahzada Bagh	I	224*	71	76	96	C
		Janakpuri	R	309*	125	72	100	C
		N.Y. School	R	192*	93	95	84	C
		Nizamuddin	R	292*	120	74	96	C
		Pritampura	R	184*	52	73	97	C
		Siri Fort	R	269*	97	74	96	C
		Town Hall	R	317*	155	96	92	C
Goa	Mormugao	Mormugao Port Trust	I	72*	37	102	17	H
	Panaji	Near Old GSPCB	R	74*	29	100	0	H
	Vasco	Electricity Deptt.	I	76*	30	78	0	H
Gujarat	Ahmedabad	Naroda	I	129*	18	104	91	C
		Shardaban Hospital	I	88*	8	97	5	H
		Behrampura	R	86*	8	104	2	H
		Cadilla Bridge Narol	R	90*	10	102	11	H
		L.D. Eng. College	R	82*	10	98	1	H
		R.C. High School	R	88*	8	105	5	H
	Anklesvar	Rallies India Ltd	I	98*	10	105	45	C
		Durga Traders	R	79*	6	105	0	H
	Jamnagar	Fisheries Office	R	106*	10	105	77	C
	Rajkot	Sardhara Indl.Corp.	I	125*	21	105	95	C
		Regional Office	R	85*	12	100	10	H
	Surat	B.R.C. High School	I	101*	9	103	58	C

	Mangalore	Stides Premises	I	41	21	104	1	M
	Mysore	K.R. Circle	R	54	20	103	3	M
		KSPCB Building	I	41	15	107	0	M
Kerala	Kochi	Eloor	I	49	59	90	14	M
		FACT Udyogmandal	I	52	64	92	16	M
		Irumpanam	I	37	18	107	0	M
		CSIR Complex	I	40	19	107	1	M
		Ernakulum South	R	40	19	108	0	M
		FCI, OEN C. O. Bldg	R	39	20	108	0	M
		M.G. Road	R	36	21	108	1	M
	Kottayam	Vadavathoor	I	36	3	96	0	M
		Kottayam	R	53	7	96	0	M
	Kozhikode	Nallalam	I	29	7	108	0	L
		Kozhikode City	R	34	13	105	0	M
	Palakkad	Carboradum/SEPR	I	50	23	118	3	M
	Trivandrum	Hi Tech Chackai	I	78*	10	108	1	H
		Sasthamangalam	R	53	7	110	0	M
		SMV School	R	63*	21	106	1	H
Maharashtra	Amravati	Apurva Oil and Ind.	I	90*	13	96	28	H
		Govt. Coll. of Engg.	R	73*	15	102	3	H
		Rajkamal Square	R	107*	19	104	65	C
	Aurangabad (MS)	C.A.D.A. Office	R	67*	23	97	7	H
		S.B.E.S. College	R	105*	36	98	2	C
		Bibi-Ka-Maqbara	S	90*	32	101	33	H
	Chandrapur	M.I.D.C.	I	125*	53	77	66	C
		Nagar Parishad	R	90*	76	69	30	H
		SRO, Bapat Nagar	R	131*	73	76	58	C
	Kolhapur	Mahadwar Road	R	87*	17	101	26	H
		S.T. Stand	R	101*	17	103	58	C
		Shivaji University	R	57	6	105	0	M
	Mahad	EHS mahad	I	154	40	45	96	-
		MNP, Phulle Hall	R	188	59	38	100	-
		WTP, Bhirwadi	R	146	41	44	89	-
	Mumbai	Parel	I	129*	69	93	62	C
		Kalbadevi	R	98*	51	87	56	C
		Worli	R	125*	42	96	72	C
	Nagpur	MIDC Industrial Area/Hingana	I	126*	88	94	50	C
		MIDC Office	I	137*	56	105	70	C
		Govt. Poly. College	R	100*	44	97	43	C
		Institution of Eng.	R	116*	48	105	57	C
		Maskasath	R	78*	41	98	35	H
		NEERI Lab	R	46	36	96	7	M
	Nashik	VIP Industrial Area	I	86*	39	102	39	H
		NMC Building	R	95*	46	103	45	C
		RTO Colony Tank	R	87*	43	103	36	H
	Navi Mumbai	MIDC Taloja	I	228*	131	105	87	C
		MPCB Central Lab	I	97*	60	104	48	C

	Bhubaneshwar	Capital Police Stn.	R	103*	48	105	34	C
		IRC	R	76*	25	104	16	H
		OSPCB Bldg	R	84*	34	112	27	H
	Cuttack	Badambi, Cuttack	R	89*	40	104	39	H
		R.O. Cuttack	R	73*	37	105	22	H
	Rayagada	LPS H. School	I	61*	18	105	0	H
		Regional Office	R	61*	19	111	1	H
	Rourkela	IDL Police Out-post	R	100*	17	105	41	C
		Regional Office	R	115*	14	106	92	C
	Sambalpur	PHD Ofice, Sambalpur	R	54	10	125	5	M
	Talcher	Coal Field Area	I	118*	42	95	2	C
		T.T.P.S Colony	I	95*	18	104	40	C
Pondicherry	Pondicherry	PIPDIC	I	47	13	64	0	M
		Chamber of Commerce	R	34	10	100	0	M
		DSTC Office	R	44	12	61	0	M
Punjab	Amritsar	Nagina Soap Factory	I	195	29	46	100	-
		A-1 Platters	R	184*	19	61	100	C
	Gobindgarh	Raj Steel	I	204*	21	122	100	C
		Modi oil & GM	R	194	21	44	100	-
		United Rolling Mills	R	206*	25	140	100	C
	Jalandhar	Focal Point	I	149	5	23	100	-
		Punjab Maltex	I	139*	10	62	100	C
		MC Tube Well No.27	R	159*	27	106	98	C
		Regional Office	R	123*	14	116	97	C
	Khanna	Markfed Vanaspati	I	247*	13	136	100	C
		A S School	R	249*	16	135	100	C
	Ludhiana	Milk Plant	I	244*	16	105	100	C
		Rita Sewing Machines	I	265*	31	91	100	C
		Bharat Nagar Chowk	R	251	6	30	100	-
		PPCB Office Bldg.	R	251*	18	124	100	C
	Naya Nangal	NFL Guest House	R	222	-	1	-	-
		Punjab Alkalies	R	100*	21	109	51	C
Rajasthan	Alwar	Gaurav Solvex Ltd.	I	188*	134	100	70	C
		RIICO Pump House	I	109*	59	102	48	C
		Regional Office	R	163*	96	106	73	C
	Jaipur	MIA	I	81*	44	105	20	H
		VKIA	I	269*	127	107	94	C
		Ajmeri Gate	R	99*	50	105	3	C
		Chandpole	R	198*	81	103	92	C
		RSPCB Office	R	81*	39	106	26	H
		Vidyadhar Nagar	R	177*	101	103	83	C
	Jodhpur	Basni Indl. Area	I	162*	57	88	84	C
		DIC	I	114*	39	99	65	C
		Housing Board	R	105*	45	83	46	C
		M M Police Thane	R	159*	45	103	89	C
		Shashtri Nagar	R	130*	49	84	67	C
		Sojati Gate	R	169*	55	83	94	C
	Kota	Regional Office	I	112*	68	104	54	C

		Kapoor Hotel	R	191*	27	91	100	C
		Mahanagar	R	191*	26	78	100	C
	Meerut	Begum Bridge	R	122	10	41	98	-
		Thana Railway Road	R	115	10	29	97	-
	Noida	GEE-PEE	I	132*	18	98	98	C
		R.O, UPPB	R	133*	19	92	98	C
	Varanasi	Regional Office	R	124*	8	89	100	C
		Sigra	R	126*	9	94	99	C
Uttarakhand	Dehradoon	Raipur Road	I	109	22	38	66	-
		Clock Tower	R	150*	44	57	93	C
West Bengal	Asansol	Asansol M.C.	I	163*	99	102	64	C
		Kangsabati Spinning Mill, Barjora	I	150	96	43	61	-
		Burnpur Town Department, Burnpur	I	149	100	43	56	-
	Durgapur	Dew India Ltd., Dr. B. C. Roy Avenue, Durgapur	I	236*	122	102	85	C
		Kwality Hotel, Bhiringi More, benachiti	I	171*	89	102	71	C
		PCBL Club, Muchipara, Bidhannagar	R	110*	60	102	55	C
		DMC Water Works, Angadpur	R	129	66	43	6	-
	Haldia	Super Market	I	138	22	9	100	-
		WBIIDC	I	136	27	9	89	-
	Howrah	Bandhaghat	I	118*	81	104	50	C
		Howrah MC	I	124*	87	104	47	C
		Bator	R	100*	73	104	39	C
		Naskarpara	R	115*	84	104	46	C
	Kolkata	Traffic Guard Building, Behala Chowrasta	I	108*	72	105	43	C
		Cossipore Police Stn	I	224*	109	97	86	C
		National Sample Survey Building, Dunlop Bridge	I	98*	73	104	41	C
		Upanagari Sporting Club, Baishnabghata	R	77*	58	105	34	H
		Kasba	R	171*	105	95	67	C
		Lal Bazar	R	190*	101	75	78	C
		A.J.C Bose Road, Minto Park	R	75*	53	104	33	H
		KMC Office Building, Moulali	R	107*	83	105	44	C
		CK Market, Salt Lake	R	87*	65	105	34	H
	Barrackpore	Barrackpore Police Station	R	110	41	44	45	-
		Dum Dum Telephone Exchange	R	132	64	44	57	-
		Khardah Municipality	R	132	65	44	57	-
	Raniganj	Jamuria Municipality	R	228	87	17	94	-
		SKS Public School, Mangalpur	R	164	117	43	63	-
		Raniganj Municipality, Raniganj	R	254	145	43	68	-
		Chandganj Nagar	R	193*	26	96	100	C

	Sankrail	P. Mukherjee's House, (Near SBI)	R	109	49	31	52	-
		Bagnan Police Station	R	141	50	31	81	-
		Dhulagarh Gram Panchayet Office	R	141	50	31	77	-
		Bharat Co-operative Housing Society, Sankrail	R	118	38	31	62	-
	South suburban	P. Roy Industrial Training Institute, Amtala	R	75	75	43	30	-
		Baruipur Police Station	R	80	56	43	28	-
		Chanditala Water Supply Pump House, Tollygunge	R	92	67	42	41	-

*Note: * - Locations where annual mean concentration of PM_{10} exceeded the NAAQS of 60 µg/m^3 for Residential/ industrial / other area and 60 µg/m^3 for sensitive area. R – Residential and other areas, I – Industrial area, S – Sensitive Areas, R:residential, I:industrial, O:others, mon:monitoring Std dev. – Standard deviation, n – number of days monitored for 16 and more hours a day L- Low, M- Moderate, H – High and C – Critical levels of pollution based on exceedence factor (calculated for n $\geq$ 50 days) classification based on Pollution Level Classification, Chapter 2,Table 2.1; % violation – percentage violation of NAAQS (24 hourly average)*

CHAPTER 6

AIR QUALITY WITH RESPECT TO SUSPENDED PARTICULATE MATTER (SPM)

Particulate matter (PM) is a complex mixture of suspended solid and liquid particle in semi equilibrium with surrounding gases. The high Suspended particulate matter (SPM) levels lead to greater prevalence of health effects depicting sub-clinical effects, impaired pulmonary function, respiratory symptoms, medication use, excess doctor room visit, asthma and bronchitis. The majority of the symptoms are reversible because of better health facilities and greater awareness about diseases. The wide spread criticality of SPM problem in the country is due to the synergistic effect of natural factors like presence of extensively large arid and semi arid region in north west region, loss of moisture from top soil strata, distribution of sea salts with sea winds, natural formation of sulfate and nitrates during secondary reactions. The anthropogenic factors responsible for high SPM are extensive urbanization and construction activities, vehicular population increase, frequent use of captive power generation unit/domestic generation, extensive use of fossil fuel and biomass (wood, leaves etc.) as well as particulate contribution from biological debris.

As the SPM are the bigger than coarse particles, these settle down fast and does not reach the respiratory tract. Therefore they have less adverse effect on health. As a result it has not been included in the revised standard. However, as it had been measured during 2009 the data is being given in this chapter.

6.1 Annual average concentration of SPM

The annual average concentration of SPM at various monitoring stations is given in Table 6.1. The data given is annual average concentration and number of observations with 16 and more hours of monitoring a day. In addition to above the spread of the data has been given in terms of standard deviation. Close examination of the data furnishes the following observation

- The average values in Andhra Pradesh indicate significant presence of SPM. However, except Ramagundun the variation of the data is low to medium.
- The same trend is observed in Assam with respect to average value with a lower magnitude but the data has a significant variation. This variation may be due to heavy rain in Assam
- With respect to Bihar SPM is significant and so is the case with Variation
- In the case of Chandigarh the presence of SPM is there but the variation is low, the same attributes is observed for Dadra and Nagar Haveli and Daman and Diu
- In case of Chattisgarh the SPM value is high but the variation is consistent
- With respect to Delhi SPM is significant with higher magnitude and high spread
- In case of Goa and Gujarat the SPM values are high but the variation is low. This trend is also observed in case of Himachal Pradesh, Jammu and Kashmir but in Jarkhand, Karnataka and Kerala the values are high, but at some cases the variation is consistent
- In case of Maharashtra in some cases the variation is high which includes Chandrapur, Nagpur, Mumbai, Navi Mumbai and Pune. However, the SPM data is also high.
- In the states like Meghalaya and Mizoram the values are low and the variation is also low. So is the case with Nagaland and Pondicherry.
- With respect to Madhya Pradesh places like Indore, Bhopal the values as well as the variation is high. In other cities the values are high but the variation is low
- With respect Orissa the values indicated are high but the variation is consistent except Angul and Badambi at Cuttack
- In Punjab the values are high but the variation is low
- With respect to Rajasthan the values are high in all cities as well as the variation
- In Tamilnadu except Thuthukudi the variation is consistent and variation in other cities is consistent and the values are noth so high
- In case of Uttar Pradesh the values are high in general but ion cities like \Agra and Firozabad the variation is high
- In case of West Bengal the values as well as the variation are high in almost all the cities.

In summary it is observer that the high value of variation occurred in the cities of Rajasthan and its adjacent state. The same trend occurred in the industrial cities and metropolitan cities. This indicates that the SPM is affected with the seasonal variation.

	Silchar	Office Building RLO	R	102	51	93
	Tezpur	Tezpur Office Bldg	R	198	192	99
	Tinsukhia	Digboi carbon factor	R	124	42	18
Bihar	Patna	Beltron Bhawan	R	255	123	84
		Gandhi Maidan T C	R	477	247	46
Chandigarh	Chandigarh	Industrial Area	I	185	65	147
		Kaimbwala Village	R	154	52	154
		Punjab Eng College	R	156	55	150
		Sector-17 C	R	158	51	154
		Sector-39	R	163	53	153
Chattisgarh	Bhilai Nagar	M.P.L.U. Nigam	I	271	20	96
		Regional Office	R	166	10	94
		Visak Hostel	R	187	24	92
	Korba	I.T.I, Rampur	R	259	29	101
		Near Ghantaghar	R	249	29	104
		Pragati Nagar	R	227	28	102
	Raipur	Wool Worth I.Pvt.Ltd	I	493	75	41
		New HIG - 9, Hirapur	R	452	88	51
		Yatayat Thana	R	395	64	45
Dadra & Nagar Haveli	Silvassa	Khadoli Ind. Area	I	307	47	78
Daman & Diu	Daman	Kadaiya Ind. Area	I	223	37	76
Delhi	Delhi	Mayapuri Indl. Area	I	519	188	96
		Shahdara	I	461	133	77
		Shahzada Bagh	I	542	151	77
		Janakpuri	R	510	162	75
		N.Y. School	R	397	151	96
		Nizamuddin	R	528	178	74
		Pritampura	R	423	103	74
		Siri Fort	R	489	151	74
		Town Hall	R	536	232	96
Goa	Mormugao	Mormugao Port Trust	I	158	96	102
	Panaji	Near Old GSPCB	R	133	48	100
	Vasco	Electricity Deptt.	I	177	97	78
Gujarat	Ahmedabad	Naroda	I	295	59	104
		Shardaban Hospital	I	196	16	97
		Behrampura	R	193	19	104
		Cadilla Bridge Narol	R	200	20	102
		L.D. Eng. College	R	185	20	98
		R.C. High School	R	196	16	105
	Anklesvar	Rallies India Ltd	I	196	21	105
		Durga Traders	R	158	12	105
	Jamnagar	Fisheries Office	R	193	20	105
	Rajkot	Sardhara Indl.Corp.	I	227	36	105
		Regional Office	R	157	20	100
	Surat	B.R.C. High School	I	202	19	103
		Near A.I. Office	R	183	26	103
	Sibsagar	Sibsagar Dh. Bldg	R	196	72	102

Kerala	Kochi	Eloor	I	102	92	90
		FACT Udyogmandal	I	114	100	92
		Irumpanam	I	55	26	107
		CSIR Complex	I	61	27	107
		Ernakulum South	R	75	33	108
		FCI, OEN C. O. Bldg	R	58	28	108
		M.G. Road	R	60	36	108
	Kottayam	Vadavathoor	I	38	3	96
		Kottayam	R	56	8	96
	Kozhikode	Nallalam	I	72	16	108
		Kozhikode City	R	72	17	105
	Palakkad	Carboradum/SEPR	I	126	45	118
	Trivandrum	Hi Tech Chackai	I	89	14	108
		Sasthamangalam	R	62	7	110
		SMV School	R	73	24	106
Maharashtra	Aurangabad (MS)	C.A.D.A. Office	R	207	63	97
		S.B.E.S. College	R	346	114	98
		Bibi-Ka-Maqbara	S	243	69	101
	Chandrapur	M.I.D.C.	I	309	166	77
		Nagar Parishad	R	174	90	69
		SRO, Bapat Nagar	R	296	193	76
	Kolhapur	Mahadwar Road	R	212	58	101
		S.T. Stand	R	298	99	103
		Shivaji University	R	120	15	105
	Mahad	EHS mahad	I	234	52	45
		MNP, Phulle Hall	R	272	79	38
		WTP, Bhirwadi	R	216	61	44
	Mumbai	Parel	I	287	129	93
		Kalbadevi	R	267	111	87
		Worli	R	230	70	94
	Nagpur	MIDC Industrial Area/Hingana	I	214	128	94
		MIDC Office	I	165	61	105
		Govt. Poly. College	R	125	48	97
		Institution of Eng.	R	142	53	105
		Maskasath	R	229	89	98
		NEERI Lab	R	103	72	92
	Nashik	VIP Industrial Area	I	146	58	102
		NMC Building	R	186	73	103
		RTO Colony Tank	R	159	77	103
	Navi Mumbai	MIDC Taloja	I	542	216	105
		MPCB Central Lab	I	245	157	104
		Airoli	R	218	200	102
		Kharghar	R	182	151	100
		Nerul	R	208	183	107
		Panvel Water Works	R	236	182	103
	Pune	Bhosari	I	212	121	106
		Nalstop	R	222	105	103
		KSPCB Building	I	60	28	107

		Regional Office	R	100	35	111
	Rourkela	IDL Police Out-post	R	206	31	105
		Regional Office	R	207	21	106
	Sambalpur	PHD Ofice, Sambalpur	R	137	17	125
	Talcher	Coal Field Area	I	274	97	95
		T.T.P.S Colony	I	212	57	104
Pondicherry	Pondicherry	PIPDIC	I	70	17	64
		Chamber of Commerce	R	57	14	100
		DSTC Office	R	68	15	61
Punjab	Amritsar	Nagina Soap Factory	I	471	49	19
		A-1 Platters	R	479	49	20
	Bathinda	Bathinda Milk Plant	I	203	18	113
	Dera Bassi	Bhanakarpur Road	I	206	14	132
		Winsome Yarns Ltd	I	206	14	123
	Naya Nangal	NFL Guest House	R	209	27	128
Rajasthan	Alwar	Gaurav Solvex Ltd.	I	325	156	100
		RIICO Pump House	I	213	86	102
		Regional Office	R	324	143	105
	Jaipur	MIA	I	218	115	105
		VKIA	I	488	180	107
		Ajmeri Gate	R	295	124	105
		Chandpole	R	474	135	103
		RSPCB Office	R	203	98	106
		Vidyadhar Nagar	R	384	172	103
	Jodhpur	Basni Indl. Area	I	404	93	88
		DIC	I	337	105	99
		Housing Board	R	322	108	83
		M M Police Thane	R	408	76	103
		Shashtri Nagar	R	363	96	84
		Sojati Gate	R	415	92	83
	Kota	Regional Office	I	240	112	104
		Municipal C. Bldg	R	176	80	103
		Samcore Glass	R	216	95	105
	Udaipur	Regional Office, MIA	I	240	128	101
		Ambamata	R	204	130	97
		Town Hall	R	263	97	102
Tamilnadu	Chennai	Govt. High School	I	180	75	94
		Kathivakkam	I	184	57	94
		M C Thiruvottiyur	I	129	46	94
		Thiruvottiyur	I	226	104	94
		Madras Med. College	R	111	35	90
		NEERI CSIR Campus	R	89	39	96
	Coimbatore	SIDCO Office	I	239	113	88
		Dist. Coll. Office	R	133	74	94
		Ponniyarajapuram	R	97	51	91
	Madurai	Fenners (I) Ltd.	I	83	19	97
		Highway Bldg.	R	85	18	97
	Rayagada	LPS H. School	I	95	32	105

		Kwality Hotel, Bhiringi More, benachiti	I	366	183	102
		PCBL Club, Muchipara, Bidhannagar	R	239	123	102
		DMC Water Works, Angadpur	R	278	133	43
	Haldia	Super Market	I	248	31	9
		WBIIDC	I	251	34	9
	Howrah	Bandhaghat	I	247	142	104
		Howrah MC	I	262	152	104
		Bator	R	212	126	104
		Naskarpara	R	232	138	104
	Kolkata	Traffic Guard Building, Behala Chowrasta	I	233	130	105
		Cossipore Police Stn	I	392	160	97
		National Sample Survey Building, Dunlop Bridge	I	220	142	104
		Upanagari Sporting Club, Baishnabghata	R	170	104	105
		Kasba	R	319	154	95
		Lal Bazar	R	332	148	96
		A.J.C Bose Road, Minto Park	R	168	96	104
		KMC Office Building, Moulali	R	223	137	105
		CK Market, Salt Lake	R	186	112	105
	Barrackpore	Barrackpore Police Station	R	223	78	44
		Dum Dum Telephone Exchange	R	272	109	44
		Khardah Municipality	R	266	109	44
	Raniganj	Jamuria Municipality	R	476	173	17
		SKS Public School, Mangalpur	R	342	232	43
		Raniganj Municipality, Raniganj	R	522	282	43
	Sankrail	P. Mukherjee's House, (Near SBI)	R	202	76	31
		Bagnan Police Station	R	282	76	31
		Dhulagarh Gram Panchayet Office	R	283	76	31
		Bharat Co-operative Housing Society, Sankrail	R	249	61	31
	South suburban	P. Roy Industrial Training Institute, Amtala	R	163	163	43
		Baruipur Police Station	R	172	95	43
		Chanditala Water Supply Pump House, Tollygunge	R	200	121	42
West Bengal	Asansol	Asansol M.C.	I	350	198	102
		Kangsabati Spinning Mill, Barjora	I	320	194	43
		Burnpur Town Department, Burnpur	I	317	206	43
	Durgapur	Dew India Ltd., Dr. B. C. Roy Avenue, Durgapur	I	492	242	102

Note: R – Residential and other areas, I – Industrial area, S – Sensitive Areas, Std dev. – Standard deviation, n – number of days monitored for 16 and more hours a day

CHAPTER 7

AIR QUALITY TREND IN METROPOLITAN CITIES

A metropolitan area is a region consisting of a populous urban core with an agglomeration of peripheral zones not themselves necessarily urban in character, but closely bound to the center socio-economically by employment or commerce. It is characterized by urbanization which is a process of human movement and centralization towards and into cities and urban areas with the associated industrialization, urban sprawl and lifestyle. Urbanization in India is more rapid around the major cities in India. The population growth has been mainly centered around cities due primarily to the large scale migration of rural population accelerated by high population growth rates. Increase in industrial activities, population both endemic and floating and vehicular population etc. have led to a rapid increase in environmental problems, one of them being air pollution.

An inventory of air pollutants is a necessary first step towards control of air pollution. Air pollutants can be natural or may be the result of various anthropogenic activities like industrial emissions. Further the air pollutants can be primary or secondary depending upon their formation mechanism. Primary pollutants are directly emitted from the source and secondary pollutants are formed in the atmosphere. Meteorological factors play a critical role in ambient concentrations of air pollutants. Even though the total discharge of air pollutants into the atmosphere may remain constant, the ambient concentrations of air pollutants may vary depending upon the meteorological conditions. Keeping all these factors in mind, an attempt is made to address the problem of air pollution in seventeen cities in India identified by Honorable Supreme Court as polluted cities. These include the metropolitan cities of India which has been classified by Census of India 2001 as metropolitan cities.
Ambient air quality monitoring is required to determine the existing quality of air, evaluation of the effectiveness of control programme and to identify areas in need of restoration and their prioritization.

This chapter gives an insight into the trends of air pollutants for SO_2, NO_2 and PM_{10} in the 35 metropolitan cities (population ≥ 10 lacs; Census 2001). Further a national mean concentration with all the monitoring station data of the residential area in also provided.

7.1 Air Quality Monitoring Stations in Metropolitan Cities

There are 146 monitoring stations in 35 metropolitan cities. These are listed in Table 7.1

Table 7.1 Details of the Air Quality Monitoring Stations in Metropolitan Cities

Indian Zone	State	City	Total No. of Operating Stations
North Zone	Delhi (11)	Delhi	11
	Haryana (2)	Faridabad	2
	Punjab (6)	Amritsar	2
		Ludhiana	4
	Uttar Pradesh (23)	Agra	6
		Allahabad	2
		Kanpur	6
		Lucknow	5
		Meerut	2
		Varanasi	2
East Zone	Bihar (2)	Patna	2
	Jharkhand (3)	Dhanbad	1
		Jamshedpur	2
	West Bengal (11)	Asansol	1
		Kolkata	10
South Zone	Andhra Pradesh (19)	Hyderabad	9
		Vijayawada	2
		Visakhapatnam	8
	Karnataka (6)	Bangalore	6
	Kerala (7)	Kochi	7
	Tamilnadu (12)	Chennai	6
		Coimbatore	3
		Madurai	3
West Zone	Gujarat (15)	Ahmedabad	6
		Rajkot	2
		Surat	3
		Vadodara	4
	Maharashtra (15)	Pune	3
		Mumbai	3
		Nagpur	6
		Nashik	3
	Rajasthan (6)	Jaipur	6
Central Zone	Madhya Pradesh (8)	Bhopal	4
		Indore	3
		Jabalpur	1
5	**15**	**35**	**146**

NB. Figures within parentheses represent number of cities

7.2 Air quality in metropolitan cities during 2009

The analysis of air quality in metropolitan cities with respect to SO_2 revels all the cities except Jamshedpur are in the low category and all are within the prescribed standard. As for NO_2 7 cities are in the low category, 21 cities are in the moderate category, therefore 28 cities out of 35 metropolitan cities comply to the standards. 5 cities fall in the high category and 2 in the critical. With respect to PM_{10} 26 cities fall in the critical category (Table7.2). Table 7.4 gives an insight to the annual average and categoties of the metropolitan cities.

Table 7.2: Number of metropolitan cities with low, moderate, high & critical air quality

Category	Metropolitan cities (population > 10 lacs)		
	SO_2	NO_2	PM_{10}
Low	34	7	0
Moderate	1	21	2
High	0	5	7
Critical	0	2	26
Total cities	35	35	35

NB. Low, moderate, high, critical classification based on Pollution Level Classification, Chapter 2,Table 2.1

Of the 35 metropolitan cities 7 (20%) and 33 (94%) cities exceed the NAAQS with respect to NO_2 and $PM_{10.}$ None of the cities exceed the standard limit with respect to SO_2 (Table 7.3)

Table 7.3. Number of metropolitan cities exceeding the NAAQS (Based on annual average data)

Category	Metropolitan cities (population > 10 lacs)		
	SO_2	NO_2	PM_{10}
Not exceeding NAAQS	35	28	2
Exceeding NAAQS	0	7	33
Total cities	35	35	35

NB.Figures withinparentheses indicate percentage of cities

Table 7.4: Air Quality of Metro cities during 2009

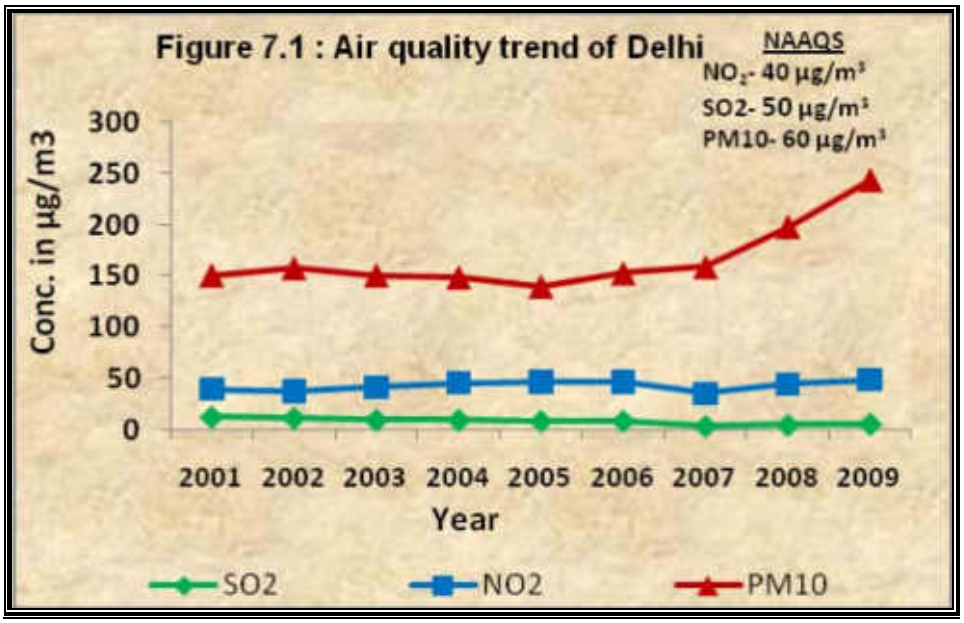
Metropolitan cities	SO_2 (Annual Avg. in µg/m^3)	Air Quality	NO_2 (Annual Avg. in µg/m^3)	Air Quality	PM_{10} (Annual Avg. in µg/m^3)	Air Quality
Agra	6	L	21	M	185*	C
Ahmedabad	16	L	21	M	95*	C
Allahabad	3	L	24	M	160*	C
Amritsar	15	L	35	M	190*	C
Asansol	9	L	62	C	163*	C
Bangalore	16	L	40	M	122*	C
Bhopal	7	L	18	L	115*	C
Chennai	9	L	17	L	70*	H
Coimbatore	6	L	29	M	74*	H
Dhanbad	17	-	41*	-	164*	C
Delhi	6	L	49*	H	243*	C
Faridabad	15	L	23	M	154*	C
Hyderabad	5	L	22	M	80*	H
Jaipur	6	L	36	M	151*	C
Jabalpur	2	L	24	M	136*	C
Jamshedpur	36	M	49*	H	172*	C
Indore	9	L	17	L	183*	C
Kanpur	8	L	31	M	211*	C
Kochi	4	L	12	L	40	M
Kolkata	11	L	68*	C	126*	C
Lucknow	8	L	36	M	197*	C
Ludhiana	9	L	37	M	254*	C
Madurai	10	L	25	M	42	M
Meerut	8	-	44*	-	119*	-
Mumbai	6	L	41*	H	117*	C
Nagpur	6	L	30	M	99*	C
Nashik	23	L	29	M	89*	H
Patna	5	L	37	M	146*	C
Pune	23	L	40	M	82*	H
Rajkot	11	L	15	L	105*	C
Surat	19	L	26	M	91*	C
Vadodara	16	L	30	M	86*	H
Varanasi	17	L	20	L	123*	C
Vijayawada	5	L	14	L	80*	H
Visakhapatnam	13	L	32	M	97*	C

*L: Low, M: Moderate, H: High, C: Critical *Concentration exceeding NAAQS*
Low, moderate, high, critical classification based on Pollution Level Classification, Chapter 2,Table 2.1
'-' inadequate data

7.3 Air quality trend in metropolitan cities

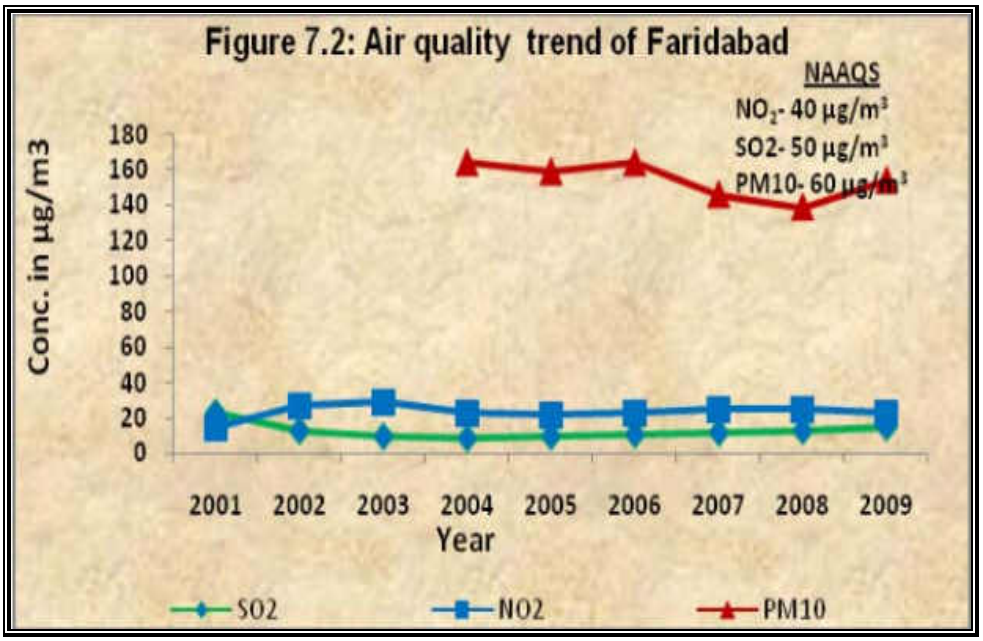
7.3.1 DELHI – the capital city

State	Delhi, largest metropolis by area and the second-largest metropolis by population in India
Location	28°22'48"N and 77°7'12"E
Area	1,484 km^2 (573 sq mi) of which 783 km^2 (302 sq mi) is rural, and 700 km^2 (270 sq mi) urban. Maximum length 51.9 km (32 mi) and maximum width 48.48 km (30 mi).
Population	1,27,9,458 (as per Census 2001)
Climate	Humid subtropical. Summers are long and extremely hot (early April to mid-October). Monsoon winds advent from end of June. Reversal in the wind direction from the north-western direction to the south-western in early March brings hot waves (called loo) from Rajasthan. Winter starts in late November and peaks in January accompanied by heavy fog. Temperature: 45ºC in summers to 4ºC in winters Rainfall: Average annual rainfall is 714 mm (28.1 inches)
Geography	Drained by river Yamuna. Mixed type of soil deposits. Quartz rock and extends from south part to west bank of the Yamuna River for about 35 km.
Industries	Engineering goods, textile, chemical, electronics, electrical goods, dyes and paints, steel, plastic, rubber, automobiles, thermal power stations (Badarpur thermal power station, Indraprastha thermal power station, Rajghat thermal power station and Gas turbine thermal power station)
Air quality stations	11 (3 residential, 8 industrial)
Air quality trend	Analysis of nine year air quality data shows an increasing trend for PM_{10}, a decreasing trend for SO_2 and fluctuating for NO_2 (Figure 7.1). The increasing trend for PM_{10} may be attributed to the increasing number of vehicles and natural dust.



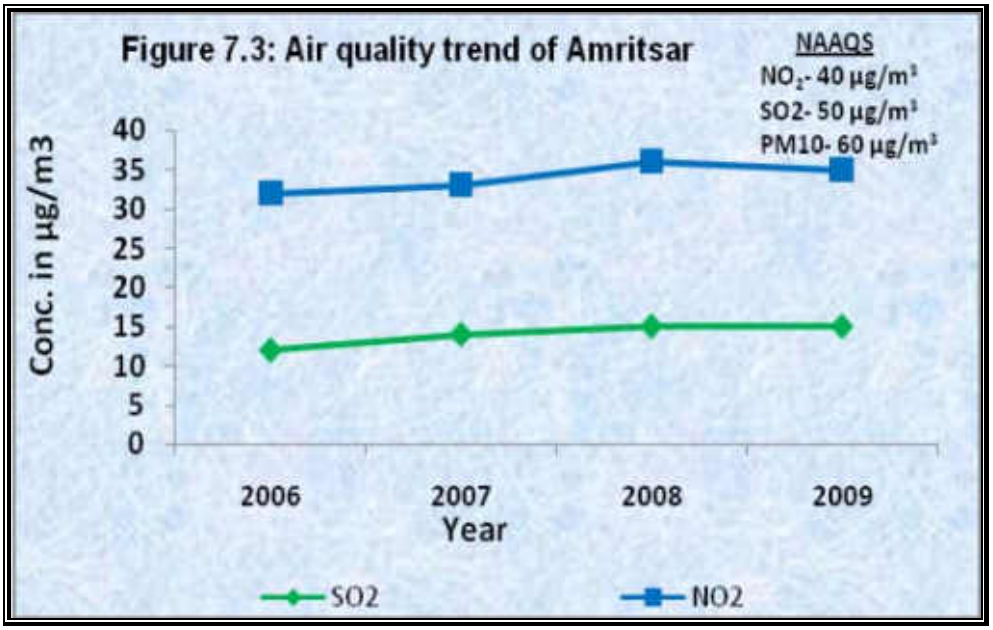
7.3.2 FARIDABAD

State	Haryana
Location	28° 15' N and 77° 13' 12" E
Area	216.4 km^2
Population	10, 54, 981
Climate	Temperature: extreme conditions of summer and cold with maximum and minimum temperatures of 45 and 5ºC respectively Rainfall: July to September with 562.9 mm
Geography	Alluvium and pre-combrian sediments systems. The stratifgraphic units are windblown sands, newer alluvium, older alluvium, slates, phyllites, quartzites, mica sheets, pagamite intrusions, silts, gravel, sand, clay and kankar
Industries	Drugs & pharmaceuticals, plastics, metal casting, agriculture equipments, automobile parts, electricals, garments, Chemicals, petrochemicals, Gas & other engineering industries. 15,000 small, medium and large scale industries are in operation.
Air quality stations	2 (1 residential, 1 industrial)
Air quality trend	Analysis of nine year air quality data shows an increasing trend for PM_{10}, a decreasing trend for SO_2 and a stable trend for NO_2 (Figure 7.2).



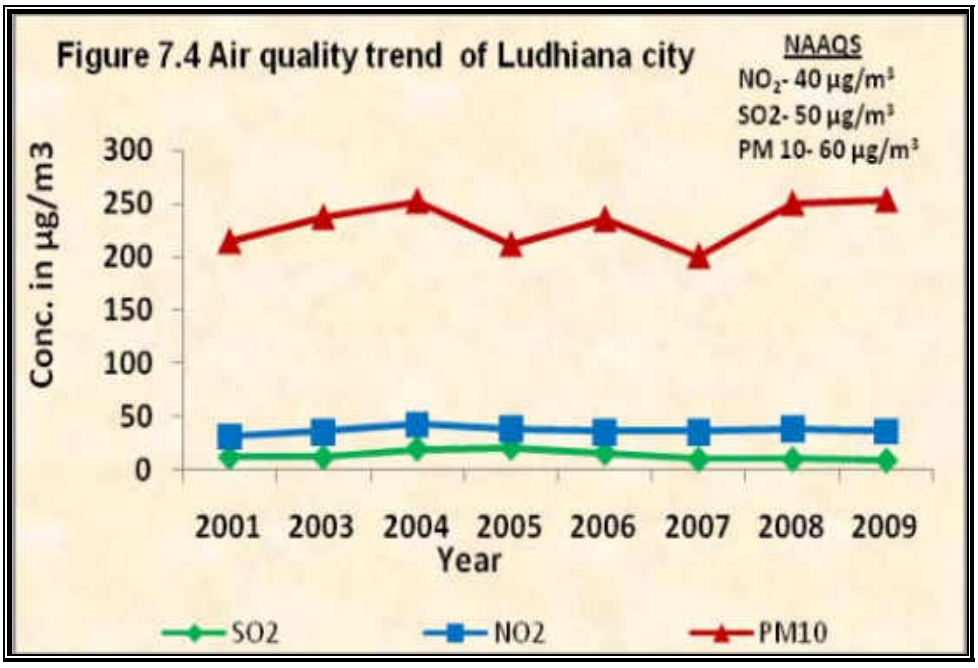
7.3.3 AMRITSAR

State	Punjab
Location	31°38′ N and 74°52′ E
Area	50 km^2
Population	10, 11,327
Climate	Tropical type with three well defined seasons winter, summer and monsoon Rainfall: annual average normal rainfall is 700 mm
Geography	Alluvial deposits of quaternary age which are a part of Indus basin
Industries	Food, textile, readymade garments and tailoring, leather goods, wood based, paper, dying & chemical, detergent, medicine, machine, agriculture, electrical goods and appliances, surgical items, auto and cycle parts, floor mills, cold storages etc. The total number of small scale industries functioning is approximately 8000
Air quality stations	2 (2 residential)
Air quality trend	Analysis of four year air quality data shows a more or less stable trend for both SO_2 and NO_2, both lying within the NAAQS (Figure 7.3).



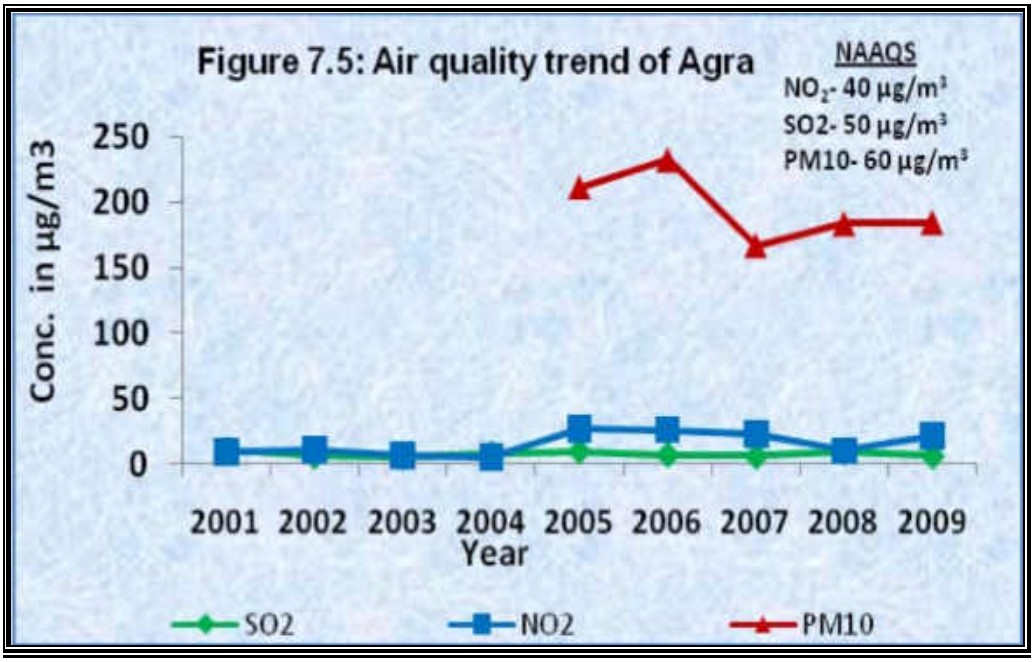
7.3.4 LUDHIANA

State	Punjab
Location	Between 30-34' N and 30"01'N and 75-18'E and 76-20'E. Average elevation of 244 metres (798 ft).
Area	310 km²
Population	13.93 lacs
Climate	Semi humid in the North and North East to semi arid to arid in the South. Summer, winter and rainy season. Rainfall: average normal rainfall is 670 mm approx. and the annual average rainfall is 437 mm.
Geography	Soil is of yellow sandstone and granite, forming small hillocks, plateaus and dips The city stands on the Sutlej River's old bank, 13 km south of its present course
Industries	Knitwear factories, hosiery yarn mills, bicycles factories, factories for machine tools, sewing machines, generators, diesel engines, tyres & tubes, and other consumer goods
Air quality stations	4 (2 residential, 2 industrial)
Air quality trend	Analysis of nine year air quality data shows an increasing trend for PM_{10}, a decreasing trend for SO_2 and a stable trend for NO_2 (Figure 7.4).



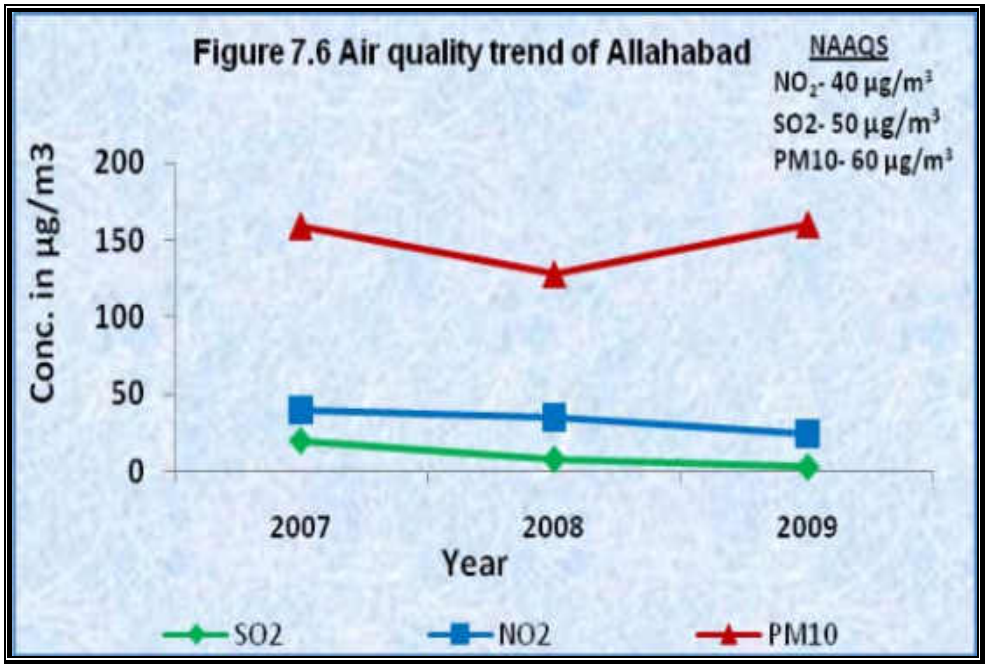
7.3.5 AGRA

State	Uttar Pradesh
Location	27°8' to 27°14' N and 77°57' to 78°04' E
Area	140 km^2
Population	13, 21,410
Climate	Semiarid climate that borders on a humid subtropical climate. Mild winters, hot and dry summers and a monsoon season Temperature: extreme temperature Rainfall: The average rainfall in the region is 685 mm
Geography	Bounded by Thar Desert on its southwest, west and northwest peripheries. Drained by Yamuna river.
Industries	73 industries and 2 industrial clusters. Textiles, hosiery items, woolen, jute, footwear, leather, metal processing, machinery parts, marble, food processing and handicrafts 6,463 small-scale units of various handicraft items like Zari work, leather craft, and marble craft and carpet craft.
Air quality stations	6 (1 residential, 1 industrial, 4 sensitive)
Air quality trend	Analysis of five year air quality data for Pm_{10} shows a decreasing trend and nine year trend for SO_2 shows a stable trend. As for NO_2 for the trend slightly increased during 2005, 2006 and 2007 but again declined in the later years (Figure 7.5)



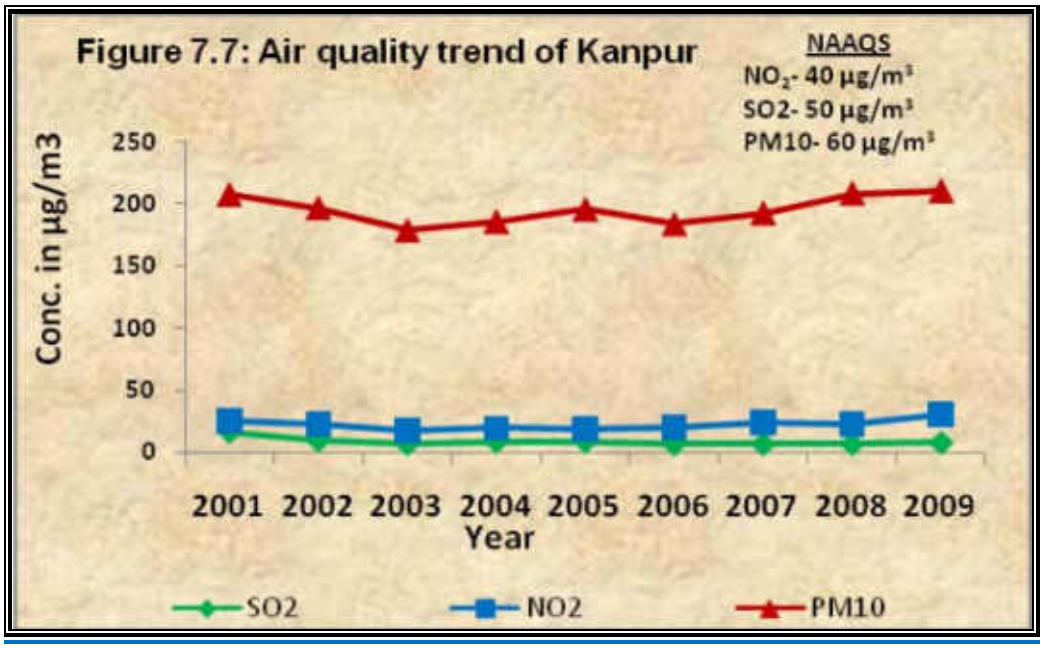
7.3.6 ALLAHABAD

State	Uttar Pradesh
Location	Between 24º 47' and 25º 47' N and 81º 19' and 82º 29' E. Elevation of 98 metres (322 ft)
Area	Length from east to west is 117 km and breadth from north to south is 101 km. Area 7261 sq. kms.
Population	15 lacs
Climate	Humid subtropical climate with hot dry summer, cool dry winter and warm humid monsoon. Monsoon begins in early July and lasts till September. Temperature: ranging between 22 °C (72 °F) and 10 °C (50 °F). Severe fog in January Rainfall: average rainfall of the city is varies from min 520.6 mm to the highest of 1276.5 mm
Geography	Soil fertile but not too moist. The southern and eastern parts are dry and rocky. Stands at the confluence of two rivers the Ganges and Yamuna
Industries	Glass and wire based industries, fertilizer complex based on naphtha as feed stock, three mega thermal power projects
Air quality stations	2 (2 residential)
Air quality trend	Analysis of three year air quality data shows a more or less stable trend for both SO_2 and NO_2, both lying within the NAAQS (Figure 7.6).



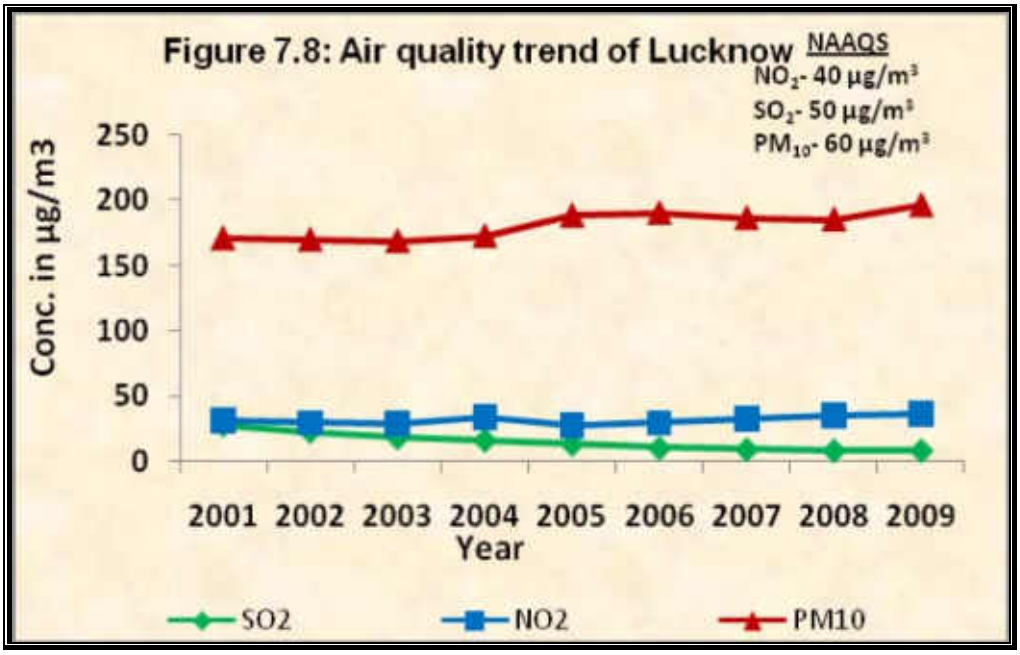
7.3.7 KANPUR

State	Uttar Pradesh
Location	26°28′ N and 80°21′ E
Area	278 km^2
Population	26,90,486
Climate	Humid subtropical climate with very hot summers, mild and relatively short winters, dust storms and a monsoon season. Severe fog in December and January. Summer excessive dry heat is accompanied by dust storms and loo. Rains appear between July and September almost at the end of regular monsoon season. Temperature: mean maximum monthly temperatures 41.7˚C during May and minimum 22.8˚C in January Rainfall: average normal annual rainfall is 833.5 mm
Geography	The area is underlain by Indo-Gangetic alluvium of quaternary age formed by fluvial processes comprising of clay, silts, sands of various texture and kankar in varying proportion Surrounded by two main rivers of India, the Ganges in the northeast and the Pandu River (Yamuna) in the south.
Industries	Biggest producers of textile and leather products. Fertilizer, chemicals, two wheelers, soaps, pan masala, hosiery and engineering industries are also present. The total number of small scale industries registered is 12000
Air quality stations	7 (4 residential, 3 industrial)
Air quality trend	Analysis of nine year air quality data shows a more or less stable trend for both SO_2 and NO_2, both lying within the NAAQS. For PM_{10} however, a fluctuating trend is seen which exceeds the NAAQS (Figure 7.7).



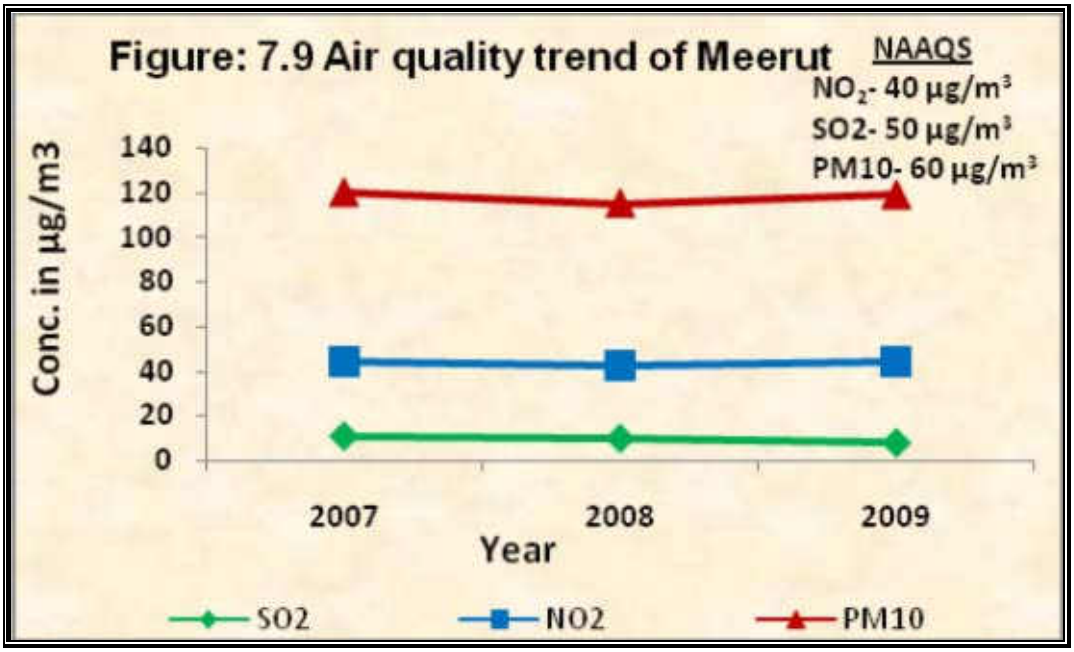
7.3.8 LUCKNOW

State	Uttar Pradesh
Location	26" 30' and 27" 10' N and 80" 34' and 81" 12' E
Area	2528 sq.kms
Population	25 lacs
Climate	Humid subtropical climate with cool, dry winters from December to February and dry, hot summers from April to June. The rainy season is from mid-June to mid-September. Fog is quite common from late December to late January. Dry except during Southwest monsoon period Temperature: In winter the maximum temperature is around 25 ^{0}C and the minimum is in the 6 to 8 ^{0}C. Summers are very hot with temperatures rising to the 40 to 45 ^{0}C Rainfall: average normal rainfall of the city is approximately 1100 mm
Geography	Situated in gangetic plain and drained by Gomti river. Located in the seismic zone
Industries	Pharmaceutical industries, sugarcane plantations and sugar industries ,small scale industries that are based on unique styles of embroidery, producer of tobacco products and handicrafts such as pottery, earthen toys, silver and gold foil work, and bone carving products.
Air quality stations	5 (4 residential, 1 industrial)
Air quality trend	Analysis of nine year air quality data shows a more or less stable trend for SO_2 and a declining trend for NO_2, both lying within the NAAQS. For PM_{10} however, an increasing trend is seen which exceeds the NAAQS (Figure 7.8).



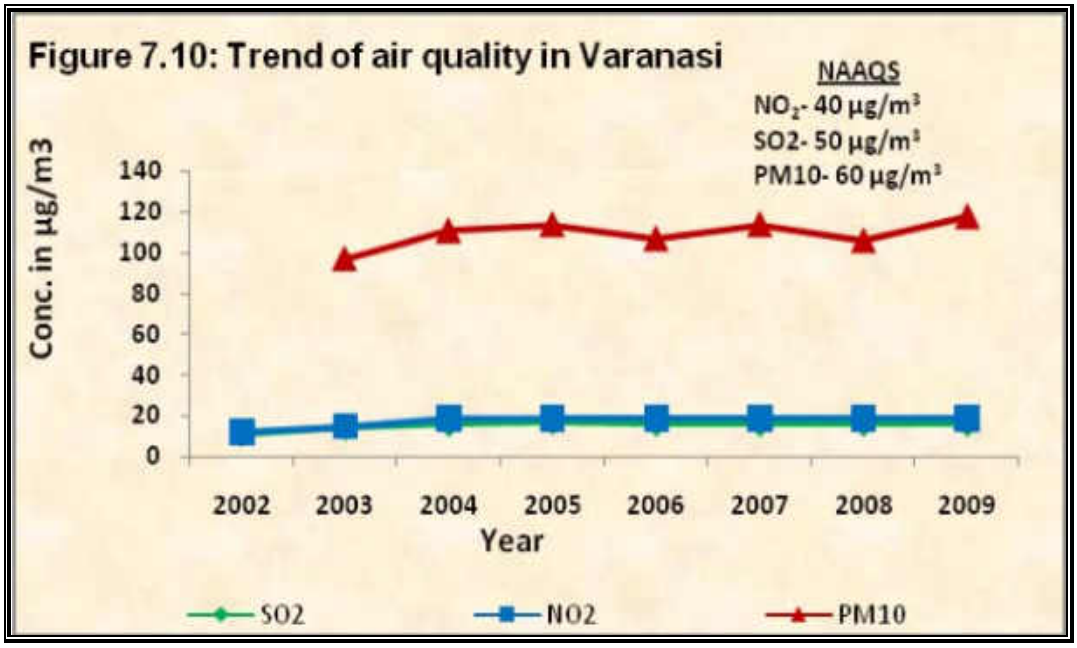
7.3.9 MEERUT

State	Uttar Pradesh
Location	28°57' to 29°02' N and 77°40' to 77°45' E
Area	142 km^2
Population	11,67,399
Climate	Moderate type of climate. Very hot summers and very cold winters. Visibility is almost zero during November to January due to fog. Temperature: summers can reach 48 degree Celsius. Lowest temperature recorded is 0.5 degrees. Rainfall: average annual rainfall is about 1000 mm
Geography	The ground is not rocky and there are no mountains. Meerut lies between plains of rivers Ganges and Yamuna
Industries	14,000 registered industrial units in the metropolitan city of Meerut, out of which only about 9,000 units are functional at present. Distillery and small scale industries like sports goods, chemicals, food processing, surgical goods, engineering works, petrochemicals, rubber, plastic, leather goods, flour mills and readymade garments predominate in the area
Air quality stations	2 (2 residential)
Air quality trend	Analysis of three year air quality data shows a more or less stable trend for all the pollutants. PM_{10} however, exceeds the NAAQS (Figure 7.9).



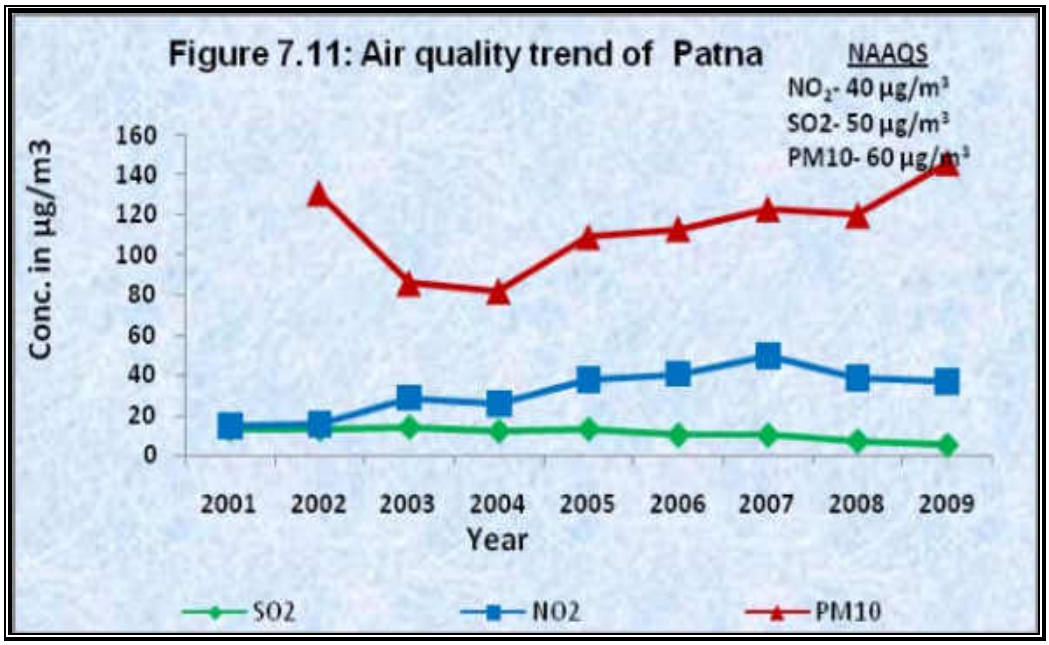
7.3.10 VARANASI

State	Uttar Pradesh
Location	Between 82º 15' to 83º 30' E and 24º 35' to 25º 30' N
Area	112.26 km^2 (approximately 43 mi^2). Mean elevation is 80.71m
Population	14 lacs
Climate	Humid subtropical climate with large variations between summer and winter temperatures. Summers are long, from early April to October, with intervening monsoon seasons and are also extremely hot. Winters in Varanasi sees very large diurnal variations, with warm days and downright cold nights. Cold waves from the Himalayan region Temperature: The temperature ranges between 32°C – 46 °C (90°F – 115 °F) in the summers and below 5 °C during December to February Rainfall: average normal rainfall of the city is varied from min 3.3 mm to the highest of1113.4 mm
Geography	Divided into two physical regions, the northern alluvial plain and the southern plateau area. The northern alluvial plain is drained by the Ganga and its tributaries namely the Gomti and the Varuna rivers and Assi .
Industries	Diesel locomotive factory, oxygen plant, small cottage industries include silk making making, the production of textiles such as hand-woven carpets, and handicrafts
Air quality stations	2 (2 residential)
Air quality trend	Analysis of three year air quality data shows a more or less stable trend for SO_2 and. PM_{10} however, shows an increasing trend and exceeds the NAAQS (Figure 7.10).



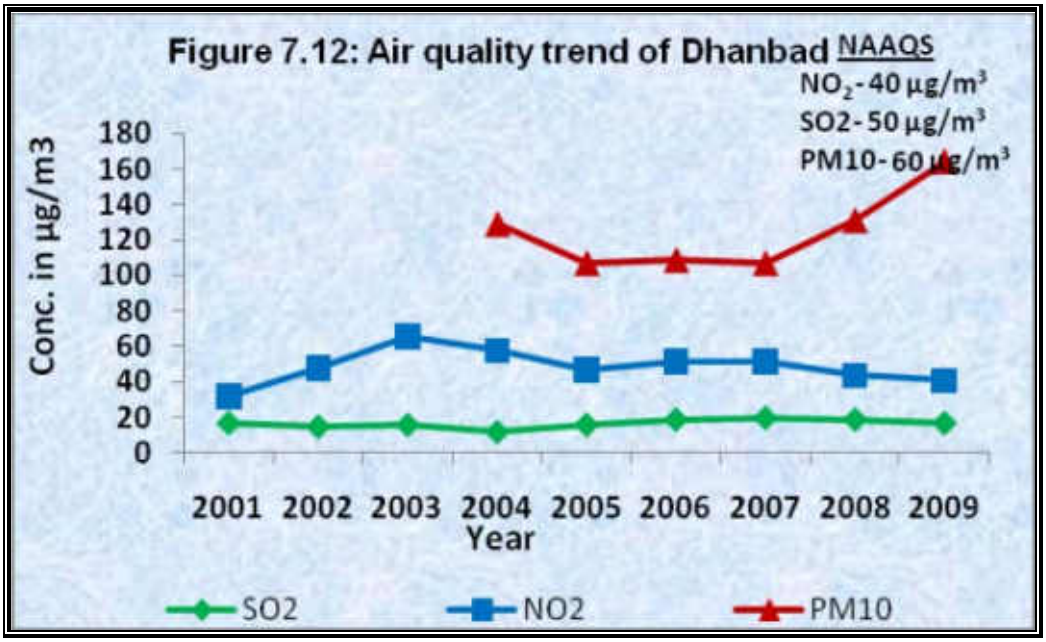
7.3.11 PATNA

State	Bihar
Location	25°22'12" N and 85°7'48" E
Area	125 km^2
Population	17,07,429
Climate	Tropical type characterized by three distinct seasons Temperature: maximum temperature is 31.6 °C varying between 23.6°C in January to 38.9°C in the month of May while the night temperature varies between 11 to 27.1°C with mean annual value of 20.8 °C Rainfall: relative humidity is comparatively higher over the year ranging between 41 to 83% lowest being in the month of April. The bulk of the annual rainfall (1109.8mm) is received through South Western monsoon between the period June to September.
Geography	River Punpun flows south of township limit and Ganga River is it's Northern limit. The township and surrounding is underlain by thick fluvial sediments deposited by the river Ganga and its right bank tributaries, Sone and Punpun. Basically the deposits belong to Quaternary period and are flood plain deposits. The sediments are admixture of clay and sand of different grades.
Industries	Plastic and steel
Air quality stations	2 (2 residential)
Air quality trend	Analysis of three year air quality data shows a more or less stable trend for SO_2 and. PM_{10} however, shows an increasing trend and exceeds the NAAQS (Figure 7.11).



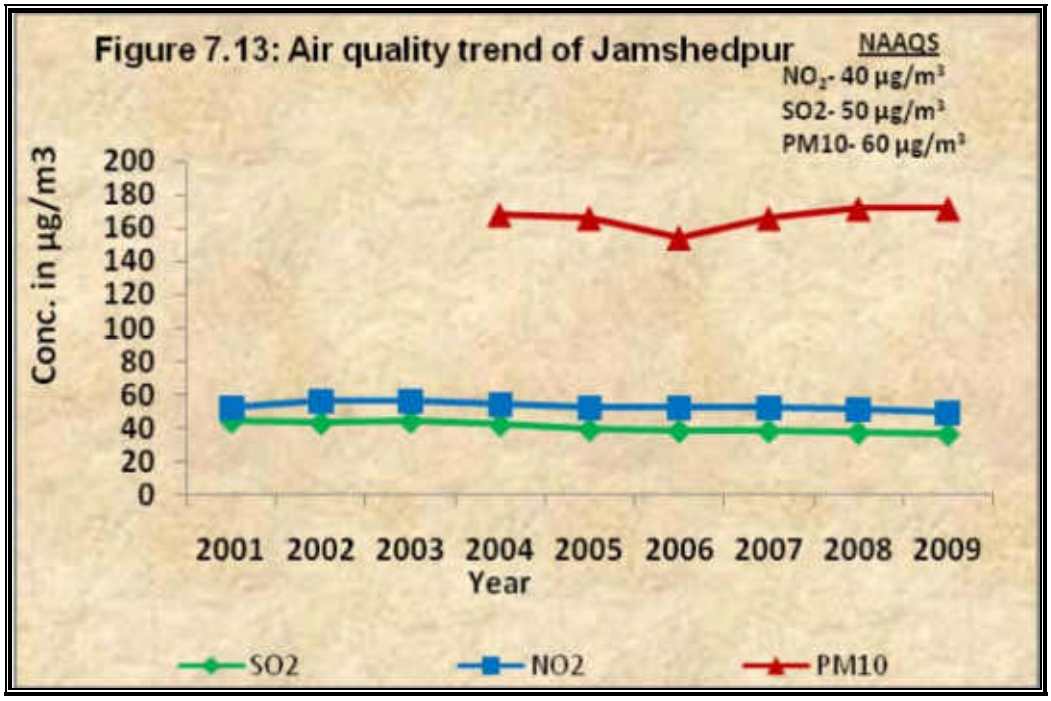
7.3.12 DHANBAD

State	Jharkhand
Location	23°48′ N and 86°27′ E
Area	355.77 km^2
Population	10,64,357
Climate	Dry and hot summer and a dry and cold winter with an intermediate monsoon period from the middle of June to the end of September. The summer is extremely hot, whereas the winter from November to February is very pleasant Temperature: varies from 8˚C to 34˚C. After February, the climate becomes warmer till the rains break in the middle of June. The temperature during these four months from March to June usually varies from 13˚C to 45.5˚C. July to October, which include the rainy season, temperature usually ranges from 15˚C to 36˚C. Rainfall: Average rainfall of the area is 1310.6 mm
Geography	Crystalline metamorphites of Archaean (Dharwar) age which form the basement. Over these rocks were deposited in slowly sinking faulted troughs (basins), the Lower Gondwana group of sedimentary strata including the coal-bearing beds
Industries	Coal and coal based industries. The total number of small scale industries registered is about 300, out of which 150 are coal based and 150 of other types.
Air quality stations	1 (1 residential)
Air quality trend	Analysis of three year air quality data shows a more or less stable trend for SO_2 and. PM_{10} however, shows an increasing trend and exceeds the NAAQS (Figure 7.12).



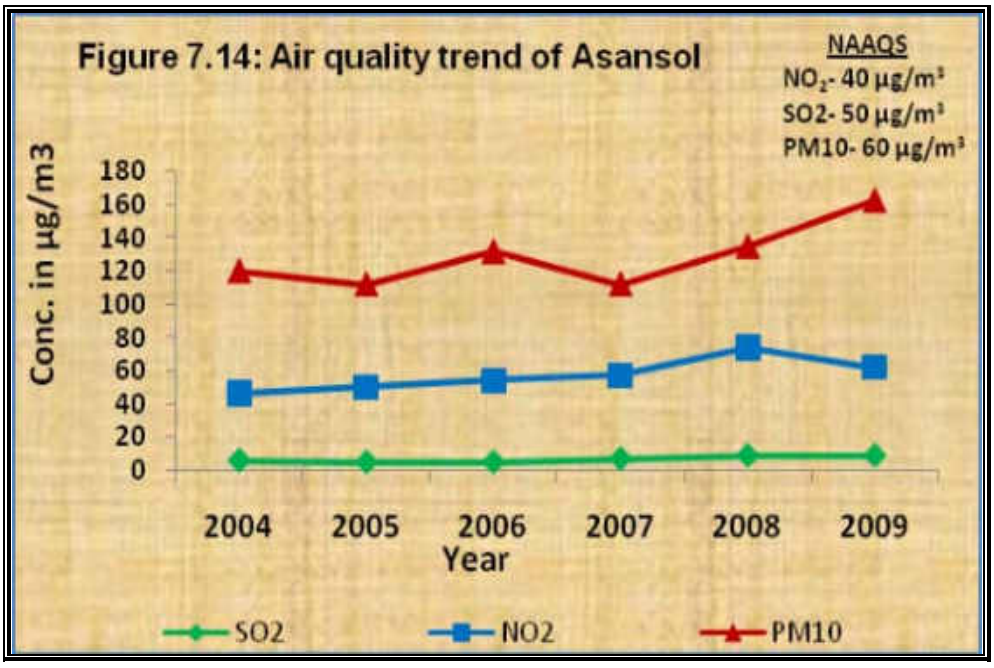
7.3.13 JAMSHEDPUR

State	Jharkhand
Location	22°48′ N and 86°11′ E
Area	149.23 km^2
Population	11,01,804
Climate	Humid climate due to inland position and presence of hills Temperature: day temperature is quite high in summer, generally around 43˚C occasionally reaching up to 48˚C Rainfall: annual rainfall in Singhbhum district is recorded as 1434 mm.
Geography	Diverse rock types are developed with a none-too-simple structure of Dunn. The areas surrounding Jamshedpur are rich in minerals, including iron ore, coal, manganese and lime.
Industries	The main industries include iron and steel, truck manufacturing, tinplate production, cement, plastic and rubber, chemicals, food and beverage, pharmaceutical, electrical, sponge foam, LPG bottling plant and other small and medium scale industries.
Air quality stations	2 (2 industrial)
Air quality trend	Analysis of six year air quality data of PM10 shows a slight increase and is above NAAS. SO_2 and. PM_{10} however, shows a stable trend (Figure 7.13).



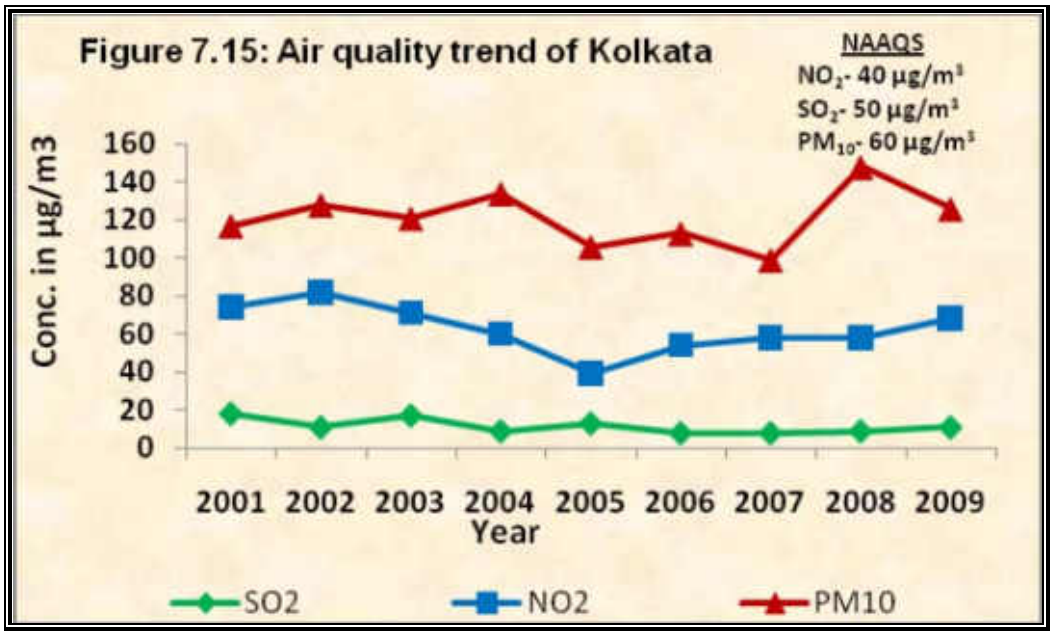
7.3.14 ASANSOL

State	West Bengal
Location	23°41′ N and 86°59′ N E
Area	127.237 km^2
Population	10,64,357
Climate	Dry and hot in summer and dry and cold in winter with an intermediate monsoon period from the middle of June to the end of September Temperature: Maximum temperature 35˚C during summer and minimum of 4˚C during winter Rainfall: Maximum of 533 mm during July
Geography	Lies on Gondwana rocks between rivers Damodar and Ajay. A small rivulet, Nunia, flows flows past Asansol
Industries	Coal mines, irol and steel, polymer industries, cement, plastic, musturd oil, rubber, leather products, polymer pipes, fabrication, paint and varnish, flour mills, PVC pipes, aromatic chemicals, food product packing etc. The total number of small scale industries registered is about 500
Air quality stations	3 (2 residential, 1 industrial)
Air quality trend	Analysis of six year air quality data of PM10 shows a slight increase and is above NAAQS. SO_2 and. NO_2, shows a stable trend. SO_2 however, slightly increased during 2008 (Figure 7.14).



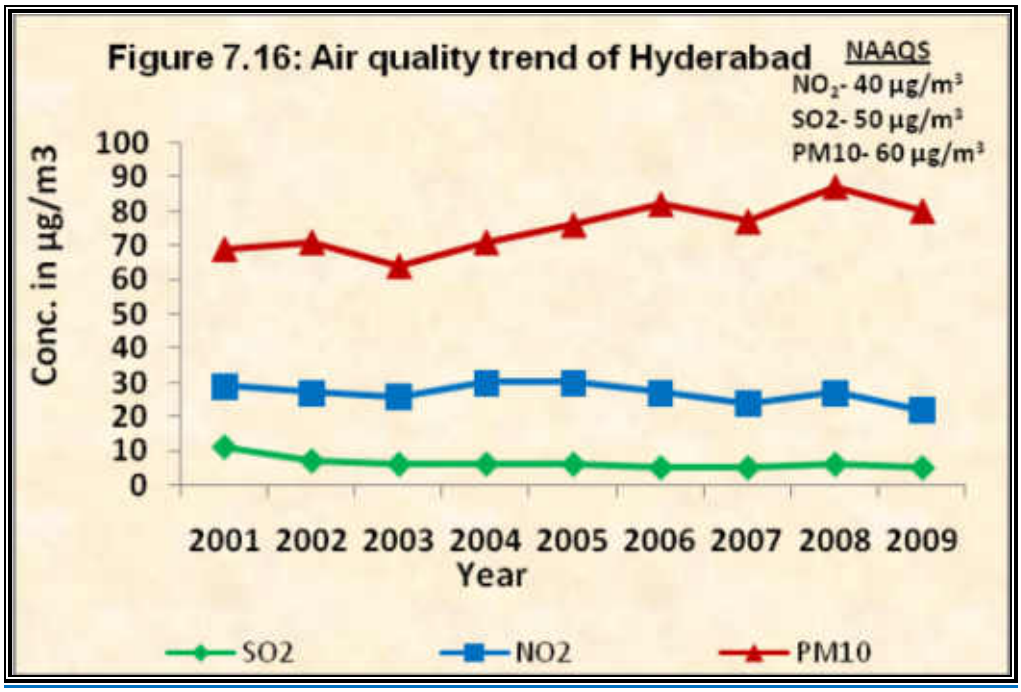
7.3.15 KOLKATA

State	West Bengal
Location	22°33′ N and 88°20′ E
Area	1750 km². elevation ranging between 1.5 m (5 ft) to 9 m (30 ft)[1]
Population	1,32,16,546
Climate	Tropical wet-and-dry climate. Summers are hot and humid with temperatures in the low 30's and during dry spells the maximum temperatures often exceed 40 °C (104 °F) during May and June. Winter tends to last for only about two and a half months, with seasonal lows dipping to 9 °C – 11 °C (54 °F – 57 °F) between December and January. Dusty squalls followed by thunderstorm or hailstorms and heavy rains with ice sleets lash during early summer. Southeast monsoon rains lash the city between June and September Temperature: annual mean temperature is 26.8˚C; monthly mean temperatures range from 19˚C to 30˚C Rainfall: annual rainfall of 1,582 mm
Geography	Spread linearly along the banks of the River Hooghly in a north-south direction. Soil type is alluvial. Quaternary sediments consisting of clay, silt, various grades of sand and gravel. These sediments are sandwiched between two clay beds, the lower one at depths between 250 m (820 ft) and 650 m (2,133 ft) and the upper one ranging between 10 m (33 ft) and 40 m (131 ft) in thickness. The town falls under seismic zone-III and wind and cyclone zone
Industries	Electronics to jute.
Air quality stations	10 (7 residential, 3 industrial)
Air quality trend	Analysis of nine year air quality data of PM_{10} shows a fluctuating trend. However, 2009 shors a reduction in the pollutant. NO2 shows a shlightly increasing trend. Both PM_{10} and NO_2 exceeds the NAAQS. SO_2 seems stable and well within limits. (Figure 7.15).



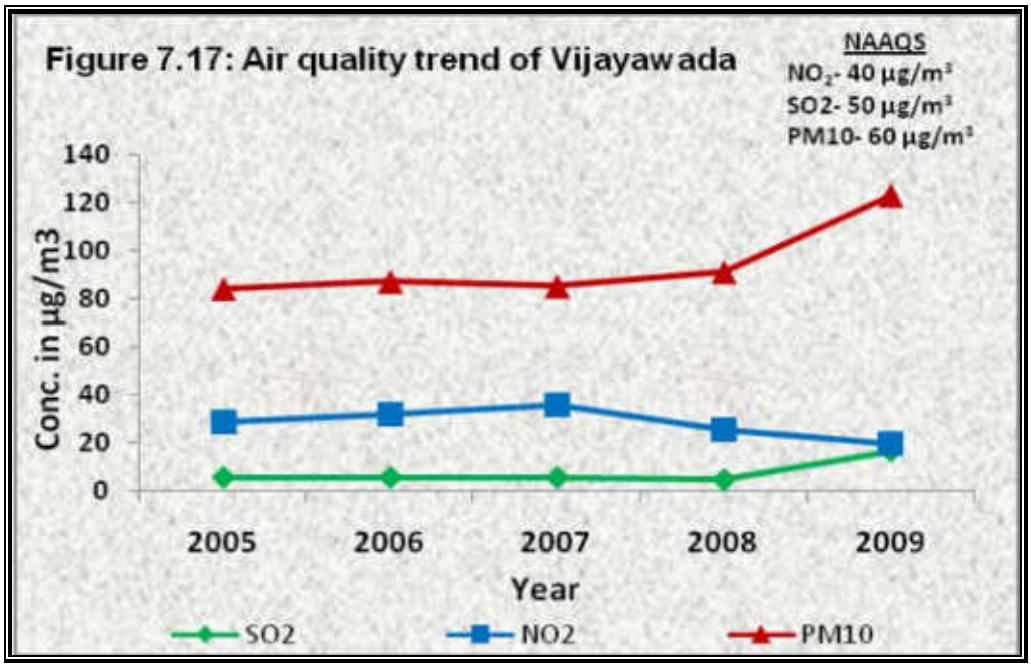
7.3.16 HYDRABAD

State	Andhra Pradesh
Location	17°12' N and 78°18' E. Average elevation of about 536 metres above sea level (1,607 ft)
Area	1000 km^2
Population	55,33,640
Climate	Combination of a tropical wet and dry climate that borders on a hot semi-arid climate with hot summers from late February to early June, the monsoon season from late June to early October and a pleasant winter from late October to early February.. Temperature: Moderate annual range of temperature Rainfall: The normal rainfall of the area is 805 mm with 76% from South-West monsoon
Geography	Situated on the Deccan Plateau. Most of the area has a rocky terrain and some areas are hilly. Spreads on the North and South bank of the river Musi, a tributary of Krishna. The Hussain Sagar Lake is centrally located in the city and connecting the Hyderabad and Secunderabad twin cities Geomorphologically the area is divided into (1) Residual Hills (2) Pediment inselberg complex (3) Shallow to moderate weathered pediplains and (4) Valley hills.
Industries	Cotton, cigarettes, refrigerators, machine tools, oil, drugs, pharmaceuticals, printing material, mint
Air quality stations	9 (5 residential, 3 industrial, 1 sensitive)
Air quality trend	Analysis of nine year air quality data of PM_{10} shows a fluctuating trend. However, 2009 shors a reduction in the pollutant. NO_2 shows a shlightly increasing trend. Both PM_{10} and NO_2 exceeds the NAAQS. SO_2 seems stable and well within limits. (Figure 7.16).



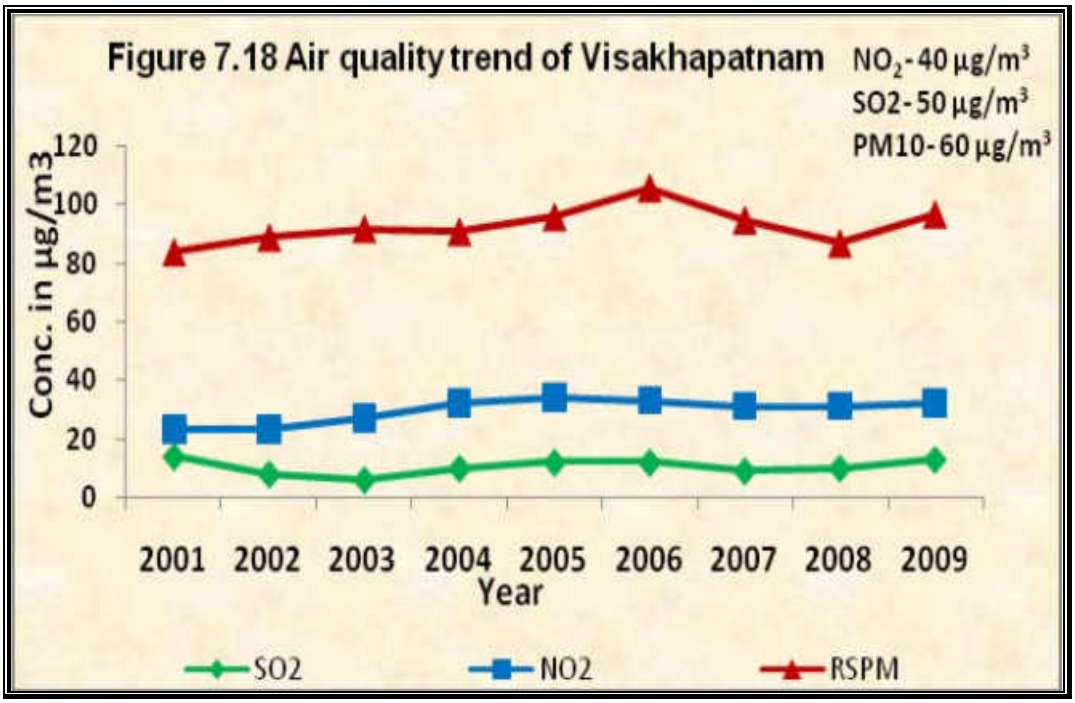
7.3.17 VIJAYWADA

State	Andhra Pradesh
Location	16°31' N and 80°39' E
Area	73 km^2
Population	10,11,152.
Climate	Tropical, specifically a tropical wet and dry climate, with hot summers and moderate winters. Temperature: peak temperature reaches 47 °C (117 °F) in May-June, while the winter temperature is 20-27 C Rainfall: normal rainfall of the district is 1028 mm
Geography	located on the banks of the Krishna River and bounded by the Indrakiladri Hills on the West and the Budameru River on the North. Soil is very fertile and cultivated intensively.
Industries	Rice mills, edible oil, beverages, tobacco products, cotton textiles, wood and wood products, paper and paper products, leather, rubber, plastic products, motor vehicle spare parts, utensils, scientific instruments, dall and flour mills, chemicals, pharmaceuticals, oil refinery of used motor oils, brawn oil companies, ayurvedic medicines, pickle companies
Air quality stations	2 (1 residential, 1 industrial)
Air quality trend	Analysis of five year air quality data of PM_{10} and SO_2 shows an fluctuating trend, NO_2 shows a decreasing trend. However NO_2 and SO_2 are within NAAQS (Figure 7.17).



7.3.18 VISHAKHAPATNAM

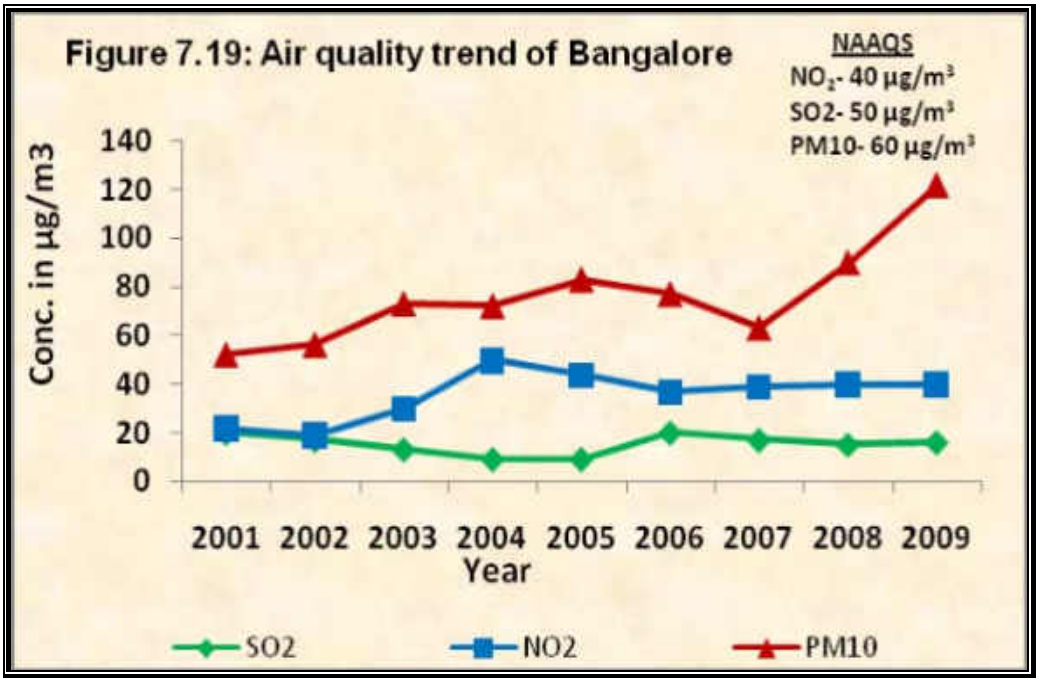
State	Andhra Pradesh
Location	17°43' N and 83°17' E
Area	Vishakhapatnam urban area comprises Vishakhapatnam Municipal Corporation covering 111 km^2 and Gajuvaka Municipality with an area of 97 km^2
Population	13,29,472
Climate	Tropical savanna climate with little variation in temperature through the year. High humidity throughout the year with aggressive summer and pleasant winter Temperature: temperature generally varies from 28 to 38°C in summer and 18 to 30°C in winter mean temperature ranges from 23.5 to 30°C Rainfall: mean annual rainfall of the area is 982 mm
Geography	Situated among the hills of the Eastern Ghats and faces the Bay of Bengal to the east. Forms a part of Eastern Ghat tectonic complex of Archaean age which include khondalites, charnockite and migmatite groups
Industries	Shipyard, steel, refinery, fertlisers, heavy plates and vessels, dredging
Air quality stations	8 (4 residential, 3 industrial, 1 sensitive)
Air quality trend	Analysis of nine year air quality data of PM_{10} shows a fluctuating trend, NO_2 and SO_2 shows a stable trend and are within NAAQS (Figure 7.18).



7.3.19 BANGALORE

State	Karnataka
Location	12°34'48" N and 77°22'48" E. Altitude of 920 m above MSL
Area	1000 km^2
Population	56,86,844
Climate	Tropical savanna climate with distinct wet and dry seasons. Due to its high elevation, Bangalore usually enjoys a more moderate climate throughout the year. The summer heat is moderated by fairly frequent thunderstorms. Temperature: 28 to 36°C during hottest months (April/May) to 16 to 25°C during winter months (December/January). Rainfall: average rainfall is 686 mm
Geography	Located on the Deccan Plateau in the south-eastern part of Karnataka. Soils consist of red laterite and red, fine loamy to clayey soils
Industries	Silicon valley of India. Major industries are aircraft, earthmoving equipments, watches, garments, silk, machine tools, handicrafts, computer software, computer hardware, electronics, telecommunication, instrumentation and information technology, steel and coffee.
Air quality stations	9 (5 residential, 4 industrial)
Air quality trend	Analysis of nine year air quality data of PM_{10} shows an increasing trend with an abrupt increase after 2007. SO_2 and NO_2 is more or less stable after 2006 and are within

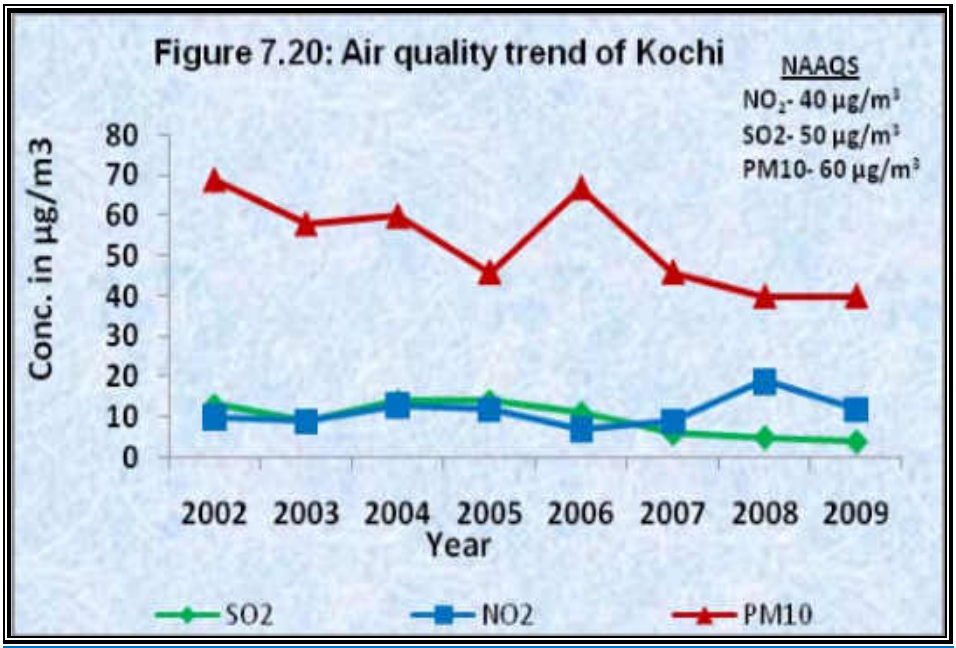
	NAAQS (Figure 7.19).



7.3.20 KOCHI

State	Kerala
Location	9°58′N to 9.967°N and 76°13′E to 76.217°E
Area	2408 km^2
Population	1,355,972
Climate	Tropical monsoon climate. From June through September, the south-west monsoon brings in heavy rains as Kochi lies on the windward side of the Western Ghats. From October to December, Kochi receives rain from the northeast monsoon, as it lies on the leeward side. Temperature: maximum of 40 ºC while in winter it is around 25ºC Rainfall: annual rainfall is about 310 cm
Geography	To the west lies the Arabian Sea, and to the east are estuaries drained by perennial rivers originating in the Western Ghats. Much of Kochi lies at sea level, with a coastline of 48 km. Soil consists of sediments such as alluvium, teri's, brown sands, etc. Hydromorphic saline soils are also found in the areas surrounding the backwaters. Predominant rock types found here are Archaean-basic dykes, Charnockites and Gneisses.
Industries	Cashew and other food products, Cochin Spices, Coir products, Chemicals and Agro products, Chemicals, Handloom, Handicrafts, Rubber, Electric, Electronic appliances, Transformers, Telephone cables, Ceramics, Tiles, Drugs, Chemicals, Paints,

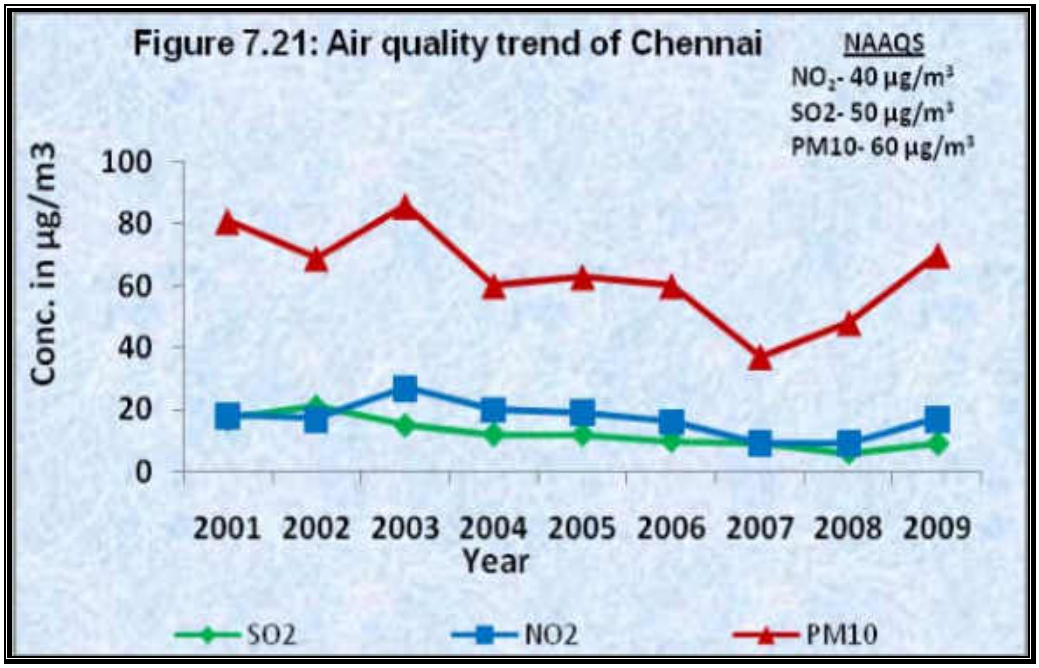
	Newsprint, Refinery and wood craft industries.
Air quality stations	7 (4 residential, 3 industrial)
Air quality trend	Analysis of nine year air quality data of PM_{10} shows an increasing trend with an abrupt increase after 2007. SO_2 and NO_2 is more or less stable after 2006 and are within NAAQS (Figure 7.20).



7.3.21 CHENNAI

State	Tamilnadu
Location	13°04' N and 80°17'E. Average elevation is around 6.7 metres
Area	173 km^2
Population	64,24,624
Climate	Tropical wet and dry climate. The weather is hot and humid for most of the year. The city gets most of its seasonal rainfall from the north-east monsoon winds, from mid-October to mid-December. Cyclones in the Bay of Bengal sometimes hit the city. T Temperature: 24.3° C (min) to 32.9 °C (max) Rainfall: annual rainfall in the region is the range from 1286 to 1233 mm
Geography	Situated on the eastern coastal plains. Drained by Cooum River (or *Koovam*) through the centre, Adyar River to the south and Kortalaiyar on the northern fringes. Soil is mostly clay, shale and sandstone.
Industries	Chemicals, oil refinery, oil storage tanks motors, cycles, rubber factory, surgical instruments factory, refinery, food factories, beverage factories, wood, paper and paper products, machinery tool industries, transport equipments, electrical machinery industries
Air quality stations	6 (2 residential, 4 industrial)
Air quality trend	Analysis of nine year air quality data of PM_{10} shows an increasing trend with an abrupt

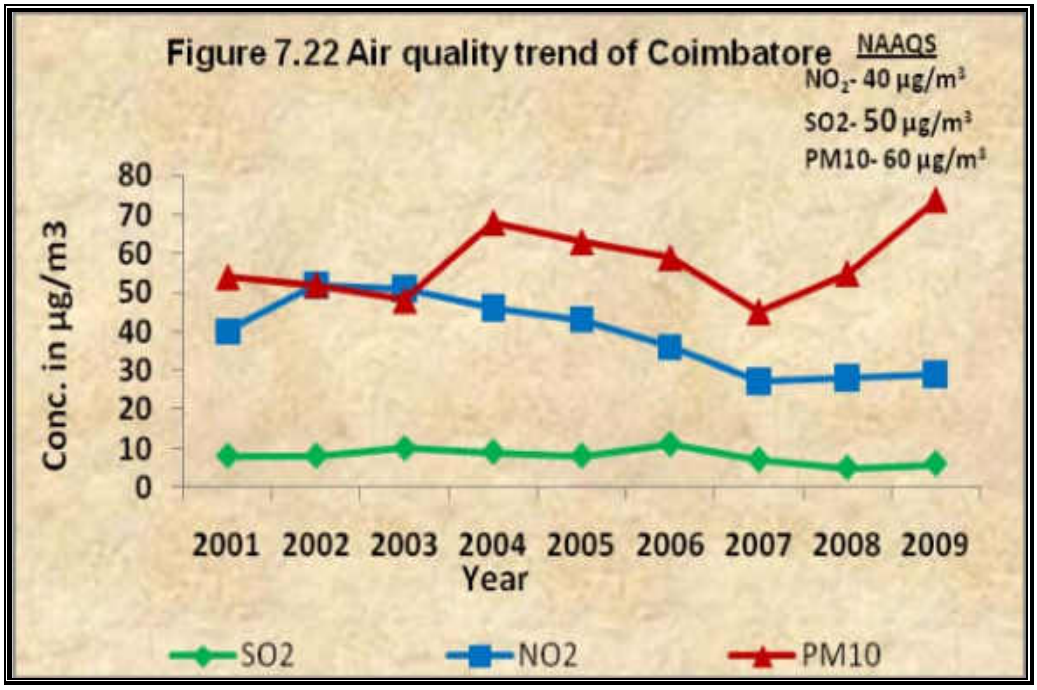
	increase after 2007. SO2 and NO2 is more or less stable after 2006 and are within NAAQS (Figure 7.21).



7.3.22 COIMBATORE

State	Tamilnadu
Location	11°00' N and 77°00' E, Elevation of about 398 meters
Area	140 km^2
Population	14,46,034
Climate	Tropical wet and dry climate. Regular monsoon starts from October lasting till early November brought about by the retreating North-eastern monsoon. Temperature: The mean maximum and minimum temperatures during summer and winter varies between 35°C to 18°C. Rainfall: annual rainfall of the district is 647 mm
Geography	The soil is predominantly black, which is suitable for cotton cultivation, but it also has some red loamy soil. Falls under the Class III/IV Seismic Zone
Industries	Textile mills, engineering industries, automobile components, washing machines, wet grinders, general engineering industries, food processing units and readymade garments.Large number of small-scale industries also florish
Air quality stations	3 (2 residential, 1 industrial)
Air quality trend	Analysis of nine year air quality data of PM_{10} shows fluctuating trend with an abrupt increase after 2007. NO2 shows a decline over the years and SO2 is stable and within

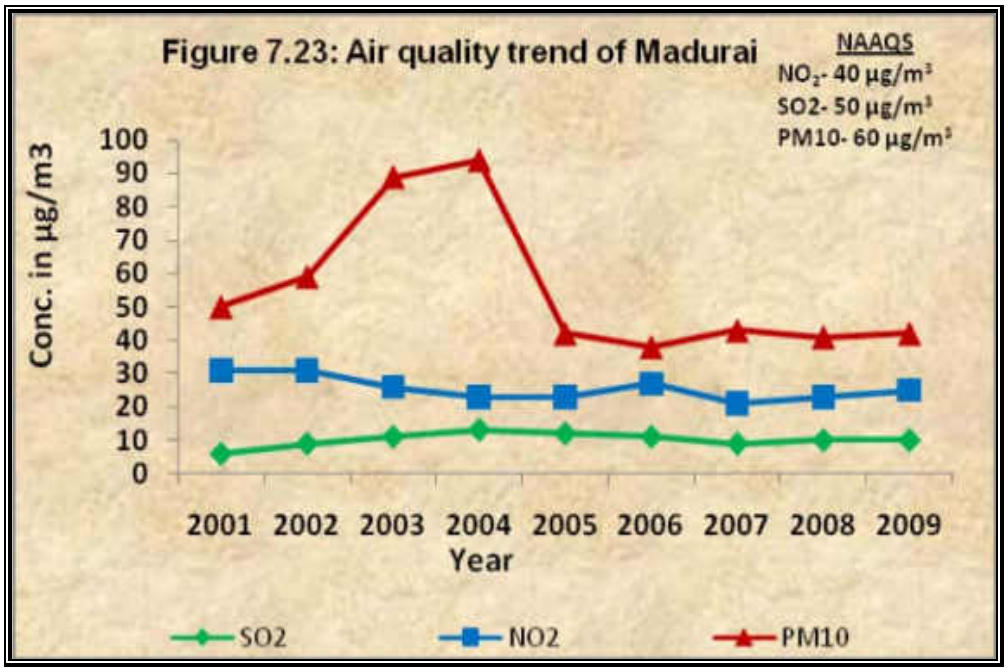
	NAAQS (Figure 7.22).



7.3.23 MADURAI

State	Tamilnadu
Location	9°58' N and 78°10' E, elevation of 101 meters above mean sea level
Area	140 km^2
Population	11, 94,665
Climate	Hot and humid, Madurai has the typical climate of the rest of the Deccan plateau. Normally, Sub tropical climate prevails over the city without any sharp variation. four distinct seasons, viz., and South West monsoon, North East Monsoon, Winter Season and Hot Summer Season Temperature: Temperatures during summer reach a maximum of 40 and a minimum of 26.3 °C, though temperatures over 43 °C are not uncommon. Winter temperatures range between 29.6 and 18 °C. Rainfall: average annual rainfall of the city is 867 mm
Geography	Situated on the banks of the River Vaigai
Industries	Textile mills, engineering industries, mechanical industries, electrical and electronic appliances, steel rolling mills and small scale industries like Food products, readymade garments, wooden industries, printing, moulding industries predominate in the area.
Air quality stations	3 (2 residential, 1 industrial)

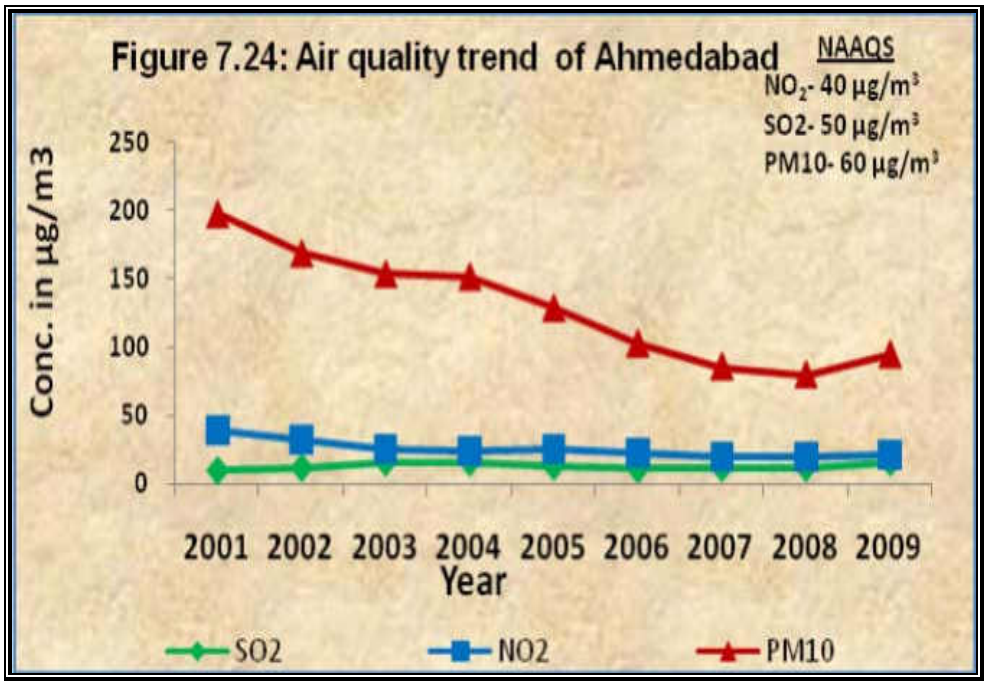
Air quality trend	Analysis of nine year air quality data of PM_{10} shows fluctuating trend with an abrupt increase after 2007. NO2 shows a decline over the years and SO2 is stable and within NAAQS (Figure 7.23).



7.3.24 AHMEDABAD

State	Gujarat
Location	23°02′ N and 72°35′ E, elevation of 53 metres
Area	300 km^2
Population	35,20,085
Climate	Semi-arid climate. There are three main seasons: summer, monsoon and winter. Aside from the monsoon season, the climate is dry. The southwest monsoon brings a humid climate from mid-June to mid-September. Temperature: May is the hottest month with mean daily maximum temperature of 41.3˚C and occasionally rises up to over 46˚C. January is the coldest month with the mean daily temperature of 29˚C. Rainfall: average annual rainfall for this period was 732 mm
Geography	The city sits on the banks of the River Sabarmati, in north-central Gujarat. falls under seismic zone-III. Area forms part of the Cambay sedimentary basin, and is underlain by post-Miocene alluvium, both aeolian and fluvial, composed of sand, silt, gravel and clay.
Industries	Textile mill, chemicals and pharmaceuticals industry.

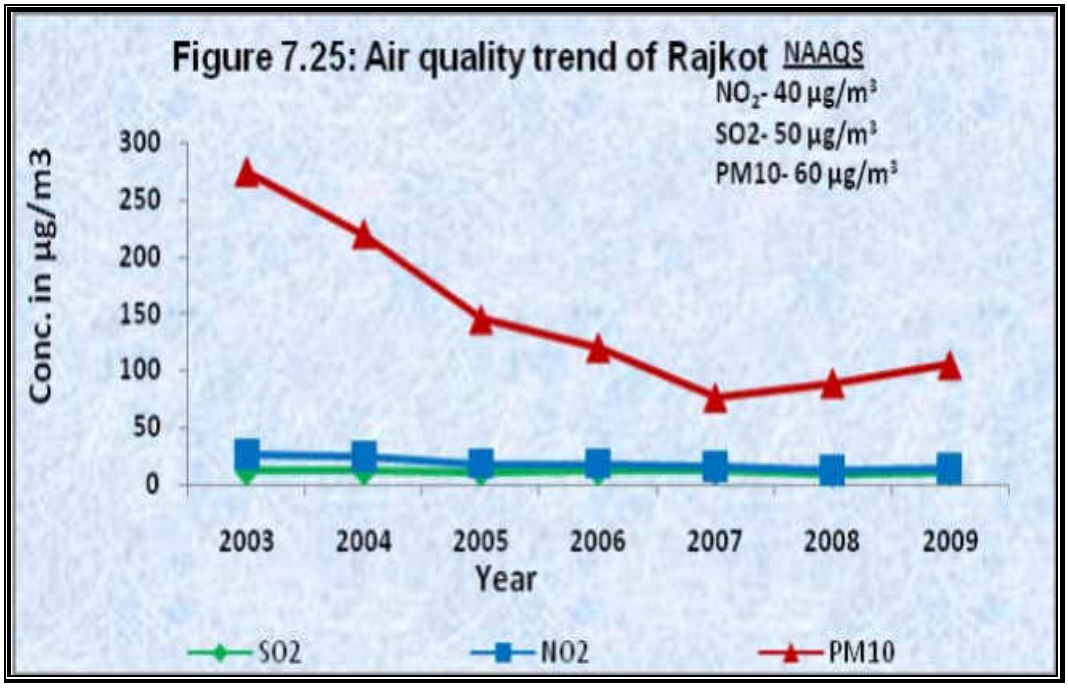
Air quality stations	6 (4 residential, 2 industrial)
Air quality trend	Analysis of nine year air quality data of PM_{10} shows a declining trend with a slight increase during 2009. Both SO2 and NO2 are more or less stable (Figure 7.24).



7.3.25 RAJKOT

State	Gujarat
Location	22°18′ N and 70°47′ E, elevation of 134 m (439 feet).
Area	104.86 km^2
Population	10,02,160
Climate	Semiarid climate with hot dry summers from mid-March to mid-June and the wet monsoon season from mid-June to October. The cyclones generally occur in the Arabian Sea during the months after the rainy season. Temperature: average maximum and minimum temperatures recorded over the last 40 years are 43.5˚C and 24.2˚C respectively Rainfall: average annual rainfall is observed about 500 mm in the area
Geography	Dharangadhra sand stones (Upper Jurassic to Lower Cretaceous), Deccan Trap (Upper Cretaceous to Lower Eocene), Fluviomarine alluvium and Milliolite limestone (Quaternary to Upper Tertiary). However, major part of the area is constituted of Basaltic lava flows.
Industries	Bearings, diesel engines, kitchen knives and other cutting appliances, watch parts (cases & bracelets), automotive parts, forging industry, casting industry, machine tools,

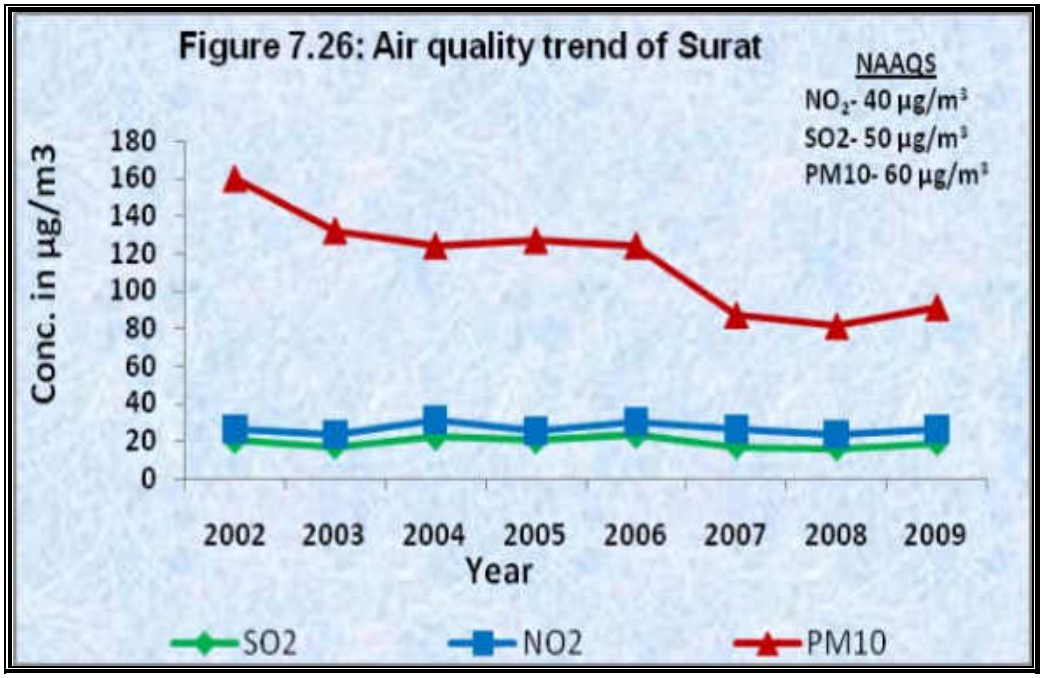
	share market and software development, textile mill There are eight industrial areas/estates functioning in the city. The total number of small scale industries registered is about 12000.
Air quality stations	2 (1 residential, 1 industrial)
Air quality trend	Analysis of nine year air quality data shows a more or less stable trend for SO2 and NO2. As for PM_{10} upto 2007 a declining trend is seen whereas a slight increasing trend is seen after 2007. (Figure 7.25).



7.3.26 SURAT

State	Gujarat
Location	21°10′ N and 72°50′ E, average elevation of 13 meters
Area	112.27 km^2
Population	28,11,466.
Climate	Tropical monsoon climate, moderated strongly by the Arabian Sea. The summer begins in early March and lasts till June. April and May are the hottest months, the average temperature being 30 °C. Monsoon begins in late June. Very often heavy monsoon rain brings floods in the Tapi basin area. Temperature: temperature of the city varies from 12˚C to 31˚C, while it varies from 24˚C to 42˚C Rainfall: 931 mm
Geography	Situated on the left bank of the Tapti River, 14 miles from its mouth soil of the area is of black cotton type upto 1.5 m followed by yellow soil and silt upto 10 m. Below 10 m depth, soft rocks are available. There is no signature of hardrock in the area.
Industries	Production of synthetic fibers and man-made fabrics, diamond-polishing industry, ,

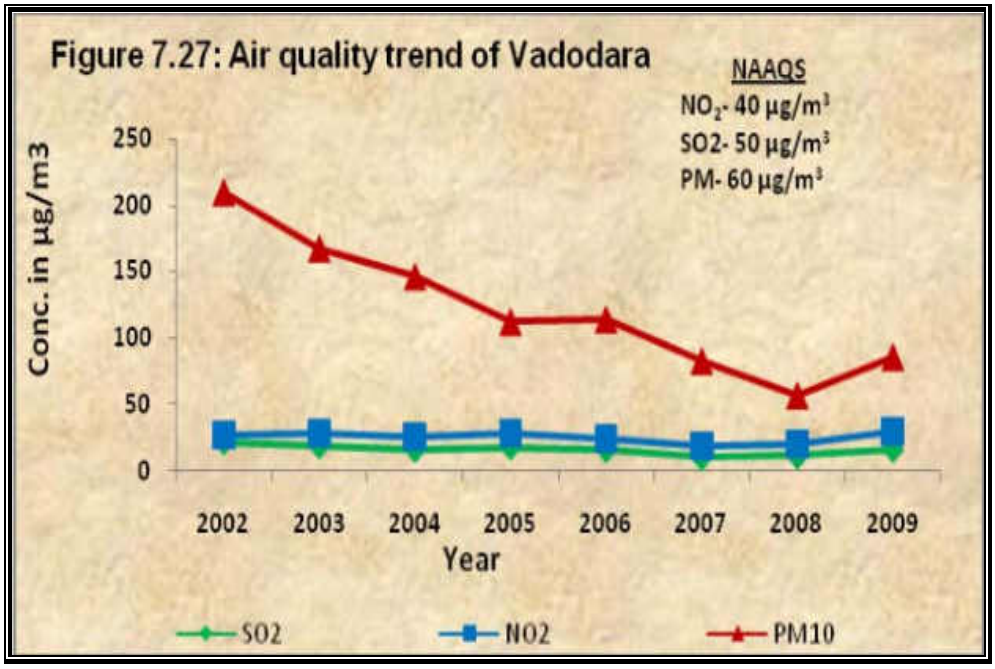
	steel. The total number of industries registered is about 45000.
Air quality stations	3 (2 residential, 1 industrial)
Air quality trend	Analysis of nine year air quality data shows a more or less stable trend for SO2 and NO2. As for PM_{10} upto 2007 a declining trend is seen whereas a slight increasing trend is seen after 2007. (Figure 7.26).



7.3.27 VADODARA

State	Gujarat
Location	22°18′ N and 73°16′ E, elevation of 39 metres (123 feet)
Area	140 km^2
Population	14,92,398
Climate	Tropical savanna climate. There are three main seasons: Summer, Monsoon and Winter. Aside from the monsoon season, the climate is dry. Temperature: The temperature of the city varies from 8˚C to 46˚C Rainfall: 900 mm
Geography	Basement rocks, exposed in northern and eastern parts, had been controlled by the Precambrian orogenies (Arvalli and Delhi cycles), and the older crystalline rocks ideally shows folds, faults and magmatism related to the two orogenies. The city sits on the banks of the River Vishwamitri, in central Gujarat, Mahi & Narmada Rivers. Falls under seismic zone-III, in a scale of I to V (in order of increasing proneness to earthquakes).

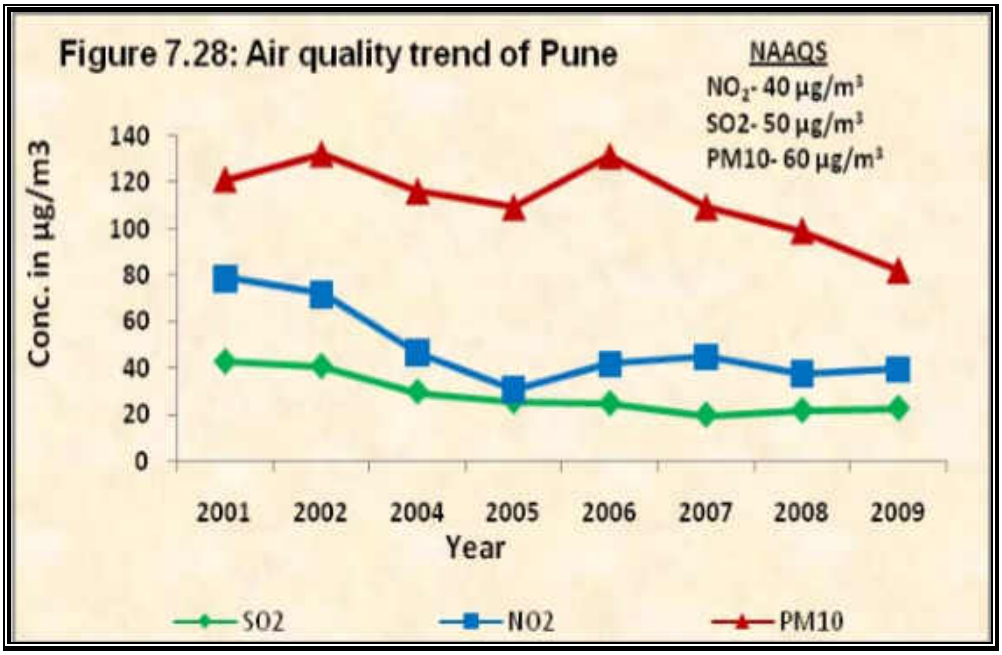
Industries	Petrochemicals, engineering, pharmaceuticals, plastics and Forex. The total number of industries registered is about 7500, out of which 6000 are functioning. There are about 2200 industries under GIDC in Makarpura.
Air quality stations	4 (3 residential, 1 industrial)
Air quality trend	Analysis of nine year air quality data shows a more or less stable trend for SO_2 and NO_2. As for PM_{10} upto 2008 a declining trend is seen whereas a slight increasing trend is seen after 2008. (Figure 7.27).



7.3.28 PUNE

State	Maharashtra
Location	18°18'36" N and 73°33' E, 560 m (1,840 ft) above sea level
Area	15,642 km^2
Population	37,55,525
Climate	Tropical wet and dry climate. Three distinct seasons: summer, monsoon and winter. The height above sea level and the leeward location with reference to the Western ghats have made the city climate moderate and salubrious. Temperature: mean summer maximum and the minimum temperatures are 37º and 23º C respectively. The same for the cold season are 30 and 12ºC respectively relative humidity ranges from 36% in March to 81% in August Rainfall: average rainfall is about 70 cm in just four months from June to September
Geography	Lcated on the western margin of the Deccan plateau on the leeward side of the Sahyadri mountain range, which form a barrier from the Arabian sea. At the confluence of the Mula and Mutha rivers. The Pavana and Indrayani rivers, tributaries of the Bhima

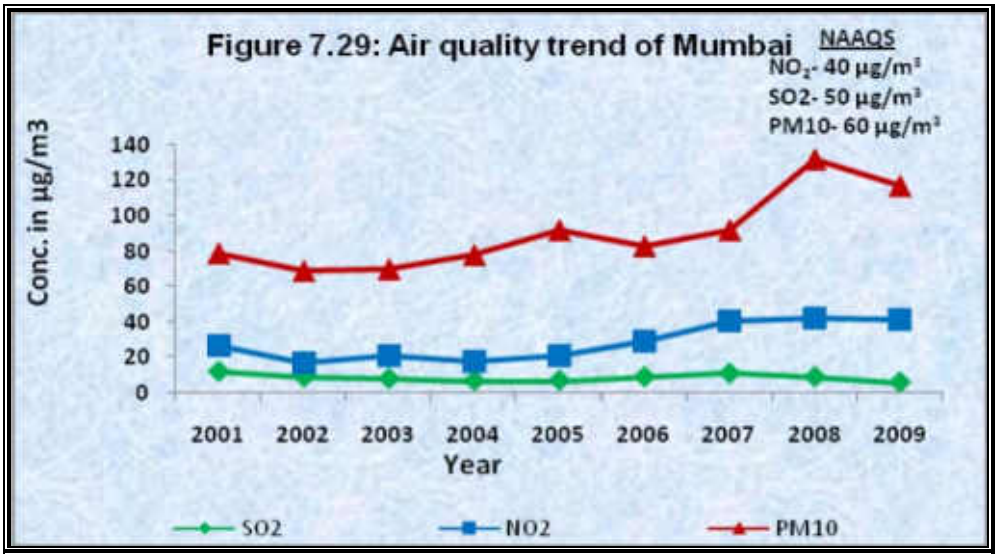
	river, traverse the northwestern outskirts of metropolitan Pune. Underlain by basaltic lava flows (Pahoehoe and AA) of upper cretaceous econe age associated with basic intrusives. The soil texture contains alluvial deposites of sand, gravels, fine silts and clays along the bank of major rivers.
Industries	One of the world's three largest two-wheeler manufacturers. Engineering, electronic and electrical industries culture.
Air quality stations	3 (2 residential, 1 industrial)
Air quality trend	Analysis of nine year air quality data shows a more or less stable trend for SO2 and NO2. As for PM_{10} upto 2008 a declining trend is seen whereas a slight increasing trend is seen after 2008. (Figure 7.28).



7.3.29 MUMBAI – commercial capital

State	Maharashtra
Location	18°55' N and 72°54' E, elevation of 14 m (46 ft)
Area	603.4 km^2 (233 sq mi)[1]
Population	1,40,00,000 lacs
Climate	Tropical climate, specifically a tropical wet and dry climate with seven months of dryness and peak of rains in July. The cold season from December to February is followed by the summer season from March to June. The period from June to about the end of September constitutes the south-west monsoon season, and October and November form the post-monsoon season. Temperature: average maximum temperature is 31.2 °C (88.2 °F), while the average minimum temperature is 23.7 °C (74.7 °F) Rainfall: average total annual rainfall is 2,146.6 millimetres (84.51 in) for the Island City, and 2,457 millimetres (96.73 in) for the suburbs
Geography	Mumbai lies at the mouth of the Ulhas River on the western coast of India, in the

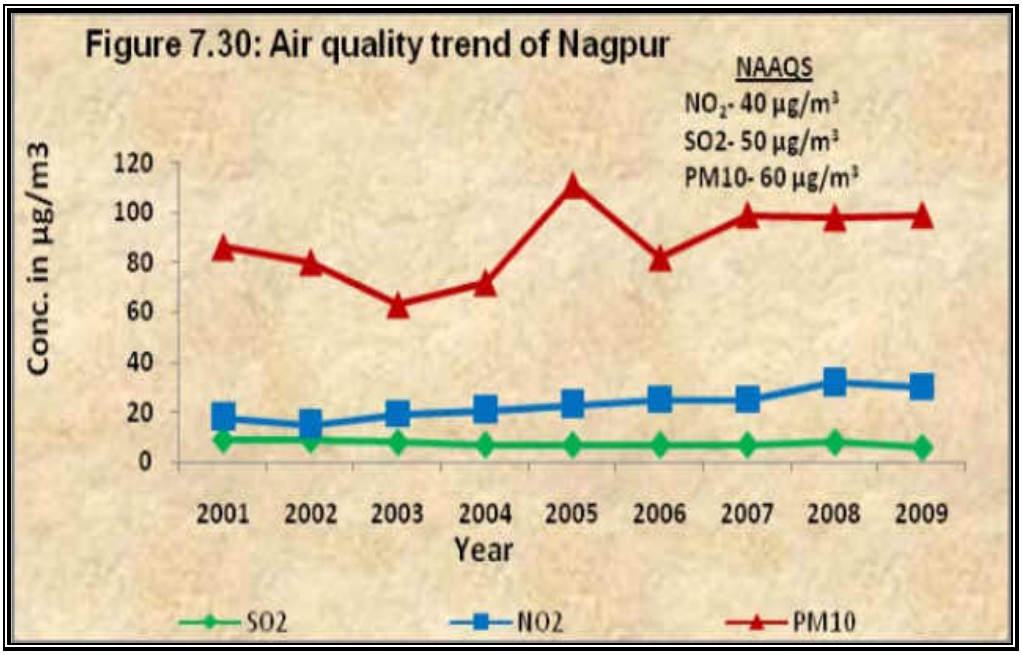
	coastal region known as the Konkan. Three small rivers, the Dahisar River, Poinsar (or Poisar) and Ohiwara (or Oshiwara) originate within the park, while the polluted Mithi River originates from Tulsi Lake and gathers water overflowing from Vihar and Powai Lakes. The coastline of the city is indented with numerous creeks and bays, stretching from Thane creek on the eastern to Madh Marve on the western front. The eastern coast of Salsette Island is covered with large mangrove swamps, rich in biodiversity, while the western coast is mostly sandy and rocky. Soil cover in the city region is predominantly sandy due to its proximity to the sea. In the suburbs, the soil cover is largely alluvial and loamy. The underlying rock of the region is composed of black Deccan basalt flows, and their acidic and basic variants It is a seismically active zone
Industries	port and shipping
Air quality stations	(residential, industrial)
Air quality trend	Analysis of nine year air quality data with respect to PM10 shows an increasing trend till 2008 and slight decrease in2009. NO2 salso showed an increasing trend b ut SO2 showed a decreasing trend. (Figure 7.29).



7.3.30 NAGPUR

State	Maharashtra
Location	21°5'24" N and 79°5'24"E, mean altitude of 310 meters above sea level
Area	218 km^2
Population	21,22,965
Climate	Tropical wet and dry climate with dry conditions prevailing for most of the year. Summers are extremely hot lasting from March to June, with maximum temperatures occurring in May. Winter lasts from November to January Temperature: mean daily temperature at 12.1°C and daily maximum temperature being 28.7 °C. Rainfall average annual rainfall being 1178.7 mm
Geography	Nagpur lies on the Deccan plateau of the Indian Peninsula The underlying rock strata is covered with alluvial deposits resulting from the flood plain of the Kanhan River. In some places these give rise to granular sandy soil. In low lying areas which are poorly

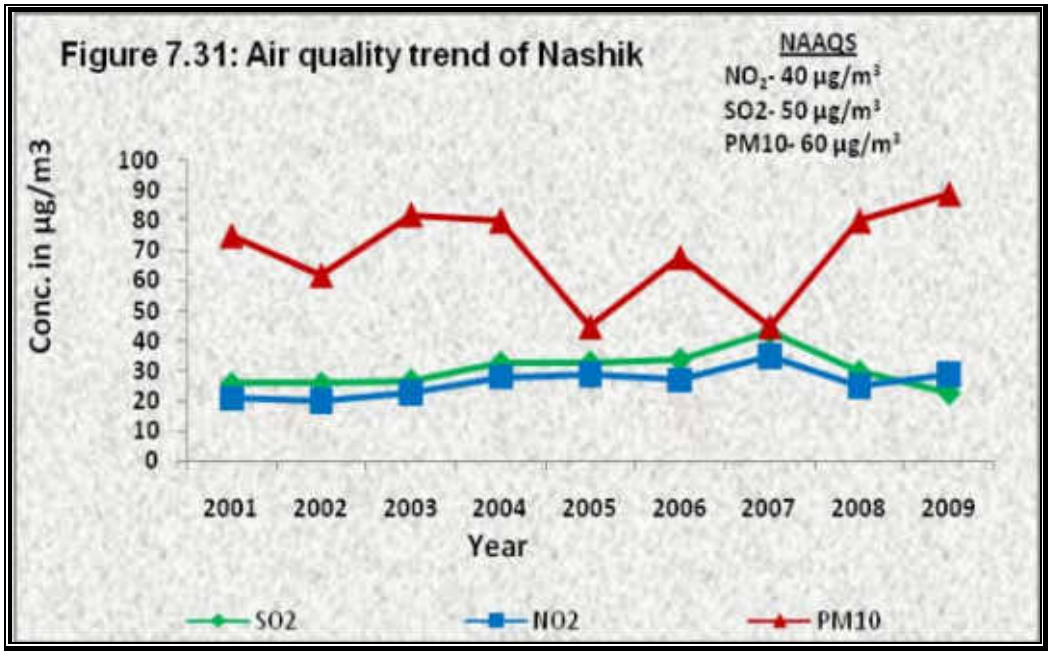
	drained, the soil is alluvial clay with poor permeability characteristics. In the eastern part of city crystalline metamorphic rocks such as gneiss, schist and granites are found, while in the northern part yellowish sand stones and clays of the lower Gondwana formations are found.[1]
Industries	Engineering Works, Saw mills, Rolling mills, Ayurvedic medicines. Different types of small scale and cottage units.
Air quality stations	6 (4 residential, 2 industrial)
Air quality trend	Analysis of nine year air quality data with respect to PM10 shows an increasing trend till 2008 and slight decrease in2009. NO2 salso showed an increasing trend b ut SO2 showed a decreasing trend. (Figure 7.30).



7.3.31 NASHIK

State	Maharashtra
Location	20°1'12" N and 73°30' E, 600m (1 968 ft) from the mean sea level
Area	259.13 km^2
Population	11,52,048
Climate	Semi-arid climate. The period from June to September is the (South West) Monsoon Season. Mild, dry winter from November to February, with warm days and cool nights, although occasional cold waves can dip temperatures. Temperature: summer and winter temperatures ranged 22 to 43°C and 20 to 3° C respectively Rainfall: average annual rainfall is about 700 mm Relative humidity is maximum 62% and minimum 43.65%.

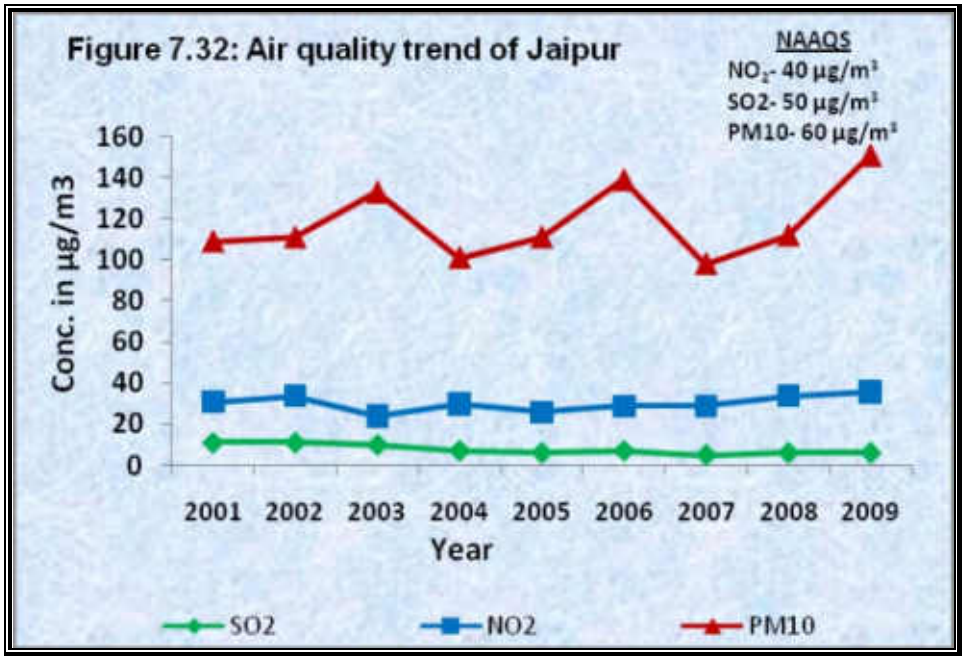
Geography	The river Godavari originates from Trimbakeshwar) flows through various parts of the city. Lies on western edge of the Deccan Plateau which is a volcanic formation. The soil here is primarily black which is favorable for agriculture. Occupied by Deccan basaltic rocks.
Industries	Aircraft manufacturing plant, automobile, pharmaceuticals, electricals, steel , nation's currency printer
Air quality stations	3 (2 residential, 1 industrial)
Air quality trend	Analysis of nine year air quality data with respect to PM10 shows an increasing trend till 2008 and slight decrease in2009. NO2 salso showed an increasing trend b ut SO2 showed a decreasing trend. (Figure 7.31).



7.3.32 JAIPUR

State	Rajasthan
Location	26°33' N and 75°31'12"E , average elevation of 431 metres (1417 ft)
Area	230 km^2
Population	23,24,319
Climate	Semi-arid climate Temperatures remain relatively high throughout the year. During the monsoon there are frequent, heavy rains and thunderstorms. Winter months of November to February are mild and pleasant, There are however occasional cold waves that lead to temperatures near freezing is dry and healthy and is subjected to extremes of cold and heat at various places. Temperature: minimum and maximum temperatures are 3°C and 45°C respectively while the mean temperature is 24°C.

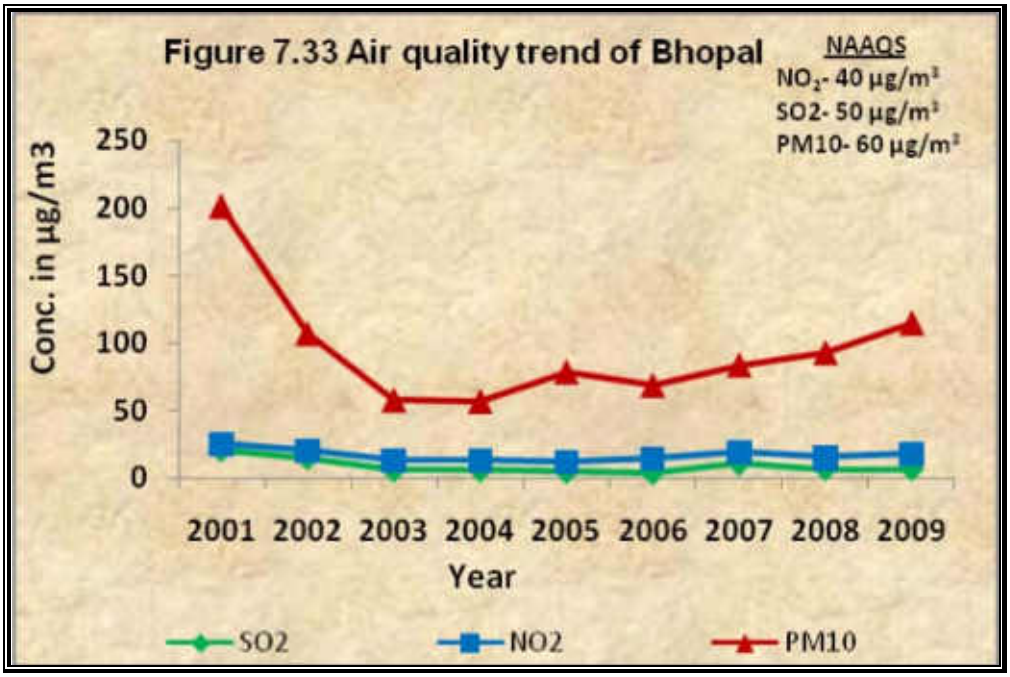
	Rainfall annual rainfall in the district is 548 mm
Geography	Ooldest groups of rock in the district are schist, gneisses, migmatite and quartzite of Pre-Aravalli, which are considered to be nearly 2,500 million year old. These rocks are covered under a mantle of sand and alluvium, of recent to sub recent age. The major rivers passing through the Jaipur district are Banas and Banganga. Ground water resources to the extent of about 28.65 million cubic meter are available in the district.
Industries	Marbel units, Readymade garments, Rolling mills, Chemical units, Printing units, Powerloom units, Gems and Jewelry unit, Casting units, Vanaspati oil mills, Precious and semi precious stone cutting units, Leather units and Electronics industries. The total number of registered small scale and artizen units in the city is 16799.
Air quality stations	6 (4 residential, 2 industrial)
Air quality trend	Analysis of nine year air quality data with respect to PM10 shows an increasing trend till 2008 and slight decrease in2009. NO2 salso showed an increasing trend b ut SO2 showed a decreasing trend. (Figure 7.32).



7.3.33 BHOPAL

State	Madhya Pradesh
Location	23°9'36" N and 77°21'36"E, average elevation of 499 metres (1637 ft)
Area	286 km^2
Population	14,54,830
Climate	Humid subtropical climate, with mild, dry winters, a hot summer and a humid monsoon season, starting in late June and ends in late September with frequent thunderstorms and flooding.. The winter peaks in January when temperatures may drop close to freezing on some nights. Temperature: Summers start in late March and go on till mid-June, the average temperature being around 30 °C (86 °F) Winters in Bhopal are mild, sunny and dry,

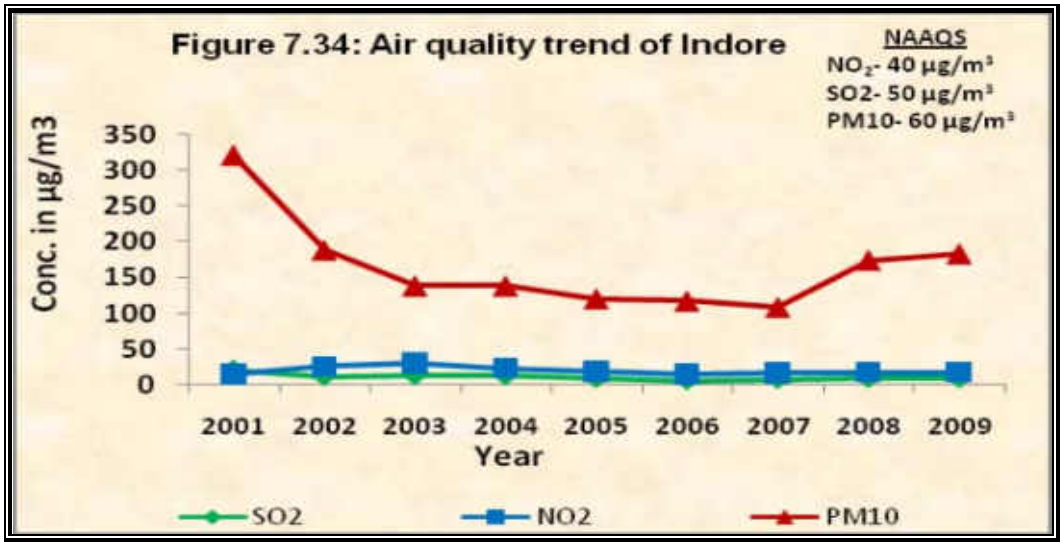
	with average temperatures around 18 °C (64 °F) Rainfall The normal annual rainfall of Bhopal city is about 1260 mm
Geography	Located in upper limit of the Vindhya mountain ranges, on the Malwa plateau. The area is occupied alluvial formations
Industries	Engineering Works, Bewerage, Bottling, Paints, Anciallary to BHEL, Electrical, Mechanical Engineering, Heavy fabrication factories, Glass fibre industries, Wooden, Saw mills, Food products, Automobiles and Agricultural equipments. The total number of registered units (small scale and cottage) in the city is 11960
Air quality stations	4 (3 residential, 1 industrial)
Air quality trend	Analysis of nine year air quality data with respect to PM_{10} shows an increasing trend till 2008 and slight decrease in2009. NO_2 salso showed an increasing trend b ut SO_2 showed a decreasing trend. (Figure 7.33).



7.3.34 INDORE

State	Madhya Pradesh
Location	22°26'24" N and 75°30'E, elevation of 550 metre above sea level
Area	130 km^2
Population	16,39,044
Climate	Tropical wet and dry climate and a humid subtropical climate. Three distinct seasons are observed: summer, monsoon and winter. Summers start in mid-March and can be extremely hot in April and May. Due to Indore's location on the southern edge of the Malwa Plateau, a cool breeze in the evenings makes summer nights quite pleasant. Temperature: Average Summer temperatures may go as high as 42-44.c (100.4 °F)

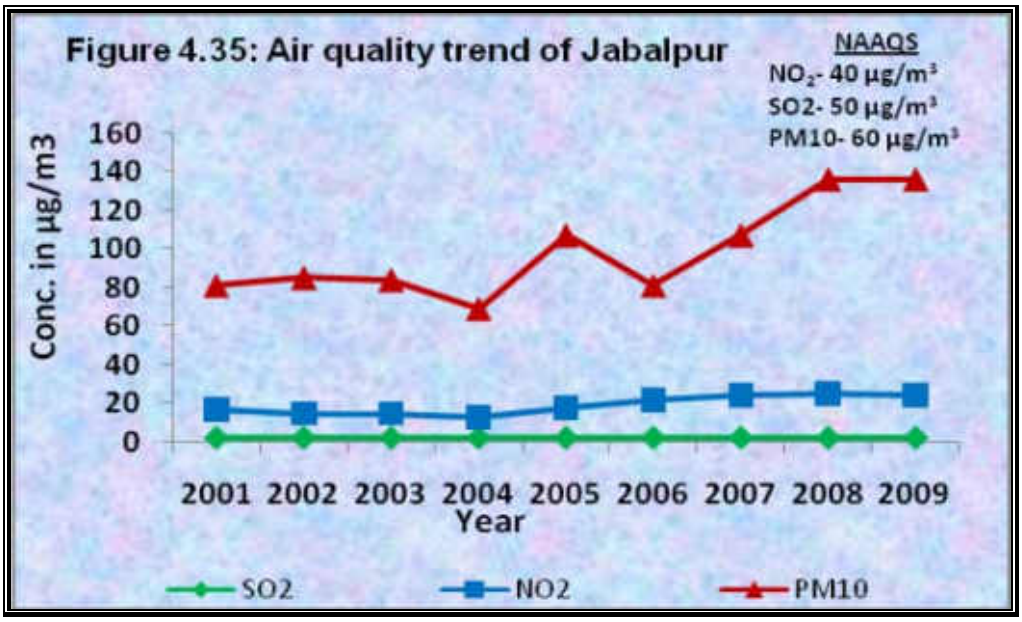
	but humidity is very low. The monsoon season starts in late June, with temperatures averaging around 26 °C (79 °F), with sustained, torrential rainfall and high humidity. Winters start in mid-November and are dry, mild and sunny. Temperatures average about 4–15 °C (39–59 °F), but can fall close to freezing on some nights. Rainfall average rainfall of Indore district is about 980 mm
Geography	Located in the southern edge of the Malwa plateau, on the Saraswati and Khan rivers, which are tributaries of the Shipra River. Isolated patches of alluvium also occur along the Kshipra and Khar rivers and the Katkiya nallla
Industries	Food product, Tobacco product, Cotton textile, Wool milk, synthetic powder, Jute product, Housary garments, Wood products, Paper and paper product, Leather and leather product, Rubber and Plastic products, Chemical and chemical product, Metal product, Basic metal industries, Machinery parts, Electric machinery product, Repairing and servicing, Steel furniture, Printing, Paints & Varnish, Pulses mills, Cold storage and Fertilizers, Electronics & Computer parts, Readymade garments, etc. The total number of registered units (small scale and cottage) in the city is 10247 (upto March 2002).
Air quality stations	3 (2 residential, 1 industrial)
Air quality trend	Analysis of nine year air quality data with respect to PM10 shows a decreasing trend till 2007 and increasing thereafter till 2009. NO2 and SO2 showed a stable trend. (Figure 7.34).



7.3.35 JABALPUR

State	Madhya Pradesh
Location	23°6' N and 79°35'24"E, average elevation of 411 metres (1348 feet).
Area	131 km^2
Population	11,17,200
Climate	Humid subtropical climate. Summers start in late March and last up to June. May is the hottest month followed by the monsoon season, which lasts until early October. Winters start in early November and last until early March. Temperature: average minimum temperature of 18.3 °C and an average maximum of 32.1 °C.

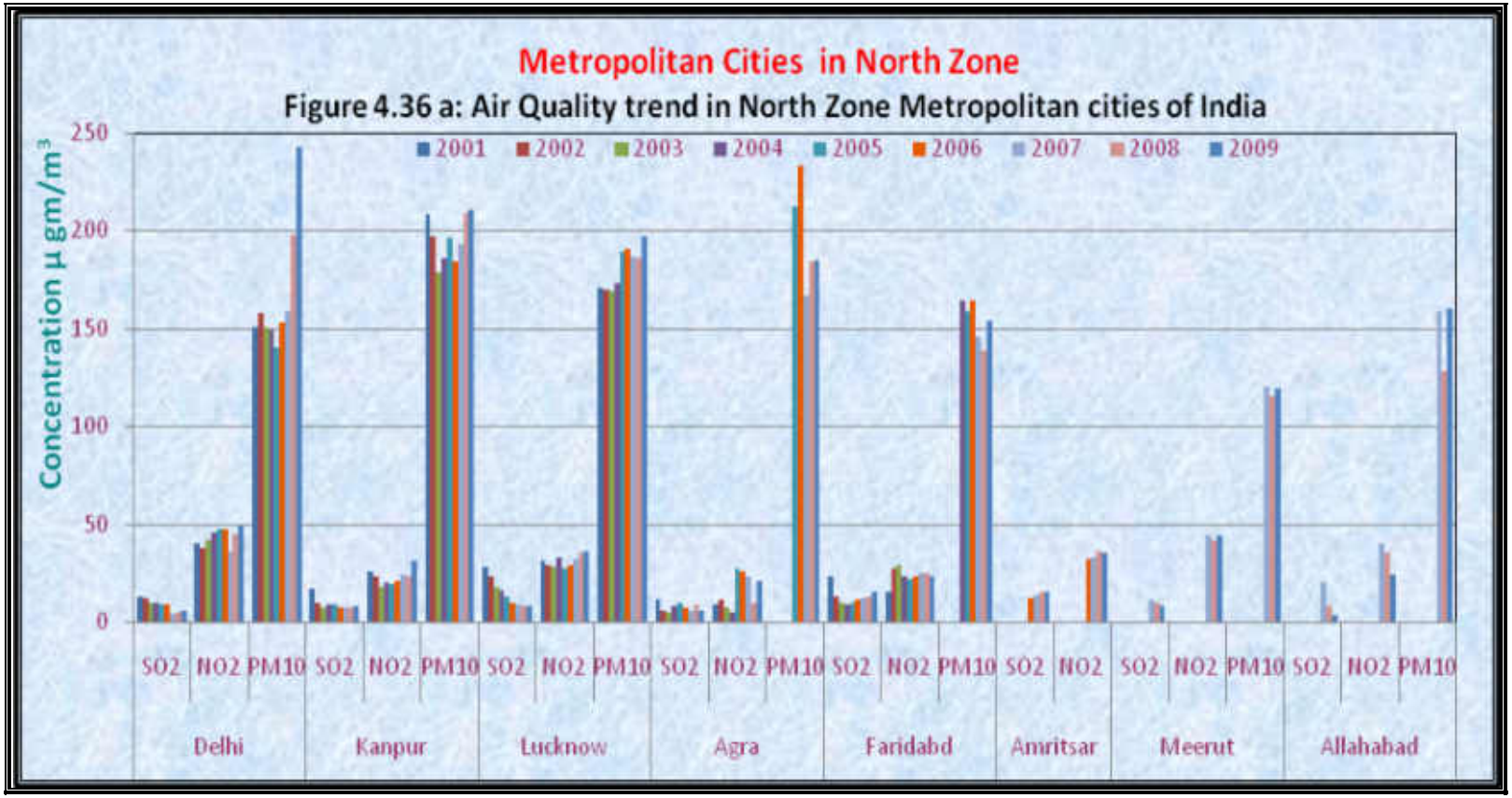
	Rainfall annual rainfall of 1130 mm with June to September being the principal rainy period
Geography	rocks of Archaen era, Bijawars, Vindhyan, Gondwanas, Lametas and Deccan traps. Schists, gneiss and granite are prevalent in the Archaeans
Industries	Steel fabrication factories, food products, polythene, RCC hume pipes, plastic base factories, sodium silicate, telecom, air products, etc. The total number of registered small scale and cottage units in the city is 320.
Air quality stations	1 (1 residential)
Air quality trend	Analysis of nine year air quality data with respect to PM10 shows a fluctuating trend where the pollutant increases during 2005 and 2008 and slightly decreases duting 2009 but remaining above NAAQS. NO2 and SO2 showed a more or less stable trend. (Figure 7.35).

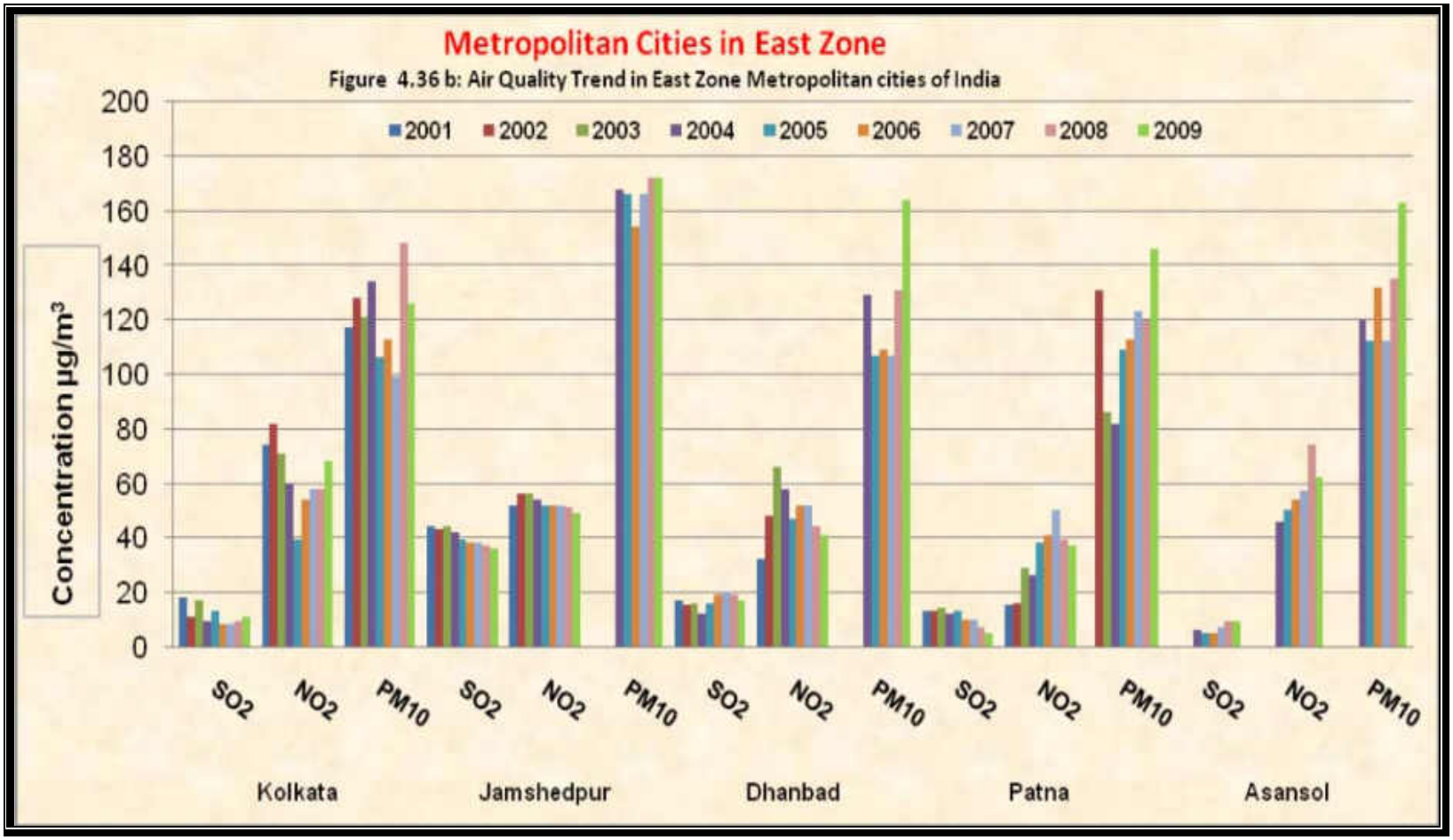


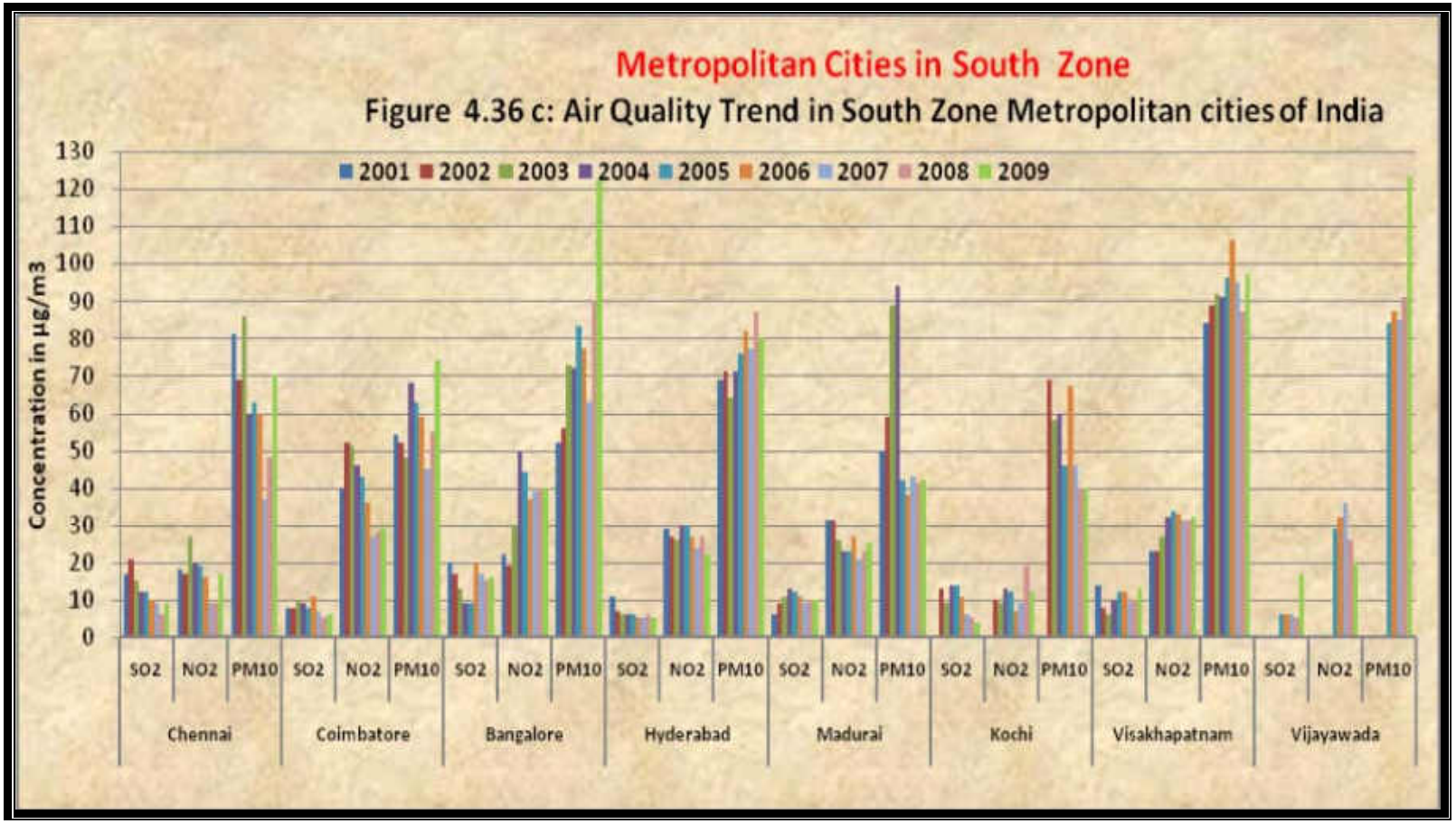
7.4 Air quality trend in different zones of India with respect to metropolitan cities

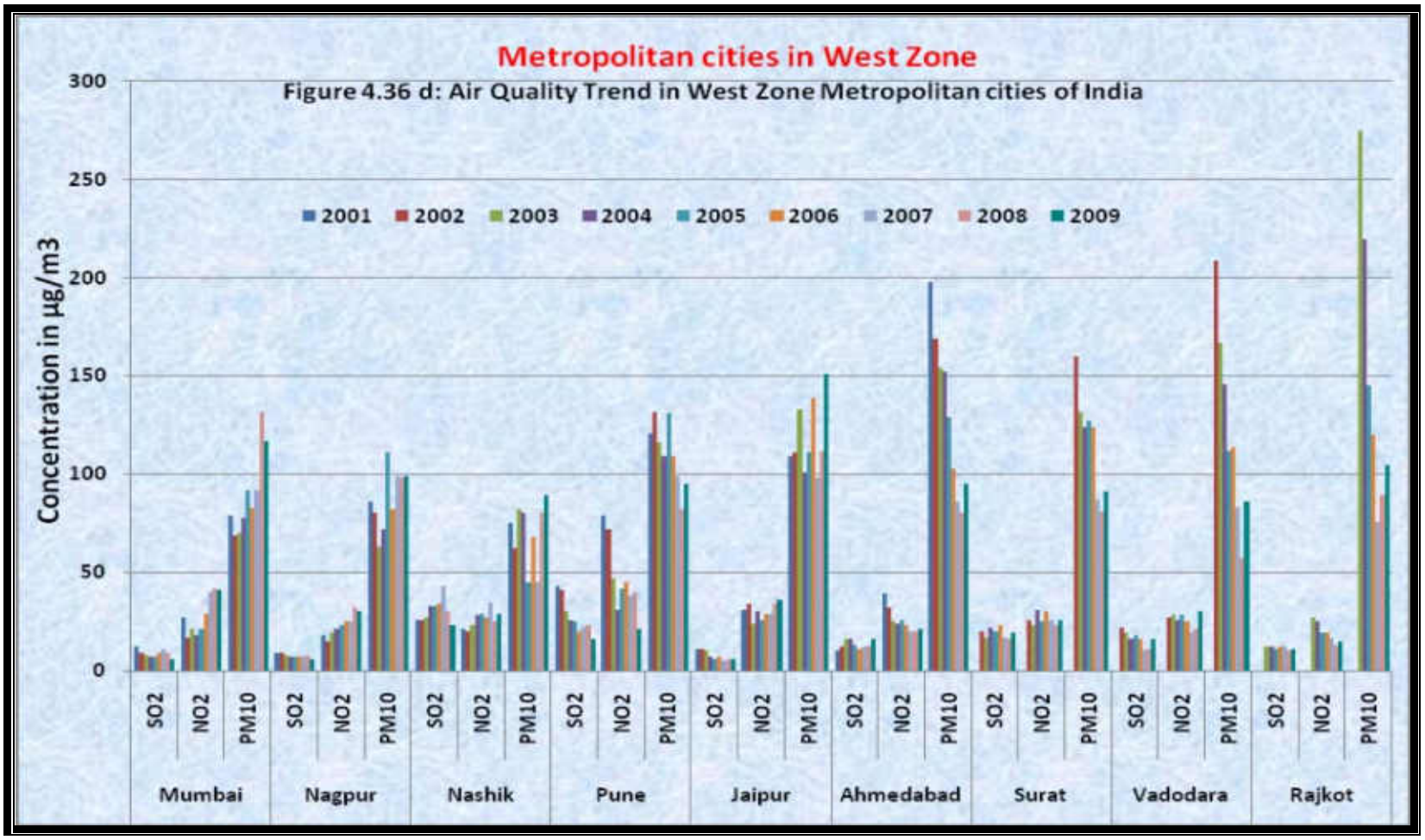
The trend in air quality in different zones viz. north, east, south, west and central zones are depicted in Figure 4.36a, b, c, d and e respectively

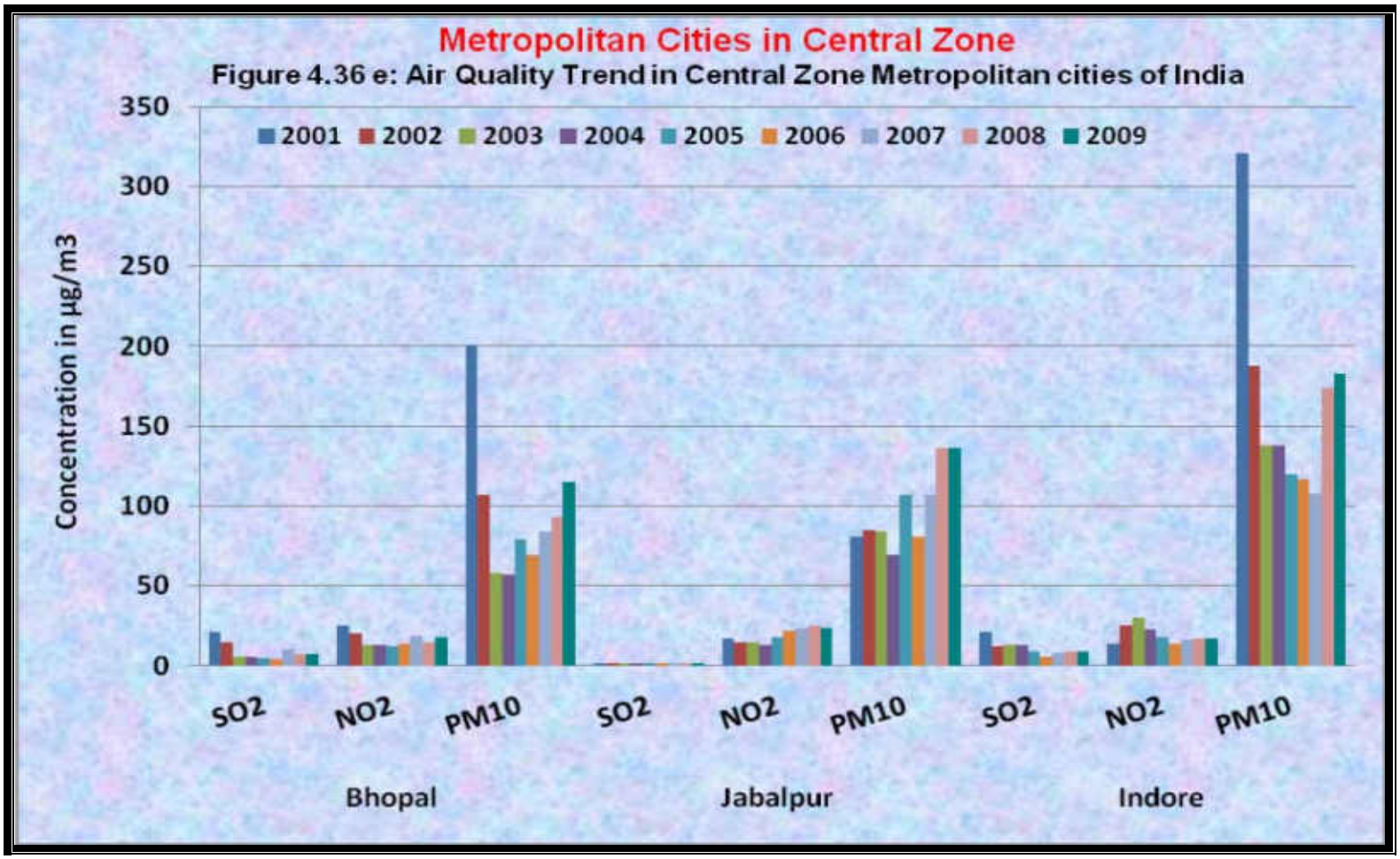
Figure 4.36 Air quality trend in the different zones (north, east, south, west, central) in India




Metropolitan Cities in East Zone
Figure 4.36 b: Air Quality Trend in East Zone Metropolitan cities of India
2001
2002
2003
2004
2005
2006
2007
2008
2009
Concentration µg/m³
200
180
160
140
120
100
80
60
40
20
0
SO2
NO2
PM10
Kolkata
Jamshedpur
Dhanbad
Patna
Asansol


Metropolitan Cities in South Zone
Figure 4.36 c: Air Quality Trend in South Zone Metropolitan cities of India
Concentration in µg/m3
2001 2002 2003 2004 2005 2006 2007 2008 2009
SO2 NO2 PM10
Chennai
Coimbatore
Bangalore
Hyderabad
Madurai
Kochi
Visakhapatnam
Vijayawada


Metropolitan cities in West Zone
Figure 4.36 d: Air Quality Trend in West Zone Metropolitan cities of India
Concentration in µg/m3
300
250
200
150
100
50
0
2001 2002 2003 2004 2005 2006 2007 2008 2009
SO2 NO2 PM10
Mumbai
Nagpur
Nashik
Pune
Jaipur
Ahmedabad
Surat
Vadodara
Rajkot


Metropolitan Cities in Central Zone
Figure 4.36 e: Air Quality Trend in Central Zone Metropolitan cities of India
Concentration in µg/m3
350
300
250
200
150
100
50
0
2001 2002 2003 2004 2005 2006 2007 2008 2009
SO2 NO2 PM10 SO2 NO2 PM10 SO2 NO2 PM10
Bhopal
Jabalpur
Indore

Chapter 8

Air pollution with respect to the additional pollutants (NH_3, CO, O_3, $PM_{2.5}$)

In addition to creation pollutants like SO_2, NO_2 and PM_{10} Central Pollution Control board carried out four additional parameters such as Ammonia (NH_3), Carbon Monoxide (CO), Ozone (O_3) and

Particulate matter with size less than 2.5 micrometer ($PM_{2.5}$). NH_3 has been measured in six metro cities viz Delhi, Mumbai, Chennai, Kolkata, Nagpur and Hyderabad with the help of National Environmental Engineering Research Institute (NEERI) under NAMP.

8.1 Ammonia Levels

Annual average concentration of ammonia has been compared with the NAAQS. The air quality has been categorized into four broad categories based on an Exceedence Factor (the ratio of annual mean concentration of a pollutant with that of a respective standard). The four categories are low, moderate, high and critical as explained in earlier chapters. Low levels were observed in Nagpur, Chennai, Kolkata, industrial areas of Hyderabad and residential areas of Mumbai. Moderate levels were observed in Delhi, residential areas of Hyderabad and industrial areas of Mumbai. There was no exceedence of air quality standards (annual average and 24 hourly averages) at all the monitored locations except Parel in Mumbai. The air quality is given in Table 8.1. Annual average concentration of ammonia at 18 monitoring stations in 6 cities are given in Table 8.2

Table 8.1 : Ambient Air Quality wrt Ammonia in India during 2009

Pollution level	**Annual Mean Concentration Range (µg/m^3)**	
Low (L)	0-50	
Moderate (M)	50-100	
High (H)	100-150	
Critical (C)	> 150	
STATE, UT / CITY	**Ammonia**	
AREA CLASS	**Industrial Areas**	**Residential Areas**
Andhra Pradesh		
Hyderabad	L	M
Delhi		
Delhi	M	M
Maharashtra		
Mumbai	M	L
Nagpur	L	L
Tamil Nadu		
Chennai	L	L
West Bengal		
Kolkata	L	L

Table 8.2: Summary of Ammonia Levels (Annual Average Concentration in μg/m^3) during 2009

S.No.	State / UT	City	Location	Type of Area	Average (μg/m^3)	Std. Dev.	n	% exceedence wrt NAAQS (24 hrly avg.)	Air Quality
1	Andhra Pradesh	Hyderabad	Nacharam	I	47	16	95	0	L
			Tarnaka	R	53	13	96	0	M
			ABIDS Circle	R	62	18	95	0	M
2	Delhi	Delhi	Mayapuri Ind. Area	I	69	19	96	0	M
			Sarojini Nagar	R	64	18	96	0	M
			Town Hall	R	70	19	96	0	M
3	Maharashtra	Mumbai	Parel	I	73	84	93	2	M
			Worli	R	49	44	96	0	L
			Kalbadevi	R	45	28	87	0	L
		Nagpur	Hingna Road	I	19	13	94	0	L
			Maskasath	R	25	17	97	0	L
			NEERI Lab., Nehru Marg	R	20	16	96	0	L
4	Tamil Nadu	Chennai	Thiruvottiyur Municipal Office	I	36	32	94	0	L
			Madras Medical College	R	41	37	90	0	L
			NEERI CSIR Campus	R	29	28	96	0	L
5	West Bengal	Kolkata	Cossipore	I	17	33	97	0	L
			Lal Bazaar	R	15	27	96	0	L
			Kasba	R	12	17	95	0	L

Note:- R – Residential and other areas, I – Industrial area, Std dev. – Standard deviation, n – number of days monitored for 16 and more hours a day L- Low, M- Moderate, H – High and C – Critical levels of pollution based on exceedence factor (calculated for n $\geq$ 50 days), % vio. Wrt NAAQS (24 hrly avg.) – Percentage violation wrt NAAQS (24 hourly average).

The close examination of the table indicates that at all annual values are within the NAAQS and the air quality w.r.t. to ammonia is low except Delhi, Hyderabad and at parel in Mumbai is moderate. It is observed that in parel there is a wide variation otherwise the data is mostly constant. With respect to 24 hr average occasional exceedence in case of parel is observed.

8.2 Carbon Monoxide

a) CO levels at BSZ Marg (ITO)

Carbon monoxide is monitored at Bahadur Shah Zafar (BSZ) Marg, New Delhi using Non-Dispersive Infrared Spectrometry (NDIR) method. Monthly average and annual average concentration of CO is given in Table 8.3. The annual average concentration of CO was 2542 $\mu g/m^3$ during 2009 and monthly average concentration varied from 1441 $\mu g/m^3$ to 4456 $\mu g/m^3$. High levels of CO might be attributed to increase in vehicular population especially passenger cars in Delhi.

Table 8.3: Concentration of Carbon Monoxide (CO) at BSZ Marg, New Delhi during 2009

Months of 2009	CO Concentration ($\mu g/m^3$)
January	2498
February	1967
March	2136
April	2584
May	2720
June	1751
July	2167
August	1441
September	2121
October	2310
November	4349
December	4456
Annual Average	2542

NA – Data not adequate

b) CO levels at Siri Fort

Carbon monoxide is monitored at Siri Fort, New Delhi using Non-Dispersive Infrared Spectrometry (NDIR) method. Monthly average and annual average concentration of CO is given in Table 8.4. The annual average concentration of CO was 1615 $\mu g/m^3$ during 2009 and the monthly average concentration varied from 756 $\mu g/m^3$ to 3142 $\mu g/m^3$. High levels of CO might be attributed to increase in vehicular population especially passenger cars in Delhi.

Table 8.4: Concentration of Carbon Monoxide (CO) at Siri Fort, New Delhi during 2009

Months of 2009	CO Concentration (µg/m^3)
January	1810
February	1378
March	1504
April	998
May	NA
June	NA
July	756
August	851
September	1019
October	1834
November	2860
December	3142
Average	1615

NA – Data not available

c) CO levels at Delhi College of Engineering (DCE), Bhawana

Carbon monoxide is monitored at Delhi College of Engineering (DCE), Bhawana, Delhi using Non-Dispersive Infrared Spectrometry (NDIR) method. Monthly average and annual average concentration of CO is given in Table 8.5. The annual average concentration of CO was 1147 µg/m^3 during 2009. The monthly average concentration varied from 443 µg/m^3 to 2140 µg/m^3. High levels of CO might be attributed to increase in vehicular population especially passenger cars in Delhi.

Table 8.5: Concentration of Carbon Monoxide (CO) at DCE, Bhawana, Delhi during 2009

Months of 2009	CO Concentration (µg/m^3)
January	1426
February	1045
March	1019
April	888
May	1062
June	773
July	913
August	573
September	443
October	1361
November	2117
December	2140
Average	1147

NA – Data not available/not adequate

d) CO levels at East Arjun Nagar, Shahadara

Carbon monoxide is monitored at East Arjun Nagar, Shahadara, Delhi using Non-Dispersive Infrared Spectrometry (NDIR) method. Monthly average and annual average concentration of CO is given in Table 8.6. The annual average concentration of CO was 1696 µg/m^3 during 2009. The monthly average concentration varied from 1208 µg/m^3 to 3391 µg/m^3. High levels of CO might be attributed to increase in vehicular population especially passenger cars in Delhi.

Table 8.6: Concentration of Carbon Monoxide (CO) East Arjun Nagar, Shahadara, Delhi during 2009

Months of 2009	CO Concentration (µg/m^3)
January	1235
February	1208
March	1196
April	1232
May	NA
June	1462
July	1215
August	1219
September	1425
October	1921
November	3391
December	3148
Average	1696

NA – Data not available/not adequate

8.3 Ozone

a) Ozone level at BSZ Marg (ITO)

Ozone was measured at BSZ Marg (ITO) using continuous analysers. Monthly average and annual average concentration of Ozone are given in Table 8.7. The annual average concentration of Ozone was 40 µg/m^3 during 2009. The monthly average concentration of ozone varied from 18 µg/m^3 to 69 µg/m^3.

Table 8.7: Concentration of Ozone at BSZ Marg (ITO), New Delhi during 2009

Months of 2009	Ozone Concentration (µg/m^3)
January	25
February	35
March	42
April	52
May	48
June	48
July	39
August	40
September	69
October	43
November	23
December	18
Average	40

NA – Data not available/not adequate

Higher ozone concentrations are observed, in general, in Summer months as it is formed by photochemical reactions of NOx and VOCs. Ozone concentrations tend to peak in early to mid afternoon in areas where there is strong photochemical activity.

b) Ozone levels at Siri Fort

Ozone was measured at Siri Fort using continuous analysers. Monthly average and annual average concentration of Ozone are given in Table 8.8. The annual average concentration of Ozone was 42 μg/m^3 during 2009. The monthly average concentration of ozone varied from 16 μg/m^3 to 68 μg/m^3. The values indicate that ozone levels are within NAAQS.

Table 8.8: Concentration of Ozone at Siri Fort, New Delhi during 2009

Months of 2009	Ozone Concentration (μg/m^3)
January	16
February	18
March	NA
April	NA
May	NA
June	NA
July	39
August	42
September	42
October	58
November	68
December	56
Average	42

NA – Data not available/not adequate

Higher ozone concentrations are observed, in general, in Summer months as it is formed by photochemical reactions of NOx and VOCs. Ozone concentrations tend to peak in early to mid afternoon in areas where there is strong photochemical activity. The values indicate that ozone levels are within NAAQS.

c) Ozone levels Delhi College of Engineering (DCE), Bhawana

Ozone was measured at Delhi College of Engineering (DCE) using continuous analysers. Monthly average and annual average concentration of Ozone are given in Table 8.9. The annual average concentration of Ozone was 53 μg/m^3 during 2009. The monthly average concentration of ozone varied from 28 μg/m^3 to 83 μg/m^3.

Table 8.9: Concentration of Ozone at DCE, Bhawana, Delhi during 2009

Months of 2009	Ozone Concentration (µg/m^3)
January	28
February	40
March	32
April	71
May	60
June	50
July	43
August	35
September	56
October	83
November	70
December	62
Average	53

NA – Data not available/not adequate

Higher ozone concentrations are observed, in general, in Summer months as it is formed by photochemical reactions of NOx and VOCs. Ozone concentrations tend to peak in early to mid afternoon in areas where there is strong photochemical activity. The values indicate that ozone levels are within NAAQS.

d) Ozone levels at East Arjun Nagar, Shahadara, Delhi

Ozone was measured at East Arjun Nagar, Shahadara, Delhi using continuous analysers. Monthly average and annual average concentration of Ozone are given in Table 8.10. The annual average concentration of Ozone was 32 µg/m^3 during 2009. The monthly average concentration of ozone varied from 10 µg/m^3 to 74 µg/m^3.

Table 8.10: Concentration of Ozone at East Arjun Nagar, Shahadara, Delhi during 2009

Months of 2009	Ozone Concentration (µg/m^3)
January	14
February	26
March	34
April	35
May	NA
June	33
July	38
August	74
September	29
October	31
November	10
December	NA
Average	32

NA – Data not available/not adequate

Higher ozone concentrations are observed, in general, in Summer months as it is formed by photochemical reactions of NOx and VOCs. Ozone concentrations tend to peak in early to mid

afternoon in areas where there is strong photochemical activity. The values indicate that ozone levels are within the NAAQS.

8.4 Particulate matter with size less than 2.5 μm ($PM_{2.5}$)

a) Particulate matter with size less than 2.5 μm ($PM_{2.5}$) at BSZ Marg (ITO), New Delhi

Particulate matter with size less than 2.5 micrometer ($PM_{2.5}$) was measured at BSZ Marg (ITO), New Delhi using continuous analysers. Monthly average and annual average concentration of $PM_{2.5}$ are given in Table 8.11. The annual average concentration of $PM_{2.5}$ was 89 μg/m^3 during 2009. The monthly average concentration of $PM_{2.5}$ varied from 48 μg/m^3 to 156 μg/m^3. Higher $PM_{2.5}$ levels were observed in winter months as mixing height is lower in winter months resulting is less volume of troposphere for mixing and hence higher concentrations. Lower concentrations were observed in monsoon months as particulate matters are washed out due to wet deposition.
.

Table 8.11: Concentration of $PM_{2.5}$ at BSZ Marg (ITO), New Delhi during 2009

Months of 2009	$PM_{2.5}$ Concentration (μg/m^3)
January	156
February	90
March	90
April	NA
May	NA
June	75
July	48
August	49
September	43
October	164
November	NA
December	NA
Average	89

NA – Data not available/not adequate

b) Particulate matter with size less than 2.5 μm ($PM_{2.5}$) at Pritampura, New Delhi

Particulate matter with size less than 2.5 micrometer ($PM_{2.5}$) was measured at Pritampura, New Delhi using continuous analysers. Monthly average and annual average concentration of $PM_{2.5}$ are given in Table 8.12. The annual average concentration of $PM_{2.5}$ was 96 μg/m^3 during 2009. The monthly average concentration of $PM_{2.5}$ varied from 40 μg/m^3 to 108 μg/m^3. Higher $PM_{2.5}$ levels were observed in winter months as mixing height is lower in winter months resulting is less volume of troposphere for mixing and hence higher concentrations. Lower concentrations were observed in monsoon months as particulate matters are washed out due to wet deposition.

Table 8.12: Concentration of $PM_{2.5}$ at Pritampura, New Delhi during 2009

Months of 2009	$PM_{2.5}$ Concentration ($\mu g/m^3$)
January	96
February	84
March	91
April	70
May	42
June	46
July	62
August	40
September	40
October	76
November	108
December	104
Average	69

NA – Data not available/not adequate

c) Particulate matter with size less than 2.5 μm ($PM_{2.5}$) at Sirifort, New Delhi

Particulate matter with size less than 2.5 micrometer ($PM_{2.5}$) was measured at Sirifort, New Delhi using continuous analysers. Monthly average and annual average concentration of $PM_{2.5}$ are given in Table 8.13. The annual average concentration of $PM_{2.5}$ was 71 $\mu g/m^3$ during 2009. The monthly average concentration of $PM_{2.5}$ varied from 32 $\mu g/m^3$ to 150 $\mu g/m^3$. Higher $PM_{2.5}$ levels were observed in winter months as mixing height is lower in winter months resulting is less volume of troposphere for mixing and hence higher concentrations. Lower concentrations were observed in monsoon months as particulate matters are washed out due to wet deposition.

Table 8.13: Concentration of $PM_{2.5}$ at Sirifort, New Delhi during 2009

Months of 2009	$PM_{2.5}$ Concentration ($\mu g/m^3$)
January	93
February	70
March	32
April	85
May	55
June	82
July	62
August	55
September	52
October	64
November	110
December	150
Average	71

NA – Data not available/not adequate

d) Particulate matter with size less than 2.5 μm ($PM_{2.5}$) at Janakpuri, New Delhi

Particulate matter with size less than 2.5 micrometer ($PM_{2.5}$) was measured at Janakpuri, New Delhi using continuous analysers. Monthly average and annual average concentration of $PM_{2.5}$ are given in Table 8.14. The annual average concentration of $PM_{2.5}$ was 58 µg/m^3 during 2009. The monthly average concentration of $PM_{2.5}$ varied from 40 µg/m^3 to 78 µg/m^3. Higher $PM_{2.5}$ levels were observed in winter months as mixing height is lower in winter months resulting is less volume of troposphere for mixing and hence higher concentrations. Lower concentrations were observed in monsoon months as particulate matters are washed out due to wet deposition.

Table 8.14: Concentration of $PM_{2.5}$ at Janakpuri, New Delhi during 2009

Months of 2009	$PM_{2.5}$ Concentration (µg/m^3)
January	78
February	49
March	56
April	63
May	62
June	77
July	40
August	61
September	47
October	69
November	NA
December	55
Average	58

NA – Data not available/not adequate

e) Particulate matter with size less than 2.5 µm ($PM_{2.5}$) at Nizamuddin, New Delhi

Particulate matter with size less than 2.5 micrometer ($PM_{2.5}$) was measured at Nizamuddin, New Delhi using continuous analysers. Monthly average and annual average concentration of $PM_{2.5}$ are given in Table 8.15. The annual average concentration of $PM_{2.5}$ was 69 µg/m^3 during 2009. The monthly average concentration of $PM_{2.5}$ varied from 36 µg/m^3 to 135 µg/m^3. Higher $PM_{2.5}$ levels were observed in winter months as mixing height is lower in winter months resulting is less volume of troposphere for mixing and hence higher concentrations. Lower concentrations were observed in monsoon months as particulate matters are washed out due to wet deposition.

Table 8.15: Concentration of $PM_{2.5}$ at Nizamuddin, New Delhi during 2009

Months of 2009	$PM_{2.5}$ Concentration (µg/m^3)

January	107
February	66
March	90
April	77
May	62
June	44
July	52
August	57
September	36
October	46
November	127
December	135
Average	69

NA – Data not available/not adequate

e) Particulate matter with size less than 2.5 μm ($PM_{2.5}$) at Shahzada Bagh, New Delhi

Particulate matter with size less than 2.5 micrometer ($PM_{2.5}$) was measured at Shahzada Bagh, New Delhi using continuous analysers. Monthly average and annual average concentration of $PM_{2.5}$ are given in Table 8.16. The annual average concentration of $PM_{2.5}$ was 87 μg/m^3 during 2009. The monthly average concentration of $PM_{2.5}$ varied from 41 μg/m^3 to 178 μg/m^3. Higher $PM_{2.5}$ levels were observed in winter months as mixing height is lower in winter months resulting is less volume of troposphere for mixing and hence higher concentrations. Lower concentrations were observed in monsoon months as particulate matters are washed out due to wet deposition.

Table 8.16: Concentration of $PM_{2.5}$ at Shahzada Bagh, New Delhi during 2009

Months of 2009	$PM_{2.5}$ Concentration (μg/m^3)
January	109
February	116
March	103
April	41
May	49
June	67
July	71
August	46
September	68
October	104
November	161
December	178
Average	87

NA – Data not available/not adequate

f) Particulate matter with size less than 2.5 μm ($PM_{2.5}$) at Shahdara, Delhi

Particulate matter with size less than 2.5 micrometer ($PM_{2.5}$) was measured at Shahdara, Delhi using continuous analysers. Monthly average and annual average concentration of $PM_{2.5}$ are

given in Table 8.17. The annual average concentration of $PM_{2.5}$ was 77 µg/m^3 during 2009. The monthly average concentration of $PM_{2.5}$ varied from 42 µg/m^3 to 144 µg/m^3. Higher $PM_{2.5}$ levels were observed in winter months as mixing height is lower in winter months resulting is less volume of troposphere for mixing and hence higher concentrations. Lower concentrations were observed in monsoon months as particulate matters are washed out due to wet deposition.

Table 8.17: Concentration of $PM_{2.5}$ at Shahdara, Delhi during 2009

Months of 2009	$PM_{2.5}$ Concentration (µg/m^3)
January	84
February	59
March	111
April	42
May	48
June	69
July	58
August	45
September	70
October	93
November	144
December	111
Average	77

NA – Data not available/not adequate

8.5 Conclusion

It is observed Ammonia (NH_3) is within NAAQS in six metro cities. With respect to Ozone (O_3) the values at Delhi are within NAAQS however in case of $PM_{2.5}$ and Carbon monoxide (CO) with respect to Delhi the value observed is mostly above the NAAQS. These observations indicate the vehicular pollution is the major cause of exceedence of CO and $PM_{2.5}$ in Delhi.

CHAPTER 9

INITIATIVES FOR CONTROL OF AIR POLLUTION

Various measures have been taken to control air pollution from vehicles, industries and other sources. The steps taken to control air pollution from vehicles and industries are as follows:

9.1 Measures taken to Reduce Vehicular Pollution

i) Vehicular Emission Norms

a) During 1990-91 India for the first time notified mass emission norms for the vehicles at the manufacturing stage as well as for in-use vehicles. These norms were notified under EPA, motor vehicles rules & Air Act.
b) The emission norms introduced in 1996 have been important in controlling vehicular pollution because of stringency of emission norms along with fuel quality in 1996. For the first time crankcase emission norms and evaporative emission norms were introduced.
c) From April 1995 passenger cars were allowed to register only if they are fitted with a catalytic converter in four metros-Delhi, Mumbai, Kolkata & Chennai. Emission norms for such vehicles were notified under motor vehicles rules during January 1998. These norms were stricter by 50 percent compared to 1996 norms.
d) The testing method for passenger car norms were changed from hot start to cold start, which is also a stringent measure, compared to the earlier one.
e) More stringent norms were introduced for the year 2000. These norms were notified under Motor Vehicle Rules during 1997. Automobile manufacturers have to undergo major modification to meet these norms.
f) As per Hon'ble Supreme Court's directions only private vehicles conforming to at least EURO-I norms are being registered in NCR from June 1999 and from April 2000 only private vehicles conforming to Euro-II equivalent i.e. Bharat Stage-II norms were registered. In Mumbai Euro-II norms for private vehicles (4 wheelers) was applicable from 2001. In Kolkata, India-2000 norms (Euro-I) have been made applicable from November 1999.
g) From 1st October 1999, emission norms for agricultural tractors were introduced throughout the country. Bharat Stage-II and Bharat Stage-III emission norms for tractors have been scheduled to be implemented from 2003 and 2005 respectively.
h) The Bharat Stage-II norms for new 4-wheeler private non-commercial vehicle were introduced in Mumbai from January 2001, Kolkata and Chennai from July 2001 to 24th October, 2001.
i) Only those taxies are being registered in Delhi, which are meeting Bharat Stage-II norms.
j) Bharat Stage-II norms for Diesel 4 wheeler transport vehicles were introduced in NCT from 24th October, 2001, in Greater Mumbai, Kolkata & Chennai from 31.10.2001
k) The expert committee on Auto Oil, Policy was constituted during September 2001. The interim report of the committee was submitted to Govt. on 1.1.2000. Recommending Bharat Stage-III emission norms for all category of 4-wheelers in 7 mega cities from 2005 and rest of the country by 2010. Final report of the committee has been submitted in September 2002 which includes road map for control of vehicular pollution up to 2010.
l) Final report of the Inter-Ministerial Task Force constituted by MO & P&NG at the instance of the Committee of Secretaries to evolve a long term policy for vehicular emission and auto fuel policy has been submitted which recommended introduction of Bharat Stage-II norms for 4-wheelers and next stage emission norms for 2/3 wheelers throughout the country from 2005 and introduction of Bharat stage-III norms for four wheelers in 7-mega cities from 2005.

ii) Fuel Quality Specifications

For the first time diesel and gasoline fuel quality with respect to environment related parameters has been notified under EPA during April 1996. Gasoline lead phase out programme is given in Table 9.1

Table 9.1: Gasoline Lead Phase Out Programme

Phase	Date of Introduction	Lead Content	Areas Covered
Phase-I	June 1994	Low lead (0.15 g/l)	Delhi, Mumbai, Kolkata, Chennai
Phase-II	1.4.1995	Unleaded (0.013 g/l)+ low leaded	Delhi, Mumbai, Kolkata, Chennai
Phase-III	1.1.1997	Low leaded	Entire country
Phase-IV	1.9.1998	Only unleaded	NCT
Phase-V	31.12.1998	Unleaded+Low leaded	Capitals of states & Uts
Phase-VI	1.9.1998	Unleaded	NCR
Phase-VII	1.2.2000	Unleaded	Entire Country

Diesel sulphur reduction programme is given in Table 9.2. Gasoline benzene reduction programme is given in Table 9.3.

Table 9.2: Diesel Sulphur Reduction Programme

Phase	Date of Introduction	Sulphur Content	Areas Covered
Phase-I	April 1996	0.50%	Four metros & Taj
Phase-II	August 1997	0.25%	Delhi & Taj
Phase-III	April 1998	0.25%	Metro Cities
Phase-IV	January 2000	0.25%	Entire Country
Phase-V	April 2000	0.05%	NCR-private vehicles
	January 2000	0.05%	Mumbai-all vehicles
	March 2001	0.05%	NCT-all vehicles
	June 2001	0.05%	NCR-all vehicles
	July 2001	0.05%	Chennai & Kolkata
Phase-VI	October 2001	0.05%	All retail outlets of four metros
Phase-VII	2003	0.05%	Ahemadabad, Surat, Agra, Pune & Kanpur
Phase-VIII	2005	0.05%	Entire country
Phase-IX	2005	0.035%	10 metro cities & Agra
Phase-X	2010	0.035%	Entire country
Phase-XI	2010	0.005%	10 metro cities

Table 9.3: Gasoline Benzene Reduction Programme

Date of Introduction	Benzene Content	Areas Covered
Before 1996	No specification	Entire Country
April 1996	5% benzene	Entire Country
April 2000	3% benzene	Metro Cities
November 2000	1% benzene	NCT & Mumbai
2005	1% benzene	All Metro cities

iii) Better traffic management in Delhi

- Restriction has been imposed on goods vehicles during day time from August 1999 in Delhi .
- Left lane has been made exclusive to buses and other HMV in Delhi.
- Time clocks have been installed in important red lights to enable the drivers to switch off their vehicles depending on the time left in the time clocks.
- Construction of more fly-overs and subways and closing of T-Junctions for better traffic flow.
- Regular information about traffic flow through radio FM bands for avoiding congested roads.

iv) Improvement of the Public transport System in Delhi

- Various steps taken for the improvement of the public transport system in Delhi are as follows:
- Number of buses has been increased to discourage use of individual vehicles by allowing private sectors for operation.
- Metro Rail Project for Various stretches in Delhi has been completed successfully and work is in progress to connect various zones of Delhi.

v) Reduction of emissions by the use of lubricants

- Specifications of 2T oil for two stroke engine with respect to smoke have been notified under EPA during September 1998 for implementation from 1.4.1999 throughout the country.
- Pre-mix 2T oil dispenser has been installed at all petrol filling stations in Delhi so that excessive oil is not being used by the vehicle owners. Sale of loose 2T oil has been banned from December 1998 in Delhi & Kolkata.

vi) Mass awareness regarding vehicular pollution control

- Messages/articles related to vehicular emissions are disseminated through newsletters, pamphlets, newspapers, magazines, Television, Radio, Internet, Workshops and Summer Exhibitions.
- Display of ambient air quality data through display system near ITO, Newspapers, daily news& Internet.
- NGOs working on vehicular pollution control are being encouraged for mass awareness campaigns.

vii) Alternate fuelled vehicles

- CNG vehicles introduced in Mumbai & Delhi. At present more than 80,000 CNG vehicles(19000 cars, 49810 Autos, 4935 RTVs & 8874 Buses) are plying in Delhi and about 23,000 in Mumbai. All city buses converted to CNG mode in Delhi .
- There are more than 111 CNG filling stations installed in Delhi with average consumption of674 tonnes per day of CNG.
- Emission norms for CNG & LPG driven vehicles has been notified.
- Petrol vehicles are running on ethanol blended (5%) petrol in states of Maharastra, AndhraPradesh, Goa, Gujarat, Haryana, Karnataka, Tamil Nadu Uttar Pradesh, Daman & Diu andUnion Territories of Dadar & Nagar Hawali, Chandigarh and Pondicherry .
- Work is in progress to run diesel vehicles on bio-diesel.

viii) Control of pollution from in-use vehicles:

- Idling emission norms notified for in-use vehicles. Pollution Under Control (PUC) certificate areissued for adherence to idling emission norms every 6/3 months. Number of computerizedPUC centers in Delhi is around 353.
- More than15 year old commercial vehicles are phased out from Delhi since 1998.
- New in- use vehicles norms proposed

ix) Recommendations of the final report of the Expert Committee on "Auto Fuel Policy"

- Bharat Stage-II norms for new vehicles except two & three wheelers, which are in place in thefour mega cities of Delhi, Mumbai, Kolkata & Chennai to be extended to Hyderabad, Bangalore, Ahemadabad, Kanpur, Pune, Surat & Agra by 2003 and entire country by 2005.

- Euro-III equivalent emission norms for all new vehicles except 2 & 3 wheelers to be applicable in 11 cities from 1 st April 2005 and extended throughout the country by 2010.
- Euro -IV equivalent emission norms for all new vehicles except 2 & 3 wheelers to be applicablein 11 cities by April 2010.
- Bharat Stage-II Emission norms for 2&3 wheelers to be applied through out the country byApril 2005 and Bharat Stage-III by 2008/2010.
- To meet Bharat Stage-II, Euro-III and Euro-IV equivalent emission norms, matching quality of petrol & diesel should be simultaneously made available.

9.2. Measures Taken for Controlling Air Pollution from Industries

The measures taken for controlling air pollution from industries are as follows:

(a) Emission standards have been notified under the Environment (Protection) Act, 1986 to check pollution.
(b) Industries have been directed to install necessary pollution control equipment in a time bound manner and legal action has been initiated against the defaulting units.
(c) 24 critically polluted areas have been identified. Action Plan have been formulated for restoration of environmental quality in these areas.
(d) Environmental guidelines have evolved for siting of industries.
(e) Environmental clearance is made compulsory for 29 categories of development projects involving public hearing/ NGO participation as an important component of Environmental Impact Assessment process.
(f) Environmental audit in the form of environmental statement has been made mandatory for all polluting industries.
(g) Preparation of zoning Atlas for siting of industries based on environmental considerations in various districts of the country has been taken up.
(h) Power plants (coal based) located beyond 1000 kms from the pit-head are required to use low ash content coal (not exceeding 34%) with effect from 1.6.2002. Power plants located in the sensitive areas are also required to use low ash coal irrespective of their distance from the pit head.

9.3. Action Plan for the control of air pollution in sixteen cities identified by the Hon'ble Supreme Court of India

With the objective of controlling these rapidly burgeoning air pollution problems in our country, the Hon'ble Supreme Court of India, in the matter of CWP No. 13029 of 1995, passed the orders on 05.04.2001, regarding formulation and implementation of action plans for control of pollution in selected cities. The Hon'ble Court stressed the need for such initiatives relating to vehicular pollution in Delhi and directed that action plan for pollution control in the cities/ towns, which do not meet the ambient air quality standards, should be prepared.

On August 14, 2003, the Hon'ble Supreme Court passed the following direction: *"CPCB's report shows that the Respirable Particulate Matter (in short "RSPM") levels in Ahmedabad, Kanpur, Sholapur, Lucknow, Bangalore, Chennai, Hyderabad, Mumbai and Kolkata are alarming."*

"Issue notices to the States of Maharashtra, Andhra Pradesh, Gujarat, Uttar Pradesh, Karnataka and Tamil Nadu. In the Meantime, we direct that the Union of India and the respective States shall draw a plan for lowering the rate of RSPM level in the aforesaid cities. After the plan is drawn, the same would be placed before EPCA. This may be done within a period of two months. We are excluding Mumbai and Kolkata where the respective High Courts are stated to be monitoring the RSPM levels in those cities. EPCA after examining the matter shall submit a report to this Court within a period of four weeks thereafter."

Further Central Pollution Control Board has also identified various non- attainment cities all over the country on the basis of national ambient air quality data under NAMP. Central Pollution has been coordinating with the concerned state governments of the sixteen critically

polluted cities identified by the Hon'ble Supreme Court of India as well as non-attainment cities identified by itself for the preparation of action plan for the control of air pollution in all these cities. Further CPCB is also reviewing and monitoring the implementation of the action plans prepared for these critically polluted as well as non- attainment cities. So far State Governments of the all the sixteen critically polluted cities as identified by the Hon'ble Supreme Court of India have submitted their action plan for controlling air Pollution from all the major sources including industrial, vehicular & domestic sources. The major actions those have been proposed for almost all the cities are:

- **Industrial Pollution**
  - Shifting of Industries from non- confirming zones.
  - Switching over to clean technologies.
  - Using clean fuels.
  - Installation of Pollution control Devices.
  - Development of green belt, etc.
- **Vehicular Pollution**
  - Implementation of the emission norms as well as fuel quality in accordance with the road map proposed by the Auto Fuel Policy.
  - Switching over to clean alternate fuels like CNG, LPG & Bio-fuels.
  - Augmentation in Public Transport system
  - Better traffic management
  - Implementation of fiscal measures, etc
- **Domestic Pollution**
  - Ban on open burning of garbage, biomass, etc.
  - Augmentation on supply of LPG as cooking fuel , etc.

Central Pollution Control Board along with EPCA has been regularly reviewing action plan submitted by State Pollution Control Boards, further it is also monitoring the timely implementation of the action plan.

Chapter 10

CONCLUSION

SUMMARY OF AMBIENT AIR QUALITY DURING 2009

1. Summary of air quality scenario in different locations

- Analysis of annual average concentration of ambient air quality in residential / industrial / rural / other area reveal that 241 locations exceeded the standard of 60 µg/m^3 (annual) with respect to PM_{10}
- With respect to NO_2, 39 locations exceeded the standard of 40 µg/m^3 (annual)
- No location exceeded the standard limit of 50 µg/m^3 (annual) for SO_2 during 2009

2. Summary of air quality scenario in different cities

- Analysis of annual average concentration of ambient air quality in residential / industrial / rural / other area reveals that 96 cities exceeded the standard of 60 µg/m^3 (annual) with respect to PM_{10}. State capital cities like Patna, Hydrabad, Ranchi, Bangalore, Kolkata, Mumbai, Jaipur and Industrial cities like Vishakhapatnam, Ahmedabad, Bhilai, Korba, Dhanbad, Jharia, Jamshedpur, Chandrapur, Dewas, Indore, Rourkela, Kota, Kanpur, Ghaziabad, Howrah, Asansol and Durgapur are critical.
- With respect to NO_2, 10 cities exceeded the standard of 40 µg/m^3. Cities like Patna, Kolkata, Howrah, Durgapur are critical.
- No city exceeded the standard limit of 50 µg/m^3 (annual) for SO_2 during 2009
- Durgapur, Howrah and Kolkata are critical with respect to PM_{10} and NO_2

3. Summary of air quality scenario in different states

- Analysis of annual average concentration of ambient air quality in residential / industrial / rural / other area reveled 22 states exceeded the standard of 60 µg/m^3 (annual) for PM_{10}
- With respect to NO_2, 3 states, exceeded the standard of 40 µg/m^3 (annual). West Bengal lie in the critical category
- No city exceeded the standard limit of 50 µg/m^3 (annual) for SO_2 during 2009

4. Summary of air quality scenario in different metropolitan cities

- Analysis of annual average concentration of ambient air quality in residential / industrial / rural / other area of metropolitan cities revealed that out of 35 cities, 33 cities exceeded the NAAQS of 60 µg/m^3 for PM_{10}.
- With respect to NO_2 7 cities exceeded the standard of 40 µg/m^3 (annual).
- No metropolitan city exceeded the standard limit of 50 µg/m^3 (annual) for SO_2during 2009

5. Percent exceedence of ambient air quality standard

- With respect to residential/industrial/rural area, considering annual average 39 (11%) location (for NO_2) and 241 (68%) locations (for PM_{10}) exceed NAAQS. SO_2 does not exceed the standard at any location.
- Taking 24-hourly average data into consideration, 11 (3%) locations for SO_2, 57 (16%) locations for NO_2 and 307 (85%) locations with respect to PM_{10} exceed NAAQS.

Chapter 11

REFERENCES

REFERENCES

Epidemiological study on effect of air pollution on human health (adults) in Delhi, http://www.cpcb.nic.in/

Census 2001, Area: 1991 and population figures

Health Effects Institute, Creation of an Air Pollutant Data Base for Health Effects Study, Report Submitted to Health Effects Institute by Atmospheric and Environmental Research, Inc., 2004

http://www http://www.epa.gov/air/urbanair/co/hlth1.html.epa.gov/air/urbanair/ozone/hlth.html

http://www.epa.gov/air/airtrends/aqtrnd01/pmatter.html

http://www.epa.gov/air/oaqps/greenbk/o3co.html#ParticulateMatte

http://www.epa.gov/air/urbanair/nox/what.html (Accessed: 22/8/2007)

http://www.epa.gov/air/urbanair/pm/hlth1.html

http://www.epa.gov/iaq/voc.html

http://www.epa.gov/oar/particlepollution/health.html (Accessed on 22/8/2007)

http://www.epa.gov/oar/particlepollution/pdfs/pm-color.pdf

http://www.epa.gov/ttn/atw/allabout.html

http://www.hc-sc.gc.ca/ewh-semt/pubs/air/office_building-immeubles_ bureaux/organic-organiques_e.html

Study on ambient air quality, respiratory symptoms, and lung function of children in Delhi, http://www.cpcb.nic.in/

United States Environmental Protection Agency, 'Research and Development Fiscal Years 1997-1998 Research Accomplishments, Research and Development (8101R) EPA 600-R-99-106, Washington D.C., Dec. 1999.\

United States Environmental Protection Agency, Air Quality Criteria for Particulate matter Chapter 1 , Executive Summary, EPA 600/P-95/001aF, April 1996, Website - http://www.epa.gov/ORD/WebPubs/execsum.html

United States Environmental Protection Agency, July 1997, EPA Office of Air Quality Planning & Standards, USEPA, Triangle Park, USA.

United States Environmental Protection Agency, Office of Air Quality Planning and Standards, National Ambient Air Quality Standards, Website:- http:// www.epa.gov/ airs/criteria.html

United States Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Quality Where You Live, PM – How Particulate Matter Affected the Way We Live & Breathe, Health and Environmental Impacts of PM, November 2000, Website - http://www.epa.gov/air/urbanair/pm/ hlth1.html

United States Environmental Protection Agency, Office of Air Quality Planning and Standards, Regulating Smog and Particle Air Pollution: An Integrated Approach, Information on Particulate Matter, August 1997, Website - http://www.epa.gov/ oaqps/regusmog/infpart.html

Wilson, W.E.; Suh, H.H., " Fine Particles and Coarse Particles: Concentration Relationships Relevant to Epidemiologic Studies" Journal of Air & Waste Management Association, 1997, 47, 1238-1249

www.wikipedia.org/

ANNEXURE

ANNEXURE 1

Air Pollutants, their sources and effects

Pollutant	Possible Sources		Effects	
	Natural	**Anthropogenic**	**Human / flora / fauna**	**Environment & Property**
Sulphur dioxide (SO_2) **SO_2** is the chemical compound produced by volcanoes and in various industrial processes and are also a precursor to particulates in the atmosphere.	• Volcanos (67%)	• combustion of fossil fuel (coal, heavy fuel oil in thermal power plants, office, factories) • paper Industry • extravtion & distribution of fossil fuels • smelting of metals (sulfide ores to produce copper, lead and zinc) • Petroleum refining • combustion process in diesel, petrol, natural gas driven vehicles	• respiratory illness • visibility impairment • aggravate existing heart and lung diseases	• acid rain • aesthetic damage
Oxides of Nitrogen (NOx) Oxides of nitrogen are a generic term for a group of highly reactive gases that contain nitrogen and oxygen in varying amounts.NOx are emitted as nitrogen oxide (NO) which is rapidly oxidized to more toxic nitrogen dioxide (NO2) Nitrogen dioxide (NO_2) is a reddish-brown toxic gas with a characteristic sharp, biting odor and is a prominent air pollutant.	• Lightning • Forest fires • Bacterial activity of soil	• High temperature combustion (internal combustion engines, fossil fuel-fired power stations, industrial) • Burning of Bio-mass and Fossil Fuels	• irritates the nose and throat • increase susceptibility to respiratory infections	• Precursor of ozone formed in the troposphere • Form atmospheric fine particulate matter burden as a result of oxidation to form nitrate aerosol
Respirable Suspended Particulate Matter (PM_{10}, size ≤ 10μm, coarse fraction PM_{10} - $PM_{2.5}$). called thoracic fraction) Particulate matter (PM) is a complex mixture of suspended solid and liquid particle in semi	• Coarse particles are produced by the mechanical break-up of larger solid particles. • Wind blown dust	• Road traffic emissions particularly from diesel vehicles • Industrial combustion plants some public power generation • Commercial and residential combustion	• cardio-pulmonary problems • asthma, bronchitis, and pneumonia in older people	Visibility reduction

Pollutant	Possible Sources		Effects	
	Natural	Anthropogenic	Human / flora / fauna	Environment & Property
equilibrium with surrounding gases. The major constituents of RSPM are organic and elemental carbon, metals/elements like silicon, magnesium, iron, ions like sulphates, nitrates, ammonium etc. PM10 can settle in the bronchi and lungs and cause health problems	such as road dust, fly ash, soot, agricultural processes • physical processes of crushing, grinding and abrasion of surfaces. • photochemically produced particles, such as those found in urban haze • Pollen grains, mould spores, and plant and insect parts • Non-combustible materials released when burning fossil fuels.	• Non-combustion processes (e.g. quarrying) • agricultural activities		

Pollutant	Possible Sources		Effects	
	Natural	Anthropogenic	Human / flora / fauna	Environment & Property
Particulate Matter 2.5 ($PM_{2.5}$, size ≤ 2.5μm, **fine** fraction size up to 2.5 μm, respirable fraction) Airborne particles smaller than 2.5 μm called fine particles. Composed mainly of carbonaceous materials (organic and elemental), inorganic compounds (sulfate, nitrate, and ammonium), and trace metal compounds (iron, aluminium, nickel, copper, zinc, and lead). pose the greatest problems, *$PM_{2.5}$*, tend to penetrate into the gas exchange regions of the lung, and very small particles (< 100 nanometers) may pass through the lungs to affect other organs. The smallest particles, however, less than 100 nm (nanoparticles) can get into the bloodstream and affect the cardiovascular system	• Fine particles are largely formed from gases. • Ultrafine particles are formed by nucleation, which is the initial stage in which gas becomes a particle. These particles can grow up to a size of 1μm either through condensation, when additional gas condensates or coagulation	• Vehicular emission • Industrial combustion plants some public power generation • Commercial and residential combustion	• oxidative stress • respiratory symptoms such as irritation of the airways, coughing, or difficulty breathing • decreased lung function • aggravated asthma • chronic bronchitis • irregular heartbeat cardio-pulmonary disordera • premature death in people with heart or lung disease	• aesthetic damage • visibility reduction
Ozone(O_3) Ozone is a pale blue gas, soluble in water and non-polar solvents with specific sharp odor somewhat resembling chlorine bleach. Ozone is a secondary pollutants formed in the atmosphere by reaction between oxides of nitrogen and volatile organic compounds (VOCs) in the presence of sunlight. Peak O_3	• ozone is present in the atmosphere in the stratosphere, in a region also known as the ozone layer between about 10 km and 50 km above the surface	• formed by the reaction of sunlight on air containing hydrocarbons and nitrogen oxides emitted by car engines, industrial operations, chemical solvents to form ozone • electronic equipment such as photocopiers	• lung function deficits • respiratory illness • premature death, asthma, bronchitis, heart attack, and other cardiopulmonary problems. • ground-level ozone and pollution which interferes with photosynthesis and stunts overall growth of some plant species	• Ozone cracking in car tires, gaskets, O-rings is caqused by attack of ozone on any polymer possessing olefinic or double bonds within its chain structure, • ozone present in the upper troposphere acts as a greenhouse gas, absorbing some

Pollutant	Possible Sources		Effects	
	Natural	Anthropogenic	Human / flora / fauna	Environment & Property
levels occur typically during the warmer times of the year.				of the infrared energy emitted by the earth.
Lead Lead is a bright silvery soft, dense, ductile, highly malleable, bluish-white metal that has poor electrical conductivity heavy metal and is highly resistant to corrosion.	• food (lead is absorbed by plants)	• Waste incineration • Metal processing • Paint Industry • lead solder in food cans, breast milk, drinking water, Cosmetics, ceramic pottery, burning of firewood or kerosene, indigenous remedies, tobacco and tobacco products, contaminated drinking water, toys, industrial effluents, lead acid batteries, ammunition, paints and varnishes, water pipes • automobile exhaust,	• Pb is rapidly absorbed into the bloodstream and is believed to have adverse effects on the central nervous system, the cardiovascular system, kidneys, and the immune system • causes blood disorders like anemia increase in blood presssure. • potent neurotoxin that accumulates both in soft tissues and the bones. • causes nephropathy, and colic-like abdominal pains. • weakness in fingers, wrists, or ankles. • Miscarriage and reduction of fertility in males, delayed puberty in girls • permanently reduce the cognitive capacity of children	

Pollutant	Possible Sources		Effects	
	Natural	Anthropogenic	Human / flora / fauna	Environment & Property
Carbon monoxide (CO) . also called **carbonous oxide**, is a colorless, odorless and tasteless gas which is slightly lighter than air. It is highly toxic to humans and animals in higher quantities. Mainly formed by incomplete combustion of carbon containing fuels.	• produced during normal animal metabolism (by the action of heme oxygenase 1 and 2 on the heme from hemoglobin breakdown and produces carboxyhemoglobin in normal persons) in low quantities and has some normal biological functions (signalling molecule) • volcanic activity • forest and bushfires	• Exhaust of internal combustion engines, especially of vehicles with petrol engines • Burning of carbon fuels • organic combustion in waste incineration • power station processes • Iron smelting • burning of crop residues	• CO enters the bloodstream through lungs and combines with hemoglobin forms carboxyhemoglobin.This condition is known as anoxemia, which inhibits blood's oxygen carrying capacity to organs and tissues. • Persons with heart disease are sensitive to CO poisoning and may experience chest pain if they breathe the gas while exercising. • adverse effects on the fetus of a pregnant woman • Infants, elderly persons, and individuals with respiratory diseases are also particularly sensitive. • anti-inflammatories, vasodilators and encouragers of neovascular growth	
Ammonia (NH3) A compound of nitrogen and hydrogen, a colourless gas with a characteristic pungent odour. Contributes significantly to the nutritional needs of terrestrial organisms by serving as a	• putrefaction of nitrogenous animal and vegetable matter • Ammonia and ammonium	• Farms • Fertilizers Industry • Industrial sites that store ammonia or use it as a refrigerant can release high levels if the chemical leaks or is spilled	• irritating to skin, eyes, throat, and lungs and cause coughing • burns • Lung damage and death may occur after exposure to very high	Odour

Pollutant	Possible Sources		Effects	
	Natural	Anthropogenic	Human / flora / fauna	Environment & Property
precursor to food and fertilizers, and either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals.	salts are also found in small quantities in rainwater, fertile soil and in seawater • during volcanic erruption • The kidneys secrete NH_3 to neutralize excess acid		concentrations of ammonia	
Benzene (C6H6) Benzene is a colorless, sweet smelling liquid. Benzene is generated whenever carbon-rich materials undergo incomplete combustion. Benzene is generated whenever carbon-rich materials undergo incomplete combustion.	• volcanoes • forest fires	• Combustion of fuel (automotive fuel, wood and stationary fossil fuel, other aromatics • evaporation (fuel storage containers, during refueling • Industrial emission • Coke oven • Perchlorethlyene is emitted from some dry cleaning facilities • tobacco smoke, wood smoke • glues, paints, furniture wax, and detergents	• Hematotoxic, neurotoxic, leukemogenic, carcinogenic effects • Chronic exposure to benzene may causechromosomal damage, immune suppression, aplastic anemia, myelodysplastic syndrome, leukemia, non-Hodgkins's lymphoma, and cancer of the lung and nasopharynx • Effect the Reproductive system, developing fetus and fertility in men, low birth weights, delayed bone formation, and bone marrow damage	
Polyaromatic hydrocarbons (BaP) (particulate phase only) is a five-ring polycyclic aromatic	• coal tar (after a forest fire), • eruption of	• Incomplete combustion of fuels (processing of coal and crude oil)	• Mutagenic and highly carcinogenic (skin, lung, and bladder cancer in	

Pollutant	Possible Sources		Effects	
	Natural	Anthropogenic	Human / flora / fauna	Environment & Property
hydrocarbon whose metabolites are mutagenic and highly carcinogenic	volcanoes	• Combustion of natural gas • Road transport • Industrial plant • Tobacco smoke • coal tar • automobile exhaust fumes (especially diesel engines), in all smoke resulting from the combustion of organic material • charbroiled food, burnt toast, cooked meat products, in burnt foods such as coffee	humans and in animals) • skin rash or eye irritation • Bronchitis	
Arsenic (As) is a solid layered, a ruffled analogue of graphite, metallic gray in color and is a semiconductor. It is a potent poison IARC) recognizes arsenic and group 1 carcinogen (IARC)	• volcanic ash, weathering of the arsenic-containing mineral and ores as well as groundwater. • food, water, soil and air	• Smelting of metals, • Combustion of fuels (especially of low-grade brown coal) • Use of pesticides. • wood preservation, glass production, nonferrous metal alloys, electronic semiconductor manufacturing. • coke oven emissions associated with the smelter industry	• epigenetic changes • multi-system organ failure • As poisoning	
Nickil (Ni) a silvery-white lustrous corrosion-resistant metal with a slight golden tinge	• urease (an enzyme which assists in the hydrolysis of urea) contains nickel	• Combustion of fossil fuels • Nickel plating • Metallurgical processes	• Nickel sulfide fume and dust is believed to be carcinogenic • allergy, dermatitis. Sensitivity to nickel may also be present in patients with pompholyx.	• explosive in air

ANNEXURE 2

Methods of Measurement

a) Sulphur Dioxide (SO_2)

Sulphur dioxide content in the ambient air is measured by the modified West and Gaeke method. Sulphur dioxide in ambient air is absorbed in a solution of 0.04M sodium tetrachloromercurate at an average flow rate of 1 liter per minute (LPM), resulting in the formation of dischlorosulphitomercurate complex. The main interference is due to the oxides of nitrogen, ozone and trace metals. Interference from oxides of nitrogen can be prevented by adding sulphamic acid, which acts as a reducing agent and converts some of the oxygenated nitrogen species to nitrogen gas. Interference from ozone can be eliminated by aging the sample prior to analysis. Interference from trace metals can be prevented by adding EDTA (disodium salt) to the unexposed absorbing solution. For analysis, the exposed sample is treated with sulphamic acid, formaldehyde and acid bleached pararosaniline containing hydrochloric acid. Pararosaniline, formaldehyde and bisulfite anion react to form violet red coloured pararosaniline methyl sulphonic acid. The intensity of the colour is measured on a spectrophotometrer at 560 nm wavelength. The detection range of the SO_2 concentration is 4 – 1050 $\mu g/m^3$.

b) Nitrogen dioxide (NO_2)

In the method the NO_2 from ambient air is absorbed in a solution of sodium hydroxide and sodium arsenite. Sulphur dioxide is the major interfering compound. The interference of sulphur dioxide is eliminated by converting it to sulphuric acid by addition of hydrogen peroxide. The absorbed nitrogen dioxide is then reacted with sulphanilamide in the presence of phosphoric acid at a pH of less than 2 and then coupling it with N-(1Nepthyl) ethylenediamine dihydrochloride. The absorbance of the highly coloured azo dye is measured on spectrophotometer at a wavelength of 540 nm. The detection range of the NO_2 concentration is 9 – 750 $\mu g/m^3$.

c) Respirable Suspended Particulate Matter (RSPM/ PM_{10})

PM_{10} are the particulate matter having aerodynamic diameter less than 10 μm and it is fraction of the particulate matter suspended in air and it represents the fraction that is considered to enter the respiratory system. Sources of PM_{10} include road dust, emission from petrol and diesel exhaust, construction and fireplaces. PM_{10} may also be formed from other pollutants (acid rain, NO_x, SO_x, organics) and from incomplete combustion of any fuel. Monitoring of RSPM is carried out for 24 hours with 8-hourly sampling. RSPM is measured gravimetrically with GFA/EPM 2000 filter paper using respirable dust sampler.

d) Suspended Particulate Matter (SPM)

SPM are particulate/aerosol having diameter less than 100μm that tend to remain suspended in the atmosphere for a long period of time. Sea salt, soil dust, volcanic particles and smoke from forest fires are the natural sources of total suspended particulates. Fossil fuel burning and industrial processes are the anthropogenic sources of suspended particulate matter. Monitoring of SPM is carried out for 24 hours with 8-hourly sampling. SPM is measured gravimetrically with GFA/EPM 2000 filter paper using high volume sampler.

For measurement of SPM, ambient air is drawn into a covered housing of HVS through a 20.3 x 25.4 cm (8 x 10") Whatman GF/A or EPM pre weighed glass fiber filter paper at a flow rate of 1.1 to 1.5 cubic meters per minute. The main housing should be rectangular (29 cm x 36 cm) and must be provided with a gable roof having 45^o to the horizontal so that the filter is protected from precipitation and particles less than 100 µm size are only collected on the filter surface. Particles within the size range of 100 to 0.1 µm are ordinarily collected on glass fiber filter.

The mass concentration of SPM in the ambient air, expressed in micrograms per cubic meter is calculated by measuring the mass of collected particulate and the volume of air drawn.