CHAPTER 2
NATIONAL AMBIENT AIR QUALITY MONITORING & NEED FOR ONLINE AIR POLLUTION MONITORING SYSTEM

Air monitoring is usually the long term systematic and routine measurements of air pollution that may be carried out for diverse purposes. The sampling sites together with the equipment involved in acquiring and analyzing the data constitute the monitoring network. The monitoring of air is an important part of any air management programme. The monitoring of air may be carried out broadly for purpose of impact assessment, surveillance or air shed management processes. Air quality monitoring can be used to determine quantities and types of pollutant emissions as well as any effects of such emissions on public health and the environment. Meaningful air quality monitoring requires understanding of the significance of various parameters as indicators of quality plus baseline data for the area under consideration.

The present chapter discusses the national ambient air quality monitoring programme in operation for the measurement of air pollutants in India. The chapter will highlight the key points on the ambient monitoring system in India, such as objectives of the monitoring programme, equipment used, and limitations of the present monitoring system. The chapter will also highlight the significance of online air pollution monitoring programme for monitoring ambient air quality in India.
2.1. INTRODUCTION:

Air quality monitoring in urban areas is of major interest because of greater migration of people to cities and diverse sources of air pollution. For the control and prevention of air pollution and air quality management, there are a number of acts in India for giving necessary legal authority for statutory implementation authorities like CPCB and State Pollution Control Boards. The Air (Prevention and Control of Pollution) Act, 1981 passed by the Government of India came into force from 16th May 1981. This act has jurisdiction throughout the country and gives a holistic approach for managing air pollution problems. This act empowers the state governments to identify and declare areas under air pollution threat in consultation with the State pollution control boards. These pollution threat areas can be revised from time to time and necessary control measures can be stipulated and implemented.

As an integral part of the air pollution control programme, CPCB has established a national network of ambient air quality monitoring stations. This nation-wide programme, called the National Ambient Air Quality Monitoring (NAAQM) was launched in 1984 with a network of with 7 stations at Agra and Anpara. Over the years, the numbers of stations have increased and presently, the network comprises 295 stations spread over 92 cities/towns distributed over 24 stations and 4 UTs. In addition to the NAAQM programme, operated by CPCB, many State Boards have set up ambient air quality monitoring stations under their own programme known as Ambient Air Quality Monitoring (AAQM) programme. National Environmental Engineering Research Institute (NEERI) monitors ambient air quality in 30 stations covering 10 major cities. In addition to the monitoring stations, operated by the Central/State Boards and Research Organizations, major industries have set up monitoring stations as part of the compliance of the consent conditions. Of the 290 monitoring stations, which include 30 stations managed by NEERI, 204 stations are operating at present (TERI, 2001). In states such as Bihar, Haryana and Karnataka, fewer than 50% of the stations are in operation (CPCB 2000).

The National air quality-monitoring network (NAMP) is operated through the following agencies.

- Central Pollution Control Board, Headquarters, Zonal and Regional Offices
- State Pollution Control Boards (SPCBs) in respective states
- Pollution Control Committees in respective Union territories
- National Environmental Engineering Research Institute in 10 major cities (NEERI 2001)
- Visveshwaraya Regional Engineering College, Nagpur and Pune (both in the state of Maharashtra) Pune University, Pune
- K'THM (Karmveer Ravsheb Thorat Kala, Bhausaheb Higher Commerce and Annsasaheb Murkute Science) College, Nasik in the city of Nasik (Maharashtra), and
- Walchand Institute of Technology, Solapur, in the city of Solapur (Maharashtra).

2.2. OBJECTIVES OF NATIONAL AMBIENT AIR QUALITY MONITORING PROGRAMME:

The main objectives of the national ambient air quality-monitoring programme are:

1. To strengthen the existing air monitoring system with the adoption of state-of-the-art methodologies to monitor the air quality;
2. To monitor the criteria pollutants depending on the locations;
3. To determine present air quality status and trend;
4. To provide background air quality data as need for industrial siting and town planning; and
5. To control and regulate pollution from industries and other sources to meet the air quality standards.

The pollutants that have been historically monitored regularly are sulphur dioxide (SO₂), nitrogen dioxide (NO₂) and suspended particulate matter (SPM). In addition to these three pollutants, NEERI monitors additional pollutants: ammonia (NH₃), hydrogen sulphide (H₂S), Respirable suspended particulate matter (RSPM) with an appropriate cut-off size of 10μm and polycyclic aromatic hydrocarbons (PAHs). The monitoring of meteorological parameters such as wind speed and direction, relative humidity and temperature was also integrated with the monitoring of air quality.

RSPM has also been recently added to the pollutants regularly monitored at many CPCB/SPCB monitoring stations. In Delhi, carbon monoxide (CO), ozone, benzene and trace elements have been monitored at a few locations by CPCB (http://envfor.nic.in/cpcb/cpcb.html). The Global Environment Monitoring System (GEMS) in India is supported by 30 monitoring stations operated by NEERI and the data are reported to CPCB, the United Nations Environment Programme (UNEP) and
the World Health Organization (WHO). Recently 8 new monitoring stations, two each in the states of Gujarat, Maharashtra, Tamil Nadu and Uttar Pradesh were established under a World Bank project. The national ambient air quality standards are given in Table 2.1. The details of the regular monitoring programme are given in Table 2.2. Details of the monitoring techniques are provided in Table 2.3. The state-wise distribution of monitoring stations is presented in Map 2.1.

Table 2.1. National Ambient Air quality Standards in India

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Time weighted averaged</th>
<th>Sensitive areas (µg/m³)</th>
<th>Industrial areas (µg/m³)</th>
<th>Residential areas (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur dioxide</td>
<td>Annual</td>
<td>15</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>24 hours</td>
<td>30</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>Oxides of Nitrogen as NO₂</td>
<td>Annual</td>
<td>15</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>24 hours</td>
<td>30</td>
<td>120</td>
<td>80</td>
</tr>
<tr>
<td>Suspended particulate matter</td>
<td>Annual</td>
<td>70</td>
<td>360</td>
<td>140</td>
</tr>
<tr>
<td></td>
<td>24 hours</td>
<td>100</td>
<td>500</td>
<td>200</td>
</tr>
<tr>
<td>Respirable suspended particulate matter</td>
<td>Annual</td>
<td>50</td>
<td>120</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>24 hours</td>
<td>75</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>Lead</td>
<td>Annual</td>
<td>0.50</td>
<td>1.0</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>24 hours</td>
<td>0.75</td>
<td>1.5</td>
<td>1.00</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>8 hours</td>
<td>1000</td>
<td>5000</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>1 hour</td>
<td>2000</td>
<td>10000</td>
<td>4000</td>
</tr>
</tbody>
</table>

Source: CPCB (2000)

2.3. QUALITY ASSURANCE / QUALITY CONTROL:

The Central Pollution Control Board (CPCB) coordinates with various agencies given under section 2.1. to ensure the uniformity, consistency and compatibility of air quality data and provides technical and financial support to them for operating the monitoring stations.
### Table 2.2. Air quality monitoring programme in India

<table>
<thead>
<tr>
<th>Monitoring agency</th>
<th>No. of locations</th>
<th>Cities</th>
<th>Programme</th>
<th>Sponsoring agency</th>
<th>Parameter monitored</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEERI</td>
<td>30 locations (3 each in 10 cities)</td>
<td>Ahmedabad, Mumbai, Calcutta, Delhi, Hyderabad, Jaipur, Kanpur, Kochi, Chennai and Nagpur</td>
<td>NAMP GEMS</td>
<td>CPCB, WHO &amp; UNEP</td>
<td>RSPM, SO₂, NO₂, NH₃, H₂S, SPM</td>
<td>The 30 stations are part of 290 stations supported by CPCB. SPM and RSPM were each monitored on 4 separate days in a month. SO₂, NO₂ are earlier monitored for 6 days a month presently these being monitored on a daily basis and NH₃, H₂S are monitored 2 days a month.</td>
</tr>
<tr>
<td>CPCB/SPCB</td>
<td>260</td>
<td>90 cities/towns</td>
<td>NAMP</td>
<td>CPCB</td>
<td>RSPM, SO₂, NO₂, SPM</td>
<td>RSPM monitoring was introduced in 1999 at 30 stations. By the end of 2000, 77 stations were monitoring RSPM.</td>
</tr>
<tr>
<td>Air pollutants</td>
<td>Monitoring method</td>
<td>Principle</td>
<td>Measuring range</td>
<td>Sampling frequency</td>
<td></td>
<td></td>
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<tr>
<td>--------------------------------</td>
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<td>---------------------------------------------------------------------------</td>
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<td>---------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphur dioxide</td>
<td>Improved West and Gacke method</td>
<td>Absorption followed by colorimetric analysis</td>
<td>4 - 1050 μg/m³</td>
<td>Twice a week</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Daily average from six 4 hour samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>Modified Jacob and Hockesser method</td>
<td>Absorption followed by colorimetric analysis</td>
<td>3 - 420 μg/m³</td>
<td>Twice a week</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Daily average from six 4 hour samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suspended particulate matter</td>
<td>High volume sampling and gravimetric filter method</td>
<td>Sampling by high volume samplers with the average flow rate not less than 1.1 m³/min</td>
<td>5 μg/m³ - 10000 μg/m³</td>
<td>Twice a week</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.3 - 100 μg size</td>
<td>Daily average from six 4 hour samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respirable suspended particulate matter (RSPM)</td>
<td>High volume sampling and gravimetric filter method</td>
<td>Sampling by RSPM sampler and cyclone size separation</td>
<td>5 μg/m³ - 10000 μg/m³</td>
<td>About 80 CPCB stations are monitoring RSPM</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.3 - 100 μg size</td>
<td>Daily average from three 8 hour samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Twice a week and daily average from 4 six hour sample</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>Nesslers reagent</td>
<td>Absorption followed by colorimetric analysis</td>
<td></td>
<td>Twice a week</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Daily average from six 4 hour samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrogen sulphide</td>
<td>Methylthiazine blue</td>
<td>Absorption followed by colorimetric analysis</td>
<td></td>
<td>Twice a week</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Daily average from six 4 hour samples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>Automatic CO analyzer Gas chromatography with Flame ionization detector</td>
<td>Non Dispersive infrared spectroscopy GC-FID</td>
<td>0.1 ppmv - 10 ppmv</td>
<td>Continuous monitoring</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>0.3 - 100 ppmv</td>
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</tbody>
</table>
Figure 2.1 National ambient air quality-monitoring network in India
The methods of measurement for the criteria pollutants are identified in the ambient air quality standards laid down by CPCB under Section 16(2)(h) of the Air Act, 1981 and notified for various air pollutants, i.e. SO₂, NOₓ, SPM, RSPM, Respirable lead and CO. The areas have been categorized as industrial, residential and sensitive. These standards provide the basis for protecting the public health from adverse effects of air pollutants and limiting those contaminants of air within the adequate margin of safety. The air quality data obtained from these monitoring stations is compiled in a report annually and published for the use of policy makers, researchers and general public.

In the NAMP, various agencies and organizations are involved. There appear to be no significant efforts towards quality control or crosschecking of the data generated by different agencies involved in the monitoring network. A CPCB report acknowledges that “the involvement of several agencies increase the probability of variations and personal biases reflecting on the data (TERI, 2001). Therefore the air quality data statistics are indicative rather than absolute and perfect”. As part of QA/QC procedures, the monitoring agencies are required to calibrate the samplers regularly for flow rate measurements, check the sampling train for leakage, select suitable filter papers and chemicals, and calibrate the colorimeter.

But it is observed that these QA/QC measures are not followed rigorously in the field. To quantify the magnitude of errors, a review (“Review of GEMS air monitoring networks in operation in certain cities of South East Asia”) was carried out by NEERI under the sponsorship of UNEP/WHO (TERI, 2001). In this programme parallel sampling and analysis was carried out in 5 cities. The instruments used in the parallel monitoring were centrally calibrated at Nagpur and checked against the practice followed in the field. The result showed a wide range of measurement errors in the selected cities (Table 2.4). The percentages in the table represent the differences in the values obtained between the two sets of instruments.

2.4. SITING OF MONITORING STATIONS
The air quality monitoring programmes are needed for almost all of the actions taken to prevent/abate air pollution from the initial assessment of existing conditions to the enforcement of current control regulations to the evaluation of the effectiveness of abatement programmes and finally to the development of new control measures. The criteria laid down in the WHO publications, 1977, entitled the, "Air Monitoring Programme, Design for Urban and Industrial Areas have been used for establishing
the ambient air quality monitoring network under the NAAQM Programme in India. The criteria guidelines as a whole could not be followed at few places keeping into the view, the location limitations.

2.5 DATA AVAILABILITY

The monitoring data will be submitted to CPCB by agencies, responsible for operation of the National Ambient Air Quality Monitoring (NAAQM) stations every month. The raw data is collated, compiled, interpreted and analyzed at CPCB. The analyzed data will be compiled in the form of report or Ambient Air Quality Status and Statistics and published every year. The monthly air quality data for few states and central regions, Delhi is compiled and made available on Internet. The regular air quality reports of the monitoring data in Delhi are published. Yearly data of the stations under the NAAQM programme is also provided on Internet. The data is made available to all the users whenever asked for. However, few of the state boards do not update the data on a period basic and there appears many missing links.

The air quality of different cities/towns with respect to four criteria pollutants are compared with the respective NAAQS and will be 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:

1. Critical pollution (C): when EF is more than 1.5;
2. High pollution (H): when the EF is between 1.0 - 1.5;
3. Moderate pollution (M): with and EF between 0.5 - 1.0; and
4. Low pollution (L): where the EF is less than 0.5.

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

2.6. DATA QUALITY CHECKS

In order to ensure that the quality of monitoring data, obtained from the network, is acceptable, regular plausibility control and the evaluation of the monitoring data is undertaken. The quality and reliability of data vary from city to city and state to state, thereby making it difficult to complete the different levels of the data, obtained from the network. In order to improve the reliability and precision of the data, collected, quality assurance and quality control needs to be introduced in the system.

CPCB with the assistance from German counterpart has developed Calibration Laboratory with In-house facilities to produce the primary and secondary standards. The facilities are being utilized to impart training to State Boards’ officials for quality control and quality assurance. Facilities are also being used to ensure uniformity in the Analytical procedure and standardization of the procedure. The present available facility is not adequate enough to meet the requirement in the entire country. Considering the importance of quality control proposal for developing facilities for quality control in ring test at more places has been formulated (www.cpcb.delhi.nic.in)

2.7. LIMITATIONS IN THE PRESENT NATIONAL AMBIENT AIR QUALITY MONITORING STATIONS:

In the manual monitoring system (high volume sampling/gravimetric analysis and wet chemical methods), there are a number of reasons as to why the potential for significant errors exists.

In the regular NAMP, the prescribed annual target sampling frequency is 104 days. But this target frequency has rarely been achieved at many monitoring locations. In certain states fewer than 50% of the stations are operational (CPCB, 2000). As reported by CPCB, (CPCB, 2000) due to such problems as instrument failure, lack of trained manpower, and power failure, the target of 104 monitoring days per year is not achieved. In some locations the number of days on which air quality is monitored is fewer than 50 a year, which is considered inadequate for the purpose of data analysis. Until recently, RSPM was regularly monitored by NEERI 4 days a month and SPM was monitored 4 different days a month. Beginning in April 2001, simultaneous monitoring of SPM and RSPM is being gradually introduced at all the stations being operated by NEERI.
In Delhi, gaseous pollutants are monitored by continuous automatic analyzers by CPCB at two stations (ITO, near the Income Tax Office, and Siri Fort). SPM and RSPM are monitored every day of the year by the manual method (high volume sampling technique). In addition to the three historically monitored pollutants, CO and ozone (O₃) are monitored at ITO by CPCB.

2.7.1. Lack of skilled manpower

Experienced or well-trained staffs are vital for the production of good quality data. The training of field assistants and other staff associated with data collection is a major requirement for generating data of adequate quality. Pollution control boards and other organizations manage the monitoring activities with limited manpower. The behavior of field staff also plays a vital role in quality assurance measures. At many stations, flow rates are not regularly calibrated. For the 24-hour monitoring of particulate matter (SPM and RSPM), the filters have to be changed every 8 hours, and the absorbing tubes have to be changed every 4 hours for gaseous pollutants. The flow rates have to be recorded frequently. Some operators do not follow these protocols regularly. Having manuals and detailed site inspection records is also important. Occasional visits by the internal inspection team helps to check the operators' behavior. This also greatly enhances the performance of the staff.

2.7.2. Financial support

The recruitment and retention of suitably qualified and self-motivated individuals requires considerably greater resources. Adequate resources are also necessary for the proper maintenance and calibration of the equipment. At one station, the allotted annual financial support for operation was only about Rs 100,000. This is grossly inadequate.

2.7.3. Data validation

Data validation enhances data integrity through the removal of spurious measurements produced by equipment malfunction, contamination or human error. This is a highly skilled procedure; it must be performed with considerable caution to ensure that invalidation of extreme but valid data does not occur. This requires time, experience and training but contributes to ensuring that data are valid and adequate for their intended use.

2.7.4. Representativeness of locations

The siting of a monitoring station is very important. It should be representative of the area selected. There should be free airflow (that is, tall buildings or trees should not
obstruct the air flow). Ideally the sampler should be located four to twelve meters (m) above ground level. But due to such practical problems as lack of accessibility, lack of availability of (reliable) power supply, and objections from residents to the noise created by the high volume air sampler, the criterion for sampling height is not satisfied at some locations where the samplers are placed 15 m above ground or even higher. Large height variation will in turn affect pollutant concentrations. In the absence of data from rural or background monitoring stations, the data obtained are not sufficient to differentiate between natural and anthropogenic source contributions.

2.7.5. Analytical methods

The present sampling and analysis techniques for gaseous pollutants also require special care. The modified Jacob and Hochheiser method is widely used for the measurement of NO₂ in the ambient air. This method is reported to give 82% absorption efficiency for NO₂ in the concentration range from 40 to 750-μg m⁻³. This method is also sensitive to temperature, flow rate, and the type of bubbler. A study conducted at different flow rates ranging from 0.2 litres per minute (lpm) to 1.4 lpm using a standard bubbler showed an average collection efficiency of 87% at a flow rate of 0.2 lpm and a much reduced collection efficiency of 55% at a flow rate of 1.2 lpm (Pandey G.H., 1991, Goyal 1998). In India the flow rate varies from 0.2 to 1.5 lpm. In many cases the flow rate is not reported. The maximum absorbing efficiency of 88% was recorded at a temperature of 26°C. At lower and higher temperatures the absorbing efficiency was lower. At 16°C and 36°C, for example, the average absorption efficiency was 85% and 78%, respectively. The temperature variations in India are large (less than 5°C in winter to 45°C or even higher in summer).

Therefore the temperature during sampling should be maintained constant, for example by keeping the sampling train in ice. Otherwise a suitable correction factor should be applied during data reduction.

The present RSPM monitoring has cyclone-based separation attached to the high volume air sampler. The commonly used equipment for RSPM monitoring is the Respirable dust sampler supplied by Envirotech Instruments Private Limited. (Envirotech Inc) The know-how was developed by NEERI. The cyclone separation is designed to provide a cut-off at 10 μm (quoted by the manufacturer). But as a centrifugal separation system, this cut-off is bound to vary with the nature and density of dust particles. The system has been tested extensively by NEERI for a variety of particles such as coal dust, cement and fly ash. However, at each particular urban
environment it is necessary to calibrate the cut off ranges for the analyzer. No air-monitoring programme is complete without the measurement of wind speed, wind direction, temperature and relative humidity. These parameters primarily help to quantify atmospheric characteristics, like pollutant transport and diffusion.

2.8. EVOLUTION OF ONLINE AIR POLLUTION MONITORING SYSTEM:
With the growing awareness towards having a cleaner and better environment, the policies and programmes during the past two decades have started reflecting this objective. Investment resources were targeted to ensure realization of these concerns. Ambient air quality has been monitored in India since 1967. However, the prescribed annual target sampling frequency is 104 days has rarely been achieved at many monitoring locations owing to economic and other constraints (TERI, 2001).

In order to tackle these problems, it has become a vital task to automate the data collection and data validation protocols to accurately keep track of the variation of ambient air pollutant levels. A realistic approach for the ambient air pollution monitoring and management should consider real time data collection, data validation using set points and periodic calibration and transferring the data through Internet.

This way round the clock cost effective monitoring can ideally achieved. By integrating with weather monitoring data a comprehensive database on the air quality index of the area can be developed showing which pollutants are exceeding national and international air quality standards and guidelines.

Development of cost effective and accurate pollution monitoring system with a mechanism to disseminate the pollution values and air quality index values to general public are essential for successful pollution mitigation measures as well as safe guarding general public to pending air pollution scenarios.

Keeping above problems in mind in recent times, concept of online pollution monitoring and disseminating the same through Internet has been developed and used effectively in many industrialized countries. As a result, most environmental agencies directly disseminate air quality information through their websites (e.g. USA—http://epa.gov.in/airnow).

2.9. ONLINE AIR POLLUTION MONITORING:
The recognition in recent years of the importance of determining health and environmental impacts of air pollutants and their long-range transport, both national and international, underlines the need for a well-established nationwide online air pollution-monitoring network for different criteria pollutants. The online air pollution
monitoring system data have attracted interest for potentially providing improved air quality data for understanding air pollution, such as formation and transport of ozone or acid deposition. An online air pollution monitoring system is the total equipment necessary for the determination of a gas or particulate matter concentration using pollutant analyzer measurements and a conversion equation, graph, or computer program to produce results in units of the applicable air pollution standard and transmission of data to World Wide Web (internet).

The results obtained from the online monitoring station can be used to improve air quality through control strategy development, to improve modeling science, and even to estimate short-term future air quality. The Online air pollution data collected hourly and year-round; therefore, they provide the most detailed source of utility emissions and fuel consumption publicly available. Air quality data from the network provide governments, and the public, with essential information about air pollution, which allows them to assess whether National Air Quality Objectives are being met.

Air quality data collected by the Online air pollution monitoring network provide the basis for evaluating air pollution control strategies, identifying urban air quality trends, and warning of emerging air pollution issues.

2.9.1. Types of online air pollution monitoring systems:

Depending upon the resources available and objectives three basic air quality networks can be set up.

1) **Uniform area based network:** also called the rectilinear grid system, in this network the sampling sites are located in the areas in a rectilinear grid

2) **Pollutant concentration based network:** This is based on the concept that the air quality is normal below standards where pollution sources are located. Most of the sampling sites in this network are located in the areas of higher pollutant concentration.

3) **Population distribution based network:** In this network the sampling sites are in the most populated areas without taking into consideration the least pollutant areas, which in fact, can be left out as they have the least population. This system of monitoring gives the levels of air pollutants to which the bulk of the population are exposed. Continuous ambient air quality monitoring is carried out either as General air pollution assessment and to assess the pollution load from roadside air pollution

1. **General air pollution monitoring stations:** This monitors the ambient air quality of a fixed region.
2. Roadside air pollution monitoring stations: This monitors the ambient air quality near road with large traffic volume and assesses air pollution caused by exhaust gas from automobiles.

3. Continuous monitoring of stationary source is defined as continuously measuring of emission of pollution from factories. In general, on-site investigation is made by local governments to check the status of emission of pollution from factories and to determine if the concentration meets emission standards for pollutants. However some local governments, where air pollution problems are serious, make pollution-control agreements with some factories and businesses to continuously monitor the concentration and volume of pollutants emitted from stacks by above-mentioned system. This is done because factories and businesses with large volume of emission gas impact the human living environment.

2.9.2. The purpose of general air pollution monitoring stations
General air pollution monitoring stations are established to obtain data to determine 1. To determine the air quality status to compare with the environmental quality standards for air pollution, 2. To obtain data which need to take measures for emergency due to the prevention of damage to human health and living environment by air pollution 3. To obtain data which need to take measures for emergency due to the prevention of damage to human health and living environment by air pollution. 4. To establish air pollution control measures and evaluate their effects. 5. To check trends of air pollutant and their effects for long time.

2.9.3. The purpose of roadside air pollution monitoring stations
Roadside air pollution monitoring stations are established to obtain data for the purposes described below: (1) To determine if air quality in the roadside region meets environmental air quality standards. (2) To establish grounds to take measures based on regulations of the Road Traffic flow, and for stating opinions regarding the structure, etc. 2.9.4. Continuous monitoring of stationary source
The purposes of establishing monitoring stations for stationary source are as follows: (1) To check the hourly values with regard to various emission standards such as total mass emission control standards for SO₂ and NOx in accordance with National Ambient air Quality Standards. (2) To effectively monitor the compliance of a factory in reducing its emission volume in an emergency. (3) To promote self-management of emission by a factory. Continuous monitoring of stationary source is effective in
managing its emission from stationary source with large emission volume. However in many cities only National Ambient air quality monitoring and background sites are used to monitor air pollutants.

2.9.5. Community oriented sites:
Community-oriented sites are located where people live, work, and play rather than at the expected maximum impact point for specific source emissions. These sites are not located within the microscale or middle-scale zone of influence of a specific, nearby particle emitter. Community oriented sites may be located in industrial areas as well as and in residential, commercial, recreational, and other areas where a substantial number of people may spend a significant fraction of their day.

Core sites are used to determine NAAQS compliance for both annual and 24-hour PM$_{2.5}$ standards. Because core sites are the only sites eligible for comparison to both the annual and 24-hour PM$_{2.5}$ NAAQS, they are the most important sites in the new PM$_{2.5}$ network. PM$_{2.5}$ concentrations may be spatially averaged among these sites within a community exposure zones when the annual average PM$_{2.5}$ at each core site is within ±20% of the spatial average on a yearly basis. Core sites should have a zone of representation of at least neighborhood scale (>0.5 km).

2.9.6. Daily Compliance Sites:

Daily compliance sites are used to determine NAAQS compliance for the 24-hour (daily) PM$_{2.5}$ standard, but not for the annual standard. Because a daily compliance site does not necessarily represent community-oriented monitoring, it may be located near an emitter with a microscale or middle-scale zone of influence.

The PM monitoring regulations state that any population-oriented site is eligible for comparison to the 24-hour PM$_{2.5}$ standard. If the monitoring site is also representative of community-wide air quality, it is eligible for comparison to the annual PM$_{2.5}$ NAAQS. With a few anticipated exceptions, almost all sites in the new network will be population-oriented. A site may be population-oriented and at the same time be source oriented or reflective of maximum concentration. The same is true for the existing PM$_{10}$ network.

Population-oriented sites may be located in hot spot locations and other portions of the above areas, which are likely to invoke exposure to fine particles for at least part of a 24-hour sampling period. Hot spot locations have a micro or middle measurement scale of representativeness. Microscale means that the 24-hour measurements should vary by no more than ±10% within a circle of diameter 100
meters. Middle scale means that the 24-hour measurements should vary no more than ±10% within a circle of diameter 100-500 meters. These distances are the area around the monitor, which may be different than the distance to the nearest major influencing source.

2.9.7. Special Purpose Monitors (SPM):
Suspended Particulate Matter may or may not be used to determine compliance with national ambient air quality standards. Their purpose is to understand the nature and causes of excessive concentrations measured at compliance monitoring sites. Special purpose monitors may be discontinued within their first two years of operation without prejudice when their purpose has been achieved. Typical special purpose monitors might include: 1) portable saturation monitors operated at many locations around central areas sites to determine zones of representation, zones of influence, and spatial uniformity; 2) sequential samplers with Teflon and quartz filters or absorbing substrates to determine diurnal distributions of PM chemical components and precursor gases; and 3) short-time-resolution continuous monitors to determine diurnal mass concentration changes in response to changes in emission rates and meteorology.

2.9.8. Ambient air quality monitoring sites:
Subsets of core and transport sites will be selected for long-term monitoring and will be designated as PM2.5 National Ambient Monitoring Stations for assessing trends and for performing future epidemiological studies.

2.9.9. Background Sites:
Background sites are intended to represent regional-scale PM_{2.5} concentrations that may be a combination of contributions from several and non-urban source areas, as well as natural emissions. These are usually located in pristine areas, such as National Parks and Wilderness areas, and possibly at elevations higher than other monitoring places, but still within the typical mixed layer of the atmosphere.

2.10. CONCLUSIONS:
Urban air pollution is one the primary priorities of environmental concern due to public awareness. Necessity to inform the public of air pollution levels is a very urgent problem nowadays. The emission resulting from natural and anthropogenic sources such as industry, road are very often of high uncertainty. Moreover, the monitoring of the criteria pollutants involves heavy financial, technical contributions, huge manpower and tedious analytical procedures with sophisticated equipment.
which could not be affordable nationwide. On the other hand the air environment has to be protected from polluting elements for the healthy survival of the future generations. A better alternative could be setting up of continuous monitoring stations at selected locations for a defined period and evolving models based on the observed data that will be useful for the implementation of mitigation strategies for controlling urban air pollution. The present chapter highlighted the various ambient air quality monitoring programmes currently being in practice in India and the need and types of continuous air pollution monitoring station.
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