

# **Assessment of dust sample for PM<sub>10</sub> & PM<sub>2.5</sub> fraction to establish its impact in Satna City (M.P.) India**

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## **Abstract:**

Ambient air quality refers to the quality of outdoor air that surrounds us in the environment. It is influenced by a variety of factors, including natural sources such as dust and pollen, as well as anthropogenic sources such as transportation and industry. Outdoor air pollution causes public health hazards like cardiovascular disease, respiratory diseases etc. Assessment is necessary to be carried out in urban areas which are severely exposed to outdoor air pollution. Air pollution is mainly associated with industrial and automobile sources of which motor vehicles are of major concern. TO carry out study on assessment of ambient air quality parameters like Sulphur Dioxide (SO<sub>2</sub>), Oxides of Nitrogen as NO<sub>2</sub>, Respirable Suspended Particulate Matter (RSPM / PM<sub>10</sub>) and Fine Particulate Matter (PM<sub>2.5</sub>) various methods can be adopted to monitor air quality. This study will lead us to discuss various approaches and methods to assess ambient air quality and counter air pollution.

**Keywords:** Ambient Air, Air Pollution, Assessment, PM<sub>10</sub>, PM<sub>2.5</sub>

## **1. INTRODUCTION**

Air pollution refers to the presence of harmful substances and particles in the air we breathe. These pollutants originate from various sources, including industries, motor vehicles, thermal power plants, and natural events such as wildfires and dust storms. The most common air pollutants include particulate matter (PM), nitrogen oxides (NO<sub>x</sub>), sulphur dioxide (SO<sub>2</sub>), ozone (O<sub>3</sub>), and carbon monoxide (CO). Air pollution adversely affects human health by causing respiratory diseases such as asthma and bronchitis, increasing the risk of cardiovascular diseases, stroke, and lung cancer, and contributing to environmental degradation, crop damage, and climate change [1, 2, 7].

Urban air quality plays a significant role in maintaining the quality of life of living beings. Recent studies conducted across different regions of the world have reported increasing concentrations of ozone (O<sub>3</sub>) and particulate matter (PM), posing serious threats to public health and environmental sustainability [3, 7, 9]. Air quality assessment has therefore become an essential component of environmental monitoring and management.

In India, the Central Pollution Control Board (CPCB) operates a nationwide ambient air quality monitoring network known as the National Air Quality Monitoring Programme (NAMP). The programme covers numerous cities and towns across the country and focuses on regular monitoring of key pollutants, namely Sulphur Dioxide (SO<sub>2</sub>), Oxides of Nitrogen (NO<sub>2</sub>), Respirable Suspended Particulate Matter (RSPM/PM<sub>10</sub>), and Fine Particulate Matter (PM<sub>2.5</sub>) [4, 8]. The National Ambient Air Quality Standards (NAAQS) established by CPCB provide guidelines for maintaining acceptable air quality levels and protecting public health [4].

Exposure to high levels of air pollution is associated with several adverse health outcomes, including respiratory infections, cardiovascular diseases, stroke, and lung cancer. Both short-term and long-term exposure to air pollutants can significantly affect human health, particularly among vulnerable groups such as children, the elderly, and individuals with pre-existing medical conditions [3, 6, 7]. Although air quality has improved in many developed countries due to stringent regulations and technological advancements, particulate matter pollution continues to remain a major public health concern worldwide [7].

Air pollution is often generated from multiple sources, making its control a complex challenge. While improvements in vehicle engine efficiency and fuel quality have reduced emissions per vehicle, the rapid increase in the number of vehicles has offset many of these gains, particularly in urban areas [6, 10]. Studies conducted in Indian cities have shown that vehicular emissions, industrial activities, and urbanization significantly contribute to deteriorating ambient air quality [8, 10, 11].

Air pollution has emerged as a major environmental concern in India due to rapid industrialization, urbanization, population growth, and increasing energy demand. Recent climatic changes have further influenced air quality patterns, creating conditions that adversely affect human health and the environment [8, 10]. Addressing air pollution requires substantial governmental investment and implementation of effective environmental policies. Developing countries like India continue to face increasing air pollution challenges due to expanding urban centers and growing anthropogenic activities [4, 8, 11].

Under the National Air Quality Monitoring Programme (NAMP), the CPCB emphasizes regular monitoring of four major pollutants, namely Sulphur Dioxide (SO<sub>2</sub>), Oxides of Nitrogen (NO<sub>2</sub>), Respirable Suspended Particulate Matter (PM<sub>10</sub>), and Fine Particulate Matter (PM<sub>2.5</sub>), which serve as important indicators of ambient air quality and environmental health [4]. Continuous monitoring and assessment of these pollutants are essential for formulating effective air quality management strategies and ensuring sustainable urban development.

## **2. Air Pollution in Satna:**

Geographically, Satna is situated in the northeastern part of Madhya Pradesh and lies between 24.57°N latitude and 80.83°E longitude. The city has an average elevation of approximately 315 metres above mean sea level and forms part of the Vindhyan plateau region. Satna is characterized by a semi-arid to subtropical climate with hot summers, moderate monsoons, and cool winters. The terrain is generally undulating with isolated rocky outcrops and small hills in the surrounding areas. Satna is an important industrial and commercial center of Madhya Pradesh, particularly known for its cement manufacturing industries. The city is well connected through road and rail networks, making it a major transportation

hub in the Baghelkhand region. Rapid urbanization, increasing vehicular traffic, construction activities, and industrial operations contribute significantly to air pollution in the city. Major air pollutants present in Satna include particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>), sulfur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), carbon monoxide (CO), ozone (O<sub>3</sub>), ammonia (NH<sub>3</sub>), and trace heavy metals. Among these pollutants, particulate matter is considered the dominant pollutant due to emissions from industries, road dust, vehicular exhaust, and construction activities.

The present study was conducted at eight major traffic intersections of Satna city, namely Civil Line Chowk, Semaria Chowk, Circuit House Chowk, Railway Station Chowk, Rajendra Nagar Chowk, B. R. Ambedkar Chowk, Bharhut Nagar Chowk, and Tikuriya Tola Chowk. These locations were selected based on traffic density, commercial activities, and population exposure. Ambient air quality monitoring was carried out during May 2025 to assess PM<sub>2.5</sub> and PM<sub>10</sub> concentrations and evaluate the air quality status of Satna city.

Table 1: Annual Average Value of PM <sub>10</sub> in Satna City (µg/m <sup>3</sup> )						
S. No.	Station / Location	YEAR				
		2018 PM <sub>10</sub>	2019 PM <sub>10</sub>	2020 PM <sub>10</sub>	2021 PM <sub>10</sub>	2022 PM <sub>10</sub>
1	MPPCB Regional Office, Satna	98	102	108	112	103
2	Industrial Area, Gahranala, Satna	112	118	127	133	126
3	Satna City (Average)	105	110	118	123	115

*Source: Central Pollution Control Board (CPCB) – National Air Quality Monitoring Programme (NAMP)*

Table 2: Annual Average Value of PM <sub>2.5</sub> in Satna City (µg/m <sup>3</sup> )						
S. No.	Station / Location	YEAR				
		2018 PM <sub>2.5</sub>	2019 PM <sub>2.5</sub>	2020 PM <sub>2.5</sub>	2021 PM <sub>2.5</sub>	2022 PM <sub>2.5</sub>
1	MPPCB Regional Office, Satna	42	46	49	53	47
2	Industrial Area, Gahranala, Satna	48	53	58	62	56
3	Satna City (Average)	45	50	54	58	52

*Source: Central Pollution Control Board (CPCB) – National Air Quality Monitoring Programme (NAMP)*

### 3. Air Quality Monitoring

The methods of measurement prescribed by CPCB for respective parameters are the combination of physical method, wet-chemical method and continuous online method. The continuous online ambient air quality monitoring systems are equipped with analyzers for measurement of PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub>, CO, NO<sub>2</sub>, O<sub>3</sub>, NH<sub>3</sub> and Benzene. The metallic parameters Pb, Ni, As are measured offline using filter based air samplers. The ambient air quality monitoring station (AQMS) consists of following systems:

- PM<sub>10</sub> & PM<sub>2.5</sub>: Operates on the principle of Beta Ray Attenuation and measures Particle Mass concentration ranging from 0 to 5 mg/m<sup>3</sup> with Minimum detection limit 1 µg/m<sup>3</sup>. The equipment includes a PM<sub>10</sub> inlet and PM<sub>2.5</sub> inlet.
- NO<sub>x</sub> and NH<sub>3</sub>: Operates on the principle of Chemiluminescence method, ranging from 0 to 2000µg/m<sup>3</sup> with minimum detection limit 0.5µg/m<sup>3</sup>.
- SO<sub>2</sub> Analyser: Operates on the principle of UV Fluorescence method, ranging from 0 to 2000 µg/m<sup>3</sup> with minimum detection limit 0.5 µg/m<sup>3</sup>.

- O<sub>3</sub> Analyser: Operates on the principle of UV Photometry method, range : 0 to 2500µg/m<sup>3</sup> with minimum detection limit 0.5 µg/m<sup>3</sup>.
- Multigas Calibrator: to calibrate gas analyzers manually, remotely controlled or automatically, for quality assurance. Multi Calibration upto 20 points.
- Automatic Weather Station (AWS): Ultrasonic Wind Sensor, Barometric Pressure, Temperature, Relative Humidity, Rainfall, Solar Radiation etc.

All these instruments except AWS are housed in a room or walk-way shelter with a proper sampling system for gaseous and particulate matter parameters. AQMS should have the calibration facility for onsite calibration with zero and standard gases. Beta Ray Attenuation for the measurement of PM<sub>10</sub> and PM<sub>2.5</sub> should be calibrated with standard filters. The detailed guideline for site selection, measurement frequency, reporting etc has been notified by CPCB. Each AQMS should also have a PC for recording and transmission of the data via the internet.

## 4. Air Quality Monitoring Mechanisms

### A. Air Quality Monitoring System (AQMS)

The **Air Quality Monitoring System (AQMS)** is an advanced automated system designed to continuously measure the concentration of various air pollutants present in the atmosphere. It provides real-time air quality data that helps environmental agencies assess pollution levels, identify pollution sources, and formulate mitigation strategies.

### Components of AQMS

#### 1. Air Quality Walkway Shelter

- A specially designed enclosure that houses all monitoring instruments.
- Protects sensitive equipment from adverse weather conditions such as rain, dust, and extreme temperatures.
- Maintains a controlled environment for accurate measurements.

#### 2. Air Quality Analyzers

- Measure concentrations of key pollutants including:
  - Particulate Matter (PM<sub>10</sub> and PM<sub>2.5</sub>)
  - Sulphur Dioxide (SO<sub>2</sub>)
  - Nitrogen Oxides (NO<sub>x</sub>)
  - Carbon Monoxide (CO)
  - Ozone (O<sub>3</sub>)
  - Ammonia (NH<sub>3</sub>)
- Different analytical techniques such as beta attenuation, chemiluminescence, UV fluorescence, and non-dispersive infrared spectroscopy are used for pollutant measurement.

#### 3. Sampling System

- Draws ambient air from the surrounding atmosphere through sampling inlets.
- Filters and conditions the sample air before it enters the analyzers.
- Ensures representative and contamination-free air samples.

#### 4. Calibration System

- Regularly checks and adjusts analyzer performance using standard reference gases.
- Maintains measurement accuracy and reliability.

- Performs automatic zero and span calibrations at scheduled intervals.

## 5. Zero Air Generator

- Produces pollutant-free air used as a reference during calibration.
- Helps eliminate measurement drift and instrument errors.

## 6. Uninterruptible Power Supply (UPS)

- Provides backup power during electricity outages.
- Ensures uninterrupted operation and continuous data collection.

## 7. Air Conditioning Units (ACs)

- Maintain stable temperature and humidity conditions inside the shelter.
- Prevent equipment malfunction due to environmental fluctuations.

## 8. Control Computer

- Collects data from all analyzers.
- Performs preliminary processing and validation.
- Stores and transmits data to local and central servers.

### Working Mechanism of AQMS

The ambient air is continuously drawn into the shelter through the sampling system. The air analyzers measure concentrations of various pollutants and transmit the readings to the control computer. The calibration system periodically verifies instrument accuracy using standard gases and zero air. The processed data are then transmitted to the city control room, where information from multiple monitoring stations is integrated. Subsequently, the data are forwarded to the Central Control Room Server at IITM Pune and FTP servers for storage, analysis, dissemination, and public reporting. This automated mechanism enables continuous, real-time monitoring of urban air quality.

### B. Digital Display System (DDS)

The **Digital Display System (DDS)** is a public information dissemination platform that displays real-time air quality information and environmental parameters for public awareness.

#### Components of DDS

##### 1. LED Display Boards

- Large outdoor screens visible from long distances.
- Display Air Quality Index (AQI), pollutant concentrations, and health advisories.

##### 2. LCD Display Boards

- High-resolution displays used in public buildings, offices, and monitoring stations.
- Provide detailed environmental information.

##### 3. Control Computer

- Receives air quality data from the FTP server.
- Processes and formats information for display.
- Controls display timing and content updates.

### **Working Mechanism of DDS**

Air quality data generated by AQMS are transmitted to the FTP server. The DDS control computer continuously retrieves updated information from the server. The data are processed into user-friendly formats such as AQI categories, pollutant concentrations, and health messages. The information is then displayed on LED and LCD boards installed at prominent public locations. This mechanism enables citizens to access real-time air quality information and take necessary precautions during high pollution episodes.

### **C. Automatic Weather Stations (AWS)**

The **Automatic Weather Station (AWS)** is an integrated meteorological monitoring system that continuously measures atmospheric parameters influencing air pollution dispersion and transport.

#### **Components of AWS**

1. **Meteorological Sensors**

- Temperature Sensor
- Relative Humidity Sensor
- Wind Speed Sensor (Anemometer)
- Wind Direction Sensor (Wind Vane)
- Rain Gauge
- Solar Radiation Sensor
- Atmospheric Pressure Sensor

2. **Data Logger**

- Collects and stores measurements from all sensors.
- Performs initial processing and quality checks.

3. **Communication System**

- Transfers weather data to local and central servers through wired or wireless networks.

4. **Control Computer**

- Receives meteorological data from multiple AWS stations within a city.
- Integrates and forwards data to the Central Control Server at IITM Pune.

#### **Working Mechanism of AWS**

Meteorological sensors continuously monitor atmospheric conditions at predetermined intervals. The collected data are stored and processed by the data logger before being transmitted to the local control computer. Information from multiple AWS stations is consolidated and sent to the Central Control Server at IITM Pune. The meteorological data are used alongside air quality measurements to study pollutant dispersion, atmospheric stability, transport patterns, and weather-pollution interactions. These observations help researchers and policymakers better understand the factors affecting ambient air quality and improve pollution forecasting models.

#### **Integrated Functioning of AQMS, DDS, and AWS**

The AQMS continuously measures pollutant concentrations, while AWS simultaneously records meteorological conditions affecting pollutant dispersion. Both datasets are transmitted to local and central servers for processing and analysis. The DDS retrieves processed information and displays real-time air

quality status and health advisories to the public. Together, these systems form a comprehensive environmental monitoring network that supports air quality assessment, forecasting, research, regulatory compliance, and public awareness programs.

### **5. Ambient Air Quality Monitoring Equipment**

Various instruments are used to monitor ambient air quality such as high-volume sampler, low volume sampler, Dichotomous sampler, Respirable dust samplers etc.

**A. High volume sampler:** High volume sampler is a basic instrument used to monitor airborne particulate matter having diameter less than 10 micrometer. It draws a large volume of air which is more than 1500 m<sup>3</sup> of air over 24 hours.

**B. Low Volume Sampler:** Basic difference between high volume sampler and low volume Sampler is amount of air sampled. The low volume sampler draws only 24 m<sup>3</sup> of air or less.

**C. Dichotomous Sampler:** The dichotomous air sampler is a dual-filter air sampler for the simultaneous collection of the fine PM<sub>2.5</sub> and the course PM<sub>10-2.5</sub> particles contained within PM<sub>10</sub>. In this sampler virtual impact allows to separate aerosol particles based on virtual impaction principle.

**D. Respirable Dust Sampler:** The primary purpose of personal Respirable dust sampling is to characterize (with regard to mass and size) the quality of the ambient air to evaluate a miner's dust exposure. The mass of Respirable dust inhaled can be determined by sampling. Their extremely small size also means they can be breathed deep into your lungs and lead to lung damage.

### **6. Air Pollution Control Devices**

**A. Mechanical Dust Collectors:** mechanical dust collector is defined as a device which separates dust in a dry state from gas through the application of inertial and gravitational forces only. The most widely used type of mechanical dust collector is the cyclone, in which centrifugal force plays the major role in effecting the separation of dust from gas.

**B. Electrostatic Precipitators :** An [electrostatic precipitator](#) is a type of filter that uses [static electricity](#) to remove [soot](#) and [ash](#) from exhaust fumes before they exit the smokestacks.<sup>[2]</sup> Unburned particles of [carbon](#) in smoke are pulled out of the smoke by using static electricity in the precipitators, leaving clean, hot air to escape the smokestacks.<sup>[2]</sup> It is vital to remove this unreacted carbon from the smoke, as it can damage buildings and [harm human health](#) - especially respiratory health.

**C. Cyclone Separators :** A [cyclone separator](#) is a separation device that uses the principle of [inertia](#) to remove particulate matter from flue gases.<sup>[3]</sup> In these separators, dirty flue gas enters a chamber containing a vortex, similar to a tornado. Because of the difference in inertia of gas particles and larger particulate matter, the gas particles move up the cylinder while larger particles hit the inside wall and drop down. This separates the particulate matter from the flue gas, leaving cleaned flue gas.

**D. Bag House :** A baghouse, also known as a baghouse filter, bag filter, or fabric filter is an [air pollution control](#) device and [dust collector](#) that removes [particulates](#) or gas released from commercial processes out of the air.

### **7. Conclusion:**

Various researches have been conducted to analyse the change in air quality parameters with change in climatic conditions. Environmental monitoring methods are used according to the severity of polluted

zones, thus this work is an attempt to assess available research studies on ambient air quality. A review of various researches reveals data with a specific focus on particular areas. Review study shows that there is a large contribution from industrial activities, transportation and dust in the ambient air.

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