PROJECT ON THE TOPIC

PARTICULATE MATTER PM 2.5
SOURCES | IMPACTS | MEASURES

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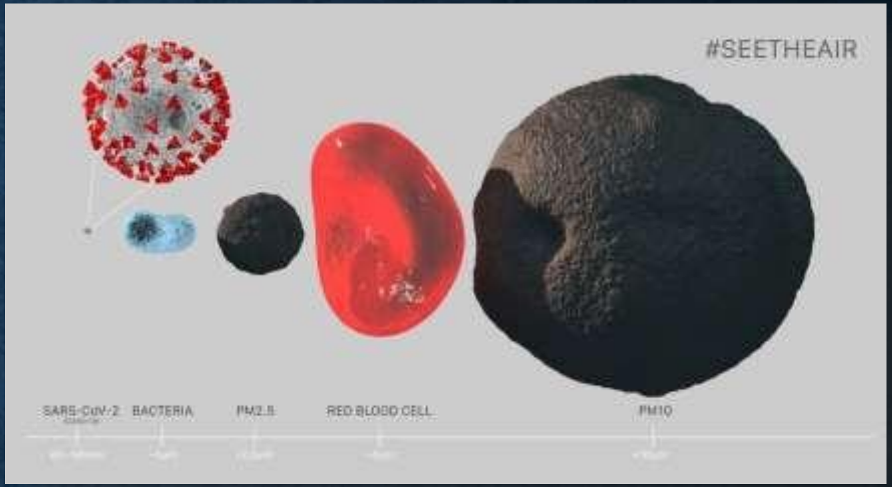
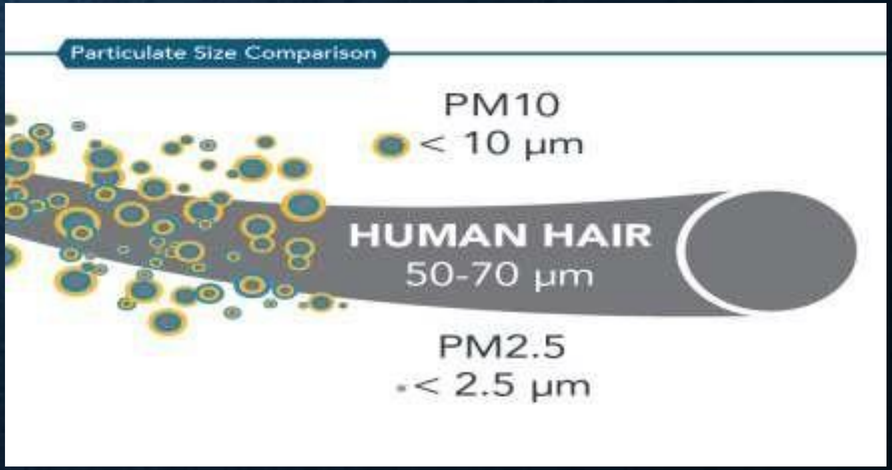
INTRODUCTION

- Particulate matter (PM) is a mixture of solid particles and liquid droplets found in the air. PM2.5 refers to particles with a diameter of 2.5 micrometers or smaller. Due to their small size, PM2.5 particles can penetrate deep into the lungs and even enter the bloodstream, posing significant health risks.
- **Importance of PM2.5 Monitoring :**
- Monitoring PM2.5 is crucial for assessing air quality and protecting public health. Elevated levels of PM2.5 are associated with respiratory and cardiovascular diseases, as well as premature death.





INTRODUCTION

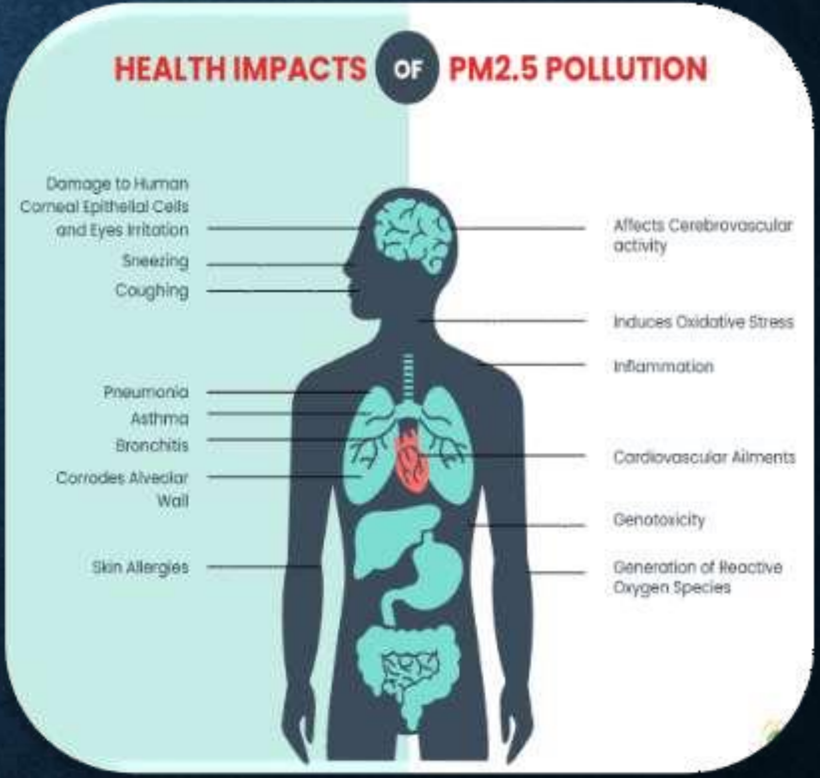
OBJECTIVES

- To identify and evaluate sampling methods for PM2.5.
- To determine the concentration of PM2.5 in different environments.
- To analyze the data and assess compliance with regulatory standards.

LITERATURE REVIEW

- **HEALTH EFFECTS OF PM 2.5 :**

- **Respiratory Effects :** Exposure to PM2.5 can cause respiratory symptoms such as coughing, phlegm production, and aggravation of asthma. Long-term exposure can lead to chronic respiratory diseases.
- **Cardiovascular Effects :** PM2.5 exposure is linked to heart attacks, irregular heartbeat, and other cardiovascular conditions.
- **Mortality :** Numerous studies have shown a correlation between PM2.5 exposure and premature mortality from cardiovascular and respiratory diseases.



LITERATURE REVIEW

- **REGULATORY STANDARDS** :

  - **World Health Organization (WHO):** The WHO recommends a 24-hour mean of 25 µg/m³ and an annual mean of 10 µg/m³.

  - **US Environmental Protection Agency (EPA):** The EPA sets the 24-hour standard at 35 µg/m³ and the annual standard at 9 µg/m³.

  - **European Union (EU):** The EU limits PM2.5 to an annual mean of 25 µg/m³.

Country	Value	Organization	Reference
China	0.15 mg/m³ of PM_{10}; 75 µg/m³ of $PM_{2.5}$	AQSIQ and CABR	[232] and (JG/T 309-2013)
Singapore	150 µg/m³(in office) [1a] of PM_{10}	Institute of Environmental Epidemiology	[233]
Australia	N/A of $PM_{2.5}$ 90 µg/m³ of PM_{10}	N/A The National Health and Medical Research Council	[234]
Canada	100 µg/m³ as 1 h average (Short-Term Exposure) 40 µg/m³ as 8 h average (Long-Term Exposure)	Health Canada	[235–238]
US	3 mg/m³ as 8 h average (Ceiling Level) [1b] 35 µg/m³ as 24 h average of $PM_{2.5}$ 15 µg/m³ as 1 y average of $PM_{2.5}$ 150 µg/m³ as 24 h average (Exposure) [2a]	American Conference of Governmental Industrial Hygienist, 2005 NAAQS/EPA ASHRAE	[236,237,239]
Finland	<20 µg/m³ as 8 h average of PM_{10} 4 mg/m³ as 8 h average of PM_{10}	FiSIAQ	[237]
Germany	50 µg/m³ as 24 h average of PM_{10}	FiSIAQ	[236,240]
Worldwide	25 µg/m³ as 24 h average of $PM_{2.5}$ 10 µg/m³ as 1 y average of $PM_{2.5}$ 20 µg/m³ as 1 y average of PM_{10}	WHO	[241,242]

[1a] Guidelines for good IAQ in office premises (Singapore); [1b] Ceiling Level: Highest possible allowed value for exposure (US, ACGIH); [2a] Exposure: It means a continual and repetitive contact with the substance over a set period (US, ASHRAE).

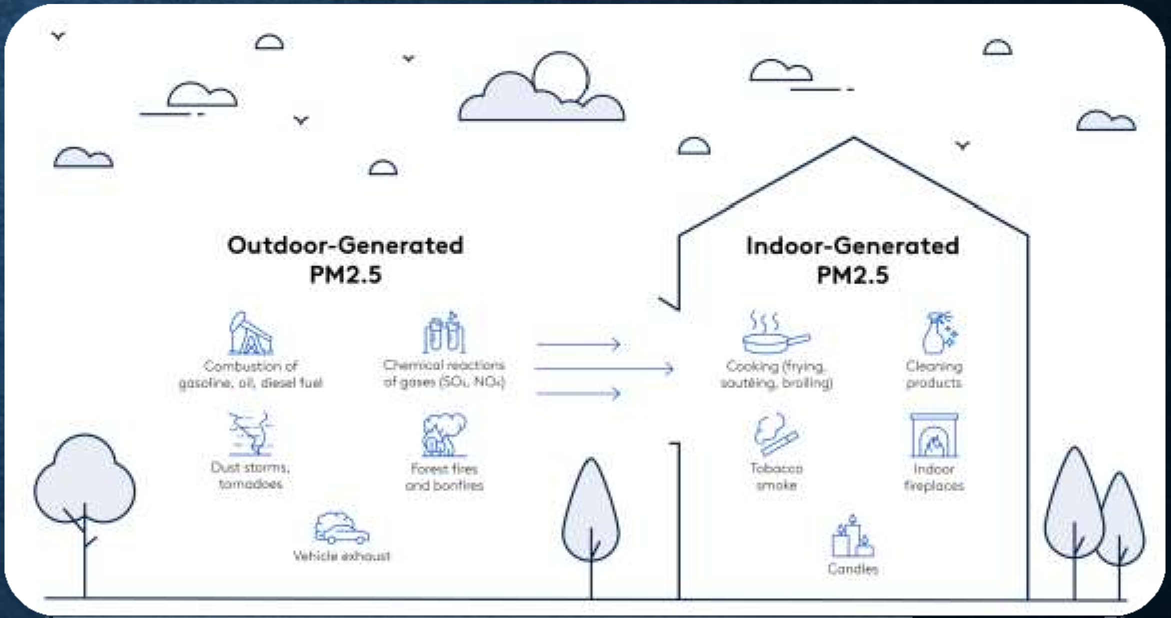
National Ambient Air Quality Standards (NAAQS) for PM2.5/PM10

Pollutant (final rule cite)		Primary/ Secondary	Averaging Time	Level	Form
Particle Pollution Dec 14, 2012	PM2.5	primary	Annual	12 µg/m³	annual mean, averaged over 3 years
		secondary	Annual	15 µg/m³	annual mean, averaged over 3 years
		primary and secondary	24-hour	35 µg/m³	98th percentile, averaged over 3 years
	PM10	primary and secondary	24-hour	150 µg/m³	Not to be exceeded more than once per year on average over 3 years

SOURCES

OUTDOOR SOURCES :

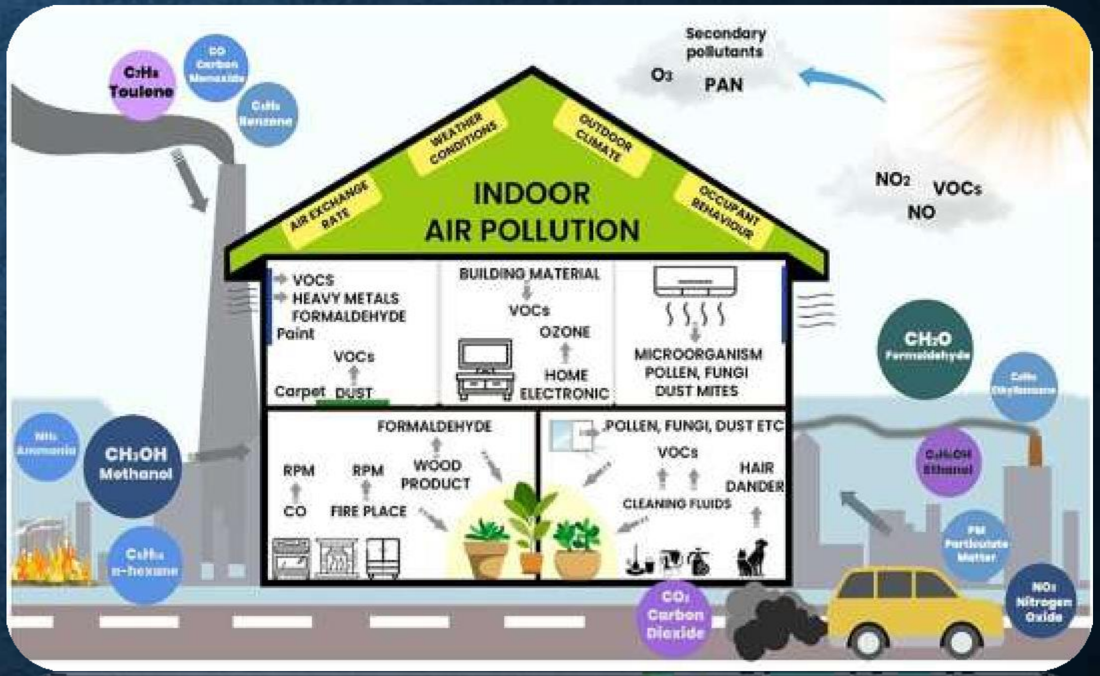
- Fuel combustion from automobiles.
- Power plants
- Blasting and painting facilities
- Mobile abrasive blast cleaning operations
- Unpaved roads
- Agricultural field and orchard operations
- Locomotive and marine diesel engines
- Natural sources (volcanoes, sand)



SOURCES

INDOOR SOURCES :

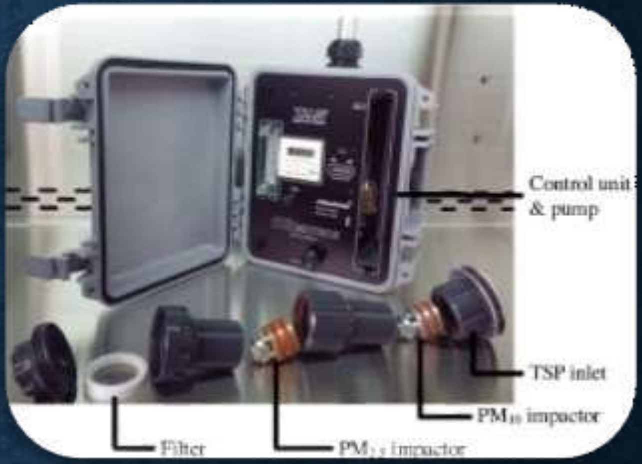
- Tobacco smoke
- Cooking (e.g., frying and boiling)
- Burning candles or oil lamps
- Operating fireplaces and fuel-burning space heaters (e.g. kerosene heaters)
- Biomass fuels
- Welding

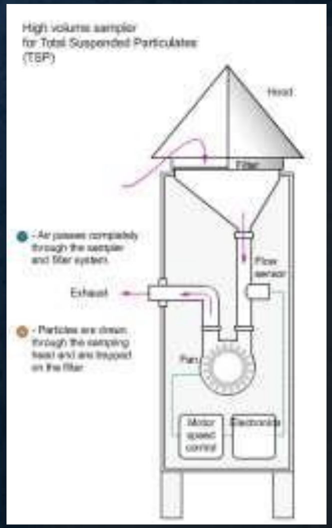


METHODOLOGY

Sampling Methods :

- **Types of Samplers**





- **High-Volume Samplers:** These samplers pull large volumes of air through a filter to collect PM2.5. They are typically used for short-term studies and provide a large sample mass for analysis.
- **Low-Volume Samplers:** These are used for long-term monitoring and operate at lower flow rates, collecting particles on a filter over extended periods.
- **Portable Samplers:** These are smaller, lightweight devices used for personal exposure assessment and can be carried by individuals to measure personal exposure to PM2.5.

METHODOLOGY

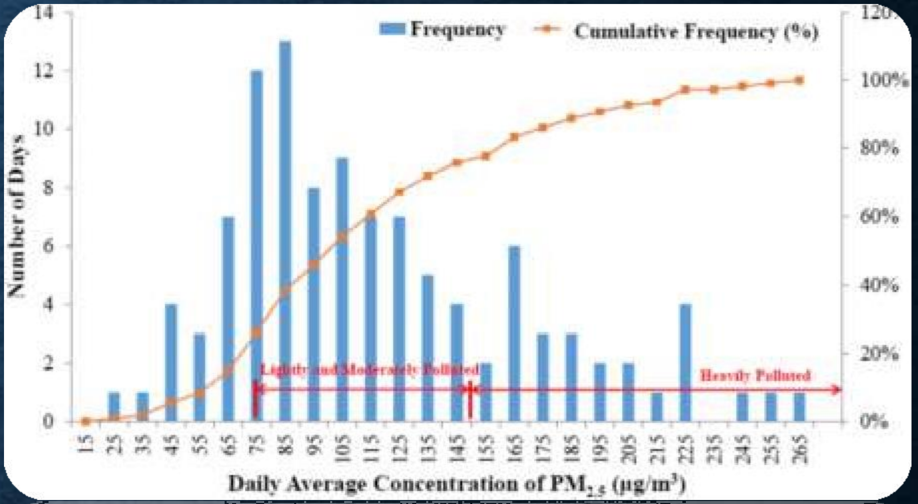
Site Selection :

- **Urban Areas:** High-density locations with significant traffic and industrial activity.
- **Suburban Areas:** Residential zones with moderate traffic and industrial activities.
- **Rural Areas:** Locations far from major pollution sources, providing baseline PM2.5 levels.
- **Proximity to Sources:** Specific sites near major roads, industrial plants, and construction sites.

METHODOLOGY

<u>Sampling Duration and Frequency</u> :

- **Continuous Sampling:** Provides real-time data and is useful for understanding diurnal variations.
- **Periodic Sampling:** Collects samples at specific intervals (e.g., daily, weekly) to analyze trends over time.
- **Seasonal Sampling:** Captures variations in PM2.5 concentrations due to seasonal changes, such as heating during winter or increased vehicular emissions during summer.



METHODOLOGY

Analytical Techniques :

➢ **Gravimetric Analysis :**

- **Filter Weighing:** Filters are pre-weighed before sampling. After sampling, the filters are weighed again to determine the mass of PM2.5 collected. This is the simplest method for determining PM2.5 concentration.

➢ **Chemical Analysis :**

- **Ion Chromatography (IC):** Used to analyse water-soluble ions in PM2.5, such as sulphates, nitrates, and ammonium.
- **Inductively Coupled Plasma Mass Spectrometry (ICP-MS):** Used for detecting trace metals in PM2.5, such as lead, cadmium, and arsenic.

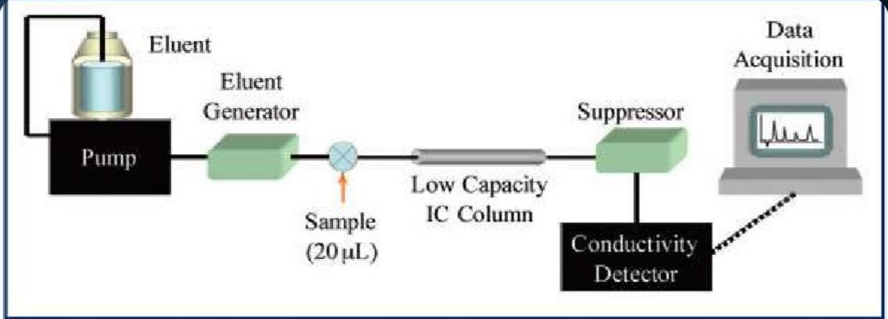
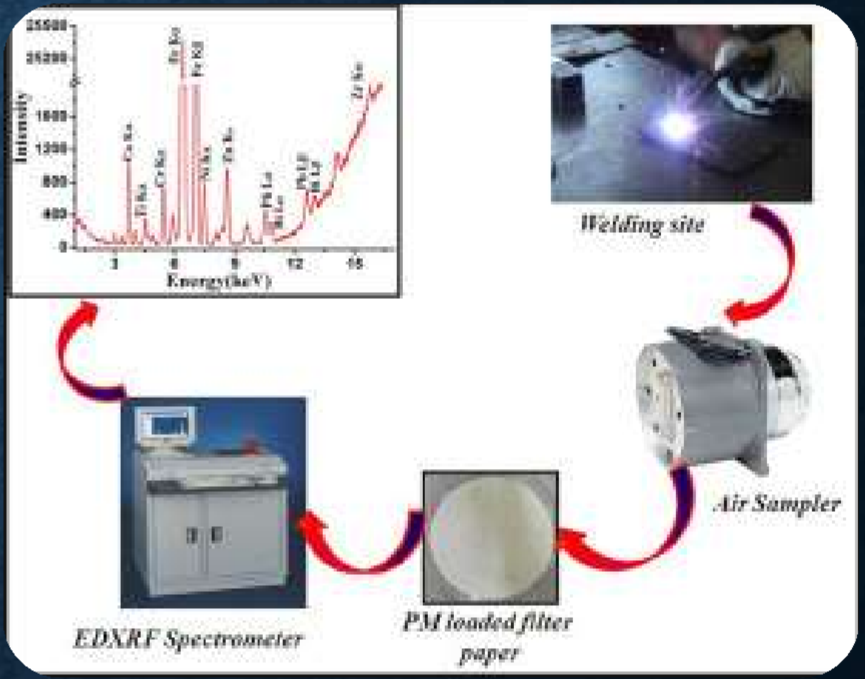


Figure 1: Schematic diagram of an IC instrument

METHODOLOGY

Analytical Techniques :

- **Chemical Analysis :**
  - **X-Ray Fluorescence (XRF):** A non-destructive technique for elemental analysis of PM2.5 filters.
- **Quality Assurance and Quality Control :**
  - **Calibration:** Regular calibration of sampling equipment to ensure accurate measurements.
  - **Blanks and Duplicates:** Use of blank filters to check for contamination and duplicate samples to assess reproducibility.
  - **Maintenance:** Regular maintenance and inspection of equipment to prevent malfunctions and ensure consistent performance.



PRINCIPLE

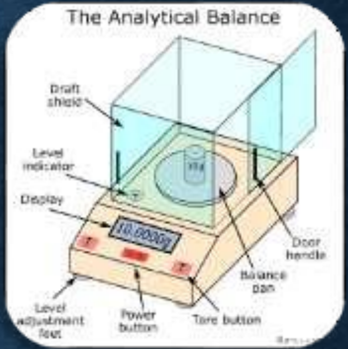
1. Air with dust enters the sampler through a circular omnidirectional inlet.
2. The air reaches the first impactor where particles larger than 10 microns are removed and retained.
3. Air containing particles smaller than 10 microns passes through the WINS impactor, which is well-shaped.
4. A filter dipped in impaction oil is placed in the well of the WINS impactor.
5. Particles hit this filter at a specific velocity maintained by the top critical hole of the WINS impactor.
6. Particles sized between 2.5 microns to 10 microns are separated at this stage.

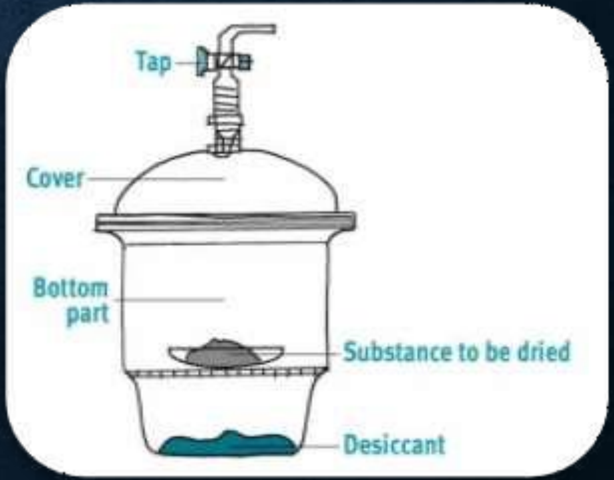
PRINCIPLE

7. Only particles sized 2.5 microns and below proceed further and accumulate on a PTFE membrane filter.
8. The accumulated dust on the filter is measured by the weight difference.
9. The total volume of air sampled is determined by the difference between final and initial DG readings.
10. PM2.5 dust concentration is calculated by dividing the weight of dust by the volume of air sampled.
11. The lower detection limit of PM2.5 dust is about 2 $\mu g/m^3$, depending on the accuracy of the digital balance.
12. A sensitive digital balance with a minimum detection limit of 0.00001 g is essential for measuring the accumulated dust.
13. A 6-digit balance (as recommended by USEPA) is preferred for more accurate weight measurements and PM2.5 values through filters.

INSTRUMENTS

1. Analytical balance
2. Desiccator – pre-conditioning of the filter paper
3. Sampler: A PM2.5 Sampler with size selective inlet for PM2.5 and automatic volumetric flow control
4. Filter Jacket
5. Injector oil/grease
6. Calibrated flow-measuring device to control the airflow at 16.67 l/min
7. Filter Media: A polytetrafluoroethylene (PTFE) filter of 47 mm size.





CALIBRATION

1. Ensure the sampler and all calibration equipment are clean and free of particulates.
2. Place the sampler in a stable and secure location.
3. Record the current environmental conditions (temperature, humidity, and pressure).
4. Attach the flow calibrator or bubble meter to the inlet of the PM2.5 sampler.
5. Make sure all connections are airtight to avoid leaks that can affect the calibration.
6. Turn on the PM2.5 sampler and allow it to warm up as per the manufacturer's instructions.

CALIBRATION

7. Set the sampler to the desired flow rate. This is often around 16.7 liters per minute (LPM), but the specific rate can vary depending on the device.
8. Start the flow calibrator and measure the actual flow rate.
9. Compare the measured flow rate to the sampler's display. If there is a discrepancy, adjust the sampler's flow rate settings until the flow calibrator and the sampler's display match.
10. Repeat the flow rate measurement multiple times to ensure consistency.
11. Typically, three to five measurements are taken, and the average is used for calibration.

PROCEDURE

1. Filter inspection: Inspect the filter for pin holes using a light table.
2. Loose particles should be removed with a soft brush. Apply the filter identification number or a code to the filter if it is not numbered.
3. Condition the filter in conditioning room maintained within 20-30 °C and 40-50% relative humidity or in an airtight desiccator for 24hours.
4. Take initial weight of the filter paper (W_i) before sampling.
5. Place the filter paper in the sampling system securely and tighten the screws of the bracket.
6. Note down the initial dry gas meter reading and time.
7. Start the sampler and adjust flow rate as per guidelines.
8. At the end stop the pump, note down final dry gas meter reading and time.
9. Remove filter cassette from the filter holder and store in filter carrier immediately and transfer it to desiccators as early as possible.
10. Condition the filter after sampling in conditioning room maintained within 20-30 °C and 40-50% relative humidity or in an airtight desiccator for 24 hours.
11. Take final weight of the filter paper (W_f).

OBSERVATION

We have determine the concentration of PM 2.5 particles near the Environmental Department of IIT ISM Dhanbad :

Initial Weight of the conditioned filter before sample collection (W_i) = 0.149017 gm
Final Weight of the conditioned filter after sample collection (W_f) = 0.15013 gm

Initial Dry Gas Meter reading = 0 m^3
Final Dry Gas Meter reading = 23.110 m^3

Volume of air sampled (V)= Final Dry Gas Meter reading - Initial Dry Gas Meter reading

= 23.110 m^3 - 0 m^3
= 23.110 m^3

CALCULATION

We have determine the concentration of PM 2.5 particles near the Environmental Department of IIT ISM Dhanbad :

We can calculate the PM 2.5 concentration in the ambient air using the formula given below :

$$\text{Concentration Of PM 2.5 (in µg}/m^3\text{)} = \frac{(w_f - w_i)}{v} \times 10^6$$

Where , W_i= Initial Weight of the conditioned filter before sample collection
W_f= Final Weight of the conditioned filter after sample collection
V = Volume of air sampled

Conc. PM 2.5 = [(0.15013 – 0.149017)× 10^6] / 23.110

= 48.161 µg/m^3

RESULT

We came across PM 2.5 Concentration = 48.161 $\mu g/m^3$

Now as we know that as per National Ambient Air Quality Standards (NAAQS) it provides two primary standards for PM2.5:

- **Annual Standard**: The annual mean PM2.5 concentration should not exceed **9.0 $\mu g/m^3$** (averaged over three years).

- **24-hour Standard**: The 24-hour mean PM2.5 concentration should not exceed **35 $\mu g/m^3$** (98th percentile averaged over three years).

Annual Standard Comparison:

- The measured concentration of 48.161 $\mu g/m^3$ significantly exceeds the annual standard of 9.0 $\mu g/m^3$. This level is more than five times the allowable annual mean, indicating a severe exceedance if this concentration were representative of a long-term average.

24-hour Standard Comparison:

- The measured concentration of 48.161 $\mu g/m^3$ also exceeds the 24-hour standard of 35 $\mu g/m^3$. This indicates that on this particular day, the air quality is worse than the allowable limit set by the EPA for short-term exposure.

IMPLICATIONS

- **Health Risks**: Exceeding both the annual and 24-hour standards suggests that the air quality poses health risks, particularly to sensitive groups such as children, the elderly, and individuals with pre-existing respiratory or cardiovascular conditions.

- **Regulatory Action**: Exceeding these standards may prompt regulatory action, such as the implementation of air quality management plans, stricter emissions controls, and public advisories to reduce exposure.

- **Public Advisories**: Authorities may issue warnings or advisories, recommending that sensitive groups limit outdoor activities when PM2.5 levels are this high.

MEASURES TO REDUCE PM 2.5

1. If you do smoke, quit smoking because it hikes particulate matter by 2.5 concentrations.
2. Avoid the continuous burning of wood, candles, and fireplaces.
3. Do not use vacuum cleaners without HEPA filters.
4. Avoid using personal transport every time, and planning many trips
5. Switch to renewable and clean sources of energy in domestics namely solar and wind energy.
6. Give use of generators in houses a miss.
7. Switching off the vehicles when waiting at red lights.
8. Stop getting unnecessary renovations and constructions at houses.

CONCLUSION

- This study aimed to sample and determine PM2.5 concentrations, analyze their sources, and evaluate their compliance with national and international air quality standards. The findings provide valuable insights into the current state of air quality and highlight the need for targeted interventions to protect public health.

Key Findings :

1. **Elevated PM2.5 Levels**: PM2.5 concentrations often exceeded both the annual and 24-hour standards set by the National Ambient Air Quality Standards (NAAQS), with levels reaching 48.161 $\mu g/m^3$, indicating severe pollution.
2. **Health Risks**: High PM2.5 levels pose significant health risks, especially to children, the elderly, and individuals with pre-existing health conditions, contributing to respiratory and cardiovascular diseases.
3. **Source Identification**: Major contributors to PM2.5 pollution include vehicular emissions, industrial activities, and residential heating. This information is crucial for designing effective mitigation strategies.
4. **Temporal and Spatial Variations**: PM2.5 levels showed considerable temporal and spatial variations, influenced by factors such as traffic and industrial activity.

RECOMMENDATIONS

1. **Policy Implementation**: Authorities should consider implementing stricter emissions standards for vehicles and industries, particularly in areas where PM2.5 levels are consistently high. Incentives for adopting cleaner technologies and renewable energy sources can also help reduce emissions.
2. **Public Awareness**: Increasing public awareness about the health risks associated with PM2.5 exposure is crucial. Educational campaigns and real-time air quality monitoring can help individuals make informed decisions about outdoor activities during high pollution periods.
3. **Further Research**: Continued research is needed to refine sampling and analytical methods, improve source apportionment techniques, and assess the effectiveness of mitigation measures. Long-term studies can provide deeper insights into trends and inform future policy decisions.
4. **Air Quality Management**: Developing comprehensive air quality management plans that incorporate data-driven strategies and community involvement can help reduce PM2.5 levels. Collaboration between government agencies, industry stakeholders, and the public is essential for achieving sustainable improvements in air quality.

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THANK YOU