

Assessment of PM_{10} Mass Concentration in Ambient Air at Jorhat, Assam

*A dissertation submitted for the partial fulfilment of the requirements for the degree of
B. Sc. in Chemistry (Paper DSE-603) under Dibrugarh University*



Under the Supervision of-

Dr. Ajit Singh

Principal Scientist

Coal and Energy Group, CE & MSD

CSIR-NEIST, Jorhat, Assam, 785006

Submitted By-

Gongutri saikia

Roll No: 14720047

Registration No.- S2205362

Department of Chemistry

N. N. Saikia College, Titabar-785630

Year: 2025

Dr. Jayanta Madhab Borah
Assistant Professor & HOD
Email: jayantamb@gmail.com



Department of Chemistry
Nanda Nath Saikia College
Titabar-785630, Assam, India

CERTIFICATE

This is to certify that the dissertation entitled "Assessment of PM₁₀ Mass Concentration in Ambient Air at Jorhat, Assam" is submitted by Gongutri Saikia, Roll No.-14720047, Reg.No.-S2205362, a B.Sc. 6th semester student of the Department of Chemistry, N. N. Saikia College, Titabar for the partial fulfillment of B.Sc. degree in Chemistry (Paper: DSE-603), is a record of original research work carried out by her under the supervision of Dr. Ajit Singh. She has fulfilled all the requirements for submitting the dissertation for the B.Sc. degree. The results embodied with this dissertation have not been submitted to any other college or institute for any other degree or diploma to the best of my knowledge.

Date: 29/05/2025

Place: Titabar

(Jayanta Madhab Borah)

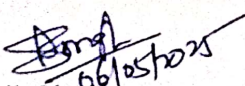
(Internal Examiner)

(External Examiner)

CERTIFICATE



This is to certify that the project report entitled "*Assessment of PM₁₀ Mass Concentration in Ambient Air at Jorhat, Assam*" submitted by *Gongutri Saikia*, a student of B.Sc. 6th semester, Department of Chemistry, Nanda Nath Saikia College, Titabor, Jorhat, Assam, embodies the winter internship carried out by her under my supervision and guidance from 01/12/2024 to 20/01/2025 at Coal & Energy Division, CSIR-North East Institute of Science and Technology, Jorhat, Assam.


Dr. Ajit Singh

Principal Scientist

Coal and Energy Group

CE&MSD



Dr. Binoy K Saikia

Principal Scientist and HoD

Coal and Energy Group

CE&MSD

DECLARATION

I hereby declare that the project report entitled "*Assessment of PM₁₀ Mass Concentration in Ambient Air at Jorhat, Assam*" submitted to the Department of Chemistry, Nanda Nath Saikia College, Titabor in partial fulfillment of the requirement of the award of the Bachelor Degree of Science in a record of Bonafide work carried out under the supervision of *Dr. Ajit Singh*, Principal Scientist Coal and Energy Group, CE&MSD, CSIR-NEIST. The matter embodied in this project has not been submitted by us for the award of any other degree.

Gongutri Saikia
Signature of the Student

Date: 06/05/2025

ACKNOWLEDGEMENT

The winter internship program I undertook at CSIR-NEIST has been a great privilege and opportunity to learn about the mass concentration of PM₁₀ in Jorhat's ambient air. I am indebted to Dr. Virendra M. Tiwari, Director of CSIR-NEIST, for permitting me to carry out this internship and allowing me to access various laboratory facilities.

*I would like to express my deepest sense of gratitude to my research guide, **Dr. Ajit Singh**, Principal Scientist, CSIR-NEIST Jorhat, for his constant inspiration, and valuable guidance which helped a lot to focus my views in the proper perspective. I take this opportunity to express my intense reverence towards him for guiding me in the right direction throughout this work.*

*I am also grateful to **Dr. Binoy K Saikia**, Head of the Coal & Energy Group at CSIR-NEIST, for his constant unwavering support and constant encouragement.*

*I sincerely thank **Mr. Binud Attry** and all the senior research scholars of the coal and energy group for their valuable help and guidance throughout my project.*

*I am thankful to **Dr. Jayanta Madhab Bora**, HOD of Chemistry, Nanda Nath Saikia College, Titabor for recommending me for this Winter Internship Program in CSIR-NEIST and inspiring me to do so. Lastly, I would like to be thankful to my astoundingly supportive parents and my friends (Sonkalpita Baruah, Pinki Chutia, Priya Saikia, Bikyaparna Gogoi, Priyanuj Hazarika) for their wholehearted help.*

Gongutri Saikia
Gongutri Saikia

TABLE OF CONTENTS

Sl. No	Contents	Page No.
	List of Figures	
	List of Tables	
1	Introduction	1-2
1.1	Air Pollution in India	2
1.2	Air Pollution in Jorhat (Assam)	3
1.3	Particulate Matter	3-5
2	Literature Review	5-8
3	Method and Methodology	9-10
3.1	Study Area	9
3.2	Sample Collection	9-10
4	Working Principle of Instrumentation	11-12
4.1	Respirable Dust Sampler (APM 460 NL)	11
4.2	Fine Particulate Sampler (APM 550)	12
5	Objective of the Study	12
6	Results and Discussion	13-16
6.1	Mass concentration of PM ₁₀	13-16
7	Future Work	17-20
7.1	Sample Preparation for ICP-MS	17
7.1.1	Sample Preparation	17
7.1.2	Microwave-Assisted Digestion	18
7.1.3	Sample Dilution	18
7.1.4	ICP-MS	18
7.1.5	ICP-MS Instrumentation	18
7.1.6	Main components of an ICP-MS	18-19
7.1.7	Principle of Microwave (MW) Digestion	20
7.1.8	Microwave digestion Process	20
8	Conclusion	21
9	Reference	22-23
10	Photo Gallery	24-25

List of Figures		
Sl. No.	Figures	Page No.
1	Parking Zone of CSIR-NEIST.	9
2	Schematic diagram of methodology followed for the study.	10
3	Microfibre Quartz blank filter paper inside the sampler before sample collection.	10
4	Microfibre Quartz filter paper after the PM ₁₀ sample collection.	10
5	Respirable Dust Sampler (Envirotech APM 460 NL).	11
6	Fine Particle Sampler (APM 550).	11
7	Comparison of PM ₁₀ concentrations with CPCB and WHO's permissible limit.	14
8	Graph showing the mean, maximum, minimum values of PM ₁₀ .	14
9	ICP-MS Instrument in CSIR-NEIST.	18
10	Schematic diagram of ICPMS	19
11	MW Digestion System in CSIR-NEIST.	20

List of Tables		
Sl. No.	Tables	Page No.
1	PM ₁₀ mass concentration for 24 hours in $\mu\text{g}/\text{m}^3$	13
2	Statistical values of PM ₁₀ mass concentration	15
3	Vehicle survey on various days and at various times during the sampling period.	16

Abstract:

Atmospheric particulate matter (PM₁₀) is considered one of the significant air pollutants that are detrimental to human health and the environment. The mass concentrations of PM₁₀ were analyzed using the gravimetric method. The average concentration of PM₁₀ found to be 82.03 µg/m³ in ambient air of CSIR-NEIST campus, which was close to the reliable CPCB (Central Pollution Control Board) and higher than the WHO (World Health Organization) permissible limit. The major sources of PM₁₀ concentration mainly come from vehicular emissions, combustion devices, and industrial activities in the study area.

Keywords: Air Pollution, Particulate Matter, PM₁₀, Gravimetric Method, Mass Concentration, Vehicle Survey.

1.Introduction:

Air is the gaseous mixture that surrounds the earth's atmosphere. The major constituents of earth's atmosphere are nitrogen (78%), oxygen (21%), argon (1%), carbon dioxide (0.03%), water vapor (0.04) and trace gases like neon (0.0018%), helium (0.0005%), methane (0.0002%), krypton (0.0001%), hydrogen (0.00005%). Air is essential to keeping life alive and is necessary for development, growth, and operation. It serves as a shield, keeping us safe from harmful radiation and extremely high or low temperatures. Air has many heavy metals including lead (Pb), mercury (Hg), cadmium (Cd), chromium (Cr), arsenic (As), zinc (Zn), copper (Cu), and nickel (Ni) all of which are anthropogenic sources mainly from transportation, burning of fossil fuels and industrialization. They can lead to serious diseases and environment degradation.

In recent decades, air pollution has grown to be one of the biggest problems facing humanity, having a negative influence on both the ecology and human health. Air pollution in India is one of the main issues affecting the environment and public health. In India, air pollution is a widespread problem that has a substantial negative influence on life expectancy and public health due to high levels of toxic pollutants and particulate matter (PM_{2.5}, PM₁₀). Air pollution is the introduction of pollutants into the natural environment that are detrimental to the human health, animals, plants and the environment. It occurs from natural sources and human activities. Natural sources such as volcanic eruptions and wildfires; and human activities such as industrial processes, vehicle emissions, household combustion device and deforestation. The presence of several harmful chemicals in the air has been shown to have a negative impact on human health, making air pollution a growing public health concern. According to the World Bank (2016) and the Human Effects Institute (HEI) in 2019, air pollution is the fourth or fifth highest global risk factor for mortality. Globally, ambient air pollution was responsible for almost 4.2 billion deaths in 2016. (WHO,2018).

Air pollutants are the contamination of chemical, physical or biological substances in the air that are endanger to the human health, other living beings and the environment. Pollutants make both humans and animals sick. These can be natural or humanmade. Among the main contaminants are Particulate Matters (PM_{2.5}, PM₁₀), carbon monoxide (CO), nitrogen oxide (NO₂), sulfur dioxide (SO₂) and ozone(O₃) which can cause a number of chronic diseases. According to WHO (2018), enhancing air quality and lowering the annual mean ambient concentration of air pollutants, particularly PM_{2.5} from 35 µg/m³ to 10 µg/m³ and PM₁₀ from 70 µg/m³ to 20 µg/m³, might avert an estimated 12.7% of deaths worldwide.

1.1. Air Pollution in India:

India is among the world's most polluted countries. India has extremely high air pollution which harms health and the economy. Because of air pollution, India's metropolitan areas are subject to unhygienic and unhealthy circumstances (Dutta et.al., 2021). In many megacities (urban regions with a population of more than 10 million) in the developing world, air pollution levels are rising quickly in both urban and rural areas (Agrawal et.al., 2005). The WHO reports that 37 Indian cities are among the top 100 cities in the world with the worst PM₁₀ pollution and that Delhi, Raipur, Gwalior and Lucknow are among the top 10 (WHO,2014). A similar assessment by WHO in 2011 listed 27 cities in the top 100. Heavy particulate pollution is wreaking havoc on Indian cities, with 52% of them (63 cities) experiencing critical levels (above 1.5 times the standard), 36 having high levels (1-1.5 times the annual standard), and only 19 moderate levels (50% below the standard) (CPCB, 2008-2011). Under the National Ambient Air monitoring program, over 100 cities have PM₁₀ levels above the WHO recommendation. WHO estimates that breathing contaminated air kills 900000 Indians annually. (WHO,2018) and United Nations International Children Emergency Fund (UNICEF 2018). In India, all 1.4 billion people are exposed to dangerously high levels of PM_{2.5} and PM₁₀

air pollutants. PM levels in some Indian cities are 5 times higher than the safety limits (Smith et.al.,2001).

1.2. Air Pollution in Jorhat (Assam):

Jorhat is the second largest city in Assam, situated in the northeastern part of India. Northeast India has a lot of anthropogenic emission activities due to its fast industrialization. The air quality in the Jorhat area is threatened by a number of man-made sources including construction activities, biomass burning and agricultural processes (Saikia et.al.,2022). The current air quality index (AQI) in Jorhat is around 152, which falls into the “unhealthy” category. Due to increased biomass burning and unfavorable weather, the city’s AQI regularly varies between moderate and bad levels, with notable jumps during the winter months. In Jorhat air quality varies periodically with winter months usually seeing the worst conditions as temperature inversions trap pollutants near the ground. Data from the Pollution Control Board of Assam (PCBA) reveals that the yearly average PM_{10} levels range from 80 to 100 $\mu g/m^3$, surpassing the established annual threshold of 60 $\mu g/m^3$. In winter season, the PM concentrations in Jorhat exceed the standard limit (Saikia et.al.,2018).

1.3 Particulate Matter (PM):

Particulate Matter is a mixture of solid or liquid particles in the air that can be hazardous. PM is separated into coarse particles (PM_{10}), fine particles ($PM_{2.5}$) and suspended particulate matter (SPM) (WHO,2000).

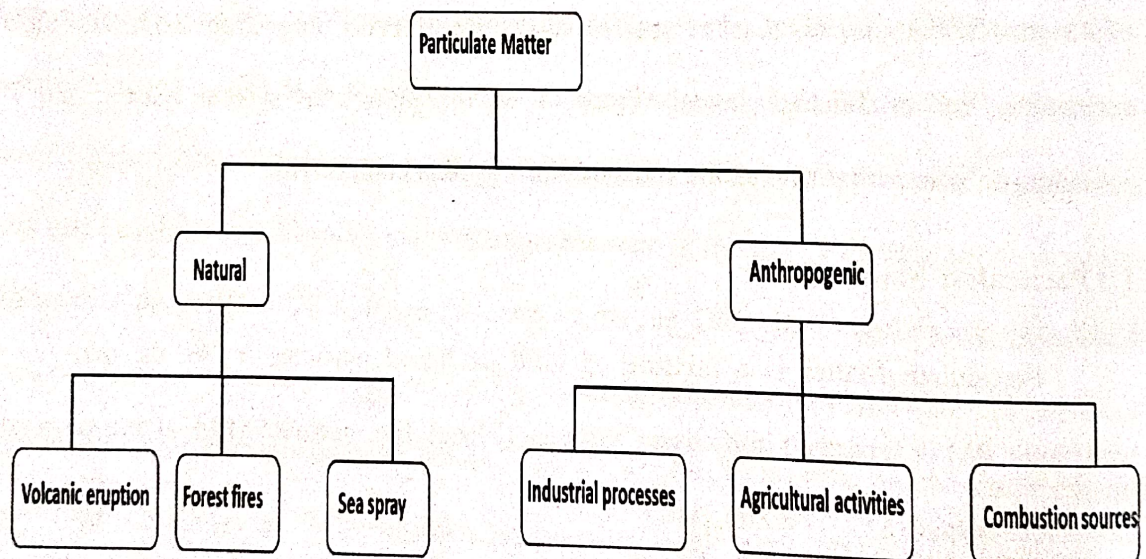
PMs contain both inorganic or organic contaminants including heavy metals in the environment and can endanger to living things. The CPCB indicate that, the levels of small particles less than 10 micron (PM_{10}) are very high. Particulates of this size are known to seriously harm the lungs. According to HEI’s report, PM pollution was considered the third important cause of death in 2017 and this rate was found to be highest in India. The effects of

PM₁₀ are more likely to affect people 65 and older than people in other age groups (Hwang et.al.,2000). The WHO states that, there is no acceptable amount of PM emissions (WHO,1999).

Types of Particulate Matter:

- 1) PM₁₀: PM₁₀ includes particles less than 10 micron in diameter. PM₁₀ are small enough to be inhaled and can be detrimental to human health. They can cause health problems such as heart disease, lung disease and cancer.
- 2) PM_{2.5}: PM_{2.5} includes particles less than 2.5 micron in diameter. The largest PM_{2.5} particles are about 30 times smaller than human hair. They can penetrate deep into the lungs and brain from blood streams.

Sources of PM (Natural and Anthropogenic):



Health Impact of Particulate Matter:

- ❖ Difficulties of breathing: Possible chances of inducing asthmatic conditions, chronic obstructive pulmonary disease (COPD) and other respiratory condition.

- ❖ Neurological effects: Exposure to PM has been linked to cognitive impairment, neuroinflammation and neurodegenerative diseases.
- ❖ Lung cancer: Exposure to PM has been linked to an increased risk of lung cancer.
- ❖ Cardiovascular disease: Increased risk of heart attacks, strokes and other cardiovascular events.

Environmental effects of Particular Matter:

- ❖ Climate change: PM can influence cloud formation and alter earth's energy balance.
- ❖ Ecosystem damage: PM can damage crops, forests and aquatic ecosystems.
- ❖ Visibility damage: PM can reduce visibility, affecting scenic views and aviation.

2. Literature Review:

Talbi et.al (2018) did a study on the assessment of PM_{10} , $PM_{2.5}$, PM_{10} and their detrimental effects on the environment and human health in Algiers, Algeria. They examined several methods including X-ray fluorescence (XRF), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), Atomic Absorption Spectrometry (AAS), and Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) to ascertain the concentration of heavy metals in samples. Sc, Mo, Se, Cr, As, Sr, Cu, Mn, Ba, Fe, Ca, Ni, Co, Hg, K, S, V, Sb, Sn, Ag, Au, Rb, Th, Sr, U, Zr, W, Ti, Cs or Pb were among the heavy metals found in PMs, according to their analysis. They unequivocally shown that one of the main causes of emissions in Algiers is traffic. PM_{10} , $PM_{2.5}$, PM_{10} mass concentrations ranged from 5.93 to $\mu g/m^3$, 9.41 to 77.15 $\mu g/m^3$, and from 15.46 to 111.30 $\mu g/m^3$ per day in roadside sites and from 7.38 to 44.57 $\mu g/m^3$, 12.37 to 84.65 $\mu g/m^3$ and 27.33 to 121.54 $\mu g/m^3$ in urban sites.

Jandacka et.al (2017) conducted a study on the levels of PM_{10} , $PM_{2.5}$, PM_{10} along an urban route in Zilina. To ascertain whether heavy metals are present in PMs, they analyze the metals using the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method. Based on

their assumptions and the likelihood that they came from vehicle traffic, they chose 17 metals Na, Mg, Al, Ca, V, Cr, Fe, Mn, Ni, Cu, Zn, As, Mo, Sb, Cd, Ba, and Pb were among the 17 metals found in PMs. For the PMs, they determined two factors: for PM₁, road dust and non-exhausted traffic sources are represented by Factor 1 (80.9%), whereas diesel fuel is represented by Factor 2 (19.1%). Diesel fuels make up 17% of PM_{2.5}, while non-exhausted traffic and road dust account for 83%. For PM₁₀, Factors 1 and 2 represent tires and road dust (52.1%), brakes and road surfaces (17%), and diesel fuel (14.2%) respectively. At the monitoring station mentioned in the Zilina, road dust and non-exhaust traffic sources might be considered the primary sources of the particulate matter that constitutes PM₁, PM_{2.5}, PM₁₀.

A study on heavy metal in atmosphere was carried out in Foshan, China by Tan et.al (2014). They examined Foshan, the most polluted city in southern China's Pearl River Delta (PRD). In the winter of 2008, they took measurements of the heavy metal concentrations in PM_{2.5}. Seven heavy metals including Zn, V, Mn, Cu, As, Cd, and Pb were specifically examined. They determined the heavy metals using the Inductively Coupled Plasma Mass Spectrometry (ICPMS) method. During the sample period, the average PM_{2.5} concentration at the four locations in Foshan city was 136.4 $\mu\text{g}/\text{m}^3$. PM_{2.5} concentrations are significantly greater than China's National Ambient Air Quality (NAAQS) (75 $\mu\text{g}/\text{m}^3$ per day and 35 $\mu\text{g}/\text{m}^3$ per year). Their research demonstrated that China experienced severe PM pollution during the winter.

Park et.al (2007) conducted a study on the concentration of heavy metals in Seoul, South Korea. For a year, they conducted monthly monitoring of ambient TSP, PM₁₀, and PM_{2.5} in a residential neighborhood in the northern portion of Seoul. They used the Inductively Coupled Plasma Mass Spectrometry (ICPMS) technique to examine the heavy metals (Cr, Cd, As, Mn, Zn, and Pb) present in PM₁₀ and PM_{2.5}. According to their data, the monthly PM₁₀ concentration was lowest in August and highest in April. PM₁₀ levels in April were 157.9 and

106.1 $\mu\text{g}/\text{m}^3$. The $\text{PM}_{2.5}$ concentration remained consistent. In Seoul's residential areas, $\text{PM}_{2.5}$ makes up roughly 35~70 % of PM_{10} .

A study on the chemical composition of airborne particulate matter ($\text{PM}_{2.5}$) collected from the Targovishte city region in Romania during the summer of 2015 was conducted by Redulescu et.al (2017). They analyzed the chemical composition of PM and its negative effects on human health. The authors employed three analytical methods for qualitative, quantitative, and morphology characterization of PM. Inductively Coupled Plasma Mass Spectrometry (ICP-MS), Attenuated Total Reflectance- Fourier Transform Infrared Spectrometry (ATR-FTIR), and Scanning Electron Microscopy- Energy Dispersive Spectrometry (SEM-EDS). According to their study, the ICPMS method was used to investigate many elements including Pb, Cd, Cr, Ni, Cu, Mn, Al, Zn, Fe. The measured concentration of these metals was then compared with values reported by the International Agency on urban areas to determine the minimal element level which cannot be considered as a potential health risk for the urban population. In $\text{PM}_{2.5}$, the authors use FTIR to examine both inorganic and organic functional groups (CO_3^{2-} , NH_4^+ , SiO_4^{2-} , NO_3^- , carbonyl and aliphatic carbons). EDS element analysis of the samples revealed that the elements C, O, Si, Ca, N, and S made up the majority of the airborne particles.

A study on the composition of atmosphere particulate matter in the urban area of Jorhat, India carried out by Rabha et.al (2022). They used the PMF model to analyze rare earth elements and heavy metals to assign sources of PM_{10} . According to their analysis, PM_{10} concentration was close to the CPCB and higher than the WHO's permissible limit. The results showed that, except Fe, Zn, and Ba, the concentrations of heavy metals in PM_{10} samples are below the critical levels recommended by WHO for Europe, according to their analysis of the elemental composition using high-resolution inductively coupled plasma spectrometry (HR-ICPMS). Anthropogenic and natural contributors were suggested by the positive anomaly of

Eu and Tm and the mean total REE concentration (REE) in PM_{10} was $0.97 \pm 0.59 \text{ ng/m}^3$. Additionally, they discovered that the urban area's five major sources of PM_{10} are mainly from combustion of coal and vehicular emission followed by biomass burning, soil dust, and industrial emission. The existence of valuable REEs in atmospheric particulate matter has never been reported before, until this study.

A study conducted by Piao et.al (2008) on the concentration of heavy metals in a northeast industrial city in China. They analyzed heavy metal pollution in urban and industrial areas. In this study, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Atomic Absorption Spectrometry (AAS) to found elevated levels of metals (Cd, Mn, Pb, Ni, Cr, and As) in PM. On the industrial area, the PM concentrations of Cd, Mn, Pb, Ni, Cr, and As were 9.3, 461.9, 588.7, 69.5, 205.7, and 57.4 $\mu\text{g/m}^3$, while on the main road, they were 5.7, 245.5, 305.0, 31.4, 58.8 and 32.5 $\mu\text{g/m}^3$. According to their investigation, the main road and industrial area have comparatively high PM metal concentrations.

The assessment of seasonal variations in the mass concentrations and composition of heavy metals in PM_{10} gathered from a typical urban-industrial site in Acerra, Italy, was conducted by Vaio et.al (2018). Heavy metals such as Al, As, Co, Cr, Fe, Mn, Ni, Pb, Sb, V and Zn were examined in airborne PM, which accounted for roughly 8% of the PM_{10} concentrations. Their analysis revealed that there were no statistically significant seasonal fluctuations in the metal's distribution or relative concentrations ($P < 0.05$).

3. Method and Methodologies:

3.1. Study Area:



Figure1: Parking Zone of CSIR-NEIST where sampling has been done.

The study was carried out at the CSIR-NEIST, campus located in Jorhat, Assam. The study area is western of Jorhat and was connected to a vast network including the NH-37, which is thought to be the primary source of pollution from vehicle emissions. There were other industrial operations in the study area. In the study area, a variety of plants helped to prevent pollution. Plants can lower air pollution levels by removing dangerous contaminants. Green plants prevent pollution from accumulating in urban areas.

3.2. Sample Collection:

The sampling of PM_{10} was collected in the parking zone of CSIR-NEIST, Jorhat (latitude: $26^{\circ}44'16.08''$ N and longitude: $94^{\circ}9'20.9''$ E). From December 17, 2024, to January 23, 2025, for roughly 8 hours per day. The sampling was done on microfiber filter paper that had been preconditioned (in an airtight desiccator for 24 hours). The sampling was performed by a Respirable dust Sampler (Model: Envirotech APM 460 NL) with a 1.3 m^3 per minute flow

rate. Quartz filter paper 8×10 inch (20.3×25.4 cm) was used to collect the PM₁₀. The initial weight of the filter papers was taken before placing them inside the sampler. After keeping for 8 hours the final weight of the filter papers was taken and then further analyses were done respectively.

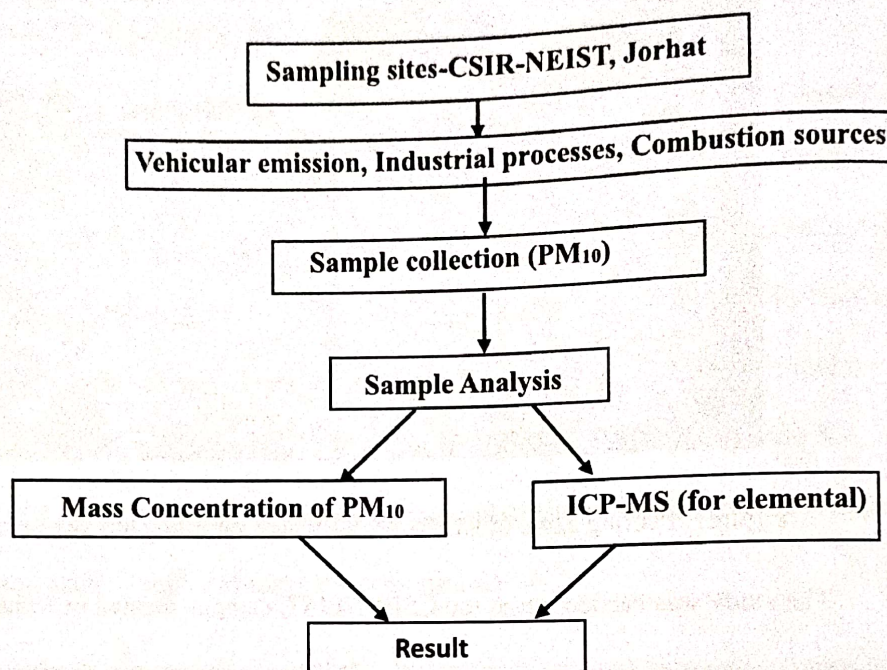


Figure2: Schematic diagram of methodology followed for the study.

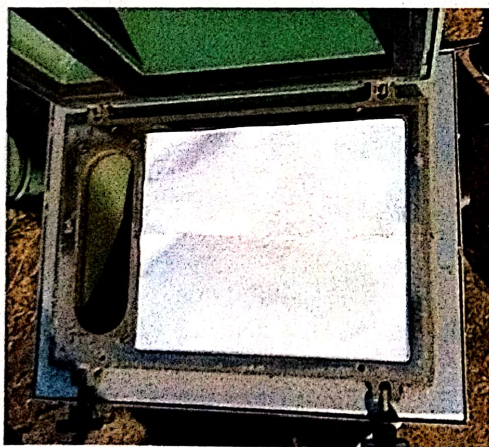


Figure 3: Microfibre Quartz blank filter paper inside the sampler before sample collection.

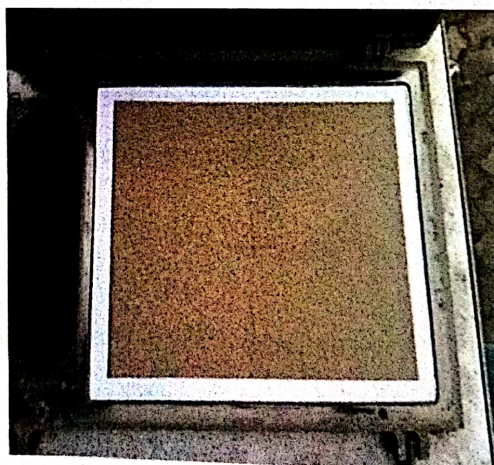


Figure 4: Microfibre Quartz filter paper after the PM₁₀ sample collection.

4. Working Principle of Instrumentation:

4.1 Respirable Dust Sampler (Envirotech APM460NL) and Fine Particulate Sampler (APM550):



Figure5: Respirable Dust Sampler (Envirotech APM 460 NL)



Figure6: Fine Particle Sampler (APM 550)

APM (Air Pollution Monitoring) 460NL: The Envirotech APM 460 NL is a manual method for sampling coarse particles (PM_{10}) in the ambient air in environmentally sensitive places. The APM 460 NL sampler measures respirable dust particles with aerodynamic diameters between 0.3 and $10 \mu m$. It uses a filter-based sampling method where air is drawn through a filter that captures the respirable dust particles. The instrument is used for environmental and occupational health monitoring as well as research and development to study the effects of respirable dust on human health and the environment. It uses as a cyclone separator to collect respirable particles (PM_{10}) while larger particles are removed. The device operates at a constant flow rate of around $1.3 m^3/min$. The special design of the blower doesn't

make any annoying noise while in operation. Thus, the machine can be operated even in silent areas like a library, hospitals, wild life sanctuary and in the other noise sensitive areas including residential areas.

APM (Air Pollution Monitoring) 550: The APM 550 is a technique for sampling fine particles ($PM_{2.5}$) in the ambient air in silent areas. Fine particulate matter with aerodynamic dimension less than $2.5\ \mu m$ is measured by the equipment. In accordance with regulatory criteria established by the Central pollution Control Board (CPCB) and the United States Environmental Protection Agency (USEPA), it is extensively utilized for air quality monitoring. By drawing air through a filter that collects the small particles, the APM 550 employs a filter-based sampling technique. It is used to check the quality of the air in urban, rural and industrial areas. The instrument is used in environmental research to examine how small particles affect the human health and the environment.

5. OBJECTIVE OF THE STUDY: To analyze the concentration of PM_{10} in the ambient air of the CSIR-NEIST campus using gravimetric method and assess its compliance with CPCB and WHO air quality standards. Additionally, the study aims to identify major anthropogenic sources contributing to PM_{10} levels and to evaluate the presence and concentration of associated heavy metals and metalloids using ICPMS for comprehensive air quality monitoring.

6. RESULTS AND DISCUSSION:

6.1 Mass concentration of PM₁₀:

The mass concentration of PM₁₀ are found in the sampling site are given below:

Table1: PM10 mass concentration for 24 hours, in $\mu\text{g}/\text{m}^3$

Date	Mass Concentration PM ₁₀ Current study	CPCB's limit for 24 hours	WHO's limit for 24 hours
17/12/2024	76.12179487	100	50
18/12/2024	90.06410256	100	50
19/12/2024	66.82692308	100	50
20/12/2024	57.53205128	100	50
21/12/2024	110.0961538	100	50
23/12/2024	92.94871795	100	50
24/12/2024	79.80769231	100	50
25/12/2024	62.82051282	100	50
26/12/2024	61.53846154	100	50
27/12/2024	80.44871795	100	50
28/12/2024	105.4487179	100	50
30/12/2024	105.1282051	100	50
31/12/2024	99.67948718	100	50
01/01/2025	93.42948718	100	50
02/01/2025	83.49358974	100	50
03/01/2025	77.56410256	100	50
04/01/2025	95.83333333	100	50
06/01/2025	67.46794872	100	50
07/01/2025	118.2692308	100	50
08/01/2025	63.94230769	100	50
09/01/2025	75.16025641	100	50
10/01/2025	80.12820513	100	50
11/01/2025	75.32051282	100	50
15/01/2025	50.96153846	100	50
16/01/2025	85.8974359	100	50
17/01/2025	78.04487179	100	50
18/01/2025	91.98717949	100	50
20/01/2025	57.21153846	100	50
21/01/2025	91.02564103	100	50
22/01/2025	114.4230769	100	50
23/01/2025	54.48717949	100	50

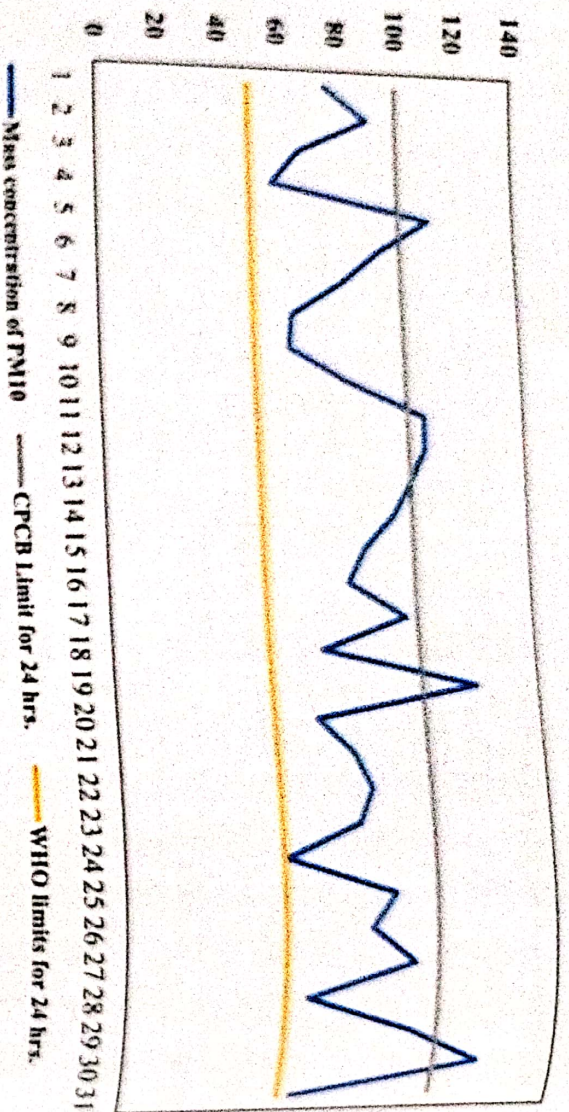


Figure 7: Comparison of PM10 mass concentration with CPCB and WHO's permissible limit

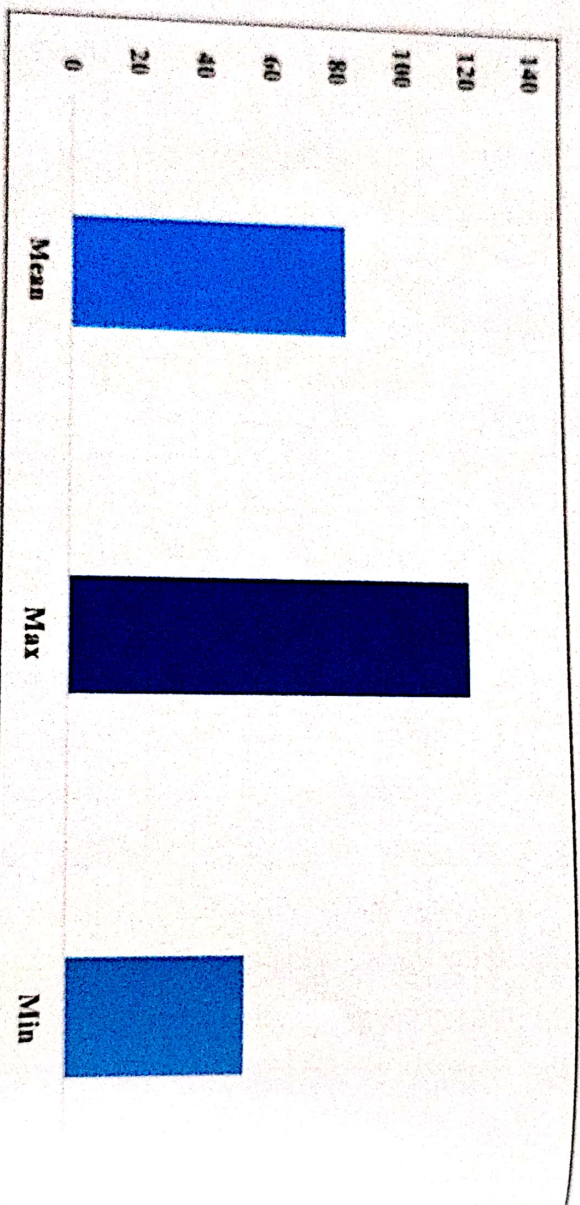


Figure 8: Graph showing the mean, maximum, and minimum values of PM10 in Jorhat during sampling time.

During a one-month winter sampling period, PM₁₀ concentrations were measured in the Jorhat urban area. The results, presented in Figure 7, illustrate the daily fluctuations in PM₁₀ mass load, which ranged between 50 µg/m³ and 100 µg/m³ throughout the study period, as depicted in the time series plot. The average concentration of PM₁₀ was found to be 82.03 µg/m³

(24-hour average). This figure is quite near to the CPCB's permissible limit of $100 \mu\text{g}/\text{m}^3$, although it is far higher than the WHO's recommended threshold of $50 \mu\text{g}/\text{m}^3$. The highest concentration of PM_{10} was $118 \mu\text{g}/\text{m}^3$, which is higher than the allowable limit of both WHO and CPCB guidelines. The lowest concentration measured was $50 \mu\text{g}/\text{m}^3$, which is equal to the WHO recommendation limit. Five of the 31 days exceeded the CPCB permissible limit, and the majority of the days exceeded the WHO permissible limit.

The average daily values of PM_{10} concentration vary significantly from day to day, mostly as a result of vehicular emissions, which can have a negative impact on both human health and the environment. In the study area, combustion sources and industrial activities also generate PM_{10} . The city's average concentration is unhealthy to inhale. It might reduce respiratory disorders by penetrating the lungs too deeply. Increased PM_{10} levels cause agricultural damage, which has an impact on the city's economy.

The mass concentrations data were measured statistically and find mean, median, mode, standard deviation as follows:

Table 2: Statistical values of PM_{10} mass concentration

Statistical measures	Values ($\mu\text{g}/\text{m}^3$)
Mean	82.03577
Median	80.12820513
Mode	105
Standard deviation	18.18277615

Table 2 provides the distribution of PM_{10} concentrations with statistical values of mean and median of $82.04 \mu\text{g}/\text{m}^3$ and $80.13 \mu\text{g}/\text{m}^3$. These concentrations are close to the CPCB permissible limit for PM_{10} but far exceed the WHO recommended limit. Some days

had the PM₁₀ concentration frequently occurred at 105 µg/m³, which elevated particulate matter levels.

Table 3: Vehicle survey on various days and at various times throughout the sampling period.

Date	Time	Total Vehicles
20/12/2024	11-12	1515
21/12/2024	11-12	1290
22/12/2024	10-11	932
23/12/2024	3-4	1310
24/12/2024	2-3	1145
25/12/2024	9-10	1107
26/12/2024	12-1	1055
27/12/2024	2-3	1288
28/12/2024	3-4	1167
2/01/2025	9-10	987

During the study period, we also surveyed vehicles passing along the national highway adjacent to the sampling sites. PM₁₀ particles are generated when certain pollutants from vehicle emissions, such as nitrogen oxides (NO_x) and volatile organic compounds (VOCs) emitted from vehicles interact with atmospheric constituents. After several days of counting, vehicles were recorded at different times, as shown in Table 3. We observed that the data indicate a clear trend: vehicular traffic volume significantly decreased on weekends compared to weekdays. We observed, that the filter-based sampling showed fewer dust particles collected on weekends, which indicates a lower concentration of PM₁₀. As a result, fewer vehicles on the road can reduce PM₁₀ and PM_{2.5} concentrations and also decrease the levels of other harmful pollutants, contributing to a cleaner and healthier environment.

7. Future Work: To further investigate the extent of ambient air pollution caused by heavy metals, it is essential to employ highly sensitive and precise analytical techniques. Inductively Coupled Plasma Mass Spectrometry (ICP-MS) stands out as one of the most powerful methods for detecting and quantifying trace levels of metals and metalloids in ambient air aerosol samples. Due to its low detection limits, wide dynamic range, and capability for multi-element analysis, ICP-MS is particularly suitable for monitoring airborne particulate matter and evaluating its metal content. A critical step before ICP-MS analysis is the preparation of samples to ensure accurate, reproducible, and representative results. Sample preparation typically involves the collection of airborne particles, followed by processes such as digestion, dilution, and filtration. Proper sample preparation not only minimizes potential contamination but also ensures that the analytes of interest are fully solubilized and compatible with the ICP-MS system. In the following sections, we will discuss the detailed sample preparation workflow for ICP-MS analysis of heavy metals in ambient air samples, including sampling techniques, acid digestion procedures, and quality control measures to validate the analytical results.

7.1 Sample Preparation for ICP-MS (Inductively Coupled Plasma Mass Spectrometry):

7.1.1 Sample Preparation:

The samples were collected from sampling site (Parking zone of CSIR-NEIST) using glass microfiber filter paper. A 1×8 strip of filter paper was cut from 8×10 inches of microfiber quartz filter paper. Following the cutting of filter papers, samples were digested using microwave digestion procedure.

7.1.2 Microwave-Assisted Digestion:

The microwave (MW) digestion procedure was used to break down the materials. 10 ml of concentrated nitric acid (HNO_3), 2 ml of hydrogen peroxide (H_2O_2) and 1/8 of a microfiber quartz filter paper was introduced to the microwave vessel for MW. The samples

were then digested at 180°C for 50 minutes. Following digestion, the materials were placed in a centrifuge tube and subjected to a 120-minutes sonication.

7.1.3 Sample Dilution:

Following sonication, 9 ml of distilled water and 1 ml of the digestate samples were added to dilute the samples, which were subsequently filtered. A syringe filter (0.22 micron) and syringe were used for filtration. After filtering, the samples were ready for ICP-MS.

7.1.4 ICP-MS (Inductively Coupled Plasma Mass Spectrometry):

The ICP-MS method was an analytical tool used to measure the amount of heavy metal in PM₁₀. Samples were prepared for ICP-MS by microwave digestion with acids, sample dilution to reduce Total Dissolved Solids (TDS), extraction and filtration. It provides information on the elemental composition and concentration by measuring ions.

7.1.5 ICP-MS instrumentation:



Figure9; ICP-MS Instrument in CSIR-NEIST

ICP-MS is a technique that can identify metals and several non-metals at extremely low concentrations in liquid samples. Using an argon (Ar) plasma, ICP-MS convert the samples into ions, which are subsequently analyzed by mass spectrometry (MS). It combines an Inductively Coupled Plasma (ICP) as an ionization source with a Mass Spectrometer (MS) to separate and quantify ions based on their mass to charge ratio.

7.1.6 Main components of an ICP-MS:

- 1) **Sample introduction system:** A nebulizer is used to deliver samples into the plasma, turning them into an aerosol.
- 2) **ICP torch:** The samples are ionized by a radiofrequency (RF) coil, which creates a high temperature argon gas plasma (6000-10,000 K).
- 3) **Mass analyzer:** A quadrupole or time-of-flight (TOF) mass analyzer is used to distinguish the ions generated in the plasma according to their mass-to-charge ratio.
- 4) **Detector:** A Faraday cup detector or an electron multiplier are used to find the separated ions.

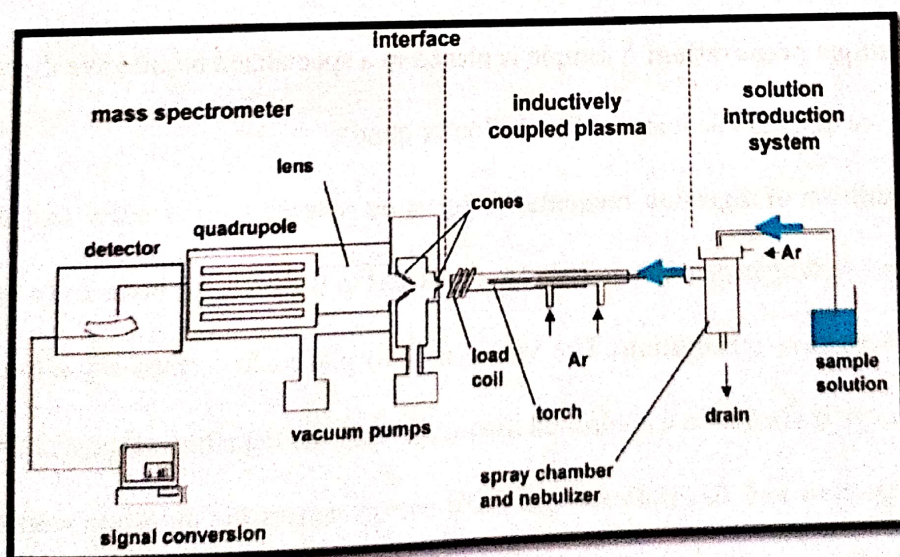


Figure10: Schematic diagram of ICPMS instrumentation

7.1.7 Principle of Microwave (MW) Digestion:

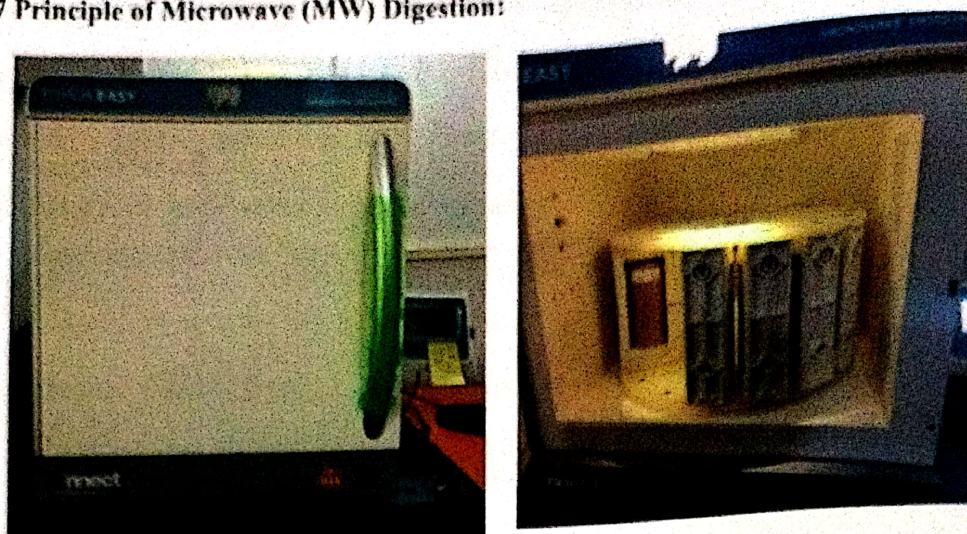


Figure10: Microwave digester for ICPMS sample preparation at CSIR-NEIST

Microwave digestion is used to prepare samples for chemical analysis by breaking down complex matrices using high temperature and high-pressure conditions in the presence of strong acids.

7.1.8 Microwave Digestion process:

- 1) **Sample preparation:** A sample is placed in a specialized microwave digestion vessel, made of a durable material like Teflon or quartz.
- 2) **Addition of digestion reagents:** A digestion reagent such as nitric acid, hydrochloric acid, hydrogen peroxide is added to the vessel to facilitate the breakdown of the sample.
- 3) **Microwave irradiation:** The vessel is then placed in a microwave oven. The MW energy is applied in a controlled manner to heat the digestion reagent and the sample.
- 4) **Digestion and Breakdown:** The MW energy causes the digestion reagent to heat up rapidly, breaking down the sample into its constituent elements or compounds.
- 5) **Cooling and Filtration:** After digestion, the vessel is removed oven and allowed to cool. The resulting solution may be filtered to remove any remaining solids.

8. Conclusion

In this study, it was observed that PM_{10} concentrations exceeded the permissible limits established by the Central Pollution Control Board (CPCB) and the World Health Organization (WHO) during the winter season. Prolonged exposure to elevated PM_{10} levels poses significant health risks to the city's residents. The findings suggest that anthropogenic activities are the primary contributors to the elevated PM_{10} concentrations. Additionally, our analysis indicates that, apart from PM_{10} , heavy metals and metalloids also play a critical role in the degradation of air quality. Therefore, assessing the presence and concentration of heavy metals and metalloids is crucial for comprehensive air quality monitoring. To achieve this, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) will be utilized to investigate the heavy metal content associated with PM_{10} .

9. References:

1. Rabha, S., Subramanyam, K. S. V., Sawant, S. S., & Saikia, B. K. (2022). Rare-earth elements and heavy metals in atmospheric particulate matter in an urban area. *ACS Earth and Space Chemistry*, 6(7), 1725-1732.
2. Hwang, J. S., Chen, Y. J., Wang, J. D., Lai, Y. M., Yang, C. Y., & Chan, C. C. (2000). Subject-domain approach to the study of air pollution effects on schoolchildren's illness absence. *American Journal of Epidemiology*, 152(1), 67-74.
3. Dutta, S., Ghosh, S., & Dinda, S. (2021). Urban air-quality assessment and inferring the association between different factors: A comparative study among Delhi, Kolkata and Chennai megacity of India. *Aerosol Science and Engineering*, 5, 93-111.
4. Guttikunda, S. K., Goel, R., & Pant, P. (2014). Nature of air pollution, emission sources, and management in the Indian cities. *Atmospheric environment*, 95, 501-510.
5. Sharma, A. K., Baliyan, P., & Kumar, P. (2018). Air pollution and public health: the challenges for Delhi, India. *Reviews on environmental health*, 33(1), 77-86.
6. Smith, S. J., Pitcher, H., & Wigley, T. M. (2001). Global and regional anthropogenic sulfur dioxide emissions. *Global and planetary change*, 29(1-2), 99-119.
7. Agrawal, M. (2005). Effects of air pollution on agriculture: an issue of national concern. *Natl Acad Sci Lett*, 28(3/4), 93-106.
8. Huang, Y. C. T. (2014). Outdoor air pollution: a global perspective. *Journal of occupational and environmental medicine*, 56, S3-S7.
9. World Health Organization. (1999). Air quality management: Air quality guidelines. *World Health Organization, Geneva* (available as of 5 January 2000 at: www.who.int/peh/air/airqualitygd.htm).

10. Saikia, J., Roy, S., Bordoloi, M., Saikia, P., & Saikia, B. K. (2018). Atmospheric aerosols around three different types of coal-based industries: Emission parameters, cytotoxicity assay, and principal component analysis. *Journal of Aerosol Science*, 126, 21-32.
11. Park, E. J., Kim, D. S., & Park, K. (2008). Monitoring of ambient particles and heavy metals in a residential area of Seoul, Korea. *Environmental monitoring and assessment*, 137, 441-449.
12. Radulescu, C., Stihl, C., Iordache, S., Dunca, D., & Dulama, I. D. (2017). Characterization of urban atmospheric PM_{2.5} by ATR-FTIR, ICP-MS and SEM-EDS techniques. *Rev. Chim*, 68(4), 805-810.
13. Tan, J. H., Duan, J. C., Ma, Y. L., Yang, F. M., Cheng, Y., He, K. B., ... & Wang, J. W. (2014). Source of atmospheric heavy metals in winter in Foshan, China. *Science of the total environment*, 493, 262-270.
14. Di Vaio, P., Magli, E., Caliendo, G., Corvino, A., Fiorino, F., Frecentese, F., ... & Perissutti, E. (2018). Heavy metals size distribution in PM₁₀ and environmental-sanitary risk analysis in Acerra (Italy). *Atmosphere*, 9(2), 58.
15. Jandacka, D., Durcanska, D., & Bujdos, M. (2017). The contribution of road traffic to particulate matter and metals in air pollution in the vicinity of an urban road. *Transportation Research Part D: Transport and Environment*, 50, 397-408.
16. Talbi, A., Kerchich, Y., Kerbach, R., & Boughedaoui, M. (2018). Assessment of annual air pollution levels with PM₁, PM_{2.5}, PM₁₀ and associated heavy metals in Algiers, Algeria. *Environmental Pollution*, 232, 252-263.
17. Piao, F., Sun, X., Liu, S., & Yamauchi, T. (2008). Concentrations of toxic heavy metals in ambient particulate matter in an industrial area of northeastern China. *Frontiers of Medicine in China*, 2, 207-210.

10. Photo Gallery



Photo: Sampling zone of CSIR-NEIST

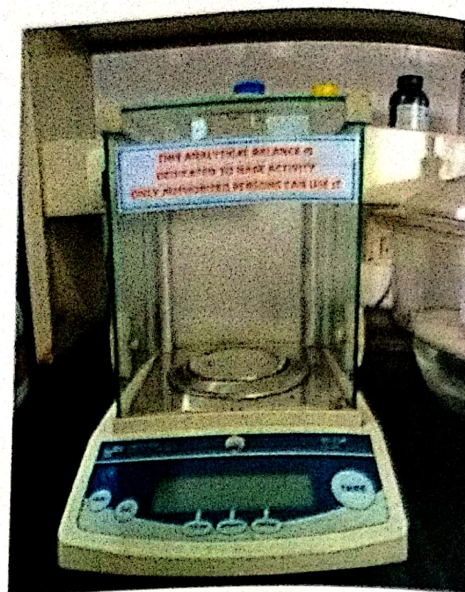


Photo: Digital Analytical Balance

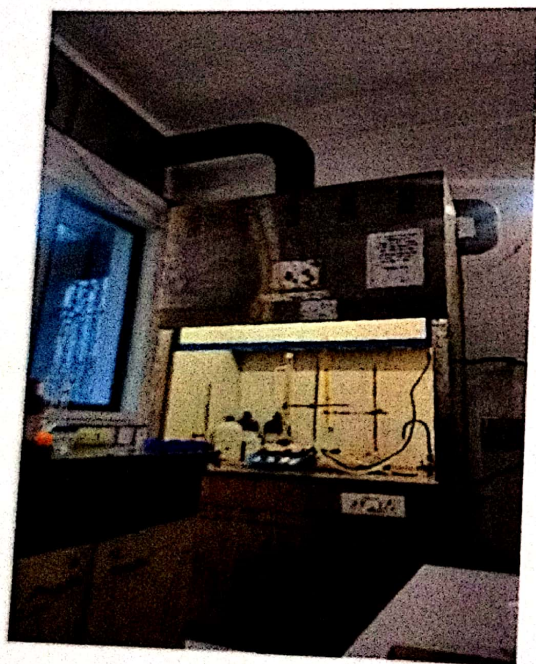


Photo: Fume Hood



Photo: Sample preparation for Microwave digestion



Photo: Microwave vessels ready for ICPMS



Photo: Sonication of the samples after MW digestion

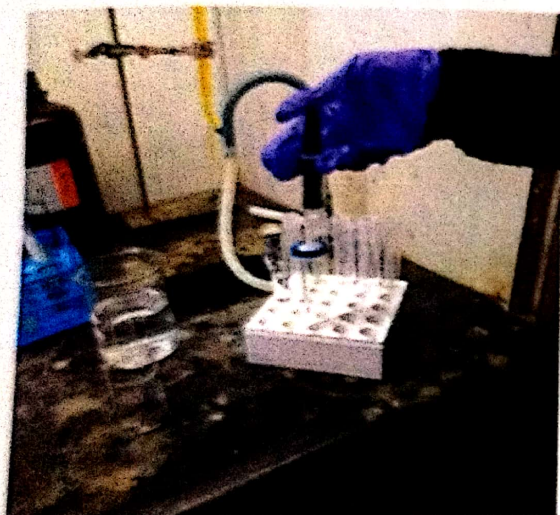


Photo: Filtration process after sample digestion



Photo: Vehicle Survey during sampling time