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PREFACE

Aryabhatta Research Institute of Observational Sciences (ARIES), Nainital and Doon University, Dehradun, is hosting the National Aerosol Conference 2024, from 17-20 December 2024, under the flagship of the Indian Aerosol Science and Technology Association (IASTA). IASTA-2024 focuses on broad topics covering aerosol/air pollution climate effects, indoor air quality and human health impact, cloud-aerosol interactions, aerosol/air quality modeling, nuclear and radioactive aerosols, aerosols for medical applications, bioaerosols, air quality control, clean energy, and sustainability development, aerosol instruments. The aim of IASTA-2024 is to provide an excellent platform for young researchers, technocrats, and policymakers to exchange their knowledge/ideas. IASTA-2024 will allow participants to interact, collaborate, and contribute toward the growth of aerosol science and technology. The conference will also provide an opportunity for the industries to showcase their technologies, different products, and innovations in the field of aerosol and air pollution. The scientific and technical program of the IASTA-2024 conference includes keynote addresses, Plenary Lectures, Invited Talks, contributed papers, and posters (108 platforms, 48 lightning, and 150 posters), along with a technical exhibition of different products and systems related to aerosol research and technology and allied areas. The conference also includes panel discussions on the topic "Air Quality in Uttarakhand" and popular lectures.

On behalf of the IASTA, the technical program committee thanks all the invited speakers, panelists, authors of the contributed papers, and sponsors who have supported in finalising the scientific and technical programmes. The committee thank all the persons involved in bringing out the proceedings, well in time for IASTA 2024. We take this opportunity to wish all the delegates interactive and fruitful discussions during the conference.

(Technical Programme Committee)
IASTA 2024

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AIR QUALITY AND ASSOCIATED HEALTH RISK ASSESSMENT OVER A METROPOLITAN CITY IN EASTERN HIMALAYAN FOOTHILL

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INTRODUCTION

Particulate matter (PM) is considered the most dangerous pollutant in almost all the urban areas of the world. The main man-made sources contributing to particles smaller than 10 micrometers (PM_{10}) in diameter are basically traffic, industry, construction, agriculture and forestry, fossil fuel power plants etc. PM_{10} particles can get deep into human lungs and some may even get into the human bloodstream. Respiratory disorders for example Asthma, Bronchitis and Chronic inflammation, are mainly due to PM that appears as dust. Exposure to fine dust particles can cause health effects such as eye, nose, throat and lung irritation, sneezing, coughing, runny nose, shortness of breath etc. The rapid growth of urban areas highlights a major issue, as expansion increases air pollution and poses serious risks to human health. Road dust (Guttikunda et al., 2014), which accounts for up to 30-40% of PM_{10} pollution in most cities, poses a significant concern, with manual sweeping often leading to the resuspension of dust into the air. Unplanned land use and land cover (LULC) changes, driven by rapid urbanization, significantly worsen air pollution leading to increased public health risks (Saha et al., 2024). Transportation is a significant contributor to PM2.5 pollution in India, with emissions from vehicles adding to the overall levels of fine particulate matter, particularly in urban areas (Venkataraman et al., 2018, Brauer et al., 2019). Respiratory disorders for example Asthma, Bronchitis and Chronic inflammation, are the most frequent illnesses caused by PM which appears as dust particles (Zaheer et al., 2018). The PM contained resulting from different sources upon human breathing produces serious effects on the lungs, heart, skin, arteries, and eyes (Jeong et al., 2011; Neghab et al., 2011; Chen et al., 2012).

In this study, we have analyzed the air pollutants and their effects on air quality over Guwahati from March 2019 to August 2024, one of India's rapidly growing cities. The land use and land cover of the Guwahati have changed significantly. Owing to the expansion of the city, more land is being used for various purposes, particularly in built-up regions used for habitation. We have also investigated LULC changes during 2019 and 2024 and compared air quality data from the Guwahati metro area with nearby rural locations. This comparative analysis indicates how urbanization impacts air quality and the urban-rural dynamics of pollution levels.

METHODS

To assess air quality in Guwahati, data are obtained from the Central Pollution Control Board (CPCB) of India (https://cpcb.nic.in/real-time-air-qulity-data/). The CPCB operates a network of 233 monitoring stations across the country, collaborating with State Pollution Control Boards and other agencies under the National Air Quality Monitoring Programme (NAMP). Air quality measurements focused on pollutants like Particulate Matter i.e. PM2.5 and PM_{10}, Sulfur Dioxide (SO_2), Nitrogen Monoxide (NO), Ammonia (NH_3) etc. The Air

Quality Index (AQI) is calculated based on CPCB standards. The sub-index (Ip) for a given pollutant concentration (Cp) as based on the 'linear segmented principle' was computed using the formula:

$$Ip = [(IHI - ILO) / (BHI - BLO) \times (Cp - BLO)] + ILO$$

Where:
BHI and BLO are the breakpoint concentrations,
IHI and ILO are the corresponding AQI values.
The final AQI was determined as the maximum sub-index:
AQI = max (Ip) (where, p = 1, 2, ..., n)

Additionally, Land Use Land Cover (LULC) data was downloaded from Landsat 8, which provides detailed imagery that enables the analysis of land use changes over time. This dataset includes nine spectral bands that capture various wavelengths, facilitating the assessment of vegetation, urban development, and other land cover types.

RESULTS AND DISCUSSIONS

The temporal variations of $PM_{2.5}$, PM_{10} and AQI from March 2019 to August 2024 over Guwahati are shown in Figure 1(a), Figure1(b) and Figure 1(c) respectively. During winter, PM2.5 levels range from 150 µg/m³ to 250 µg/m³. The pre-monsoon season of April and May in 2023 and 2024 shows a remarkable rise in both PM2.5 and PM_{10} concentrations, significantly higher compared to previous years.

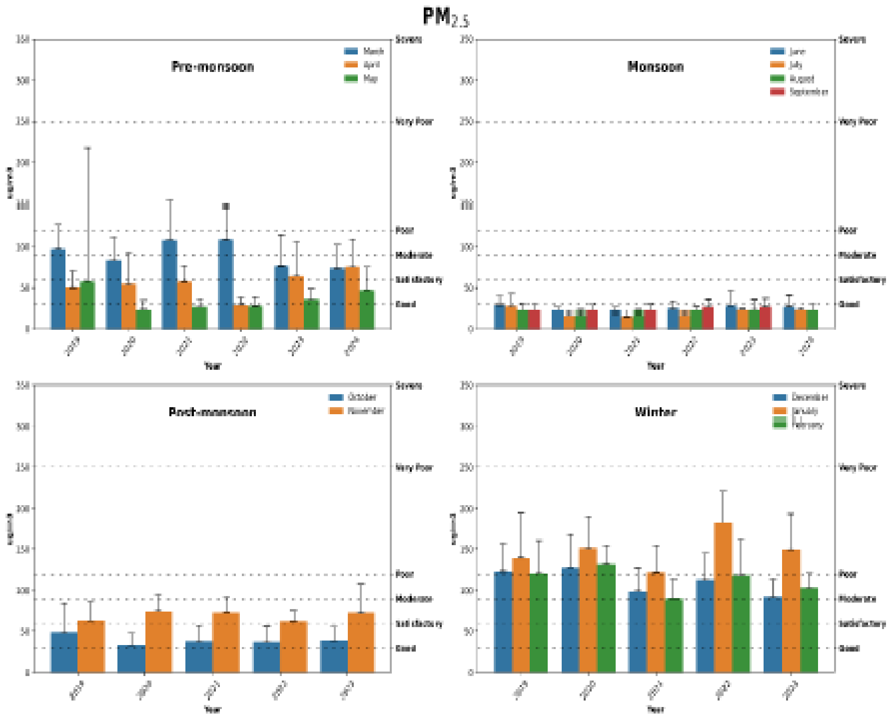

Figure 1(a): Monthly variations of PM2.5 over Guwahati from March 2019 to August 2024.

The monsoonal months consistently suppress PM concentrations due to heavy rainfall, which efficiently clears particulate matter from the atmosphere. A standout observation is the spike in March 2021, where PM2.5 concentrations exceeded 400 µg/m³. Similarly, January 2022 holds the record for the highest PM levels throughout the entire 6-year study, indicating it as the most polluted month during this period.

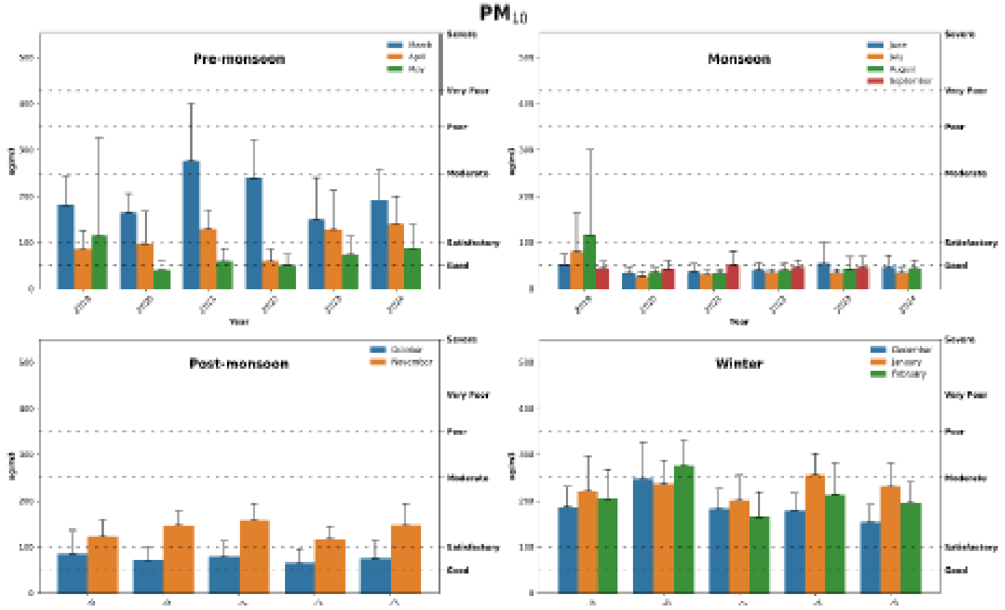

Figure 1(b): Monthly variations of PM10 over Guwahati from March 2019 to August 2024.

Over this period, the AQI consistently fluctuates within the poor to moderate range, with values typically between 200 and 300. Notably, significant spikes occur in January, where AQI levels exceed 350 points. During the pre-monsoon season, March emerges as the most critical month, with AQI values rising sharply from 200 to 350.

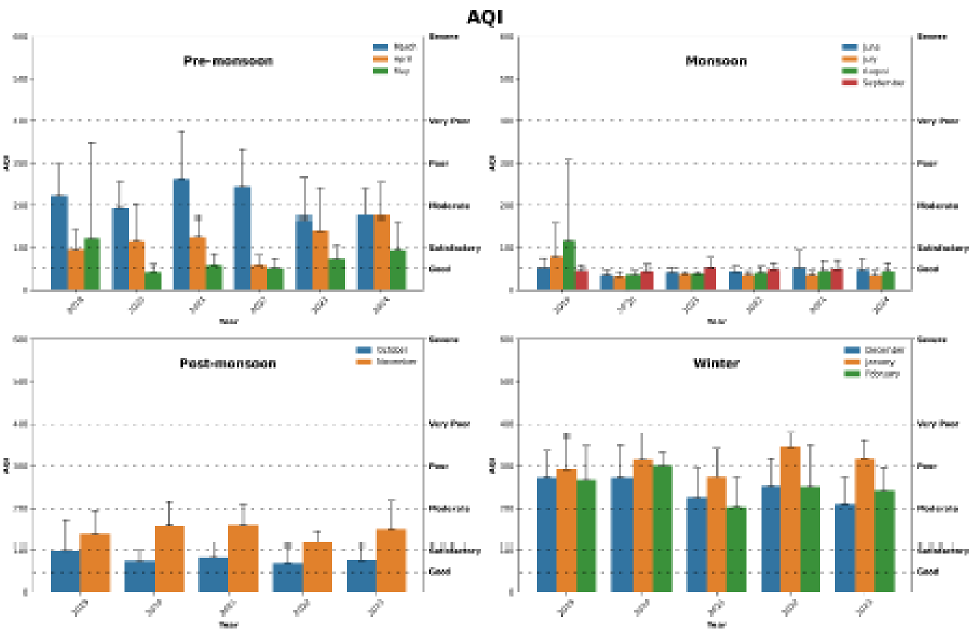

Figure 1(c): Monthly variations of AQI over Guwahati from March 2019 to August 2024.

After this peak, air quality gradually improves in the subsequent pre-monsoon months. The monsoon season brings relief, with AQI values generally falling into the good category, as heavy rainfall helps clear the air of particulate matter, keeping values below 100. However, in the post-monsoon season, air quality again begins to deteriorate steadily from October to November. The most polluted period during these 6 years was observed in January 2022, with AQI levels nearing 400, marking the worst air quality during the study.

The variations of air pollutants along with AQI across urban and rural locations of Guwahati are also compared for the years 2019 and 2023. Figure 2 presents a comparative analysis of these pollutants across the two monitoring stations, highlighting the trends and variations observed throughout 2023. The Guwahati Railway Monitoring Station indicates higher PM2.5 concentrations during the winter months; however, values generally remain consistent during the post-monsoon period. In contrast, the Guwahati Airport exhibits significant increases in PM_{10} concentrations during the monsoon months of 2023 year. Despite this, the PM_{10} levels at the railway station are typically lower than those observed at the airport, making it a more favourable site when compared to historical climatology.

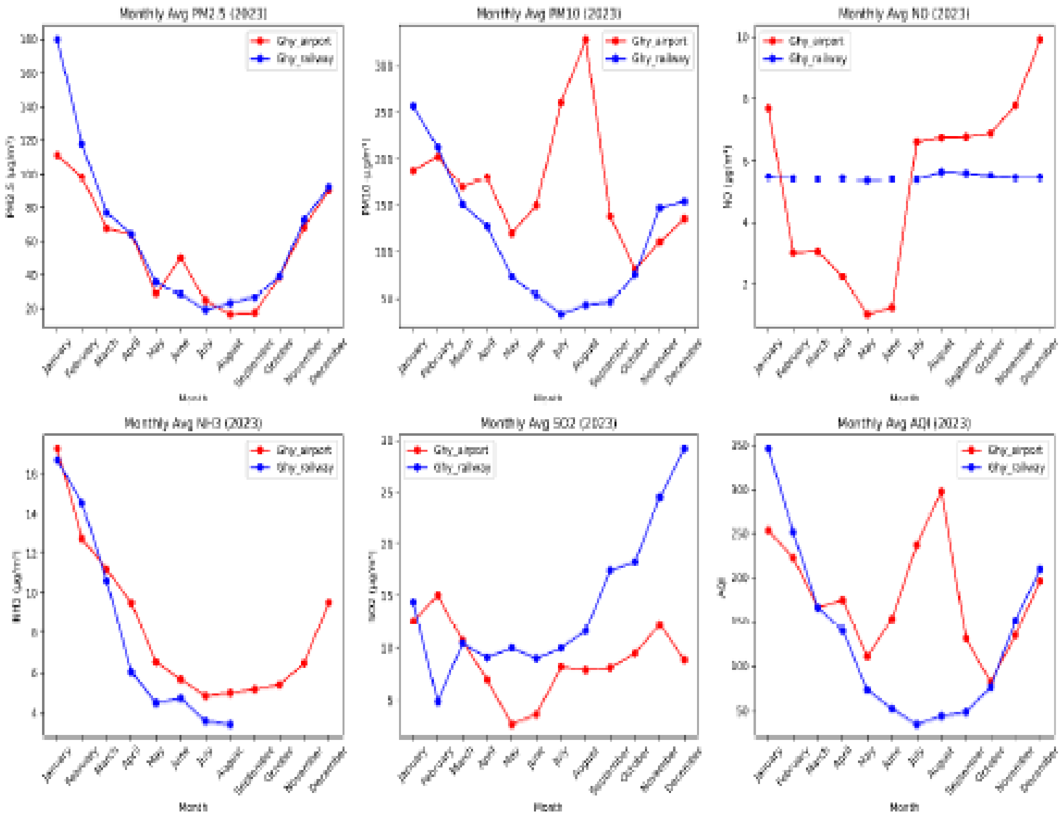

Figure 2: Comparison of monthly average pollutant levels (PM2.5, PM10, NO, AQI, NO2, and SO2) in 2023 between Railway Guwahati and Airport Guwahati station

The elevated PM_{10} levels at the airport may be attributed to ongoing construction activities and infrastructure development in the surrounding area, which likely impacts the AQI during the monsoon months. Additionally, SO_2 concentrations at the railway monitoring station are notably higher, averaging around 25 to 30 µg/m³, compared to those measured at the airport. NH_3 concentrations remain relatively stable during the winter months. In contrast, NO concentrations at the railway monitoring station fluctuate, typically ranging between 4 to 6 µg/m³. However, the airport monitoring station recorded a significant peak in NO levels during December, reaching approximately 10 µg/m³. This notable increase warrants further investigation to understand the underlying causes and implications for air quality in the are

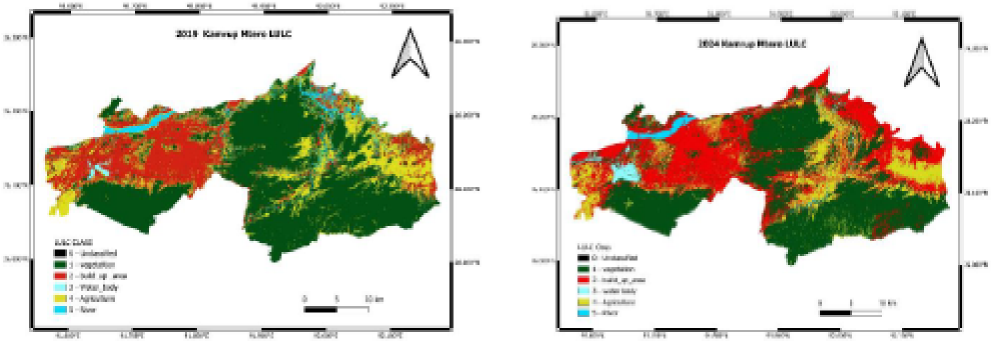

Figure 3: Land Use Land Cover (LULC) maps for 2019 and 2024 in land cover categories between the two years

Considering the observed variations in air quality, it is crucial to examine the Land Use Land Cover (LULC) changes in the region, as these can significantly influence pollutant concentrations. Figure 3 illustrates the LULC maps from 2019 to 2024, revealing a substantial increase in built-up areas, particularly on the eastern side of the metropolitan district.

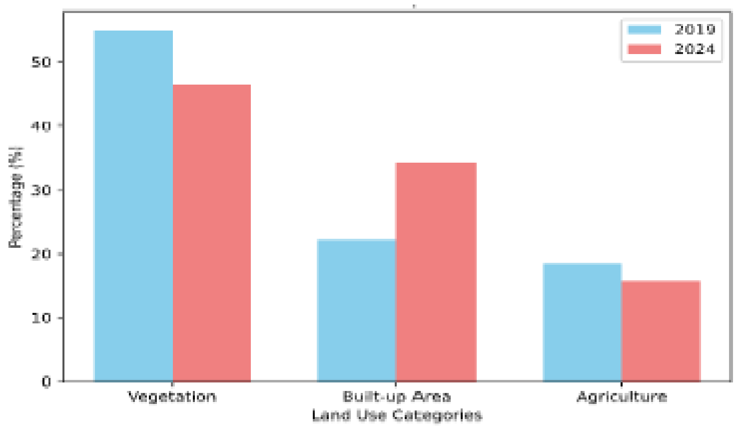

Figure 4: Percentage wise comparison of LULC features between 2019 and 2024

Over this period, approximately 10% of vegetation cover has diminished, while built-up areas have expanded by 15% (Figure 4). This drastic shift in LULC is likely contributing to the rising levels of particulate matter (PM) pollutants, particularly during construction activities. Additionally, the increase in population density and transportation infrastructure plays a major role in exacerbating air quality issues in the region.

CONCLUSIONS

The Air Quality Index (AQI) over the past five years predominantly fluctuated within the poor to moderate range, with January 2022 recording the highest pollution level with an AQI of nearly 400. Monsoon rains improved air quality significantly, keeping AQI values below 50. Winter PM2.5 concentrations ranged from 150 to 250 µg/m³, with a notable spike above 400 µg/m³ in March 2021. The years 2023 and 2024 saw significant increases in PM concentrations during the pre-monsoon months compared to previous years. Monitoring station comparisons showed that the Ghy Railway Station had higher PM2.5 levels in winter, while the Ghy Airport experienced increased PM_{10} concentrations during monsoon months, likely due to nearby construction.SO_2 levels at the railway station averaged 25 to 30 µg/m³, surpassing those at the airport. Notably, fluctuations in NO levels at both stations highlight the need for further investigation into air quality. The Land Use Land Cover (LULC) changes from 2019 to 2024 revealed a 15% increase in built-up areas and a 10% decrease in vegetation cover, contributing to rising PM levels amid urbanization.

ACKNOWLEDGEMENTS

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