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Air Pollution Correlation and Seasonal Variability in Chattogram's Urban Ecosystem

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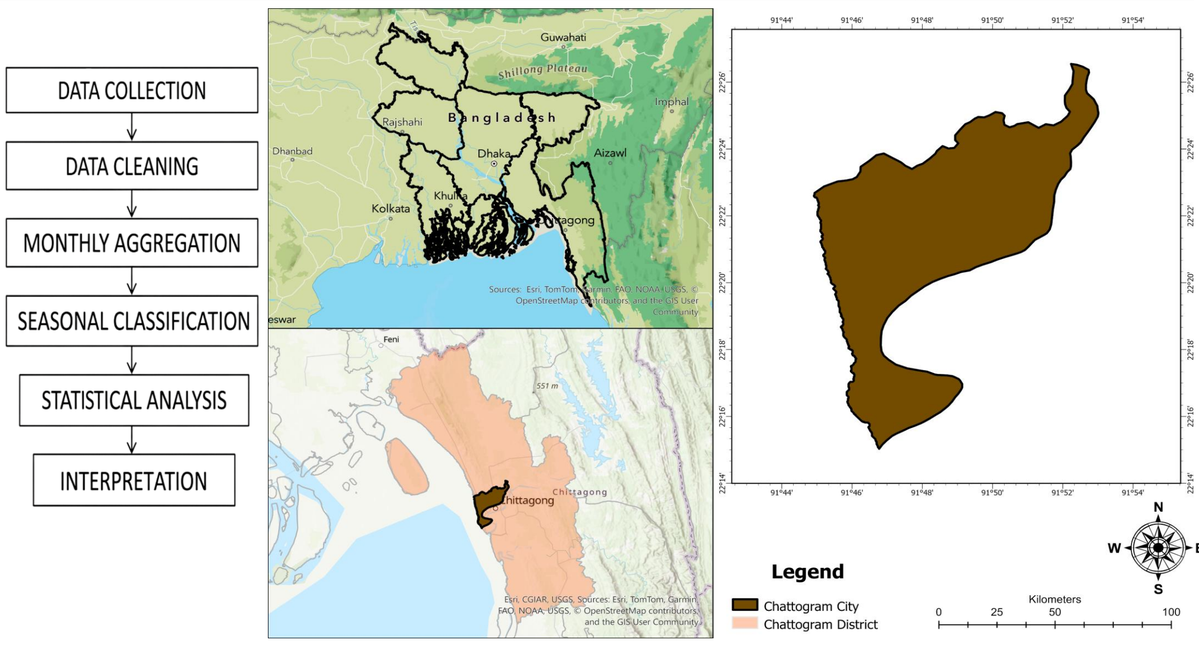
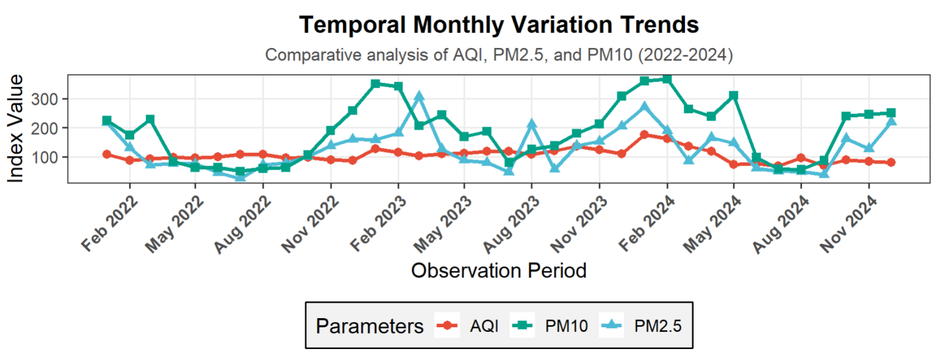
ABSTRACT

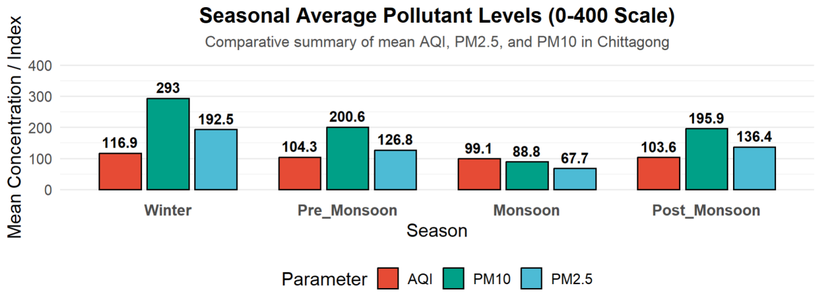
Due to rapid urbanization and industrial growth, Chattogram has become a major industrial and maritime hub in Bangladesh, with a dynamic new urban ecosystem. The rise in vehicle numbers and manufacturing industries has made particulate matter (PM2.5 and PM10) and nitrogen dioxide (NO2) the primary pollutants of concern. This study evaluates Department of Environment (DoE) records from 2013 to 2024, analyzing monthly extremes and decadal trends. The results revealed that the winter months (December–February) consistently recorded the highest hazard levels, with mean $PM_{2.5}$ of 122.77 µg/m³, PM_{10} of 216.15 µg/m³, and AQI near 188. In contrast, the monsoon months showed the lowest concentrations ($PM_{2.5}$: 17–25 µg/m³; PM_{10}: 43–51 µg/m³; AQI: 43–55). Annual means remain well above WHO guidelines, with PM2.5 at 44.08–76.4 µg/m³ and PM10 at 106.78–162.83 µg/m³, respectively. NO_2 exhibited episodic peaks, with a maximum of 280 µg/m³, and a minimum of 0.2 µg/m³. The highest seasonal mean for NO_2 occurred in autumn (35.13 µg/m³), while the decadal peak appeared in 2018 (34.4 µg/m³) before declining to 6.3 µg/m³ by 2024. The monthly maxima occurred in November at 38.94 µg/m³. It peaked in 2018 at 34.40 µg/m³, dropping to 6.28 µg/m³ in 2024. These trends show how urban structure, meteorology, and industrial activity jointly shape ecological functions. These findings highlight the need for ecosystem-based management that incorporates green buffer zones, emission zoning, and seasonal control strategies.

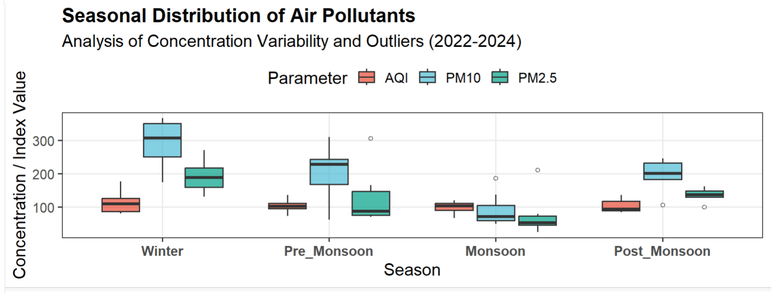
METHODOLOGY & STUDY AREA

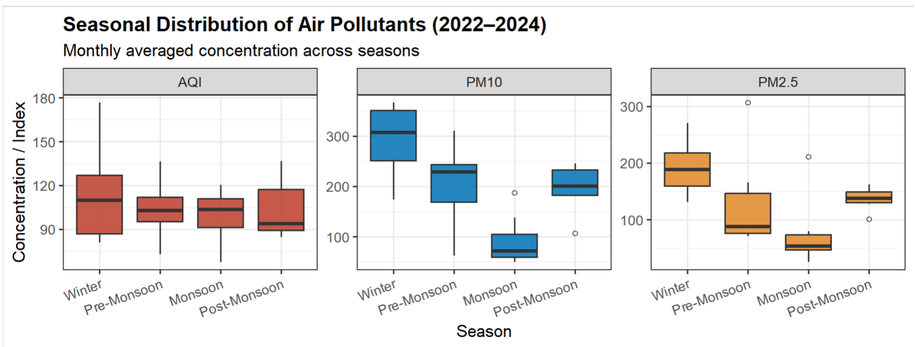


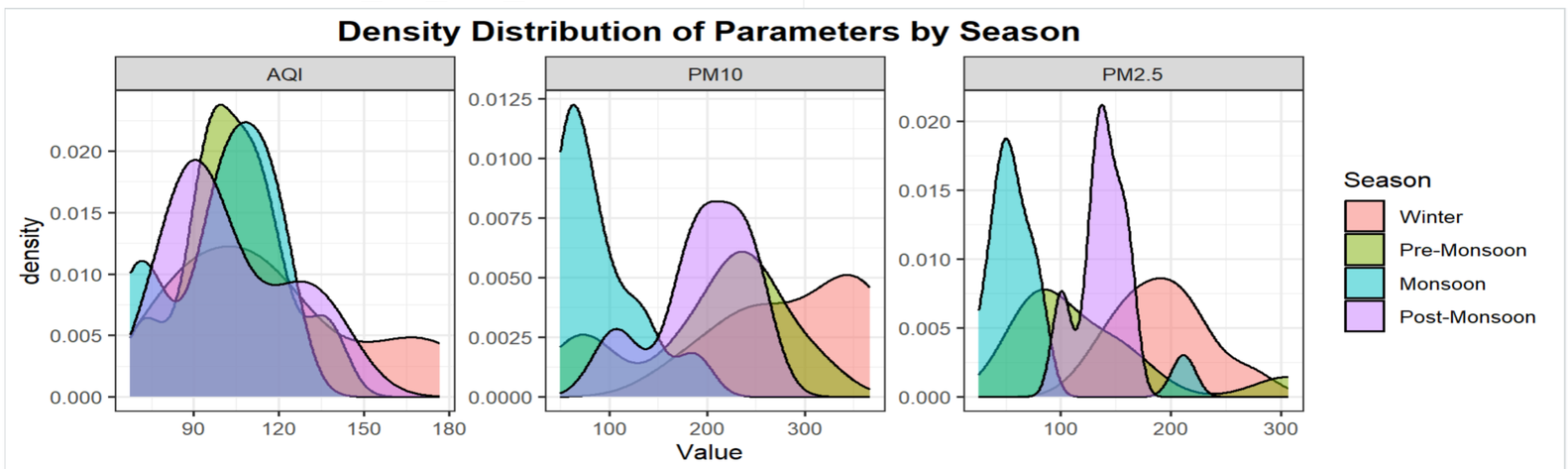
RESULTS AND DISCUSSION

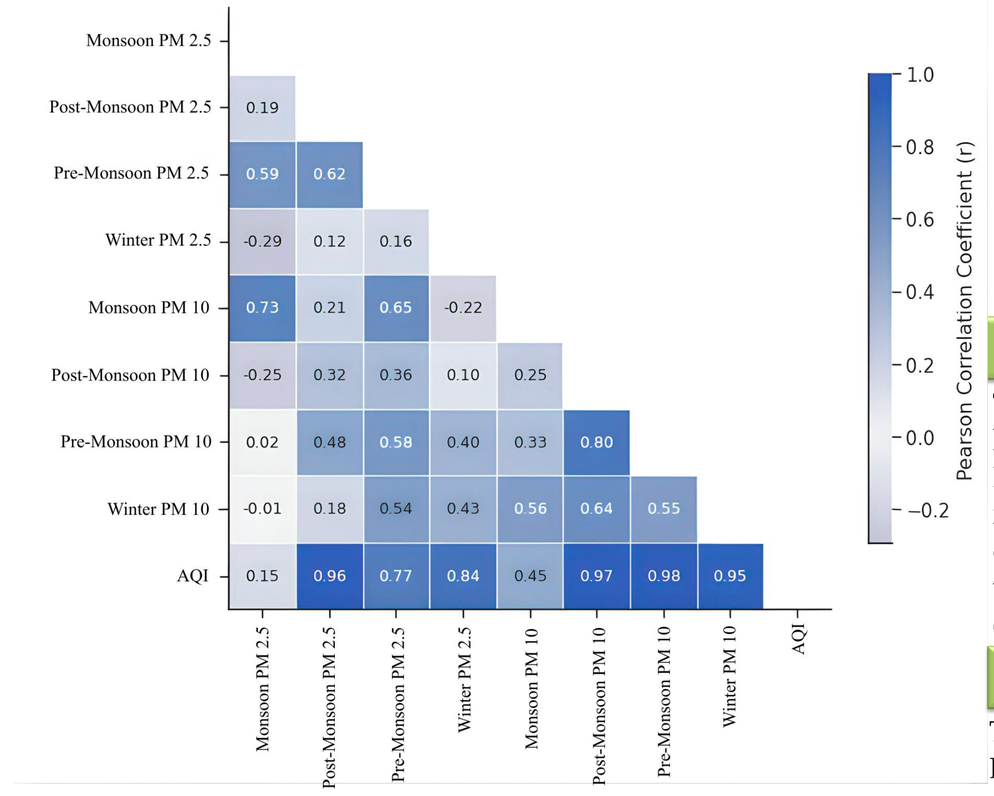












The present analysis validates the presence of significant seasonal variability of airborne pollutants in the urban environment of Chattogram. It closely resembles the trends mentioned in the abstract of this manuscript. Peak concentration of PM2.5, PM10, and Air Quality Index (AQI) was found during winter months, while the monsoon season had significantly low concentrations. Analysis and density analysis studies also indicate that winter pollution is not only increased, but also more heterogeneous, implying episodic accumulation events. This seasonal variability, in contrast, tends to support the hypothesis that reduced atmospheric dispersion and quasi-stable boundary layer conditions during the winter months favor the accumulation of pollutants, whereas rainfall associated with the monsoon favors wet deposition and atmospheric renewal. Correlation analyses show a high correlation between AQI and particulate matter, especially PM10, for most of the seasons. The strong AQI-PM correlations suggest that particulate contamination is the major factor for air quality fluctuations in Chattogram. Seasonal variability in coupling between the inter-pollutants further suggests that winter conditions exert an effect on pollutant co-accumulation, whereas monsoon dynamics reduce the coupling through enhanced dispersion mechanisms.

CONCLUSION

This analysis has confirmed severe seasonal variations in the air quality of Chattogram, with the winter seasons showing the highest concentrations of PM2.5, PM10, and the AQI, while relatively low concentrations characterize the monsoon periods. Results show that particulate matter (especially PM 10) is the main contributor to the fluctuations of AQI. The higher intensities of inter-pollutant coupling in winter indicate accumulation of the pollutant under mainly stable atmospheric conditions, while weaker relationships in the monsoon indicate increased dispersion and wet deposition processes. Overall, these results show that the combined effects of anthropogenic emissions and seasonal meteorological forcing drive the dynamics of air quality in Chattogram.

REFERENCES

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