Leveraging Low-Cost Sensors to Characterize Particulate Matter Exposure in Suburban Regions of Kedah and Kelantan

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Abstract

Particulate Matter (PM_{10} and $PM_{2.5}$) poses significant health risks, particularly in suburban areas with limited monitoring. This study addresses these gaps by analyzing PM_{10} and $PM_{2.5}$ levels along with meteorological variables (temperature and humidity) using low-cost sensors in Kedah (Sept 2022–Aug 2023) and Kelantan (Nov 2022–Apr 2023), located in the northwest and northeast of Peninsular Malaysia, respectively. Data were examined for daily to seasonal trends based on monsoonal patterns. A 72-hour backward ensemble trajectory analysis was performed at the site with the highest daily particulate matter concentration to ascertain the origin of the air masses contributing to the elevated concentration levels. Health risk assessments for various age groups were conducted. In Kedah, median $PM_{2.5}$ levels (19.8 µg/m³) exceeded the annual Malaysian Ambient Air Quality Standard (15 µg/m³), while the median PM_{10} concentration remained within safe limits (20.7 µg/m³). Kelantan recorded a median $PM_{2.5}$ level of 15.3 µg/m³, slightly above the annual safe limits, and a PM_{10} median concentration of 28.4 µg/m³. Unexpectedly, higher PM concentrations were observed during the Northeast monsoon, suggesting the influence of local activities. The hazard quotient (HQ) for $PM_{2.5}$ in Kedah surpassed safe limits (HQ > 20) across all age groups, with adults facing ten times the cancer risk compared to Kelantan. Low-cost sensors effectively detected pollution peaks that were missed by reference stations, underscoring their value in enhancing air quality surveillance in underserved regions.

Keywords: Low-cost sensors, Particulate Matters, Meteorological Variables, Backward Trajectories, Health Risk Assessment.