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Assessing Air Pollution Vulnerability in the Kathmandu Valley: Insights from Personal Particulate Matter Exposure Monitoring with Portable Sensors

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Air pollution remains a leading public health concern, disproportionately affecting densely populated urban areas in low and middle-income countries such as Nepal. Limited regulatory monitoring infrastructure and data scarcity constrains the assessment of population level exposure and vulnerability. This study employed portable aerosol sensors (Aerocet 831-Met One Instrument Inc., Grant Pass, Oregon, USA), to measure real-time personal exposure to PM1, PM2.5, PM4, and PM10 across indoor, outdoor, and mixed microenvironments in the Kathmandu valley.

The study area was sampled into urban zones with relatively higher PM concentrations and sub-urban zones with lower PM concentrations using satellite-derived PM2.5 data, enabling stratified analysis of personal exposure across spatially varying pollution levels. Households were selected using a snowball sampling method from both exposure zones, to include diverse socio-economic, occupational, and educational backgrounds, encompassing both home and workplace microenvironments. Two participants, usually one female and one male, were recruited from each selected household to understand the difference in exposure patterns based on gender. The participants carried a backpack with sensors for a continuous 72-hour period to monitor personal exposure. The data was collected between January and April 2025, capturing the winter season, which is characterised by elevated air pollution levels in the study area.

33 households participated in the study, comprising a total of 66 participants. Aerosol sensor measurements were integrated with participant-reported daily activity logs to characterise personal exposure patterns. Furthermore, combining sensor data with socio-demographic characteristics and microenvironmental information, the study aims to identify populations most vulnerable to air pollution exposure. Preliminary findings suggest variability in exposure across socio-economic groups, microenvironments, and exposure zones. Comprehensive analysis, including data normalisation, will ensure comparability across exposure zones, socio-economic characteristics, and microenvironments, thereby clarifying patterns of vulnerability.

The study approach demonstrates the application of portable sensors to understand exposure in communities with a limited regulatory monitoring network. The results will inform actionable strategies for targeted public health interventions.