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Linking Occupant Movement to Indoor Air Quality Dynamics: Insights from Sensor-Based Monitoring

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Indoor air quality is strongly influenced by both ventilation dynamics and occupant activity, yet the relationship between these factors remains insufficiently characterized. In this study, we deployed a network of low-cost MegaSense sensors across a university campus to continuously monitor several key environmental parameters, including gaseous compounds (CO, NO₂ and O₃), particulate matters (PM_{2.5} and PM₁₀), total volatile organic compounds (TVOCs), and noise levels. People counters were also installed side-by-side for an academic year. Initial results revealed pollutants were accumulated overnight due to reduced ventilation, and rapidly diluted in the early morning once ventilation resumed. We also found that whilst PM and gaseous pollutants were strongly linked with ventilation cycles, TVOC concentrations and noise levels exhibited pronounced diurnal patterns closely aligned with occupant movement. The correlation between TVOC concentrations and with people flow ($r \approx 0.7$) is strong, likely attributed to emissions from breath, skin, and personal care products, as well as redistribution of localized VOCs through airflow disturbances. Noise levels showed an even stronger correlation ($r \approx 0.8$), which indicated human presence through speech, footsteps, and mechanical interactions. O₃ concentrations, in contrast, displayed no discernible diurnal variation.

These findings highlight the potential of integrating occupant movement and noise monitoring as effective proxies for estimating TVOC dynamics in indoor environments. More broadly, the study demonstrates opportunities of using low-cost sensor networks in capturing the complex relationships between human activity and indoor air quality, which is able to offer valuable insights for sustainable building management and exposure assessment for human's health. As future work, such sensor applications can be scaled to diverse indoor settings (e.g. occupational, residential, etc) to further explore these relationships.