healthRiskADAPT: Advanced Ventilation and Filtration Strategies for Indoor Air Quality and Thermal Comfort

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ABSTRACT

The TNO contribution in the EU healthRiskADAPT project focuses on developing and validating a multi-zone ventilation and thermal comfort model to quantify health risks associated with heatwaves, air pollution, wildfire emissions, and pollen exposure in residential and healthcare environments. The research integrates dynamic simulations with real-world monitoring to improve predictive accuracy for indoor air quality (IAQ) and thermal resilience under extreme climate conditions.
Four energy-efficient dwellings equipped with balanced ventilation systems with heat recovery were monitored for key IAQ parameters, including PM2.5, CO_2, relative humidity, and temperature. Advanced sensor networks tracked window status and occupant presence to capture behavioural influences on ventilation performance. Results demonstrate that indoor PM2.5 concentrations are strongly influenced by mechanical ventilation rates, infiltration dynamics, window operation, indoor emission sources, and filter efficiency.
Comparative analysis of coarse G3 filters versus fine F7 filters revealed that fine filtration significantly reduces indoor PM2.5 concentrations, achieving levels below WHO annual guidelines. Infiltration factors were markedly lower with fine filters, and the validated model accurately predicted ventilation and infiltration flows using CO_2-based algorithms.
Future work will extend the model to healthcare facilities, incorporating high-efficiency ASPRA filtration systems and advanced thermal modelling to address combined heat and pollutant stress. This integrated approach supports evidence-based design for resilient, low-energy buildings that safeguard occupant health under evolving environmental challenges.

KEYWORDS

Indoor Air Quality (IAQ), PM2.5 Filtration, Balanced Ventilation, Heat Recovery, Multi-Zone Modelling, Thermal Comfort, Infiltration Dynamics, CO_2-Based Ventilation Control, ASPRA Filters, Energy-Efficient Buildings, Health Risk Assessment, Climate Adaptation, Wildfire Emissions, Pollen Exposure, WHO Guidelines