A Pre-Post Retrofit Evaluation on Indoor Air Quality and Comfort in Classrooms and Offices: Pre-Retrofit Findings

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SUMMARY

The BENEFIT project evaluates the indoor environmental quality in non-domestic buildings where energy efficiency upgrades will be implemented; a baseline for indoor air quality hass been established across 50+ environments prior to the commencement of retrofit activities. Initial findings in pre-retrofit environments reveal widespread underventilation and the significant influence of outdoor $PM_{2.5}$ levels indoors in existing classroom and office environments. Detailed pre-retrofit results will be presented at an upcoming conference.

KEYWORDS

Low-cost sensors; Long-term monitoring; PM2.5; Natural Ventilation

1 INTRODUCTION

Retrofitting existing buildings to improve energy efficiency is crucial for reducing greenhouse gas emissions, particularly since a large portion of the existing buildings will remain in use beyond 2050. In Ireland, 37% of CO_2 emissions stem from the built environment [1], the public sector plays a pivotal role in leading climate action, exemplified by initiatives like the Public Sector Climate Action Mandate [2]. While previous studies focussed on IAQ measurements in pre-post retrofits, these studies focussed on residential dwellings [3, 4]. There remains a significant knowledge gap regarding the impacts of energy retrofits on IEQ, namely, classrooms and offices. While reducing emissions is essential, it's equally important to ensure adequate IEQ for occupants' health and well-being through proper ventilation and retrofit strategies.

2 METHODOLOGY

The study employs a dual-monitoring approach using research-grade and consumer-grade ('low-cost') sensors to measure a large suite of environmental parameters. Research-grade monitors capture precise week-long data on key indoor air quality metrics pre- and post-retrofit (including PM2.5, NO2, CO, O3, formaldehyde, limonene, BTEX, temperature, humidity, CO2, TVOCs), while low-cost sensors provide long-term data for up to a year pre- and post-retrofit (including CO_2, temperature, humidity, radon, TVOCs).

Complementing monitoring data, surveys on thermal comfort, occupant satisfaction, building/ventilation characteristics, and activity/occupancy profiles contribute additional insights into indoor air pollution sources. Meteorological conditions and outdoor pollutant concentrations are sourced from nearby monitoring stations and historical forecasts, facilitating the identification of indoor and outdoor pollution contributions.

The study encompasses 17 buildings with multi-zone monitoring, typically three rooms per building. The monitoring campaign commenced in May 2023 and concluded in June 2024.

3 RESULTS

Figure 1 illustrates CO_2 levels during school hours from a sample of 14 classrooms, revealing prolonged periods where concentrations exceed 1000 ppm, a threshold often associated with inadequate ventilation. The interquartile ranges for temperature and humidity during occupied hours were 18-21°C and 41-53%, respectively. However, there were instances where temperature levels dropped as low as 13°C, and humidity levels rose as high as 76% during opening hours. These deviations from the typical ranges warrant further investigation to understand their causes and implications. Additionally, frequent exceedances of WHO daily mean guideline values for $PM_{2.5}$ have been observed (Figure 2), in instances exceeding the guideline value sixfold. Preliminary analysis indicates considerable spatial variability in $PM_{2.5}$ concentrations, potentially influenced by factors such as building orientation, flooring materials, occupant activities, and window orientation and usage patterns.

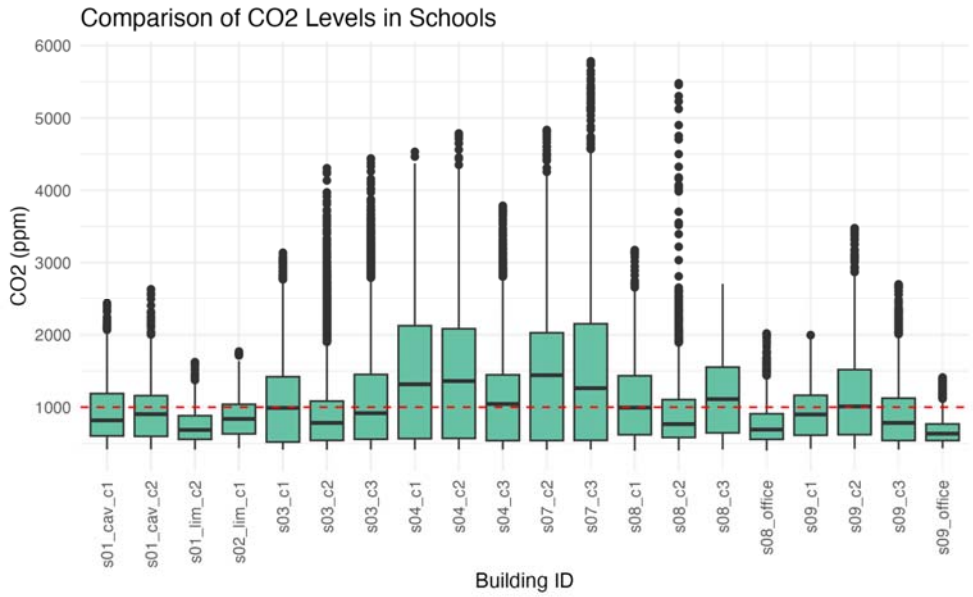

Figure 1, CO2 concentration (ppm) during occupied hours across 20 school environments. The dashed line at 1000ppm, for reference, is frequently used as a marker of poor ventilation.

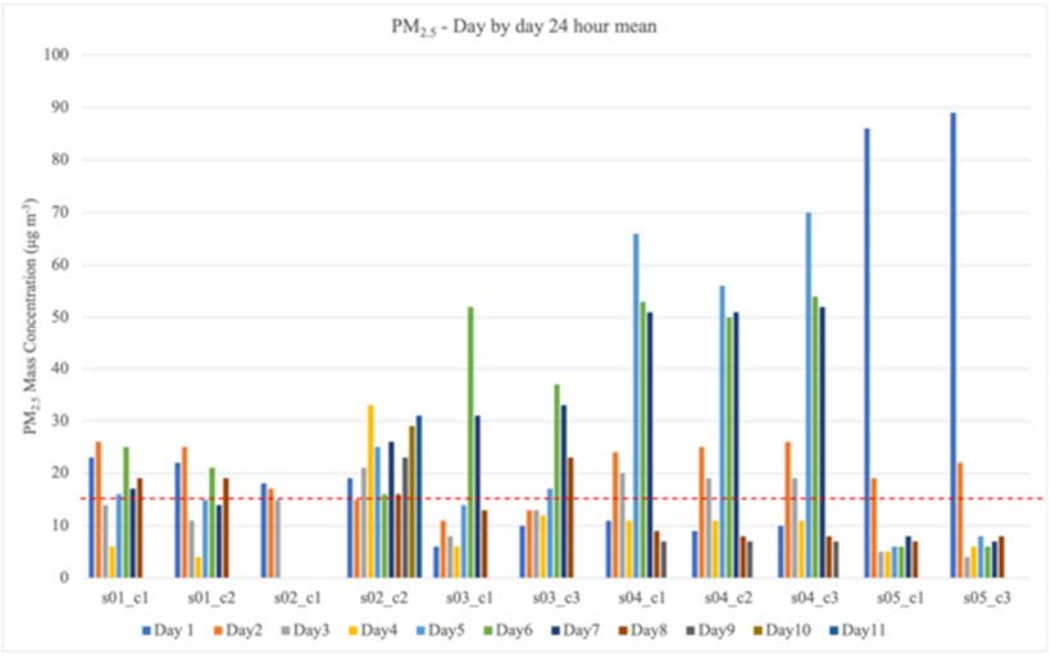

Figure 2. Daily mean PM2.5 concentration highlighting exceedance of WHO guideline value (red line) and temporal variation across 7 days of monitoring.

4 CONCLUSIONS & DISCUSSION

The preliminary findings reveal significant indoor environmental quality challenges in Irish offices and schools, including suboptimal temperature, humidity, ventilation, and particulate matter concentrations. To address these issues, a thorough statistical analysis is planned to better understand pollutant behaviours and building performance. Additionally, the effectiveness of current ventilation strategies and key determinants of indoor air pollution will be assessed to inform targeted interventions. Future work includes a post-retrofit monitoring campaign starting in Autumn 2024 across 50+ environments to evaluate the impact of energy efficiency and thermal retrofits on indoor environmental quality, providing comparative insights into pre- and post-retrofit conditions.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

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