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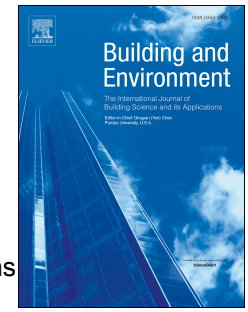

A pre and post evaluation of indoor air quality, ventilation, and thermal comfort in retrofitted co-operative social housing

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A pre and post evaluation of indoor air quality, ventilation, and thermal comfort in retrofitted co-operative social housing

Abstract:
In comparison to building energy performance, assessment of the impact of energy upgrades on indoor air quality and occupant comfort has received little attention.
Concentrations of indoor air pollutants in fifteen, three bed semi-detached co-operative social dwellings were monitored before and after an energy upgrade during the winter periods of 2015 and 2016. The fifteen dwellings consisted of seven cavity wall (CW) dwellings and eight hollow block (HB) wall dwellings. Concentrations of indoor air pollutants including CO, $PM_{2.5}$, CO_2, TVOCs, formaldehyde, BTEX, NO_2 and thermal parameters including temperature and relative humidity, were measured in the main living area and main bedroom before and after the energy upgrade.
Building air tightness decreased from pre retrofit values of 9.26 - 10.00$m^3/(h.m^2)$ @ 50 Pato an average of 5.53 $m^3/(h.m^2)$ @ 50 Pa and 8.61$m^3/(h.m^2)$ @ 50 Pa post retrofit (CW group and HB group, respectively). Concentrations of CO_2, TVOC, and $PM_{2.5}$ significantly changed post-retrofit, increasing post retrofit in both dwelling groups (CW; p= 0.014; p= 0.009; p= 0.005) (HB; p= 0.003; p= 0.032; p= 0.008). Increases in pollutant concentrations were correlated with lower building air exchange rates post retrofit. This study suggests that the energy retrofit had a positive impact on occupant comfort and building temperature; however, concentrations of some pollutants were found to increase following the retrofit.
The study highlights the importance of characterising indoor air quality post energy retrofits within the overall building energy performance to ensure improved health outcomes for building occupants post retrofit.

Key words:
Indoor air quality, occupant comfort, renovation, semi-detached dwellings, social housing, ventilation, energy retrofit

1. Literature review:

Ireland's building stock is amongst the lowest energy performers in Northern Europe (Lapillonne, 2012) and the Irish Government has identified energy efficiency retrofitting of housing as a significant opportunity to address fuel poverty and meet climate change targets (Department of Communications Energy and Natural Resources, 2014). The Better Energy programme, introduced in 2011, offers financial incentives to improve the energy performance of dwellings (Department of Communications Energy and Natural Resources, 2014). The scheme supports improvements such as the installation of roof and wall insulation and high efficiency (>90%) boilers for heating. The scheme is estimated to have produced annual savings of up to 751 GWh or €47 million (SEAI, 2013). The Irish Government Department of Housing, Planning, Communities and Local Government also provide energy retrofit measures for local authority dwellings, and it is estimated that up to 58,000 dwellings availed of this scheme over the period 2013 to 2016 (Department of Environment Community and Local Government, 2016).

Building envelopes significantly impact upon the thermal performance of dwellings; uninsulated or partially insulated cavities can allow the ingress of outdoor-originating particulates and the addition of evenly pumped insulation can reduce this ingress (Liu and Nazaroff, 2001). Mitigating heat loss through the building envelope is the main focus of most retrofitting schemes, and in Ireland cavity wall insulation and roof insulation are the most common upgrades used to limit heat loss from external walls and roofs (Cuce and Cuce, 2016, Byrne et al., 2016). Replacing old windows with double-glazed windows can also reduce ventilation rates by 0.25 ACH (Ridley et al., 2003).