Quantify Factors Influencing Radon Flux in Dwellings

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SUMMARY

Radon, a naturally occurring radioactive gas, is a leading cause of lung cancer and has the potential to increase significantly due to current renovation strategies. Understanding the factors influencing radon infiltration into buildings is vital. Radon flux into buildings is a highly dynamic process influenced by various factors. The current study analyses a historical time-series dataset to determine radon entry rates into buildings and identify statistical factors driving the radon flux based on meteorological, environmental, and building characteristics. Through this research and analysis, this project seeks to enhance our understanding of radon factors in dwellings and improve the predictive ability regarding radon within dwellings.

KEYWORDS

Radon, Indoor Air, Energy Retrofits, Radon Entry Rates, Model Parameterisation.

INTRODUCTION

Radon ($^{222}_{86}Rn$) is a naturally occurring radioactive gas and is the leading source of radiation exposure, contributing to 350 cases of lung cancer in Ireland each year [1] and further concerns caused by energy retrofits have already been identified [2]. Radon typically enters buildings from the ground through minuscule gaps in the floor or foundation of the building. However, the rate at which radon enters the building is highly dynamic, even within the same dwelling, and is influenced by several variables, including soil permeability, meteorological conditions, and building ventilation rates [3].

Fluctuations in these variables can cause significant variations in indoor radon levels over short-time period. In order to evaluate radon as part of energy strategies, radon within dwellings needs to be reliably predicted. However, to date, detailed model parameterisation values that account for this dynamic process are lacking. The INFORM project seeks to enhance the understanding of factors that influence radon flux into dwellings, determine model parametrisation values, and ultimately improve indoor radon modelling capabilities.

MATERIALS

During a previously completed project, real-time monitors (Wave Plus, Airthings, Oslo, Norway) measured radon, temperature, pressure, relative humidity, carbon dioxide, and volatile organic compounds [4]. Long-term measurements were conducted from October 2019 to December 2021 across 87 Irish homes. Sampling was conducted in four zones within each house: the living room, bedroom, kitchen, and bathroom. Radon concentrations were collected hourly, resulting in an extensive dataset of approximately 55 million hourly data points, including additional outdoor meteorological data.

METHODOLOGY

The radon entry rates (E) are derived using a mass-balance equation (1). E is the dynamic radon entry rate (Bq/h), C_{in} is the indoor radon concentration (Bq/m^3) at this time step t, C_{out} is the outdoor radon concentration (Bq/m^3), λ_v is the air exchange rate (h^{-1}), λ_{Rn} is the radon decay constant (h^{-1}), λ_l is the building area leakage rate (h^{-1}), and V is the zonal volume.

$$E=\frac{\left[C_{in_{(t)}}-C_{in_{(t-1)}}e^{-(\lambda_v+\lambda_l+\lambda_{Rn})t}\right][V(\lambda_v+\lambda_l+\lambda_{Rn})]}{(1-e^{-(\lambda_v+\lambda_l+\lambda_{Rn})t})}-V(\lambda_v)C_{out} \quad (1)$$

RESULTS

Radon entry fluxes (entry rates per area) were determined based on Equation 1 and preliminary data is presented in Figure 1. Figure 1 shows a box plot of radon entry flux distributions among 84 case studies over 18 months for the living room in each dwelling. As expected, there is considerable variability across the dwellings and within each dwelling, which is reflected by the wide distribution, highlighting the dynamic process. Ongoing analysis is investigating the correlation between the radon entry rates to seasonal and metrological factors to account for this distribution.

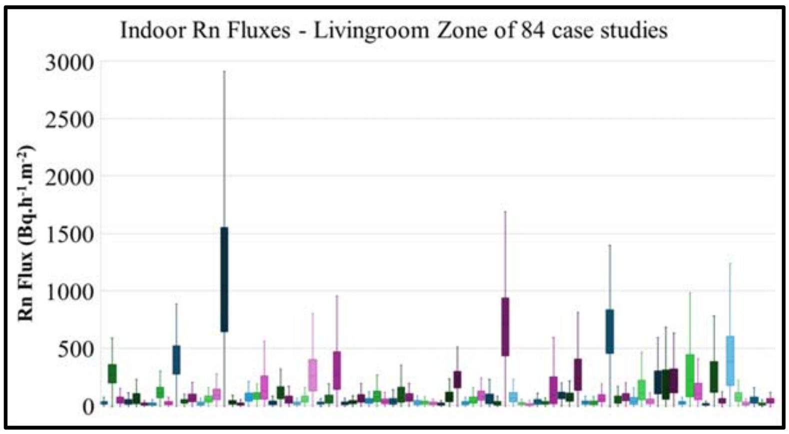

Figure 1. Box plots of radon fluxes distributions of 84 case studies over 18 months.

CONCLUSION

The initial analysis supports the temporal variation in radon concentrations by accounting for the wide distribution of radon flux rates in dwellings. The following stages will focus on refining the radon fluxes, providing a more detailed understanding of radon dynamics. The study outcomes will enhance modelling capabilities and inform radon mitigation strategies.

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