Author

Sid Ahmed Ryad Tiarti

Organization

Université de Montréal – Montréal, QC

Title

Radon in the Workplace: Estimating the Effective Radiation Dose

Abstract

Background:
Radon is recognized as one of the most significant sources of natural radiation exposure to humans. It remains a major public health and an occupational safety concern due to its well-established carcinogenicity and widespread presence in indoor environments. Since 1987, the International Agency for Research on Cancer (IARC) has classified radon as a proven human carcinogen for lungs, and is identified as the leading cause of lung cancer among non-smokers. This odorless, colorless, and tasteless ubiquitous radioactive gas originates from the decay of uranium-238 in the Earth's crust and can seep into buildings through cracks and openings in the foundations.
Worldwide, the average annual effective dose from radon exposure is estimated at 1.2 mSv, exceeding the recommended limit of 1 mSv/y for the public and for workers non-occupationally exposed to radioactive materials (outside of the nuclear industry). While radon has been extensively studied in residential settings, occupational exposure particularly in non-mining workplaces remains insufficiently characterized, leading to uncertainties in risk assessment and radiation protection strategies. Our objective is to estimate the effective dose due to radon exposure received by workers in Quebec (Canada) across different occupational environments.
Methods:
A long-term measurement campaign of indoor radon concentrations was conducted during the 2022-2023 cold season in various workplace environments across four regions of Québec. The regions were selected based on their indoor radon potential (high or low), according to a predictive radon potential map developed by Drolet et al., 2014. To be included, workplaces had to have over 4 hours of work activities in a basement or at slab-on-grade level. Indoor radon concentrations were measured by the research team in various workplaces using AT-100 passive alpha-track detectors approved by the Canadian National Radon Proficiency Program (C-NRPP), which have a limit of detection of 15 Bq/m^3. Questionnaires were distributed across workplaces to document working hours, staff number, the nature of the work performed, the occurrence of naturally occurring radioactive materials (NORM), workers' effort level, and the type of ventilation system used. The questionnaire responses were

consolidated through the research team members' on-site visits to the workplaces. The effective dose was estimated using a dosimetric approach that incorporates the alpha energy of radon progeny (5.56×10^{-6} mJ·m^{-3}/Bq·m^{-3}), appropriate dose conversion coefficients (3-6 mSv per mJ·h·m^{-3}), and the recommendations outlined in the International Commission on Radiological Protection (ICRP) Publication 137.

Results:

A total of 354 radon measurements were conducted across 57 buildings in 54 workplaces. Of these, 191 measurements were below the detection limit, and 10 buildings had all measurements below this limit. Annual working hours for each workplace ranged from 960 to 3,600 hours, and they employed between 1 and 200 workers. Detected radon concentrations and corresponding effective dose varied greatly by workplace and by occupational sector. Water treatment facilities (4 buildings) and municipal buildings (28 buildings) exhibited low minimum detected dose levels (~0.168 and 0.38x mSv/y, respectively), while public service workplaces (6 buildings), indoor vegetable culture (3 buildings), and fish hatcheries (5 buildings) showed slightly higher minimum detected effective dose values (~0.40-0.49 mSv/y). The granite transformation sector (1 building) presented higher estimated doses, with a minimum of 1.15 mSv/y and a maximum of 2.26 mSv/y. Municipal buildings, the largest group studied, displayed a broad range of detected effective dose, from a minimum detected level of ~0.168 mSv/y to a maximum of ~7.17 mSv/y. Overall, all sectors had maximum estimated doses well above 1 mSv/y. Fish hatcheries presented the highest estimated effective dose, reaching up to a maximum of 46 mSv/y, highlighting a sector-specific potential for increased occupational exposure.

Conclusion:

The core findings of our study indicate that the effective doses estimated across all studied sectors can exceed the recommended 1 mSv/y limit for non-nuclear energy workers, and can reach well above the limit of 20 mSv/y in workplaces involving NORM such as in fish hatcheries. These results highlight the urgent need for targeted radon mitigation strategies and continuous monitoring in high-risk workplaces. While our study was limited to winter measurements in selected regions, the observed variability suggests that current occupational safety guidelines may be insufficient. Future research should focus on year-round exposure patterns, sector-specific factors such as ventilation and building design, and the development of intervention strategies. Policymakers and employers should prioritize radon monitoring programs and mitigation measures to protect workers and ensure compliance with international dose limits.