Radon in Indoor Air in Nova Scotia

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Introduction

Radon is a naturally occurring radioactive gas that originates from the decay of uranium in soil and rock. It can easily migrate through the ground and infiltrate buildings via cracks and openings in foundation floors and walls (Health Canada, 2023). This accumulation can lead to hazardous radon concentrations in indoor air and is particularly concerning in basements. Inhalation of radon is recognized as the second leading cause of lung cancer after smoking.

The 2024 Cross-Canada Survey of Radon Exposure in the Residential Buildings of Urban and Rural Communities found that approximately 1 in 5 (17.8%) houses in Canada have radon levels at or above the current radon guideline of 200 Bq/m³. An additional 24.2% of people reside in houses with radon levels between 100-199 Bq/m³. These estimates are greater than the previous Cross-Canada Survey results obtained in the late 2000s (Health Canada, 2012), which indicated 6.9% of houses that at the time were at or above 200 Bq/m³ (Health Canada 2024). Specifically, in Nova Scotia, approximately 36.8% of homes are expected to have radon levels exceeding the guideline, compared to the national average of 17.8% (Health Canada, 2024). It is estimated that radon contributes to over 3,000 deaths annually in Canada (Health Canada, 2012). This has led to an estimated 100 radon-related deaths each year in the province (CAREX Canada, 2016). In 2007, Health Canada updated its guideline for indoor radon levels to 200 Bq/m³ (Health Canada, 2007; Government of Canada, 2007).

Between 2023 and 2024, the Geological Survey Division, Nova Scotia Department of Natural Resources focused on increasing public awareness of radon exposure and enhancing the radon database. Key activities included validating the 2013 model with the latest indoor air radon measurements from 3,776 homes (up from 524 in 2013), participating in four home shows to promote awareness and testing, launching a follow-up program to investigate the temporal variability of radon levels in indoor air, engaging with the Nova Scotia and Atlantic Radon Working Groups, and supporting the Nova Scotia Public Libraries' Radon Detector Loan Program.

Risk Map Update

Indoor air radon measurements from 3,776 homes (from 524 in 2013) were used to validate the 2013 model (O'Reilly et al., 2013) in addition to update the probability of exceeding the radon guideline in high-, medium- and low-risk areas (Table 1). The 2024 results found that the average probability of homes expected to exceed the guideline across all three risk areas was 32.9%, which closely correlates with the latest Cross Canada Radon Survey that found that more than 1 in 3 homes (36.8%) in Nova Scotia exceed the Health Canada Guideline (Health Canada, 2024).
The radon measurements were obtained from three datasets, one of which were provided by Health Canada from a Halifax Regional Municipality survey, one that was provided by LungNSPEI which included province-wide data from 2017-2024, and

one that was compiled from DNR residential radon surveys between 2019 and 2024. Further details about how the risk map was derived are provided in O'Reilly et al. (2010). As indicated in Table 1, the radon test results used to validate the map show that

- 55% of buildings in the high-risk areas exceed the radon guideline (up from 40% in 2013).
- 31% of buildings in the medium-risk areas exceed the guideline (up from 14% in 2013), and,
- 19% of buildings in the low-risk areas exceed the guideline (up from 5% in 2013).

Table 3: 2024 Radon survey results displaying percentage of homes exceeding the Health Canada guideline of 200 Bq/m^3 for high, medium and low risk areas.

Risk Area	Rn Score from map	No. of Rn readings	No. Homes >200Bq/m^3	% Homes >200Bq/m^3	No. Homes >600 Bq/m^3	% Homes >600Bq/m^3
Low	<120	1310	246	18.8	16	1.2
Medium	121-170	1477	455	30.8	68	4.6
High	>170	989	543	54.90	174	17.6
	Total	3776	1244	32.9	258	6.8

These results demonstrate that even homes in low-risk areas should be tested. Testing is the only way to determine the radon concentration in your home, so it is important to test no matter where you live. The radon risk map is also useful for assisting with municipal planning and raising awareness about radon gas. Do-it-yourself long-term radon testing kits can be ordered from LungNSPEI.

Library Loan Program

The Radon Detector Library Loan Program was launched in 2017 and allows the public to borrow a digital radon detector for a period of four to six weeks to test their home at any time of the year. However, the loan period is insufficient for determining the average annual radon level, which is crucial since the Canadian radon guideline is based on annual averages. Additionally, it is generally recommended to conduct radon tests during the winter heating season, when radon levels are expected to be highest. Since the library loan program is not restricted to winter months, homeowners may inadvertently test during periods when radon levels are lower.

As part of the library loan program, homeowners can voluntarily submit their radon test results via a dedicated email address (radon@novascotia.ca). These results are compiled into a database, which is instrumental in mapping radon risk throughout the province. This data helps identify areas with higher radon levels, guiding targeted interventions and raising public awareness about radon exposure.

Between January 2023 and October 2024, a total of 135 radon test results were received and are summarized below in Table 2. Approximately 10% of these exceed the Canadian indoor air radon guideline of 200 Bq/m^3. Homeowners with high radon results were provided information on how to reduce radon levels in their homes.

Table 4. Voluntary radon test results received from homeowners through the Library Loan Program from January 2023 to October 2024.

Description	Value
Number of Samples (n)	135
Number exceeding Canadian radon guideline of 200 Bq/m^3	14
Maximum (Bq/m^3)	1,683
Minimum (Bq/m^3)	1
Average (Bq/m^3)	110
Median (Bq/m^3)	66
Average length of test (weeks)	5
Number of tests that were at least four weeks long	122

Radon Reduction Grant Program

In partnership with LungNSPEI, the Radon Reduction Grant Program was launched in 2024 to support lower-income households in Nova Scotia that may otherwise not be able to test for radon gas and remediate their homes if necessary. Since its inception, the program has provided 306 free test kits and successfully mitigated seven homes with radon levels exceeding Health Canada's guideline of 200 Bq/m^3. This initiative aims to enhance the safety and health of vulnerable communities by addressing the risks associated with radon exposure.

At home shows in Halifax, Pictou, and Truro, members from GSD, LungNSPEI, and Health Canada engaged with over 1,000 families in 2024. They addressed questions and concerns about radon, offering information on how to test homes and take steps to reduce associated risks.

Seasonal Variability Studies

Radon levels are known to vary significantly over seasons and time, sometimes doubling within a single day (Health Canada, 2023) and, therefore, a full year of radon monitoring is needed to determine the average annual radon level in a home. However, most building owners carry out their radon tests for one to three months, rather than one year (Drage et al. 2021). It also is commonly projected that indoor radon levels are higher in winter than summer and, therefore, winter testing (November to April) is normally recommended. It is assumed that radon levels are higher in winter because windows

and doors are closed and the thermal stack effect that can draw more radon gas from the soil is usually strongest (Health Canada, 2017). Several researchers have reported that radon levels are higher in winter months (e.g., Bossew and Lettner, 2007; Al-Khateeb et al., 2017). However, other researchers have reported that there is no consistent seasonal pattern, and that radon can be higher in winter, summer, or show no significant variation across seasons (Cortina et al., 2008; Miles et al., 2012; Stanley et al., 2019, From Drage, 2021).

2019-2023 Seasonality

Study Background

Between 2019 and 2023, the Geological Survey Division, Nova Scotia Department of Natural Resources conducted a long-term radon monitoring program. The study aimed to assess the seasonal variability of radon levels in Nova Scotian homes and evaluate the effectiveness of short-term radon tests from the Library Loan Program in predicting if a home exceeds the annual radon guideline of 200 Bq/m³. The study was done by placing real-time digital radon detectors in 12 volunteer homes for a period of one year.

Three of the 12 homes in the study had average annual radon levels above the guideline and all three homes had four-week running averages throughout the year that exceeded the short-term conservative threshold value of 150 Bq/m³ used by the Library Loan Program to indicate if a home is likely to exceed the radon guideline. The limited data available suggested that short-term, four-week radon tests can be used to appropriately identify homes that have average annual radon levels exceeding the radon guideline of 200 Bq/m^3 when a conservative radon threshold level (150 Bq/m^3) is used to indicate that a home potentially exceeds the radon guideline however, further testing was recommended to confirm this proposition.

The results of radon seasonal variability found only one of the twelve homes had higher radon levels in the winter, while seven homes had higher radon levels in the summer or fall, and four homes had similar radon levels across two or more seasons. While the study provided valuable insights, its limited sample size of 12 homes suggested the need for further research to confirm the temporal variability findings across a broader population. More extensive studies would enhance our understanding of radon temporal dynamics.

2023-2024 Seasonality

Study

In response to the need for additional data, a follow-up program was conducted between Spring 2023-2024 that involved testing radon levels in seven Nova Scotia homes using continuous, hourly measurements with Airthings Wave radon detectors. All volunteer homes in the 2023-2024 study were located in the Halifax Regional Municipality and ranged in construction age from 1976 to 2022. The radon detectors were positioned at a height of 1 to 2 meters in the lowest living space of each home, ensuring they were away from windows, doors, and vents for a period of one year.

A summary of the radon monitoring results is provided in Table 2 and an example of the annual radon data from one site is provided in the graph in Figure 1. The results in Table

3 show that the average annual radon levels at the sites ranged from 72 to 1,092 Bq/m³, and four of the seven sites exceeded the radon guideline of 200 Bq/m³. The graph in Figure 1 confirms that homes can experience significant variations in radon levels throughout the year, with this example showing a range from 40 to 3,976 Bq/m³, and an annual average of 1,092 Bq/m³. The seasonal results in Table 3 show that one of the sites had their highest radon levels in the spring (Mar-Apr-May), one site had the their highest levels in the summer (Jun-Jul-Aug), two sites had their highest levels in the fall (Sep-Oct-Nov), two sites had their highest level in the winter (Dec-Jan-Feb), and one site had similar radon levels across two or more seasons (i.e., no one season had radon levels that were more than 20 Bq/m³ greater than another season).

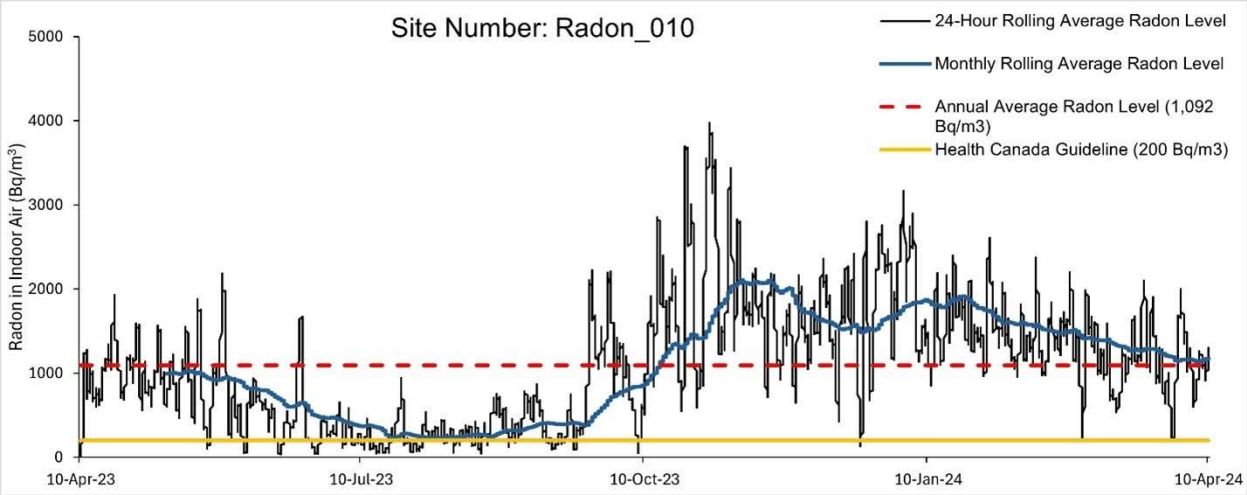

Figure 4. Continuous radon indoor air measurements over a one-year period at a residential home in Nova Scotia, Radon010 (April 2023 – April 2024).

While the findings of the 2023-2024 program align with earlier studies, the study was comprised of a small subset (n=7). For the homes that were found to have levels exceeding the guideline, each experienced its highest radon levels in different seasons (e.g., Spring - Radon007, Summer - Radon012, Fall - Radon003, and Winter - Radon010). In all cases where the average annual radon level exceeded the guideline, the winter radon levels were above the radon guideline.

Table 5. 2023-2024 Indoor air radon results by season over a 1-year period from 7 households in Nova Scotia.

Site Number	Device Number	House Age	Community	Floor Tested	Measurement Period	Average Radon Level (Bq/m^3)				
						Spring	Summer	Fall	Winter	Annual
1	Radon003	1986	Halifax	Basement	May 2023 - May 2024	553	710	1257	1007	**880**
2	Radon004	1976	Halifax	Basement	Mar 2023 – Mar 2024	144	107*	174	162	147*
3	Radon006	2007	Timberlea	Basement	Mar 2023 – Mar 2024	72	25	101	118	79
4	Radon007	1988	Stillwater Lake	Basement	Apr 2023 – Apr 2024	366	221	335	292	**304**
5	Radon008	1977	Dartmouth	Basement	Mar 2023 – Mar 2024	72	76	80	61	72
6	Radon010	2022	Herring Cove	Basement	Apr 2023 – Apr 2024	1050	344	1366	1618	**1092**
7	Radon012	2019	Herring Cove	-	May 2023 - May 2024	297	390	262	269	**304**

Notes:

1. The seasonal values are shaded grey to show the season with the highest radon levels.
2. No shading is shown for sites where the highest radon level was within 20 Bq/m^3 for two or more seasons, indicating that radon levels are not substantially higher in one season compared to other seasons.
3. Average annual radon levels that exceed the radon guideline of **200** Bq/m^3 are bold and underlined.
4. *Radon004 experienced levels up to 16678 Bq/m^3 followed by periods of 0 Bq/m^3 however, this is believed to be a device error. Outliers were omitted in calculating the monthly averages for June and July.

2024-2025 Seasonality Study

The 2024-2025 fiscal year has seen a significant expansion in the radon monitoring program, allowing for a comprehensive study of temporal variations in radon levels across Nova Scotia. This increased capacity has allowed the current program to utilize **33 real-time radon detectors,** to be placed across volunteer homes for a full year, a fourfold increase compared to previous studies.

25 of the 33 homes participating in the study are located in the Halifax Regional Municipality. To ensure data reliability, duplicate radon measurements will be taken at **5 homes** using Alpha Track radon detectors (AT-100 Long Term Alpha Track Kit). These will be placed close to the Airthings Wave devices for comparative analysis after one year. After monitoring at each home is complete, the radon detectors will be re-deployed to new volunteer homes with the hope that the study will generate

enough data to meet the study's objectives. Preliminary results from this project indicate that approximately 75% of the homes tested during the 2024-2025 study have an annual average radon level below the health guideline however, many sites have not reached a three-month testing period and therefore cannot definitively predict a long-term average. In addition, these preliminary results are not sufficient to make predictions on seasonal variability which will be deferred and discussed in subsequent reports.

For additional information about radon, please visit the Nova Scotia radon website at novascotia.ca/radon, which includes links to the radon risk map, how to go about purchasing a radon test kit, and how to find certified radon contractors for completing mitigation work.

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