FACTORS AFFECTING RADON LEVELS
IN HOMES IN BRITISH COLUMBIA, CANADA

by

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ABSTRACT

British Columbia, Canada's most westerly province, has diverse geologic and climatic characteristics, making it a region where predicting radon gas levels is quite complex. Data recently obtained for eleven (11) communities confirm an association between background terrestrial gamma radiation measurements and indoor radon levels in homes. Direct links between radon levels and other factors such as home design/construction features and heating/ventilation systems were observed in data for some communities, but not necessarily from the overall data.

INTRODUCTION

In the mid 1970's, public health concerns about radon in homes began to emerge in Canada. At that time, radon/radon daughter surveys were carried out in homes in two areas of the province, using grab sample techniques (1, 2). The two studies identified widely differing levels, between those for the Vancouver area (which were low) and those in the Castlegar area, which were higher.

With the emergence of improved radon detection devices in the mid 1980's, the B.C. Ministry of Health commenced a program of long-term measurements in homes in a selection of eighteen communities with differing radon potential, to assess the extent of radon as an environmental health risk to the public. Results of radon measurements for eleven communities are presented in this paper, along with an assessment of the association with factors thought to impact the radon levels.

DATA COLLECTION

Communities were selected as a representative sample for the province, based principally upon a variety of geological, climatic and geographical factors. Volunteers were solicited from each community to permit their homes to be tested for radon. Trained staff from the Ministry placed the radon detectors in appropriate locations in the home and they undertook the completion of survey questionnaire with the occupants, regarding the physical characteristics of the home and some lifestyle information. A minimum of seventy (70) single family dwellings were required for each community to provide a statistically representative sample.

Radon levels were assessed using commercially available alpha track detectors (available from the Barringer, REM and Terradex companies). Two detectors were normally placed in each home for a period of one year. One detector was placed in the lowest living area of the home (e.g. basement) and one in the main living area. Duplicate detectors were placed side by side in a selective number of homes to provide information on the reproducibility of the measurements.

Terrestrial gamma radiation levels were determined using a portable high pressure ionization chamber instrument (Reuter Stokes model RSS-111). At least five (and usually more) separate readings were made in representative locations in each community. Readings were corrected for local cosmic ray contribution, to provide the net terrestrial gamma component.

For each home selected, a questionnaire survey was completed, in which the following information was obtained:

1) Building factors - age of home, type of foundation, basement/lower level structure, heating system type and location, and air conditioning use.

2) Personal factors - number of persons in the home, occupancy factors, smoking habits, and incidence of cancer.

RESULTS

Table 1 presents a summary of the radon levels measured, for lowest/basement levels and for main floor areas of the home. The mean values for main floor areas ranged from a low of 18 Bq/m^3 (0.5 pCi/l) for the Greater Vancouver area to a high of 240 Bq/m^3 (6.5 pCi/l) for the City of Castlegar. In the Castlegar sample, approximately 41% of the main floor levels exceeded 150 Bq/m^3 (4 pCi/l) while 6% exceeded 750 Bq/m^3 (20 pCi/l).

Figure 1 illustrates the correlation between main floor radon levels and the local terrestrial gamma radiation level for each of the eleven communities given in Table 1. A positive correlation was observed, with a coefficient value of 0.66 ($p=.04$). From figure 1, it appears that more than one trend exists, suggesting that the radon levels may be significantly affected by more than one variable. For Castlegar and Prince George, which have clearly outlying radon values above the general trend (in figure 1), both communities are situated on permeable soil structures.

Table 1 - Radon Measurement Results In Homes In B.C. Communities

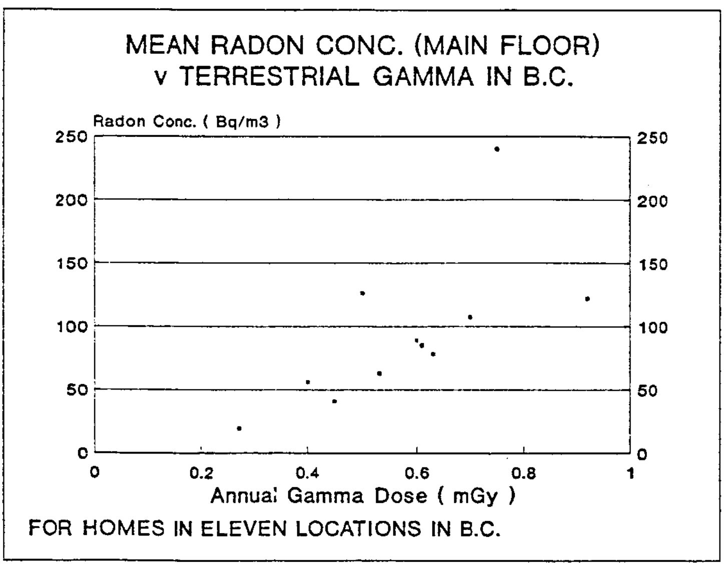
BASEMENT

Location	# of Homes	Min. (Bq/m^3)	Max. (Bq/m^3)	Mean (Bq/m^3)	Mean Ranking
Castlegar	69	33	1750	390	1
Cranbrook Area	67	15	330	74	9
Kamloops	39	4	280	56	10
Kelowna	76	15	1080	140	5
Nelson	73	33	1490	200	4
Penticton	72	22	1730	260	2
Prince George	74	33	2070	240	3
Quesnel	70	22	570	85	8
Valemount	51	22	550	140	6
Greater Vancouver	-	-	-	-	-
Vernon	74	30	430	130	7

MAIN FLOOR

Location	# of Homes	Min. (Bq/m^3)	Max. (Bq/m^3)	Mean (Bq/m^3)	Mean Ranking
Castlegar	68	26	1470	240	1
Cranbrook Area	90	7	830	63	8
Kamloops	84	4	160	41	10
Kelowna	77	19	900	85	6
Nelson	74	22	1270	122	3
Penticton	73	15	810	107	4
Prince George	75	26	680	126	2
Quesnel	69	4	250	56	9
Valemount	51	22	260	90	5
Greater Vancouver	135	7	60	18	11
Vernon	75	26	250	78	7

Figure 1



Results from the questionnaire surveys, relating to the building and personal actors, were analyzed for association with radon levels. The general findings are reviewed in the following discussion.

DISCUSSION

Good correlation existsbetween mean radon levels in a sample of homes and the general terrestrial gamma radiation levels for a community. This is to be expected since elevated terrestrial gamma levels are associated with increased concentrations of uranium and its decay products in surface soils. Radium-226 is the uranium decay product that produces radon.

Although terrestrial gamma measurement has been found to be useful technique for determining which communities may have elevated radon levels, other factors such as soil permeability, moisture content (3) etc. play an important role in radon transportation to affect the concentration in air. Work to date has indicated no correlation between the indoor radon levels in any individual home and the terrestrial gamma level measured at the site.

Building factors were evaluated in relation to radon levels, on a community-by-community basis as well as from the overall (pooled) data. The pooled data indicates that homes with air conditioning were more likely to have lower radon levels, both on the main floor (probability coefficient $p=0.078$) and in the basement/lower level ($p=0.025$). For homes with heating furnaces located in the basement, the main floor radon level was likely to be elevated ($p=0.065$). If uncovered soil areas exist in the lower level, then radon concentrations were likely to be higher ($p=0.059$).

Other building factors were statistically significant within an individual community's data, but were not consistent from community to community.

Such factors include (1) age of the home; (2) type of foundation; (3) type of heating system; (4) separation of lower level(basement) from main floor; and (5) the presence of opening windows in the lower level.

Personal factors did not appear to have any significant association with radon levels, either within individual community data or with the overall data.

NOTE

Data is expected for a further seven (7) communities which were still under test at the time of writing this paper. This additional information will provide valuable guidance on radon levels in British Columbia's more northerly and coastal communities, as well as adding to the overall data base for further analysis.

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