EFFECT OF LOCAL GEOLOGY ON INDOOR RADON LEVELS: A CASE STUDY*

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Abstract

This paper presents the results of radon monitoring in 40 East Tennessee homes that were a component of a larger study to evaluate indoor air quality. Measurements were conducted during two 3-month time periods with passive integrating track etch monitors in each of the forty homes. In a subset of homes, measurements were also conducted with a real-time monitor that provided readings on an hourly basis. The results of the monitoring indicate that about 30% of the homes had radon levels greater than 4 pCi/L in the living space. Homes with elevated radon levels were associated with local variations in geology; most of the homes having higher levels were located on the porous dolomite ridge partially surrounding Oak Ridge, Tennessee.

Introduction

Radon is one of the pollutants of concern in evaluating indoor air quality. The decay of radon and subsequent inhalation of the progeny are of health concern. There is a growing body of information on indoor exposure levels suggesting that a significant fraction of homes may have levels of radon greater than 4 pCi/L (3) which is an EPA guideline level for consideration of potential remedial action. Many of the initial investigations were conducted to ascertain the relationship between radon levels and energy conservation measures. The results of some of these studies indicate that variations in the source strength of the soil on which a home is built is much more important than other parameters in determining the levels of radon measured in the home (4,7). For example, one particular study found dramatic differences in levels associated with siting on a particular geologic formation (7).

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DISCLAIMER

Experimental

The homes monitored during this study were located in Oak Ridge and Knoxville, Tennessee, and were selected from volunteers on the basis of home age, insulation type, and heating sources (2). Hourly radon concentrations were obtained using a Wrenn detector (5) in a subset of 10 homes for about one week (see Figure 1). Radon diffused into the active volume through a foam filter that removed progeny. Following decay of the radon, the positively charged decay products were electrostatically collected on a ZnS(Ag) phosphor coupled to a photomultiplier tube. Subsequent alpha decay was counted, and a printout of Radon concentration was produced each hour.

Passive track etch detectors (1) were placed in all 40 homes from December 1982 through February 1983 (Period I). Triplicate samplers were placed at two locations (one in the basement, if appropriate) of each home. A repeat measurement of the levels in the 40 study homes was conducted from September 1983 through November 1983 (Period II). Only one sampler was used in each of two locations during the second measurement period. The passive radon monitor works by diffusion of the radon through a progeny filter into a cup containing a plastic detector (see Figure 2). A fraction of the subsequent alpha decays produce damage tracks in the foil. At the end of the 3-month sampling period the detectors were returned to the vendor for analysis.

Results

Table 1 shows the results obtained for homes where measurements were conducted on three occasions. The average of the hourly concentrations is reported for the instrumental measurements. Even though the measurements were made at different times, the agreement between these averages and the results of the two monitoring periods with the passive detectors is good, with all three values frequently within ±25% of the mean value. In the initial track etch monitoring period with triplicate detectors, the three replicate results were within ±15% of the mean 73% of the time (only means greater than 2 pCi/L were used in this analysis of precision). This illustrated good precision and led to the decision to use single detectors during the second period.

Figure 3 shows the distribution of radon levels as measured with the passive detectors during the two sampling periods. The room value for the first period was obtained by averaging the three replicate measurements. The geometric mean and geometric standard deviation for the first period were 1.8 pCi/L and 2.7, respectively. For the second period the geometric mean was 2.2 pCi/L and the geometric standard deviation was 2.4.

Table 1. Mean radon levels (pCi/L) in homes where both active and passive measurements[a] were made.

Home no.	Start date for Method 1	Radon concentration Method 1	Radon conc. Method 2 (Period I)	Radon conc. Method 2 (Period II)	Home location
2	04-13-82	3.8 ± 1.3	3.5	4.8	Ridge
		(5.3 ± 1.2)[b]	(5.7)	(5.2)	
82	04-05-82	8.0 ± 1.0	13.2	-	Ridge
		(18.0 ± 6.0)	(17.4)	-	
4	04-20-82	10.0 ± 3.0	12.0	8.2	Ridge
14	01-18-82	4.7 ± 2.0	3.8	3.9	Ridge
7	02-17-82	0.8 ± 0.5	0.8	1.0	Valley
11	03-05-82	0.7 ± 0.3	1.0	0.9	Valley
27	05-25-82	1.0 ± 0.5	1.9	1.6	Valley
64	06-10-82	1.2 ± 0.7	3.3	2.6	Valley
70	05-05-82	3.3 ± 2.3	7.8	7.1	Valley
81	10-15-82	0.7 ± 0.2	0.8	1.3	Valley

[a]Method 1 = Wrenn chambers; Method 2 = track etch monitors.
[b]Values in parentheses are basement measurements.

The elevated radon levels showed a high correlation with location of the homes. Homes that were located on the ridge surrounding Oak Ridge generally had higher levels than homes not located on the ridge (designated as valley homes). Table 2 shows the mean radon values in basements and living spaces for both ridge and valley homes. The levels for ridge homes are about twice the levels for valley homes.

Table 2. Mean radon levels (pCi/L) measured in the ridge and valley homes.

Location	Ridge	Valley
Basement	5.4 (n=17)[a]	3.4 (n=17)
Living area	4.8 (n=33)	2.2 (n=89)

[a]n = number of rooms measured.

Much of Oak Ridge is located over underlying shale deposits that are relatively high in uranium content (6). The porous dolomite ridge appears to offer relatively less resistance to radon permeation than does the less permeable soil cover in the valleys. The results of this study offer additional data to indicate that even within a relatively small area there can be significant differences in radon levels, presumably due to local geology.

Conclusions

A recently completed indoor air quality study in East Tennessee includes information on radon levels. Results indicate generally good reproducibility for radon measurements obtained at different times and with different techniques. Approximately 30% of the concentrations were greater than 4 pCi/L. Significant differences in levels within the studied population appear to be due to local geological differences.

Acknowledgements

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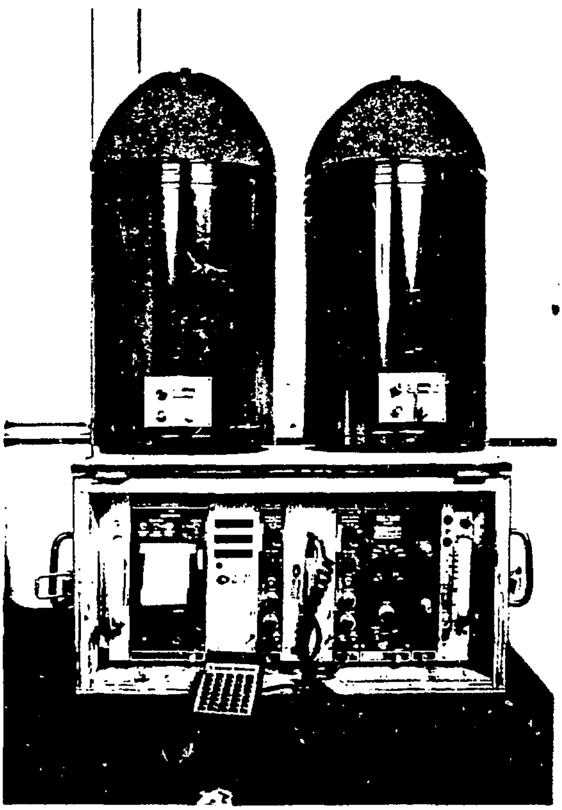

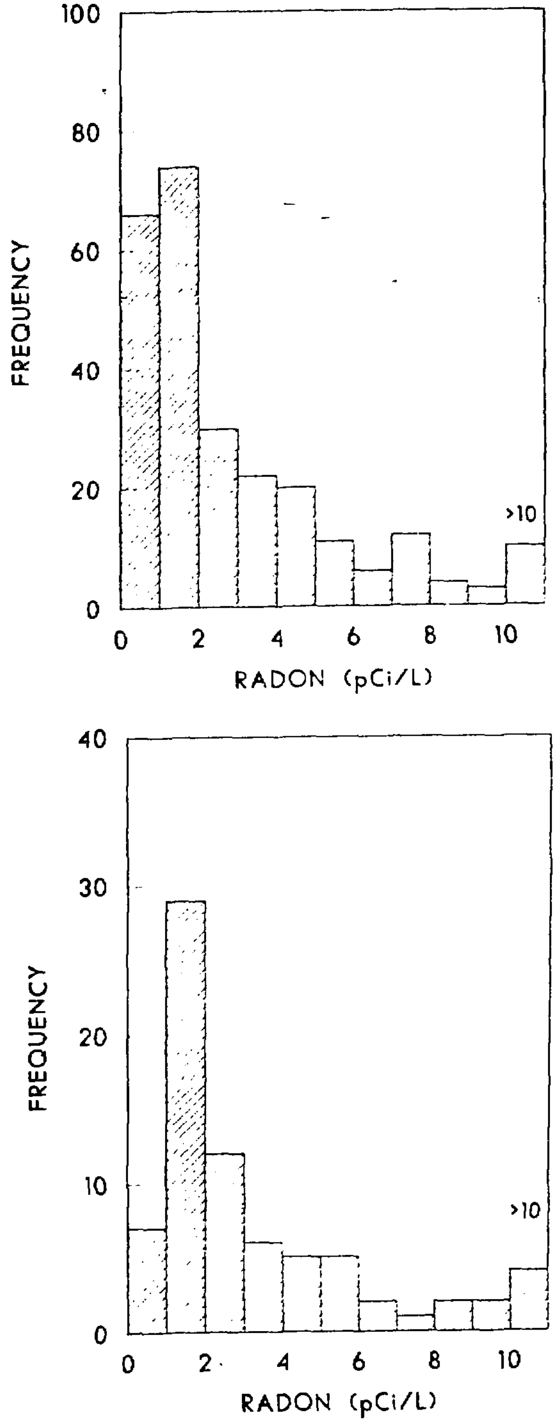
FREQUENCY
100
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RADON (pCi/L)
FREQUENCY
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RADON (pCi/L)

Fig. 3

Figure Captions

Figure 1. Photograph of Wrenn detector used to obtain hourly radon levels in a subset of homes.

Figure 2. Photograph of passive track etch radon monitors used in all forty homes in the study.

Figure 3. Distribution of radon measurements obtained with track etch detectors during period 1 (top plot - December 1982 through February 1983) and period 2 (bottom plot - September 1983 through November 1983). Basement measurements are included.