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NORMAL AND SEASONALLY AMPLIFIED INDOOR RADON LEVELS[1]

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DISCLAIMER

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ABSTRACT

Winter and summer indoor radon measurements are reported for 121 houses in Freehold, New Jersey. When presented as winter:summer ratios of indoor radon, the data closely approximate a lognormal distribution. The geometric mean is 1.49. Freehold is located on the fairly flat coastal plain. The winter:summer ratios are believed to represent the norm for regions of the U.S. with cold winters and hot summers. The Freehold data set can be compared to corresponding data sets from other locations to suggest seasonal perturbations of indoor radon arising from unusual causes.

INTRODUCTION AND PURPOSE

Porous soil and rocks underlying buildings on sloping terrains can give rise to enhanced seasonal incursions of indoor radon. Subterranean airflows occur in upward (winter) and downward (summer) directions. The driving force for these flows are density differences between the below ground and the outside air. These air density differentials are produced by a near constant underground temperature and outdoor air temperatures that are below (in winter) or above (in summer) the below ground temperature. An underground stack effect operates that is the analogue of the well documented indoor stack effect. Houses "tapping into" these subterranean airflows experience exaggerated indoor radon levels in either winter or summer. Steep-sided ridges of sand and gravel from old glacial streams, known as eskers, were first recognized in Finland for producing this problem (Arvela et al., 1988). The more common problem areas involving karst (porous limestone) terrains were identified by Dudney, et al., and Gammage, et al., 1992.

More recently we examined data sets of winter and summer indoor radon measurements taken within four cities in different karst regions of the southern Appalachians (Gammage, et al., 1993). The winter:summer ratios of radon were described best by lognormal distributions. The geometric mean ratio was used to identify the season of the year that aerostatically driven movements of air amplify indoor levels within a particular city.

To know whether there is unusual amplification, or suppression, of the winter:summer ratio of indoor radon, one needs to know what the "normal" ratio should be. In many parts of the USA, the wintertime indoor thermal stack effect produces higher indoor radon levels during the winter. Cohen, 1990, reports a general winter:summer ratio of 1.3, but without consideration of local geology or

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terrain. The purpose of the present study is to obtain an estimate of the normal summer:winter ratio of indoor radon. We chose the generally non-hilly, coastal plain of New Jersey as an appropriate region of the country.

EXPERIMENTAL DESIGN

Alpha track detectors were used to make three-month, integrated measurements of radon during the summer and winter. The detectors were provided and read out by a commercial company, Landauer, Inc.

Measurements were made in 125 basement houses in Freehold, New Jersey. Freehold is located in a fairly flat coastal plain, and experiences cold winters and hot summers. The indoor radon levels are generally higher than the national average, which improves the chance of obtaining accurate radon data.

RESULTS

Detectors exposed during both winter and summer seasons were returned for evaluation from 121 of the original 125 houses. The data are plotted in Fig. 1 in which the straight line represents a perfect lognormal distribution.

The geometric mean values are listed in Table 1 where comparison can be made to the analogous mean values from the data sets for the four cities in the southern Appalachians.

Table 1. Summary statistics for winter:summer indoor radon measurements in five cities.

City, State/Number of Houses	Seasonal RatioWinter:Summer Mean, Geometric
Freehold, NJ / 121	1.49
Huntsville, AL / 86	0.80
Birmingham, AL / 18	0.92
Chattanooga, TN / 14	1.72
Kingston & Harriman, TN / 226	1.63

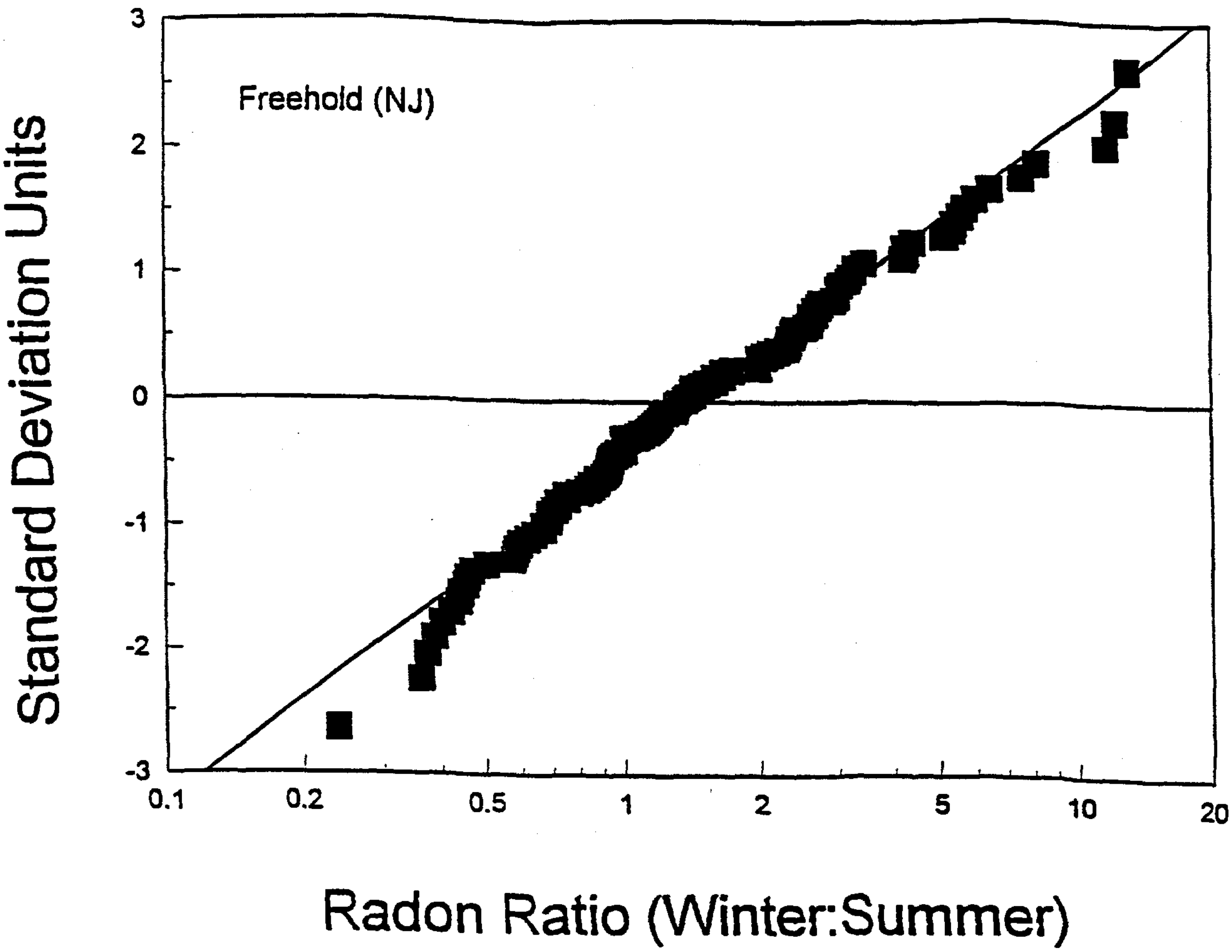

Fig. 1. Distributions of winter:summer ratios of indoor radon for Freehold, New Jersey, 1992/1993.

DISCUSSION

There is a close to lognormal distribution of winter:summer ratios of indoor radon for the set of houses in Freehold, New Jersey. The geometric mean (GM) value is 1.49. We anticipate that this value represents the norm for nonhilly regions of the U.S. that experience cold winters and hot summers. The values are close to the winter:summer ratio of 1.3 reported as being a representative figure for the country as a whole (Cohen, 1990).

In locales where one is evaluating the likelihood of some mechanism perturbing the winter:summer ratios of indoor radon away from the norm, comparison with the Freehold data set will probably be beneficial. We can, for instance, compare our own data sets for the four southern Appalachian cities with the Freehold data set. The winter:summer geometric means are below the Freehold GM in the cases of Huntsville (0.84 GM) and Birmingham (0.92 GM) and above the Freehold GM for Chattanooga (1.72 GM) and Kingston/Harriman (1.63 GM).

These numbers deviate to varying degrees from the Freehold GM value and are, therefore, indirectly supportive of our previous hypothesis that aerostatically driven movements of air within karst regions are perturbing indoor radon levels (Gammage, et al., 1992). The winter season in New Jersey is longer and colder than in the southern states of Alabama and Tennessee. The indoor stack effect, and the elevation of wintertime indoor radon that it promotes, will be more marked in Freehold than in the four cities of the more southern states. For these four cities, therefore, the Freehold GM is somewhat too high to be the ideal benchmark. Using due discretion, we suggest that the Freehold data set be used as a benchmark against which to compare other data sets of winter:summer ratios and alert one to the occurance of some unusual seasonal amplification of indoor radon.

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