Title
INDOOR RADON SOURCES, CONCENTRATIONS, AND STANDARDS

Author
Nero, A.V.

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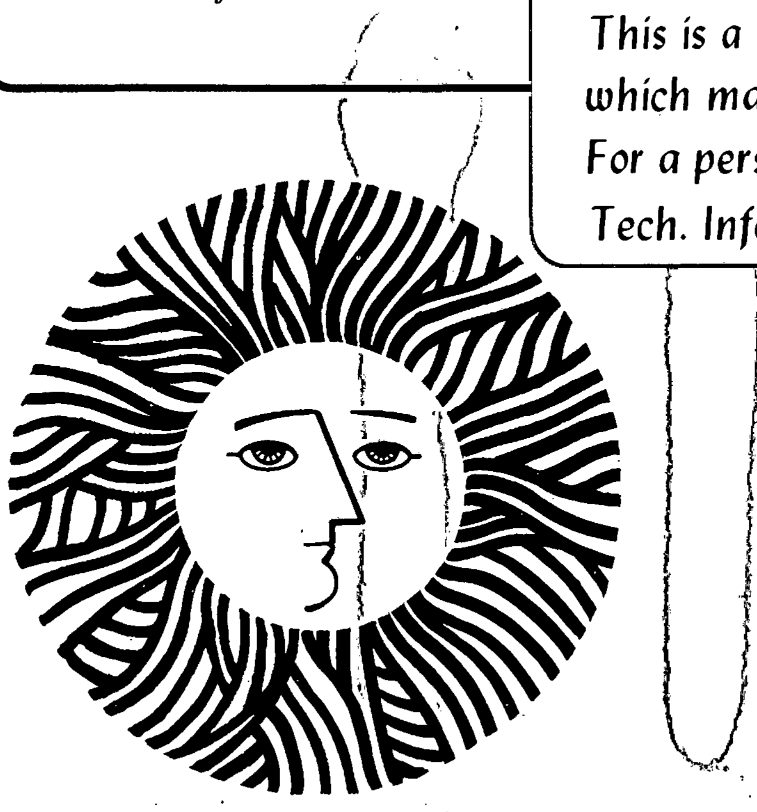

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A.V. Nero

Building Ventilation and Indoor Air Quality Program
Energy and Environment Division
Lawrence Berkeley Laboratory
Universtiy of California
Berkeley, CA 94720

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ABSTRACT

Indoor exposures to daughters of radon 222 contribute significantly to the radiation dose that the general public receives. Controlling such exposures is complicated by the fact that indoor radon concentrations vary substantially from one geographical area to another and even from one home to another; the major cause of this variation appears to be the source magnitude, defined as the rate at which radon enters the home. Even for concentrations considered to be typical in U.S. housing, the attendant risk of lung cancer that may be estimated, although relatively low, is sufficient to warrant attention. Moreover, for the small proportion of the population living in homes where radon concentrations are much higher than average, the risk of developing cancer could be increased a few percent over their lifetime. Survey programs and air quality standards should be designed to give special attention to those at high risk.

Keywords: air quality standards, indoor concentrations, radiation exposure limits, radon

Indoor exposures to daughters of radon 222 contribute significantly to the radiation dose that the general public receives. Controlling such exposures is complicated by the fact that indoor radon concentrations vary substantially from one geographical area to another and even from one home to another; the major cause of this variation appears to be the source magnitude, defined as the rate at which radon enters the home. Even for concentrations considered to be typical in U.S. housing, the attendant risk of lung cancer that may be estimated, although relatively low, is sufficient to warrant attention. Moreover, for the small proportion of the population living in homes where radon concentrations are much higher than average, the risk of developing cancer could be increased a few percent over their lifetime. Survey programs and air quality standards should be designed to give special attention to those at high risk.

Lawrence Berkeley Laboratory has measured radon and radon daughter concentrations, and concurrent infiltration rates, in conventional and energy-efficient houses throughout the U.S. Radon concentrations were found to vary over a large range (0.1 pCi/l to 20 pCi/l) and bore little apparent correlation to infiltration rates.[1] From measurements of radon concentrations and associated air exchange rates, source magnitudes can be derived. Figure 1 displays frequency distributions of source magnitude per unit volume for residences monitored in England[2] and for a subset of measurements made in the United States and Canada. Source magnitudes in both England and the U.S. are found to range over two to three orders of magnitude, and this variability appears to be a principal cause of the variability observed in indoor radon concentrations, generally.

Data accumulated to date in U.S. residences[3] are not adequate to allow characterization of average radon daughter exposures or their frequency distribution. Moreover, at low exposure levels, dose-response factors for estimating lung cancer incidence are highly uncertain. Nonetheless, estimates indicate that exposure of the general population to indoor radon daughter concentrations of 0.005 working level, a reasonably typical value, could account for 1000 to 20,000 cases of lung cancer annually in the United States.[4] As suggested, this rate is sufficiently large to require its consideration in formulating codes and voluntary standards for builders and architects. A more urgent question, however, is that of individuals exposed to much higher concentrations over their lifetimes. Surveys have indicated that in some houses the exposure level exceeds the national average by a factor of 10. For the most part, these higher exposures are associated with unusually large source magnitudes, which monitoring programs could be designed to identify through regional surveys.

Whether for radon daughters or other pollutants, indoor standards ought to give explicit consideration to variations in source strength, and be structured to include special protection for the small portion of the population that is subjected to unusually high exposures. In the case of radon daughters, such a standard could be written in two parts: 1) a not-to-be-exceeded concentration limit that applies to individuals and protects against excessive risk; and 2) a lower average exposure value that applies to populations and corresponds to an acceptable average risk. The limit for individuals would be the basic criterion for remedial action in existing homes that have high radon concentrations requiring reduction of source strength or increase in ventilation rate. The population exposure value would be based on the average costs and benefits of adopting specific housing design features, including those aimed at reducing radon concentrations as well as those intended to save energy by reducing ventilation rates. The resulting average exposure goal could be achieved by careful formulation of building standards, which could give explicit consideration to geographic variations in source magnitude and to differences in building practice that are related to geographical region or building type.

The wide variability observed in indoor radon concentrations appears to be due in large part to variation of the source magnitude over more than two orders of magnitude. The risk estimated to be associated with observed concentrations warrants substantial regulatory attention, particularly to those exposed to much higher than average levels. It is important that resulting indoor radon standards differentiate between protection of each individual from excessive risk and achievement of satisfactorily low average exposures.

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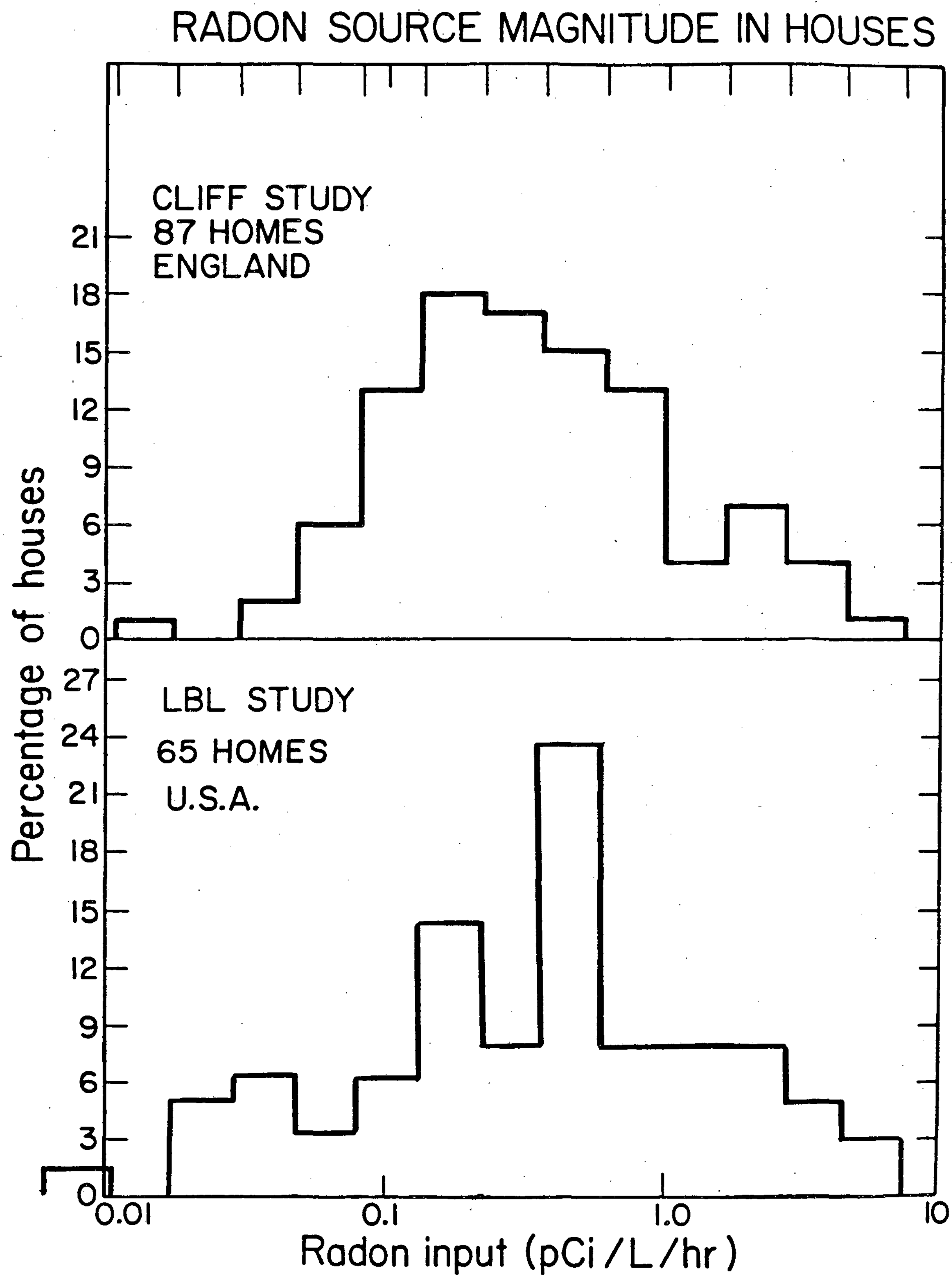
References

1. A.V. Nero and W.W. Nazaroff, "Distribution of Indoor Radon Concentrations and Source Magnitudes," to be presented at the International Symposium on Indoor Air Pollution, Health and Energy Conservation, Amherst, Mass., Oct. 13-16, 1981.
2. K.D. Cliff, Phys. Med. Biol., 23, 696-711 (1978).
3. A.V. Nero, "Airborne Radionuclides and Radiation in Buildings," Lawrence Berkeley Laboratory report, LBL-12948, to be submitted to Health Physics (1981).
4. A.V. Nero, Indoor Radiation Exposures from Radon and Its Daughters: A View of the Issue, Lawrence Berkeley Laboratory report, LBL-10525, July 1981.

Figure Caption

Figure 1. Frequency distribution of source magnitudes in residences; the upper half of the figure is based on measurements in England (ref. 1), and the lower half on LBL data in energy-efficient houses throughout the United States and Canada and in conventional houses in the San Francisco area and in rural Maryland.


RADON SOURCE MAGNITUDE IN HOUSES
CLIFF STUDY
87 HOMES
ENGLAND
LBL STUDY
65 HOMES
U.S.A.
Percentage of houses
0
3
6
9
12
15
18
21
24
27
0.01
0.1
1.0
10
Radon input (pCi / L / hr)

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LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720