RADON LEVELS IN AUSTRALIAN HOMES

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INTRODUCTION

There is currently little data published on the magnitude and geographical distribution of radon exposure for dwellings within Australia (1,2). To address this lack of data, the Australian Radiation Laboratory (ARL) is investigating radon levels within domestic dwellings in Australia. These measurements form part of an on-going programme by ARL to establish representative values for radiation exposure to the Australian public from natural sources, including radon. ARL has underway a large scale survey of Australian homes. A total of 12,000 persons, randomly selected from the electoral roll, have been invited to participate in a one year survey of radiation levels in their homes. The expected rate of positive reply is 30%, leading to an expected 3600 dwellings for study. Radon levels in these dwellings will be measured using a passive monitor containing nuclear track material, and the external gamma-ray radiation will be measured using a thermoluminescent dosimeter (TLD). This survey will be completed mid 1989. ARL has carried out a preliminary study of radon in domestic dwellings, using a charcoal-based, passive radon monitor developed at the Laboratory. These measurements were limited to homes in three cities and two towns, and were for an exposure period of 7 days. This paper reports the methodology and results of these initial surveys and examines the likely trends in average radon levels for houses in Australia.

RADON SURVEY

Charcoal-based passive radon monitors have been used by many workers to assess integrated radon exposure for periods of up to 10 days (3,4,5). These monitors collect radon by adsorption onto activated charcoal and gamma-ray counting determines the quantity adsorbed. A number of these designs incorporate some form of diffusion barrier to increase the integration time and provide a better measure of integrated radon for changing radon concentrations (3,4). The monitor developed at ARL is a low-cost variant of this type of monitor. Its main features and its operating characteristic are described elsewhere (6). The monitors were used to survey homes in three cities and two towns in a number of states around Australia. The distribution method was chosen for convenience and was not designed to provide a random sampling of a particular location. The exposures were restricted to periods of 6 to 8 days and may be affected by seasonal variations. The derived radon concentrations should be indicative of general trends, but they may not be truly representative of the Australia-wide yearly average radon exposure.

Volunteers were given a questionnaire by a central contact in a government laboratory or university department in the city or area under study. This questionnaire covered details on the construction of the dwelling to be surveyed. Following the return of these forms, each participant was provided with a radon monitor. The monitor was exposed in the participant's home and the exposure details recorded on a label on the cup. The monitors were returned to the appropriate central contact, who then returned all the monitors to Melbourne for counting. This survey method ensured rapid distribution and collection of the monitors and minimised possible delays. Preparation and counting of the monitors was carried out at ARL, providing consistency in measurements from different locations.

Measurements were made in the cities of Melbourne (67 homes) and Sydney (45 homes) on the east coast, and Perth (45 homes) on the west coast of Australia. Two small towns in areas known to have higher than average uranium concentrations in the ground were also surveyed. Jabiru (43 homes) is situated close-by to the Ranger uranium mine and Armidale (55 homes) is situated in an area of granitic rock, containing uranium and thorium in higher than average levels. The mean and median radon concentrations in these homes for the periods sampled are summarised in Table 1. The highest radon concentration measured was 395 Bq/m^3. The combined radon data for all five locations (255 homes) approximates a log-normal distribution, with a derived geometric mean and geometric standard deviation of 20 Bq/m^3 and 2.6, respectively. The derived inter-quartile range was 10 to 46 Bq/m^3.

Table 1. Average radon concentrations for Australian homes

Location	No. of Homes	Month	Rn Concentration (Bq/m^3) Geometric mean	Inter-quartile range
Melbourne	47	May	53	39 - 70
Melbourne	20	July	19	6 - 24
Sydney	45	July	21	5 - 45
Perth	45	May	15	7 - 32
Jabiru	43	May	19	9 - 40
Armidale	55	August	10	4 - 31

SEASONAL RADON VARIATION

In general, Australian homes are well ventilated. For the 255 homes surveyed, 43% were built on a concrete slab and 51% had wooden floors with a ventilated area underneath. Less than 4% of homes had some form of basement. In the absence of a strong localised radon source, domestic radon levels could be expected to follow the open-air radon levels. Some support for this was found in measurements at Jabiru, where no significant difference was found between indoor and outdoor radon exposures. Short-term measurements of radon exposure in homes may suffer from sampling bias due to seasonal variations in ambient radon. The two sets of radon measurements in Melbourne during May and July gave mean radon concentations of 53 and 19 Bq/m^3, respectively. Further charcoal cup measurements of homes in Armidale (NSW) during the period July to November gave mean monthly radon concentrations of 20, 10, 5, 26 and 23 Bq/m^3, respectively, showing a minimum in the mean radon exposure during the months of August and September.

This seasonal variation is also present in the results of an extended measurement of ambient radon levels, using a continuously sampling electronic radon monitor, located at ARL in Melbourne. Table 2 summarises the average values, derived from the monitor, for ambient radon concentration, over a one year period at Yallambie, Victoria. The monthly average values were derived from the alpha count-rate on the second filter of a 200 litre two-filter tube, operated continuously over this period. This data shows an autumn maximum and a spring minimum, with a 30% range around the yearly average of 12.7 Bq/m^3.

Table 2. Open-air average monthly radon concentrations (Bq/m^3) for period November 86 to November 87, derived from two-filter tube measurements (at 3 meters) at ARL, Melbourne.

	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
Mean	11.3	11.4	14.3	16.3	16.5	18.8	16.1	10.1	12.6	7.9	9.7	8.0
1 SD	6.9	7.3	8.8	8.6	10.7	10.4	12.0	7.5	6.5	3.1	5.5	5.0
SEOM	0.3	0.3	0.3	0.4	0.3	0.4	0.4	0.3	0.2	0.1	0.3	0.2

DISCUSSION

Within the limitations of this preliminary survey, a number of general trends in the measured radon levels can be observed . The locations surveyed were geographically widely separated, in some cases by many thousands of kilometres.

Climate ranged from tropical (Jabiru) to temperate (Melbourne), with widely varying local geology. Despite these differences, the derived mean radon levels for each city and town were remarkably similar. Small scale surveys with short-term exposure periods may be biased due to the monitor distribution methodology and possible seasonal variations. The measurements of seasonal variations indicate that, relative to the yearly average radon concentrations, the measurements made in Melbourne during May may be seasonally enhanced, while the Armidale results for August may be seasonally reduced. Both locations produced a mean radon level of approximately 20 Bq/m^3 during July, corresponding to the derived mean value for the five cities and towns sampled.

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