Survey of Indoor Radon Concentrations in New Zealand Buildings

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Prepared for Office of Radiation Safety, Ministry of Health

by

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CONTENTS

1 INTRODUCTION

This report summarises the findings of a national survey of indoor concentrations of radon in buildings (mostly private dwellings) sampled during the winter period of 2015.

The survey was designed to be a population representative national radon survey. The sample size in this survey was relatively small. A larger national radon survey was last conducted in 1988 by National Radiation Laboratory. The aim of this smaller survey is to determine whether any significant changes have occurred and to assist in guiding national policy on the management of radon exposures to the general population.

The national median radon concentration identified from this survey is 23 Bq/m3. This is broadly consistent with that reported in the last national survey (1988) which was reported as approximately 18 Bq/m3.

The slightly higher value in this survey is most likely due to the seasonal variation, as this survey was conducted over a winter period, where higher radon concentrations are expected.

Compared to radon concentrations in buildings in most other countries, the levels measured in New Zealand are low.

The report sets out recommendations for setting national reference levels for radon concentrations in houses and workplaces in line with best international practice. Additional sampling and assessment in properties where elevated radon concentrations were recorded and a targeted survey of workplaces that may be expected to have higher radon concentrations are also recommended. In the longer term additional measurement and assessment to map geographical variations, further assess building construction factors and determine seasonal correction factors are recommended.

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2 Method

2.1 Introduction

The survey was designed to be a population representative national radon survey. The sample size in this survey was relatively small. A comprehensive national radon survey was last conducted in 1988 by National Radiation Laboratory, so the aim of this smaller survey is to enable a review of the situation to determine whether any significant changes have occurred and to assist in guiding national policy on the management of radon exposures to the general population.

2.2 Sampling scheme

A total of 260 buildings were sampled in this survey (with 2 measurements per building). The majority (241) were private dwellings/houses. In addition 19 workplaces were sampled.

Householders were sought on a voluntary basis to take part in the survey. The majority of properties surveyed were in the main centres, which gives a good representation by population. However it is accepted that full geographical representation cannot be achieved with this sample size.

Conversely, the workplace sample locations selected were the regional Public Health Offices. This provided coverage throughout the country. However it should be noted that this is a very small sample size, so the information obtained is only intended to be indicative of occupational exposures in office type accommodation.

2.3 Monitored rooms

In order to obtain results representative of population exposure, radon detectors were placed in the most occupied rooms, ie living room and main bedroom for private dwellings. Instructions on where to place the detectors were provided to all participants. (see Apendix)

2.4 Measurement Technique

The measurement technique utilised a passive measuring device based on alpha track detection systems. The devices were obtained from the UK Public Health England (PHE) (formerly National Radiological Protection Board). After the sampling period the devices were returned to PHE for assessment.

The alpha track detector supplied by PHE uses a proprietary plastic known as CR-39. The passage of alpha particles (emitted by radon) produces tracks in the plastic which are processed and counted by the supplier using an automated system. Based on the sampling period and the alpha track counting results they are able to make an assessment of Rn-222 concentration (reported in Bq/m3). PHE (formerly NRPB) has been providing this service for several decades and is subject to rigorous calibration protocols, quality assurance and international peer review.

The sampling period for this survey was approximately 3 to 4 months and co-incided with the New Zealand winter period (May to August). In order to measure the annual average radon concentration, a radon survey should ideally cover the full period or provide seasonal correction values where they are known. As these factors are not known for New Zealand (as that cover each season have not been performed), this winter sampling period is likely to be a worst case and will to some extent provide an over- estimate of the average annual radon concentrations in buildings . It is known that in other countries with seasonal variations, indoor radon concentrations tend to be highest in winter due to less natural ventilation in the home.

2.5 Operative issues, protocols and questionnaire

All participants were supplied with an information pack which included instructions on reducing unintended detector exposures (ie keeping sealed before use and resealing after sample period), some basic information about radon and exposure pathways, placement of detectors in the home and a questionnaire to provide contact details, physical address and relevant questions about the property that may influence radon concentrations (eg construction materials, foundations, number of stories,age of property, heating type).

Participants were also required to mark the start and end dates of rhe sample period and the room sampled on each detector.

Once the radon detectors were all returned at the end of the sampling period (> 90 % return rate) they were shipped to PHE UK for assessment. Additional precautions were taken to ensure the radon detectors were well sealed when in transport (use of aluminium foil and plastic sealed bags).

2.6 Collation of results

The supplier (PHE) provided a database of all the assessed radon detectors, reporting Rn-222 concentrations in Bq/m3. This was then used to create spreadsheets detailing all the results against the locations, rooms sampled and the full questionnaire information. The spreadsheets of full results are available to MoH as a separate electronic record.

3 RESULTS

3.1 Introduction

The full and complete results of the survey are reported in the spreadsheet which can be viewed electronically as an attachment to this report.

The spreadsheet provides the names of participants, addresses, contact details, building details including number of stories, foundation type, construction materials, heating type, age of property, sampling period and Rn-222 concentration results for the living room and main bedroom of each property.

In addition there is a spreadsheet for the workplaces sample with similar data reported.

Note the spreadsheets are supplied to MoH for completeness. The data contains personal information of participants so should remain confidential.

3.2 Summary of results for the whole sample

The results are based on a total of 520 measured samples in a total of 260 buildings, 241 of which are private dwellings and 19 are workplaces

The results can be summarised as follows:

Median of the whole sample is 23 Bq/m3 (Rn-222)
Standard Deviation is 26.5

Only two properties returned results with radon concentrations in excess of 200 Bq/m3. One was measured in a property in Dunedin (302 Bq/m3 living room) and the other in Rangiora (near Christchurch) (202 Bq/m3 living room).

A total of ten properties returned results in excess of 100 Bq/m3.

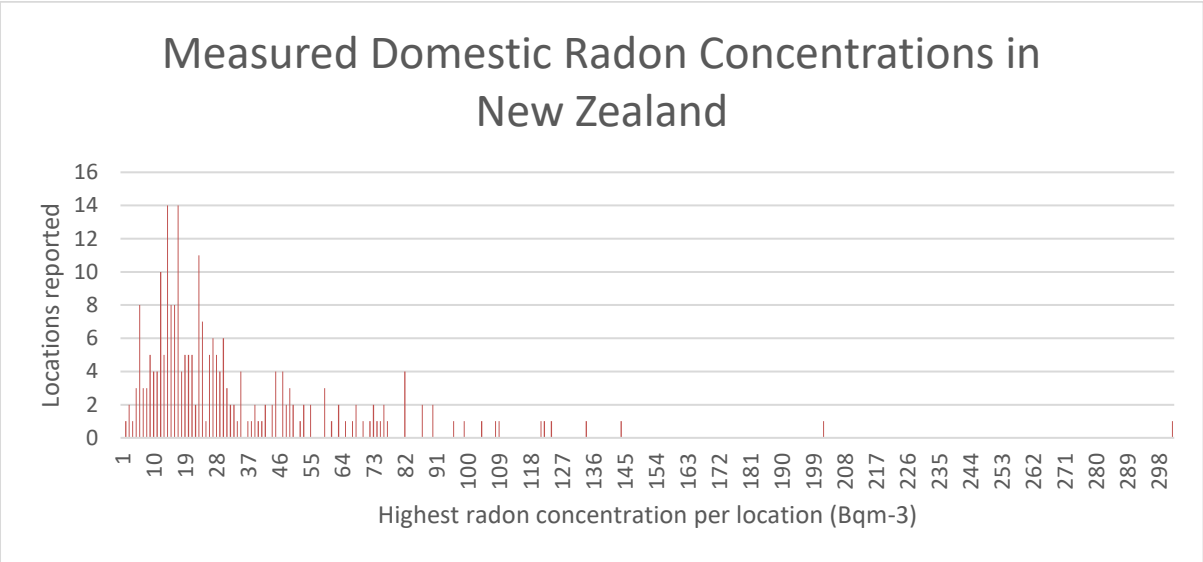
All of the workplaces sampled returned results well below 100 Bq/m3.

The results are displayed in the following graphs.

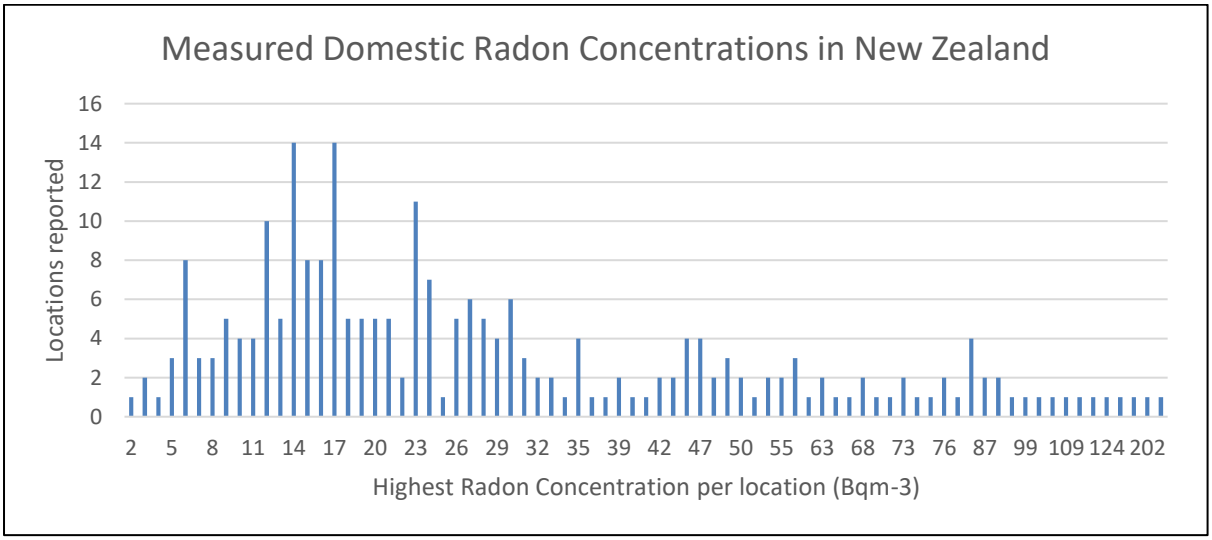
The distribution graphs for the domestic properties are shown below:

Distribution Graphs for Radon Concentrations in New Zealand Dwellings

1) True x axis.



2) Compact x axis



3.3 Geographical location

The median radon concentrations calculated from the measurements for the major centres sampled were as follows:

Auckland 15 Bq/m3
Christchurch 28 Bq/m3
Wellington 20 Bq/m3
Dunedin 35 Bq/m3

3.4 Foundation type

The median radon concentrations were calculated from the results for buildings with and without concrete foundations.

A foundation was considered Concrete if at least part of the foundation was reported by the participant as concrete or stone. Concrete pile or ring foundations were considered as non-concrete foundations.

Median of concrete based is 30 Bq/m3
Median of non-concrete foundations is 17 Bq/m3

3.5 Comparison of median radon concentrations by property age

The median radon concentrations were calculated from the results according to the approximate age of the property.

Age of property	Median Radon Concentration
Before 1921	20 Bq/m3
1921 - 1945	16 Bq/m3
1946 - 1960	23 Bq/m3
1961 - 1970	19 Bq/m3
1971 - 1980	21 Bq/m3
1981 - 1990	17 Bq/m3
1991 - 2000	48 Bq/m3
2001 - 2009	33 Bq/m3
2009 - 2015	27 Bq/m3

4 CONCLUSIONS AND RECOMMENDATIONS

4.1 National median radon concentration

The national median radon concentration from this survey is 23 Bq/m3. This is broadly consistent with that reported in the last national survey conducted by the National Radiation Laboratory in 1988 which was reported as approximately 18 Bq/m3.

The slightly higher value in this survey is likely due to the seasonal variation. This survey was conducted over a 3 month winter period. Radon concentrations in homes are generally elevated in the winter by comparison to the warmer seasons due to the effect of reduced natural ventilation as houses are more "sealed" to retain heat.

It is also possible that improved insulation and also more use of concrete in modern buildings contribute to slightly higher median concentrations (these results are discussed in 4.2 and 4.3 below).

Compared to radon concentrations in buildings in most other countries, the levels measured in New Zealand are low. As a comparison, the following table is extracted from a European Commission report in 2005:

Country	Annual mean radon concentration (Bq/m3)
Austria	97
Belgium	48
Czech Republic	140
Denmark	53
Finland	120
France	63
Germany	50
Ireland	89
Italy	70
Luxembourg	115
Netherlands	23
Norway	89
Spain	90

4.2 Elevated radon concentrations

A small number of the properties sampled showed elevated radon concentrations. Ten properties had readings in excess of 100 Bq/m3, two of which were over 200 Bq/m3. The two locations with the highest readings are up at about the level where IAEA and WHO consider that countermeasures may be indicated to reduce radon levels.

However it is likely that these results are an overestimate of the average annual radon concentrations for these properties. This is because the sampling was performed during the winter months and there has been no adjustment for seasonal variation. Therefore before considering recommendations for countermeasures for these properties, it is worth performing further assessment to determine the radon concentration that is more representative of the average over the full year in these properties. Also to gain a better understanding of seasonal variations in New Zealand it is worth extending this additional assessment to all ten properties that returned results > 100 Bq/m3.

RECOMMENDATION 1: Conduct additional radon assessments for the properties that returned results > 100 Bq/m3. The sampling phase should be timed over a summer period to allow comparison with the measurements made over a winter sampling period. Consideration of countermeasures, if any are indicated following this additional assessment, should be discussed with affected residents/homeowners on a case by case basis.

4.3 Variations according to geographical location, construction materials and age of property

The results shown in sections 3.3, 3.4 and 3.5 indicate some variations in median radon concentrations depending on geographical location, construction materials and the age of the property.

This survey is a smaller sample than the survey reported by the National Radiation Laboratory in 1988. The results of this survey are generally consistent with the earlier study.

The median radon concentrations are higher in Dunedin and Christchurch than Auckland and Wellington. However the levels are still considered low and no areas are identified as “radon affected areas” that warrant specific attention. However it should be noted that this survey is more population based and has not set out to map the full geographical variations in radon concentrations around the country.

The results also indicate that properties with concrete based foundations yield higher indoor radon concentrations and newer builds (last 25 years) indicated slightly higher median values.

RECOMMENDATION 2: Further studies should be considered to obtain more data on geographical variations. Such studies would also be able to obtain more data in variations associated with building materials, foundations and age of the property. However as the upper range in variations in median concentrations are still relatively low compared to worldwide median concentrations, this is not seen as an urgent priority. Rather it should form part of a longer term strategy in building a radon map for New Zealand.

4.4 Workplaces

The workplace sample is very small in this survey (19 premises), although the geographical spread for the sampling of this group covered most regions in the country . No elevated

results were observed (all well below 100 Bq/m3). The vast majority of workplaces in New Zealand are likely to be similarly low. However there are also likely to be some specific workplaces where elevated radon levels exist, for example underground locations such as mines and show caves. A targeted survey of these types of workplaces should be considered.

RECOMMENDATION 3: Consideration should be given to performing a survey of targeted workplaces where elevated radon concentrations may be anticipated and identified as such in other jurisdictions. This would include mining, show caves and oil and gas industries.

4.5 Setting national reference levels

4.5.1 Private dwellings and other buildings with high occupancy by members of the public

IAEA (Basic Safety Standards requirement 50) place a requirement on governments to set national reference levels for Rn-222 concentrations in dwellings and high occupancy buildings for the public and for workplaces.

To protect the members of the public, IAEA recommends that the Rn-222 reference level for dwellings and other buildings with high occupancy factors, taking into account social and economic factors should not in general exceed an average activity concentration of 300 Bq/m3 .

WHO recommend reference levels in the range of 100 to 300 Bq/m3 and advise that national factors such as the distribution of radon, the number of existing homes with high radon concentrations, the arithmetic mean indoor radon level and the prevalence of smoking should be taken into consideration. WHO also state that a Rn-222 concentration of 300 Bq/m3 represents a dose of approximately 10 mSv per year.

Reference levels for dwellings and high occupancy public buildings adopted by different countries vary around the world. The Rn-222 reference levels in dwellings for Australia, UK and Ireland are 200 Bq/m3.

RECOMMENDATION 4: The national reference level for average annual indoor Rn-222 concentrations in dwellings and buildings that have high occupancy factors for members of the public (such as schools, kindergartens and hospitals) should be set at 200 Bq/m3

4.5.2 Workplaces

IAEA (BSS requirement 52) recommend that regulatory bodies establish requirements to protect against radon in workplaces, including the establishment of a reference level for Rn-222 to be set at a value that does not exceed an annual average activity concentration of 1000 Bq/m3.

Reference levels for workplaces adopted by different countries vary around the world. The Rn-222 reference level for workplaces in Australia is 1000 Bq/m3. In UK and Ireland it is 400 Bq/m3.

UK and Ireland have relatively high annual average radon concentrations in private dwellings and other buildings and therefore they have imposed more restrictive levels in workplaces than the IAEA recommended upper reference level in an attempt to reduce overall radon exposures to the population. Australia has relatively low indoor radon concentrations in private dwellings and so it is not so critical to impose more restrictive workplace levels. New Zealand similarly has relatively low average radon concentrations in buildings compared to other parts of the world and therefore a similar approach to Australia is reasonable.

RECOMMENDATION 5: The national reference level for average annual Rn-222 concentrations in workplaces should be set at 1000 Bq/m3.

5. References

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