Practical issues in retrospective estimation of long-term indoor radon exposure with ^{210}Pb in household dust

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Abstract

Radon decays to a long-lived isotope, ^{210}Pb, with a half-life of about 22 years. Measuring concentrations of ^{210}Pb in household dust could be an alternative method of determining indoor radon levels. A previous study conducted in 2008 in the city of Winnipeg demonstrated that ^{210}Pb concentrations in household dust correlate reasonably well to radon concentrations in homes (*R^2=0.57*). To confirm the viability of this retrospective method, a field experiment was repeated in 2010 to further study the correlation between ^{210}Pb in household dust and indoor radon concentration. The results showed that ^{210}Pb is a reasonably good indicator of long-term radon exposure indoors when dust samples collected are representative of household dust in a house.

Introduction

Radon is a naturally occurring radioactive gas generated by the decay of uranium bearing minerals in rocks and soils. Radon and its progenies have been identified as the second leading cause of lung cancer after tobacco smoking. The Canadian radon guideline released in 2007 recommends that remedial measures should be undertaken in a dwelling whenever the average annual radon concentration exceeds 200 Bq/m^3 in the normal occupancy area.

Since radon levels in a home can vary significantly over time, a long-term measurement period (3 to 12 months) will give a much better indication of the annual average radon concentration compared to short-term tests. Although detectors for long-term radon testing are commercially available, many homeowners wish to know radon levels much sooner. Alternative methods to quickly estimate long-term indoor radon concentrations are therefore being explored.

Methods

To study the correlation, radon concentrations and concentrations of ^{210}Pb in household dust accumulated over the radon test period are required.

In radon measurements, passive integrated radon-thoron discriminative detectors (RADUET) were used. The test duration was 3 months.

The survey was designed to collect household dust in vacuum bags during the test period.

To prepare for analysis by gamma counting, fine dust was obtained by sieving to 100µm.

Activity concentrations of ^{210}Pb were determined by counting the 46.5keV peak in the unit of Bq/g. Uncertainties for the 46.5keV peak area were calculated for each sample.

Results and Discussion

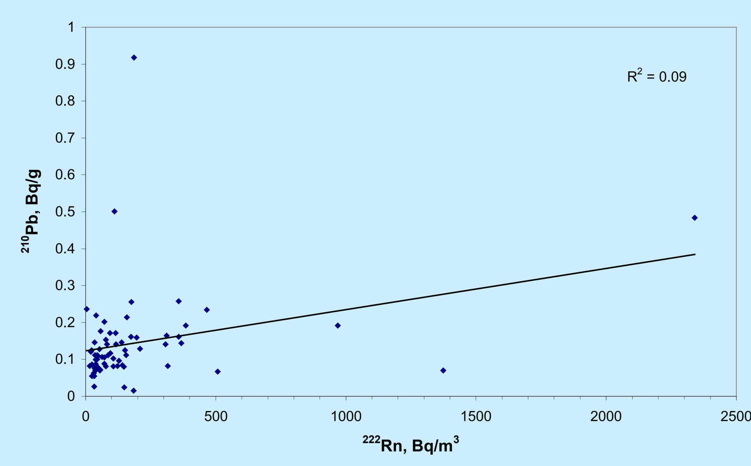
Dust samples and radon concentrations were available in a total of 66 homes.

Even though a special instruction was given at the beginning of the study to collect the entire vacuum bag used during the test period for household cleaning, many of dust samples received were still in small quantities, much less than expected. A few participants even provided white dirt (possibly from dry-wall collected in house renovation) instead of real household dust.

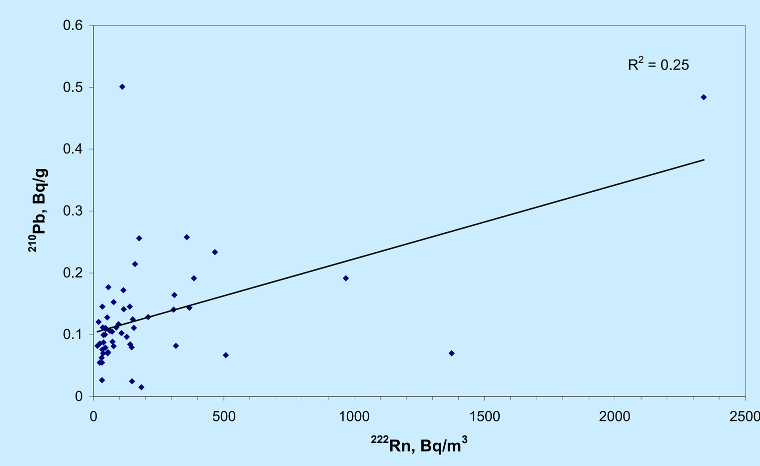
Dust samples were first sieved to 100µm to remove the large objects. All sieved samples were contained in PVC vials, and then analyzed for the levels of ^{210}Pb by counting on a Gamma Analyst Integrated Gamma Spectrometer (GAM-AN2) until the uncertainty < 15%.

After sieving to 100µm, the weights of fine dust samples varied from 2.3 to 98.2g.

The correlation between ^{210}Pb and ^{222}Rn concentrations was studied by linear regression. The correlation coefficient R^2 is a measure of the correlation, i.e. linear dependence between ^{210}Pb and ^{222}Rn concentrations.



^{210}Pb in dust versus indoor ^{222}Rn concentration, and linear fit through all 66 data points available in this study.

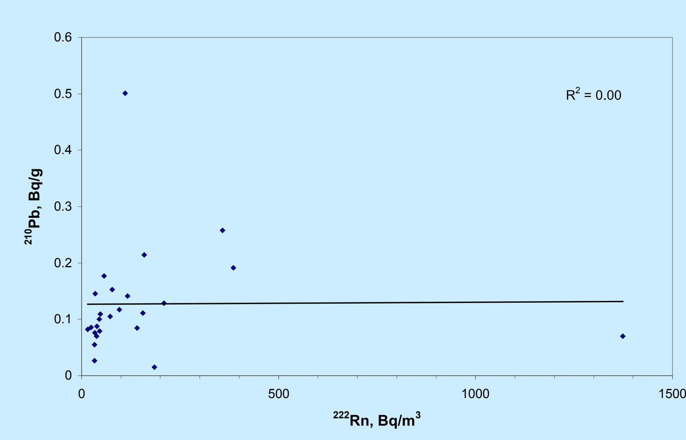


^{210}Pb in dust versus indoor ^{222}Rn concentration for 54 dust samples of 10 g and more.

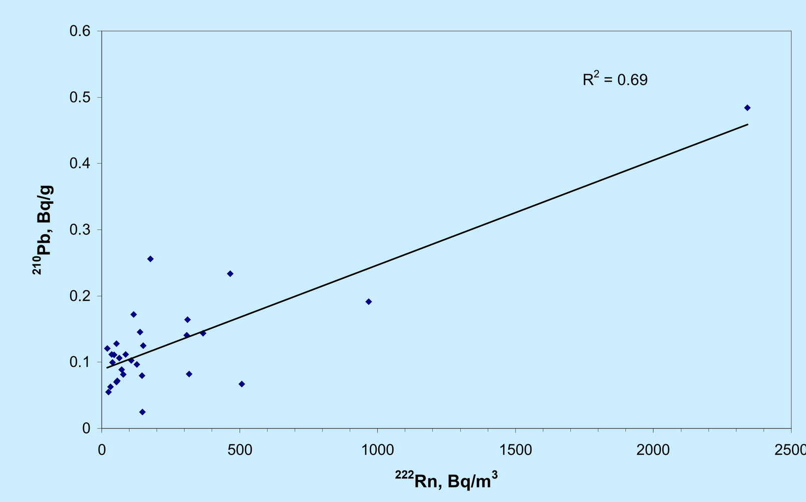
The linear regression of all 66 paired values of ^{210}Pb and ^{222}Rn concentrations revealed a R^2 of 0.09 indicating practically no correlation. If considering only dust samples of 10g and more, the correlation coefficient improved to 0.25.

It is of interest to see whether the correlations could be different for samples from different cities. Among the 54 dust samples of 10g and more, 25 samples were from Fredericton while the other 29 from Halifax.

The ^{210}Pb and ^{222}Rn concentrations in 25 homes in Fredericton showed absolutely no correlation. This is a clear indication that the predictive power of this retrospective method could vanish if non-representative dust samples were provided.



^{210}Pb in dust versus indoor ^{222}Rn concentration for 25 dust samples of 10g and more from Fredericton.



^{210}Pb in dust versus indoor ^{222}Rn concentration for 29 dust samples of 10g and more from Halifax.

A promising correlation with R^2 = 0.69 was found in 29 homes in Halifax.

However, in principle, the correlation coefficient, R^2, should not depend on geographic location. To make this method a practical and viable tool for quick estimation of long-term indoor radon concentration, it is important to make sure, before performing the analysis, that the sample is representative household dust collected in the past several months and from most surfaces in a house. Only dust representing indoor dust deposition over several months can be used to reasonably estimate the long-term indoor radon exposure condition.

CONCLUSION

Compared to the previous study in Winnipeg, a similar correlation coefficient is observed among samples from the city of Halifax. A rather promising correlation coefficient of R^2 = 0.69 indicates that theoretically speaking, ^{210}Pb is a reasonably good indicator of long-term radon exposure indoors, when experimental conditions are well controlled and many uncertainty factors can be eliminated or reduced in the determination of both ^{210}Pb and ^{222}Rn concentrations.