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Time-integrating radon gas measurements in domestic premises: comparison of short-, medium- and long-term exposures

C.J. Groves-Kirkby [a,*], A.R. Denman [a,b], R.G.M. Crockett [b], P.S. Phillips [b], A.C. Woolridge [b], G.K. Gillmore [c]

[a] *Medical Physics Department, Northampton General Hospital NHS Trust, Cliftonville, Northampton NN1 5BD, UK*
[b] *School of Applied Sciences, University College Northampton, Boughton Green Road, Northampton NN2 7AL, UK*
[c] *Department of Environmental Sciences, University of Bradford, Bradford, West Yorkshire BD7 1DP, UK*

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Abstract

To identify the most applicable technology for the short-term assessment of domestic radon levels, comparative assessments of a number of integrating detector types, including track-etch, electret and activated charcoal were undertaken. Thirty-four unremediated dwellings in a high-radon area were monitored using track-etch detectors exposed for one-month and three-month periods. In parallel, one-week measurements were made in the same homes at one-month intervals, using co-located track-etch, charcoal and electret detectors exposed simultaneously, while three of the homes were also monitored by continuous-sampling detectors at hourly intervals over extended periods. Calibration of dose-integrating devices against each other and against continuous-monitoring systems confirmed good responsivity and linearity. Although track-etch, charcoal and electret devices are suitable in principle for one-week measurements, zero-exposure offset and natural radon variability cause many one-week results to be equivocal, necessitating repetition of the measurement. One-week exposures can be

* Corresponding author. Tel.: +44 1604 545765; fax: +44 1604 544612.
E-mail address: chris.groves-kirkby@ngh.nhs.uk (C.J. Groves-Kirkby).

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reliable indicators in low-radon areas or for new properties, but in high-radon areas, the use of three-month exposures is indicated. This analysis also established confidence limits for short-term measurements.

Keywords: Radon; Track-etch; Electret; Activated charcoal; Continuous sampling; Comparative assessment; Health risk; Domestic properties

1. Introduction

Radon is a naturally-occurring radioactive noble gas, having variable distribution in the geological environment as a decay product of uranium found, in differing degrees, in a wide range of rocks and soils and in building materials incorporating or manufactured from these sources. There are three naturally occurring isotopes of radon, ^{222}Rn, a direct product of ^{226}Ra in the ^{238}U decay-series with a half-life of 3.8 days; ^{220}Rn, a decay product of ^{232}Th, with a half-life of 55.6 s; and ^{219}Rn, a decay product of ^{235}U, with a half-life of 3.6 s. Radon has high mobility, enabling it to move out of underlying rocks and ground-water into caves, mines and the built environment. Of the three isotopes, ^{222}Rn is the most significant, its relatively long half-life enabling it to migrate quite significant distances within the geological environment before decaying. Although radon dissipates rapidly once in outdoor air, it can concentrate in the built environment. For UK dwellings, the mean radon level is around 20 Bq m^{-3}, compared to 4 Bq m^{-3} in outside air (Wrixon et al., 1998) but levels up to 17,000 Bq m^{-3} have recently been found in residential properties (NRPB, 2004).

Ionising radiation is well known to have adverse health effects, and inhalation of radon and its progeny ^{218}Po and ^{214}Po adsorbed onto atmospheric particulates is currently believed (Darby et al., 2005; Krewski et al., 2005) to provide the majority of the dose to the respiratory system. This results in damage to the sensitive inner lining of the lung, increasing the risk of cancer, and it is further estimated that the annual mortality from exposure to radon in buildings represents 9% of all deaths from lung cancer, and 2% of all cancer deaths, in Europe (Darby et al., 2005). The total annual mortality from this type of cancer in the UK is between 30,000 and 35,000 (UK Dept. of Health), suggesting that between 1800 and 2100 deaths annually are caused by exposure to radon and its progeny.

Indoor radon levels are subject to a number of variations. In addition to the natural daily cycle, other longer temporal and spatial cycles are evident, related to occupancy, weather conditions and seasonal factors, indoor radon levels being generally higher in winter than in summer. As the risk of lung cancer increases with increasing radon exposure, the preferred measure of this risk is the long-term average radon level, the current UK recommendation being the use of three-month measurements in conjunction with the application of a Seasonal Correction Factor (Pinel et al., 1995; Gillmore et al., 2005). In some circumstances, however, particularly