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Measuring radon concentrations in air using radon adsorption materials or air grab sampling at the progeny non-secular equilibrium time frame

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The Nuclear Engineering Laboratory of NTUA (NEL-NTUA), as part of their educational activities, regularly test radon absorbers and grab sampling devices suitable for radon concentration measurements. Most common absorbing devices are those based on activated carbon or zeolite, while a popular grab sampling contraption is the so-called "Lucas-cell". To achieve a radon concentration measurement with carbon or zeolite, one should expose the absorbing material for adequate time (hours or up to some days), then enclose the material in an air-tight box and wait at least 3 hours for the development of gamma emitting radon progeny in equilibrium. The box may then be measured by means of a total gamma measuring system. The measurement is translated to radon exposure in $Bqh^{-1}m^{-3}$, provided that a calibration factor has been derived experimentally. For measurements with a Lucas-cell, one grabs into a glass cell, some radon containing air from the environment to be tested, using a small air pump. The cell is then air-shielded and one waits at least 3 hours for the growth of alpha emitting radon progeny in equilibrium. The cell may then be measured by means of a PMT to capture light produced from the interaction of alphas with ZnS(Ag) powder enclosed in the cell. The measured light is translated to radon concentration in Bqm^{-3} using a calibration factor from calibration experiments. The problem in both methods is that there is a quite long time gap since the end of sampling, within which the experimenter would not be able to obtain calibrated results. However, if the calibration experiments could be also performed and calibration factors could be obtained at the progeny non-secular equilibrium state, i.e. in the time span between the end of sampling and the 3 hours, this difficulty may be overcome. To this end one has to make himself available solutions of the Bateman differential equations for all gamma and alpha emitting radon daughters at any given time before the limit of 3 hours. This would allow for obtaining the denominator gamma or alpha activity necessary for calibration factors at any given time. In this work, the Bateman differential equations are solved for radon daughters activity using MS Excel. Calibration experiments were performed for various Lucas-cells and various radon concentrations in air. The calibration factors found were acceptably steady, within uncertainty, per alpha emitting event. Given the time moment of measurement, the implementation in MS Excel allows for inversely solving the equations from Lucas-cell measurement back to radon concentration, using some trial and error.

References

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