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Monte Carlo simulation of air sampling methods for the measurement of radon decay products

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Content

Frequently the air concentration of radon decay products is assessed by sampling a certain volume of air through a filter. The activity collected on the filter is measured according to an appropriate protocol, which is defined by the measurement channels, with specific detection efficiency of each decay product, and by the measurement intervals. The relations between the concentrations and the measurement results are then used for obtaining the concentrations. In a previous study, this approach was implemented in a least squares computer code for the calculation of the concentrations of 222Rn and 220Rn decay products [1].The code can be applied for a broad range of measurement protocols. The uncertainty of the results is evaluated by assuming Gaussian distributions and the propagation of variances. The current requirement for realistic evaluation of the uncertainties of the measurement results, as well as the construction of a radon chamber in IFIN-HH (Bucharest, Romania), renewed our interest for this problem. In the present work we develop a more realistic procedure for the evaluation of the uncertainties of the activity concentrations of radon decay products measured by air sampling methods. The procedure is based on Monte Carlo simulation and propagation of the distributions, in accord with GUM Supplement 1 [2]. In essence, a large set of simulated numbers of counts corresponding to a given measurement protocol is generated, the activity values are calculated for each set and finally the distribution of these values is constructed. The model applied for the preparation of a sample of the numbers of counts has the following main features. The radon concentration is considered stationary in a given volume. The average concentration of each decay product in the air is characterized by the corresponding equilibrium factors. However, as a result of the statistical processes of production and decay, the number of radioactive nuclei of any type in the volume is a random variable. Assuming that there is no correlation between the numbers of nuclei in disjoint volumes, the distribution of the number of nuclei in any volume can be computed. Then the number of nuclei from the air volume pumped in an elementary filtration act and collected on the filter can be appropriately sampled by Monte Carlo techniques. Next the random decay of these nuclei and the detection processes are simulated in a standard way, recording the number of counts in the appropriate measurement channels and time intervals. The air sampling procedure is repeated by a number of times corresponding to the duration of air filtration. Finally, by counting the number of signals accumulated in each measurement channel in each measurement interval, a particular sample of the number of counts is obtained. The procedure developed can provide a realistic description of the uncertainties of the activity concentrations of the radon decay products. It can be used also for optimizing the parameters of the measurement protocol. [1]. O. Sima, Comprehensive software for the assessment of 222Rn and 220Rn decay products based on air sampling measurements,Appl. Radiat. Isot.67 (2009) 867-871 [2]. JCGM 101:2008, Evaluation of measurement data – Supplement 1 to the "Guide to the expression of uncertainty in measurement" – Propagation of distributions using a Monte Carlo method

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