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Radon retrospective dosimetry in different environments

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Abstract In the present study of retrospective dosimetry, measurements of Radon (^{222}Rn) and Polonium (^{210}Po) were performed. Radon is a radioactive gas and is concentrated in the interior of residential buildings and working places and is considered as a primary cause of lung cancer. To evaluate measurements in different environments, alpha spectrometry was employed in estimating exposure to radon in various locations over a long period of time (hence, the use of the term “retrospective”) through exposure of plastic and glass surfaces. Following these measurements, the Conversion Factor (CF) was calculated. This factor correlates the measured surface concentrations of ^{210}Po with the ^{222}Rn concentrations in the environments under study.

Keywords Retrospective radon dosimetry, alpha spectrometry

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INTRODUCTION

Radon (^{222}Rn) is a radioactive gas, released from the soil and from building materials and it is concentrated in the interior of residential buildings. Inhalation of radon is an important factor in public health because it is the primary cause of lung cancer. Radon measurements may not be representative of a person's cumulative exposure during his lifetime.

To evaluate measurements in different environments, alpha spectrometry was employed in estimating ^{210}Po activity on glass and plastic surfaces exposed to radon in various locations, over a long period of time (hence the use of term “retrospective”). Following these measurements, the Conversion Factor (CF) was calculated. This factor correlates the measured surface concentrations of ^{210}Po with the ^{222}Rn concentrations in the environments under study. In this presentation three different sets of measurements are described.

MATERIALS AND METHODS

Alpha Spectrometry

For the α -spectrometry measurements the Canberra Model 7401 was used (Fig. 1A). This is a complete α spectrometer that includes a vacuum chamber, bias supply, preamp/amplifier, pulser, discriminator, counter, and digital display in a versatile double-width NIM. Samples up to 5 cm in diameter can be analyzed in the chamber, which is made of stainless steel. Front panel controls allow the user to set and read high voltage bias, calibration pulser energy, and discriminator and preset time settings for the built-in counter. Additionally, the front panel display provides readout of pressure, detector leakage current, counts and elapsed time. Samples were measured with a Canberra PIPS detector of the A900-29AM series with an active surface area of 900 mm². The amplified signal of the detector was led to an ADC ORTEC card installed in a desktop PC. The collection of spectra and their analysis was implemented using the ORTEC MAESTRO software package.

Sampling and counting

In the first set of measurements, samples of glass and plastic were collected from a basement of a detached house with relatively high radon concentration. This concentration was measured using an ALGADE Barasol unit (www.algade.com). The measuring unit consists of a cylindrical chamber, 57 cm long and 60 mm in diameter, equipped with an implanted silicon junction for the detection of radon alpha particle emissions. A micro-processor is used to integrate and store the data, acquired during user-preset measuring intervals between 15 and 240 min. Meteorological parameters, such as temperature and atmospheric pressure are simultaneously recorded. All data are read out by a portable PC (Fig. 1B).

The samples had been exposed in this environment for a long period of 14 to 20 years. Following collection, the samples were measured in the α -spectrometer system described previously and the corresponding CFs were calculated.

For the second set of measurements, pieces of plastic and glass were placed inside the cave of Perama at Ioannina, at NW Greece. The samples were left there for 2 months in the deepest point of the cave, in which the radon concentration was measured before equal to $925 \pm 420 \text{ Bq m}^{-3}$ [1]. Following exposure, the samples were measured in the α -spectrometer system and the corresponding CFs was calculated.

For the third experiment, samples of plastic material were placed inside a tube of 0.5 m in length and 6 cm in diameter and stayed there for 5.4 months. The tube was placed in soil so that its top was 5 cm higher than ground surface. At the same time, 7338 measurements of radon emanation were performed over a 6 months period, with the Barassol II Algade system, of which the radon detector also was placed in the tube. These measurements showed that the mean concentration of ^{222}Rn inside the tube is $27747 \pm 9200 \text{ Bq m}^{-3}$. The samples were measured with the α -spectrometer system and the corresponding CF was calculated.

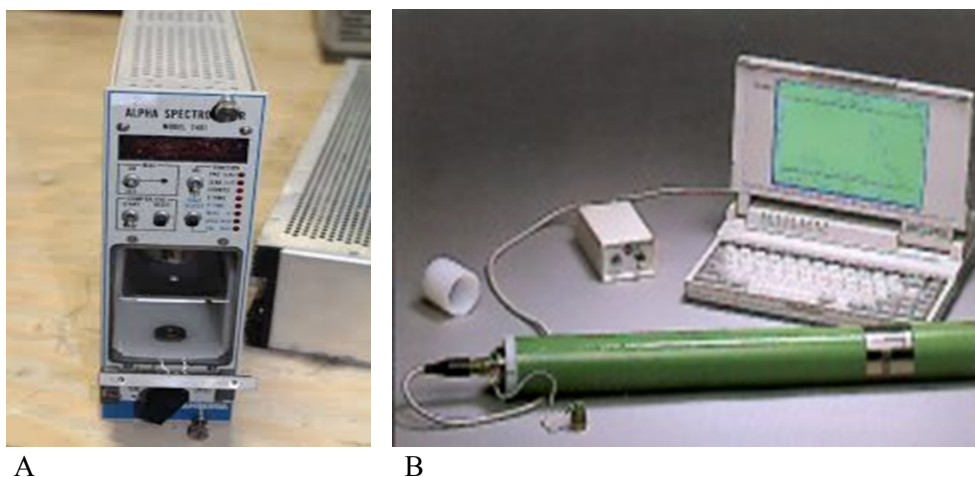


Figure 1. (A) The α spectrometer. (B) The Barasol system.

RESULTS AND DISCUSSION

A typical spectrum of the α activity measured in the different samples is shown in Fig. 2. The counting times were long and lasted up to a week. Allowing time enough for the decay of short lived radon daughter isotopes, only ^{210}Po is seen.

In Fig. 3, radon counting in the basement under study, using the Barasol system is shown. The average radon concentration was calculated equal to $(245 \pm 160) \text{ Bq m}^{-3}$.

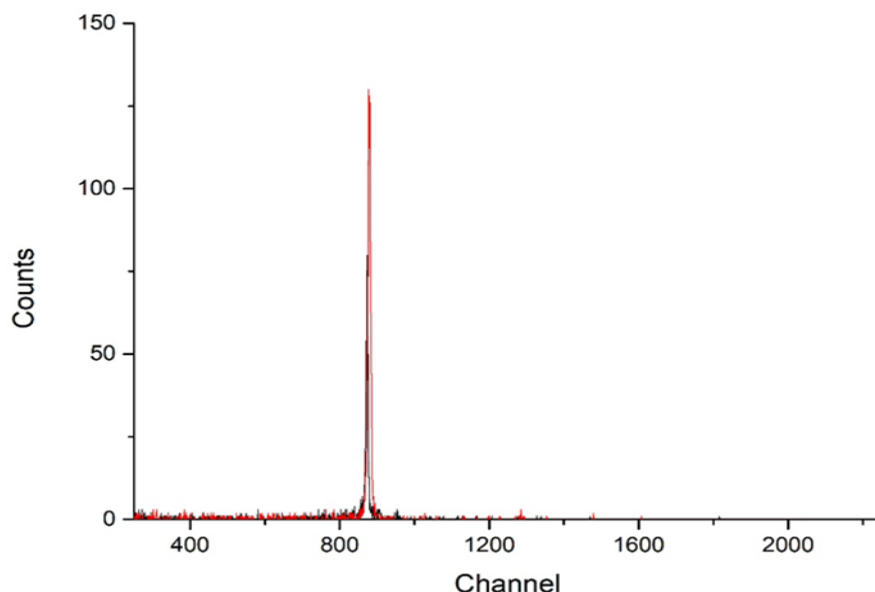


Figure 2. Typical alpha spectrum collected from exposed glass and plastic samples.

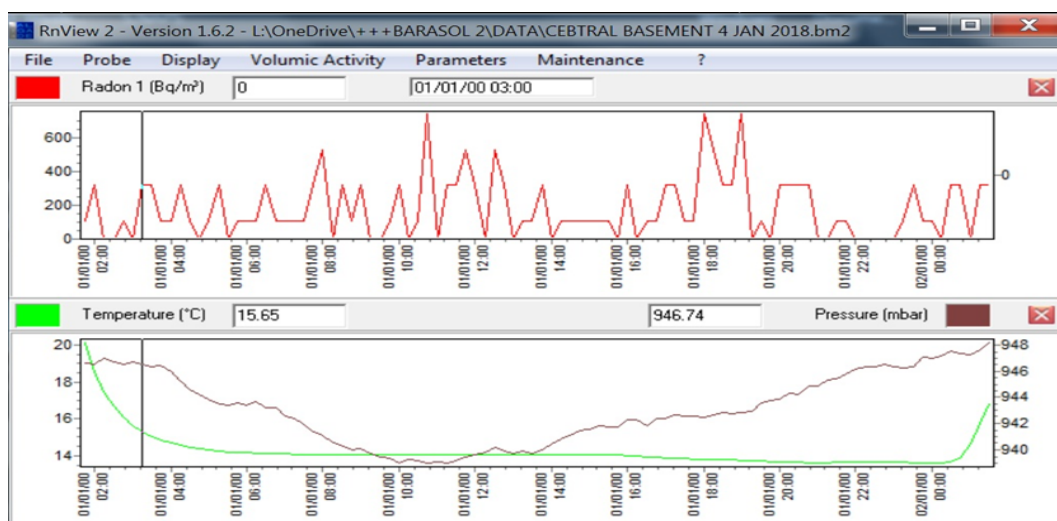


Figure 3. Output of the Barasol system, placed in the basement under investigation.

In Table 1, the average values of the computed CFs and the corresponding 1σ errors are presented. The results of the first two experiments were significantly similar and provided CFs ranging from $(1.6 \pm 0.4) \times 10^{-3} (\text{Bq m}^{-2} \text{ }^{210}\text{Po} / \text{Bq m}^{-3} \text{ }^{222}\text{Rn})$ to $(2.11 \pm 0.98) \times 10^{-3} (\text{Bq m}^{-2} \text{ }^{210}\text{Po} / \text{Bq m}^{-3} \text{ }^{222}\text{Rn})$. The average value of CF calculated from the tube in soil experiment was orders of magnitude lower and equal to $(6 \pm 11) \times 10^{-6} (\text{Bq m}^{-2} \text{ }^{210}\text{Po} / \text{Bq m}^{-3} \text{ }^{222}\text{Rn})$. The difference is attributed to soil humidity condensing to water droplets on the surface of the plastic material.

Table 1. Conversion factors for the exposure of glass and plastic surfaces in different environments

MEASUREMENTS SET	Conversion factor (glass) $\left(\frac{Bq}{m^2} {}^{210}Po\right) / \left(\frac{Bq}{m^3} {}^{222}Rn\right)$	Conversion factor (plastics) $\left(\frac{Bq}{m^2} {}^{210}Po\right) / \left(\frac{Bq}{m^3} {}^{222}Rn\right)$
BASEMENT	$(1.73 \pm 0.81) \times 10^{-3}$	$(1.63 \pm 0.44) \times 10^{-3}$
PERAMA CAVE	$(0.59 \pm 0.27) \times 10^{-3}$	$(2.14 \pm 0.98) \times 10^{-3}$
TUBE IN SOIL		$(6 \pm 11) \times 10^{-6}$

CONCLUSIONS

In the present work we succeeded in detecting ${}^{210}Po$ from ${}^{222}Rn$ decay on glass and plastic surfaces. No significant difference was observed between CFs for glass and plastic. This finding is attributed to similar mode of attachment and/or inclusion of ${}^{210}Po$ precursors to a radon exposed surface.

References

- [1] C. Papachristodoulou *et al.*, Health Phys. 86, 619 (2004)