Outdoor radon measurements by means of SSNTD and active monitoring

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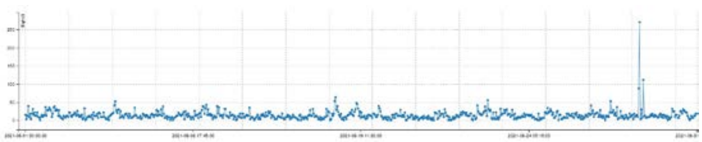
The aim

Accurate measurements of outdoor atmospheric radon activity concentrations are of interest both for radiation protection and climate research communities. Particularly, radon concentrations below 100 Bq/m^3, which are very important for the retrieval of radon priority areas and for atmospheric process modelling. The calibration and measurement capabilities of outdoor low-level radon concentrations lack robust metrological traceability chain to ensure their quality. For this purpose, the **traceRadon** project works towards improved traceable low-level outdoor radon measurements, and will help EU member states to comply with the Council Directive 2013/59/Euratom.

Table 1. Average values recorded at IFIN-HH atmospheric station (1 Aug – 31 Aug 2021) and PTB reference field (29 Nov – 20 Dec 2021) for atmospheric radon concentrations.

Reference site	Radon Monitor	Radon activity concentration, average value ± unc [Bq/m^3]
IFIN-HH	AlphaGuard (PQ2000 PRO)	12.6 ± 6.4 (for k=1)
PTB	ANSTO 200L	4.7 ± 0.20 (for k=2)

Figure 1. Atmospheric radon concentrations measured at IFIN atmospheric station in august 2021, hourly recorded data for one month.



Outlook

In the future, a better solution to perform long radon exposures of nuclear track detectors in the radon chamber (for two weeks or more) would be to use low activity radium (^{226}Ra) sources with certified radon emission rates, directly connected to the radon chamber (in a closed/open circuit). Such a new experimental setup would allow us to obtain radon activity concentrations at lower values (<100 Bq/m^3) to be kept (relatively) constant in time, and verify once again the calibration factor. This option will be investigated in the frame of the European joint research project EURAMET EMPIR 19ENV01 traceRadon (2020–2023), where IFIN-HH/LMRI participates. Also as a joint effort within the research project the above mention test will be performed at PTB and IFIN-HH following the same protocol.

A photo showing of an integrated ^{222}Rn Source/Detector (IRSD) based on a 450 mm^2 Canberra PIPS® detector, modified with a layer containing 440 Bq $^{226}RaCl_2$ developed by PTB (Mertes F., Röttger S., Röttger A., Development of ^{222}Rn Emanation Sources with Integrated Quasi 2π Active Monitoring. Int. J. Environ. Res. Public Health 2022, 19, 840. https://doi.org/10.3390/ijerph19020840).

Conclusions

These results will feed into the traceRadon project with respect to radionuclide metrology and radiation protection at the environmental level. Knowledge of such joint efforts can offer a solid background in providing more accurate and traceable results for these measurement methods. This is even more challenging due to the outdoor environment.

Introduction

One of the techniques used to quantify radon activity concentrations is by means of the solid state nuclear track detectors (SSNTD). This study aims to observe the integral radon exposure of SSNTD at an Atmospheric Monitoring Network Station (AMNS) and compare the radon activity concentration estimated from the integral values and the average radon activity concentration measured by active monitoring devices. In operational services, the sensitivity and accuracy of the SSNTD readings are key factors, and must be properly estimated to provide correct exposure from radon.

An activity planned within the traceRadon project is the stability comparison (of at least one month) with the transfer standard at least at two different AMNS, to prove consistency of the conventional true value of the transfer standard and that of the radon activity concentration monitor of each AMNS, as a quality assurance procedure. For this activity, at least five SSNTD are used to determine the integral radon exposure during these comparisons.

Experiments

Firstly, in august 2021, the SSNTDs were placed at IFIN-HH atmospheric station. The TASTRAK solid-state nuclear track detectors were used in the present work, together with the dosimetry system and optical reading TASLIMAGE (produced by Track Analysis Systems Ltd. (TASL), Bristol, UK). The measurements of the SSNTDs were compared with the data recorded by the active radon monitor Alpha Guard – PQ 2000 Pro. The results showed that the average radon activity concentration obtained from SSNTDs, (62 ± 22) Bq/m^3, is higher than that from the Alpha Guard, (12.6 ± 6.4) Bq/m^3 (see Fig. 1 and Table 1)) for k=1.

The SSNTDs were tested for their calibration factor at the radon chamber from IFIN-HH/LMRI, and was experimentally confirmed during the period 26 November–1 December 2021 in a reference radon atmosphere of (2797 ± 159) Bq/m^3 for k=1.

Experimental arrangement of the TASTRAK nuclear track detectors inside the IFIN-HH/LMRI radon chamber (Luca A., et al., Recent Progress in Radon Metrology at IFIN-HH, Romania. Atmosphere 2022, 13, 363. https://doi.org/10.3390/atmos13030363).

A second experiment was conducted during November-December 2021 at PTB atmospheric station, using the same type of SSNTDs. In this case, two active radon monitors were in place, an ANSTO 200L detector developed by Australian Nuclear Science and Technology Organisation and the Armon detector developed by Institut de Tècniques Energètiques (INTE) and Universitat Politècnica de Catalunya (UPC). The results showed again higher radon activity concentration readout from SSNTDs (40 ± 14) Bq/m^3 then those from active monitors (see Table 1).

Due to the above applications, there is a need of building a metrological chain to ensure high quality radon activity concentrations measurements. Both climate and radiation protection research communities underline the need for improved traceability in low-level atmospheric radon measurement.

Acknowledgment

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