

Calibration Factor for LR 115 Type II Detectors Used to Measure Indoor ^{220}Rn

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Abstract

Major aim of the paper is to determine calibration factor for LR 115 type II detectors used to measure indoor ^{220}Rn . To determine calibration factor, LR 115 detectors were fixed on top and bottom inside urban cup chamber and sent to NIRS, Japan to ^{220}Rn calibration exposure. After detectors have been calibration exposure at NIRS, authors carried out following all steps of procedure, which set up at laboratory in INST, Vietnam. This paper discusses the experimental method that is used in calculating the calibration factor of ^{220}Rn inside the urban cup, calibration factors (CF) were determined by experimental with detectors placed at top and bottom inside urban cup were 0.023 ± 0.004 and 0.038 ± 0.007 (tracks. $\text{cm}^{-2}/\text{Bq.m}^{-3}.\text{d}$), respectively. The curve between integrated ^{220}Rn concentration and tracks density with factor $R^2=0.96$ and 0.97 at top and bottom inside urban cup, respectively. In order to precision evaluation, authors used 20 couple of LR-115 detectors at 8cm detector-source distance with relative standard deviation less than 1.48%.

Keywords: LR-115 type- II; Rn-220; Spark counter

Introduction

Thoron (^{220}Rn) is a natural radon (^{222}Rn) isotope with a relatively short half-life (55.6 s), comparing with ^{222}Rn (3.82 day). Therefore, its indoor concentrations depend strongly on the distance from the point where ^{220}Rn is emanated [1-3]. Therefore, short half-life ^{220}Rn which makes accurate measurements of ^{220}Rn concentrations extremely difficult to obtain. Nevertheless, the accurate measurement of ^{220}Rn in the environment is an important task from the viewpoint of radiation protection [4]. Determining the radiation hazard from ^{220}Rn and its progeny has become imperative. Additionally, determining an accurate activity concentration for ^{220}Rn and its progeny needs to concern calibration factor (CF).

Besides this large concern in ^{222}Rn , importance of ^{220}Rn has recently been recognized, ^{220}Rn is present everywhere together with ^{222}Rn , and a quantity of ^{220}Rn is sometimes much larger than that of ^{222}Rn at a certain position in dwellings Why was ^{220}Rn underestimated in the past studies? The following reasons can be considered: there are many difficulties in measurement and calibration ^{220}Rn , there are no epidemiological data related to ^{220}Rn exposure and the ^{220}Rn risk seems to be negligible.

What is a clear difference between mine studies and indoor studies on ^{222}Rn ? It is the presence of ^{220}Rn . When considering a radon risk in indoor studies, special attention should be paid to ^{220}Rn present together with ^{222}Rn . However, recent statements about the contribution of ^{220}Rn on the dose have to be reconsidered. Studies have shown that people living in environments with high ^{220}Rn concentration in Brazil, China and India are receiving a high dose from ^{220}Rn [2,5-9]. This is the reason why ^{232}Th rich environment has to be taken into account in radiological point of view to prevent elevated risk originated from high ^{220}Rn levels.

The aim of this study was to determine calibration factor CF to measure ^{220}Rn used to LR-115 type II detector is placed inside Urban cup. Detectors are fixed on the top and bottom inside urban cup and sent to NIRS, Japan to ^{220}Rn calibration exposure, after calibration exposure detectors sent back to Vietnam. Detectors were etched with 2.5 N NaOH solution following the etching protocols in INST's lab, Vietnam. Tracks developed were counted using a spark counter. The CF (tr. cm^{-2} per Bq.d. m^{-3}) for individual experiment was obtained by relating these tracks with the respective measured gas concentrations (Tables 1 and 2).

Materials and Methods

Equipment

LR-115 type II detector: Using 12 μm thick LR-115 type II cellulose nitrate alpha track detectors manufactured by Kodak Pathe, France. The detectors consist of an active layer of red cellulose nitrate on a 100 μm clear polyester base substrate as shown in Figure 1. Detectors used with dimensions 3×3 cm.

Urban cup chamber: It is commonly named as the "Karlsruhe" with inner base radius of 2.35 cm, top radius of 3.35 cm and height of 4.8 cm. There are holes in the brim of the chamber, which allow air to flow in and out of the chamber. LR-115 detectors are fixed in top and bottom inside urban cup as shown in Figure 2.

Spark counter system: Spark Counter Model 9201 T-G has been researched and manufactured since 1994 at INST, Vietnam.

Etching system: The system as shown in Figure 3. The etching solution NaOH 2.5 M was maintained at $60 \pm 1^\circ\text{C}$ in a water bath. The water bath was sheltered by a plastic cover to reduce water loss. The region of damage around each track was extended by the etchant so that the tracks became visible as small holes on the surface of the detector. After 1.5 h, chemical etching the films are rinsed in running cold water for 30 minutes, dried, and put back into a plastic bag for protection.

^{220}Rn calibration system at NIRS, Japan: The NIRS developed a compact ^{220}Rn calibration chamber. The chamber consists of four components: exposure system, calibration system, monitoring system and humidity control system. A 150L stainless steel vessel is used as

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Expt. No.	Exposure duration (h)	²²⁰ Rn (kBq/m ³)	Tracks (tr.cm ⁻²)	CF (tr.cm ⁻² per Bq.m ⁻³ .d)
1	22	24	472.8	0.021
2	22	24	383.0	0.017
3	40	25.4	901.0	0.021
4	40	25.4	1254.0	0.030
5	66	30.5	2121.0	0.025
6	66	30.5	2124.0	0.025
Average				0.023 ± 0.004

Table 1: Calibration factor (CF) for LR-115 type II detector at top inside urban cup.

Expt. No.	Exposure duration (h)	²²⁰ Rn (kBq/m ³)	Tracks (tr.cm ⁻²)	CF (tr.cm ⁻² per Bq.m ⁻³ .d)
1	22	24	573.6	0.026
2	22	24	782.8	0.036
3	40	25.4	1799.0	0.042
4	40	25.4	1758.6	0.042
5	66	30.5	3635.8	0.043
6	66	30.5	3363.2	0.040
Average				0.038 ± 0.007

Table 2: Calibration factor (CF) for LR-115 type II detector at bottom inside urban cup.

the exposure chamber. In order to make a homogeneous distribution of ²²⁰Rn concentration, an inner fan is installed. Lantern mantles are used as the practical ²²⁰Rn source. The ²²⁰Rn concentration is measured using a single scintillation cell method [6].

Experiment

The experimental arrangement is shown in Figure 4, authors prepared fifteen detectors LR-115 with dimensions 3 × 3 cm and six urban cup chambers. Twelve Detectors is fixed in top and bottom inside six urban cup chambers, three retained detectors to background counter. Then chambers with detectors is wrapped by polyethylene and sent to NIRS, Japan to calibration exposure. Procedure of calibration exposure is helped by Sorimachi et al. [6-9]. After calibration, exposure detectors were sent back to Vietnam. Detectors were etched with 2.5 N NaOH solution at constant temperature 60 ± 1°C following the etching protocols which set up at laboratory in INST, Vietnam. Tracks developed were counted using a spark counter is shown in Figure 5. The CF (tr. cm⁻² per Bq d m⁻³) for individual experiment was obtained following equation (1). The experimental results were shown in Tables 1 and 2.

$$CF = \frac{24 * (\rho_t - \rho_b)}{C_{Tn} * H} \quad (1)$$

where:

C_{Tn} : ²²⁰Rn calibration exposure concentration (Bq/m³)

ρ_t : Density of calibration exposure detectors (tr.cm⁻²)

ρ_b : Density of background detectors (tr.cm⁻²)

H: Exposure duration (h)

CF: Calibration factor (tr.cm⁻² per Bq.m⁻³.d)

Results and Discussion

Table 1 summarizes the results of the average CF obtained from a

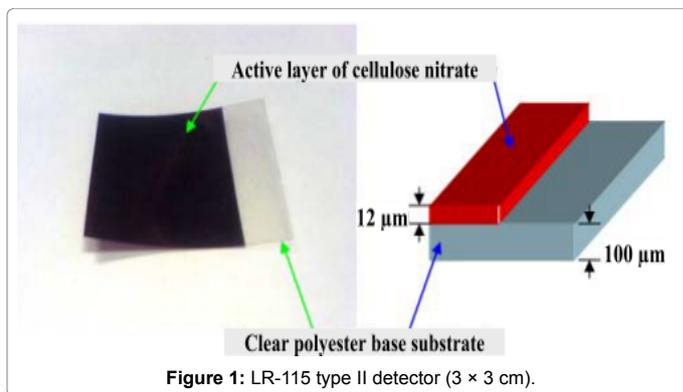


Figure 1: LR-115 type II detector (3 × 3 cm).



Figure 2: Urban cup chamber.



Figure 3: Spark Counter system.



Figure 4: Etching system.

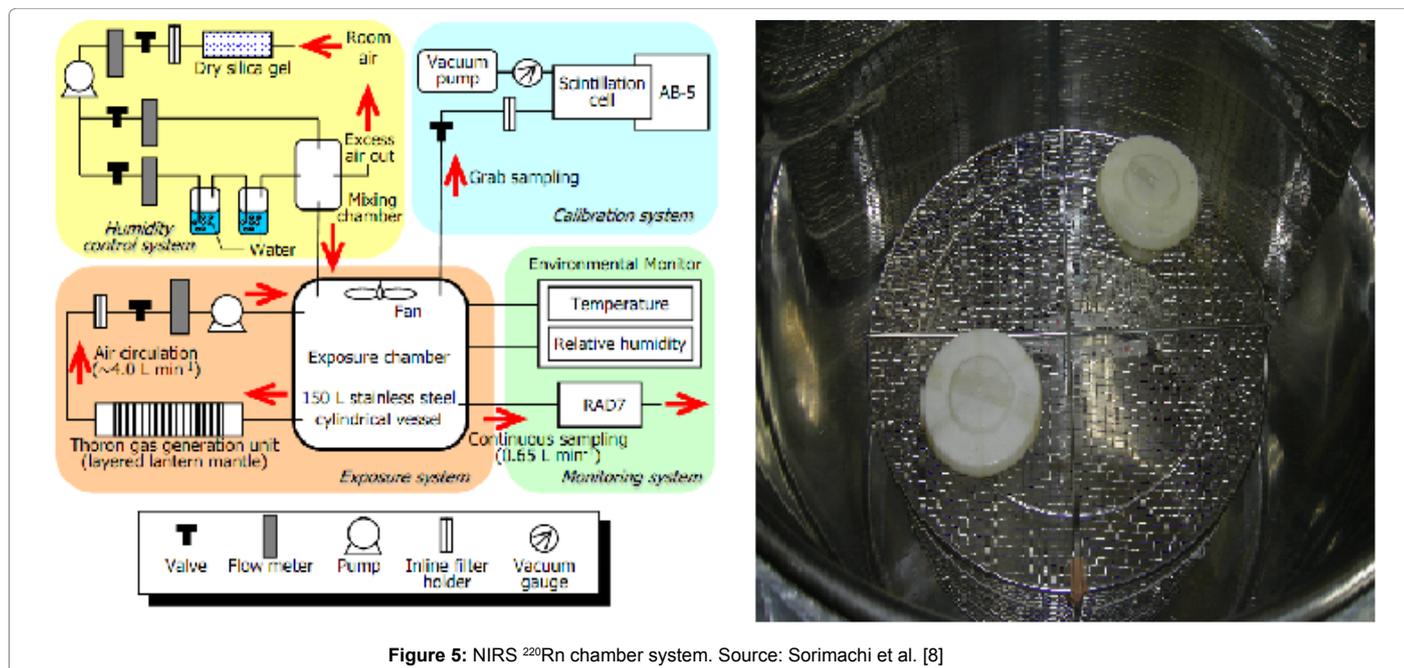


Figure 5: NIRS ^{220}Rn chamber system. Source: Sorimachi et al. [8]

few experiments with varying concentrations and exposure durations for LR-115 type II detector is placed in top inside urban cup was 0.023 ± 0.004 (tracks.cm⁻²/Bq.m⁻³.d). Relationship between integrated thoron concentration and track density at top inside urban cup as shown in Figure 6 with R²=0.96.

Table 2 summarizes the results of the average CF obtained from a few experiments with varying concentrations and exposure durations for LR-115 type II detector is placed in bottom inside urban cup was 0.038 ± 0.007 (tracks.cm⁻²/Bq.m⁻³.d). Relationship between integrated thoron concentration and track density at bottom inside urban cup as shown in Figure 7 with R²=0.97.

Conclusions

A practical methodology has been developed to determine average calibration factors (CF) for LR-115 type II detector. Precision evaluation authors used 20 couples of LR-115 detector at 8cm detector-source distance with relative standard deviation less than 1.48%.

The results of the average CF obtained from a few experiments with varying concentrations and exposure durations for LR-115 type II detector is placed in top inside urban cup was 0.023 ± 0.004 (tracks.cm⁻²/Bq.m⁻³.d). Relationship between integrated ^{220}Rn concentration and track density at top inside urban cup as shown in Figure 5 with R²=0.96.

The results of the average CF obtained from a few experiments with varying concentrations and exposure durations for LR-115 type II detector is placed in bottom inside urban cup was 0.038 ± 0.007 (tracks.cm⁻²/Bq.m⁻³.d). Relationship between integrated ^{220}Rn concentration and track density at bottom inside urban cup as shown in Figure 6 with R²=0.97.

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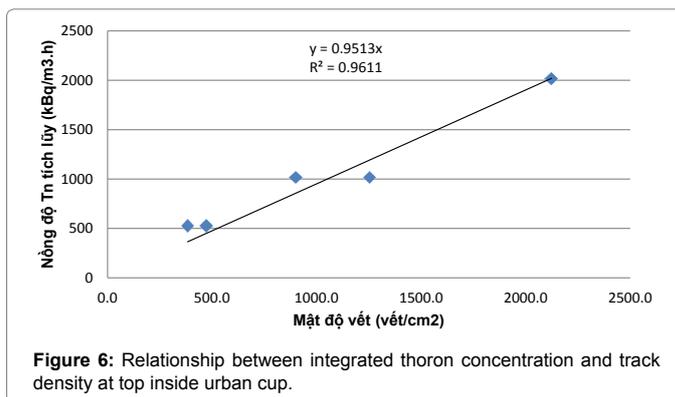
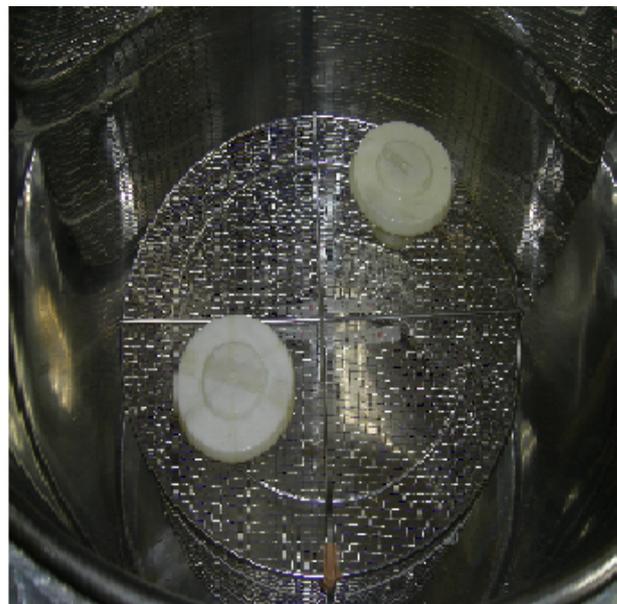


Figure 6: Relationship between integrated thoron concentration and track density at top inside urban cup.

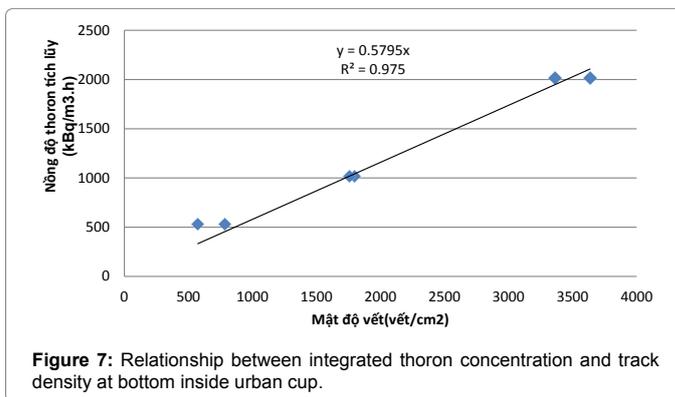


Figure 7: Relationship between integrated thoron concentration and track density at bottom inside urban cup.

References

- Kobayashi S (1994) The passive radon-thoron discriminative dosimeter for practical use. Japan J Health Phys 29: 155-166.
- Eappen KP, Sahoo SK, Ramachandran TV, Maya YS (2008) Calibration factor for thoron estimation in cup dosimeter, Radiat Meas 24: 410-414.
- Nuccetelli C (1998) The thoron issue: monitoring activities, measuring techniques and dose conversion factors. Radiat Prot Dosim 78: 59-64.

4. Tokonami (2005) International Congress Series 1276 Elsevier, The Netherlands p 151.
5. Tokonami S (2005) Summary of dosimetry (radon and thoron) studies. Int Congr 1276: 151-154.
6. Sorimachi A, Ishikawa T, Janik M, Tokonami S (2010) Quality assurance and quality control for thoron measurement at NIRS. Radiat Prot Dosim 141: 367-370.
7. Sorimachi A, Tokonami S, Takahashi H, Kobayashi Y (2008) Performance of NIRS thoron chamber system. In: The American Institute of Physics (AIP) Conference Proceedings Series 1034: 206-209.
8. Sorimachi A, Sahoo SK, Tokonami S (2009) Generation and control of thoron emanated from lantern mantles. Rev Sci Instrum 80: 015104.
9. Yamada Y, Sun Q, Tokonami S, Akiba S, Zhuo W, et al. (2006) Radon–thoron discriminative measurements in Gansu province, China, and their implication for dose estimates. J Toxicol Environ Health A 69: 723-734.