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CR-39 detector compared with Kodalpha film type (LR115) in terms of radon concentration

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Abstract

CR-39 detectors and Kodalpha film type (LR115) were compared in terms of radon radiation concentration. Thirteen CR-39 detectors with the same number of Kodalpha film type (LR115) were used in this study. The correlation factor between the radon concentrations, obtained by the two groups of detectors was found to be 0.99. Detector time efficiency (DTE) was calculated for both types of detectors. DTE of Kodalpha film is larger than that of CR-39 detector and this indicates that LR115 is more efficient and sensitive for radon radiation than CR-39 detector.

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Keywords: CR-39 detector; Kodalpha film type (LR115); Correlation factor; Detector time efficiency (DTE)

1. Introduction

Indoor radon exposure has become a problem all over the world due to the fact that it accounts for approximately 60% of the total natural background radiation [1]. Radon concentration measurements are nowadays routinely performed and different laboratories around the world have developed several types of radon radiation detectors. The suitable choice of detector depends on several factors: study purpose, sensitivity, cost, etc. In this paper, we have studied the sensitivity of two radon detectors CR-39 detector and Kodalpha film type (LR115). This study is based on comparison method between the two types (above-mentioned) in terms of indoor radon concentration. CR-39 is a solid state nuclear track detector (SSNDs) and has been widely used in radon concentration measurement. The durability, the simplicity and the markedly specific nature of the response of these detectors led to their rapid application in a wide variety of fields [2,3]. The technique of track etch is widely applied in Europe for measuring the total indoor radon level [4]. The sensitivity of CR-39 for radon radiation depends on: use method (bare or inside diffusion chamber), measurement period, etching process, filter type, calibration, etc. Despite, CR-39 detector can respond to radon radiation for short-term measurement, it is considered an integrated detector, in other words it gives more accurate result for long-term measurement. Kodalpha film type (LR115) radon dosimeter is a small, black box of dimensions $4 \times 7.5 \times 0.5$ cm. The radon-sensitive part, which is the actual dosimeter, is a small film badge which is housed on the inside section of the hinged lid of the dosimeter. These film badges are LR115 type nuclear track films produced by KODAK and they consist of a 100 μm thick polyester substrate that is coated with a 12 μm thick layer of red colored cellulose nitrate. Kodalpha film type (LR115) has been used for radon measurement by many laboratories throughout the world and by most important radiation safety institutes like the United States of America-Environmental Protection Agency (USA-EPA) and United Kingdom-National

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Radiological Protection Board (UK-NRPB). Kodalpha film type (LR115) has several characteristics: (1) very sensitive to alpha particles only; (2) can be used for short-term measurement at minimum 10–30 days of exposure and also for long-term measurement, 3 months up to 1 year; (3) insensitive to environmental changes such as humidity, water and temperature up to 60 °C; (4) suitable to use for radon measurements in stagnant or flowing water and in oil. The aim of this work is to study the CR-39 and Kodalpha film type (LR115) detectors revealing for radon concentration and the exposure time is the variable of this study.

2. Material and method

Fourteen CR-39 detectors of size 1.5 × 1.5 cm were fixed at the bottom of polyethylene cups of 6 cm mouth diameter, 4 cm bottom diameter and 9 cm height. The top of the cups are covered with a thin membrane, which separate radon from dust and other types of radiation, by permitting diffusion of radon into the cups. These dosimeters were mounted on the walls (1.5 m from the floor) of different places among four hospitals (Al-Watani, Refedia, Al-Ethad, Al-Enjeli) and two health centers (Al-Tadamon, Al-Rahama) in Nablus city, Palestine. At the same time, close to each dosimeter we fixed one Kodalpha film type (LR115) 5 cm away from each other, horizontally. After a period of about 2 months 13 Kodalpha films (LR115) were collected and one was lost. Then they had been sent to France by mail in approved plastic pouch for etching and reading. Fourteen dosimeters were collected after an exposure period of about 4 months and the CR-39 detector that corresponds to the lost Kodalpha is excluded from the study. The collected CR-3 detectors were etched in 6.25 N NaOH solution at 100 °C for 1 h. After etching CR-39 detectors were washed with distilled water and dried in open air. The alpha tracks recorded on CR-39 detectors were counted 10–15 times for each detector using normal microscope at 100 × magnification. The tracks density used to calculate radon concentration by

$$C_{\mathrm{Rn}} = \frac{6.68N}{t}, \tag{1}$$

where C_{Rn} is radon concentration in Bq m^{-3}, 6.68 is calibration factor, derived at An-Najah University, N is tracks density (tracks/cm^2) and t is the exposure time (days).

To study how both types of detectors respond to radon radiation, we will introduce a new term, detector time efficiency (DTE). DTE is defined as the ratio between the particles number (tracks) registered by detectors and the exposure time. Another definition, in case of radon, is the ratio between radon concentration and the exposure time

$$\mathrm{DTE} = \frac{C}{t}, \tag{2}$$

$$\text{Detector efficiency (\%)} = \mathrm{DTE} \times \frac{1}{\text{source activity}} \times 100\%, \tag{3}$$

where DTE is the detector time efficiency (in Bq m^{-3} unit time), C is radon concentration (in Bq m^{-3}) and t is the exposure time.

3. Results and discussion

The result of indoor radon concentration measured with CR-39 detectors and Kodalpha films type (LR115) is depicted in Fig. 1. In terms of indoor radon concentrations the two groups of detectors are correlated and the correlation factor was found to be 0.99 (Fig. 1). DTE for both Kodalpha films type (LR115) and CR-39 detector was calculated using Eq. (2). DTE of Kodalpha is larger than that of CR-39 (Fig. 2) and this indicates that the response time of Kodalpha film type (LR115) for radon radiation is shorter than that of CR-39 detector. Since the efficiency of the detector is linearly proportional with DTE (see Eq. (3)),

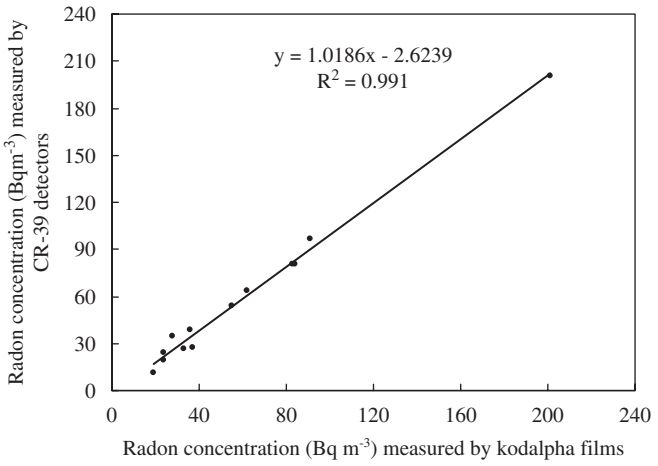

Fig. 1. Correlation between radon concentrations measured with the two groups of detectors Kodalpha and CR-39.

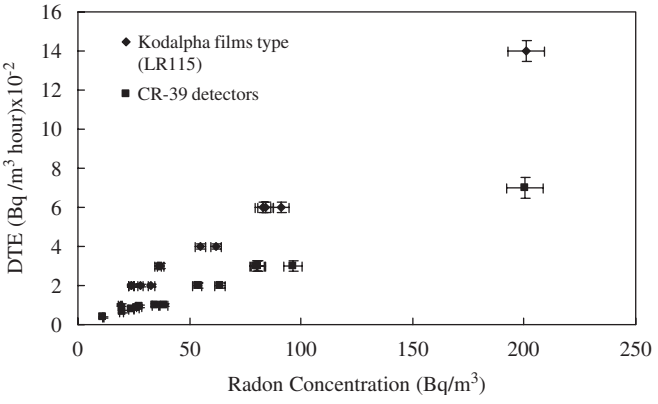

Fig. 2. Detector time efficiency (DTE) of Kodalpha films and CR-39 detectors variation with radon concentration.

Kodalpha film type (LR115) is more efficient and sensitive for radon radiation than CR-39 detector. In general, the sensitivity of track detectors for radon radiation depends on several factors such as detector structure, exposure condition, exposure time, etching process and calibration process (in case of CR-39 detector).

Kodalpha film type (LR115) does not need calibration, pre-used preparation and easier to use than CR-39 detector. While CR-39 detector needs calibration, pre-used preparation and cheaper than Kodalpha film (LR115). Which one is the best to use depends on several factors: measurement scale, user experience (calibration and etching process of CR-39). In case of large scale measurements CR-39 detector can be used and the sensitivity of CR-39 can be compensated by long-term exposure. Otherwise it is better to use Kodalpha film type (LR115), especially for those who have no experience with calibration and etching process of CR-39 detector.

4. Conclusion

DTE of Kodalpha film is larger than that of CR-39 detector. Kodalpha film is more sensitive and efficient for radon radiation, easier to use than CR-39, more expensive, etching process is done by a dedicated and validated laboratory and does not need calibration (open face). On the other hand, CR-39 detector is less sensitive and efficient for radon radiation, need preparation before used (diffusion chamber), cheap, etching process can be done by any laboratory (simple tools) and needs to be calibrated. The sensitivity of CR-39 can be increased through increasing the exposure time.

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