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Radon exhalation study in building materials used in Al - Diwaniyah governorate, Iraq

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Abstract

Long-term exposure to radon increases the risk of developing lung cancer. There is a considerable public concern about radon exhalation from building materials and its contribution to indoor radon levels. To address this concern, radon exhalation rates were determined for 24 different samples of building material commonly used in Al-Diwaniyah, Iraq dwellings, using solid-state nuclear track detectors (CR-39). The highest contribution is found in Granite from Italy, 169.04 ± 11.38 (Bq/m^3), 386.184 (mBq/m^{2}h), and 4.26 (mSv/y) for radon concentration, surface radon exhalation rate, and the annual effective dose, respectively. On the other hand, the lowest contribution is found in Gypsum from Najaf - Iraq with radon concentration (Bq/m^3), radon exhalation rate (mBq/m^{2}h), and the annual effective dose (mSv/y) of about 11.40 ± 0.11, 22.716, and 0.284. The obtained average values of these three quantities are $104.276 \pm 7{,}50$, 108.21, and 1.45, respectively. The average annual effective dose of radon concentrations is acceptable, compared with the standard limit value presented in ICRP.

Keywords: radon exhalation, radon concentration, building materials, annual effective dose

1. Introduction

The knowledge of the natural radioactivity of building materials is important for the determination of population exposure to radiation, as most of the residents spend about 80% of their time indoor. The isotopes of radon are naturally emitted from ^{238}U, ^{235}U, and ^{232}Th [1,2]. Radon has three natural isotopes: radon (^{222}Rn) is one of the decay products of the (^{238}U) series with half live of 3.82 d, thoron (^{220}Rn), which is formed by the decay of the (^{232}Th) series, and (^{219}Rn) is a decay product of the (^{235}U) chain [3,4]. There is a considerable public concern about radon exhalation from building materials, especially those used for interior decoration; the main health risk associated with long-term, elevated exposure to radon is an increased risk of developing lung cancer [5,6]. The radionuclides in building materials, such as radon concentration in closed space, have been identified as a significant cancer risk for the general public. There are recent studies of people exposed to radon isotopes in homes represents a serious health hazard [7-12].

The purpose of this study is to estimate the radon concentration in building materials and its hazard index in some building materials samples commonly used in Al-Diwaniyah, Iraq dwellings using the nuclear track detector (CR-39).

2. Materials and methods

Twenty-four samples of building materials are commonly used in Al-Diwaniyah, Iraq dwellings. The passive method has been used solid state nuclear track detectors CR-39 with (PVC - tube) [13]. The samples were dried in an oven at 110 °C for 3 hours, and then the samples ground several times using a hand mortar to produce dry powder and homogeneous. Ten grams was put in a cylindrical plastic can (PVC- tube) with a diameter of (6 cm) and a high of (7.5 cm) as shown in figure 1. After that, a piece of detector CR-39 with dimensions (1×1 cm^2) was fixed on the top cover of can from inside and then closed tightly for 60 days [14]. After 60 days, CR-39 detectors were etched chemically by 6.25 N from NaOH solution that dilute with 250 ml of distilled water at 70 °C for 6 hours. Then, the tracks were

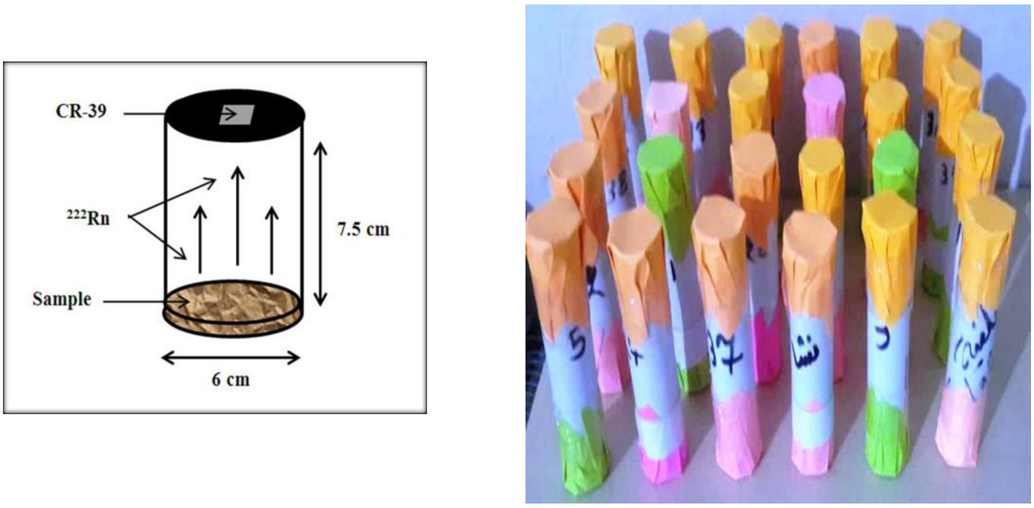

Figure 1. Sealed can technique.

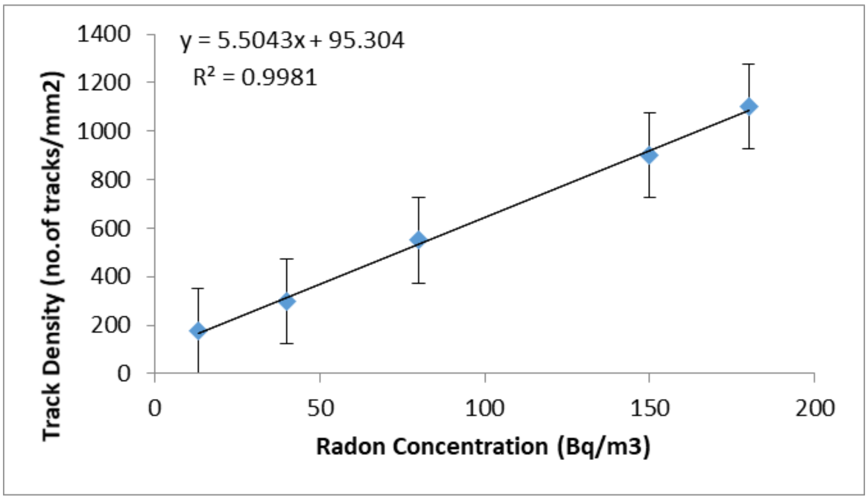

Figure 2. Standard sample radon concentration with track density.

recorded using Olympus optical microscope with a magnification of 400X [15,16]. The track of α-particles densities are calculated using equation [17-19]:

$$\rho = \frac{N_{ave}}{A}, \quad (1)$$

where, ρ is track density (tr./mm^2), N_{ave} is average of tracks number, and A is area of field view. Then, to measure the radon concentration in building material samples was recognized by the contrast between the track densities registered on the detector of building material samples and the standard sample densities across the following equation:

$$C_x = \frac{\rho_x \times C_s}{\rho_s}, \quad (2)$$

where ρ_x and ρ_s are tracks densities of the unknown sample and standard sample in (track/mm^2) and C_s and C_x are the concentrations of radon for the standard sample and unknown samples in (Bq/m^3), respectively. The slope of linear relation between concentrations of radon and track density of standard building materials sample was equivalent to the reciprocal of the second term on the right side. The equation 2 used to measure the radon concentration. On the other hand, the calibrations curve is present in figure 2 [21].

$$c_x = \frac{\rho_x}{slop} = \frac{\rho_x}{(\rho_x / c_s)}, \quad (3)$$

To measure the flux of radon released from the surface of a substance, the radon exhalation rate (E_A) in mBq/m^2 h is defined as [20]:

$$E_A = \frac{CV\lambda T / A}{[T + \lambda^{-1}(e^{-\lambda T} - 1)]}, \quad (4)$$

where, C is the integrate radon exposure, T is the exposure time (60 days), V is the volume of the can (211.95 cm^3), A is the surface area of soil samples (56.52 cm^2), and λ is the decay constant of ^{222}Rn.

Finally, the annual effective dose was determined using the equation:

$$AED = C_{Rn} \times \varepsilon \times H \times T \times F_{Rn}, \quad (5)$$

where ε is the equilibrium factor (0.4), T is the time in hours in one year (8760 h/y), and F_{Rn} is the dose conversion factor, 9 nSv/(Bq.hm^{-3}).

3. Results and discussion

Table1 represents the radon concentrations, the surface radon exhalation rate and the annual effective dose of 24 samples of building materials commonly used in Al - Diwaniyah - Iraq.

Table 1. Radon concentration, radon exhalation rate, and annual effective dose of building materials samples collected from Al-Diwaniyah, Iraq.

No.	Type of samples	Origin	C_{Rn} (Bq/m^3)	E (mBq/m^2.h)	AEDE (mSv/y)
1	Brick	Russia	32.008±9.8	59.524	0.804
2	Brick	Saudi Arabia	28.844±8.51	48.176	0.724
3	Brick	Egypt	25.216±7.77	23.72	0.632
4	Thermostone	Basrah1/ Iraq	24.124±6.82	46.264	0.604
5	Thermostone	Najaf/ Iraq	21.204±4.01	29.46	0.532
6	Thermostone	Babylon/ Iraq	18.088±4.12	29.748	0.452
7	Cement	Karbala/ Iraq	52.164±6.6	235.816	1.312
8	Cement	Najaf / Iraq	76.108±10.1	198.92	1.916
9	Cement	Samawah/ Iraq	47.24±9.58	85.86	1.188
10	Ceramic	Italy	76.98±9.1	126.12	1.936
11	Ceramic	Turkey	84.728±10.45	82.564	2.132
12	Ceramic	China	64.024±7.96	64.088	1.612
13	Granite	Italy	169.048±11.38	386.184	4.26
14	Granite	China	90.084±9.6	281.588	2.268
15	Granite	Saudi Arabia	148.476±10.77	175.516	3.74
16	Gravel	Mosul/ Iraq	40.808±4.8	98.456	1.028
17	Gravel	Karbala/ Iraq	27.652±3.52	45.168	0.696
18	Gravel	Diyala/ Iraq	29.22±3.22	31.988	0.736
19	Gypsum	Mosul/ Iraq	18.016±0.31	48.584	0.452
20	Gypsum	Karbala/ Iraq	12.844±0.11	31.98	0.32
21	Gypsum	Najaf / Iraq	11.4±0.11	22.716	0.284
22	Porcelain	China	64.09±6.12	199.24	1.612
23	Porcelain	Italy	128.84±11.32	111.128	3.244
24	Porcelain	China	89.763.98	82.532	2.26
	Mean		104.276± 7.5	108.21	1. 45

Table 2. Obtained averages values for radon concentration, radon exhalation rate, and annual effective dose of building materials samples collected from Al-Diwaniyah, Iraq.

No.	Type of Sample	C_{Rn} (Bq/m^3)	E (mBq/m^2. h)	AEDE (mSv/y)
1	Brick	28.69±5.36	43.81	0.72
2	Thermostone	21.14±4.98	35.16	0.53
3	Cement	58.50±8.76	173.53	1.47
4	Ceramic	75.24±9.17	90.92	1.89
5	Granite	135.87±10.58	281.10	3.42
6	Gravel	32.56±3.85	58.54	0.82
7	Gypsum	14.09±0.17	34.76	0.35
8	Porcelain	94.23±6.14	130.97	2.37

The results indicted the highest contribution found in Granite from Italy were 169.04 ± 11.38 (Bq/m^3), 386.184 (mBq/m^{2}h), and 4.26 (mSv/y) for radon concentration, surface radon exhalation rate, and the annual effective dose, respectively. While the lowest contribution found in Gypsum from Najaf - Iraq for radon concentration (Bq/m^3), radon exhalation rate (mBq/m^{2}h), and the annual effective dose (mSv/y) were 11.40 ± 0.11, 22.716, and 0.284, with an averages of 104.276 ± 7,50, 108.21, and 1.45, respectively. The results proved that the radon concentration depends on the type of building material source, and this depends on the type of soil and rocks.

According to table 2, the highest values were in Granite of building materials samples that exported from Italy, while the lowest values were in Gypsum collected from Najaf, Iraq. On the other hand, the annual effective dose from granite samples is higher than the dose limit 0.1 mSv/y recommended by ICRP, and within the action level 3-10 mSv/y recommended by ICRP. The average concentration of radon was acceptable with limit value present in ICRP [22].

4. Conclusions

Radon concentrations was measured in building materials samples collected from the market in Al-Diwaniyah, Iraq. The surface radon exhalation rate and annual effective dose were determined. Depending on the results; the samples of building materials are good and acceptable to be used for building house, except Granite exported from Italy. The variance results have been found in different types of building materials depend on the origin of the sources of soil and rock. The average annual effective dose was within the action level 3-10 mSv/y recommended by ICRP standard. The results indicate radon levels within the dose limit compared to the recommended by the American Environmental Protection Agency.

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