Measurement of Radium Content and Radon Exhalation Rates in Building Material Samples using Passive and Active Detecting Techniques

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Abstract

Experimental results concerning the radon concentration and radon exhalation rate from samples of building materials which were collected from the Iraqi Kurdistan using passive and active detecting techniques. the passive techniques, was used (CR-39NTDs) for a period of 2 month in each measurement. In the active techniques, was used (RAD7) for a duration of 24h for each samples. In both techniques, The highest and lowest of radon concentration was found in sand and ceramic tile samples respectively, It depends on the radioactive content of the materials, emanation factor and diffusion coefficient of radon in that material, porosity and density of the material. The radon exhalation rate varies from 115.85 ± 6.38 to 345.86 ± 6.82 (mBq/m^2.h) and 14.46 ± 1.84 to 22.32 ± 2.12 (mBq/Kg.h) for different building materials. The exhalation rate is a function of diffusion length, which, in turn, depends on several physical parameters of the material humidity, porosity and geometry

Key words: Radon, CR-39NTDs, RAD7, Building Materials, Iraqi Kurdistan.

1-Introduction

Radon (^{222}Rn) is a radioactive gas arising from the uranium (U) decay chain, and is the largest single source of radiation exposure to many populations [1]. Inhalation of ^{222}Rn and its daughter products could cause a significant health hazard when they are present in enhanced levels [2,3]. Construction materials are sources of indoor airborne radioactivity and external radiation from the decay series of uranium in buildings. Exhalation o f ^{222}Rn from these materials is of interest since the short-lived decay products of radon are the greatest contributors to the lung dose of inhaled radionuclide's [4]. Radon gas is found in walls, floors and ceilings of buildings or soil in the surrounding areas before being permeated into the cracks of buildings. The gas is emitted to closed spaces from building materials that contain uranium resulting in an increase in concentration in the air. Radon enters the body system during inhalation, which results in an increase in the exposure dose that can result in the development of lung cancer [5]. Building materials like sand, soil, bricks, and gravel aggregates contain a trace amount of ^{226}Ra which generates radon. However, only a fraction of radon from radioactive material becomes able to escape to the atmosphere that can be transported to an indoor environment through diffusion and convective flow. The amount of activity released per unit surface area per unit time from a material is termed as the exhalation rate. It depends on the radioactive content of the materials, emanation factor and diffusion coefficient of radon in that material, porosity and density of the material [6,7,8].

In this work, study the radon concentration, radon exhalation rate and the radium content in building material samples in Iraqi Kurdistan using passive and active techniques type CR-39 NTDs and RAD7 respectively.

3- MATERIALS AND METHODS

In order to measure radon activity concentration more thoroughly, two types of passive and active detectors. In passive techniques used CR-39 track detectors of sizes (15×15×0.5) mm^3 were acquired from the Moulding, UK, manufactures the detectors. A barrier is installed inside radon dosimeters at a distance of 7 cm from the surface of the samples. The dosimeter has been calibrated by Ismail and Jaafar [9]. The cylindrical container was sealed and the samples were stored for 60 days. After the exposure, CR-39 detectors were etched in 6N NaOH at $70C^o$ for 10h, and then the detectors were washed in distilled water. To determine the track density per cm^2, optical microscopes at 400X.In active techniques used the RAD7 that enables you to measure of radon concentration acquired from the DURRIDGE Company- USA. After powdered building materiel samples, the exposure time for each sample 24hr for 12 cycles.

4-THE MEASUREMENTS

Average radon concentration in the soil samples is calculated using the following formula [10];

$$C_{Rn}(Bq.m^{-3}) = \frac{\rho_{Rn}}{K_{(Rn)}.t} \qquad (1)$$

where ρ_{Rn} is the radon track density (track/cm^2) , $K_{(Rn)}$ is the calibration factor for radon (=0.2315 track. cm^{-2}. d^{-1}/ $Bq.m^{-3}$) which is calibrated in previous work [9], and t is the exposure time (60 days).

The exhalation rate of radon in soil samples was determined in terms of surface area $E_{s\,(Rn)}$ and mass $E_{m\,(Rn)}$, using the following formula [11,12]:

$$E_{s(Rn)} = \frac{CV(\lambda_{Rn}+\beta)}{ATe}; E_{m(Rn)} = \frac{CV(\lambda_{Rn}+\beta)}{MTe} \qquad (2)$$

where, , M is the mass of the sample, A is the surface area of the sample, and C represents the integrated radon exposure ($Bq.m^{-3}.h$). Te is the effective exposure time (=1306.66h) which is related with the actual exposure time t(=1440 h) and is defined as.

$$\left[Te = t + \frac{1}{(\lambda_{Rn}+\beta)}\left\{\exp^{-(\lambda_{Rn}+\beta)t} - 1\right\}\right] \qquad (3)$$

(β); the diffusion parameter can be defined as [13];

$$\beta = \frac{\lambda_{Rn} \times p \times V_s}{V} \; ; p = 1 - \frac{V_d}{V_w} \qquad (4)$$

where λ_{Rn} is the decay constant of radon (7.5×10^{-3} h^{-1}), V is the effective volume (197.82×10^{-6} m^3) inside the container, Vs is the volume of building material samples, p is the porosity of sample porous material, V_w and V_d are the volumes of wet and dry sample, respectively.

4- Result and Discussion

The values of radon concentration ($Bq.m^{-3}$), radon exhalation rates and the radium content in building material samples was collected in Iraqi Kurdistan are listed in Table 1.

Tale (1) Radon Concentration , Radium content and Radon exhalation rate for some building materials

Matriala Building	Radon Concentration (Bq/m^3)		Radium Content (Bq / Kg)	Radon exhalation rate	
	Passive	Active		EA ($mBq/m^2.h$)	EM (mBq/Kg.h)
sand	480.71 ± 4.52	435.72±11.38	9.72± 1.68	345.86 ± 6.82	22.32 ± 2.12
Gravel	391.69 ± 3.68	362.28±12.85	8.64 ± 1.52	272.54 ± 7.44	19.73 ± 1.88
Cement	344.21± 3.76	310.26±9.56	7.33 ± 2.12	215.44 ± 5.82	18.56 ± 1.76
Block	314.15 ± 5.12	292.74±10.21	6.24 ± 1.94	184.38 ± 7.82	17.84 ± 1.68
Gypsum	284.86 ± 3.18	260.86±8.95	5.56± 1.64	156.34 ± 6.46	17.35 ± 2.16
Gypsum Board	237.39 ± 4.48	204.64±9.34	4.78 ± 1.72	132.76 ± 5.18	16.56 ± 2.26
Ceramic Tile	154.30 ± 5.24	138.94±7.36	3.35 ± 2.28	115.85 ± 6.38	14.46 ± 1.84

The radon concentration had high in sand sample and low in ceramic sample as showing in Fig1., this different it depends on the radioactive content of the materials, emanation factor and diffusion coefficient of radon in that material, porosity and density of the material.Fig.2 shows the variation ratio of building materials to indoor radon concentration with the radium content. Linearity between active and passive detectors for measure radon concentration. A good correlation (R=0.996) has been observed between the results of the passive and active detector for measure radon concentration in the soil samples in Fig.3

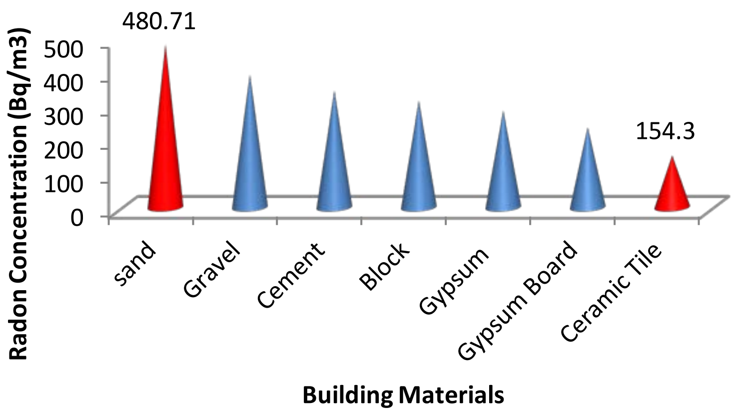

Fig.1 Radon concentration in building materials

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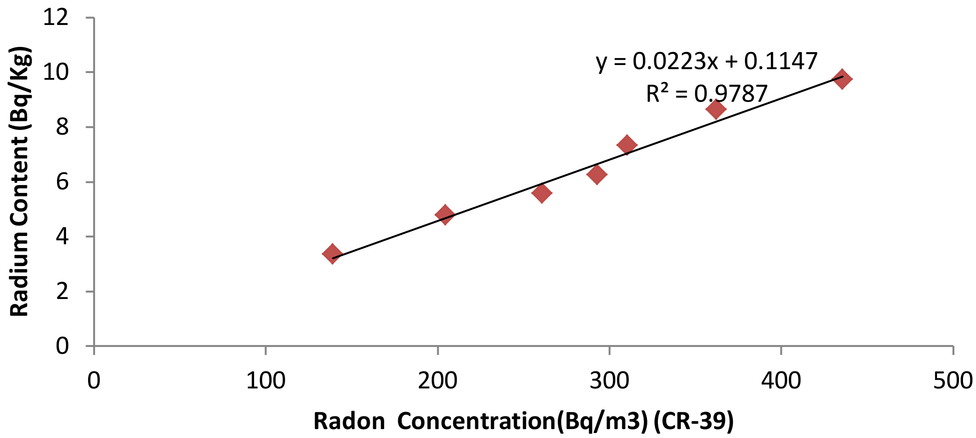

Fig. 2 Variation ratio of building materials to indoor radon concentration with the radium content

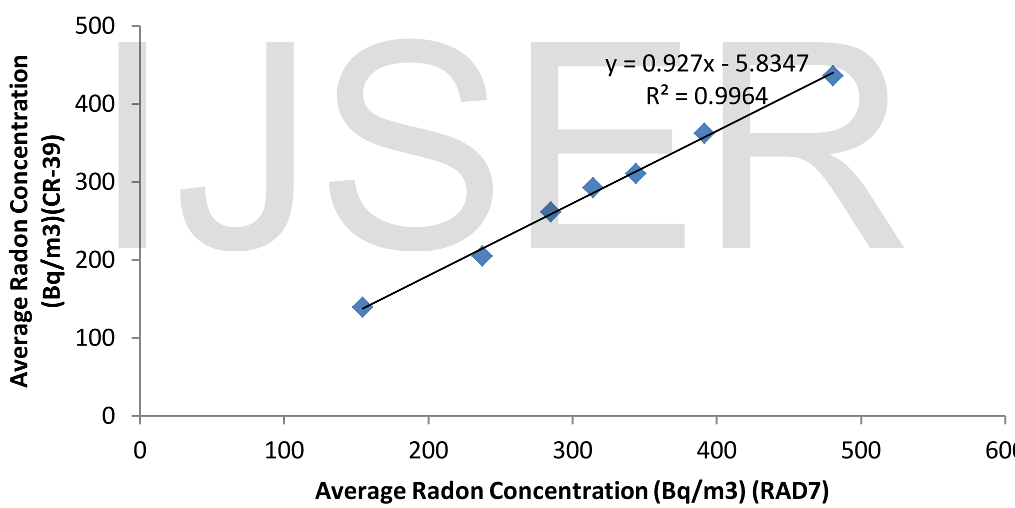

Fig.3 Linearity between active and passive detectors for measure radon concentration (Bq/m^3)

4- Conclusions

The results of the present work indicate that the area under investigation has a different ratio of radon concentration for both methods. A good correlation between the results of the passive and active detector for measure radon concentration in the building material samples has been demonstrated that the efficiency of our detector type CR-39NTDs was in high efficiency. This is approved that the real value of radon concentration can be gotten from long measurements using NTDs instead of short measurements. The result obtained from the current study shows that the radium content in sand highest for other building materials, this it depends on the radioactive content of the materials, emanation factor and diffusion coefficient of radon in that material, porosity and density of the material.

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