International Journal of Physics, 2013, Vol. 1, No. 3, 73-76
Available online at http://pubs.sciepub.com/ijp/1/3/3

DOI:10.12691/ijp-1-3-3

Radon Concentration in Some Building Materials in Iraq Using CR-39 Track Detector

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Received May 07, 2013; Revised May 27, 2013; Accepted May 30, 2013

Abstract The building materials are the sources of radon gas in the indoor air. The determination of radon and its progeny was performed by passive detection technique. Fifteenth commonly building construction materials used in Iraq were studied for radon concentration using the "sealed can technique" and CR-39 solid state nuclear track detectors (SSNTDS). The result of radon concentrations in the selected building materials ranges from 121.95Bq/m^3 in Iraqi natural building stone, Iraqi Kashi and Egyptian ceramics to 383.3Bq/m^3 in Turkish red granite. The radon surface exhalation rate and mass exhalation rate were ranged from 0.72Bq.m^{-2}.h^{-1}, 0.21Bq.kg^{-1}.h^{-1}to 2.3 Bq.m^{-2}.h^{-1}, 0.65Bq.kg^{-1}.h^{-1} respectively.

Keywords: *radon, building materials, solid state nuclear track detector, exhalation rate, sealed can technique*

1. Introduction

^{222}Rn is radioactive gas which is produced continuously from the natural decay series of ^{238}U in the most soils, rocks and water all over the earth. The half life of ^{222}Rn (3.8days)is long enough for part of it to diffuse from the indoor radon sources to the inside of the room .Therefore ^{222}Rn is the most dominant hazardous radionuclide among the radon isotopes .Both radon and its progeny attached to aerosols are present in the ambient air. ^{222}Rn gas can enter the house from the soil through cracks in concrete floors and walls, floor drains, sump pumps ,construction joints and tiny cracks or pores in hollow-block walls. When it penetrates into closed rooms and become concentrated, it sometimes reaches harmful levels for public health [1].

Radon and its daughter products may pose a significant health hazard especially when concentrated in some enclosed areas such as underground mines, caves, cellars or poorly ventilated and badly designed houses. Thus radon concentration in dwellings is important due to the health risk and to determine the design of control strategies [2].

The assessment of radiological risk related to inhalation of radon and radon progeny is based mainly on the integrated measurements of radon. The international commission for Radiological protection has suggested that areas where 1% or more of the building have indoor radon concentration higher than the 10 times of national average should be considered as "radon prone" areas. Therefore, it is desirable not only to measure the radon but also to find out the sources of radon especially in the houses [3]. Radiation exposure due to natural radionuclide's in building materials, as well as radon concentration in closed space, were recognized as a significant cancer risk for the general population only in early seventies of the 20th century [4].

Radon exhalation from building materials depends not only on the radium concentration, but also on factors such as:

- The fraction of radon produced which is released from the material's grain to its interstitial space, also known as the emanation power of fraction
- The porosity of the material
- The surface preparation and building material covering [5].

Knowledge of ionizing radiation levels in buildings, related to radionuclide content in building material samples, is clearly of fundamental importance in the assessment of population exposure as most of the residents spend about 80% of their time indoors [6].

Thus, this paper aims is to measure radon concentration, surface exhalation rate and mass exhalation rate in commonly building construction materials used in Iraq.

2. Materials and Methods

The radon and its daughters were detected by a passive technique of solid state nuclear track detectors using the " sealed can technique" [7,8]. A total of 15 building material samples were collected from different countries. These samples were milled and sieved through a 200 mesh (74μm), (10g) of each sample which was placed inside a plastic cylindrical container facing a CR-39 track detector into a diffusion chamber Figure 1.

The container was then sealed for two months; during that time, α particles emitted by radon and their daughters bombarded the CR-39 track detectors. After the irradiation, the detectors were developed in NaOH solution 6.25N at

60°C for 6 hours; after chemical etching, α particle track densities were determined by an optical microscope 400X.

The radon concentration C_{Rn} in Bq/m^3 was determined by the following equation:

$$C_{Rn} = \frac{\rho_x}{Ft} \quad (1)$$

Where ρ_x is the track density in (tracks.mm^{-2}), t is the exposure time in (days) and F is the calibration factor of (0.42± 0.02 tracks.m^3.cm^{-2}.Bq^{-1}.h^{-1}) Figure 2.

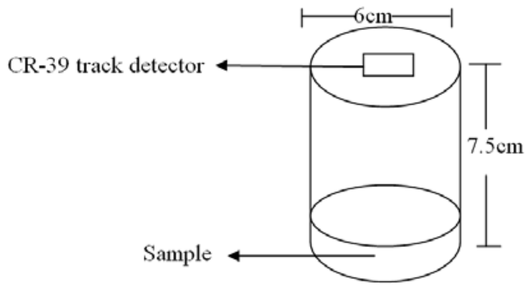

Figure 1. Sealed Can Technique

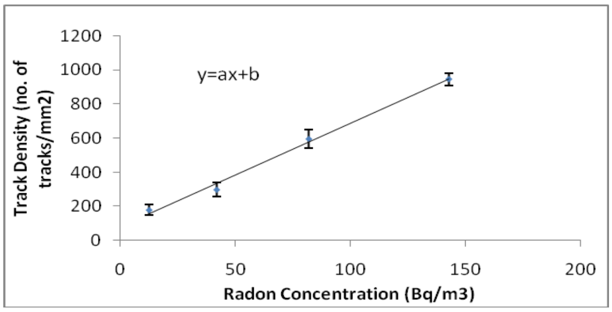

Figure 2. Radon concentration (Bq/m^3) and track density for standard samples

The radon exhalation rate in terms of area E_A in (Bq.m^{-2}.h^{-1}) was calculated as follows [9,10]:

$$E_x = \frac{CV\lambda}{A\left[T + \lambda^{-1}\left\{e^{\lambda T} - 1\right\}\right]} \quad (2)$$

Where C is the integrated radon exposure measured by the CR-39 SSNTD (Bq.m^{-3}.h), V is the effective volume of the container (m^3), λ is the decay constant of radon (h^{-1}), T is the exposition time (h), and A is the area covered by the container (m^2) [3].

The radon exhalation rate in terms of mass E_m in (Bq kg^{-1}h^{-1}) was calculated as:

$$E_m = \frac{CV\lambda}{M\left[T + \lambda^{-1}\left\{e^{-\lambda T} - 1\right\}\right]} \quad (3)$$

Where M is the mass of the sample (kg).

3. Results and Discussion

The concentrations of naturally occurring radionuclides in building materials have been reported in several publications which can vary according to the type and origin of the building material. The most common structural building materials used worldwide are concrete, sand–lime bricks, gypsum and cement. The radon concentration, the surface exhalation rate and the mass exhalation rate were calculated by Equations 1, 2 and 3 respectively and the results are shown in Table 1.

The radon concentration varies from 383.3 Bqm^{-3} in Turkish red granite sample imported from Turkish to 121.95 Bqm^{-3} in Stone and kasha building Iraqi samples, We noticed from the data given in table1 that radon and thoron alpha-activities per unit volume in red granite sample were higher than those of the other samples. This is due to the fact that these samples contain more uranium and thorium than the others.

Figure 3 shows that the Turkish samples (red granite, porcelain, green ceramics, black marble, white marble) and Iraq (Cement) have a radon concentration higher than the global permissibility limit of exposure to radon for the population to be (200 Bqm^{-3}) [10].

The concentrations of the remaining samples were below the global permissibility limit which is well observed all over the world [11-16].

Table 1. Radon Concentration, Surface exhalation rate, Mass exhalation rate for the some Building Materials

Sample	Country of Origin	Radon concentration (Bq/m^3)	Surface exhalation rate (E_x) Bq.m^{-2}.h^{-1}	Mass exhalation rate (E_m)Bq.kg^{-1}.h^{-1}
White Cement	Iraq Fallujah	156.74	0.94	0.26
Plaster	Iraq Fallujah	165.5	1.0	0.28
Cement	Iraq Sulaymaniyah	205.05	1.24	0.35
Bricks	Iraq	166.55	1.01	0.28
Block	Iraq	251.58	1.52	0.43
Stone building	Iraq	121.95	0.72	0.21
Kashi	Iraq	121.95	0.72	0.21
Ceramics	Syria	174.12	1.05	0.3
Porcelain	Turkish	270.04	1.63	0.46
Black marble	Turkish	209.04	1.26	0.36
Green Ceramics	Turkish	217.77	1.31	0.37
Red granite	Turkish	383.3	2.3	0.65
White marble	Turkish	200.27	1.21	0.34
Ceramics	Egypt	123.1	0.74	0.21
Ceramics	China	139.36	0.84	0.24

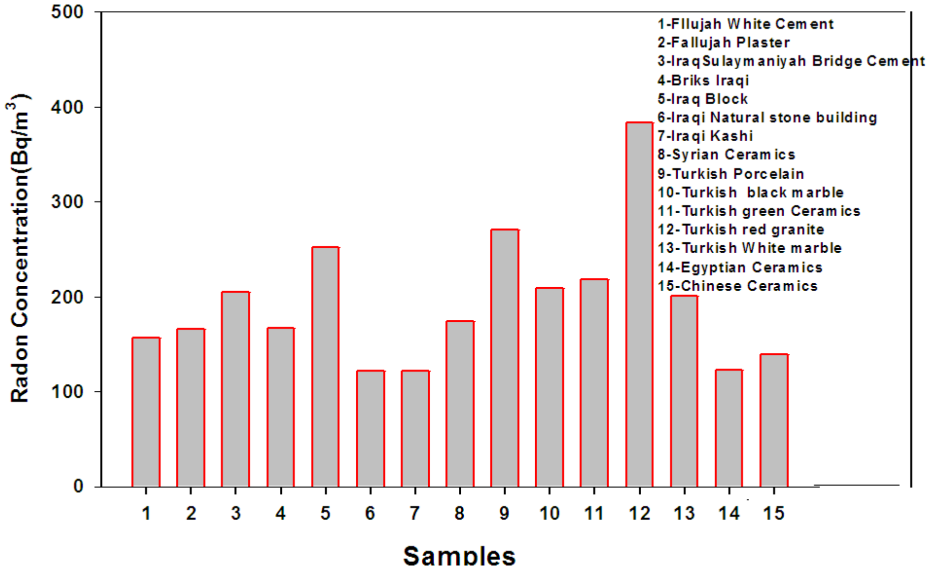

Figure 3. Radon activity concentration (Bq.m^{-3}) for building materials samples

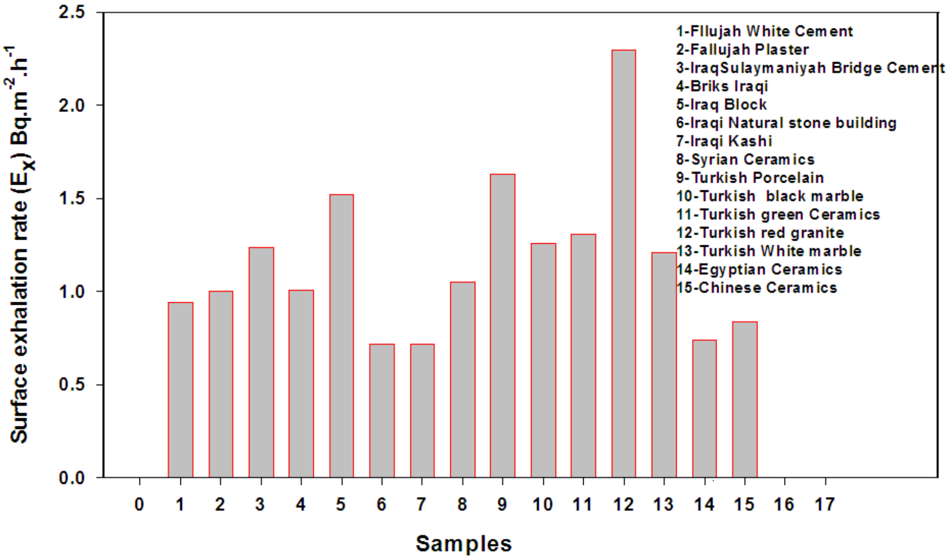

Figure 4. Surface Exhalation rate (Bqm^{-2}h^{-1}) for Building materials samples

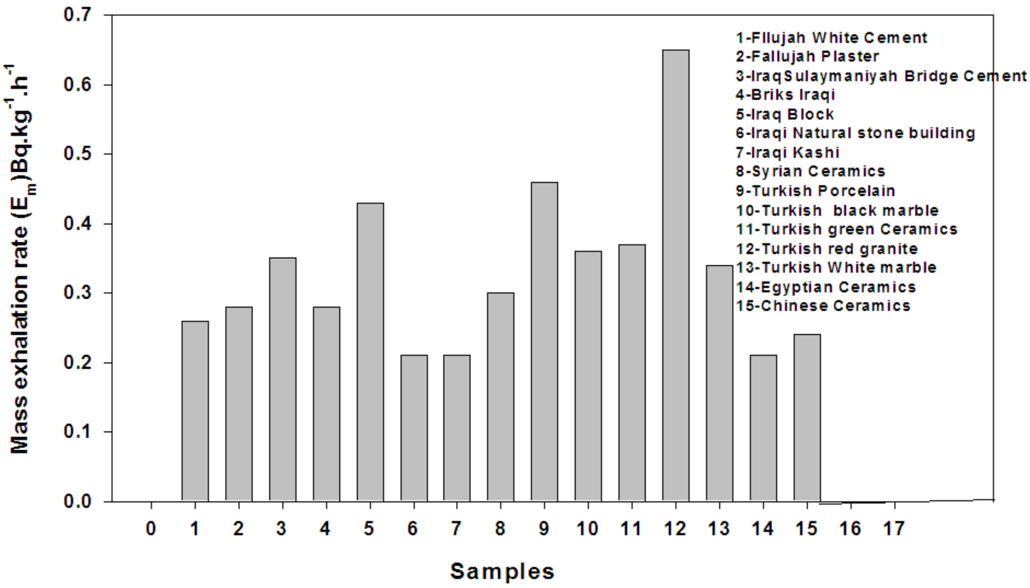

Figure 5. Mass Exhalation rate (Bqm^{-2}h^{-1}) for Building materials samples

The surface exhalation rate in Figure 4 varies from 2.3 $Bq.m^{-2}.h^{-1}$ to 0.72 $Bq.m^{-2}.h^{-1}$ in Turkish red granite, Iraqi Kashi and Iraqi Stone building respectively. The mass exhalation rate shown in Figure 5 varies from 0.65 $Bq.kg^{-1}.h^{-1}$ to 0.21 $Bq.kg^{-1}.h^{-1}$in Turkish red granite, Iraqi kashi and Iraqi stone building respectively. The surface and mass exhalation rate for all samples had lower values than the other results [11], the surface and mass exhalation rate for radon increases when the porosity of the building materials increases.

The reason of the highest radon concentration was due to the presence of high level uranium concentration in the imported red granite, green ceramics, black marble, white marble and cement.

4. Conclusion

1. The highest concentration of radon was detected for each of: red granite Turkish, porcelain Turkish, green ceramics Turkish, black marble Turkish, white marble Turkish and Iraqi cement.
2. The lowest concentration of radon was detected for Iraqi kashi and Iraqi stone building and Egyptian ceramics.
3. The measured surface exhalation rate was higher than the mass exhalation rate. The surface area is considered to be the reason behind rising exhalation rate.

It is recommended to use Iraqi stone building, kashi white cement plaster and bricks, Egyptian ceramic, Chains ceramic and Syrian ceramic from among other building materials and also recommended not to use Turkish red granite, porcelain, green ceramics, black marble, white marble and Iraqi cement too much.

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