STUDY ON RADON EMANATION FROM SELECTED BUILDING MATERIALS IN Iraqi Kurdistan Region

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ABSTRACT

The air concentrations of radon (Rn-222) emitted to the atmosphere from 7 types of construction materials (sand, gravel, cement, block, gypsum, gypsum board and ceramic tile) used Iraqi Kurdistan, were measured and analyzed using continuous radon monitoring equipment model 1029. Each sample was placed for 84 hours inside 0.118 m³ sealed container. Of the seven samples examined, the sand showed the highest levels of radon emission 235.45±4.21 Bq.m⁻³, whereas the ceramic tile showed the lowest level 75.38±5.16 Bq.m⁻³. The average radon exhalation rate from the sand and ceramic tile showed approximately the same value, which was higher than that of the ceramic floors by more than 19%.

Key words: Radon emanation, Building materials, Radon exhalation rate, Iraqi Kurdistan

1. INTRODUCTION

Radon is tasteless, odorless, and colorless, radioactive gas that is a decay product of radium. An emitter of ionizing radiation, it is the second leading cause of lung cancer after smoking [1]. Due to the long half-life of radon gas, it can reach from the earth’s crust or from the walls and floors of buildings into both outdoor and indoor air. In the case of indoor air, the risk of exposure to radon is higher, especially for buildings with poor ventilation systems, which may lead to a higher indoor concentration of radon[2]. Radon comes from a decay of radium, present in all soils and rocks, water, and building materials. Rn-222 spontaneously breaks down into its four relatively short-lived progenies (Po-218, Pd-214, Bi-214, and Po-214) which mix with room air, then are inhaled by human lung, they emit alpha-particle, and may strike sensitive cells in the bronchial tubes and increase the risk of lung cancer. However, long lived radon progeny (Pd-210, Bi-210, and Po-210) contribute little to the dose because they are eventually removed by the mucous and cilia in GI tract before they can decay [3,4,5]. 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 [6]. Since there are many factors control the emanation of radon from building materials: material structure, meteorology conditions, and radium, the later is the most important factor of radon emanation comparing other factors, which will allow us to measure and estimate radon [7,8].

In the current study, we measure radon emanation from building materials, which placed inside tightly radon container with Professional Continuous Radon Monitor Model 1029 for 84 h. This work documents the importance of continuous short -term radon monitoring to perform the correct calculations of radon exhalation rate for building materials.

2- MATERIALS AND METHOD

Some chosen locally produced samples of construction and covering materials (sand,
gravel, cement, block, gypsum, gypsum board and ceramic tile) commonly used in Iraqi Kurdistan were purchased from the supplier of building materials. The Professional Continuous Radon Monitor Model 1029, which detected the alpha particles emitted by radon and its two daughters, polonium-218 and polonium-214 in the detection volume of the tight sealed container (0.118 m³) was attached to the ceiling of the tight sealed container as shown in Figure 1. Background radon emanation for each sealed sample in the sealed container was measured for 24 h. Next, each selected sample was placed inside the tightly radon container and radon concentration was allowed to build up with time and measured by radon monitor for 84.

3- THE MEASUREMENT

3-1 Radon Concentration

In this study radon concentration (At) from each sample inside the tightly radon container was allowed to build up with time and was measured in 1 h cycle for 84 h radon activity given by equation [9]:

\[ C_{Rn}(t) = C_{eq}(1 - e^{-\lambda t}) \]  

Where \( C_{Rn}(t) \) is the radon activity concentration (Bq.m\(^{-3}\)) at time \( t \) (h); \( C_{eq} \) (Bq.m\(^{-3}\)) is Rn-222 activity concentration in case of secular equilibrium at time \( t \), \( t = 7 \ T_{1/2} \); \( \lambda \) is the decay constant radon (7.567 x 10\(^{-3}\)h\(^{-1}\)); \( t \) is the time of the buildup of radon activity inside the tight exhalation container (84 h).

3-2 Radon Exhalation Rate

The exhalation rate of radon in building material samples was determined in terms of surface area \( E_s \) (Rn) and mass \( E_m \) (Rn), using the following formula [10,11,12].

\[ E_m = C_{eq} \lambda_{Rn} V_{eff}/M \quad E_s = C_{eq} \lambda_{Rn} V_{eff}/S \]  

where, \( M \) is the mass of the sample; \( S \) is the Surface area of granular or powder sample (0.124 m\(^2\)); \( V_{eff} \) is the air volume of Radon-tight chamber with granular sample (0.118 m³)

3-3-Radium Content

The effective radium content of the building material samples \( C_{Ra} \) was calculated by using the following relation [10,13].

\[ C_{Ra} = E_m / \lambda \]  

where, \( C_{Ra} \) (Bq/Kg) is the effective radium content of the sample per unit mass of sample

4- RESULT AND DISCUSSION

Results of measurements as presented in Table 1. The highest radon concentration was found in sand sample 235.45±4.21Bq.m\(^{-3}\), and lowest was found in ceramic tile 75.38±5.16 Bq.m\(^{-3}\), as showing in Fig.2. The radon exhalation rates are predictable from the radium content and that the radon exhalation rates cannot be presumed to be constant within building materials. Each different building material will exhale different values of radon exhalation, even if the effective radium content remains the same due to the role of the superficial and inner pores of the investigated material sample. The radium content of samples has been found to vary from 3.70±0.36 to 11.62±0.92 Bq/Kg, as showing in Fig.3. The variation ratio of building materials to indoor radon concentration with the radium content as showing in Fig.4.

5-CONCLUSIONS

This study measured the air concentration of radon emitted to the atmosphere from building material samples in Iraqi Kurdistan (sand, gravel, cement, block, gypsum, gypsum board and ceramic tile). Among the seven samples, the values for sand were the highest for radon and the value for ceramic tile were the lowest for radon. In generally, the aerial radon exhalations of the investigated building materials were low in comparison with the world average limit of 57600 mBq.m\(^{-2}\).h\(^{-1}\) [14].

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REFERENCE

Table 1: Radon Concentration, Radium Content, Radon Exhalation Rate and Equilibrium Radon Concentration for Building Materials

<table>
<thead>
<tr>
<th>Sample</th>
<th>Mass (Kg)</th>
<th>$CR_n$ (Bq/m$^3$)</th>
<th>$E_a$ (Bq/m$^2$.h)</th>
<th>$E_m$ (mBq/Kg.h)</th>
<th>$CR_a$ (Bq/Kg)</th>
<th>$C_{eq}$ (Bq/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>5</td>
<td>235.45±4.21</td>
<td>3.60±0.54</td>
<td>88.66±2.42</td>
<td>11.62±0.92</td>
<td>500.95±3.84</td>
</tr>
<tr>
<td>Gravel</td>
<td>5</td>
<td>205.65±3.89</td>
<td>3.14±0.34</td>
<td>78.07±2.87</td>
<td>10.30±0.23</td>
<td>437.18±4.55</td>
</tr>
<tr>
<td>Cement</td>
<td>5</td>
<td>190.48±3.56</td>
<td>2.91±0.82</td>
<td>72.31±1.54</td>
<td>9.51±0.86</td>
<td>404.93±3.96</td>
</tr>
<tr>
<td>Block</td>
<td>5</td>
<td>158.54±5.21</td>
<td>2.42±0.36</td>
<td>60.18±2.86</td>
<td>7.92±0.54</td>
<td>337.03±5.44</td>
</tr>
<tr>
<td>Gypsum</td>
<td>5</td>
<td>130.82±3.78</td>
<td>2.02±0.54</td>
<td>49.66±3.21</td>
<td>6.47±0.68</td>
<td>278.11±4.62</td>
</tr>
<tr>
<td>Gypsum Board</td>
<td>5</td>
<td>105.88±4.84</td>
<td>1.62±0.64</td>
<td>40.19±2.33</td>
<td>5.28±0.52</td>
<td>225.08±5.84</td>
</tr>
<tr>
<td>Ceramic Tile</td>
<td>5</td>
<td>75.38±5.16</td>
<td>1.21±0.42</td>
<td>28.61±1.24</td>
<td>3.70±0.36</td>
<td>160.24±5.28</td>
</tr>
</tbody>
</table>

Fig. 1 Experiment Container.

Fig. 2 Radon concentration in the investigated building materials as a function of exposure time (84) hours.
Fig. 3 Distribution radium content (Bq/Kg) for building material

Fig. 4 Variation ratio to indoor radon concentration with the radium content

y = 0.049x - 0.018
R² = 0.999