Measurement of Alpha Activity in Several Types of Iraqi Ceramic and Cement in the Iraqi Markets

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Abstract. In this study fifteen samples of ceramic and cement collected from Iraqi markets have been determined for the radium efficacy and radon exhalation rates using the CN-85 plastic track detectors. For the estimation of the effective radium content and exhale rate, these samples comprised 15 different Iraqi materials. The effective radium content values ranged from 2.108 to 21.689 Bq / kg to an average of 9.399 Bq / kg and standard deviation of 6.950. The mass exhalation levels for radon ranged from 0.106 to 1.092 mBq / kg.day, with an average value of 0.473 mBq / kg.day and standard deviation of 0.312 Bq / kg. The exhalation rate for the radon surfaces ranged from 1.889 to 19.44 mBq / kg.day. The mean radon exhalation levels, which are an effective radium element, were found to fall below the world average of 57600 Bq / m2 in the samples of ceramic and concrete materials and Soil: 35 Bq / kg. In addition, the study's showed that the effective radium content in this study and the associated radon exhalation do not pose a human health risk when they are used in daily life in Iraqi markets.

1. Introduction
The world is radiated and contains normal levels of radiation, which plays a significant role in our lives. There is radiation in the soil and the human body, as well as in the air that we breathe in [1]. Most exposure to radiation comes from terrestrial and extra-terrestrial natural sources. Extra-terrestrial radiation is produced in the universe and enters the atmosphere as primary cosmic rays. Terrestrial radiation is produced in the Earth's crust from small quantities of radioactive nuclides, including soils and rocks, that expose the organisms and hydrosphere. These types of radiation are also emitted through food chains or inhalations from nuclear weapons, which are transferred to people and deposited into their tissues. Additionally, people are always exposed to natural ionising radiation [2]. Exposure to elevated levels of radon in the population over an extended period contributes primarily to several pathological effects, including respiratory and pulmonary cancers [3]. Knowledge of the radioactivity that is present in building materials allows the use of such materials to evaluate all possible radiological risks to humanity. Therefore, the radioactivity of common construction materials is important considering the above evidence. From the perspective of radiation safety, the concentration values and levels of exhalation rates for building materials are very important due to the high attenuation power, as the alpha-emitting radioactive substance can harm the human body’s normal tissues. Their chemical and radioactive toxicity may damage the normal tissues of different organisms [4]. Most hazards are due to low inhalation. The risk of radon is due to its radioactive progeny, which uses its physical properties to spread in or attach to the lungs and deposit energy into
the tissues. This produces greater ionisation densities than beta or gamma rays. Radon's energy is also deposited in the lungs. The health effects of inhaling radon-decay products include lung cancer, skin cancer and children diseases [5]. Radionuclide activity levels are important for assessing population exposure in construction materials and their components, as most people spend 80 % of their time inside buildings [6]. Radon gas and dijas are inhaled, which expose the pulmonary tissue to nuclear radiation that can raise the risk of pulmonary cancer. Radon gas is one of the key causes of skin cancer and is likely to cause epithelial cell damage because of the accumulation of radon on the skin. In some people who are exposed to radon, kidney-related diseases have also been found. The reason for this is that after radon has been transmitted from the pulmonary to the kidney, a higher dose is absorbed in comparison to other organisms [7].

In nearly all soil, rock and water, uranium is naturally present. The dominant isotope, uranium238, comprises a wide list of declined components, including radium-226 and radon-222. In the natural series of uranium, radone is the decay product of radium. The distance, which is determined by several variables, including the diffusion rate, effective soil permeability and own half-life, travels freely from the radon's source as inert gas. Radon can be identified as a normal alpha-emitter by an alpha-sensitive detector [8]. Alpha emitters must be studied in ceramic and cement materials regarding the role of causes of different diseases, especially cancer. The aim of this work is to determine the radon levels from various ceramics and cement materials, as well as to calculate the effective radium content and exhalation rate in Iraqi building materials.

2. Materials and Methods
Passive technologies of solid-state detectors used the 'sealed-can technique' for the assessment of radium content and exhalation rate of radon [9,12].

2.1. Collection and Preparation of Samples
Fifteen samples from various markets in Iraq were collected from ceramic and cement. This material is widely used in all Iraqi cities for the packaging and coating of buildings, both inside and out. In addition, we collected seven ceramic samples and eight cement samples with different origins in Iraq and abroad. Moreover, these samples were dried, milled crushed and sieved using a two-mm mesh, and 85 grams per sample were placed in a cylindrical plastic container in a diffusion chamber. The samples also faced a CN-85 detector track, as shown in Fig.1. The procedure involved putting approximately 85 grams of ceramic and cement samples into an emanation container, which was then closed to balance the radium with the radon for three weeks.

The CN-85 detectors were placed at the closed end of the plastic cup (diameter 7.8 cm and length 9.5 cm). The sampling distance was six cm, and the ceramics and cement samples were kept in plastic canisters at a volume of 167.2 cm³, as shown in Fig. 1.
2.2. Etching and Scanning Process
The detector reports traces of $\alpha$-particles that form radon gas, as formed by the $\alpha$-decay of the sample radium. The detectors had been exposed for approximately 60 days. The detectors were removed and etched in a 6.25N NaOH solution at 60 °C and kept in a constant bath for one hour after exposure to the tracks. The detectors were then washed and dried, and the $\alpha$-tracks were counted using a 400x magnification (40x objective and 10x eye piece) optical-mission microscope (kruss-mbl 2000).

3. Theoretical Considerations
The densities of the tracks were calculated using the equation below [13]:

$$\rho = \frac{\sum N_i}{nA} \quad (1)$$

Where $A$ is the view field area, $N_i$ is the total number of tracks and $n$ = the total number of view fields. Therefore, by using the conversion factor (K), the track density observed was transformed into radium concentration [14].

$$\rho = K C_{Ra} T_e \quad (2)$$

where K is the plastic detector sensitivity factor, CN-85 is the 0.0092 sensor cm$^{-2}$h$^{-1}$/($\text{Bq m}^{-3}$) [15] and $T_e$ refers to the effective exposure time [16].

$$T_e = [T - \lambda_{Rn}^{-1}(1 - e^{-\lambda_{Rn}T})] \quad (3)$$

Given that 226Ra's half-life is approximately 1600 years and 222Rne’s is 3.82 days, it should be assumed that the radium-radon members of the decline series will have an effective...
balance (approximately 98%) in three weeks. After a radioactive balance has been established, the radon alpha analysis can be used to determine the stable level of radium activity. After closure according to relation, the activity concentration of radon starts to increase with time [17].

\[ C_{Rn} = C_{Ra}(1 - e^{-\lambda_{Rn}T}) \] (4)

Where \( C_{Ra} \) is a good radius element of the sample and \( Rn \) is a constant decrease of 222Rn, since a plastic track detector measures the time-integrated value of the above expression, i.e. the total number of alpha disintegrations in the unit volume of the can during exposure time \( T \) with a K sensitivity.

3.1. Effective Radium Content
The effective radium content was measured using the following formula [18, 20]:

\[ C_{Ra}(Bq.kg^{-1}) = \left( \frac{\rho}{K \cdot T_e} \right) \left( \frac{hA}{M} \right) \] (5)

Where \( M \) is the mass of building sample materials in kg, \( A \) is the cross-sectional region of the dust in m\(^2\) and \( h \) is the height between the detectors and the top surface of the sample (0.03 m).

3.2. Radon Exhalation Rates
With the expression, the sample surface (area) exhalation rate can be calculated for the release of radon [21, 22].

\[ E_A = \frac{C_{Rn}V\lambda}{A[T + \lambda^{-1}(e^{-\lambda T} - 1)]} \quad (mBq/m^2.day) \] (6)

Where \( E_A \) is the mBq / m.day area-exhalation radius, \( CRn \) is the built-in radon exposure, \( V \) is the cup's efficient volume in m\(^3\), \( T \) is the hourly exposure, \( CRn \) is the 222Rn (h-1) decline constant and \( A \) is the m\(^2\) cup area. The sample exhalation rate for radon release can be calculated using the following expression [21, 22]:

\[ E_M = \frac{C_{Rn}V\lambda}{M[T + \lambda^{-1}(e^{-\lambda T} - 1)]} \quad (mBq/kg.day) \] (7)

Where \( E_M \) is the mass exhalation of radon in terms of mBq / kg.day, and \( M \) is the mass of the sample in terms of kg.

4. Result and Discussion
Fifteen different samples were analysed in this work using the ceramic and cement technique. The effective radium content, surface exhalation and mass exhalation rates are indicated in Table 1. This is because the CN-85, as a component to other solid-state detectors for nuclear plotting, was measured using the CN-85 detector as a passive radon dosimeter. In Iraq's ceramic and cement samples, the effective radium content was distributed, while the relative comparison of mass variation and surface exhale radon with radium content was found, the radon exhalation rates match the estimated values of the radium content. The exhalation value of the mass and surface radon in Table 1 is below what many scientists have recorded [10, 23–25]. In the current sample, the radon exhalation levels are slightly
lower than the 57 600 mBq / m2 h world average (0.016 Bq / m). Therefore, residents are safe from health risks [26]. The values reported in Table 1 for radium content are smaller than those shown by scientists [27, 28]. In the present study, the effective radium values for the ceramic and cement samples were below the recommended action level of 370 Bq / kg [29]. In addition, there was less than 35 Bq / kg in the soil, which is also the average global value [30]. Therefore, the result shows that the radium health risks are safe for this material. We noticed from the data that in the samples, the effective radium content differs with a mean value of 9.399 bq / kg from 2.108 to 21.689. The mass exhalation rates also varied with an average value of 0.473 / mBq / kg.day from 0,106 to 1,092 mBq / kg.day, a standardised exhalation rate from 1 889 to 19.44 / m2.day to 1 8,524 mBq / m2.day and a standardised exhalation level of 5,552. The highest values were calculated in Iranian cement in the cement sample -1 value and the lowest in Iraqi-resistant cement. However, the highest values were in the Spanish ceramic -1 value and the least were in the Chinese ceramics -2 value. This means that samples of ceramic and cement material from the Iraqi market cannot produce dangerous indoor radon levels when used as materials.

Table 1: Collected from Iraqi market efficient radium content and exhale rate of radon of ceramic and cement materials.

| No. | Sample                      | $\rho \times 10^4$ (Trac/cm$^2$) | CRa Bq/kg | Em mBq/kg.day | ES mBq/m$^2$.day |
|-----|-----------------------------|---------------------------------|-----------|---------------|-----------------|
| 1   | Cement ordinary Iranians   | 3.680                           | 10.317    | .519          | 9.247           |
| 2   | Iranian Cement -1           | 4.832                           | 13.547    | .682          | 12.142          |
| 3   | Iranian Cement -2           | 2.208                           | 6.190     | .311          | 5.548           |
| 4   | Cement ordinary Iraqis -1  | 2.408                           | 6.751     | .340          | 6.051           |
| 5   | Cement ordinary Iraqis -2  | 2.912                           | 8.164     | .411          | 7.317           |
| 6   | Cement-resistant Iraqis     | 1.272                           | 3.566     | .179          | 3.196           |
| 7   | Cement Lebanese             | 3.360                           | 9.420     | .474          | 8.443           |
| 8   | Spaniard Ceramic -1         | 6.720                           | 18.840    | .949          | 16.887          |
| 9   | Spaniard Ceramic -2         | 7.736                           | 21.689    | 1.092         | 19.440          |
| 10  | Iranian ceramics            | 1.336                           | 3.746     | .188          | 3.357           |
| 11  | Ceramic Syrian              | 4.000                           | 11.214    | .565          | 10.051          |
| 12  | Egyptian ceramics -1        | 1.576                           | 4.418     | .222          | 3.960           |
| 13  | Egyptian ceramics -2        | 1.096                           | 3.073     | .154          | 2.754           |
| 14  | Chinese Ceramics -1         | 6.400                           | 17.943    | .904          | 16.083          |
| 15  | Chinese Ceramics -2         | .752                            | 2.108     | .106          | 1.889           |

Maximum | 7.736 | 21.689 | 1.092 | 19.440 |
Minimum  | .752  | 2.108  | .106  | 1.889  |
Mean     | 3.352 | 9.399  | .473  | 8.424  |
Standard Deviation | 2.209 | 6.195  | .312  | 5.552  |
Figure 2: The variation of effective radium content in different ceramic and cement materials.

Figure 3: The variation of the mass exhalation rate with effective radium content in ceramic and cement.

Figure 4: Surface exhalation rate change with effective radium in ceramic and cement.
5. Conclusion
Effective rates of the radium content of radon were successfully measured using CN-85 plastic track detectors and the sealed-can technology. The distribution of radium in ceramic and cement samples is heterogeneous, as radium content varies from sample to sample in the Iraqi markets. The average overall radium value for the ceramic and cement samples from this study was 9.399 Bq / kg, whereas the global average radium content value for the Earth’s crust is 40 Bq / kg. These samples showed that the exhalation of radon is far less than the world average of 57 600 mBq / m2 h (0.016 Bq / m2 s). Therefore, these materials are not a health risk because they can be used for construction purposes. In the ceramics and cement samples, we found that the effective radium content was low and did not pose a health hazard. In summary, this study found that material samples are safe for use in building materials. They will not produce hazardous levels of alpha radiation in dwellings. The radium content of the ceramic and cement samples correlated with the radium exhalation rate.

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