Distribution of Radon Concentration in Farmland Soil Samples in Al-Shamiyah City, Al-Qadisiyah, Iraq

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Abstract. Radon concentration has determined in 46 samples collected from farmland soil of Al-Shamiyah city, Al-Qadisiyah, Iraq with alpha-emitters records their out of radon in nuclear track detector (CR-39). The results showed the maximum concentration of radon is 13.02 Bq/m$^3$ and the minimum concentration of radon is 0.12 Bq/m$^3$, with a mean value of 6.48 ± 0.77 Bq/m$^3$. Results reveal that the exhalation radon mass varied from 4.271 to 6.004 mBq/kg.h. The results explained the radon concentrations in farmland soil were less than 200 Bq/m$^3$ that it is recommended by UNSCEAR. On the other hand, the results observed that the samples do not create any impact on humans.

1. Introduction
Natural radionuclides are typically long-lived for more than a hundred million years. They exist in varying amounts in the air, water, vegetables, animals, soil, rocks and in the human body itself [1-4]. Soil is important to humans and their health. It provides a resource that can be used as a shelter and for food production. Terrestrial radionuclides series for example (U-238, U-235 and Th-232) have been indicted in every level of the state in the world. Terrestrial radionuclides and their daughters represent the major contribution of radiation doses are given human beings [5-7]. Activities of human in the soil can change the concentration of radioactivity. Natural radionuclides exist in phosphate fertilizers, and thus the application of fertilizers leads to changing the properties of the soil [8]. Chemical fertilizers have been used in all kinds of farming systems. Consequently, the determined of natural radioactivity is a dangerous on the humankind. The major supplier of radiation is radon (Rn-222). Radon and its progeny doses have been the high levels of reasons for lung cancer [1]. The decay scheme of radon products from the isotope of radium (Ra-226) presents in soil and rock in all its kinds. The radon atoms product are transiting to air filled pores after that move by diffusion and advection in the space by the exhale through the atmosphere [9]. There are many studied to estimate the radon concentration in the world [10-12]. The aim of this study is to measure the concentration of radon and the exhalation radon rate (mass and area) in farmlands soil of Al-Shamiyah city, Al-Qadisiyah, Iraq by nuclear track detector (CR-39).
2. Materials and Methods:

2.1. Description of Study Area
The study area lies in Al-Shamiyah city (180 Km) south of the capital Baghdad, which has an area of (948) km² on both sides of the Shatt al-Shamiyah (a branch of the Euphrates River), at Latitude (31.96 36 11°) north, longitude (44.59 88 89°) east [13]. In this study, the samples were collected from farmland soil in different villages for 10 different regions are includes the villages as, Al-Joboor, Abo Kofoof, Al-Hadadi, Tabar Al-Zaweed, Al-Filahi, Al-Chalakh, Al-Najaria, Al-Giratia, Al-Hafar and Nodaiba, as shown in figure 1.

2.2 CR-39 detector
CR-39 is a clear, colorless, rigid plastic, with a density of 1.30 g/cm³. The sensibility of CR-39 is such that it is physically able to register low energy alphas. Its high degree of reproducibility from batch to batch ensures the correct determination of the “background signal”, giving an accurate estimate of the actual radon concentration [14].

2.3 Tube-Technique (PVC)
PVC tube is a plastic cylinder, made from PVC (polyvinylchloride in the form of a cylinder of 2 mm thickness, a diameter of 3 cm and 11 cm long, used in this work to determine the radon concentration in the soil samples [15].

2.4 Calculated Concentration of Radon
Determination of the particles of alpha out of radon found in samples of soil concentrations were introduction using CR-39 detector with thickens (500×10⁻⁶ m) and area is (1cm×1 cm). These samples were collected from different regions in Al-Shamiyah city, Qadisiyah, and then crushed it to small pieces to get powder of samples with diameter (200×10⁻⁶ m). After
that, the sample was weighted (5g) then stored for 60 days in a sealed cup as shown in Figure 2. After then the detectors were prepared for etched by solution (NaOH) for normality (6.25 N) for temperature of (60 C) for a while (7 h). To record the tracks were and used an optical microscope to calculate the tracks density of alpha emitted from. Equation 1 and 2 used to calculate the density of the tracks (ρ) and radon concentration respectively [16].

\[ \rho = \frac{N}{A} \]

where \( N \) is the mean of track, \( A \) area of field view.

\[ C_{Rn} = \frac{\rho}{K \times T} \]

where \( T \) is exposure time. \( K \) is calibration factor of CR-39 (0.024 tr.cm\(^{-2}\) per Bq/m\(^3\).d) [17].

![Sealed-cup technique](image)

**Figure 2.** Sealed-cup technique.

### 2.5 Radon exhalation rate

As shown in Figure 2, the can technique was used to measure radon exhalation. Each 5 g soil sample was divided into separate plastic cans and closed. The detectors from all the cans were repossessed after 60 days of exposure. At several conditions, the detectors were etched as explained above. By an optical microscope with a 400X objective lens to find out the track density, 50 fields were scanned for each detector. The radon exhalation rate was measured in terms of mass and area [11, 16].

\[ E_M (mBq / kg.h) = \frac{CV \Delta T I M}{T + \frac{1}{A} (e^{-\lambda T} - 1)} \]

\[ E_A (mBq / m^2.h) = \frac{CV \Delta T I A}{T + (e^{-\lambda T} - 1)} \]

where \( E_M \) and \( E_A \) are the mass and surface area exhalation rate, \( C \) the integrate radon exposure, \( T \) the exposure time (60 days), \( V \) the volume of the can (77.72 cm\(^3\)), \( M \) the mass of the soil samples (5 gm), \( \lambda \) the decay constant of \(^{222}\)Rn, \( A \) the surface area of soil samples (177.75 cm\(^2\)) and \( k \) is the factor of calibration.

**3. Results and Discussion:**
3.1. Concentration of Radon

In this study, the radon concentration has measured in farmland soil samples collected from Al-Shamiyah, which it famous for the production of agricultural crops, especially cereals of rice and wheat. The estimated values of radon concentration are tabulated in Table 1. The maximum concentration of radon was found in Al-Filahi is 13.02 Bq/m$^3$, and the minimum radon concentration is 0.12 Bq/m$^3$ collected from Al-Hadadi, with an average of 6.48 Bq/m$^3$. The average value of the radon concentration is below the world average value of (200 Bq/m$^3$) as recommended by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) [1]. All the results were compared with other studies in the world, the present study is shown the concentration of radon is indicated the lower than in the radon concentration in Brazil, Egypt, India, Libya and Pakistan as shown in Table 2. The results indicated that the concentration varied from country to country due to the differences in the geological nature of the soil.

Table 1. Radon concentration ($C_{Ra}$) for Farmland soil samples collected from Al-Shamiyah.

| Sample code | Region               | $C_{Ra}$ (Bq/m$^3$) | Min. | Max. | Mean   |
|-------------|----------------------|---------------------|------|------|--------|
| S01         | Al-Joboor            | 3.95                | 12.33| 8.31±2.09 |
| S06         | Abo Kofoof           | 0.35                | 09.19| 4.70±0.19  |
| S11         | Al-Hadadi            | 0.12                | 12.56| 5.84±0.39  |
| S16         | Tabar Al-Zaweed      | 0.23                | 07.56| 5.30±0.06  |
| S21         | Al-Filahi            | 2.33                | 13.02| 8.00±0.81  |
| S26         | Al-Chalakh           | 0.93                | 06.51| 4.67±0.7   |
| S31         | Al-Najaria           | 2.09                | 09.77| 6.49±0.46  |
| S36         | Al-Girattia          | 4.77                | 09.07| 8.49±1.02  |
| S41         | Al-Hafar             | 6.05                | 09.77| 8.07±2.02  |
| S46         | Nodaiba              | 0.35                | 08.02| 4.95±0.03  |
| **Average** |                      |                     |      | 6.48±0.77  |

Table 2. Radon concentrations compared with the values reported for other countries.

| Country                  | $C_{Ra}$ (Bq/m$^3$) | Min. | Max. | Mean | References |
|--------------------------|---------------------|------|------|------|------------|
| Brazil                   |                     | 4    | 404  | 69   | [18]       |
| Egypt                    | 3130                | 6970 | 5110 |      | [19]       |
| India                    | 177.5               | 583.4| 330.5|      | [20]       |
| Libya (Benghazi)         | 31.1                | 469  | 220.3|      | [21]       |
| Libya (Al-Marj)          | 59.3                | 515.8| 325.5|      |            |
| Pakistan                 | -                   | -    | 261.67|     | [11]       |
| Al-Shamiyah city          | 0.12                | 13.02| 6.48 |      | Present study |

3.2. Radon exhalation rate

Table 3 is indicated the values of radon exhalation (for mass and surface area) in the soil samples collected from the different regions of Al-Shamiyah city. The radon exhalation in terms of mass ranges from 4.27 to 6.19 mBq/kg h and the radon exhalation of the area ranges from 0.10 to 1.83 mBq/ m$^2$ h. The exhalation rate depends on some of parameters that behave in a stochastic and independent fashion. The mean radon exhalation rates measured in terms of mass and area of the soil samples are 5.16 mBq/kg h and 1.04 mBq/m$^2$ h, respectively. Table 4 shows the values of radon exhalation rates compared with other references in the
The mean radon exhalation rates are higher than the concentration of radon exhalation in Pakistan and below the concentration of India and Malaysia.

Table 3. Radon exhalation in the soil for Farmland samples collected from Al-Shamiyah city.

| Sample code | Region        | $E_M$(mBq/kg h) | $E_A$(mBq/m²h) |
|-------------|---------------|----------------|----------------|
| S01         | Al-Joboor     | 4.40           | 0.91           |
| S06         | Abo Kofoof    | 5.17           | 0.30           |
| S11         | Al-Hadadi     | 4.27           | 0.10           |
| S16         | Tabar Al-Zaweed | 5.64       | 1.03           |
| S21         | Al-Filahi     | 6.19           | 1.83           |
| S26         | Al-Chalakh    | 5.50           | 0.81           |
| S31         | Al-Najaria    | 4.81           | 1.80           |
| S36         | Al-Giratia    | 5.11           | 1.72           |
| S41         | Al-Hafar      | 6.01           | 0.90           |
| S46         | Nodaiba       | 4.47           | 1.06           |
| Mean        |               | 5.16           | 1.04           |

Table 4. A comparative study of the concentration of Radon exhalation ((mBq/kg h) with other worldwide published data.

| Country               | Radon exhalation | References |
|-----------------------|------------------|------------|
| Pakistan              | 1.56-3.33        | [22]       |
| Odisha, India         | 4.2-13.7         | [23]       |
| Erasaima, India       | 648              | [24]       |
| Tusham, India         | 11.54            | [25]       |
| Seberang Paria, Malaysia | 4.526        | [16]       |
| Al-Shamiyah city      | 5.16             | Present study |

4. Conclusions

The radon concentration has measured in farmland soil samples collected from Al-Shamiyah, which it famous for the production of agricultural crops, especially of rice and wheat. The average value (0.12 Bq/m²) of the radon concentration is below the world average value as recommended in UNSCEAR. All the results were compared with other studied in the world, the present study are shown the radon concentrations represented lower than the concentration in other countries. On the other hand, the mean radon exhalation rates are higher than the concentration of radon exhalation in Pakistan and below the concentration of India and Malaysia.

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