Calculation of Concentration of Radon Gas in Specimen of Rivers Water samples in Diwaniya-Iraq'By Using CR-39Track Detector

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Abstract. The concentration of radon gas in a specimen of water of specific areas in 'Al-Diwaniya' province was calculated through employing alpha-emitters registrations, which is in '(CR-39)' nuclear track detector. The study focuses in determining the concentration of the gas in tap water specimen provided by the water grid of houses in 'Al-Diwaniya' province. The findings indicate that the radon maximum level in water specimen was in (Alshanaafia 5) area assigned to be (0.56 ± 0.30 Bq/L), and the minimum level is in(Afak 5) area around (0.165 ± 0.031Bq/L), in addition, to a rate value of (0.336 ± 0.075 Bq/L). The results also indicate that the radon gas in tap water is less than the acceptable boundary from (ICRP) organization which is (0.5994 Bq/L), but the concentrations of radon exhalation rate (RER) is about '(0.245– 0.072 μSv/y) and the rate value is'(0.1462 ±1.23 μSv/y).

Keywords: radon concentration, ground water, annual effective dose, CR-39, Al-Diwaniya province

1. Introduction

A radioactive gas 'Rad0n (222Rn)' with a (t1/2t= 382d)'is made by the degeneration of natural 'radionuclide'(226Ra) which is basically a degeneration result of uranium (238U) chains. A radon isotope, Thoron gas (220Rn) "is a degeneration result of the thorium (232Th) chains. Thoron half-life is (56 s) which is less than the radon [1].The concentrations of radon gas in ground'water depends on the geological circumstances of the area in addition to the human activities' pollution such as 'phosphate fertilizers, mining, and combustion of coal or other fuels .The rocks that happened naturally' by dissolving the granite rocks in natural uranium was mixed with the ground-water through leaching and precipitation (illumination process) [2]. In current examinations, the passive technique called the solid situation nuclear track detectors SSNTDs is used. The Nuclear track detection technique which depends on radon size and'CR-39 detector used in the present work due to its’ clarity and continuing integrated read out; high sensitivity to alpha-particle radiation ruggedness, which is available and easy to handle [3]:. The radon that exists in tap water represents a hazard for developing cancer of organs such as stomach cancer. Nevertheless, this hazard is nothing beside the hazard of developing lung cancer from radon released by water to air especially when water comes out a tap and the melted gases are free [4]. Actually, the study covers the area that is situated in Al-Diwaniya province in further parts of Euphrates, see figure 1. The goal of the study is to identify the
concentration of radon gas in a specimen of tap water in selected areas in Al-Diwaniya province by employing alpha-emitters registrations that are released from radon gas of in CR-39 nuclear track detector using sealed-cup technique [5].

Figure 1. The dots are the locations where specimen taken from in Al-Diwaniya province with the numbers of stations.

2. Experimental Method

In this work, 20 samples of water were collected from different locations in some areas of Al-Diwaniya governorate as shown in figure 1. Each sample with 0.25 liter was placed at the bottom of a cylindrical sealed can of 10 cm height and 6 cm diameter. Solid State Nuclear Track Detector (SSNTD) with sheet thickness of 500μm was used in this study, which is usually known as CR-39 plastic detector [14]. Square pieces of detector of the sizes (1 cm × 1 cm) were fixed on the top of the inner surface of the can, in such a way, that the sensitive surface is always facing the water’s sample [6]. The detectors were exposed to a period of 60 days. During exposing, the sensitive side of the detector is always facing the sample, and is exposed freely to the emergent radon from the water sample, so it could record alpha particles resulting from the decay of radon in the remaining volume of the can as seen in figure 2. After completing the exposure, the detectors were collected and chemically etched using 6.25 N NaOH at (70 C°) for (6 h). After that, these SSNTDs were washed, dried and scanned using an optical microscope with magnification of 400X (40x objective and 10x eyepiece) to count the number of the tracks per cm² in each detector. The determinations of the concentrations of alpha particles from radon gas in the samples were performed using CR-39 from the Intercast Europe Srl Company [7]. The radon gas concentration in the ground water samples was obtained by a comparison between track densities registered on the detectors of the sample and that of the standard water samples; using the following relation [8]

\[
\text{Tracks density (ρ)} = \frac{\text{Rate number of total pits (track)}}{\text{area of field view}} \tag{1}
\]

; The concentration of the radon gas is calculated using the following relationship [9];

\[
C_X = \rho_X \left( \frac{C_S}{\rho_S} \right) \tag{2}
\]

where

- \(C_X\): the concentration of alpha molecules in an unidentified specimen
- \(C_S\): the concentration of alpha molecules in the standard specimen
- \(\rho_X\): Density of track of an unidentified specimen; (track/mm²)
\( \rho_S \): Density of track of the standard specimen; \((\text{track/mm}^2)\)

The effective dose per year for a consumer based on the radon intake of ground water is assessed through the relationship [10];

\[
AED_w = C_w C_{Rw} D_{cw}
\]

where \(AED_w\) is the annual effective dose \((\text{Sv/y})\) due to the absorption of radionuclide from the consumed water;

\(C_w\) is the concentration of radon in the consumed ground water \((\text{Bq/L})\)

\(C_{Rw}\) is the annual intake of drinking water \(= 1095 \text{ L/y}\);

\(D_{cw}\) is the ingested dose conversion factor \(= 4 \text{ Sv/Bq}[11]\).

![Figure 2. A graphic figure of the technique of;sealed-cup in water specimen](image)

### 3. Results and Discussion:

In this survey, a total of 20 specimens of drinking water are collected from various regions in Al-Diwaniya province through sealed-cup technique. Table 1 and Figure (4) shows the concentration of radon gas in the specimen of drinking water from various areas in the Al-Diwaniya province. It may be noted that the maximum level of the concentration of radon gas in the specimen of potable water is found in (Alshanaafia5) area which equal to \((0.56 \pm 0.30 \text{ Bq/L})\), while, the minimum level is found in (Afak 5) area which equal to \((0.165 \pm 0.031 \text{ Bq/L})\) and a rate value of \((0.336 \pm 0.075 \text{ Bq/L})\). Alshanaafia5 area has the maximum value of the annual effective dose in the specimen of potable water equal to \((0.2452 \mu\text{Sv}/\text{y})\), and the minimum value of the annual effective dose \((\text{AED})\) is in (Afak 5) area equal to \((0.0722 \mu\text{Sv}/\text{y})\), and the rate value of \((\mu\text{Sv}/\text{y})\) \((0.1462 \pm 1.23 \mu\text{Sv}/\text{y})\); The annual effective dose \((\text{AED})\) of all the specimens are below the standard world parameters, which is equivalent to \((1\mu\text{Sv}/\text{y})\); Hence, the potable water in Al-Diwaniya province is safe as far as the concentration of the radon is concerned.

The recent paper measures the concentrations of the radon gas in 20 ground water specimens taken from different compartments (five specimen in each site) in Al-Diwaniya province by employing the sealed-cup technique. Based on the results, the concentration of the radon gas in the specimens of tap water in Al-Diwaniya Province (Iraq) is less than the permitted parameter from; (ICRP) agency that is equal to \((0.59 \text{ Bq/L})[12]\).

### 4. Calibration Curve for standard samples

To calibrate the curve plot between standard of different concentration of the radon gas solutions of known concentrations from \((0 - 0.55 \text{ Bq/L})\) that have been arranged to calibrate the paper and track the density using neutron induced radiography that is depended on the norm of solid state nuclear detectors SSNTDs; CR-39. The concentrations of radon gas are calculated by comparing track dense register on the detectors of the specimen and the standardized specimen from the Regression equation:

\[
y = 130.55 X +1.446, \quad R^2 = 0.9968.
\]

A linear calibration as seen in Figure (3) is detected, tracked by measuring the slope. The findings are investigated in \((\text{mg Bq}/\text{L})\).
Figure 3. Relationship of concentration of gas of radon and density track in standardized specimen of water.

Table 1. Concentration of gas of radon CRn (Bq/L), the specimen annual effective dose (AED) of potable water in Al-Diwaniya province

| site Number | site Name   | CRn (Bq/m³) | Mean of CRn (Bq/m³) | Effective dose (mSv/y) |
|-------------|-------------|-------------|---------------------|------------------------|
|             |             | 1  | 2  | 3  | 4  | 1  | 2  | 3  | 4  | 1  | 2  | 3  | 4  | 1  | 2  | 3  | 4  | 1  | 2  | 3  | 4  |
| W1          | Alshanaafia 1 | 0.14 | 0.21 | 0.27 | 3.1 | 0.23 ±0.07 | 0.1007 |
| W2          | Alshanaafia 2 | 8.0 | 7.0 | 6.0 | 5.0 | 59 | 0.258 | 0.1533 |
| W3          | Alshanaafia 3 | 12.0 | 11.0 | 10.0 | 9.0 | 51 | 0.32 | 0.47±0.11 |
| W4          | Alshanaafia 4 | 0.43 | 0.45 | 0.49 | 0.52 | 0.47±0.04 | 0.2058 |
| W5          | Alshanaafia 5 | 0.41 | 0.58 | 0.62 | 0.66 | 0.56±0.30 | 0.2452 |
| W6          | Afak 1       | 0.23 | 0.33 | 0.38 | 0.55 | 0.37±0.13 | 0.1620 |
| W7          | Afak 2       | 0.22 | 0.26 | 0.35 | 0.44 | 0.31±0.09 | 0.1357 |
| W8          | Afak 3       | 0.24 | 0.29 | 0.34 | 0.49 | 0.34±0.10 | 0.1489 |
| W9          | Afak 4       | 0.33 | 0.34 | 0.37 | 0.4 | 0.36±0.03 | 0.1576 |
| W10         | Afak 5       | 0.13 | 0.15 | 0.18 | 0.2 | 0.16±0.03 | 0.0722 |
| W11         | Afak 6       | 0.11 | 0.15 | 0.19 | 0.22 | 0.16±0.04 | 0.0731 |
| W12         | Rufieat 1    | 0.21 | 0.25 | 0.28 | 0.3 | 0.26±0.03 | 0.1138 |
| W13         | Rufieat 2    | 0.22 | 0.25 | 0.29 | 0.32 | 0.27±0.04 | 0.1182 |
| W14         | Rufieat 3    | 0.31 | 0.34 | 0.38 | 0.41 | 0.36±0.04 | 0.157 |
| W15         | Um alkhayl 1 | 0.27 | 0.3 | 0.34 | 0.39 | 0.32±0.05 | 0.1401 |
| W16         | Um alkhayl 2 | 0.35 | 0.38 | 0.41 | 0.43 | 0.39±0.03 | 0.1708 |
| W17         | Um alkhayl 3 | 0.33 | 0.42 | 0.45 | 0.47 | 0.41±0.06 | 0.1795 |
| W18         | Ghmas 1      | 0.25 | 0.27 | 0.31 | 0.35 | 0.29±0.04 | 0.1270 |
| W19         | Ghmas 2      | 0.15 | 0.17 | 0.21 | 0.23 | 0.19±0.03 | 0.0832 |
| W20         | Ghmas 3      | 0.36 | 0.39 | 0.42 | 0.45 | 0.40±0.03 | 0.1752 |

Rate 0.336 ± 0.075  0.146286 ± 1.23
Figure 4. A histogram demonstrates the alteration in concentration of gas of radon (Bq/L) in the specimen of all studied areas water.

References

[1] Iskandar D Iida Yamazawa T Morizumi H Koarashi J Yamasoto J Yamasaki K Shimo K Tsujimoto M T shikawa Fukuda M and Kojima H 2005 Appl. Rad and Isotopes 63 401.

[2] Sánchez A M Pérez J D T Sánchez A B R and Correa F L N 2012 Journal of Environmental Radioactivity 107 86.

[3] Al-Ubaidi K H 2006 Identification and measurements of natural and industrial radioactive pollutants in environment of Baghdad city using gamma spectrometry and solid state nuclear track detector CR-39 Ph D Thesis College of Education, Ibn-Alhaitham, University of Baghdad.

[4] Kadhem M M 2013 Estimation of radon concentration and annual effective dose in Al-Najaf city hospitals MSc Thesis, Kufa University, College of Science.

[5] Radiation protection against radon in workplaces other than mines 2003 International atomic energy agency, safety reports chains 33 3.

[6] Ammar A. Battawy and Hana I. Hussein 2010 J. of University of Anbar for pure science 4 (1).

[7] Al-Kazwini AT and Hasan MA 2003 J Radiol. Prot 23 439.

[8] Ferreira A O Pecequilo B R and Aquino RR 2011 Radioprotection Journal 46 (6) 49.

[9] Ismail A H 2004 Measurement of radon activity concentration in Iraqi Kurdistan soil by using CR-39 nuclear track detectors MSc Thesis, Uniof Salahaddin, Erbil-Iraq.

[10] Baixeras C Erlandsson B Font L and Jonsson G 2001 Radon emanation from soil specimen, Radiat Measur 34 441.

[11] Al-Gaim H R M Al-Khalifa I J M and AlHelal A A 2012 Journal of Basrah Researches 38 8.

[12] Kansal S Mehra R and Singh N P 2012 Applied Radiation and Isotopes 70 1110.