Estimation of Annual Effective Dose Due to Radon Emitted from Soil Samples in Southern of Iraq Using Lexan SSNTDs

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Abstract

It is known that inhaling and swallowing radon gas has raised concerns about its health risks to humans due to exposure to radon gas. In this study, the SSNTD device was used to detect the nuclear pathway of the solid-state laxative to estimate radon gas concentration in 18 soil samples randomly collected from the eastern part of Basra in southern Iraq. Concentrations of radon gas obtained using alpha (Lexan reagent) according to the technique of distribution inside a closed container, to assess the effective dose rate for travelers resulting from exposure to radon gas and its products. The results indicate that the average value of Radon gas concentration is and the annual effective dose is in Abu Al Khasib city. While the average results obtained in Ad Dayer city of Radon gas concentrations and the annual effective dose are, and respectively. All the results obtained within the acceptable limits by (ICRP) and (WHO). So, the soil is suitable for construction purposes without any health hazards.

Key Words: Lexan Detector, Alpha Detector, Radon Concentration, Annual Effective Dose.
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Introduction

Prolonged exposures to a minimum levels ionizing of radiation can increase health risks to the human population. The study of alpha activity in soil is critical because alpha radiation is 1000 times more carcinogenic than gamma radiation (1). Therefore, measurement of radioactivity in a region is necessary to provide basic reference concentrations and radioactive isotope behavior, their transport across ecosystems, and the development of models for their distribution and transport (2). Natural radionuclides in the soil are responsible for background exposure to humans and about 80% of the radiation dose a person is exposed to from natural background radiation. The levels of natural radioactivity depend on the geological aspects, especially on rocks and soil where they are found in different concentrations (2,3).

The dose of radiation a person receives from the radon radiation source is about 55% (4). Risks through their interaction with the energy with the cell they deal with, and, accordingly, the possibility of developing cancer because it radiates the ionizer and may cause DNA damage (5). One of the various methods used to measure the concentrations of radon in materials is the Lexan detector.

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Solid-State Nuclear Track Detectors (SSNTDs) detections of ionizing radiation through occurring track by heavy ionizing particles that can be identified by an electronic microscope, Lexan detector used to measure of ^{222}Rn from alpha particles emitted from decay ^{222}Rn and daughters hit the detection and let the latent tracks in it (5,6). The aim of this study the determined the contaminated areas in Basrah city south of Iraq, as a result of the bombing during the war on Iraq since the year 1991 to 2003, by using the technique of counting the effects of nuclear from Solid State Nuclear Track Detectors Lexan detector.

Materials and Methods

Study Areas

Samples Collection and Measurements

The present study was conducted into two sites in Basrah southern Iraq; the first site is Abu al Khasib at 478.50 km (30.252N, 48.0737E), and the second is Ad Dayer at 411.67 km (30.829N, 47.574E) south of the capital Baghdad Fig. 1. 18 samples are collected randomly, nine soil samples from Abu Al-Khaseeb and nine samples from the monastery during the winter season. These samples are placed in marked plastic bags. Samples dry on trays for five days until they lose moisture completely. Then the dried samples are collected in a fine owder with a stainless steel ball mill and sifted through a 0.5 mm mesh. Each soil sample weighs approximately 40g and is placed in a transparent plastic container 13 cm in length and 7 cm in diameter, as shown in Figure 2. Lexan reagent sheets have been cut into dimensions (1 cm x 1 cm) and affixed under the plastic cover of each container. The container is securely closed to ensure no alpha particle ports.

Figure 1. Location map of study

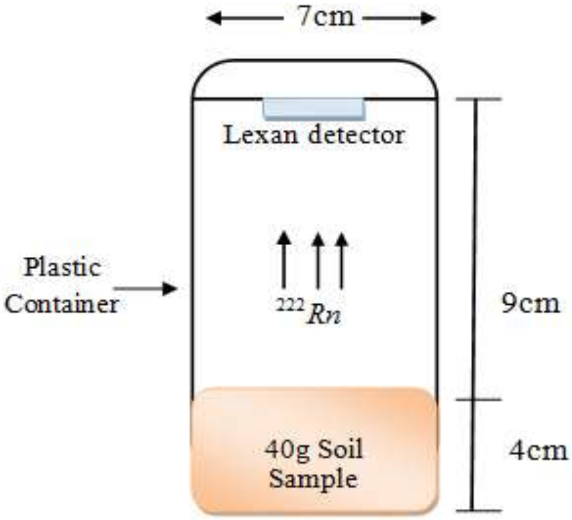

Figure 2. Experimental setup for the estimation ^{222}Rn by using Lexan detector

Measurement with Lexan Detector

Lexan detector, solid nuclear path detectors (SSNTDs), thickness (1µm). Used to record alpha particles emitted from decay Rn-222 with a power range (0.5-2) MeV (5), small pieces of area (1 cm x 1 cm) were cut and left about (45 days) to irradiate by alpha particles.

The chemically collected reagents were stirred using NaOH 6.25N colloidal, at 60 ° C, for 6 hours. The reagents in the solution were covered in a small container in a water bath. At the end of the drilling process, the detectors were completely washed with distilled water and left to dry. The alpha paths in each detector were visually calculated using an optical microscope with a power outage (400X).

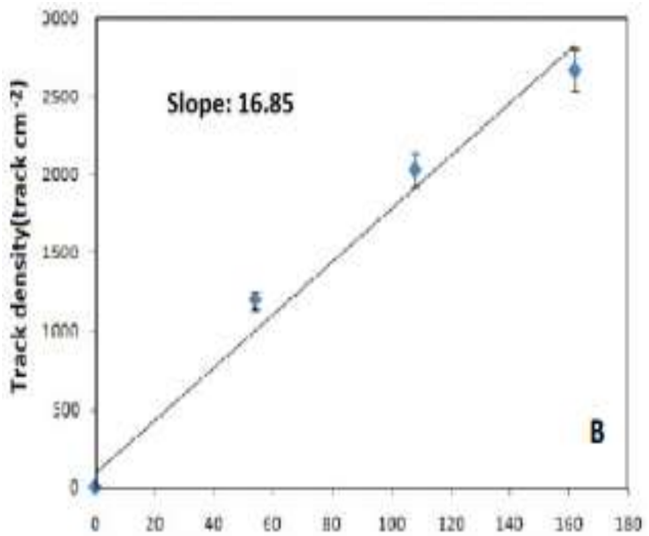

Figure 3. Standard Relation of Radon Gas Concentration and Track Density of Alpha Piratical (6)

The tracks densities were measured using the following eq. 1(5):

$$\rho = \frac{N}{A} \quad (1)$$

Where:

ρ=track density (number of tracks/mm^2) of distributed detectors. N: Average of total alpha tracks. A: Area of the scope of view.

To measure radon concentration levels in the soil $C_{Rn}\left(\frac{Bq}{m^3}\right)$ given by the following eq .2 (8).

$$C_{Ra}\left(\frac{Bq}{m^3}\right) = \frac{\rho}{\eta t} \quad (2)$$

t= exposure time in a day of distributed detectors and η is the calibration factor $[(\text{track}/\text{cm}^2)\text{per }(\text{Bq.day}/\text{m}^3)]$, the calibration factor (η value was determined by (6).

Calculation of the Potential Alpha Energy (PAE)

The concentration caused by the short-lived radon gas masses expressed by the radon gas concentration (EEC) concentration is related to the concentration of the radon gas activity by an equivalent. 3 (7): 18

$$\text{EEC}\left(\frac{Bq}{m^3}\right) = C_{Rn} * F \quad (3)$$

where F is the global average of equilibrium factor that equivalent to 0.4 in the indoor atmosphere (9). Lexan detector registers track density that belongs to the potential alpha energy (PAE) concentration in Working Level (WL) units. Moreover, WL represents the radon progeny collection according to 1.3 ×10^5 MeV of PAE per liter of air (7).

The Potential Alpha Energy (PAE) concentration calculated in (mWL) using the eq. 4 (7):

$$\text{PEA} = \frac{\text{EEC}}{3700} \quad (4)$$

Exposure to indoor ^{222}Rn in terms of working level month (WLM) for indoor has been calculated using the following eq .5 (7):

$$\text{WLM} = \text{WL}\frac{8760}{170} \quad (5)$$

Calculation of the Annual Effective Dose of Gas in the Soil Samples

To estimate the annual effective dose AED (in mSv per year) due to exposure to radon and its progeny was determined using the following eq. 6 According to (UNSCEAR 2000) (10).

$$AED = C_{Rn} * K * H * T * D_f \quad (6)$$

Where: C_{Rn} is the soil Radon gas concentration in (Bq/m^3), K is the adjustment factor (0.4 for indoor exposure), H is the occupancy factor (0.8 for indoor exposure), T is the number of hours in the year (8760h/y), D_f is the dose conversion factor for the whole body dose measure ($9.0*10^{-6}$ mSv per Bq. m^{-3}.h). all these factors, except C_{Rn}, are given in the UNSCEAR report (10).

The radiation has a negative biological effect, to count the "annual" equivalent dose, two kinds of weighting factors should be investigated to evaluate the dose level.

W_R represent the A radiation weighting factor for alpha particles equal to (20) as advised via (ICRP) (11), also W_T represent an applied tissue weighting factor. In this research, the weighting factor that used is (0.12) (12). Therefore, the "annual" equivalent dose calculated by using the following eq. 7:

$$H_E = AED * W_R * W_T \quad (7)$$

Where $H_E(mSvy^{-1})$ is the annual equivalent dose, AED ($mSvy^{-1}$) is the annual effective dose, W_R is radiation weighting factor and W_T is a tissue weighting factor.

Results and Dissection

Lexan (SSNTDs) are used to detect ionizing radiation through track formation of massive ionizing particles. The radon gas concentrations have been obtained by using the distribution technique within a sealed-container.

Table 1, includes calculations radon gas concentrations, equilibrium-equivalent radon concentration (EEC), (PAE), and (WLM), determined in soil samples collected from randomly selected two locations in the eastern part of Basrah Governorate in Southern Iraq.Soil Radon gas concentrations range from 20.46 to 106.46 Bq/kg with the mean value of 61.436 Bq/kg and from 18.47 to 83.53$Bqkg^{-1}$ with the mean value of 37.18 Bq/kg in Abu al Khasib and Ad Dayr cities, respectively. With regard to radon exposure of the population, the permissible threshold, and according to the International Commission on Radiological Protection (ICRP 2010) (12) and World Health Organization (WHO 2009) (14), has identified the exposure recommended level of 200Bqm−3. The present results reference the soil radon gas concentrations in all the samples that are lower than the global recommended value. The average values of (EEC), and (PAE), (WLM), listed in table 1 were$191.16\ Bq/m^3$, 59.78 mWL, 3080.16 and $14.88\ Bq/m^3$, 4.02mWL, 207.29 in the two locations mentioned above respectively.

Table 1. Statistics of tracks density (ρ), Radon Gas Concentration, (EEC), potential alpha energy concentration, and (PAE), monthly work level (WLM) in the soil of Basrah city

No. of samples	ρ $(Track/mm^2)$	Radon Gas Concentration(Bq/m^3)	$EEC(Bq/m^3)$	PAE (mWL)	WLM
Abu al Khasib					
1	372.20	49.53	19.81	5.36	275.92
2	155.50	20.69	8.28	2.24	115.43
3	472.20	62.83	25.13	6.79	349.89
4	355.50	47.31	18.92	5.12	263.83
5	566.60	75.40	30.16	8.15	419.97
6	800.00	106.46	42.58	11.51	593.10
7	588.80	78.35	1.34	8.47	436.45
8	405.50	53.96	21.58	5.83	300.42
9	438.80	58.39	23.36	6.31	325.15
Avg.	461.678	61.436	191.16	59.78	3080.16
Ad Dayr					
10	144.40	19.22	7.69	2.08	107.18
11	627.70	83.53	33.41	9.03	465.31
12	138.80	18.47	7.39	2.00	103.06
13	316.60	42.13	16.86	4.56	234.97
14	366.60	48.79	19.52	5.28	272.08
15	161.10	21.44	8.58	2.32	119.55
16	216.60	28.82	11.53	3.12	160.77
17	261.10	34.74	13.90	3.76	193.75
18	284.50	37.50	15	4.05	208.90
Avg.	279.71	37.18	14.88	4.02	207.29

From Table 2 it is seen that the annual effective dose AED (mSv/y) result exposure to radon gas and its progeny, and the annual equivalent dose in soil samples varies from 0.52 to 2.69 mSv/y with the mean value of 1.55 mSv/y, and from 1.25 to 6.45mSv/y with the mean value of 3.72 mSv/y in Abu al Khasib area, while the values in Ad Dayr area varies from 0.49 to 2.11mSv/y with the mean value of 0.94mSv/y, and from 1.16 to 5.06mSv/y with the mean value of 2.25mSv/y, the high values of the annual effective dose in this work were (2.69mSv/y) in Abu al Khasib area and (2.11mSv/y) in Ad Dayr area.

These values within the permissible limits by world health organization (WHO) (13) which it is equal (1-3) mSv/y.

Table 2: Annual absorbed dose EDA(mSv/y) and the annual effective dose H_E (mSv/y)

No. of samples	EDA (mSv/y)	$H_E(mSv/y)$
Abu al Khasib		
1	1.25	2.99
2	0.52	1.25
3	1.59	3.80
4	1.19	2.87
5	1.90	4.57
6	2.69	6.45
7	1.98	4.74
8	1.36	3.27
9	1.47	3.54
Avg.	1.55	3.72
Ad Dayr		
10	0.49	1.16
11	2.11	5.06
12	0.47	1.12
13	1.1	2.55
14	1.23	2.95
15	0.54	1.30
16	0.73	1.75
17	0.88	2.10
18	0.95	2.27
Avg.	0.94	2.25

Table 3 summarizes the comparison between Most of the reported studies in other countries is about the concentration of soil Radon gas and the annual effective dose with those conducted. It seems that our results are less than the other results

Table 3. Average Soil Radon Gas Concentration and the Annual Effective Dose in the Present Study Compared and with other Studies and the World's Average

Study area	Technique	^{222}Rn Concentration(Bq/m^3)	EDA (mSv/y)	References
Malaysia	CR-39	198.44	——	[14]
India	RAD7	4560.65	12.08	[15]
Egypt	CR-39	136.99- 874.51	3.40 - 22.06	[16]
Abu Al Khasib	Lexan	61.436	1.55	Present study
Ad Dayer		37.18	0.94	
World's average		200	1-3	[10]

Conclusion

In recent years, exposure to radon gas and its daughters in the environment has become a global problem. Since radon gas has a negative impact on human health and the second leading cause of lung cancer, it is necessary to increase the level of public awareness of the risks of radon gas in this matter and take the necessary measures to reduce radon gas in the surrounding environment when radon gas has a gas concentration above the regulatory limits of global health . In this study, the results of apparent radon concentration and annual effective dose in soil samples from Abu Al-Khaseeb and Al-Dayer in Basra Governorate, southern Iraq, fall within the safe limits recommended by the International Radiation Protection Committee (ICRP) and the World Health Organization (WHO).

Conflicts of Benefit

The authors assure that there are no conflicts of benefit.

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