

# Distribution of Radon Concentration in Agricultural Soil Samples in AL-Qadisiyah, Iraq

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## Abstract

In this study, radon concentration, radon exhalation rates and the annual effective dose were measured in 55 samples collected from the soil in AL- Qadisiyah Governorate, Iraq by nuclear track detector (CR-39). The results showed the maximum concentration of radon is  $323.95 \pm 62.87$  Bq/m<sup>3</sup> and the minimum concentration of radon is  $83.14 \pm 8.60$  Bq/m<sup>3</sup>, with a mean value of  $178.05 \pm 36.52$  Bq/m<sup>3</sup>. Results reveal that the exhalation radon mass  $\mu\text{Bq}/(\text{kg}\cdot\text{h})$  ranged from 0.740 to 2.882, and the exhalation radon surface ranged  $\text{mBq}/(\text{m}^2\cdot\text{h})$  from 0.021 to 0.083. Furthermore, for the annual effective dose  $\text{mSv}/\text{y}$  ranged from 0.524 to 2.007, with average values of 1.584, 0.046, and 1.121, respectively. The results showed that all radon concentrations for soil samples were lower than 200 Bq/m<sup>3</sup> which is one of the lowest ones that it is recommended by UNSCEAR, excluding some of samples that were slightly larger than this limit, but they were lower than the level of 600 Bq/m<sup>3</sup>, which is the highest value in the range of reference levels recommended by UNSCEAR. While, values of radon exhalation rate in terms of mass and area were much less than the recommended limit world average of 20  $\text{mBq}/(\text{kg}\cdot\text{h})$  ( $72\text{Bq}/(\text{kg}\cdot\text{h})$ ) and 0.016  $\text{Bq}/(\text{m}^2\cdot\text{s})$  ( $57.6\text{Bq}/(\text{m}^2\cdot\text{h})$ ), respectively. On the other hand, the results observed that the average effective dose value is below the recommended action level by ICRP in 1993 which is (3-10 $\text{mSv}/\text{y}$ ) and higher than reference levels the recommended global average of 1 $\text{mSv}/\text{y}$  by ICRP in 2007, so, according to the results of the area under study it not pose a significant risk to human beings.

**Keywords:** CR-39, Radon Concentration, Radon exhalation rate, Annual Effective Does

## 1. INTRODUCTION

Natural radionuclides usually last for a long period of more than 100 million years, they are present in varying quantities in vegetables, animals, water, air, soil and rocks, and are also present in the human body itself 1,3. Terrestrial radionuclides and their daughters are the main contribution to radiation doses that a human receives 4. In recent years, researchers have paid great attention to the detection of radon and its effects, as radon is a carcinogen and the second major cause of lung cancer after smoking in the United States, according to the US Environmental Protection Agency 6.

Radon (Rn-222) is the main source of radiation[1]. 238U series generates radon (222Rn) as a daughter of radium (226Ra), which consists of other isotopes, thoron (220Rn) and action (219Rn), the smooth daughters

of 232Th and 235U in respectively. Radon is a chemically inert gas that is heavier than air, colorless, tasteless and odorless, which usually remains close to the ground floors. Radon gases of Rn-219, Rn-220 and Rn-222 have a half-life of 3.96 s, 56.65 s and 3.82 d, respectively. 222Rn is capable of moving within the soil for large distances or in the ground before it completely decomposes, and as the soil is an important source of human health, it provides a resource that can be used as a shelter to living and production of the food, therefore, must be a complete knowledge of the production of radon and its daughters 6.

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The assessment of radiological risk related to inhalation of radon and its progeny is based mainly on the integrated measurements of radon. The measure of the relative concentration of radon in the soil directly refers to the relative concentration of uranium in the soil or in other substances such as fertilizers. Cultivated soils using fertilizers are expected to contain higher radioactivity than arid soils. Fertilizers are made from different materials and uranium is expected to be found there 7,8. When using or handling fertilizers (storage, handling and during agriculture), farmers are exposed to radon gas. It is therefore important to measure relative radon concentrations in soil samples that take from different locations and depths 9. It was shown through the radon decay scheme of radon isotope (Ra-226) in rocks and soils of all kinds. The radon atom product moves into air-filled pores and then moves through fusion and spread into space by exhaling through the atmosphere 10. Many researchers have measured radon concentrations in soils in different parts of the world because of the importance of the subject and its impact on people's health and the environment, The content of radon gas was in soil changes from one country to other country 11,12.

In order to analyze the behavior of radon in the atmosphere,

a complete understanding of the occurrence and the rate of radon exhalation in terms of (mass and area), in addition to the annual effective dose from radon is required, this study is designed to check soil of AL- Qadisiyah Governorate Iraq ,using the nuclear track detector(CR-39).

## 2. MATERIALS AND METHODS

### 2.1. Study Area

Al-Qadisiyah is one of the governorates of Iraq, located in the center of Iraq. It is nearly 190 km from the capital of Baghdad, Iraq. It covers an area of 8153 km<sup>2</sup> and is located on the Euphrates River between latitudes 31.17-32.24 °N, and longitudes 44.24-45.49 °E. As for its administrative borders, it is bordered to the north by Babil Governorate, to the west by Kut Governorate, to the south by Samawah Governorate, and to the east by Najaf Governorate. The population of the province is estimated at about 1.5 million people, according to the 2014 census, and its center is the city of Diwaniyah. In this study, soil samples (agricultural or non-agricultural soils) were collected from 11 sites as shown in Figure 1.

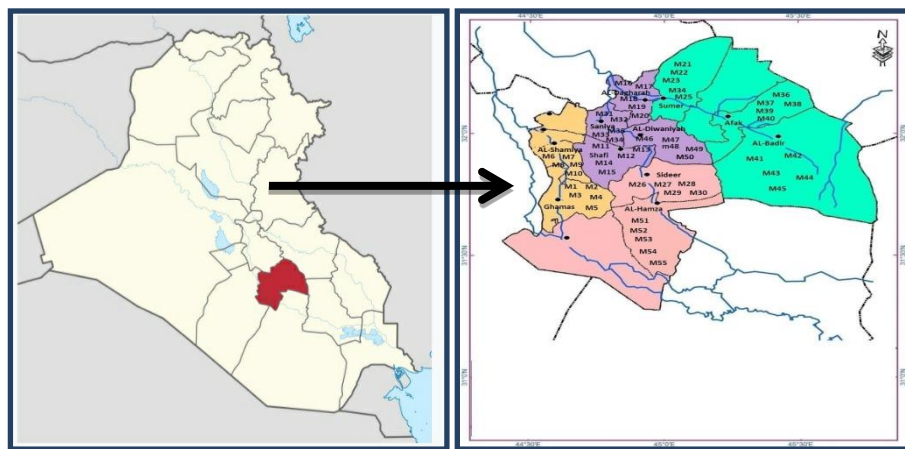


Figure 1. Map of the studied area of Al-Diwaniyah governorate

### 2.2. Collection and Preparation of Samples

Fifty five soil samples were collected from 11 sites from Al-Qadisiyah Governorate, Iraq. 5 samples were collected from each site, as shown in Table 1. The samples were taken from a depth of (5-15 cm) using a manual drill, after the collecting all samples were exposed to the air for two day, then the stones and root parts from soil samples were removed, where the samples were dried at 80°C by the oven for 1 h to get rid of moisture. Soil samples were finely ground and sieved through a 75 mm nylon mesh to form a powder to ensure the homogeneity of the samples. About 10 g of soil powder was weighed and transferred to PVC tubes (PVC is a plastic cylinder made of polyvinyl chloride, it was

designed by the researcher for the purposes of the study with 10.5cm high, 2.1cm).

To determine the concentration of radon gas in soil samples, the samples put in the bottom of the tube, it is well closed by a stopper to prevent radon from leaking from the tube, each tube is equipped with a nuclear track detector CR-39 and the detector (CR-39) is a solid plastic detector with thickness is 500 μm, it was cut using a very sharp cutter into small pieces with an area of (1.5 cm × 1.5 cm) and the detector is fixed at the bottom of the inside of the tube cover with adhesive tape before closing, as in Figure 2. The detector CR-39 records the tracks of alpha particles emitted from radon gas during the exposure period for 30 days. The reagents are then

pulled from all pipes and the reagents are prepared and drilled into the sodium hydroxide solution (NaOH) by caliber (6.25N) at a temperature of 70°C for 6h. The detector is then taken, washed with distilled water and dried. The number of tracks in 40 fields per detector is then scanned

using an

Optical Microscope by zooming in on 400X objective lens to determine the density of the track per cm<sup>2</sup> 2,12.

**Table 1. Coordinates and soil type of areas studied.**

<i>Location</i>	<i>Name of Region</i>	<i>Co.</i>	<i>Coordinates</i>
Ghammas	Miri AL-Attiyah	M1	31°40'16.87" N, 44°46'57.55" E
	AL-Hafar	M2	31°43'36.46" N, 44°40'33.06" E
	Juweiha village	M3	31°44'09.93" N, 44°36'40.89" E
	Sawb AL-Saghir	M4	31°44'09.70" N, 44°36'03.86" E
	AL-Mashtabi district	M5	31°43'52.94" N, 44°36'24.71" E
AL-Shamiya	AL-Muhannawi	M6	32°03'10.91" N, 44°33'59.41" E
	AL-Salaha (AL-Filahi)	M7	31°59'58.81" N, 44°33'00.97" E
	SayedRafie	M8	31°58'15.18" N, 44°38'29.33" E
	AL-Hanawit village	M9	31°57'42.94" N, 44°40'07.38" E
	AL-Salaha (Zahra district)	M10	32°00'54.07" N, 44°33'02.76" E
Shafeia	Shafeia center	M11	31°56'26.97" N, 44°50'35.54" E
	Stain Street	M12	31°56'17.41" N, 44°50'35.63" E
	AL-Mamal village	M13	31°57'14.49" N, 44°49'29.51" E
	Shafeia	M14	31°57'26.47" N, 44°50'18.88" E
	AL-Hussein district	M15	31°57'01.62" N, 44°50'25.78" E
AL-Dagharah	Police district	M16	32°07'57.54" N, 44°56'00.87" E
	Zabid AL-Bonael Rode	M17	32°05'31.83" N, 44°55'00.10" E
	Shuhada district	M18	32°08'31.94" N, 44°55'47.83" E
	AL-Khalat	M19	32°08'26.31" N, 44°58'14.08" E
	Frist Freedom district	M20	32°08'41.44" N, 44°56'03.41" E
Sumer	Ibrahimia village	M21	32°12'53.79" N, 45°01'10.30" E
	AL Bo Ukhzal village	M22	32°08'58.21" N, 44°58'20.52" E
	AL Ziad village	M23	32°08'54.93" N, 44°57'52.69" E
	Fadhilia village	M24	32°09'22.63" N, 45°00'05.93" E
	Sumer entrance	M25	32°08'48.39" N, 44°58'41.27" E
Sideer	AL Dyab	M26	31°48'33.84" N, 44°57'09.08" E
	AL Bandar village	M27	31°49'15.49" N, 44°53'54.17" E
	Surah	M28	31°50'07.24" N, 44°55'43.86" E
	Murshid	M29	31°51'02.10" N, 44°55'57.80" E
	Sideer entrance	M30	31°50'18.96" N, 44°56'39.18" E
AL-Saniya	Jassim AL-Hammadi	M31	31°58'59.001" N, 44°50'03.17" E
	AL-Dora village (1)	M32	32°03'04.86" N, 44°46'01.31" E
	AL-Dora village (2)	M33	32°02'28.61" N, 44°44'01.97" E
	AL Maaleh	M34	32°02'03.43" N, 44°42'35.02" E
	AL-Hamran	M35	32°02'00.14" N, 44°47'12.32" E
Afak	AL-Mukhadhare village	M36	32°03'17.09" N, 45°14'52.51" E
	AL Bo Khashm village	M37	32°03'21.15" N, 45°12'30.40" E
	Five	M38	32°03'29.53" N, 45°11'20.10" E
	Masters AL-Awawedah	M39	32°03'17.96" N, 45°09'06.35" E
	FalakahAfak	M40	32°03'08.30" N, 45°13'59.15" E
AL-Badir	AL-Nadurat	M41	31°57'49.23" N, 45°24'54.33" E
	Falakah AL-Dalla	M42	31°58'53.46" N, 45°24'37.58" E
	AL Bo Nashi village	M43	32°01'14.24" N, 45°20'04.04" E
	Sayyid Mohammed AL-Aris	M44	32°02'16.77" N, 45°18'41.94" E
	AL Bo Rashed	M45	32°03'42.98" N, 45°16'33.63" E
AL-Diwaniyah	Third Taqea	M46	31°58'04.63" N, 44°53'47.09" E
	AL-Manasir village	M47	32°02'22.15" N, 45°01'38.12" E
	Atta	M48	31°56'28.51" N, 44°54'12.67" E
	AL-Kassar masters	M49	31°54'28.72" N, 44°54'36.60" E

AL-Hamza	Third Renaissance district	M50	31°59'02.69" N, 44°57'30.87" E
	Shufa	M51	31°42'11.85" N, 45°00'01.77" E
	AL-Aksha	M52	31°38'43.13" N, 45°01'45.15" E
	AL-Baji	M53	31°46'51.57" N, 44°59'16.27" E
	Khazaal	M54	31°42'26.06" N, 44°56'29.02" E
	AL-Mustafa district	M55	31°44'13.35" N, 44°58'35.72" E

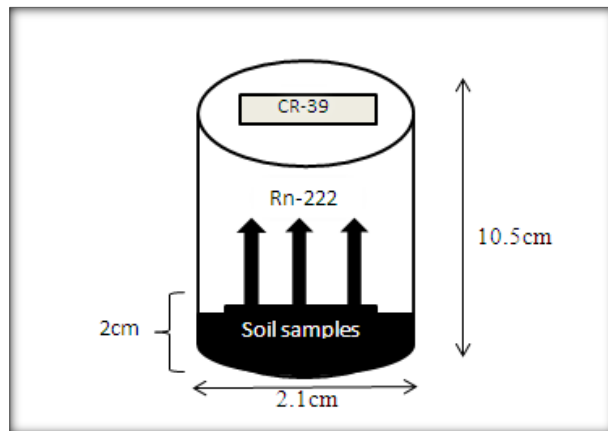


Figure 2 . PVC tube to the storage of the soil samples

### 3. CALCULATION

The tracks of alpha particles shown on CR-39 are counted to measured concentration radon gas emitted from soil samples through the use of an Optical Microscope,

The equation (1) and (2) found to calculate the track density ( $\rho$ ) and the concentration of radon, respectively [13].

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

Where N is the mean number of tracks on detector and A is area of field view.

$$C = \frac{\rho}{k \times t} \quad (2)$$

Where t: is exposure time for radon (30 d), K: is calibration factor of CR-39( $K = 0.02607 \text{ track.cm}^{-2} / \text{Bq.m}^{-3}$ ) [7]. The radon exhalation rate was measured in terms of mass and area through the following equations [15, 16].

$$T_{eff} = [t - \frac{1}{\lambda_{Rn}} (1 - e^{-\lambda_{Rn}t})] \quad (3)$$

$$E_m (\frac{\mu\text{Bq}}{\text{kg.h}}) = \frac{CV\lambda_{Rn}}{mT_{eff}} \quad (4)$$

$$E_A (\frac{\text{mBq}}{\text{m}^2.\text{h}}) = \frac{CV\lambda_{Rn}}{A_s T_{eff}} \quad (5)$$

$E_m$  and  $E_A$  are the exhalation rate of mass and surface area of radon gas in the samples, C is radon

concentration( $\text{Bq}/\text{m}^3$ ), V is volume of tube ( $6.924\text{cm}^3$ ),  $\lambda$  the decay constant of  $^{222}\text{Rn}$  ( $0.1814 \text{ 1/d}$ ), m is the mass of soil samples in the tube (10 g), and  $A_s$  is the surface area of soil samples ( $3.462\text{cm}^2$ ).

So, it was can calculate the annual effective dose (AED) based on the model of the United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR)[1] according to the following equation:

$$AED = C \times F \times H \times T \times D \quad (6)$$

Where F represents the equilibrium factor (0.4), H is the occupancy factor (for outdoor) estimated to be(0.2), T is the number of hours in a year (8760h/y) and D is the does conversion factor ( $9 \times 10^{-6} \text{mSv}/\text{Bq}/(\text{m}^3.\text{h})$ ).

### 4. RESULTS AND DISCUSSION

In this study, the radon levels were measured in soil samples collected from Al-Qadisiyah Governorate, as shown in Table 2. This Table shows the values of radon gas concentrations in soil samples, where the maximum concentration of radon was found in Al -Badir sub district in the (Falakah Al-Dalla) region (sample M42)  $323.95 \pm 62.87 \text{Bq}/\text{m}^3$  and the minimum concentration was found in Al-Diwaniyah center in the area (Third Renaissance district) (M50 sample)  $83.14 \pm 8.60 \text{Bq}/\text{m}^3$  with an average value of  $178.06 \pm 36.52 \text{Bq}/\text{m}^3$  The results indicate that the concentration varies from one regain to another due to differences in the geological nature of the soil. Table2 shows the values of exhalation rate radon in terms of (mass and surface area) in soil samples. The radon exhalation in terms of mass ranges from 0.740 to 2.882  $\mu\text{Bq}/(\text{kg.h})$  and the radon exhalation of the area ranges from 0.021 to 0.083  $\text{mBq}/(\text{m}^2.\text{h})$ , both found in Al-Diwaniyah

center in the area (Third Renaissance district) (M50 sample) and in Al -Badir sub district in the (Falakah Al-Dalla) region (sample M42) with an averages of values of 1.584 and 0.046, respectively. In addition to that, the annul effective dose (mSv/y) was calculated in Table 2, where dose values range from 0.524 to 2.043 at an average of 1.123.

The concentration of radon gas, the exhalation rate, and the annual effective dose in soil samples depend on some of parameters that behave in a stochastic and independent fashion. For the areas that were surveyed in this study, the averages of radon concentrations, radon exhalation rate (mass and rate), and the annual effective dose for these areas were calculated, as shown in Table 3. The highest concentrations were (233.94±39.43Bq/m<sup>3</sup>, 2.081µBq/kg.h, 0.060 mBq/m<sup>2</sup>.h, and 1.476mSv/y) respectively, where all those concentrations were in the Sumer region, while the lowest were in AL-Shamiya region (145.64±33.44Bq/m<sup>3</sup>, 1.296µBq/kg.h, 0.037mBq/m<sup>2</sup>.h, and 0.919mSv/y) respectively. That's mean; the Sumer region is highest radiological, in contrast to AL-Shamiya region, which is lowest.

Depending on Table 4, all present results were compared with other studies in the world, it was indicates that the average concentration of radon gas was lower than all the studies in the table, except for Thiqr and Al- Shamiyah, Al-Qadisiyah, Iraq, which were less than this study. For the

values of radon exhalation rates (mass and area) for present study were below than the other studies. While the results of the effective dose were compared with other studies in the world too, and the current study indicates that the mean of the effective dose are less than in Egypt and higher than the other studies in the Table4.

The results showed that all radon concentrations for soil samples were lower than 200 Bq/m<sup>3</sup> that it is recommended by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) 1, excluding samples (M1, M4, M14, M18, M21, M23, M24, M26, M27, M29, M33, M36, M37, M39, M42, M48, M52), these samples are slightly larger than these allowable limit, which is one of the lowest ones, but they were lower than the level of 600 Bq/m<sup>3</sup>, which is the highest value in the range of reference levels recommended by the International Commission on Radiological Protection in its last publication on the matter (ICRP, 1993) and 9. All values of radon exhalation rate in terms of mass and radon exhalation rate in terms of area of radon for this study were much less than the recommended limit worldly average of 20 mBq/kg/s (72Bq/(kg.h)) and 0.016 Bq/m<sup>2</sup>/s (57.6 Bq/(m<sup>2</sup>.h)), respectively 17. So, all annul effective dose values are higher than the permissible limit 1mSv/y according to the recommendations of the ICRP 3,6.

**Table 2:Radon concentration, radon exhalation rate (mass and rate), and annul effective dose in soil samples collected from Al-Qadisiyah Governorate.**

<i>Co.</i>	<i>CRn</i> ( <i>Bq/m<sup>3</sup></i> )	<i>Em</i> ( <i>µBq/kg.h</i> )	<i>EA</i> ( <i>mBq/m<sup>2</sup>.h</i> )	<i>AED</i> ( <i>mSv/y</i> )
M1	253.28±31.92	2.244	0.065	1.591
M2	108.94±27.04	0.969	0.028	0.687
M3	189.21±40.94	1.683	0.049	1.193
M4	246.54±26.27	2.193	0.063	1.555
M5	186.34±34.52	1.658	0.048	1.175
M6	149.07±24.99	1.326	0.038	0.94
M7	177.74±44.04	1.581	0.046	1.121
M8	123.27±34.04	1.097	0.032	0.778
M9	111.80±20.06	0.995	0.029	0.705
M10	166.27±44.04	1.479	0.043	1.049
M11	169.14±32.56	1.505	0.043	1.067
M12	177.74±59.86	1.581	0.046	1.121
M13	91.73±30.87	0.816	0.024	0.579
M14	243.68±40.94	2.168	0.063	1.537
M15	126.14±51.60	1.122	0.032	0.796
M16	117.54±39.41	1.046	0.03	0.741
M17	183.47±44.78	1.632	0.047	1.157
M18	223.61±38.03	1.989	0.057	1.41

M19	129.01±34.52	1.148	0.033	0.814
M20	94.60±31.53	0.842	0.024	0.597
M21	266.61±35.80	2.372	0.069	1.682
M22	180.61±62.87	1.607	0.046	1.139
M23	272.34±19.23	2.423	0.07	1.718
M24	255.14±29.93	2.27	0.066	1.609
M25	194.94±49.32	1.734	0.05	1.23
M26	235.08±42.13	2.091	0.06	1.483
M27	298.55±8.600	2.576	0.074	1.826
M28	173.60±24.99	1.224	0.035	0.868
M29	269.48±19.23	2.397	0.069	1.7
M30	103.20±34.40	0.918	0.027	0.651
M31	140.47±37.26	1.25	0.036	0.886
M32	174.87±37.26	1.556	0.045	1.103
M33	212.14±34.40	1.887	0.055	1.338
M34	160.54±46.58	1.428	0.041	1.013
M35	100.33±36.82	0.893	0.026	0.633
M36	240.81±31.92	2.142	0.062	1.519
M37	278.08±22.39	2.474	0.071	1.754
M38	154.80±42.90	1.377	0.04	0.976
M39	260.88±39.41	2.321	0.067	1.645
M40	86.005±25.64	0.765	0.022	0.542
M41	192.07±48.05	1.709	0.049	1.211
M42	323.95±29.93	2.882	0.083	2.043
M43	134.74±49.73	1.199	0.035	0.85
M44	172.01±28.66	1.53	0.044	1.085
M45	120.40±35.80	1.071	0.031	0.759
M46	157.67±46.66	1.403	0.041	0.994
M47	146.20±53.55	1.301	0.038	0.922
M48	263.74±42.61	2.346	0.068	1.664
M49	143.34±36.26	1.275	0.037	0.904
M50	83.14±8.60	0.74	0.021	0.524
M51	197.81±33.92	1.76	0.051	1.248
M52	249.41±42.61	2.219	0.064	1.573
M53	131.87±44.78	1.173	0.034	0.832
M54	106.07±48.05	0.944	0.027	0.669
M55	088.87±34.99	0.791	0.023	0.561
Average	178.06±36.52	1.584	0.046	1.123
Max.	323.95±62.87	2.882	0.083	2.043
Min.	83.14±8.60	0.740	0.021	0.524

**Table 3. The averages of radon concentrations, radon exhalation rate (mass and rate), and the annual effective dose in soil samples collected from Al-Qadisiyah Governorate.**

Location	CRn (Bq/m <sup>3</sup> )	Em (μBq/kg.h)	EA (mBq/m <sup>2</sup> .h)	AED (mSv/y)
Ghammas	196.66±32.14	1.749	0.051	1.240
AL-Shamiya	145.64±33.44	1.296	0.037	0.919
Shafeia	161.69±43.17	1.438	0.042	1.020
AL-Dagharah	149.65±37.66	1.331	0.038	0.944
Sumer	233.94±39.43	2.081	0.060	1.476
Sideer	206.99±25.87	1.841	0.053	1.306
AL-Saniya	157.68±38.47	1.403	0.041	0.995
Afak	204.12±32.46	1.816	0.052	1.287
AL-Badir	188.64±38.44	1.678	0.048	1.190
AL-Diwaniyah	158.82±39.84	1.413	0.041	1.002
AL-Hamza	154.81±40.87	1.377	0.040	0.977

**Table 4. A comparative study of the radon concentration, the radon exhalation rate, and annual effective dose with other worldwide published data.**

Country	CRn (Bq/m <sup>3</sup> )	Em (μBq/kg.h)	EA (mBq/m <sup>2</sup> .h)	AED (mSv/y)	References
SeberangPerai, Malaysia	-	4526.4	0.1086	-	[16]
Etah, India	-	2.99	7.77 × 10 <sup>-2</sup>	-	[18]
Bangladesh	851.41	-	-	0.008092	[19]
Egypt	236.34-717.78	(1.06-13.40)×10 <sup>3</sup>	(0.28-0.86)×10 <sup>3</sup>	7.15-21.72	[8]
Dadri, India	222.50-673.60	-	(0.08-0.24)×10 <sup>3</sup>	0.011	[5]
El-Hosh, Sudan	-	0.10×10 <sup>3</sup>	4.86 ×10 <sup>3</sup>	-	[20]
Kumaun, India	-	104.4×10 <sup>6</sup>	.	0.14	[21]
Kerbala, Iraq	-	48.409×10 <sup>3</sup>	1478.5	-	[17]
Thiqar, Iraq	75.875±21.80	-	82.780	-	[22]
Al- Shamiyah, Al-Qadisiyah, Iraq	6.48 ± 0.77	5.16×10 <sup>3</sup>	1.04	-	[15]
UNSCEAR	200	-	-	-	[1]
ICRP,1993	600	-	-	(3-10)	[6]
Limit world	-	72×10 <sup>3</sup>	57.6×10 <sup>3</sup>	-	[17]
ICRP,2007	-	-	-	1	[3]
AL-Qadisiyah, Iraq	178.06±36.52	1.584	0.046	1.123	Present
	83.14-323.95	0.740-2.882	0.021-0.083	0.524-2.043	Study

### 5. CONCLUSION

Radon concentration was measured in soil samples collected from Al-Qadisiyah Governorate, Iraq. It was found that the average value of the radon concentration is below the world average value as recommended world. However, some values were found that exceed the minimum limit but fall within a maximum limit of permissible global limits. In addition that, radon exhalation rate for mass and area of radon was much less than the recommended limit worldly. On the other hand, the annual effective doses have been within the permissible limit according to the

recommendations world. On the other hand, the mean radon exhalation rates are below than all concentrations of studies .In general, the concentration have been concluded radiological safe, except for some samples.

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## Compliance with Ethical Standards statements

Ethical approval :The University of Al-Qadisiyah / Iraq / certifies the ethical approval, Funding details (In case of Funding) :I am responsible for paying the financing, Conflict of interest :There is no conflict of interest, Informed Consent: Department of Research and Studies, University of Al-Qadisiyah \ Agreed

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