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Determination of Radon Gas Concentrations and Radon Exhalation Rate in Soil Sample in Selected Regions in Anbar Governorate

Dhameer A. Mutlak
Department of Physics, College of Science, Al- Anbar University, Al-Anbar, Iraq

Talal A. Alani
Department of Physics, College of Science, Al- Anbar University, Al-Anbar, Iraq

Ahmed O.Farhan
Center of desert studies in Anbar governorate, Al-Anbar, Iraq

Abstract
In the present work, we have measured the radon gas concentrations in soil samples from depth (5 cm) of selected regions in Anbar governorate by using alpha particles-emitters registrations which are emitted form radon gas in (CR-39) nuclear track detector. The results show that, the average radon gas concentration ranged from 44.2±5.0 Bq/m3 in Hit (Zuea District) region to 228.2±11.2 Bq/m3 in AL-Ratba region, with an average value of 106.62±46.5 Bq/m3, while the radon exhalation rate in terms of area ranged from 120.53 µBq/m2h - 622.30 µBq/m2h ,with an average value of 290.74±126 µBq/m2h. Finally, the radon exhalation rate in terms of mass ranged from 4.24 µBq/kg h - 21.90 µBq/kg h, with an average value of 10.22±4.4 µBq/kg h. The present results show that the radon gas concentration in soil samples from depth 5 cm is below the allowed limit from (ICRP, 1993) agency, apart from regions [AL-Ramadi (AL-Warar District), AL-Ratba and Al-Qaim (AL-Abedi District)] which were higher than the allowed limit given by (ICRP, 1993).
Keywords: Radon concentration, Soil , Radon exhalation rate, CR-39 nuclear track detector.

1.Introduction

Radon is a radioactive gas with a half-life 3.823d that is an element of the periodic table and falls within the noble group elements (Helium, Neon and Xenon, etc.). It is difficult to detect radon because it's a colourless and odorless gas. Its Atomic number is (86), boiling point is about (61.8 oC), freezing point is about (-71.0 oC) and density (9.73 Kg.m-3), and it is produced by the decay of the natural radioactive uranium series, which starts with uranium.

Radon concentrations in soil gas within a few meters of the surface of the ground are clearly important in determining radon rates of entry into pore spaces and subsequently into the atmosphere and it's depend on the radium concentration in the bedrock and on the permeability of the soil . The measurement of 222Rn concentration in soil gas, in principle, can be used as a method of evaluating the potential for elevated indoor radon concentrations . Radon-prone areas can be identified directly by using indoor measurements or indirectly using radon concentration in the soil, by previous established correlation with the indoor radon concentrations
The aim of the present work is to determine the radon gas concentration in soil and the radon exhalation rate in terms of area (RERA) and radon exhalation rate in terms of mass (RERM) in selected regions in Anbar governorate by using alpha-emitters registrations which are emitted form radon gas in (CR-39) nuclear track detector by using the sealed-cup technique from depth (5 cm) in soil.

2.Experimental Procedure

2.1 Description of Study Area

Anbar governorate is the largest province in Iraq geographically. Encompassing much of the country's western territory, it shares borders with Syria, Jordan, and Saudi Arabia as shown in Figure (1) . Geographically, Anbar province consider part of the arabian peninsula. Characterized by desert climate, and low rainfall and high variation of heat between day and night, where summer temperatures rise to about (50 oC), in the winter down amounted to about (0 oC). The northwesterly winds and the south-west wind sometimes amounting to a maximum speed of about (21 m/s). The latitude and longitude of Anbar governorate are (31.5º-35º N) and (39 º-44 º E). It is located about (60 m) above the sea level, with a total area is approximately of about (140000 km2) .

2.2 The Detector

The CR-39 plastic detector used in the present study is sensitive to alpha particles of energy up to 40 MeV .It was used as integrating detector of α-particles from 222Rn and daughters nuclei.

When an α-particle penetrates the detector, the particle causes damage along its path, the damage is then made visible by chemical etching. The etching produces a hole in the detector along the path of the particle. The hole can be easily observed in a light transmission microscope with moderate magnification .

2.3 The Exposure

The determination of the concentrations of alpha particles emitted from radon gas in soil samples were performed by using the nuclear track detector (CR-39) of thickness (250 μm) and area of about (1×1 cm2).
The samples of soils were collected from different sites in Anbar governorate from depth (5 cm), and then were dried and cleaned from the doping grinds by using special sieve (0.27 mm in diameter) and weight of the sample was about (20 g), the radon gas concentration in soil samples was obtained by using the sealed-cup technique as shown in Figure. (2).

After the irradiation time (30 day), the (CR-39) track detectors were etched in (6.25 N) (NaOH) solution at temperature of (70 oC) for (6 h) , the tracks density were recorded using an optical microscope with magnification (400x). The density of the tracks (ρ) in the samples were calculated according to the following relation .

$$\text{Tracks density } (\rho) = \frac{\text{Average number of total pits (track)}}{\text{Area of field view}} \quad \ldots\ldots\ldots (1)$$

The radon gas concentration in the soil samples were obtained by the comparison between track densities registered on the detectors of the sample and that of the standard soil samples, using relation:

$$CX = \rho X \,.\, (CS / \rho S) \quad \ldots\ldots\ldots (2)$$

Where :
CX : alpha particles concentration in the unknown sample.
CS : alpha particles concentration in the standard sample.
ρX : track density of the unknown sample (track/mm2).
ρS : track density of the standard sample (track/mm2).

2.4 Calculation of Radon Exhalation Rate

The radon exhalation rate in terms of area (RERA) in units Bq.m-2.h-1 can be calculated by using relation (3):

$$RERA = \frac{C\ V\ \lambda}{A\ [T + \lambda^{-1}(e^{-\lambda T} - 1)]} \quad \ldots\ldots (3)$$

Where:
C: is the integrated Radon exposure (Bq.m-3.h).
V: is the volume of air in cup (m3) =150 cm3= 0.00015 m3
λ :is the decay constant for 222Rn (h-1) = 0.1812 day-1 =0.00755 h-1
A: is the surface area of the sample (m2) = 1.52×3.14=7.0685 cm2=0.0007068 m2
T: is the exposure time (h) = 30day =720 h

The radon exhalation rate in terms of mass (RERM) in units Bq.kg-1.h-1 can be calculated by using relation (4) [8] :

$$RERM = \frac{C\ V\ \lambda}{M\ [T + \lambda^{-1}(e^{-\lambda T} - 1)]} \quad \ldots\ldots\ldots (4)$$

Where M is the mass of the sample (kg).

3.Results and Discussion

The radon concentration in soil sample from depth (5 cm) from different compartments for 20 different locations (with five samples in each location) in Anbar governorate by using the sealed-cup technique.

Table (1) present radon gas concentration (CRn) in soil samples from different regions in Anbar governorate. It can be noticed that, the highest average radon gas concentrations in soil samples in S10 AL-Ratba region which was (228.2±11.2 Bq/m3), while the lowest average radon gas concentration was found in S15 Hit (Zuea District) region which was (44.2±5.0 Bq/m3), see figure (3) , with an average value of (106.62±46.5 Bq/m3), also from Table (1) present the highest radon exhalation rate in terms of area (RERA) was found in S10 AL-Ratba region which was (622.30 μBq/m2h), while the lowest radon exhalation rate in terms of area (RERA) was found in S15 Hit (Zuea District) region which was (120.53 μBq/m2h), see figure (4) , with an average value of (290.74±126 μBq/m2h), finally , it can be noticed from Table (1) present the highest radon exhalation rate in terms of mass (RERM) was found in S10 AL-Ratba region which was (21.90 μBq/kg h), while the lowest radon

exhalation rate in terms of mass (RERM) was found in S15 Hit (Zuea District) region which was (4.24 µBq/kg h), see figure (5) , with an average value of (10.22±4.4 µBq/kg h).

All the present results show that the radon gas concentration (CRn) in soil samples from depth 5 cm in soil is below the allowed limit from (ICRP, 1993) agency which was (200 Bq/m3) , apart from, (S4 ,S10 , S19) which were higher than the allowed limit given by (ICRP, 1993).

The difference in soil radon gas concentrations at the studied areas is due to difference in the underlying bedrocks and the geology of the studied areas. The most important parameter of the soil radon concentration is the type of bedrock beneath the soil. It is found that, the variety of rocks that contain radionuclide concentrations plays important factors in radon concentration. In most cases, rocks with high 226Ra concentrations develop soils with high radon concentrations.

Not only the 238U or 226Ra concentration of a soil controlled by the type of bedrock, but also the gas permeability of a soil, that which determines the migration distance are depends on the bedrock, while the radon exhalation rate increases when the porosity of the soil increases and the variation in values of radon exhalation rate may be due to the difference porosity of the soil.

4.Conclusions

From the present work, it can be concluded that the radon gas concentrations in soil samples from depth (5 cm) all regions studied in Anbar governorate were below the allowed limit given by (ICRP, 1993) which was equal to (200 Bq/m3), apart from, (S4 ,S10 , S19) which were higher than the allowed limit given by (ICRP, 1993).

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Tables & Figures

Table (1) present radon gas concentration (CRn) in soil samples from different regions in Anbar governorate.

Code No.	Regions	CRn (Bq.m-3)					Mean of CRn (Bq.m-3)	(RERA) (µBq/m2h)	(RERM) (µBq/Kg h)
		1	2	3	4	5			
S1	AL-Ramadi (AL-Taimeem Directorate)	111	119	123	128	133	122.8±6.2	334.87	11.78
S2	AL-Ramadi (AL-Andalus District)	89	92	95	99	108	96.6±5.5	263.42	9.27
S3	AL-Ramadi (AL-shurta District)	62	64	67	77	83	70.6±7.5	192.52	6.77
S4	AL-Ramadi (AL-Warar District)	199	206	206	215	225	210.2±7.8	573.21	20.17
S5	Treabeel	56	65	68	77	79	69±7.2	188.16	6.62
S6	Arar	74	83	87	95	103	88.4±8.4	241.06	8.48
S7	AL-Nakeab	44	56	76	76	87	67.8±14.2	184.89	6.50
S8	AL-Habbaneai	45	53	57	68	71	58.8±8.5	160.34	5.64
S9	AL-Waleed	75	75	82	86	92	82±5.6	223.61	7.87
S10	AL-Ratba	200	229	229	239	244	228.2±11.2	622.30	21.90
S11	Brawanna	76	88	96	97	104	92.2±8.1	251.42	8.85
S12	AL-Hbarea	58	59	62	65	74	63.6±4.7	173.43	6.10
S13	Aucashat	78	85	86	95	205	109.8±38.1	299.42	10.54
S14	Hit (Kabesa District)	37	37	45	52	56	45.4±6.8	123.80	4.35
S15	Hit (Zuea District)	38	38	44	48	53	44.2±5.0	120.53	4.24
S16	Hit (Mradea District)	43	58	62	65	77	61±8.4	166.34	5.85
S17	Hadetha	109	111	119	128	153	124±13.2	338.14	11.90
S18	Anah	65	78	79	87	96	81±8.4	220.88	7.77
S19	Al-Qaim (AL-Abedi District)	208	213	224	227	239	222.2±9.3	605.93	21.33
S20	Al-Qaim (AL-Resala District)	177	190	194	202	210	194.6±9.1	530.67	18.66
Average							106.62±46.5	290.74±126	10.22±4.4

Table (1) Radon gas concentration (CRn) and radon exhalation rate in terms of area (RERA) and mass (RERM) for soil samples in Anbar governorate.

Anbar governorate is the largest province in Iraq geographically. Encompassing much of the country's western territory, it shares borders with Syria, Jordan, and Saudi Arabia as shown in Figure (1)

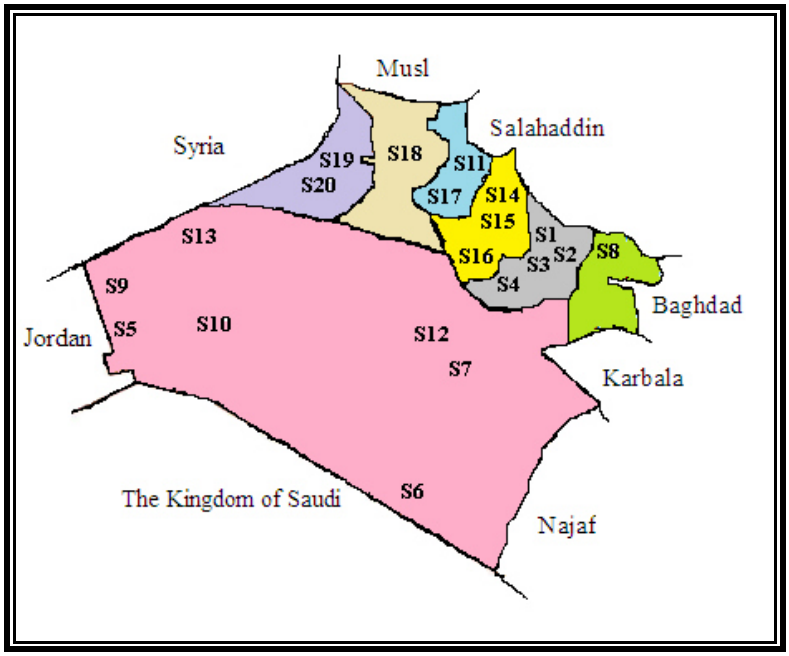

Figure (1) Sketch map shows locations of study samples in Anbar governorate.

The samples of soils were collected from different sites in Anbar governorate from depth (5 cm), and then were dried and cleaned from the doping grinds by using special sieve (0.27 mm in diameter) and weight of the sample was about (20 g), the radon gas concentration in soil samples was obtained by using the sealed-cup technique as shown in Figure. (2).

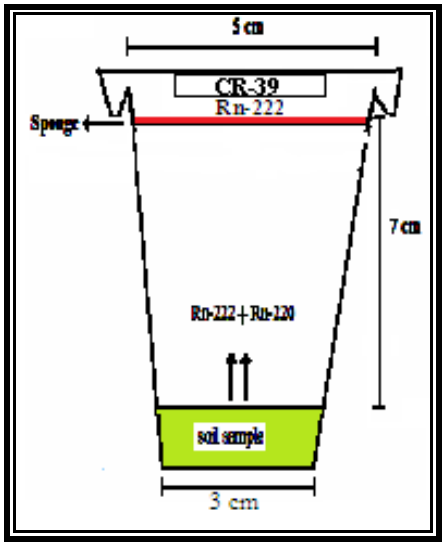

Fig.(2) A schematic diagram of the sealed-cup technique in soil sample.

The lowest average radon gas concentration was found in S15 Hit (Zuea District) region which was (44.2±5.0 Bq/m3), see figure (3)

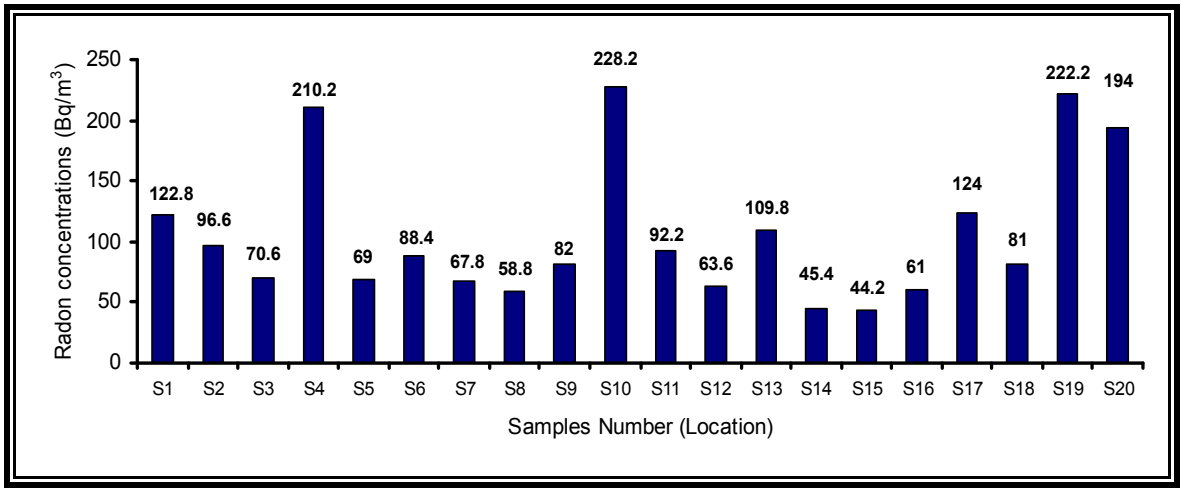

Figure (3) A histogram illustrating the change in the radon gas concentrations (Bq/m3) for soil samples in all regions studied in Anbar governorate.

The lowest radon exhalation rate in terms of area (RERA) was found in S15 Hit (Zuea District) region which was (120.53 µBq/m2h), see figure (4).

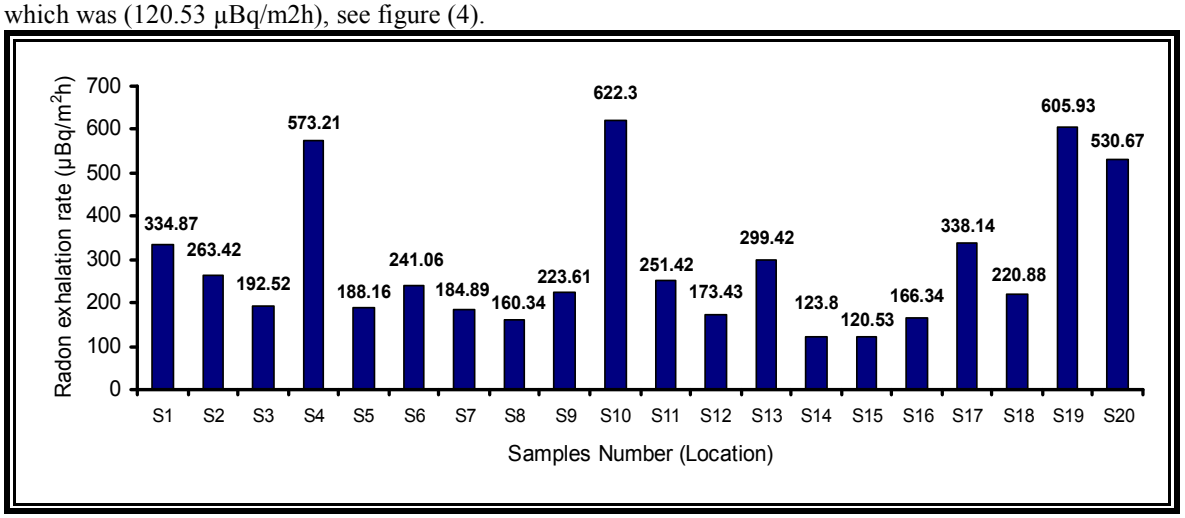

Figure (4) A histogram illustrating the change in the radon exhalation rate in terms of area (RERA) for soil samples from in all regions studied in Anbar governorate.

The lowest radon exhalation rate in terms of mass (RERM) was found in S15 Hit (Zuea District) region which was (4.24 µBq/kg h), see figure (5)

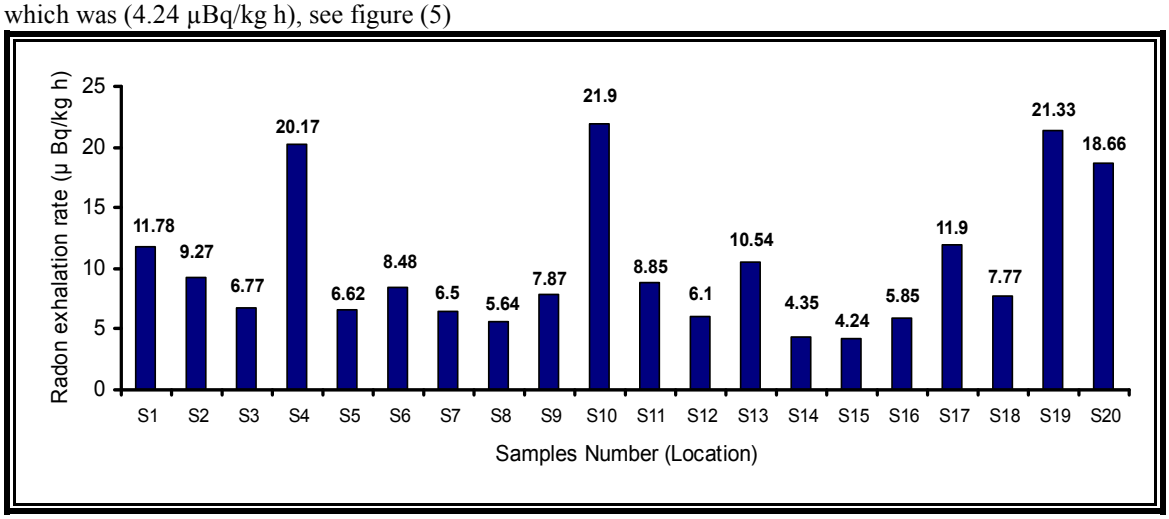

Figure (5) A histogram illustrating the change in the radon exhalation rate in terms of mass (RERM) for soil samples from in all regions studied in Anbar governorate.

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