Measurement of radon gas concentration in water and soil samples in AL-Najaf governorate by using nuclear track detector (CR-39)

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Received 2, April, 2014
Accepted 28, September, 2014

Abstract:

The radon gas concentration in environmental samples soil and water of selected regions in Al-Najaf governorate was measured by using alpha-emitters registrations which are emitted form radon gas in (CR-39) nuclear track detector. The first part is concerned with the determination of radon gas concentration in soil samples, results of measurements indicate that the highest average radon concentration in soil samples was found in (Al-Moalmen) region which was (100.0±7.0 Bq/m^3), while the lowest average radon concentration was found in (Al-Askary) region which was (38.5±4.7 Bq/m^3), with an average value of (64.23±14.9 Bq/m^3) ,the results show that the radon gas concentrations in soil is below the allowed limit from (ICRP) agency which is (200 Bq/m^3), while the radon exhalation rate (RER) ranged from (35.23-91.52 µBq/m^{2}h), and average value which was (58.77±13.6 µBq/m^{2}h).

The second part is concerned with the determination of radon gas concentration in samples of tap water obtained from networks in dwellings in Al-Najaf governorate, the results indicate that the highest average radon concentration in water samples was found in (Meassan) region which was (0.59±0.08 Bq/L), while the lowest average radon concentration was found in (Al-Jamhorah) region which was (0.16±0.04 Bq/L), with an average value of (0.36±0.1 Bq/L), the present results show that the radon gas concentrations in tap water is below the allowed limit from (ICRP) agency which is (0.5994 Bq/L), while the radon exhalation rate (RER) ranged from (2.15-0.58 µSv/y), and average value which was (1.28±0.31 µSv/y).

Key words: Radon concentration, Soil, Radon exhalation rate, CR-39 nuclear track detector.

Introduction:

Gaseous radioactive radon (^{222}Rn), decay product of the radium isotope ^{226}Ra presents in all types of soil and rock. Radium atoms decays in soil particles, the resulting atoms of radon entering to air filled pores and then transported by diffusion and advection through this space in order to exhale into the atmosphere [1]. Radon concentrations in soil gas within 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 [2]. Since radon is a gas, it may escape into the air from the material in which it is formed, and since uranium and radium

occur widely in soil and water, radon gas is ubiquitous-outdoors as well as indoors, the air that we inhale contains radon [3] .
Some radon stays in the tap water containing radon presents a risk of developing internal organ cancers, primarily stomach cancer [4]. However, this risk is smaller than the risk of developing lung cancer from radon released to air from water. When water leaves a faucet, dissolved gases are released. [5].
The aim of the present work is to determine the radon gas concentration in soil surface and tap water samples in selected regions in AL-Najaf governorate by using alpha-emitters registrations which are emitted form radon gas in (CR-39) nuclear track detector by using the sealed-cup technique.

Materials and Methods:

.**A- Description of Study Area**

AL-Najaf governorate is located in the south of Iraq and in the southwest of Baghdad governorate (the capital of the republic of Iraq), and it is about 161 km far from Baghdad governorate, with location of latitude 32^{o} N, and longitude 44^{o} E. It is located about 70 m above the sea level, with a total area of nearly 28,824 km^{2} and a population of nearly 1,200,000 inhabitants. AL-Najaf governorate has a desert climate characterized by extreme heat during the day, an abrupt drop in temperature at night, and slight, erratic rainfall. The weather in AL-Najaf governorate is dry and hot in summer; cold and less rainy in winter. Najaf governorate does not have a seaport. Its lands are flat and leveled in areas linked to waters from the Euphrates River and higher in the southern portions of the desert areas, extending to the republic of Iraq [6], in the present work radon concentrations, were measured for soil and tap water samples in different locations for 10 different regions in Al-Najaf governorate which includes regions (Al-Forat, Al-Askary, Tamoz , Al-Motanaby , Meassan, Al-Askan, Al-Moalmen , Al-Karama, Al-Zahraa , Al-Jamhorah), the first part was measured for soil sample, from table (1) summarize the results obtained in the present work for radon gas concentrations in soil samples in different sites in Al-Najaf governorate .

B- Calculation of Radon gas concentration

The determination of the concentrations of alpha particles emitted from radon gas in soil and water samples were performed by using the nuclear track detector (CR-39) of thickness of about (250 μm) and area of about (1×1 cm^{2}).
The samples surface of soils were collected from different sites in Al-Najaf governorate, the surface soil samples were crushed to small pieces then to fine powder by using electrical mill, the fine soil powder will convert to the grain size of (200 μm). The weight of the sample was of about (40 g). The samples of tap water were also collected from the same sites of the above Al-Najaf governorate, (0.25 litter) volume of tap water, the tap water obtained from the water networks in dwellings in Al-Najaf governorate, the radon gas concentration in soil and water samples was obtained by using the sealed-cup technique as shown in Fig. (1) and Fig. (2), respectively.
After the irradiation time (30 day), the (CR-39) track detectors were etched in (6.25 N) (NaOH) solution at temperature of (60 ^{o}C) for (7 h), and the tracks density were recorded using an optical microscope with magnification (400x).Calculation of Radon gas concentration:
The radon gas concentration in the soil and water samples were obtained by

the comparison between track densities registered on the detectors of the sample and that of the standard soil and water samples which are shown in Fig.(3) and Fig. (4) respectively, using the relation [7]:

The density of the tracks (ρ) in the samples were calculated according to the following relation [8].

Tracks density

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

$$C_X = \rho_X \,.\, (C_S / \rho_S) \quad \ldots.. (2)$$

Where :

C_X : alpha particles concentration in the unknown sample.

C_S : alpha particles concentration in the standard sample.

ρ_X : track density of the unknown sample (track/mm^2).

ρ_S : track density of the standard sample (track/mm^2).

C-Calculation of radon exhalation rate in soil samples

The radon exhalation rate of any sample is defined as the flux of radon released from the surface of material. The surface exhalation rate (E_{exh}) in units Bq.m^{-2}.h^{-1} can be calculated by [9]:

$$E_{exh} = \frac{CV\lambda}{A[T+\lambda^{-1}(e^{-\lambda T}-1)]} \quad \ldots\ldots (3)$$

Where:

C: is the integrated radon exposure (Bq.m^{-3}).

V: is the volume of air in cup (m^3) =140 cm^3= 0.00014 m^3

λ :is the decay constant for ^{222}Rn (h^{-1}) = 0.1812 day^{-1} =0.00755 h^{-1}

A: is the surface area of the sample (m^2) = 2.5^2×3.14=19.63 cm^2=0.0019636 m^2

T: is the exposure time (h) = 30 day =720 h

D- Calculation the annual effective dose in water samples

The annual effective dose of an individual consumer due to intake of radon from tap water is evaluated using the relationship [10]

$$AED_w = C_w\, C_{Rw}\, D_{cw} \quad \ldots\ldots (4)$$

Where AED_w is the annual effective dose (Sv/y) due to ingestion of radionuclide from the consumption of water.

C_w is the concentration of radon in the ingested drinking water (Bq/L).

C_{Rw} = 730 L/y , D_{cw} is = 5 × 10^{-9} Sv/Bq

Results and Discussion:

From Table (1) it can be noticed that , the highest average radon concentration in soil samples was found in (Al-Moalmen) region which was (100.0±7.0 Bq/m^3), while the lowest average radon concentration was found in (Al-Askary) region which was (38.5±4.7 Bq/m^3), see fig. (5), with an average value of (64.23±14.9 Bq/m^3), the present results show that the radon gas concentration in soil is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency which is (200 Bq/m^3) [11], while the radon exhalation rate (RER) ranged from (35.23-91.52 µBq/m^{2}h), and average value which was (58.77±13.6 µBq/m^{2}h).

The second part is concerned with determination of radon gas concentration in samples of tap water obtained from networks in dwellings in Al-Najaf governorate, from Table (2), it can be noticed that, the highest average radon concentration in water samples was found in (Meassan) region which was (0.59±0.08 Bq/L), while the lowest average radon concentration was found in (Al-Jamhorah) region which was (0.16±0.04 Bq/L), see Fig. (6), with an average value of (0.36±0.1 Bq/L), the present results show that the radon gas concentration in tap water is below the allowed limit from (International Commission of Radiation Protection) (ICRP) agency which is (0.5994 Bq/L)

[12], while the radon exhalation rate (RER) ranged from (2.15-0.58 μSv/y), and average value which was (1.28±0.31 μSv/y).
It might be mentioned that, thoron gas is an alpha emitter which is also present in soil and water environments, however, the average diffusion distance of thoron gas is very small compared to that of radon [10], which means that the present results might also contained a small amount of thoron , and therefore might be considered roughly as an upper limit results which are still within the allowed limit of (ICRP) agency . Also it should be remembered that the half–lives of radon and thoron are about (3.82 d) and (56 s) respectively. However, the present result might be more refined be using, for example, a filter to separate radon gas from thoron gas [13].

Conclusions

From the present work, it can be concluded that, in soil samples the results show that the radon gas concentration in soil is below the allowed limit from (ICRP) agency which is (200 Bq/m^3), while in tap water samples the results show that the radon gas concentration in tap water is below the allowed limit from (ICRP) agency which is (0.5994 Bq/L).

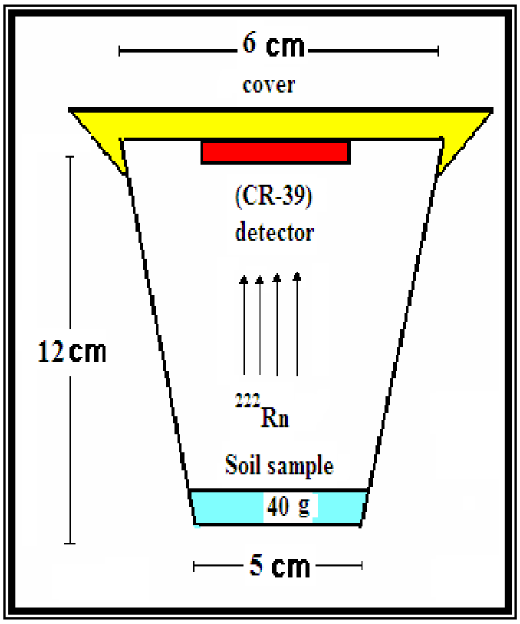

Fig.(1) A schematic diagram of the sealed-cup technique in soil sample.

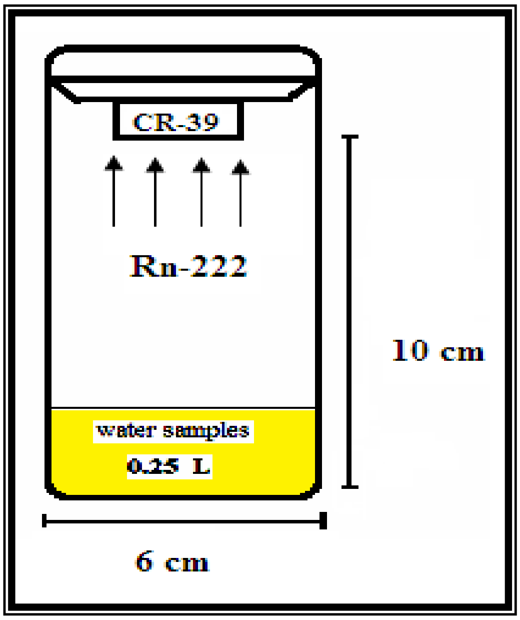

Fig.(2) A schematic diagram of the sealed-cup technique in water sample.

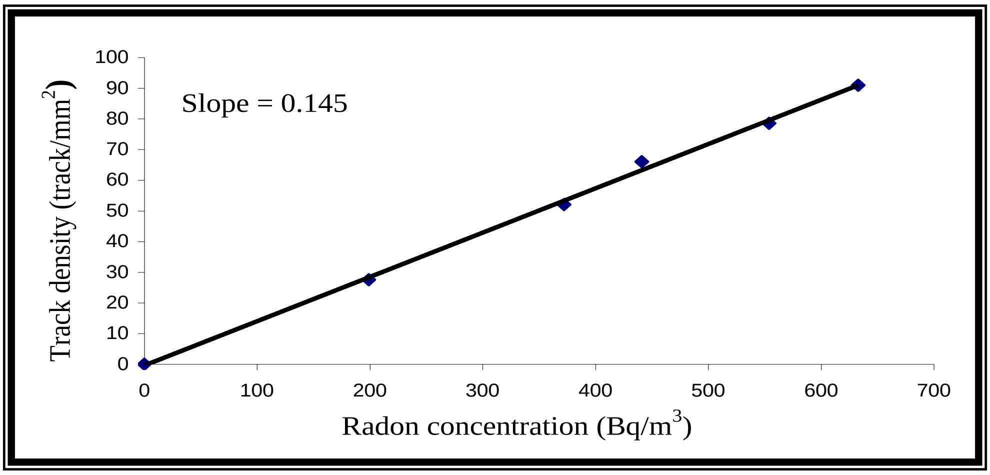

Fig.(3) relation of radon gas concentration and track density in soil standard samples.

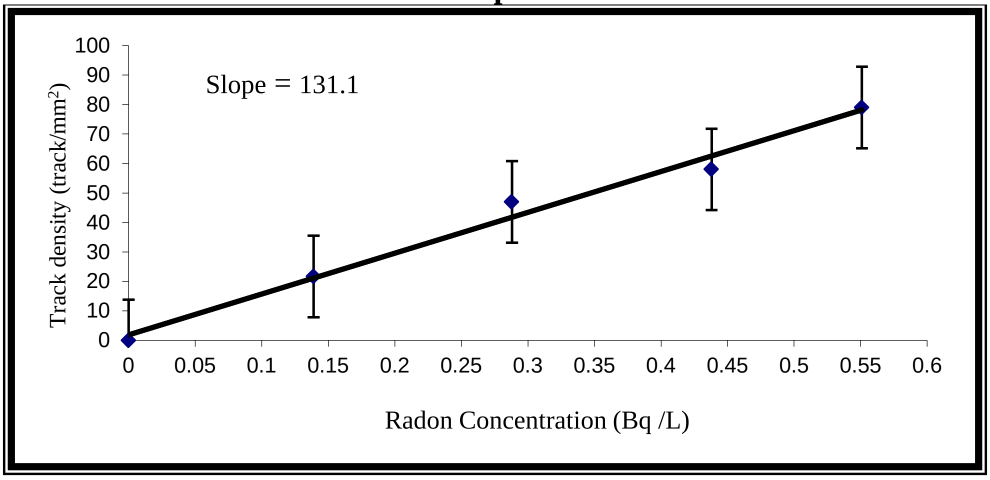

Fig.(4) relation of radon gas concentration and track density in water standard samples.

Table (1) shows the radon gas concentration C_{Rn} (Bq/m^3), radon exhalation rate (RER), for soil samples in Al-Najaf governorate.

No.	Region	C_{Rn} (Bq/m^3)				Mean of C_{Rn} (Bq/m^3)	(RER) (μBq/m^{2}h)
		1	2	3	4		
1	Al-Forat	44	48	54	58	51.0±4.0	46.67
2	Al-Askary	32	37	37	48	38.5±4.7	35.23
3	Tamoz	65	66	70	72	68.25±2.7	62.46
4	Al-Motanaby	48	54	57	61	55.0±4.0	50.33
5	Meassan	43	48	54	59	51.0±5.5	46.67
6	Al-Askan	59	64	71	82	69.0±7.7	63.15
7	Al-Moalmen	92	94	104	110	100.0±7.0	91.52
8	Al-Karama	78	84	88	96	86.5±5.5	79.17
9	Al-Zahraa	43	45	56	62	51.5±7.0	46.67
10	Al-Jamhorah	64	66	74	84	72.0±7.0	65.89
Average						**64.23±14.9**	**58.77±13.6**

Table (2) radon gas concentration C_{Rn} (Bq.L^{-1}), annual effective dose (AED), for tap water samples in Al-Najaf governorate.

No.	Region	C_{Rn} (Bq.L^{-1})				Mean of C_{Rn} (Bq.L^{-1})	(AED) (μSv/y)
		1	2	3	4		
1	Al-Forat	0.16	0.20	0.33	0.43	0.28±0.1	1.02
2	Al-Askary	0.34	0.42	0.54	0.57	0.46±0.08	1.80
3	Tamoz	0.21	0.25	0.43	0.57	0.36±0.13	1.31
4	Al-Motanaby	0.43	0.43	0.49	0.53	0.47±0.04	1.17
5	Meassan	0.43	0.60	0.63	0.71	0.59±0.08	2.15
6	Al-Askan	0.33	0.34	0.41	0.54	0.40±0.07	1.46
7	Al-Moalmen	0.21	0.25	0.32	0.43	0.30±0.07	1.09
8	Al-Karama	0.24	0.30	0.36	0.47	0.34±0.07	1.24
9	Al-Zahraa	0.22	0.23	0.34	0.38	0.29±0.06	1.05
10	Al-Jamhorah	0.11	0.13	0.17	0.23	0.16±0.04	0.58
Average						**0.36±0.1**	**1.28±0.31**

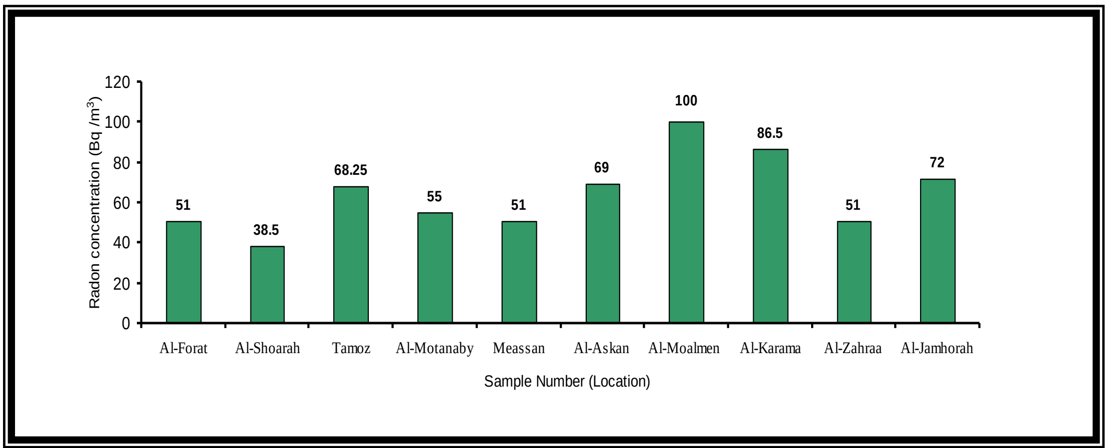

Fig.(5) A histogram illustrating the change in radon gas concentration (Bq/m^3) in soil samples in all regions studied.

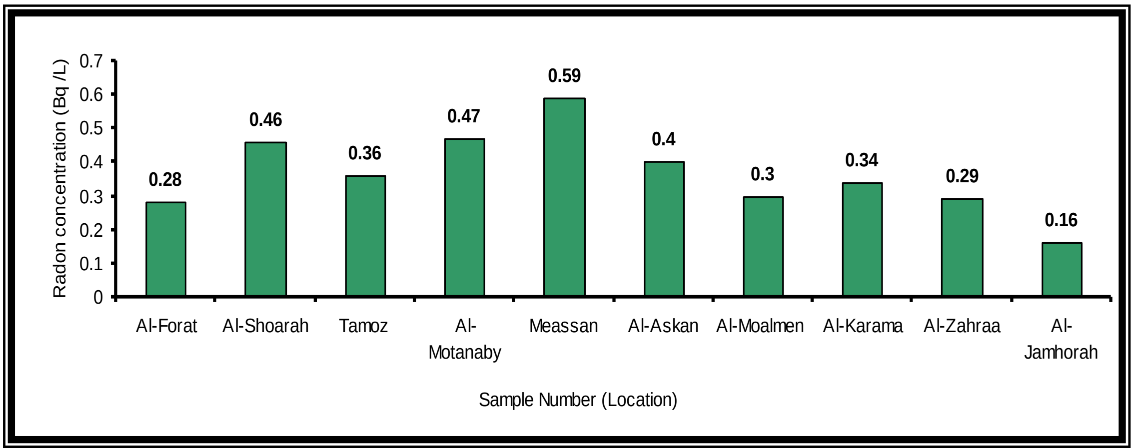

Fig.(6) A histogram illustrating the change in radon gas concentration (Bq/L) in water samples in all regions studied.

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قياس تركيز غاز الرادون في نماذج من التربة والمياه في محافظة النجف باستخدام كاشف الأثر النووي (CR-39)

تغريد خالد حميد

قسم الفيزياء ، كلية التربية ، الجامعة المستنصرية

الخلاصة:
في هذا البحث تم قياس تركيز غاز الرادون في نماذج بيئية (تربة و مياه) ولمناطق مختلفة من محافظة النجف وذلك باستخدام تقنية عد آثار جسيمات الفا المنبعثة من غاز الرادون في كاشف الأثر النووي (CR-39). تضمن الجزء الأول تحديد تركيز غاز الرادون في التربة ، وكانت النتائج تشير النتائج إلى ان أعلى معدل لتركيز غاز الرادون في التربة كان في منطقة المعلمين (100.0 ± 7.0 Bq/m^3) بينما اقل معدل لتركيز غاز الرادون كان في منطقة العسكري (38.5 ± 4.7 Bq/m^3) وبمعدل (64.23 ± 14.9 Bq/m^3), النتائج الحالية كانت ضمن الحدود المسموحة للوكالة الدولية للوقاية من الإشعاع (200 Bq/m^3)، بينما نسبة انبعاث الرادون تتراوح بين (91.52-35.23 µBq/m^{2}h) وبمعدل (58.77 ± 13.6 µBq/m^{2}h) .
الجزء الثاني تضمن تحديد تركيز غاز الرادون في مياه الحنفية تم جمعها من شبكات المياه في المنازل في محافظة النجف ، وكانت النتائج تشير إلى ان أعلى معدل لتركيز غاز الرادون في المياه كان في منطقة ميسان (0.59 ± 0.08 Bq/L) بينما اقل معدل لتركيز غاز الرادون كان منطقة الجمهورية (0.16 ± 0.04 Bq/L)، وبمعدل (0.36 ± 0.1 Bq/L) . النتائج الحالية كانت ضمن الحدود المسموحة للوكالة الدولية للوقاية من الإشعاع (0.5994 Bq/L)، بينما نسبة انبعاث الرادون تتراوح بين (2.15-0.58 µSv/y) وبمعدل (1.28 ± 0.31 µSv/y).

الكلمات المفتاحية: تركيز الرادون، تربة، نسبة انبعاث الرادون، كاشف الاثر النووي (CR-39) .