Measurement of the radon gas emanation from drinking water samples from regions in northwest Baghdad governorate by using nuclear track detector (CR-39)

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Abstract

In the present work, we have measured the radon gas concentration in water samples were taken directly from drinking water (tap water) in sites houses was carried some region in northwest Baghdad governorate by using alpha-emitters registrations which are emitted from radon gas in (CR-39) nuclear track detector. The results of measurements indicate that the highest average radon concentration in water samples was found in Al-Washash region which was (0.36±0.01 Bq/L), while the lowest average radon gas concentration was found in (Al-Taji) region and (Al-Jihad) region which was equal to (0.15±0.01 Bq/L), with an average value of (0.129±0.02 Bq/L), the present results show that the radon gas concentrations in drinking water in the northwest Baghdad governorate is below the allowed limit from Environmental Protection Agency (EPA, 2000).

Keywords: :radon concentration , Baghdad governorate, drinking water ,CR-39.

قياس غاز الرادون المنبعث من نماذج مياه الشرب لمناطق من شمال غرب محافظة بغداد باستخدام كاشف الأثر النووي (CR-39)

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الخلاصة

في هذا البحث تم قياس تركيز غاز الرادون في نماذج مياه اخذ مباشرة من ماء صالح للشرب (ماء حنفية) من المنازل لبعض المناطق من شمال غرب محافظة بغداد وذلك باستخدام تقنية عد آثار جسيمات الفا المنبعثة من غاز الرادون في كاشف الأثر النووي (CR-39). وكانت النتائج تشير إلى ان أعلى معدل لتركيز غاز الرادون في المياه كان في منطقة الوشاش (0.36±0.01 Bq/m^3)، بينما اقل معدل لتركيز غاز الرادون كان في منطقة التاجي ومنطقة الجهاد (Bq/m^3

0.15±0.01)ومعدل التراكيز (Bq/L 0.02±0.129) ،النتائج الحالية تبين ان تراكيز غار الرادون في مياه الشرب لبعض المناطق من شمال غرب بغداد كانت ضمن الحدود المسموحة لوكالة حماية البيئة لعام ٢٠٠٠.

الكلمات الافتتاحية : تركيز الرادون ، محافظة بغداد ، مياه الشرب ، (CR-39) .

Introduction

Radon (^{222}Rn) is a radioactive gas with a half- life time is about (3.825 d). It is produced by the decay of naturally occurring radionuclide (^{226}Ra), which is in turn is a decay product in the uranium (^{238}U) series. Thoron gas (^{220}Rn) , which is a radon isotope, is a decay product in the thorium (^{232}Th) series. The half- life of thoron is about (56 s) which is much shorter than that of radon. Because of such a short half-life of thoron. Its emanation from building materials, as well as, its infiltration from the ground and further migration is restricted to a few centimeters only. When radon is inhaled into the lungs it decays by means of alpha-emission which causes ionization damage when it strikes the lung tissue. Over time, this damage causes lung cancer [1].

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 water, rocks and soil, radon gas are ubiquitous - outdoors as well as indoors, the air that we inhale contains radon. The radon gas has been recognized as a radiation hazard causing excess lung cancer among underground miners [2].

The earth's crust contains trace amounts of ^{238}U and ^{232}Th which decay to radon and thoron gas respectively. Radon and two of its daughters, ^{218}Po and ^{214}Po, are alpha emitters, while ^{214}Pb and ^{214}Bi are beta or gamma emitters [3]. Inhalation of radon and thoron alpha daughters poses a radiation health hazard to the lungs and the physical half life of radon is 3.825 days and half-elimination time from lungs 30 min. However, thoron is often ignored in these studies because of its short half-life ($t_{1/2}$ = 55.3 seconds) and the fact that it is generally lower in concentration than ^{222}Rn in geological material [4]. Health an implication of radon in drinking water (The source of drinking water, such as spring water, river water, Artesian well water… etc considering an important factor for limiting radon levels in drinking water) refers to ingestion of dissolved radon will result in a radiation dose to the lining of the stomach. Moreover, inhalation of radon gas that has been released from drinking water will contribute to the radon content of indoor air and if inhaled will result in a radiation dose to the lung. Long-term exposure to high concentrations of radon in indoor air increases the risk of lung cancer [5]. The aim of the present work is to

determine the radon gas concentration in drinking water for selected regions in northwest Baghdad governorate by using alpha-emitters registrations which are emitted form radon gas in (CR-39) nuclear track detector by using the sealed-cup technique.

Experimental Methods

Detection Material

CR-39 is the most popular member of the solid state nuclear track detectors (SSNTDs) family it was selected because of its good sensitivity, stability against various environmental factors and high degree of optical clarity. Pershore moulding, Ltd., in UK supplied large sheets of CR-39. Sheets of 500 μm thickness were used for robustness and to avoid the possibility of tracks on the back surface being detected by the image analyzer, and the sheets were cut into square shapes sized (1 cm ×1cm).

The Exposure

The drinking water were collected (1/4 litter) see Figure (1) ,volume of samples of drinking water were also collected from the same sites in Baghdad governorate [6]. The drinking water obtained from the water networks in sites houses. After one month of exposure the detectors were etched chemically in NaOH solution for 6.25 N at temperature 70°C for 8 hours. After the etching, the detectors were washed for 30 minutes with running cold water, then with distilled water and finally with a 50% water/alcohol solution. After a few minutes of drying in the air, the detector was ready for track counting. Etched tracks are observing by using an optical microscope (Olumps) fitted with an objective lens of 400 times magnification.

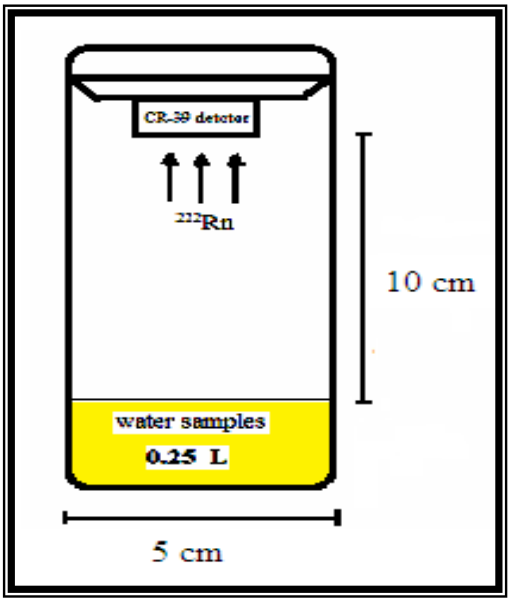

Figure (1) A schematic diagram of the sealed-cup technique in drinking water samples.

Radon Concentration Measurement

Ttrack density registered by using the relation [7]:

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

The radon gas concentrations in the drinking water samples was obtained by the comparison between track densities registered on the detectors of the sample and that of the standard water sample which are shown in Figure (2), using the relation[8]:

$$C_X = \rho_{X.} (C_S / \rho_S) \quad \ldots\ldots (2)$$

Where:

C_X : alpha particle concentration in the unknown sample.

C_S : alpha particle 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).

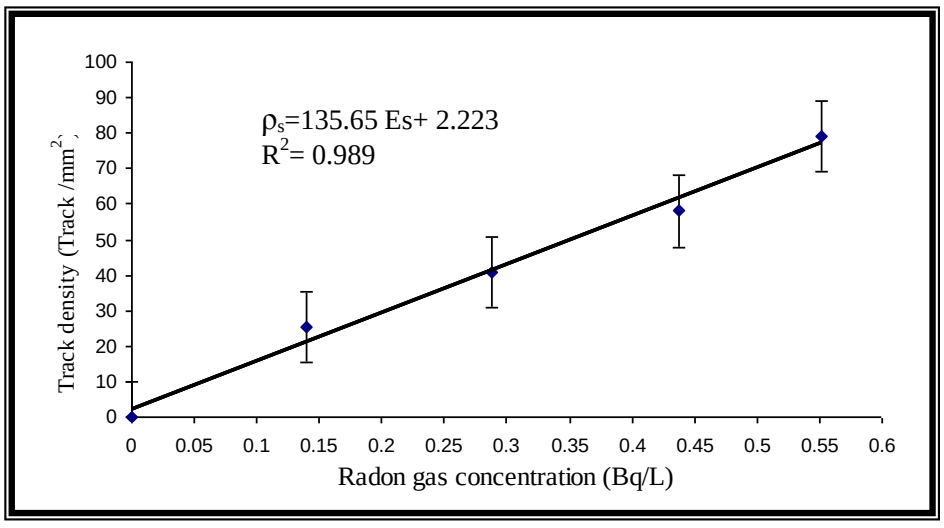

Figure (2) the relation of radon gas concentration and track density in water standard samples.

The annual effective dose in water

The annual effective dose of an individual consumer due to intake of radon from drinking water is evaluated using the relationship [9]

$$AED_w = C_w \, C_{Rw} \, D_{cw} \quad \ldots\ldots (3)$$

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} is the annual intake of drinking water (L/y)

D_{cw} is the ingested dose conversion factor for radon (Sv/Bq).

Calculation radon exhalation rate in soil and water samples

The radon exhalation rate of any sample is defined as the flux of radon released from the surface of the material. The surface exhalation rate (RER) in units $Bq.m^{-2}.h^{-1}$ can be calculated by [10]:

$$RER = \frac{CV\lambda}{A[T + \lambda^{-1}(e^{-\lambda T} - 1)]} \quad \ldots\ldots (4)$$

Where:

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

V: is the volume of air in the cup (m^3)

λ :is the decay constant for ^{222}Rn

A: is the surface area of the sample

T: is the exposure time (h)

Results and Discussion

In this survey, a total number of 12 drinking water samples were collected from various regions in the northwest Baghdad governorate by using the sealed-cup technique.

Table (1) present, radon gas concentration in drinking water samples from different regions in the northwest Baghdad governorate. It can be noticed that, the highest average radon gas concentration in drinking water samples was found in Al-Washash region which was equal to (0.36±0.01 Bq/L), while the lowest average radon gas concentration was found in (Al-Taji) region and (Al-Jihad) region which was equal to (0.15±0.01 Bq/L), see Figure (3), with an average value of (0.129±0.02 Bq/L). The highest value of annual effective dose (AED) in drinking water samples was found in Al-Washash region which was equal to (1.31 μSv/y) , while the lowest value of annual effective dose (AED) was found in (Al-Taji) region and (Al-Jihad) region which was equal to (0.55 μSv /y), see Figure (4), with an average value of (0.82±0.17 μSv/y), the highest value of radon exhalation rate (RER) in drinking water samples was found in Al-Washash region which was equal to (43.26 $\mu Bq/m^2h$), while the lowest radon concentration dissolved in drinking water samples was found in (Al-Taji) region and (Al-Jihad) (18.02 $\mu Bq/m^2h$) see Figure (5), with an average value of (26.94 ±5.7 $\mu Bq/m^2h$). The present results in Baghdad governorate show that the radon gas concentration in drinking water samples is below the allowed

limit from (EPA, 2000) which was equal to (11 Bq/L) [11], while the annual effective dose (AED) in all samples studies is below the normal limits of world which was equal to (1 mSv/y) [12], therefore the drinking water in northwest Baghdad governorate is safe as far as radon concentration is concerned.

Conclusions

The drinking water samples in all regions in northwest Baghdad governorate are lower than the recommended value of (11 Bq/L) reported by the Environmental Protection Agency (EPA, 2000).

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Table (1) radon gas concentration C_{Rn} ($Bq.L^{-1}$), annual effective dose (AED), radon exhalation rate (RER), drinking water samples in Baghdad governorate.

Location Sample	**C_{Rn} ($Bq.L^{-1}$)**				**Mean of C_{Rn} ($Bq.L^{-1}$)**	**(AED) (µSv/y)**	**(RER) ($\mu Bq/m^2h$)**
	1	**2**	**3**	**4**			
Al-Washash	0.34	0.35	0.37	0.39	0.36±0.01	1.31	**43.26**
Al-Kadamiyah	0.22	0.24	0.26	0.26	0.25±0.01	0.91	**30.04**
Al-Hurriya	0.16	0.2	0.22	0.25	0.21±0.02	0.77	**25.23**
Al-Taji	0.13	0.14	0.16	0.18	0.15±0.01	0.55	**18.02**
Al-Salaam	0.25	0.21	0.2	0.18	0.21±0.02	0.77	**25.23**
Al-Shula	0.2	0.18	0.18	0.15	0.18±0.01	0.66	**21.63**
Al-Jihad	0.12	0.15	0.15	0.18	0.15±0.01	0.55	**18.02**
Al-Atifiya	0.27	0.29	0.31	0.32	0.30±0.01	1.1	**36.05**
Al-Yarmouk	0.22	0.24	0.25	0.25	0.24±0.01	0.88	**28.84**
Al-Ghazaliya	0.14	0.14	0.16	0.18	0.16±0.01	0.58	**19.23**
Al-Mansour	0.18	0.21	0.23	0.26	0.22±0.02	0.8	**26.43**
Al-Mushahda	0.21	0.25	0.29	0.29	0.26±0.03	0.95	**31.24**
Average					**0.129±0.02**	**0.82±0.17**	**26.94 ±5.7**

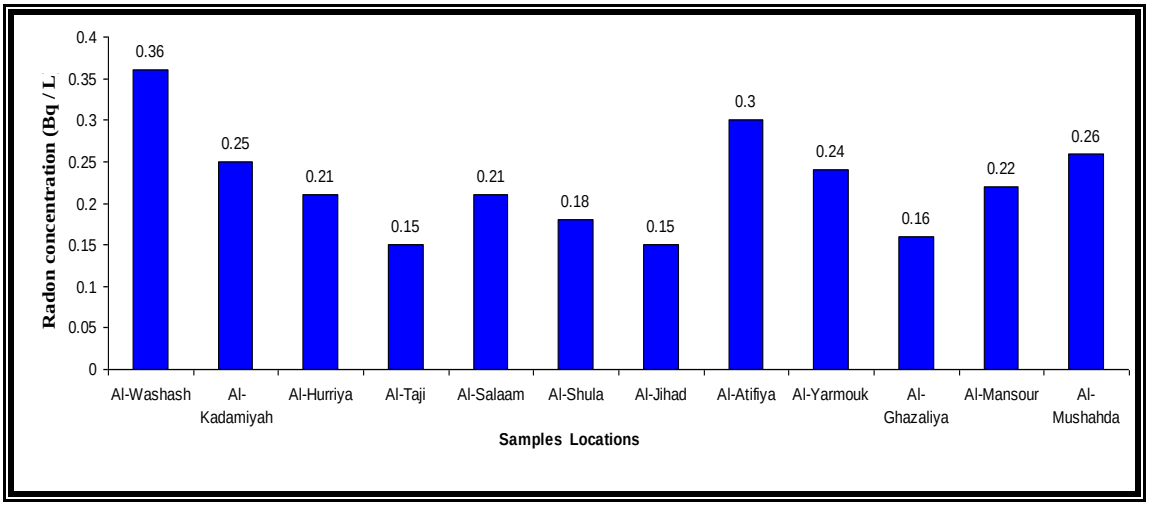

Figure (٣) a histogram illustrating the change in the radon gas concentration (Bq/L) in drinking water samples in all regions studied in north west Baghdad governorate.

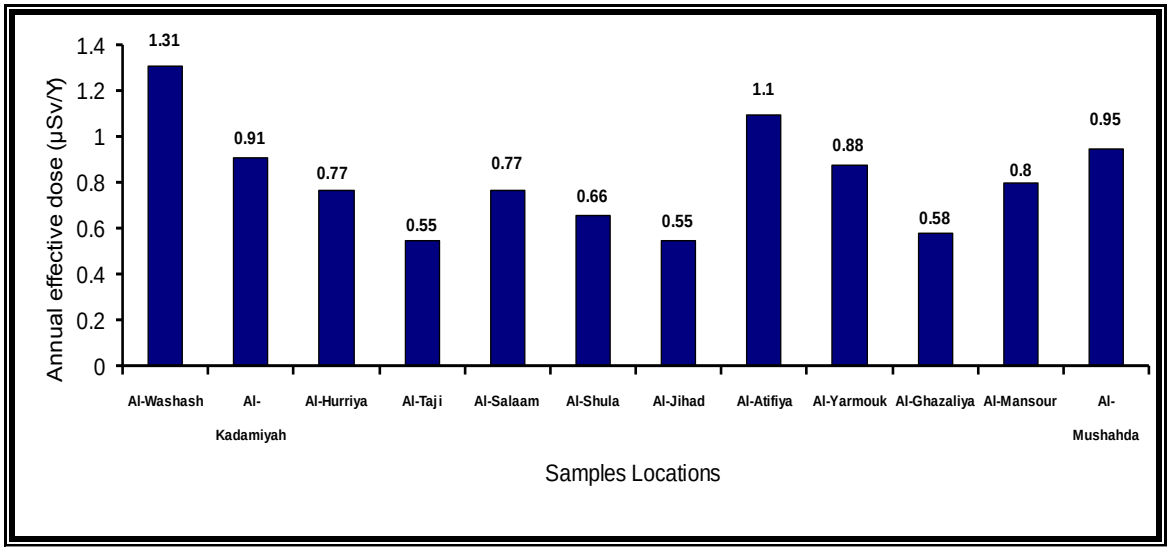

Figure (٤) a histogram illustrating the change in the annual effective dose (µSv/y) in drinking water samples in all regions studied in north west Baghdad governorate.

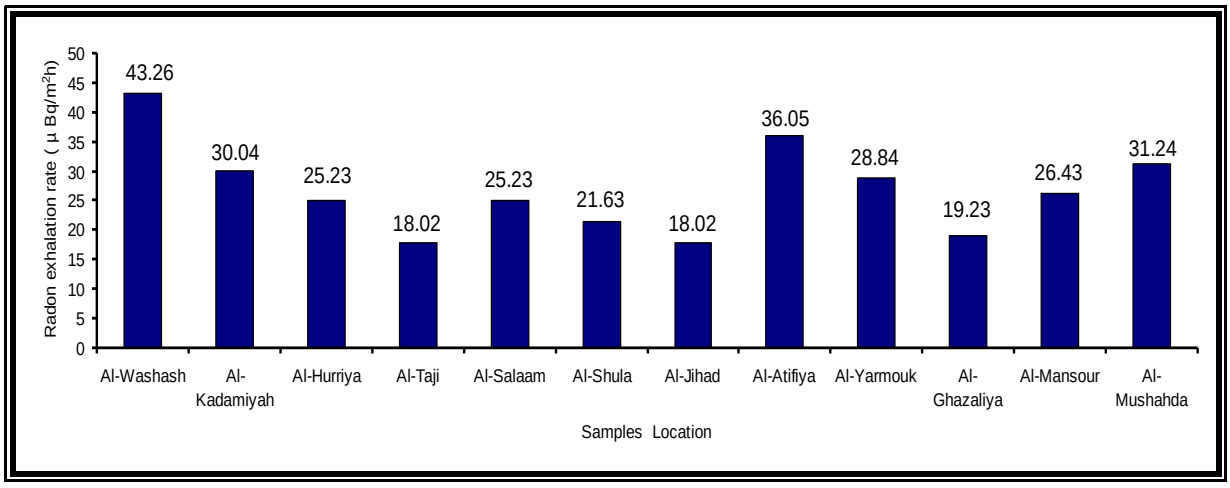

Figure (٥) a histogram illustrating the change in the radon exhalation rate (µBq/m^2h) in drinking water samples in all regions studied in north west Baghdad governorate.