JOURNAL OF COLLEGE OF EDUCATION
NO.1……2015

Determination of radon gas concentrations and annual effective dose in ground water samples in some regions in Anbar governorate

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Abstract

In this work, we have measured the radon gas concentration in the environmental ground water sample of some regions in Anbar governorate by nuclear track detector (CR-39). The results of measurements indicate that the highest average radon gas concentration in ground water samples was found in AL-Ratba region which was equal to (13.1±1.0 Bq/L), while the less average radon gas concentration was found in AL-Habbaneai region which was equal to (2.16±0.6 Bq/L), with an average value of (5.89±2.6 Bq/L). The annual effective dose in ground water samples varied from (0.33 mSv/y) to (0.05 mSv/y) ,with an average value of (0.145±0.06 mSv/y).

Keywords: radon concentration ,ground water, annual effective dose, CR-39.

حساب تراكيز غاز الرادون و الجرعة السنوية المكافئة في نماذج مياه جوفية في بعض مناطق محافظة الانبار

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الخلاصة

في هذا البحث تم قياس تركيز غاز الرادون في نماذج مياه جوفية لبعض مناطق من محافظة الانبار باستخدام كاشف الأثر النووي (CR-39) . كانت النتائج تشير إلى ان أعلى معدل لتركيز غاز الرادون في في نماذج مياه جوفية في محافظة الانبار كان في منطقة الرطبة والذي كان (13.1±1.0 Bq/L) بينما اقل معدل لتركيز غاز الرادون كان في منطقة الحبانية والذي كان (2.16±0.6 Bq/L) وبمعدل (5.89±2.6 Bq/L), الجرعة السنوية المكافئة في نماذج مياه جوفية تتراوح بين (0.33 mSv/y) الى (0.05 mSv/y) وبمعدل (0.145±0.06 mSv/y) .

Introduction

Radon (^{222}Rn) is a radioactive gas with a half- life of (3.82 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 (56 s) which is much shorter than that of radon [1].

The radon gas concentrations in ground water depend on lithology and other geological conditions of the region and also contamination from human activities such as the use of phosphate fertilizers, mining, and

combustion of coal or other fuels. The natural weathering of rocks such as granite dissolves the natural uranium, which goes into the ground water by leaching and precipitation called illumination process [2].

In the present investigations, the passive technique using the solid state nuclear track detectors (SSNTDs). Nuclear track detection technique based on radon measurement with CR-39 detector was used during the currently conducted study because of its simplicity and long-term integrated read out, high sensitivity to alpha-particle radiation ruggedness, availability and ease of handling [3].

Experimental part

Detectors CR-39) of thickness (250 μm) and area of about (1x1 cm^2) the samples of water were collected (1/2 litter) volume of samples of ground water were also collected from the same sites in Anbar governorate , after one month of exposure the detectors were etched chemically in NaOH solution for 6.25N at temperature 70°C for 6 hours. After the etching, the detectors were washed for 30 minutes with running cold water. After a few minutes of drying in the air, the detector was ready for track counting. The tracks were counted using an optical microscope having a magnification of 400X.

The radon gas concentration in the ground water samples were obtained by the comparison between track densities registered on the detectors of the sample and that of the standard water samples, using the relation [4] :

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

The radon gas concentration in ground water sampl`es were obtained by the comparison between track densities registered on the detectors of the sample, using the relation [5] :

$C_X = \rho_X . (C_S / \rho_S)$ ---------- (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).

The annual effective dose of an individual consumer due to intake of radon from ground water is evaluated using the relationship [6]

$AED_w = C_w C_{Rw} D_{cw}$ ---------- (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 ground water (Bq/L).

C_{Rw} = 730 L/y

$D_{cw} = 5 \times 10^{-9}$ Sv/Bq

Results part

This study was to measure the radon gas concentrations in ground water sampling 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 concentrations in ground water samples for selected regions in Anbar governorate. It can be noticed

that, the highest average radon gas concentration C_{Rn} in ground water samples was found in S_{10} AL-Ratba region which was equal to (13.1±1.0 Bq/L), while the less average radon gas concentration C_{Rn} was found in S_8 AL-Habbaneai region which was equal to (2.16±0.6 Bq/L), see Figure (1), with an average value of (5.89±2.6 Bq/L).

The highest value of annual effective dose (A.E.D) in ground water samples was found in S_{10} AL-Ratba region which was equal to (0.33 mSv/y), while the less value of annual effective dose (A.E.D) was found in S_8 AL-Habbaneai region which was equal to (0.05 mSv/y) , see Figure (2), with an average value of (0.145±0.06 mSv/y) .

All the present results show that the radon gas concentration in ground water samples is less than the recommended value of (11 Bq/L) reported by the Environmental protection agency (EPA) [7], apart from, (S_4 ,S_{10} , S_{19}) which were higher than the allowed limit given by (EPA), while the annual effective dose (A.E.D) in all samples study is below the normal limits of world which was (1 mSv/y) [8].

Conclusions

The ground water samples in some regions in Anbar governorate is safe as far as radon concentration is concerned , apart from, (S_4 ,S_{10} , S_{19}) which were higher than the allowed limit given by Environmental protection agency (EPA).

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Table (1) radon gas concentration C_{Rn} ($Bq.L^{-1}$), annual effective dose (A.E.D) in ground water samples.

Code No.	Regions	C_{Rn} ($Bq.L^{-1}$)					Mean of C_{Rn} ($Bq.L^{-1}$)	(AED) (mSv/y)
		1	2	3	4	5		
S_1	AL-Ramadi (AL-Taimeem Directorate)	6.2	6.6	7.3	7.7	8.2	7.2±0.6	0.18
S_2	AL-Ramadi (AL-Andalus District)	4.3	4.4	5.0	5.5	5.5	4.94±0.4	0.12
S_3	AL-Ramadi (AL-shurta District)	2.1	2.7	3.1	3.3	4.2	3.08±0.5	0.07
S_4	AL-Ramadi (AL-Warar District)	9.9	10.8	12.1	12.9	13.7	11.88±1.2	0.29
S_5	Treabeel	2.3	2.6	3.4	3.4	4.6	3.26±0.6	0.08
S_6	Arar	3.2	3.9	4.7	5.1	5.2	4.42±0.7	0.11
S_7	AL-Nakeab	1.8	2.5	2.9	3.8	3.8	2.96±0.6	0.07
S_8	AL-Habbaneai	1.1	1.7	2.4	2.6	3.0	2.16±0.6	0.05
S_9	AL-Waleed	4.2	4.7	5.0	6.2	6.4	5.3±0.8	0.13
S_{10}	AL-Ratba	11.4	12.4	12.9	14.1	14.7	13.1±1.0	0.33
S_{11}	Brawanna	3.4	3.8	4.5	4.7	5.6	4.4±0.6	0.11
S_{12}	AL-Hbarea	2.7	2.9	3.3	4.2	5.1	3.64±0.8	0.09
S_{13}	Aucashat	4.5	5.6	5.7	6.0	6.3	5.62±0.4	0.14
S_{14}	Hit (Kabesa District)	2.2	2.5	2.5	3.1	4.3	2.92±0.6	0.07
S_{15}	Hit (Zuea District)	3.4	3.7	4.4	5.3	5.7	4.5±0.8	0.11
S_{16}	Hit (Mradea	4.5	4.7	4.7	5.2	5.8	4.98±0.4	0.12

	District)							
S_{17}	**Hadetha**	**6.3**	**6.8**	**7.1**	**7.9**	**7.9**	**7.2±0.5**	**0.18**
S_{18}	**Anah**	**2.2**	**3.2**	**3.6**	**4.4**	**4.7**	**3.62±0.7**	**0.09**
S_{19}	**Al-Qaim (AL-Abedi District)**	**11.1**	**11.6**	**12.4**	**13.1**	**14.0**	**12.44±0.8**	**0.31**
S_{20}	**Al-Qaim (AL-Resala District)**	**8.1**	**9.6**	**10.8**	**11.6**	**11.6**	**10.34±1.1**	**0.26**
Average							**5.89±2.6**	**0.145±0.06**

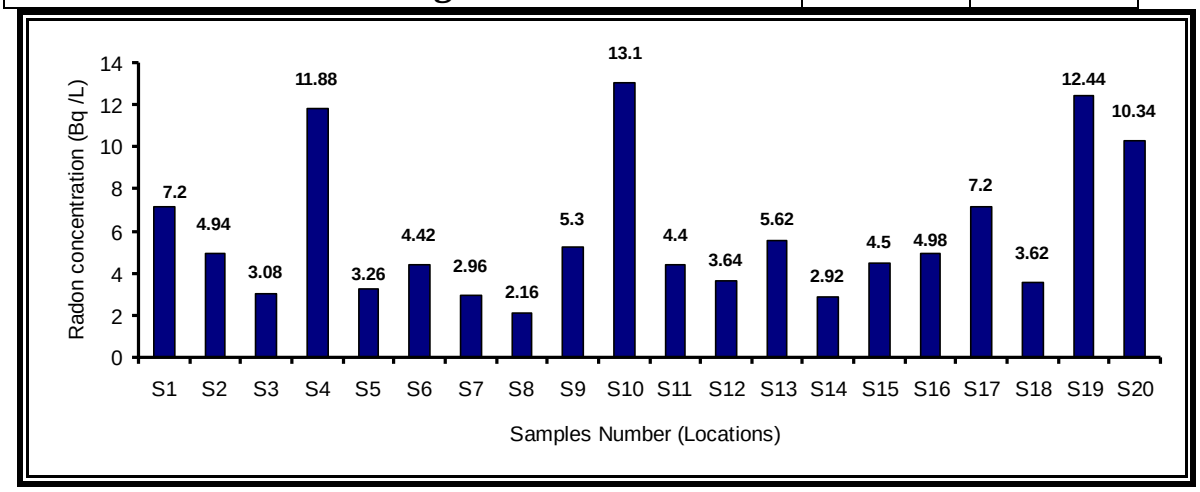

Figure (1) a histogram illustrating the change in the radon gas concentration (Bq/L).

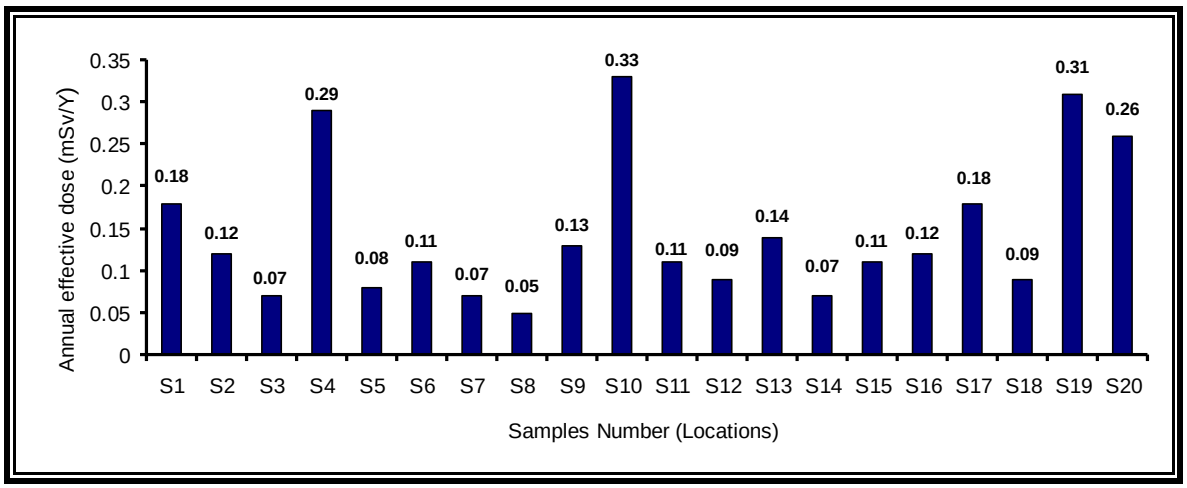

Figure (2) a histogram illustrating the change in annual effective dose (mSv/y).