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Calculation of Radon Gas Concentrations and Effective Dose of Al-Hindia, Euphrates River in Karbala Governorate Using RAD7

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Abstract

In this research, the radon gas concentration was measured for samples from the water of the Euphrates River in the Hindia district of Karbala governorate. The selected collection locations were 30 different local ones on the river between the ancient and modern bridges, heading north and south, respectively; the distance between locations was 100 meters. The concentrations and effective dose of radon were measured using the RAD7 device technology. The highest value was for sample 21, where the effective dose was (0.00001752 Bq/m^3). The same value for the effective dose was of sample 7. The lowest value was in sample 27, where the effective dose was (0 Bq/m^3), the same value of sample 3. It was observed from the study that the remaining values of the samples ranged from sample 1 as the lowest value of the effective dose (0.0799 Bq/m^3) and also for sample 2 and sample 15. The highest value was for samples 29 and 23, where the value of the effective dose was (0.00001314 Bq/m^3). However, from observing the results, these values are within the internationally permissible limits according to the recommendations of US Environmental Protection Agency, which is 11 Bq/ L.

Keywords: Effective dose, Rad7, Radon gas

حساب تراكيز غاز الرادون و الجرعة الفعالة في نهر الفرات في قضاء الهندية من محافظة كربلاء باستخدام جهاز راد7

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الخلاصة

في هذا البحث تم قياس تراكيز غاز الرادون في نهر الفرات في قضاء الهندية. تم اختيار عينات من مياه نهر الفرات في قضاء الهندية بمحافظة كربلاء من 30 موقع مختلف على النهر بين الجسور القديمة والحديثة المتجهة شمالا وجنوبا على التوالي, وتبلغ المسافة بين كل عينتين 100 متر حيث تم قياس تراكيز الرادون والجرعة الفعالة باستخدام تقنية جهاز 7RAD وكانت اعلى قيمة للعينة21 حيث كانت الجرعة الفعالة (0.00001752بيكريل/م^3) .ايضا نفس القيمة للجرعة الفعالة من العينة7. كانت اقل قيمة في العينة27, حيث كانت الجرعة الفعالة (0بيكريل/م^3),وكذلك نفس القيمة للجرعة الفعالة في العينة3. لوحظ من الدراسة ان القيم المتبقية للعينات تتراوح من 1 كأدنى قيمة للجرعة الفعالة (0.0799بيكريل/م^3)والعينة 2 والعينة 15 تشترك معها .كانت اعلى قيمة للعينة 29 و 23حيث كانت قيمة الجرعة الفعالة (0.00001314) بيكريل/م^3

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ومع ذلك ، من خلال مراقبة النتائج ,يمكننا القول انها كانت ضمن الحدود المسموح بها دوليا وفقا لتوصيات وكالة حماية البيئة.

1. Introduction

Radon gas is a natural gas soluble in water and is odorless and colorless. Radon is an inert gas, heavier than air, with a density of 9.7 kg/m^3; as a result, it accumulates with time in poorly ventilated places [5]. It is a radioactive gas, meaning that other elements are formed when it decomposes. The rate of radioactive decay of radon is determined by its half-life. Half-life can be defined as the time required for half of the radioactive element to decay. The half-life of radon is 3.8 days. The main source of radon is through the radioactive decay of uranium. For this reason, it was discovered that the amount of radon is higher in places where uranium-rich rocks such as granite rocks are found [1]; also, the earth crust contains trace amounts of ^{235} U and Th^{232} which decompose into Rn^{220}.

The earth's crust contains trace amounts of ^{238}U and ^{232}Th, which decay to ^{222}Rn and ^{220}Rn, respectively [2], thus building up significant concentrations of (^{222}Rn) and two of its daughters, (^{218}Po) and (^{214}Po), which are alpha emitters, while (^{214}Pb) and (^{214}Bi) are beta and gamma emitters. ^{222}Rn represents the most important radon isotope [3]. The main sources of radon are soil and water, which produces about 80% of radon from the upper layer of the earth; moreover, the building materials made from the soil and rocks, such as cement and bricks, contain radioactive materials of a natural origin such as uranium and radium generating radon and these radionuclides contribute to the radioactive radiation background [4].

There is natural radiation around us everywhere, and its source is rocks and soil as part of it comes to us from the sun and stars, called cosmic rays.
Therefore, higher radon amounts are commonly detected in areas underlined by granites and similar rocks that usually contain high amounts of uranium, where the rate of these gamma rays increases with height above the surface of the earth. In the second half of the twentieth century, the use of radiation technology and nuclear reactors began increasing the sources of radiation around us.

2. Sources of radioactive Background:

1- Radioactivity within the human body. The human body radiates from the inside through the air it breathes, food and water. The air is the main source of the radiation dose, and its main source is radon gas present in the earth's atmosphere and generated by the spontaneous decomposition of uranium-238 found naturally in the rocks of the earth's crust. Likewise, the food that humans eat, whose source is the soil, absorbs this substance and enters into its composition; some of the dust that falls on plants contains traces of these radioactive substances. The radioactive substances also enter the human body with the drinking water, just as all the bodies of living organisms contain the radioactive carbon isotopeic-14 [6,7].
2- Natural radioactivity in the earth's crust: Among the most important radioactive elements in the rocks of the earth's crust are potassium 40, rubidium 87 and the two series of radioactive elements generated from the decomposing of uranium-235 and thorium-232. There are approximately forty radioactive isotopes. The half-lives of the basic radioactive elements in the rocks of the earth's crust are very long. That's why they have remained in the earth until now, and the level of radioactive activity in the earth's crust is very close to the earth surface. There are places on earth where natural background radiation is high because of the high concentrations of the naturally radioactive elements present in rocks of the earth's crust [8,9].

2- Manufactured radiation: Scientists have been able to produce about 1,300 radioactive isotopes. The most important manufacturing radioactive sources are nuclear reactors, neutron sources, gamma-ray sources, and electronic accelerators [10,11].

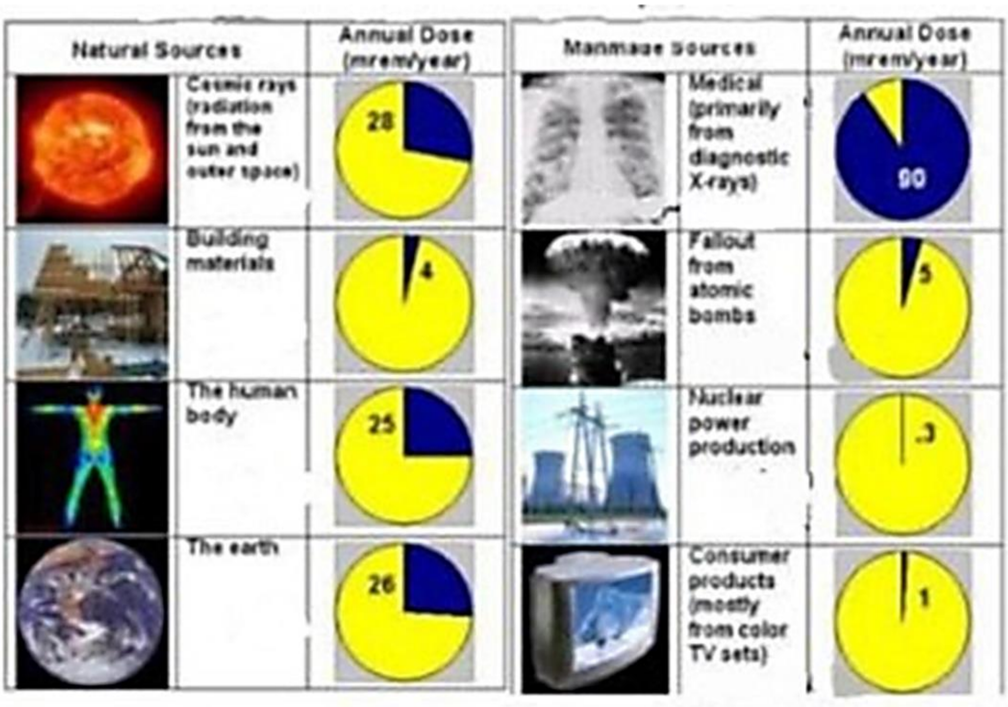

Figure 1: High energy radiation sources [8]

3. Study Area

Al-Hindia district is one of the districts of Karbala governorate. The area of the district, after adding the Al-Khairat sub-district to it in 1987 AD, is about 157 km. It is about 20 km east of the city of Karbala and almost the same distance west of the city of Hilla; it is located in the middle of the distance between Hilla and Karbala. It is situated on the banks of the river or Shatt al-Hindiya, one of the branches of the Euphrates River, which is connected to the Hilla River. It has a population of about 230,000 people, according to the 2014 census, and is located at latitude (442218331E) and longitude (3253887N). The location of the district in relation to the administrative units is shown in the map in Figure 2.

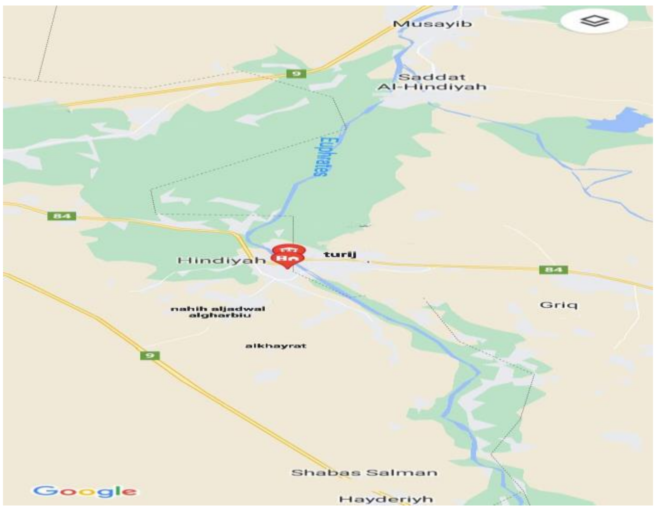

Figure 2: Map of administrative units by sub-district in Karbala

4. **Experimental method**

Thirty water samples (250 ml volume each) were collected from different areas of the Euphrates River in Al-Hindia district. The samples were placed in a closed container and then placed in the Rad7 device for forty-five minutes to measure the radon concentration. The Rad7 device is a versatile device used to detect radon gas. It is an advanced device widely used in research and laboratories for various purposes. The device is made by Durridge Company Inc. Using Drystik in the Rad7 experiment. The activity remaining at the background is short-term in the detector after the air sample is rinsed from the measuring chamber, the higher the radon concentration and the longer the sample stays in the cell, the more activity for the daughter who gives birth to her successor. Radon capture graph test is drawn to show the concentration, temperature and humidity on the right side of the recorder screen while the older readings move to the left and the recorder contains a set of controls to start and stop tests. Rapid response to radon gas in water can be monitored BAL DURRIDGE is an accessory to RAD7 where air passes through RADAQUA to measure the rapid and continuous response to radon. It is possible to filter water completely and keep it completely dry for the duration of the measurement. The Drystik needle valve must be set so the sample can be aerated without any water entering and damaging the sensitive equipment. After closing the needle valve and operating with a 100% duty cycle, there will be some bubbles in the vial. The graph recorder displays a graph with a test graphic where a set of virtual pens plot concentration, temperature and humidity data along the right side of the recorder screen. The recorder comes with a set of controls for starting and stopping tests. Below the controls is a status display panel with a detailed readout. From which all necessary data about the sample can be taken.

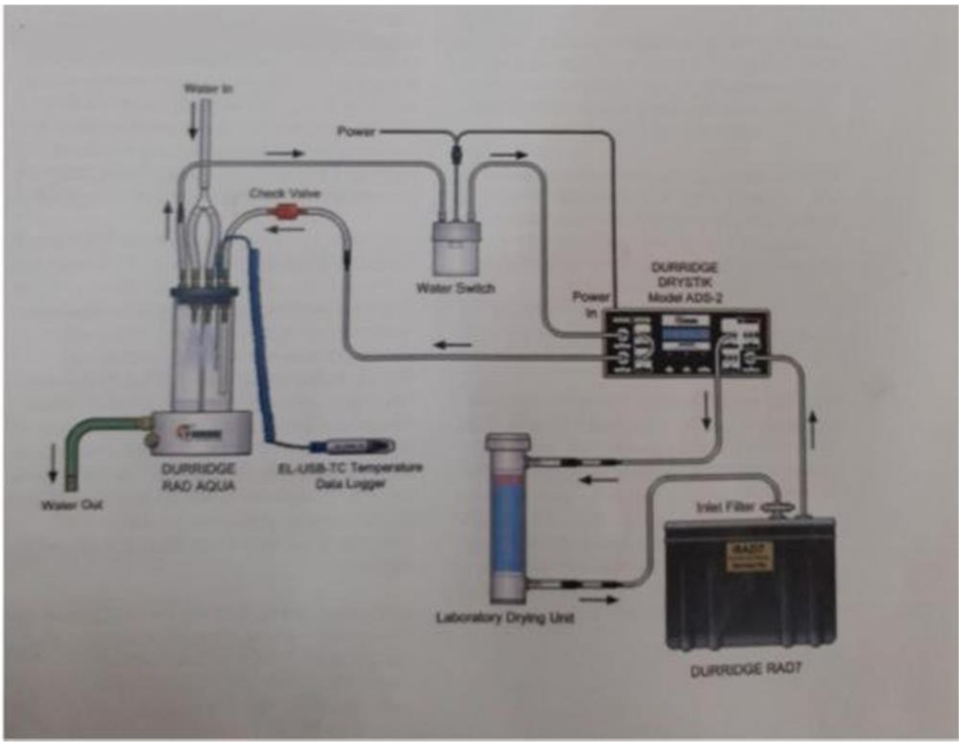

Figure 3: Components of Rad H_2O connected with the Rad7

5. Detector Mechanism and efficiency of Rad7

Radon is a radioactive gas that decays by emitting alpha particles to give a series of radioactive nuclides. Its measuring process is based on detecting the alpha particles using a solid-state alpha detector (usually silicon). The effective dose is calculated by equation (1)[2]:

$$D_{w=}C_w \;\; CR_w DC_w \tag{1}$$

Where*:* DC_w is the effective dose, C_w is the radon concentration in the water (Bq\m^3) and CR_w is the amount of consumption (1095 L\y)

6. Results and Discussion

The water samples were taken from different places of the river in the study area. This water is raw water, which people of the region depend on for their daily uses after filtering and converting it into potable water. At the public network water, water is kept for a period of time for treatment, storage and distribution. Therefore, it is sufficient for radon to dissolve in water before it reaches buildings.

Table 1 shows the results of the water samples of the study taken from different places of the river. It was noted that there was more than one sample with the same value of concentration and effective dose due to the different geological nature of rocks and soils. The obtained results were compared with the allowable limit value set by the US Environmental Protection Agency (EPA); the upper allowable limit for radon concentration in water is 0-0.5 Bq/m^3. Radon gas concentrations in the water samples ranged between 0 and 0.12Bq/m^3; All samples were within the limits set by the World Health Organization [7]. The highest concentration of radon gas was for samples 8, 16 and 23 of 0.12 Bq/m^3; the lowest concentration was for samples 3 and 27 of 0 Bq/m^3. Table 1 also shows that the highest value of the effective dose was 000001314 Bq/m^3, and the lowest was 0 Bq/m^3. The total average radon gas concentration in different sites was 0.06523Bq/m^3.

Table 1: The rate of radon concentration and effective dose for each sample

e Sample	Low	High	Mean(Bq\m^3)	D_W(MSv\Y)	Sample locations
W1	0	160	0.0799+-0.0002	0.00874902	0441307570E 32018932N
W2	0	160	0.0799 +-0.0006	0.00874902	0441307304E 320225332N
W3	0	0	0	0	044130702E 320271433N
W4	0	320	0.08+-0.0005	0.00000876	04413067364E 320314832N
W5	0	320	0.08+-0.0004	0.00000876	0441306552E 32346032N
W6	0	480	0.2397+-0.0009	0.026247	0441306356E 320376032N
W7	0	320	0.16+-0.0007	0.00001752	0441306155E 320408432N
W8	0	320	0.12+-0.0006	0.00001314	0441305879E 3204511332N
W9	0	480	0.159+-0.0001	0.00174102	0441305632E 320493732N
W10	0	160	0.04 +-0.0003	0.00000438	0441305441E 32521832N
W11	0	159	0.0397 +-0.0004	0.00434715	0441305250E 3205506032N

W12	0	320	0.1592 +-0.0008	0.00174324	0441305085E 320580332N
W13	0	160	0.04 +-0.0008	0.00000438	0441304838E 320616332N
W14	0	150	0.0398+-0.0007	0.00043281	0441304590E 320651832N
W15	0	320	0.0799+-0.0005	0.00087482	0441304324E 320688932N
W16	0	160	0.12 +-0.0004	0.00001314	0441304008E 320733832N
W17	0	160	0.04 +-0.0001	0.00000438	0441304709E 320852632N
W18	0	636	0.159 +-00.0003	0.00174102	0441304339E 32890132N
W19	0	320	0.159+-0.0002	0.00174102	0441304013E 320926332N
W20	0	160	0.0797 +-0.0003	0.00872719	0441303662E 320959132N
W21	0	320	0.16 +-0.0001	0.00001752	0441303296E 320997132N
W22	0	160	0.04 +-0.0002	0.00000438	0441302916E 33037033N
W23	0	320	0.12 +-0.0002	0.00001314	0441302500E 32085632N
W24	0	320	0.0797+-0.0001	0.00872719	0441302110E 330117132N
W25	0	160	0.0797+-0.0005	0.00872719	0441301676E 33161133N
W26	0	320	0.0797+-0.0006	0.00872719	0441301433E 33202832N
W27	0	0	0	0	0441300739E 33257732N
W28	0	160	0.04 +-0.0002	0.00000438	0441300248E 330293332N
W29	0	320	0.12 +-0.0008	0.00001314	0441300003E 330394233N
W30	0	320	0.239 +-0.0005	0.00261705	0441209805E 33394233N

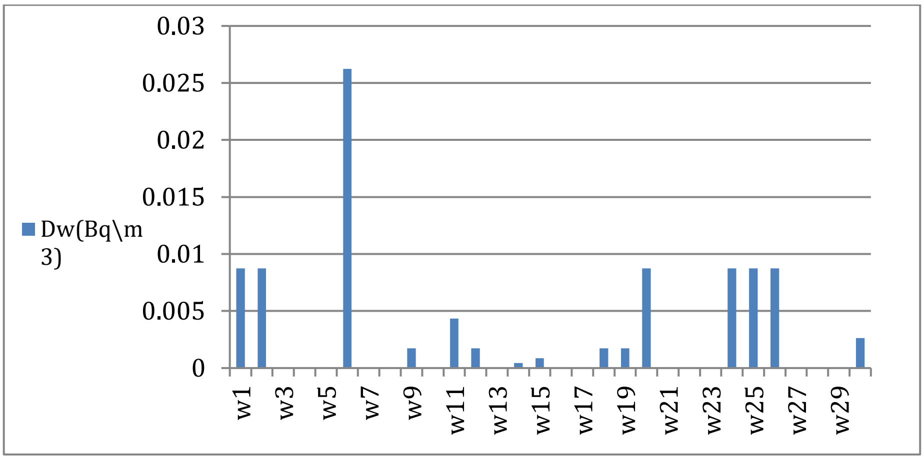

Figure 4: Statistical distribution of the effective dose of the samples.

7. Conclusions

This study shows that the rate of radon gas concentrations in water of the Euphrates River in the Hindia district of Karbala Governorate is high in some regions and low in others. This is due to the nature of the earth's components, environmental conditions, seasons and the movement of water and its constant change, which leads to the deposition of radionuclides. The presence of high radon gas concentrations in the surface water is low compared to that of the underground water. According to WH, the total average radon gas concentration in the drinking water is within the allowed levels.

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