

# Measurement and Study on the Concentration of Radioactive Radon Gas in Selected Sample of Artesian Groundwater in the Vcinity of Al-Zubair District, Basra Governorate/ Iraq

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## Abstract

This study included measuring the concentration of radioactive radon gas in selected samples of artesian groundwater in the vicinity of Al-Zubair district. Fifty-two sample were collected from that region in Basra Governorate, southern Iraq, using the electronic radon detector RAD-7. Mean of radon gas concentration and the standard deviation mean were calculated and its value was  $(0.08 \pm 5.392)$ , The annual effective dose rate was  $(1.189 \text{ E-}05)$ , and thus the concentration of radon gas in the groundwater was within the natural limits set by the competent organizations, as the maximum allowable limit for the concentration of radon gas in the water according to the EPA agency was  $(11.1 \text{ Bq.L}^{-1})$ . The paper topic was chosen because topic due to the importance of groundwater in the Al-Zubair district for desalination of drinking water and irrigation of agricultural crops such as tomatoes, eggplant, onions, vegetables and palms in the region.

## 1. Theoretical Part

Radon is located in the group of noble elements containing helium, neon, argon, krypton, and xenon of the periodic table. Radon atoms are similar to the atoms of all noble gases, as they rarely interact with other atoms to form molecules, so radon can flow freely through porous materials because it does not interact chemically. Radon gas is colorless and odorless and cannot be detected by human senses or by any traditional method. Therefore, its detection depends mostly on the radiation accompanying its disintegration and its disintegration products. Radon gas has a melting point of  $(-71^\circ \text{ C}$  or  $-96^\circ \text{ F})$  and a boiling point  $(-61.7^\circ \text{ C}$  or  $79.1^\circ \text{ F})$  [ 1] and it dissolves greatly in toluene. For this, toluene is used in the extraction of gas radon from the water. Groundwater usually contains a high concentration of radon gas. Also, igneous coal absorbs radon gas, so it is used to remove radon gas from water and to measure the concentration of radon in the air. Approximately 80% of the radon gas in the atmosphere emanates from the boiling layers of the earth's crust. Radium and uranium are the basic predecessors of radon.

Radon is a chemically inert gas, its atomic number is 86 .It has three radioactive isotopes: radon  $^{222}\text{Rn}$ , thoron  $^{220}\text{Rn}$ , and actinon  $^{219}\text{Rn}$ . Known in geological and environmental studies, it is the isotope 222 due to its relatively long half-life (3.83) days, while the role of the other two isotopes, , can be neglected due to its short life. Their half-lives ar( 56) seconds in a row [ 2 ]Radon becomes a problem in housing and various places of residence because it leaks continuously from groundwater and soil to the space of dwellings, especially the basements and

the ground floor, its concentration is more than the upper floors, natural gas and water from other sources that emit radon In homes, as radon moves with water through pipes and the water cycle in nature, and when water is used in household chores such as washing, cooking, and cleaning, where radon dissolved in water is emitted due to the movement of water during use into the air around us, and thus it is inhaled with the air during breathing, during bathing, and in household uses[3].

In the area surrounding Al-Zubair district, from which the examined samples were taken, most of the houses use groundwater directly in watering crops, washing and other household uses except for drinking.

Radon gas penetrates through the cracks in the walls and joints in the floors of the houses and is released when watering the winter crops in the closed plastic houses used in the winter to protect the crops from the cold and thus it is inhaled by farmers during work, which may lead to the risk of lung cancer and can vary The concentrations of radon gas in adjacent houses and the variation of its percentage in the same house from day to day and from hour to hour. In view of these fluctuations, estimating the annual rate of radon gas concentration in the indoor air requires measuring its concentration for a period of not less than three months [4].

As for the adjacent farms, there was a variation in the concentration of radon gas from one artesian well to another and from one location to another

Radon has health risks through two outlets, the first is the inhalation of radon gas and its decomposition products after its liberation from water into the air, and the second is the intake of radon gas directly through drinking water [5]. Alpha particles emitted

from radon and its decomposition products are considered heavy charged particles. When emitted and collided with the atoms that make up the cells of the tissues and organs of the body, they have tremendous effects and disturbances in the cells, in addition to the chemical effects on the molecular level. For human tissues, as it sticks to the wall of the lungs and decomposes into other elements (Allen and Samuel 1989). The risk of lung cancer as a result of inhaling radon decay products, as radon is not associated with a specific disease more than it is associated with lung cancer, because the risks of inhalation may exceed much more than ingestion [6]. There are many studies in different regions of the world to find out the levels of exposure to radon gas. [7] studied the radioactivity of ground and surface water in Babylon province and calculated the radon concentration by calculating the concentration of radium in samples selected using a high-purity germanium detector [HPGe], and [8] were able to measure the radon concentration in the groundwater of Del. It is the Indian one using the RADH2O detector, and in Khartoum [9] conducted a study to determine the concentration of radon gas in the water of the public network and groundwater and the annual exposure to radiation using a high-purity germanium detector. RAD7, as well as the researchers [10] to measure the radon concentration of a source of drinking water at the University of Peshawar in Pakistan using the detector RADH2O, And from hilla river was able to collect (22) samples from in different locations in Babel Governorate [11], central Iraq by using the RAD-7 detector, also its had been measured radioactive radon gas in samples of drinking water in the schools of Abu Gharq district in Babel Governorate [12]. Therefore the aim of this work is studying the concentration of radioactive radon gas in the groundwater near the center of Al-Zubair district and the surrounding areas from the west, south and east in Basra Governorate, at southern Iraq, using the electronic solid-state detector RAD-7. This topic was chosen due to the lack of previous studies in the study area, and because it was noticed that diseases and environmental pollution increased as a result of the events and wars that took place, in Basra Governorate in general and in Al-Zubair district in particular.

#### Location of the study area

The location of the study is Al-Zubair district, located west of Basra Governorate (30°23'39.0"N ,47°38'04.3"E ) and about five kilometers away from it. It is characterized as an agricultural and oil area. Its area is (1082 square km) and the population of the center is (511,224) according to 2018 statistics. Figure (1) Location of the study.

#### Experimental Part

The device that was used in this study is RAD-7 detector is made of semiconductor material (silicon). It receives the energy of alpha radiation resulting from the decomposition of ( $^{218}\text{Po}$  or  $^{214}\text{Po}$ ) and

converts it directly into an electrical signal. It is amplified through the electronic circuits of the detector and then converted into a digital format because the RAD7 device is a data processor that receives the signal and stores it in its circuit. The spectrum can be formed with an energy range of (0-10) MeV Interest is noted in the region with an energy range of (6-9) MeV, because most of the radon and thoron dissolutions are within this range of energy. The spectrum appears divided into 200 channels in 8 windows, and each channel has an energy level equal to To (05.0) Mev, and thus RAD7 determines the type of isotope by distinguishing its electronic energy associated with alpha particles. Thus, radon isotopes ( $^{218}\text{Po}$ ) can be distinguished by alpha radiation (6Mev) as well as  $^{214}\text{Po}$  (7.97MeV). The spectrum is printed by RAD-7, including windows A, B, C, D and Figure (2) illustrate the above [14]



Figure (1) Map of the locations of the studied samples.[13]

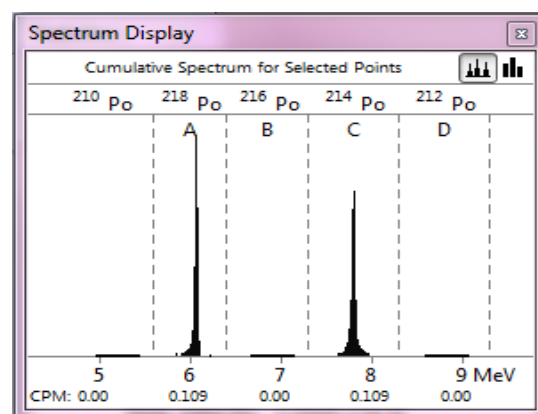
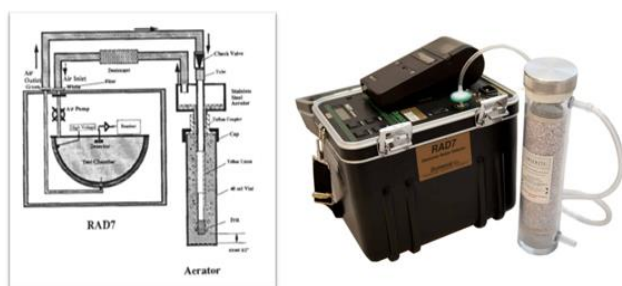


Figure (2) Alpha spectrum at RAD7 [ 14 ]

When operating the RAD-7 device, it prepares itself electronically for the stages of conducting the examination of the samples to be examined, and before starting the measurement, it must be noted that the memory of the device is not full by observing the sequence of the number for the last cycle so that it is less than 99. RAD-7 device for new measurements. At the beginning of the test, we dry the RAD-7 device (purge) step It which should be less than (6%) and duration of one sample test is 30 minutes. The percentage of radon gas removal from the water in the closed air loop with the device is very high in the water sample with a volume of 250 ml, which is 94% Durrige Company Inc,2020. Figures (3a) and (3b) show the schematic diagram of

RADH2O.



Figures (3 a and b) the schematic diagram of RADH2O [14]

Calculate the annual effective dose (Dw (Sv. y-1) for exposure to radon gas in water [15].

$$Dw = Cw \cdot CRw \cdot Dcw \dots\dots\dots(1)$$

Where.

CRw: amount of consumption (1095 L.y-1) (as a general average per capita consumption)

Dcw: dose conversion factor for radon (Sv Bq-1 5\*10-9) [16].

Cw: the concentration of radon in the water.

## 2. Results and Discussion

Table (1) the results obtained in this study from water samples that were measured in Al-Zubair district, Basra Governorate, where Mean is the average value of radon gas concentration, High is the highest value, and Low is the lowest value of the average radon concentration. These values are measured in units of Bq. L<sup>-1</sup>, and column the latter represents the GPS location from which the examined samples were taken.

Table (1) Concentration of radioactive radon gas in groundwater samples					
Sample No	Mean (Bq.L-1)	High (Bq. L-1)	Low (Bq. L-1)	Effective dose mSv.y-1	Location
1	0.8	1.44	0.161	0.00000438	N 30°20'47.2 E 47°42'49.2
2	1.32	1.92	0.48	0.000007227	N 30°20'45.5 E 47°43'19.0
3	2.2	4.64	0.32	0.000012045	N 30°22'04.4 E 47°42'27.2
4	1.4	2.02	0.959	0.000007665	N 30°23'53.6 E 47°39'43.0
5	2.065	2.99	1.28	1.13059E-05	N 30°23'39.0 E 47°38'04.3
6	1.008	1.78	0.162	5.5188E-06	N 30°25'30.8 E 47°36'37.5
7	1.32	1.91	0.639	0.000007227	N 30°24'24.6 E 47°33'32.7
8	3.31	4.0	2.4	1.81223E-05	N 30°24'14.7 E 47°33'04.6
9	1.175	1.91	0.16	6.43313E-06	N 30°24'28.5 E 47°32'15.3
10	0.08	0.32	0	0.000000438	N 30°22'43.0 E 47°34'52.2
11	1.91	3.02	1.28	1.04573E-05	N 30°21'27.9 E 47°34'18.1
12	2.955	3.34	2.4	1.61786E-05	N 30°20'29.1 E 47°35'03.9
13	1.8	3.2	1.12	0.000009855	N 30°22'04.7 E 47°34'28.3
14	2.36	2.72	1.91	0.000012921	N 30°19'59.1 E 47°44'07.8
15	4.52	5.92	3.68	0.000024747	N 30°19'19.0 E 47°44'28.1
16	0.719	1.12	0.159	3.93653E-06	N 30°17'59.3 E 47°45'10.7
17	3.875	5.12	3.02	2.12156E-05	N 30°16'06.0 E 47°46'39.2
18	1.24	1.59	0.799	0.000006789	N 30°14'17.8 E 47°47'03.3
19	0.918	0.959	0.795	5.02605E-06	N 30°13'21.4 E 47°47'41.0
20	0.12	0.16	0	0.000000657	N 30°12'27.5 E 47°48'09.4
21	1.48	1.91	1.12	0.000008103	N 30°11'27.4 E 47°49'18.9
22	2.24	3.2	1.59	0.000012264	N 30°10'14.3 E 47°49'21.2
Sample No	Mean (Bq.L-1)	High (Bq. L-1)	Low (Bq. L-1)	Effective dose mSv.y <sup>-1</sup>	Location
23	4.39	4.88	3.82	2.40353E-05	N 30°09'21.0 E 47°49'48.5
24	1.4	1.76	0.639	0.000007665	N 30°08'30.4 E 47°50'55.0
25	0.2	0.32	0.159	0.000001095	N 30°08'02.2 E 47°50'55.0
26	1.36	2.44	0.159	0.000007446	N 30°06'38.8 E 47°51'59.5
27	2.16	3.36	1.28	0.000011826	N 30°06'04.8 E 47°52'28.8
28	1.397	1.76	0.639	7.64858E-06	N 30°06'16.7 E 47°52'21.5
29	1.56	1.76	1.28	0.000008541	N 30°07'21.8 E 47°51'17.8
30	2.92	3.68	2.07	0.000015987	N 30°18'46.9 E 47°43'08.2
31	3.475	5.280	2.4	1.90256E-05	N 30°18'33.4 E 47°43'17.0
32	4.43	4.8	4.16	2.42543E-05	N 30°18'47.5 E 47°43'38.3
33	3.155	4.32	2.56	1.72736E-05	N 30°18'15.3 E 47°43'02.1
34	0.519	0.799	0.16	2.84153E-06	N 30°18'11.0 E 47°43'25.3
35	3.712	4.45	3.2	2.03232E-05	N 30°17'47.9 E 47°42'43.0
36	1.278	1.92	0.795	6.99705E-06	N 30°17'32.0 E 47°42'35.5
37	4.04	5.28	3.36	0.000022119	N 30°17'41.4 E 47°42'04.2
38	2.515	3.2	1.76	1.37696E-05	N 30°17'32.0 E 47°41'39.1
39	3.63	4.16	3.18	1.98743E-05	N 30°17'11.0 E 47°40'55.6
40	1.202	1.77	0.799	6.58095E-06	N 30°16'16.0 E 47°40'06.4
41	1.44	1.92	0.639	0.000007884	N 30°17'30.7 E 47°42'02.6
42	3.39	4.88	2.88	1.85603E-05	N 30°17'28.4 E 47°42'28.8
43	1.36	1.6	1.12	0.000007446	N 30°17'02.3 E 47°42'24.5
44	1.28	1.92	0.48	0.000007008	N 30°16'49.8 E 47°42'37.5
45	5.392	7.190	4.00	2.95212E-05	N 30°21'02.1 E 47°44'48.0
46	2.707	3.2	1.6	1.48208E-05	N 30°20'43.2 E 47°45'15.2
Sample No	Mean (Bq.L-1)	High (Bq. L-1)	Low (Bq. L-1)	Effective dose mSv.y <sup>-1</sup>	Location
47	1.555	1.91	1.27	8.51363E-06	N 30°20'36.3 E 47°45'45.3
48	4.39	4.77	4.0	2.40353E-05	N 30°20'09.1 E 47°45'56.2
49	3.155	4.0	1.92	1.72736E-05	N 30°19'42.2 E 47°46'06.7
50	0.878	1.28	0.639	4.80705E-06	N 30°19'21.6 E 47°46'39.2
51	3.08	3.84	1.91	0.000016863	N 30°18'47.5 E 47°46'53.9

The results of the examination appeared for groundwater samples that were taken from artesian wells from houses, palm farms, various vegetables, water desalination plants, building materials factories, and military barracks. Underground (2.5 Bq. L<sup>-1</sup>), the highest rate of radon concentration appeared (4 Bq.L<sup>-1</sup>), as it ranged from the highest S value (4 Bq.L<sup>-1</sup>) to the lowest value (1 Bq.L<sup>-1</sup>), and the annual effective dose ranged between (0.5 mSv.y<sup>-1</sup>) and mean of (0.2 mSv.y<sup>-1</sup>). The standard deviation is the square root of the values and decreases with increasing and increasing the time of assembly. The standard deviation has appeared and may have large values higher than the average, and this leads to a discrepancy in the measurement results, as the RAD7 depends on the distribution Poisson to calculate the standard deviation. If the rate is small, then RAD7 uses 1 + SQR(N) [17]. Thus, if the rate is zero, then the standard deviation is of a certain value greater than zero, relying on the principle of imprecision[ 17 ] as, the figure (4) and figure (5) .

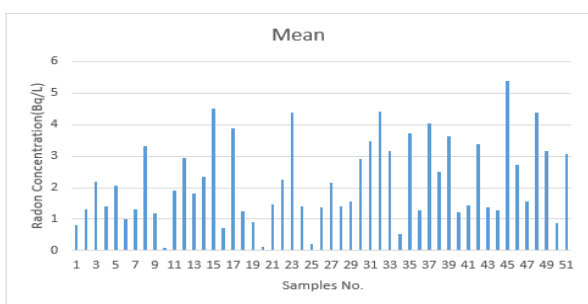


Figure (4) the graph showing the difference in the concentration of radon gas in groundwater samples

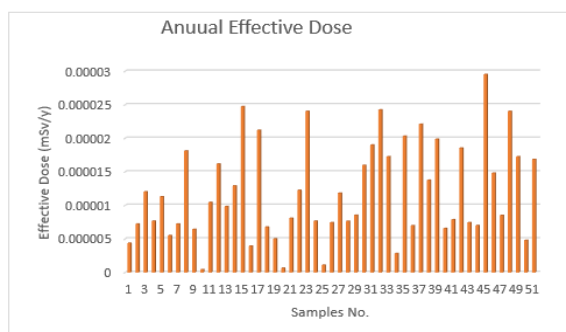


Figure (5) the graph showing the annual effective dose of radon gas in groundwater samples

Below is a comparison of the results of the current study with other studies of types of water from different sources as shown in the table

Table (2) The average concentration of radon gas in the water for some countries compared to the current research	
Radon concentration Bq.L-1	The state
0.118 [11]	Iraq - drinking water
0.103 [11]	Iraq - Hilla River
0.299[12]	Iraq – Al-kifl
0.0948 [12]	Iraq – Hilla school
0.173 [12]	Iraq – Abu -Ghareg
0.74 [18]	Kuwait
0.21-3.89 [19]	Iran

3.9 [20]	Jordan
2.172 present study	Iraq - Zubair district

### 3. Conclusions

- 1- The concentration of radioactive radon gas at a rate of (5.392 ± 0.08 Bq. L<sup>-1</sup>) appeared in the groundwater of artesian wells in Al-Zubair district for all samples examined.
- 2- The average concentration of radon gas in the artesian wells from which samples were taken was within the normal limits set by the competent organizations, because the maximum allowable limit for the concentration of radon gas (11. 1Bq.L-1) as set by the Environmental Protection Agency [20]
- 3- The annual effective dose of groundwater appeared (1.18931E-05) which is less than the dose determined by the competent organizations, which is (1 mSv.y-1) [16].

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