

# Measurement and Study of Radioactive Radon Gas Concentrations in the Selected Samples of River Hilla / Iraq

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## Abstract

In this study measuring concentrations of radon in water for Hilla province of Babylon (100 Km) south of capital Baghdad. Was chosen as the water River Hilla study by 88 sample from 22 regions by using the electronic radon detector RAD7, and the average concentration of radon in the Hilla River ( $0.103 \pm 0.057$ ) Bq.L<sup>-1</sup>, where the highest value ( $0.181 \pm 0.07$ ) Bq.L<sup>-1</sup> and the lowest value ( $0.036 \pm 0.05$ ) Bq.L<sup>-1</sup> and effective dose for human exposure to radon was ( $0.45$ ) mSv.y<sup>-1</sup>. Has been chosen this subject of the current study of the importance of water in human life and living, and the lack of previous studies in the study area.

**Keywords:** radon concentrations, River Hilla, Annual effective dose, RAD7.

## 1. Introduction

Radon is a naturally occurring, chemically inert, alpha particle emitting radioactive gas. This colorless, tasteless and odorless gas is produced by natural radioactive decay of uranium, radium and thorium found in trace amounts everywhere in the rocks and soils of the Earth's crust [1]. The three naturally occurring isotopes of radon are radon (<sup>222</sup>Rn) is produced from the decay of <sup>238</sup>U having natural abundance of about 99.3% of the total uranium within the Earth's crust, thoron(<sup>220</sup>Rn) is produced in nature during the decay of <sup>232</sup>Th and action(<sup>219</sup>Rn) is formed during the decay of <sup>235</sup>U [2]. The most stable and abundant isotope of radon is(<sup>222</sup>Rn) which has a half-life of 3.8 days. It decays by emitting an ( $\alpha$ ) particle of (5.49 MeV) and creates radioactive daughters. [1,2].

Radon gas can also dissolve and accumulate in water from underground sources (ground water), such as wells. When water containing radon is used in the home for showering, washing dishes, and cooking, radon gas escapes from the water into the air. (This is similar to carbonated soda drinks where carbon dioxide is dissolved in the soda and is released when you open the bottle) [3]. Some radon stays in the water. Radon generally is not a concern in water that comes from lakes, rivers, and reservoirs (surface water), because the radon is released into the air before it reaches the tap[2,3].

Radon is the major source of naturally occurring radiation exposure for humans Exposure occurs via the ingestion of radon dissolved in water and the inhalation of airborne radon. According to EPA [4], <sup>222</sup>Rn is the second leading cause of lung cancer in the U.S, smoking being the first. The nature of building materials, soil, and water used for drinking and other domestic applications can make variable contributions to the radon level in indoor environment [4].

## 2. Location of the study area

Study area is located in the province of Babylon (100 Km) south of the capital Baghdad, where the city of Hilla, which has an area of (49.816) km<sup>2</sup> on both sides of the River Hilla (a branch of the Euphrates River), at Latitude(29' 32") north, longitude (26' 44") east, as shown in Fig. (1). Geographical location (of the River

Hilla) is located in the center of the province of Babylon approximately between longitudes ( $15^{\circ} 44'$ ) and ( $44^{\circ} 50'$ ) east and the constituencies of latitude ( $32^{\circ} 15'$ ) and ( $32^{\circ} 44'$ ) north [5] and a length of the study area (17.673) km.

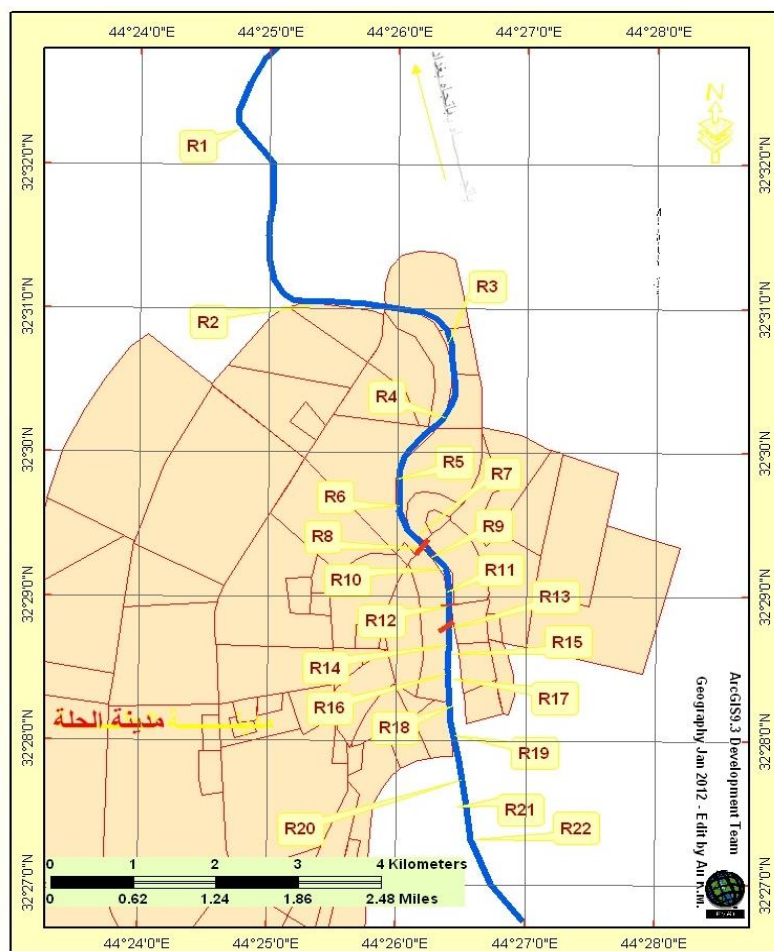


Fig.(1) Map of river Hilla showing sampling locations [6]

Where R refers to the river

### 3.Experimental Part

RAD7 a radon-in-air monitor of Durrige Company of USA was used for monitoring radon concentration in 88 water samples collected from 22 regions different locations within River Hilla and adjoining area using the RAD H<sub>2</sub>O technique [7]. The RAD H<sub>2</sub>O is an accessory to the RAD7 that measures radon in water with high accuracy, over a wide range of concentrations, capable of obtaining a reading for radon concentration in water within an hour of taking the sample [8]. The RAD H<sub>2</sub>O makes use of standard, pre-set protocols, built into the RAD7, which furnish a direct reading of the radon concentration in the water sample, itself. The RAD7 detector has the capability to calculate the concentration of radon in water sample by multiplying the concentration of radon in the air loop by a fixed conversion coefficient. For a 250 mL vial of water sample conversion coefficient of 4 has been derived from the volume of the air loop, the volume of the sample and the equilibrium radon distribution coefficient at room temperature. The method makes use of a closed loop aeration design in which the air volume and water volume are kept constant and are independent of the flow rate [7,8].

The RAD H<sub>2</sub>O setup consists of three components, namely, [8] (a) the RAD7 radon monitor, on the left, (b) the water vial with aerator, in the case near the front, and (c) the tube of desiccant, supported by the retort stand above as shown in Fig.(2). Diagrammatic illustrations of the radon-monitor, RAD7with RAD H<sub>2</sub>O accessory for measuring radon in water samples has been shown in the Fig.(3). Care must be taken in taking the water sample such that it has never been in contact with the open air. A choice of selection among two different protocols (Wat 40 and Wat 250) is available in the setup of RAD7 for a user enabling him to calculate radon concentration in vials of two different (40 or 250 mL) supplied with the equipment. In our case we used vials of 250 mL capacity[9].

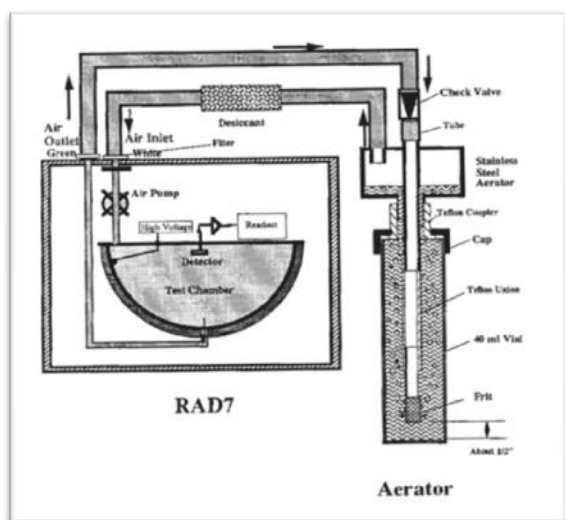


Fig.(3) Schematic diagram of RAD7, a solid state, ion implanted, planar Silicon alpha detector with RAD H<sub>2</sub>O assembly[8]

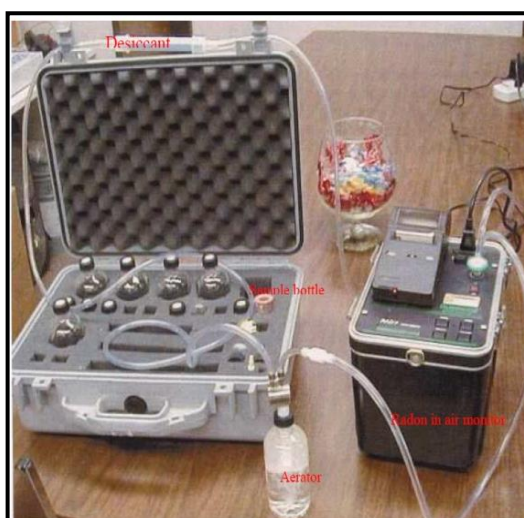


Fig. (2) Diagram showing arrangement of apparatus for measuring radon content in water sample in a 250 mL vial[8]

A water test in a pre-set Wat 250 protocol is normally completed in 30 min time. At the beginning of a test the inbuilt pump of RAD7 starts running automatically for 5 min duration, aerating the sample and delivering the degassed radon to the RAD7 measuring chamber. During the 5 min of aeration, more than 94% of the available radon is removed from the water. After 5 min operation the pump stops automatically and the system then wait for a further 5 min interval. After that the system then starts counting. After 5 min, the system prints out a short-form report for a 5 min cycle[4,8]. The same thing happens again 5 min afterward, and for two more 5-min periods after that. At the end of the run (30 min after the start), the RAD7 prints out a summary, showing the average radon concentration in four counted cycles each of 5 min duration, a bar chart of the four readings, and a cumulative spectrum. The radon concentration shown is that of the water, and is calculated automatically by the RAD7[8,10].

The annual effective dose to an individual consumer due to intake of radon from drinking water is evaluated using the Eq. (1) [10], as shown in the table (1).

$$D_w = C_w C_{Rw} D_{cw} \quad (1)$$

where  $D_w$  is the annual effective dose ( $Sv\ y^{-1}$ ),  $C_w$  concentration of  $^{222}Rn$  ( $Bq\ L^{-1}$ ),  $C_{Rw}$  annual intake of drinking water ( $1095\ L\ y^{-1}$ ),  $D_{cw}$  is the ingested dose conversion factor for  $^{222}Rn$  ( $4\ Sv\ Bq^{-1}$ ). [7,10].

#### 4. Results and discussion

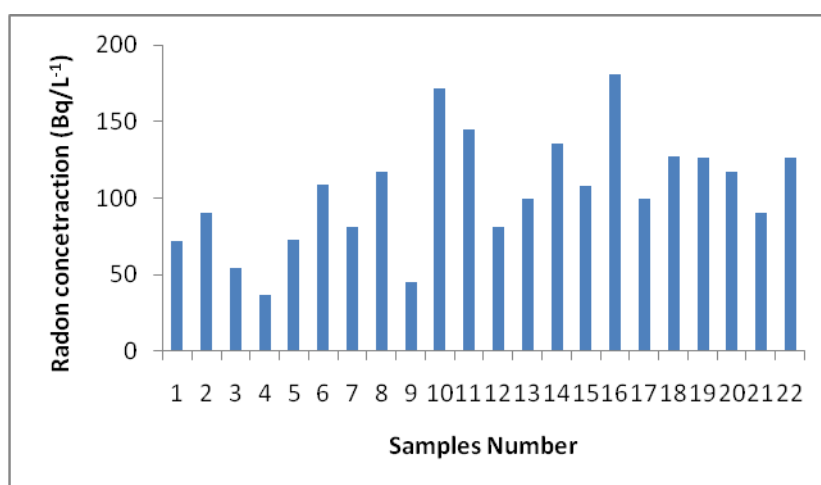
Table (1) shows the results were obtained in this study where the :  
 (Mean) represents the value of average concentration, (SD) represents the value of the standard deviation, (High) highest value, (Low) is lower value of the average radon concentration and are all measured in( Bq.L<sup>-1</sup>). The last column represents a the sample Location using GPS.

**Table (1) radioactive radon gas concentrations in samples from the River Hilla**

Sample Point	Mean (Bq.L <sup>-1</sup> )	High (Bq.L <sup>-1</sup> )	Low (Bq.L <sup>-1</sup> )	Effective dose(mSv.y <sup>-1</sup> )	Samples location
R1	0.066 ± 0.07	0.0005 ± 0.145	0.29 ± 0	0.315	N 32°,32', 17. 0" E 44°,24',39.3"
R2	0.08 ± 0.09	0.217 ± 0.16	0.036 ± 0.051	0.394	N 32°,31', 22. 0" E 44°,24',53.2"
R3	0.04 ± 0.054	0.11 ± 0.108	0.29 ± 0	0.236	N 32°,31', 10. 35" E 44°,25',23.9"
R4	0.05 ± 0.036	0.109 ± 0.11	0.29 ± 0	0.157	N 32°,31',00. 4" E 44°,25',52.6"
R5	0.029 ± 0.07	0.109 ± 0.11	0.036 ± 0.051	0.315	N 32°,30', 17. 2" E 44°,26',12.1"
R6	0.12 ± 0.108	0.289 ± 0.19	0.036 ± 0.051	0.473	N32°,29', 27. 6" E 44°,26',00.6"
R7	0.053 ± 0.081	0.144 ± 0.13	0.036 ± 0.051	0.354	N 32°,30', 55. 8" E 44°,26',12.7"
R8	0.045 ± 0.117	0.181 ± 0.15	0.072 ± 0.08	0.512	N 32°,28', 02. 6" E 44°,26',29.4"
R9	0.034 ± 0.042	0.072 ± 0.08	0 ± 0.29	0.183	N 32°,28', 43. 2" E 44°,26',21.9"
R10	0.045 ± 0.172	0.217 ± 0.16	0.109 ± 0.11	0.753	N 32°,28', 02. 8" E 44°,26',21.2"
R11	0.051 ± 0.145	0.181 ± 0.15	0.072 ± 0.08	0.635	N32°,29', 41.3" E 44°,25',54.1"
R12	0.045 ± 0.081	0.144 ± 0.13	0.036 ± 0.051	0.354	N32°,29', 12. 1" E 44°,26',23.2"
R13	0.017 ± 0.099	0.109 ± 0.11	0.072 ± 0.08	0.433	N 32°,28', 25. 2" E 44°,26',18.1"
R14	0.03 ± 0.135	0.181 ± 0.15	0.108 ± 0.11	0.591	N32°,28', 06. 1" E 44°,26',20.0"
R15	0.051 ± 0.108	0.145 ± 0.13	0.036 ± 0.051	0.473	N 32°,29', 02. 5" E 44°,26',23.0"
R16	0.07 ± 0.181	0.289 ± 0.19	0.108 ± 0.11	0.788	N 32°,28', 43. 6" E 44°,26',18.0"
R17	0.08 ± 0.099	0.217 ± 0.16	0.036 ± 0.051	0.433	N 32°,28', 35. 6" E 44°,26',18.2"

R18	$0.07 \pm 0.126$	$0.217 \pm 0.16$	$0.036 \pm 0.051$	0.551	N 32°27', 58.4" E 44°26',30.6"
R19	$0.104 \pm 0.126$	$0.253 \pm 0.18$	$0 \pm 0.29$	0.551	N 32°29', 25.7" E 44°26',08.7"
R20	$0.07 \pm 0.117$	$0.217 \pm 0.16$	$0.036 \pm 0.051$	0.512	N 32°29', 41.6" E 44°25',59.1"
R21	$0.03 \pm 0.091$	$0.144 \pm 0.13$	$0.072 \pm 0.08$	0.398	N 32°29', 11.3" E 44°26',23.7"
R22	$0.08 \pm 0.126$	$0.181 \pm 0.15$	$0 \pm 0.3$	0.551	N 32°29', 15.3" E 44°26',15.5"

The recorded radon concentrations in 88 water samples from 22 different region in River Hilla were found to vary from  $(0.181 \pm 0.07)$  to  $(0.036 \pm 0.05)$  Bq.L<sup>-1</sup> with an average of  $(0.103 \pm 0.057)$  Bq.L<sup>-1</sup>, As for the rest of the samples varied between R10 ( $0.172 \pm 0.045$ ) and R20 ( $0.117 \pm 0.07$ ) Bq.L<sup>-1</sup>, shown in table (1) that there is a difference in measurement results for water according to locations samples as shown in Fig. (4) the reason is attributed to the difference in the geological nature of each region of the earth and environmental conditions and seasons of the year and to the movement of water and change it constantly, which leads to the deposition of radionuclides So the presence high concentrations of radon in the surface waters be small compared to groundwater [2,13,14].



**Fig.(4) Bar diagram showing variation in radon concentration of the water samples**

By comparing the results of this study with the studies described in the table (2), we find that the average concentration of radon in water lower as compared with these studies :

**Table (2) shows the average of radon concentration in the water for some countries compared to the present research**

country	Radon concentration average	
Iraq- Nenava	[11]	1.133 Bq.L <sup>-1</sup>
present study	Iraq-River Hilla	0.103 Bq.L <sup>-1</sup>
Turkey	[12]	0.091 Bq.L <sup>-1</sup>
Kuwait	[13]	0.74 Bq.L <sup>-1</sup>
Syria	[14]	13 Bq.L <sup>-1</sup>
Iran	[15]	(0.21-3.89) Bq.L <sup>-1</sup>
Jordon	[16]	3.9 Bq.L <sup>-1</sup>
Khartoum	[17]	59.2 Bq.L <sup>-1</sup>
Algeria	[18]	7 Bq.L <sup>-1</sup>

## 5. Conclusions

The study of radon in water showed all samples tested had radon activity concentrations well below the recommended EC [19] action level of 1 MBq. m<sup>-3</sup> the related by organizations as the maximum allowable concentration of radon in water (11 Bq.L<sup>-1</sup>) (As defined by the Environmental Protection Agency EPA) [20].and the effective dose in the River Hilla was 0.45 mSv. y<sup>-1</sup>. This study is the first of its kind in the province of Babylon necessitating larger and more comprehensive studies of all areas of the province.

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