Available online at www.worldscientificnews.com

World Scientific News

WSN 52 (2016) 130-142 EISSN 2392-2192

Radon Concentration in Drinking Water Samples at Hilla city, Iraq

Mohsin Kadhim Muttaleb Al-jnaby

Department of Physics, College of Science, University of Babylon, Babylon, Iraq

E-mail address: mam50_24@yahoo.com

ABSTRACT

The radioactivity of radon gas in thirty eight samples of drinking water that manufactured in different regions of Hilla, the center of Babylon (Iraq) have been measured by RAD7 detector. The high and low average radon concentration, average standard deviation and the annual dose have been calculated, where the result were A16 (0.193 ±0.0211) $Bq \cdot L^{-1}$, A1 (0.0361 ±0.00014) $Bq \cdot L^{-1}$, the average of radon concentration (0.115 ±0.048) $Bq \cdot L^{-1}$ and the annual effective dose was 0.413 $mSv \cdot y^{-1}$

***Keywords*:** Babylon; water; radon; concentrations; annual effective dose; RAD7; UNSCEAR

1. INTRODUCTION

Radiation is a fact of life. We live in a world in which radiation is naturally present every-where. Light and heat from nuclear reactions in the sun is essential to our existence. Radioactive materials occur naturally throughout the environment, and our bodies contain radioactive materials such as carbon-14, potassium-40 and polonium-210 quite naturally. All life on Earth has evolved in the presence of this radiation. Means radioactive contamination environmental presence of radioactive elements emitting particles and photons of radionuclide to the environment from various sources such as accidents and nuclear tests and these radionuclide transmitted to the ground, and causes vegetation to its appearance to the outside,

and can be transmitted through the food chain to the human body [1]. Radon is the leading source of natural radiation exposure and the second leading cause of lung cancer. Where does it come from? Well, usually from soil, but it is found everywhere. The ground that we all walk and build our homes upon contains varying levels of naturally occurring radioactive elements that decay into radon gas. Radon from chemically inert gases and radioactive naturally produced from the natural radioactive decay of uranium found in rocks and soil. Emit radon easily from the soil to spread in the air where dissolved to derivatives, short-lived, called the adat radon emission alpha particles and sticking with dust and other particles suspended in the air and when inhaled air accumulate those Aloledat in the cells that cover the bronchial tree where can alpha particles damage to those cells and cause lung cancer [2]. Radiates the human body from the inside by all of the air we breathe and the food and water that reaches the stomach. The air is the main source of dose Radioactive natural that reach inside the human body and their primary source of radon gas found in the earth's atmosphere. Moreover, some dust that falls on the plant contains traces of radioactive materials to those that are slightly radioactive our bodies from the inside because of some radioactive elements, such as carbon-14, potassium-40 [3].

Physical properties of radon gas

1- Radon gas is a radioactive element that is produced by the decay of uranium, which is present in virtually all rocks and soils. The ability of radon to migrate through soil is strongly dependent upon physical properties of the soil**.**
2- The concentration of radon decreases with decreasing distance from the surface because the gases escape to the open air above the ground.
3- The concentration for radon in water affected by meteorological factors as barometric pressure, humidity, rain fall and temperature [4].

Radon Health Risks

Radon gas decays into radioactive particles that can get trapped in lungs when breathe. As they break down further, these particles release small bursts of energy. This can damage lung tissue and lead to lung cancer over the course of lifetime. Not everyone exposed to elevated levels of radon will develop lung cancer. And the amount of time between exposure and the onset of the disease may be many years. Like other environmental pollutants, there is some uncertainty about the magnitude of radon health risks. However, know more about radon risks than risks from most other cancer-causing substances. This is because estimates of radon risks are based on studies of cancer in humans.

Smoking combined with radon is an especially serious health risk. Stop smoking and lower your radon level to reduce your lung cancer risk. Children have been reported to have greater risk than adults of certain types of cancer from radiation, but there are currently no conclusive data on whether children are at greater risk than adults from radon [5].

The Aim of Study

Find concentrations of radon gas in the soil samples for the city of Hilla in different places, using a solid-state detector stems RAD7 radon interest in being a source of danger to people's health because of the breadth of its spread in the water.

Location of the study

The study area lies in Hilla city (100 km) south of the Baghdad, which has area of (49.816) km^2 on both sides of the Shatt al-Hilla (a branch of the Euphrates River), at Latitude (29’32°) north, longitude (26’44°) east as shown in Figure (1).

Figure 1. Map of Hilla city

2. PRACTICAL PART

Solid State Detector RAD7

The solid state detector as shown in Figure (2) was made of a semiconductor material (silicon) converts the energy of alpha radiation resulting from the decomposition of (^{218}Po or ^{214}Po) directly into an electrical signal which if RAD7 can filter the type of isotope discrimination electronic energy related with alpha particles and thus we can distinguish isotopes of radon (^{218}Po) fires the alpha card 6MeV ^{214}Po card or 7.97 MeV [6] .

RAD7 has a cell size (0.7L) has the form of a hemispherical possible that we observe in Figure (3) within the hemisphere coated electrical connector with high voltage equip shipments into the connector to the effort around (2000-2500) volt This creates an electric field across the cell urges the electric field of charged particles positive in the detector cell, degrade atoms ^{222}Rn inside the cell and leave behind a positive charge ^{218}Po which affix to the detector, the nucleus ^{218}Po has a life half a relatively short and when decomposed will have the opportunity (50%) to enter the detector produces an electrical signal and energies of alpha particles [7].

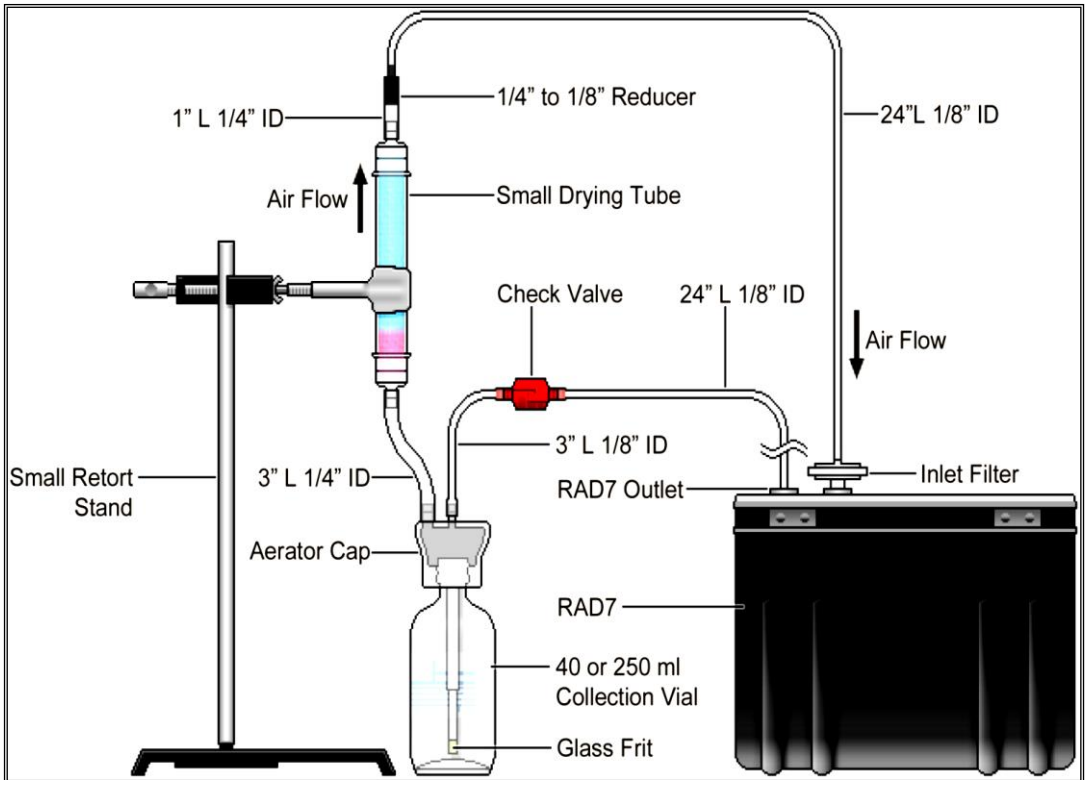

Fig. 2. Schematic presentations of radon-in-air monitor RAD7. Adapted from reference with permission [8].

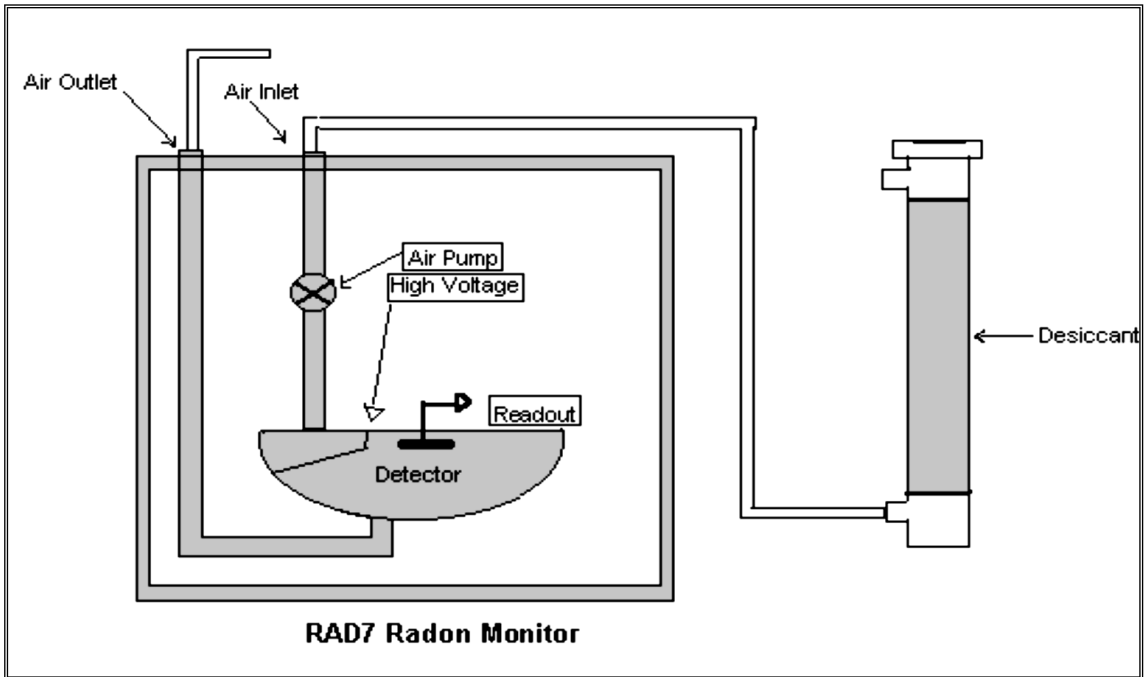

Figure 3. Scheme device RAD7 [9].

RAD7 a radon- in- air monitor of Durridge Company of USA was used for monitoring radon concentration in 38 water samples collected from 38 regions different locations within Hilla City and adjoining area using the RAD H_2O technique [7]. The RAD H_2O 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 [10].

The RAD H_2O 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].

A water test in a pre - set Wet 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 [8,11].

The same thing happens again5 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 i calculated automatically by the RAD7 [8,12].

The annual effective dose to an individual consumer due to intake of radon from drinking water is evaluated using the Eq. (1) [12], as shown in the Table (1).

$$Dw = Cw\ CRw\ Dcw \quad \ldots\ldots\ldots\ldots (1)$$

where:
Dw is the annual effective dose (Sv y^{-1}),
Cw concentration of ^{222}Rn (Bq·L^{-1}),
CRw annual intake of drinking water (1095 L y^{-1}),
Dcw is the ingested dose conversion factor for ^{222} Rn (4 Sv Bq^{-1}) [7,12].

3. RESULTS AND DISCUSSION

Table (1) and Table (2) shows the results obtained in this study. Where (A) refers to the area, Mean represents the average value of concentration, High represents higher-value, Low represents less valuable and all measurements by (Bqreal / liter) Bq·L^{-1}

Table 1. Samples measurements of sites in Hilla city.

No.	Sample Point	Region	Samples location (GPS)
1	A1	Hay Al-Askary	N 32º,26′, 54.8″ , E 44º,24′,49.6″
2	A2	Hay-Al-Akramean	N 32º,28′, 10. 1″ , E 44º,24′,11.2″
3	A3	Hay-Al-Karama	N 32º, 29′, 26. 0″ , E 44º, 25′, 09.6″
4	A4	Hay-Al-Hukaam	N 32º,24′, 40. 5″ , E 44º,25′,36.7″
5	A5	Hay-Al-Tayara	N 32º,29′, 44. 5″ , E 44º,25′,32.5″
6	A6	Hay-Al-Thawra	N 32º,30′, 20. 7″ , E 44º,25′,09.4″
7	A7	Hay-17 Tamooz	N 32º,30′, 08. 0″ , E 44º,25′,01.5″
8	A8	Abu-Kistawi	N 32º,30′, 37. 8″ , E 44º,24′,12.2″
9	A9	Hay-Al-Moharbean	N 32º,29′, 26. 7″ , E 44º,24′,49.2″
9	A10	Hay-Al-Asatetha	N 32º,28′, 52. 9″ , E 44º,24′,32.6″
10	A11	Hosseinieh street	N 32º,28′, 39. 0″ , E 44º,24′,31.5″
11	A12	Hay-Al-Hussen	N 32º,28′, 51. 2″ , E 44º,25′,06.7
12	A13	Hay-Al-Katheya	N 32º,28′, 59. 8″ , E 44º,25′,34.9″
13	A14	Mustafa Ragheb	N 32º,28, 47. 1″ , E 44º,25′,36.1″
14	A15	Hay-Shubbar	N 32º,29′, 09. 7″ , E 44º,25′,39.1″
15	A16	Hay-Al mashta	N 32º,28′, 22. 3″ , E 44º,25′,28.7″
16	A17	Hay-Al-Imam	N 32º, 29′, 49. 4″ , E 44º,24′,39.7″
17	A18	Mhayzim	N 32º,29′, 47. 1″ , E 44º,24′,23.2″
18	A19	Hay-Al-Thubbat	N 32º,30′, 22. 2″ , E 44º,24′,32.0″
19	A20	Hay-Al amer	N 32º,27′, 50. 8″, E 44º,25′,27.8″
20	A21	Hay Al-Zahraa	N 32º,27′, 47. 8″ , E 44º,25′,40.9″
21	A22	Hay-Chaoui	N 32º,28′, 07. 2″ , E 44º,25′,45.9″
23	A24	Hay-Al-Mortatha	N 32º,28′, 09. 2″ , E 44º,25′,21.4″
24	A25	Hay-Al-Iscan	N 32º,27′, 56. 8″ , E 44º,25′,24.9″

25	A26	Hay-Al-Jameaya	N 32º,28′, 16. 6″ , E 44º,24′,51.8″
26	A27	Hay-Al-Kosrwya	N 32º,29′, 25. 2″ , E 44º,26′,19.5″
27	A28	Hay-Al-Thayla	N 32º,28′, 40. 6″ , E 44º,26′,35.2″
28	A29	Hay-Al-Saha	N 32º,30′, 10. 0″ , E 44º,26′,02.4″
29	A30	Hay-Al- Jazaar	N 32º,30′, 50. 8″ , E 44º,26′,33.3″
30	A31	Hay-Babil	N 32º,29′, 38. 0″ , E 44º,25′,59.6″
32	A32	Almohandseen	N 32º,27′, 23. 3″ , E 44º,24′,16.9″
33	A33	-Akramean Althanya	N 32º,28′, 01. 4″ , E 44º,24′,07.7″
34	A34	Hay-Al moalmen	N 32º,28′, 08. 3″ , E 44º,24′,00.2″
35	A35	Hay Al-Askary Althanya	N 32º,26′, 58. 9″ , E 44º,24′,45.4″
36	A36	Hay- Al jemhorei	N 32º,28′, 20. 7″ , E 44º,26′,17.3″
37	A37	Al-Bakerly	N 32º,29′, 37. 2″, E 44º,26′,40.2″
38	A38	Hay-Kratah	N 32º,28′, 29. 4″ , E 44º,25′,55.9″

Table 2. Radon (Rn^{222}) concentration in water samples in Hilla city.

Sample Point	**Mean ($Bq \cdot L^{-1}$)**	**High ($Bq \cdot L^{-1}$)**	**Low ($Bq \cdot L^{-1}$)**	**Effective dose ($mSv \cdot y^{-1}$)**
A1	0.0362 ± 0	0.0362 ± 0.0724	0.0362 ± 0.0724	0.158
A2	0.127 ± 0.027	0.181 ± 0.138	0.0724 ± 0.0836	0.556
A3	0.157 ± 0.0549	0.217 ± 0.145	0.109 ± 0.217	0.687
A4	0.0723 ± 0.00014	0.0724 ± 0.0836	0.0722 ± 0.0834	0.316
A5	0.0542 ± 0.0255	0.0722 ± 0.0834	0.0362 ± 0.0724	0.237
A6	0.121 ± 0.0836	0.217 ± 0.0832	0.072 ± 0.144	0.529
A7	0.145 ± 0.1022	0.217 ± 0.187	0.0724 ± 0.145	0.635
A8	0.145 ± 0.1022	0.217 ± 0.187	0.0724 ± 0.145	0.635

A9	0.109 ± 0.0515	0.145 ± 0.00039	0.072 ± 0.0834	0.47742
A10	0.127 ± 0.0255	0.145 ± 0.118	0.109 ± 0.139	0.55626
A11	0.109 ± 0.0514	0.145 ± 0.205	0.0722 ± 0.0834	0.47742
A12	0.0361 ± 0.00014	0.0362 ± 0.0724	0.036 ± 0.072	0.158118
A13	0.109 ± 0.0513	0.145 ± 0.118	0.0724 ± 0.0836	0.47742
A14	0.145 ± 0.0502	0.18 ± 0.273	0.109 ± 0.0724	0.6351
A15	0.121 ± 0.1162	0.253 ± 0.139	0.036 ± 0.072	0.52998
A16	0.193 ± 0.0211	0.217 ± 0.345	0.180 ± 0.072	0.84534
A17	0.0542 ± 0.0255	0.0722 ± 0.0834	0.0362 ± 0.0724	0.237396
A18	0.181 ± 0.0509	0.217± 0.187	0.145 ± 0.167	0.79278
A19	0.09 ± 0.0764	0.144 ± 0.118	0.036 ± 0.072	0.3942
A20	0.145 ± 0.1028	0.217 ± 0.187	0.0722 ± 0.0834	0.6351
A21	0.166 ± 0.022	0.181 ± 0.0725	0.15 ± 0.125	0.72708
A22	0.145 ± 0.036	0.181 ± 0.139	0.145 ± 0.118	0.6351
A23	0.181 ± 0.0509	0.217 ± 0.145	0.145 ± 0.118	0.79278
A24	0.145± 0.0516	0.181 ± 0.138	0.108 ± 0.0723	0.6351
A25	0.126 ± 0.0256	0.144 ± 0.118	0.108 ± 0.138	0.55188
A26	0.127 ± 0.128	0.217 ± 0.345	0.036 ± 0.072	0.55626
A27	0.091 ± 0.026	0.109 ± 0.0724	0.0722 ± 0.0834	0.39858
A28	0.145 ± 0.0885	0.253 ± 0.0722	0.0362 ± 0.0724	0.6351
A29	0.109 ± 0.0513	0.145 ± 0.118	0.0724 ± 0.145	0.47742
A30	0.0902 ± 0.0252	0.108 ± 0.139	0.0724 ± 0.0836	0.395076

A31	0.0543 ± 0.0256	0.0724 ± 0.0836	0.0362 ± 0.0724	0.237834
A32	0.163 ± 0.0255	0.181 ± 0.217	0.145 ± 0.205	0.71394
A33	0.109 ± 0.096	0.217 ± 0.186	0.0362 ± 0.0724	0.47742
A34	0.109 ± 0.0513	0.145 ± 0.167	0.0724 ± 0.0836	0.47742
A35	0.0726 ± 0.0515	0.109 ± 0.0724	0.0362 ± 0.0724	0.317988
A36	0.109 ± 0.00071	0.109 ± 0.139	0.108 ± 0.216	0.47742
A37	0.0725 ± 0.0359	0.108 ± 0.0723	0.0362 ± 0.0724	0.31755
A38	0.109± 0.0513	0.145 ± 0.118	0.0724 ± 0.0836	0.47742

Table 3. Shows the average of radon concentration in the water for some countries compared to the present research.

Country	Radon concentration average	Refrence
Turkey	0.091 $Bq \cdot L^{-1}$	[19]
Jordon	3.9 $Bq \cdot L^{-1}$	[20]
Iran	(0.21-3.89) $Bq \cdot L^{-1}$	[21]
Syria	13 $Bq \cdot L^{-1}$	[22]
Kuwait	0.74 $Bq \cdot L^{-1}$	[23]
Khartoum	59.2 $Bq \cdot L^{-1}$	[24]
Iraq - River Hilla	0.181 $Bq \cdot L^{-1}$	[18]
Iraq - Najaf	Range (0.188 – 0.027) $Bq \cdot L^{-1}$	[25]
Iraq - Nenava	1.133 $Bq \cdot L^{-1}$	[17]
present study	Iraq-Uni. of Bab. 0.183 $Bq \cdot L^{-1}$	

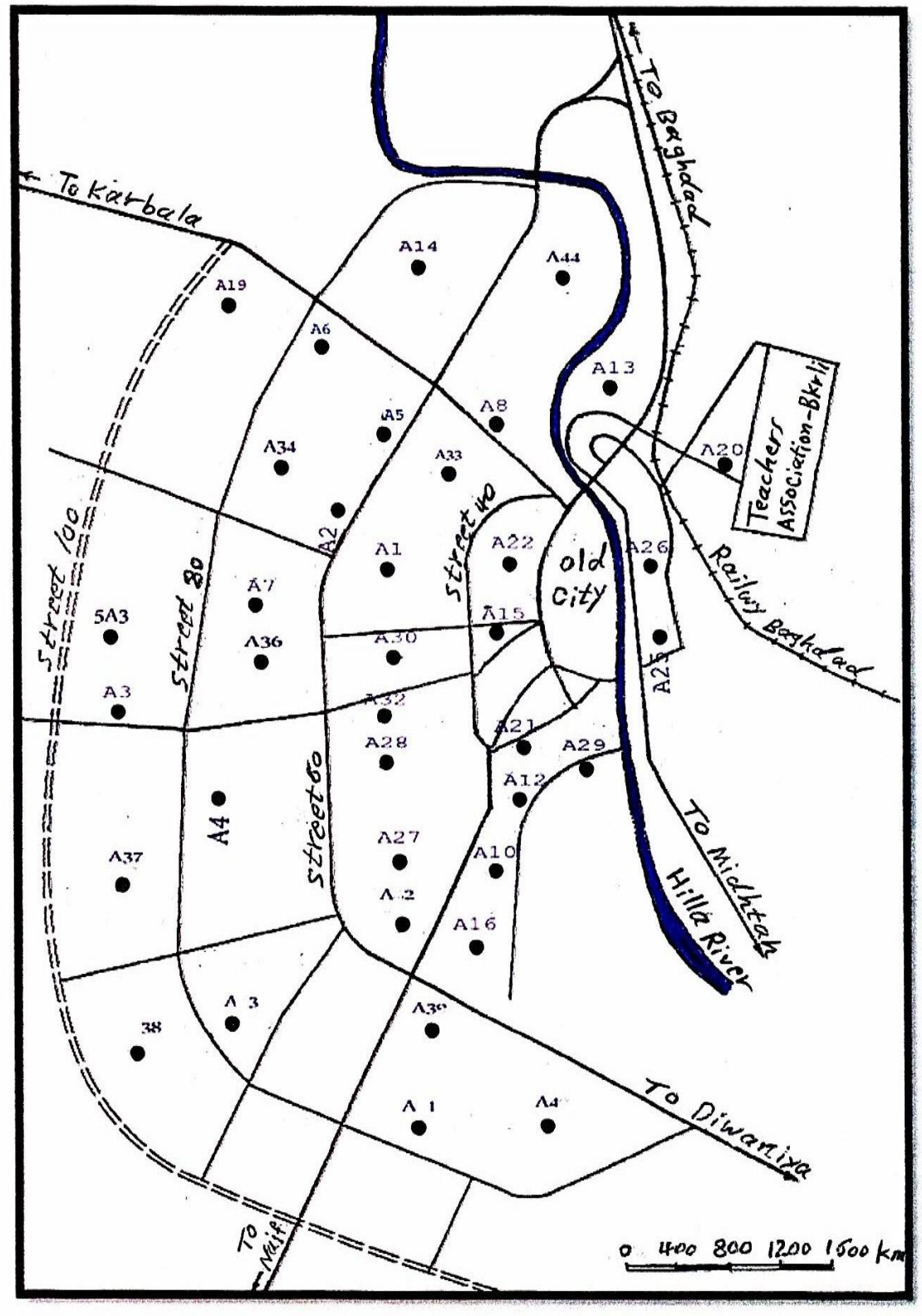

Fig. 4. Map of Hilla showing sampling locations.

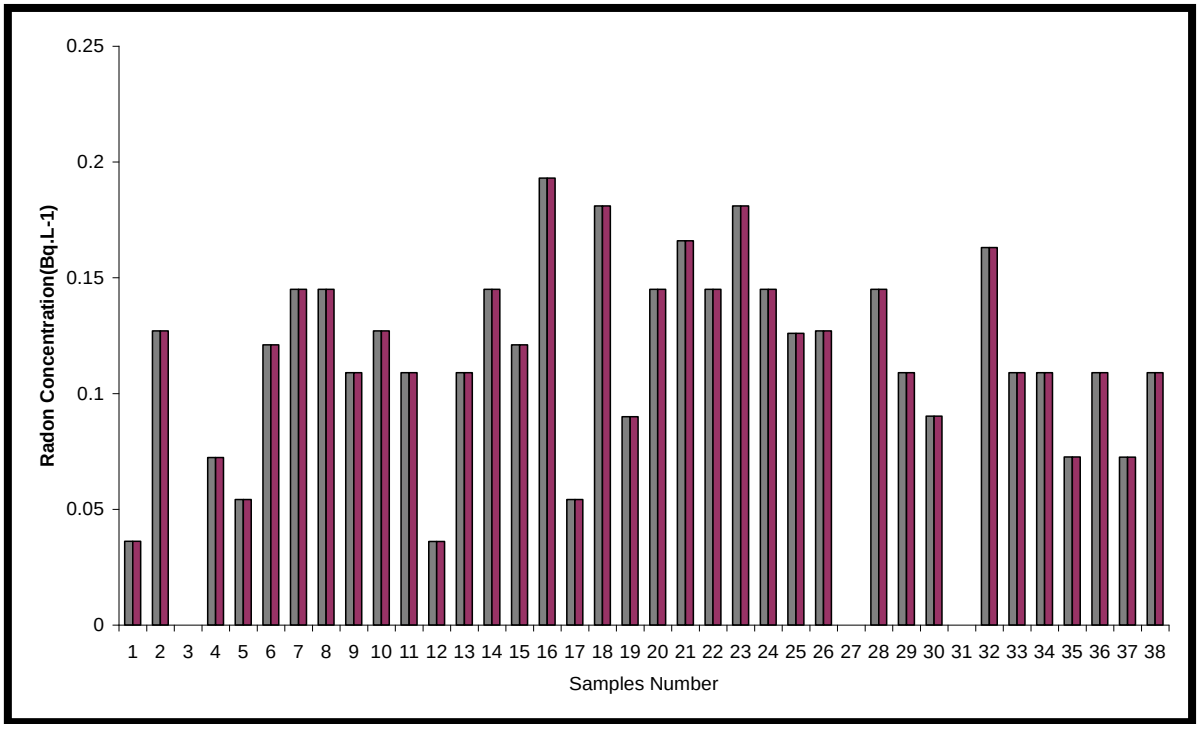

Fig. 4. Bar diagram showing variation in radon concentration of the water samples.

To ensure the quality control and reliability of the sampling and measurement methods, Each sample was analyzed in 4 cycles where we calculated the mean of these 4 readings and finally we calculated the mean for the 38 samples' means. Table (2) show there is difference in measurement results for water according to locations samples as shown in Fig. (4) Where the radon concentrations ranged from (0.0361 to 0.1930) $Bq \cdot L^{-1}$. The main Study finding points that all the readings for wells and springs were lower than the maximum contaminated level (MCL) of 11.1 $Bq \cdot L^{-1}$ [14,15]. These generally low concentration levels of radon in water tap could be explained from the geological context of the surrounding rocks. Indeed and environmental conditions [16].

As there is no absolute safe value of radiation from radon on general public. Although there are few studies on radon level in the water in Iraq [17,18] no water radon level reference has been established and therefore, there has been no specific safe limit value for radon until now in Iraq. Even in the neighbor countries, no standard safe level has been developed and they still depend on the U.S or European standard safe levels. In comparison with radon concentration in some countries the studies described in the Table (3), we find that the average concentration of radon in water lower as compared with these studies:

4. CONCLUSIONS

- The concentration of radon ^{222}Rn in water samples under study in the city of Hilla, Babil province reached 0.362 to 0.193 $Bq \cdot L^{-1}$,

- Clear from this study that the highest concentration of radon was in A_{16} (0.193 ± 0.0211) $Bq \cdot L^{-1}$ and less concentration in A_1 0.0361 ± 0.00014) $Bq \cdot L^{-1}$).
- The results obtained are consistent to some extent with the results of published studies.
- It found that the annual effective dose is 0.413 $mSv \cdot y^{-1}$.
- The method of measuring radon RAD7 using the device you need to moderate the temperature and humidity of the fact that this device is done depends on the semi-conductive reagents.

References

[1] A.D. Wrixon, "Radiation, People and the Environment". International Atomic Energy Agency, 1-3, 2014.

[2] United Nations Scientific Committee on the Effects of Atomic Radiation's, "Sources and Effects of Ionizing Radiation"; New York; 1996.

[3] E.B. Podgoorsak, "Radiation physics for medical physicist", Springer-Verlag Berlin Heidelberg, 2006.

[4] Exposures in two radon-prone areas, Ştei (Romania) and Torrelodones (Spain). Science of the Total Environment 407 (2009) 4452-4460.

[5] Barbara Veloso and Jose Rocha Nogueira. "Lung cancer and indoor radon exposure in the north of Portugal – An ecological Study" Cancer Epidemiology 36 (2012) 26-32.

[6] Durridge Company Inc., RAD7 Radon Detector. User Manual, 2011.

[7] Durridge Company Inc., Manual CAPTURE version 4.7.5, 2011.

[8] Durridge Company Inc., RAD7 $RAD_{H2}O$ Radon in Water Accessory. Owner's Manual, 2016.

[9] R.G. Sonkawade ,R. Mehra and K. Badhan, "Radon Activity Measurements in Drinking Water and in Indoors of Dwellings, Using RAD7", Tenth Radiation Physics and Protection Conference, Nasr City - Cairo, Egypt, 2010.

[10] Durridge Company Inc., RAD7 RAD H_2O Radon in Water Accessory. Owner's Manual, 2011.

[11] N. U. Khattak, M. A. Khan, M. T. Shah and M. W. Javed, "Radon concentration in drinking water sources of the Main Campus of the University of Peshawar and surrounding areas, Khyber Pakhtunkhwa, Pakistan", Journal of Radio analytical and Nuclear Chemistry 290 (2011) 493-505.

[12] R. K. Somashekar and P. Ravikumar, "Radon concentration in groundwater of Varahi and Markandeya river basins, Karnataka State, India", Journal of Radio analytical and Nuclear Chemistry, 285 (2010) 343-351.

[13] Visual artificial lunar satellite Landsat 7, packages (1,2,3), Landsat.gsfc.gov., 2005.

[14] Environmental Protection Agency United States Environmental Protection Agency. A citizen's guide to radon, 2009.

[15] UNSCEAR, United nations scientific committee on the effects of atomic radiation. Ionizing Radiation: Sources and Effects of Ionizing Radiation, New York, USA, 1993.

[16] N. U. Khattak, M. A. Khan," Radon concentration in drinking water sources of the Main Campus of the University of Peshawar and surrounding areas, Khyber Pakhtunkhwa, Pakistan", Journal of Radioanalytical and Nuclear Chemistry 290 (2011) 493-505.

[17] Sabah Yousif Hassan Ukla, "Determination of Radon, Uranium and Other Radioactive Isotopes Concentration In Different Types of Natural Water In Nenava Governorate", M.Sc., University of Mosul, 2004.
[18] Khalid H.H Al-Attiyah1, Inaam H. Kadhim. "Measurement and Study of Radioactive Radon Gas Concentrations in the Selected Samples of River Hilla / Iraq", Journal of Natural Sciences Research, 3(14) (2013).
[19] C. Canbazoğlu, M. Doğru, N. çelebi and G. Kopuz," Assessment of natural radioactivity in Elazıg region eastern Turkey", Journal of Radioanalytical and Nuclear Chemistry, 292 (2012) 375-380.
[20] A.T . Al-Kazwini, M.A. Hasan, "Radon Concentration in Jordanian Drinking Water and Hot Springs". Institute of Physics Publishing, J. Radiol. Port. 23 (2003) 439-448.
[21] A.Behtash, A. Jalili-Majareshin and D. Rezaei-Ochbelagh, "Radon concentration in hot springs of the touristic city of Sarein and methods to reduce radon in water", Radiation Physics and Chemistry, 81 (2012) 749-757.
[22] G. Jonsson, "Solid State Nuclear Track Detector in Radon Measurement Indoor and Soil". Nucl. Tracks Radiat. Meas., Vol. 25 (1991) 335-338.
[23] A. F. Maged, "Estimating the radon concentration in water and indoor air", Environ Monit Assess, Vol. 152, p. 195-201, 2009.
[24] A. K. Sam, H. Idriss and I. Salih ,"Study of radon in ground water and physicochemical parameters in Khartoum state", Journal of Radioanalytical and Nuclear Chemistry, Vol. 290 (2011) 333-338.
[25] Ali Abid AboJassim & Ahmed Rahim Shitake, "Estimated the mean of annual effective dose of radon gases for drinking water in some locations at Al-Najaf city", Journal of Kufa – Physics Vol. 5, No. 2, 2013.

(Received 02 July 2016; accepted 18 July 2016)