Analysis of Radon Concentration in Drinking Water in some Locations at Baghdad City/ Iraq

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Abstract

One of the most important characterizations of social health is existence the availability of safe drinking water. Since one of the sources of water contamination is nuclear contamination from radon gas, so in this research ^{222}Rn concentration levels in water supplies in Baghdad (capital of Iraq) is investigated. 10 water samples were collected and analysed using RAD7 detector. Review the results of these measurements show that, Radon activity concentration in the range of (0.289- 0.072) $Bq.L^{-1}$ with an average value of (0.1) $Bq.L^{-1}$,and the effective dose for human exposure to radon was (0.008) $mSv.y^{-1}$. Upon comparing the radon concentration values obtained with EPA it was found they were far below the maximum contaminant level of EPA (11.1 $Bq.L^{-1}$) , To reduce radon concentration, it is better to effective dose due to radon ingestion is consistent with WHO (1 $mSv.y^{-1}$) recommended dose level with keep water in open pools in contact with air before the water is delivered to users. 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, drinking water , annual effective dose, RAD7.

الخلاصة

واحدة من أهم خصائص المجتمع الصحي هو توفر ماء صالح للشرب ، وقد وجد إن غاز الرادون هو احد مصادر التلوث وفي هذا البحث تم التحقق من مستوى تركيز غاز الرادون في إمدادات ماء الإسالة لمحافظة بغداد (عاصمة العراق) ، حيث تم جمع 10عينات من المياه في بعض المنازل وتحليلها باستخدام كاشف الرادون RAD7 وقد أظهرت النتائج إن تركيز غاز الرادون يتراوح (0.289−0.072) $Bq.L^{-1}$ وبمعدل تركيز (0.1 $Bq.L^{-1}$) والجرعة الفعالة كانت مساوية (0.008 $mSv.y^{-1}$) وعليه وجد أن تركيز غاز الرادون في المياه هي ضمن الحدود الطبيعية التي حددتها المنظمات المختصة حيث إن الحد الأعلى المسموح به لتركيز غاز الرادون في الماء حسب وكالة EPA (11.1 $Bq.L^{-1}$) وقد تم اختيار هذا الموضوع للدراسة الحالية لأهمية الماء والهواء في حياة الإنسان والكائنات الحية، ولقلة الدراسات السابقة في منطقة الدراسة .

الكلمات المفتاحية: تراكيز الرادون، مياه الشرب، الجرعة الفعالة السنوية ، كاشف الرادون RAD7 .

1. Introduction

Radon gas and its radioactive isotopes have special attention among all other naturally occurring radioactive minerals, because it has the largest amount of total annual effective dose to humans [Knoll,1979]. The most important aspect of radon in high concentrations can be health hazards for human mainly a cause of lung cancer [Martin & Harbison,1986] .However, a very high level of radon in drinking water can also lead to a significant risk of the stomach and gastrointestinal cancer [Zajic,1999]. Knowledge of the levels of radon in each source including household water, particularly water from ground sources is necessary to protect public from consequences of excessive exposure to radiations mainly from the risk of lung cancer. Radon was

measured in water in many parts of the world, mostly for assessing the risk due to consumption of drinking water [WHO,2004].

Most of the radon that enters a building comes directly from soil that is in contact with or beneath the basement or foundation. Radon is also found in groundwater and will enter a home whenever this water is used [Knoll,1979]. In many situations such as showering, washing clothes and flushing toilets, radon is released from the water and mixes with the indoor air. Thus, radon from water contributes to the total inhalation risk associated with radon in indoor air [Nazaroff & Nero,1988]. In addition to this, drinking water contains dissolved radon and the radiation emitted by radon and its radioactive decay products is exposed to sensitive cells in the stomach as well as other organs once it is absorbed into the bloodstream [Zajic,1999]. The groundwater has normally much higher concentrations of radon than surface water such as lakes and streams [Suad & Najat, 2012] .

Health an implication of radon in drinking water (The source of drinking water such as spring water, river water, Artesian wells water… etc considering an important factor for limiting radon levels in drinking water) refers to ingestion of dissolved radon will result in a radiation dose to the lining of the stomach [WHO,2004]. Moreover, inhalation of radon gas that has been released from tap water will contribute to the radon content of indoor air and, if inhaled, will result in a radiation dose to the lung. Long-term exposure to high concentrations of radon in indoor air increases the risk of lung cancer [National Research Council ,1999].

2. Location of the study area

Baghdad is the capital of Iraq and is one of the largest cities in Iraq ,as well as it's one of the most populous urban agglomerations of the Middle East. Is located in central eastern Iraq The province has a total area of (4555 km²) .its geographical coordinates are 33° 20' 19" North, 44° 23' 38" East as show Figure 1. Baghdad is located alongside the Tigris River about (530 km) from the headwaters of the Persian Gulf, is in the heart of ancient Mesopotamia. The Tigris splits Baghdad in half, with the eastern half being called 'Risafa' and the Western half known as 'Karkh' [maps of world.com].

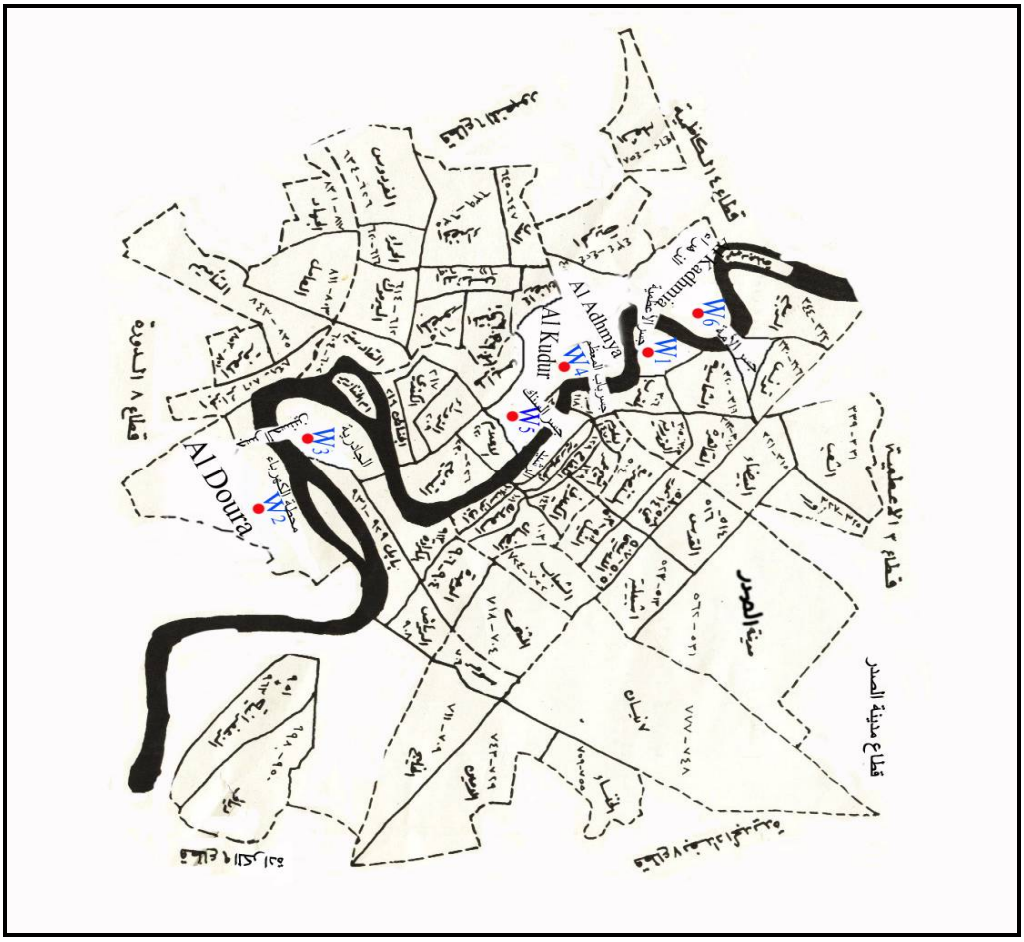

Fig.(1) The locations of collected water samples from different sites in Baghdad city [maps of world.com]

3.Experimental Part

A total of 10 water samples from hand pumps were collected and analyzed for radon concentration .The RAD7 radon detector manufactured by Durridge Company Inc. has been used for radon concentration measurement in the water samples. The equipment is portable and battery operated and the measurement is fast. Figure **2** shows the schematic diagram of RAD7 H_2O assembly [RAD7 Manual,2014]. The water samples were taken in 250‑ml vials designed for the RAD7 device and provided by the manufacturer [RADH_2O Manual,2014]. Water samples from hand pumps were measured for radon during the month February 2014 and the weather conditions during the sampling period were fairly stable. The hand pumps from where the sample collection was done were in proper working condition. The system was pumped for 10‑15 min before the sample was taken. Water sampling is complicated for the fact that the gas easily escapes from water, and therefore has to be done without any aeration, which might lead to outgassing [RAD7 Manual,2014]. Hence the water samples should be collected in such a way that there should be no bubbling. In the present research, as sample was collected, it was analyzed immediately on the entire sampling site. The time difference between taking the sample and analyzing it was few hours and hence no decay of radon in the water occurred. For accurate readings, the RAD7 has been dried out thoroughly to reduce the relative humidity below 10% before making each measurement [Somashekar &. Ravikumar,2010].

The RAD7 H_2O is an accessory to RAD7 that enables measurement of radon in water [RADH_2O Manual,2014]. The operation of this instrument is based on the

following principle: (i) radon is expelled from water sample by using a bubbling kit, (ii) expelled radon enters a hemisphere chamber by air circulation, (iii) polonium decayed from radon is collected onto a silicon solid state detector by an electric field, (iv) radon concentration is estimated from the count rate of polonium. RAD H_2O gives results after a 30 min analysis with a sensitivity that matches or exceeds that of liquid scintillation methods.

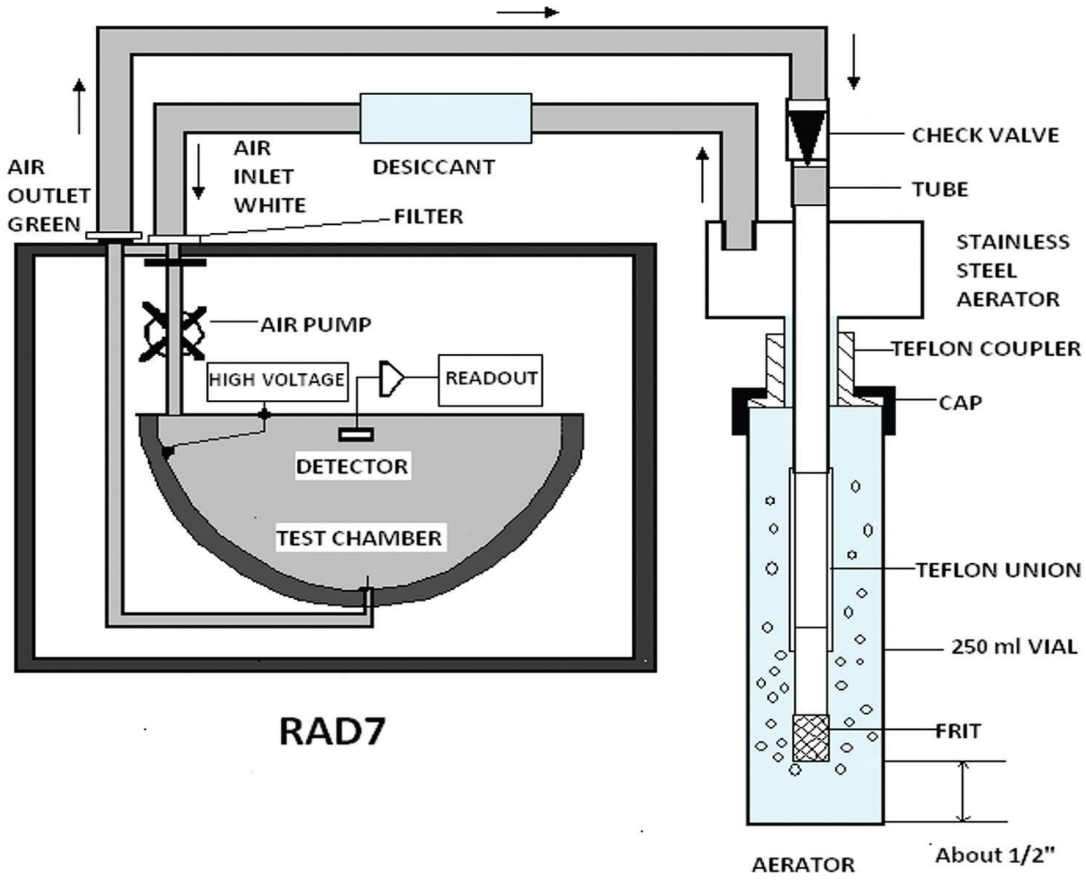

Fig.2: The schematic diagram of RAD7 H_2O assembly[RADH_2O Manual,2014].

The RAD H_2O method employs a closed loop aeration scheme whereby the air volume and water volume are constant and independent of the flow rate. The air recirculates through the water and continuously extracts the radon until a state of equilibrium develops [RAD7 Manual,2014]. The RAD H_2O system reaches this state of equilibrium within about 5 min, after which no more radon can be extracted from the water. The extraction efficiency or percentage of radon removed from the water to the air loop is very high about 94% for a 250 ml sample. The exact value of the extraction efficiency depends somewhat on ambient temperature, but it is almost always well above 90%. The RAD7 detector converts alpha radiation directly to an electric signal [RADH_2O Manual,2014]. The RAD7 has the ability to tell the difference between the new radon daughters and the old radon daughters left from previous tests [RAD7 Manual,2014].

The annual effective dose to an individual consumer due to intake of radon from drinking water is evaluated using the relationship [Somashekar & Ravikumar,2010].

$$D_w = C_w\, CR_w\, DC_w \qquad (2)$$

where, D_w is the annual effective dose (Sv .y^{-1}) due, C_w concentration of ^{222}Rn in the ingested drinking water (Bq.L^{-1}), CR_w annual intake of drinking water (1095 L.y^{-1}),

DC_w is the ingested dose conversion factor for ^{222}Rn ($5x10^{-9}$ $Sv.Bq^{-1}$). suggested by the United Nations Scientific Committee on the Effects of Atomic Radiation has been used [UNSCEAR,1993].

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($Bq.L^{-1}$),(W) Water sample .

Table (1) radioactive radon gas concentrations in samples from water in Baghdad

Sample Point	Mean ($Bq.L^{-1}$)	High ($Bq.L^{-1}$)	Low ($Bq.L^{-1}$)	Effective dose($mSv.y^{-1}$)
S1	0.145 ±0.118	0.29	0	0.007
S2	0.181 ±0.18	0.432	0.145	0.009
S3	0.126 ± 0.07	0.181	0.072	0.006
S4	0.289 ± 0.07	0.325	0.253	0.015
S5	0.09 ± 0.03	0.108	0.072	0.004
S6	0.144 ± 0.05	0.181	0.108	0.0078
S7	0.253 ± 0.15	0.362	0.144	0.013
S8	0.072 ± 0.08	0.145	0	0.0039
S9	0.108 ± 0.138	0.288	0	0.0059
S10	0.145±0.2	0.435	0	0.0079

The present study showed that the radon concentration in drinking water samples from Baghdad city is well within the maximum contaminant level (MCL) [EPA,2009] value (11 $Bq.L^{-1}$). The measured radon concentrations vary from (0.072 to 0.289) $Bq.L^{-1}$ with an average value of (0.1 $Bq.L^{-1}$) as show Figure 3 and will pose none serious health risks. Hence the study area is considered to be safe for the residents. The U.S. National Academy of Sciences reports that the average concentration of radon in public water supplies derived from surface waters is usually less than 0.4 $Bq.L^{-1}$, and it is about 20 $Bq.L^{-1}$ in ground water [National Research Council ,1999]. Even the annual effective dose values were varying with respect to the increase in radon concentration with an average (0.008 $mSv.ye^{-1}$) and were significantly lower than the WHO recommended limit for members of the public of (1 $mSv.ye^{-1}$) [WHO,1993].

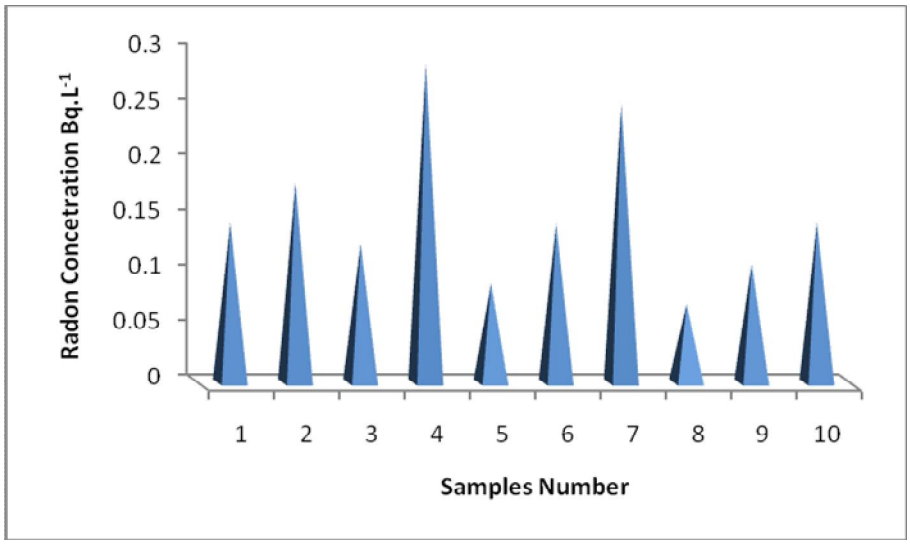

Fig.(3) Bar diagram showing variation in radon concentration of the water samples

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	1.133 $Bq.L^{-1}$ [Ukla,2004]
present study	0.3 $Bq.L^{-1}$ Iraq -Baghdad
Turkey	0.091 $Bq.L^{-1}$ [Canbazoğlu,et.al,2012]
Kuwait	0.74 $Bq.L^{-1}$ [Maged,2009]
Syria	13 $Bq.L^{-1}$ [Jonsson,1991]
Iran	(0.21-3.89) $Bq.L^{-1}$ [Behtash,et.al,2012]
Jordon	3.9 $Bq.L^{-1}$ [Al-Kazwini. & Hasan,2003]
Khartoum	59.2 $Bq.L^{-1}$ [Sam,et.al,2011]
Algeria	7 $Bq.L^{-1}$ [Amrani,2002]

5.Conclusions

In this paper, the results of the ^{222}Rn measurements in 10 drinking water samples collected from Baghdad city are presented. The measurements were performed by RAD7 radon detector manufactured by Durridge Company Inc. The observed values of radon concentration are within the international recommended limit and hence safe for drinking purposes. The total effective dose in all locations of the studied area is found to be within the safe limit (1 $mSv.y^{-1}$) recommended by World Health Organization and EU Council. The results show no significant radiological risk due to radon ingestion for the inhabitants of the studied regions. These data must be regarded as preliminary and further extensive studies should be done on large scale by initiating further detailed investigation of whole command area completely for radon contamination, to increase awareness and mitigate possible hazards.

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