Estimated the mean of annual effective dose of radon gases for drinking water in some locations at Al-Najaf city

***Ali Abid AboJassim** ****Ahmed Rahim Shitake**

* Uni. of Al-Kufa / Sci. Coll. /Dep. Phys. ** Uni. of Al-Kufa/Med. Teeth. Coll.

Abstract

In this work, Radon concentrations in drinking water were measured at 24 locations in Al-Najaf cities, using RAD-7 radon monitoring system of Durridge company USA.

The annual effective dose for all samples of drinking water were estimated by equations depending on UNSCEAR organization. It is found that the radon concentrations in samples in studied area were varied from (2.43±0.879 Bq/m^3) to (225.5±12.657 Bq/m^3), while the mean annual effective dose of Ingestion and Inhalation varied from (0.017739 $\mu S.y^{-1}$) to (1.64615 $\mu S.y^{-1}$) and (0.088807 $\mu S.y^{-1}$) to (0.704526 $\mu S.y^{-1}$) respectively.

When the results were compared of radon concentrations with the internationally recommended reference levels (World healthy Organization limit 500 Bq/m^3) and the mean effective annual dose for radon in drink water normal limits of world (1 mSv/y), there were no indications of existence of radon problems in the water sources in this survey. therefore the drinking water in Al-Najaf city is safe as far as radon concentration is concerned.

تخمين معدل الجرعة السنوية المكافئة لغاز الرادون في مياه الشرب في بعض مناطق مدينة النجف

***علي عبد ابوجاسم** ****احمد رحيم شلتاغ**

* جامعة الكوفة /كلية العلوم/ قسم الفيزياء ** جامعة الكوفة /كلية طب الأسنان

الخلاصة

في هذا العمل ، تم قياس تراكيز الرادون في مياه الشرب لـ 24 موقع من مدينة النجف وذلك باستخدام منظومة التتبع لغاز الرادون RAD-7 الأمريكية الصنع.

كما وقد تم حساب الجرعة السنوية المكافئة لجميع العينات من مياه الشرب بالاعتماد على معادلات منشورة من قبل منظمة الصحة العالمية (UNSCAR) . وجد إن تركيز غاز الرادون في مي النماذج للمساحة المدروسة تتغير من (27.5 ± 2.437 Bq/m^3) إلى ($188.25\pm8.796 Bq/m^3$) لكن بعض النماذج لم يكشف بها غاز الرادون، بينما معدل الجرعة السنوية المكافئة تتغير من (0.0038665 $mS.y^{-1}$) إلى (0.02646795 $mS.y^{-1}$).

تم مقارنة النتائج تراكيز الرادون مع الحد المسموح به عالميا (منظمة الصحة العالمية والتي حددت الحد المسموح (500 $Bq.m^{-3}$) وكذلك معدل الجرعة السنوية المكافئة لغاز الرادون في مياه الشرب والمحدد (1 $mSV.y^{-1}$)، لم تكن هناك من مشاكل في مصادر المياه في هذه الدراسة تشير على وجود غاز الرادون. لذلك فان مياه الشرب في مدينة النجف صالحة بقدر ما موجود من تراكيز الرادون.

Introduction

^{222}Rn's lifetime is considered long relative to the other isotopes. This is of significance, since radon is formed in the ground or building materials [1] and has significantly more time to diffuse through the material into the indoor environment in buildings or the outdoor atmosphere. The radon formed relatively close to the earth's surface can diffuse through the soil or be driven by pressure gradients [2].

In many countries, radon is the second most important cause of lung cancer after smoking. The proportion of lung cancers attributable to radon is estimated to range from 3 to 14%. Significant health effects have been seen in uranium miners who are exposed to high levels of radon. However, studies in Europe, North America and China have confirmed that lower concentrations of radon – such as those found in homes – also confer health risks and contribute substantially to the occurrence of lung cancers worldwide [3-5]. The risk of lung cancer increases by 16% per 100 Bq/m^3 increase in radon concentration. The dose-response relation is linear – i.e. the risk of lung cancer increases proportionally with increasing radon exposure. Radon is much more likely to cause lung cancer in people who smoke.

There are some scientists modernly using RAD-7 detector to measure radon and thoron concentrations in air, soil, gas and water. R.K. Somashekar and et al. in (2010)[6] studied the distribution of radon (^{222}Rn) activity concentration in groundwater samples and their annual effective dose exposure in the Varahi and Markandeya command areas. Radon measurement was made using Durridge RAD-7 radon-in-air monitor, using RAD H2O technique with closed loop aeration concept. Yanliang Tan and Detao Xiao in (2011) [7] used RAD-7 detector for Measuring the Radon Exhalation Rate from the medium surface . The common calculation method for deriving the exhalation rate as based on an assumption that the radon concentrations in the detector's internal cell and that in accumulation chamber are equal with sufficient accumulation time. In (2012) A. N. Todorovic and et al. [8] studied the radon level of bottled drinking water and from tap water in the city of Novi Sad, Serbia. The measurements were performed by RAD-7 radon detector manufactured by DURRIDGE COMPANY Inc. In order to make the correlation between radon and radium concentrations in the tap water and in the water from public drinking fountain, the gamma- spectrometric measurements were performed.

Area of Study

Najaf is located on the edge of western plateau of Iraq, at southwest of Baghdad the capital city of Iraq, at 160 km far from the capital. It is 70 meters above sea level and is situated on longitude of 44 degree and 19 minutes, latitude of 31 degree and 59 minutes [9]. It is boarded from north and northwest by Karbalaa city (which is 80 km far from it), and from the south and west by low sea of Najaf, and Abi Sukhair (which is 18 km far from the city) and from the east by Al- Kufa city (which is 10 km far from the city)[10].

In the present study (24) regions were chosen as fair distribution in Al-Najaf cities. The regions were determined using (GIS) as shown in Fig.(1) that Al-Najaf city. Table (1) showed the sites of measurement in studied area for taking samples.

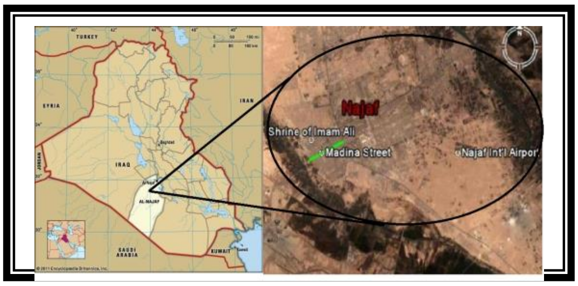

Fig.(1) Map of Al- Najaf Al-Ashraf Province

Materials and methods

The RAD-7 radon detector manufactured by DURRIDGE COMPANY Inc. has been used for the radon concentration measurement in the water samples. The lower limit of detection(LLD)is less than $0.37BqL^{-1}$. The equipment is portable and battery operated, and the measurement is fast. The RAD-7, H_2O

gives results after 30 min analysis with a sensitivity that matches or exceeds that of liquids scintillation methods(RAD-7, RAD H_2O). A number of fact or affect the accuracy and precision of a radon in water measurement. Most critical among these factors is the sampling technique. Other factors include the sample concentration, sample size, counting time, temperature, relative humidity and background effects(RAD-7, H_2O). Sampling technique is generally the majors our conferrer in measuring the radon content of water. The water sample must be representative of the water being tested and such that it has never been in contact with air. In this experiment the samples were collected using the techniques proposed by the manufacturer(RAD-7, H_2O). In the method a bowl is putout the faucet so that the water over flowing the bowl prevents the water when leaving the faucet from aching the air and the vial is filled with water at the bottom of the bowl. In the measurement, a 250 ml vial was taken for radon concentration less than 100 BqL^{-1}. If the radon concentrations higher than 100 BqL^{-1}, a 40 ml vial is used. Because in this investigation the radon concentration in water was unknown, the samples in both sizes were taken. When sampling a tap water, water was let run for 10 min before taking the sample, in order to let out the water from the possibly stagnant pipe section, and to obtain parameters characteristic of the fresh water. The sampling vial (volume 250 ml) was placed in the bottom of the bowl, and the tube end was put into the vial. The water flow for a while, keeping the vial full and flushing with fresh water. The vial was cap while still under the water.

A relative humidity showed the greatest impact on measurement error in the presented results. For accurate readings, the RAD-7 should be dried out thoroughly before making the measurement. If the RAD-7 is thoroughly dried out before use, the relative humidity inside the instrument will stay below10% for the entire 30 min of the measurement. If not, then the humidity will rise during the 25 min that the RAD-7 is counting and the pump is stopped, and may rise above 10% before the end of the measurement period. High humidity reduces the efficiency of collection of the polonium-218 atoms, formed when radon decays inside the chamber. However, the 3.05 min half-life of ^{218}Po means that almost all the decays that are actually counted come from at mode posited in the first 20 min of measurement. So a rise in humidity above10% over the last10 min of the counting period will not have a significant effect on the a accuracy of the result. On the other hand, if the humidity rises above 10% before the end of the first counting cycle, there will be an error whose size is indeterminate (RAD-7, RADH_2O). The experimental setup is shown in Fig.(2) below. Using RAD H_2O technique employs closed loop concept, consisting of three components; (a) the RAD-7 or 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 marked in the figure.

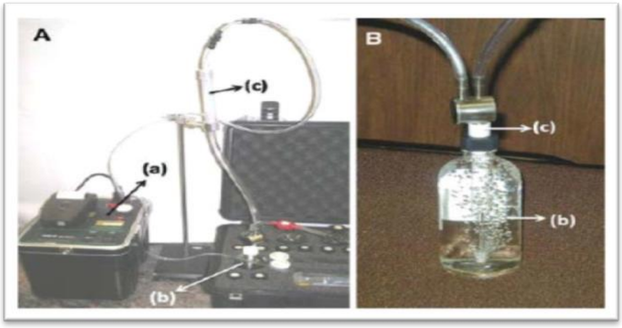

Fig.(2): Schematic presentations of radon-in-air monitor RAD-7[11].

For the ingestion part, radon and its daughters in drinking water impact a radiation dose to the stomach. The committed annual effective dose contribution of citizens, taking ^{222}Rn concentrations in account, was calculated according to the Somlai et al.[12], using the formula:

$$E = K \times C \times KM \times t$$

where E is the committed effective dose from ingestion (Sv), K is the ingesting dose conversion factor of ^{222}Rn (10^{-8} Sv Bq^{-1} for adults, and 2×10^{-8} Sv Bq^{-1} for children[13], C is the concentration of ^{222}Rn (BqL^{-1}), KM is the water consumption (2 $L.day^{-1}$), t is the duration of consumption (365days)[14]. For the dose calculations, a conservative consumption of 2 $Lday^{-1}$ per year for ‘‘standard adult’’ drinking the same water and directly from the source point was assumed [13,15]. The radon concentration of drinking waters decreases during storage, processing, etc., so by the evaluation of dose, the consumption test is that of water taken directly from the tap[12].

Exposures to radon come mainly from the inhalation of the decay products of radon, which deposit in homogeneously within the human respiratory tract and irradiate the bronchiale pithelium [8]. According to the UNSCEAR report UNSCEAR, 1993 [13], 1 Bqm^{-3} of radon in air, with an equilibrium factor of 0.4 and occupation factor of 0.8, gives and effective dose to the lung of 25 mSv year^{-1}. Assuming the ratio between the radon concentrations in air released from water to that in water to be 10^{-4}, the conversion factor from unit concentration of radon at equilibrium is 2.8 mSv Bq^{-1} m^3 [16]

Result and discussion

. Table (2) showed the results of radon concentrations for unit of mean concentrations (Bq.m^{-3}) and the rate annual effective dose (for unit µS.y^{-1}) of drinking water in Al-Najaf city.

From Table (2) and Fig.(3) the location sample (S14) (Al.Qadesea) had highest radon concentration of each location samples which had mean value (225.5±12.657 Bq.m^{-3}), and location sample (S8) (Al.Jazera) had lowest radon concentration of each location samples which had mean value (27.5±2.654 Bq.m^{-3}). Also Table(2), showed the highest value of the rate of annual effective dose for Ingestion and Inhalation in sample (S14) were (1.64615 and 0.704526) µSv.y^{-1} respectively, but the less value in sample (S8) were (0.20075 and 0.158006) µSv.y^{-1} respectively.

From the spectra that shown in Fig. (4) and (5) for higher and lower of location sample in study area can be noted the relation between the count rate and the energy which consist of Radon daughters in A(^{218}po) , B(^{214}po) and Thoron daughters D(^{216}po) , E(^{212}po).

Results of the average radon of concentration drinking water in Al-Najaf city were smaller than the accordable limit as reported in WHO [14]. The allowed maximum concentrations level for ^{222}Rn in water is 500 Bq.m^{-3} . The reason for vibration in radon concentration could be a function of geological structure of the area, depth of the water source and also differences in the climate . Others have reported that the geological structure of an area is a predominant factor for high radon concentration and climate is also an important factor[17]. All results of the annual dose effective for ^{222}Rn of drinking water at Al-Najaf city were smaller than the normal limits of world (1) msv.y^{-1} [11].

All the results summarized in Fig.(3) as well. In the lack of radon map for Iraq, one may compare these data with the surrounding area. The work of Misconi and Navi summarized the average radon concentration in different Middle East countries [14]; in Iran (Hamadan) 364 Bq m^{-3}, Syria (Damascus 45 Bq m^{-3} , Jordan (north) 144 Bq m^{-3}, Israeil (national) 47 Bq m^{-3}, Saudia Arabia (Al- Jauf) 30 Bq m^{-3} and Yemen (Hodeidah) 42 Bq m^{-3}. However those are mainly for doweling, which is affected by the water used.

Conclusion :

The discussion of the result , which are obtained from this study leads to the following **conclusions :**

1. All results of radon concentrations were obtained in this study are less than the allowed concentration level.
2. The estimated main of annual effective dose for **Ingestion and Inhalation** are less than the allowed maximum concentration level in drinking water.

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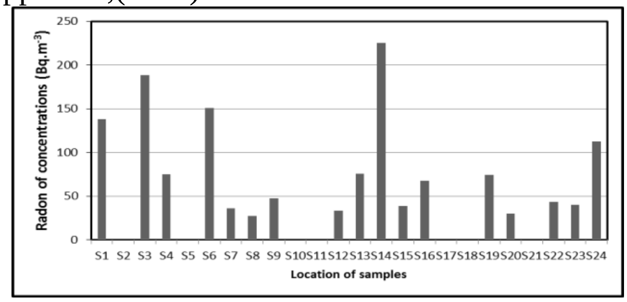

Fig. (3) Radon Concentration of drinking Water in Al-Najaf city

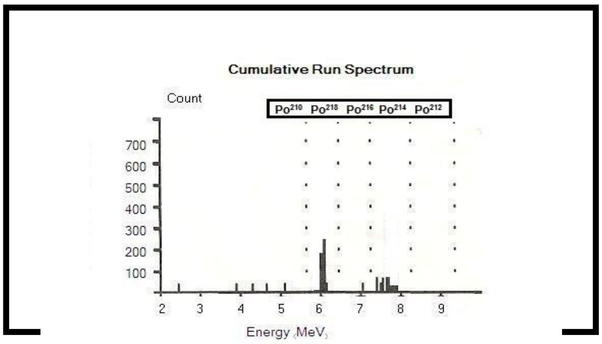

Fig.(4) alpha energy spectrum of location Sample(S21)

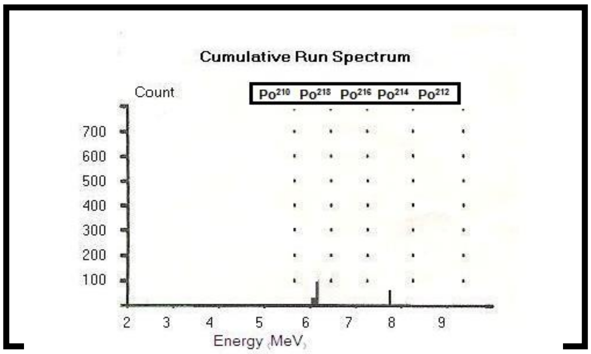

Fig. (5) alpha energy spectrum of location Sample(S8)

Table (1): The sites of measurement in studied area for taking samples

No.	Location name	Sample	Coordinates	No.	Location name	Sample	Coordinates
1	Al.Qodes	S1	44⁰22/ 07.653// E , 31⁰58/ 42.548// N	13	Al.Wafaa	S13	44⁰20/ 51.423// E , 32⁰2/ 52.177// N
2	Al.Ameer	S2	44⁰21/ 52.161// E , 32⁰0/ 32.683// N	14	Al.Qadesea	S14	44⁰22/ 22.582// E , 32⁰0/ 4.373// N
3	Al.Ansar	S3	44⁰22/ 24.948// E , 31⁰59/ 36.667// N	15	Al.Ashteraky	S15	44⁰21/ 10.642// E , 32⁰0/ 13.086// N
4	Al.Gadeer	S4	44⁰20/ 47.083// E , 32⁰0/ 58.077// N	16	Al.Jedada	S16	44⁰19/ 41.911// E , 32⁰59/ 41.865// N
5	Al.Adala	S5	44⁰21/ 30.821// E , 32⁰1/ 18.069// N	17	Old city	S17	44⁰19/ 41.876// E , 32⁰59/ 41.764// N
6	Al.Gharry	S6	44⁰20/06.197// E , 32⁰1/ 21.629// N	18	Adan	S18	44⁰20/ 59.407// E , 31⁰59/ 33.891// N
7	Al.Saad	S7	44⁰20/ 28.962// E , 32⁰0/ 01.317// N	19	Al.Shorta	S19	44⁰19/ 56.902// E , 31⁰58/ 57.733// N
8	Al.Jazera	S8	44⁰19/ 59.966// E , 32⁰2/ 52.596// N	20	Al.Moalmen	S20	44⁰20/ 23.281// E , 31⁰59/ 30.868// N
9	Al.Nafot	S9	44⁰19/ 42.213// E , 32⁰1/ 22.965// N	21	Al.Karama	S21	44⁰20/ 29.888// E , 3200/ 51.634// N
10	Al.Jameah	S10	44⁰19/ 51.106// E , 32⁰2/ 22.302// N	22	Al.Forat	S22	44⁰21/ 7.855// E , 32⁰1/ 13.828// N
11	Al.Hendaa	S11	44⁰20/ 31.904// E , 32⁰3/ 12.871// N	23	Al.Jameah	S23	44⁰19/ 51.106// E , 32⁰2/ 22.302// N
12	Al.Mellad	S12	44⁰18/ 47.597// E , 32⁰2/ 49.890// N	24	Al.Wafaa	S24	44⁰20/ 51.423// E , 32⁰2/ 52.177// N

Table (2) Radon concentration in ($Bq.m^{-3}$) and mean annual effective dose in ($\mu Sv.y^{-1}$) of drinking water sample in Al-Najaf city.

No.	Location of samples	Radon of concentrations (Bq.m-3)	The rates of annual effective dose	
			Ingestion (µSvy-1)	Inhalation (μSvy^{-1})
1	S1	138±12.345	1.0074	0.463008
2	S2	---------	---------	---------
3	S3	188.25±16.223	1.374225	0.601708
4	S4	75±4.768	0.5475	0.289115
5	S5	---------	---------	---------
6	S6	150.75±13.145	1.100475	0.498201
7	S7	36.25±6.301	0.264625	0.182157
8	S8	27.5±2.654	0.20075	0.158006
9	S9	47.5±3.987	0.34675	0.21321
10	S10	---------	---------	---------
11	S11	---------	---------	---------
12	S12	33.5±7.980	0.24455	0.174567
13	S13	75.5±5.435	0.55115	0.290495
14	S14	225.5±12.657	1.64615	0.704526
15	S15	38.75±5.369	0.282875	0.189058
16	S16	67.75±6.781	0.494575	0.269104
17	S17	---------	---------	---------
18	S18	---------	---------	---------
19	S19	74.5±8.987	0.54385	0.287735
20	S20	30±2.345	0.219	0.164906
21	S21	---------	---------	---------
22	S22	43.75±8.787	0.319375	0.202859
23	S23	40±7.547	0.292	0.192508
24	S24	112.75±10.342	0.823075	0.393313