



A Review on Measurement of Radon Gas Concentration in Drinking Water

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ABSTRACT

Radon is a noble gas that has a high risk to the human body, and existence at various rates in soil, air and different sources of water. Moreover, radon has a short lifetime but it can produce more risk to public health. Humans are good users of water by food, drinking water, vegetables, showers and dishwashing, however, we do have not good knowledge about the risk of radon, and we need to do more research because it's one of the main factors to various types of cancer such as lung and stomach cancer. This review used different data in some research in different countries (Romania, China, Brazil, Sudan, India, Syria, Iraq, and Yemen) in (2012-2020) that used the RAD7 detector because it has higher resolution and is faster in measurement. In the current review, a higher average reading of radon was found in Nigeria, its reading was (36.1 Bq/L) which was more than the standard value in the world for drinking water (11.1 Bq/L). In any country, there are so many factors to high and low concentration of radon in drinking water which are discussed and explained in this review.

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1. INTRODUCTION

Just as Materials used in biomedical technology must have biocompatibility properties to be able to adapt to the living organisms in which they are used without causing side effects such as smart materials and biomaterials. [1-15], Similarly, water used for both drinking and technology and production must be ensured to be clean and fit for use. However, pollution and the mixing of some harmful radiation substances in water often pose a threat to the use of water for some daily needs. Also, in our daily life, we contact with different types of indoor and outdoor contamination of radiation in various quantities. We have two sources of water, ground and surface water. Radium and its progeny (radon) exist in different quantities in air, soil and water. The radon concentration in water comes from escaping and contact of water with both soil and rocks [16, 17]. Radon was found in 1900 by Fredrick Dorn, a German scientist and at that time called radium emanation in 1923. It is generated in the process of the decay of both parent nuclides of uranium and thorium in soil and rocks [16, 18, 19]. Radon chemically unreactive gas (inert gas) with some remarkable properties of being tasteless, odorless, colorless and highly dissolved in water and contaminated [17, 19, 20]. There are two main

mechanisms of inhalation and ingestion to enter radon into the human body, the first one during breathing and another due to consumption of water and other types of fruits, vegetables, showering and so on [17, 21]. According to the Environmental Protection Agency (EPA), the maximum contamination level (MCL) of radon in drinking water is 11 Bq/L. In the decay chain of uranium, one of the progeny is ²²²Rn with a measurable half-life of about 3.82-day emitting alpha particles and changed to ²¹⁸Po ($t_{1/2} = 3.11$ m) and continues to decay until it reaches the ²¹⁰Pb, is effectively stable [22]. The dose comes from Radon contributes about one-half of all total annual doses from radiations' of other kinds [21]. According to the World Health Organization (WHO), radon can be regarded as the second source of lung and stomach cancer after cigarettes. The present study aims to mention the different methods to evaluate the radon concentration in drinking water, collect the data and compare the results of the researchers for future work and planning. In addition, appear risk of normal water uses for shower is minimized from indoor radon. Because water is the most fundamental component in human life, therefore, certain restrictions are necessary to protect humans from the risks of radon and other radionuclides. For this purpose, the European Commission recommended the concentration of radon by

(1000Bq/L) and suggest that if the value in any area exceeds the guideline value, it must be treated differently than the standard approach, and the environmental protection agency for a higher level of radon damage in drinking water is (11.1 Bq/L). [16]. Because radon in underground water simply can arrive at the surface through the soil and to air then published deliveries, in addition naturally can develop by the geological structure. Because the risk of radon is higher and humanity can't neglect, therefore, (WHO) partnership with (the IAEA) radon state can create the first radiation source and its risk for public health because it can be contact with air at the same time humanity can receive the dose from breathing [18, 23]. The effect of radon on health may be in two ways first by breathing and second by swallowing [24]. Most of the risk is on the stomach as in the United States 21000 people die yearly from lung cancer it's about twice of a accident car [20]. They'll die (129) yearly from the radon formation in drinking water[25]. This review used different data from some research in different countries (Romania, Chania, Brazil, Sudan, India, Syria, Iraq, and Yemen) from (2012 to 2020), Each of them has tried to

measure the amount of radon in drinking water at different places and explain the reasons for the presence of radon in water.

2. RAD 7 DETECTOR.

In the current study, it was demonstrated that the standard material methods have been used in the previous studies to determine the radon concentration in the drinking water. The commonly used method known as the RAD 7 detector (Figure 1.), Figure 1 showed the schematic diagram of RAD7. Because it has a higher quality detector to detect radon with a fast way to record the data and recording it during every 30 minutes, Also, RAD7 is possible in the laboratory and the field its easy and higher design quality in measuring because it can be organized by quality techniques and accuracy for measuring radon and isotopes at the short time. Researchers use RAD7 in laboratory, study area and at home the results is more reliable when compared with other detectors [17, 18].

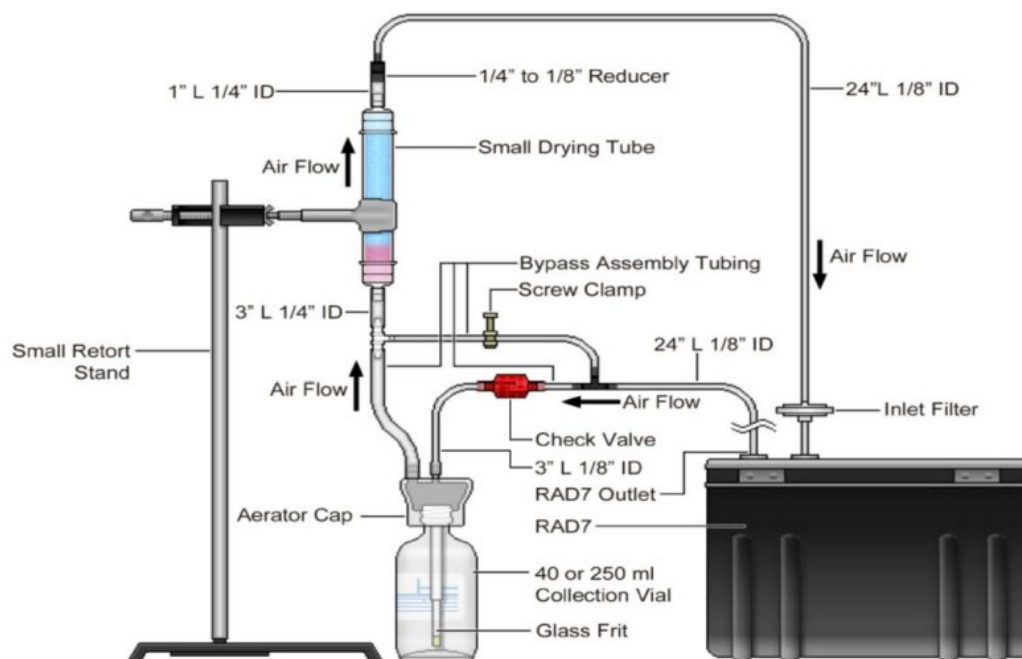


Figure 1. A schematic diagram of the RAD7 [17].

The equipment RAD7 radon detector is generated by DURRIDGE company INC [17, 26]. RAD7 uses a semiconductor solid state to change straightly alpha particle radiation to an electric signal with reward an electronically any alpha particle and concerning diagnose Isotopes (^{218}Po , ^{214}Po) which are produced from radiation, and used to distinguish older radon from new radon, thoron and one that comes from electronic noise. RAD7 is described by the hemisphere that enters (0.7 ml) of water which covers a conductor and semiconductor lie the center of the hemisphere. When (2000 - 2500 V) is applied to the conductor the electrical field fits to the hemisphere and attracts any positive aerated particles to the equipment surface. The operation of RAD7 onset the air rotation through the entire water to distinguish radon from water until the equipment system arrives at the

equilibrium state, Mechanically the system stops and ambushes for 5 minutes in oscillation. The same process is repeated for 5 minutes later. At the end of the operation, the detector prints out the radon concentration. The time passed during the sampling and running process was corrected using the formula [27]. By the disintegration and the period, $\lambda = \frac{\ln 2}{t_{1/2}}$, $t_{1/2}$ for radon is 3.83 days. To save public health from the risk of radioactive nuclide in the drinking water because different quantity of radon in drinking water creates a dangerous risk for people for a long time, and the value of any radioactive nuclide is increased by some parameter known as TENORM. In addition, some countries recorded the maximum value therefore this water is not safe to use and the best work for this area is will be aware people, Caution from the risk of radon and treatment instantly [28]. Sometimes the ratio of

radon is different values in water, therefore, we need more guidance about radon and risks, It can be minimised concentration in drinking water by measuring consciously with reliability, accuracy and similarity with international and European countries, and can treated with one of the ways when the level of radon is extra the safety limit, it's very difficult to control and distributed from the drinking water, the process is different between groundwater and surface water because in groundwater it is closed and it's more related with geology structure and existence uranium rock in the area[28, 29]. The used technique to determine radon is different, but at the same time must follow one of the standards but something attention in (WHO) has no recommendation and the (E-DWD) organization proposes different ways to measure radon for standards way its

Table1. Measured radon concentration in drinking water from 2012-2020.

No.	Location	Average 222Rn Bq/L	year	references
1	Romania	11.4	2012	[16]
2	Chania	5.87 - 4.63	2014	[30]
3	Brazil	15.4	2014	[31]
4	Sudan	14.24	2014	[32]
5	India	13.6	2015	[33]
6	Syria	10.8 ± 2.5	2015	[34]
7	Iraq	8.158	2016	[27]
8	Yemen	3.306	2016	[35]
9	Jamaica	18 ± 2	2017	[23]
10	Nigeria	36.1	2019	[36]
11	Iran	0.92 – 17.12	2020	[37]
12	India	8.5 ± 0.6	2020	[24]

In Romania (2012). Nita et al. measured the 222Rn in drinking water and indoor air in the north and west regions (well water, spring water, tap water and surface water) using the LUK-VR system. The maximum activates of radon in spring water was recorded (68.9 Bq/L) and the lower value (0.9 Bq/L) measured in surface water, the arithmetic mean value was (10.65 Bq/L) when compared to the standard recommended value is smaller than it[16]. In China (2014). Wu. et al. measured the radon concentrations in surface and ground drinking water in Beijing City using a simple technical method based on radon in an air monitor to an air exchanger. The determined radon activity ranges from (4.63-5.87 Bq/L), the obtained values are lower than the recommended value EPA (Environmental Protection Agency) for drinking water (11 Bq/L). Measurement of 222Rn concentration in 38 samples of drinking water in Shimoga district[30]. (Elzain, 2014) estimated the radon concentration in 248 water samples collected from different types of water in Sudan, using solid state nuclear track detector. From the results, it was observed that the range of 222Rn changes from 6.93 to 22.74Bq/L, with an arithmetic mean of 14.24 Bq/L. From the study, it was concluded that there was no remarkable variation seen in radon concentration taken from Hafier water and rivers[32]. In India (Rangaswamy et al.2015) using the Emanometry method. The results show that the radon activities ranged from 3.1 ± 0.25 to 38.5 ± 1.54 with an arithmetic mean of $(13.6 \pm 1.15$ Bq/L), this was somewhat higher than the global average of (11 Bq/L).[24]. In 44 mineral water from southeast Brazil was done (Bonotto, 2014, p. 21), with the help of a RAD 7 detector. The results showed all bottled drinking water is safe for use except for the sample from AQUA VIVA natural water with a radon concentration of 1463Bq/L,

trusted, and it must be samples differently and unity different in location to be seen possibility, with reliance to the volume of water, the measuring in any laboratory depend on some parameters such as equipment's, accuracy because it has short life time analyzing [23, 28].

3. LITERATURE REVIEW.

Table (1) summarises some reported data on 222Rn concentrations in various studies from different countries with different sources of drinking water. The radon gas can be regarded as a second factor of lung cancer after smoking. The activity concentration of 222Rn in drinking water reported from different countries in the world during 2012-2020 was tabulated and arranged in Table 1.

which significantly exceeded the recommended value. The reason for the high concentration was attributed to the source of the water of volcanic origin[31]. (Shweikani and Raja, 2015) measured the 222Rn concentration in 12 different types of drinking water taken from the home city and their sources in Syria. The measurements were performed using the gas extraction method. Results have shown that the radon concentration varied from 2.8 to 15.3 Bq/L in homes and 7.5 to 28.4 Bq/L in water sources. It was observed that there is a significant difference between the water in homes and their sources. They concluded that the drinking water in homes and water sources were within the internationally allowed limits. Measured the radon concentration[34]. Jafir, Ahmed and saridan in 2016. Measured Seasonal variations of 222Rn in 164 drinking water samples collected from Darbandikhan Lake water resources at Kurdistan Region-Northeastern of Iraq. The measurements carried out using electronic RAD7 detector. It was found that the average radon concentrations during four seasons which is 1.999Bq/L. they concluded that all collected samples under the average limit except the only two positions of the out of the safety limit[27]. (Abdurabu et al 2016) measured the activity of 222Rn and the corresponding biological health risk in groundwater samples obtained in Juban District, Ad Dali Governorate, Yemen. The measurements were performed by RAD7 detector. The activity concentrations of 222Rn ranged from minimum (1 ± 0.2 Bq/L) to maximum (896 ± 0.8 Bq/L)[35]. Fifty-seven per cent of the groundwater samples were above the US Environmental Protection Agency (USEPA) limit. In Jamaica (2017) Smith and Voutchkov determined the radon level in 22 drinking water wells with the help of electronic RAD7. The range of the detective 222Rn activities varied from 11.1 ± 1 to 49.932 Bq/L with an average value of $(18.2 \pm 1$ Bq/L),

above the recommended values, it was observed that there is a wide variation in the data due to changes in the geographical structure of the study area and detected alluvium and white limestone[23]. In Nigeria (2019) Bello et al. measured the annual effective dose that arise from radon in 8 surface drinking water collected from gold mining ream of shanono, Bagawi and Kano stage using the scintillation counter to analyzing the data. The average recoded values of ^{222}Rn was 18Bq/L. which above the safety limit[36]. In Iran (2020) Shamsaddini et al. estimated the ^{222}Rn concentration in 51 samples of drinking water in Sabzevaran using RAD7 detector. The activity of ^{222}Rn concentration changed from minimum (0.92 Bq/L) to maximum (17.12 Bq/L), the fluctuations of data due to the changing geography of the structure area[37]. Yashaswini et al. (2020). Measured the ^{222}Rn concentration in 36 different locations of ground and drinking water in Kabini, River Basin, Karanata, India. The Emanometry technique has been used. The maximum activity of radon was recorded to be (38.5 Bq/L) and the minimum value of (1.1 Bq/L) with a geometrical mean of (8.5 Bq/L) which is lower than the average declared value[33].

4. DISCUSSION

Water is important in life, without water life is meaningless because our life depends on it when the water impurity by radioactive nuclide acts on health and does some hazards because it has a clear risk of producing various types of cancer. The presence of radon in different quantities in drinking water reflects on individual health if its value is greater than the standard concentration in water (11.1 Bq/L). All drinking water does not contain radon but if you drink water from the surface like a lake and river or any underground water may might have a radon before arriving home. When any society can give a suitable source of drinking water it has a good effect on people about money and time-limited, because if they have a good source of drinking water it means people have safe health and protect personal from risk to finding safe source of water. The bad effect is indicated on children when they cannot participate in school and it harms life people for a long time and sometimes creates poverty in the country. All developed countries control the level of radioactivity in the source of the drinking water but developing countries are not aware of it. This study reviews some papers from (2012 – 2020) in a different country for the measurement of radon in drinking water, In some countries different region has various concentration of radon because any location is different in geological structure and rocks. This review plays an important role to aware society of the effects of radionuclides especially radon in drinking water, about disease and how to protect from it. The measurement of radon in some countries recorded more than recommendation value (Romania, Brazil, Sudan, India, Jamaica, and Nejeria) as shown in table (1) radon concentration in (China, Iraq, Syria, Iran) in any location in this study area is below the recommendation value, in this study the maximum average value of concentration of radon in Nigeria was (36.1 Bq/L) it is higher than the average declared value because rich granitic rocks and geological formation. Radon 222 is a significant isotope because it can be changed to the progeny of (218 PO) and continue to decay to produce

(214 PO), it is different because it is dangerous and worst effect on the human body. Radon except for the main effect that causes cancer Some of the people in the radioactive area believe that radon has more effects on the human body and is lethal in the lung and pointedly chronic interstitial fibrosis and the same effect appears in the skin and causes malignant melanoma. Radon is the main reason for developing cancer, The International Agency for Research Cancer (IARC) (1989) stated that radon can produce cancer in the human body and after that (WHO) supported them and introduced them by carcinogens. In the United States no knowledge about ethnicity, age, and education level, but noted that there is no more knowledge about radon and many people have no information about radon and its effects. In some countries especially developed countries contamination of drinking water can't be seen as a political problem between countries, Another treatment like reducing the population in the radioactive area, and spreading increasing knowledge about radiation, because it public problem but the reducing program for radon is the important treatment. ETA is the organization that is responsible for water quality and responsible for this problem of drinking water, At the same time person aware and gives him information about it, because this issue is related to the general people. In some data measured it's different with the date in a cold day the temperature is decreased, because on a cold day, the activity of radon is increasing, and usually the maximum value measuring the wells. From (1995 - to 1997) research in the United States in New York state among (1000) people many couldn't answer two questions (Have you heard about radon?) Many of the people answered (no), which indicates have a low educate about radon because only %21 peoples listened but no any information about, but others research repeated in (2004) the information people is increase about the name of radon with a few knowledge about of effect some others only know radon caused cancer with mistakes about affect many of them said believed that radon caused headache and some others mixed sign of the carbon monoxide which headache is the main sign of them. Therefore, knowledge about radon is the main reason for treatment and it can remain in the future we need many types of research and more study to educate and reduce the effect of radon on humanity because is a public problem in any country was existence by the different dose, nobody can't neglect the influence of the radon.

5. Conclusion

Radiation is the main part of our environmental life, All people are exposed to ionization radiation from different sources and in general radiation exists all around the earth, the majority of radon is exposed indoors by travelling of soil gas. Radon cannot be easily detected in air, water and soil, however, it has a short lifetime but creates a risk for our health and is the second different source of cancer, in addition, we need more knowledge and education about how to protect ourselves from radiation if it is more than the recommendation value, in this overview measurement of radon in drinking water about eight countries has been studied, Nigeria, Jamaica and Brazil recorded higher value than the declared value and in Iran, China is lower than it, the common parameter

for various value in any region in the study area has different in geological structure and rocks.

In the world the radiation problem, in many countries have similarity For example in the United States approaches 21000 person die every year and twice in accident car, This data it's not simple we cannot neglect, in addition radon is the second factor to produces lung cancer until now it's not known and people not educate

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