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Concentration and effective dose of Radon 222 in the Genow hot spring; Bandar Abbas City, IRAN

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Abstract

Radon 222 gas is a radioactive, colorless and odorless element that can cause lung cancer and stomach in humans with alpha-ray emissions. An important source of Radon 222 is the output water in springs, especially hot springs. In this cross-sectional study, concentration of Radon 222 in 12 water samples collected from Genow hot water were measured by Radon meters RTM1688-2 model. Then, the mean concentration of Radon 222 and effective dose from drinking water with standards limits were compared. The mean and range of concentration of Radon 222 was 684±265 Bq/m^3 and 205±10-1054±52 Bq/m^3, respectively. Also, the range and mean of effective dose received radon 222 in the adult resulted from spring water consumption is 0.0021±0.0001-0.01±0.0005 mSv/y and 0.007±0.0027 mSv/y, respectively. Mean concentration of Radon 222 and effective dose for adults resulting from the consumption of spring water of Genow is much less than the WHO and EPA standard limits. Hence, it can be said that there is no need to remove the Radon gas 222 from the water of this spring for drinking consumptions.

Keywords: Concentration of Radon 222, Hot Spring, Effective Dose

1. Introduction

Radon 222 (^{222}Rn) is produced by the decay of radium-226 in uranium-235 chain. This radioactive element is odorless, colorless and with a half-life of 3.83 days [2 ,1]. ^{222}Rn has high solubility in water and its solubility amount will also increase by reducing temperature of water [3]. Due to higher contact of groundwater with igneous rock (granite) and sedimentary beds, the concentration of radioactive substances in the water can be higher than surface waters [7-3]. Also, concentration of ^{222}Rn in groundwater resources is 2 to 3 times higher than other radioactive materials [8]. Humans are continuously exposed to internal or external radioactive materials, especially ^{222}Rn through inhalation of air and ingestion of drinking water [10 ,9]. When inhaled, the gas ^{222}Rn is inserted into the lungs, where it began to decay. With the release of alpha radiation during decay, DNA lung cells are damaged and the cancer cells are finally formed [11]. The studies have shown that consuming water containing high concentration of ^{222}Rn causes an increase in the effective dose received and then increasing lung and stomach cancer [12]. WHO[1] and European Committee standards for ^{222}Rn of drinking water is 100000 Bq/m^3 [13]. Also, EPA[2] has proposed 11000 Bq/m^3 for ^{222}Rn drinking water [14]. WHO and European Committee has announced annual effective dose ^{222}Rn caused by consuming drinking water 0.1 mSv/y [14]. Many studies have shown that the concentration of ^{222}Rn gas in hot springs is more than cold springs [15]. Genow hot spring at Hormozgan Province is located at northwest at 27° 26´.44" N and 56° 18´.84"E geographic coordinates. Due to the closeness of Genow hot

[1] World Health Organization
[2] American Environmental Protection Agency

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spring to Bandar Abbas city and using many of these people from this hot spring for recreation and therapy, the necessity to measure the concentration of ^{222}Rn and calculating the effective dose received of humans in this spring was taken into consideration.

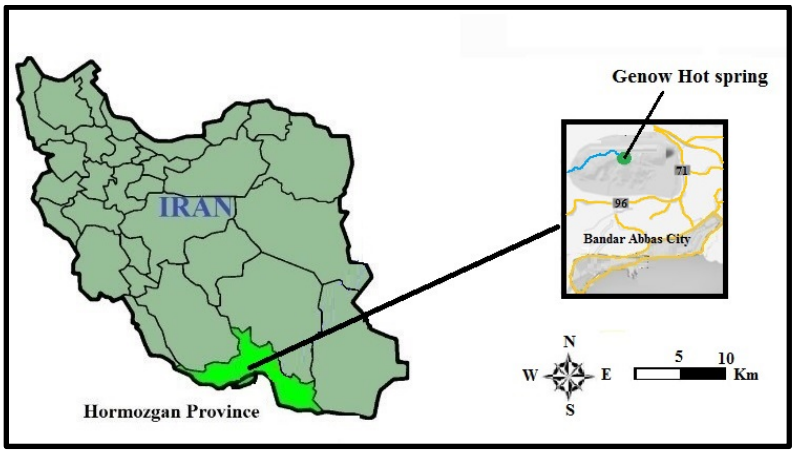

Figure 1. Genow hot spring in the northwest Bandar Abbas City

2. Materials and Methods

Sample collection was performed at two stages and during two months of June and July, 2014 (one stage per month). At each stage, 6 water samples of 1.5 liters was collected from Genow hot spring (totally 12 water sample). The samples were transmitted to Chemical Laboratory of Health Faculty for measurement according to the sampling instruction EPA at 4-6°C [16].

2.1. Measurement Concentration of ^{222}Rn

Given the effects of temperature on ^{222}Rn emission of water before measurement, the temperature of all samples was the same and was reached to 12°C [18 ,17]. Concentration of ^{222}Rn measured by RTM166-2 model made in Sarad Company in Germany (Figure 2). The sensitivity of this device is 150 minutes of continuous measurement 5.6 cts/ (min×KBq/m^3) [19]. High sensitivity along with alpha spectrum measurement analysis is led to the short response time even in low concentration. Measuring the concentration of ^{222}Rn water samples was done according to the measurement guideline presented by Sarad Company. Also, two-hour mean concentration of ^{222}Rn for all samples was recorded and analyzed [20].

Figure 2. Concentration of ^{222}Rn measurement by Radon meter device RTM1688-2 model

2.2. Calculation annual effective dose

To calculate the effective dose from ingesting water containing ^{222}Rn, an equation by the UNSCEAR[3] has been proposed [21]:

Equation 1 $E=K\times G\times C\times T\times 1000$

In this equation, the annual effective dose received in terms of mSv/y, K; conversion coefficient concentration of ^{222}Rn to effective dose (Sv/Bq), G; daily drinking water (l/d), C; concentration of ^{222}Rn (Bq/l) ,T; water consumption period (365 days) and 1000 conversion coefficient Sv to mSv, respectively. K coefficient for the adults is 18×10^{-9} Sv/Bq [22 ,16]. Global information on the amount of daily water consumption is limited. Daily water consumption by humans is under the weather conditions, physical activity, culture, economy and etc. Mean daily water consumption of adult humans is 2.723 l/p-d [23].

3. Results

The range and mean concentration ^{222}Rn for water samples is 205±10-1054±52 Bq/m^3 and 684±265 Bq/m^3, respectively. Also, range and mean effective dose for adults is 0.0021±0.0001-0.01±0.0005 mSv/y and 0.007±0.0027 mSv/y, respectively.

Table 1. Concentration of ^{222}Rn in 12 samples of Genow hot spring (M±SE)

Number	Concentration of ^{222}Rn (Bq/m^3)
1	854±42
2	954±47
3	654±32
4	356±17
5	487±24
6	1054±52
7	654±32
8	487±24
9	205±10
10	659±32
11	905±45
12	946±47
Mean	684
SD[4]	265

[3] International Scientific Committee for the impact of nuclear radiation
[4] Standard deviation

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4. Discussion

Mean and range of concentration of ^{222} Rn in 12 samples of hot spring water in Genow is much less than the standard limits (103×100 Bq/m^3, WHO) and (103 × 11 Bq/m^3, EPA). Mean concentration of ^{222}Rn Genow hot spring to the standard limits WHO and EPA is 2.6 % and 0.68%, respectively. This huge difference could be due to lack of water passing through layers of igneous rocks (granite) (Figure 2 and 3) [7-3]. On the other hand, due to the inverse relationship between water temperature with concentration of ^{222}Rn and high temperatures of this hot spring, this lower concentration can also be caused by the high temperature of hot spring [24 ,3].

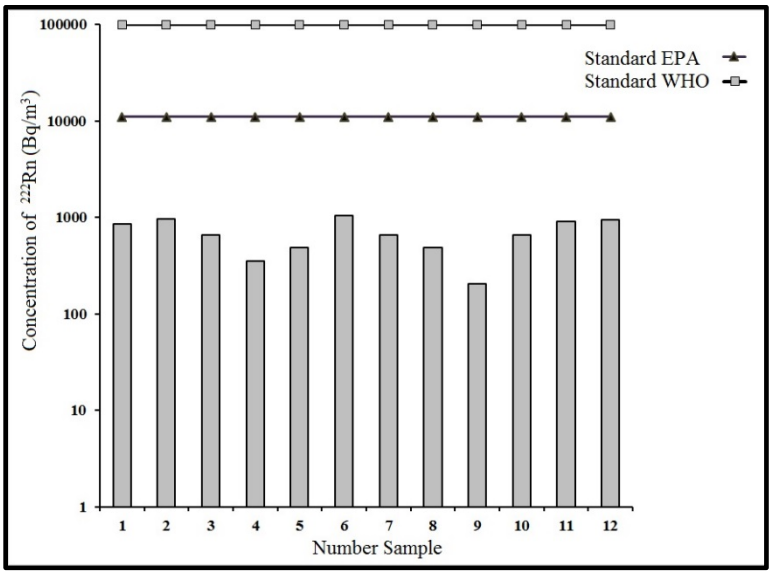

Figure 2 .Comparing ^{222}Rn concentration in 12 water samples with EPA and WHO standard limits

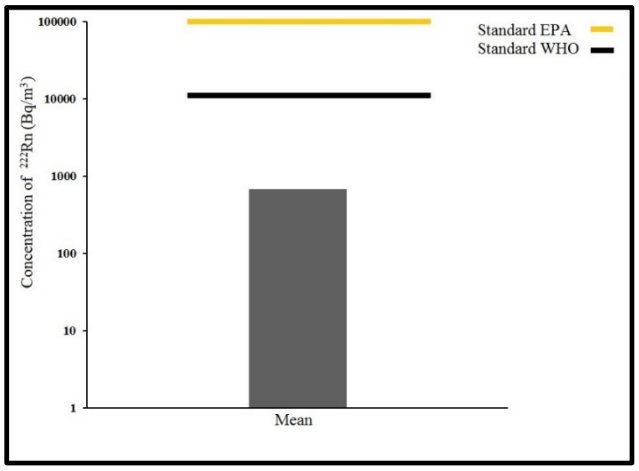

Figure 3 .Comparing ^{222}Rn concentration with EPA and WHO standard limits

As can be seen in Figure 4, since the received effective dose is the function of ^{222}Rn, hence the effective dose received from the Rn222 hot spring water (0.007±0.0027 mSv/y) is much lower than the standard WHO and EC (93% less than the standard level) [25 ,23].

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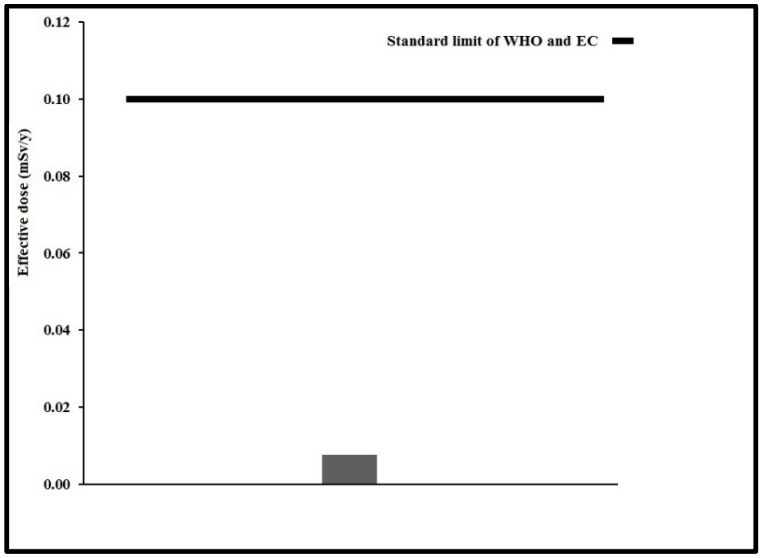

Figure 4. Comparing the effective dose ^{222}Rn by WHO and EU standard limits

Table 2. Comparing the concentration of ^{222}Rn Genow hot spring water with other cities and countries [26]

Countries/ cities	Concentration of ^{222}Rn (Bq/m^3)
Austria	0.12-18
Brazil	120
Jordan	3.9
Poland	74
Turkey	10.84
Chahar mahal and Bakhtiari springs	2.3
Shirvan	9.74
Nishapur	17.99
Ramsar	2.6±1.6
This Study	0.684±0.265

In our study, the mean concentration of ^{222}Rn Genow spring water is much less than countries like Austria, Brazil, Jordan, Poland, Turkey and the Chahar mahal and Bakhtiari springs, Shirvan, Nishapur and Ramsar (Table 2). But the minimum concentration of ^{222}Rn Genow hot spring in our study is higher than the minimum concentration of ^{222}Rn in Austria.

Maximum concentration of ^{222}Rn in our study is much less than the minimum concentration of ^{222}Rn in Romanian spring water in the study done by Cosma et.al (1120 Bq/m^3) [26]. Also, the mean concentration of ^{222}Rn in our study is much less than the mean concentration of ^{222}Rn in the Hot Springs Highland (27100 Bq/m^3) in the study

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conducted by Somlai et.al and one hot spring in Thailand by sola et.al (minimum concentration 2000 Bq/m3) [27, 28].

5. Conclusion

The mean concentration of ^{222}Rn in the hot spring water and effective dose received is less than the standard limits. Hence, it can be said that if humans need water treatment for drinking, there is no need to remove ^{222}Rn from water.

6. Acknowledgements

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