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RESEARCH ARTICLE

Radon and Radium Measurement in Water Supplies of Sadatshahr and Javaherdeh Regions in Iran

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ABSTRACT
Radon is a naturally occurring radioactive gas that is emitted from soils and rocks and is in some water sources. Radon is estimated to cause many thousands of deaths each year. That's because when humans breathe air containing radon, can get lung cancer or when drink water containing radon, this element makes series problem to digestion system. Also, drinking water containing ^{226}Ra, the parent nuclide of ^{222}Rn, is dangerous for people health. Because this element deposits it in bones and caused to bone cancer. In this study radon and radium concentrations of the 43 water samples of the Sadatshar and Javaherdeh regions have been measured by PRASSI system. 4 samples have radon concentration higher than 11 Bq/l as normal level. Also, ^{226}Ra alone, in 2 samples have concentration higher than 0.555 Bq/l as normal level for gross alpha. For improvement of the social health level, it is essential that to reduce the radon and radium concentrations in the drinking water before using by people.
KEY WORDS: *Radon, Radium, Drinking water, PRASSI system, Sadatshahr and Javaherdeh Regions.*

INTRODUCTION

^{222}Rn is a radioactive noble gas isotope, which is produced by the decay of ^{226}Ra within the natural decay chain of ^{238}U. The radon readily escapes from the soil or rock where it is generated and enters surrounding water or air. Breathing air that contains radon in high concentrations can be health hazard for humans. Relationship between lung cancer and inhalation of radon and its progeny has been demonstrated [1]. Radon in water can follow two different paths to enter the human body. Firstly, some of the radon dissolved in tap water will escape to indoor air. The proportion lost in this way will depend on circumstances. However, UNSCEAR has suggested that, as a general rule, radon in tap water gives rise to radon in room air at a concentration 10^{-4} lower than that in the water [2]. Secondly, ingestion drinking water containing radon. The organ at greatest risk from the ingestion of water containing radon is considered to be the stomach [3], that can be a factor in the induction and progression of stomach cancer. Of the four isotopes of radium , ^{226}Ra (the parent nuclide of ^{222}Rn) causes the most concern due to a combination of its long half-life (1600 years) and radiological effects [4]. Exposure to higher levels of radium over a long period of time may result in harmful effects including anemia, cataracts, fractured teeth, cancer (especially bone cancer), and death [5].
So, presence these radioactive contaminants in drinking water is dangerous and many studies, especially about radon, have been done in this area [6- 11]. These reasons caused we measured radon and radium concentration in water sources of Sadatshahr and Javaherdeh region.
In the present research results of radon measurement in 43 water samples, sources and tap water are actually used for drinking and other household uses in Sadatshahr and Javaherdeh. Radon of water samples that have been measured using PRASSI system includes a ZnS (Ag) scintillation detector.

MATERIALS AND METHODS

Radon Measurement in the Water Samples by PRASSI System

The PRASSI (Portable Radon Gas Surveyor SILENA) Model 5S has been used to radon concentration measurement in the water samples, which is particularly well suited for this type of measurement that must be performed in the closed loop circuit. Fig. 1 shows the system set up of measurement including bubbler and drier column.
PRASSI pumping circuit operates with constant fallow rate at 3 liters per minute in order to degassing the water sample properly. Its detector is a scintillation cell coated with ZnS (Ag) 1830 cm3 volume. The sensitivity of this system in continuous mode is 4 Bq/m3 during the integration time 1 hour.

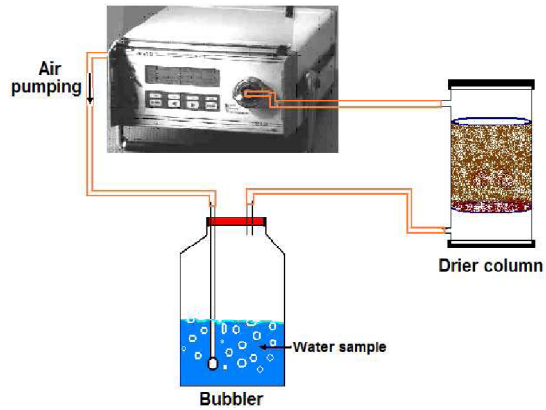


Fig. 1: The PRASSI system set up for radon measuring in the water sample.

Numbers shown by the device is based on Bq/m³. Using relationship Eq. 1, radon gas density is calculated based on (Bq/L):

$$Q_{Rn}\left(\frac{Bq}{L}\right) = Q_{PRASSI} \times \frac{V_{tot}(m^3)}{V(lit)} \times \left[\!\left[exp\left(\frac{Ln2}{3.824\times24}\Delta t\right)\right]\!\right] \qquad (1)$$

Where:

Q_{PRASSI} = The value recorded by the device

Vtot = The total volume of air connections

V = The volume sample and within the brackets is a correction factor in the delay measurement

Radium measurement

For measuring radium in water samples, we have kept 150 ml of the water samples in the bottles for 35 days to let radon reach the equilibrium with radium. So, by measuring radon of the water sample as described before, we obtain radium concentration.

RESULTS AND DISCUSSION

The US Environmental Protection Agency (EPA) has proposed a Maximum Contaminant Level (MCL) of 11Bq/L and requires that action be taken to reduce radon levels above an Alternative Maximum Contaminant Level (AMCL) of 150 Bq/L [12]. The goal in establishing the AMCL was to provide regulatory flexibility characterized by both the regulated drinking water arena and the unregulated indoor air quality arena.

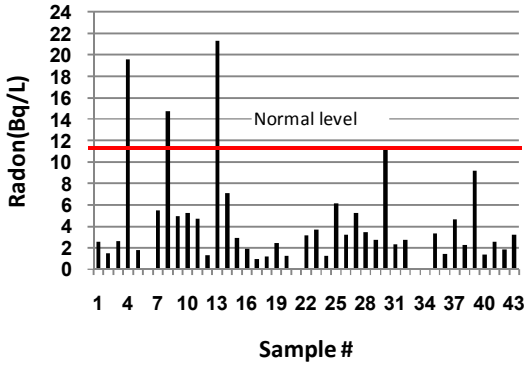
In his study radon concentration in the 43 water sources of Sadatshahr and Javaherdeh Regions has been measured. The third column of Table 1, presents the concentration of radon in water samples. Also the histogram of radon concentration in different water samples is shown in Fig. 2.

The results show 4 samples (No.: 4, 8, 13, 30) have radon concentration higher than normal level. Results in Table 1 showed that the dissolved radon concentrations ranged from 0.000 to 21.291 Bq/L for the sampled 43 sites. The mean radon concentration for samples is 4.183 Bq/L. Generally ^{222}Rn concentration in groundwater is much higher than that in surface water, because Radon-222 is a water-soluble radioactive gas generated underground by the decay of Radium-226 [13]. About sample 13 that is river with radon concentration 21.291 Bq/L, we must mention that the high radon concentration in this river due to mixing of surface water with groundwater, whereas this river is very near Abmadan spring.

Figure 3 shows the histogram of radium concentration in different water samples as well as the data are listed in fourth column of Table 1. The minimum and maximum radium concentrations in samples are 0.000 and 0.891 Bq/L, respectively and mean ^{226}Ra concentration of all samples is 0.197 Bq/L. Specific drinking water standards have not been established for radium 226 or other alpha emitters, but in 2 samples of total samples, ^{226}Ra concentration even higher than MCL for gross alpha is 15 pCi/L (0.555Bq/L) that determined by U.S Environmental Protection Agency and in 18 samples ^{226}Ra concentration higher than MCL for combined ^{226}Ra and ^{228}Ra 5 pCi/L (0.185Bq/L).

Table 1: Radon and radium concentration data of different water samples

Sample number	Source or place of water sampling	Q_{Rn}(Bq/L)	Q_{Ra}(Bq/L)
1	Spring near Nesarood river	2.594	**0.000**
2	Bamsi spring	1.489	**0.066**
3	Safarood spring	2.610	**0.308**
4	Abmadan spring	19.573	**0.000**
5	Javaherdeh spring	1.810	**0.510**
6	Latmahale spring	0.000	**0.112**
7	Sadatshahr hot spring (No.1)	5.490	**0.276**
8	Sadatshahr hot spring (No.2)	14.751	**0.377**
9	Sangbone hot spring	4.991	**0.317**
10	Katolom hot spring	5.266	**0.339**
11	Markooh hot spring	4.751	**0.490**
12	Bamsi river	1.333	**0.334**
13	Abmadan river (Javaherdeh)	21.291	**0.441**
14	Javaherdeh river	7.125	**0.214**
15	Dashtejalami river	2.958	**0.089**
16	Katalom river	1.973	**0.338**
17	Markooh river (No.1)	1.015	**0.000**
18	Markooh (No.2) environs of Ramsar city	1.230	**0.000**
19	Chalakrood river	2.457	**0.000**
20	Nesarood river	1.298	**0.465**
21	Javaherdeh drinking water (No.1)	0.000	**0.000**
22	Javaherdeh drinking water (No.2)	3.179	**0.085**
23	Javaherdeh drinking water (No.3)	3.725	**0.398**
24	Javaherdeh drinking water (No.4)	1.263	**0.000**
25	Javaherdeh drinking water (No.5)	6.153	**0.329**
26	Javaherdeh drinking water (No.6)	3.248	**0.165**
27	Javaherdeh drinking water (No.7)	5.285	**0.342**
28	Javaherdeh drinking water (No.8)	3.494	**0.775**
29	Javaherdeh drinking water (No.9)	2.831	**0.524**
30	Javaherdeh drinking water (No.10)	11.403	**0.110**
31	Javaherdeh drinking water (No.11)	2.381	**0.012**
32	Javaherdeh drinking water (No.12)	2.789	**0.005**
33	Payam nour university (Sadatshahr)	0.000	**0.891**
34	Kashani street (Sadatshahr)	0.000	**0.000**
35	Bibisekine region (Sadatshahr)	3.383	**0.000**
36	End of kashani street (Sadatshahr)	1.471	**0.000**
37	15 hkordad street (No.1) (Sadatshahr)	4.665	**0.000**
38	15 hkordad street (No.2) (Sadatshahr)	2.292	**0.117**
39	Shahid dastgheyb street (Sadatshahr)	9.189	**0.046**
40	Shahid dastgheyb street, yas alley (Sadatshahr)	1.413	**0.000**
41	End of shahid dastgheyb street (Sadatshahr)	2.576	**0.000**
42	15 khordad street, golsar alley (Sadatshahr)	1.916	**0.002**
43	End of 15 khordad street (Sadatshahr)	3.225	**0.000**



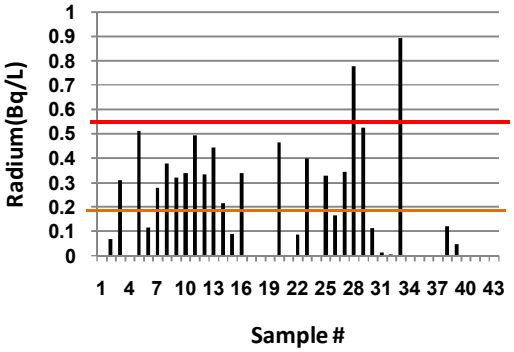


Fig. 2: The histogram of radon gas concentration

Fig. 3: The histogram of radium concentration

CONCLUSION

Measurement results of radon concentration in the water samples shows that only 9.30% sample concentrations are higher than the normal 11 (Bq/L). The results of radium concentration show that about 4.65% of total samples are greater than 0.555Bq/L and 41.86% of total samples are greater than 0.185Bq/L. There for improvement of the social health level, it would be better to reduce the radon in the drinking water before using by people.

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