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Radon and Radium Measurement in Drinkables Water Supplies of Shirvan Region in Iran by Prassi System

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Abstract

Radon and its radioactive progenies in indoor places are recognized as the main sources of public exposure from the natural radioactivity. Alpha emitted by this radioisotope and other radiation emitted from its progenies increase the absorbed dose in respiratory and digestion systems, which may cause cancers. The tap water used for drinking and other household uses can make variable contributions to the indoor radon level. This study has provided data on radon and radium concentrations in water samples of Shirvan region in Iran. Radon and radium concentration of the water samples have been measured by PRASSI system. The results show that 5 samples have radon concentration higher than 10 kBq/m^3 as normal level, and radon in 3 samples are near normal level.

Key words: Radon and Radium measurement; Drinkable water; PRASSI system; Shirvan region.

Introduction

Radon and its short-lived decay products in dwellings are recognized as the main sources of public exposure from the natural radioactivity, contributing to nearly 50% of the global mean effective dose to the public (UNSCEAR, 2000). The type of soil, building materials, and water used for drinking and other household uses can make variable contributions to the indoor ^{222}Rn level. The available data indicate that the main source of the indoor ^{222}Rn is the soil underlying a building (UNSCEAR, 1993). However, certain building materials with high concentrations of radium and even using water with high concentrations of ^{222}Rn can make major contributions to indoor radon exposure [1]. The most important aspect of radon in high concentrations can be health hazard for humans, mainly a cause of lung cancer [2-3]. However, a very high level of radon in drinking water can lead to a significant risk of stomach and gastrointestinal cancer [4]. Knowledge of the levels of ^{222}Rn in each source including household water, particularly water from groundwater sources, is necessary to protect public from consequences of excessive exposure to radiation, mainly from the risk of lung cancer. Some recent reports of radon concentration in drinking water in different places [5-8] caused we measured radon concentration in drinkable water sources of Shirvan region.

Shirvan is the second big city of Khorasan-shomali province, located in north-east of Iran, 773 km far from Tehran. Which the household water is supplied from various sources, deep wells and springs. This paper presents the results of measurements of radon and radium concentrations in water samples as public water supplies, and in tap water actually used for drinking and other household uses in Shirvan. The measurements have been carried out using PRASSI system. Also, the estimated radiation dose to public due to waterborne radon has also been presented.

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 litters per minute in order to degassing the water sample properly. Its detector is a scintillation cell coated with ZnS (Ag) 1830 cm^3 volume. The sensitivity of this system in continuous mode is 4 Bq/m^3 during the integration time 1 hour.
To measure the content of radon, we consider V_{sample}=150 ml of the water sample in bubbler and the PRASSI will read a concentration of [9]:

$$Q_{PRASSI}[Bq/m^3] = \frac{A_{Rn}[Bq]}{V_{tot}[m^3]} \qquad (1)$$

which V_{tot} is the total volume of system equal $2.4\times10^{-3}\ m^3$ and A_{Rn} is the radon activity. It is follows that the concentration of radon in water is:

$$Q_{Ra}[Bq/m^3] = \frac{A_{Rn}[Bq]}{V_{sample}[m^3]} = Q_{PRASSI}\frac{V_{tot}[m^3]}{V_{sample}[m^3]} \qquad (2)$$

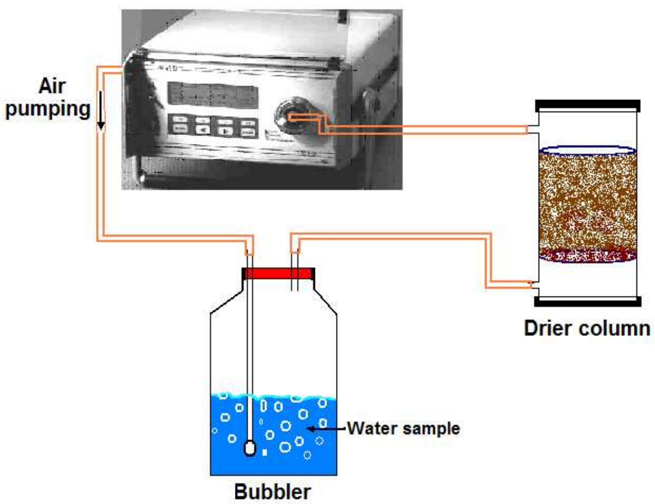

Fig. 1: The PRASSI system set up for radon measuring in the water sample

Results and Discussion

The USA environmental protection agency (EPA) has proposed a maximum contaminant radon level of 10 Bq/l in drinkable water (EPA, 1991). In this research, radon concentration in the 15 drinkable water sources of Shirvan region has been measured three times. The histogram of average radon concentration in different water samples are shown in Fig. 2. The results show 5 samples (No.: 2, 5, 6, 13, 14) have radon concentration higher than normal level, and radon in 3 samples are near normal level (No.: 3, 4, 10).

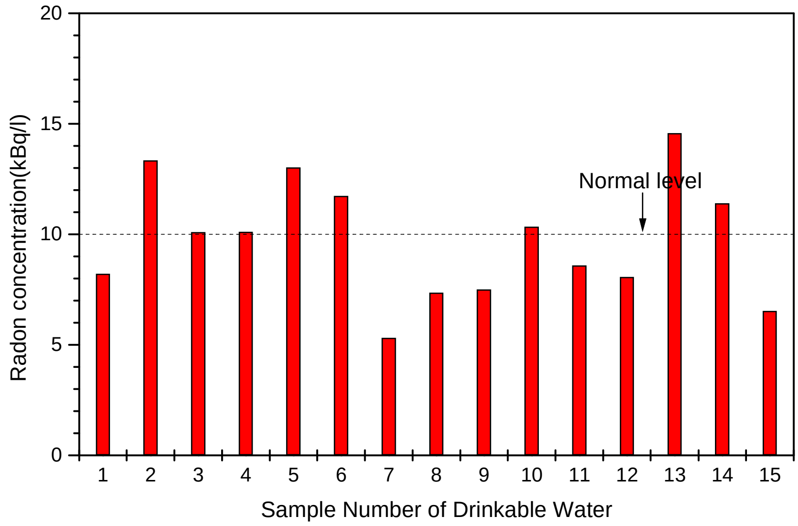

Fig. 2: The histogram of average radon concentration in different drinkable water samples of Shirvan region

To evaluate annual dose of radon in water, we need to know have radon in water can enter to human body and which organs irradiated mostly by radon. Radon in water can enter the human body in two ways:

1. Radon in drinking water or mineral drinks can enter the human body directly through the gastro-intestinal tract and irradiate whole body which the largest dose being received by the stomach. Assuming an average consumption of 2.5 litters of water per person per day, and stomach dose per Bq of radon is 5 nGy/Bq (UNSCEAR, 1998), with the consider 0.12 for stomach tissue weighting factor and 20 for quality factor of α radiation, the annual equivalent dose per Bq of radon concentration in water is about 2.19×10^{-6} μSv/(year Bq. l) [10].
2. Radon can escape from household water and became as an indoor radon source, which then enter the human respiratory tract system to deliver radiation dose. According to the report of UNSCEAR at 1993, the effective dose of the lung due to 1 Bq/l of radon in air with 0.4 equilibrium and 0.8 occupation factors is about 28 mSv/year [11]. The radon transfer coefficient from water to indoor air is estimated to be 10^{-1} [10], so the conversion factor from unite radon concentration at equilibrium situation is 2.8 μSv l/Bq.

The annual effective dose due to the radon of water in stomach and lung are listed in table 1. 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. Fig. 3 shows the histogram of radium concentration in different water samples. The data are listed in table 2. The results show samples 1, 3, 6 and 10 have higher radium concentration.

Table 1: Average radon concentration data and annual effective dose of different water sources of Shirvan

Water Sample	Average Radon level (Bq/l)	Annual effective dose(μSv/y)	
		Stomach	Lung
Sample 1: Atr spring	8.2176	21.56	22.93
Sample 2: Hanameh spring	13.344	35.07	37.23
Sample 3: Dirnking water of Hanameh	10.0992	26.54	28.18
Sample 4: Dirnking water of Ghaleh-chah	10.112	26.58	28.21
Sample 5: Dirnking water of Mohammad ali khan	13.032	34.18	36.28
Sample 6: Deep well Aman Abad	11.736	30.85	32.75
Sample 7: Dirnking water of Khanlogh	5.312	13.96	14.82
Sample 8: Dirnking water of Zibashar	7.36	19.35	20.54
Sample 9: Dirnking water of Zyarat	7.504	19.72	20.94
Sample 10: Deep well of Zyarat	10.3504	27.2	28.88
Sample 11: Dirnking water of Shirkooh region	8.5952	22.59	23.98
Sample 12: Dirnking water of Hashemieh region	8.0704	21.2	22.51
Sample 13: Dirnking water of University	14.5712	38.3	40.65
Sample 14: Dirnking water of Varzesh region	11.3968	29.95	31.8
Sample 15: Dirnking water of Farhangian region	6.5344	17.18	18.24

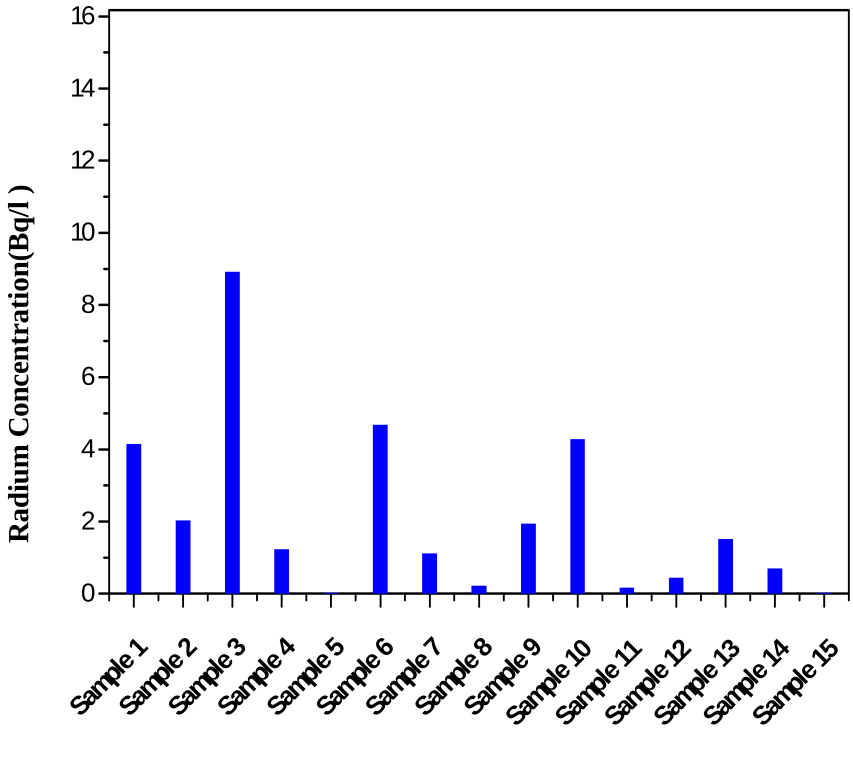

Fig. 3: The histogram of radium concentration in different water samples

Table 2: Radium concentration data of different water samples of Shirvan

Water Sample	Radium level (Bq/l)
Sample 1: Atr spring	4.1472
Sample 2: Hanameh spring	2.0272
Sample 3: Dirnking water of Hanameh	8.9152
Sample 4: Dirnking water of Ghaleh-chah	1.22576
Sample 5: Dirnking water of Mohammad ali khan	0.022
Sample 6: Deep well Aman Abad	4.6768
Sample 7: Dirnking water of Khanlogh	1.1086
Sample 8: Dirnking water of Zibashar	0.212
Sample 9: Dirnking water of Zyarat	1.9376
Sample 10: Deep well of Zyarat	4.2752
Sample 11: Dirnking water of Shirkooh region	0.16912
Sample 12: Dirnking water of Hashemieh region	0.4408
Sample 13: Dirnking water of University	1.5112
Sample 14: Dirnking water of Varzesh region	0.69472
Sample 15: Dirnking water of Farhangian region	0.017

Conclusion

Nearly 50% of annually radiation dose absorption of human is due to radon which is one of the main cancers cause at respiratory and digestion systems. For improvement of the social health level, it would be better to use the low radon level water source, or reduce the radon in the drinkable water before using by people. The results show 5 samples have radon concentration higher than $10kBq/m^3$ as normal level and radon in 3 samples are near normal level. Therefore, annual effective dose in stomach and lung organs due to the radon in drinkable water for Shirvan region are not considerable. But, for improvement of the social health level, it would be better to reduce the radon in the drinkable water before using by people.

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