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Assessment of radon content in water using SMART RnDuo in Mizoram, Northeast India

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Radon is a radioactive inert gas that is produced naturally from the decay of uranium to radium. As it is formed, it is released into air or water-containing pores between soil and rock particles. From soil and rock natural forces move it into the earth and it dissolves in groundwater. This is of great medical concern as environmental radon is one of the major causes of dangerous health problems such as lung cancer. Measurements of radon content in water was carried out in the northeastern part of India namely Aizawl district and Kolasib district of Mizoram using SMART RnDuo. About 30 sources of water were examined in each district during the winter of 2017. Water samples were collected from stream water, spring water, pump water, open well, pond and Government supplied water. Radon content in water from Aizawl district ranges between 0.309 Bq/L to 32.53 Bq/L, and those from Kolasib district the range is 1.11 Bq/L to 22.18 Bq/L. The overall average content of radon in water was found to be 6.88 Bq/L. The radon content measured for most of the sources were found to be well within the range which is considered safe (EPA 1998) except for few samples analysed.

Keywords: RnDuo, water source, radon content in water, Aizawl, Kolasib.

INTRODUCTION

Radon is naturally-occurring radioactive inert gas, with a half-life of 3.8 days produced from the decay of uranium to radium and then to radon. As radium decays, radon is formed and is released into air or water-containing pores between soil and rock particles. If this occurs near the soil surface, the radon may be released to ambient air, at the same time it may also dissolve into groundwater (Prasad Ganesh *et al.*, 2009). The presence of radon in water is predominantly due to the decay of radium found in rock and soil, and not from the radium dissolved in water (WHO, 2011). The principle characteristic of radon that gives it more radiological significance than earlier member of the uranium decay chain is the fact that it is a noble gas. Once it is formed, the transport and release from a soil into air or water occurs through diffusion and flow of the air or water (UNSCEAR, 1982). Radon can therefore reach air or water to which humans have access, provided that transport took place before the radon decay (Nazaroff, 1988).

The major contribution of radiation dose in uranium decay series comes from radon (222Rn) which makes it one of the largest single sources of radiation exposure to the population (UNSCEAR, 2000). From the total radiation received by humans, radon and its decay products contributes 51% through inhalation and 0.21% through ingestion (Kumar *et al.*, 2017). Measurement of radon concentration in water is also very significant for understanding radon migration processes (Singh *et al.*, 2015). Therefore proper assessment of radon is required to assess the concentration of radon in water as it can associate with the public health.

In this paper, the radon content in water has been measured using SMART RnDuo detector from Kolasib and Aizawl districts within Mizoram during winter season from different sources, namely bore well, spring water, stream and government supplied water. The measurement is expected to provide a part of baseline data for radon content in water in Mizoram.

MATERIALS AND METHODS

Study area

Figure 1 shows the geographical sites where the water samples were collected. The state of Mizoram is a hilly area with an average elevation of about 500 to 800 meters from sea level. It is a tropical region with moderate climate and the temperature varies from 11°C to 24° C during the winter season and 18°C to 29°C during summer. The sampling area extends from 23°54ˈ8.8ˈˈto24° 30ˈ38.2ˈˈ latitude and 92°35ˈ54.4ˈˈ to 92°51ˈ38.1ˈˈ longitude with an area of about 4957 sq km. Water samples were collected from 64 different locations within the study area.

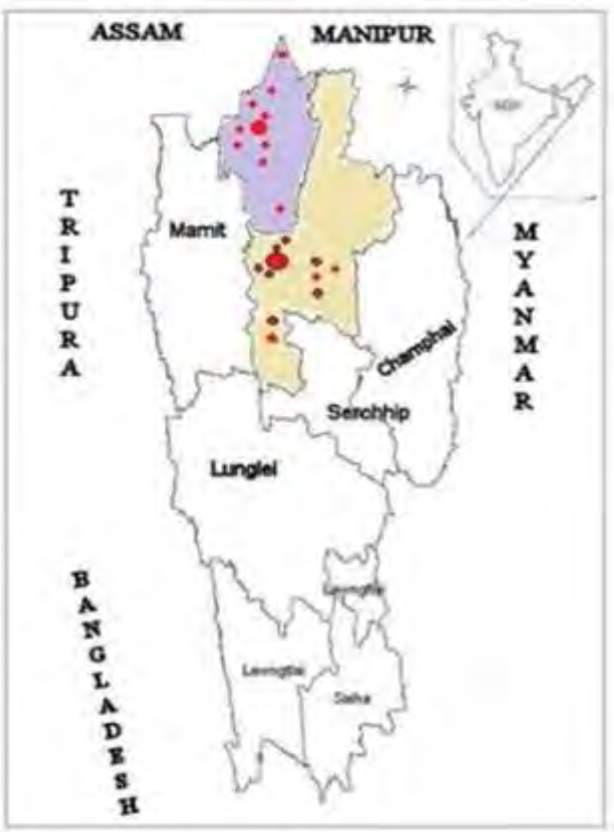

Figure 1: Map of Mizoram showing locations from where samples were collected.

Radon measurement

Radon content in water was obtained using SMART RnDuo which is a scintillation cell method. To measure radon content in water the radon gas in the setup was flushed for 5 minutes by using an inbuilt pump to eliminate any background. RnDuo monitor was connected with bubbler attached to the sampling bottle using flexible tubing as shown in Figure 2. Then the pump was on again for 3 minutes so that the dissolve radon can escape in to the tubing. Measurement was taken in 15 minute-cycle for 1 hour. The radon concentration in liquid (C_{liq}) (Bq/m3) from the concentration measured in air (C_{air}) was calculated by using the equation:

$$C_{liq} = C_{air}\left(K + \frac{V_{air}}{V_{liq}}\right) \qquad (1)$$

Where K is partition coefficient of radon in liquid with respect to air, V_{air} is volume of air and V_{liq} is volume of liquid in sampling bottle.

RESULTS

Within this study area as shown in Figure 1, a total of 64 water sources were selected, 36 from Aizawl district and 28 from Kolasib district. Among these, water samples were taken from 36 samples are from springs, 19 samples from bore-well, 6 samples from streams and1 sample each from pond, open-well and Government supplied water. The radon content in water was found to be varying from 0.309 Bq/L to 32.53 Bq/L with an average of 6.88 Bq/L.

In Aizawl district, in the case of bore-well it was found to vary from 0.309-32.53 Bq/L with an average of 11.14 Bq/L, 1.04-20.74 Bq/L in spring with an average of 5.28 Bq/L, 1.22-6.56 Bq/Lin streams with an average of 3.77 Bq/L. In Kolasib district, in the case of bore-well it was found to vary from 7.6-17.11 Bq/L with an average of 12.42 Bq/L, 1.11-22.17 Bq/Lin spring with an average of 5.26 Bq/L.

Figure 3 shows the comparison of average activity concentration of different water sources in Aizawl and Kolasib districts. In both cases, it can be seen that average activity concentration was found to be highest in bore-well. According to WHO, groundwater from wells and boreholes usually contains higher radon concentrations than surface waters (WHO, 2011) that is because ground water are enclosed and the radon content are not released in to the ambient air. The result obtained was in accordance with guidelines provided by WHO as mentioned above.

DISCUSSION

Radon is among environmental pollutants that can cause serious health effects. It is directly linked to the development of lung cancer, resulting in a number of deaths throughout the world (Yoon *et al.*, 2018). It in-

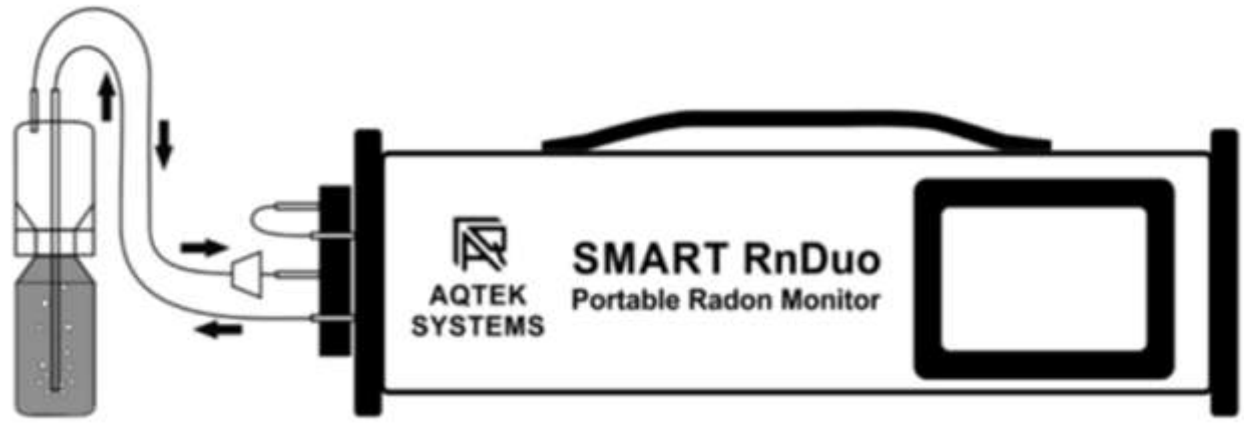

Figure 2: Schematic diagram of measurement of radon in water using RnDuo detector.

Table 1: Results of measurement of radon content in water using RnDuo in Aizawl and Kolasib district, Mizoram.

.Sl. No.	Sample Code	Sample source	Radon in water (Bq/L)	Sl. No.	Sample Code	Sample source	Radon in water (Bq/L)
1	A-1	Bore well	3.904	33	A-33	Stream	6.56
2	A-2	Spring	20.74	34	A-34	Spring	4.89
3	A-3	Bore Well	9.028	35	A-35	Stream	6.13
4	A-4	Spring	4.50	36	A-36	Supplied	0.30
5	A-5	Bore Well	2.71	37	K-1.	Borewell	14.54
6	A-6	Bore Well	32.53	38	K-2.	Spring	1.26
7	A-7	Spring	9.41	39	K-3.	Spring	3.75
8	A-8	Spring	3.23	40	K-4.	Spring	5.57
9	A-9	Bore Well	21.85	41	K-5.	Spring	2.72
10	A-10	Bore Well	26.42	42	K-6.	Spring	2.29
11	A-11	Spring	6.97	43	K-7.	Spring	1.76
12	A-12	Bore Well	3.21	44	K-8.	Borewell	7.62
13	A-13	Stream	1.65	45	K-9.	Spring	10.11
14	A-14	Bore Well	15.53	46	K-10.	Spring	2.15
15	A-15	Bore well	5.34	47	K-11.	Spring	1.63
16	A-16	Bore Well	5.34	48	K-12.	Spring	2.37
17	A-17	Spring	2.37	49	K-13.	Open-well	8.49
18	A-18.	Bore Well	1.48	50	K-14.	Spring	9.18
19	A-19	Bore Well	6.30	51	K-15.	Pond	2.54
20	A-20	Spring	2.257	52	K-16.	Spring	1.78
21	A-21	Spring	6.30	53	K-17.	Spring	1.18
22	A-22	Bore Well	27.49	54	K-18.	Spring	1.11
23	A-23	Bore Well	2.05	55	K-19.	Spring	1.29
24	A-24	Bore Well	3.91	56	K-20.	Spring	9.57
25	A-25	Spring	2.86	57	K-21.	Spring	6.51
26	A-26	Spring	3.26	58	K-22.	Spring	15.71
27	A-27	Stream	4.87	59	K-23.	Spring	2.58
28	A-28	Stream	2.20	60	K-24.	Spring	5.00
29	A-29	Spring	3.15	61	K-25.	Borewell	10.40
30	A-30	Spring	1.04	62	K-26.	Spring	6.05
31	A-31	Spring	2.85	63	K-27.	Spring	22.17
32	A-32	Stream	1.22	64	K-28.	Borewell	17.11

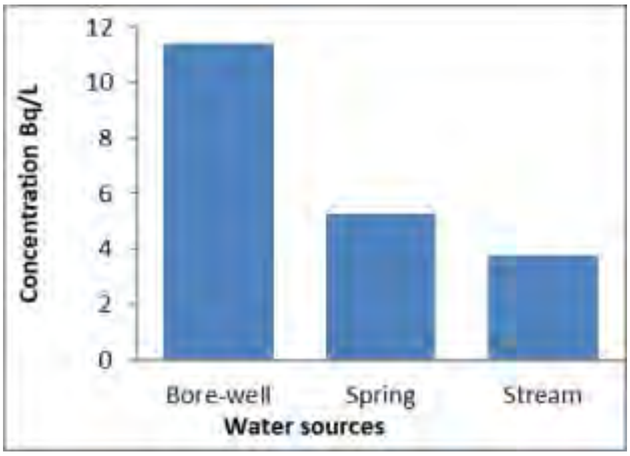

Figure 3: Comparison of average radon content in water from different sources in the study areas.

duces cancer development in smokers and non-smoker alike. It is estimated to be the second leading cause of lung cancer, specifically in the UK, after smoking. It is further established that lung cancer is enhances by radon among tobacco smoker (Robertson *et al.*, 2013). As such Radon-222 and its decay products are listed in the International Agency for Research on Cancer (IARC) as Group 1 carcinogen, i.e. they are directly carcinogenic to humans (El Ghissassi *et al*., 2009). Therefore, it is important to assess the level or radon in our habitations and water sources, as radon is a naturally occurring gas.

The average radon content in water was found to be 7.33Bq/L in Aizawl District and 6.31Bq/L in Kolasib District. The total average content of radon in both districts was found to be 6.88Bq/L which was found to be within the safe limit of 11 Bq/L prescribed by US EPA (EPA, 1998). But 7 samples from bore-well, i.e. A-6, A-9, A-10, A-14, A-22, K-1 and K-28 and also 2 samples from springs, i.e. A-2 and K-22, the radon content were found to be higher than prescribed by the US EPA but are below the critical limit proposed by WHO (WHO, 2011).

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