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Radon Monitoring in Underground Water of Punjab State and Thermal Springs of Himachal Pradesh

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Abstract

The source of Radon gas is generally within the rock strata in the form of an intermediate decay product of the U/Th radioactive series. It migrates from the earth's crust to atmosphere by diffusion in the aqueous media. Radon monitoring is carried out to study health hazard effects. Scintillometry technique was used for measurement of Radon concentration in groundwater of Gurdaspur district and Parbati valley of HP. Radon concentration values show wide spread variation in drinking water of area under study. The hand pumps drawn water has higher value of radon concentration compared with the other sources including motor-driven pumps, tube-wells, municipal water supply and canal water. The average radon concentration values are 6.5, 5.8, 5.0, 4.7 and 1.1 Bq/l for hand-pumps, motor-driven pumps, tube-wells, water supplies and canal waters, respectively. Most of the thermal springs are distributed along the major thrust faults in N-W Himalayas. Our purpose was to monitor radon in thermal springs of Parbati valley, HP state. The radon concentration varies from 15.9 to 716.3 Bq/l. The high radon concentration is correlatable with radium and uranium content of water and soil in the Parbati valley.

Keywords: Radon, groundwater, thermal springs, scintillometry, Parbati river

INTRODUCTION

The source of radon gas is generally within the rock strata in the form of an intermediate decay product of the U/Th radioactive series. It migrates from the earth's crust to atmosphere by diffusion in the aqueous media. During recent years, radon monitoring has become a global phenomenon due to its health hazard effects inside the dwellings [1–3], its use as a tracer for exploration of oil and gas deposits [4] and as a precursor for earthquake prediction studies [5–7]. Radon measurements have been carried out in soil-gas, groundwater/thermal springs and in the air by our group [8–10] but there is hardly any systematic study carried out in drinking water in India.

Radon emanation is a well understood phenomenon. It is a colorless, odorless and tasteless gas, which is 7.5 times heavier than air. Hence its presence in drinking water is not felt during consumption. Its half-life is 3.38 days and it decays with the emission of 5.48 MeV α-particles. The decay product of radon, i.e., its progeny is highly radioactive and gets absorbed to aerosol particles suspended in water. The range of recoil radon atom in water is about 0.1 µm. Radon is transported by either an aqueous or an air medium from rock capillaries or fractures to environment. Its transport in soil depends upon porosity and permeability of the soil.

Radon gas is soluble in water in the sense that the gas is transported through water in the house. The mole fraction solubility of radon in water is

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2.3×10^{-4} at 15°C, in which it is produced mainly by leaching of hexavalent uranium present in traces. When the ground water is pumped out into the storage facility, the dissolved gases in water dissipate and escape into the air under atmospheric pressure. Meteorological parameters have influence on the emanation of radon in the soil and groundwater. The temperature, pressure and wind velocity have positive correlation with radon while humidity and rainfall have negative correlation.

Geochemical studies of some thermal springs in India have been carried out in the recent past [11, 12]. Radioactivity of thermal springs has not been reported in these studies. Radon monitoring is carried out in thermal springs for the first time in the Parbati valley of Himachal Pradesh [9]. Most of these thermal springs have been known since historical times as pilgrimage centers. Some of these have now become tourist spots and spas where people take lip to cure rheumatism.

EXPERIMENTAL TECHNIQUE

Radon monitoring was carried out in the soil-gas and groundwater by scintillometry, using silver-activated zinc sulphide phosphor, ZnS (Ag), as the scintillation material. The photons were registered and amplified by the photomultiplier tube until it could be detected as a single pulse.

Water samples were collected at ambient temperature and pressure from different sources in the Gurdaspur and Bathinda districts of the Punjab state for radon estimation. Alpha Scintillometer (GBH 2002) with Lucas cell assembly supplied by International Environmental Consulting, Germany was used to record alpha counts from 1 l of water over an interval of 10 min. Radon gas emanated from radium present in the water or dissolved in it was sucked by a pump connected to a radon bubbler with an extraction efficiency of more than 90%. The electronic digital counter recorded the alpha counts and radon concentration in water is measured by using the calibration constant (10 counts=1 Bq/l). The detection limit for the Lucas cells used in Alpha Scintillometer was 0.02 Bq/l.

DISCUSSION OF RESULT

Radon concentrations monitored in potable water samples of Batala, Gurdaspur, Dinanagar and Dhariwal towns and some villages of Gurdaspur district are summarized in Table 1. Radon concentrations measured in mineral water samples supplied by different manufacturing units in India are given in Table 2.

Table 1. Radon concentration from different sources of groundwater in the Gurdaspur district of Punjab.

S. No.	Place	Source	Avg. Radon Conc. (Bq/l)
1.	Gurdaspur City	Hand-pump	8.8
		Water motor	8.2
		Water supply	5.6
		Tube-well	7.3
2.	Batala Town	Hand-pump	3.3
		Water motor	3.3
		Water supply	3.0
		Tube-well	3.5
		Canal water	2.0
3.	Dhariwal town	Hand-pump	6.4
		Water supply	5.3
		Tube-well	4.0
		Canal water	0.2
4.	Dinanagar town	Hand-pump	8.6
		Water supply	5.8
5.	Bariar village	Hand-pump	6.0
		Tube-well	5.2
6.	Bathvala village	Hand-pump	6.1
		Water-supply	4.0

Table 2. Radon concentration in different mineral waters.

S. No.	Mineral Water (Company Name)	Radon Concentration (Bq/l)
1	Sample 1 (Hello)	0.50
2	Sample 2 (Paras)	0.10
3	Sample 3 (Bisleri)	0.01
4	Sample 4 (Minscot)	0.03
5	Sample 5 (Yes)	0.04
6	Double Distilled Water (Phys. Lab.)	0.02

In this study, radon concentrations were measured in different sources of drinking water used by inhabitants of different localities of Gurdaspur district. There are different sources of drinking water, viz., hand-pumps, electric-motor-driven pumps, tube-wells, and municipal water supply schemes. Groundwater drawn by hand pumps shows the maximum value of radon concentration and water supplied after storage in water tanks through the pipes shows the minimum value. The radon concentration in hand-pump drawn water samples lies between 3.2 and 13.0 Bq/l, electric motor drawn water between 3.2 and 10.1 Bq/l, tube-well water between 3.8 and 8.5 Bq/l and municipal water supply sources between 2.9 and 5.8 Bq/l. However, the mineral water samples contain minimum or almost negligible radon concentration lying between 0.01 and 0.53 Bq/l.

The values of radon concentration in different sources can be explained as follows: Groundwater drawn by hand-pumps has maximum value of radon concentration as the surface leakage of radon is minimum. Loss of radon gas is maximum in water supplied through pipes after storage in the water tanks. The radon concentration in the electric-motor driven hand-pumps and ordinary hand-pumps are almost identical. Tube-well drawn water undergoes agitation and turbulence, as a consequence, the radon gas concentration is lowered due to dissipation at a faster rate into the air. Municipal water supplies are based on the deep tube-well drawn water used for storage in water tanks. The loss of radon gas is augmented by the storage and then circulation over long distances.

Radon concentration in mineral waters is found to be minimum as this water is manufactured under cascade distillation for removal of aerosol particles and other contaminants, which adsorb radon and its progeny. A comparison of radon concentration measured in double distilled water obtained from our laboratory with that of mineral water, supports our hypothesis for lowest values in mineral water. Some villages use canal water for irrigation and in case of drought etc., for drinking purpose also. The radon concentration values for canal water are also in the lower ranges from 0.2–2.0 Bq/l. The radon gas escapes from flowing water due to turbulence and high winds, which remove the gas from the surface.

Radon contents of thermal springs at Kasol on the bank of Parbati river are given in Table 3 along with radon content in the flowing river water. For the sake of comparison, radon contents of two natural water springs, being used for supply of drinking water at Bradha and Takrer in the vicinity of Parbati valley are also reported. The area around Parbati valley is known for uranium mineralisation, and as a consequence, the radon content of natural springs is also quite high [13].

Table 3. Radon content in thermal springs of Parbati Valley (H.P.)

S.N.	Place	Spring	Temperature (°C)	Radon Value (Bq/l)
1.	Kasol	Thermal 1	90	371.9
2.	Kasol	Thermal 2	91	518.1
3.	Kasol	Thermal 3	91	716.3
4.	Kasol	River Water	12	52.4
5.	Bradha	Bauli 1	24	34.2
6.	Takrer	Bauli 2	19	15.9

The highest value 716.3 Bq/l is recorded at Kasol in thermal spring (No.3) and the lowest value of 15.9 Bq/l in natural spring water (*bauli*) from Takrer. The Parbati river water records a radon content of 52.4 Bq/l, which is more than the recommended upper safe limit of 40 Bq/l; hence it should not be used for daily consumption.

Table 4. Radon concentration from different sources of groundwater in the Bathinda district of Punjab.

S. No.	Place	Source	Avg. Radon Conc. (Bq/L)
1.	Jodhpur village	Hand Pump	2.31
2.	Gobindpur village	Hand Pump Tube well	4.30 5.54
3.	Bibiwala village	Hand Pump	2.70
4.	Bhucho Khurd village	Hand Pump	3.42
5.	Bhucho Kalan village	Hand Pump	4.61
6.	Thermal colony	Tube Well	2.42
7.	NFL colony	Hand Pump Lake Water	4.16 2.01
8.	Thermal Colony (Lehra Mohabat)	Hand Pump Tube Well	2.98 4.97
9.	Pitho Village	Hand Pump Tube Well	3.95 2.92
10	Rampura Mandi	Hand Pump Tube Well	3.95 2.92

CONCLUSION

1. The potable drinking water in Gurdaspur district has higher concentration of radon as compared to the water from neighboring district Amritsar in Punjab [14].
2. Mineral waters are free from radioactivity and safe for drinking purposes.
3. The value of radon content recorded in Parvati river is 52.4 Bq/l at Kasol which is higher than radon values recorded in other Himalayan rivers [15, 16].
4. The recorded values of radon concentration in ground waters of different areas of Gurdaspur (Table 1) and Bathinda districts (Table 4) are within the safe limits of 4 to 40 Bq/l recommended internationally for drinking water [17].
5. There is a need for epidemiological investigation in high radon areas identified as ‘hot spots’ in Himachal Pradesh to study the health effects on general population living in the area.

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