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Indoor radon level measurements in the dwellings of Northern Rajasthan, India

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ABSTRACT

The environmental monitoring of radon in different dwellings of Northern Rajasthan has been carried out. This study has been undertaken for the purpose of health risk assessments. RAD7 an electronic radon detector (Durridge co. USA) was used to estimate the indoor radon concentration levels in dwellings of Northern Rajasthan. The indoor radon activity in dwellings varies from 8.75 to 157.50 Bq/m^3 with an average of 32.31 Bq/m^3. The observed radon concentration values were well below the action level (200-300 Bq/m^3) recommended by International Commission on Radiological Protection. The indoor radon concentrations in majority of the houses surveyed in the present study are within the safe limit (148 Bq/m^3) recommended by US Environmental Protection Agency. The ventilation conditions are found to affect radon concentration in dwellings. Analysis of ventilation conditions reveal that the indoor radon concentration values are more in poorly ventilated dwellings compared with the well-ventilated ones.

Keywords: Dwellings, Health risk, Indoor radon, RAD7, Ventilation conditions

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INTRODUCTION

Radon is a naturally occurring odourless, colourless, tasteless inert gas which is imperceptible to our sense. It is produced continuously from the decay of naturally occurring radionuclide such as U-238, U-235, Th-232. The isotope Rn-222, produced from the decay of U-238, is the main source (approximately 55%) of internal radiation exposure to human life [1]. Worldwide average annual effective dose from ionizing radiation from natural sources is estimated to be 2.4 mSv, of which about 1.0 mSv is due to radon exposure [2]. Radon gas escapes easily from the ground into the air and disintegrates through short-lived decay products called radon daughter or radon progeny. The short-lived progeny, which decay emitting heavy ionizing radiations called alpha particles, can be electrically charged and attach to aerosols, dust and other particles in the air we breathe. As a result, radon progeny may be deposited on the cells lining the airways where the alpha particle can damage the DNA and potentially cause lung cancer. When radon gas itself is inhaled, most is exhaled before it decays, A small part of the inhaled radon and its progeny may be transferred from the lungs to the blood and finally to other organs, but the corresponding doses and associated cancer risks are negligible compared to the lung cancer risk [3]. In India many research workers are engaged in the measurement of indoor radon levels in dwellings for health risk assessments and its control [4-7]. The residential radon is regulated by an action level of radon concentration between 200 and 300 Bqm^{-3} based on ICRP recommendations [8]. Radon has classified as a human carcinogen by the International Agency for Research on Cancer [9]. In the past decades, systematic radon surveys in dwellings were carried out the entire world, but

Northern Rajasthan districts of India have not been studied for environmental radon so far. Therefore, the present study has been carried out first time in the study area, in order to assess the health risks due to radon.

Geology of study area
Rajasthan is located in northwest of India. It lies between latitude 27° 00' N and longitude 74° 00' E. Fig. 1 Shows the geographic location of the state of Rajasthan in India, as well as the location of the sampling sites in Rajasthan. The studied area is bounded on the western side by Pakistan, on the northeast side by Haryana and Punjab to the north. Sriganganagar and Hanumangarh districts have plain surface covered with thick layer of alluvium and wind blown sand. Ghaggar river is an ephemeral one and has northeast to southeast course near Hanumangarh and divide the Ganganagar district into two halves. Churu district is a part of the Thar desert soil of churu district are pale brown, single grained, deep and well drained. The soils of the Sikar district are predominantly light textured, weak structured well drained alluvial & eolian in nature. The Khandela village of Sikar district in studied area is known for radioactive mineralization and is also known as copper belt. Most of the area of Rajasthan exposes wide variety of hard rocks including various types of metamorphic rocks like schist, quartzite, marble and gneisses of Precambrian age with associated acid basic intrusive rocks. Most of the houses in the study area are cemented houses and poorly ventilated.

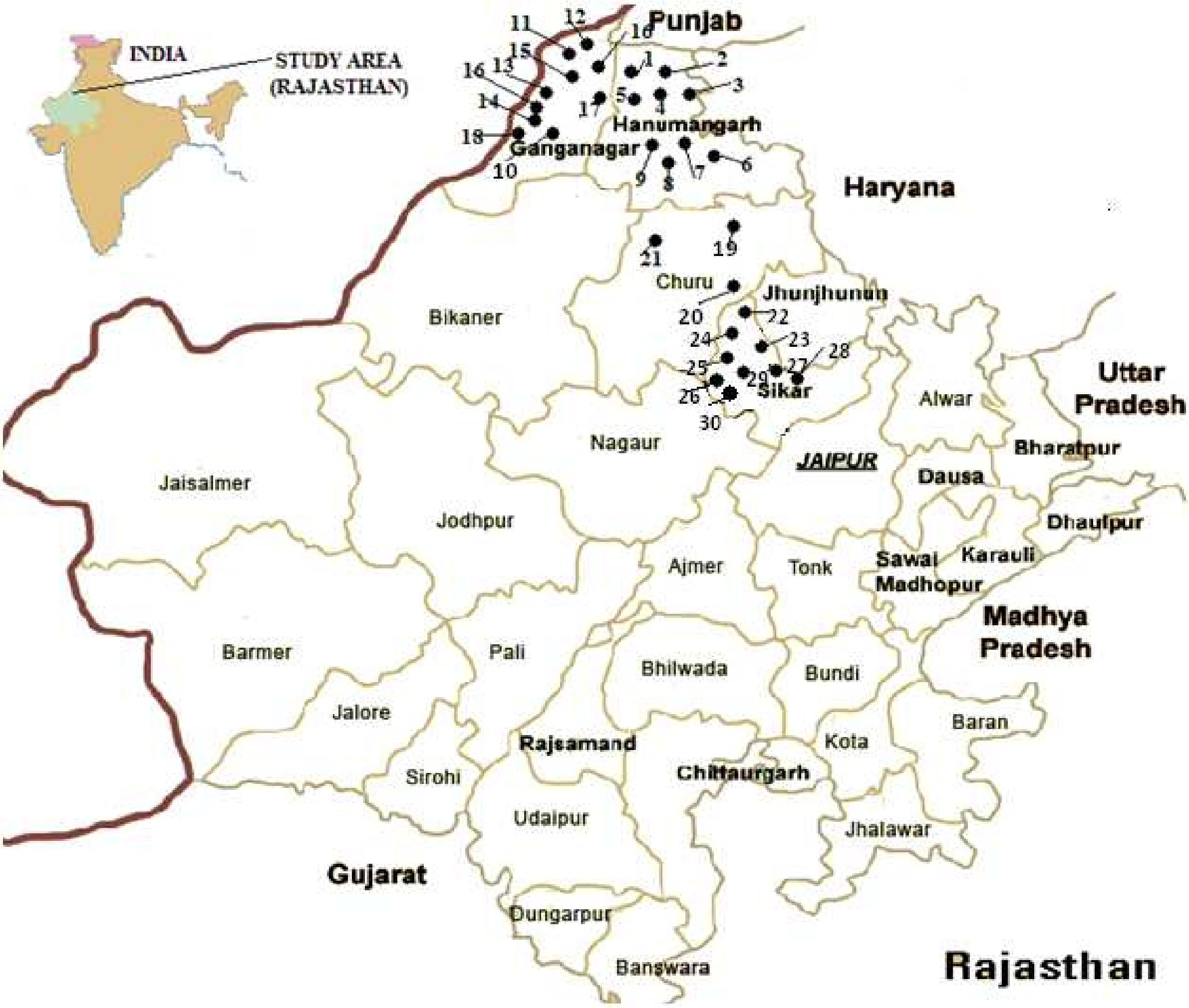

Fig. 1 Map of Rajasthan showing the area surveyed during the present investigations.

MATERIALS AND METHODS

Radon concentration in indoor air was measured with RAD7 an electronic radon detector connected to a Drystik accessory (Durridge co. USA) in a closed loop configuration. Fig.2. shows the scheme of drying tube, connections and air flow way. The RAD7 was used for fast measurement of indoor radon activity levels on sites. RAD7 uses a semiconductor material (silicon) that converts alpha radiation directly to an electrical signal. As per EPA recommendations that all continous radon monitors be calibrated at least every 6 months in a radon calibration chamber, the instrument was calibrated recently. One important advantage of solid state devices is the ability to electronically determine the energy of alpha particle. Every nucleus of ^{222}Rn decays through the sequence Polonium-218, Lead-214, Bismuth-214, Polonium-214 and Lead-210. With each transformation the nucleus emits alpha, beta or gamma radiation. The RAD7 was designed to detect alpha particle only [10].

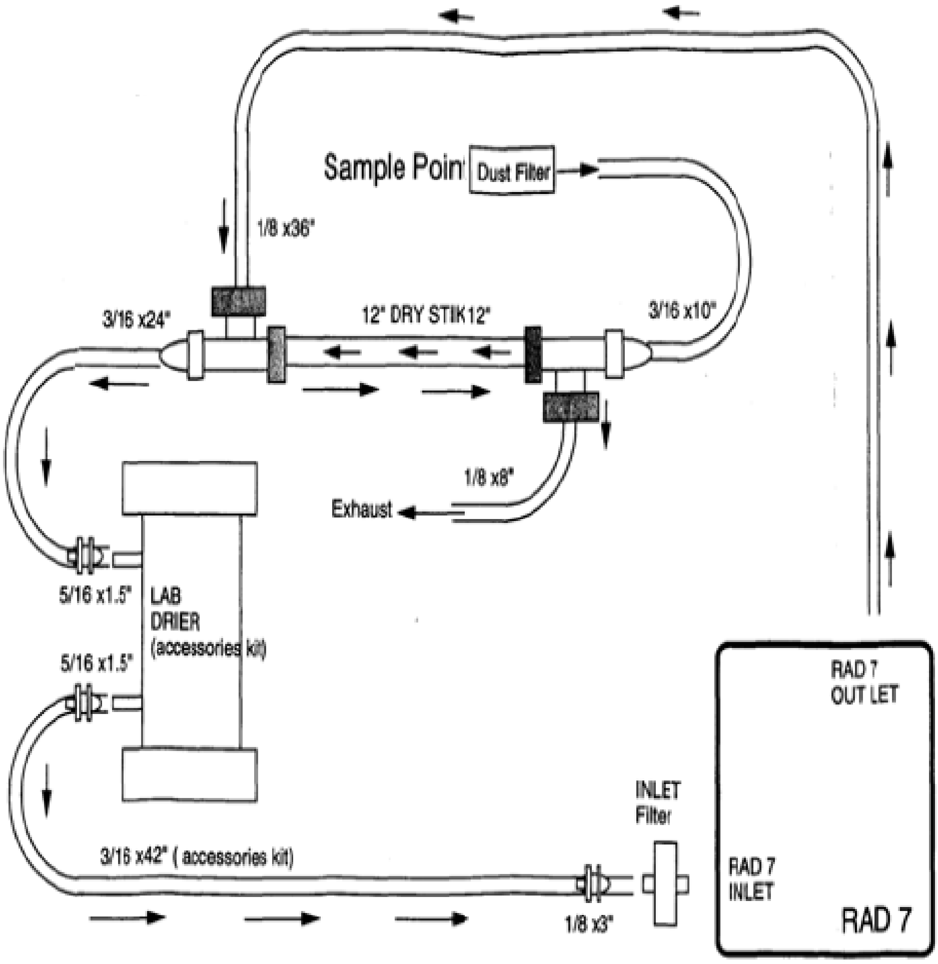

Fig.2. The scheme of drying tube, connections and air flow way.

RESULTS AND DISCUSSION

The indoor radon concentration levels recorded in 30 villages of Sriganganagar, Hanumangarh, Sikar and Churu districts of northern Rajasthan are given in Table 1. The indoor radon concentration values in the dwellings of the Hanumangarh district varies from 8.75 to 87.7 Bq/m^3. The indoor radon concentration values in the dwellings of the SriGanganagar district varies from 8.75 to 105.43 Bq/m^3. The indoor radon concentration values in the dwellings of the Churu district varies from 8.75 to 52.50 Bq/m^3. The indoor radon concentration values in the dwellings of the Sikar district varies from 8.75 to 157.50 Bq/m^3. The indoor radon activity in dwellings for whole of the studied area varies from 8.75 to 157.50 Bq/m^3 with an average of 32.31 Bq/m^3. Indoor radon values recorded in some of the dwellings in northern Rajasthan are slightly higher than the average value reported for the dwellings worldwide 40 Bq/m^3 [2]. The observed radon concentration values were well below the action level (200-300 Bq/m^3) recommended by International Commission on Radiological Protection [8]. In 97% of the dwellings, recorded values were found to be lower than the guidelines of Environmental Protection Agency (148 Bq/m^3) [11]. However, more than 3% of the dwellings, recorded values were found to be higher than EPA guidelines.

Table1. The radon concentration levels recorded in Sriganganagar, Hanumangarh districts of Northern Rajasthan.

Sr. No.	Sample Location	Ventilation Conditions	Radon Concentration (Bq/m^3)	R.H (%)	Temp(^{o}C)
District Hanumangarh					
1	Rawatsar	Well ventilated	8.75	6	20.4
2	Amarpura jallukhatt	Poorly ventilated	87.7	9	24.6
3	Morjand Sikhan	Poorly ventilated	43.9	15	26.1
4	Hanumangarh city	Poorly ventilated	8.75	9	22.5
5	Shahpini	Partially ventilated	17.50	11	19.4
6	Nukera	Poorly ventilated	17.55	22	25.8
7	Sangaryia	Well ventilated	11.67	15	28.6
8	Rasuwala	Poorly ventilated	17.50	8	23.6
9	Pilibanga	Partially ventilated	8.75	17	25.5
District SriGanganagar					
10	Karanpur	Partially ventilated	26.25	18	23.7
11	23Z	Poorly ventilated	17.50	11	25.8
12	3H	Poorly ventilated	105.43	8	24.3
13	Gulabawala	Well ventilated	8.75	9	24.9
14	Malakana Kalan	Poorly ventilated	26.25	12	24.0
15	Kalian	Poorly ventilated	44.05	8	26.4
16	Sangatpura	Poorly ventilated	70.00	12	21.9
17	Radewala	Partially ventilated	8.75	11	26.4
18	14Q	Partially ventilated	11.67	15	24.6
District Churu					
19	Taranagar	Poorly ventilated	52.50	11	27.7
20	Ratangarh	Poorly ventilated	17.50	22	22.8
21	Rajgarh	Well ventilated	8.75	28	24.9
District Sikar					
22	Raseedpura	Well ventilated	8.75	8	26.4
23	Sikar city	Poorly ventilated	35.0	9	27.7
24	Dadhia	Partially ventilated	8.75	11	17.0
25	Kotri	Well ventilated	17.50	7	17.3
26	Khandela Gokul	Poorly ventilated	52.50	18	25.8
27	Kotri Lalasar	Poorly ventilated	43.75	15	26.1
28	Khandela	Poorly ventilated	157.5	9	16.7
29	Fatehpur	Partially ventilated	17.50	9	27.4
30	Laxmangarh	Well ventilated	8.75	7	25.5

Table 2. – Comparison of indoor radon-222 levels in different environs of India

Region	Values from Literature (Bq/m^3)	Reference
Malwa region, Punjab	54-168	Mehra et al., 2006
Northern Haryana	66-104	Chauhan et al., 2010
Srivaikuntam, Tamilnadu	30-287	Kumar et al., 2007
Thankassery, Kerala	44.3-373.3	Kumar et al., 2007
Delhi	43.5-334.7	Gupta et al., 2011
Kulu, Himachal Pradesh	156.11-635.42	Singh et al., 2001
Agra	98-305	Kumar et al., 2010
Garhwal Himalaya	13-178	Gusain et al., 2009
Worldwide average	40	UNSCEAR, 2000
Northern Rajasthan	8.75-157.50	Present Investigations

The indoor radon levels in the environment of Northern Rajasthan are compared with the literature values in Table 2. Mehra et al. has reported radon concentration in the dwellings of Malwa region of Punjab in the range of 54-168 Bq/m^3 [4]. Chauhan has reported radon concentration in dwellings of Northern Haryana in the range of 66-104 Bq/m^3 [12]. Kumar et al. has reported radon concentration in dwellings of Tamilnadu in the range of 30-287 Bq/m^3 [13]. Kumar et al. has reported radon concentration in dwellings of Kerala lies in the range of 44.3-373.3 Bq/m^3 [14]. Gupta et al. has reported radon concentration in dwellings of Delhi lies in the range of 43.5-334.7 Bq/m^3 [15]. Singh et al. has reported radon concentration in dwellings of Kulu area of Himachal Pradesh lies in the range of 156.11-635.42 Bq/m^3 [5]. Kumar et al. has reported radon concentration in dwellings of Agra lies in the range of 98-305 Bq/m^3 [16]. Gusain et al. has reported radon concentration in dwellings of Garhwal Himalaya lies in the range of 13-178 Bq/m^3 [17]. It is clear from the table that radon levels in Northern Rajasthan are very much lower compared to the value reported for Kulu, Himachal Pradesh. However, the results lies within the values reported for other regions of India.

CONCLUSION

The indoor radon activity in dwellings varies from 8.75 to 157.50 Bq/m^3 with an average of 32.31 Bq/m^3. The observed radon concentration values were well below the action level (200-300 Bq/m^3) recommended by International Commission on Radiological Protection [8]. The indoor radon concentrations in majority of the houses surveyed in the present study are within the safe limit (148 Bq/m^3) recommended by US Environmental Protection Agency [11]. The ventilation conditions are found to affect radon concentration in dwellings. Analysis of ventilation conditions reveal that the indoor radon concentration values are more in poorly ventilated dwellings compared with the well-ventilated ones.

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