PAPER

INDOOR RADON LEVELS IN SOME AREAS OF HIMACHAL PRADESH : AN INTER – COMPARISON OF ACTIVE AND PASSIVE TECHNIQUES

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ABSTRACT : Indoor radon levels in the dwellings of Ramera and Asthota villages of Hamirpur district located near the uranium bearing sites in Himachal Pradesh are determined using both active and passive techniques. An inter-comparison of two techniques establishes the efficacy of track-etch technique for radon survey of indoor air in dwellings. The radon levels are found to be higher in winter season after the rains. The mean values of radon, by track-etch technique, in Ramera village are 89.90 Bq / m^3 and 144.10 Bq / m^3 for two different sasons and the corresponding values for Asthota village are 62.40 Bq / m^3 and 87.00 Bq / m^3 respectively. The Alpha-guard grab sampling average radon values are 118 ± 53 Bq / m^3 and 187 ± 50 Bq / m^3 for the two seasons in Ramera village and 151 ± 49 Bq / m^3 in January 1998 for Asthota village. The correlation coefficient between these two techniques is found out to be 0.61.

Keywords : Indoor radon, Alpha-logger, Plastic detector LR-115 type II, Calibration constant

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1. INTRODUCTION

Our laboratory is engaged in uranium/ thorium estimation and radon concentration studies in soil, water and atmospheric air since 1980 in the Siwalik Himalayas (Virk et al., 1982; Ramola et al., 1987; Singh et al., 1989; Virk 1990; 1997). Radon surveys were carried out particularly in Himachal Pradesh in the areas well-established for uranium mineralisation (Dar, 1964; Narayan Das et al., 1979) using various techniques, viz., gamma scintillometry, track-etch technique, surface-barrier silicon-junction detectors and pulse ionisation counters (alpha-loggers). Radon concentration in the ambient air of indoor environment is being recorded under a BRNS- co-ordinated project of Department of Atomic Energy in Punjab and Himachal Pradesh.

It is well known that radon-rich air is drawn out of the underlying rock, soil, or even building materials and seeps through the floors and walls into the homes. Indoor radon levels are governed by many factors, to name a few, such as local geology, atmospheric pressure, pressure differentials, indoor- outdoor temperature differentials, air exchange rate, wind velocity, rainfall, humidity, orientation of the house and last, but not the least, the habits of the house occupants. The radon activity in the soil is highly variable changing as much as 30 times over a domain of 10 m (Toth et al., 1997). As consequence, the radon levels are different in different rooms of the same house, the maximum concentration being recorded in underground cellars.

2. EXPERIMENTAL METHODS

Radon is an inert-gas produced from radioactive decay of uranium and thorium. It has three isotopes, ^{222}Rn, ^{220}Rn and ^{219}Rn. ^{222}Rn with half life of 3.825 days, is of particular interest because other two isotopes, ^{220}Rn and ^{219}Rn are very short-lived. At a given site on the ground, however, the levels of uranium and thorium present depend on local geology. Radon can diffuse readily out of surface soil into the atmosphere and into basements and living areas of houses.

Experimental methods for radon detection and measurement are based on alpha counting of radon and its daughters. Both active and passive devices are available for this purpose. Real-time measurements are carried out by electronic counters, commonly known as alpha-loggers, while plastic detectors basd on track-etch technique are used for long-term integrated measurements of radon levels in the dwellings.

2.1 Alpha-logger Technique

Short-term radon (^{222}Rn) measurements were carried out using an Alpha-Guard (PQ 2000 PRO model) supplied by Genitron Instruments, Germany. It is a pulse ionisation based counter which can record alpha counts from the decay of ^{222}Rn in the indoor air of dwellings. It is a highly sensitive, rugged and portable device with a

wide dynamic range from 2 to 2 x 10^6 Bq / m^3. It can be operated in both diffusion and flow modes and radon activity is recorded from 1 min. to 24 hrs. intervals. Its main advantage being that it is a multi-sensor device, calibrated using international standards, fully automatic and can record the meteorological parameters such as temperature, pressure and relative humidity.

2.2 Track-etch Technique

Plastic detector LR-115 type II is a cellulose nitrate film of 12 μm thickness manufactured by Kodak Pathe, France. It is a pelliculable, red coloured film, highly sensitive to radon alphas and with negligible background. Because of its low cost, ruggedness and a fine window for recording alpha particles emanating from radon and its daughters, it is highly useful for integrated measurements from a few days to a few months.

Plastic films (2.5 x 2.5 cm^2) were loaded in dosimeter cups obtained from Environmental Assessment Division (EAD), BARC, under the BRNS project. These cups were suspended in living rooms of houses in a few selected villages of Himachal Pradesh using the standard protocol (NWSUR, 1994). The plastic films were removed from the cups after an interval of three and half months. The film exposed in the bare mode, filter mode and membrane mode were etched in 2.5 N NaOH solution at 60° C for 80 minutes in a constant temperature bath. These films were washed, dried and scanned under Carl Zeiss binocular microscope for track density measurements due to total radon and its progenies, radon plus thoron and radon respectively. The etched films of LR 115 type II were peeled off from the base and counted for the tracks registered using a spark counter following standard protocol. The track density difference in the two techniques is of the order of 10 percent.

3. RESULTS AND DISCUSSION

Track-etch radon and thoron data of selected dwellings in village Ramera and Asthota are summarized in Tables 1 and 2, respectively. The radon values were measured in the living rooms on ground floor using dosimeter cups suspended from the ceiling. The construction of houses is almost similar in the two villages as local sandstone is used for the walls, dolomite slates for the roof and mud clay for the flooring. Only a few houses have pucca flooring. The average value of radon level varies from 31.60 Bq/m^3 to 196.00 Bq / m^3, i.e. by a factor of 6.2 among the houses (D and A) of Ramera village (Table - 1), with a mean value of 89.90 Bq / m^3. The corresponding thoron value varies from 21.70 Bq / m^3 for house D to 114.70 Bq / m^3 for house C with a mean value of 44.10 Bq / m^3. The radon values were recorded in four dwellings of village Asthota (Table - 2) with minimum and maximum values of 53.60 Bq / m^3 and 71.70 Bq / m^3, respectively, with AM value of 62.40 Bq / m^3. The thoron concentration varies from 12.60 Bq / m^3 to 50.30 Bq / m^3 with AM value of 27.80 Bq / m^3. The radon and thoron measurements cover the time interval between 22 August, 1997 to 5 December, 1997. It was usually wet season in the year during our investigations and due to closure of pore spaces in the soil, the radon emanation rate is suppressed.

Table – 1 : Track-etch Radon and Thoron Data for Village Ramera (H.P.)

House Code	Aug. 1997 - Dec. 1997		Jan. 1998 - Apr. 1998	
	Radon Conc. (Bq / m^3)	Thoron Conc. (Bq / m^3)	Radon Conc. (Bq / m^3)	Thoron Conc. (Bq / m^3)
A	196.00	22.90	130.90	76.80
B	97.70	29.30	164.20	29.40
C	57.10	114.70	279.60	45.40
D	31.60	21.70	59.40	20.20
E	70.20	23.60	–	–
F	–	–	161.30	56.00
G	124.30	43.00	114.10	26.60
H	52.60	53.70	101.10	24.00
Average	89.90	44.10	144.10	39.80

Table – 2 : Track-etch Radon and Thoron Date for Village Asthota (H. P.)

House Code	Aug. 1997 - Dec. 1997		Jan. 1998 - Apr. 1998	
	Radon Conc. (Bq / m^3)	Thoron Conc. (Bq / m^3)	Radon Conc. (Bq / m^3)	Thoron Conc. (Bq / m^3)
A	53.60	12.60	59.80	15.40
B	69.20	17.10	68.20	36.20
C	55.10	31.20	100.60	99.20
D	71.70	50.30	119.20	64.30
Average	62.40	27.80	87.00	53.80

The track-etch radon and thoron data for villages of Ramera and Asthota for the interval January to April, 1998 are summarized in Tables 1 and 2. It is observed that radon values are generally enhanced in dwellings during the winter season. The mean values for Ramera and Asthota are 144.10 Bq / m^3 and 87 Bq / m^3, respec-

Table – 3 : Alpha-Guard Radon Values in the Living Rooms of Ramera and Asthota District Hamirpur (H. P.) during August, 1997 and January, 1998

S. No.	Village Name	House Code	Radon Value (Bq / m^3)	Tmperature (°C)	Pressure (mbar)	Rel. Humidity (%)
1	Ramera (Aug., 1997)	A	118 ± 62	29	922	75
		B	108 ± 39	24	907	89
		C	138 ± 45	29	921	76
		D	66 ± 35	28	922	76
		E	159 ± 83	28	922	77
2	Ramera (Jan., 1998)	A	213 ± 51	16	927	66
		B	165 ± 45	17	927	66
		C	297 ± 60	15	927	69
		D	53 ± 40	17	924	61
		E	205 ± 55	16	925	62
3	Asthota (Jan., 1998)	A	170 ± 56	22	939	50
		B	201 ± 60	20	939	55
		C	132 ± 40	20	939	55
		D	100 ± 38	17	938	60

Table – 4 : Inter-comparison of Alpha-Guard and Track-etch Radon Data for Some Dwellings in Ramera (H. P.)

House Code	Alpha-Guard Radon Data (Bq / m^3)		Track-etch Data (Bq / m^3)	
	Aug. 1997	Jan. 1988	Aug. 1997 - Dec. 1997	Jan. 1998 - Apr. 1998
A	118 ± 62	213 ± 51	196.00	130.90
B	108 ± 39	165 ± 45	97.70	164.20
C	138 ± 45	297 ± 60	57.10	279.60
D	66 ± 35	53 ± 40	31.60	59.40
E	159 ± 83	205 ± 55	70.20	–
AM	118 ± 53	187 ± 50	90.50	158.50
SD	35 ± 20	89 ± 8	63.60	91.80

Table – 5 : Inter-comparison of Alpha-Guard and Track-etch Radon Data for Some Dwellings in Asthota (H. P.)

House Code	Alpha-Guard Data (Bq / m^3)	Track-etch Data (Bq / m^3)	
	Aug. 1997	Aug. 1997 - Dec. 1997	Jan. 1998 - Apr. 1998
A	170 ± 56	53.60	59.80
B	210 ± 60	69.20	68.20
C	132 ± 40	55.10	100.60
D	100 ± 38	71.70	119.20
AM	151 ± 49	62.40	87.00
SD	44 ± 11	9.40	27.80

tively. However, the mean thoron concentration values show some decline for Ramera village while it nearly doubles for Asthota village.

Indoor radon levels recorded by Alpha-Guard during grab sampling in August, 1997 and January, 1998 in the living rooms of dwellings of villages Ramera and Asthota are summarized in Table - 3. It is observed that radon values are generally high during the winter session after the rains. However, there is one exception in case of house D (Ramera), where radon level shows a slight fall. An inter-comparison of Alpha-Guard and track-etch radon data for village Ramera is given in Table - 4. A similar inter-comparison of Alpha-Guard radon data with track-etch data for village Asthota is given in Table - 5.

4. CONCLUSIONS

Some interesting conclusions can be drawn from this inter-comparison of radon data recorded by active and passive techniques. Radon level in Ramera dwellings recorded during the month of August, 1997 is lower than the corresponding value recorded during the

month of January, 1998. It clearly shows that radon emanation rate has seasonal variation. After the rainy season, it is enhanced during the dry spell. The indoor radon level also depends upon ventilation conditions. During winter, all the windows are kept closed to conserve heat, hence indoor radon level will be higher. There is one exception in case of house D, where radon level shows a slight fall. This house has a 'pucca' cement flooring and shows unusual behaviour. The overall correlation coefficient between the Alpha-guard and track-etch radon values in determined to be 0.61; it it 0.76 for Ramera and –0.91 for Asthota.

Since both the active and passive techniques are based on different physical principles, we cannot expect perfect matching of radon data recorded in indoor air of dwellings. Moreover, Alpha-guard survey was a spot sampling survey carried out for one hour only in each dwelling. Both the techniques have their advantages and drawbacks. Considering the vast geographical area to be mapped for indoor radon levels in India, the efficacy of track-etch technique using plastic detectors is established from this inter-comparison.

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