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A study of Indoor Radon / Thoron Levels in Some Dwellings by using Solid State Nuclear Track Detectors

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Abstract

Indoor radon and thoron measurements in dwellings of Pathsala area of Bajali sub-Division have been carried out using LR-115 (type II) detectors in plastic twin chamber dosimeter cups (BARC type). The estimated indoor radon levels varied from 89.51 to 125.41 Bq.m^{-3} with a mean value 103.7 Bq.m^{-3}. The thoron levels were found to vary from 36.0 to 55.03 Bq.m^{-3} with a mean value 37.87 Bq.m^{-3}. The estimated inhalation dose for the inhabitants varied from 0.47 to 0.59 μSv.h^{-1} with a mean value 0.53 μSv.h^{-1}

Keywords: Radon, Thoron, Dwellings, LR-115.

Introduction

Radon (222_{Rn}), the decay product of radium in the naturally occurring U^{238} series, a radio active inert gas which is responsible for the most of the radiation dose received by the general population (UNSCEAR, 1994).

Radon isotopes can isolate themselves and migrate away from the parent nuclei due to diffusion process through the soil and enter the atmosphere . The radon and its progeny attached to aerosols present in the ambient air constitute significant radioactive hazards to human lungs. During respiration, radon progeny deposits in the lungs and irradiate the tissue thereby damaging the cells and may cause lung cancer (Sevc, J. et al, 1976).

Henshaw et al (1990) claimed that indoor radon exposure is associated with the risk of leukemia and certain other cancers, such as melanoma and cancer of kidney and prostate. The concentration of radon and its decay products show large temporal and local fluctuations in the indoor atmosphere due to the variations of temperature, pressure, nature of building materials, ventilation conditions and wind speed etc.(Singh Surinder et al , 2005).

Area under Investigation

In the present study, effort has been made to estimate the indoor radon / thoron levels in some of the Reinforced cement concrete (RCC) types of houses in four wards of Pathsala area of Bajali Sub-Division of Barpeta district, Assam, India. The area comprises of a plain area having no any industrial belt. Geographical location of the area is $26^{o}30^{l}$ N latitude and $91^{o}11^{l}$ E longitude. The height of the ground level is 50 meter from the mean sea level. The map of the study area is shown in figure 1.

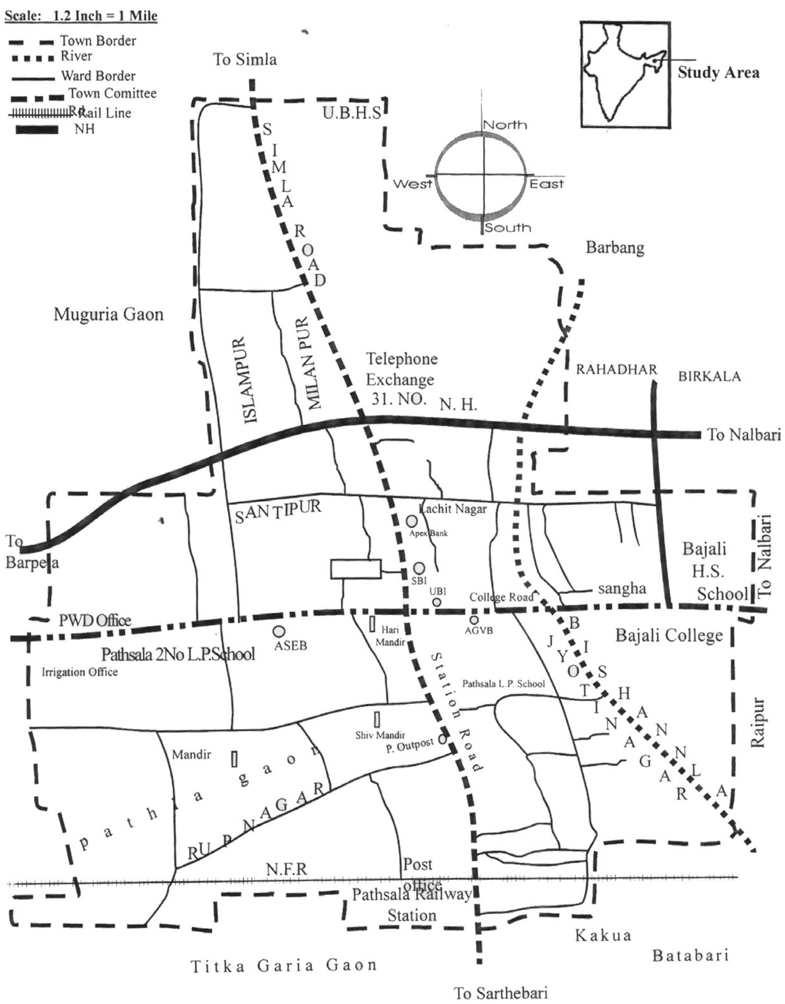

Figure 1: Map of Investigation Area of Pathsala of Bajali Sub-Division of Barpeta Dist. (Map available form Pathsala Town Committee office).

Methodology

Several methods are in use for the measurement of radon and its daughter elements in dwellings. Some measuring the short-term values are called active methods and others measuring the integrated values are called passive methods.

In the present study, strippable cellulose nitrate film LR-115 (type II) available from Kodak, pathe was exposed in three different modes: (i) Bare Mode (ii) Cup with filter paper and (iii) Cup with filter paper and Mylar in a plastic twin chamber dosimeter cups (BARC type)(Deka P.C et al,2003).The schematic diagram of the dosimeter cup is shown in fig.2. It is a plastic cylindrical vessel of 11 cm length and 7 cm diameter and opened at both the ends. There is a plastic dividing wall at the middle which divides the whole cylinder into two chambers each of length 5.5 cm. Detectors can be attached on both sides of this wall at the middle. On the outer surface of the cylinder in a fixed position, the detectors can also be attached and exposed to radiation. Open ends are covered by perforated sheets. These three modes give the level of radon and thoron gas in $Bq.m^{-3}$ and the potential alpha energy concentration of individual progenies in terms of working level units.

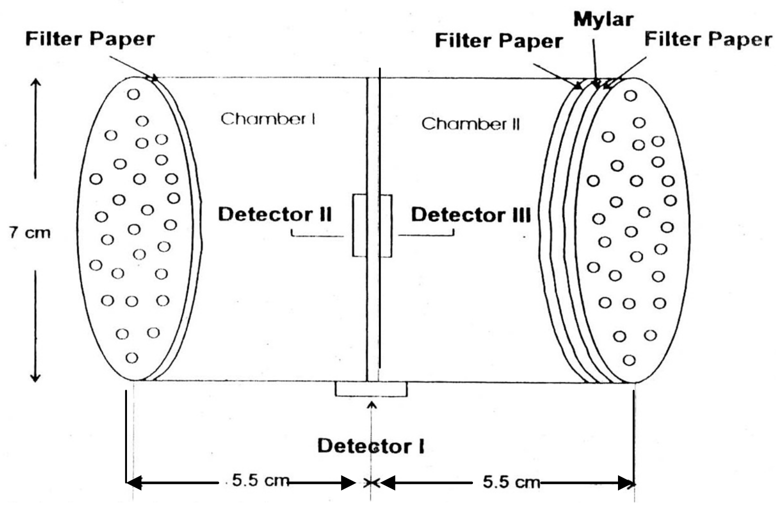

Figure 2: Schematic diagram of Plastic twin-chamber dosimeter cup(BARC Type) used for the measurement.

Three pieces of LR-115 (type II) detector of size 3 cm×3 cm were placed in proper position of the dosimeter cups. A 'bare' detector was mounted on the out side of the cup. This views a hemisphere of air in which the minimum radius is 9.1 cm, the range of 212 $_{po}$ alpha in air or 6.4 cm, the range of 214 $_{po}$ alpha (Durrani SA et al ,1998). It records all the tracks due to radon, thoron and their progenies. In the cup under 'filter paper mode', the detector was fixed on the dividing wall within the dosimeter cup and the mouth of the chamber on its side was covered with a filter paper. In the other chamber of the cup, the detector was fixed on the other side of the same wall and the mouth of the chamber on this end was covered with a filter paper, mylar film and then another filter paper. Filter paper and mylar film do not permit the solid daughter products of thoron to pass through them and partly reduce the rate of diffusion of thoron gas itself due to its short half life (51.5 sec). It has been estimated that 98% of radon penetrates but thoron does not enter a cup closed in this way (Jojo pj, 1993, Mayya et al, 1998).

The plastic twin chamber dosimeter cups with detectors were installed inside the rooms in the RCC houses in such a way that no wall or other surfaces (like roof) is closer than 10 cm. The cups were exposed for about 90-95 days after which they were retrieved. The cups were exposed for four different quarters of the year in this way. The choice of the houses was random and one room in each house was selected for the measurement.

After retrieving, the detectors were chemically etched in 2.5 N, NaOH solution and the etching was done at $(60\pm 1)^{o}$ c for 90 min. A magnetic stirrer with mild agitation was used throughout for uniform etching. The optically visible tracks were counted using an (OLYMPUS) optical microscope at 400X magnification.

Let T_1 and T_2 be the track densities registered in membrane and filter mode exposure (as observed through microscope), d is the exposure days, C_R and C_T be the concentrations of radon and thoron in Bq. m^{-3}, K_R and K_T be the sensitivity factors for radon and thoron gas. Then (Dwivedi et al, 2001)

$$C_R = T_1/d\, K_R$$

$$C_T = (T_2 - T_1)/dK_T$$

Where K_R=0.020 $Tcm^{-2}d^{-1}/Bqm^{-3}$ and K_T=0.019 $Tcm^{-2}d^{-1}/Bqm^{-3}$ calibration constants for radon and thoron gas in the membrane and filter compartments.

Also the estimated inhalation dose is given by

$$D = \{(0.17+9F_R)C_R+(0.11+32F_T)C_T\}/1000\ \mu Sv.h^{-1}$$

where F_R and F_T are the equilibrium factors for radon and thoron progeny respectively.

A computer program was developed in order to carry out these computations.

Results and Discussion

The results of indoor radon / thoron concentration levels in different RCC types of houses of Pathsala area for one full calendar year (2006-07) taken over in four quarters to study the seasonal variations are given in table 1 and 2 respectively. It is seen that the mean indoor radon levels varies from 89.51 to 125.41 Bq.m^{-3} with a mean value 103.7 Bq.m^{-3} and that of thoron levels varies from 36.02 to 55.03 Bq.m^{-3} with a mean value 37.87 Bq.m^{-3}.

These values are two or three times greater than that of world average of 40 Bq.m^{-3} (UNSCEAR, 2000). This may be due to the difference in the concentration of radioactive elements viz. Uranium and radium in the soil and building materials of the study area. However, these values are less than the lower limit of action level (200-600 Bq.m^{-3}) recommended by (ICRP, 1993).

The seasonal variations of indoor radon/thoron concentration in different RCC types of houses are given in the table 3 and 4. It is observed from the table that the value of radon/thoron concentration during the winter season is higher and is lower in summer season. This is due to the differences in the ventilation during winter and summer. Seasonal variation of mean radon and thoron concentration of Pathsala area is shown in Fig :3.

The winter/summer ratio of indoor radon/thoron ranges from 1.42 to 1.79 with an average value 1.5 and 1.2 to 4.9 with an average value 2.3.

The inhalation dose rates received by the inhabitants of the study area in different seasons are shown in table 5. It varies from 0.47 to 0.59 $\mu Sv.h^{-1}$ with a mean value 0.53 $\mu Sv.h^{-1}$.

In almost all the dwellings, radon concentration is quite below the recommended action level.

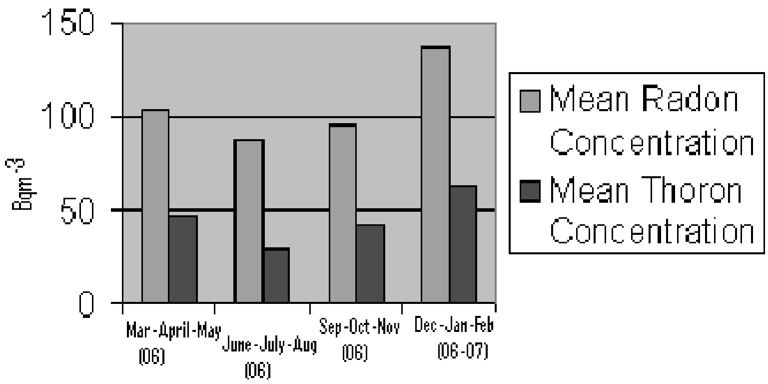

Figure 3: Seasonal Variation of Mean Radon & Thoron Concentration of Bajali (Pathsala-Area).

Table1: Measured Indoor Radon Levels in RCC Types of houses of Bajali (Pathsala Area).

Location	House No.	Radon Concentration in $Bq.m^{-3}$				Mean value
		March-April-May-06	June-July-Aug-06	Sep-Oct-Nov-06	Dec-Jan-Feb-06-07	
Ward 1	1	98.246	74.854	86.55	130.994	95.55±2.41
Ward 1	2	116.959	95.906	98.246	145.029	112.43±2.27
Ward 1	3	98.246	93.567	102.924	135.673	106.44±1.96
Ward 2	4	109.942	102.924	98.246	149.708	113.58±2.34
Ward 2	5	121.637	100.585	112.281	180.117	125.41±3.5
Ward 3	6	116.959	74.854	70.175	121.637	92.97±2.7
Ward 3	7	95.906	65.497	102.924	112.281	92.3±2.02
Ward 4	8	112.281	98.246	112.281	140.351	114.82±1.7
Ward 4	9	93.567	88.889	74.854	126.316	94.16±2.1
Ward 4	10	72.515	74.854	88.889	133.333	89.51±2.82

Table2: Measured Indoor Thoron Levels in RCC types of houses of Bajali(Pathsala Area).

Location	House No.	Thoron concentration in $Bq.m^{-3}$				Mean value
		March-April-May06	June-July-August06	Sept-Oct-Nov06	Dec-Jan-Feb06-07	
Ward 1	1	51.714	41.23	48.40	53.10	48.54±0.2
Ward 1	2	44.444	33.333	47.222	72.222	47.41±0.61
Ward 1	3	43.421	30.321	41.826	51.232	40.98±0.5
Ward 2	4	36.111	22.222	33.333	58.333	35.34±1.5
Ward 2	5	46.222	15.555	30.632	76.333	36.0±3.2
Ward 3	6	43.321	23.333	66.667	72.222	45.87±1.9
Ward 3	7	36.111	25.0	30.312	64.111	36.39±1.5
Ward 3	8	41.667	21.222	27.778	45.444	33.21±1.07
Ward 4	9	69.444	44.444	50.0	75.0	55.03±1.47
Ward 4	10	52.778	35.323	45.232	58.333	47.14±0.9

Table3: Seasonal Variation of Radon Levels observed in RCC types of houses of Bajali(Pathsala Area)

Location	House No.	Radon concentration in $Bq.m^{-3}$				Winter */ Summe r Ratio
		March-April-May06	June-July-August06	Sept-Oct-Nov06	Dec-Jan-Feb06-07	
Ward 1	1	98.246	74.854	86.6	130.994	1.74
Ward 1	2	116.959	95.906	98.246	145.029	1.51
Ward 1	3	98.246	93.567	102.924	135.673	1.45
Ward 2	4	109.942	102.924	98.246	149.708.	1.45
Ward 2	5	121.637	100.585	112.281	180.117	1.79
Ward 3	6	116.959	74.854	70.175	121.637	1.62
Ward 3	7	95.906	65.497	102.924	112.281.	1.71
Ward 4	8	112.281	98.246	112.281	140.351	1.42
Ward 4	9	93.567	88.889	74.854	126.316	1.42
Ward 4	10	72.515	74.854	88.889	133.333	1.78
Mean Value		103.6258	87.0176	94.737	137.5439	1.5

*Winter:Dec-Jan-Feb ,Summer:june-july-August

Table 4: Seasonal Variation of Thoron levels observed in RCC types of houses of Bajali (Pathsala Area).

Location	House No.	Thoron concentration in Bq.m^{-3}				Winter/ Summer Ratio
		March-April-May06	June-July-August06	Sept-Oct-Nov06	Dec-Jan-Feb06-07	
Ward 1	1	51.714	41.23.	48.40	53.10	1.2
Ward 1	2	44.444	33.333	47.222	72.222	2.1
Ward 1	3	43.421	30.321	41.826	51.232	1.6
Ward 2	4	36.111	22.222	33.333	58.333	2.6
Ward 2	5	46.222	15.555	30.632	76.333	4.9
Ward 3	6	43.321	23.333	66.667	72.222	3
Ward 3	7	36.111	25.0	30.312	64.111	2.5
Ward 4	8	41.667	21.222	27.778	45.444	2.1
Ward 4	9	69.444	44.444	50.0	75.0	1.6
Ward 4	10	52.778	35.323	45.232	58.333	1.6
Mean Value		46.52	29.19	42.11	62.45	2.3

Table 5: Estimated total inhalation dose rate received by inhabitants of Bajali (Pathsala Area).

Location	House No.	Dose Rate µSv.h^{-1}				Mean value
		March-April-May-06	June-July-Aug-06	Sep-Oct-Nov-06	Dec-Jan-Feb-06-07	
Ward 1	1	0.536	0.448	0.492	0.641	0.524±0.008
Ward 1	2	0.588	0.472	0.527	0.786	0.582±0.01
Ward 1	3	0.517	0.5	0.535	0.622	0.541±0.05
Ward 2	4	0.534	0.462	0.481	0.757	0.547±0.01
Ward 2	5	0.615	0.49	0.442	0.955	0.59±0.02
Ward 3	6	0.551	0.393	0.485	0.698	0.52±0.01
Ward 3	7	.481	0.357	0.471	0.626	0.47±0.01
Ward 4	8	0.57	0.444	0.515	0.667	0.542±0.009
Ward 4	9	0.601	0.482	0.448	0.706	0.55±0.01
Ward 4	10	0.448	0.429	0.455	0.696	0.49±0.01

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