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Measurements of Indoor Radon, Thoron Progeny Levels in some Dwellings by Using SSNTD

H.K. Sarma*[a], P.C. Deka[b], S. Sarkar[c], T. D. Goswami[d] and B. K. Sarma[d]

[a]*Department of Physics, B.B.K. college, Nagaon- 781309, Barpeta, India .*
[b]*Department of Physics, Rangia College, Rangia-781354, India.*
[c]*Department of Physics, Nagaon College, Nagaon-782001, India.*
[d]*Department of Physics, Gauhati University, Guwahati-781014, India.*
**E-mail: sarmahiranya@yahoo.co.in*

Abstract

Radon and its progeny are the main contributors in the radiation dose received by general population. The indoor radon and thoron progeny levels in Pathsala area of Bajali subdivision of Assam, have been carried out using LR-115(type-II) Solid State Nuclear Track Detectors in Plastic twin chamber dosimeter cups (BARC type). The results of the measurement of radon and thoron progeny levels in different types of R C C (Reinforced Cement Concrete) dwellings for one complete year in four quarters are presented in this paper. The measured indoor radon progeny levels are found to vary from 0.33to 0.43mWL with a mean value 0.38 mWL and the thoron progeny levels were found to vary from 0.07 to 0.127 mWL with a mean value 0.09 mWL.

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

1. Introduction

Radon (Rn^{222}) and Thoron (Rn^{220}), the naturally occurring radioactive inert gases , result from the radioactive decay of Ra^{226} and Ra^{224}, the daughter of U^{238} and Th^{232} [1]. Radon in indoor environment contributes more than one half to the collective effective dose received by human population from all sources of exposure. Precisely out of 98% of average radiation dose received by man from natural sources, about 52% is due to breathing of radon, thoron and progeny present in dwellings[2]. Radon decays into a series of short lived daughter products. Out of which Po^{218} and Po^{214} emit high energy alpha particles which are highly effective in damaging tissues and when these particles are inhaled during breathing can cause lung cancer in human beings[3,4]. The main sources of radon in dwellings are the soil or the rock underneath, building materials and the etc.

2. Area under Investigation

In the present study effort has been made to estimate the indoor radon and thoron progeny levels in some dwellings (ground floor) of reinforced cement concrete (RCC) houses in Pathsala area of Bajali Sub-division of Barpeta district of Assam, India in four seasons in a full calendar year (2006-07). The area comprises of a plain area with no industrial unit of any sort located within the area. Geographical location of thearea is 26°30′ N latitude and 91°11′ 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.

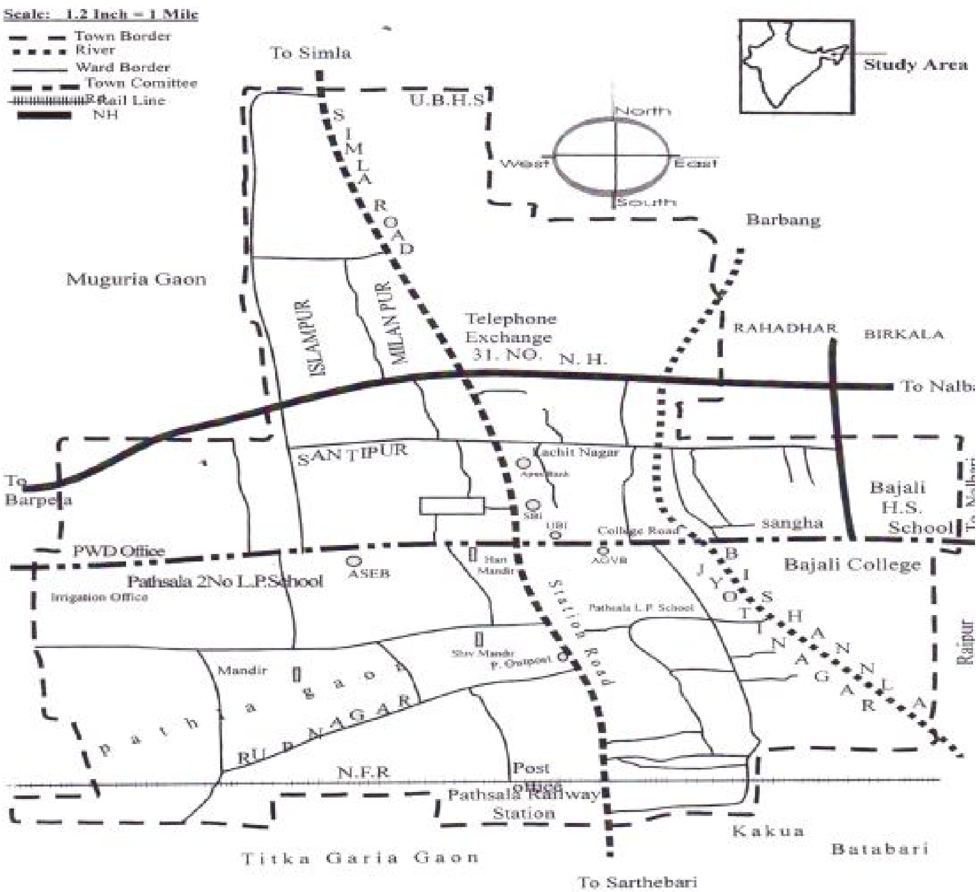

Figure 1: Map of the study area.

3. Experimental Technique

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) [9].It is a plastic cylindrical vessel of 11cm. in length and 7cm in 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 5.5cm. 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 radon and thoron gas in $Bq.m^{-3}$ and the potential alpha energy concentration of individual progenies in terms of working level unit.

Three pieces of LR-115 (typeII) detectors of size 3cm × 3cm were placed in proper positions of the dosimeter cups. The bare mode 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 Po^{212} alpha in air or 6.4 cm, the range of $_{Po}{}^{214}$ alpha[5]. 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 [6,7].

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 10cm. The cups were exposed for 90-95 days after which they were retrieved. The cups were exposed for four different quarters of a 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 2.5N, NaOH solution and the etching was done at $(60\pm1)^o$ C for 90 minutes. 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. The recorded track density was then converted to progeny concentration in mWL, by using following calibration factors [8,9]. For determination of radon concentration the calibration factor is taken to be 0.020 $Tr.cm^{-2}d^{-1}$ per $Bq.m^{-}3$ and for thoron concentration determination, 0.019 $Tr.cm^{-2}d^{-1}$ per $Bq.m^{-}3$ is used as the calibration factor. These factors are again used in determining progeny level using relation $WL_R = C_RF_R / 3.7$ and $WL_T = C_TF_T / 275$, where C_R and C_T are radon and thoron concentration level with corresponding equilibrium factors 0.013 and 0.001 respectively.

4. Results and Discussions

The results of the measured indoor radon and thoron progeny levels in different types of RCC houses of Pathsala area for one complete calendar year (2006-07) taken over in four quarters to study the seasonal variations are given in table 1 and 2 respectively.

Table 1: Measured Indoor Radon Progeny Levels Observed in RCC types of houses of Bajali (Pathsala Area).

Location	House No.	Radon Progeny Concentration in mWL				Mean Value	Winter/ Summer Ratio
		March-April-May-06	June-July-August-06	Sept-Oct-Nov-06	Dec-Jan-Feb-06-07		
Ward 1	1	0.353	0.269	0.311	0.47	0.34±0.01	1.74
Ward 1	2	0.420	0.344	0.353	0.521	0.409±0.008	1.5
Ward 1	3	0.353	0.336	0.369	0.612	0.404±0.01	1.8
Ward 2	4	0.396	0.353	0.482	0.537	0.43±0.008	1.52
Ward 2	5	0.361	0.237	0.403	0.646	0.38±0.01	2.7
Ward 3	6	0.420	0.252	0.269	0.437	0.33±0.0009	1.73
Ward 3	7	0.344	0.235	0.509	0.766	0.42±0.02	3.0
Ward 4	8	0.403	0.353	0.403	0.504	0.41±0.006	1.4
Ward 4	9	0.336	0.269	0.319	0.453	0.33±0.007	1.6
Ward 4	10	0.279	0.250	0.419	0.698	0.37±0.02	2.73
Mean Value	-----	0.364	0.285	0.377	0.555	-----	1.9

It is seen that the mean indoor radon progeny levels varies from a minimum value 0.33 to a maximum value 0.43 mWL with a mean value 0.38 mWL and indoor thoron progeny level varies from a minimum value 0.07 to a maximum value 0.127 mWL with a mean value 0.09 mWL. The differences of the values of radon and thoron progeny levels are due to the nature of building materials used or the underlying soil, rock formation over which the building is located. Similar variations of radon and thoron progeny levels in different regions of Assam are reported by other workers [10,11]. The radon progeny levels in areas, in and around Mangaldoi and Nalbari are found within range 0.10 to 0.58 mWL and 0.17 to 0.64 mWL respectively where as thoron progeny levels are found within range 0.01 to 0.06 mWL and 0.01 to 0.05 mWL respectively.

The seasonal variation of indoor radon and thoron progeny levels in different RCC types of houses is given in table 1 and 2 respectively.

Table 2: Measured Indoor Thoron Progeny Leveles observed in RCC types of houses of Bajali (Pathsala Area)

Location	House No.	Thoron Progeny Concentration in mWL				Mean value	Winter/ Summer Ratio
		March-April-May-06	June-July-Aug- 06	Sept-Oct-Nov-06	Dec-Jan-Feb-06-07		
Ward 1	1	0.094	0.09	0.097	0.109	0.097±0.006	1.2
Ward 1	2	0.097	0.073	0.103	0.158	0.103±0.003	2.1
Ward 1	3	0.092	0.083	0.091	0.097	0.09±0.002	1.1
Ward 2	4	0.079	0.05	0.073	0.127	0.077±0.002	2.54
Ward 2	5	0.103	0.012	0.073	0.182	0.06±0.007	2.4
Ward 3	6	0.083	0.067	0.146	0.158	0.106±0.04	2.3
Ward 3	7	0.079	0.073	0.077	0.27	0.104±0.009	3.6
Ward 4	8	0.091	0.049	0.061	0.097	0.07±0.023	1.9
Ward 4	9	0.152	0.097	0.109	0.164	0.127±0.003	1.6
Ward 4	10	0.115	0.079	0.097	0.223	0.11±0.006	2.8
Mean Value	-------	0.096	0.059	0.088	0.150	----	2.5

It is observed from the table that during winter season (ie. Dec. to Feb) radon and thoron progeny levels are higher and lower in summer season (ie June to August). It is due to the differences in the ventilation during winter to summer. Although the rooms selected for indoor radon and thoron level measurements are well ventilated, in the sense that all rooms have at least two to three windows, a door and two to three ventilators facilitating cross ventilation of air , the differences in ventilation arise between winter to summer, because during winter, in most of the times doors, windows and ventilators are remain closed compared to summer and other seasons. The seasonal variation of indoor radon and thoron progeny levels of the study area is shown in Figure 2 & 3.

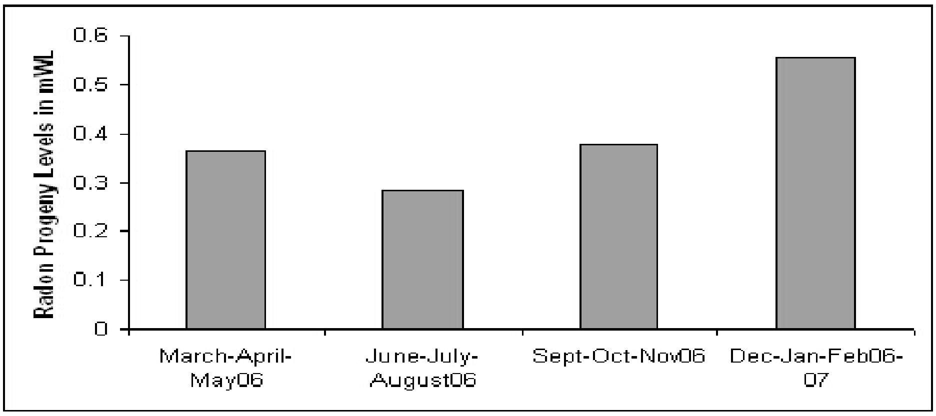

Figure 2: Seasonal Variation Of Radon Progeny levels observed in RCC types of houses of Bajali (Pathsala Area).

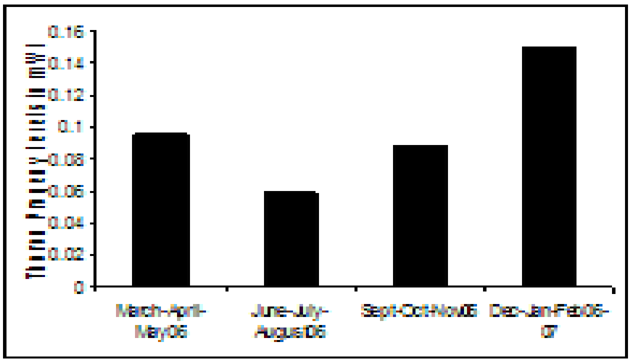

Figure 3: Seasonal Variation of Thoron Progeny Levels Observed in RCC types of houses of Bajali (Pathsala Area).

The winter/ summer ratio of indoor radon and thoron progeny levels ranges from 1.4 to 3.0 with an average value 1.9 and 1.1 to 3.6 with an average value 2.5. The estimated total inhalation dose rate received by inhabitants of the dwellings varies from 0.47 ± 0.01 to 0.59 ± 0.02 µSv.h^{-1}.

Conclusion
In almost all the dwellings, radon concentration is quite below the recommended action level (200-600) Bq.m^{-3} [12]. Thorough investigation of indoor radon levels and their dependence on building materials, radon content in soil and geology of the location will help in understanding causes of variation of indoor radon and thoron progeny levels and recommending preventive measures.

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