International Journal of Physics and Applications.
ISSN 0974-3103 Volume 6, Number 2 (2014), pp. 93-102

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A Study of Indoor Radon, Thoron Progeny Levels in Some Dwellings by Using SSNTD

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Abstract:

Radon and its progeny are the main contributors in the radiation dose received by general population. Solid State Nuclear Track Detectors (SSNTD) are widely used for the measurements of indoor radon and thoron levels. They are the most effective passive detectors available to obtain time integrated levels of radon, thoron and their progenies. Results of the measurement of indoor radon / thoron progeny levels in different types of R.C.C. (Reinforced Cement Concrete) dwellings in and around Numaligarh Refinery of Assam, India, for a one complete year in four seasons are presented in this paper. The measurements were carried out by using LR-115 (TypeII) detectors in plastic twin chamber dosimeters (BARC type). The estimated indoor radon and thoron progeny levels varied from 0.34 mWL to 0.47 mWL and 0.04 mWL to 0.09 mWL with mean values 0.40 mWL and 0.06 mWL respectively. The estimated inhalation dose received by the inhabitants of the study area varied from 0.23 μSvh^{-1} to 0.61 μSvh^{-1}.

Keywords: Radon, Thoron, Dwellings, LR-115

1. Introduction:

Radon is constantly generated all over the earth due to the decay of radium present in crustal materials. Radon (Rn^{222}), 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)

2. 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 different places of Numaligarh Refinery area, Assam, India. The area comprises of a area of a Refinery belt. Geographical location of the area is $26^{o}35^{l}$ N latitude and $93^{o}47^{l}$ E longitude. The height of the ground level is 160 meter from the mean sea level.

3. 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, Sarma H.K. et al, 2010 , Sarma H.K. et al,2013).

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.

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.

4. Results and Discussion:

The results of indoor radon / thoron progeny levels in different RCC types of houses of Numaligarh for one full calendar year (2012-13) taken over are given in table below. The seasonal variation of indoor radon/ thoron progeny levels are also given in table below.

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).

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 progeny levels of Numaligarh area are shown in Fig 1 to Fig 6.

The inhalation dose rates received by the inhabitants of the study areas in different seasons are varies from 0.23 μSvh^{-1} to 0.61 μSvh^{-1}.

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

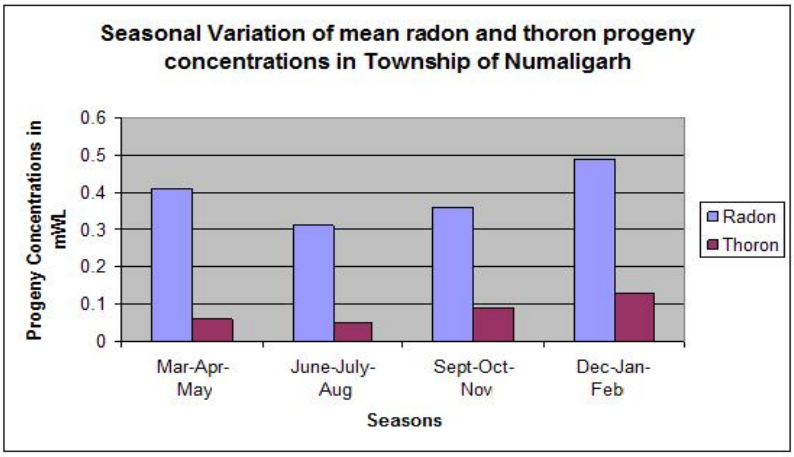

Fig.1

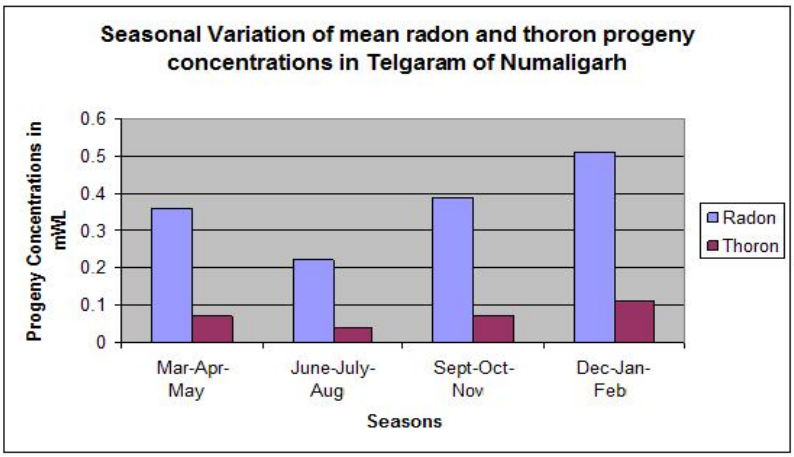

Fig.2

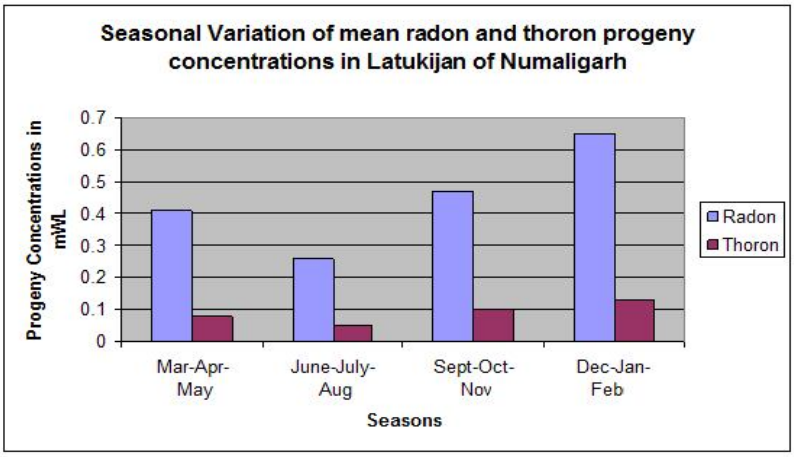

Fig.3

Table 1: Measured Indoor Radon Progeny Concentration in R.C.C types of houses of Township, Telgaram and Latukijan of Numaligarh

Location	House No.	Radon Progeny Concentration in mWL				Mean Value	
		March-April-May(2012)	June-July-Aug(2012)	Sept-Oct-Nov(2012)	Dec-Jan-Feb(2012-2013)	A.M.	G.M.
Township	1	0.37	0.27	0.35	0.56	0.39	0.37±0.01
	2	0.42	0.31	0.39	0.63	0.44	0.42±0.01
	3	0.40	0.32	0.38	0.52	0.41	0.4±0.01
	4	0.57	0.27	0.41	0.57	0.45	0.43±0.02
	5	0.44	0.24	0.42	0.64	0.44	0.42±0.01
	6	0.34	0.22	0.31	0.66	0.38	0.36±0.01
	7	0.29	0.18	0.36	0.68	0.38	0.36±0.02
	8	0.41	0.26	0.38	0.70	0.49	0.47±0.01
Telgaram	9	0.39	0.21	0.43	0.55	0.40	0.38±0.01
	10	0.38	0.24	0.36	0.40	0.36	0.34±0.02
	11	0.40	0.26	0.51	0.62	0.45	0.43±0.01
	12	0.35	0.22	0.42	0.51	0.38	0.36±0.02
	13	0.36	0.17	0.39	0.52	0.36	0.34±0.01
	14	0.37	0.20	0.35	0.49	0.35	0.34±0.01
	15	0.35	0.24	0.36	0.48	0.48	0.46±0.02
	16	0.34	0.28	0.43	0.52	0.39	0.37±0.03
Latukijan	17	0.42	0.23	0.39	0.66	0.42	0.41±0.01
	18	0.42	0.35	0.43	0.68	0.47	0.45±0.02
	19	0.39	0.31	0.51	0.70	0.48	0.46±0.01
	20	0.41	0.25	0.48	0.58	0.43	0.41±0.01
	21	0.47	0.26	0.46	0.56	0.44	0.42±0.02
	22	0.41	0.33	0.53	0.69	0.49	0.47±0.01
	23	0.35	0.26	0.58	0.71	0.47	0.45±0.01
	24	0.39	0.27	0.57	0.70	0.48	0.46±0.02

Annual geometric mean of radon progeny concentrations for RCC houses in Township: 0.40 mWL

Annual geometric mean of radon progeny concentrations for RCC houses in Telgaram: 0.37 mWL

Annual geometric mean of radon progeny concentrations for RCC houses in Latukijan: 0.44 mWL

Annual geometric mean of radon progeny concentrations for all RCC houses in Numaligarh: 0.40 mWL

Table 2: Measured Indoor Thoron Progeny Concentration in R.C.C types of houses of Township, Telgaram and Latukijan of Numaligarh

Location	House No.	Thoron Progeny Concentration in mWL				Mean Value	
		March-April-May(2012)	June-July-Aug(2012)	Sept-Oct-Nov(2012)	Dec-Jan-Feb(2012-2013)	A.M.	G.M.
Township	1	0.08	0.03	0.10	0.12	0.08	0.07±0.004
	2	0.09	0.05	0.11	0.12	0.09	0.08±0.002
	3	0.04	0.02	0.05	0.10	0.05	0.04±0.001
	4	0.06	0.03	0.06	0.09	0.06	0.05±0.002
	5	0.09	0.06	0.10	0.14	0.10	0.09±0.003
	6	0.04	0.02	0.05	0.10	0.06	0.05±0.001
	7	0.08	0.05	0.09	0.11	0.06	0.05±0.002
	8	0.07	0.04	0.08	0.10	0.07	0.06±0.001
Telgaram	9	0.04	0.02	0.05	0.10	0.05	0.04±0.002
	10	0.08	0.05	0.09	0.10	0.08	0.07±0.004
	11	0.09	0.07	0.10	0.13	0.10	0.09±0.003
	12	0.07	0.04	0.08	0.10	0.07	0.07±0.001
	13	0.06	0.04	0.07	0.10	0.07	0.06±0.001
	14	0.07	0.05	0.07	0.10	0.07	0.06±0.001
	15	0.08	0.05	0.06	0.12	0.08	0.07±0.002
	16	0.07	0.05	0.08	0.14	0.08	0.07±0.005
Latukijan	17	0.06	0.04	0.07	0.10	0.07	0.06±0.002
	18	0.07	0.05	0.09	0.11	0.08	0.07±0.003
	19	0.06	0.04	0.07	0.11	0.07	0.06±0.001
	20	0.05	0.04	0.06	0.10	0.06	0.05±0.004
	21	0.08	0.06	0.09	0.13	0.09	0.08±0.001
	22	0.09	0.06	0.11	0.15	0.08	0.07±0.001
	23	0.07	0.05	0.08	0.11	0.08	0.07±0.002
	24	0.06	0.04	0.08	0.11	0.07	0.06±0.004

Annual geometric mean of thoron progeny concentrations for RCC houses in Township: 0.05 mWL

Annual geometric mean of thoron progeny concentrations for RCC houses in Telgaram: 0.06 mWL

Annual geometric mean of thoron progeny concentrations for RCC houses in Latukijan: 0.06 mWL

Annual geometric mean of thoron progeny concentrations for all RCC houses in Numaligarh: 0.06 mWL

Table 3: Seasonal Variation of indoor radon progeny concentration in R.C.C. houses of Township, Telgaram and Latukijan in Numaligarh

Location	House No.	Radon Progeny Concentration in mWL				Winter/ Summer ratio
		March-April-May(2012)	June-July-Aug(2012)	Sept-Oct-Nov(2012)	Dec-Jan-Feb(2012-2013)	
Township	1	0.37	0.27	0.35	0.56	2
	2	0.42	0.31	0.39	0.63	2
	3	0.40	0.32	0.38	0.52	1.6
	4	0.57	0.27	0.41	0.57	2
	5	0.44	0.24	0.42	0.64	2.6
	6	0.34	0.22	0.31	0.66	2.9
	7	0.29	0.18	0.36	0.68	3.7
	8	0.41	0.26	0.38	0.70	2.7
Mean Value	AM	0.40	0.25	0.37	0.62	2.4
	GM	0.39	0.24	0.36	0.61	2.4
Telgaram	9	0.39	0.21	0.43	0.55	2.5
	10	0.38	0.24	0.36	0.48	2
	11	0.40	0.26	0.51	0.62	2.3
	12	0.35	0.22	0.42	0.51	2.2
	13	0.36	0.17	0.39	0.52	2.9
	14	0.37	0.20	0.35	0.49	2.4
	15	0.35	0.24	0.36	0.48	1.9
	16	0.34	0.28	0.43	0.52	1.8
Mean Value	AM	0.37	0.23	0.40	0.52	2.2
	GM	0.36	0.22	0.39	0.51	2.2
Latukijan	17	0.42	0.23	0.39	0.66	2.8
	18	0.42	0.35	0.43	0.68	1.9
	19	0.39	0.31	0.51	0.70	2.2
	20	0.41	0.25	0.48	0.58	2.3
	21	0.47	0.26	0.46	0.56	2
	22	0.41	0.33	0.53	0.69	2
	23	0.35	0.26	0.58	0.71	2.7
	24	0.39	0.27	0.57	0.70	2.5
Mean Value	AM	0.40	0.28	0.49	0.66	2.3
	GM	0.39	0.27	0.48	0.65	2.3
Grand Mean Value	AM	0.39	0.25	0.42	0.60	2.4
	GM	0.37	0.24	0.40	0.58	2.4

Table 4: Seasonal Variation of indoor thoron progeny concentration in R.C.C. houses of Township, Telgaram and Latukijan in Numaligarh

Location	House No.	Thoron Progeny Concentration in mWL				Winter/ Summer ratio
		March-April-May(2012)	June-July-Aug(2012)	Sept-Oct-Nov(2012)	Dec-Jan-Feb(2012-2013)	
Township	1	0.08	0.03	0.10	0.12	4.2
	2	0.09	0.05	0.11	0.12	2.4
	3	0.04	0.02	0.05	0.10	5
	4	0.06	0.03	0.06	0.09	3.3
	5	0.09	0.06	0.10	0.14	2.4
	6	0.04	0.02	0.05	0.10	3.7
	7	0.08	0.05	0.09	0.11	2.1
	8	0.07	0.04	0.08	0.10	2.5
Mean Value	AM	0.06	0.03	0.08	0.11	3.
	GM	0.06	0.03	0.07	0.11	3
Telgaram	9	0.04	0.02	0.05	0.10	5
	10	0.08	0.05	0.09	0.10	2.1
	11	0.09	0.07	0.10	0.13	1.9
	12	0.07	0.04	0.08	0.10	2.4
	13	0.06	0.04	0.07	0.10	2.5
	14	0.07	0.05	0.07	0.10	2
	15	0.08	0.05	0.06	0.12	2.1
	16	0.07	0.05	0.08	0.14	2.6
Mean Value	AM	0.07	0.04	0.07	0.11	2.5
	GM	0.07	0.04	0.07	0.11	2.5
Latukijan	17	0.06	0.04	0.07	0.10	2.3
	18	0.07	0.05	0.09	0.11	2.2
	19	0.06	0.04	0.07	0.11	2.3
	20	0.05	0.04	0.06	0.10	2.7
	21	0.08	0.06	0.09	0.13	2.2
	22	0.09	0.06	0.11	0.15	2.2
	23	0.07	0.05	0.08	0.11	2.2
	24	0.06	0.04	0.08	0.11	2.4
Mean Value	AM	0.06	0.05	0.08	0.11	2.2
	GM	0.06	0.04	0.08	0.11	2.2
Grand Mean Value	AM	0.06	0.04	0.07	0.11	2.2
	GM	0.06	0.03	0.07	0.11	3

Table 5: Estimated total inhalation dose rate received by inhabitants of Township, Telgaram and Latukijan of Numaligarh

Location	House No.	Dose Rate μSvh^{-1}				Mean Value
		March-Apr-May(2012)	June-July-Aug(2012)	Sept-Oct-Nov(2012)	Dec-Jan-Feb (2012-2013)	
Township	1	0.55	0.35	0.45	0.72	0.51±0.01
	2	0.63	0.37	0.50	0.81	0.55±0.01
	3	0.48	0.44	0.47	0.68	0.51±0.01
	4	0.38	0.39	0.52	0.72	0.48±0.01
	5	0.60	0.40	0.54	0.81	0.57±0.01
	6	0.52	0.37	0.49	0.90	0.54±0.01
	7	0.43	0.34	0.55	0.82	0.51±0.01
	8	0.54	0.43	0.46	0.89	0.55±0.01
Telgaram	1	0.45	0.33	0.60	0.77	0.51±0.01
	2	0.42	0.02	0.50	0.66	0.24 ±0.02
	3	0.57	0.02	0.47	0.68	0.26±0.02
	4	0.51	0.02	0.56	0.74	0.26±0.03
	5	0.37	0.01	0.56	0.81	0.23±0.03
	6	0.40	0.01	0.52	0.76	0.23±0.03
	7	0.56	0.02	0.48	0.67	0.25±0.02
	8	0.57	0.02	0.59	0.63	0.27±0.02
Latukijan	1	0.47	0.32	0.58	0.90	0.53±0.02
	2	0.60	0.40	0.60	0.97	0.61±0.03
	3	0.57	0.39	0.64	0.77	0.57±0.02
	4	0.51	0.32	0.63	0.64	0.51±0.03
	5	0.63	0.39	0.60	0.72	0.57±0.01
	6	0.57	0.45	0.70	0.68	0.59±0.01
	7	0.48	0.38	0.71	0.77	0.56±0.01
	8	0.50	0.40	0.68	0.90	0.59±0.02

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