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Estimation of Indoor Radon and Thoron Concentration in Some Dwellings of Trans-Yamuna Region, North East Delhi, India

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Abstract Measurement of indoor radon and thoron levels in the indoor dwellings has a great impact on the health of people residing there .Exposure to high concentration of radon, thoron and their decay products for prolonged duration may lead to serious health problems. The present paper is an attempt to detect the levels of above mentioned radioactive gases with their progenies in the dwellings of Trans –Yamuna region. The research was conducted in winter season in 50 dwellings of Trans – Yamuna region. To calculate and study the results International Commission on Radiological Protection (ICRP) guidelines were followed. Results show the concentration of radon, thoron and their progeny Trans-Yamuna region was under safety limits.

Keywords: *PRTM, DTPS/DRPS, indoor radon, thoron, inhalation dose*

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1. Introduction

In the past few years' scientists have indicated that the air within our homes and other buildings is going to be more polluted than the outdoor air even in the largest and most industrialized cities. Reason is Radioactive Isotopes of Uranium and Radium present in nature in soil, sand, water and rocks. Decay of these radioactive elements give rise to radon and thoron gases. Radon and Thoron gases are not safe for human beings if the level increases a particular limit [1]. Exposure to high concentration of radioactive decay products of radon, thoron & its progeny should be dealt carefully as prolonged contact with them may be fatal for health. Research show that bronchial epithelium is affected by these and may cause lung cancer [2,3].

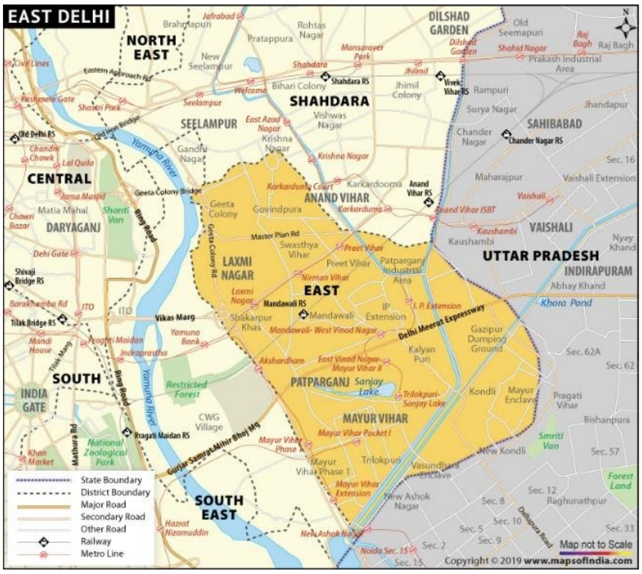

Figure 1.

The present work focuses on study of indoor radon, thoron and their progeny in regions of Trans Yamuna, Delhi, India.

This area has not been researched much by other researchers as evident from studies [4]. SSNTDs using LR-115, Type 2 plastic strippable thin cellulose nitrate films were used because of their long lasting and enduring nature [5] wire mesh capped DTPS/DRPS comprising of LR 115 type track detectors were used for measuring progeny concentrations [6].

Aluminized Mylar and cellulose nitrate were used as an absorber [7]. In this paper, we have used dose conversion factors to calculate annual effective dose (AED) for radon, thoron and their decay products. Annual effective doses for mouth and nasal breathing have also been calculated.

2. Materials and Methods

2.1. Geology of Study Area

The perceptivity into the indoor radon and thoron levels of Trans Yamuna region, Delhi, India shown in fig 1 is provided in the current work. Trans –Yamuna region which is closely associated with North East Delhi was taken for research .North East Delhi is one of the 11 administrative the Northern and Eastern borders of North East district of Delhi are districts of Delhi, India. It was established in 1997. People of this region are dependent on river Yamuna for water and agriculture. River Yamuna is one of the tributaries of largest river of India- The Ganges. Yamunotri in Himalayas is considered as the origin point for Yamuna. Palla Village is the place from where Yamuna enters into Delhi after covering the distance of about 224km [8].

North East Delhi's climate is an overlap between monsoon-influenced humid subtropical and semi-arid .There is a high temperature and precipitation difference between summer and winter temperatures. Beyond subtropical and semi- arid climate the climate here is further classified inti continental and monsoon. Trans Yamuna has four seasons South West Monsoon (June-August), North East Monsoon (September to December). Winter (December to March) and summer (April to June).

Shared with Ghaziabad district of Uttar Pradesh. As per 2011 census the population of North East Delhi was 2,241,624 and the density/Km2 was 36,155. Trans Yamuna region is highly urbanised as 92% of its population has been marked as urban [9]. Trans Yamuna region is located at a latitude of 27.2085 and longitude of 78.0609. "The texture of soil is sand to loamy in recent flood plains, sandy loam to clay loam for alluvial plains and clay loam/silty clay for low lying plains and depressions," [10].

2.2. Experimental Technique

2.2.1. Pin Hole Based Twin Cup Dosimeter with Single Entry for Rn and Th

Pin hole based twin cup dosimeters are used to measure concentration of these gases as shown in Figure 2. The dosimeter comprises of pin holes in the central disc to differentiate between radon and thoron gas. The dosimeters were kept indoor in the places where measurement of indoor radon and thoron, its decay product was to be done.

The dosimeters with LR-115 type-II films were hanged in the well ventilated indoor places and at a distance of around 25 cm from the wall such that dosimeter should not touch the wall.

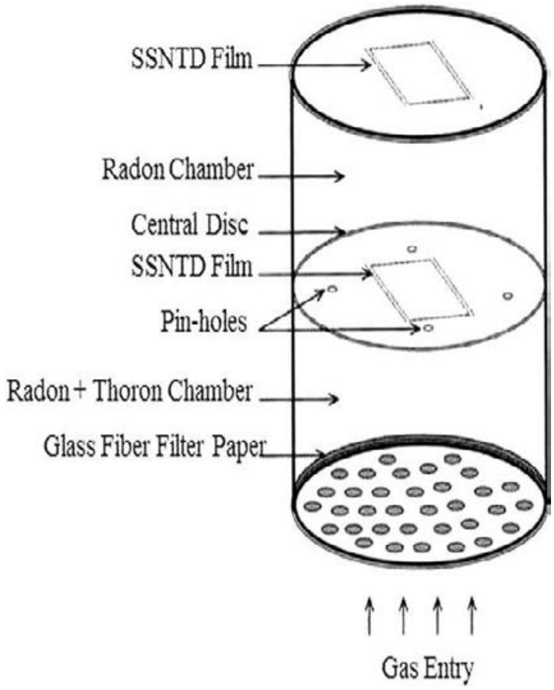

Figure 2. Pin hole based twin cup dosimeter

50 dosimeters were hanged at different dwellings of Trans Yamuna region which were selected uniformly so that whole region could be studied properly. After 3 months of the season, detectors were retrieved, chemical etched in 2.5 NaOH solution at 60oC because of which tracks became enlarged. Track were counted using spark counter, process details were given elsewhere [4] Radon and Thoron concentrations can be calculated as referred in [1]

$$C_R = T_1 / d_1 K_R \quad (1)$$

$$C_T = (T_2 - T_1) / d_1 K_T \quad (2)$$

Where C_R and C_T are Radon and Thoron concentration
T_1: Track density observed in compartment of "Radon"
K_R: Calibration factor of Radon in its compartment
T_2: Track, density observed in "radon+ thoron" compartment
K_T: Calibration factor of compartment of "radon+ thoron"
d: Count of exposure days

Annual effective dose of radon and thoron using their concentration can be calculated as:

$$D = \left[(0.17 + 9\ F_R)C_R + (0.11 + 32\ F_T)C_T\right] x1700\ x10^{-6} \quad (3)$$

Where D= Annual effective dose of radon and thoron

$$F_R = Equilibrium\ factor\ for\ radon = 0.4\ [11]$$

$$F_T = Equilibrium\ factor\ for\ radon = 0.1\ [11]$$

2.2.2. DTPS/ DRPS

DTPS (Direct Thoron Progeny Sensor) and DRPS (Direct Radon Progeny Sensor) were used to measure concentration of progeny of radon and thoron, decay products of radon and thoron. DRPS element comprises of LR-115 cellulose nitrate and aluminised Mylar with a thickness of 37µm. This set up can detect alpha particles of 7.67 MeV produced by ^{212} Po and alpha particles of 8.78 MeV produced by ^{212} Po. DTPS/DRPS with wire mesh and without wire mesh were deployed along with dosimeters in the selected dwellings of Trans Yamuna region as shown in Figure 3 and Figure 4 respectively. After the completion of three months films were removed and etched as discussed above.

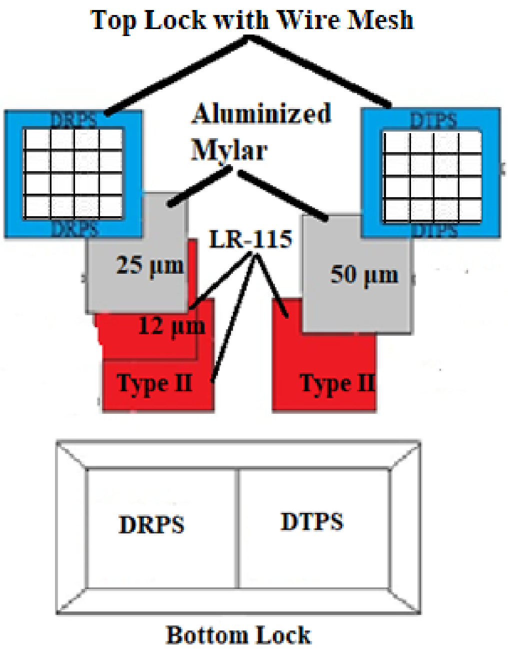

Figure 3. DTPS/DRPS with wire mesh schematic representation

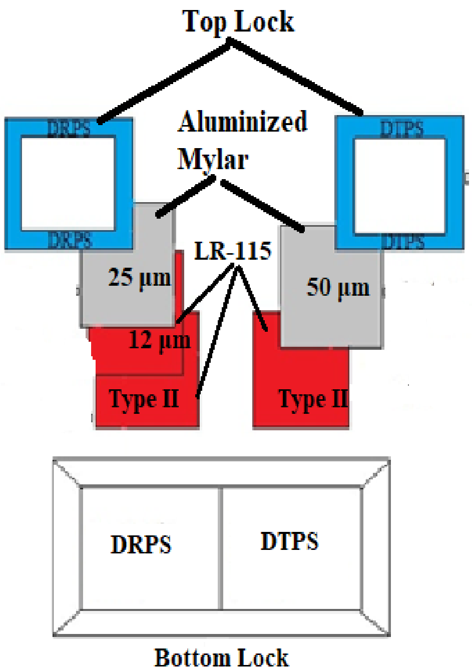

Figure 4. DTPS/DRPS schematic representation

2.2.3. Measurement of Equilibrium Equivalent Indoor Radon Concentration

EERC: Equilibrium Equivalent Radon Concentration

$$T_{RN} = T_{DRPS} - \eta_{RT} x\, T_{DTPS} / \eta_{TT}$$

η_{RT} is the track registration efficiency for thoron progeny in DRPS = 0.01 ±0.0004

η_{TT} is the track registration efficiency for thoron progeny in DTPS = 0.083±0.004

$$EERC = T_{RN} / t\ x\ S_R$$

S_R = Sensitivity factor for Radon progeny = 0.09±0.0036

EETC attached progeny

$$EETCa = T_{DTPSWM} / txS_{Ta}$$

Where T_{DTPSWM}= Track Density of DTPSWM

S_{Ta} = Sensitivity factor for thoron attached progeny =0.33.

2.2.4. Measurement of Attached and Unattached Progeny Concentration of Radon and Thoron

EERCa have same calculations as mentioned above, the track densities of DRPS wire mesh and DTPS wm has to be taken.

S_{Ra} = Sensitivity factor for attached progeny is 0.034 tracks x m^3 /cm^2day Bq

$$EETCu = EETC - EETCa$$

$$EERCu = EERC - EERCa$$

Fine Fraction f_{Rn} = EERCu/ EERC

$$f_{Th} = EETCu / EETC$$

Equilibrium Factor

f_{Rn}=EERC/ C_R C_R= Radon Concentration

F_{Th}= EETC/C_T C_T= Thoron Concentration

Dose Conversion Factors

$$DCF_{mouth} = 101\, xF_{Rn} + 6.7x\left[1 - f_{Rn}\right]$$

$$DCF_{NOSE} = 23\, xf_{Rn} + 6.2x\left[1 - f_{Rn}\right]$$

2.2.5. Measurement of Inhalation Dose from Mouth and Nose

$$ID_{mouth} = C_R x\, F_{Rn} / 3700\ x\ 7000 / 170\ xDCF\ mouth$$

$$ID_{nose} = C_R x\, F_{Rn} / 3700\ x7000 / 170xDCF_{nose}$$

3. Results and Discussion

The given table has been floated for 50 dosimeters in dwellings of Trans Yamuna region for winter season. Indoor radon concentration range from 225.49 Bq/m^{-3} to 29.41 Bq/m^{-3} with an average of 29.41 Bq/m^{-3}. These values are found to be in safety limits prescribed by both ICRP'S and world health organization [12,13]. The inhalation dose produced from mouth varies from the range 0.83 mSvy^{-1} to 14.87 mSvy^{-1} with an average of 4.83 mSvy^{-1}. Inhalation dose from nose varies from 0.55 mSvy^{-1} to 4.33 mSvy^{-1} and average of 1.79 mSvy^{-1}. As the values are below the recommended reference level 10 mSvy^{-1} given by WHO [13]. The values are within the safe limit range of 0.2 to 10 mSvy^{-1} by UNSCERAR [14] and 3 to 10 mSvy^{-1} by ICRP [12].

Table 1. Observed Concentration of indoor radon, thoron, (EERC AND EETC), attached and unattached progeny, Equillibrium factors for radon and thoron dose from mouth and nose, Annual Inhalation dose rates for radon and thoron

Sr. No.	222Rn conc	220Rn conc.	EEC-222 Rn	EEC-220 Rn	EERC a	EETC a	EERC u	EETC u	AID-222 Rn	AID-220 Rn	AID-Total	EF-Rn	EF-Tn	DCF m	DCF n	IDm	IDn
1	124.18	38.89	15.9	2.1	13.1	1.38	2.76	0.72	1.15	0.62	1.77	0.13	0.05	23.1	9.13	4.08	1.61
2	104.58	88.89	13.2	1.68	11.7	1.18	1.49	0.5	0.96	0.54	1.5	0.13	0.02	17.3	8.1	2.54	1.19
3	133.33	106.67	23	2.33	17.4	1.92	5.61	0.41	1.61	0.73	2.34	0.17	0.02	29.7	10.3	7.6	2.63
4	58.82	68.89	15	1.82	13.4	1.68	1.58	0.14	1.02	0.56	1.58	0.25	0.03	16.7	7.98	2.78	1.33
5	31.37	22.22	7.52	0.89	7.27	0.77	0.25	0.11	0.51	0.27	0.78	0.24	0.04	9.88	6.77	0.83	0.57
6	68.63	4.44	13.6	0.99	10.3	0.98	3.26	0.02	0.94	0.28	1.22	0.2	0.22	29.4	10.2	4.43	1.54
7	55.56	100	13.4	1.64	11.6	1.55	1.76	0.09	0.91	0.54	1.45	0.24	0.02	19.1	8.42	2.84	1.25
8	50.98	34.44	7.24	1.11	6.95	1.04	0.28	0.07	0.52	0.34	0.86	0.14	0.03	10.4	6.86	0.84	0.55
9	36.6	21.11	10.6	1.36	10.3	1.25	0.31	0.11	0.71	0.4	1.11	0.29	0.06	9.49	6.7	1.12	0.79
10	225.49	83.33	24.8	2.33	17.1	2.19	7.78	0.14	1.84	0.72	2.55	0.11	0.03	36.2	11.5	10	3.17
11	140.52	66.67	12.2	1.58	10.2	1.38	2.04	0.2	0.94	0.5	1.43	0.09	0.02	22.5	9.01	3.05	1.22
12	55.56	105.56	18.7	1.29	16.9	1.21	1.85	0.08	1.25	0.44	1.69	0.34	0.01	16	7.86	3.34	1.64
13	94.77	116.67	13.8	1.29	11.9	1.28	1.9	0.01	0.98	0.45	1.43	0.15	0.01	19.7	8.51	3.02	1.31
14	89.54	80	17.4	1.58	14.3	1.48	3.09	0.1	1.2	0.51	1.71	0.19	0.02	23.5	9.19	4.54	1.78
15	58.82	50	18.6	0.93	15	0.91	3.62	0.02	1.24	0.3	1.54	0.32	0.02	25.1	9.47	5.18	1.96
16	85.62	26.67	14.4	1.18	11.7	1.14	2.69	0.04	1.01	0.35	1.36	0.17	0.04	24.3	9.34	3.9	1.5
17	65.36	166.67	7.66	1.95	6.86	1.68	0.8	0.27	0.56	0.68	1.24	0.12	0.01	16.5	7.95	1.41	0.68
18	142.48	85.56	22	1.84	19.5	1.52	2.51	0.33	1.56	0.58	2.14	0.15	0.02	17.5	8.12	4.28	1.99
19	163.4	66.67	25.2	3.05	20.3	2.26	4.91	0.79	1.78	0.91	2.69	0.15	0.05	25.1	9.48	7.03	2.65
20	59.48	56.67	14.3	1.11	12.2	1.04	2.09	0.07	0.97	0.36	1.33	0.24	0.02	20.5	8.66	3.26	1.38
21	73.86	40	11.4	1.35	9.58	1.31	1.8	0.03	0.81	0.41	1.21	0.15	0.03	21.6	8.86	2.74	1.12
22	145.1	110	30.2	2.87	18.2	2.36	12	0.52	2.08	0.89	2.97	0.21	0.03	44.3	12.9	14.9	4.33
23	98.04	61.11	13.9	2.1	13.2	1.89	0.72	0.22	0.99	0.64	1.63	0.14	0.03	11.6	7.07	1.79	1.09
24	75.16	55.56	15.2	1.36	12.3	1.25	2.92	0.11	1.05	0.42	1.47	0.2	0.02	24.8	9.43	4.2	1.59
25	107.19	63.33	20	1.78	18.9	1.72	1.05	0.07	1.39	0.55	1.94	0.19	0.03	11.7	7.08	2.59	1.57
26	64.71	36.67	12.3	1.12	9.36	0.94	2.93	0.18	0.85	0.34	1.19	0.19	0.03	29.2	10.2	3.99	1.39
27	80.39	36.67	11.7	1.43	8.6	1.31	3.05	0.12	0.83	0.43	1.26	0.14	0.04	31.4	10.6	4.07	1.37
28	73.2	36.67	12.1	1.7	11.1	1.45	0.99	0.25	0.85	0.51	1.35	0.16	0.05	14.4	7.58	1.93	1.02
29	118.95	45.56	23.6	2.35	18.1	1.89	5.51	0.47	1.63	0.69	2.32	0.2	0.05	28.7	10.1	7.53	2.66
30	53.59	38.89	8	0.99	6.21	0.84	1.8	0.15	0.57	0.31	0.88	0.15	0.03	27.9	9.97	2.48	0.89
31	98.04	83.33	20.9	1.52	16.6	1.18	4.31	0.35	1.44	0.49	1.93	0.21	0.02	26.1	9.66	6.08	2.25
32	137.25	63.33	28.1	2.65	20.3	2.26	7.89	0.39	1.94	0.79	2.73	0.2	0.04	33.1	10.9	10.4	3.42
33	101.96	63.33	21.7	2.17	16.5	1.52	5.16	0.66	1.49	0.66	2.15	0.21	0.03	29.1	10.2	7.03	2.46
34	48.37	55.56	10.8	0.99	9.52	0.81	1.33	0.18	0.74	0.32	1.06	0.22	0.02	18.3	8.26	2.2	1
35	123.53	62.22	25.3	2.09	17.8	1.52	7.41	0.58	1.74	0.63	2.37	0.2	0.03	34.4	11.1	9.66	3.13
36	94.77	60	17.6	1.62	12.9	1.38	4.64	0.24	1.22	0.5	1.72	0.19	0.03	31.6	10.6	6.18	2.08
37	29.41	36.67	8.48	0.82	6.24	0.71	2.24	0.11	0.57	0.26	0.83	0.29	0.02	31.6	10.6	2.98	1
38	134.64	82.22	28.2	2.92	20.5	2.32	7.67	0.6	1.94	0.88	2.82	0.21	0.04	32.4	10.8	10.1	3.38
39	67.97	33.33	21.4	2.59	17.7	1.89	3.68	0.7	1.43	0.75	2.18	0.32	0.08	22.9	9.09	5.46	2.17
40	63.4	51.11	13.5	0.86	10.8	0.81	2.65	0.05	0.93	0.28	1.21	0.21	0.02	25.3	9.51	3.79	1.43
41	103.92	32.22	15.8	1.95	13.6	1.78	2.2	0.17	1.12	0.57	1.69	0.15	0.06	19.8	8.54	3.49	1.5
42	127.45	65.56	25.6	2.49	18.9	2.05	6.76	0.44	1.77	0.75	2.52	0.2	0.04	31.6	10.6	9.01	3.03
43	111.76	217.78	16.1	1.95	12.6	1.85	3.5	0.1	1.15	0.71	1.86	0.14	0.01	27.3	9.87	4.87	1.76
44	88.24	90	23.6	2.36	15.7	1.92	7.82	0.44	1.59	0.73	2.32	0.27	0.03	38	11.8	9.96	3.09
45	65.36	28.89	13	1.44	9.01	1.25	3.99	0.2	0.9	0.43	1.32	0.2	0.05	35.6	11.4	5.15	1.64
46	88.24	23.33	13.3	2.01	11.2	1.89	2.06	0.12	0.94	0.58	1.52	0.15	0.09	21.4	8.81	3.15	1.3
47	91.5	33.33	11.6	1.6	11.3	1.52	0.26	0.08	0.84	0.47	1.31	0.13	0.05	8.79	6.57	1.13	0.85
48	32.68	24.44	6.5	1.11	5.97	1.04	0.52	0.07	0.45	0.33	0.78	0.2	0.05	14.3	7.55	1.03	0.55
49	42.48	26.67	18	0.89	12.8	0.81	5.23	0.08	1.19	0.27	1.46	0.42	0.03	34.1	11.1	6.83	2.22
50	145.75	86.67	29.7	2.79	21.8	2.36	7.92	0.43	2.05	0.85	2.89	0.2	0.03	31.9	10.7	10.5	3.53

Table 2. Min, Max and Average values of indoor radon, EERC & EETC, attached and unattached progeny, Equilibrium factors for radon & thoron, Inhalation dose from mouth and nose

Sr. No.	222Rn conc	220 Rn	EEC-222Rn	EEC-220	EER Ca	EETC a	EER Cu	EETC u	AID-222	AID-220	AID-Tota	EF-Rn	EF-Tn	DCF m	DCF n	IDm	IDn
Avg	89.65	62.64	16.80	1.71	13.34	1.47	3.41	0.25	1.16	0.53	1.69	0.20	0.037	24.10	9.30	4.83	1.79
Max	225.49	217.78	30.2	3.05	21.76	2.36	12.03	0.79	2.08	0.91	2.97	0.42	0.22	44.26	12.89	14.87	4.33
Min	29.41	4.44	6.5	0.82	5.97	0.71	0.25	0.01	0.45	0.26	0.78	0.09	0.01	8.79	6.57	0.83	0.55

4. Conclusion

Table 2 represents the maximum, minimum and average values .Attached and unattached progenies of both radon and thoron.

The measured annual average for radon was found to be in safety limits as recommended by ICRP [12].

The average inhalation dose from mouth and nose was also found to be less than 10 as recommended UNSCEAR [14] and by ICRP.

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