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Monitoring of indoor radon, thoron levels and annual effective dose in some dwelling of Jaipur, Rajasthan, India using double dosimeter cups

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ABSTRACT

In present investigation, Solid State Nuclear Track Detectors (SSNTD$_S$) based twin chamber dosimeter with LR-115 track detector were used for estimating Radon (^{222}Rn) and Thoron (^{220}Rn) gas concentration levels in the dwellings of Jaipur city. Radon and thoron concentration levels in the studied dwellings were found to vary from 4.6 to 27.4 Bq m^{-3} and thoron concentrations is found to vary from 3.8 to 22.9 Bq m^{-3}. The annual effective dose due to the exposure to radon and progeny was found to vary from 0.13 to 0.79 mSv whereas from thoron found to vary from 0.09 to 0.57 mSv.

Key words: Radon, Thoron, Double Dosimeter Cup, LR-115 type-II plastictrack detector, SSNTDs,

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INTRODUCTION

Measurements of Radon, thoron and their progeny exposure due to their detrimental effects on the health of the inhabitants because, precisely, out of 98% of average radiation dose received by man from natural sources, about 52% is due to breathing of radon, thoron and their progeny present in the dwellings[1]. [2], reports estimate that the contribution of thoron and its decay products to the annual effective dose from radon is about 8%. The presence of thoron might cause problems for radon measurements, since radon and thoron are isotopes of same element, their separation can only be based on the large difference of decay rates of the two isotopes [3]. The radon isotopes, ^{222}Rn, ^{220}Rn, and ^{219}Rn are gaseous and they may be released from the ground, rocks and also from building materials and are accumulated with their short-lived daughters in closed spaces and in particular in Indian dwellings. Exposure to Radon (^{222}Rn) and its progeny in indoor atmosphere can result into significant inhalation risk to population particularly to those living in homes with much higher levels of radon. Natural radiation which originates from the Earth crust, cosmic radiations etc. are the major contributors to the total background exposures to human population. All radiations give a world average value of 2.4 mSv for the annual effective dose equivalent from natural back ground radiation of which 1.4 mSv comes from the radon, thoron and their daughter products [4]. Radon is estimated to cause thousands of deaths worldwide each year. As the radon progeny contributes a major part of natural radiation dose to general population, attention has been given to the large scale and long-term measurement of radon and its progeny [5]. It is assumed that the inhalation dose to the human beings from thoron and its progeny is negligible although recent studies in many countries have revealed that this may not be entirely correct [6]. Thoron and its progeny contribute little for the radiation dose in normal back ground region due to its small half life. In homes the predominant source of radon in indoor air is the soil beneath structures, but building materials and water used in the homes and in a few cases natural gas may also contribute [7]. Keeping the radiation risk of radon for general population in mind, it is quite important to make a systematic study of the indoor radon concentration in Indian dwellings. For this purpose, radon measurements have been carried out in a number of dwellings in Jaipur city, Rajasthan.

MATERIALS AND METHODS

Solid State Nuclear Track Detectors ($SSNTD_S$) based twin chamber dosimeter cups were used for the measurement of indoor Radon and Thoron concentration. It was developed at the Bhabha Atomic Research Centre (BARC) and is reported elsewhere [8,9]. LR-115 type –II detector films are sensitive to α particles of energy range 0.1 to 4 MeV [10] and are unaffected by electrons, X-rays and γ-rays [11]. The pieces of pelicullable, cellulose nitrate based SSNTDs, LR-115 type –II detector films of size 3.0×3.0 cm, were fixed in twin chamber dosimeter cups having different mode holders. The exposure of detector fitted inside the cup is termed as filter and membrane mode. Membrane mode measures radon only and filter mode allows both radon and thoron gases to diffuse and hence the tracks on the detector film placed in this chamber are due to the concentrations of both the gases. Twin chamber dosimeter cups fitted with LR-115 type-II film were suspended on the wall inside the houses at a hight of 2.5 m from the floor [12] in different dwellings of Jaipur city, Rajasthan state of India, for a period of 100 days. The detector films were retrieved and chemically etched in 2.5N NaOH solution at 60^0C for 70 minutes in a constant temperature water bath. The detector films are pre-sparked using spark counter [3] at a voltage of 900 V to fully developed etched track holes. The tracks are then counted at the voltage corresponding to the plateau region of the counter (450V). The calibration factors have been obtained by using the setup described by [9]. From track density, concentration of radon (C_R) and thoron (C_T) were calculated using the sensitivity factor determined from the controlled experiments [8,5]:

$$C_R(Bqm^{-3}) = \frac{T_m}{d \times S_m} \quad (1)$$

$$C_T(Bqm^{-3}) = \frac{(T_f - d \times C_R \times S_{rf})}{d \times S_{tf}} \quad (2)$$

Where, C_R is radon concentration; C_T is thoron concentration; T_m is track density in membrane compartment; T_f is track density in filter compartment and d - Exposure time.

Sensitivity factor for membrane compartment (S_m) was taken 0.019 ± 0.003 Tr cm^{-2} d^{-1} (Bq m^3)$^{-1}$ and sensitivity factor (S_{rf}) and (S_{tf}) for radon and thoron as 0.020 ± 0.004 and 0.016 ± 0.005 Tr cm^{-2} d^{-1}(Bq m^{-3})$^{-1}$ respectively.

Figure 1 Twin chamber double dosimeter cup

RESULTS AND DISCUSSION

The measured values of indoor radon concentration in the dwellings of Jaipur city were found to vary from 4.6 to 27.4 Bq m^{-3} with a mean value of 13.0 Bqm^{-3} whereas thoron concentration were found to vary from to 3.8 to 22.9 Bq m^{-3} with an average value of 10.6 Bq m^{-3}.

The annual effective dose due to the exposure of radon and its progeny in the houses of study area were calculated by the formula [2]:

$$\text{Annual effective dose} = C_{R}\,(\text{Bq m}^{-3}) \times 0.46 \times 7000\ \text{h} \times 9\ \text{nSv}\ (\text{Bq h m}^{-3})^{-1} \qquad (3)$$

Where C_R is the average of measured radon concentration in the houses of study area and 0.46 is the average of equilibrium factor for radon and progeny measured for Indian dwellings[12]. The annual effective dose due to exposure to radon and progeny in the houses of study area were found to vary from 0.13 to 0.79 mSv with an average value of 0.37 mSv.

The annual effective dose due to the exposure to thoron and progeny in the houses of study area were calculated by the formula [2]:

$$\text{Annual effective dose} = C_{T}\,(\text{Bqm}^{-3}) \times 0.09 \times 7000\ \text{h} \times 40\ \text{nSv}\ (\text{Bq h m}^{-3})^{-1} \qquad (4)$$

Where C_T is the average of measured thoron concentration in the houses of study area and 0.09 is the average of equilibrium factor for Thoron and progeny measured for Indian dwellings [12]. The annual effective dose due to exposure to thoron and progeny in the houses of study area vary from 0.09 to 0.57 mSv with an average value of 0.26 mSv. The annual effective dose, radon and thoron concentrations are lower than the permissible limits.

Radon and Thoron concentration and annual effective dose in dwellings of Jaipur city of Rajasthan state of India

Location	**Indoor concentration (Bq m^{-3})**		**Annual effective dose (mSv)**	
	Radon (C_R)	**Thoron(C_T)**	**Radon**	**Thoron**
H.No-1	11.3	11.1	0.32	0.27
H.No-2	11.6	18	0.33	0.45
H.No-3	23.9	9.3	0.69	0.23
H.No-4	27.4	10	0.79	0.25
H.No-5	4.6	3.8	0.13	0.09
H.No-6	8.7	12.6	0.25	0.31
H.No-7	15.7	10.1	0.45	0.25
H.No-8	5.9	7.7	0.17	0.19
H.No-9	16.6	22.9	0.48	0.57
H.No-10	11.1	6.5	0.32	0.16
H.No-11	12.8	9.6	0.37	0.24
H.No-12	6.3	6.6	0.18	0.16
H.No-13	15.2	11.5	0.44	0.28
H.No-14	13.6	9.9	0.39	0.24
H.No-15	10.5	10.1	0.30	0.25
Average Value	13.0	10.6	0.37	0.26
Maximum	27.4	22.9	0.79	0.57
Minimum	4.6	3.8	0.13	0.09

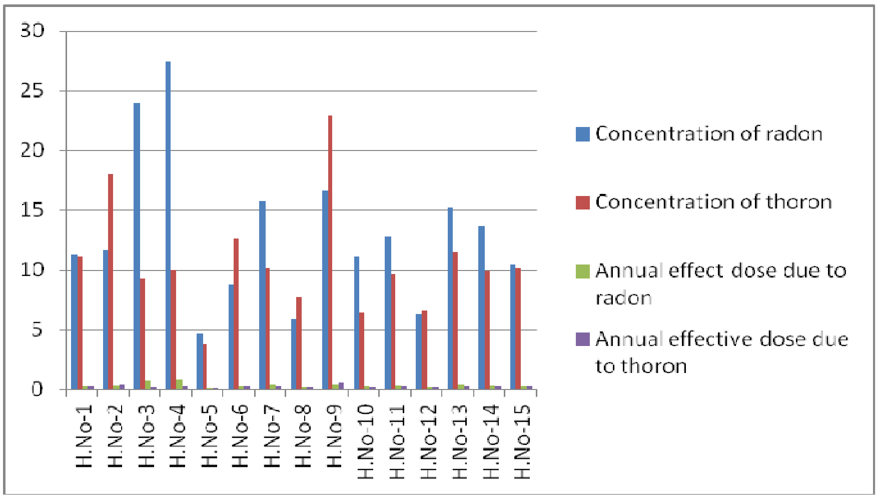

Figure 2 Variation of indoor radon, thoron concentrations and annual effective dose in the some Houses of Jaipur, Rajasthan state of India

CONCLUSSION

The indoor radon and thoron concentration levels were found lower than the permissible level. The values of annual effective dose due to the exposure to radon and thoron are below the recommended limit by[13]. Present study concludes that the houses are safe without posing significant radiological threat to the human beings.

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