

# MEASUREMENTS AND SEASONAL ANALYSIS OF RADIOACTIVE GASES IN THE ENVIRONMENT OF RAMPUR AND NEARBY TOWN (U.P.) BY USING SOLID STATE NUCLEAR TRACK DETECTOR (SSNTD) TECHNIQUE

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## Abstract

Measurements of radioactive gases i.e. radon and thoron & their progeny concentration were carried out in some selected dwellings in Rampur and nearby towns of Uttar Pradesh by using Solid State Nuclear Track Detector (SSNTD). The radon-thoron twin dosimeter cups were used for the measurements. The measurement was repeated on a time integrated four quarterly cycles to cover all the four seasons (summer, rainy, autumn & winter) of the calendar year. During summer, rainy, autumn and winter seasons the radon concentration was found to vary from 9 Bq/m<sup>3</sup> to 55 Bq/m<sup>3</sup> with an average of 18.72 Bq/m<sup>3</sup>, 11 Bq/m<sup>3</sup> to 40 Bq/m<sup>3</sup> with an average of 24.41 Bq/m<sup>3</sup>, 15 Bq/m<sup>3</sup> to 46 Bq/m<sup>3</sup> with an average of 29.95 Bq/m<sup>3</sup> and 25 Bq/m<sup>3</sup> to 85 Bq/m<sup>3</sup> with an average of 44.92 Bq/m<sup>3</sup> respectively where as its progeny concentration varied from 0.57mWL to 5.94mWL with an average value of 2.02mWL, 1.18mWL to 4.32mWL with an average value of 2.63mWL, 1.62mWL to 4.97mWL with an average value of 3.23mWL and 2.70mWL to 9.18mWL with an average value of 4.85mWL respectively. The thoron concentration was found to vary from 7.33 Bq/m<sup>3</sup> to 22.5 Bq/m<sup>3</sup> with an average value of 11.86 Bq/m<sup>3</sup>, 10.50 Bq/m<sup>3</sup> to 23 Bq/m<sup>3</sup> with an average value of 16.06 Bq/m<sup>3</sup>, 11.66 Bq/m<sup>3</sup> to 24.5 Bq/m<sup>3</sup> with an average value of 17.44 Bq/m<sup>3</sup>, and 17.66 Bq/m<sup>3</sup> to 30 Bq/m<sup>3</sup> with an average value of 21.35 Bq/m<sup>3</sup> respectively where as its progeny concentration varied from 0.19mWL to 0.60mWL with an average value of 0.32mWL, 0.28mWL to 0.62mWL with an average value of 0.43mWL, 0.31mWL to 0.66mWL with an average value of 0.47mWL and 0.47mWL to 0.81mWL with an average value of 0.57mWL respectively in different seasons. All values were observed below the recommended action level (200 Bq/m<sup>3</sup>) set by the various organizations (ICRP, 1993)

**Keywords:** Radioactive gases, solid state nuclear track detector, dwelling, environment, nuclear tracks

## INTRODUCTION

The earth's crust contains small amount of the primordial radionuclides <sup>238</sup>U and <sup>232</sup>Th. These decay through a chain of radioactive nuclides to stable isotopes of lead. Most of the decay products are isotopes of solid elements but two are gasses. <sup>222</sup>Rn from the decay of uranium and <sup>220</sup>Rn from thorium. The name "radon" sometimes used generally for all isotopes of the gas but is sometimes reserved for <sup>222</sup>Rn. <sup>220</sup>Rn being called thoron. In the nature three isotopes of radon are present and all these isotopes alpha emitters, <sup>222</sup>Rn ( $T_{1/2}=3.8$ d), <sup>220</sup>Rn ( $T_{1/2}=55$ s), <sup>219</sup>Rn ( $T_{1/2}=3.62$ s). They are a members respectively, of uranium, thorium, and actinium chains. Only <sup>222</sup>Rn (known as radon), and <sup>220</sup>Rn (known as thoron) are present in the environment in the considerable amounts. The half-lives of <sup>222</sup>Rn progeny are shorter than 30 minutes. Due to this fact, product decay inside the respiratory tracts, when inhaled, is very high. Similar situation is observed of thorium-<sup>232</sup>Th chains. As a result of decay of <sup>220</sup>Rn short lives progeny produced and the most important among them is <sup>212</sup>Pb with half-life 106h. Some of the radon daughter products are alpha emitters and this type of radiation can cause high doses in the tissues in the respiratory tracks. Therefore radon progeny plays so important role for the radiation hazard for the humans, more important as the role of the parent isotope-radon. Radon is the main source of a radiation for any human being. Human beings have been exposed to them since inception. Exposure of ionizing radiation, which can not be detected by any sense of our body, is injurious to our health. <sup>222</sup>Rn and <sup>220</sup>Rn and its short-lived daughters are the most important source of ionizing radiations prevalent in our environment, which are probably responsible for causing adverse affects on human lungs. In India out of 98% exposure dose from natural radioactive sources, about 75% is due to radon and its progeny. The contribution of indoor-thoron concentration is generally considered negligible because of its short half-life about 55.6second (Ramola et. al., 2005). Also thoron being short lived and due to its movement up to 1-1.5 ft from ground level, it is considered to have negligible effect on the nuclear track detectors (Toussaint et. al., 1995). As the detectors were placed at a height of 1.75 meter from the ground level; thoron and its progeny have no impact on the detectors film. Therefore special attention has been drawn to the indoor radon concentration, since Radon (<sup>222</sup>Rn) and Radon progeny indoors contribute the largest dose of exposure to the population at large among natural radiation sources (Tracy et. al, 2006; UNSCEAR, 1993; Obayashi et. al. 1990 and UNSCEAR, 2000). Indoor thoron (<sup>220</sup>Rn) and its progeny however have not been taken seriously in the national survey in many countries. Since it is assumed for some reason or other that indoor thoron and its progeny have not been regarded to contribute to the effective dose of the general public significantly in comparison with the indoor Radon and its progeny. A UK survey (Cliff et al., 1992) of exposures to <sup>220</sup>Rn suggested that doses from this nuclide would exceed those from radon in only about 2% of cases and that the mean dose from <sup>220</sup>Rn is about an order of magnitude smaller than that from <sup>222</sup>Rn. It has been estimated (Metters, 1992) that domestic radon exposures are responsible for about 2,000 of the 40,000 lung cancer deaths in Britain each year. Smoking is of course, by far the dominant cause of lung cancer, but estimates suggest that radon is more important than passive smoking, thought to be responsible for a few hundred deaths each year (Hackshaw et. al., 1996). It has been established that prolonged

inhalation of high concentration of Radon and its progeny especially  $^{218}\text{Po}$  and  $^{214}\text{Po}$  attached to aerosols present in the ambient air constitutes a significant health hazard and may lead to lung cancer (HCG, 2008; Sevc et. al., 1976 and Ramchandran., 1998). If you inhale a radon atom, the atom can disintegrate while it is in your lungs, when it disintegrates, it becomes polonium-218, which is a metal. This metal atom can settle in your lungs and over the next hour or so it will emit a number of alpha particles beta particles and gamma rays. It eventually turns into lead-210 with a half-life of 22 days, which is fairly stable in this context. It is the quick, hour-long sequence of alpha, beta and gamma emission that can lead to the mutations in the lungs tissue, which can cause cancer Therefore measurement of indoor radon radiation and its progeny in human dwelling is very important from radiation protection point of view.

#### BRIEF GEOGRAPHY OF STUDY AREA

The measurements of radioactive active gases i.e. indoor radon, thoron and their progeny were carried in the dwellings of Rampur city and nearby town of Uttar Pradesh. Rampur is a city and headquarters of Rampur district in the Indian state of Uttar Pradesh. Rampur is located between longitude  $79^{\circ}05'$  E



Fig. 1. Map showing Rampur city and nearby town

and latitude  $28^{\circ}48'$  N and spread in area of 2367 Sq.Km. in Moradabad division of Uttar Pradesh and it is 192 meter above sea level in north and 166.4 meter in south. The selection of dwellings for installing dosimeters was done taking into account the degree of ventilation, type of floor, number of windows and doors as they all responsible for variation in indoor radon concentration.

#### EXPERIMENTAL TECHNIQUE

The radioactive gases i.e. radon, thoron and their progeny concentration in were measured in some selected dwellings of Rampur and nearby town of western Uttar Pradesh using alpha sensitive LR-115 type II plastic track detectors. It is a 12 micrometer thick film red dyed cellulose nitrate emulsion coated on inert polyester base of 100 micrometers thickness and has maximum sensitivity for alpha particles. About 100 detectors were installed but 70 sites are included in the study and 30 detectors considered lost, mistreated or damage. The houses chosen for installation of detectors are mud as well new one. The small Pieces of detector film of 2.5 cm x 2.5 cm. will be fixed in a twin cup radon dosimeter having three different mode holders' namely bare mode, filter mode and membrane mode. The bare mode detector registers track due to radon, thoron gases and their progeny concentrations while the filter made detector records tracks due to the radon and thoron gases, membrane made records tracks only by radon gas. Radon-Thoron mixed field dosimeter system is shown in the figure 2. The dosimeters fitted with LR-115 plastic track detectors are suspended inside the selected houses in field area at a height of about 150 cm to 200cm from the ground floor. When alpha particles strikes on LR-115 film it creates narrow trails called Tracks. The detectors were exposed for a period of three months and, after retrieval, were etched for two hours in 2.5N NaOH solution maintained at  $60^{\circ}\text{C}$  in constant temperature bath and scanned in the laboratory for the track density using spark counter. The measured track densities for indoor radon, thoron and progeny is then converted into activity concentrations ( $\text{Bqm}^{-3}$ ) using the following calibration factors (Ramola et al., 1996; Ramachandran, 1998).

$$\begin{aligned} 125 \text{ tracks cm}^{-2} \text{ d}^{-1} &= 1 \text{ WL} \\ 3.12 \times 10^{-2} \text{ tracks cm}^{-2} \text{ d}^{-1} &= 1 \text{ Bqm}^{-3} \end{aligned}$$

The radon, thoron and their progeny concentrations are calculated by the following relations (Mayya et.al., 1998).

$$C_R \text{ (Bq/m}^3\text{)} = T_m / d \times S_m$$

$$C_T \text{ (Bq/m}^3\text{)} = T_f - d \times C_R \times (S_{rf} / d \times S_{tf})$$

where  $T_m$  is track density of the film in membrane compartment,  $d$  is the Period of exposure (days),  $S_m$  is the Sensitivity factor of membrane compartment,  $T_f$  is the track density of the film in filter compartment,  $S_{rf}$  and  $S_{tf}$  are the sensitivity factor of radon and thoron in filter compartment, respectively. The obtained values of radon and thoron concentration was converted in to progeny concentration (or Potential Alpha Energy Concentration) by using the formula

$$C_R \text{ or } C_T \text{ (Bq/m}^3\text{)} = \text{PAEC (mWL)} \times 3700/F$$

Where  $F$  is the equilibrium factor having values are 0.4 and 0.1 for radon and thoron respectively. (UNSCEAR, 2000)



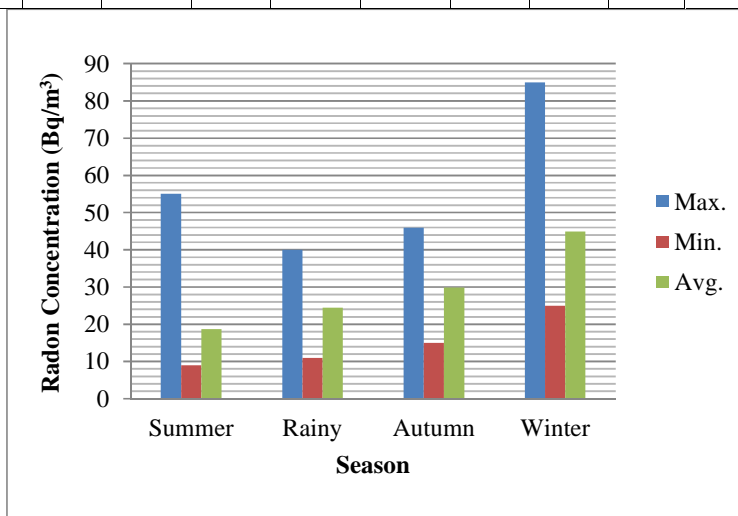
**Figure 2. Radon-Thoron mixed field dosimeter system**

## RESULT AND DISCUSSION

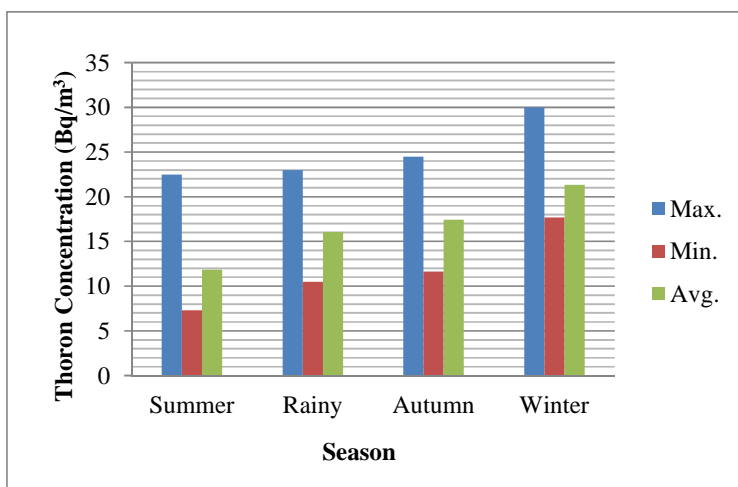
Observed values of radon, thoron and progeny concentration from different location in a four different seasons of a calendar year in Rampur and nearby town are given in table1. From the observation it was found that during summer season indoor radon concentration was found to varied from 9 Bq/m<sup>3</sup> to 55 Bq/m<sup>3</sup> with an average of 18.72 Bq/m<sup>3</sup> where as its progeny concentration was found to vary from 0.97 mWL to 5.94 mWL with an average value of 2.02 mWL. During rainy season indoor radon concentration was found to vary from 11 Bq/m<sup>3</sup> to 40 Bq/m<sup>3</sup> with an average of 24.41 Bq/m<sup>3</sup> where as its progeny concentration was found to vary from 1.18 mWL to 4.32 mWL with an average value of 2.63 mWL. During autumn season indoor radon concentration was found to vary from 15 Bq/m<sup>3</sup> to 46 Bq/m<sup>3</sup> with an average of 29.95 Bq/m<sup>3</sup> where as its progeny concentration was found to vary from 1.62 mWL to 4.97 mWL with an average value of 3.23 mWL. During winter season the radon concentration was found to vary from 25 Bq/m<sup>3</sup> to 85 Bq/m<sup>3</sup> with an average of 44.92 Bq/m<sup>3</sup> where as its progeny concentration was found to vary from 2.70 mWL to 9.18 with an average value of 4.85 mWL. During summer season indoor thoron concentration was found to varied from 7.33 Bq/m<sup>3</sup> to 22.5 Bq/m<sup>3</sup> with an average of 11.86 Bq/m<sup>3</sup> where as its progeny concentration was found to vary from 0.19 mWL to 0.60 mWL with an average value of 0.32 mWL. During rainy season indoor thoron concentration was found to vary from 10.50 Bq/m<sup>3</sup> to 23 Bq/m<sup>3</sup> with an average of 16.06 Bq/m<sup>3</sup> where as its progeny concentration was found to vary from 0.28 mWL to 0.62 mWL with an average value of 0.43 mWL. During autumn season indoor thoron concentration was found to vary from 11.66 Bq/m<sup>3</sup> to 24.50 Bq/m<sup>3</sup> with an average of 17.44 Bq/m<sup>3</sup> where as its progeny concentration was found to vary from 0.31 mWL to 0.66 mWL with an average value of 0.47 mWL. During winter season the thoron concentration varied from 17.66 Bq/m<sup>3</sup> to 30 Bq/m<sup>3</sup> with an average of 21.35 Bq/m<sup>3</sup> where as its progeny concentration was found to vary from 0.47 mWL to 0.81 with an average value of 0.57 mWL. The variation of radon and thoron concentration in different season from various locations are shown in figures 3 and 4 where as the variation of radon and thoron progeny concentration in different season from various locations are shown in figure 5 and 6. The results shows quite higher radon and thoron levels in winter season as compared to the other season. This maximum concentration is essentially by the intense temperature inversion, which generally occurs in winter season when the wind velocity is low. The maximum concentration in winter is also the result of decreased ventilation because in this season the houses are closed for a long time and radon accumulated inside the room. The concentration of radon, thoron and their progeny levels in study area were observed below the recommended action level (200 Bq/m<sup>3</sup>) set by the various organizations (ICRP, 1993). All values obtained under the limit (ICRP, 1993), depending on the type of house construction, ventilation conditions and location.

**Table 1. Observed values of radioactive gases i.e. radon and thoron & their progeny concentration from different locations in a four different seasons**

Season	Radon Conc. (Bq/m <sup>3</sup> )			Thoron Conc. (Bq/m <sup>3</sup> )			Radon progeny Conc. (mWL)			Thoron progeny Conc. (mWL)		
	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Summer	55	9	18.72	22.5	7.33	11.86	5.94	0.97	2.02	0.60	0.19	0.32
Rainy	40	11	24.41	23	10.50	16.06	4.32	1.18	2.63	0.62	0.28	0.43
Autumn	46	15	29.95	24.5	11.66	17.44	4.97	1.62	3.23	0.66	0.31	0.47
Winter	85	25	44.92	30	17.66	21.35	9.18	2.70	4.85	0.81	0.47	0.57



**Figure 3. Variation of radon concentration in different season**



**Figure 4. Variation of thoron concentration in different season**

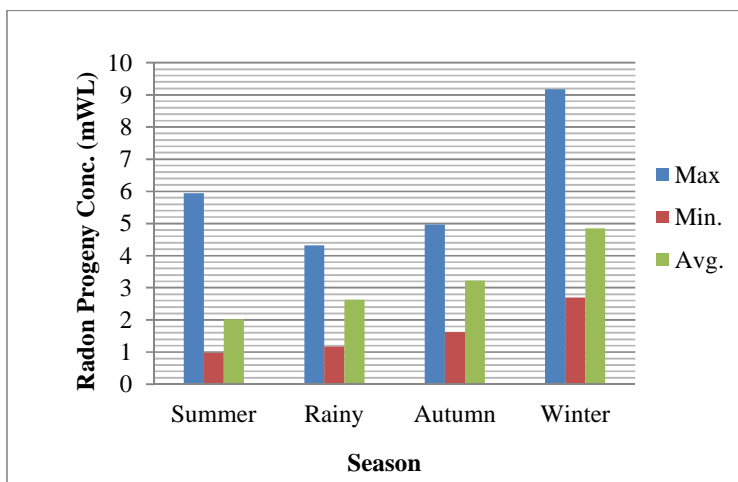


Figure 5. Variation of radon progeny concentration in different season

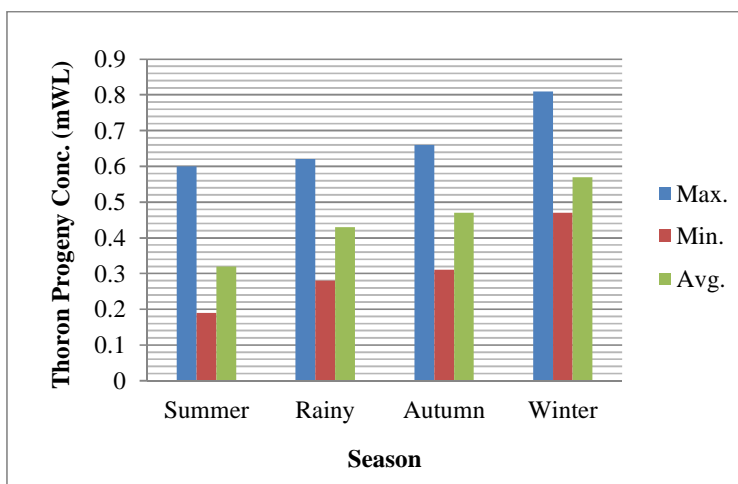


Figure 6. Variation of thoron progeny concentration in different season

## CONCLUSION

The measured values of radioactive gases i.e. radon and thoron and their progeny concentration in the dwellings of Rampur and nearby town are reported in the table 1. The results show quite higher radon and thoron levels in winter season as compared to the other season. This maximum value of radon and thoron levels is essentially by the intense temperature inversion, which generally occurs in winter season when the wind velocity is low. The maximum concentration in winter is also the result of decreased ventilation because in this season the houses are closed for a long time and radon accumulated inside the room. The radioactive gases i.e. radon and thoron and their progeny levels in study area were observed below the recommended action level ( $200\text{Bq/m}^3$ ) set by the various organizations (ICRP, 1993). Thus, it is concluded that the study area is quite safe from radiation protection point of view.

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