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Levels of natural radioactivity in environment in residential area of Moradabad District, Western Uttar Pradesh

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ABSTRACT: Indoor radon and thoron have been measured in the houses of Moradabad District, Uttar Pradesh India, by means of solid state nuclear track detectors. Radon, an invisible radioactive gas, occurs naturally in indoor atmospheres and along with thoron is the most important contribution of human exposure to natural sources. Radon exists in soil gas building materials and indoor atmosphere to name but a few. Risk of lung cancer depends on the concentration of radon and thoron and their decay products in the environment above recommended levels. The present article measures the concentration of indoor radon and thoron in 60 dosimeters by means of a solid state nuclear track detector in different house types of Moradabad district, Uttar Pradesh. The measurements have been carried out in residential buildings at a height of 2 m from the sea level, using a twin chamber radon dosimeter. The value of radon concentration in the present study varies between 10.5 Bq/m^3 and 29.5 Bq/m^3 with an average of 19.8 Bq/m^3 while that of thoron is between 5.6 Bq/m^3 and 24 Bq/m^3 with an average of 14.9 Bq/m^3 respectively. Results, obtained with twin cup radon/thoron dosimeter, show that the concentration of indoor radon and thoron have been within the recommended level, with all the values staying under the safe limits, decreed by the International Commission on Radiological Protection (ICRP) and United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR).

Keywords: dosimeter, radon/thoron, residential buildings, solid state nuclear track detector.

INTRODUCTION

Studies of natural radioactivity and natural environmental radiation are of high account as they make the subject of Health Physics, radiation Physics, and all relevant branches of natural sciences. The measurement of radon and thoron concentration in indoor atmospheres has been the topic of many researches by scientists all over the world. According to Ramachandran et al. (2003), in our daily life, we come across both natural as well as artificial sources of radiation. The former is composed of cosmic rays and natural radioactivity existing in the soil and rocks.

As a result of radiological risks for humans in indoor atmosphere, the behavior of radioactive gases has received considerable attention over the past few decades. High levels of radon have been

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measured in residential places in a number of countries such as the United States, Sweden, and the United Kingdom (UNSCEAR, 2000). What is more, there is some concern over the possibility of radon levels' contribution to an increased risk of lung cancer. Such high levels of radon indoors may exceed international guidelines and are associated with a number of factors like soil porosity, uranium content of the soil, building materials, mode of construction, ventilation, and metrological parameters as suggested by Bajwa et al. (2008). The variability of these factors accounts for the large range of the radon levels, measured in these houses. WHO (2007, 2008) reports that according to recent epidemiological evidence inhaling the products of radon decay in domestic environments could be a cause of lung cancer.

The important factors that affect the indoor concentration of radon/thoron are: (1) Properties of the building construction material and the ground. Here the radon exhalation rate from the building concentration materials or the ground chiefly depends on the uranium/thorium content as well as density and the porosity of the material; and (2) the ventilation rate and metrological parameter (Sharma et al., 2014).

Radon and thoron levels have been measured by solid state nuclear track detectors in various types of houses at 10 different locations around Bangalore city, India. In 220 cases radon levels were above the global average (10 Bq/m^3). Having surveyed Dehradun as well as the nearby towns of U.P., Ramola et al. (2000, 2005) suggested a slightly-higher radon concentration than the normal one; therefore, there was a need to survey radon concentration in different regions of the state. As a result, Moradabad district of western Uttar Pradesh has been chosen as the study area with the purpose of conducting a systematic study and an estimation of radon and thoron concentration in indoor atmosphere in the residential buildings of the area.

Measurements have been done in both bedrooms and drawing rooms of the houses (Choubey et al., 2003). The residential houses in plane area, selected for installation of dosimeters, are mostly poorly–ventilated, having either a small window or no window at all.

MEASUREMENT TECHNIQUES

Concentration of radon and thoron in the environment has been measured in 60 houses of the Moradabad district, Western Uttar Pradesh, using alpha sensitive LR-115 type-II plastic track detectors (Fig. 1).

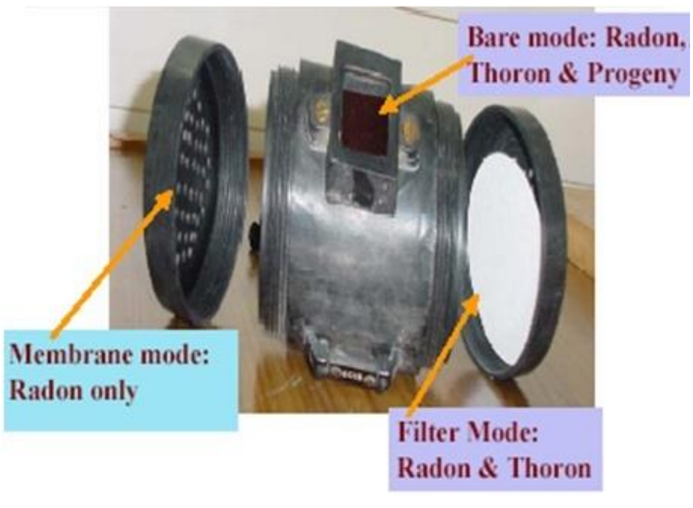

Fig. 1. Twin Cup Radon –Thoron Dosimeter with alpha sensitive LR-115 type-II plastic track detector

It is a 12-micrometer thick film red-dyed cellulose nitrate emulsion, coated on inert polyester base, 100 micrometers thick, which has maximum sensitivity for alpha particles. Eappen and Mayya (2004), Zhuo et al. (2000, 2001), and Duggal et al. (2013) took small pieces of detector film (2.5 cm * 2.5 cm) and had them fixed in a twin cup radon dosimeter with three different mode holders, namely bare, filter, and membrane mode. According to Eappen et al. (2001), Tokonami et al. (2003), and Khan et al. (2014) the bare mode detector keeps track of radon and thoron gases along with their progeny concentrations, while the filter mode focuses on the radon and thoron gases and the membrane mode, the radon gas merely. The dosimeters fitted with LR-115 plastic track detector are suspended inside the selected houses in the field area at a height of about two meters from the ground floor. When alpha particles strike on LR-115 film, it creates narrow trails called tracks. The detectors were exposed for about three months and, eventually when they were retrieved, they got etched and scanned in the laboratory for the track density using spark counter (Milic et al., 2013; Singh et al., 2015)**.** The measured track densities for indoor radon and progeny were then converted into Working Levels (WL) and activity concentrations (Bq/m^3) using the following calibration factors used by Ramola (1996) and Ramola et al. (1997, 2005).

- ✓ 125 tracks $cm^{-2}.d^{-1}$=1 WL
- ✓ 3.12x10^{-2} tracks $cm^{-2}\,d^{-1}$= $1\,Bq/m^3$

Area of Study

Moradabad district is situated in Western Uttar Pradesh state of India. According to Mishra et al. (2014) it forms part of a genetic alluvial plain, between 28° 20' and 29° North latitudes and 78° 24' and 79° East longitude, covering an area of about 3759.79 Sq. KM (Fig. 2).

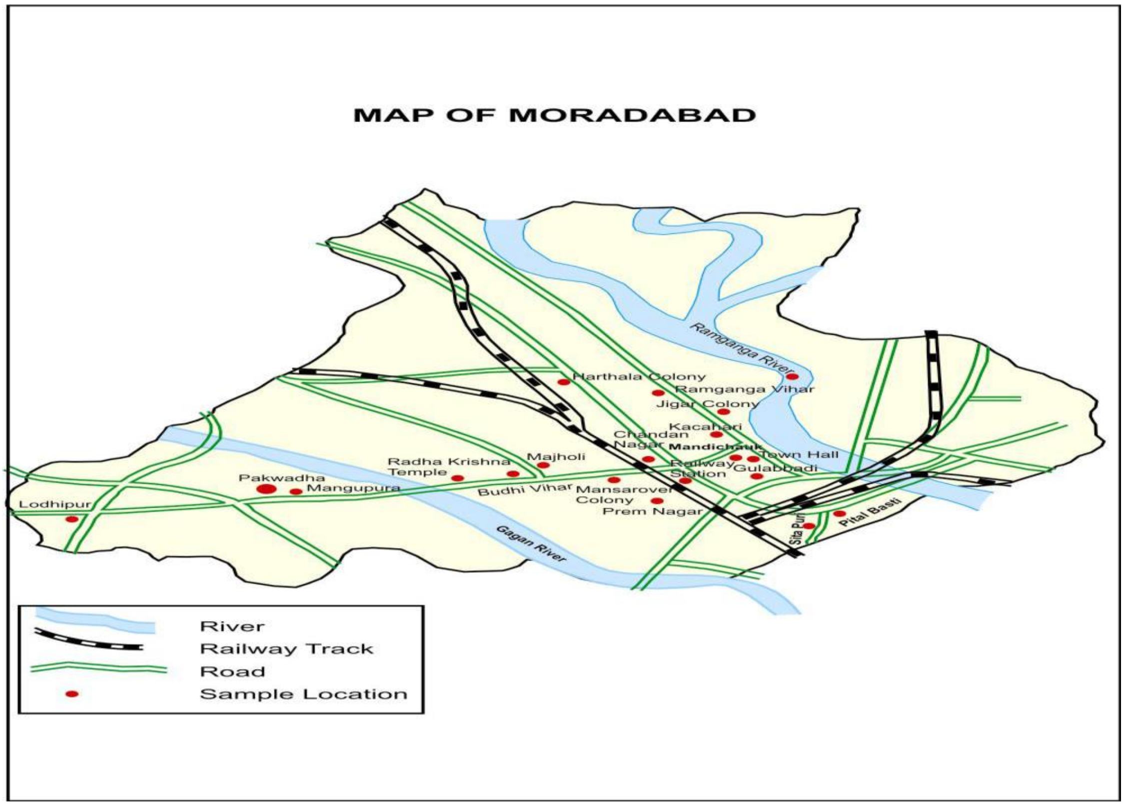

Fig. 2. Map of Moradabad

It can be divided into two broad geological unities, namely Younger Alluvium and Older Alluvium. The district has two rivers, called Ram Ganga and Gagan. The ground of Moradabad is almost plane, except for some elevations. The river water contains soil, silt, and sand in varying proportion. Moradabad's soil is mainly of three types: domat, matiyaan, and bhud. The houses in study area are good and poorly ventilated. Buildings are constructed of concrete, cement, bricks, and blocks, some having glass doors and windows too.

RESULTS AND DISCUSSION

The present paper emphasizes the long-term measurements of radon and thoron concentrations in 60 dwellings using solid state nuclear track detectors (Table 1). The residential buildings, selected for installing dosimeters, are both new and old (Kumar et al., 2014). They are mainly made of bricks along with cement and concrete. The selection of these houses for dosimeters installation took the degree of ventilation, floor types, and number of windows and doors into account as they are all responsible for variations in indoor radon/thoron concentration. All the measurements took place at noon in different seasons. However, the recorded values of radon and thoron progeny as well as the resulting gases fall well below the internationally-recommended levels, which clearly indicates that the houses in Central Uttar Pradesh are quite safe in terms of protection from any radiation (Rawat et al., 2011).

Table 1. Variations of indoor radon and thoron concentration in different seasons

Sr. No	Sample Locations in Moradabad District	Environmental Indoor Radon Concentration (Bq /m^3)				Environmental Indoor Thoron Concentration (Bq /m^3)			
		Autumn	Summer	Rainy	Winter	Autumn	Summer	Rainy	Winter
1.	Lodhipur	**18.5**	**15**	**17**	**20.1**	**14**	**10.67**	**13.5**	**18.5**
2.	Pakwara	17.5	14.75	15	21.75	12.5	10	11	19
3.	Mangupura	18	13	14.5	27	13.5	11.5	12	20.5
4.	RadhaKrishan Mandir	20	15.3	18.6	22	14	11	14.5	20
5.	Manjholi	17.5	16	16	21	12	9	13.5	18
6.	Mansrover Colony	17.25	17	18.75	22.5	14.5	7.5	15	17.66
7.	Budhi Vihar	20.3	17.5	23.75	25	10.76	8.5	10.5	17.5
8.	Prem Nagar	19.25	18.5	19	22.25	14	7.6	12	18
9.	Chow ki basti	23.5	17.5	22	29.5	17.5	14	17.8	24
10.	Gulab bari	20.6	15.75	19	21.75	14	10.75	21.33	19.5
11.	Petal Basti	22.6	14.5	21	24	18.33	11	18.33	20.5
12.	Sita puri	20.5	18	20	23	14	10.67	14	21
13.	Mandichawk	21	19.5	24.5	27	13.8	12.5	13.5	22
14.	Jigar colony	22.5	10.5	20	21.5	10.5	5.6	10.75	17
15.	Harthala colony	19.6	16.75	21.75	24.5	15	12.5	14.5	20
16.	Chandan nagar	20	17.5	18	25	15.67	13	15.8	22
17.	Ram Ganga Vihar	19.75	18	23	26.6	14.5	11.65	14	21.5
18.	Town Hall	20.2	19.25	20	23.3	12	10.5	12.5	19.5
19.	Gaytri Nagar	18	15	17.5	22	16.25	6.5	14.66	17.66
20.	Rati muhala	20	18.5	19.5	27	18.5	14	19.5	24
21.	Hanuman Nagar	23.5	20	23	24.5	15	13	16.5	21.5
22.	Vikas Nagar	14	13.5	14.5	22	16	13.5	16.5	23.75
Minimum Concentration		**14**	**10.5**	**14.5**	**20.1**	**10.5**	**5.6**	**10.5**	**17**
Maximum Concentration		**23.5**	**20**	**25**	**29.5**	**18.5**	**14**	**21.33**	**24**
Average Concentration		19.72	16.42	19.37	23.7	14.37	10.67	14.62	20.13

The present study showed a minimum indoor radon concentration of 10.5 Bq/m^3 in Jigar Colony during summer (recorded around noon) and a maximum concentration of 29.5 Bq/m^3 in Chow ki Basti during the winter. The overall average value of indoor radon concentration was 19.8 Bq/m^3 for the entire year. The minimum indoor thoron concentration was 5.6 Bq/m^3 in Jigar colony in summer (recorded around noon), and the maximum concentration was 24 Bq/m^3 in Reti Muhhala in winter with the overall average value of indoor thoron concentration being 14.9 Bq/m^3 for the entire year. The concentration remained minimum in summer and maximum in winter, since in summer, the houses' doors are open for a long time, which in turn increases the rate of air exchange, whereas in winter with the doors closed for long hours, this rate decreases. This is the possible cause for radon/thoron variation (Figs. 3 & 4).

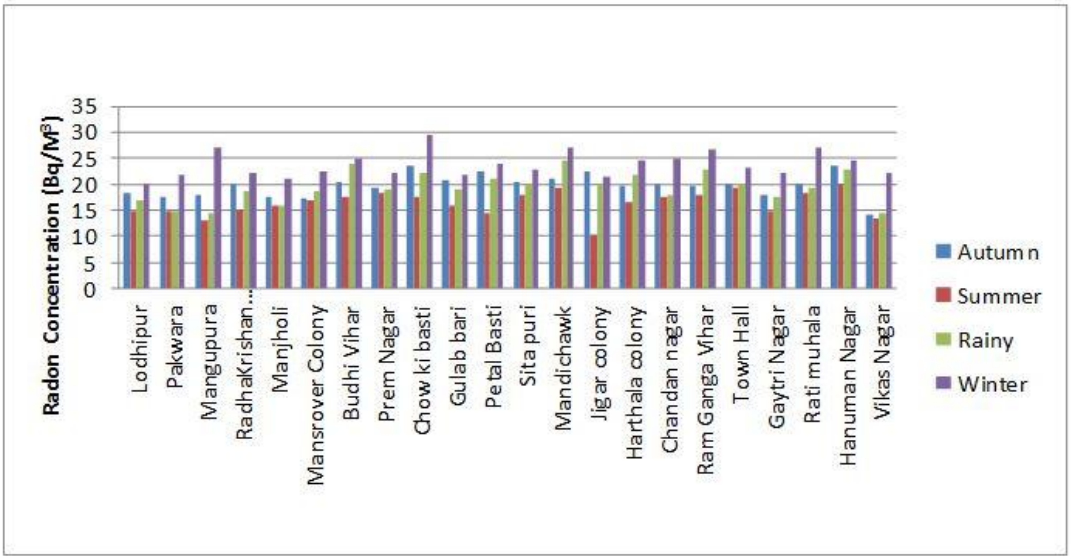

Fig. 3. Variation of radon concentration in different seasons

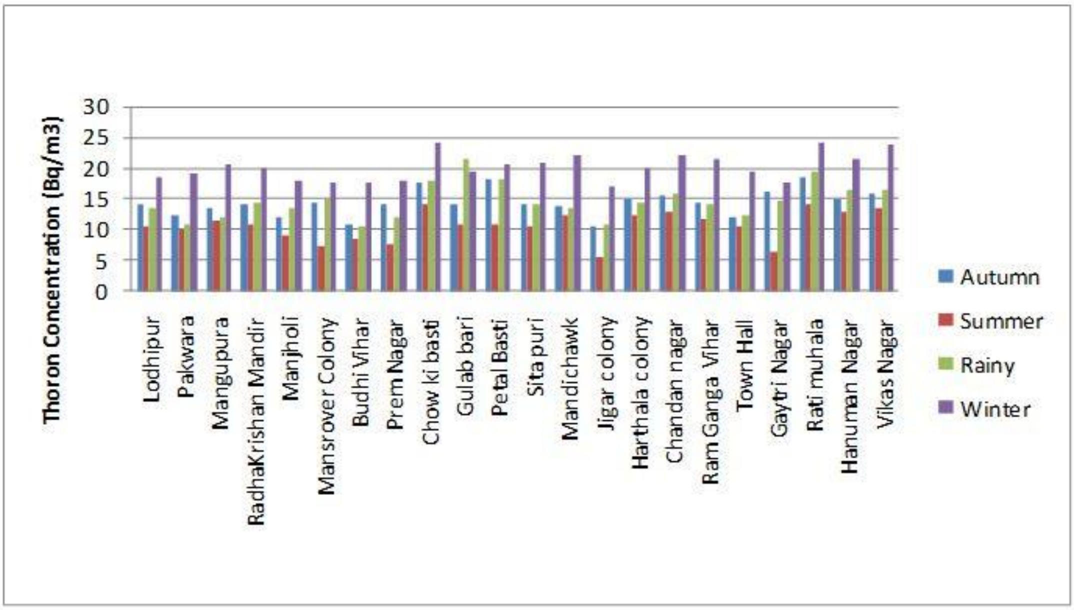

Fig. 4. Variation of thoron concentration in different seasons

Results of the systematic study have been obtained by considering the room as a space in which the radon and thoron levels are directly related to the dynamic and static parameters.

CONCLUSIONS

Based on the results, obtained from the houses of Moradabad district of Uttar Pradesh, during all four seasons, it can be concluded that the measurement values are comparable to the recorded values of radon and thoron, BEIR (2006) and the measured results of the tables are well below internationally recommended levels Therefore the results clearly indicate that the houses in differing areas of Moradabad district of Western Uttar Pradesh are quit safe in terms of radiation protection.

Building materials can influence the indoor radon concentrations slightly. Brick and concrete houses show higher radon levels, while wood and adobe houses present lower ones. Moreover, floors also have an impact on radon concentrations as well as the existence of concrete floor capping (Armencea (Mutoiu) et al., 2012).

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