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Calculative Analysis of Dimensions of Ordinary Radioactivity Levels in the Indoor Environment during 4 Seasons in Firozabad District of Uttar Pradesh

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ABSTRACT
Measurements of natural radioactivity levels have been carried out in the dwellings ofFirozabad District (U.P.) in the indoor environment by using radon-thoron twin cup dosimeter.For the measurements of activity levels, the dosimeters containing LR-115, type II SSNTD filmwere installed in both old houses (i.e. poorly ventilated Mud houses having one small window or without window and with only one door)as well as new one. It was found that during winter season, indoor radon activity varies from 25 Bq/m^3 to 80 Bq/m^3 with an average value of 45.32 Bq/m^3 whereas a thoron activity level varies from 18Bq/m^3 to 41Bq/m^3 with an average value of31.44. In summer season indoor radon activity levels varies from 12Bq/m^3 to 55 Bq/m^3 with an average of 19.84 Bq/m^{3}thoron activity levels varies from 10Bq/m^3 to 30Bq/m^3 with an average value of17.28Bq/m^3.In rainy season indoor radon activity level varies from 19 Bq/m^3 to33 Bq/m^3 with an average value of 25.16 Bq/m^{3}thoron activity levels varies from 19Bq/m^3 to 31Bq/m^3 with an average value of 23.41Bq/m^3. In autumn season indoor radon activity levels varies from 19 Bq/m^3 to 42 Bq/m^3 with an average of 30.40 Bq/m^{3}whereas thoron activity levels varies from 18Bq/m3 to 39Bq/m^3 with an average value of 27.25 Bq/m^3.Present result shows thatlevels of natural activity were found below the recommended action level (147Bq/m^3) as set by ICRP [5] and EPA [17]. Thus the study area is safe from radiation protection point of view.
Keywords: *Radon, Thoron, Solid State Nuclear Track Detector (SSNTD), dosimeters, dwellings*

I. INTRODUCTION

At present, changes in living conditions among the population, and the significant increase and differences of sources of pollution in the environment produce a significant effect on the health of the population. One source of such health problem of pollution is indoor radon. The inhalation of radon and its short-lived daughter products represents the main source of exposure to natural radiation. Radon is now believed to be the most important source of ionizing radiation in our environment [1]. Radon is a gas that is produced naturally in the ground and seeps into most houses. Inhalation of radon or more specifically the Radon daughters, leads to deposition of radioactive atoms on the walls of the lung, especially in the bronchial region. When these atoms are decayed, alpha particles are emitted which irradiate the cells of the lung tissue through which they pass. These irradiated cells may become cancerous. The contribution of indoor thoron concentration is generally considered negligible because of its short half-life about 55.6 second[2, 3].

Therefore special attention has been drawn to the indoor radon concentration. The behaviors of the radioactive gasses have received considerable attention over the past few decades due to the radiological risks to humans in indoor atmosphere. High radon and thoron activity levels were measured in dwellings of different country and there is a concern that high levels of radon and thoron may contribute to an increased risk of lung cancer if the radon levels exceed to the recommended international accepted levels [4]. In India out of 98% exposure dose from natural radioactive sources, about 75% is due to radon and its progeny. Recent epidemiological evidence suggests that inhalation of radon decay products in domestic environments could be a cause of lung cancer [5-10]. Therefore activity levels of radon and thoron should be measured across the different part of the country from radiation protection point of view. It is observed that the seasonal variation of indoor radon and thoron activity levels (concentration) depends on several parameters such as type of houses, radon source, living style of inhabitants, temperature, pressure, humidity, ventilation system of the houses and outdoor climate. In the present paper an attempt has been made to measure the natural radon and thoron activity levels i.e. radon and thoron concentration in the dwellings of firozabaddistrict of western Uttar Pradesh in the indoor environment.

II. MEASUREMENT TECHNIQUES

The indoor radon/thoron activity levels in the indoor environment of Firozabad district have been measured using LR-115 type- II alpha sensitive plastic track detectors by means of twin cup radon dosimeter.

The experimental arrangement for the same is shown in the figure 1(a) and figure1 (b). The alpha sensitive plastic track detector is a 12 µm thick film red dyed cellulose nitrate emulsion coated on inert polyester base of 100 µm thickness and has maximum sensitivity for alpha particles[11, 12], fission fragments and ionizing particles. Small pieces of LR-115 type II plastic track detectors film of size 2.5cm x 2.5cm is put in a radon twin cup dosimeter having three mode namely bare mode, filter mode and membrane mode. The filter mode of the dosimeter gives radon and thoron gasses whereas the membrane mode of the dosimeter gives radon gas only. The bare mode of the dosimeter gives the tracks of radon and thoron gasses along with the progeny concentration. The dosimeters containing LR-115, type II film were suspended inside the house at a height of about two meters. Forthe measurements of natural activity levels of radon and thoron, eighty (80) dosimeters were installed in the dwellings of the study area. The houses chosen for installation of dosimeters are mud house as well new one. In rural area some dosimeters are also installed in mud houses. In order to install the dosimeters, the dwellings are chosen taking into account the degree of ventilation, type of floor, number of windows and doors as they are responsible for variation in indoorconcentrationof radon/thoron.

Figure 1(a): Twin cup radon Dosimeter

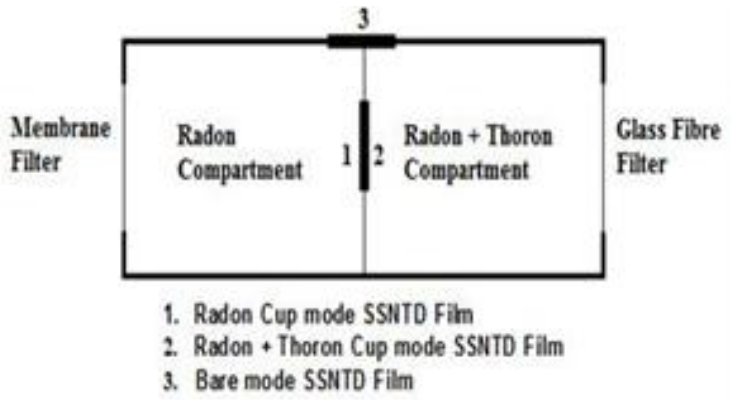

Figure1 (b): Experimental setup

The dosimeters containing the LR-115 detector film were exposed for a period of three months. After the completion of exposure time, the detectors were removed. After that the detector were subjected to chemical etching with a solution of 2.5 NaOH at 70^0C in a constant temperature bath for one hour and thirty minutes and scanned in the laboratory for track density. The season wise indoor radon/thoron activity levels were obtained after converting measured track densities with spark counter in Bq/m^3 by using appropriate calibration factor formula [13-16].

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

III. RESULTS AND DISCUSSION

The observed radon and thoron activity levels recorded at different locations in four different seasonsi.e. winter, summer, rainy and autumn of a calendar year are given in a table 1 and 2.

Table 1: Natural **radon activity** levels in the indoor environment at different locations inBq/m^3

S.No.	Locations	No. of sample	Seasons			
			Winter (Bq/m^3)	**Summer** (Bq/m^3)	**Rainy** (Bq/m^3)	**Autumn** (Bq/m^3)
1	Site 1	4	45	20	28	32
2	Site 2	3	39	18	23	35
3	Site 3	4	80	15	34	35
4	Site 4	2	57	20	29	42
5	Site 5	5	29	31	30	30
6	Site 6	4	54	13	NA	22
7	Site 7	3	58	17	32	39
8	Site 8	3	36	18	19	20
9	Site 9	5	59	15	27	36
10	Site 10	4	25	18	20	19
11	Site 11	2	42	17	19	19
12	Site 12	4	51	21	25	37
13	Site 13	2	46	20	23	29
14	Site 14	3	32	17	23	27
15	Site 15	3	52	55	26	35
16	Site 16	2	36	15	20	20
17	Site 17	3	42	18	24	33
18	Site 18	2	34	23	23	24
19	Site 19	4	48	20	23	25
20	Site 20	3	49	19	21	30
21	Site 21	3	45	12	29	35
22	Site 22	2	50	18	20	36
23	Site 23	2	45	17	23	29
24	Site 24	5	40	21	30	39
25	Site 25	3	39	18	33	32
Maximum / Minimum		-	**80/25**	**55/12**	**33/19**	**42/19**
AVERAGE		-	**45.32**	**19.84**	**25.16**	**30.40**

Table 2: Natural **thoron activity** levels in the indoor environment at different locations inBq/m^3

S.No.	Locations	No. of sample	Seasons			
			Winter(Bq/m^3)	**Summer**(Bq/m^3)	**Rainy**(Bq/m^3)	**Autumn**(Bq/m^3)
1	Site 1	4	31	19	21	31
2	Site 2	3	20	18	20	29
3	Site 3	4	37	15	30	34
4	Site 4	2	41	20	23	39
5	Site 5	5	26	30	27	27
6	Site 6	4	24	13	NA	21
7	Site 7	3	18	17	31	37
8	Site 8	3	29	15	19	20
9	Site 9	5	42	13	25	31
10	Site 10	4	19	17	20	19

S.No.	Locations	No. of sample	Seasons			
			Winter(Bq/m^3)	**Summer**(Bq/m^3)	**Rainy**(Bq/m^3)	**Autumn**(Bq/m^3)
11	Site 11	2	28	10	19	18
12	Site 12	4	38	20	23	32
13	Site 13	2	36	19	21	24
14	Site 14	3	30	16	23	26
15	Site 15	3	39	23	19	32
16	Site 16	2	29	14	18	19
17	Site 17	3	32	19	23	31
18	Site 18	2	31	20	21	22
19	Site 19	4	31	17	27	20
20	Site 20	3	37	18	24	26
21	Site 21	3	32	11	28	31
22	Site 22	2	41	16	21	28
23	Site 23	2	31	15	19	23
24	Site 24	5	29	20	29	34
25	Site 25	3	35	17	31	31
Maximum / Minimum		-	**41/18**	**30/10**	**31/19**	**39/18**
AVERAGE		-	**31.44**	**17.28**	**23.41**	**27.25**

In the present study, the observed result shows that during winter season, indoor radon activity varies from 25 Bq/m^3 to 80 Bq/m^3 with an average of 45.32 Bq/m^{3}where as thoron activity levels varies from 18Bq/m^3 to 41Bq/m^3 with an average value of31.44Bq/m^3. In summer season indoor radon activity levels varies from 12Bq/m^3 to 55 Bq/m^3 with an average of 19.84 Bq/m^{3}thoron activity levels varies from 10Bq/m^3 to 30Bq/m^3 with an average value of17.28Bq/m^3.In rainy season indoor radon activity level varies from 19 Bq/m^3 to33 Bq/m^3 with an average of 25.16 Bq/m^{3}thoron activity levels varies from 19Bq/m^3 to 31Bq/m^3 with an average value of 23.41Bq/m^3. In autumn season indoor radon activity levels varies from 19 Bq/m^3 to 42 Bq/m^3 with an average of 30.40 Bq/m^{3}whereas thoron activity levels varies from 18Bq/m3 to 39Bq/m3 with an average value of 27.25 Bq/m^3. Observed result shows that in winter season the indoor radon and thoron activity levels was found maximum (80Bq/m^3 and 41Bq/m^3) and minimum (12 Bq/m^3 and 10Bq/m^3) in summer season.Observed data represent that the radon and thoron activity levels (concentration) is maximum in winter and minimum in summer. The maximum activity levels in winter aredue to intense temperature inversion which generally occurs in winter season when the wind velocity is low. The maximum activity levels in this season is also the result of decreased ventilation as the doors and windows of the houses are closed for maximum time which results in accumulation of radon inside the room. The radon and thoron activity levels (concentration) gradually decreases towards summer and monsoon. Due to high temperature and low pressure in summer, the radon and thoron activity levels are decreases. Due to strong south west wind velocity and heavy precipitation in the monsoon season, a decrease in radon and thoron activity levels was found. Decrease of radon and thoron activity levels is also due to the saturation of soil with water during the monsoon season. The result obtained in different seasons for radon measurement show variations due to change in design of the houses, geology of the soil, moisture in the atmosphere, temperature, pressure, humidity, ventilation, and wind speed. In summer season people lives self-ventilated, houses keep open which result the minimum radon concentration. Based on the result, it was also concluded that the activity concentration of radon and thoron levels are largely influenced by the factors such topography, temperature, humidity, atmospheric pressure, type of houses construction, building materials and ventilation. As temperature increases virtual mixing and rising of aerosol and dust particles to higher altitude as a result there will be the reduction in aerosol and dust particles near the surface of earth and hence the radon and thoron activity levels i.e. concentration decreases. As the temperature increases, the humidity decreases which results in the maximum vertical mixing and rising of dust particles and vice versa. In a national radon survey done by BARC, Mumbai and published by Head, Library and information services Division in September 2003, the minimum and maximum concentration of radon in India was reported 4.6 Bq/m^{3}and 147.3 Bq/m^3 respectively. The result obtained in the present work was found below the recommended action level (147Bq/m^3) as set by International Commission on Radiological Protection [5] and Environmental protection Agency [17, 18].

IV. CONCLUSIONS

The observed values of natural radon/ thoron activity levels measured at different locations in four different seasons winter, summer, rainy and autumn at different locations of the study area are given in the table 1 &2. Based on the results, it was found that the natural radon/thoron activity levels are maximum in winter season whereas minimum in summer season. The maximum activity levels in winter are due decreased ventilation because in winter season the houses are closed for long time and radon accumulated inside the room. The minimum value of radon-thoron activity levels in summer is due to fact that the house are open for a large time and therefore most of the radon-thoron gas escaped away from the house. Also the decreased radon and thoron activity level towards summer is also due to thehigh temperature and low pressure in summer. Obtained result shows that natural radon and thoron activity levels were found below the recommended action level (147Bq/m^3) as set by International Commission Thus the study area is safe from radiation protection point of view.

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