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Advances in Applied Science Research, 2011, 2 (5): 421-426

ISSN: 0976-8610
CODEN (USA): AASRFC

Monitoring of indoor radon and its progeny in dwellings of Delhi using SSNTDs

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ABSTRACT

The study of radon and its progeny in dwellings is important as exposure to radon (^{222} Rn) can result in to a significant inhalation risk to population particularly to those living in homes. Radon and its radioactive daughters present in the environment results into the largest contribution to the average effective natural radiation dose received by human beings. In the present study, the indoor radon activity has been calculated using LR-115 type II solid state nuclear tracks detectors (SSNTDs). The radon activity in the corresponding dwellings has been found to vary from (43.5 ± 12.0) to (334.7 ± 33.5) Bqm^{-3} with an average value (166.9 ± 23.0) Bqm^{-3}. The annual effective dose received due to radon and its progeny by the inhabitants in the dwellings under study has also been calculated which found to vary from (1.5 ± 0.4) to (11.3 ± 1.1) mSv y^{-1} with an average value of (5.6 ± 0.8) mSv y^{-1}.

Key words: Indoor radon, LR-115 Type-II SSNTDs, annual effective dose.

INTRODUCTION

It has been found that radon, which is a topic of health concern, a ubiquitous indoor air pollutant in dwellings to which all persons are exposed [1, 2]. Radon has been identified as the second leading cause of lung cancer after tobacco smoking. Studies have shown that 5-20% of all lung cancer deaths are attributing to the inhalation of air containing radon and its progeny. Radon, ^{222}Rn is an inert radioactive element with a half-life of 3.8 days produced by the decay of ^{226}Ra, as an inert gas, radon can move freely through the soil from its source, the distance is determine by the factors such as rate of diffusion, effective permeability of the soil and by its own half-life [3].

The elevated levels of ^{222}Rn could be present in certain type of human dwellings. The inhalation of short-lived daughter products of naturally occurring ^{222}Rn forms a major contribution to total radiation dose to exposed subjects. The solid α-active decay products of radon (^{218}Po, ^{214}Po) become airborne and attach themselves to the dust particle and water droplets in the atmosphere. When inhaled, these solid decay products along with air may get deposited in the trachea-bronchial (T-B) and pulmonary (P) region of lungs resulting in the continuous irradiation of the cells by α-particle, which may cause lung cancer [4,5]. Radon is present in trace amount, almost everywhere (indoor and outdoor) on the earth. The concentration of radon in the atmosphere varies, depending on the place, time and the height above the ground and metrological condition. Radon and its decay products may pose a significant health hazards, especially when concentrate in some enclosures such as underground mines, caves, cellars or poor ventilated and badly designed houses. A concern for home owners is the possibility that radon gas could accumulate to dangerous levels.

The interest in the study of radon is mainly due to detrimental effect on human health. Keeping the radiation hazards of radon for general population in mind radon measurements have been carried out in a number of dwellings of Delhi.

MATERIALS AND METHODS

The method involved exposure of the film to the indoor environment for a known period of time, during which the alpha particles from radon and its daughters would leave tracks on the film. LR-115 type II solid state nuclear track detectors (SSNTDs) were employed for measuring the potential alpha energy concentration (PAEC) of radon progeny in working level (WL) units. LR-115 type II is an alpha sensitive detector and records alpha particles of range 0.1 to 4 MeV and is unaffected by electrons, x-rays and γ-rays. A small strip of LR-115 type II solid state nuclear tracks detector film of size 2 × 2 cm. fixed on a thick flat card was exposed in "bare mode". Several detectors were mounted at different locations such as drawing room, kitchen and bed room, inside the dwellings for a period of 100 days, such that detectors viewed a hemisphere of radius at least 6.9 cm. and can record alpha particle from a hemisphere of air of this radius which corresponds to the range of alpha particles from ^{214}Po [3]. No surface was closer than this range as the decay products would acts as an indeterminate source of α-particles. Detectors were mounted vertical and locations were so selected that dust collection on the detectors to be minimum. After an exposure time of 100 days, detectors films were etched in 2.5N NaOH solution at 60^0 C for 90 min. in a constant temperature water bath. Then, these SSNTDs were washed, dried and scanned under a binocular microscope with a magnification of 400× track density measurements.

All α-particles that reach the LR-115 type II SSNTDs with a residual energy are registered as bright track holes. The track density on the bare track detector is related to the potential alpha energy concentration expressed in Working Level (WL) units. WL is the concentration of any combination of radon progeny corresponds to 1.3×10^{5} MeV of PAE per litre of air. The track density registered in the bare detector will, therefore, be a function of radon progeny concentration in air. The radon concentration (R_n) in (Bq m^{-3}) is calculated using the following relation [6, 7].

$$R_n = WL \times 3700]/ F$$

The equilibrium factor (F) for radon has been taken as 0.4 as suggested by UNSCEAR, 2000 [8]. To obtain the Potential Alpha Energy Concentration (PAEC) of radon progeny in mWL, it is essential that LR-115 type II detector films should be calibrated with a known radon concentration under the conditions almost similar to those which prevail in Indian dwellings. For this purpose, the detectors were calibrated in a radon exposure chamber at the facility available at the Environmental Assessment Division of Bhabha Atomic Research Centre, Mumbai [9, 10]. The mean calibration factor for LR-115 type II detector was found to be 442 tracks $cm^{-2}d^{-1}$ per WL. The effective dose equivalent to the occupant of the house estimated from PAEC levels. The estimation based on the conversion factor of 4mSv/WLM recommended by ICRP, 1994 [11] for home exposure condition based on epidemiological approach.

RESULTS AND DISCUSSION

Table 1 presents the measurements made for PAEC values of radon daughters in WL units, radon concentration in Bqm^{-3}**,** and annual effective dose in mSv to the occupant of the dwellings of Delhi. A total of 57 exposures were made at different locations inside the dwellings. The PAEC obtained values vary from 4.7 ± 1.3 to 36.2 ± 3.6) mWL with an average value of 18.0 ± 2.5 mWL. The significant value of radon activity varies from 43.5 ±12.0 to 334.7 ± 33.5 Bqm^{-3} with an average value of 166.9 ± 23.0 Bqm^{-3}**.** Annual effective dose varies from 1.5 ± 0.4 to 11.3 ± 1.1 mSv y^{-1} with an average value of 5.6 ± 0.8 mSv y^{-1}**.** Results show higher indoor radon levels and radon effective does especially in kitchen as compared to other locations. High values of radon activity may be due to ventilation condition and use of water and cooking gas in kitchen. Gas, whether natural or from oil, comes from ground and contain so many radioactive elements. Radon concentration was found to be lowest in bed room.

Table: 1 Indoor Radon Levels in Dwellings of Delhi

S.No.	Location	Potential alpha energy concentration (PAEC) (mWL)	Radon activity (Bqm^{-3})	Annul effective dose (mSv y^{-1})
1.	Kitchen	26.1 ± 3.1	241.1 ± 28.4	8.2 ± 1.0
2.	Kitchen	17.4 ± 2.5	160.7 ± 23.1	5.4 ± 0.8
3.	Kitchen	8.7 ± 1.8	80.3 ± 16.4	2.7 ± 0.6
4.	Kitchen	30.8 ± 3.3	284.6 ± 30.7	9.6 ± 1.0
5.	Kitchen	16.3 ± 2.4	150.6 ± 22.6	5.1 ± 0.8
6.	Kitchen	20.0 ± 2.7	184.1 ± 24.8	6.2 ± 0.8
7.	Kitchen	36.2 ± 3.6	334.7 ± 33.5	11.3 ± 1.1
8.	Kitchen	9.4 ± 1.8	87.0 ± 17.1	2.9 ± 0.6
9.	Kitchen	12.7 ± 2.2	117.1 ± 20.1	4.0 ± 0.7
10.	Kitchen	18.1 ± 2.6	167.3 ± 23.6	5.7 ± 0.8
11.	Kitchen	12.0 ± 2.1	110.1 ± 19.2	3.7 ± 0.6
12.	Kitchen	18.8 ± 2.6	174.1 ± 24.2	5.9 ± 0.8
13.	Kitchen	20.3 ± 2.7	187. 5 ± 25.1	6.3 ± 0.8
14.	Kitchen	20.3 ± 2.7	187.1 ± 25.1	6.3 ± 0.8
15.	Kitchen	22.4 ± 2.8	207.6 ± 26.4	7.0 ± 0.9
16.	Kitchen	36.2 ± 3.6	334.7 ± 33.5	11.3 ± 1.1
17.	Kitchen	10.5 ± 1.9	97.0 ± 18.0	3.3 ± 0.6
18.	Kitchen	9.4 ± 1.8	87.0 ± 17.1	2.9 ± 0.6
19.	Kitchen	16.7 ± 2.5	154.0 ± 22.6	5.2 ± 0.8

20.	Kitchen	36.2 ± 3.6	334.7 ± 33.5	11.3 ± 1.1
21.	Bed Room	12.7 ± 2.1	117.1 ± 20.0	4.0 ± 0.7
22.	Bed Room	30.4 ± 3.3	281.2 ± 31.0	9.5 ± 1.0
23.	Bed Room	4.7 ± 1.3	43.5 ± 12.0	1.5 ± 0.4
24.	Bed Room	16.6 ± 2.4	153.5 ± 22.6	5.2 ± 0.8
25.	Bed Room	25.3 ± 3.0	234.0 ± 27.8	7.9 ± 1.0
26.	Bed Room	18.8 ± 2.6	173.9 ± 24.2	5.9 ± 0.8
27.	Bed Room	6.5 ± 1.5	60.1 ± 14.2	2.0 ± 0.5
28.	Bed Room	23.5 ± 2.9	217.4 ± 27.0	7.4 ± 0.9
29.	Bed Room	11.6 ± 2.0	106.4 ± 18.8	3.6 ± 0.6
30.	Bed Room	14.1 ± 2.2	130.4 ± 20.9	3.6 ± 0.6
31.	Bed Room	31.8 ± 3.4	294.1 ± 31.5	9.9 ± 1.0
32.	Bed Room	7.2 ± 1.6	66.9 ± 15.0	2.3 ± 0.5
33.	Bed Room	15.6 ± 2.4	143.4 ± 21.8	4.8 ± 0.7
34.	Bed Room	21.3 ± 2.8	197.5 ± 25.7	6.7 ± 0.9
35.	Bed Room	25.3 ± 3.0	234.0 ± 28.0	8.0 ± 1.0
36.	Bed Room	11.9 ± 2.1	110.4 ± 19.2	3.7 ± 0.6
37.	Bed Room	9.4 ± 1.8	87.0 ± 17.1	2.9 ± 0.7
38.	Bed Room	28.6 ± 3.2	264.4 ±29.6	8.9 ± 1.0
39.	Bed Room	10.8 ± 2.0	100.4 ± 18.3	3.4 ± 0.6
40.	Drawing Room	14.1 ± 2.2	130.5 ± 20.9	4.4 ± 0.7
41.	Drawing Room	25.3 ± 3.0	234.0 ± 28.0	7.9 ± 0.9
42.	Drawing Room	24.6 ± 3.0	227.6 ± 27.5	7.7 ± 0.9
43.	Drawing Room	21.7 ± 2.8	200.7 ± 26.0	6.8 ± 0.9
44.	Drawing Room	22.8 ± 2.9	210.9 ± 26.6	7.1 ± 0.9
45.	Drawing Room	13.5 ± 2.2	123.9 ± 20.3	4.2 ± 0.7
46.	Drawing Room	15.5 ± 2.3	143.9 ± 21.9	4.9 ± 0.7
47.	Drawing Room	10.5 ± 1.9	97.0 ± 18.0	3.3 ± 0.6
48.	Drawing Room	15.9 ± 2.4	147.2 ± 22.2	5.0 ± 0.7
49.	Drawing Room	7.2 ± 1.6	68.3 ± 15.3	2.3 ± 0.5
50.	Drawing Room	15.2 ± 2.3	140.6 ± 21.6	4.8 ± 0.7
51.	Drawing Room	8.3 ± 1.7	77.0 ± 16.0	2.6 ± 0.5
52.	Drawing Room	19.2 ± 2.6	177.4 ± 24.3	6.0 ± 0.8
53.	Drawing Room	12.7 ± 2.1	116.5 ± 19.7	4.0 ± 0.7
54.	Drawing Room	13.7 ± 2.2	127.2 ± 20.6	4.3 ± 0.7
55.	Drawing Room	26.1 ± 3.1	240.5 ± 28.4	8.1 ± 0.9
56.	Drawing Room	28.9 ± 3.2	267.3 ± 29.9	9.0 ± 1.0
57.	Drawing Room	9.0 ± 1.8	83.6 ± 16.7	2.8 ± 0.6
	Average value	*18.0 ±2.5*	*166.9 ±23.0*	*5.6 ±0.8*
	S.D.	*8.0 ±0.6*	*74.2 ±5.2*	*2.5±0.2*
	Rel. std%	*44.4 ±24.0*	*44.4 ±22.6*	*44.6±25.0*

Table: 2. Comparison of indoor radon levels with some other studies of the Area

Radon activity (Bqm^{-3})	Region
58-240	Punjab
37-134	Rajasthan
145-165	Himachal Pradesh
42-168	Palampur (H.P.)
30-287	Tamilnadu
44-373	Kerala
13.5-143	All India
66-104	Northern Haryana
43.5-334.7	Delhi (Present Study)

The main object of this measurement was to see indoor radon level and its daughters. The International Commission on Radiation Protection [12] has recommended that remedial action against radon and its progeny is justified above a continued effective dose of 3-10 mSv y^{-1} has been proposed. The action level for radon activity should be in the range 200-600 Bqm^{-3}. The measured values are below the recommended action levels. A comparison of radon levels in the dwellings of neighboring states is present in Table 2 [13].

CONCLUSION

The radon activities were measured in dwellings of Delhi. The LR-115 type II detectors were mounted for 100 days with all information collected in questionnaires for each dwelling. Significant variation of radon concentration was found in the different type of rooms. Kitchens show the maximum radon activity may be due to the contribution of radon from fuels (gas, kerosene etc.) and water. Annual effective dose has been calculated from radon concentration to carry out the assessment of the variability of expected radon exposure of the population due to radon and its progeny. It is found that radon activity and radon effective dose rate depend upon many factors inside the dwellings. Ventilation plays an important role as far as the problem is concerned. Computed data indicates that region is safe without posing significant radiological threat to population.

Acknowledgement
The authors would like to express our thanks to the residents of the study areas for their cooperation during the research work. Sincere thanks are also due to Dr. Amit Roy, Director, Inter-University Accelerator for providing constant temperature water bath and microscope for the analysis of radon concentrations.

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