Study Of Indoor Levels of Radon and Its Daughter Products Using Solid State Nuclear Track Detectots

A. Rawat*

Abstract

The major part of the average annual radiation dose to man is due to inhalation of short-lived radon and its progeny. Different geological regions produce and emanate different amounts of radon. In dwellings radon and its progeny concentrations depend on several factors such as soil building materials etc. and vary considerably according to the season of the year. In the present study measurements of radon levels in Agra (UP, India) have been made. LR-115 type II plastic track detectors were exposed in 'Bare' mode to the ambient air in different types of rooms for about 100 days. The average potential alpha energy level measured is found to vary from 4.40 mWL to 9.54 mWL. The average internal exposure dose to the tracheobronchial and pulmonary regions of lungs shows a variation from 1.63 mSv Y^{-1} to 3.52 mSv Y^{-1}.

DOI Number: 10.48047/nq.2020.18.8.NQ20213 **NeuroQuantology 2020; 18(8):121-125**

1. INTRODUCTION

Radon is a noble gas and has a half-life of 3.82 days. The decay products Ra-A Ra-B. Ra-C and Ra-C are short lived and remain airborne by aching to the aerosol particles present in the air. Radon escapes from rock, soil or groundwater containing Radium-226 in different concentrations[1-3]. It is present in the atmosphere and can accumulate in enclosures like rooms, caves, cellars and basements since it has a fairly long half-life. The atmospheric content of Rn varies from 3.7 to 18.5 Bq m^{-3} depending on the time of the day and the season of the year while the concentration of radon in an enclosure may build up to as high as 7.8 x 10^3Bq m^{-3}[4,5].

Exposure of persons to high concentrations of radon and its short-lived progeny for a long period leads to pathological effects likes the respiratory functional changes and the occurrence of lung cancer[6-8] indicates that inhalation of short-lived radon daughters seems to be the most important component of the radiation exposure of the population from natural sources. A limited data is available for exposure[9-13] . According to this data, the risks appear to be consistent with the earlier estimates that are based on the data of mine workers. Therefore, to assess the population lung cancer risk due to the indoor radon exposure, the data of mine workers is usually considered. A number of models for calculation of the lung cancer risk due to the indoor radon exposure have been reported in the literature[14-16].

Radon and its daughter's concentration reduces as the ventilation rate increases and vice-versa. Measurement, carried out by Porstendorfer et al[17] have shown that the indoor radon concentration is greatly influenced by exhalation and ventilation. Atmospheric parameters like temperature, pressure etc also influence the indoor radon levels, very considerably with the reasons of the year.Since the types and materials of the construction of houses, topography and meteorological conditions very regionally, measurements should be made in different regions for the whole year in order to determine a reliable average pollution dose in the region. Significant

***Corresponding Author:**A. Rawat
Address:*Department of Physics, M. S. J. Govt. PG College, Bharatpur- 321001, Rajasthan, India
Email: anandmsj@gmail.com

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

variation in the winter to summer ratio of radon concentration has been reported[18]. For the estimation of effective dose equivalent from radon daughters in dwellings, it is necessary to know PAEC (Potential alpha energy concentration) of radon daughters in working level(WL) units. PAEC can be calculated if the equilibrium factor F between radon and its progeny is known Solid State Nuclear Track Detector (SSNTD), which are the best for long term measurement; have been used in the present measurements.

2. EXPERIMENTAL

Several techniques like the measurement of alpha particles by scintillators, thermo-luminescent dosimeters and plastic nuclear track detectors are used to measure radon and its daughter concentration in dwellings. All these methods cannot be used for environmental monitoring on a large scale since some of them are laborious, time consuming and uneconomical. We have used track detector method for the measurement of radon and its daughters concentration[19-21]. Radon and its daughters' concentration have been measured in different types of rooms of dwelling in Agra, Uttar Pradesh (India).Radon decays to Ra-A which decay to Ra-B, to Ra-C and to Ra- C. Ra-C is highly short-lived (1.5 x 10^{-5} sec). Thus, the important short-lived daughters are essentially Ra-A, Ra-B and Ra-C. Measurement of the concentrations of these nuclides lead to the calculation of working level (WL) of radon daughters. The WL is given by the relation-

$$WL = (2.8 \times 10^{-5} \times X) + (1.4 \times 10^{-4} \times Y) + (1.0 \times 10^{-4} \times Z)$$

where X, Y and Z are the concentrations of Ra-A, Ra- B and Ra-C respectively in

For the measurement of radon and its daughter's concentration we have used LR-115 type - II plastic track detector. This detector has been used by many workers[20-23]. LR-115 type II track detector consists of a sensitive deep red dyed cellulosenitrate layer of 12 um thickness on a 100 µm thick polyester support so that a track that penetrates the thin red layer produces a white hole on a red back ground. This gives LR-115 type-II its high optical contrast features and makes the counting of tracks easier. This detector is manufactured by DOSIRAD, France and Kodak Pathe, France.LR-115 is an alpha sensitive detector recording alpha tracks up to 4 MeV, thus free from uncertainties due to plate out effects. The detectors were exposed in bare mode for which small places (2 cm x 2 cm) of detectors were mounted on thick flat card. These detectors were fixed at different locations in different dwellings for a period of about 100 days and due to being in contact with ambient air could record tracks of alpha particles originated from radon as well as airborne radon daughter products. After exposure the detectors were collected from different locations and etched in 2.5 N NaOH at 60° C for 90 min. for revelation of tracks due to latent damage produced in them. The tracks were counted using an optical research microscope with magnification 450 X. The whole area of each detector was scanned to get average track density and to minimize the uncertainties due to counting statistics.

3. RESULTS AND DISCUSSION

To obtain the activity concentration from measured track density, the calibration experiment was performed by SubbaRamu and coworkers[19] in controlled conditions at BARC, Bombay simulating theatmosphere. The calibration curve enabled to estimate the potential alpha activity in Working Level ' units. Taking the equilibrium factor as 0.45 for Indian dwellings[24], radon concentration in Bq $m^{-3}$was calculated using the relation-

$$Rn = [3700 \times WL] / F$$

The exposure dose to the basal thin layer of Trachea Bronchial Pulmonary regions are also calculated in terms of the effective dose equivalents using the conversion factor 9 mSv/WLM[25]. The standards set for the upper limits of radon exposure by different agencies are given below:

(A) STANDARDS SET BY AEC BOARD, CANADA

If the inhalation exposure due to radon is

(i) > 550 Bq m^{-3}, Immediate provisional intervention.

(ii) > 80 Bq m^{-3}, General limit, Ventilation should be improved.

(iii) > 40 Bq m^{-3}, Investigation limit.

(B) STANDARDS SET BY EPA OF USA

If the inhalation exposure due to radon is –

(i) > 190 Bq m^{-3}, Immediate intervention desirable.
(ii) 40-190 Bq m^{-3}, Intervention considered.
(iii) < 40 Bq m^{-3}, No intervention.
(iv) 15 Bq m^{-3}, Normal background concentration.

Table-1 shows the results for the average track density, potential alpha energy, radon concentration and effective dose equivalent whereas the figures 1-5, show the radon concentration (Bq m^{-3}) obtained from the measurements carried out in different dwellings. The potential alpha activity has been found to vary from 34.40 mWL to 9.52 mWL. The radon concentration varies from 36.14 Bq$m^{-3}$to 78.28 Bqm^{-3}.The internal exposure dose to the Trachea - Bronchial and Pulmonary region of lungs shows a variation from 1.63 mSv Y^{-1} to 3.52 mSvY^{-1} The results obtained from the present measurements compare well with the previous measurements in India[20,26-29]. In India, the measurements carried out so far have shown the potential alpha energy in dwellings varies from 0.2 mWL to 178.2 mWL and the radon concentration[30] from 3.5 Bq m^{-3} to 880 Bq m^{-3}. Results also show that the radon concentration depends on ventilation conditions of the rooms[17]. In each dwelling the radon concentration is maximum in store rooms. because in dwellings the store rooms have poor ventilation conditions. It has also been observed that the radon concentrations in kitchens are quite high. The reason for this is that in all the kitchens under investigation, LPG was used as a cooking fuel and the average radon concentration in LPG has been estimated to be about 700 Bq m^{-3}as reported by Gesell[31].

Table-1

S.No.	Dwellings	Tr cm^{-2} d^{-1}	mWL	Bq m^{-3}	mSv Y^{-1}
Ist	Drawing Room	2.30	4.79	39.40	1.77
	Bed Room	2.16	4.50	37.00	1.66
	Kitchen (Exhaust)	2.95	6.15	50.53	2.27
	Store Room	4.23	8.81	72.46	3.26
IInd	Drawing Room	2.35	4.90	40.26	1.81
	Bed Room	2.51	5.23	42.99	1.93
	Kitchen (Exhaust)	2.83	5.90	48.48	2.18
	Store Room	4.33	9.02	74.17	3.33
IIIrd	Drawing Room	2.23	4.65	38.20	1.72
	Bed Room	2.11	4.40	36.14	1.63 min.
	Kitchen (Exhaust)	3.62	7.54	62.01	2.79
	Store Room	4.38	9.12	75.03	3.37
IVrth	Drawing Room	2.51	5.23	42.99	1.93
	Bed Room	2.17	4.52	37.17	1.67
	Kitchen (Exhaust)	3.57	7.44	61.15	2.74
	Store Room	4.42	9.21	74.71	3.40
Vth	Drawing Room	2.43	5.06	41.62	1.87
	Bed Room	2.21	4.60	37.86	1.70
	Kitchen (Exhaust)	3.59	7.48	61.50	2.76
	Store Room	4.57	9.54	78.28	3.52 max.

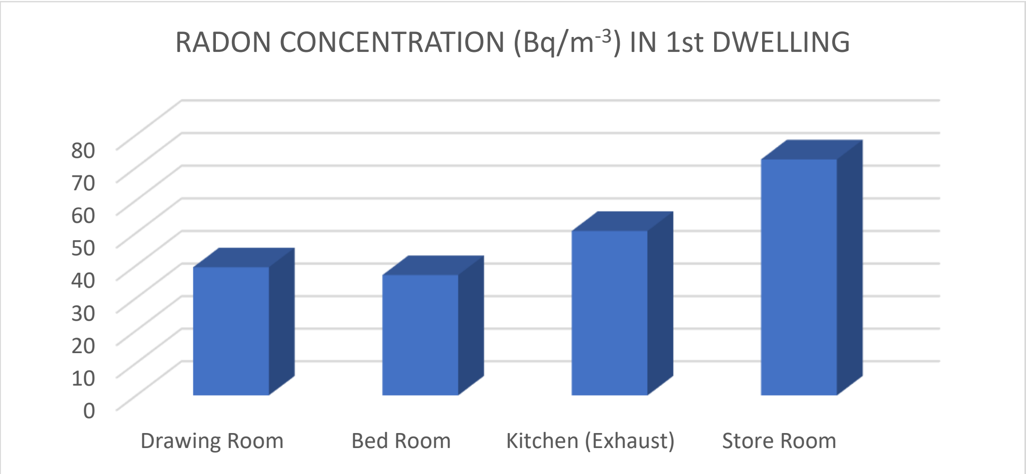

Fig. 1

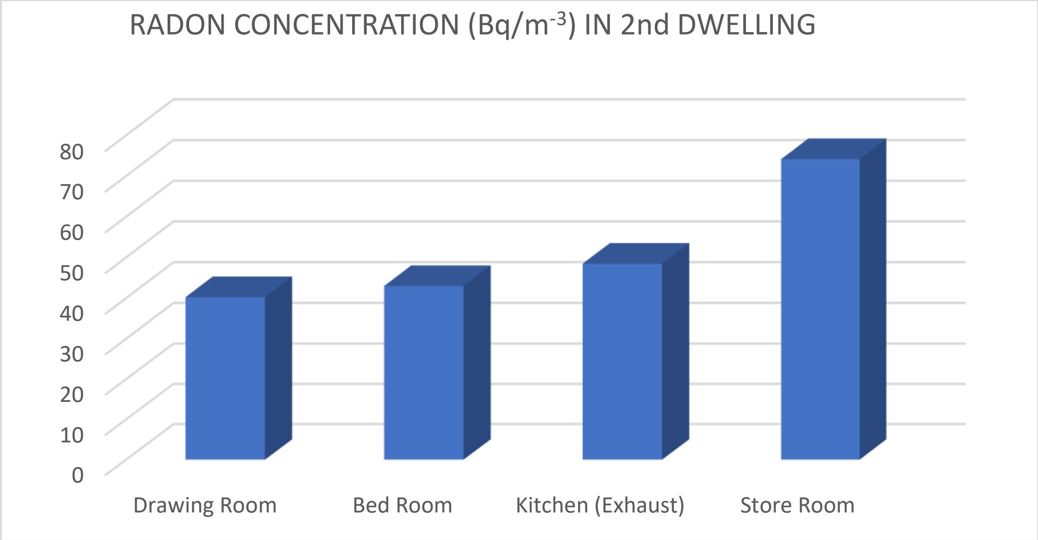

Fig. 2

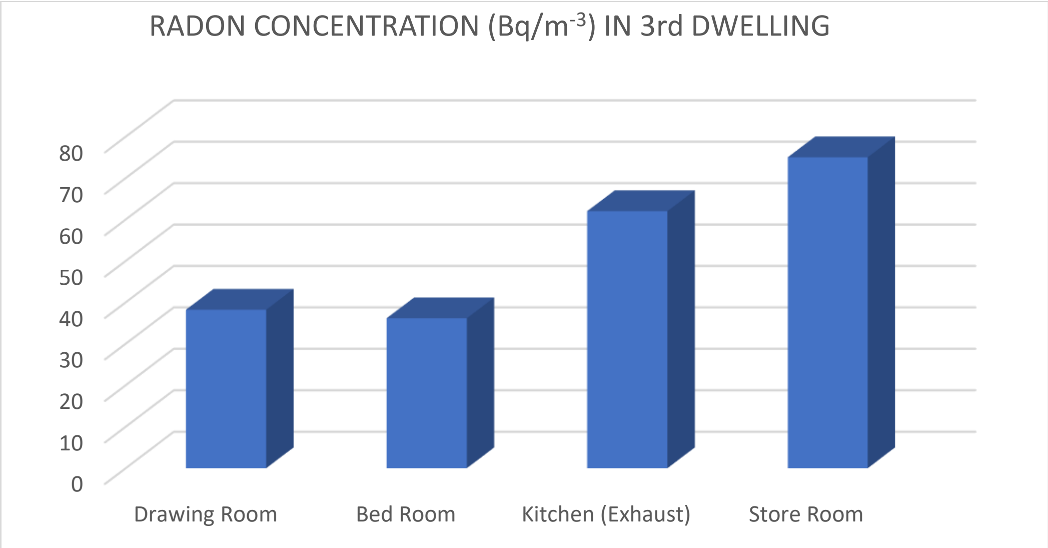

Fig. 3

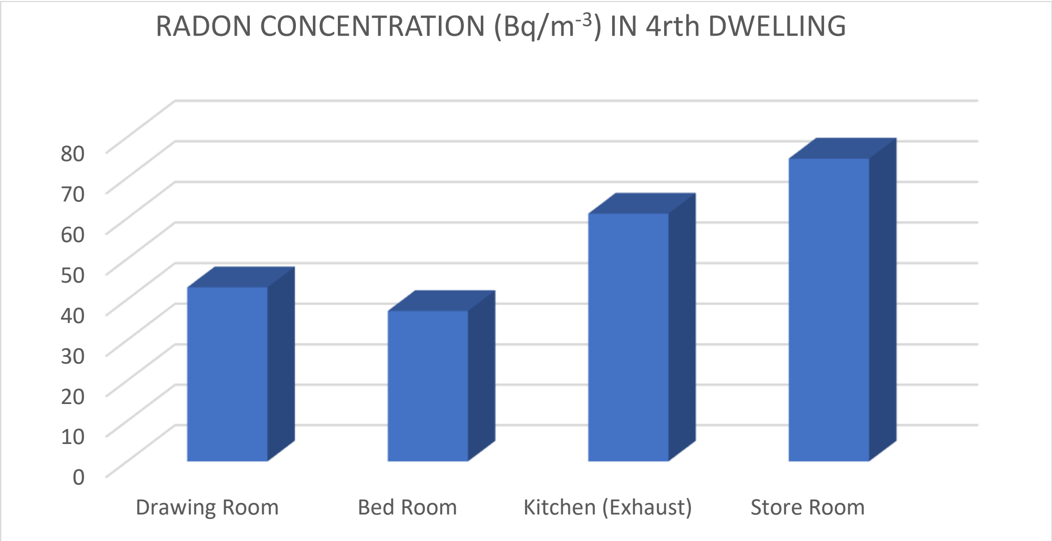

Fig. 4

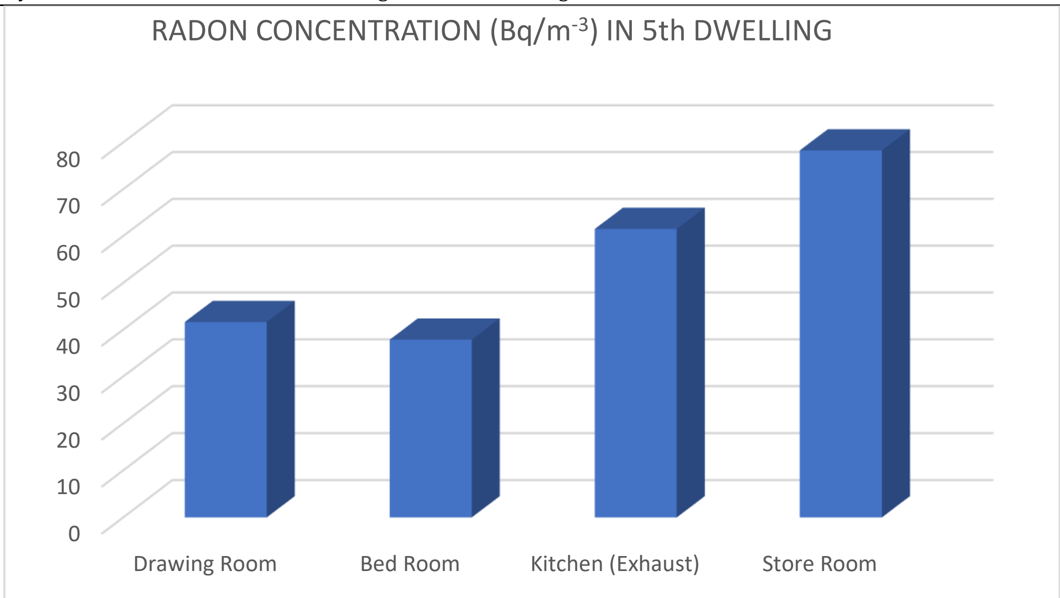

Fig. 5

4. REFERENCES

1. Edsfeldt C. (2001) Ph.D. Thesis, Royal Institute of Technology, Stockholm, Sweden.
2. Musa L.S.M.(2003) Ph.D Thesis Faculty of Health Science, Linkoping, University, Sweden.
3. Sasaki T., GunjiY. and Okuda T., (2004) Nuclear science and Technology 45. 843-849.
4. Hess C. T. Weiffenbach C.V. And Norton S.A. (1983) Health phys. 45, 2, 339.
5. Ramachandran T.V., SubbaRamu M.C. And Mishra V.C. (1990) Current science, 59(20) 979-82
6. BEIR (1972) Biological Effect of lonizing Radiation, National Academy of science US.
7. Jocobi, W. (1983) TIC,US, Dept. Energy. p-3.
8. NRC(National Research Corencel) (1999), National Academic press, Washington D.C.
9. ICRP 60, (1990) International Commission on Radiological Protection, Publication 60, Pergamon Press, Oxford UK.
10. Pershagen LZ Hrubec, Z., Svenson C and Boice J. D. (1992) Health phys. 63, 179-186.
11. Field RW, Steck DJ, Smith BJ, Brus C.P, Fisher EL, Neuberger, J.S., Platz CE, Robinson R.A. Woolson RF and Lynch CF (2000) America Journal of Epidemiology 151, 1091-1102.
12. Field, R.W. (2001). Reviews on Environmental Health preprint 16, 151-167.
13. Field, R.W. and Beckere (2001) Radiation protection Dosimetry, 95, 75-81.
14. NCRP (1984) Report No. 78.
15. EPA (1986) Report, EPA -86-005, US Environmental Protection Agency, Washington, DC.
16. UNSCEAR (1988) United Nations Scientific Committee on the Effects of the Atomic Radiation, Report to the General Assembly.
17. Porstendorfer J. and Mercer T.T.(1978), Atmospheric Environmental, 12. 2223-2238.
18. Abu-Jarad F. Fremlin J.H., (1984) Health phys. 46, 1126-1129.
19. SubbaRamu M.C., Shaikh A.N., Muraleedharan T.S. And Ramachandran T.V. (1992) Deffence Science Journal 42, 4, 219-225.
20. Kumar A, Jojo P.J. Singh A.K., Rawat A. and Prasad R. (1993) Proc. 2 nd National Symposium on Environment Jodhpur.
21. Yu K.N., Nikezic D, Ng F.M.F and Leung J.K.C(2005) Radiation Measurements, 40, 560-568.
22. Amgarou K., Font L. and Baixeras C. (2003) Nucl. Instrum. Meth. A 506, 186-198
23. Nikezic D, Ng E.M.F. and Yu K.N. (2004) Applied Radiation and Isotopes 61, 1431-1435.
24. SubbaRamu M.C., Ramachandran T.V. and Muraleedharan T.S. (1988) Radiation Protection Dosimetry 22, 187-191.
25. ICRP (1986) ICRP Publication-50.
26. Khan A.J., Varshney A.K. Prasad R. and Tyagi R.K. (1987) Nucl. Tracks Rad Meas. 13,1, 77-80.
27. Ramola R.C., Singh M, Singh S. and Virk H.S.(1987) Indian J. of Pure andApplied Phys. 25, 127-129.
28. Kumar S. Gopalani D., Ramaseshu, P., Gehlot G.S. and Nagaratnam A. (1989), Bull. of Rad. Prot. 12,3, 33-35.
29. SubbaRamu M.C., Ramachandran T.V., Muraleedharan T.S. And Shaikh A.N. (1990) Radiation Protection Dosimetry 30, 41-44.
30. Ramachandran TV. Muraleedharan T.S., Shaikh G.N. and SubbaRamu M.C. (1989) Proc. Of 16 Annual Conference of Radiation Protection, Jan 9-12, Bombay.
31. Gesell, T.F. (1975) Health phys. 29, 681-687.