International Journal of Innovative Research & Growth
E-ISSN: 2455-1848
homepage: http://www.ijirg.com/ijirg/
Volume: 15 Issue: 3, July 2026

Measurement of Indoor/Outdoor Radon Concentration in Bhadohi District of Eastern Uttar Pradesh using LR-115 Type II Plastic Track Detector (SSNTD´s)

Santosh Kumar Prajapati[1*], Padam Singh[2]
[1,2]Department of Physics, Mahamaya Rajkiya Mahavidyalay Dhanupur Handia Prayagraj-221503, U.P., India

CORRESPONDING AUTHOR

Santosh Kumar Prajapati
e-mail: santosh150794p@gmail.com

KEYWORDS

SSNTDS, Dosimeter, Indoor /Outdoor Environment, Residential Building.

ARTICLE DETAILS

Received 11 June 2026; revised 20 July 2026; accepted 24 July 2026

DOI: 10.26671/IJIRG.2026.3.15.175

CITATION
Prajapati, S. K., Singh, P. (2026). Measurement of Indoor/Outdoor Radon Concentration in Bhadohi District of Eastern Uttar Pradesh using LR-115 Type II Plastic Track Detector (SSNTD´s). *Int J Innovat Res Growth*, 15(3), 153049-153054. DOI

Abstract

A study of indoor radon dwelling of Bhadohi Uttar Pradesh, India. Radon is a colorless and odorless radioactive gas. Radon has been a natural component of the air we breathe. Radon is an invisible radioactive gas that occurs naturally in the indoor atmosphere. It comes from the naturally breakdown of uranium in soils and rocks. Lung cancer risk depends upon the concentration of radon, thoron and their decay product in air. Measurement of indoor radon concentration was carried out in the residential housdes, indoor and outdoor environment of district Bhadohi, Uttar Pradesh using solid state nuclear track detector (SSNTDs). Radon exists in soil gas, building materials, Indoor atmosphere etc. Solid state nuclear track detector using 25 dosimeters in indoor and 25 dosimeters in outdoor, the radon concentration were measured in total 50 dwellings of Bhadohi district in the eastern U.P.in the winter season and inhalation dose in (mSv/y). Significant variation of radon concentration was found in the different type of houses. A study of indoor/ outdoor radon dwelling of Bhadohi Uttar Pradesh, India. This paper presents the experimental calibration of LR-115 type II plastic track detectors for monitoring environmental radon. The indoor/ outdoor concentration however depends on various factors viz. ventilation condition, type of construction seasonal variation and geology of the area. Radon in dwellings originates from walls, floors and ceilings and also depends on the construction material. The conditions prevailing in India eastern region in the Utter Pradesh with respect to people's life-styles, building construction type, topography and meteorological parameters are greatly different. Concentration of Radon measured in different houses, SSNTDs technique is used for present work in selected indoor/outdoor environments. Detector mounting for three months. Detector used in Bare on card mode and Dosimeter. Most of the houses in Bhadohi district are houses with typical construction their dense population, different geological and environment conditions which provide a wide scope of radon studies in this area. A result of measurements of radon concentration in Bhadohi (India) are presented.

1. Introduction

Radon is a colorless and odorless radioactive gas. Radon has been a natural component of the air we breathe. Natural radiation is present throughout the biosphere due to radioactive elements and their decay products in the earth. The monitoring of indoor radon levels has acquired a significant importance all over the world from the public health point of view. Radon in dwellings originates from walls, floors and ceilings and also depends on the construction material. The conditions prevailing in India eastern region in the Utter Pradesh with respect to people's life-styles, building construction type, topography and meteorological parameters are greatly different. I visited Bhadohi district. I found some specific reason of the eastern U.P. (Bhadohi district) to measure the radon concentration level by using the method of LR-115 type II plastic track detector. In present investigation concentration of Radon measured in different houses, SSNTDs technique is used for Sample mounted in Bhadohi district dividing it into five parts east, south, north, west and central region. 5 sample mounting in each region, five indoor environment and 5 outdoor environments. I visited Bhadohi Gopiganj, Aurai, Gyanpur Suriyawan in Bhadohi district. I found some specific reason of the eastern U.P. (Bhadohi district) to measure the radon concentration level by using the method of LR-115 type II nuclear track detector for research work and I mounted the nuclear track detector in the we were choosing Bhadohi district some specific reason. It is very useful for measurement of radon concentration. Detector mounting for three months. Detector used in Bare on card mode and Dosimeter. The sample exposure in these conditions: (a) ventilation rate~ 1 h-1, (b) ventilation rate>1 h-1, and(c) closed rooms. Most of the houses in (Bhadohi district) are houses with typical construction their dense population, different geological and environment conditions which provide a wide scope of radon studies in this area.

2. Experimental Details

Radon are invisible, odorless, heavy and radioactive gases which are present in dwellings and in the environment. LR-115, Type- II plastic track detectors commonly known as solid state nuclear track detectors (SSNTDs) used to measure the radon concentration. The measurements were carried out in the field of radon and the detectors were exposed for about 30 days. The passive time-integrating method of using a solid-state nuclear track detector was employed for measuring the Potential Alpha Energy Concentration (PAEC) of radon daughters in Working Level (WL) units. The LR-115 type II track detector was used in bare mode. The piece of detector film (1 cm x 1 cm) fixed on a thick flat card was exposed for a period of 3 months. The tracks registered in the detector due to alpha particles. The detectors were placed in the room where the occupants of the house spent most of their time. The detectors were either hung in an interior surface or placed on a horizontal surface so that it was exposed to room air. To obtain the PAEC of radon daughters in WL, it is essential to calibrate the detectors with known radon daughter concentrations in a radon chamber under conditions almost similar to those which prevail in Indian dwellings. The calibration experiment was performed under controlled conditions and the details of the experiment are given elsewhere. The PAEC in WL of radon daughters was calculated by using the calibration factor. After the exposure, the detectors were brought back to the laboratory and chemically etched in 2.5N NaOH solution at 60±1°C for 2 hours in a constant temperature water bath. The resulting tracks due to alpha particles from radon progeny were counted by using a research microscope under magnification of 100 X.The results of these measurements are shown in tables. Present the measured radon concentration distributions and show that in all five places radon concentrations vary appreciably from dwelling to dwelling. The radon distributions in the present measurements are found to be approximately log-normal in Bhadohi district (Uttar Pradesh). Measurements to collect enough data to separate the houses with higher concentrations from those houses with lower concentrations to find features responsible for the difference. I used this type of LR-115 film, mounting nuclear track detectors in specific areas.

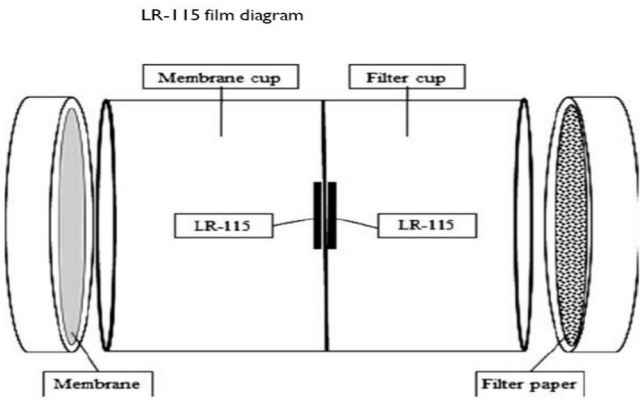

Fig.1 LR115 Nuclear track detector.

Table-1: Radon levels in District: Bhadohi District

Sample location in Area	Detector code	Track density rate (Tracks cm^{-2} d^{-1})	PAEC (m WL)	Concentration of Radon (Bq/m^3)
Bhadohi	BS1	5.06	5.90	46.40
	BS2	4.73	5.95	55.04
	BS3	4.72	7.59	72.84
	BS4	6.15	8.16	75.48
	BS5	4.44	5.50	51.30
Gopiganj	BS6	3.86	5.56	47.74
	BS7	5.26	6.11	58.52
	BS8	4.63	6.25	49.25
	BS9	4.70	8.59	69.56
	BS10	6.22	8.72	80.60
Aurai	BS11	3.93	5.52	47.83
	BS12	3.74	6.69	57.78
	BS13	5.67	7.49	69.29
	BS14	6.32	6.52	49.12
	BS15	7.03	6.13	85.21
Gyanpur	BS16	3.98	5.77	47.10
	BS17	3.75	6.72	54.31
	BS18	5.76	6.52	73.40
	BS19	6.64	4.30	70.83
	BS20	2.78	6.05	56.97
Suriyawan	BS21	3.91	4.60	53.72
	BS22	5.70	6.55	70.83
	BS23	4.73	5.23	57.60
	BS24	2.31	6.30	51.02
	BS25	5.44	7.72	80.47

Table 2: Observed Indoor Radon concentration and Outdoor Radon concentration at different area in Bhadohi

Sample Location in Area	Detector code	Concentration of Radon (Bq/m^3) Indoor	Concentration of Radon (Bq/m^3) Outdoor
Bhadohi	BS1	46.30	25.95
	BS2	54.98	33.40
	BS3	71.84	40.99
	BS4	75.48	45.56
	BS5	50.32	28.17
Gopiganj	BS6	48.11	25.30
	BS7	57.51	33.25
	BS8	49.10	26.98
	BS9	68.98	40.75
	BS10	81.60	46.09
Aurai	BS11	44.30	25.85
	BS12	55.78	32.82
	BS13	68.29	36.59
	BS14	50.62	30.57
	BS15	76.21	42.97

Gyanpur	BS16 BS17 BS18 BS19 BS20	44.12 55.31 70.48 69.82 57.96	26.98 32.61 41.25 38.33 31.98
Suriyawan	BS21 BS22 BS23 BS24 BS25	42.90 73.84 56.50 49.02 81.48	30.77 49.91 36.79 26.01 56.98
Minimum Concentration		44.12 Bq/m³	25.30 Bq/m³
Maximum Concentration		81.48 Bq/m³	56.98 Bq/m³
Average Concentration		58.92 Bq/m³	32.24 Bq/m³

The value of radon progeny (PAEC) in mWL for radon progeny was estimated by using the following equation

$$Cp\ (m\ WL) = \ / K.\ t$$

The SSNTD sensitive plastic track detectors provide a very useful and less expensive, method for integrated radon measurements (Frank and Benton., 1977; Fleischer et al., 1980) generally two plastic detectors have been used for this. The radon concertation C measured by α- sensitive plastic detectors is related to the track density ρ and the time of exposure t by the formula (Abu-Jarad et al. 1980).

$$\rho = K.C.t$$

K is the sensitivity factor with a valuse which depend on the configuration of the detectors Viza -viz its surroundings, and also on the etching conditions used, Although the value of K can be calculated for different geometries (Fleischer et a., 1980). The calculation is not very straight forward except in the case of "BARE" detector mode (Abu Jurad et al., 1980). It is always preferable to use the calibrated value of K obtained from laboratory calibration experiments using a standard radon chamber. Where is corrected track density in tracks/cm², t is the exposure time and K is the calibration or sensitivity factor. The average calibration factor for LR-115 type II plastic in the BARE on card mode reaches 625 T $cm^{-2}d^{-1}$ WL. Calibration factor for LR-115 radon detectors in BARE on card mode. (D. S. SRIVASTAVA, P. SINGH, N. P. S. RANA, A. H. NAQVI, A. AZAM, T. V. RAMACHANDRAN and M. C. SUBBA RAMU Nucl. Geo phys. Vol. 9, No. 5, pp. 487-495, 1995, Copyright f 1995 Elsevier Science Ltd.) For the measurement of radon concentration (in Bq/m³).

$$C_{Rn}\ (Bq/m^3) = WLconc. \times 3700/\ F_R$$

$$C_{Rn}\ (Bq/m^3) = PAEC\ (mWL) \times 3.7\ /\ F_R$$

F_R = equilibrium factor (0.4) in Indoor environment
F_R = equilibrium factor (0.7) in Outdoor environment
C_{Rn} = radon concentration in Bq /m³.
PAEC (mWL) = potential a-particle energy concentration
ρ = corrected track density in tracks/cm² K =sensitivity factor
K =sensitivity factor
t = time of exposure
Where F_R is the equilibrium factor for radon having the value 0.4 given by UNSCEAR [UNSCEAR, 2000]. The radon levels or PAEC values (in mWL) calculated by using the equations

$$PAEC\ (mWL\ ) = C\ n \times F\ /\ 3.7$$

Where, F_R is equilibrium factors for radon and having the value of 0.4 [UNSCEAR, 2000]. Most of the houses in Jaunpur and Mirzapur district are houses with typical construction their dense population, different geological and environment conditions which provide a wide scope of radon studies in this area.

3. Results and Discussion

Table 1 and 2 gives the PAEC levels of radon daughters in WL and track production rate (tracks cm d per WL) along with the calibration factor (tracks T cm d /WL) for BARE on card mode and dosimeter. It is seen that the average calibration factor for LR-115 type II plastic in the BARE on card mode and dosimeters reaches 625 T cm d per WL. It is seen that the values of calibration factor for a LR-115 detector are slightly more than those reported by Ramachandran et. al. (1988). This difference may be due to use of a different manufacturing batch and also due to differences in etching conditions. Hence, it is desirable to have detectors from each batch

calibrated before using them for environmental radon measurements. The values of radon concentrations in typical ground floor rooms Indoor and Outdoor environment of Bhadohi city are much less than those levels causing concern (150 Bq m).

4. Conclusion

The radon concentrations were measured in 50 dwellings of district of eastern U.P.in the Indoor and Outdoor environment. Significant variations of radon concentrations were found in the different types of houses. The different types of houses show the maximum or minimum radon concentration. These high values may be due to high emanation from the ground surface and from the building materials of the house. The minimum and maximum value of radon concentration. The data in the tables (1) and (2) shows that the region is in safe limit from the radiation protection point of view. Significant variations of radon concentrations were found in the different types of houses. The different types of houses show the maximum or minimum radon concentration. The concentration of radon inhalation dose present in the dwellings at different places of the Bhadohi city of Utter Pradesh, India. The indoor concentration of radon varies from to Bq/m³ with an average value of Bq/m³ and the outdoor concentration of radon varies from 25.30 to 56.98 Bq/m³ with an average value of 32.24 Bq/m³ so no action required. The values of inhalation dose are also found lower than the worldwide average background radiation dose [UNSCEAR,2000] of 2.4 mSv/these high values may be due to high emanation from the ground surface and from the building materials of the house. This difference may be due to use of a different manufacturing batch and also due to differences in etching conditions. Hence, it is desirable to have detectors from each batch calibrated before using them for Environmental radon measurements. The primary source of radon and its progeny in the dwellings are the soil adjacent to the building material. The indoor concentration however depends on various factors viz. ventilation condition, type of construction seasonal variation and geology of the area. We were choosing the some- II plastic track detector. Bhadohi district is the dense region we would like to check the radon level in environment of certain areas. Bhadohi district was selected for our study because of their dense population different geological conditions and environment. We studied radon concentration in different houses, environment in these districts. 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 concentration. All the measurements took place at noon/night in winter seasons. However, the recorded values of radon the resulting gases fall well below the internationally-recommended levels, which clearly indicates that the houses in Bhadohi Eastern Uttar Pradesh are quite safe in terms of protection from any radiation (Rawat et al., 2011). 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. The concentration maximum in winter, in the winter the doors closed for long hours since in summer, the houses' doors are open for a long time, which in turn increases the rate of air exchange. This is the possible cause for radon variation. The results of Radon concentration and its progeny will help the scientists and environment a list to establish the radiation and safety standards for human beings. The LR-115 type II plastic tracks detectors provide a very useful and less expensive, method for integrated radon measurements.

Acknowledgements

The authors are thankful to the residents of dwellings in District Bhadohi (Uttar Pradesh) for allowing the detectors to be placed in their living rooms and outdoor environment. The experimental support received from Prof. Padam Singh (Associate Professor) in Mahamaya Rajkiya Mahavidyalay Dhanupur Handia Prayagraj is thankfully acknowledged.

Conflict of Interest

The author declares no conflict of interest.

Funding Information

This research received no external funding.

Author Contribution Statement

Santosh Kumar Prajapati Conceptualization, Data curation, Formal analysis, Investigation, Methodology, writing original draft, Padam Singh– Review the manuscript and methodology.

References

[1] Abu Jarad F., Fremlin J. H., Bull R. (1980). A study of radon emitted from building materials using plastic-track detectors. *Phys. Med. Biol.* 25, 683-694.

[2] Azam, A., Rana, N. P. S., Singh, P., Naqvi, A. H., Srivastava, D. S. (2000). Radon progeny (WL) concentration studies in different kind of rooms using LR-115 type-II plastic track detector. In *Solid state nuclear track detectors and applications* (pp. 263–267). Guru Nanak Dev University.

[3] Cherouati, D.E., Djeffali, S., Durrani, S. A. (1988). Calibration factor for LR- 115 detectors used for measurement of aepha activity from radon. *Nucl. Track Radiat, Meas.* 15, 583-586.
[4] Fleischer, R. L., Giard, W. R., Mogro-Campero, A., Turner, L. G., Alter, H. W., Gingrich, J. E. (1980). Dosimetry of environmental radon: Methods and theory for low-dose, integrated measurements. Health Physics, 39(6), 957–962.
[5] Frank, A. L., Benton, E. V. (1979). Radon dosimetry using plastic nuclear track detectors. Nuclear Tracks, 3(4), 149–179.
[6] International Commission on Radiological Protection. (1987). Lung cancer risk from indoor exposures to radon daughters: A report of a task group of the International Commission on Radiological Protection. Annals of the ICRP, 17(1), 1–60.
[7] Jonsson G. (1988). Indoor Radon Measurement is Sweden with solid state nuclear track detector technique, *Health Phys.* 54, 271.35.
[8] Kumar, A., Saxena, A., Rawat, R.B.S., Sharma, D. (2014). Natural Radioactivity levels in some village in Shahjahanpur Uttar Pradesh, India. *IJRSI,* 32 (12), 1-3.
[9] Ramachandran, T. V., Muraludharan, T. S., Subba Ramu, M. C. (1990). Calibration of nuclear track detectors for the measurement of indoor radon and thoron levels. *Ind. J. Phys*. 64 A, 365- 374.
[10] Ramachandran, T. V., Subba Ramu, M. C. (1994). Variation of equilibrium factor between Radon and its short-lived decay product in an indoor Atmosphere. *Nucl. Geophys*., 8,499-503.
[11] Ramachandran, T. V., Subba Ramu, M. C., Mishra, U. C. (1988). *Assessment of radiological effect of indoor radon progeny* (BARC Report No. 1432*)*. Bhabha Atomic Research Centre.
[12] Rawat, R.B.S., Kimar, A., Singh, I. (2011). A Comparative study of environment indoor radon and thoron in Shahjahanpur and Hardoi district of Central Uttar Pradesh. *Recent Resear. Sci. Techn*., 3(6), 19-21.
[13] Singh, M., Singh, N. P., Singh, S., Virk, H. S. (1986). Calibration of radon detectors. *Nuclear Tracks and Radiation Measurements*, 12(1–6), 739–741.
[14] Singh, P., Rana, N. P. S., Azam, A., Naqvi, A. H., Srivastava, D. S. (1996). Levels of uranium in waters from some Indian cities determined by fission track analysis. Radiation Measurements, 26(5), 683–687.
[15] Singh, P., Rana, N. P. S., Naqvi, A. H., Srivastava, D. S. (1993, October 27–29). Quantitative determination of uranium in water samples from Jhansi and Allahabad. *VIII National Symposium on Solid State Nuclear Track Detectors (SSNTD),* Aligarh Muslim University, Aligarh, India.
[16] Somogyi, G. (1986). *Track detection methods of radium measurements* (Report No. ATOMKI-E-25). Magyar Tudományos Akadémia, Atommag Kutató Intézete (ATOMKI). https://inis.iaea.org/records/9jd7t-01y74
[17] Srivastava, D. S., Naqvi, A. H., Singh, P., Rana, N.P.S., Azam A. (1993). Radon measurement inside some rooms in the A.M.U. campususing LR-115 type II plastic track detectors, Proc. At *Conference-cum Workshop on Radiation Standard and Measurement, B.A.R.C., Bombay*. Jan. 4-6, pp. 23-24.
[18] Srivastava, D. S., Singh, P., Rana, N. P. S., Naqvi, A. H., Azam, A., Ramachandran, T. V., & Subba Ramu, M. C. (1995). Calibration factor for LR-115 type II track detectors for environmental radon measurements. *Nuclear Geophysics*, 9(5), 487–495.
[19] Subba Ramu, M. C., Shaikh, A. N., Muraleedharan, T. S., Ramachandran, T. V., Nambi, K. S. V. (1991, October 9–11). Environmental radon monitoring in India: A plea for a national effort. *National Conference on Particle Tracks in Solids*, Jodhpur, India.
[20] United Nations Scientific Committee on the Effects of Atomic Radiation. (2000). *Sources and effects of ionizing radiation: United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2000 report to the General Assembly, with scientific annexes:* Volume I: Sources. United Nations. https://doi.org/10.18356/49c437f9-en