

Radon Exhalation Rates from Some Soil Samples of Nangal, Punjab

Vimal Mehta¹, R P Chauhan³ and G S Mudahar²

¹Deptt of Physics, M. M. University, Mullana (Ambala)-133 207, India

²Deptt of Physics, Punjabi University, Patiala- 147 001, India

³Deptt of Physics, National Institute of Technology, Kurukshetra- 136 119, India

Corresponding author: mehta_vimal78@yahoo.co.in

Abstract:-Radon and its progeny are major contributors in the radiation dose received by general population of the world. Radon is the second leading cause of lung cancer in North America and the leading cause of lung cancer for individuals who have never smoked. It was also the first respiratory occupational carcinogen ever to be identified. Radon is a decay product of radium that itself is a part of uranium decay series. Uranium is a naturally occurring radioactive material and can be found in trace amount in most rocks and soils. Because radon is a noble gas, a large portion of it is free to migrate away from radium. A sufficient quantity of radon migrates out of rock and soil in the environment. The primary sources of indoor radon are soils and rocks source emanations, off-gassing of waterborne radon into a building, emanation from building materials, and entry of radon into a structure from outdoor air. Keeping this in mind the study of radon exhalation rate from some soil samples of the Nangal, Punjab has been carried out using Can Technique. The equilibrium radon concentration in various soil samples of Nangal area of Punjab varied from 8.3 Bqm⁻³ to 64.6 Bqm⁻³ with an average of 33.4 ± 11.2 Bqm⁻³. The radon mass exhalation rates from the soil samples varied from 0.28 to 2.2 mBq/kg/h with an average of 1.2 ± 0.4 mBq/kg/h and radon surface exhalation rates varied from 6.4 to 52.8 mBq/m²/h with an average of 27.1 ± 9.1 mBq/m²/h. The radon mass and surface exhalation rates of the soil samples of Nangal, Punjab were lower than that of the world wide average.

Keywords: Radon; SSNTD; Mass exhalation rate; Surface exhalation rate

1. Introduction

Radioactivity in the environment is the biggest concern for the human beings. Due to unawareness about it, this becomes a potential risk for living things. In 1956 a term "Radiation Ecology" came into existence to denote this area of the broad field of ecology concerned with the assessment of radioactivity in the environment. The development and subsequent expansion of nuclear energy for military and peaceful purposes has been accompanied by environmental problems. The problems are primarily concerned with the ecological effects of radionuclides released into the environment, effects of ionizing radiation on man, his domesticated plants and animals. Natural radioactivity is common in the rocks, soil, water, oceans that make up our planet, and in our building materials. The world is naturally radioactive, and around 90% of human radiation exposure arises from natural sources such as cosmic radiations. The naturally-occurring radionuclides of interest are uranium, thorium, actinium series elements ⁴⁰K and ¹⁴C. These radionuclides are of main concern due to their relative long half-lives and are principal sources of exposure of natural radiation. Since these radionuclides are not uniformly distributed, the knowledge of radionuclides distribution and radiation levels in the environment is important for assessing the effects of radiation exposure to human beings. Natural radioactivity is widespread in the earth's environment and it exists in various geological formations in soils, rocks, plants, water and air (Ibrahiem et al., 1993; AlyAbdo et al., 1999). Some of the radionuclides from these sources may be transferred to human beings through food chain or inhalation.

Radionuclides such as ²²²Rn and ²²⁰Rn and their daughter products represent sources of internal radiation exposure to man from inhalation from indoor air. As it was realized that most individuals spend 90% of their time indoors, so indoor air quality became important to those responsible for protection against adverse health effects caused by the inhalation of these radionuclides. Uranium and radium are naturally occurring radioactive elements present in trace amounts throughout the earth's crust. The decay of radium leads to radon in the environment (indoor and outdoor), soil, ground water, oil and gas deposits. The inhalation of short-lived decay products of radon (²²²Rn) accounts on average about 55% of the effective equivalent dose on the human being. ²²²Rn is part of the ²³⁸U decay chain and is frequently generated close to it. Migration of ²²²Rn is limited mainly by its 3.824 day half-life. Radon appears mainly by diffusion processes from the point of origin following α -decay of ²²⁶Ra in underground soil and building materials used in the construction of floors, walls, and ceilings. Due to the potentially serious public health implications of exposure to high levels of radon, the measurement of radon exhalation rates from some soil samples of Nangal area of Punjab has been carried out using canister technique.

2. Materials and methods

For the measurement of radon concentration and exhalation rates from soil samples the “Canister Technique” (Abu-jarad, 1988) used by many groups (Khan et al., 1992; Chauhan and Chakarvarti, 2002; Sonkawade et al., 2008; Mahur et al., 2008; Gupta et al., 2009; Nain et al., 2010) has been adapted. The exhalation rate is the amount of radon emanated from a given sample per unit mass (for mass exhalation rate) or per unit surface area (for surface exhalation rate) per unit time. The materials samples under study from different locations were dried in oven at 110 °C for 24 hours to remove the moisture. The samples were finely powdered and sieved through 100-mesh sieve. A known amount 100g of fine powder of the samples was placed in different cylindrical canister having dimension similar to that used in calibration process by Singh et al., (1997). The LR-115 plastic track detector is fixed on the bottom of the lid of each can with tape such that sensitive side of the detector always faced the specimen.

The can is tightly closed from the top and sealed as shown in Fig. 1. At the end of the exposure time (~100 days), the detectors are removed and subjected to a chemical etching process in 2.5 N NaOH solution at 60±0.5°C for 90 minutes in a constant temperature water bath. The etched detectors are thoroughly washed and then immediately after the completion of washing, the red sensitive layer is stripped because of spark counting (not in case of optical counting). The stripping is quite easily done by pinching one of the corners of the film between the thumb and the index finger. All that is then required is to pull the sensitive layer in a direction parallel to the base until the two are completely separated. The dried detectors are then used for alpha counting using a spark counter. The detectors were first pre-sparked at 900 V twice and then tracks were counted at 500 V twice.

From the track density (track/cm²/day), the radon activity was obtained in Bqm⁻³, using the calibration factor of 0.056 tr. cm⁻² d⁻¹/Bqm⁻³ obtained from an earlier calibration experiment(Singh et al. 1997).The radon mass and surface exhalation rates from the soil sample can be calculated by following relation

$$E_A = \frac{CV\lambda}{A(T + \frac{1}{\lambda}(e^{-\lambda T} - 1))} \quad (1)$$

$$E_M = \frac{M(T + \frac{1}{\lambda}(e^{-\lambda T} - 1))}{M(T + \frac{1}{\lambda}(e^{-\lambda T} - 1))} \quad (2)$$

Where C is equilibrium radon activity inside the canister, V and A are volume and area of cross-section of the canister, M is the mass of the sample and λ is the radon decay constant, T is the time of exposure.

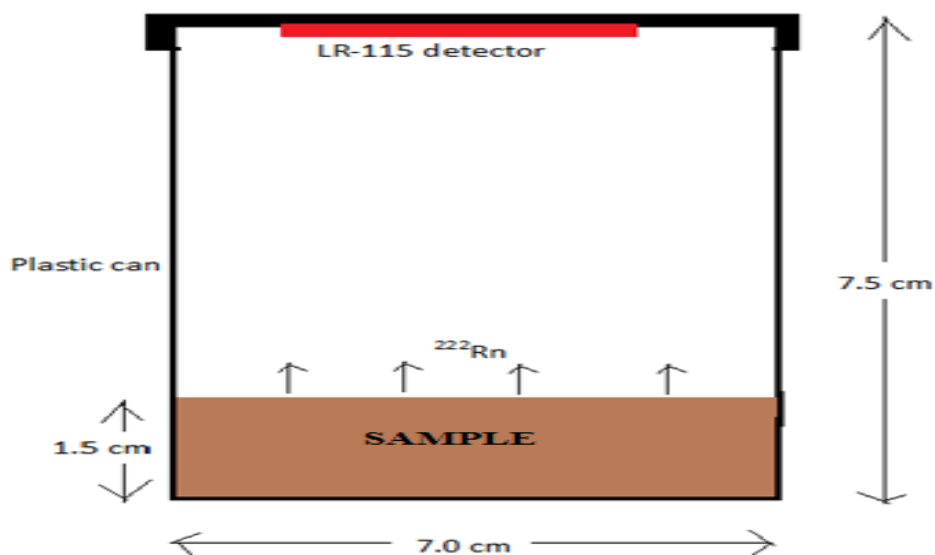


Fig. 1: The plastic can used for the measurement of equilibrium radon concentration and exhalation rates from different soil samples.

3. Results and discussion

The values of exhalation rates found were tabulated in Table 1. The radon concentration in various soil samples of Nangal, Punjab varied from 8.3 Bqm⁻³ to 64.6 Bqm⁻³ with an average of 33.4 ± 11.2 Bqm⁻³. The radon mass exhalation rates from the soil samples varied from 0.28 to 2.2 mBq/kg/h with an average of 1.2 ± 0.4 mBq/kg/h and radon surface exhalation rates varied from 6.4 to 52.8 mBq/m²/h with an average of 27.1 ± 9.1 mBq/m²/h.

Table 1: Equilibrium radon concentration, radon mass and surface exhalation rates from soil samples of Nangal, Punjab

Sr. No.	Location	Equilibrium Radon conc. (Bqm ⁻³)	Mass exhalation rate (mBqkg ⁻¹ h ⁻¹)	Surface exhalation rate (mBqm ⁻² h ⁻¹)
1	Vill. Chhotewal	8.3	0.28	6.4
2	Vill. Passiwal	23.2	0.84	19.4
3	Vill. Patti	55.2	2.1	44.4
4	Municipal Council Nangal	15.8	0.54	12.5
5	Vill. Takhatgarh	64.6	2.2	52.8
AM ± SE		33.4 ± 11.2	1.2 ± 0.4	27.1 ± 9.1

- AM(arithmetic mean); SE (standard error) = σ/\sqrt{N} , Where σ is SD (standard deviation) and N is the no. of observations; Vill.(Village)

4. Conclusion

- The radon exhalation rates of soil sample collected from the study area are nearly the same having not much difference. The radon exhalation rates from soil samples are less than the world wide average (UNSCEAR, 2000).
- The measurements indicate normal levels of natural radioactivity in soil samples of the study area.

References

- [1] Abu-Jarad F., Application of nuclear track detectors for radon related measurements, Nucl. Tracks Rad. Meas. **15(1-4)** (1988) 525.
- [2] AlyAbdo A.A., Hassan M.H. and Huwait M.R.A., Radioactivity assessment of fabricated phosphogypsum mixtures, in Fourth Radiation Physics Conference, 15-19 November, Alexandria, Egypt, (1999) 632.
- [3] Chauhan R.P. and Chakarvarti S.K., Radium concentration and Radon exhalation measurements in the water around thermal power plants of north India, Indian J. Pure & Appl Phys. **39** (2002) 491.
- [4] Gupta M., Saini M., Chauhan R.P., Measurement of alpha radioactivity in some building construction materials, Asian J. Chem. **21(10)** (2009) S052.
- [5] Ibrahiem N.M., Abdel-Ghani A.H., Shawky S.M., Ashraf E.M. and Farouk, M.A., Measurement of radioactivity levels in soil in the Nile Delta and Middle Egypt, Health Phys. **64** (1993) 620.
- [6] Khan A.J., Tyagi R.K. and Prasad R., Measurement of radon exhalation rate from some building materials, Nucl. Tracks Radiat. Meas. **20** (1992) 609.
- [7] Mahur A.K., Kumar R., Mishra M., Sengupta D. and Prasad R., An investigation of radon exhalation rate and estimation of radiation doses in coal and fly ash samples, Appl. Radiat. Isotop. **66** (2008) 401.
- [8] Nain M., Gupta M., Chauhan R.P., Kant K., Sonkawade R.G. and Chakarvarti S.K., Estimation of radioactivity in tobacco, Indian J. Pure & Appl. Phys. **48** (2010) 820.
- [9] Singh A.K., Jojo P.J., Khan A.J., Prasad R. and Ramachandran T.V., Calibration of track detector and measurement of radon exhalation rates from soil sample, Radiat. Prot. Environ. **20** (1997) 129.
- [10] Sonkawade R.G., Kant K., Muralithar S., Kumar R. and Ramola R.C., Natural radioactivity in common building construction and radiation shielding materials, Atm Environ. **42(9)** (2008) 2254.
- [11] UNSCEAR: Sources and Effects of Ionizing Radiation. Report to the General Assembly with Scientific Annexes, United Nations Scientific Committee on the Effects of Atomic Radiation, New York (2000).