Estimation of Radon Exhalation Rate and Radium Content in Soil Samples of Pathankot District, Punjab Using LR-115 Plastic Detector

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Abstract

In the present investigation, soil samples were collected from 10 villages belonging to Pathankot district, Punjab, India and assessed for radium content using LR-115 plastic detector. The 'track etch' technique has been employed for measuring the radium content. From the radium content, radon exhalation rates and mass exhalation rates were calculated for these samples. The mass exhalation rate in soil samples has been found to vary from 1.91 mBqkg-1h-1 to 6.55 mBqkg-1h-1 and radium concentration varies from 1.39 Bq/Kg to 5.31 Bq/kg. A strong correlation (correlation coefficient= 0.99) has been observed between radium and radon exhalation rate. The radium content in soil in the study area is below the safe limit recommended by UNSCEAR [1].

Keywords

Radon Exhalation Rate, Radium Content in Soil, LR-115 Plastic Detector

I. Introduction

Uranium is the ultimate source of radium and radon in the soil and rocks. Radium is a solid radioactive element under ordinary conditions of temperature and pressure. It decays to radon emitting α-particles followed by γ-radiations. It is the concentration of radium which governs how many radon atoms are formed. How many of the produced radon atoms leave i.e. emanate from, the mineral grain or matter and enter the pore spaces depends on; where the radium atoms are situated in the grain, the texture and size of the grain, the permeability of the grains, temperature and pressure [2-5]. The inhalation of radon and its daughter products can cause a significant health hazard when present in enhanced levels in the enclosed indoor environments like a human dwelling. The alpha particles emitted from Rn222 and two of its daughter elements viz. Po214 and Po218 are highly effective in damaging the tissue and are considered to be a causative agent for lung cancer in human beings. The measurements of radon thus necessitate the need for radium and radon exhalation rate estimation in the parent source for public health risk measurements.

To estimate the radon risk it is necessary to check correlation between radium concentration and the radon exhalation rate. If uranium rich material lies close to the surface of earth there can be high radon exposure hazards [6,7]. Radium and radon exhalation studies have been carried out in Hamirpur, Kullu and Una districts of Himachal Pradesh [8]. However in the present investigation, the survey has been carried out first time for the measurements of radium and radon exhalation rate from some soil samples of some areas of Pathankot district, Punjab . The aim of the work is to estimate the radium and radon content for health risk assessments in the study area.

II. Experimental Technique

A. Radium Concentration and Radon Exhalation Measurements

The 'can technique' of Abu-Jarad (1988) [9] has been used for the measurement of radium and radon exhalation rates in soil samples as shown in fig. 1. About 250 gms of the soil sample was placed in an emanation chamber (1 litre glass bottle) which was then closed for a period of three weeks in order to get equilibrium between radium and radon.

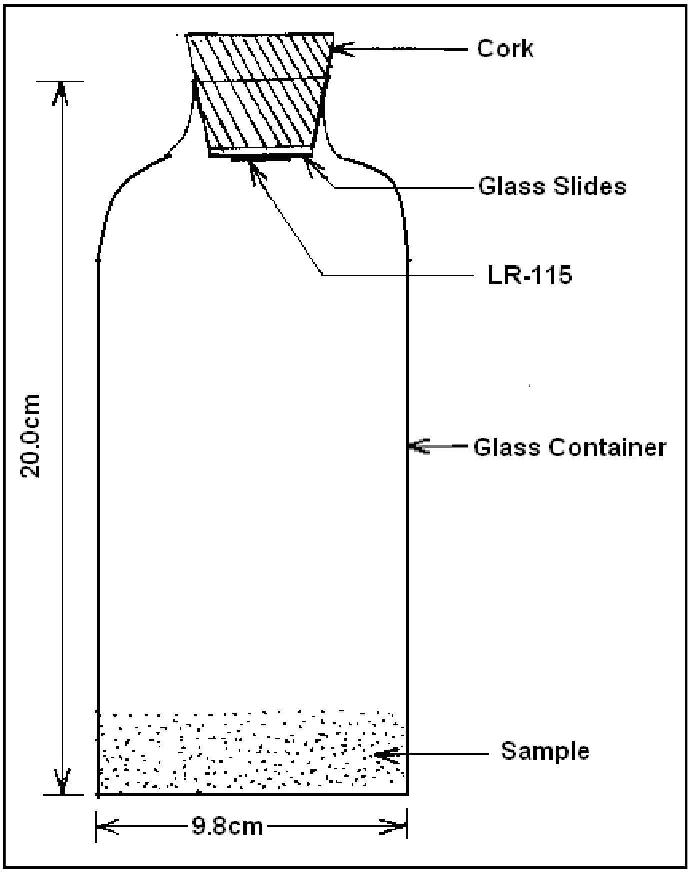

Fig 1: The Apparatus Used to Study the Radium and Radon Exhalation Rate of Soil Samples

After this period LR-115 type-II plastic track detector was fixed on the top inside of a glass bottle, which was closed for a period of 90 days. After exposure the detectors were removed and then etched in 2.5N NaOH solution at 60^{0}C for 2 hours using a constant temperature bath. The tracks were counted using an Olympus microscope.

The effective radium content of the soil sample was calculated using the formula [10]:

$$C_{Ra}(Bq/kg) = \left(\frac{\rho}{KT_e}\right)\left(\frac{hA}{M}\right)$$

where M, A and h are the mass of the soil sample (250gm), area

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of cross section in m^2 ($7.55 \times 10^{-3} m^2$) and the distance between the detector and the top of the solid sample in meters (0.153m) respectively. The effective exposure time was calculated using the equation:

$T_e = T - 1/\lambda(1 - e^{-\lambda T})$

Where λ is the decay constant for radon-222, K is the sensitivity factor and its value as calculated by Azam et al. (1995) [11] is 0.0245 tracks $cm^{-2}d^{-1}$ per (Bqm^{-3}). The 'radon exhalation rate' in terms of area and mass was obtained from the expression reported by Abu-Jarad (1988) [9] and Khan et al. (1992) [12]:

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

where EA is radon exhalation rate in terms of area ($Bqm^{-2}hr^{-1}$); C the integrated radon exposure as measured by LR-115 plastic track detector ($Bqm^{-3}hr$); V the effective volume of the 'Can' (m^3); λ the decay constant for radon (hr^{-1}); T the exposure time (hr); A the area of the 'Can' (m^2). This formula is also modified to calculate the radon exhalation rate in terms of mass ($BqKg^{-1}hr^{-1}$):

$$E_M = \frac{CV\lambda}{M [T + 1/\lambda (e^{-\lambda T} - 1)]}$$

where E_M is radon exhalation rate in terms of mass ($BqKg^{-1}hr^{-1}$) and M is the mass of the sample.

III. Results and Discussion

The results for radium activity and radon exhalation rate in soil and rock samples belonging to some areas of Pathankot district, Punjab are reported in Table 1. The radium activity in soil samples ranges from 1.39 $Bqkg^{-1}$ in Nalwa Bridge village to 5.31 $Bqkg^{-1}$ in Nehru village. The values of radon exhalation rate varies from1.62 to 216.96 m $Bqkg^{-1}hr^{-1}$ in soil samples belonging to the study area.

Table 1: Radium activity and radon exhalation rate in soil samples from some areas of Pathankot district, Punjab

S. No.	Location (Village)	Radium Activity ($Bqkg^{-1}$)	Radon exhalation rate	
			E_M ($mBqkg^{-1}hr^{-1}$)	E_A ($mBqm^{-2}hr^{-1}$)
1	Jamalpur	4.96	6.12	202.71
2	Dheera	5.03	6.22	205.87
3	Deriwaal	3.64	4.49	148.86
4	Sunder Nagar	1.55	1.91	63.34
5	Nalwa Bridge	1.39	1.62	53.39
6	Nehru Nagar	5.31	6.55	216.96
7	Dolatpur	2.51	3.10	102.94
8	sahura	1.55	1.91	63.34
9	Dhaner	5.22	6.27	215.68
10	Nauni	4.91	6.05	195.21

Thus both the radium activity and radon exhalation rate are maximum in the soil of Nehru village. In the present investigations the observed values of radium and radon exhalation rate are lower in soil to those determined in the soil of Una district by Kumar et al. (2001) [8] and also lower than those reported in the soil of Hamirpur and Kullu districts of Himachal Pradesh [13,14]. The values of radon exhalation rate and radium concentration in rocks are quite low as compared with those reported in the soil of Hamirpur district [13].These values of radium concentration are also less than the permissible value of 370 Bq kg^{-1} [15] and much lower than those reported by Nageshwara Rao et al. (1996) [16] for Rajasthan area. This may be due to the fact that our sample collection is from the surface whereas the others have reported work in the mining area of this region. The values of radium and radon exhalation are also below the recommended safe limit and are not significant from the exploration point of view. Thus, the results reveal that the area is safe as for as the health hazard effects of radium and radon exhalation are concerned. Transport of radon / radium through the soils/rocks largely depends on the geology of the area, which include lithology, compression, porosity and structural / tectonics features like thrust, faults, joints and fractures. A direct correlation exists between radium activity and radon exhalation rate of the study area as shown in fig. 1.

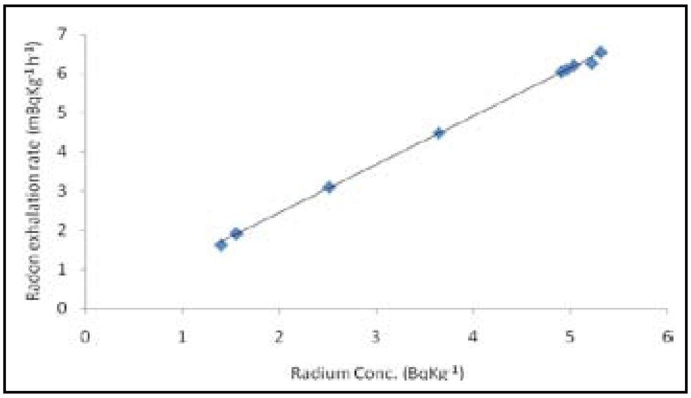

Fig. 2: Radium Activity vs Radon Exhalation Rate in Soil Samples

IV. Conclusion

1. The solid state nuclear track detectors are best suited for the measurement of radium activity and radon exhalation rate in soil and rock samples.
2. Both the radium content and radon exhalation rate are more in soil as compared to rock samples. A strong correlation has been found between radium content and radon exhalation rate. The radium content in soil in the study area is below the safe limit.

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