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A study of radon concentration in water and radon exhalation rate in soil samples belonging to Kapurthala district, Punjab, India

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ABSTRACT

Radon and its daughter products are the major sources of radiation exposure and recognized as one of the health hazards for mankind. In the Present work, an attempt has been made to assess the levels of radon concentration in some drinking water samples and radon exhalation rate in soil samples belonging to some locations of Kapurthala district, Punjab. Radon concentrations were measured using RAD 7 electronic detector and radon exhalation rate were measured using can technique. The alpha sensitive solid state nuclear track detectors (LR-115 Type II) were used in the can technique. The radon values vary from 0.0342 Bq / l of Kaul Talwandi village to 0.204 Bq / l of Kapurthala. The Radium concentration in soil samples were found to vary from 2.40 Bq / Kg to 4.65 Bq / Kg and the values of exhalation studies ranges from 2.96 mBqkg^{-1}hr^{-1} to 5.74 mBqkg^{-1}hr^{-1}. The values are found to be within the safe limits as recommended by the International Commission of Radiation Protection (ICRP) and World Health Organization (WHO). The results reveal that these areas are safe from the health hazard point of view as for as the radon is concerned. A good correlation has been observed between radon and exhalation rate.

Keywords: RAD 7, LR-115, Radon, water, soil

INTRODUCTION

Radon is a radioactive inert gas, which is produced during the decay of radium in the naturally occurring uranium series. In the recent past environmental scientists all over the world have been expressing great concern about the radiation hazards from ^{222}Rn and its short lived daughter products inside buildings [1,2]. Inhalation of ^{222}Rn and its daughter products, especially ^{218}Po and ^{214}Po attached to aerosols present in ambient air, constitute a significant radiological hazard to human lungs. Radon appears mainly by diffusion processes from the point of origin [3] following α-decay of ^{226}Ra in underground soil and building materials used in the construction of floors, walls, ceilings, etc.

The earth is radioactive since its creation. The inhalation and ingestion of these radio nuclides above the permissible level becomes a health hazard. Therefore, concern of the monitoring of these radio nuclides in the environs is increasing at all levels, due to their harmful effects. If inhaled or ingested, uranium activity poses an increased risk of lung and bone cancer [4].

The magnitude of indoor radon concentration indoors depends primarily on a building construction and the amount of radon in underlying soil. The concentration of radon and its decay products show a large temporal and local fluctuations in the indoor atmosphere due to meteorological variables [5, 6]. A study of radon exhalation rate from building materials is important for understanding the relative contributions of individual materials to the total radon content found inside a room. Such a study has been carried out in our laboratory using solid state nuclear track detectors. The aim of the present study is to investigate the radon concentration in groundwater and radon exhalation rate in soil samples of Kapurthala area, Punjab for public health risk measurements

MATERIALS AND METHODS

Estimation of Radon Concentration in Water samples

For radon in water measurement, the RAD-H_2O closed loop aeration method has been employed [7-9]. The RAD7 continually measures radon and thoron concentration, showing both on a spectrum printout, and also functions as a sniffer with audible count signal to locate radon entry points. Radon in water was measured by unit RAD-7.0 detector supplied by DURRIGDE Company INC, USA. It has a sample cell of 0.7 litre hemisphere, coated inside with an electrical conductor. A solid state Ion implanted planer silicon alpha detector is at the centre of hemisphere. A voltage of 2000V to 2500V creates an electric field. Radon 222 nucleus that decays within the cell creates polonium 218 which enters the hemisphere and the signal is amplified and counted electronically. The unit features the fastest response and recovery time of any system on the market, and is able to measure radon concentrations at the 200 Bq/m^3 action level in less than 1 hour with 10% standard deviation. The virtual absence of intrinsic background (0.2 Bq/m^3) gives the RAD7 an extremely low detection threshold, easily measuring below 4 Bq/m^3. The instrument is microcomputer controlled, featuring step-by-step instructions for ease of use. The instrument is a complete, portable stand-alone system with a built-in air pump, supplied in a rugged carrying case, total weight 5 kg. Additional accessories allow measurement of radon in soil and water (continuous and sample measurement); the RAD AQUA continuous water measurement accessory allows measurement of water radon to extremely low concentrations, whereby the air volume and water volume are constant and independent of the flow rate. The air circulates through the water and continuously extracts the radon until a state of equilibrium develops. The RAD-H_2O system reaches this state of equilibrium within about 5 minutes, after which no more radon can be extracted from the water. The extraction efficiency, or percentage of radon removed from the water to the air loop, is very high. The RAD H_2O gives results after 30 minutes analysis with a sensitivity that matches or exceeds that of liquid scintillation methods.

Radium concentration and radon exhalation measurements

Radium concentration and radon exhalation rate in solid samples were determined using the Can technique [10, 11] as shown in Fig.2. About 250 gm 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. 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 60^0C 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]

$$C_{Ra}(Bq/kg) = \left(\frac{\rho}{T_e}\right)\left(\frac{h.A}{M}\right)$$

where M, A and h are the mass of the soil sample (250gm), area of cross section in m^2 (7.55x $10^{-3}m^2$) 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.[12] 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) [13] and Khan et al. (1992) [14]:

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

where E_A 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.

RESULTS AND DISCUSSION

The values of radon concentration in water samples of the study area are given in Table 1. The values in samples from Kapurthala area lies in the range 0.23 (Karalan) to 2.1(Kapurthala). The US Environmental protection agency has proposed that the allowed maximum contamination level (MCL) for radon concentration in water is $11Bql^{-1}$ (USEPA, 1991). The values of radon concentration in groundwater was compared with those reported by other investigators. Duggal et al.[7] Have reported a radon concentration range 0.9 Bql^{-1} to 5.1 Bql^{-1} of Bathinda district, Punjab [7] and Rani et al. [15] have reported a radon concentration range 0.5 t0 85.7 Bql^{-1} in groundwater samples of Rajasthan area, India. Radon concentration values obtained in the groundwater samples lies well within the range. The results for radium activity and radon exhalation rate in soil samples belonging to some areas of Kapurthala district, Punjab are reported in Table 1. The radium activity in soil samples ranges from 2.48 $Bqkg^{-1}$ in Kaultalwandi 1 village to 5.73 $Bqkg^{-1}$ in Karalan village. The values of radon exhalation rate varies from 3.06 $mBqkg^{-1}hr^{-1}$ to 7.07 $mBqkg^{-1}hr^{-1}$ in soil. A direct correlation exists between radium activity and radon exhalation rate in case of soil of the area (Fig. 4) but no direct correlation exists between radon concentration in water samples and radon exhalation rate in soil as shown in fig.3. The values of radium activity determined in soil are less than the permissible value 370 $Bqkg^{-1}$ which is acceptable for safe use [16]. The results reveal that the area is safe as for as the health hazard effects of radium are concerned.

Table 1. Radon Concentration in water samples and Exhalation studies in soil samples of Kapurthala area

S. No.	Location	Radon Concentration (Bql^{-1})	Radium Conc. ($Bqkg^{-1}$)	Radon Exhalation rate E_M ($mBqkg^{-1}hr^{-1}$)	Radon Exhalation rate E_A ($mBqm^{-2}hr^{-1}$)
1	Kaul Talwandi 1	0.68	2.48	3.06	101.35
2	Kaul Talwandi 2	0.34	2.63	3.25	107.68
3	Karalan	0.23	5.73	7.07	234.37
4	Hussainpur	1.7	2.40	2.96	98.18
5	Rail Coach Factory	0.68	3.79	4.68	155.19
6	Kapurthala	2.21	3.29	4.06	134.26
7	Sheikhpur	1.12	4.65	5.74	190.03
8	Dhirpur	0.57	2.31	2.52	100.02
9	Dera baba Jaimal Singh	0.71	2.60	3.01	103.21
10	Dhaliwan	0.59	2.43	2.99	99.56

Fig. 1 Map showing the surveyed area

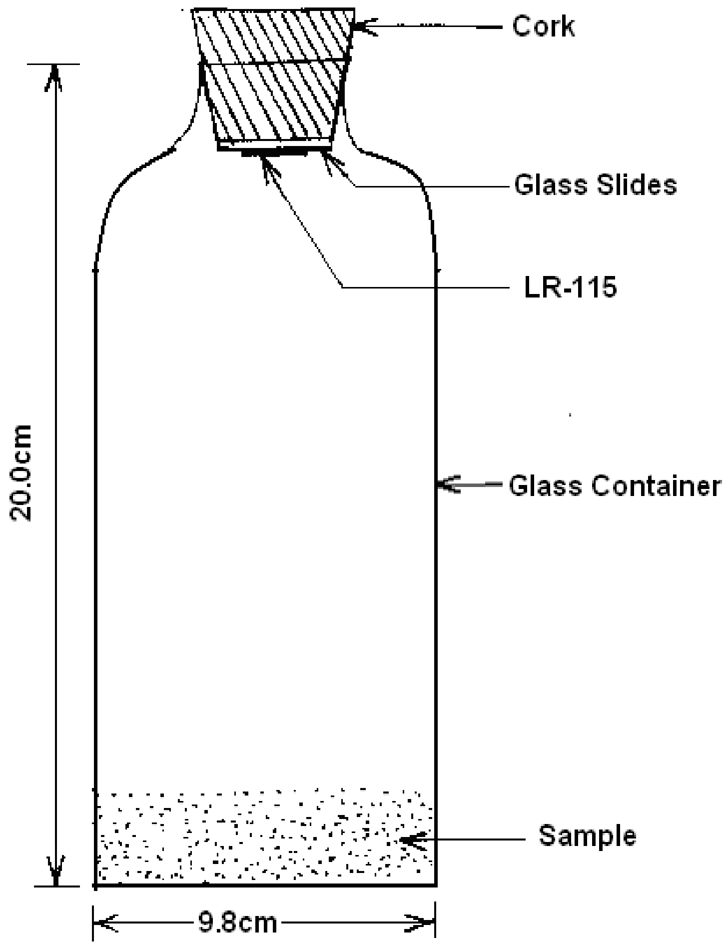

Fig. 2 The apparatus used to study the radium and radon exhalation rate of soil samples

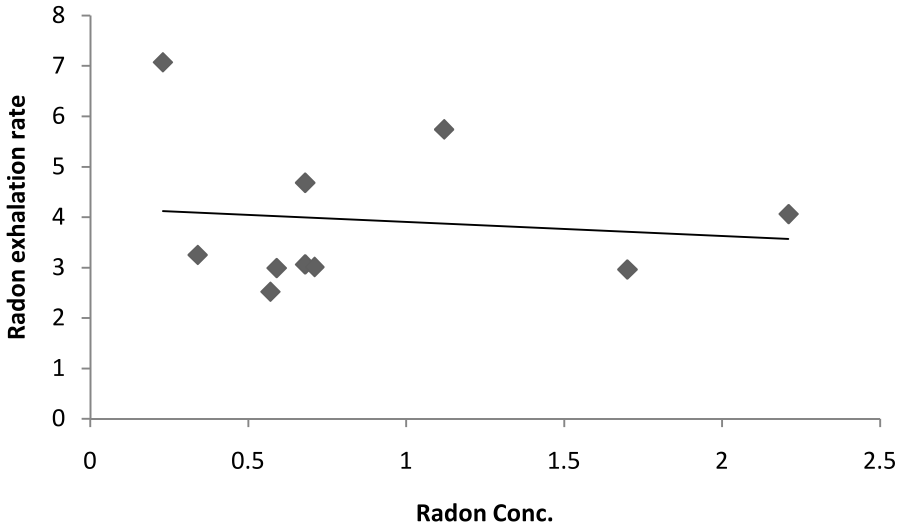

Fig.3 Radon Concentration vs Radon Exhalation Rate

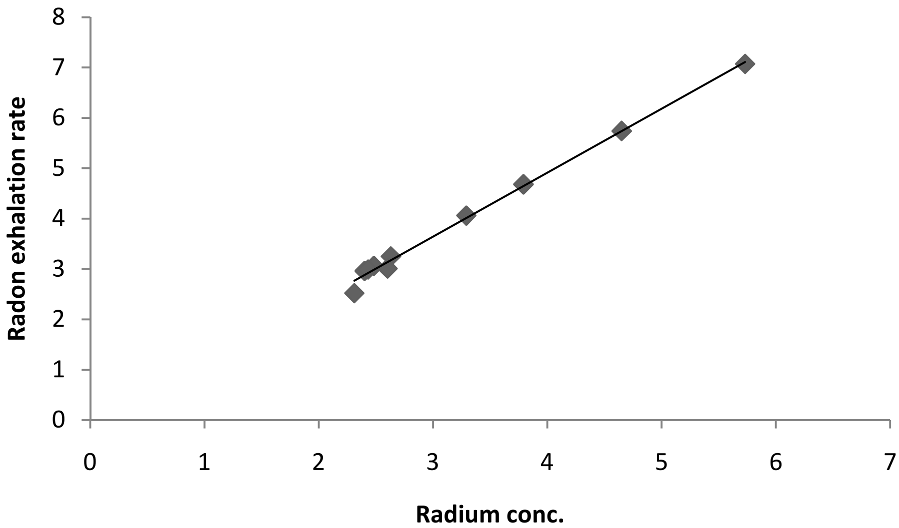

Fig. 4 Radium Concentration vs radon exhalation rate

CONCLUSION

The values of Radon concentration in the groundwater samples are within the safe limit recommended by the US Environmental Protection agency [17] and United Nations Scientific Committee on the Effects of Atomic Radiation [18]. A strong correlation (correlation Coefficient = 0.9) has been found between radium content and radon exhalation rate in the soil samples of the study area. The radium content in soil in the study area is below the safe limit. The results show no significant radiological risk for the inhabitant of the study area.

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