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A comparative study of indoor radon level measurements in the dwellings of Punjab and Himachal Pradesh, India

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Abstract

The LR-115 type-II plastic track detector has been used for measuring the indoor radon levels in the dwellings of some villages of Punjab and Himachal Pradesh. In Punjab, the villages surveyed are Rampura Phul, Lehra Mahabat and Pitho (villages in Bathinda district), and Amritsar city. The average indoor radon levels in these areas are found to vary from 64 to 152 Bq/m^3, which are quite within the safe limits recommended by International Commission on Radiological Protection (Ann. ICRP 23(2)). The indoor radon levels have also been measured in the dwellings of Hamirpur district of Himachal Pradesh. The villages surveyed in this area are Nukhel, Badarn, Galore-Khas, Har-Upper, Tikker Brahamana and Awah-Lower where radon concentration has been found to vary from 261 to 724 Bq/m^3. These values are higher than the recommended limit.

Keywords: Radon; LR-115; Uranium; Dwellings; Chemical etching

1. Introduction

Measurement of indoor radon is of importance because the radiation dose to human population due to inhalation of radon and its daughters contributes more than 50% of the total dose from natural sources (UNSCEAR, 1988). The three radon isotopes (^{219}Rn, ^{220}Rn, ^{222}Rn) are gaseous and they may be released from the ground, rocks and also from building materials and accumulate with their short lived daughters in closed spaces, and in particular in dwellings. ^{220}Rn and ^{219}Rn mainly because of their short half-life are not as important as ^{222}Rn, which concentration in air may reach significant levels in terms of radiological protection. The dose deriving from the presence in the air of ^{222}Rn is linked to the inhalation of its short-lived daughters, which are deposited in the respiratory organs, if deeply inhaled, emit alpha-particles in direct contact with the bronchial and pulmonary epithelium. For these reasons, the dose deriving from the exposure to ^{222}Rn in closed spaces has been placed in direct relation to the risk of lung cancer (ICRP, 1987, 1994). The epidemiological evidence for the induction of lung cancer following inhalation of radon comes from several case studies of underground miners.

During recent years, several reports have appeared in literature demonstrating the ever increasing interest in monitoring the radon in the dwellings all over the world (Abu-Jarad and Fremlin, 1981; Keller and Folkerts, 1984; Nazaroff and Doyle, 1985; Ramachandran et al., 1986; Subba Ramu et al., 1990; Jonsson, 1991; Marx and Toth, 1997; Virk et al., 1999) and the results of the studies show that some countries (e.g. Sweeden, Norway, Hungary and some parts of USA) have high radon concentrations in many of their dwellings (Swedjemark and Mjones, 1984; UNSCEAR, 1988) and even in certain cases, doses from this source for some people living in these areas may exceed those received by occupational workers.

The main sources of indoor radon levels are the soil-gas, building materials, tap water and natural gas used for cooking. The topography, house construction type, soil characteristics, ventilation rate, wind direction, atmospheric pressure and even the life style of the people, also significantly influence it (Stranden et al., 1979; Abu-Jarad and Fremlin, 1983), which emphasizes the importance of long-term integrated measurements, thus indicating the

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importance of the SSNTD techniques in these measurements. In the present investigations, the passive technique using the Solid State Nuclear Track Detectors (SSNTDs) has been utilized for the comparative study of the indoor radon levels in the dwellings of Punjab and Himachal Pradesh states, India.

2. Experimental

Experimental methods for radon detection and measurements are based on alpha-counting of radon and its daughters. Active and passive devices are available in the literature for this purpose. In the present investigations we have utilized the passive method using the SSNTDs. These plastic films (LR-115 type II) of size 2 cm × 2 cm were fixed on glass slides and then these slides were mounted on the walls of different dwellings at a height of about 2 m from the ground level with their sensitive surface facing the air. After an exposure time of 3–4 months, detector films were removed and etched in 2.5 N NaOH solution at 60°C for 80 min in a constant temperature bath. Then these films were washed, dried and scanned under a Carl Zeiss binocular microscope for track density measurements. The exposed area of the each film was scanned thoroughly and sufficiently large number of graticules were counted to get average track density and to minimize the uncertainty due to counting errors. The track density is converted to radon concentration in dwellings using a calibration factor 0.021 tracks/cm^2/day = 1 Bq/m^3. The calibration factor was obtained after two inter-laboratory intercomparison exercises carried out at the National level by the Environmental Assessment Division of BARC, Mumbai.

3. Results and discussion

The results of indoor radon concentration measured in the dwellings of Rampura Phul and Lehra Mohabbat of district Bathinda, Punjab, where observation have been taken from September, 2000 to March, 2001 are reported in Table 1 and the indoor radon levels, which have been measured in the same duration in the dwellings of village Pitho of the same district have been reported in Table 2. The indoor radon levels which have also been measured in concrete dwellings of Amritsar city of Punjab are tabulated in Table 3. These results shows that average radon concentration in the mud dwellings of village Pitho (152 Bq/m^3) is 2 to 3 times higher than that of the completely concrete dwellings in Rampura Phul and Amritsar cities, where average radon concentration are 86 and 64 Bq/m^3, respectively. It is evident from Table 2 that the P1 and P2 dwellings of the village Pitho show comparatively higher concentrations than the dwellings P3–P6 of the same village. This may be because of these two dwellings have mud floors and quite poor ventilation conditions, whereas concrete floors of the other dwellings mainly prevent the radon from the soil to enter in the room, thus giving comparatively less concentrations. Radon diffusion length in some building materials has been found to be varying from 61.6 to 164.6 cm (Singh et al., 1999). The radon concentration

Table 1
Radon concentration levels in the dwellings of Rampura Phul and Lehra Mohabbat, of Punjab

House code	Floor condition	Ventilation condition	Radon concentration (Bq/m^3)
Rampura Phul R1$_a$	Concrete	Quite good	69
R1$_b$	Concrete	Poor	114
R2	Concrete	Quite good	63
R3	Concrete	Good	88
R4$_a$	Concrete	Good	74
R4$_b$	Concrete	Good	106
Average			86
Lehra Mohabbat			
LM1	Concrete	Good	139
LM2	Concrete	Good	116

Table 2
Radon concentration levels in the dwellings of Pitho village, Punjab

House code	Floor condition	Ventilation condition	Radon concentration (Bq/m^3)
P1	Mud	Poor	218
P2	Mud	Poor	183
P3$_a$	Mud	Good	138
P3$_b$	Concrete	Good	152
P4	Concrete	Poor	133
P5	Concrete	Quite good	124
P6	Concrete	Quite good	119
Average			152 Bq/m^3

Table 3
Radon concentration levels in the dwellings of Adarsh Nagar locality, Amritsar city, Punjab

House code	Floor condition	Ventilation condition	Radon concentration (Bq/m^3)
A1	Concrete	Poor	76
A2$_a$	Concrete	Quite good	51
A2$_b$	Concrete	Poor	81
A3	Concrete	Good	75
A4	Concrete	Quite good	42
A5	Concrete	Good	60
Average			64 Bq/m^3

levels in Rampura Phul city (Table 1) is varying from 63 to 114 Bq/m^3. The dwelling R1$_b$ because of its quite poor ventilation condition is showing the highest concentrations of 114 Bq/m^3, as compared to all other dwellings where the radon concentration have been measured in this city. The indoor radon levels measured in Amritsar city (Table 3), shows variation from 42 to 81 Bq/m^3 only. The dwelling A4, is showing comparatively quite less concentration of 42 Bq/m^3 as compared to all other dwellings in this locality. This may be because of its situation on the first floor of the house. The dwelling A2$_b$ which is showing the highest concentration of 81 Bq/m^3, may be because of its quite poor ventilation conditions as its having only a single door and no other ventilator, where as in the same house the dwelling A2$_a$ (Lobby) is giving us comparatively less concentration because of its quite good ventilation conditions. The dwellings LM1 and LM2 of Lehra Mohabbat, Thermal Colony (Table 1), in spite of their concrete floors and good ventilation conditions are giving the radon concentration of 139 and 116 Bq/m^3 respectively, which is slightly higher than the average radon concentration of concrete dwellings of Rampura Phul and Amritsar cities. This may be because they are situated in the thermal power colony where thermal power plant is being operated regularly and the coal and fly ash may have contributed towards their higher radon concentration. Even the variation of radon concentration between different dwellings of both the Rampura Phul and Amritsar city can be explained due to different ventilation rates and even the nature of the soil underneath, as now it is well established that the radon activity in soil and gas is highly variable, changing as much as by an order of magnitude over a domain of 10 m (Toth et al., 1997).

The results of indoor radon concentration levels measured in the village of Nukhel, Badaran, Galore Khas, Har Upper, Tikker Brahmne ans Awah-Lower, where radon levels has been measured in same winter interval, are reported in Table 4. As can be observed, the measured concentration in these villages, which has been situated in a uranium mineralized zone of Himachal Pradesh, is much higher than the indoor radon levels observed in the dwellings of Punjab. In most of the dwelling in these villages the indoor radon levels has been showing the variation from 200 to 1350 Bq/m^3, which is quite higher than the international recommendations. These large variations of indoor radon levels between different dwelling of these villages can be explained due to different ventilation rate, nature of the soil underneath and particularly due to the geological considerations. On the other hand, indoor radon levels measured in the dwellings of Punjab state, during the same winter interval are comparatively much lower, as the maximum variation is between 40 and 200 Bq/m^3. The lower indoor radon levels in these dwellings may be due to lower radium content in bricks and cement, which is being used as the building material for construction. Secondly these particular dwellings has cemented floor and walls which results in the reduction of radon levels in these houses. On the other hand, the higher concentration

Table 4
Radon concentration levels in the dwellings of villages situated in a uranium mineralized zone of Himachal Pradesh

Village/house No.	Ventilation conditions	Radon average (Bqm^{-3})
Nukhel		
N1	Well	216
N2	Partially	248
N3	Poorly	356
N4	Well	305
N5	Well	178
(Average)		261
Badaran		
B1	Poorly	654
B2	Poorly	502
B3	Poorly	496
B4	Partially	362
B5	Poorly	546
B6	Poorly	667
(Average)		538
Galore Khas		
G1	Poorly	1094
G2	Well	356
G3	Partially	512
G4	Well	457
G5	Poorly	337
G6	Well	235
(Average)		498
Har Upper		
H1	Poorly	615
H2	Partially	541
H3	Partially	581
H4	Partially	433
(Average)		542
Tikkar Brahmne		
T1	Partially	502
T2	Poorly	586
T3	Poorly	450
T3	Partially	740
T5	Poorly	1344
(Average)		724
Awah-Lower		
A1	Poorly	689
A2	Poorly	575
A3	Well	356
A4	Poorly	957
(Average)		644

of indoor radon levels in the villages situated in uranium mineralized zones of Himachal Pradesh is mainly due to the higher concentration of radon gas emanating from uranium being rocks and soils of this area and may also be due to high radium content in the building materials like stones, mud, etc., which has been extensively utilized in concentration of these dwellings.

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