



Studies on spatial variations of radon and its progeny inside a dwelling, Mysore city, India.

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Abstract: The amount of radon that emitted from the earth's surface depends mainly on the amounts of ^{238}U , ^{232}Th and ^{226}Ra present in soil and also the on the nature of soil, its porosity and meteorological conditions. Indoor radon and its progeny concentration vary with exhalation rate of radon from the building materials, structure of the building and ventilation condition. The spatial distribution of radon and decay products was systematically studied inside a dwelling at different co-ordinates and time scales. The results show that, very close to the surface of the wall and the floor, radon progeny concentrations were low due to attachment on the surfaces. The radon concentration slightly decreases with increasing height from the floor and it becomes almost uniform above 1.0m. The results show that, highest radon concentration of 33.8 Bq.m^{-3} was observed at height 0.5 m above the floor and 0.5 m away from the wall. Lowest radon concentration observed was 10.6 Bq.m^{-3} , at a height of 1.5m from the ground and 0.1 m away from the wall.

Keywords: Radon, radon progeny, radon exhalation, Mysore.

I. Introduction

^{222}Rn a decay product of ^{226}Ra in the naturally occurring ^{238}U series is a radioactive inert gas and constitutes about half the radiation dose received by general inhabitants. The quantity of ^{222}Rn that emitted from the ground surface depends mainly on the amounts of ^{226}Ra present in the area and also the type of the soil and its porosity. Radon and its short-lived decay products can be deposited in the lung tissues and give rise to elevated radiation doses. Long time exposure of people to higher concentrations of radon and its progeny may lead to lung cancer and other pathological effects such as respiratory functional changes. Health effects of radon, most notably lung cancer, have been studied for several decades. Radon is now recognized as the second most important cause of lung cancer after smoking in the general population [1].

The radon exhalation rate from the ground surface depends on the geological factors such as porosity, temperature difference between top layers of soil, moisture content and permeability of the soil. Meteorological factors such as rainfall, wind speed, atmospheric humidity and atmospheric pressure influence the transport and distribution of radon and its progeny concentrations in the atmosphere [2-4].

The understanding of radon sources, transport mechanisms and their distribution in the atmosphere has evolved over several decades [2-5]. The spatial distribution of radon/thoron in a room is not homogeneous, higher concentrations are expected close to the surfaces exhaling radon/thoron gases. In the present investigation a systematic study of the distribution of radon and its daughter products has been carried out in a small room at different co-ordinates and time scales.

II. Materials and Methods

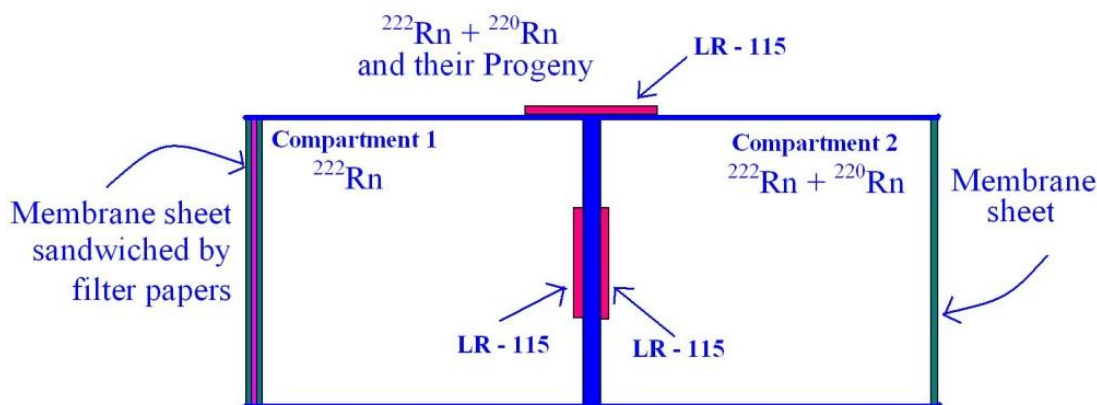
The concentrations of radon and its progeny were determined in three rooms of the department of studies in Physics using Solid State Nuclear Track Detectors (SSNTD). Which are thin sheets of dielectric materials such as cellulose nitrate (CN) and polycarbonates. They are sensitive to alpha but not to beta and gamma radiations. They are unaffected by moderate humidity, temperature changes and ambient light. In the present investigation LR-115 TYPE II (Kodak Pathe, France) plastic track detector (C N film) were used [6,7].

The schematic diagram of a twin cup dosimeter is shown in figure 1. Two SSNTD films were fixed inside a twin cup dosimeter for the study of radon and its progeny concentrations. The SSNTD film which is placed inside one of the compartment measures only radon, which diffuses from the ambient air through a semi-permeable latex membrane sandwiched by two glass fiber filter papers. Because of low permeability constants in the range of 10^{-8} - $10^{-7} \text{ cm}^2 \text{ s}^{-1}$ these membranes allow more than 99% of the radon gas to diffuse and suppress thoron gas to less than 1% [7,8]. The second SSNTD film placed in another compartment measures both radon and thoron gases. The glass fiber filter paper covering the second compartment allows both radon and thoron gas to diffuse. The

third SSNTD film is fixed on the outer surface of the dosimeter registers alpha tracks due to the concentrations of both the gases and their progeny.

These dosimeters are hung at different positions away from the floor and walls inside the room. At the end of the stipulated period of exposure (90 days), the dosimeters are retrieved. SSNTD films are etched with 10% of NaOH solutions for 60 min at constant temperature of 60°C following the standard procedure. The track density due to alpha particles in the film was measured using a spark counter [6-8]. All the measurements were carried out in three rooms at the department of studies in physics, university of Mysore, Mysore city, Karnataka state, India.

Figure 1. Schematic diagram of a twin cup dosimeter.



The radon concentration was calculated by the following relation [6].

$$C_R (\text{Bq.m}^{-3}) = \frac{T_m}{d.S_m}$$

where, C_R is the ^{222}Rn concentration, T_m is the track density of the film in membrane compartment, d is the period of exposure, (days) and S_m is the Sensitivity factor of membrane compartment.

The radon progeny concentration was calculated by the following relation [6].

$$R_n (\text{mWL}) = \frac{C_R F_R}{3.7}$$

where, R_n = Radon Progeny Concentration and F_R is the equilibrium factor for radon progeny respectively, corresponding to the extracted ventilation rate [6-8].

$$F_R = 0.104f_{RA} + 0.518 f_{RB} + 0.37f_{RC}$$

Where f_{RA} , f_{RB} and f_{RC} are activity fractions with respect to parent gas.

III. Results and Discussions

Radium present in soil, rocks and building material are the sources of radon in the environment. The transfer of radon atom from mineral grains to the soil capillaries depends on the water content in the interstitial pores and temperature gradient of the soil [9-11]. The soil moisture in interstitial pores directly affects radon emanation by capturing the radon recoiled from the soil medium [11,12]. The building materials used for the construction of floor and walls are mainly of stones, cement, concrete and bricks. This leads to significant radon exhalation rate and significant spatial variation of radon and its progeny in atmosphere.

The indoor radon and its progeny concentration vary with ventilation condition, exhalation of radon from the floor, surface of wall and structure of the building. Radon progeny concentrations increase in increasing height and away from wall and then gradually decreases but radon concentration does not change very much. Radon progeny concentration inside a room is influenced by various factors such as [2,5,13]:

1. Radon concentration in outdoor air.
2. Radon exhalation rate from floors and walls.
3. Atmospheric pressure difference between outdoor and indoor.
4. Ventilation conditions.
5. Room area towards outdoor air.
6. Ratio of room volume to room surface area of radon emitting building material.

The variation of radon concentration at different heights from the floor and at different distance from the wall is shown in Table 1. The results show that the radon concentration slightly decreases with increasing height and it becomes almost uniform above 1.0m from the floor. Highest radon concentration of 33.8 Bq.m^{-3} was observed at

height 0.5 m above the floor and 0.5 m away from the wall. Lowest radon concentration observed was 10.6 Bq.m^{-3} , at a height of 1.5m from the ground and 0.1 m away from the wall.

The radon concentration slightly decreases with increasing height and it becomes almost uniform above 1.0m.

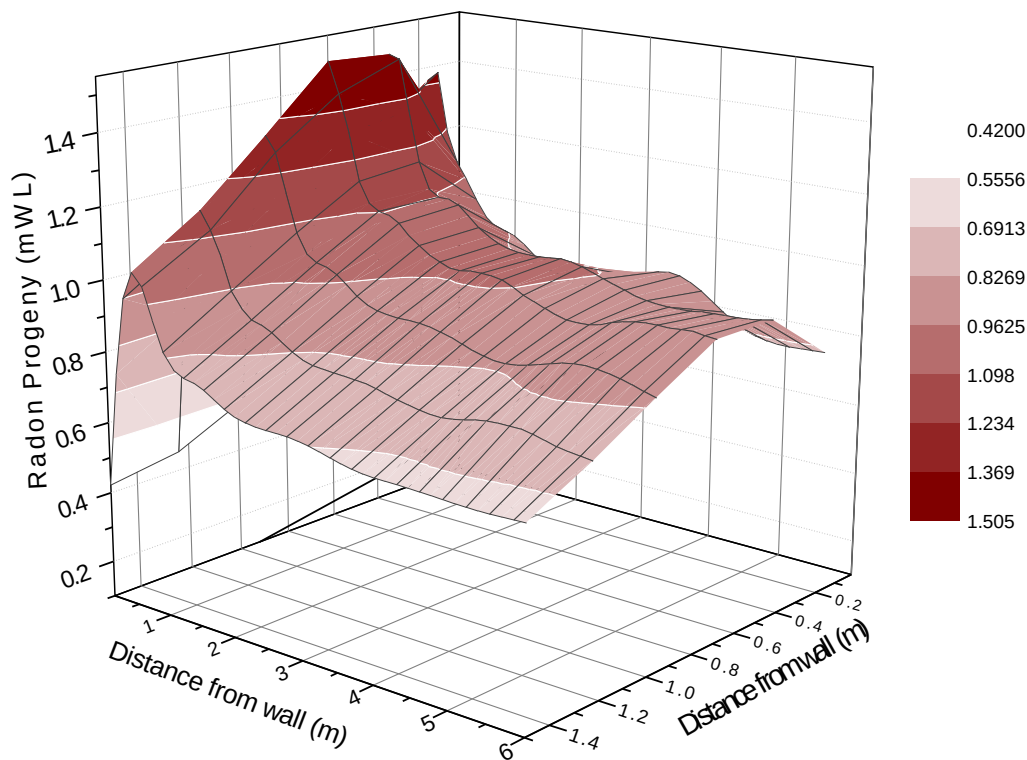
The special distribution of radon progeny concentration inside a small room is shown Figure 2. The room was in the first floor had a width of 2.85 m, depth 7.26 m and height 4.20 m. Front wall had a door and a small window and the back wall had two windows one above the other. The room was ventilated by natural means and minimum human activity is maintained throughout the period of study.

Indoor radon and its progeny concentration are influenced by radon exhalation rate from the floor and walls, ventilation condition, outdoor radon and its progeny concentrations. The results show that very close to the surface of wall and floor the concentrations were lower. This is due to attachment and loss of radon progeny on the surfaces [14-16]. At optimum a distance from the wall and floor the concentrations are maxima and decrease as distance increases away from the surface.

Table 1. Variation of radon concentration at different heights from the floor and at different distance from the wall.

Distance from the wall (m)	Radon concentration (Bq. m^{-3}) at different heights from the floor				Average
	0.2 m	0.5m	1m	1.5m	
0.1	13.2	16.3	11.3	10.6	12.9
0.2	16.2	21.1	19.3	16.2	18.2
0.5	32.6	33.8	33.1	25.3	31.2
1.0	24.0	29.5	23.8	23.5	25.2
1.5	19.7	25.1	25.4	16.6	21.7
2.0	22.1	27.6	21.6	15.9	21.8
3.0	19.6	25.7	22.0	16.9	21.1
4.0	21.0	21.7	21.1	18.4	20.6
5.0	18.1	24.8	20.1	16.2	19.8
6.0	19.3	20.4	21.4	14.7	19.0
Average	20.6	24.6	21.9	17.4	21.1

Figure 2. Spatial distribution of radon progeny inside a room.



IV. Conclusions

The spatial distribution of radon and decay products was systematically studied inside a dwelling at different co-ordinates and time scales. The results show that, very close to the surface of the wall and the floor, radon progeny concentrations were low due to attachment on the surfaces. The radon concentration slightly decreases with increasing height and it becomes almost uniform above 1.0m from the floor. Highest radon concentration of 33.8 Bq.m⁻³ was observed at height 0.5 m above the floor and 0.5 m away from the wall. Lowest radon concentration observed was 10.6 Bq.m⁻³, at a height of 1.5m from the ground and 0.1 m away from the wall. Indoor radon and its progeny concentration vary with ventilation condition, exhalation of radon from the floor, surface of wall and structure of the building. The results show that, very close to the surface of the wall and the floor, radon progeny concentrations were low due to attachment on the surfaces. Indoor radon and its progeny concentration are influenced by radon exhalation rate from the floor and walls, ventilation condition, outdoor radon and its progeny concentrations.

VI. References

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