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Indoor ^{220}Rn and its Progeny Levels in a Dwelling

L.A. Sathish[1*], S. Sundareshan[2] and T.V. Ramachandran[3]

[1]Department of Physics, Government Science College, Bangalore, India
[2]Department of Physics, Vijaya College, Bangalore, India
[3]Ex-Environmental Assessment Division,
Bhabha Atomic Research Center, Mumbai, India
[*]Corresponding Author E-mail: lasgayit@yahoo.com

Abstract

In the traditional dwellings, source of ^{220}Rn is the bare soil floor, either soil in cave dwellings or unburned adobe bricks and uncovered stone, wall in above ground dwellings. Because of the short half life of ^{220}Rn, the indoor concentration is not homogeneous but increases towards the walls, floorings and ceilings. In view of this an extensive study is made by using the solid state nuclear track detector based dosimeters which were installed in parabolic fashion to see the variations of ^{220}Rn and its progeny levels as a function of distance in a room of volume 30 m^3. Higher concentrations were observed at the flooring, wall and ceiling of the room and it decreases as the detector is moved away from them. ^{220}Rn progeny concentrations did not show any variations with the distance from the wall.

Keywords: Thoron, progeny, distribution, dwellings.

Introduction

The ^{220}Rn has a short half-life, 55.6 seconds, compared to ^{222}Rn. This means the distance that the ^{220}Rn gas atoms can migrate in the ground and inside building materials and buildings before it decays is much shorter than ^{222}Rn gas and also it is easily stopped by wall paper and other surface sealants. Therefore the risk for high ^{220}Rn levels in indoor can be expected to be low, at least much lower than the risk for high levels of ^{222}Rn. However, in buildings with an ineffective barrier between soil and indoor air the entry of ^{220}Rn could be significant, especially if the gravel or the soil itself immediately under the building has a high concentration of ^{232}Th. Soil as a significant source of indoor ^{220}Rn has been demonstrated by Li et al [1]. Enhanced ^{220}Rn levels were reported in residential traditional dwellings in India [2] and in China

[3]. The indoor ^{220}Rn concentration is not only determined by the exhalation but also by the detector distance from the wall, ceiling and the flooring of the room. In the report of UNSCEAR [4] the annual effective dose from ^{220}Rn and its progeny was evaluated to be 75 µSv, only about 6% of that of ^{222}Rn and its progeny. Measurements were performed in order to form a basis for assessing the risk for high indoor ^{220}Rn levels of Bangalore city.

Methods and Measurements

Solid State Nuclear Track Detectors (SSNTD)

SSNTD based dosimeters were used for the measurement of thoron and its progeny concentrations. This is a good technique to study the long-term measurements taking into account the diurnal, monthly and seasonal variations of ^{222}Rn and ^{220}Rn concentrations [5]. The mode of sampling is passive and integrated. The detailed description of experimental methodology [6] and calibration procedure [7] is available in the literature.

Spark Counter

Spark counter technique is applicable to plastic detectors, which provides a convenient, economical and fast method for track counting. This technique was developed by Cross and Tommasino [8] and is discussed in detail by Samyogi et al [9].

Results and discussion

The main objective of the study is to find the dependence of concentrations on distance and to assess the possible health hazards from indoor ^{220}Rn levels in Bangalore city. Buildings were chosen regardless the natural ^{232}Th concentrations. All the measurements were performed on the ground floor. The dosimeters were suspended in the room of volume 30 m^3 in a lower and upper parabolic fashion shown in Figs. 1-2. Large numbers of dosimeters were suspended in particular fashion to reveal the actual information about the dependence of concentration as a function of distance.

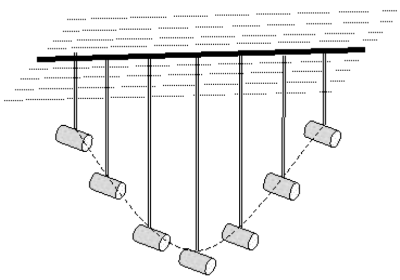

Figure 1 : Parabolic curve: focus away from the floor

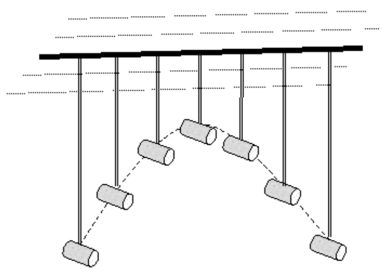

Figure 2 : Parabolic curve: focus away from the Ceiling

The results of the measurement of variations of ^{220}Rn concentrations with floor distance are shown in Fig.3. The steep increase in concentration close to the floor or wall is observed and the concentration drops exponentially as the detector distance increases from the floor or wall and it may be due to its short half life. This suggests that it is necessary to keep the distance from the floor or wall when we measure indoor ^{220}Rn concentration [10]. It is evident from the Figure 3 that the ^{220}Rn concentration is declining towards the room center and it may be because of the short half life of ^{220}Rn and the time necessary for its transport [10].

It is evident that the walls and floor of rooms were made of local soil material and bricks, which are the source of indoor ^{220}Rn concentrations. Figs. 4 represent the vertical profiles of ^{220}Rn concentrations, as the detector distance increases from the floor the concentration decrease exponentially. During the measurement period with twin cup dosimeters, the distribution of ^{220}Rn progeny and ^{222}Rn concentration were also measured at the different distance from wall and floorings. ^{220}Rn progeny concentration was nearly independent of the distance from soil wall. The uniformity of concentrations in a dwelling is may be due to their long half life [11] and this was confirmed through model calculation [12].

In contrast, the ^{222}Rn concentration is homogeneous within the dwelling due to its longer half-life of 3.8 days. Close to the walls or floorings the ^{220}Rn concentration is significantly higher. At increasing wall or floor distances, the ^{220}Rn concentration may decrease but the ^{222}Rn concentration remains steady. This type of observation was also made in several dwellings in the Gansu area [13], so that it appears to represent a general feature of indoor ^{222}Rn concentration. The turbulent transport from the wall into the room center decreases the relative contribution of the ^{220}Rn close to the wall. This is important for the dose assessment of dwellers only at ventilation rates above the exhalation saturation the total activity declines [14].

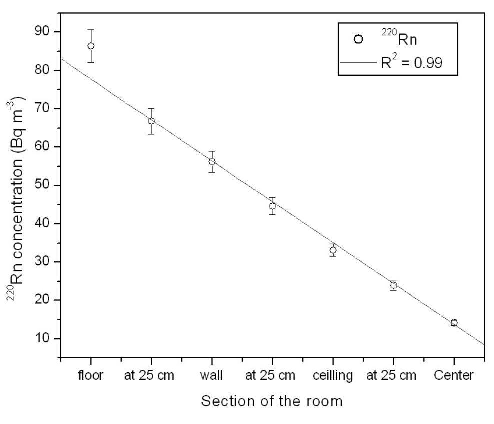

Figure 3 : Concentration profile of ^{220}Rn

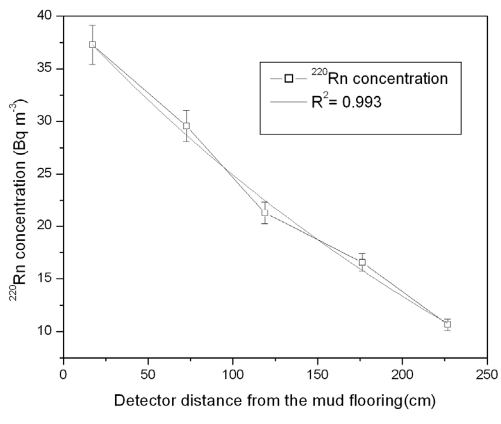

Figure 4 : Vertical Distribution of ^{220}Rn levels

Conclusion

The concentrations were high near the wall and flooring of the room and it drops exponentially with the distance from wall and flooring. Indoor ^{220}Rn progeny concentrations are uniform with the distance from the wall. Continuous and long-term studies such as diffusion of ^{220}Rn from each wall of the building materials and factors that influences the ^{220}Rn progeny levels in dwellings are necessary to assess the dose due to ^{220}Rn and its progeny. More detailed studies on the evaluation of public exposure from the natural radiation; particularly the exposure from indoor ^{220}Rn and its progeny should be planned and performed in the country.

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