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# Measurement of Radon Concentration in Some Dwellings near Kabini River, Karnataka, India

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Radon is the daughter product of $^{226}$Ra, and is exist in large concentration compared to all other radioactive elements present in the atmosphere and contributes more annual effective dose to human than all other radiation sources. Inhaling radioactive radon mainly causes of lung cancer. The effect of radon exposure prevention measures is initially determined by how successfully and quickly information persuades people to test properties. Usually, this is accomplished through educating locals on the dangers radon poses to their health.The activities of radon, thoron and their progenies were measured in the present study using pinhole dosimeters with alpha sensitive films, LR-115 type-II in 26 dwellings with a variety of flooring materials, including cement, tiles, mud, and granite, in both excellent and bad ventilation conditions along the Kabini river bank. The total yearly effective dose obtained from the study area is varied from 0.81 to 5.26 mSv.y$^{-1}$, with an average dose value of 2.54 mSv.y$^{-1}$ and is less than the suggested range ofICRP 2011 and the WHO -2011recommended level.

**Keywords:** Radon; Pinhole dosimeter; LR-115; SSNTDs

## 1 Introduction

Prolonged exposure to concentrated radon leads skin and lung cancer. According to IARC (International Agency for Research on Cancer), the radon exposure is primary contributor of lungs cancer, because it emits alpha particles, which can cause genetic abnormalities in lung cells that lead to the development of cancer[1]. Radon radiation is expressed as Becquerel (Bq) per cubic metre of air. Long-term radon exposure of 100 Bq.m$^{3}$ increases the relative lifetime risk of lung cancer by 16%[2]. Radon has received a lot of attention recently, especially with regard to the issues associated with exposure to radon and its offspring in homes and buildings. Significant attention has been given to radon in recent years, particularly the issues associated with exposure to radon and its daughter products in dwellings. Radon concentration levels in indoor environment are routinely reported across the world[3-6].

The estimated average AED from ionizing radiation from natural sources at the global level is 2.4 mSv.y$^{-1}$, of which approximately 1.0 mSv.y$^{-1}$is attributable to radon exposure[7]. Humans are exposed to radiation by breathing of short-lived decay products of the $^{222}$Rn and $^{220}$Rn. Elevated levels of radon in dwellings, as well as environmental factors contribute to this.$^{218}$Po, $^{214}$Po, $^{214}$Pb, and $^{214}$Bi are the radon progenies which persist in the atmosphere for a very long time and are inhaled by human beings. By producing high-energy alpha particles, they are transformed into other radioactive elements until they become stable elements. The lung cells that are exposed to the alpha particles interact, resulting in cell damage and lung cancer[8], $^{210}$Pb, $^{210}$Bi and $^{210}$Po are the long-lived progenies of $^{222}$Rn. $^{210}$Po and $^{214}$Bi are the most important long-lived progenies of $^{222}$Rn. They have unrestricted movement and can enter an enclosed space through crevices and air-filled holes in rocks and soil[9].

Contrary to radon, indoor thoron concentrations are typically low. However, its concentrations are high under a few unusual circumstances. The dose from indoor inhalation increases due to the elevated level of radon and thoron in the indoorenvironment. Variations in the concentration of radon, thoron, and their offspring are caused by the local geology,

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weather conditions, building types, building materials, ventilation conditions, minerals, types of soil, and rocks[10].

Particularly when concentrated in some enclosures such as underground mines, caverns, cellars, or inadequately ventilated and poorly constructed homes[10], radon and its decay products may pose serious health risks. Since we spend the majority of our time indoors, it is crucial to measure and restrict the radon content in indoor [11-16].

The extent of the health dangers posed by radon is unclear, similar to other environmental contaminants. Up to 22,000 lung cancer fatalities may be brought on annually in the US by radon, according to EPA estimates[7].The negative impact on human health is the fundamental reason for the interest in radon research. The study area has wide range of rocks such as granulites, schist belts, green stone belts, dolerite and gabbro dykes, close pet granite, and dolerite dykes. Four different types of dwellings made of with different building materials are found. Thus, keeping in mind the radiation hazards of radon to the general public, the concentration of $^{222}$Rn, $^{220}$Rn, and their progenies in the study area of the Kabini river basin have been measured using SSNTD-based pin-hole dosimeters.

### 1.1 Geology of the study area

In the state of Kerala, Wayanad District, the Kabini River has its beginnings. Kabini River flows eastward and merges into Kaveri in T. Narasipura, Mysuru. Fig. 1 depicts the Haggadadevanakote and Chamundi granites that surround the Kabini River Basin. This region is mostly composed of granulites with charmockites, schist belts with migmatites, green stone belts, dolerite and gabbro dykes, closepet granite, and dolerite dykes[17].The dwellings chosen for the study had a variety of floors, including vitrified tiles and cement roofs, mud floors and thatched roofs, cement floors and clay tiles, and granite floors and concrete roofs. Construction materials such as mud bricks, mud plastering etc., are of derived from local soil of the study area [17-20].

## 2 Materials and Methods

Radon, thoron concentrations are measured in 26 dwellings of 10 villages using pin-hole dosimeter having LR-115 type II films. The schematic diagram of pin-hole dosimeter, direct radon and thoron progeny sensors are shown in Fig. 2, Fig. 3 and Fig. 4 respectively. The dwellings are selected on the basis of availability of permission of owners in 10 villages.

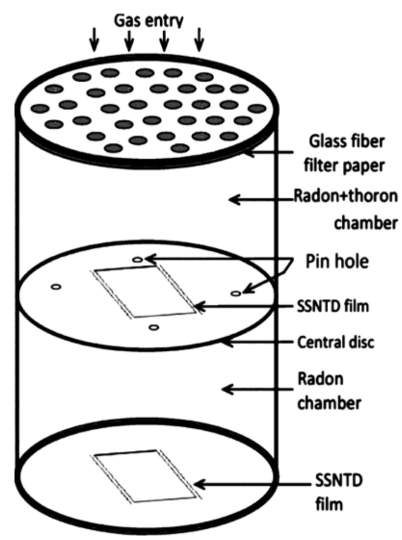


Fig. 2 — Schematic diagram of Pin-hole dosimeter.


Fig. 1 — Geological map of Kabini River Bank, Karnataka, India.

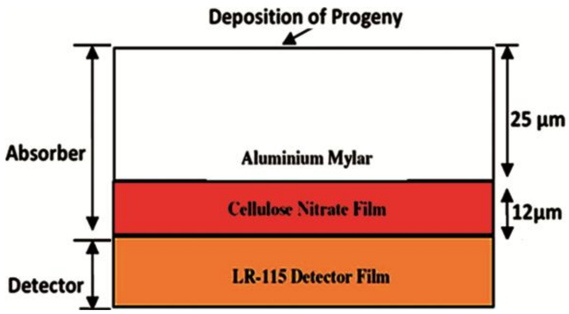

Fig. 3 — Schematic diagram of DTPS

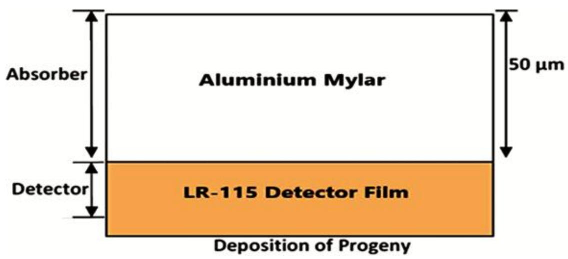

Fig. 4 — Schematic diagram of DRPS

Pin hole dosimeters after inserting the LR-115 are suspended from the midpoint of the dwellings with 2m height from flooring level. After 90 days of exposure in the same location, the pin-hole dosimeters are collected and LR-115 films are collected and further etching process has been made using sodium hydroxide solution having the concentration of 2.5N for a period of 60 min with 60 °C constant temperature. Cellulose acetate base is separated from film and density of alphas are counted using spark counter [21].

### 2.1 Measurement of radon and thoron concentration

Concentrations of radon $C_R$ and thoron $C_T$ has been calculated with the equations given below[22-24].

$$C_R(Bqm^{-3}) = \frac{T_1 - B}{txK_r} \qquad \dots (1)$$

$$C_T(Bqm^{-3}) = \frac{T_2 - T_1}{txK_t} \qquad \dots (2)$$

where, $T_1$, $T_2$are the track density of LLR-115 film in the radon chamber and in Radon+thoron chamber, $B$ is measured as 6 tracks cm$^{-2}$as background track density before exposure, period of exposure is $t$ and calibration factor of radon chamber and radon + thoron chamber are $K_r$ and $K_t$ respectively[22-24].

### 2.2 Equilibrium equivalent radon and thoron progeny concentrations

EETC has been estimated using the following equation[23]

$$EETC(Bqm^{-3}) = \frac{T_T - B}{tx\, S_T} \qquad \dots (3)$$

where, $T_T$ is the number of trackscm$^{-2}$ in DTPS, $S_T$ is the thoron progeny sensitivity factor (0.94 ± 0.027 tracks cm$^{-2}$ d$^{-1}$ Bq$^{-1}$ m$^{-3}$).

A 25 micrometer thick DTPS, an insensitive to progenies of radon has been used to measure EETC. To calculate the exact track density from progenies of radon from DRPS, the number of tracks obtained from DTPS is subtracted from the number of tracks from DRPS as given in below equation[23].

$$T_{Rn} = T_{DRPS} - \left[\frac{\eta_{RT}}{\eta_{TT}}\right] T_{DTPS} \qquad \dots (4)$$

where, $T_{Rn}$ are tracks obtained only from the radon progeny, $T_{DRPS}$ , $T_{DTPS}$ are the number of tracks observed in DRPS and DTPS respectively. $\eta_{RT}$, $\eta_{TT}$ are the efficiency in registering radon and thoron progenies in DRPS and DTPS, respectively [22,23].

The EERC has been estimated using equation given below[23,24]

$$EERC(Bqm^{-3}) = \frac{T_{Rn} - B}{tx\, S_R} \qquad \dots (5)$$

where, $S_R$ is the radon progeny sensitivity factor.

### 2.3 Annual effective dose

The combined effect of radon and its progenies are calculated using AEDR and AEDT with the equations given below for both radon and thoron [23,24].

$$AEDR=[(C_R X0.17)+(EERCX9)]X8760hX0.8X10^{-6} \qquad \dots (6)$$

$$AEDT=[(C_T X0.11)+(EETCX40)]X8760hX0.8X10^{-6} \qquad \dots (7)$$

Sum of AEDR and AEDT give us TAED

## 3 Results and Discussion

Four different types of dwellings are selected for the measurement, such as cement floor and clay tiles, granite floor with concrete roof, mud floor with thatched roof, vitrified floor with concrete roof in the study area has been tabulated in the Table 1. $C_R$varies from 41.83 to 146.41 Bq.m$^{-3}$with average value of 73.08 Bq.m$^{-3}$. $C_T$ varies from 6.67 to 60.00 Bq.m$^{-3}$ with average value of 36.11 Bq.m$^{-3}$. The variation in radon concentration and thoron concentration is mainly due to concentration of radionuclides in the surrounding, the type of dwelling with different ventilation condition and construction materials in dwellings[24]. The measured concentration of radon and concentration of thoron is within the limit as suggested by ICRP[25] with 1.64 mSv.y$^{-1}$ average radon concentration, the AEDR ranges from 0.52 mSv.y$^{-1}$ to 3.64 mSv.y$^{-1}$. The AEDT ranges from 0.28 mSv.y$^{-1}$ to 1.62 mSv.y$^{-1}$, with an average thoron concentration

Table 1 — Concentration of radon and thoron, equilibrium equivalent radon and thoron progeny concentration and annual effective dose as measured in Kabini river bank.

| Villages | Type of dwelling | $C_R$ (Bq $m^{-3}$) | $C_T$ (Bq $m^{-3}$) | EERC (Bq $m^{-3}$) | EE (Bq $m^{-3}$) | AEDR (mSv $y^{-1}$) | AEDT (mSv $y^{-1}$) | TAED (mSv $y^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1.Beechanahalli | cement (Floor) -clay tiles (Roof) | 64.71 | 27.78 | 2.29 | 20.32 | 1.36 | 0.66 | 2.02 |
| 11.9694°N | Vitrified Tiles (Floor)- Concrete (Roof) | 71.24 | 28.89 | 3.55 | 29.82 | 1.97 | 1.02 | 2.98 |
| 76.3576°E | | | | | | | | |
| 2.Nallur | Vitrified Tiles (Floor)- Concrete (Roof) | 64.71 | 31.11 | 3.66 | 29.35 | 1.93 | 1.05 | 2.98 |
| 11.9854°N | Mud (Floor)- Thatched (Roof) | 70.59 | 20.00 | 1.36 | 9.96 | 0.71 | 0.40 | 1.11 |
| 76.3215°E | | | | | | | | |
| 3.Magudilu | cement (Floor) -clay tiles (Roof) | 67.97 | 27.78 | 2.43 | 18.25 | 1.23 | 0.70 | 1.94 |
| 11.9972°N | Vitrified Tiles (Floor)- Concrete (Roof) | 67.97 | 27.78 | 3.69 | 31.20 | 2.05 | 1.06 | 3.10 |
| 76.3715°E | | | | | | | | |
| 4.Manchahalli | cement (Floor) -clay tiles (Roof) | 60.13 | 50.00 | 3.61 | 31.74 | 2.07 | 1.05 | 3.12 |
| 11.9030°N | Vitrified Tiles (Floor)- Concrete (Roof) | 67.97 | 46.67 | 3.46 | 30.61 | 2.01 | 1.01 | 3.02 |
| 76.6008°E | Mud (Floor)- Thatched (Roof) | 41.83 | 6.67 | 0.99 | 7.48 | 0.52 | 0.28 | 0.81 |
| 5.Shanathipura | Granite (Floor) - Concrete (Roof) | 71.90 | 37.78 | 5.04 | 30.96 | 2.04 | 1.44 | 3.48 |
| 12.2651°N | cement (Floor) -clay tiles (Roof) | 70.59 | 40.00 | 2.30 | 20.26 | 1.36 | 0.68 | 2.04 |
| 76.432°E | Vitrified Tiles (Floor)- Concrete (Roof) | 83.66 | 41.11 | 1.21 | 15.92 | 1.10 | 0.37 | 1.47 |
| 6.Yadakola | cement (Floor) -clay tiles (Roof) | 84.97 | 31.11 | 2.70 | 19.29 | 1.32 | 0.78 | 2.10 |
| 12.2741°N | Vitrified Tiles (Floor)- Concrete (Roof) | 84.31 | 40.00 | 3.50 | 28.95 | 1.93 | 1.01 | 2.94 |
| 76.4491°E | Granite (Floor) - Concrete (Roof) | 146.41 | 60.00 | 5.60 | 55.02 | 3.64 | 1.62 | 5.26 |
| 7.Shankahalli | cement (Floor) -clay tiles (Roof) | 75.82 | 38.89 | 2.53 | 25.92 | 1.73 | 0.74 | 2.46 |
| 12.2741°N | Vitrified Tiles (Floor)- Concrete (Roof) | 76.47 | 38.89 | 3.70 | 18.30 | 1.25 | 1.07 | 2.31 |
| 76.4491°E | Granite (Floor) - Concrete (Roof) | 76.47 | 42.22 | 4.89 | 30.20 | 2.00 | 1.40 | 3.40 |
| 8.Maraluru | cement (Floor) -clay tiles (Roof) | 75.82 | 34.44 | 2.41 | 18.37 | 1.25 | 0.70 | 1.95 |
| 12.1101°N | Vitrified Tiles (Floor)- Concrete (Roof) | 71.24 | 50.00 | 3.35 | 27.37 | 1.81 | 0.98 | 2.79 |
| 76.7161°E | | | | | | | | |
| 9.Hadinaru | Granite (Floor) - Concrete (Roof) | 66.67 | 11.11 | 5.07 | 26.71 | 1.76 | 1.43 | 3.19 |
| 12.1667°N | cement (Floor) -clay tiles (Roof) | 65.36 | 35.56 | 2.25 | 19.20 | 1.29 | 0.66 | 1.95 |
| 76.7394°E | | | | | | | | |
| 10.Anchehundi | cement (Floor) -clay tiles (Roof) | 69.28 | 37.78 | 2.29 | 17.61 | 1.19 | 0.67 | 1.86 |
| 12.2108°N | Granite (Floor) - Concrete (Roof) | 75.82 | 55.56 | 4.50 | 32.16 | 2.12 | 1.31 | 3.42 |
| 76.8216°E | Vitrified Tiles (Floor)- Concrete (Roof) | 67.97 | 22.22 | 3.32 | 26.13 | 1.73 | 0.95 | 2.68 |
| | Mud (Floor)- Thatched (Roof) | 60.13 | 55.56 | 1.35 | 18.91 | 1.26 | 0.42 | 1.68 |
| | Minimum | 41.83 | 6.67 | 0.99 | 7.48 | 0.52 | 0.28 | 0.81 |
| | Maximum | 146.41 | 60 | 5.6 | 55.02 | 3.64 | 1.62 | 5.26 |
| | Geometrical Mean | 72.05 | 32.36 | 2.93 | 23.10 | 1.55 | 0.85 | 2.41 |

value of 0.90 mSv.$y^{-1}$. The range of the TAED and its progeny concentrations is 0.81 mSv.$y^{-1}$ to 5.26 mSv.$y^{-1}$, with a mean annual effective dose of 2.54 mSv.$y^{-1}$. In a dwelling with concrete roofing and granite floors, a larger annual effective dosage has been observed. Granite rocks also contain radionuclides with higher activity[25]. As a result, granite floor dwellings have higher TAED and in granite floor with concrete roof dwellings ventilation is poor due to accumulated air inside the dwellings that do not exchange with outdoor environ easily due to less porosity and accumulated air inside dwellings can diffuse only through windows. But in case of mud floor with thatched roof huts, due to high porosity, radon will diffuse in to the outer atmosphere and thus in thatched roof huts concentration of radon is less. Dwelling having mud floor and thatched roof have lower TAED. Bamboo sticks, leaves of coconut and dry ragi plants are used for thatched roof, radon get diffused easily due to high porosity in the thatched roof so radon will not concentrated inside the dwellings of thatched roof[43,44]. Dwelling having Granite material as flooring with concrete roof in Yadakola have higher value of annual effective dose this location is surrounded by granodiorite, Tonalite and Migmatite type of rocks having higher activity of radionuclides. dwelling having mud floor and thatched roof in Manchahalli have low annual effective dose this location is surrounded by dolerite gabbro dykes type of rocks, dolerite rocks have lesser concentration of radionucides, hence the radon and thoron concentration is low[25-30].

The average annual effective dose for four types of dwellings are represented in Fig. 5. The average annual effective dose for dwellings with concrete roofs and granite floors is 3.75 mSv.$y^{-1}$, while the average annual effective dose for vitrified tile floors and concrete roofs dwellings is 2.70 mSv.$y^{-1}$, for

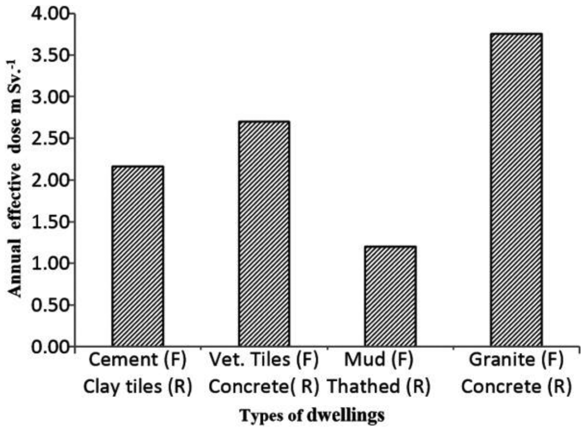


Fig. 5 — Types of dwellings verses annual effective dose.

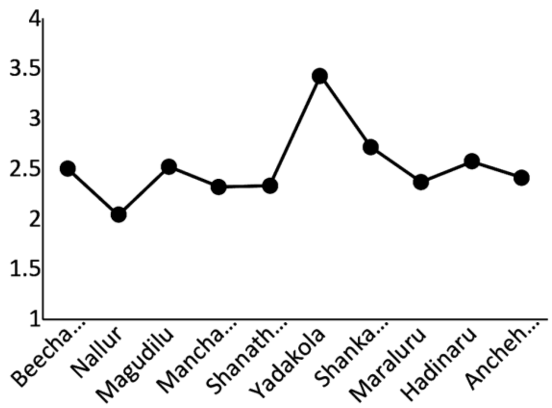


Fig. 6 — Annual effective dose in some dwellings of Kabini River Bank, Karnataka

cement floors and clay tile roofs dwellings is 2.16 $mSv.y^{-1}$, and for mud floor, thatched roofs huts is 1.20 $mSv.y^{-1}$. The granite floor dwellings have the highest concentration of radon because granite has a high concentration of radionuclides. Thus annual average effective dose in granite floor dwellings is higher than other types of dwellings[26,27, 29]. The thatched roof dwellings have high porosity as thatched roof made of dry paddy plants that will allow the radon to pass through it easily, so the concentration of radon in thatched roof type of dwelling has less concentration. The minimum value of TAED is observed in thatched roof dwellings. Fig. 6 depicts the annual effective dosage at each listed in Table 1, Yadakola granite-floored dwelling have higher $C_R$.

## 4 Conclusions

Nearly all homes along the Kabini River bank have higher radon concentrations than thoron. The key factor influencing radon and thoron levels is the type of dwellings. Dwellings having granite floors with concrete roofs have high radon and thoron concentrations. Dwellings with thatched roofs and mud floors typically have low quantities of $C_R$ and $C_T$. The TAED values estimated in four different types of dwellings of Kabini river bank have below the recommended level of 10 $mSv.y^{-1}$.

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