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Study of indoor radon and thoron levels in Vijayanagar, Bangalore, India

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ABSTRACT

Results of the measurement of indoor radon and thoron carried out in and around Vijayanagar, Bangalore, India using passive detector technique is presented. Measurements were carried out using twin cup radon-thoron dosimeter using small strips of 12 micron thick LR-115 type II nuclear track detectors. Measurements were carried out in 44 dwellings for a period of one year on a time integrated quarterly cycle to have the seasonal variation. After the exposure period, the detectors were chemically analyzed using 2.5 N NaOH at 60 °C for a time of 90 min and the etched detectors were scanned by spark counter techniques. The estimated ^{222}Rn and ^{220}Rn levels in the studied locations showed the higher concentrations during winter season, in bath rooms, in concrete walls and in granite flooring houses. In this paper the authors have also made an attempt for the measurement of concentrations of indoor radon along with its distribution pattern based on construction material.

KEYWORDS

Radon;
Indoor exposure;
Dwellings;
Seasons.

INTRODUCTION

Radon and its progenies are identified as a cause of lung cancer among the miners[1]. It has not been clear weather radon poses a similar risk of causing lung cancer in humans exposed at generally lower levels found in homes, but a number of indoor radon survey have been carried out in recent years around the world. The assessment of radiological risk related to inhalation of radon and its progeny is based mainly on integrated measurements of radon[2]. Additional information about the degree of equilibrium between the different radio nuclides is necessary to access the true exposures. Generally, the thoron concentration in dwellings is considered negligible because of the short lifetime of the thoron (55.6 sec). The worldwide average estimated by UNSCEAR is 3 Bq m^{-3}[1]. While calculating the risk, the contribution of thoron and its progeny cannot be ignored. As such the radon measurements should be accompanied by the thoron measurement for assessment of the correct level of dose due to radio nuclides present in the environment. During last several years, a number of studies dealing with radon and thoron measurements were carried out all over the world[3,4]. Radon exposure is largely determined by the geology underlying the buildings, its construction and ventilation conditions[5]. The concentrations of radon and its progeny show large temporal and local fluctuations in the indoor and outdoor atmosphere due to variation of temperature, pressure, building materials, ventilation condition, wind speed, etc.[6]. The track-etch technique is recognized as the most reliable technique for integrated and long term measurement of indoor radon/thoron concentrations[7]. In present investigation, the measurements of radon, thoron and their daughter products are carried out by using LR-115 type II plastic track detector. In recent years, it is observed that the exposure to radon is the most significant element of human irradiation by natural sources[1].

It is therefore important to know the annual average indoor radon concentration in human environment. Keeping in view this fact, the survey was designed taking into account that its main goal is to obtain the annual average indoor radon concentration in different parts of Bangalore city and to find out the average radon value. In spring 2007, the UGC sponsored research project was started. A twin cup dosimeter was used for simultaneous measurements of ^{222}Rn and ^{220}Rn levels inside the houses. The work presented in this paper is a part of the investigations of the research project. About 44 houses were surveyed in Vijayanagar area of Bangalore city and the results of integrated measurements of two year are presented.

METHODS AND MEASUREMENTS

The concentrations of ^{222}Rn and ^{220}Rn levels are measured in dwellings of Vijayanagar area by using Solid State Nuclear Track Detectors, which are thin sheets of dielectric materials such as cellulose nitrate and polycarbonates. They are sensitive to alpha but not to beta and gamma radiations. They are unaffected by moderate humidity, heat and light. For indoor measurements normally LR-115 type II plastic track detector is preferred. The detailed description of methodology and the calibration experiments has been given by Sathish et al[8].

RESULTS AND DISCUSSION

Ventilation wise variations

Houses were selected on the basis of ventilation conditions depending on the number windows available ranged from 0-5. Ventilation wise seasonal variations of ^{222}Rn and ^{220}Rn levels in different dwellings of Vijayanagar area of Bangalore city is shown in Figure 1.

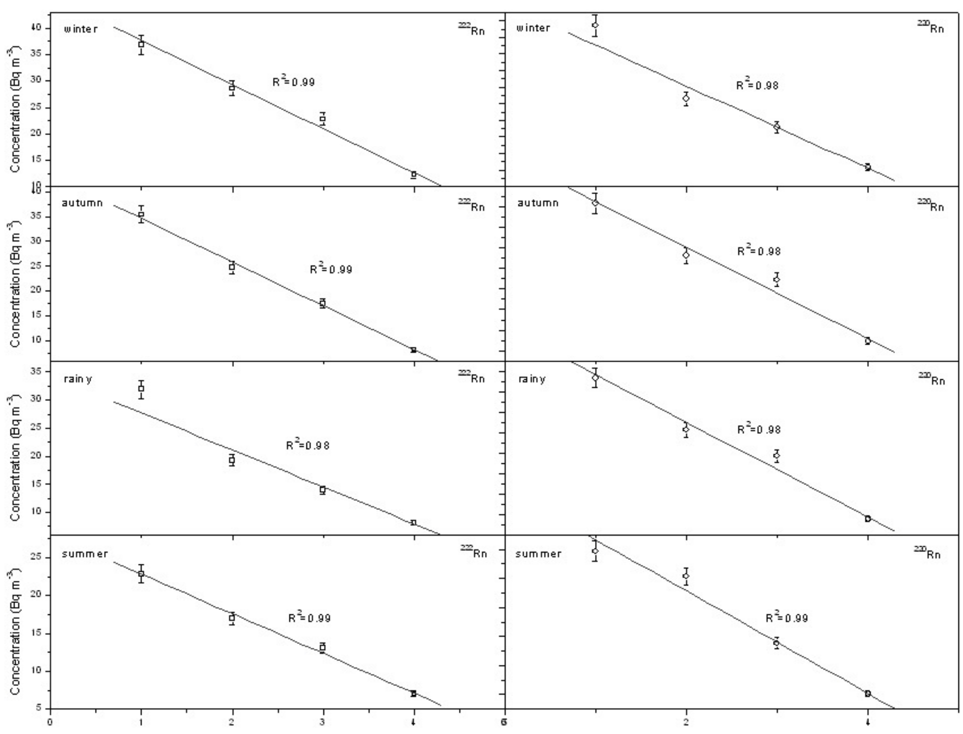

Figure 1 : Variation of ^{222}Rn and ^{220}Rn with respect to ventilation

The maximum concentration was observed during the winter periods as observed elsewhere[9]. It may be essentially influenced by the temperature inversion and also because most of all the windows are closed during winter season. But in summer low concentrations of ^{222}Rn and ^{220}Rn were observed because of the vertical mixing and dispersion. Further during summer fans are used and all windows are kept open. During the rainy season and autumn the ^{222}Rn and ^{220}Rn concentrations do not show much variation. The average value of ^{222}Rn and ^{220}Rn of all the studied dwellings during winter, summer, rainy and autumn seasons were found to be 36.8, 13.8, 23.2 Bq m^{-3} and 24.5 and 20.0, 8.1, 13.2 and 14.4 Bq m^{-3} respectively. It is known that the ^{222}Rn and ^{220}Rn gases are continuously diffused into the indoor environment due to the radioactive decay of naturally occurring radionuclide present in the soil beneath the dwellings and the construction materials used for the dwellings. Since the soil beneath the dwellings in a given location is expected to be of same type[10]. The average values of ^{222}Rn and ^{220}Rn levels of all the studied dwellings reveal maximum in winter and minimum in summer season. The gradual decrease of radon in summer is due to high temperature and low pressure in summer. Still decrease in monsoon may be due to saturated water in the soil. Winter to rainy season ratio of measured radon concentration is slightly more than the winter to summer ratio season ratio. The high values in winter are mainly because of ventilation factor[11].

Flooring wise variations

Dwellings were chosen on the basis of different floorings. The variations of ^{222}Rn and ^{220}Rn concentrations in dwellings of different floorings with respect to the number windows available in the monitored houses are shown in Figure 2. The measurements were made covering all the four seasons in a calendar year. The walls and flooring of the houses are of different materials. The materials used for construction of buildings are sufficiently porous and allow ^{222}Rn to enter into the indoor atmosphere[12]. The integrated data reveal the higher concentration in granite floorings and lower in mosaic flooring.

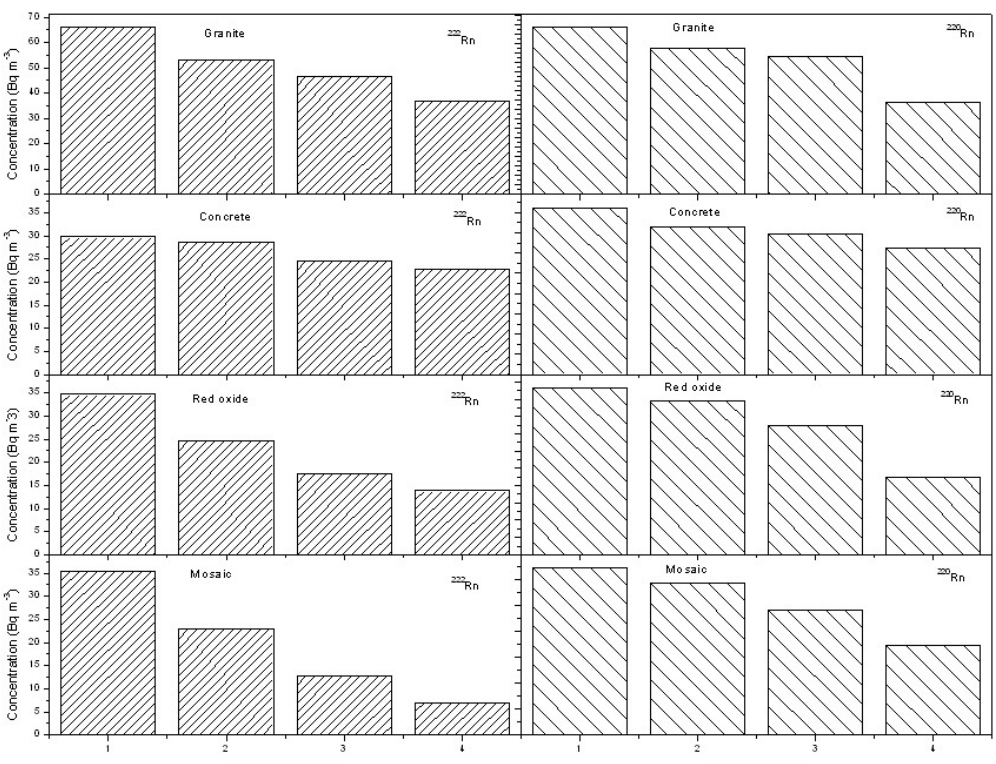

Figure 2 : Variation ^{222}Rn and ^{220}Rn with respect to floorings

The data shows that in the houses with brick and cement flooring, concentration is less but in the house with granite flooring it is slightly higher because granite contains high concentrations of ^{226}Ra. Sannappa et al.[13] have shown that there is a positive correlation between the exhalation rate and concentration in building materials. Granite samples show higher ^{222}Rn exhalation rate than marble, and the correlation of the ^{226}Ra content of granite with ^{222}Rn exhalation and ^{222}Rn concentration is observed by several researchers[14,15]. Mosaic flooring houses show slightly less ^{222}Rn exhalation rate than cement flooring houses. The huts have mud walls, bare flooring and poor ventilation. The ^{222}Rn concentration in huts is lower than in concrete and mosaic flooring houses even though ^{222}Rn exhalation from bare flooring is higher than other types of flooring. This may be attributed to the possibility of out flow of air from huts through the coconut dry leaves that form the roof. Further the fume emitting from cooking stove would increase the air pressure inside dwellings and forcing it outside. ^{222}Rn exhalation in mud walls is less compared to the cemented walls. High ^{222}Rn exhalation from concrete walls may be responsible for increasing the concentration in cement and mosaic flooring houses. This may be due to the high ^{222}Rn concentration in the concrete floorings and also because of the porous floor concrete slab through which ^{222}Rn could easily enter the houses. In addition to this the high Indoor ^{222}Rn concentration could be attributed to cracks in the floor as a consequence of poor quality of materials used for construction[16]. The average concentrations of ^{222}Rn and ^{220}Rn in Vijayanagar area of Bangalore city were found to be 12.2, 19.3, 24.5 and 36.8 Bq m^{-3} and 8.3, 15.9, 15.2 and 35.4 Bq m^{-3} for mosaic, red oxide, concrete and granites floorings respectively.

Wall wise variations

The concentrations of ^{222}Rn and ^{220}Rn in houses of different walls are shown in Figure 3. The concentration levels are found to vary from wall to wall. The variation is may be due to random distribution of radioactive rock species used ignorantly in the construction of the houses[17]. Further the high radon level in mud houses suggests that the building materials and mode of the construction of houses influence the indoor radon levels. In view of the quality and number of mud houses in the area, a large population in that area is expected to expose to a high value of ^{222}Rn and ^{220}Rn with a potential risk of lung cancer[11].

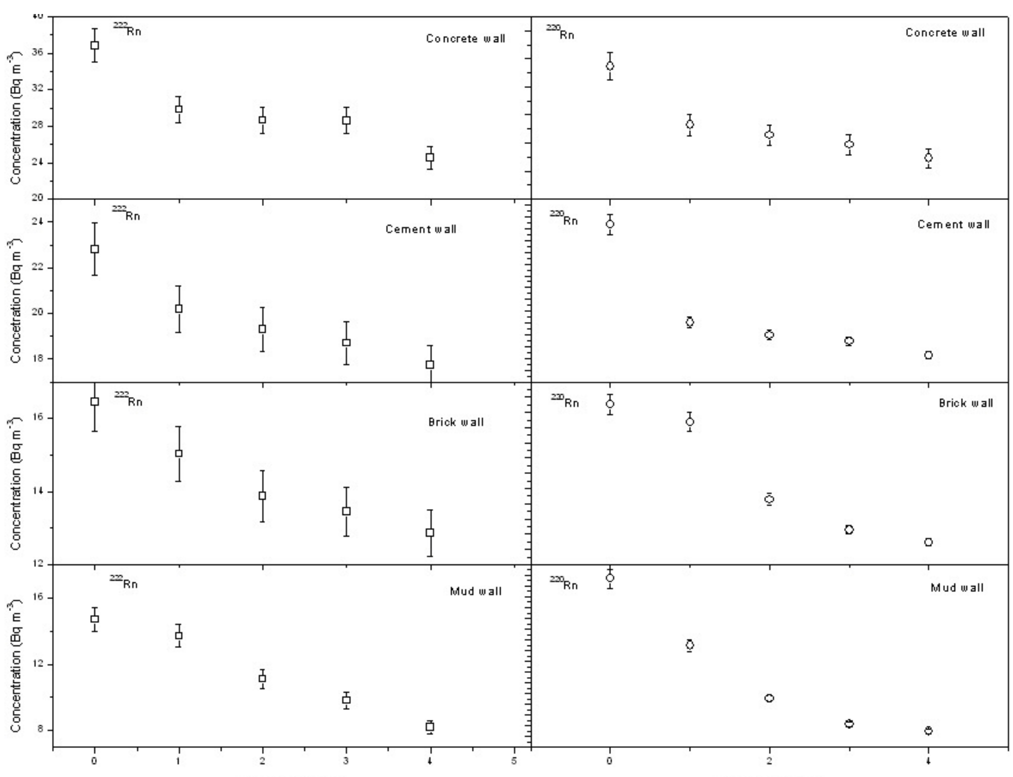

Figure 3 : Variation of ^{222}Rn and ^{220}Rn with respect to walls

The average values of ^{222}Rn and ^{220}Rn in different walls of the dwellings were found to be 11.1, 14.4, 22.8 and 36.8 Bq m^{-3} and 8.3, 7.5, 12.5 and 19.4 Bq m^{-3} respectively. Guo et al[18] have reported that the

^{220}Rn concentration seemed more sensitive to ventilation conditions than that of ^{222}Rn. Indoor radon and thoron also showed a good correlativity with field c dose rate. The ranges of ^{222}Rn and ^{220}Rn exhalation rate from the surface of adobe wall were 22.5 – 42.9 and 21.11 – 40.12 mBqm^{-2}s, respectively. For the surface of brick wall, the ranges of ^{222}Rn and ^{220}Rn exhalation rate were 11.1–26.4 and 317–1022 mBqm^{-2}s, respectively. Both $^{222}Rn/^{220}Rn$ concentrations were measured with 1-h cycle in five adobe and brick houses; the range of the average concentrations of each measured room was 152–412 Bq m^{-3} for ^{222}Rn and 82–403 Bq m^{-3} for ^{220}Rn (5 cm from the ground and far from the wall). Authors have also reports that rather high levels of radon and thoron with a wide and varied range were found in both adobe and brick houses as well. High ^{220}Rn exhalation rates from the surface of adobe walls suggested that the adobe walls were the sources of the high thoron concentrations indoors. Our observations are similar to the observations made elsewhere[18].

Room wise variations

The concentrations of ^{222}Rn and ^{220}Rn in different rooms of different dwellings are shown in Figure 4.

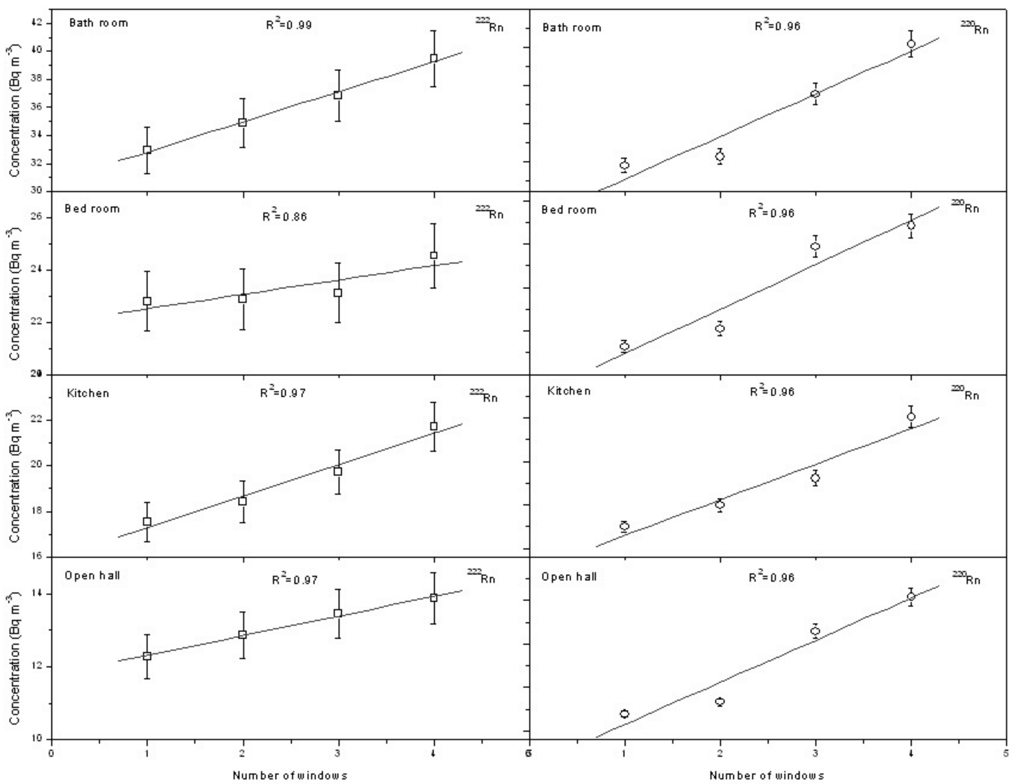

Figure 4 : Variation of ^{222}Rn and ^{220}Rn with respect to rooms

One can clearly see that there is high concentration in bathroom compared to the other rooms in the houses. The differences were clearly present, bathroom was found to have higher ^{222}Rn concentration, kitchen ranked second, next bed rooms and living room the least. Bed rooms might be expected to be least ventilated, on the average based upon limited use patterns and bath rooms may receive some additional ^{222}Rn due to ^{222}Rn dissolved in water[19]. ^{222}Rn is shown to be released in spray from faucets or shower fixture[20]. NCRP[21] reports that 40% of houses use water from private wells or similar sources having high radon content. Although domestic water use varies widely in the amount of radon released, some uses such as showers and dish washing release up to 98% of the radon in the water to indoor air. Of the 50 to 100 gallons of water used per day per person approximately 70% of the radon is released to the indoor environment. On this basis some 0.5 to 3% of the approximately 40 Bq m^{-3} mean radon concentration of radon in homes originates from the domestic water supply[21]. It is also estimated that 370 Bq L^{-1} of

^{222}Rn in water contributes about 37 Bq L^{-1} of ^{222}Rn to the indoor air of a houses depending upon the water temperature and to the extent that the water is aerated[19,22]. This also supports our results of higher concentrations in bath rooms. Air in living rooms on the other hand is most readily diluted due to outdoor air blow. The average values of ^{222}Rn and ^{220}Rn levels in bath room, bed room, kitchen and living rooms of different dwellings of the monitored dwellings were found to be 32.9, 24.5, 17.5 and 13.4 Bq m^{-3} and 28.8, 15.2, 13.1 and 6.9 Bq m^{-3} respectively.

Figure 5 reveals that there is a positive correlation between ^{222}Rn, ^{220}Rn and their progenies. The results differ somewhat from dwellings to dwellings, but this may be mainly due to the differences in location and meteorological conditions. Generally, sites with such radon and its progeny concentrations, such as that studied here, could possibly be found in many countries and may become important sources of information regarding the effect on health of low doses due to natural radiation exposure outdoors. On the other hand, theoretical modeling is necessary to help interpret the data and to make predictions beyond the observations (for example, regional deposition in the human lung). In addition the dwellings of high indoor radon and thoron concentration are in accordance with the distribution maps of ^{226}Ra and ^{232}Th concentrations in surface soil, respectively, and granite[23].

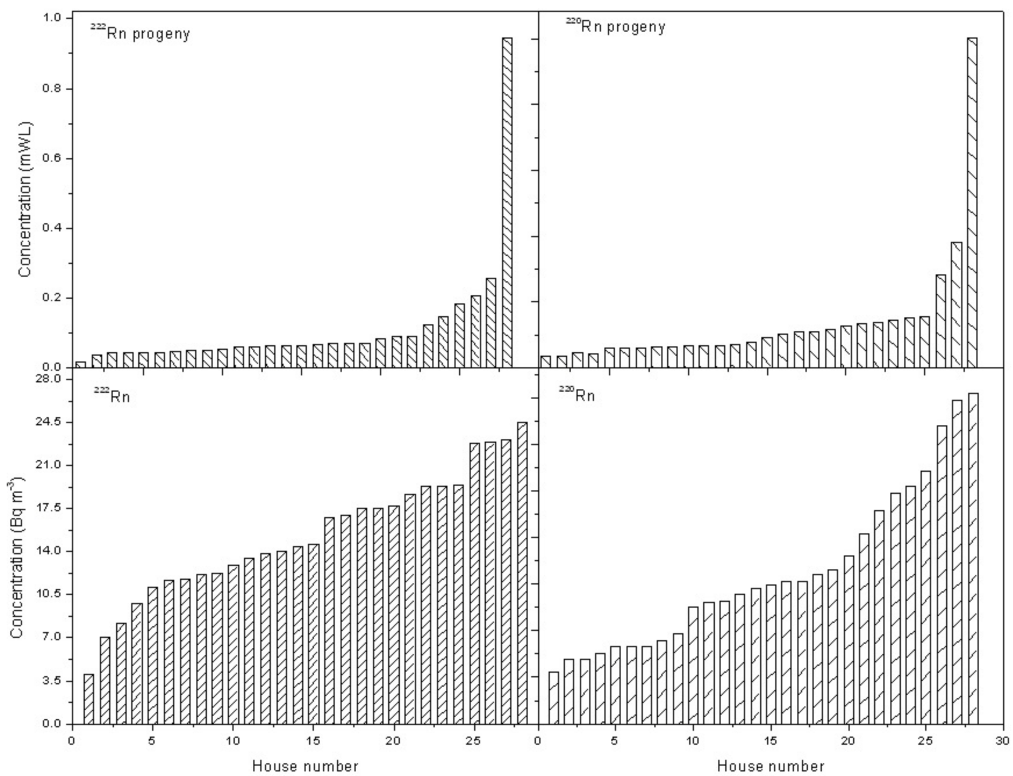

Figure 5 : Variation of ^{222}Rn and ^{220}Rn

CONCLUSIONS

The dose rates recorded during this study are due to the contribution of the natural background radiation and did not show any abnormal raise in the radiation level at any place, which can be attributed to any radionuclides other than due to natural background. Radon/thoron and their progeny concentrations in the indoor atmosphere vary with ventilation conditions, types of the flooring, and types of the materials used for construction of houses. The average concentrations of radon and thoron are 23.78 Bq.m^{-3} and 14.69 Bq.m^{-3} for their progenies they are 0.082mWL and 0.044mWL respectively, the radon concentration is less than the global average (40 Bq.kg^{-1}) but thoron concentration is higher than the global average (10Bq.kg^{-1}). Total annual inhalation dose due to radon/thoron and their progeny and ambient gamma radiation in Bangalore is slightly lower than the global average value. Radon/thoron and their progeny concentrations in Bangalore city vary with ventilation conditions, types of the flooring, and types of the materials used for construction of houses. High concentration is observed in very poorly ventilated and loose-cemented flooring houses. The average annual dose to the population of Bangalore city due to radon and thoron daughter activity works out to be 1.68 mSv y^{-1}. All India mean effective dose equivalent is 2.49 mSv y^{-1} and the global effective dose equivalent is 2.4 mSv y^{-1} Seasonal variations in the concentration of indoor radon/thoron and their progeny concentrations are observed. Higher values were found in winter and lower in summer. Also maximum concentrations have been observed in rainy and autumn seasons in some dwellings. Indoor radon/thoron concentrations at Bangalore are comparable with the global average value; the global average values of indoor radon/thoron concentrations being 40 $Bq.m^{-3}$ and 10 $Bq.m^{-3}$, respectively.

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