Study on influence of soil and atmospheric parameters on radon/thoron exhalation rate in the Bangalore University campus, Bengaluru

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Abstract

In the present study, Radon ($^{222}_{\text{Rn}}$) and Thoron ($^{220}_{\text{Rn}}$) concentration have been measured in the Bangalore University Campus using RAD7 during the postmonsoon season. The results reveal that $^{222}_{\text{Rn}}$ concentration ranged from 360 ± 146 to 643 ± 196 Bq/m$^3$ with the geometric mean (GM) of 497 ± 173 Bq/m$^3$ whereas $^{220}_{\text{Rn}}$ Concentration varied from 2668 ± 208 to 6128 ± 246 Bq/m$^3$ with the GM of 4287 ± 262 Bq/m$^3$. The radon and thoron exhalation rates were also calculated and found to lie between 15.62 ± 6.34 and 27.91 ± 8.51 mBq/m$^2$/s with the GM of 21.58 ± 7.50 mBq/m$^2$/s and 1316 ± 102 and 3024 ± 121 mBq/m$^2$/s with the GM of 2115 ± 129 mBq/m$^2$/s, respectively. An attempt was made to see the dependence of radon/thoron exhalation rate on few soil and atmospheric parameters. The concentration of radon and thoron was observed to be normally distributed and hence arithmetic mean, GM and median were found to be nearly same.

Keywords: Moisture content, radon exhalation rate, relative humidity, soil temperature, thoron exhalation rate

INTRODUCTION

Natural radiation exists in our living environment since from the formation of the earth. Radon-222 (radon) and radon-220 (thoron), naturally existing radioactive gaseous isotopes, contribute more than 50% of radiation dose to the mankind.[5] Human beings are exposed to radon, thoron, and their progenies constantly. These radionuclides being the decay products of $^{238}_{\text{U}}$ and $^{232}_{\text{Th}}$ present in the earth’s crust can easily escape into the atmosphere through the soil pores by the process called exhalation. Inhalation and ingestion of these radionuclides are injurious to human health in one or the other way. In prospect of this, a study has been conducted on radon exhalation rate[5] and influence of atmospheric parameter on it at the Department of Physics, Bangalore University, Bengaluru which falls in the proposed study area. In the present study, an attempt has been made to infer the influence of soil moisture content and temperature on radon and thoron exhalation rate.

Study area

In this study, measurements were conducted at the Bangalore University campus, Bengaluru, Karnataka. It is located at 12.94°N latitude 77.51°E longitude in the south-west region of Bengaluru and spreads over 1100 acres. The experiments were conducted along the 4 directions considering the
Department of Physics to be at the center. The sampling spots were selected in such a way that they cover the maximum area of the university by avoiding the influences from building, human disturbances, and surface run off. The outer circle in the study area [Figure 1] represents the boundary of the Bangalore University campus.

MATERIALS AND METHODS

*In situ* measurements of \(^{222}\text{Rn}\) and \(^{220}\text{Rn}\) concentration in the soil samples were carried out during postmonsoon using a closed loop accumulation method which comprises two devices, namely (a) measuring equipment (RAD7) and (b) sampling unit (accumulation chamber). In this method, RAD7 will draw air from the surface emission chamber into the detector chamber through the desiccant tube followed by the inlet filter. The air was then run into the same chamber through the vent of the RAD7 to form a closed loop. The conventional representation of the experimental setup is shown in Figure 2.

From the measured radon and thoron concentration, its exhalation rate was calculated using the following relation,[3]

\[
J = \frac{C \times V}{A(1-e^{-\lambda t})} \text{ mBq/m}^2/\text{s}
\]

Where \(C\) is the radon/thoron concentration at the surface of the soil

\(\lambda\) is the radon/thoron decay constant

\(V\) is the total volume (volume of the inner cell of RAD7 + volume of the chamber)

\(A\) is the surface area of the soil covered by the accumulation chamber

\(t\) is actual exposure time

Soil samples which were collected from the study location were investigated further for soil parameters. Soil moisture content (%) is the one which was calculated using the well-known technique called oven dry method.[4,5]

\[
\text{Soil moisture content (\%) = } \frac{\text{Mass of soilwater}}{\text{Mass of dry soil}} \times 100
\]

RESULTS AND DISCUSSION

The results obtained in the present study are tabulated in Tables 1 and 2. It is evident from Table 1 that, \(^{222}\text{Rn}\) concentration varies from 360 ± 146 to 643 ± 196 Bq/m\(^3\) with the geometric mean (GM) of 497 ± 173 Bq/m\(^3\) whereas \(^{220}\text{Rn}\) concentration is found to range between 2668 ± 208 and 6128 ± 246 Bq/m\(^3\) with the GM of 4287 ± 262 Bq/m\(^3\).

From measured radon and thoron concentration, their exhalation rate were also calculated and found to lie between 15.62 ± 6.34 and 27.91 ± 8.51 mBq/m\(^2\)/s with the GM of 21.58 ± 7.50 mBq/m\(^2\)/s and 1316 ± 102–3024 ± 121 mBq/m\(^2\)/s with the GM of 2115 ± 129 mBq/m\(^2\)/s, respectively. The variation observed in the radon and thoron concentration may be ascribable to the geological formation underneath the study location. The values obtained in the present study are well within the worldwide average as given in UNSCEAR 2000.[6]

To understand the parameters affecting radon/thoron exhalation rate, an effort is made to analyze the influence of few soil and atmospheric parameters on it. From Figure 3a, it can be seen that the radon exhalation rate increases with increase in moisture content up to approximately 7%; later on, decreases as moisture content increases. The same tendency is also exhibited in the thoron exhalation rate, which is depicted in Figure 3b. This may be ascribable to the fact that water content in soil favors the exhalation of radon/thoron up to a certain limit; after that, it begins to suppress the radon/thoron gas inside the voids as water

![Figure 1: Map showing sampling spots in the study area](http://www.rpe.org.in)
blocks the voids which helps them to get out from the soil matrix.\(^7\) The atmospheric and soil temperature were also measured using the standard thermometer and are found to vary from 20.6°C - 24.1°C and 23°C - 25.5°C, respectively. The variation of these parameters and radon/thoron exhalation rate in different sampling locations is shown in Figure 4a and b. It can be seen from these figures that the observed variation in the soil and atmospheric temperature of the sampling locations of the study area is not much and do not influence much on the rate of radon/thoron exhalation. Whereas, in case of radon exhalation rate and relative humidity (RH), it is noted to be a moderate positive correlation (\(R^2 = 0.54\)). This may be due to the fact that RH in the surrounding environment nearer to the surface may play a vital role with the moisture content at the surface soil. To come to an authentic conclusion, the detailed study has to be borne out in the region of Bengaluru including the present study location with more number of samplings in the future work.

**CONCLUSIONS**

The results obtained in the present work reveal that radon/thoron exhalation rate is comfortably within the world average value as given in UNSCEAR 2000. It is observed that both radon and thoron exhalation rate do depend on moisture content. Soil moisture content favors the exhalation rate up to a certain level, after it suppresses the exhalation rate of radon/thoron. From the correlation study, it is found that there is moderate positive correlation (\(R^2 = 0.54\)) between radon exhalation rate and RH. The detailed study is necessary to reach an authentic conclusion of the present investigation in the future work.
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Conflicts of interest
There are no conflicts of interest.

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