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Measurement of indoor concentrations of radon and thoron in Mizoram, India

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Abstract

Radon, thoron and their progenies as a natural radiation hazards to human health is well known. These gases are present in the environment and their level of concentration depends upon geographical and geological conditions, meteorological factors, etc. The indoor radon/thoron concentration is also influenced by building materials, ventilating system and soil gas diffusion. Measurement of radon/thoron concentration in Mizoram is reported in this paper covering three districts, namely Aizawl, Kolasib and Champhai. In this study, we used solid-state nuclear track detectors to obtain the time integrated concentration levels of indoor radon/thoron. The study was conducted by measuring the cumulative exposure for a period of about 90 days each in 149 houses during rainy season (May-August). Houses were selected on the basis of geological characteristics of the area and the construction types in order to determine variation of concentrations of radon and thoron due to these factors. Among the three districts, Champhai District had the highest radon/thoron concentrations, while Kolasib District had the maximum thoron concentration. Among the different types of houses, concrete building had the average maximum concentration of radon followed by Assam type building with G.I. Sheet walls while the contribution due to asbestos walls of Assam type building was found to be lowest.

Key words: Construction types of buildings; Mizoram; radon; solid state nuclear track detectors; thoron; twin cup dosimeter.

Introduction

Natural radiation is the largest contributor to the collective radiation dose to the world population. The major contribution of dose from natural radiation in normal background region arises due to inhalation of radon and its progeny and to certain extends due to thoron and its progeny.[1] Radon is naturally occurring radioactive inert gas, with a half life of 3.8 days produced from the decay series of

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^{238}U. The inhalation of radon/thoron daughters can be sufficiently high as to cause an increase in lung cancer occurrence.[2]

Radon/thoron present in the atmosphere is a serious threat to health hazards due to quick circulation to surrounding atmosphere. It becomes environmental hazards particularly when it remains in enclosed places such as houses, caves and mines. The outdoor concentration level depends on geological and geophysical conditions, atmospheric influences such as barometric pressure and rainfall. The indoor concentration depends upon building materials and ventilation system, while entry into indoor environment from outside depends on certain factors, *viz* soil gas infiltration, openings like doors, windows, ventilation, cracks in solid floor and walls, etc. On the basis of its geological and seismic characteristics north-eastern region of India[3] is expected to have higher concentrations of radon.

In this report, the measurements for indoor radon/thoron concentrations in Mizoram were made in different geographical locations: Aizawl, Champhai and Kolasib districts. Aizawl city in Aizawl district contains distinct geological characteristics like fault regions and fossil area. In the remaining districts the geological characteristics remained unrepresented and may be treated as unrepresented location. The types of houses selected according to the building material are reinforced cement concrete (R.C.C.) and Assam type.

In Assam type construction the roofs consists of G.I. sheets and walls are mostly made up of asbestos (tile), wooden or bamboo; and floors are made of concrete, wooden planks or earth. It is interesting to note that in Mizoram, being a hilly terrain landscape, some RCC buildings are constructed on a steep slope in such a way that the fifth floor may have a wall adjacent to the soil on its sides and hence radon/thoron emanation through these walls is supposed to be enhanced concentration of the gases in addition to the contribution due to building materials of the wall.

Materials and Methods

For indoor radon/thoron measurement, solid state nuclear track detector (SSNTD) based dosimeters[4] developed by Bhabha Atomic Research Centre (BARC), Mumbai, were used for the survey. The dosimeter system is a cylindrical plastic chamber divided into two equal compartments. Cellulose nitrate film (LR-115, Type II) are used as detectors. One end of the compartment called filter cup allows the entry of both radon and thoron inside by covering the cup with a glass fiber filter and hence tracks formed on the film due to both radon and thoron gases. On the other side of the compartment only radon gas was allowed to enter which has a modification from previous measurement[5] by using a cap with a pin hole in it. This pin hole is designed in size and thickness of cap so as to block thoron from entry inside by considering the diffusion length and half life of thoron.

The dosimeter is hanged over on the ceiling of the selected houses at a height of minimum 1.5 m from floor and at least 10 cm away from any surface for a period of about 90 days. Bedroom ceiling is preferred as this is a room where one has maximum occupancy. After the period of exposure is over the detector is retrieved and chemically etched using 2.5 N NaOH solution at constant temperature of 60°C for 90 minutes. The etched SSNTD films are then counted by using a spark counter.[6] The limit of detection of radon gas depends on the exposure time and radon concentration, the number of background tracks in unexposed films.[7]

Results

The study was conducted by measuring the cumulative exposure for a minimum period of about 90 days in each house during rainy season (May-August) in 2008 covering 149 houses. The radon/thoron concentration in

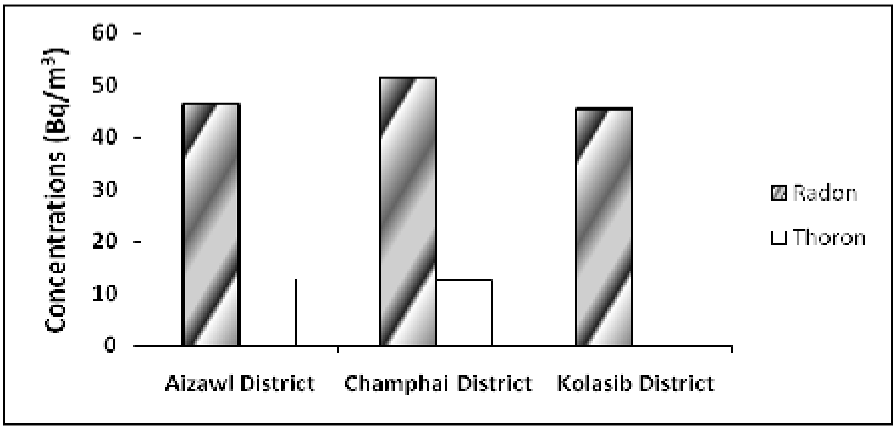

Figure 1. Radon and thoron concentrations with geographical location.

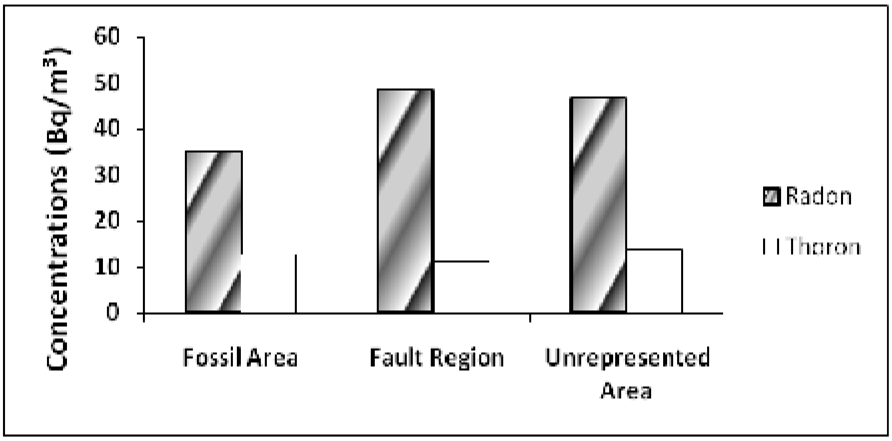

Figure 2. Radon and thoron concentrations with geological location.

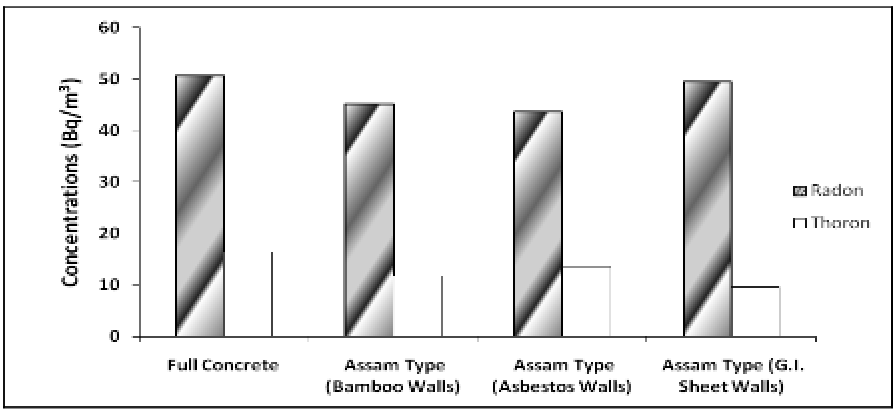

Figure 3. Correlation of radon/thoron concentration with construction types.

this particular season is indicated in this report and seasonal variation of these gases in the same area was reported elsewhere.[8] The data obtained were correlated with the geographical location, geological location and construction type of buildings. A previously determined calibration factors (concentration conversion factors) by the manufacturer were used for radon/thoron dosimeter cups. For rodon+thoron in pinhole compartment was 0.023 track/cm^2/day/(Bq/m^3) and that of thoron in filter compartment was 0.016 track/cm^2/day/(Bq/m^3).

Radon/thoron concentrations with geographical locations

Figure 1 shows the concentrations of radon and thoron versus geographical distribution. In Aizawl district we obtained radon concentration from 17.7 to 101.56 Bq/m^3 with GM of 46.30 Bq/m^3, and thoron varying from 0.47 to 69.94 Bq/m^3 with 12.90 Bq/m^3 GM. In Champhai district, radon varied from 23.76 to 111.37 Bq/m^3 with 51.33 Bq/m^3 GM, and of thoron varied from 1.31 to 93.38 Bq/m^3 with 12.56 Bq/m^3 GM. In Kolasib district the concentration of radon varied from 26.86 to 85.06 Bq/m^3 with 45.41 Bq/m^3 GM, and thoron varied from 1.54 to 106.48 Bq/m^3 with 16.67 Bq/m^3 GM. Comparing these three districts Champhai district had the highest concentration of radon while Kolasib district had the highest concentration of thoron.

Radon/thoron concentration vs geological characteristics

In Figure 2, we show average radon and thoron concentrations versus the geological characteristics (fossil areas, fault areas and unrepresented areas), respectively, in Aizawl districts only. Here, concentration of radon in fossil region varied from 18.59 to 61.29 Bq/m^3 with a GM of 35.07 Bq/m^3, and that of thoron varied from 4.32 to 27.04 Bq/m^3 with 12.82 Bq/m^3 GM. In fault region, the radon varied from 23.45 to 91.13 Bq/m^3 with 48.48 Bq/m^3 GM, and that of thoron varied from 0.83 to 69.94 Bq/m^3 with 11.37 Bq/m^3 GM. In normal area, the concentration of radon varied from 17.7 to 101.56 Bq/m^3 with 46.67 Bq/m^3 GM, and concentration of thoron varied from 0.47 to 52.16 Bq/m^3 with 13.85 Bq/m^3 GM. It is clear that fault regions showed highest radon levels and unrepresented area had highest thoron concentrations.

Radon/thoron distribution with construction types of buildings

A chart was plotted using the average concentrations of radon/thoron versus the construction type of buildings in Figure 3. It can be observed that the RCC type of building had the highest concentrations of radon, varying from 25.33 to 101.56 Bq/m^3 with 50.68 Bq/m^3 GM and that of thoron varied from 0.47 to 97.8 Bq/m^3 with 16.46 Bq/m^3 GM.

In Assam type building with bamboo walls, the concentration of radon varied from 23.76 to 76.5 Bq/m^3 with GM of 45.2 Bq/m^3, and that of thoron varied from 0.83 to 106.4 Bq/m^3 with 11.85 Bq/m^3 GM with asbestos walls, the concentration of radon varied from 17.7 to 111.37 Bq/m^3 with 43.72 Bq/m^3 GM, and that of thoron varied from 1.31 to 93.38 Bq/m^3 with 13.55 Bq/m^3 GM. Again with G.I. sheet walls, the concentration of radon varied from 32.48 to 85.06 Bq/m^3 with 49.51 Bq/m^3 GM, and that of thoron varied from 1.15 to 63.16 Bq/m^3 with 9.59 Bq/m^3 GM. Here one can see that in Assam type buildings, the G.I. sheet walls had the highest radon concentration.

Discussion and Conclusion

The results show that overall concentration of radon and thoron in the study area are low compared to that of the level found in high background radiation areas like the western coast of Kerala.[9] It has been found that the radon gas concentrations are higher than the thoron concentrations in all the parameters regardless of geographical, geological or house type distributions. However, in all the cases the indoor radon or thoron level does not exceed the ICRP limit,[10] which is 200 Bqm^{-3}. In spite of limited knowledge of Geological distribution in Mizoram, survey result shows that fault regions do really show higher average level of radon/thoron concentrations compared to other places. The fossil region is a stone quarry and no dwellings are constructed inside the area but around the area at about 30 m away. Hence considering the diffusion coefficient[11] of radon in different soil types to air as 10^{-5} m^2 s^{-1}, the radon/thoron level cannot be expected to increase in these dwellings due to nearby fossil quarry.

Due to mild climate in Mizoram throughout the year, (maximum 35°C in summer and as low as 7°C in winter), it is neither too hot nor too cold and most of the houses are having good ventilation systems. This good ventilation rate can contribute to the low level occurrence of radon/thoron concentrations. The RCC type of construction having materials of higher natural radioactivity content[12] has higher radon/thoron concentrations as expected compared to Assam type buildings. In Assam type also, one found that those with G.I. sheet as walls have high radon level which can be due to lesser ventilation rate and its ability to block radon from escaping outside. However, higher concentration of thoron in asbestos than other types of walls could be attributed due to the higher natural activity content of asbestos material.[13]

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