Study of natural background gamma radiation levels in Hyderabad and its surroundings, Andhra Pradesh, India

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The natural background gamma radiation levels were measured in the dwellings of urban Hyderabad and its surroundings using thermoluminescence (TL) dosimeters and Geiger-Muller based µR-survey meter. The measured minimum, maximum and average radiation levels were found to be 226, 506 and 314±47 nGy h\(^{-1}\) for urban Hyderabad and 190, 462 and 309±81 nGy h\(^{-1}\) for surroundings of Hyderabad. In this study, the natural background gamma radiation levels in different dwellings with types of constructions have been correlated. It was found that these levels are higher in the constructions made by mud, which is of local soil. The annual effective dose due to natural background gamma radiation exposure in the Hyderabad and its surroundings is calculated and found to be 1.54±0.23 mSv and 1.52±0.40 mSv, respectively.

Keywords: Natural background radiation, TL dosimeters, µR-survey meter, Annual effective dose

1 Introduction
Natural background radiation contributes significantly (about 80%) to the annual effective dose received by the general population\(^1,2\). Therefore, the knowledge of natural sources of background radiation is the most important and immediate concern to the general population. Natural background radiation arises due to the radionuclides \(^{238}\)U, \(^{232}\)Th, \(^{40}\)K, \(^{222}\)Rn and \(^{220}\)Rn present in the indoor and outdoor environment. The distribution and availability of these radionuclides depend mainly on the geology and geographical characteristics of the place and human activities\(^3,4\). The variation of amount of radiation received depends on the location, rock and soil types, type of building materials, etc. The presence of natural radionuclides in building materials may cause increase of both external and internal radiation exposure of general population in the dwellings, since most of the dwellers spend almost 80% of their time in indoors\(^5\). External exposure in indoors arises from gamma-emitter radionuclides present in the materials used for the construction of dwellings. The most important radionuclides are \(^{40}\)K and the members of two natural radioactive series (i.e. \(^{212}\)Th and \(^{238}\)U).

The study area covered in the present investigation is urban Hyderabad and its surroundings. This region consists of varieties of granites. Based on the sample survey made on the abundance of radioactive elements in the exposed soil/rocks across the country\(^6\), it was reported that this area is a good geochemical host for \(^{238}\)U, \(^{232}\)Th and \(^{40}\)K. For this study, the dwellings were selected randomly in urban Hyderabad and its surroundings, and an attempt has been made to study the natural background gamma radiation levels in the dwellings with different construction types and to calculate the annual effective dose.

2 Measurement Techniques
Field measurement is an important aspect in the monitoring of radiation levels. Several techniques are available to monitor the natural background gamma radiation levels\(^7\). In the present investigation, we have employed two different techniques, one the time integrated and the other instantaneous, due to their versatility in the field work. For the time integrated measurements of radiation levels, the phenomenon of thermoluminescence (TL) was put to use\(^8\) since early 1950’s. Among the different TL-materials natural CaF\(_2\) powder is known to be the best one for dosimeter applications. For the present study, the required CaF\(_2\) powder was supplied by Environmental Assessment Division (EAD), BARC, Mumbai, India. The TL dosimeters were prepared by filling 40±0.2 mg of annealed powder in a pair of brass capsules and thereafter, wrapping them with a weather proof PVC
jacket. These dosimeters were installed at a height of about 1.5 ft below the roof and about 2 ft from the walls in different dwellings and left them undisturbed in their places for a stipulated period of exposure (90 days). The details about the study of TL glow curves of exposed dosimeters and calibration for monitoring the natural background gamma radiation levels was explained elsewhere\textsuperscript{9,10}. Geiger-Muller based micro-Roentgen survey meter (Nucleonix Systems Pvt. Ltd., Hyderabad make) was used for instantaneous measurements. The sensitivity of the survey meter is 0.1 µR hr\(^{-1}\). It was calibrated frequently at Health Physics Unit, Nuclear Fuel Complex, Hyderabad, by exposing to known radiation levels. The natural background gamma radiation levels were measured using the survey meter by placing it at a height of about 3 ft from the floor in different dwellings (including the dwellings where TLDs were installed). Repeated measurements were made in each location spanning over several days and average of all these measurements was taken as the value for that particular location.

### 3 Results and Discussion

The natural background gamma radiation levels were measured for four quarters using both TL dosimeters (TLD) and micro-Roentgen survey meter (SM) in thirty one dwellings of urban Hyderabad. The dwellingswise measured average values for four quarters is presented in Table 1. The correlation between the above two types of measurements was found to be 0.91. Since the correlation is good, only survey meter was used for further measurements. For more reliability, measurements using survey meter were repeated more number of times spanning over several days at each location.

The overall annual average values of natural background gamma radiation levels measured using survey meter in different dwellings of urban Hyderabad (in about 100 dwellings) and its surroundings (in about 20 dwellings) and corresponding radon and thoron radiation levels in the same dwellings is given in Table 2. It may be noted that the measured average levels of natural background gamma radiation are almost the same for the dwellings of both the urban Hyderabad and its surroundings, but significant variation can be observed in radiation levels of radon and thoron. These levels are low in surroundings than those of urban Hyderabad. This may be due to the enhanced air movement in the village habitats than in the urban Hyderabad.

\[ \text{Table 1 — Average natural background gamma radiation levels (nGy h}^{-1}\text{) measured using TL dosimeters (TLDs) and Survey meter (SM)} \]

<table>
<thead>
<tr>
<th>S No</th>
<th>TLD</th>
<th>SM</th>
<th>S No</th>
<th>TLD</th>
<th>SM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>373</td>
<td>381</td>
<td>17</td>
<td>371</td>
<td>372</td>
</tr>
<tr>
<td>2</td>
<td>371</td>
<td>357</td>
<td>18</td>
<td>350</td>
<td>320</td>
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<td>271</td>
<td>267</td>
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<td>4</td>
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<td>314</td>
<td>331</td>
<td>22</td>
<td>312</td>
<td>278</td>
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<tr>
<td>7</td>
<td>341</td>
<td>353</td>
<td>23</td>
<td>368</td>
<td>348</td>
</tr>
</tbody>
</table>

\[ \text{Table 2 — Measured annual average levels of radon (Bqm}^{-3}\text{), thoron (Bqm}^{-3}\text{) and natural background gamma radiation levels (nGy h}^{-1}\text{)} \]

<table>
<thead>
<tr>
<th>Urban Hyderabad</th>
<th>Hyderabad Surroundings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rn Tn NBRL*</td>
<td>Rn Tn NBRL*</td>
</tr>
<tr>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>17 8 225</td>
<td>3 2 190</td>
</tr>
<tr>
<td>311 330 506</td>
<td>47 90 462</td>
</tr>
<tr>
<td>62 55 314</td>
<td>10 15 309</td>
</tr>
<tr>
<td>45 57 47</td>
<td>8 16 81</td>
</tr>
</tbody>
</table>

*NBRL: Natural background gamma radiation level

Figures 1 and 2 show the distribution of average values of natural background gamma radiation levels among the dwellings of urban Hyderabad and its surroundings, respectively. It may be inferred from these distributions that nearly 30\% of dwellings have the radiation levels above 360 nGy h\(^{-1}\). A close scrutiny was made for possible contributing factors to those higher levels of radiation and it was found that almost all those dwellings falling under this category are located in and around the rocky areas. The soil analysis for radium (\(^{226}\text{Ra}\)), thorium (\(^{232}\text{Th}\)) and potassium (\(^{40}\text{K}\)) in these areas was carried out and the corresponding average values of radioactivity levels in soils were found to be 32±17, 134±56 and 890±154 Bq kg\(^{-1}\), respectively. The radioactivity levels of soil under present investigation are relatively higher when compared with national and global average values\textsuperscript{11}.

One can expect the seasonal variation in the gamma radiation levels in the indoors\textsuperscript{12} since the contribution of radon and thoron progenies account for about 30\% to the natural background gamma levels in India\textsuperscript{13}. But in the present study, no considerable seasonal variation was observed. It may be due to the
insignificant seasonal variations found earlier in the radon and thoron levels in the dwellings of same study area.\textsuperscript{11,14}

The data based on the categorization of the dwellings on the construction type has been analyzed. More emphasis was given to the type of flooring as it is one of major sources of natural radioactivity in indoors. The floorwise variation of natural background gamma radiation levels is presented in Table 3.

It is observed that the dwellings with mud floor have relatively higher average value of natural background gamma radiation levels when compared with other floors. This indicates that the soil present below the floor may be of the main causative factors for the relatively higher natural background gamma radiation levels. Similar variations were also observed in the case of radon/thoron levels in the dwellings of same study area.\textsuperscript{9,11,14} The other types of floorings, even though the soil beneath them is of same type, impede the natural background gamma radiation levels to some extent. The variations of natural background gamma radiation levels in the dwellings were also studied with the type of walls and found that the dwellings with mud walls have relatively higher radiation levels than the cement plastered walls. This may be due to the shielding effect of plastering materials. These variations are consistent with the earlier findings.\textsuperscript{12}

The annual effective dose to the individuals due to the exposure of natural background gamma radiation levels as estimated from the present study for urban Hyderabad and its surroundings is found to be 1.54±0.23 mSv and 1.52±0.40 mSv, respectively based on an occupancy factor of 0.8. These are slightly higher than those of other regions of the country.\textsuperscript{15}

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|l|l|}
\hline
 & Concrete & Mosaic & Mud & Stone \\
\hline Min & 265.3 & 277.4 & 255.6 & 224.9 \\
Max & 362.6 & 452.1 & 504.5 & 388.7 \\
Ave & 328.4 & 344.3 & 369.1 & 303.8 \\
SD & 27.9 & 50.4 & 99.2 & 41.3 \\
\hline
\end{tabular}
\caption{Natural background gamma radiation levels in the dwellings with different floors (nGy/h)}
\end{table}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig1.pdf}
\caption{Distribution of natural background radiation levels in the dwellings of urban Hyderabad}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{fig2.pdf}
\caption{Distribution of natural background radiation levels in the dwellings of Hyderabad surroundings}
\end{figure}

\section{Conclusions}

The findings of this study established that the dwellings constructed in and around the rocky area and mud (local soil) type constructions have relatively higher radiation levels. The calculated annual effective doses due to natural background gamma radiation levels in the study region are higher than those of other regions of the country.

\section{Acknowledgement}

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\section{References}