The Indoor concentrations of radon in dwellings belonging to some areas of Kangra district, Himachal Pradesh, India

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Publication History
Received: 04 August 2014
Accepted: 12 September 2014
Published: 24 December 2014

Citation
Ajay Kumar. The Indoor concentrations of radon in dwellings belonging to some areas of Kangra district, Himachal Pradesh, India. Indian Journal of Science, 2014, 11(30), 90-93

ABSTRACT
The natural radioactivity present in the environment is a health hazard for human populations. The work has been undertaken for the health risk assessments. The results of radon activity recorded in 29 dwellings of Kangra area, Kangra district, Himachal Pradesh, India are reported. LR-115 Type 2 films in the bare mode were exposed for four seasons of three months each covering a period of one year for the measurement of indoor radon levels. The calibration constant of 0.020 tracks cm$^{-2}$ d$^{-1}$ per Bqm$^{-3}$ has been used to express radon activity in Bqm$^{-3}$. The average indoor radon concentrations in 7 different villages of the area are found to vary from 197.55±21.36 Bqm$^{-3}$ to 525.67±26.40 Bqm$^{-3}$. Most of the indoor radon values lie in the range of action levels (200-600 Bqm$^{-3}$) recommended by International Commission on Radiological Protection.

Key words: Indoor radon; LR-115 plastic; Dwellings; action level

1. INTRODUCTION
Radiation in the environment mainly consists of three naturally occurring radioactive decay series viz. $^{238}\text{U}$, $^{235}\text{U}$ and $^{232}\text{Th}$. $^{222}\text{Rn}$ is a noble radioactive gas produced by decay of $^{226}\text{Ra}$, which is a member of $^{238}\text{U}$ series. The exposure due to inhalation of radon and its daughters present in the environment is highest of the natural radionuclides to which human beings are exposed. It is an established fact that the enhanced levels of indoor radon in dwellings can cause health hazards and may cause serious diseases like lung cancer in human beings (Axelson, 1995; Bochicchio et al., 1998; Field et al., 2000). Therefore measurement of $^{222}\text{Rn}$ concentration in the environment is of special interest to mankind. By diffusion through soil, $^{222}\text{Rn}$ enters into the atmosphere. The concentration of radon and its decay
products show large fluctuations depending upon the building materials, underground soils, ventilation conditions and wind speed etc. (King, 1978; Strong and Levins, 1982; Singh et al., 1988).

Numerous measurements of radon activity concentrations and its short lived decay products in different countries have been published in recent years (Keller et al., 1982; Nazaroff and Doyle, 1985; Khan et al., 1987; Ramachandran et al., 1990; Liu et al., 1994; UNSCEAR, 2000). Though the indoor radon data is available for Hamirpur, Kullu and Una districts of Himachal Pradesh (Kumar et al., 1994; Singh et al., 2001), the Nurpur area of the Kangra district has not been studied for environmental radon so far. So in order to generate a database, the survey was carried out first time for the measurement of $^{222}\text{Rn}$ in the dwellings located in Kangra city and its adjoining villages, Himachal Pradesh, India. The district Kangra lies between $31^\circ40'-32^\circ25'$ East longitudes and $70^\circ35'-77^\circ5'$ North latitudes in the Himachal Pradesh state of India (Balokhra, 1997). The elevation varies from 500 meters to 5,500 meters from the mean sea-level. The district is criss-crossed by mountain ranges and valleys.

2. EXPERIMENTAL TECHNIQUE

In the present investigations the indoor $^{222}\text{Rn}$ concentration has been studied in 70 dwellings of 17 villages of the area. The houses were chosen randomly in such a way that the dwellings constructed with different types of building materials such as soil, bricks, cement, marble, concrete, wood in different localities of the village are covered. The track etch detector technique has been used to measure the level of indoor radon concentration in the dwellings. The LR-115 type 2 (Pelliculable) plastic track detectors having a size of about 1.5 cm x 1.5 cm fixed on micro glass slides were suspended at the centre of the room in the bare mode for four seasons of three months each covering a period of one year from December 2001 to December 2002 in order to assess the seasonal variations of indoor radon concentration levels. All the measured dwellings have a single floor level (ground floor). The exposed detectors were etched in 2.5 N NaOH solution for 90 minutes in a constant temperature bath (60°C). After etching the detectors were thoroughly washed and scanned manually for track density measurements using Carl Zeiss binocular optical microscope at a magnification of 400X. The track density so obtained was converted into the units of Bq m$^{-3}$ using the calibration factor (0.020 $\pm$ 0.002 tracks cm$^{-2}$ d$^{-1}$/Bq m$^{-3}$) determined experimentally by Eappen et al. (2001) which satisfies the conditions prevailing in the Indian dwellings. The average background track density for the unexposed films of LR-115 type 2 detector was found to be 35 tracks cm$^{-2}$ and this value was subtracted from the observed values.

3. RESULTS AND DISCUSSION

The annual average indoor radon concentration levels recorded in 7 villages of district Kangra, Himachal Pradesh are given in Table 1. From the table we find that the indoor radon concentration varies from 197.55$\pm$21.36 Bq m$^{-3}$ in Jassur village to 525.67$\pm$26.40 Bq m$^{-3}$ in Old Kangra village. The error shown in the results is the standard error calculated on the basis of number of measurements of radon level in each village. The indoor radon values obtained in the present investigations in Nurpur area of district Kangra are comparatively lower than those reported in some dwellings of Hamirpur (660-1060 Bq m$^{-3}$, Kumar et al., 1994), Kullu (156-635 Bq m$^{-3}$, Singh et al., 2001) and Una (235-970 Bq m$^{-3}$, Singh et al., 2002) districts of Himachal Pradesh. The higher indoor radon values in Old Kangra may be due to the cross section of longitudinal and transverse lineaments (Dhar et al. 2002, Sharma et al. 2013). Higher values radon in the tectonically active adjoining Dharamsala region along transverse lineaments have also been reported (Dhar et al. 2002).

The high levels of indoor radon concentration in the dwellings of village old kangra may be due to the fact that most of the houses in village are built of mud, wood and unfired clay bricks as compared to the adjoining areas. Moreover the houses are poorly ventilated. The indoor radon concentration may also depend on the soil gas radon beneath the dwellings and the environmental conditions. Figure 1 shows that in the bar graph of radon concentration in area of district Kangra, Most of the houses have the radon concentration which lies between the action level (200-600 Bq m$^{-3}$) (ICRP, 1993).

ACKNOWLEDGEMENTS

The authors are thankful to the residents of Nurpur area for their cooperation during the fieldwork.

REFERENCE

7. ICRP. Protection against radon-222 at home and at work. ICRP Publication 65, Annals of the ICRP, 1993, 23(2)
Table 1
The average indoor radon levels recorded in 7 villages of Kangra city and its adjoining areas, Himachal Pradesh

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Location (Village)</th>
<th>No. of dwellings studied</th>
<th>Annual average radon activity (Bqm⁻³) ±S.E.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>New Kangra</td>
<td>4</td>
<td>285.37±50.52</td>
</tr>
<tr>
<td>2</td>
<td>Old Kangra</td>
<td>5</td>
<td>525.67±26.40</td>
</tr>
<tr>
<td>3</td>
<td>Jyanti vihar</td>
<td>4</td>
<td>312.90±32.19</td>
</tr>
<tr>
<td>4</td>
<td>Nagrota</td>
<td>4</td>
<td>342.29±46.92</td>
</tr>
<tr>
<td>5</td>
<td>Jassur</td>
<td>4</td>
<td>197.55±21.36</td>
</tr>
<tr>
<td>6</td>
<td>Larth</td>
<td>4</td>
<td>281.35±18.75</td>
</tr>
<tr>
<td>7</td>
<td>Ganoh</td>
<td>4</td>
<td>324.26±17.43</td>
</tr>
</tbody>
</table>

*S.E. (Standard Error) = SD/√N
Where SD is the standard deviation,
N represents the number of measurements in each village