STUDY OF RADON CONCENTRATION IN DRINKING WATER OF EASTERN HARYANA

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ABSTRACT:

This study aimed to assess radon concentration measurement in drinking water of Eastern Haryana, India using RAD7, electronic silicon solid state detector. Radon is the decay product of radium which lies in the uranium decay series. Radon is second cause of lungs cancer after smoking. Groundwater is used as a drinking water source in study region, it is important to study the radon concentration in drinking water of this region. In this region, radon concentration in water samples has been found to vary between 22.3 Bq\textsuperscript{l-1} to 495.1 Bq\textsuperscript{l-1} with an average of 33.9 Bq\textsuperscript{l-1}. The measured radon content in all water samples has been found to be higher than the maximum contaminated limit of 11 Bq\textsuperscript{l-1} (UNSCEAR 2000). The measured radon content in 42.85% water samples has been found to be higher than the reference range of 4-40 Bq\textsuperscript{l-1} (UNSCEAR 1993). Radon concentration in all the water samples lies within the safe limit of 100 Bq\textsuperscript{l-1} recommended by European Commission (EC 2001). Ingestion dose in the study area varies from 28.5 to 57.6 μSv/y with an average value of 43.3 μSv/y, which is below the recommended limits. Drinking water of the study area is safe as a radiation hazard point of view. The high radon concentration observed in certain areas is due to interaction of ground water with the soil formation of this region and the local subsurface geology of the region.

Keyword: Radon, RAD7, Ingestion dose, Drinking Water.


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1. INTRODUCTION
Natural radioactivity and radiation has always been a part of the environment since the creation of the earth. The radiation, which proves hazardous for the living beings vary from place to place that, depends on the distribution and absorption of natural radionuclides like $^{238}$U, $^{232}$Th and $^{40}$K present in the soil, water and air. These radioisotopes emit gamma rays externally and alpha particles due to radon internally (UNSCEAR 2006). These radionuclides enter in food chain through ingestion and inhalation. In study area, groundwater is used as drinking water source. Uranium and its decay products are present in groundwater and its concentration depends on the geological and geographical conditions, and appears at various levels in the water of every part in the world (UNSCEAR 2000). Upon the geological conditions and fault lines present in the region. Radon is inert gas which is the decay product of radium which lies in decay series of uranium. Radon is natural occurring which is health hazardous if it is present in high concentration in drinking water. Subsurface water is cleaner and it is easier to treat as compares to surface water which is obtained through well. However, groundwater coantines many chemicals which creates health problem to population of that area (Skeppstrom and Olofsson, 2007). Today, most important issue is water quality which is used as drinking water source. According to UNICEF’s report “Fresh Water for India’s Children and Nature,” nearly 1 million children in India die of diarrheal diseases each year directly as a result of drinking unsafe water and living in unhygienic conditions (Duggal et al., 2014). Radon concentration in groundwater is proportional to uranium concentration in adjacent rocks whereas in surface water its concentration is very low mainly in water bodies used as drinking water sources (Durrani and Ilic, 1997) so that radon concentration is different in different water sources. Radon enters into the human body through inhalation (house hold water release radon gas which is breathing) and ingestion (drinking water containing radon). In many ways such as washing clothes, bathing, cooking, dish washing and flushing toilets, radon gas comes out of water source and mixes with the indoor air (Horton, 1983; Hess et al., 1987; Kendall et al., 1988; Al Zabadi et al.2012). When radon is inhaled by the living beings, its daughter products, especially polonium-218 and polonium-212 attached to aerosols present in ambient air, constitute a significant radiological hazard to human lungs resulting in lung cancer NCRP 1984. Radon is leading cause of lungs cancer after smoking. Radon in water does not affect on health directly but it contributes to the health risk associate with indoor radon (cross et al. 1985). Radon is more important as it contributes about half of the background radiation to which we are all exposed (Cothern 1986). Due to higher radon emanation power, the lung tissues may be irradiated with alpha particles from radon progeny to a high degree, increasing the possibility of lungs cancer. After smoking, it is considered as the cause of lung cancer (Al-Khateeb et al.2012). The indoor radon exposure may be risk of leukaemia and certain other cancers, such as melanoma and cancers of kidney and prostate (Hensaw et al. 1990). Thus, it is important to study the radon concentration in drinking water which is used by population of area for radiation health hazard point of view. Many researchers has been studied the health effect of Radon from drinking water (Strain et al., 1979; Bean et al., 1982; Andelman,1985; Xinwei, 2006; Somashekar and Ravikumar, 2010; Krishan et al., 2015; Ademola and Ojeniran, 2017) but Bhiwani district is no more data available in literature. So, it becomes important to study radon concentration in this region. High heat progeny region, which is the main geological feature of study area where natural radionuclide’s ($^{238}$U, $^{232}$Th and $^{40}$K) and indoor radon concentration is reported high (Bajwa et al., 2008). In this work, we directed our efforts to assess radon concentration measurement in drinking water of Bhiwani district of Haryana, India using RAD7.
2. GEOLOGY OF STUDY AREA

Study area is located in Haryana state of India between 28° 40’ 30” to 29° 05’35” north latitude and 76°13’ 22” to 76° 51’ 20” east latitude. The altitude of district is about 220 meter from mean sea level. Jawahar Lal Nehru feeder and Bhalaut sub Branch are main canals. The study area is occupied by Indo-Gangetic alluvium. There is no surface features worth to mention. Physiographically the area is flat terrain. The area slopes towards northeast to southwest with an average gradient of 0.19 m/km. The soils of the district are fine to medium textured. It comprises sandy loam in Rohtak, Sampla, and Lakhan Majra blocks whereas it is loamy sand with occasional clay loam in Kalanaur and Mehram Blocks. The soils of the district are classified as arid brown (Solemnized) and sierozem.

The annual rainfall is 373 mm, which is mainly received during monsoon in the months of July to September. The air temperature varies from 2.5 °C in winter to 47 °C in summer. Rainfall is a major source of groundwater recharge. The main crop cycle of the area is wheat-rice or wheat-cotton. The soil content of the study area is sandy loam to loam in texture. Soils are calcareous and normally have a Kankar layer at the depth of 0.75m to 1.25 m. The serious problems particularly in the irrigated area are salinity and alkalinity. Wind erosion is also familiar feature in this area. The groundwater occurs in the thick zone of saturation in the alluvium both under confined and unconfined conditions. Sohna fault line passes through the study area which the one of the reason of radioactivity in study area. Ground water in the most of the area is polluted by nitrate and fluoride in some parts and is also polluted by heavy metals like Mn, Pb, Fe at many places. High heat producing granite (Tosham hill) is the vicinity of study area (Kochar, 1989; Bhandari and Kale, 2009, Bajwa et al. 2008). This area is famous for mining and agriculture. Geological map of study area is shown in Fig 1.

![Figure 1 Geological map of Study area.](image)

3. MATERIALS AND METHODS

RAD-7.0 detector supplied by DURRIGE Company Inc, USA was used for measuring radon gas in water samples. Samples were taken in 250 ml vials which are connected to the RAD7 (Fig. 2). These vials are specially designed for the RAD7 device by the manufacturer. For radon measurement in water, the RAD-H₂O closed loop aeration method was employed (Tabar and Yakut, 2014).
Doses due to radon concentration in drinking water:

The annual effective dose value from drinking water samples due to ingestion of the radon concentration in water samples is calculated using equation (Singh et al., 2017)

\[
D_i (\mu Sv \cdot y^{-1}) = \frac{222Rn (Bq l^{-1}) \times 3651 \times 10^{-3} \times 3.5 nSv Bq^{-1}}{Bq l^{-1} \cdot y^{-1}}
\]

The annual effective dose was calculated by assuming average water consumed by a human being in a year and conversion coefficient for ingestion is 3.5 nSv Bq⁻¹. Safe Limit of annual effective dose due to radon in drinking water is 100 μSv y⁻¹ as recommended by WHO, 2011.

4. RESULTS AND DISCUSSION

The data for radon concentration and ingestion dose (μSv/y) are summarized in table 1. The Radon concentration in water samples in this area is found to vary from 22.3 Bq/l to 45.1 Bq/l with an average of 33.9 Bq/l. The lowest value of radon concentration (22.3 Bq/l) is found in water sample of Nigana village while the highest value of radon concentration (45.1Bq/l) is found in Borewell Submersible water sample of Sudana village (Fig. 3).

Table 1 Radon concentration and ingestion dose in drinking water of Eastern Haryana

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Village Name</th>
<th>Radon Concentration (Bq/l)</th>
<th>Ingestion dose uSvy-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>RH-1</td>
<td>Basana</td>
<td>27.4</td>
<td>35.0</td>
</tr>
<tr>
<td>RH-2</td>
<td>Lahli</td>
<td>35.1</td>
<td>44.9</td>
</tr>
<tr>
<td>RH-3</td>
<td>Nigana</td>
<td>22.3</td>
<td>28.5</td>
</tr>
<tr>
<td>RH-4</td>
<td>Pilana</td>
<td>28.4</td>
<td>36.3</td>
</tr>
<tr>
<td>RH-5</td>
<td>Sundana</td>
<td>45.1</td>
<td>57.6</td>
</tr>
<tr>
<td>RH-6</td>
<td>Chandi</td>
<td>31.4</td>
<td>40.1</td>
</tr>
<tr>
<td>RH-7</td>
<td>Indergarh</td>
<td>39.6</td>
<td>50.6</td>
</tr>
<tr>
<td>RH-8</td>
<td>Lakahan Majra</td>
<td>40.2</td>
<td>51.4</td>
</tr>
</tbody>
</table>
These levels are set to represent a concentration that does not result in any significant risk to health over a lifetime’s drinking water. This may be due to leaching of uranium from adjoining/basement granite rich rock formations. The measured radon content in all water samples has been found to be higher than the maximum contaminated limit of 11 Bq/l (UNSCEAR, 2000). The measured radon content in 25% water samples has been found to be higher than the recommended safe limit of 4-40 Bq/l (UNSCEAR 1993). Even the average value of 33.9 Bq/l for the entire study area has been found to be lower than safe limits recommended by various health and environmental protection agencies except maximum contaminated limit recommended by UNSCEAR 1993. Radon concentration in all the water samples lies within the safe limit of 100Bq/l recommended by European Commission (EC 2001). The radon content in all water samples may be varying largely due to different agitation degrees and deviation in meteorological parameters. The radon occurrence in
groundwater can reasonably be related with the uranium content of the bedrock and it can easily move into the interacting groundwater by the effect of lithostatic pressure (Kansal et al. 2011). No direct variation of radon concentration with the source type and depth of the source have been observed in all the samples. Radon concentration in drinking ground water samples obtained in this study is compared with other studies (Table 2). Radon concentration is less than the Doon Valley of Outer Himalayas (Choubey et al. 2008) and higher than other neighbouring areas. Ingestion dose in the study area varies from 28.5 to 57.6 μSv/y with an average value of 43.3 μSv/y. The average value of ingestion dose lies below the recommended limit as shown in fig 4. Radon concentration and ingestion dose is high in Sudana which is near to the fault line pass through the study area. This shows that area near the fault line show high concentration than area far away from fault line. Hence, radon concentration in water depends on the geological condition of the area. Average value of radon concentration is below the recommended limit, this represent that this area is safe from radiological effect due to ingestion of radon through drinking water.

Table 2 Comparison of radon concentration in ground water samples of study area with other studies

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Country</th>
<th>Radon concentration (BqL⁻¹)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Jammu, India</td>
<td>5.40-20.09</td>
<td>Kumar et al.2016</td>
</tr>
<tr>
<td>2.</td>
<td>Kathua, India</td>
<td>0.86-4.02</td>
<td>Singh et al.2016</td>
</tr>
<tr>
<td>3</td>
<td>Kangra, India</td>
<td>1.4-7.62</td>
<td>Singh et al.2016</td>
</tr>
<tr>
<td>4</td>
<td>Doon valley, India</td>
<td>25.4 – 92.5</td>
<td>Choubey et al.2008</td>
</tr>
<tr>
<td>5</td>
<td>Central Haryana, India</td>
<td>16.06 – 57.35</td>
<td>Panghal et al., 2017</td>
</tr>
<tr>
<td>6</td>
<td>Austria</td>
<td>1.46 - 644</td>
<td>Wallner and Steiningier, 2007</td>
</tr>
<tr>
<td>7</td>
<td>UK</td>
<td>0.91 – 71.1</td>
<td>Henshaw et al., 1993</td>
</tr>
<tr>
<td>8</td>
<td>Italy</td>
<td>1.5 - 181</td>
<td>Cantaluppi et al., 2014</td>
</tr>
<tr>
<td>9</td>
<td>Spain</td>
<td>1.4 - 105</td>
<td>Fonollosa et al., 2016</td>
</tr>
<tr>
<td>10</td>
<td>Eastern Haryana, India</td>
<td>33.9</td>
<td>Present Study</td>
</tr>
</tbody>
</table>

5. CONCLUSION

The measured radon content in all water samples has been found to be higher than the maximum contaminated limit of 11 BqL⁻¹ (UNSCEAR 2000). The measured radon content in 42.85% water samples has been found to be higher than the recommended safe limit of 4-40 BqL⁻¹ (UNSCEAR 1993). Ingestion dose in the study area varies from 28.5 to 57.6 μSv/y with an average value of 43.3 μSv/y which is below the recommender limit by WHO. 2011. Radon concentration is high in area near fault line as compare to area away from fault line. This shows that radon concentration in water depends upon the local geology of the area. Average value of radon and ingestion dose is below the reference level; hence study area is safe from radiological effect of radon on the population.

REFERENCE


Study of radon concentration in drinking water of Eastern Haryana


