Indoor radon concentration in Örencik and Doğançay villages of Sakarya, Turkey

F. Ertuğral1,2, Y. Sağlam1, N. Demirci1, H. Yakut1,2, E. Tabar1,2, Z. Zenginerler1

1. Sakarya University, Department of Physics, Sakarya, Turkey
2. Sakarya University, Biomedical, Magnetic and Semiconductor Materials Research Center (BIMAS-RC), Sakarya, Turkey

Corresponding author email: ertugral@sakarya.edu.tr

ABSTRACT

Indoor radon measurements were performed using LR-115 type-II Solid State Nuclear Track Detectors (SSNTDs) in Örencik and Doğançay villages of Sakarya, Turkey for two seasons. Twelve radon stations were determined in each study region and in each dwelling LR-115 films were installed in the reception rooms. Radon activities ranged from 137 to 1319 Bqm⁻³ during winter period, from 76 to 447 Bqm⁻³ during spring time for two places. As expected the highest radon concentration measured in winter whereas the minimum was observed in the winter. The measured activities for Örencik in winter time higher than allowed radon concentration range of 200-600 Bq m⁻³ in buildings. These places bedrock is partly granite and consist of small houses. The winter (from January 2013 to March 2013) is characterized by 1.8 times for Doğançay and 4 times for Örencik higher average indoor radon activity concentration than the spring (from April 2013 to June 2013).

Key words: Indoor radon, Örencik, Doğançay, Turkey, LR-115.

Introduction

Radon (²²²Rn) is the product of the alpha-decay of the parent Radium ²₂₆, naturally occurs in most soils, rocks and water after a rather long alpha and beta decays process in the uranium-²³₈ decay radiative series. The radioactive noble gas radon with a half life 3.85 d, 7.5 times heavier than air, and its short lived decay products is the main sources of natural doses of internal radiation exposure to ionising radiation to human life and the second largest cause of lung cancer after smoking worldwide (UNSCEAR, 2000). Radon and its decay products leads to damage to DNA in lung because of highly ionizing alpha particle are emitted by the decay of its when intake of radon and its decay products via inhalation or ingestion of indoor air. Therefore, great attention to measure indoor radon concentration in buildings has been seen in the last three decade (UNSCEAR, 2000). Monitoring radon levels can be found differently depends on the season, time, soil parameters and features such as moisture content, grain size, granitic or sedimentary, building materials and also floor level (Schweikani et al., 1995, Khayrat, 2001) and allowed radon concentration range of 200-600 Bq.m⁻³ in buildings (ICRP, 2003). The release of radon by some types of rocks and soils under the buildings to the indoor air can cause a great risk to individuals which spent a large part of their time in indoors.

In the present study, the indoor radon concentration was firstly monitored randomly selected at 30 location in Örencik and Doğançay of Sakarya city in Turkey using LR-115 solid state track etch detectors. These places bedrock is partly granite which can contain naturally occurring radioactive elements as radium, uranium and thorium. The release of radon from some types of rocks especially granite and soils under the buildings to the indoor air such as dwellings can cause individual risk which spent a big portion of their time in indoors.

Materials and Methods

Doğançay Village

In general, as administrative, it depends with the Geyve district. It’s situated at latitude N 40° 37’ 35” and longitude E 30° 20’ 08” (Leroy et al., 2009). The population of the village is 494. Geologically the study area is characterised by very large granite formation. Height above sea level of the village is 95 m. 15 km distance from the center of Geyve (Çiçek and Özdemir, 1998).

Örencik Village

This village located North of the Geyve district and 10 km distance from the center of Geyve. It’s situated at latitude N 40°35’3.9516” and longitude E 30°20’21.2208” (Leroy et al., 2009). The population of the village is
approximately 220. Geologically the study area is characterised by very large granite formation like Doğançay. 12 km distance from Geyve districts and 26 km distance from Sakarya city (Canbulut, 2005). Figure 1 shows the location of the places.

![Figure 1. Map of the study areas of Sakarya, Turkey](image)

LR-115 detectors with dimensions 1.5 cm x 1.5 cm were mounted in a plastic cup of 7 cm height, 7.2 cm diameter at one end and 5 cm at the other end. After exposure, the detectors were chemically etched in 2.5 N NaOH solution at 60 °C for 90 min. After etching, track density of alpha particles was counted under an optical microscope at magnification 100x (Tabar et al., 2013). The detectors calibrated with a radium source in TAEK-ÇANEM. Calibration coefficient of these detectors was determined as 0.051 track cm⁻² d⁻¹ Bq⁻¹ m⁻³. The annual mean effective doses for indoor air were calculated using the formula recommended by UNSCEAR (UNSCEAR, 2000) \( D_{\text{inh}}^{\text{Ra}} = C_{\text{Ra}} \times F \times T \times DCF \) where \( C_{\text{Ra}} \) is the indoor radon concentration (in Bq m⁻³), \( F \) is the equilibrium factor between radon and its decay products (0.4), \( T \) is the average indoor occupancy time per person (7000 hy⁻¹) and \( DCF \) is a dose conversion factor, 9 nSv (h Bq⁻¹ m⁻³)⁻¹. In the present study, the indoor radon concentration levels were measured in the randomly selected 30 houses of each places which Lr-115 detectors were placed in the most reception room which normally keep the windows of this rooms during winter and spring seasons.

### Results and Discussions

The results of the indoor radon measurements (maximum, minimum and mean) are listed in Table 1. The maximum average radon concentration was recorded in Örencik village for winter and spring time (see Fig 1).

<table>
<thead>
<tr>
<th>Study area</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
</tr>
<tr>
<td>Doğançay</td>
<td>434</td>
<td>137</td>
</tr>
<tr>
<td>Örencik</td>
<td>1319</td>
<td>297</td>
</tr>
</tbody>
</table>

![Figure 2. Average radon concentration in Örencik and Doğançay villages.](image)
As can be seen from Table 1, radon activities ranged from 137 to 1319 Bq/m$^3$ during winter period, from 76 to 447 Bq/m$^3$ during spring time. There is not clear appreciable differences in the present study radon activity for dwellings between Örencik and Doğançay villages for spring time. As you can see from Table 1 and Figure 2, the radon concentration very high for Örencik places especially in winter time. These study area also lies on the western section of the North Anatolian Fault Zone. Soil gas radon activity measurements were also made around the western section of the North Anatolian Fault Zone. They found radon concentration varies from 29 to 7059 Bq/m$^3$ with an average value of 1930 Bq/m$^3$ (Tabar, 2013). The other work for determining indoor radon concentration was performed in schools and dwellings of Adapazari, Sakarya, Turkey which 47 km far from our studies place. The average radon concentrations which used Cr$^{3+}$ passive radon detectors for 75 days in 2010 winter time have been found 59.9 Bq/m$^3$ for dwellings in 15 districts of Adapazari region (Kaptan and Altınsoy, 2012). Our average indoor radon activity concentration results for örencik and Doğançay higher than Adapazari result. In general, primary factors affect the radon concentrations in indoor air are ventilation, season, height, age of the dwellings and building material (Nazaroff and Nero, 1987). The reason may be Örencik consists of old small houses. It is well known that the radon concentrations in old buildings are relatively higher than new buildings since cracked walls in the old buildings allow radon escape (Khan, 2005). The other reason may be geological setting of the village that consist of granite rocks bearing high radioactive material. Another factor is building materials, but they usually contribute very little compared to other factors (Kaptan and Altınsoy, 2012).

**Conclusion**

An indoor radon survey has been carried out using passive radon detectors in randomly selected 20 houses of each places. As expected the highest radon concentration measured in winter. The activities reported in the present study for Örencik in winter time higher than allowed radon concentration range of 200-600 Bq m$^3$ in buildings. This reason may be geological setting of the village that consist of granite rocks bearing high radioactive material.

**References**


