Süleyman Demirel Üniversitesi Fen Edebiyat Fakültesi Fen Dergisi
Süleyman Demirel University Faculty of Arts and Sciences Journal of Science
2019, 14(2): 402–407
DOI: 10.29233/sdufeffd.623677
Atıf için / For Citation: A. Gümüş, H. A. Yalım, "The relationship between soil gas radon concentration level and the distance of sampling point to Akşehir fault zone", *Süleyman Demirel Üniversitesi Fen Edebiyat Fakültesi Fen Dergisi*, 14(2), 402-407, 2019.

The Relationship between Soil Gas Radon Concentration Level and the Distance of Sampling Point to Akşehir Fault Zone

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(Alınış / Received: 24.09.2019, Kabul / Accepted: 15.11.2019, Yayımlanma / Published: 30.11.2019)

Abstract: Radon is a tasteless, odorless, colorless radioactive noble gas which is produced in the decay chain of uranium existed in the rock layer. Since radon is in the gas form, it is more mobile than its parent radionuclides which namely are uranium and radium. Therefore, radon can easily escape soil and rocks through the pores between the soil granules, and the openings in the rock, cracks, and fractures. Because of these characteristics, changes in radon concentration levels are commonly used for seismological purposes. The aim of this study is to investigate the relationship between the radon activity concentration in soil gas on Akşehir fault zone and the vertical distance of the sampling points to the fault zone. For this purpose, radon activity concentrations were monthly determined at 10 sampling points during six-month period. Although no significant correlation can be seen for all sampling points at all, a correlation coefficient of 0.96 was obtained when only the six of sampling points taken into account.

***Key words**:* Radon in soil gas, Distance to fault zone, Akşehir fault zone, Afyonkarahisar

Toprak Gazı Radon Konsantrasyon Seviyesi ile Örnekleme Noktasının Akşehir Fay Hattına Uzaklığı Arasındaki İlişki

Özet: Radon, kaya tabakasında bulunan uranyumun bozunum zinciri içinde oluşan tatsız, kokusuz, renksiz radyoaktif bir soy gazdır. Radon gaz halinde olduğu için, uranyum ve radyum olan ana radyonüklidlerinden daha hareketlidir. Bu yüzden, radon, toprak granülleri arasındaki gözeneklerden, kayadaki açıklıklar, çatlaklar ve kırıklardan kaçmasıyla toprağı ve kayaları kolayca terk edebilir. Bu özelliklerden dolayı, radon konsantrasyon seviyelerindeki değişiklikler genellikle sismolojik amaçlar için kullanılır. Bu çalışmanın amacı, Akşehir fay hattındaki toprak gazında radon aktivite konsantrasyonuyla örnekleme noktalarının fay hattına olan dik uzaklığı arasındaki ilişkiyi incelemektir. Bu amaçla, radon aktivite konsantrasyonları altı aylık dönemde 10 örnekleme noktasında aylık olarak belirlenmiştir. Tüm örnekleme noktaları için anlamlı bir korelasyon görülmemesine rağmen, yalnızca altı örnekleme noktası dikkate alındığında 0.96'lık bir korelasyon katsayısı elde edilmiştir.

***Anahtar kelimeler**:* Toprakta radon, Fay hattına uzaklık, Akşehir fay hattı, Afyonkarahisar

1. Introduction

^{222}Rn (radon) is produced by the alpha-decay of ^{226}Ra (radium) within the ^{238}U (uranium) decay chain in rocks and soil all over the earth. It has a half-life of 3.82 days and known as chemically inert and the only radioactive noble gas with. Radon can easily escape soil and rocks through the pores between the soil granules, and the

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openings in the rock, cracks, and fractures. Some of the atoms of radon isotopes present in all terrestrial materials are released from the solid material by recoil when the radium decays. They have sufficient time to escape from the mineral grain into the pore space, when the decay occurs within the recoil distance of the grain surface which is 20-70 nm in common minerals, 100 nm in water, and 63 μm in air [1]. Since radon is in the gas form, it is more mobile than its parent radionuclides, namely uranium and radium in the soil. Radon can diffuse through rocks and soil, can move from one place to the other and can leak out in the atmosphere from the soil. The mobility of radon in soil is very small (several meters), mainly due to the short half-life and the low gas permeability of soil [2]. Radon gas naturally chooses the easiest way to get to the surface. That is, it uses fault or fracture planes extending from surface to various depths. For this reason, radon gas measurements in the soil are used effectively in the areas where active faults are intense [3]. Radon concentration measurements are used for mapping active fault zones since it is expected that radon activity concentration is a higher in active fault zones than inactive faults [4-7]. Studies show that significant increases in radon concentrations can be obtained in faulting areas, so that radon gas measurements are used to outline fault maps [8, 9].

This study aims to determine the radon activity concentration in soil at 10 different points around the Akşehir fault zone and to examine the relationship between the change in radon concentrations and the distances of sampling points to the fault.

2. Material and Method

2.1 The Geology of study area

The Akşehir fault zone is one of the most important faults reflecting internal deformation of the Anatolian block [10]. All regions in Afyonkarahisar province located in central western Anatolia are within the 1st and 2nd degrees seismic zone. Small to medium magnitude earthquakes due to this fault is known from both historical and instrumental records. The study area of the present study is located in the Midwest Anatolia (Figure 1) which is characterized as an extensional neotectonics region by [11].

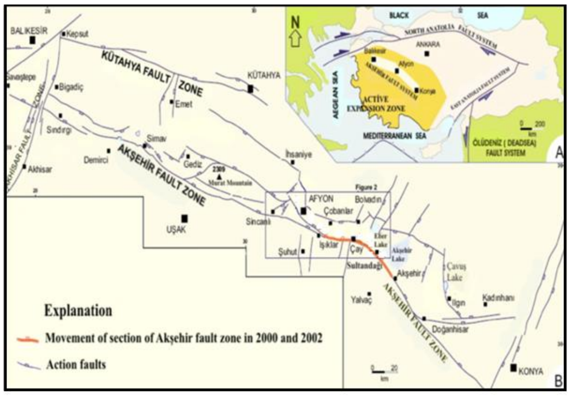

Figure 1. Location of the present study area

Soil gas radon activity concentrations were determined at 10 sampling points located near the Akşehir fault zone. Measurements were repeated in monthly intervals for 5 months. The details of sampling points are given in Table 1 and their locations are shown in Figure 2.

Table 1. Details of the sampling points

Source No	Latitude	Longitude	Altitude (m)
1	38.7110°	30.6055°	1008
2	38.6070°	30.9098°	1005
3	38.6759°	30.7372°	1000
4	38.6458°	30.8342°	1001
5	38.6070°	30.9098°	1005
6	38.5979°	30.9882°	988
7	38.5900°	31.0951°	996
8	38.6093°	31.1623°	983
9	38.5799°	31.2251°	991
10	38.4019°	31.3211°	971

Figure 2. Locations of the sampling points

2.2. Sampling and measurements

Measurements were made between August-December 2015 at 10 sampling points in monthly intervals. Soil gas radon activity concentrations were measured using soil-gas probe and Alpha-Pump (AP) connected to an AlphaGuard PQ2000 PRO detector shown as in Figure 3 [12-14]. In this measurement, a sharp-edged metallic container is inserted into the ground at least a depth of 70 cm and soil gas is pumped through the AG ionization chamber at a flow rate of 1 dm^3/min for 5 minutes.

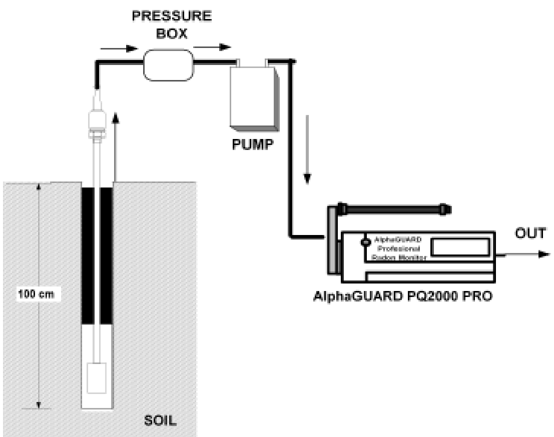

Figure 3. Soil gas radon measurement device

3. Results

The soil gas radon activity concentrations were measured between a minimum value of 5.36 kBq/m^3 and a maximum value of 47.62 kBq/m^3, whereas the average values were ranged from 10.23 to 31.77 kBq/m^3 for the sampling points. In order to determine the relationship between the average soil gas radon activity concentrations of the sampling points and the vertical distances of the sampling points to the Akşehir fault zone, the locations of the sampling points were obtained by using the Global Positioning System (GPS) device, and the vertical distances to the fault zone were determined in the Google Earth program. The average radon activity concentration values and the vertical distances to the Akşehir fault zone are given in Table 2.

Table 2. The average radon values and the vertical distances to the Akşehir fault zone

S. Point	Distance to the fault zone (km)	Average Concentration (kBq/m^3)	±σ
1	5.70	31.77	2.34
2	1.50	26.66	2.88
3	1.64	24.06	2.56
4	4.84	19.23	2.89
5	0.24	27.46	2.98
6	1.20	13.47	3.06
7	2.50	13.23	2.72
8	6.93	10.23	2.47
9	8.08	10.89	2.50
10	10.39	28.90	2.60

By using these values, the graph in Figure 4 was obtained to determine the correlation between the average radon concentration values and the vertical distances of the sampling points to the Akşehir fault zone.

According to Figure 4, one can conclude that no significant correlation is seen between the soil gas radon activity concentrations and distances of the sampling points to the fault zone. However, there exists a promising correlation when only the six of sampling points taken into account, which are the sampling points of 2, 3, 4, 5, 8 and 9. For these sampling points, the average soil gas radon activity concentration values are inversely proportional to the vertical distance from the fault zone. In other words, there might be obtained higher radon concentration at the sampling points nearer to a fault zone. This relationship is shown in Figure 5 with the correlation coefficient of 0.96.

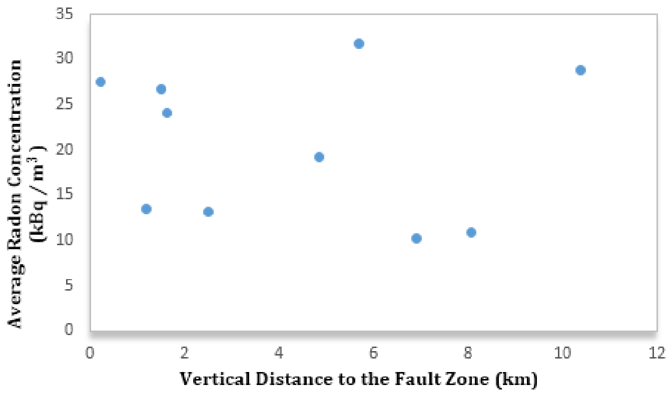

Figure 4. The correlation between the average radon concentration values and the vertical distances to the Akşehir fault zone

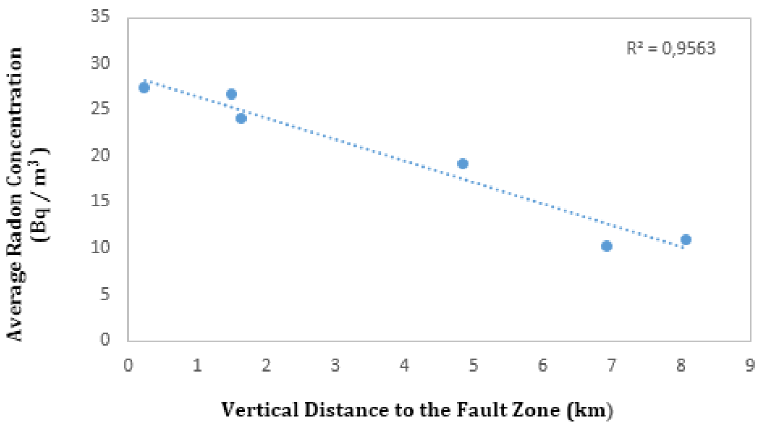

Figure 5. The correlation between the average radon concentration values and the vertical distances to the Akşehir fault zone for six sampling points

4. Conclusion and Comment

In the literature, there are studies showing that radon concentrations are significantly increased in the faulting areas and radon gas measurement results can be used in the extraction of fault maps [8, 9, 15-23]. Therefore, it is assumed that a higher radon concentration might be obtained in the active fault zones than inactive fault zones [4-7, 24, 25]. From this point of view, the present study is compatible with the literature.

In the present study, an expected relation between the radon activity concentrations of soil gas and distances of the sampling points to the fault zone was obtained for the six of 10 sampling points, whereas the results of the 4 sampling points did not obey this relation. There might be many reasons affecting the present results such as the geological formation and structure of the study area and the meteorological conditions in the studying period. Similar comments can be found in the literature as reported by [26] on the effect of the geological structure of the location and as indicated by [27] that changes in radon concentrations are not only caused by tectonic movements but also by the lithological structure. It is thought that it would be beneficial to continue the soil gas radon concentration measurements in this district by extending the sampling points.

Acknowledgment
This research was supported by Afyon Kocatepe University Science Research Projects Coordination Unit (AKU BAPK) with the project number 15.FENBİL.39.

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