ISSN:1306-3111
e-Journal of New World Sciences Academy
2006, Volume: 1, Number: 2
Article Number: A0006

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NATURAL AND APPLIED SCIENCES
ENGLISH (Abstract: TURKISH)
NWSA Received: February 2006
NWSA Accepted: April 2006

DETERMINATION OF RADIUM AND RADON CONCENTRATIONS IN SOME ROCK SAMPLES

ABSTRACT

The concentrations of radium (^{226}Ra), radon (^{222}Rn) and radon exhalation rate in nine rock samples have been determined using solid-state nuclear track detectors (CR-39). The measured maximum values of radium, radon and radon exhalation rate in rock samples were found to be 24.62 Bq/kg, 4911.32 Bq/m^3 and 4,86 Bqm^{-2}h^{-1}, respectively. Linear correlation was observed among radon concentration, radon exhalation and radium concentration. The linear correlation coefficient between radium content and radon concentration was found to be 0.62. Nevertheless, it was found that there is a linear correlation (R^2 = 0.99) between the radon concentration and radon exhalation rate.
Keywords: Radon, Rock, CR-39

BAZI KAYA ÖRNEKLERINDE RADYUM VE RADON KONSANTRASTONLARIN BELIRLENMESI

ÖZET

Dokuz kaya örneklerinde etkin radyum, radon konsantrasyonları ve radon yayılım oranı katı hal iz detektörleri (CR-39) kullanılarak belirlenmiştir. Radyum, radon ve radon yayılım oranları için ölçülen en yüksek değer sırasıyla, 24.62 Bq/kg, 4911.32 Bq/m^3 ve 4,86 Bqm^{-2}h^{-1} bulunmuştur. Radon konsantrasyonu ile radon yayılımı ve radyum konsantrasyonu arasında doğrusal bir ilişki gözlendi. Radyum içeriği ile radon konsantrasyonu arasındaki doğrusal ilişki 0.62 olarak bulundu. Bununla birlikte radon yayılım oranı ile radon konsantrasyonu arasında doğrusal bir ilişkinin (R^2 = 0.99) vardır.
Anahtar Kelimeler: Radon, Kayaç, CR-39

1. INTRODUCTION (GİRİŞ)

Radioactive elements (^{238}U, ^{232}Th, ^{40}K) found in the crust and mantle form the basis for several major applications in geophysics and geochemistry. Radon (^{222}Rn) an α-radioactive inert gas signals the presence of radium and its ultimate precursor uranium in the ground. These elements occur virtually in all type of rocks but due to geo-chemical processes which have slowly recycled the crustal material to and from the earth's mantle. Concentration measurements of ^{226}Ra (the direct precursor of the longest-lived radon isotope ^{222}Rn) in rocks are much better predictors of the radon potential than are uranium and thorium contents in these rocks. Radon is a radioactive nuclide with half life 3.8 days that is chemically inert gas. It's produced continuously in rocks and minerals through α-decay of ^{226}Ra.

Several different methods such as gamma and alpha spectroscopy and solid-state nuclear track detector (SSTND), of measuring radon and radium concentration in environmental samples have been developed and widely used. One of the commonly used methods, SSTND, is simpler and relatively cheaper than the others.

Radon concentration, radon exhalation rate and radium content measurements have been carried out by many researchers worldwide using the "closed-can technique" [1, 2, and 3].

In the present work, we have carried out determination of radon, radium concentration and radon exhalation rate of nine rock samples. Measurements of radon, effective radium and radon exhalation rate were obtained by using passive nuclear track detectors (CR-39).

2. RESEARCH SIGNIFICANCE (ARAŞTIRMANIN ÖNEMİ)

Natural radioactivity is composed of primordial and cosmogenic radionuclides. Natural occurring primary radionuclides (^{238}U, ^{232}Th and ^{40}K) and their daughters (especially ^{222}Rn) play an important role in public health. These radio nuclides are the main sources of the radiation derived from soil, rocks in living area. Monitoring of any releases radioactivity to the environment is important for environmental protection of radiation exposure. Especially, ^{238}U (^{226}Ra), ^{232}Th and ^{40}K radio nuclides have externally and internally exposure risks due to their gamma radiation and alpha particles (^{222}Ra) inhalation, respectively. The environmental radioactivity depends on geological features (kind of rock and soil) and it varies from place to place.

3. EXPERIMENTAL WORK (DENEYSEL ÇALIŞMA)

The radon concentration, radon exhalation rate and radium concentration were carried out by using passive track detectors (CR-39) which is capability to register tracks at the different levels of registration sensitivity. The 0.5 kg samples were ground homogenized and sieved to about 150 meshes by crushing machine. The samples were dried at 100 ^{0}C for 48 h to ensure that moisture is completely removed. Weighed samples were placed in polyethylene bottles, 500 cm^3 volumes, each. The bottles were completely sealed for more than one month to allow radioactive equilibrium to be reached. This step was necessary to ensure that the radon gas is confined within the volume and that the daughters will also remain in the sample. Each sample was placed in a plastic bottle chamber of radius 4.5 cm and length 9 cm. Squared pieces (2 cm x 2 cm) of solid-state nuclear track detectors (SSNTDs) CR-39 were mounted on the bottom of cylindrical plastic cans. These cans were sealed and stored for 30 days. Exposed detectors were collected and chemically etched using 6 M NaOH at 60 ^{o}C for 12h. Etched detectors were washed thoroughly in running water for 5 min and then in distilled water for another 5 min. The track density (track/cm^2) on CR-39 detector samples was counted using the optical microscope at a magnification of 100X.

For the purpose of calculating ^{222}Rn concentration levels in rock sample was determined by measuring the tracks density on the passive detector according to the Equation 1.

$$C_{Rn} = \frac{\rho}{\eta T} \tag{1}$$

Where, ρ is the measured track density of the background corrected tracks on the exposed detectors (track/cm^2), T is the exposure time of the samples and η is the detection efficiency (0.095 tracks cm^{-2} d^{-1} recorded per Bq m^{-3}of radon).

The radon exhalation rate, E, in soil sample was calculated by using Eq. 2.

$$E = \frac{\rho h \lambda}{\eta T_{eff}} \tag{2}$$

The effective radium content is calculated from following equation.

$$C_{Ra} = \frac{\rho V}{\eta M T_{eff}} \tag{3}$$

Where, h is height of sample cup, V is effective volume of the cylindrical container (m^3), λ is the decay constant of ^{222}Rn. T is the total exposure time, T_{eff} is the effective exposure time $[T_{eff} = T + 1/\lambda(e^{-\lambda T} - 1)]$, M is mass of the sample (kg) and η is the detector efficiency.

4. CONCLUSION AND SUGGESTIONS (SONUÇ VE ÖNERİLER)

Radon concentration, radon exhalation rate and effective radium content of some rock samples are given Table 1.

Table 1. Radon concentration, radon exhalation rate and effective radium content of some rock samples
(Tablo 1. Bazı kayaç örneklerinin radon konsantrasyonu, radon yayılım oranı ve etkin radyum miktarı)

Samples No	Radon Concentration (Bq/m^3)	Radon Exhalation Rate (E) (Bqm^{-2}h^{-1})	Radium Concentration (Bq/kg)
1	4911.32	4.86	24.62
2	1812.65	1.79	14.62
3	2596.50	2.57	10.06
4	1971.87	1.95	7.95
5	2333.18	2.31	20.63
6	1837.15	1.81	8.73
7	1432.98	1.41	2.20
8	1475.84	1.34	6.87
9	1794.28	1.64	3.87

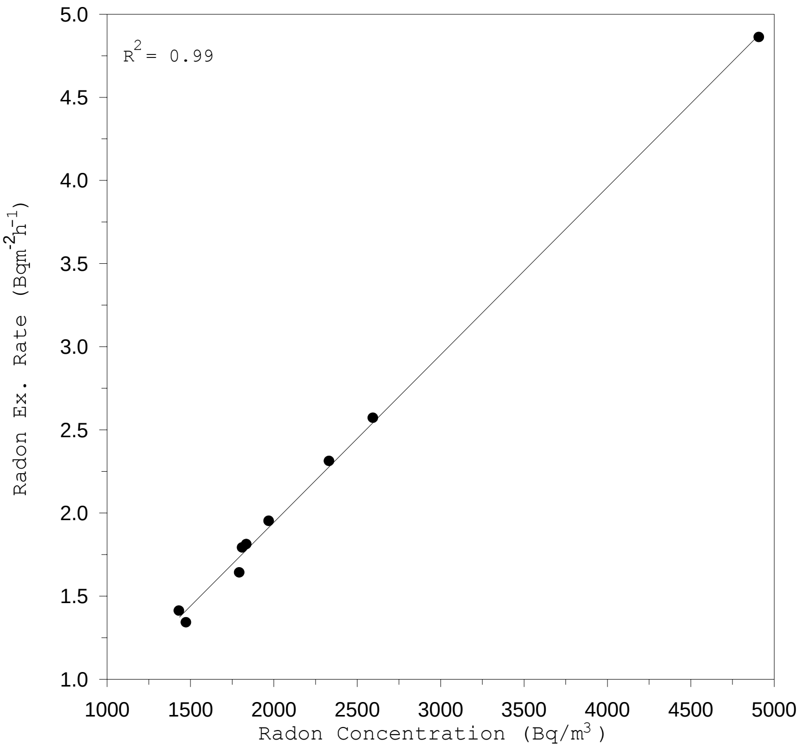

Figure 1. Relationship between radon exhalation rate and radium concentration.
(Şekil 1. Radyum konsantrasyonu ve radon yayılım miktarı arasındaki ilişki)

Nine rock samples were analyzed for radon exhalation rate, radon concentration and effective radium content using solid state nuclear tracks detectors, CR-39. The average radon exhalation rate from rock samples was 2.18 Bq $m^{-2}h^{-1}$. It was also found that the radon emanations are in good correlation with the radium contents.

The radon concentrations and effective radium concentration ranged between 1432.98 and 4911.32 Bq/m^3 and between 2.20 and 24.62 Bq/kg, respectively. Also, radon exhalation rate of the rock samples ranged from 1.34 to 4.86 Bq/m^2h. The relationship between radon exhalation rates and radon concentrations for rock samples are shown in Fig.1. The relationship between the radium and radon concentration is not found to be in a strong correlation. For this reason, porosity and density of this rock samples are very variable. But, there is a positive correlation between them (0.62, Fig 2). The effective radium content varied from 2.20 to 24.62 Bq/kg. The fluctuations in these values may be attributed to the variation of uranium (radium) concentrations in different kind of rocks. The highest and lower radon, radium concentration and radon exhalation rate have been found in the sample #1 and #7, respectively.

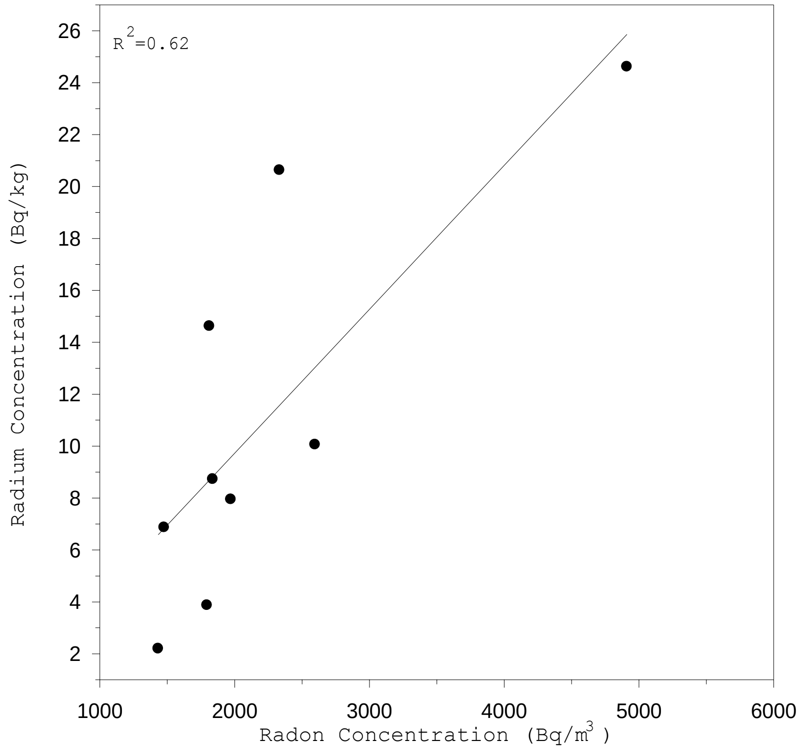

Figure 2. Relationship between radium and radon concentration.
(Şekil 2. Radyum ve radon konsantrasyonu arasındaki ilişki)

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