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RADON (Rn-222) CONCENTRATIONS AND ANNUAL AVERAGE EFFECTIVE DOSES OF SOME WELL WATER IN AFYONKARAHISAR-ÇAY-SULTANDAĞI LINE

ABSTRACT

This study aims on determination radon concentrations and annual average effective doses in some water wells near Afyonkarahisar-Çay-Sultandağı Line. Measured radon concentrations are between 2,2 Bq/L and 22,7 Bq/L, and annual average effective doses varied between 13,2 $\mu Sv.y^{-1}$ and 136,2 $\mu Sv.y^{-1}$. The human environment is surrounded with natural radiation with main components of cosmic and cosmogenic radiation, terrestrial gamma radiation from natural radio nuclides in rocks and soil, and natural radioactive substances in our diet and in the air we breathe. More than half of the natural radiation that human receives are caused by radon gas or by its decay products. Radon gas, which lies in Uranium decay series, is released from underground since Uranium and its decay products are easily dissolved in water. High exposure to radon gas may lead to lung cancer and some other major health problems. Due to these health risks, the scientists have increased their efforts on determining ^{222}Rn concentration in water samples in recent years.

Keywords: Well water, Radon, Annual Average Effective Dose

AFYONKARAHİSAR–ÇAY–SULTANDAĞI HATTINDAKİ BAZI KUYU SULARININ RADON (Rn–222) KONSANTRASYONLARI VE YILLIK ORTALAMA ETKİN DOZLARI

ÖZET

Bu çalışmanın amacı; Afyonkarahisar-Çay-Sultandağı hattında bulunan bazı kuyu sularının radon konsantrasyonlarını ve yıllık ortalama etkin doz miktarlarını belirlemektir. Elde edilen radon konsantrasyonları 2,2 Bq/L ile 22,7 Bq/L değerleri arasında, yıllık ortalama etkin doz miktarları ise 13,2 $\mu Sv.y^{-1}$ ile 136,2 $\mu Sv.y^{-}$ değerleri arasında değişmektedir. Canlılar, kaynağı yeraltından yeryüzüne çeşitli yollarla çıkan radyoaktif maddeler ve uzaydan gelen çeşitli kozmik ışınlar olan, doğal radyasyonla iç içe yaşamaktadır. İnsanların maruz kaldığı doğal radyasyonun yarıdan fazlasını radon gazı ve bozunum ürünleri oluşturmaktadır. Uranyum serisinde yer alan radon, uranyum ve bozunum ürünlerinin suda kolaylıkla çözünebilmesi nedeniyle yeraltından yüzeye çıkmaktadır. Radon gazı yüksek dozlarda maruz kalındığında, özellikle akciğer kanseri başta olmak üzere birçok sağlık sorununa neden olabilmektedir. Bu risklerden dolayı son yıllarda canlıların en önemli ihtiyacı olan su örneklerindeki ^{222}Rn konsantrasyonlarını belirlemeye yönelik çalışmalarda önemli bir artış görülmektedir.

Anahtar Kelimeler: Kuyu Suları, Radon, Yıllık Ortalama Etkin Doz

1. INTRODUCTION (GİRİŞ)

Radon (^{222}Rn) is produced continuously in rocks and minerals through α decay of radium (^{226}Ra), which is a member of Uranyum (^{238}U) series. Radon is chemically inert, highly soluble in water, odorless, colorless and tasteless gas. Radon has a half life of 3.82 days. Radon decay products emit highly energized α particles by ionization. Generally, ^{222}Rn and its decay products are main source of natural radiation dose. In recent years, international health organizations pointed out that radon gas and daughters are the carcinogens and contributing to the lung cancer incidence in the general population. This leads to increase in research to determine radon concentrations in water samples. The results indicate that some measured values exceeded the accepted level by international health organizations. For example, measured radon concentration in deep well water samples in the United States averaged about 39,96 Bq/L [1].

Studies on natural radiation indicated that radon is the main (about 55%) contributor to the doses received by the vast majority of the general population [2]. Radon is carried out to air through the cracks of subsoil and rocks, and water. For this reason, studies on measuring radon concentrations are carried on soil gas and underground water [3].

2. RESEARCH SIGNIFICATION (ÇALIŞMANIN ÖNEMİ)

The vast body of literature indicates that the studies on natural radioactivity, with different doses, in water found the leading agent to be radon. Previous studies reported some measurements as following: underground water range between 0,95 Bq/L to 36 Bq/L, sea water ranged from 0,3 Bq/L to 0,54 Bq/L, tap water ranged from 0,39 Bq/L to 0,47 Bq/L and in rivers ranged from 0,43Bq/L to 2,40 Bq/L [4 and 5]. The variation in measured values prompted us to make measurements in this region. Besides, this is the first published data for Afyonkarahisar province to our best knowledge which adds additional importance to our measurements.

3. EXPERIMENTAL AND ANALYTICAL STUDY (DENEYSEL VE ANALİTİK ÇALIŞMA)

Radon concentrations have been determined in the region of Afyonkarahisar-Çay-Sultandağı Line. The water samples were collected once a week, from 20 different public water wells. Most of the wells are more than 100 m deep. Fig.1 shows the location of the places where well water was collected. In Table 1 the places where water samples were collected are named. A 500 ml glass bottle was used to collect water sample after allowing water to flow for some time to ensure a sample of fresh water from each well. The bottles were filled completely in order not to allow any air in the bottle and closed tightly.

The radon concentrations were measured using the commercially available WG-1001 Vacuum Water Degassing System and AB-5R Radiation Monitor produced by Pylon Electronics. The system was evacuated by pump to a minimum of 584 mm-Hg which is a reduction in the barometric pressure at the altitude of Afyonkarahisar (1000 m). Background radiation of the scintillation cell was measured for 15 min and the outcome was converted to a cpm (count per minute) basis; B. For counting, the scintillation cell was placed in the radiation monitor for approximately 3.5 hours after sampling (i.e. when the radon activity in the cell had come to equilibrium). After the decay of fluorescence, the cell is counted for three times five minute

intervals. The outcome was recorded and converted to a cpm basis; C, and the time of count; T_c recorded. The mean values of those three counts were used to calculate C.

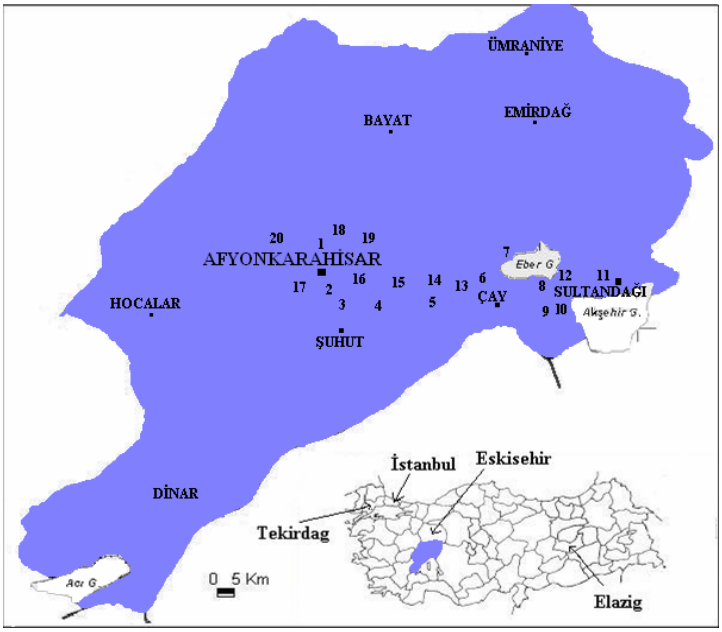

Figure 1. Source places where the samples were collected
(Şekil 1. Toplanan örneklerin kaynak yerleri)

Table 1. The numbering of the places where the samples were collected
(Tablo 1. Toplanan örneklerin yerlerinin numaralandırılması)

Source Number	Source Name
1	DSİ Piknik Alanı Kuyusu
2	Afyonkarahisar Belediyesi Su pompalama Tesisleri
3	Devlet Su İşleri Arıtma tesisleri
4	Devlet Parkı Piknik Alanı Kuyusu
5	Devlet Su İşleri 36610 nolu sondaj kuyusu
6	Ali Kaleli Tesisleri
7	Küçük Sanayi Sitesi
8	Devlet Su İşleri 49601 nolu sondaj kuyusu
9	Devlet Su İşleri 49602 nolu sondaj kuyusu
10	Doğancık Köyü
11	Sultandağı Şebeke Suyu 1
12	Sultandağı Şebeke Suyu 2
13	Karakuzu Petrol Ofisi
14	Çarıkçılar Petrol Ofisi
15	Gevrek Petrol Ofisi
16	Yakasenek Köyü
17	Keson Kuyu (Ataköy)
18	Beşler Bahçe İçi Kuyu
19	Beşler
20	Küçük Çobanlı

Following the operating instructions of the experimental system used for radon determination described in detail by the manufacturer [6] the radon concentrations were determined in water using the following relationship:

$$A = \frac{(C-B)}{F \times 6.66 \times D \times S \times V} \times 0.037$$

Where A is the Rn-222 concentration in $Bq.L^{-1}$, C is the gross count rate (cpm), B is the background rate (cpm), F is the cell counting efficiency which normally is 0.745 in the present case, D is the degassing efficiency of 300A Lucas cell and its value is 0.9, S is the correction for decay of radon from sample time T_s to the count time T_c, V is the sample volume in liters (0.19 L) and 0.037 is the conversion factor between pCi and Bq.

4. FINDINGS AND DISCUSSIONS (BULGULAR VE TARTIŞMALAR)

In this study, the radon concentrations from 20 different wells in the Afyonkarahisar-Çay-Sultandağı region have been measured. Both the average radon concentration and annual average effective doses have been determined by using the dose conversion factors of 6 $\mu Sv \cdot y^{-1} \cdot (Bq \cdot L^{-1})$ [7,8]. The average values of radon concentration ranged from 2.2 Bq/L to 22.7 Bq/L and annual average effective dose varied between 13.2 $\mu Sv.y^{-1}$ and 136.2 $\mu Sv.y^{-1}$. The obtained measurements of radon concentration and annual average effective doses are shown in Table 2.

Table 2. The average radon concentration and the related annual effective doses in well water samples
(Tablo 2. Kuyu suyu örneklerinde ortalama radon konsantrasyonu ve ilgili yıllık etkin dozları)

Source Number	Average Radon Concentration (Bq/L)	The Annual Effective Dose ($\mu Sv.y^{-1}$)
1	7,7 ± 1,6	46,7 ± 6,4
2	2,7 ± 0,7	16,2 ± 4,2
3	2,2 ± 0,8	13,2 ± 4,8
4	2,4 ± 0,9	14,4 ± 5,4
5	3,4 ± 0,8	20,4 ± 4,8
6	2,5 ± 1,0	15,0 ± 6,0
7	3,0 ± 0,8	16,0 ± 4,8
8	2,8 ± 1,0	16,8 ± 6,0
9	2,9 ± 1,2	17,4 ± 7,2
10	4,1 ± 1,5	24,6 ± 9,0
11	4,8 ± 0,7	28,8 ± 4,2
12	6,7 ± 1,4	40,2 ± 8,4
13	7,6 ± 1,0	45,6 ± 6,0
14	4,8 ± 1,3	28,8 ± 7,8
15	3,2 ± 0,5	19,2 ± 3,0
16	10,2 ± 1,1	61,2 ± 6,6
17	21,0 ± 0,8	126,0 ± 4,8
18	22,0 ± 1,3	132,0 ± 15,0
19	22,7 ± 1,4	136,2 ± 8,4
20	20,3 ± 1,3	121,8 ± 7,8

5. CONCLUSION AND SUGGESTIONS (SONUÇ VE ÖNERILER)

A total of 20 water samples from wells which were all located around Afyonkarahisar-Çay-Sultandağı Line for average radon concentrations, were examined. The results were graphed radon concentrations against to sample sources with a comparison to USEPA [9] and Euratom [10] accepted upper limits in Figure 2. The variations

in annual doses of samples and their accepted upper limits by USEPA and Euratom were presented in Figure 3.

The radon concentrations in well water sample sides 1-16 are below USEPA and Euratom upper limits but it was found that the radon concentrations in well water sample sides 17-20 exceeded the recommended USEPA value of 11 Bq/L whereas it is below the Eurotom value of 100 Bq/L.

On the other hand, when we look at the annual average effective doses as shown in Figure 3, the annual average effective doses in well water sample sides 1-16 are below USEPA and Euratom upper limits but it was found that the annual average effective doses in well water sample sides 17-20 exceeded the recommended USEPA doses of 66 $\mu Sv.y^{-1}$ whereas it is below the Eurotom doses of 600 $\mu Sv.y^{-1}$.

The variations in annual average effective doses of samples and their accepted upper limits by USEPA and Euratom were presented in Figure 3.

The results indicate that similar studies should continue and the natural radiation map of the region should be completed. Our constant effort in completing the study is continuing and results are going to be shared with scientific community as they come.

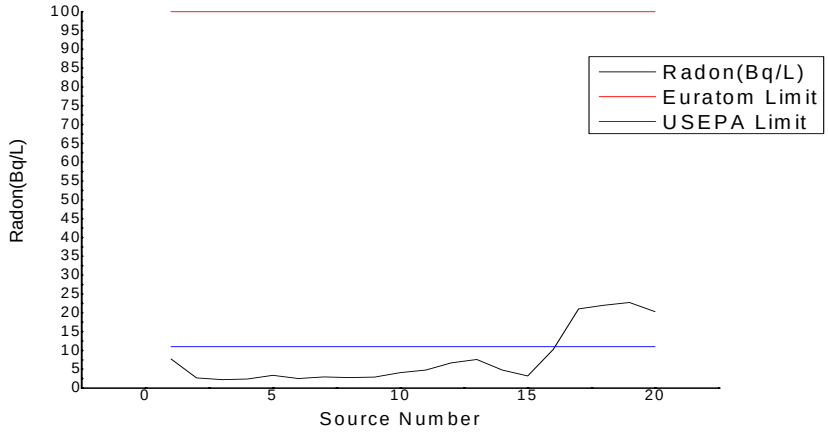

Figure 2. Radon concentrations and limit values for the samples
(Şekil 2. Örnekler için radon konsantrasyonları ve limit değerler)

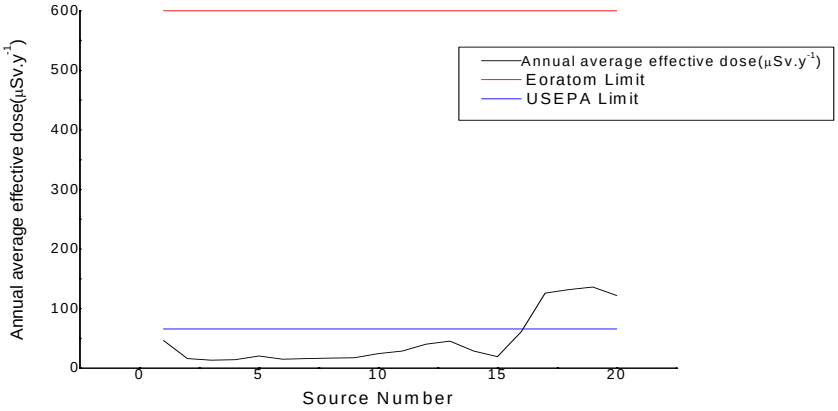

Figure 3. Annual average effective doses and accepted limit doses
(Şekil 3. Yıllık ortalama etkin dozlar ve kabul edilmiş dozlar)

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