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Assessment of Outdoor Terrestrial Gamma Dose Rates in the Konya-Ilgın-Çavuşçu Lignite Deposit (Turkey)

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Abstract: This study assesses the terrestrial gamma radiation dose rates from the naturally occurring radionuclides in the lignite coalfield of Ilgın district of Konya. The measurements were performed above the surface soil using NaI(Tl) gamma-ray detector. The average external annual effective doseswere also calculated using these terrestrial gamma radiation dose rates for each measurement location.

***Key words*:** Gamma dose rate, Ilgın lignite deposit, terrestrial radiation

Konya-Ilgın-Çavuşçu Linyit Maden Yatağında Dış Ortam Gama Doz Oranlarının Belirlenmesi

Özet: Bu çalışmada Konya'nın Ilgın ilçesindeki linyit kömür yatağındaki doğal olarak oluşmuş radyoaktif çekirdeklerden kaynaklanan karasal gama doz oranları belirlenmiştir. Ölçümler, toprak yüzeyinin üstünde ve NaI(Tl) gama-ışın detektörü kullanılarak gerçekleştirilmiştir. Ayrıca, ölçülen bu karasal gama doz oranları kullanılarak her bir ölçüm noktası için ortalama harici yıllık etkin dozlar hesaplanmıştır.

***Anahtar kelimeler*:** Gama doz oranı, Ilgın linyit yatağı, karasal radyasyon

1. Introduction

Radiation is energy emission that comes from a radioactivesource and travels through space and may be able to penetrate various materials. Also, all living organisms are subject to ionizing and this is a lifelong.Natural radiation includes externalradiation, which are terrestrial and cosmic radiations, and internal radiation. The most important contribution to natural radiation exposures comes from radioactive nuclides that originated from the crust of earth. The naturally occurring radionuclides U-238, Th-232 and K-40 are the main sources of radiation in soil and rocks. The human body is exposedto the gamma radiation from external sources which are mainly radionuclides in the U-238 and Th-232 series and K-40 radionuclide. These radionuclides are found in various concentrations depending on geological conditions of the region. They may cause external exposure risk due to their gamma-ray emission. They are also present in the human body and they irradiate various organs with alpha and beta particle radiations, as well as gamma electromagnetic radiation [1].

Ilgın is a district of Konya province and has lignite a deposit which is known as Ilgın-Çavuşçu Lignite Deposit. The average thickness of the lignite is about 8 m (up to 25m) and it hasdark brown or blackish browncolors. It is seen that the uranium concentration of lignite is higher than the uranium content of the most of the coals in the world [2]. Due to its higher uranium concentration, the measurement of outdoor

terrestrial gamma dose rates in Ilgın-Çavuşçu Lignite Deposit is important for public health.

2. Materials and Method

Outdoor terrestrial gamma dose rates at 35 locations were measured in the region of Ilgın-Çavuşçu Lignite Deposit of Konya in the spring of 2015. Ilgın-Çavuşçu Lignite belongs to Middle Miocene age and it occurs within lacustrine sediments deposited under subtropical climatic conditions [2]. Active lignite deposit of the region is located near the Çavuşçugöl village (first region in Figure 1) and it is still being processed as an open-cast mining. There is also a former lignite deposit located near the Gölyaka village (second region in Figure 1).

Figure 1. Study area

The measurements were performed for about 1 minute at a height of 1 meter above the surface soil using a portable survey meter (Ludlum 2241-3 RK) connected with a plastic NaI(Tl) gamma ray scintillation detector [3]. The main function of the crystal is to convert gamma ray to the photons of visible light process called scintillation. Outdoor gamma dose rates (OGDR) in the air were measured as a unit of μR/h. Also, the external gamma absorbed dose rate in air (ADRA) and annual effective dose equivalents (AEDE) were calculated using Equation 1 and 2, respectively. In equation 1, 8.7 nGy/μRis a conversion factor from gamma dose rate (μR/h) to absorbed dose [4,5]. The external gamma absorbed doses in nGy h^{-1} include both the cosmic ray and terrestrial component of the gamma radiation. In equation 2, DCF and OF are the dose conversion factor (DCF) from the absorbed dose to the effective dose and outdoor occupancy factor, respectively [1]. As shown in Equations 1 and 2, the calculations for occupational factor and dose conversion factor are assumed to be 0.2 and 0.7for adults according to the UNSCEAR 2000 datas[1].

$$ADRA(nGy/h) = OGDR(\mu R/h) \times 8.7\ (nGy/\mu R) \quad (1)$$

$$AEDE = ADRA(nGy/h) \times DCF(0.7\ Sv/Gy) \times OF(0.2) \times T(8760\ year) \quad (2)$$

The estimation of lifetime cancer risk (LTCR) was calculated by equation (3):

$$ELCR = AEDE \times LE \times RFSE \quad (3)$$

LE is the lifetime expectancy at birth by Konya province (78 years) [6], and RFSE is the risk factor for stochastic effects of the common population. The risk factor per Sievert is used as values of 0.05 Sv^{-1} according to the ICRP 1990 reports [7,8].

3. Results and Discussion

The results of the absorbed dose ratein the region of the Konya-Ilgın-Çavuşçu Lignite deposit are varied from 43.5 nGy/h (location# 32, 35) to 304.5 nGy/h (location# 19) for 35 locations (Table 1). The annual effective dose equivalent values in the region were calculated in units of μSva^{-1} for 35 locations as shown Table 1.We analyzed the results of the annual effective dose equivalent rates by grouping the measurement locations into three separate regions as follows: First region shows active (locations# 1-15) lignite deposit. second and third regions show former (locations# 17-26) lignite deposit and neighborhood of these lignite deposit (locations# 16, 27-35), respectively. Results of the average of the dose equivalent rates in the regions can be seen in Table 2. According to the results, the highest average of the annual effective dose equivalent rate was found to be 217.66 μSva^{-1} in second region which the highest value of the absorbed dose is also in. The average of the annual effective dose equivalent rate for the first region, the third region and all of them are 105.84 μSva^{-1}, 88.88 μSva^{-1} and 132.90 μSva^{-1}, respectively. The annual effective dose equivalent is 73.6 μSva^{-1} for the world average [1].The calculated average of the annual effective dose equivalent in the region of the Konya-Ilgın-Çavuşçu Lignite deposit is above the average of the world according to UNSCEAR 2000data [1]. It is possible to observe such situations in some other regions of Turkey. For example, the annual effective dose equivalent value in Kütahya is changes between 96.4 μSva^{-1} (Çavdarhisar region) and 1091.2 μSva^{-1} (Simav region) [9]. Also average of the annual effective dose equivalent was found to be 214.5 μSva^{-1} for Artvin [10].

Table 1. Outdoor gamma dose rate, annual effective dose equivalent and cancer risk for people living in the region of Ilgın lignite deposits.

Location Code	Gamma Dose Rate (μRh^{-1})	Absorbed Dose* ($nGy\ h^{-1}$)	Annual Effective Dose Equivalent(μSva^{-1})	Lifetime Cancer Risk ($x10^{-4}$)
1	12	104.4	128.04	4.99
2	8.3	72.21	88.56	3.45
3	8.5	73.95	90.69	3.54
4	11	95.7	117.37	4.58
5	12	104.4	128.04	4.99
6	10	87	106.70	4.16
7	10	87	106.70	4.16
8	10	87	106.70	4.16
9	13	113.1	138.71	5.41
10	11	95.7	117.37	4.58
11	8	69.6	85.36	3.33
12	8	69.6	85.36	3.33

Table 1. Continued

13	12	104.4	128.04	4.99
14	8	69.6	85.36	3.33
15	7	60.9	74.69	2.91
16	9	78.3	96.03	3.75
17	14	121.8	149.38	5.83
18	14	121.8	149.38	5.83
19	35	304.5	373.44	14.56
20	20	174	213.39	8.32
21	32	278.4	341.43	13.32
22	15	130.5	160.05	6.24
23	15	130.5	160.05	6.24
24	12	104.4	128.04	4.99
25	20	174	213.39	8.32
26	27	234.9	288.08	11.24
27	12	104.4	128.04	4.99
28	9	78.3	96.03	3.75
29	6.8	59.16	72.55	2.83
30	9.5	82.65	101.36	3.95
31	10	87	106.70	4.16
32	5	43.5	53.35	2.08
33	9	78.3	96.03	3.75
34	8	69.6	85.36	3.33
35	5	43.5	53.35	2.08
MEAN			**132.90**	**5.18**

* occupational factor: 0.2 [1].

Table 2. Arithmetic Mean of the annual effective dose equivalent rates of three separate region of study area.

Region (Location code)	Annual Effective Dose Equivalent (μSva^{-1})
First (1-15)	105.84
Second (17-26)	217.66
Third (16, 27-35)	88.88

The average of cancer risk for adults in the region of the Konya-Ilgın-Çavuşçu Lignite Deposit are exposed to as a result of outdoor gamma dose rate is measured as 5.18×10^{-4}. While this value is approximately two times higher than the world average, 2.9×10^{-4} [1] it is also lower than the result found to be 7.5×10^{-4} in the study done in Artvin [10].

4. Conclusions

In Konya-Ilgın-Çavuşçu Lignite Deposit, calculated average of the annual effective dose equivalent was found to be 132.90 μSva^{-1}, which is also above the average of the

world. According to our results, the highest average of the annual effective dose equivalent rate was found in the second region, which is a former lignite deposit. This situation may be associated with the long time use of this former lignite deposit. As the average of cancer risk for adults is higher than the world average, this indicates that in future there is a need for wider risk analysis related to environmental radioactivity in the region.

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