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Determination of Outdoor Absorbed Gamma Dose Rates of Kahramanmaraş Province, Turkey

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Abstract. Outdoor absorbed gamma dose rates were measured in 118 different regions at a height of 1 m above the ground in the gonad (genitals) level in humans in Kahramanmaraş province and its vicinity using Eberline portable detector. Outdoor gamma dose rates varied from 32.7 nGy/h and 96.4 nGy/h with an arithmetic average of 64.8 nGy/h. The average value of the corresponding annual effective dose rate was estimated as 79.5 µSv/y. Lifetime cancer risk values estimated according to ICRP 103, BEIR VII and ICRP 60 were found to be 0.032, 0.036 and 0.040 respectively.

***Keywords*:** Cancer risk, effective dose, gamma dose.

Türkiye'nin Kahramanmaraş İlinde Soğurulan Gama Doz Seviyesinin Belirlenmesi

Özet. Kahramanmaraş İli ve çevresinde 118 farklı bölgede açık havada soğurulan gama radyasyon doz düzeyini belirlemek için insanlarda gonad (üreme organları) hizasında yerden yaklaşık 1m yükseklikte Eberline marka portatif dedektörle ölçümler alınmıştır. Her bölgede ölçümler alınırken 5 metre yarıçapında üç farklı okuma yapılmış ve bu üç değerin ortalaması alınarak her bir ölçüm bölgesi için gama doz değerleri belirlenmiştir. Kahramanmaraş ili geneli için gama dozu ölçümlerinin değeri 32,7 nGy/s ile 96,4 nGy/s arasında bulunmuş olup, aritmetik ortalaması 64,8 nGy/s olarak hesaplanmıştır. Soğurulan gama radyasyon dozu kullanılarak hesaplanan yıllık etkin doz eşdeğerinin ortalama değeri ise 79,5 µSv/y olarak hesaplanmıştır. Kahramanmaraş ilinde yaşam boyu kanser risk değerleri ICRP 103, BEIR VII ve ICRP 60 için yüzdelik ortalamaları sırasıyla 0,032, 0,036 ve 0,040 olarak bulunmuştur. Elde edilen sonuçlarla Türkiye'de diğer illerde yapılan benzer çalışmaların sonuçları ve dünya ortalamaları ile karşılaştırılmıştır.

***Anahtar Kelimeler*:** Kanser riski, etkindoz, gama doz.

1. INTRODUCTION

During the life of the people, they live inthe environment in which they live, depending on their environment and quality of life significantly natural radiation, nuclear weapons experiments, nuclear plant accidents, nuclear power plant emissions and leaks as a result of artificial radiation sources and internal and external irradiation as a result of radiation under the influence of [1].

Radionuclides with higher half-life such as ^{238}U an ^{232}Th radioactive uranium series and radioactive potassium (^{40}K) are naturally present from the formation of the earth's crust. The gamma rays that they broadcast form a large part of the environmental radiation. Their effect on these gamma rays depends on the concentration of radioactive elements in their territory. The activity concentrations of ^{238}U, ^{232}Th and ^{40}K vary with

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soil and rock types. Therefore, the absorbed gamma dose rate measured in the outdoor air is closely related to the concentrations of radio-nuclei in the soil [2, 3].

The main purpose of environmental radiation measurements is to determine the radiation type and dose of people from environmental sources and to evaluate the risk they will generate. In this, the environmental concentrations of radionuclides, which constitute the sources of natural radiation, and the effects of radiation on biological systems, especially in humans, need to be determined. In addition, the relationship between the radionuclides in the environment and the radiation dose that people receive from these sources should also be determined. However, after such research, it can be decided whether a region is suitable for natural radiation or not. The difference in the concentration of radioactivity in the earth crust is one of the most important factors affecting the level of radiation. The differentiation of the radioactivity concentration varies depending on the geographic and geological structure of the region, the mineralogical structure of the rock and its soils and the elevation above sea level [4].

In addition to the dose and type of radiation in the world and Turkey as human research for assessing the risk they might have on health it is made. After the Chernobyl nuclear accident in 1986, a number of studies aimed at determining the level of natural background radiation in Turkey, especially in regions affected by this accident could have been made [5, 6].

However, despite the majority in Turkey take place in the Mediterranean region, located in the northern and northeastern parts of Eastern Anatolia Region does not have a sufficient number of studies to determine the gamma dose levels of Kahramanmaras. For this reason, this study was conducted to measure, evaluate and understand. This data will also be useful in assessing possible future environmental pollution.

2. MATERIALS & METHODS

Geology of the survey area

Kahramanmaraş, 37^{o} 11' and 38^{o} 36' north latitude of 36^{o} 15' and 37^{o} 42' east longitude is between 14 457 km^{2} area in terms of area size and Turkey's 12 largest cities. As seen in Figure 1, although the majority of the Kahramanmaraş province is located in the Mediterranean Region, some parts of the north and northeast are in Eastern Anatolia. The eastern parts of the Çağlayancerit and Pazarcık districts are within the borders of the Southeastern Anatolia Region. In terms of land structure and altitude, flatness, pit and mountainous areas are numerous [7]. Most of the landforms consist of collapsed areas between the mountains, which are the extensions of the Southeast Taurus Mountains and these mountains. The vast majority of the plains are located around the Ceyhan Valley. The plateaus are located between the mountainous areas and the plains. 59.7% of the province of Kahramanmaraş consists of mountains, 24% plateaus and 16.3% plains. The altitude ranges from 350 meters to 3090 meters [8].

Figure 1. Research Region of Kahramanmaraş.

Gamma Scintillation Detector

In this study, Eberline Smart Portable (ESP-2) model, portable microcomputer and a SPA-6 plastic scintillation detector connected device were used to determine the external gamma radiation levels. ESP-2 is a device specially designed for radiation measurements, which can record the measured information and then transfer the information recorded to a connected printer. Allows multiple reads (over 500) and subsequently a computer can be connected to the printer. The SPA-6 detector is highly sensitive to the detection of radiation emitted from low-activity radionuclides descending into the ground with fallout with measurements of natural gamma radiation. The ESP-2 has seven multi-function opening switches and a liquid crystal display (LCD), designed as an interface for the user. The data can be given either as scientific or motion point recording and in selectable measurement units [9].

Scintillation detectors consist of a substance used as a scintillator and a photon amplifier tube connected directly behind it. Ionizing radiation interacts with some of the solid, liquid or gaseous substances, called scintillation phosphorus, resulting in ionization and stimulation. When the energy given to the electron is not enough to detach it from the environment, the electron is emitted and the visible light is released as it returns to its original state. The light emitted by the scintillation phosphors is collected by photon multiplier tubes and converted into voltage pulses. The amplitude of the pulse is proportional to the energy of the radiation. These detectors are used for counting and also for energy separation. Although scintillation phosphors may be in liquid or crystalline form, only crystal ones are still used in radiation control work [9].

In order to minimize measurement errors during the determination of gamma dose values, three readings were made at each measurement point and the mean of these three values were determined and the gamma dose values for each measurement region were determined. The results include contributions from both terrestrial radionuclides and cosmic rays. The portable detector used in the measurements shows the measurement results in μR/h. After getting the average of three different measurements, results were recorded in μR/h and then the conversion factor of 8.7 nGy μ/Rwas used to change the unit of μR/ h to the nGy/h[10].

Determination of outdoor gamma dose rates

After getting the average of three different measurements, results were recorded in μR h^{-1} and then the conversion factor of 8.7 nGy μR^{-1} was used to change the unit of μR h^{-1} to the nGy h^{-1}. To obtain the annual effective dose equivalent (AEDE), the following equation was used [11,12].

$$AEDE = ADRA \times DCF \times OF \times T \quad (1)$$

In this equation, the environmental gamma dose conversion factor is determined as 0.7 Sv/Gy and this value does not change for measurements both inside and outside the home. Another factor that should be known in this equation is the Busy Factor, that is, the time that people are exposed to these rays. In the calculations made in this study, it is considered that people spend 20% of their time in open areas and 80% in closed areas (occupancy factor is taken as 0.8 for home and 0.2 for outside house). Time is the number of hours in a year (8760 s/y). Lifetime cancer risk (ELCR) was calculated using equation 2 [11,13].

$$ELCR = AEDE \times DL \times RF \quad (2)$$

Here AEDE is the annual effective dose equivalent, DL, mean life expectancy (mean 70 years) and RF is the fatal cancer risk factor in Sv^{-1}, and in this study, the RFs of ICRP 103, BEIRVII [14] and ICRP 60 for the public as 0.057, 0.064 and 0.072, respectively, have been used [15].

3. RESULTS AND DISCUSSION

The absorbed dose rate in air (ADRA) 1 m above the ground consisting of the terrestrial and the cosmic gamma components was determined as 64,8 nGy h^{-1} for the entire region. Thereadingsrangedfrom 32,7 to 96,4 nGy/ h. The measured outdoor gamma exposure dose rates (GEDR) in μR/h and absorbed gamma dose rates in air (ADRA) in nGy/h are presented for each distinct of the Kahramanmaraş in Table 1.

Table 1. Gamma Exposure Dose Rate and Absorbed dose rate for each distinct of the Kahramanmaraş.

	GEDR (Gamma Exposure Dose Rate) (µR/h)			**ADRA (Absorbed Dose Rate in Air) (nGy/h)**		
Distinct	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**	**Mean**
KahramanmaraşMerkez	3.75	7.90	6.44	32.7	68.8	56
Türkoğlu	5.65	6.86	6.09	49.2	59.7	53
Pazarcık	6.27	9.60	7.07	54.6	83.6	61.5
Çağlayancerit	7.06	10.97	7.97	61.5	95.5	69.4
Andırın	6.60	10.39	7.96	57.5	90.4	67.3
Afşin	7.40	10.88	8.81	64.4	94.7	76.7
Elbistan	7.52	10.32	8.32	65.5	89.8	72.5
Göksun	7.05	10.18	7.85	61.4	88.6	68.3
Ekinözü	7.11	10.80	8.12	61.9	94.3	70.7
Nurhak	6.40	11.08	9.22	55.7	96.4	80.3
Region	3.75	11.08	7.45	32.7	96.4	64.8

The absorbed gamma dose map obtained as a result of the measurements in Kahramanmaraş province and its districts was drawn. Figure 2 shows the general distribution of the absorbed gamma dose rate throughout the province in the form of an isodose map. Red areas represent areas where Kahramanmaras province and overall absorbed gamma dose doses are high.

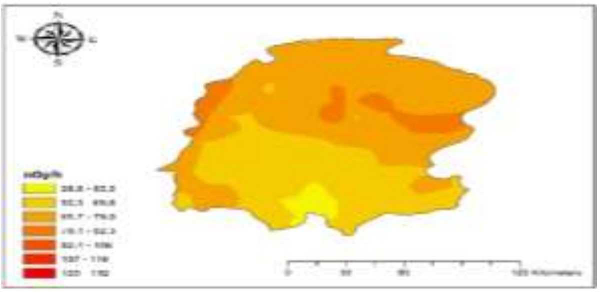

Figure 2.ADRA in Kahramanmaraş.

Table 2 presents the radiation doses (yearly effective dose equivalents) of people exposed to one year during the year and the risk factors for life-long cancer caused by environmental gamma radiation for a year by using absorbed gamma dose values in Kahramanmaras province.

Table 2. The average annual effective dose values and Lifetime cancer risk.

		Lifetime cancer risk %		
	AEDE Annual effective dose (µSv/y)	**ICRP 103**	**BEIR VII**	**ICRP 60**
Kahramanmaraş Merkez	68.7	0.027	0.031	0.035
Türkoğlu	65	0.026	0.030	0.033
Pazarcık	75.4	0.030	0.034	0.038
Çağlayancerit	85	0.034	0.038	0.042
Andırın	83	0.033	0.037	0.042
Afşin	94	0.038	0.042	0.048
Elbistan	89	0.036	0.040	0.045
Göksun	84	0.034	0.038	0.042
Ekinözü	87	0.035	0.039	0.044
Nurhak	98.5	0.039	0.044	0.050
Region	79.5	0.032	0.036	0.040

The annual effective dose equivalent calculated using the absorbed gamma dose measurement varies between 40.1 µSv/y and 11.2 µSv/y, but the average value was found to be 79.5 70 µSv/y. As can be seen in Table 3, the annual effective dose equivalent is 79.5 µSv/y, the world average is greater than 70 µSv/y [12].

Table 3. Absorbed Dose Rates in Air (ADRA) in close cities to region and worldwide averages.

	ADRA (AbsorbedDose Rate) (nGy/h)	**AEDE (Annualeffectivedose) (µSv/y)**
İstanbul [16].	65	79.7
Kastamonu [17].	54.81	67.21
Şanlıurfa [18].	60.9	74.7
Kırklareli [19].	118	144.7
Tekirdağ [20].	43.85	53.77
Çanakkale [21].	66.4	81.4
Çankırı [22].	69.6	87.7
Trabzon [23].	59	72.4
Yalova [24].	84	103
Balıkesir [25].	127	155.8
Kahramanmaraş	64.8	79.5
Worldwide [12].	60	70

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