
Araştırma Makalesi / Research Article

Adana ve Çevresinde Radyoaktivite Seviyesi ve Sağlık Riski

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Öz

Adana İli ve çevresinde havadaki gama radyasyon doz seviyelerini belirlemek için 133 farklı noktada toprak yüzeyinden yaklaşık 1 m yükseklikte ölçümler yapıldı. Ölçümler, doğal gama radyasyonu ölçümleri ile birlikte serpinti ile birlikte inen düşük aktiviteli radyonüklidlerden yayılan radyasyonun tespitine duyarlı olan portatif bir gama sintilasyon detektörü kullanılarak ölçüldü. Bu çalışmada, Adana ili ve çevresinde bulunan gamma doz seviye ölçümlerinin aritmetik ortalaması 71.2 (nGy /h) olarak bulundu. Bu değer yıllık etkin doz eşdeğeri 87.3 µSv/y değerinde etkin doz ortalamasına karşılık gelmektedir. Elde edilen sonuçlar, Türkiye'nin farklı bölgelerinde yapılan çalışmalar ve dünya ortalamasıyla karşılaştırılmıştır.

Anahtar kelimeler: Radyasyon, Gama Dozu, Kanser Riski, Yıllık Etkin Doz, Adana

Radioactivity Levels and Health Risks of in and Around the Adana Region, Turkey

Abstract

In order to determine the gamma radiation dose levels in the Adana Province and its vicinity, measurements were made at a height of approximately 1 m from the soil surface at 133 different points. The measurements were measured using a portable gamma scintillation detector that was sensitive to detection of radiation emitted by low-activity radionuclides descending with fallout along with natural gamma radiation measurements. In this study, the arithmetic average of gamma dose level measurements in Adana province and its surroundings was found to be 71.2 (nGy /h). This value corresponds to the mean effective dose equivalent of 87.3 µSv /y. The obtained results were compared to studies conducted in different regions of Turkey and the world average.

Keywords: Radiation, Gamma Dose, Cancer Risk, Annual Effective Dose, Adana.

1. Introduction

Radiation is caused by radioactive nuclei in the earth's building, from cosmic rays formed in the solar system, or artificial radiation produced by human beings. The basic source of radiation that people are exposed to in the environment they live in is natural radiation. The investigation of the dose, the effects on people's lifespan, and the harm they will cause is of great importance in the study of environmental radioactivity. The majority of the external gamma dose rate on ordinary soils is due to the primary radio-nuclei in the ground. K-40 (35%), Th-232 (50%) and U-238 (15%) are the main cores that make up the gamma dose in the ground. The predominant gamma dose distribution over soil is due to radioactive materials at depths of 30 cm of soil. However, uranium and thorium concentrations are higher in some parts of the world, especially in oil regions. There are two important factors that influence the changes, namely radio-nuclear condensation and armor (insulation) [1].

The dose varies according to the radio-nucleus composition in the soil and rocks and the geological structure of the region. Generally, the volcanic rocks have a high dose level, which is

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associated with the high silica (flintstone, quartz sand) amount present in the acidic rocks. Generally, sedimentary rocks have lower radioactive material concentrations in volcanic rocks. Radioactivity in the soil arises from the rocks, where radioactivity can be increased or decreased by sedimentation / dissolution and abrasion with dilution with other materials by sedimentation in groundwater [2,3,4].

The measurement of environmental radiation is very important for determining the amount of natural baseline level of activity change. From here, it can be easily determined whether there is any radioactive pollution and monitoring of the contamination is very important due to environmental protection. Therefore, the main purpose of environmental radiation measurements is to determine the radiation dose and the type of radiation and to evaluate the risk that this radiation will form. The concentration of the radionuclides which form the natural radiation sources in the environment must be determined by the influence on the biological systems, especially in the radiation. This is because irradiation of cells in the background of the radiation can cause DNA damage. Radiation effects against DNA can result in a return to normal structure or can lead to changes that can vary depending on the causes (chromosomal abnormalities and mutations) in surviving cells in DNA [5]. Due to the damages of background radiation, different studies have been carried out to prevent the risk of harm to human health [6].

Therefore, in this study, was investigated in terms of activation concentration and outdoor gamma dose rates of radionuclides in order to reveal the possible potential health risks for Turkey's formably population in the Mediterranean region reveal Turkey's fourth largest city with Adana distribution radyolüsit provincial and local residents.

2. Materials and Methods

Adana is located between 35°-38° north latitudes and 34°-36° east longitude and in the Mediterranean Region. As shown in Figure 1, there are 15 towns including Seyhan, Yüreğir, Çukurova, Sarıçam, Aladağ Karaisalı, Ceyhan, Imamoglu, Feke, Pozantı, Karataş, Kozan, Saimbeyli, Yumurtalık and Tufanbeyli. The Adana province borders are one of the interesting aspects of the Taurus belt in terms of covering most of the tectonostratigraphic units of the Taurus, or rock-stratigraphic units representing all systems of the Cambrian-Tertiary space [7,8]. The area under investigation is between the Yumurtalık fault and the Ececi Fay. The region of Adana within the boundaries includes different tectonostratigraphic associations with distinct tectonic contact between them in terms of their distinctive stratigraphy, structure and rocking characteristics.



Figure 1. Research Region of Adana

The Bolkar Mountain association includes rocks with olistostrome, along with carbonate and crushed rocks deposited from the Devonian-Lower Tertiary area. The steppe association includes acidic tuffs, basic and ultrabasic rocks and serpentinites, which represent different facies and

environments ranging from continental pelagic and oceanic rocks deposited in the Triassic-Senonian range to shelf-type rocks. Aladağ unit includes shelf type carbonate and rugged rocks representing the Devonian-Cretaceous interval. Deer Mountain association, carbonate and cratered rocks of the Cambrian-Early Tertiary range. The Görbiyes Mountain association includes carbonate sediments, olistolith and olistostromal formations, possibly representing the Jurassic-Late Cretaceous interval. The Mount of Gorbıyes shows low grade metamorphism. The Keban-Malatya association is represented by the metamorphic, predominantly platform-type metaplastic and metacarbonates with Upper Paleozoic-Lower Cretaceous age range. The Misis-Andirin association, deposited in the Cretaceous-Tertiary time interval, provides mélangé-like and volcanosedimentary facies features [9].

In this study, in order to determine the levels of gamma radiation levels in 133 different regions of different parts of Adana province, measurements were taken for 2 minutes at a height of about 1 m from the ground in the direction of gonads (reproductive organs).

The coordinates of the sample areas, altitude, population and station numbers are shown in Table 1.

Table 1. Distribution of stations in the research region of Adana

District	Latitude (N)	Longitude (E)	Altitude (m)	Catchment area (km ²)	Population	Number of Stations
Kozan	37.45°	35.81°	110	1690	130456	10
Aladağ	37.54°	35.39°	850	1347	15896	8
Pozantı	37.42°	34.87°	780	946	19215	9
Çukurova	37.04°	35.30°	23	240	364118	5
Sarıçam	37.01°	35.38°	100	770	163833	7
Yüreğir	36.98°	35.33°	27	1538	424999	14
Seyhan	36.97°	35.33°	23	444	800387	10
Karataş	36.56°	35.38°	10	862	22098	9
Yumurtalık	36.76°	35.72°	18	447	17211	13
Ceyhan	37.02°	35.81°	20	1472	160616	26
Tufanbeyli	38.26°	36.22°	1474	964	16640	5
Saimbeyli	37.98°	36.09°	971	989	14840	4
Feke	37.81°	35.91°	620	1116	16572	7
Imamoğlu	37.26°	35.66°	76	445	28405	6

The results of the gamma irradiation rates that were absorbed by the Eberline Smart Portable (ESP-2) device in open air were obtained in $\mu\text{R}/\text{h}$. The results obtained were converted to the absorbed dose rate nGy/h using a conversion factor from the definition of Rontgen ($8.7 \text{ nGy}/\mu\text{R}$) [10].

Equation 1 was found to be equivalent to the annual effective dose (AEDE) [11, 12].

$$\text{AEDE} = \text{ADRA} * \text{OF} * \text{DCF} * \text{T} \quad (1)$$

Here, ADRA is the rate of gamma radiation dose absorbed in the air DCF is the environmental gamma dose conversion factor, the occupation factor is OF, T is the time. The environmental gamma dose conversion factor was determined to be $0.7 \text{ Sv} / \text{Gy}$ to convert the absorbed dose ratio to the annual effective dose equivalent. In addition, 20% of the people spent in the field during a year ($8760 \text{ h}/\text{y}$) was spent in open areas, taking into consideration the coefficient of occupation 0.2 Lifetime cancer risk (ELCR) was calculated using Equation 2 after finding the annual effective dose value [12,13].

$$\text{ELCR} = \text{AEDE} * \text{DL} * \text{RF} \quad (2)$$

Here, DL is the average duration of life (mean 70 years) and RF is a risk factor and for stochastic effects. ICRP risk factors for lethal cancer in the whole population are used respectively ($1 / \text{Sv}$), RF for ICRP 103, BEIR VII [14] and ICRP 60 for 0,057, 0,064 and 0,072 values [15].

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.

3. Results and Discussion

Table 2 shows the minimum, maximum and average values of gamma exposure dose rate and absorbed dose rate for each district of the Adana.

The arithmetic mean of the gamma dose measurements performed in 133 different regions in Adana and its vicinity was calculated as 71,2 nGy /h.

Table 2. Gama exposure dose rate and absorbed dose rate for each distinct of the Adana

District	GEDR (Gamma Exposure Dose Rate) (μ R/h)			ADRA (Absorbed Dose Rate in Air) (nGy/h)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Kozan	10.3	16.8	13.1	89.6	146	114
Aladağ	2.97	9.62	6.47	25.8	83.7	56.3
Pozantı	6.46	13.5	9.98	56.2	118	86.8
Çukurova	6.10	7.78	6.98	53.1	67.7	60.8
Sarıçam	5.02	7.64	6.35	43.7	66.5	55.2
Yüreğir	4.36	8.37	6.76	37.9	72.8	58.8
Seyhan	5.84	9.51	7.84	50.8	82.7	68.2
Karataş	5.12	9.10	6.90	44.5	79.2	60
Yumurtalık	5.24	8.99	6.50	45.6	78.2	56.6
Ceyhan	4.66	9.87	7.41	40.5	85.9	64.5
Tufanbeyli	10.2	12.3	11.6	88.7	107	101
Saimbeyli	11.1	13.9	12.6	96.6	121	110
Feke	6.37	15.4	8.97	55.4	134	78
Imamoğlu	6.80	9.5	8.74	59.2	82.7	76
Region	2.97	8.18	13.1	25.8	146	71.2

In Figure 2, the absorbance gamma dose map obtained from measurements for Adana province and its surroundings is plotted. The overall distribution of the gamma dose rate absorbed in Figure 2 is in the form of an isodose map. The red areas represent areas where the absorbed gamma dose values in Adana province and in general are high.

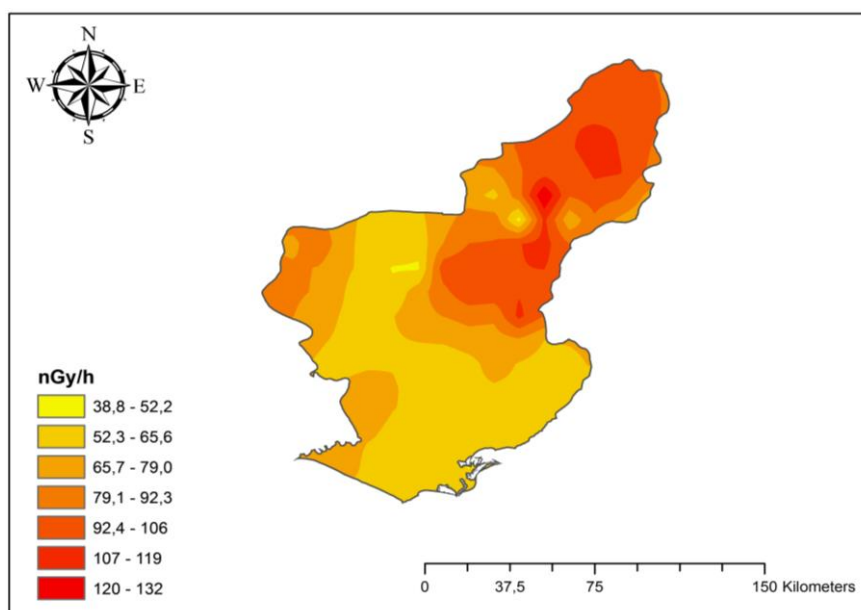


Figure 2. ADRA in Adana

The mean value of the annual effective dose calculated using external gamma dose was found to be 87.3 $\mu\text{Sv} / \text{y}$. This value is higher than the world average of 70 $\mu\text{Sv} / \text{y}$ [11]. The average annual effective dose values (AEDE) arising from average measured absorbed gamma dose rates in air (ADRA) for each districts of Adana and the estimated lifetime cancer risk values in public using three different models are given in Table 3.

Table 3. The average annual effective dose values and lifetime cancer risk

	AEDE ($\mu\text{Sv}/\text{y}$)	Lifetime cancer risk %		
		ICRP 103	BEIR VII	ICRP 60
Kozan	140	0.056	0.063	0.070
Aladağ	69	0.028	0.031	0.035
Pozantı	106	0.042	0.047	0.053
Çukurova	74.6	0.030	0.033	0.038
Sarıçam	67.7	0.027	0.030	0.034
Yüreğir	72.1	0.029	0.032	0.036
Seyhan	83.6	0.033	0.037	0.042
Karataş	73.6	0.029	0.033	0.037
Yumurtalık	69.4	0.028	0.031	0.035
Ceyhan	79.1	0.032	0.035	0.040
Tufanbeyli	124	0.049	0.056	0.062
Saimbeyli	135	0.054	0.060	0.068
Feke	95.7	0.038	0.043	0.048
Imamoğlu	93.2	0.037	0.042	0.047
Region	87.3	0.035	0.039	0.044

These calculated values may vary depending on altitude, weather conditions, outdoor exposure time and humidity. The mean cancer risk values calculated using equation 2 in Adana and its vicinity were found as 0.035, 0.044 and 0.039 for ICRP 103, ICRP 60 and BEIR VII, respectively.

Table 4. ADRA and AEDE values

	ADRA (nGy/h)	AEDE (μ Sv/y)
İstanbul [17].	65	79.7
Şanlıurfa [18].	60.9	74.7
Kastamonu [19].	54.81	67.21
Kırklareli [20].	118	144.7
Çanakkale [21].	66.4	81.4
Tekirdağ [22].	43.85	53.77
Trabzon [23].	59	72.4
Çankırı [24].	69.6	87.7
Yalova [25].	84	103
Balıkesir [26].	127	155.8
Kahramanmaraş [27].	64.8	79.5
Hatay [28].	61.9	75.91
Adana	71.2	87.3
Dünya [11].	60	70

The absorbed dose rates and annual effective gamma doses were also determined much higher than the world's averages in terms of health effects of background radiations. These calculated mean values are considerably smaller than the 1 mSv /y value determined by the ICRP as the limit value of the annual effective dose equivalent [16]. The mean ADRA value observed in the study area is lower than other cities and the world average due to the low radionuclide concentration seen in the area as can be seen in Table 4.

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