



Investigation of Outdoor Gamma Dose Rates in Yalova, Turkey

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Abstract

Radioactivity measurements were performed, at the Yalova (Turkey), part of the Marmara Sea, for natural radiation using a scintillation detector SP6 (via using portable counter ESP2, Eberline). Based on the measurement results, the lowest outdoor gamma concentration was calculated to 27.70 nGy/h while the highest one calculated to 66.00 nGy/h. And, the average of the measured gamma dose rates calculated to 48.13 nGy/h while the annual effective dose equivalent was calculated to 59.02 µSv/y. Mean value of excess lifetime cancer risk also obtained $2.07 \cdot 10^{-4}$ from using measurement area. The results checked against the world average determined by UNSCEAR. It was concluded that the calculated gamma dose values in Yalova are below the world average.

Keywords: Gamma dose rates, Scintillation detector, Yalova, Turkey

1. Introduction

The world is in interaction with radiation since its existence. Mankind lives with background radiation originate from radioactive atoms. For this reason, people are always exposed to radioactive substances from air, water, soil and cosmic rays. In addition, with the rapid development of the nuclear industry, the usage of radioactive materials has become widespread [1]. Natural background radiation levels may vary greatly from one location to another as well as may change over the same location over time.

Today, environmental radiation measurements are made in order to survey the radioactivity of a region. By measuring natural background radiation, it is possible to show how much radiation people are exposed to. The level of background radiation of a region varies depending on the geological and geographical structure of the region, the altitude from sea level (proportional to cosmic rays), and the mineralogical structure of the soil and rocks. Nuclear weapons tests, leaks of nuclear power plant accidents and radioactive materials used in the industry and medicine increase the level of natural background radiation of a zone [2].

Kam et.al (2016) conducted the study "Gamma dose rate values in the Kulakçayırı natural lake and the vicinity (Arnavutköy, Istanbul)". In the study, he performed gamma dose measurements at twenty locations in Kulakçayırı and its surroundings. As a result of this measurement, the average gamma dose rate was calculated as 37.5 nGy / h (19). Yümün et.al (2019) conducted the study "Gamma dose values of stratigraphic units surfaced in Behramkale (Çanakkale) - Zeytinli (Edremit-Balıkesir) section of Kaz Mountains". In the study, gamma dose rate was measured in twenty-five locations around Edremit and Behramkale. The calculated average gamma dose rate was 111.2 nGy / y, and the effective gamma dose value was determined as 0.14 mSV (20). Karataşlı M. (2018), "Environmental Gamma Radiation Measurement in Hatay and Its Surroundings" study, measurements were taken at 183 different points. As a result of the measurements, the mean value of gamma dose measurements was calculated as 61.9 nGy / h, while the average value of the annual effective dose equivalent was calculated as 75.91 MSv / y (21).

In this study, the natural background radiation level of Yalova region has been revealed. Many points of the study area were evaluated by measuring gamma doses with a scintillation detector.

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2. Material Method

2.1 Measuring Area

Yalova province is located at the entrance of Izmit bay in the Marmara Sea. As seen in Figure 1, Yalova territory is bordered by the province of Marmara Sea, the province of Kocaeli to the east and the province of Bursa to the southwest [3]. The working area is divided into 6 districts: Altinova, Armutlu, Çiftlikköy, Çınarcık, Termal and Yalova [4]. Based on TÜİK datas, the city's population has been rising continuously for years. Yalova, a tourism city, has been invested in industry, transportation, agriculture and many other areas and these investments are continuing consistently [5,6].

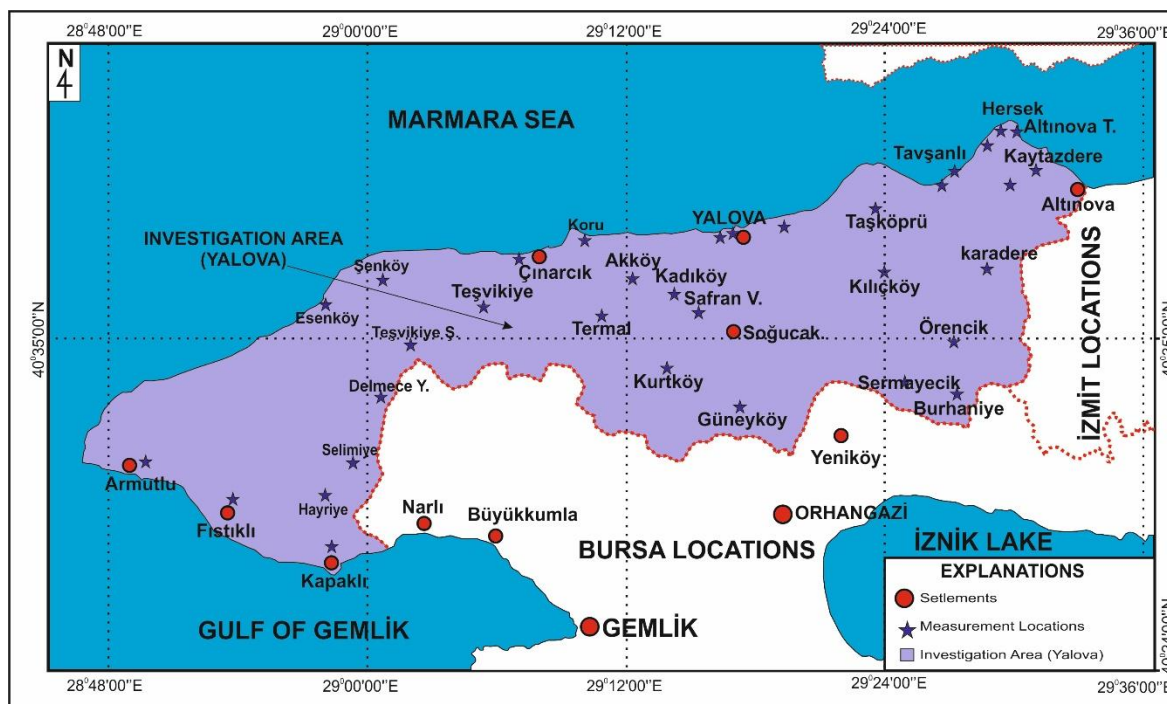


Figure 1: Map of investigation area ()

2.2 Process

The device used in the study is a scintillation detector. Scintillation detectors are highly efficient for gamma ray detection. A portable gamma-ray spectrometer is a crucial tool for radionuclide identification in environmental surveying and many other scientific and industrial applications. In environmental measurements, detectors collect radioactive data from the air and analyze simultaneously. The ability to take quick measurements, compact size and low cost are the most precious features of portable devices [7]. In this study, outdoor gamma dose rates were measured by a high resolution Eberline smart portable device (ESP-2). All measurements were taken 1 m above ground level. And, the measurement duration was roughly one minute for each station. After gamma dose rates were measured, the equivalent dose rate expected to be taken annually by a person was calculated. In this way, the average annual effective dose equivalent (AEDE) was calculated by using the following equation:

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

where ADRA is absorbed dose rate in air ($nGy \text{ h}^{-1}$), DCF is dose conversion factor ($0.7 \text{ Sv } \text{y}^{-1}$), occupancy factor is outdoor of (0.2), and T is the time ($8760 \text{ h } \text{y}^{-1}$) [8,16,17]. Excess Lifetime cancer Risk was calculated by using following equation [9]:

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

where AEDE is the annual effective dose equivalent (μSv), DL is duration of life (accepted 70 years) and RF is risk factor (Sv^{-1}) [9].

3. Results

3.1. Gamma Dose Measurements

Within the scope of the study, 36 gamma dose measurements from different stations were taken from the districts of Yalova province. The measured absorbed dose rates and calculated AEDE and ELCR values are given in Table I.

Table I: Gamma dose rates of Yalova districts

Stations	Coordinates		Absorbed Dose Rate (nGy/h)	Annual Effective Dose Equivalent ($\mu\text{Sv/y}$)	Excess Lifetime Cancer Risk ($*10^{-4}$)
Kaytazdere	40°41'49.7"N	29°30'58.6"E	52.20	64.02	2.24
Hersek	40°43'26.4"N	29°30'17.2"E	64.00	78.49	2.75
Karadere	40°38'12.3"N	29°28'23.5"E	59.40	72.85	2.55
Örencik	40°35'34.2"N	29°26'38.8"E	37.80	46.36	1.62
Sermayecik	40°33'42.8"N	29°26'37.3"E	40.80	50.04	1.75
Burhaniye	40°34'07.3"N	29°24'11.2"E	43.40	53.23	1.86
Kılıçköy	40°38'03.6"N	29°23'36.7"E	66.00	80.94	2.83
Taşköprü	40°40'28.1"N	29°23'21.1"E	56.20	68.92	2.41
Çiftlikköy	40°39'45.2"N	29°18'47.7"E	51.40	63.04	2.21
Yalova Merkez	40°39'27.4"N	29°16'06.5"E	40.80	50.04	1.75
Yalova Merkez	40°39'31.1"N	29°16'31.1"E	27.70	33.97	1.19
Safran Köyü	40°36'33.4"N	29°14'54.7"E	40.80	50.04	1.75
Güneyköy	40°33'13.9"N	29°16'41.1"E	47.00	57.64	2.02
Kurtköy	40°34'35.1"N	29°13'25.1"E	44.40	54.45	1.91
Kadıköy	40°37'09.6"N	29°13'32.1"E	60.40	74.07	2.59
Termal	40°36'23.1"N	29°10'22.9"E	50.80	62.30	2.18
Akköy	40°37'43.0"N	29°11'44.9"E	46.52	57.05	2.00
Koru	40°39'18.9"N	29°09'26.6"E	38.20	46.85	1.64
Çınarcık	40°38'36.7"N	29°06'24.6"E	44.60	54.70	1.91
Şenköy	40°37'39.1"N	29°00'06.7"E	64.00	78.49	2.75
Teşvikiye	40°36'42.1"N	29°04'54.7"E	43.60	53.47	1.87
Teşvikiye Şelale	40°35'17.6"N	29°01'34.9"E	57.00	69.90	2.45
Esenköy	40°36'49.1"N	28°57'10.9"E	47.00	57.64	2.02
Armutlu	40°31'09.1"N	28°49'41.6"E	35.40	43.41	1.52
Fıstıklı	40°29'27.6"N	28°53'34.0"E	56.20	68.92	2.41
Kapaklı	40°27'38.0"N	28°58'12.2"E	46.80	57.40	2.01
Hayriye	40°30'05.3"N	28°58'04.6"E	41.10	50.40	1.76
Selimiye	40°31'03.1"N	28°58'57.6"E	47.01	57.61	2.02
Delmece Yaylası	40°33'25.8"N	29°00'22.9"E	52.40	64.30	2.25
Altınova Merkez	40°41'19.5"N	29°29'49.7"E	59.01	72.40	2.53
Tavşanlı	40°41'42.2"N	29°27'14.1"E	40.80	50.03	1.75
Tavşanlı	40°41'32.2"N	29°26'46.1"E	43.60	53.50	1.87
Tavşanlı	40°41'14.3"N	29°26'36.3"E	54.40	66.71	2.34
Altınova Tersaneler	40°43'15.4"N	29°29'16.0"E	55.80	68.40	2.40
Altınova Tersaneler	40°42'53.0"N	29°28'42.2"E	38.20	46.81	1.64
Altınova Tersaneler	40°42'05.0"N	29°28'04.1"E	37.80	46.40	1.62
AVERAGE			48.13	59.02	2.07

As a result of the measurements, outdoor gamma dose rates in air are ranging from 27.70 nGy/h to 66.00 nGy/h. The mean value of gamma dose rate was obtained to 48.13 nGy/h. Next, the average annual effective dose equivalent of 36 stations was calculated to 59.02 μSv . Using this data, the lifetime cancer risk was calculated to 2.07 ($*10^{-4}$). In the light of the data in Table 1, AEDE values of six districts of Yalova are shown in Figure 2.

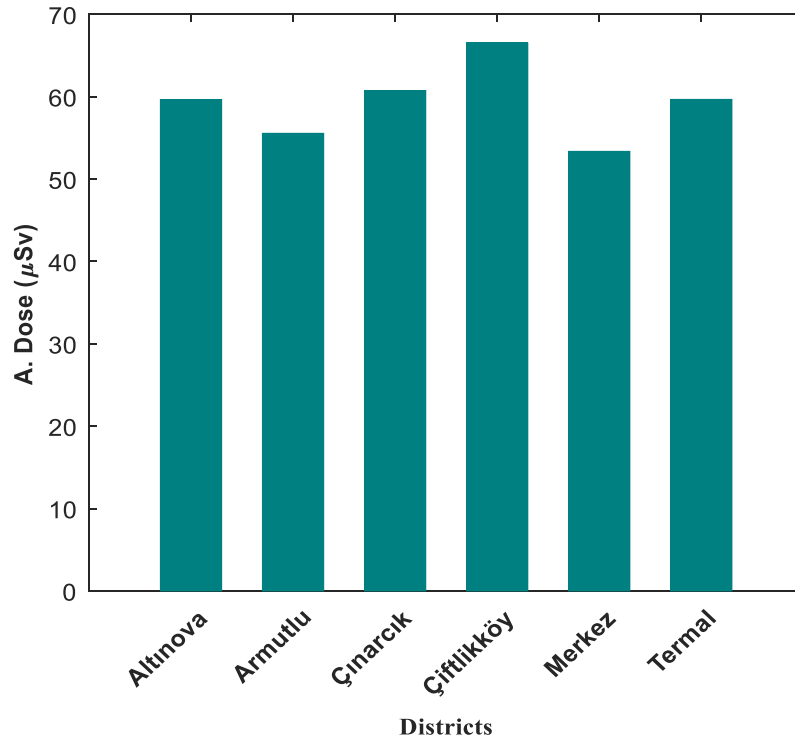


Figure 2. Bar chart of annual doses

The gamma dose distribution map of the districts of Yalova province has been prepared (Figure 3)

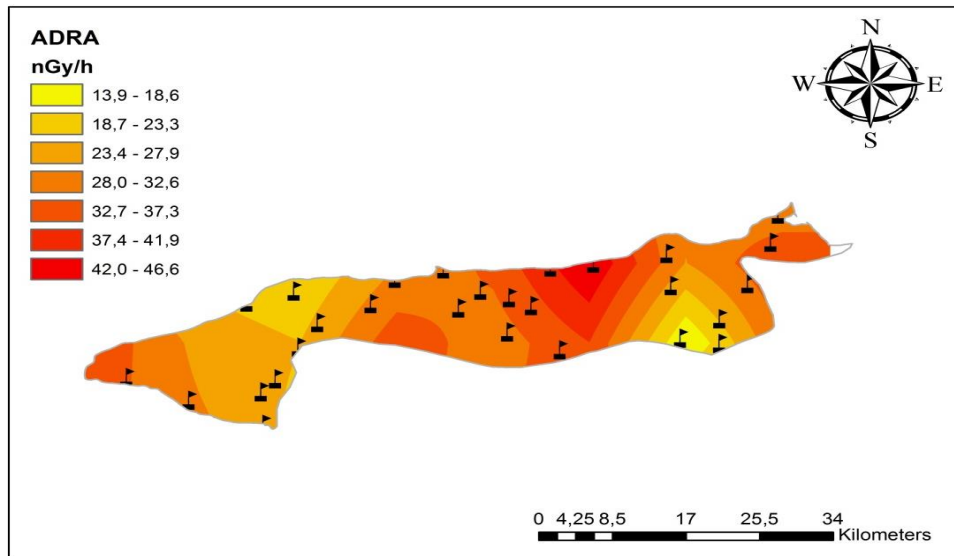


Figure 3: Distribution map of ADRA values by region

As seen in Figure 2 and Figure 3, it is understood that the region with the highest radioactive contamination is Çiftlikköy. However, there is not a crucial difference between other districts about average doses. This study was compared with studies conducted on different regions in Turkey (Table II). the number of references should be increased.

Table II: Gamma dose values of different stations in Turkey

Stations	Average Dose Rates (nGy/h)	Average AEDE ($\mu\text{Sv/y}$)	References
Istanbul (2000)	65	80	[10]
Kirklareli (2009)	118	144	[8]
Kastamonu (2007)	48	58.9	[11]
Tekirdag (2005)	43	52.7	[12]
Hatay (2015)	52.13	63.93	[13]
IDA villages (2019)	162.04	198.66	[14]
World average	59	73.6	[15]
Present Study	48.13	59.02	-

3.2. Relationship Between Geology and Gamma Dose

Geological formations of Yalova have been obtained from Turkey's 1/500000 scale geological maps . This map was prepared by the General Directorate of Mineral Research and Exploration (Figure 4).

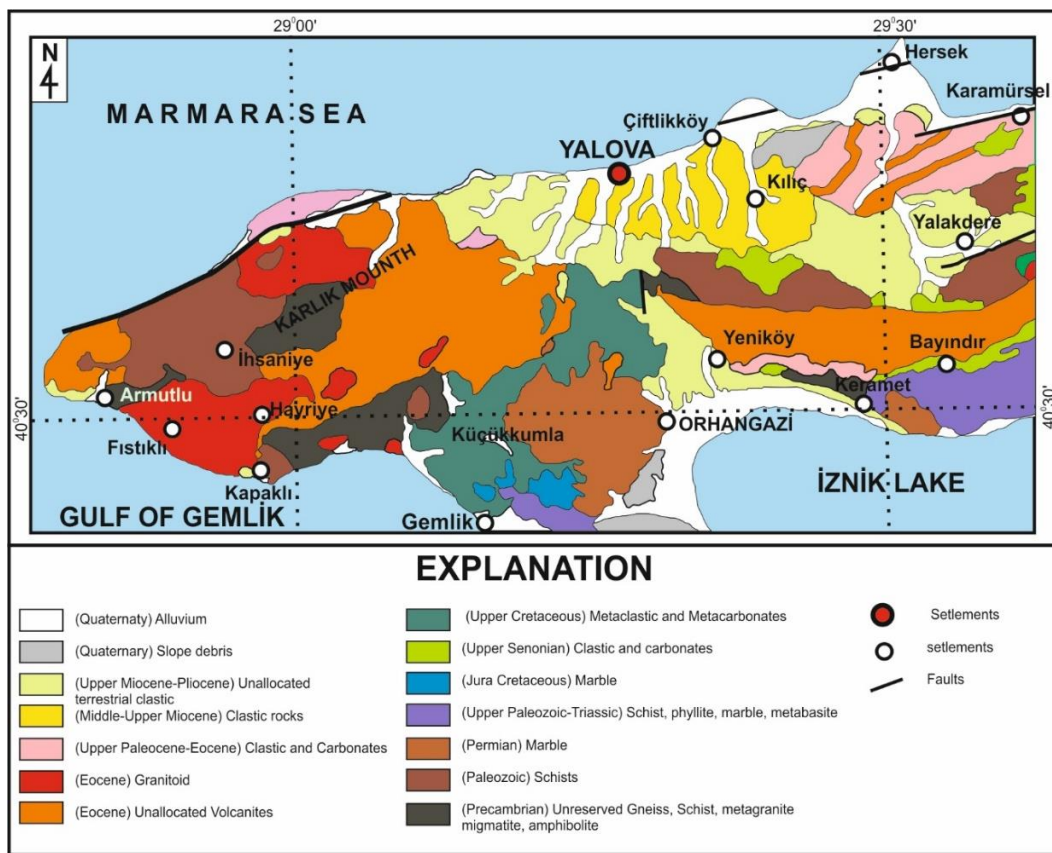


Figure 4: Geology map of Yalova and Surroundings (18)

In the study area, there are Precambrian, Paleozoic, Mesozoic and Cenozoic units from bottom to top. Precambrian units are unallocated gneiss, schist, metagranite, migmatite and amphibolites. Paleozoic units are Schists, marbles and Upper Permian-Triassic schist, phyllite, marble and metabasites. Mesozoic Units are Jurassic marbles, Upper Senonian Clastic rocks and carbonates, and Upper Cretaceous metaclastic and metacarbonates. Cenozoic units consists of Eocene and Paleocene rocks. Eocene consists of undivided volcanites and granitoid. Upper Paleocene-Eocene Unites are clastic rocks and carbonates, and Upper Miocene-Pliocene unites also consist of undivided continental sediments. All units are unconformably covered from quaternary alluvium and slope debris.

4. Conclusion

In this study, gamma dose rates of the Yalova were determined. A total of 36 measurements were taken with a scintillation detector. As a result of the measurements, average gamma dose rate and average AEDE value was calculated to 48.13 nGy/h and 59.02 $\mu\text{Sv/y}$, respectively. And, average excess lifetime cancer risk was calculated to $2.07 \cdot 10^{-4}$. These values are low compared to many other

regions. Also, it was observed that the measured gamma dose values were below the world average. In conclusion, there is no health risk related to outdoor gamma radiation of living beings in the region.

In Section 3.2, geological formations of yalova and its surroundings are evaluated. There are rocks of all periods from the oldest to the youngest in the field. Both magmatic, metamorphic and sedimentary rocks can be seen in the region. It is seen that gamma dose values in the region are independent from geological formations. Contrary to the knowledge that gamma dose values may be high in granitoids, gamma dose values do not differ much between lithologies.

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