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Primordial and Artificial Radioactivity Levels in Soil Samples of Hatay Region, Turkey

Muttalip Ergun Turgay
Electronic and Automation Division, Mustafa Kemal University, Hatay 31001, Turkey

Abstract: In this study, the radioactivity analysis was performed for soil samples of Hatay province which is in the Southeast region of Turkey. By gamma-ray spectrometry method, the average Radium (Uranium), Thallium (Thorium), Potassium and Cesium activity concentrations of totally 55 soil samples were measured as 23.35 ± 1.40 $Bqkg^{-1}$, 14.55 ± 0.97 $Bqkg^{-1}$, 242.36 ± 20.12 $Bqkg^{-1}$ and 8.20 ± 0.68 $Bqkg^{-1}$ respectively. There are a few values for the Uranium little bit up to the limit value of 33 $Bqkg^{-1}$. All values for the Thorium were lower than the limit value of 45 $Bqkg^{-1}$. Only a few values for the Potassium were little bit up to the limit value of 420 $Bqkg^{-1}$. Nearby the average for Hatay province is still under the limit value which were recommended by United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). By using these activities, ADRA and AEDE values were calculated to get the outdoor Terrestrial Gamma Dose.

Key words: Radionuclides, activity, ADRA, AEDE, soil, Hatay.

1. Introduction

The largest contribution to total radiation dose received by humans, comes from Natural Radiation. Therefore environmental radioactivity measurements are necessary for determining the background radiation level. The natural radiation consists of cosmic rays and terrestrial radiation. Terrestrial component is due to radioactive nuclides that are present in the water, soil, air and building materials. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) estimates the global average human exposure from natural radiation sources as 2.4 mSv per year and radionuclides that are present of soil samples are considered to be responsible for a portion of this amount [1]. Over the past two decades, some results of radioactivity levels have been published in some papers for soil samples in Turkey ([3-10]). Nearby, there is no detailed study for Hatay region. Therefore, the purpose of this study is to determine the active concentrations of U, Th, K and Cs in soil samples collected from different locations throughout Hatay, and then assess the risk to human life by calculation of the terrestrial gamma dose.

1.1 Sampling Area

Hatay, the southeast province of Turkey, is near to board of Syria. It is located between 35°52′-37°04′ N as latitudes and 35°40′-36°35′E as longitudes. Highest pick is Migirtepe (2,240 m). The territory of Hatay is covered by 46% mountain, 33% plain, 20% plateau and hillside. The Orontes River rises in the Bekaa Valley in Lebanon and runs through Syria and Hatay. There are some mineral deposits: Iskenderun is home to Turkey's largest iron and steel plant, and the district of Yayladagi produces a colorful marble called Rose of Hatay. Average temperature is 24.08 °C and average rainfall is 65 mm. The region spans an area of 5,403 km^2 and with a population of about 1.5 million [10]. The map of Hatay is shown in Fig. 1.

1.2 Sample Collection and Settlements

Sampling points were selected as uncultivated locations, close to dense population areas. Usually flat

Corresponding author: Muttalip Ergun Turgay, Dr., assistant professor, research field: biomedical device technology program.

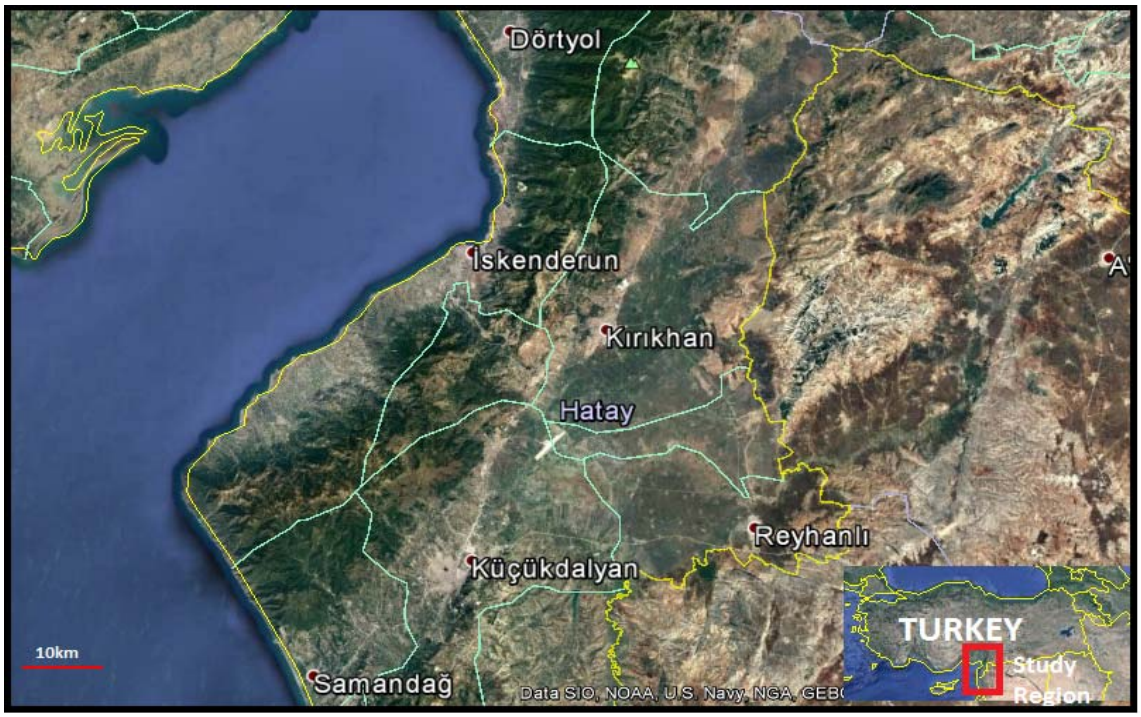

Fig. 1 Regional map of Hatay Province, Turkey [2].

and open areas was obtained and first, top soil of 5 cm from surface, was picked up. Samples were cleaned out the plants, stones etc., then sealed and numbered. After drying process (2 days) in the oven up to 100 ^{o}C, all ones were elected through 2 mm sieve to get the homogenius sand form. Samples were filled to Marinelli containers regarding the nominal measurement geometry. Samples were kept during one month in order to assess the secular equilibrium between radium and decay products. System calibration was made by using of standard mixtures, gamma emitting radioisotopes in the same containers, in order to keep the geometry and measurement coincidence. Standards and samples were counted for the same time period, 50,000 s, using the gamma transmission spectrum. In spectrum, it was used the ^{226}Ra (186.0 keV) peak in order to determine activity of Uranium. It was also used the ^{208}Tl (583.1 keV) peak in order to determine activity of Thorium.

1.3 Measurement System

Germanium detectors consist of active components as diodes. Ionizing radiation, high energetic x-rays and also gamma can be measured by having a p-i-n structure in which the intrinsic (I) region. Intrinsic layer is undoped and pin diode is proper for its photodetector application. When a photon interacts with the material within the depleted volume of a detector, charge carriers; holes and electrons are produced and are also swept by the electric field to the P and N electrodes (Canberra, *product brochure*). This charge has direct corelation to the energy which deposited in the detector by the incident photon, is converted into a voltage pulse by an integral charge sensitive preamplifier. There are a few specifications were mentioned for the detector GX5020 [12] like that: Relative Efficiency is 50%; Resolution is 2.0 keV at 1.33 MeV of FWHM from Co-60. Gamma Spectroscopy Software is Genie-2000, Multichannel Analyzer is DSA 100.

2. Results

Average activity concentrations for Uranium, Thorium, Potasium and Cesium are calculated to 23.35, 14.55, 242.36 and 8.20 Bqkg^{-1}, respectively for all around Hatay. The average activity of eU-238 was measured for Arsuz to 8.5 Bqkg^{-1} as minimum; for

Samandag county 41.2 Bqkg^{-1} as maximum. The maximum peak is recorded of Samandag to 108.4 Bqkg^{-1}. The average activity of eTh was measured for Erzin to 2.75 Bqkg^{-1} as min.; for Reyhanli county to 36.2 Bqkg^{-1} as max. The max. peak is recorded of Reyhanlı to 38.1 Bqkg^{-1}. The average activity of ^{40}K was measured for Erzin to 63.6 Bqkg^{-1} as min.; for Reyhanli county to 420.4 Bqkg^{-1} as max. The max. peak was recorded of Kırıkhan to 659.2 Bqkg^{-1}. The average activity of ^{137}Cs was measured for Belen to 1.8 Bqkg^{-1} as min.; for Hassa county to 19.1 Bqkg^{-1} as max. The max. peak is recorded of Hassa to 39.8 Bqkg^{-1}. Average values regarding the counties of Hatay were given in Table 1. Comparison will be possible with the other cities for Hatay province in Table 2. Besides, activity map of eUranium was given only as an example in Fig. 2, too. Besides, terrestrial gamma dose rate map was also shown in Fig. 3. Now, it is possible to calculate ADRA and AEDE values [1] by using these concentrations in Eqs. (1) and (2):

$$ADRA = 0.461 * A_U + 0.623 * A_{Th} + 0.0417 * A_K + 0.1243 * A_{Cs} \quad (1)$$

$$AEDE = ADRA * DCF * OF * T \quad (2)$$

Where ADRA is absorbed dose rate in air (nGyh^{-1}), A is activity, DCF is dose conversion factor (0.7 Sv Gy^{-1}), OF is outdoor occupancy factor (0.2), T is exposure time (8,760 h y^{-1}). AEDE is annual effective dose equivalent (μSv). By using data from Table 1, now it is possible to assess ADRA and AEDE values by means of Eqs. (1) and (2). ADRA and AEDE values are given in Table 3.

Table 1 Activity concentrations of eUranium, eThorium, Potasium and Cesium.

Nm.	County	^{226}Ra (eU-238)	^{208}Tl (eTh-232)	^{40}K	^{137}Cs
S	Name	Bqkg^{-1}	Bqkg^{-1}	Bqkg^{-1}	Bqkg^{-1}
(5)	Altınözü	22.6 ± 1.4	7.52 ± 0.6	172.8 ± 14.9	2.0 ± 0.3
(10)	Antakya	22.4 ± 1.4	13.6 ± 0.9	202.6 ± 17.8	8.4 ± 0.7
(2)	Arsuz	8.5 ± 0.6	8.8 ± 0.5	209.5 ± 16.3	3.6 ± 0.3
(2)	Belen	11.7 ± 0.8	11.6 ± 0.8	179.5 ± 14.6	1.8 ± 0.3
(2)	Dörtyol	20.4 ± 1.2	20.2 ± 1.3	322.8 ± 25.6	2.1 ± 0.2
(2)	Erzin	13.3 ± 0.8	2.75 ± 0.3	63.6 ± 6.2	16.0 ± 1.2
(9)	Hassa	23.7 ± 1.4	19. 5 ± 1.2	338.4 ± 26.8	19.1 ± 1.3
(5)	Iskenderun	16.9 ± 1.1	9.8 ± 0.8	192.2 ± 17.8	3.0 ± 0.4
(4)	Kırıkhan	13.8 ± 0.9	14.9 ± 1.0	274.9 ± 22.0	2.4 ± 0.3
(2)	Kumlu	16.9 ± 1.3	15.7 ± 1.3	250.0 ± 23.4	6.3 ± 0.8
(3)	Reyhanlı	38.9 ± 2.2	36.2 ± 3.3	420.4 ± 33.7	18.8 ± 1.5
(6)	Samandag	41.2 ± 2.3	11.6 ± 0.9	173.1 ± 16.0	5.6 ± 0.5
(3)	Yayladag	26.6 ± 1.6	15.1 ± 0.9	327.8 ± 26.2	3.4 ± 0.4
(55)	Average	23.35 ± 1.40	14.55 ± 0.97	242.36 ± 20.12	8.20 ± 0.68

Table 2 Comparison of the activity concentrations for a few Turkish provinces.

Country	^{226}Ra (eU-238)	^{208}Tl (eTh-232)	^{40}K	^{137}Cs
Name [ref nm.]	Bqkg^{-1}	Bqkg^{-1}	Bqkg^{-1}	Bqkg^{-1}
Hatay [10]	23.35	14.55	242.36	8.20
Adana [4]	17.6	21.2	297.50	--
Çanakkale [5]	94.55	110.40	1,273.00	19.39
Gaziantep [8]	25.20	23.70	289.20	8.02
İstanbul [7]	21.00	37.00	342.00	--
Kırklareli [9]	37.00	40.00	667.00	8.00
Şanlıurfa [3]	20.80	24.95	298.60	9.08
Tekirdağ [6]	29.00	39.00	580.00	5.20
World [1]	33.00	45.00	420.00	--

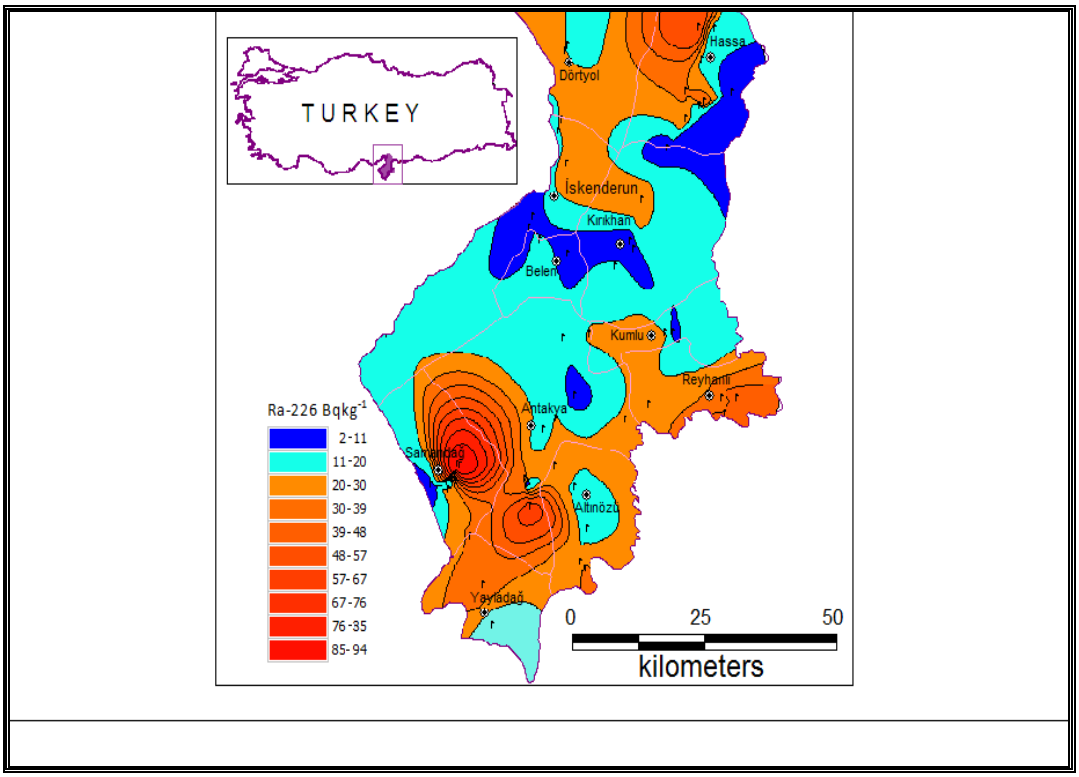

Fig. 2 Activity (eU-238) map [11].

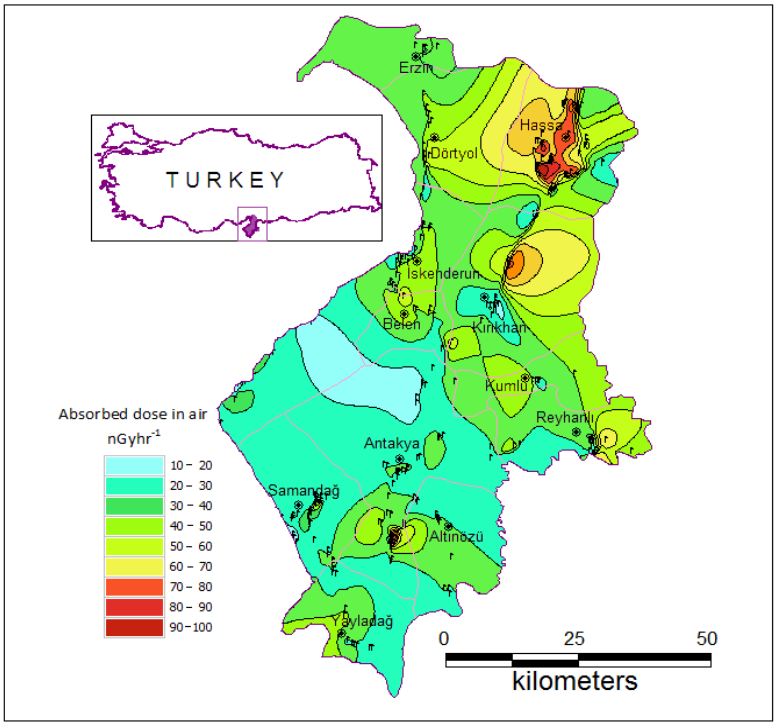

Fig. 3 Terrestrial gamma dose rate in air [11].

Table 3 ADRA and AEDE values regarding Terrestrial Gamma Ray effects of Hatay.

County	ADRA ($nGyhr^{-1}$)	AEDE (μSv)	County	ADRA ($nGyhr^{-1}$)	AEDE (μSv)
Altınözü	22.56	27.67	Iskenderun	22.28	27.33
Antakya	28.29	34.70	Kırıkhan	27.41	33.61
Arsuz	18.58	22.79	Kumlu	28.78	35.30
Belen	20.33	24.93	Reyhanlı	60.35	74.02
Dörtyol	35.71	43.80	Samandag	34.13	41.86
Erzin	12.49	15.31	Yayladag	35.76	43.86
Hassa	39.56	48.52	HATAY	30.95	37.96

3. Conclusion

It is seen that in the Comparison table, average values in the world were seen for Uranium, Thorium and Potasium as 33, 45 and 420 $Bqkg^{-1}$ respectively. For just a few points, activities are up the limit values, which could be reasoned due to changes for concentrations of primordial nuclides and also altitudes. Nearby, Hatay average results are under these limits. ADRA is 30.95 $nGyh^{-1}$ and Annual Terrestrial Gamma dose originates of these nuclides effect, is calculated to 37.96 μSv. Old studies were shown that the average of limit value, for terrestrial gamma dose rate (ADRA) is 60 $nGyh^{-1}$ [1]. The world average annual terrestrial gamma dose (AEDE) was declared to 70 μSv in literature [1]. These results, in our study, indicate that: there is no risk which originates to the soil samples around Hatay region. It could be said that there is no risk to human healthy, comes from the Uranium, Thorium, Potasium and Cesium stated inside of soil around Hatay province in Turkey. Besides, the data obtained in this study are baseline for future studies which can be used to evaluate possible changes. For example, after a possible nuclear attack, it would be performed the comparison with early values, too.

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