

# Determining Natural Radiation Level in River Water of Upper Euphrates (Karasu) Basin's Part Located in Erzincan Province Borders

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**Abstract:** Within the scope of this study, it is aimed to contribute to the efforts for forming a database including the natural radiation levels throughout the country and developing a foundation for radiation safety. Karasu portion of the Euphrates valley within the provincial border of Erzincan was chosen for the investigation and natural radiation levels were detected by analyzing the samples taken in terms of radioactivity, natural environment's radiation streams. Throughout the region of Karasu, 29 different samples from the water and 17 from the soil were taken and their total alpha, beta activities were detected. To take samples from the water and then they were measured by low background counter (Berthold brand LB770 10-channel counter). Total alpha and beta analyses were made according to the standard methods. Average values of alpha and beta concentrations of samples were measured as 0.0421 Bq/L and 1.806 Bq/L, respectively. For the soil samples HPGe gamma spectrometer system was used and radioisotope activity concentrations were found within the intervals of 2.7-27.8 Bq/kg for <sup>226</sup>Ra; 3.2-39.4 Bq/kg for <sup>232</sup>Th; 98-714 Bq/kg for <sup>40</sup>K; < 0.4-57.8 Bq/kg for <sup>137</sup>Cs, respectively. Different radioisotopes were detected in some of the samples taken from streaming beds joining river water.

**Key words:** Natural radiation, Erzincan, Karasu River Valley, radioactivity, gross alpha and gross beta.

## 1. Introduction

The most significant factor, which affects radiation levels, is different amount of radioactivity emitting concentrations in the Earth crust. This difference varies depending on geological and chemical structure of the surface. For instance, radioactivity concentration in volcanic rocks is higher than radioactivity concentration in sedimentary rocks. Terrestrial-radiation depends on the radioactive elements (uranium, thorium, potassium etc.) which are placed in water, soil and air changing according to geological and geographical features of a region. Radionuclides are carcinogen in human and a known

kidney toxin [1]. Cosmic radiation originates from high-energy cosmic rays from the galactic and solar system. In addition to the natural sources, artificial sources of radiation produced by humans such as nuclear events, reactor accidents can also affect the background level in a region. Very long-lived radioactive elements in Earth's structure, cosmic rays, nuclear tests and using the developing technological products increase radiation level in our environment. The annual dose of radiation received by a person is approximately equal to 2.8 mSv in a year. Approximately 82% of this dose originates from natural resources [2].

Considering former studies on natural radiation, analyses were carried on drinking and using water and soil in some residential areas in Turkey and World using various methods [3-10].

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In another similar study carried out in Gediz River, natural radioactivity (radium) amount carried to Aegean Sea [11]. In water samples from the river the result for concentration of  $^{226}\text{Ra}$  was found as 6.70 pCi/l. Moreover, in the study, the radium amount carried to the sea was calculated in terms of the river's monthly flow.

The aim of this work is to measure natural radiation levels, from water and soil samples in Karasu Portion of the Euphrates valley within the provincial border of Erzincan. For this purpose, the present study has been carried out to evaluate the level of natural radioactivity in 29 different samples from the water and 17 different samples from the soil in Karasu Portion.

The absorbed gamma dose rate in air and the annual effective dose equivalent from outdoor terrestrial gamma radiation have been calculated and compared with internationally recommended values [12] in order to assess the radiological risk to human health. The chemical toxicity of radionuclides especially uranium as a heavy metal has raised public health concerns, especially in areas where contamination of local soils from radioactive material has taken [13]. The long-continued application of phosphate fertilizers and their by-products can redistribute and elevate  $^{40}\text{K}$  and  $^{226}\text{Ra}$  concentrations in soils. As a result, their availability for plants and subsequent transfer to the human food chain, mainly in acidic soils, cannot be avoided. In this way, it is important to know the proportion of such a transfer for human and animal health points of view. The manufacture and use of phosphates can cause to the contamination of agricultural land during cultivation, also contamination of the air and water supplies. Therefore, phosphates have a potential radiological health concern in addition to their chemical toxicity. Typical concentrations of Uranium in phosphate rock range between 30 and 260 ppm [14].

## **2. Material and Method**

In this study, the Karasu distributary, which is a

part of Euphrates and located in Erzincan province, borders and surroundings were chosen as research area. Water and soil samples were collected from the areas close to the river, specifically from surroundings of brook beds reaching to the river.

### *2.1 Collecting Water Samples and Determining Natural Radiation Levels*

In this study, for alpha and beta counting system of water samples, computer controlled Berthold brand LB770 model 10 channel gas-flow alpha-beta counting device, was used. Operating voltage of the detector is 1650 V and its diameter is 5 cm. Fluid gas used in these counters contains 90% argon and 10% methane. And 29 research areas, among the joints of brook beds reaching to the Karasu River, were determined for collecting water samples. Local name of place of water samples, their coordinates detected by GPS, instant air and water temperatures of sample collecting time and the pH of the water were measured. Measured or gathered data for water samples are indicated in Table 1. The water samples filled in three-litre-plastic bottles had been previously cleaned. All the samples were enumerated and labelled. The samples were acidified and protected in their original containers in the laboratory. The counting system which we apply for total alpha and beta counting enables measuring residual fraction mostly up to 600 mg. Thus, a sample of 500 mL enables enough amount of residual fraction for our counting system. Therefore, 500 mL of each water samples to be examined was poured to beakers in order to get enough residual fractions which can be measured by the counting system.

As a next step, 1% of nitric acid ( $\text{HNO}_3$ ) was added to the samples. The reason of this procedure was to provide the sediments and particles cling to the inner surface and walls of the beakers to fall down during the evaporation. The water samples in beakers were slowly evaporated at about 70 °C, until the water amount decreased from 500 mL to 100 mL. Then, 100 mL

**Table 1** Local names of the places where the water samples collected, analysis codes, coordinates, water pH, air and water temperatures at the time the samples are taken.

Location name of sample taken	Code	Degree	pH	Air temperature	Water Temp.
K. Arika Brook	D1	39° 14' 52"K 38° 30' 11"D	8.3	32.2 °C	13.8 °C
Kemaliye Agca Aga Brook	D2	39° 14' 44"K 38° 30' 45"D	8.0	36.0 °C	15.9 °C
Kemaliye Central	D3	39° 15' 52"K 38°29' 43"D	8.2	35.3 °C	11.1 °C
Kemaliye Venk Brook	D4	39° 16' 48"K 38°30' 07"D	8.5	35.5 °C	18.7 °C
Ilic Central	D5	39° 27' 24"K 38° 31' 33"D	8.3	36.7 °C	24.1 °C
Ilic Kuru Creek	D6	39° 31' 16"K 38° 34' 03"D	8.1	34.2 °C	24.2 °C
Atma 1 Bridge	D7	39° 35' 56"K 38°47' 33"D	8.4	33.1 °C	20.6 °C
Kemah Bogazici Village	D8	39° 35' 29"K 38° 54' 10"D	8.1	33.8 °C	19.5 °C
Kemah Komur Creek	D9	39° 36' 58"K 39° 02' 14"D	8.2	30.2 °C	18.1 °C
Kemah Soran Creek	D10	39° 37' 18"K 39° 13' 11"D	8.5	24.0 °C	11.5 °C
Kemah Karni Brook	D11	39° 37' 35"K 39° 13' 14"D	8.5	22.7 °C	17.0 °C
Tercan Tuz Creek	D12	39° 48' 11"K 40° 31' 15"D	8.3	30.2 °C	18.1 °C
Tercan Kucuk Begendik Brook	D13	39° 46' 52"K 40° 21' 27"D	8.7	33.3 °C	24.4 °C
Mercan Brook	D14	39° 43' 51"K 40°15' 13"D	8.5	33.5 °C	19.8 °C
Yedisu	D15	39° 34' 34"K 40°09' 13"D	8.7	33.8 °C	20.2 °C
Soguksu Bridge	D16	39° 33' 59"K 39° 59' 53"D	8.2	35.5 °C	17.2 °C
Cibice Bridge	D17	39° 34' 52"K 39° 55' 50"D	8.4	34.6 °C	19.6 °C
Tunceli Turnout	D18	39° 35' 28"K 39° 52' 16"D	8.3	35.6 °C	17.7 °C
Selepur Bridge	D19	39° 36' 14"K 39° 51' 06"D	8.5	34.8 °C	19.8 °C
Avclar Surroundings	D20	39° 37' 06"K 39° 49' 00"D	8.4	34.6 °C	19.8 °C
Sulperen Bridge	D21	39° 37' 40"K 39° 47' 34"D	8.2	34.7 °C	19.3 °C
Derebag Yalinca	D22	39° 37' 52"K 39° 40' 19"D	8.1	34.8 °C	20.2 °C
Turkmenoglu Village I	D23	39° 41' 47"K 39° 29' 24"D	8.3	31.0 °C	19.6 °C
Kemaliye Surroundings	N1	39° 15' 04"K 38° 30' 24"D	8.0	36.0 °C	17.0 °C
Kemah Central	N2	39° 36' 58"K 39° 02' 14"D	8.4	30.2 °C	17.3 °C
Kemah Karni Brook	N3	39° 37' 35"K 39°13' 14"D	8.7	22.7 °C	17.3 °C
Kargin Location	N4	39° 36' 56"K 40°11' 21"D	8.4	35.0 °C	17.7 °C
Mertekli Location	N5	39° 38' 52"K 39°44' 02"D	8.2	38.0 °C	18.2 °C
Turkmenoglu Village II	N6	39° 42' 00"K 39°30' 11"D	8.3	32.7 °C	18.1 °C

of water was poured into the tared planchettes. During the pouring, the loss of residual fractions and particles cling to the inner surface and walls of the beakers were prevented by using pure water and 1% of HNO<sub>3</sub>.

The water in the planchettes, was evaporated in 40 °C until dryness level. When the water evaporated totally, the planchettes were weighed with precision scale warmed to room temperature in a desiccator and residual fractions were determined. Then, steel containers were dried thoroughly with oven stove at 105 °C. Then, measurements were done for the alpha and beta determination of all samples.

As total alpha and beta activities of the water samples are in low-level radiation range, measurements

are done in long periods. After 29 water samples from the study area were evaporated in suitable conditions and taken to the planchettes, they were counted with gas flow proportional counting device described in Section 2.1. In our experimental research, all of the water samples were counted by putting in a detector throughout 500 minutes to determine their total alpha and beta activities. Total alpha and beta measurements of river water samples were carried out according to the "EPA 900.0" standard method. This method consists of measuring the amount of the total alpha and beta emitter radionuclides in water samples. This method is a screening technique which is also used to determine if any further analysis for drinking water

and resources is necessary according to the safe drinking limits or not [15].

### 2.2 Collecting Soil Samples and Determining Their Concentration Levels

Soil samples were intentionally collected from the measurement points previously determined coordinates in maps and surroundings in which the brooks join the rivers. The samples from the measurement points where brooks join rivers and things which brooks carried with stream give specific information about soil structures of surroundings, specifically about sloping lands. This situation will give idea about which brooks have carried more natural radiation to the Karasu River.

The locations of the samples were determined among the places in which no agricultural or farming activities were carried out. Daily accumulated trash, dust and wastes on those points were cleaned 10 cm in depth. From those cleaned points, using 25 cm

diameter soil take device which can penetrate 30 cm in depth about 2 kg soil was collected and put in clean bags. During the soil sample collection, useless things in the soil such as: plants and root residues, stone, grass, wood pieces, tree barks, biological remains were not included in the samples. The soil was grinded properly and dried at room temperature about 10 days. After the samples dried completely, jigged with 2 mm mesh sieves, put in tared marinelli counting containers, weighed out and each sample was recorded labelling according to their location's local name, their determined codes for analysis, their coordinates determined with GPS device, temperatures measured with thermometer and sample collection date. Those determined data and the date of sample collection were saved to the labels. The measured or gathered information for soil samples is indicated in Table 2.

In order to determine the radioactivity levels of the samples, they were dried in 100 °C for 12 hours without

**Table 2 Local names of the places where the soil samples collected, analysis codes, coordinates and temperature values.**

Location Name of Sample Taken	Code	Coordinate	Degree	Air Temperature
Kemaliye Ariki Brook	D1	37 457103E - 4344463N	39° 14' 52''K 38° 30' 11''D	32.2 °C
Kemaliye Ağca Ağa Brook	D2	37 457925E - 4344223N	39° 14' 44''K 38° 30' 45''D	36.0 °C
Kemaliye Venk Brook	D4	37 457083E - 4348049N	39° 16' 48''K 38°30' 07''D	35.5 °C
İliç Central	D5	37 459194E - 4367647N	39° 27' 24''K 38° 31' 33''D	36.7 °C
İliç Kuru Creek	D6	37 462822 E - 4374766N	39° 31' 16''K 38° 34' 03''D	34.2 °C
Atma 1 Bridge	D7	37 482173E - 4383338N	39° 35' 56''K 38°47' 33''D	33.1 °C
Kemah Boğaziçi Village	D8	37 491547E - 4382488N	39° 35' 29''K 38° 54' 10''D	33.8 °C
Kemah Kömür Creek	D9	37 503182E - 4385224N	39° 36' 58''K 39° 02' 14''D	30.2 °C
Tercan Tuz Creek	D12	37 630184E - 4407087N	39° 48' 11''K 40° 31' 15''D	30.2 °C
Tercan Küçük Beğendik Brook	D13	37 616246E - 4404342N	39° 46' 52''K 40° 21' 27''D	33.3 °C
Mercan Brook	D14	37 607423E - 4398714N	39° 43' 51''K 40°15' 13''D	33.5 °C
Soğuksu Bridge	D16	37 585722E - 4380187N	39° 33' 59''K 39° 59' 53''D	35.5 °C
Cibice Bridge	D17	37 579907E - 4381750N	39° 34' 52''K 39° 55' 50''D	34.6 °C
Selepür Bridge	D19	37 573099E - 4384223N	39° 36' 14''K 39° 51' 06''D	34.8 °C
Avcılar Surroundings	D20	37 570108E - 4385773N	39° 37' 06''K 39° 49' 00''D	34.6 °C
Sülperen Bridge	D21	37 568042E - 4386800N	39° 37' 40''K 39° 47' 34''D	34.7 °C
Derebağ Yalınca	D22	37 557661E - 4387105N	39° 37' 52''K 39° 40' 19''D	34.8 °C
Kemaliye Surroundings	N1	37 457420E - 4344834N	39° 15' 04''K 38° 30' 24''D	36.0 °C
Kemah Central	N2	37 503182E - 4385224N	39° 36' 58''K 39° 02' 14''D	30.2 C°
Kemah Karnı Brook	N3	37 518925E - 4386405N	39° 37' 35''K 39°13' 14''D	22.7 °C
Kargın Location	N4	37 602088E - 4385850N	39° 36' 56''K 40°11' 21''D	35.0 °C
Mertekli Location	N5	37 562979E - 4388980N	39° 38' 52''K 39°44' 02''D	38.0 °C
Türkmenoğlu Village II	N6	37 543135E - 4394660N	39° 42' 00''K 39°30' 11''D	32.7 °C

being subjected to any chemical treatment and then jigged with 80 mesh sieves and weighed out as 100 g. Then, they were put in cylindrical plastic boxes of 57 mm-diameter and 44 mm high they were tightly capped and kept for 45 days for the formation of radioactive balance. Finally, the analysing of those soil samples was carried out with using multi-channel gamma analyser.

### 3. Findings

#### 3.1 Findings Related to Total Alpha and Beta Radioactivity in Water Samples

The average alpha and beta concentrations values of

water samples collected from the research area were measured respectively: 0.0534 Bq/L and 0.135 Bq/L. Minimum detectable activity (MDA) amount for the measured samples was calculated for alpha and beta as 0.008 Bq/L, 0.007 Bq/L, respectively. As we investigate Table 3, it can obviously see that in determining total alpha activities under MDA amounts gathered from water samples collected in Kemah Karni Brook, Tercan Tuz Creek, Tercan Kucuk Begendik Brook, Yedisu Location and Soguksu Bridge, the highest alpha activity was measured as 0.421 Bq/L in the samples from Sulperen Bridge surroundings.

**Table 3 Analysis of water samples.**

Location name of sample taken	Code	Radyoactivity (Bq/L)	
		Alpha ( $\alpha$ )	Beta ( $\beta$ )
Kemaliye Arika Brook	D-1	0.085 ± 0.022	0.154 ± 0.017
Kemaliye Agca Aga Brook	D-2	0.057 ± 0.019	0.161 ± 0.017
Kemaliye Central	D-3	0.018 ± 0.009	0.080 ± 0.010
Kemaliye Venk Brook	D-4	0.047 ± 0.012	0.071 ± 0.009
İlic Central	D-5	0.052 ± 0.012	0.083 ± 0.010
İlic Kuru Creek	D-6	0.052 ± 0.015	0.070 ± 0.011
Atma 1 Bridge	D-7	0.030 ± 0.008	0.060 ± 0.009
Kemah Bogazici Village	D-8	0.025 ± 0.007	0.090 ± 0.011
Kemah Komur Creek	D-9	0.026 ± 0.013	0.142 ± 0.016
Kemah Soran Creek	D-10	0.046 ± 0.010	0.083 ± 0.010
Kemah Karni Brook	D-11	< MDA*	0.013 ± 0.006
Tercan Tuz Creek	D-12	< MDA	0.028 ± 0.007
Tercan Kucuk Begendik Brook	D-13	< MDA	0.012 ± 0.005
Mercan Brook	D-14	0.022 ± 0.008	0.021 ± 0.007
Yedisu Location	D-15	< MDA	0.014 ± 0.006
Soguksu Bridge	D-16	< MDA	0.063 ± 0.010
Cibice Bridge	D-17	0.021 ± 0.006	0.041 ± 0.007
Tunceli Turnout	D-18	0.086 ± 0.013	0.118 ± 0.011
Selepur Bridge	D-19	0.024 ± 0.009	0.066 ± 0.008
Avcilar Surroundings	D-20	0.016 ± 0.005	0.052 ± 0.007
Sulperen Bridge	D-21	0.421 ± 0.147	1.806 ± 0.229
Derebag Yalinca	D-22	0.015 ± 0.005	0.028 ± 0.007
Turkmenoglu Village I	D-23	0.047 ± 0.026	0.172 ± 0.018
Kemaliye Surroundings	N-1	0.027 ± 0.007	0.066 ± 0.008
Kemah Central	N-2	0.011 ± 0.004	0.025 ± 0.006
Kemah Karni Brook	N-3	0.039 ± 0.012	0.107 ± 0.015
Kargin Location	N-4	0.008 ± 3E-04	0.027 ± 0.008
Mertekli Location	N-5	0.069 ± 0.009	0.126 ± 0.015
Turkmenoglu Village II	N-6	0.038 ± 0.009	0.007 ± 0.014

\* Minimum detectable activity (MDA).

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As it is seen in Table 3 the beta activities in samples collected from Kemah Karni Brook, Tercan Kucuk Begendik Brook, Yedisu Location are less than 0.02 Bq/L. It is determined that the samples from Kemaliye Ariki Brook, Kemaliye Agca Aga Brook, Kemah Komur Creek, Tunceli Turnout, Turkmenoglu Village, Kemah Karni Brook, Mertekli Location have more activity values than 0.100 Bq/L. Yet, as we investigate Table 3 in the sample collected from Sulperen Bridge, we can see that both alpha and beta activity concentrations are at high levels. Those values were measured, in order, as 0.0421 Bq/L and 1.806 Bq/L. These measurement point data are easily seen in Table 3.

In order to determine the alpha and beta concentrations, the following map which indicates the points of samples collected from the locations of research area depending on their coordinates is shown in Fig. 1.

#### 3.2 The Findings Related to Soil Samples for Radioisotopes and Their Activities

In the study, 17 soil samples were analysed using the HPGe gamma spectrometer. From the

measurement results of the soil samples from the research area, comparing their detectable limits with literature values, it was determined that  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ ,  $^{40}\text{K}$  and  $^{137}\text{Cs}$  radioisotopes existed in all of them more common and deserved to be measured. In some of the samples collected from brook beds joining to the river, isotopes different from the ones mentioned above were encountered, yet, as those were not encountered in every sample and no unusual counting results were encountered in the samples they existed, any further investigations were not needed. While the activities of the radioisotopes were being calculated, natural background values were disregarded from the results. Radioactivity concentrations of the radionuclides existing in each soil samples are indicated in Table 4 in Bq/kg.

At the end of the counting, the radioisotopes activity concentration for  $^{226}\text{Ra}$  was found between 2.7-27.8 Bq/kg.  $^{226}\text{Ra}$  is decomposition of  $^{238}\text{U}$  and  $^{226}\text{Ra}$  has a half-life of 1,599 years. Among the soil samples, the lowest activity concentration of  $^{226}\text{Ra}$  was measured as  $2.7 \pm 0.5$  Bq/kg in the samples collected around Komur Creek. The highest value ( $27.8 \pm 2.4$  Bq/kg) was determined in the sample collected

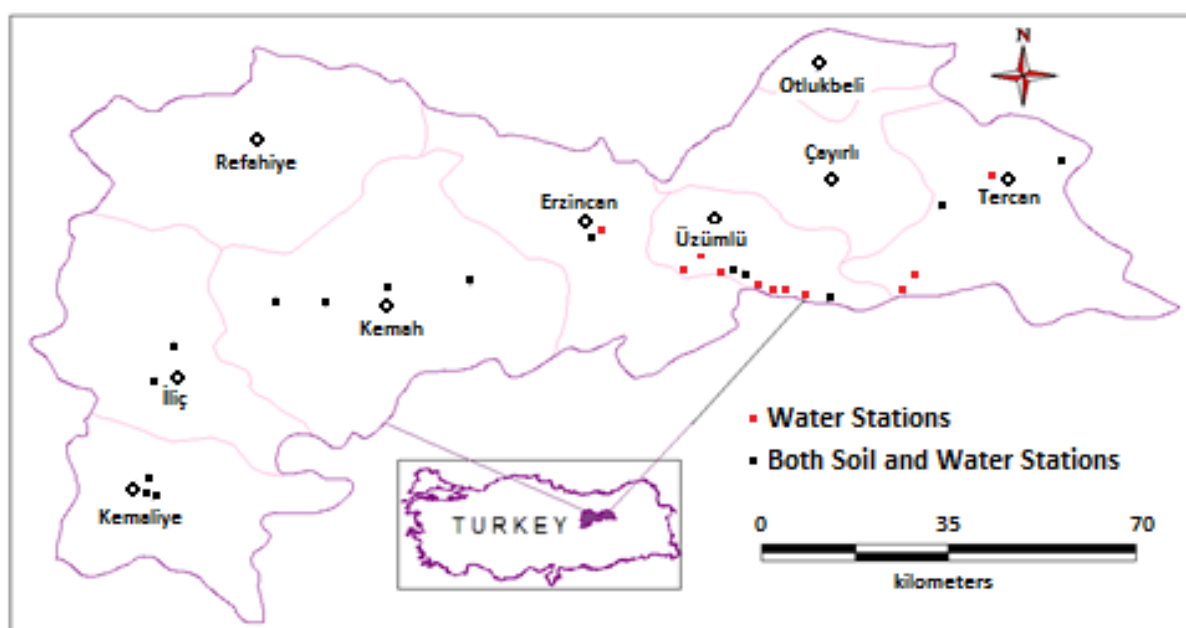


Fig. 1 The map indicating the locations of water and soil samples according to their coordinate points.

from Kemah Bogazici Village Location and this situation can easily be seen in Table 4.

The activity concentration of  $^{232}\text{Th}$  was found between 3.2-39.4 Bq/kg, the lowest value ( $3.2 \pm 0.2$  Bq/kg) was measured in the sample from Komur Creek surroundings. The highest value was determined as  $39.4 \pm 1.3$  Bq/kg from the sample from Agca Aga Brook and its surroundings (Table 4).

The  $^{40}\text{K}$  radioisotope does not belong to the decomposition series and is single in the nature. Its half-life is  $1.26 \times 10^9$  years. It has an abundance of  $\gamma$  peak as 11% in 1460 keV [16]. It exists in  $^{40}\text{K}$  soil in extremely high concentrations. The activity concentration for  $^{40}\text{K}$  was found between 98-714 Bq/kg. At the end of the measurements, among the soil samples  $^{226}\text{Ra}$  activity concentration was also detected and the lowest value ( $98 \pm 0.4$  Bq/kg) was measured in the sample from Komur Creek and surroundings. The highest value ( $714 \pm 27$  Bq/kg) was measured in the sample from Agca Aga Brook location (Table 4).

The half-life of  $^{137}\text{Cs}$  is 30.17 years. It has a  $\gamma$  peak in abundance of 85% in 662 keV [16].  $^{137}\text{Cs}$  is fission product and from the results of nuclear tests or nuclear

accidents, fission product radionuclides emitted to the atmosphere falls down with radioactive rains. In time, they can penetrate in depth of the soil with rain and discharge water. Among the soil samples researches in the literature, various concentrations of  $^{137}\text{Cs}$  radioisotopes were encountered. In this study, the activity concentrations for  $^{137}\text{Cs}$  were determined between  $< 0.4$ -57.8 Bq/kg. From the results of the measurements, among the soil samples, for the lowest  $^{137}\text{Cs}$  activity concentrations, the samples from Atma 1 Bridge location, Komur Creek, Kemah Brook, Soran Brook and Tuz Creek and surroundings the activity concentrations below 0.4 Bq/kg value were measured. The highest value ( $57.8 \pm 1.8$  Bq/kg) for  $^{137}\text{Cs}$  was determined in the samples from Agca Aga Brook location (Table 4).

According to the locations of samples, the radioactivity concentrations determined for  $^{226}\text{Ra}$ ,  $^{232}\text{Th}$ ,  $^{40}\text{K}$  and  $^{137}\text{Cs}$  radioisotopes are indicated comparatively in Table 4. As it is noticed from table 4, when the  $^{40}\text{K}$  activity concentration is compared with other isotopes, it is more than the others several hundred times in each Bq/kg. When the activity concentrations compared with the others, it is

**Table 4 Analysis of soil samples.**

Location name of sample taken	Code	Radioactivity of radioisotopes (Bq/kg)			
		$^{226}\text{Ra}$	$^{232}\text{Th}$	$^{40}\text{K}$	$^{137}\text{Cs}$
Kemaliye Arika Brook	D-1	$20.9 \pm 0.8$	$28.9 \pm 1.1$	$507 \pm 20$	$15.8 \pm 0.6$
Kemaliye Agca Aga Brook	D-2	$25.1 \pm 0.8$	$39.4 \pm 1.3$	$714 \pm 27$	$57.8 \pm 1.8$
Kemaliye Venk Brook	D-4	$16.1 \pm 1.5$	$17.8 \pm 1.7$	$325 \pm 33$	$31.7 \pm 3.2$
İlic Central	D-5	$9.7 \pm 0.9$	$11.5 \pm 1.1$	$322 \pm 32$	$11.8 \pm 1.2$
İlic Kuru Creek	D-6	$15.3 \pm 1.7$	$18.3 \pm 1.8$	$520 \pm 52$	$11.8 \pm 1.2$
Atma 1 Bridge	D-7	$8.3 \pm 0.4$	$8.4 \pm 0.6$	$183 \pm 11$	$< 0.4$
Kemah Bogazici Village	D-8	$27.8 \pm 2.4$	$18.0 \pm 1.7$	$534 \pm 55$	$11.2 \pm 1.2$
Komur Creek	D-9	$2.7 \pm 0.5$	$3.2 \pm 0.2$	$98 \pm 4$	$< 0.4$
Kemah Soran Creek	D-10	$6.4 \pm 1.0$	$8.2 \pm 0.4$	$152 \pm 66$	$< 0.4$
Kemah Karni Brook	D-11	$18.0 \pm 1.7$	$18.1 \pm 1.7$	$419 \pm 41$	$8.2 \pm 0.9$
Tercan Tuz Creek	D-12	$4.6 \pm 1.1$	$10.8 \pm 5.5$	$119 \pm 87$	$< 0.4$
Mercan Brook	D-14	$17.6 \pm 1.2$	$22.6 \pm 1.8$	$176 \pm 13$	$6.0 \pm 0.7$
Soguksu Bridge	D-16	$13.4 \pm 0.7$	$17.9 \pm 3.2$	$404 \pm 17$	$2.8 \pm 1.2$
Avcilar Surroundings	D-20	$11.0 \pm 0.9$	$12.4 \pm 1.1$	$383 \pm 38$	$0.6 \pm 0.1$
Sulperen Bridge	D-21	$5.0 \pm 2.5$	$8.5 \pm 5.5$	$169 \pm 92$	$1.2 \pm 0.7$
Turkmenoglu Village İ	D-23	$11.2 \pm 1.1$	$12.7 \pm 1.4$	$311 \pm 33$	$2.0 \pm 0.3$
Kemaliye Surroundings	N-1	$9.7 \pm 0.10$	$12.6 \pm 1.4$	$303 \pm 31$	$0.2 \pm 0.1$

recognized that  $^{137}\text{Cs}$  radioisotope is the second. According to the data of this study, it is seen that the activity concentrations results gathered from the samples from Tercan and Mercan district and surroundings of Karasu River's parts in Erzincan province borders, are the lowest compared with all of the measured radioisotopes but the highest compared with the samples from Kemaliye district surroundings. Specifically, in all of the soil samples measured for the analysis, when the data from Kemaliye Agca Aga Brook (the highest values for all the radioisotopes), Kemaliye Ariki Brook and Kemaliye Venk Brook are compared with other points, it can obviously be seen in Table 4 that they have higher values.

#### 4. Conclusion and Recommendations

The area of between Tercan Tuz Creek, Mercan Brook and Kemaliye Agca Aga Brook, Kemaliye Ariki Brook which are the branches of Karasu River in Erzincan Province borders is determined as the research area, natural radiation an radioactivity concentrations of water samples from the brook beds joining to this river and soil samples from the surroundings collected from the locations close to the water samples were analysed via sampling. The total alpha and beta activities for 29 water samples collected from the study area, activity concentrations for 17 soil samples were determined. Berthold brand LB770 model 10 channel gas-flow alpha-beta counting device was used for 29 water samples, HPGe gamma spectrometer was used for 17 soil samples. The average alpha and beta activity concentrations of water samples collected from Euphrates were measured in order as: 0.0421 Bq/L and 1.806 Bq/L.

Among the parameters towards determining the amount of quality relevant to radioactivity, total indication dose provided for 0.1 mSv/year limit value is a value for minimizing the natural radiation dose gathered from drinking water represents 10% of the minimum values of average radiation doses gathered from natural sources all over the world. Therefore, formerly advised radioactivity limits by the World Health Organization for total alpha activity as 0.1 Bq/L, total beta activity as 1.0 Bq/L, were rearranged within the framework of the concept of total indicative dose were given in the 9th section (radiological aspects) related to the guidelines for the quality of drinking-water named as "Guidelines for Drinking-water Quality, First Addendum. Volume 1, Recommendations, Third Edition", published in 2006, the tracking limit values of alpha emitter as (total alpha activity) 0.5 Bq/L, the tracking limit values of beta emitter as (total beta activity) 1.0 Bq/L. Therefore, it was decided that total alpha ( $\alpha$ ) activity 0.5 Bq/L and total beta ( $\beta$ ) activity 1.0 Bq/L should not exceed the 0.1 mSv/year limit values and it is advised that further investigations should be carried on waters from the values given in Table 5 and count total indication dose. The reference values were published by the World Health Organization [17] and Turkish Standarts Institution (TSE) in 1997 in Table 5.

The highest alpha activity concentration measured in this study is 0.0421 Bq/L and beta activity concentration is 1.806 Bq/L. As the world-wide accepted as reference, the values mentioned above in Table 5 considered, from these results, total alpha ( $\alpha$ ) activity is below the limit values, yet total beta ( $\beta$ ) activity in the sample from Sulperen Bridge research

**Table 5 Limits on radioactivity in drinking water.**

Parameter	Value	Unit
Total indicative dose (TID)	0.10 mSv/yıl	
World Health organization (1996) (WHO)	Alpha emission ( $\alpha$ )	0.1 Bq/L (2.7 pCi/L)
	Beta emission ( $\beta$ )	1 Bq/L (27 pCi/L)
The Turkish Standards Institute (TSE) (1997)	Alpha emission ( $\alpha$ )	0.037 Bq/L (1 pCi/L)
	Beta emission ( $\beta$ )	0.37 Bq/L (10pCi/L)



**Table 6 The comparison of the measurement results of natural radionuclides in soil with limits values [12].**

		Concentration of Radionuclides (Bq/kg)			
		<sup>226</sup> Ra	<sup>232</sup> Th	<sup>40</sup> K	<sup>137</sup> Cs
Reference Values	Change Interval	17 - 60	11 - 64	140 - 850	0.33 - 14.08
	Average	35	45	400	5.1
This Work	Change Interval	2.7 - 27.8	3.2 - 39.4	98 - 714	< 0.4 - 57.8
	Average	13.1	15.84	301.7	9.47

point (Analysis code is D-21, and coordinates are 39°37'40"N 39°47'34" E), (1.806 Bq/L) the reference values were measured as 0.8 Bq/L and this value was higher in other. The β activity results for water samples from other points were also below the reference limits. The results from the data for water samples are indicated in Table 3.

The radioisotope activity concentrations from the soil samples collected from the research area were measured for <sup>226</sup>Ra as 2.7-27.8 Bq/kg, for <sup>232</sup>Th as 3.2-39.4 Bq/kg, for <sup>40</sup>K as 98-714 Bq/kg and for <sup>137</sup>Cs as < 0.4-57.8 Bq/kg. Those results are given in Table 6 as limit values and value ranges of reference values and average values together. As Table 6 is investigated, it is noticed that the average findings of <sup>226</sup>Ra, <sup>232</sup>Th and <sup>40</sup>K are far below the reference values. Yet, the average measurement results gathered for <sup>137</sup>Cs were far above the reference values. The reasons of those high values are originated as it is seen in Table 4 from the results from Kemaliye Agca Aga Brook are far above the average.

Especially Kemaliye Agca Aga Brook, Kemaliye Ariki Brook and Kemaliye Venk Brook data compared with the data from the other points are noticed to be higher. This situation is similar to the analyses by Yalcin et al. [18] in a study on drinking and using water samples and soil samples from close areas to the water samples locations in the settlements of Erzincan. Similar to research carried in Kemaliye surroundings, the radioisotope activity concentrations were high.

The average of dose that we exposed through foods, drinks and air we breathe is proximately 0.25 mSv/year. Because of the especially <sup>40</sup>K and other radioactive elements, we are exposed to some amount

of radiation. The world average of inner radiation which we are exposed in this way throughout a year is about 0.23 mSv.

The citizens, who live in and around Erzincan province, should also be benefited from this study. Especially, the fact that total beta (β) in water samples from Sulperen Bridge are higher than the reference values and from the result of soil analysis of Kemaliye Agca Aga Brook for <sup>137</sup>Cs, gathered results are much higher than the reference values should also be recognized by the beneficiaries. Moreover, according to the results of the study, for total beta (β) activity concentrations, Sulperen Bridge research point and for <sup>137</sup>Cs activity concentration, Kemaliye Agca Aga Brook and its surroundings and reasons of those activity concentrations should also be researched.

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