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Concentrations of Environmental Radioactivity in Sediment Cores from Kulakcayiri Lake

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Abstract: This paper is about measurements of environmental radioactivity in samples taken from a lake bed and from different depths. The study is based on gamma spectrometric analysis of some radioisotopes encountered in sediment samples. For this purpose, sediments that have accumulated for thousands of years were used. Three core samples were taken from Kulakcayiri lake by drilling and taken from heights of 5-5.5 m, 10-10.5 m and 15-15.5 m at the same point and then moved to the laboratory. The analyses of the samples were carried out in the laboratory with the semiconductor HPGe detector. According to the results, the K-40 concentrations of the samples were 325 ± 18 Bq/kg, 353 ± 19 Bq/kg and 367 ± 19 Bq/kg, while their Th-232 concentrations were 38 ± 6 Bq/kg, 43 ± 6 Bq/kg and 42 ± 6 Bq/kg, respectively. Their concentrations of Ra-226 were calculated as 29 ± 5 Bq/kg, 26 ± 5 Bq/kg and 26 ± 5 Bq/kg, while the Cs-137 concentrations of the three samples were calculated as ≤MDA (Minimum Detectable Activity) and existed at very low concentrations. The average activities of K-40, Th-232, Ra-226 and Cs-137 were found to be about 348 ± 186 Bq/kg, 41 ± 6.3 Bq/kg, 27 ± 5.1 Bq/kg and ≤MDA, respectively. The results were compared with those of similar studies. These findings and assessments are expected to be an example for future studies and to be of reference quality.

Keywords: Core sediments, environmental radioactivity, gamma, Kulakcayiri Lake, Turkey.

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INTRODUCTION

The radioactivity levels of the Earth are influenced by natural and artificial pathways. Unstable elements in the earth emit radioactive rays, which increase natural radioactivity levels. The best example of natural radioactivity is uranium decay. Artificial radioactivity occurs when stable isotopes in nature become unstable as a result of exposure to radiation. Radioactive substances emit alpha (α), beta (β) and gamma (γ) rays (1).

Natural radioactivity on Earth originates from cosmic rays, gamma rays from the Earth, radon gases in the air and in drinking water and radionuclides present in food and beverages. There is no way to reduce natural background radiation. However, the accumulated concentration of radon gas in houses can be easily reduced by ventilation (2).

There are many factors that increase the levels of radioactivity on Earth, especially nuclear power-plant accidents. Atmospheric, aquatic, and underground nuclear weapon tests, as well as nuclear reactor explosions, are activities that initiate radioactive pollution (3). Considering their possible effects on human health, it is important to investigate radioactivity in populated regions. Water, soil, food and sediments have been investigated under radioactive pollution studies.

Our study investigated the natural radioactivity levels in sediments of Kulakcayiri lake using a gamma spectrometer. Considering its proximity to the 3rd airport that will be built in Istanbul, the region around the lake is expected to become highly active in the coming years. It will be difficult to conduct a radioactivity study in this region in the future because it will become more intensely developed. For these reasons, it is expected that our work will provide a basis for future work, as well as an example for future generations.

STUDY AREA

The study area is Kulakcayiri lake, which is located in the Arnavutkoy district in Istanbul and covers approximately 500 hectares (4). Kulakcayiri lake, which is considered to be one of the great lakes of the Marmara region in the past, is a shallow lake; it used to be possible to picnic and fish along its borders, but it is now dried up. The 3rd Airport Project plans to occupy the current site of the Lake. The location map of the study area is shown in Figure 1.

Figure 1. Location Map of Study Area (5).

MATERIAL AND METHODS

Sample collection

A core was taken from a suitable spot in Kulakcayiri Lake. Sample were collected from the core at depths of approximately 5, 10 and 15 m. The co-ordinates of the samples were recorded, and the samples were named and moved to the laboratory. The coordinates of the sediment samples are shown in Figure 1.

Table 1. Locations of the samples (5)

	SAMPLE NO	X (East)	Y(North)
Kulakcayiri Lake	BH-1	645459.77	4572767.77
	BH-2	645529.00	4572399.00
	BH-3	645511.81	4572001.24

Sample preparation for radioactivity measurements

The sediment samples were taken from the study area and brought to the laboratory. They were dried for approximately 1 week at room temperature to solidify their muddy consistency. The sediments were dried in an oven for approximately 2 days at 50 °C to remove as much moisture as possible. The dried sediment samples were separately ground without mixing with each other. The samples were milled until powdered and transferred to 170 mL Marinelli beakers with standard geometry. The samples were then left to stand in the Marinelli beakers for approximately 40 days at room temperature to form radon-disintegration products and to reach equilibrium. At the end of this entire procedure, the samples were prepared for counting.

Measurement Methodology

The gamma-spectrometric analyses were performed with a high-purity, germanium-doped HPGe detector (Canberra GX5020). The instrument was calibrated prior to analysis in accordance with the geometry of the Marinelli beakers that held the samples. After calibrating, each sample was counted for approximately 1-1.5 days, and their concentrations were calculated in terms of Bq/kg (6).

RESULTS AND DISCUSSION

The gamma-spectrometry results of the core samples from Kulakcayiri lake provide information about the radioactivity levels of this region for the literature. The analysis results are shown in Table 2. According to Table 2, the concentrations of K-40 were calculated as 325 ± 18 Bq/kg, 353 ± 18 Bq/kg and 367 ± 19 Bq/kg, with an average value of 348 Bq/kg. Their Th-232 concentrations were calculated as 38 ± 6.2 Bq/kg, 43 ± 6.6 Bq/kg and 42 ± 6.5 Bq/kg, with an average value of approximately 41 Bq/kg. In addition, the measured Ra-226 activity values were 29 ± 5.4 Bq/kg, 26 ± 5.1 Bq/kg and 26 ± 5.1 Bq/kg, with an average value of approximately 27 Bq/kg. The activity of Cs-137 is below the minimum detectable activity (MDA) value for all sediment samples.

Table 2. Activity concentrations of K-40, Th-232, Ra-226 and Cs-137 in sediment samples (Bq/kg)

	Activity (Bq/kg)			
Sample Location	**K-40**	**Th-232**	**Ra-226**	**Cs-137**
BH-1	325±18	38±6.2	29±5.4	≤MDA
BH-2	353±18	43±6.6	26±5.1	≤MDA
BH-3	367±19	42±6.5	26±5.1	≤MDA

The analysis results showed that the activity of K-40 was significantly higher than those of the other radionuclides (Figure 2).

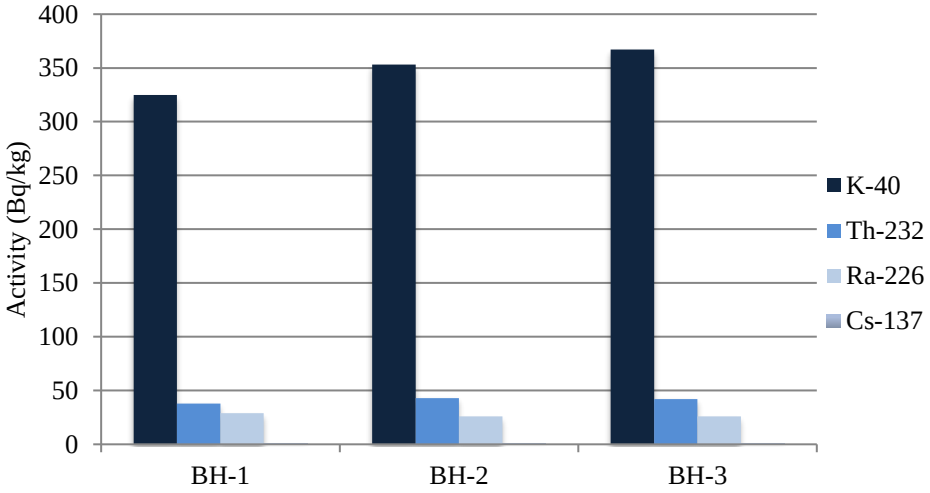

Figure 2. Distribution of Activity Concentrations.

CONCLUSION

This study was carried out in order to determine the natural radioactivity levels of the natural Kulakcayiri lake. This study started with the extraction of 3 sediment samples by sounding. Gamma spectrometric analyses were then performed using the HPGe detector, and the activities of the various radionuclides were calculated. The results of this study were compared with similar studies in other countries (Table 3).

Table 3. Comparison of Radioactivity Concentrations of Kulakcayiri Lake Sediments with Other Works.

Sample Stations	Activity (Bq/kg)				
	K-40	Th-232	Ra-226	Cs-137	References
Ionian Sea, Albania*	266-675	13-40	14-27	3-38	(7)
Hunza, Gilgit and Indus Rivers,** Pakistan	173-825	12-172	174-825	-	(8)
Miami Bay,*** Malaysia	314-495	37-5622	24-2641	-	(9)
Niger Delta, Nigeria ****	96-530	12-40	13-46	-	(10)
Algeria *****	56-607	7-32	-	2-9	(11)

(Tsabarisa et al., 2007), ** (Shuaibu et al., 2017), *(Qureshi et al., 2014), ****(Agbalagba et.all, 2011), ***** (Noureddıne et al., 2003)*

In this study, we examined the radioactivity levels of the lake. The results of the study showed that the activity of the fission product Cs-137 fell below the MDA value, while the concentration of K-40 was found to be higher than those of the other radionuclides.

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