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Effects of radionuclides on the recent foraminifera from the clastic sediments of the Çanakkale Strait-Turkey

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ABSTRACT

The radionuclides that cause radioactivity accumulate in the sediments as they descend to the seabed, similar to heavy metals. As radionuclides are present on the surface of the sediment or within the sediment, marine benthic foraminifera can be affected by the radioactive pollution. In this study, the habitat of benthic foraminifera was evaluated for radioactive pollution in the Çanakkale Strait, which constitutes the passage of the Marmara Sea and the Aegean Sea.

In 2015, seven core samples and one drilling sample were taken from the shallow marine environment, which is the habitat of benthic foraminifera, in the Çanakkale Strait. Locations of the core samples were specifically selected to be pollution indicators in port areas. Gamma spectrometric analysis was used to determine the radioactivity properties of sediments. The radionuclide concentration activity values in the sediment samples obtained from the locations were Cs-137: <2–20 (Bq/kg), Th-232: 17.5–58.3 (Bq/kg), Ra-226: 16.9–48.6 (Bq/kg) and K-40: 443.7–725.6 (Bq/kg). These values were compared with the Turkish Atomic Energy Agency (TAEK) and the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) data and environmental analysis was carried out.

The Ra-226 series, the Th-232 series and the K-40 radionuclides accumulate naturally and increase continuously due to anthropogenic pollution. Although the Ra-226 values obtained in the study areas remained within normal limits according to UNSCEAR values, the K-40 and Th-232 series values were observed to be high in almost all locations. The values of Cs-137 were found to be maximum 20 in Çanakkale Dere Port and they were parallel to the values in the other places. In the study, 13 genera and 20 species were identified from core and drilling samples. The number of foraminifera species and individuals obtained at locations with high pollution was very low compared to those in non-polluted zones.

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1. Introduction

Throughout the world, technological developments can cause radioactive pollution that results from industrial and nuclear waste. Furthermore, radioactive elements with very long lives that occur naturally in the Earth's crust also form a natural radiation level. Every living creature on the Earth is continuously exposed to radioactive substances that are formed by both natural radiation and human activities. Radioactive pollutants entering the marine environments through dry and wet precipitation are also carried to the sea by streams. As seen in the Chernobyl disaster, transport of contaminated soils to the sea by erosion also contaminates these environments. Water contaminated with radioactive pollutants that is entering the marine environment is circulated between the sediment and the organisms (Güven and Öztürk, 2005).

Benthic foraminifera will be affected by radioactive contamination in marine sediments, especially as they live in sediments on the seabed. Therefore, the habitats of foraminifera were evaluated as pollution indicators in marine environments.

Natural radionuclides such as the 238 U series, 232 Th series and 40 K exist in various levels in the soil, sediment, water, plants, and air. The natural radionuclide distribution depends on the geological and geographical conditions of each region (Kurt et al., 2016).

Cs-137, one of the artificial radionuclides, has high water solubility and it can move easily. In the ecological environment, the

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presence of Cs-137 indicates nuclear weapons tests or fallout. After the nuclear accidents in 1986, Chernobyl and in 2011, Fukushima, artificial radionuclides such as Cs-137 have mixed with the receiving mediums (e.g., sea, rivers, air, and soil) and have been very quickly transported kilometers from their sources. In particular, nuclear power plants that have been installed in earthquake-prone areas have the potential to be either completely destroyed or damaged by earthquake, causing leaks (e.g., Metsamor Nuclear Power Plant in Armenia) and posing a great threat to worldwide living conditions (Kam, 2016). In this study, natural and artificial radionuclide distributions were investigated by using gamma spectrometry in core sediment samples and drilling samples taken from different points in the Çanakkale Strait.

Table 1 shows the values of the radionuclides determined around the Çanakkale Strait in the distribution chart of soil and water radioactivity of the Turkish Atomic Energy Agency. The values given in Table 1 were compared with the radionuclide values obtained in this study and the basis of the high values in the sea were investigated (Güven and Öztürk, 2005).

2. Materials and methods

In this study, one drilling sample was taken from the Çanakkale Strait (BH-7) and eight core samples were taken from eight different locations (Burhanlı, Dereliman, Eceabat, Gelibolu, Kumkale, Lapseki, Seddülbahir, and Şevketiye) (Table 2 and Fig. 1). Samples were collected with the YUMUN 01 drilling platform. Attention was paid to the existing pollution conditions while taking the core samples and drilling sample. The drilling samples were taken with the drilling platform installed on the sea with the rotary drilling system. However, the core samples were taken by hydraulic pressure method.

The cores and drilling cores were divided into 10 cm sections from top to bottom and samples were prepared for foraminifera analysis. Each sample was kept in a 10% H_2O_2 solution for 24 h, then filtered through a 125 μm to remove the foraminifera. Segregation was carried out using a stereozoom microscope and systematic descriptions of each foraminifera were made. For radionuclide analysis, samples were first prepared for radioactive analysis by keeping them at room temperature in a laboratory environment. Analyses of the prepared samples were performed in the Çekmece Radioactivity and Analytical Measurement Department. The samples were finely powdered by filtering through a 100-μm sieve. The powdered samples were placed in 1000 mL Marinelli test bottles and bottle openings were sealed to prevent air contact. The samples were kept for 40 days after weighing to equilibrate between radium, thorium and other degradation products.

Gamma spectrometry analysis (Canberra GX5020) was used with an HPGe detector, which was joined to a coaxial high-purity germanium (Bozkurt et al., 2007). The setup was calibrated by using solid, diverse gamma emitting reference sources in a 1 L Marinelli beaker. The gamma activity relied on 238U series, 609.3 keV; 232Th series, 583 keV; 228Ac, 911.2 keV; 226Ra, 185.7 keV; 137Cs, 661.7 keV; 40 K, 1460,8 keV (UNSCEAR, 2000).

Table 1
Turkey atomic energy agency soil radionuclide values in Çanakkale Strait (Güven and Öztürk, 2005).

Radionuclides	Low (Bq/kg)	High (Bq/kg)
Th-232	5.00	50.10
Ra-226	10.10	75.00
K-40	50.00	100.00
Cs-137	0.00	20.00

Table 2
Core sample coordinates.

Sample code	Sample Amount (L)	Coordinates (UTM, 6 Degree)	
		(Y)	(X)
1-Burhanli (Çanakkale)	2.5	463,791	4,463,231
2-Dereliman (Çanakkale)	2.5	449,212	4,443,871
3-Eceabat (Çanakkale)	2.5	445,495	4,448,541
4-Gelibolu (Çanakkale)	2.5	471,306	4,478,121
5-Kumkale (Çanakkale)	2.5	436,965	4,428,080
6-Lapseki (Çanakkale)	2.5	473,852	4,466,935
7-Seddülbahir (Çanakkale)	2.5	430,862	4,432,732
8-Şevketiye (Lapseki)	2.5	489,498	4,471,929

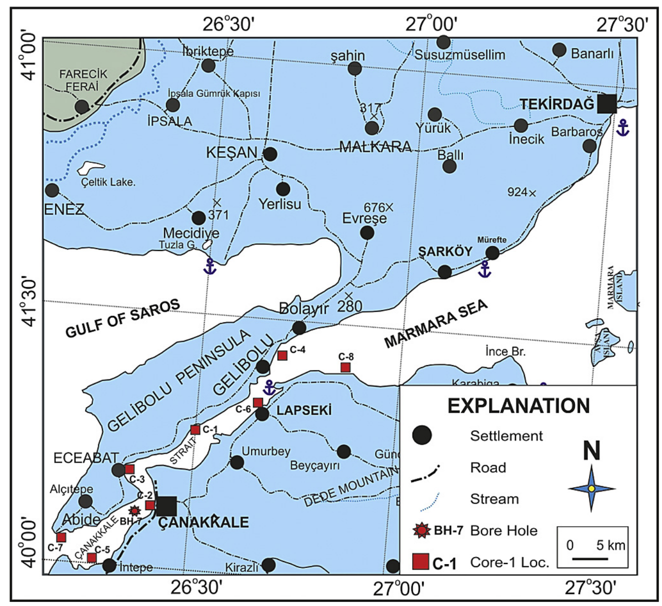

Fig. 1. Location map of eight points where core samples and Bore Hole Samples (BH-7) were taken at Çanakkale Strait.

3. Results and discussion

3.1. Geological setting of investigation area

The investigated area is the Çanakkale Strait, which constitutes the passage of the Marmara Sea which is part of the strait system connecting the Black Sea and the Mediterranean (Fig. 1).

Between the Gallipoli and Biga peninsulas, the Çanakkale Strait is 61 km long, between 12 and 6 km wide, and has a maximum depth of 82 m and an average depth of 55 m (Artüz, 2007). From the geological and morphological point of view, the Çanakkale Strait has undergone quite a complex evolution. Geologically, the Çanakkale Strait extends along the deepest point of a depression formed by Neogene-aged sediments. Both basins of the Çanakkale Strait, the main and Neogene covers, were cut by an Upper Pliocene age abrasion surface descending toward the strait axis. The Strait was formed on the depressions that formed this abrasion surface and later sank with its branches and acquired its current form.

The Çanakkale Strait and neighboring area, which was an important settlement in ancient times, also have strategic importance due to its geopolitical position. Surrounded by the Çanakkale Province, the economic activities of the strait are mostly agricultural. Industry and trade have also developed as a result of these agricultural activities.

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