Gross Alpha and Gross Beta Activity Concentrations in Sediments in Gulf of Izmir (Eastern Aegean Sea, Turkey)

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Abstract: The concentrations of gross alpha and gross beta radioactivity were analyzed in Holocene sediments of the Gulf of Izmir (Eastern Aegean Sea). The sediments were collected from four different locations affected by industrial activities, overpopulation, and shipping in the Gulf of İzmir. Each sample was determined for gross alpha and gross beta radioactivity by using a low-background counter (Berthold, LB 770 10 - channel $\alpha-\beta$ low-level counter). The obtained results show that natural gross alpha and gross beta activity concentrations in the drilling cores range from 537 ± 77 to 1800 ± 207 Bq kg^{-1} and 993 ± 60 to 1842 ± 102 Bq kg^{-1}, respectively. These results were compared with previous studies throughout the world, and the study could be a reference data for the future researches related to radiological mapping or environmental monitoring in the area.

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INTRODUCTION

Natural background sources of radiation are divided into cosmic radiation, primordial radiation, and cosmogenic radioactivity (1). Cosmic radiation is the earliest source, which emerges at the formation of the universe. Primordial radionuclides are the second source that created with the occurrence of the Earth, and its essential radionuclides are U-238, Th-232 and their decay products, besides natural K-40 (2). The third source of natural background radiation is cosmogenic radioactivity that is formed as a result of interactions between cosmic radiation and the atmosphere in a continuous manner. The mainly cosmogenic radionuclides are ^{3}H (tritium), ^{7}Be (beryllium-7) and ^{14}C (carbon-14) (3). Additionally, artificial radionuclides such as Cs-137, Cs-134, Sr-90, and I-131 are generated by a number of human activities. (4). Most of the radioactive elements in the marine environment mainly come from atmospheric nuclear weapons testing, nuclear reactor accidents, and non-nuclear industries (3, 5).

The measurement of radioactivity is crucial to evaluate the radiation effect on the environment and living organisms. Radioactivity is a form of energy released from radioactive elements, and the degree of damage depends on many factors such as dose rate and type of radiation (alpha, beta, gamma, x-ray, and neutron radiation). The easiest way to detect for the total radioactivity in the samples is the detection system. (6).

Alpha particles are being made up of two protons and two neutrons; therefore, they have a positive electrical charge. Alpha emitting radiation comes from naturally occurring elements such as uranium and radium and some man-made elements. Because of their charge and relatively large size, alpha particles collide strongly with matter and drop their energy quickly. They are unable to penetrate the first layer of skin, but if an alpha emitting material is ingested in food or air, they can affect the body cells.

Beta particles are fast moving electrons or positrons ejected from an atom. They are much smaller than alpha particles and can penetrate a few centimeters of skin or water. A thin sheet of aluminum or plastic can stop them.

Sediments have a crucial role in the aquatic environment as they accumulate and distribute radioactive contaminants in the geographic areas. Gross alpha and gross beta activity concentrations in sediments are defined as the total radioactivity of all alpha and beta emitters. Gross alpha radioactivity comes from U-238, Th-232, Ra-226, Rn-222 and their decay products, while gross beta radioactivity consists of naturally long-lived K-40, and fission products of Sr-90, Cs-137 and I-125 (7). Consequently, analyzing sediment samples in marine medium enables valuable information with regard to environmental pollution including natural and artificial radioactivity (2).
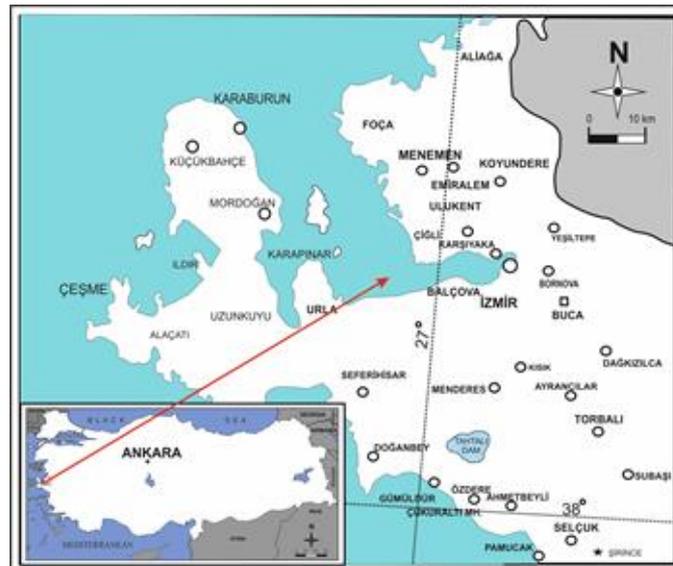
Gross alpha and gross beta analysis are generally carried out as a screening measurement for determining alpha and beta radioactivity in environmental research (4). This study presents the analysis of gross alpha and gross beta activity concentrations of sediment specimens in the Gulf of Izmir.
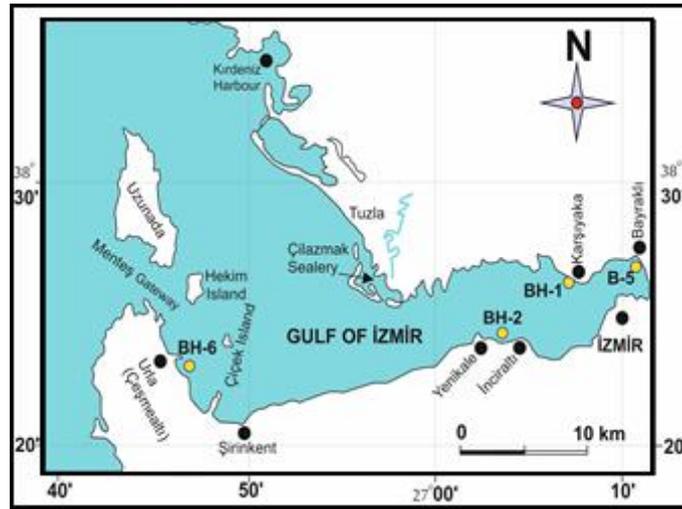
EXPERIMENTAL

Study Area

The Gulf of Izmir is a semi-open natural gulf, and located in the Eastern Aegean Sea (Figure 1). It has a total surface area of over 500 km^2, a total length of 64 km, and water capacity is 11,5 billion m^3 (8). The Gulf is naturally divided into three regions: Inner, Middle and Outer in terms of topographic and hydrographic circumstances (9). Important streams and rivers flow into the Gulf of Izmir are Bostanlı, Ilıca, Bayraklı, Bornova, Manda, Arap, Melez, Poligon, Balçova, Narlıdere and Gediz River that is the biggest one flows to the outer Gulf (10). The Outer Section is situated from Karaburun to Foca with distance 20 km. The depth reaches up to 70 m in the outer Gulf while swallowing towards to the inner Gulf (max 15 m). The middle and inner Gulf in total have 36 km long and 6-8 km wide. The major sources of pollution flow to the Gulf are streams and over hundreds of small domestic discharges.

The industry in Izmir is densely populated in comparison to the middle and the outer Gulf. The major sources of income are food, oil, tannery, chemical industry, soap, paint production, paper and pulp mills, wood processing, cement factory, metal processing and beverage bottling factory (9).

Figure 1: Location map for the study areas.

Figure 2: Location map of four sampling stations.

Sampling and Preparation

The young sediment drill hole samples were collected from the 4 stations in the Gulf of Izmir (38° 41'-38° 21' N, 26° 30'-27° 08' E) as a part of a drilling platform of the YUMUN01 in 2013 (Figure 2). The points of the core drilling method were selected by considering paleontological and sedimentological features. Investigated areas are Karsiyaka BH-1, Bayrakli BH-5, Inciralti BH-2 and Cesmealti BH-6, and the depths of core sediment samples change between 0 to 30 meters (Table 1). In a vertical distribution of the drilling sediment samples have different components (Table 2). The components of the sediments in Karsiyaka BH-1 and Bayrakli BH-5 are blackish gray sandy clay with high water content (slime), Inciralti BH-2 is less sandy, greenish gray colored clay (slime), and Cesmealti BH-6 is blackish gray colored sandy shelled clay with high water content (slime).

The core samples were collected in the form of the 1.5 m maneuvers and lined up in core boxes. At the end of the sounding, the sediment samples placed in a plastic bag immediately and brought to the laboratory. The samples were kept at room temperature for one week and prepared for radioactivity analysis.

The bottom sediments of the Gulf of Izmir are affected by the meteorological activities, waves, topographic characteristics of the land, and morphological properties of the undersea (11). The Gulf's sediment grain sizes turn into minor as it goes from the coast to deeper sea levels (12).

Experimental Setup

The activity concentrations of the gross alpha and beta in the core sediment samples were measured using a gas proportional α/β counter of low background multiple detector type (Berthold LB-770). The dried sediments were ground and then powdered before analyzing. Approximately 130 mg of each powder were weighed on a sensitive balance and transferred into the empty planchet. Distilled water was dropped homogeneously and spread the sediments on

the planchet.

Table 1: Properties of the drilling samples (13).

Sample No	Depth of Sample (m)	Quantity of Sample (g)	Sample Coordinates (WGS-84, 6⁰)	
			X	**Y**
Karşıyaka BH-1	12,50-13,50	1047	4255697	510456
Bayraklı BH-5	6,50-7,50	1021	4258790	513920
İnciraltı BH-2	10,00-12,00	1023,5	4253810	502590
Çeşmealtı BH-6	4,50-5,00	1035,7	4249770	478170

Each sediment sample was dried in an oven at 105 °C for 2 hours. The sediments were kept in a desiccator to return to room temperature without moisture. After these procedures, 100 mg of the each sediment were taken, again weighed on a sensitive balance, and dried in an oven at 105 °C for 2 hours. They were kept in a desiccator repeatedly.

Finally, all sediments were counted for 1000 min in 2 cycles by LLB 770 system to obtain gross alpha and gross beta activity concentrations. The system was calibrated for gross alpha and gross beta radioactivity by using the same concentration standard and known sample geometries of Am-231 and Sr-90 solutions (14).

Activities were calculated by using equations below:

$$Activity(a) = \frac{NetCounting}{60 \times Efficiency \times Mass(kg)}$$ (Eq. 1)

$$Activity(b) = \frac{N(a) - B(crosstalk)}{60 \times Efficiency \times Mass(kg)}$$

(Eq. 2)

RESULTS AND DISCUSSIONS

Gross alpha and gross beta radioactivity concentrations in sediment samples of the Gulf of Izmir are given in Table 3. The activity concentrations of the gross alpha and beta values are ranged from 0.49 to 1.6 Bq kg^{-1} with a mean of 0.77 Bq kg^{-1} and 3.05 to 5.20 Bq kg^{-1} with a mean of 3.66 Bq kg^{-1}, respectively.

According to Table 3, the gross beta activity is higher than the corresponding gross alpha activity concentrations at all locations. K-40 isotope in molten state potassium results in high radioactivity in seawater. Thorium isotope's solubility is low in seawater, so gross alpha activity comes from uranium and radium radionuclides (15).

Table 2: The vertical distribution of the drilling samples (13).

DEPTH (m)	Karşıyaka BH-1	Bayraklı BH-5	İnciraltı BH-2	Çeşmealtı BH-6
0,0-1,0	Sea Water (0,0-11,0 m)	Sea Water (0,0-4,0 m)	Sea Water (0,0-10,0 m)	Sea Water (0,0-10,0 m)
1,0-2,0				
2,0-3,0				
3,0-3,5				
3,5-4,0				
4,0-4,5		Blackish gray sandy clay with high water content (Slime)		Blackish gray colored sandy shelled clay with high water content (Slime)
4,5-5,0				
5,0-5,5				Greenish yellow-gray colored, thin gravelly sandy clay and clayey sand
5,5-6,0				
6,0-6,5				
6,5-7,0				
7,0-7,5				
7,5-8,0				
8,0-8,5				
8,5-9,0				
9,0-10,0				
10,0-10,5			Less sandy, greenish gray colored clay (slime)	Grayesh yellow colored, claystone inter-baded midium-thin layered sandston
10,5-11,0				
11,0-12,0	Blackish gray sandy clay with high water content (Slime)			
12,0-13,0		Blackish brown, silty clayey sand with less gravel		
13,0-13,5				
13,5-14,0				
14,0-14,5				
14,5-15,0				
15,0-15,5				
15,5-16,0	Less clayey sand		Clayey, greenish gray colored thin sand	
16,0-17,0				
17,0-18,0				
18,0-19,0				
19,0-20,0	Clayey gravelly sand (19,0-30,0)	Brown colored, thin gravelly sandy clay	Yellowish gray colored less sandy clay	
20,0-21,0				
2,00-21,5				
21,0-22,0				
22,0-23,0		Brown colored, thin gravelly clayey sand (22,00-25,00)		
23,0-24,0				
24,0-25,0				
25,0-30				
	End of Driling 30,00 m	End of Driling 30,00 m	End of Driling 30,00 m	End of Driling 30,00 m

There is no regulatory standard for radiological contaminants in gross alpha and gross beta activity concentrations in sediments for comparing obtained data. Table 4 shows a comparison of results with various studies.

The results showed that gross alpha and gross beta activity concentrations in sediment samples were relatively higher than the majority of the other works. The differences can be explained by geological features of the sea and the content of mineral substances. The gross alpha activity concentrations in sediments are illustrated as the entire radioactivity of all alpha emitters that is mainly coming from the uranium and radium isotopes. Natural radionuclides are found mostly in high concentrations in volcanic, phosphate, granite, and salt rocks (16). Andesite-type volcanic rocks and their decomposition products are highly widespread around the Gulf of Izmir (17). BH-1, BH-2 and BH-5 shows similar results than BH-6 because Cesmealti (Urla) covers volcanic density stream sediments (18).

The highest concentrations of both gross alpha and gross beta were found at Cesmealti BH-6 sampling site. It may be due to high amount of potassium entering the sea. Moreover, agricultural activities may cause greater beta activity as a result of the extensive usage of fertilizers (2, 4).

Table 3: The gross alpha and beta radioactivity concentrations in core sediments.

Locations	Gross α (Bq/kg)	Gross β (Bq/kg)
Karşıyaka BH-1	557±79	1064±64
İnciraltı BH-2	592±77	1238±85
Bayraklı BH-5	537±77	993±60
Çesmealtı BH-6	1800±207	1842±102

Table 4: Comparison of the concentration range of radionuclides in sediments from different studies.

Stations	Gross α (Bq/kg)	Gross β (Bq/kg)	References
Gulf of Izmir	537-1800	993-1842	Present study
Maritza River, Turkey	30-200	6-1397	(2)
Tundja River, Turkey	30-158	87-486	(2)
Bosna River, Bosnia	215-610	495-628	(4)
Bendimahi River, Turkey (in May)	782-4596	482-10372	(19)
Bendimahi River, Turkey (in August)	580-5824	303-9702	(19)

CONCLUSION

The main goal of this study was to obtain the background information about natural radioactivity in the intensive areas for the Gulf of Izmir by determining gross alpha and gross beta activity concentrations in sediment samples. The results indicated relatively high concentrations in the sediments that might be geological formation, mineral content and agricultural activities heavily affected the occurrence of natural radioactivity. The number of analyzing samples has to be done more, and the radiological levels and chemical parameters must be determined in air and water in the Gulf of Izmir to obtain a statistical conclusion.

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