International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:10, No:3, 2016

Distribution of Gamma Radiation Levels in Core Sediment Samples in Gulf of Izmir: Eastern Aegean Sea, Turkey

D. Kurt, Z. U. Yümün, I. F. Barut, E. Kam

Abstract**—**Since the development of the industrial revolution, industrial plants and settlements have spread widely along coastlines. This concentration of development brings environmental pollution to the seas. This study focuses on the Gulf of Izmir, a natural gulf of the Eastern Aegean Sea, located west of Turkey. Investigating marine current sediment is extremely important to detect pollution. This study considered natural radioactivity pollution of the marine environment. Ground drilling cores (the depth of each sediment is different) were taken from four different locations in the Gulf of izmir, Karşıyaka (12.5-13.5 m), Inciralti (6.5-7.5 m), Cesmealti (4.5-5 m) and Bayrakli (10-12 m). These sediment cores were put in preserving bags with weight around 1 kg, and were dried at room temperature to remove moisture. The samples were then sieved into fine powder (100 mesh), and these samples were relocated to 1000 mL polyethylene Marinelli beakers. The prepared sediments were stored for 40 days to reach radioactive equilibrium between uranium and thorium. Gamma spectrometry measurement of each sample was made using an HPGe (High-Purity Germanium) semiconductor detector. In this study, the results display that the average concentrations of the activity values are 8.4 ± 0.23 Bq kg^{-1}, 19.6 ± 0.51 Bq kg^{-1}, 8 ± 0.96 Bq kg^{-1}, 1.93 ± 0.3 Bq kg^{-1}, and 77.4 ± 0.96 Bq kg^{-1}, respectively.

Keywords**—**Gamma, Gulf of Izmir, Eastern Aegean Sea, Turkey, natural radionuclides, pollution.

I. Introduction

EVERY living creature is exposed to a wide range of natural radiation that occurs spontaneously in nature, and anthropogenic radioactivity originates from human activities. [1]. There are two main factors which cause natural radiation; cosmic rays and terrestrial gamma rays.

The ozone layer usually shields cosmic rays to protect the Earth's absorption of radiation and as a result, cosmic rays are not damage people so much. However, because external radiation is stored in the Earth's crust, people are always exposed to natural radioactivity. The main radionuclides are U-238, Th-232 and their decay products and natural K-40. These radionuclides are stored on the soil surface, then washed and drifted through rivers carrying by cause of rainwater, fallout, erosion, and finally entering the marine environment [2].

In the last three decades, particularly after the Chernobyl and Fukushima Daiichi nuclear reactor accidents, many researchers have given importance to the study of environmental radioactivity. As a result of nuclear accidents and nuclear weapon tests, the radioactive particles (fallout) emerge to the ground; some of the important fission products are Cs-137, Sr-90, and I-131. These are durable and anthropogenic radioactive elements, and pass to the marine environment from the air [3].

This study aims to investigate both natural and artificial radioactive pollution in drilling core sediments in the Gulf of Izmir by using a gamma spectrometer analyzing system.

II. Experimental

A. Study Area

The study area, Gulf of Izmir, is in the west of Izmir (Turkey) province. The Gulf occurs to sidles up to the Aegean Sea approximately 68 km. Settlements are more intensive in İzmir province in the west of the Gulf. The Gulf of Izmir is one of the magnificent natural gulfs of the Aegean Sea, covering over 200 km^2 of areas and containing 11.5 billion m^3 of water. Because of its hydrological and ecological characteristics, the Gulf of Izmir is divided in three sections; the inner, middle and outer gulfs. The inner gulf has a depth of no more than 20 meters, and it is suitable for maritime transports. The middle and outer gulfs have maximum depths of 45 and 75 meters respectively [4].

In terms of economic characteristics, Izmir has become an important industrial center and has a population that is constantly increasing. The most common commercial activities in the region are food processing, beverage manufacturing and bottling, textile industry, oil, soap and paint production, paper, metal and wood processing, and chemical industries [5]. In addition, both commercial and subsistence fishing along the coast of Izmir has become an important sector as a source of livelihood.

B. Sampling and Preparation

The sediments were collected from the Karşıyaka BH-1, İnciraltı BH-2, Bayraklı BH-5, and Çeşmealtı BH-6 locations. These drilling cores were taken considering the Gulfs current pollution (Table II). In this study, the drilling method was used because the soundings were to describe the sediment logic and paleontological features. Samples were collected by the YUMUN01 drilling platform, and the samples' stations are indicated in Fig. 2. Considering the lithological properties, the vertical distribution with depth of the soundings obtained is given in Table I, and the sediments were the highest levels of

Dilek Kurt is with the Yıldız Technical University, Istanbul, Turkey (e-mail: dilek_uzunali@hotmail.com).

ground profile. These samples are commonly blackish gray sandy clay with high water content (slime).

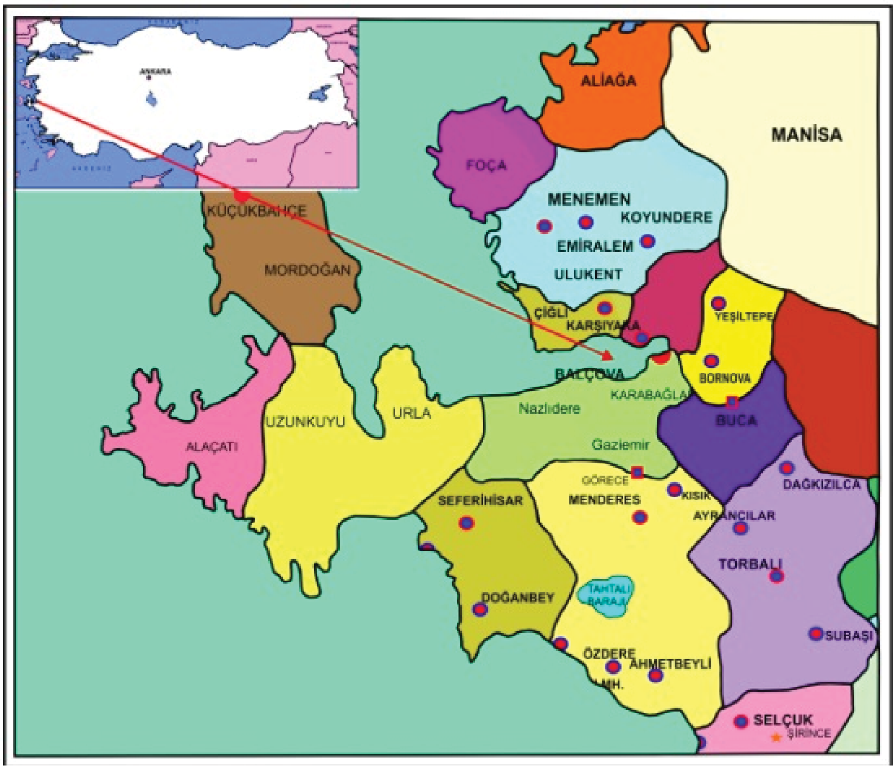

Fig. 1 Location map of study area

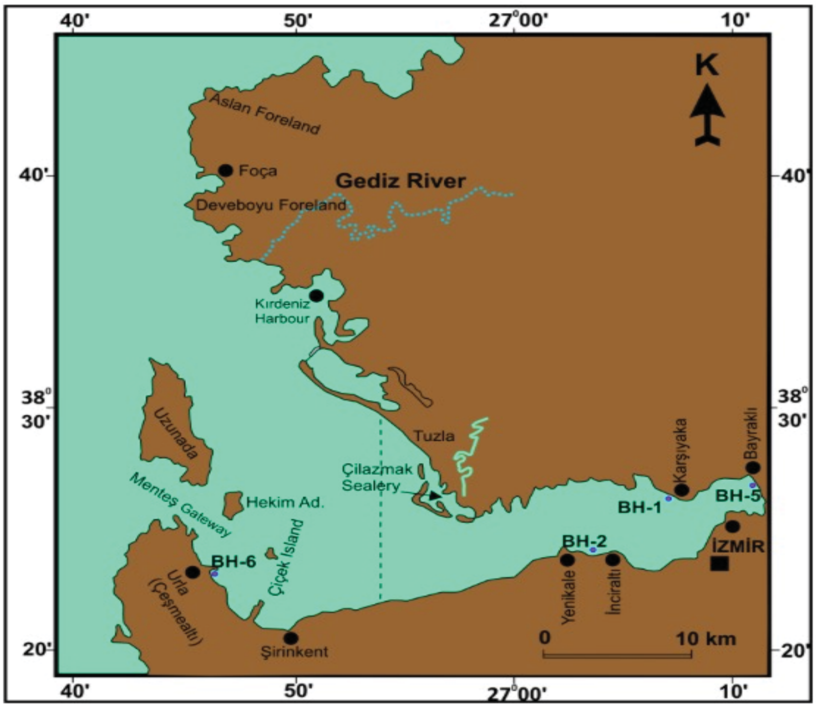

Fig. 2 Location map of four points where taken core samples at İzmir Bay

TABLE I
VERTICAL DISTRIBUTION OF DRILLING SAMPLES

<table>
<tr><th>DEPTH (m)</th><th>Karşıyaka BH-1</th><th>Bayraklı BH-5</th><th>İnciraltı BH-2</th><th>Çeşmealtı BH-6</th></tr>
<tr><td>0,0-1,0</td><td rowspan="18">Sea Water
(0,0-11,0 m)</td><td rowspan="5">Sea Water
(0,0-4,0 m)</td><td rowspan="16">Sea Water
(0,0-10,0 m)</td><td rowspan="6">Sea Water
(0,0-10,0 m)</td></tr>
<tr><td>1,0-2,0</td></tr>
<tr><td>2,0-3,0</td></tr>
<tr><td>3,0-3,5</td></tr>
<tr><td>3,5-4,0</td></tr>
<tr><td>4,0-4,5</td><td rowspan="14">Blackish gray sandy clay with high water content (Slime)</td></tr>
<tr><td>4,5-5,0</td><td>Blackish gray colored sandy shelled clay with high water content (Slime)</td></tr>
<tr><td>5,0-5,5</td><td rowspan="9">Greenish yellow-gray colored, thin gravelly sandy clay and clayey sand</td></tr>
<tr><td>5,5-6,0</td></tr>
<tr><td>6,0-6,5</td></tr>
<tr><td>6,5-7,0</td></tr>
<tr><td>7,0-7,5</td></tr>
<tr><td>7,5-8,0</td></tr>
<tr><td>8,0-8,5</td></tr>
<tr><td>8,5-9,0</td></tr>
<tr><td>9,0-10,0</td></tr>
<tr><td>10,0-10,5</td><td rowspan="8">Less sandy, greenish gray colored clay (slime)</td><td rowspan="21">Grayish yellow colored, claystone inter-banded medium-thin layered sandstone</td></tr>
<tr><td>10,5-11,0</td></tr>
<tr><td>11,0-12,0</td><td rowspan="7">Blackish gray sandy clay with high water content (Slime)</td></tr>
<tr><td>12,0-13,0</td><td rowspan="9">Blackish brown, silty clayey sand with less gravel</td></tr>
<tr><td>13,0-13,5</td></tr>
<tr><td>13,5-14,0</td></tr>
<tr><td>14,0-14,5</td></tr>
<tr><td>14,5-15,0</td></tr>
<tr><td>15,0-15,5</td><td rowspan="5">Clayey, greenish gray colored thin sand</td></tr>
<tr><td>15,5-16,0</td><td rowspan="4">Less clayey sand</td></tr>
<tr><td>16,0-17,0</td></tr>
<tr><td>17,0-18,0</td></tr>
<tr><td>18,0-19,0</td><td rowspan="5">Brown colored, thin gravelly sandy clay</td></tr>
<tr><td>19,0-20,0</td><td rowspan="8">Clayey gravelly sand
(19,0-30,0)</td><td rowspan="8">Yellowish gray colored less sandy clay</td></tr>
<tr><td>20,0-21,0</td></tr>
<tr><td>2,00-21,5</td></tr>
<tr><td>21,0-22,0</td></tr>
<tr><td>22,0-23,0</td><td rowspan="4">Brown colored, thin gravelly clayey sand
(22,00-25,00)</td></tr>
<tr><td>23,0-24,0</td></tr>
<tr><td>24,0-25,0</td></tr>
<tr><td>25,0-30</td></tr>
<tr><td></td><td>End of Drilling 30,00 m</td><td>End of Drilling 30,00 m</td><td>End of Drilling 30,00 m</td><td>End of Drilling 30,00 m</td></tr>
</table>

Undisturbed core samples were brought to the laboratory and were put in preserving bags with weight around 1 kg, and were dried at room temperature for a week to remove moisture. The samples were transferred to the Çekmece Radioactivity and Analytical Measurement Section, and then they were digested into the fine dust to cross through a 100-sieve filter. The powdered samples were put in 1000 mL Marinelli beakers and they were sealed to avoid contact with air. The samples were weighed and then they were kept for almost 40 days in order to achieve equilibrium between radium, thorium, and their decay products [6].

C. Gamma Spectrometric Analysis

Gamma spectrometry analysis (Canberra GX5020) was carried out with an HPGe detector, which was joined to a coaxial high-purity germanium detector [7]. The setup was calibrated by using a solid, diverse gamma emitting reference sources in a 1 L Marinelli beaker. The sources were selected photo peaks for the full energy peak efficiency. The gamma activity relied on ^{238}U series, 609.3 keV; ^{232}Th series, 583 keV; ^{228}Ac, 911.2 keV; ^{226}Ra, 185.7 keV; ^{137}Cs, 661.7 keV; ^{40}K, 1460,8 keV. Every sediment was counted 750 000 s to have numerical reliable conclusions. Finally, gamma activity concentrations were determined in units of Bq kg^{-1} after altering for background and Compton input.

III. RESULTS AND DISCUSSION

The activity concentration of U- 238, Th- 232, Ra- 226, K-40, and Cs- 137 respectively range from 1 to 18 Bq kg^{-1}, 12 to

40 Bq kg^{-1}, 0.24 to 13 Bq kg^{-1}, 71 to 82 Bq kg^{-1}, and background to 3 Bq kg^{-1}. The average activity concentrations are in turn 8.369 ± 0.23 Bq kg^{-1}, 19.6 ± 0.51 Bq kg^{-1}, 8 ± 0.96 Bq kg^{-1}, 77.38 ± 0.96Bq kg^{-1}, and 1.93 ± 0.3 Bq kg^{-1}. The radionuclides activity values for each sample are given in Table III.

TABLE II
PROPERTIES OF DRILLING SAMPLES

Sample No	Depth of Sample (m)	Quantity of Sample (gr)	Sample Coordinates (WGS-84, 6^0)	
			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
Çesmealtı BH-6	4,50-5,00	1035,7	4249770	478170

International average limits of radionuclides are U- 238, 35 Bq kg^{-1}; Th- 232, 30 Bq kg^{-1}; Ra- 226, 35 Bq kg^{-1}; K- 40, 400 Bq kg^{-1} [8]. In this study, all results are lower than UNSCEAR reports. The obtained numerical results are varied because the sediment samples have different characteristics such as physical, chemical and geological forms and their location in space [9].

As the results show, the highest activity absorption is that of K-40. Since potassium is widely used in fertilizers and he chosen stations are quite close to the shore, there may be releases from fertilized soil affecting the radioactivity concentrations.

Table IV displays that a comparison of radioactivity concentrations in marine sediments with other locations of the worldwide. Fig. 3 shows the distributions of the indicated radionuclides activity concentrations in four different locations in the Gulf of Izmir.

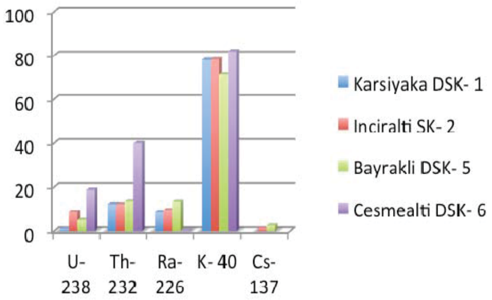

Fig. 3 Distribution of the activity concentration (Bq/kg)

IV. CONCLUSION

The radioactivity concentrations of Ra-226, U-238, Th-232, K- 40 and Cs- 137 in core sediments collected from four different locations in Aegean Sea were analyzed. The greatest activity concentrations of Th- 232 and K-40 were observed in sediments from Izmir Bay. The highest activity concentrations of ^{40}K were from Çesmealtı. The fission product of ^{137}Cs was found at almost background levels for all locations, which means that there is no fallout of nuclear power plant or nuclear weapon tests. The outcomes of the study can be used as a criterion for forthcoming research and the obtained data would be useful for radiological mapping of the particular areas.

TABLE III
ACTIVITY CONCENTRATION OF U-238, TH-232, RA-226, CS-137 AND K-40 IN MARINE SEDIMENT SAMPLES (BG/KG)

Sample Locations	Activity (Bq kg^{-1})				
	U- 238	Th- 232	Ra- 226	K- 40	Cs- 137
Karşıyaka DSK- 1	1.016 ± 0.033	12,36 ± 0.45	8.5 ± 1.24	78 ± 1.03	Background
İnciraltı SK- 2	8.64 ± 0.22	12.3 ± 0.34	9.53 ± 0.98	78.2 ± 0.74	1.26 ± 0.21
Bayraklı DSK- 5	5 ± 0.16	13.7 ± 0.48	13.6 ± 1.61	71.4 ± 0.97	2.59 ± 0.38
Çeşmealtı DSK- 6	18.82 ± 0.5	40 ± 0.78	0.24 ± 0.02	81.9 ± 1.08	Background

TABLE IV
COMPARISON OF DRY WEIGHT RADIOACTIVITY CONCENTRATIONS OF KARŞIYAKA, İNCIRLI, BAYRAKLI AND ÇESMEALTI SEDIMENTS WITH OTHER PRESENT WORKS

Regions	Activity (Bq kg^{-1})					
	U-238	Th-232	Ra-226	K-40	Cs-137	References
Red Sea	25.3	31.4	32.4	427.5	-	[10]
East Malaysian	-	-	30	462	-	[11]
Algeria	10.8	6.5-31.7	-	55.9- 607.4	1.9- 8.5	[12]
Norwegian Sea	-	-	-	-	6- 272	[13]
Caspian Sea (Iran)	61	49	-	537	-	[14]

REFERENCES

[1] Isinkaye M. O., Emelue H. U., "Natural radioactivity measurements and evaluation of radiological hazards in sediment of Oguta Lake, South East Nigeria," Journal of Radiation Research and Applied Sciences, vol. 8, issue 3, July 2015, pp. 459- 469.

[2] El Samad, O., Baydoun, R., Nsouli, B., & Darwish, T., "Determination of natural and artificial radioactivity in soil at North Lebanon province," Journal of Environmental Radioactivity, vol. 125, pp. 36- 39, Nov. 2013.

[3] Yii Mei- Wo, Nurrul Assyikeen Md., Jaffary and Zaharudin Ahmad, "Radiation Hazard From Natural Radioactivity in the Sediment of the East Coast Peninsular Malaysia Exclusive," Economic Zone (EEZ) Vol. 15 No. 2 (2011), pp. 202- 212

[4] Gülşen, F.D., "Historical Trends of Heavy Metals in Sediment From Izmir Bay" (2014), pp. 25

[5] Küçüksezgin, F., Kontas, A., Altay, O., Uluturhan, E., Darılmaz, E., "Assessment of marine pollution in Izmir Bay: nutrient, heavy metal and total hydrocarbon concentrations," Environment International, vol. 32, pp. 41- 51 (2006).

[6] Aközcan S., "Distribution of natural radionuclide concentrations in sediment samples in Didim and Izmir Bay (Aegean Sea-Turkey)," Journal of Environmental Radioactivity, vol. 112, pp. 60- 63, Oct. 2012.

[7] Bozkurt A., Yorulmaz N., Kam E., Karahan G., Osmanlioglu A. E., "Assessment of Environmental Radioactivity for Sanliurfa Region of Southeastern Turkey," Radiation Measurements Vol 42, Issue 8 (2007), pp. 1387- 1391

[8] UNSCEAR, 2000. Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the effects of atomic radiation. Report to General Assembly with Scientific Annexes. United Nations, New York.

[9] Abdi, M.R., Kamali, M., Vaezifar, S., "Distribution of radioactive pollution of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs in northwestern coasts of Persian Gulf, Iran," Marine Pollution Bulletin, vol. 56, issue 4, April 2008, pp. 751- 757.

[10] M.W. Yii, A. Zaharudin, I. Abdul-Kadir, "Distribution of naturally occurring radionuclides activity concentration in East Malaysian marine sediment," Applied Radiation and Isotopes, vol. 67, issue 4, April 2009, pp. 630- 635.

[11] El Mamoney, M.H., Khater, A.E.M., "Environmental characterization and radio- ecological impacts of non-nuclear industries on the Red Sea coast," Journal of Environmental Radioactivity, vol. 73, issue 2, 2004, 151- 168.

[12] Noureddine, A., Benkrid, M., Hammadi, A., Boudjenoun, R., Mnacer, M., Khaber, A. and Kecir, M. S., "Radioactivity Distribution In Surface And Core Sediment Of The Central Part Of The Algerian Coast: An Estimation Of The Recent Sedimentation Rate," Mediterranean Marine Science, Vol. 4, no. 2, pp. 53- 55 (2003).

[13] Radioactivity in the Marine Environment 2011, Results from the Norwegian Marine Monitoring Programme (RAME), pp. 22

[14] Abdi, M.R., Hassanzadeh, S., Kamali, M., Raji, H.R., "^{238}U, ^{232}Th, ^{40}K and ^{137}Cs activity concentrations along the southern coast of the Caspian Sea, Iran," Marine Pollution Bulletin, vol. 58, issue 5, May 2009, pp. 658–662.