Journal of the Turkish Chemical Society Section: A Chemistry
TURKISH CHEMICAL SOCIETY

The Origin of the Gross Alpha and Beta Radiation Values of the Waters of Çanakkale Strait (Çanakkale/Turkey)

Erol KAM*[1], Melike ÖNCE[2] and Sevinç YÜMÜN[2]

1. Yildiz Technical University, Faculty of Arts and Sciences, Physics Department, Davutpaşa Campus, 34220 Esenler/ İstanbul, TURKEY.
2. Namık Kemal University, Çorlu Engineering Faculty, Environmental Engineering Department, 59860 Çorlu, Tekirdağ, TURKEY.

Abstract: This study is an evaluation of radioactivity the waters of the Çanakkale Strait. The gross alpha- and gross beta-radioactivity counts (Berthold, LB770-PC 10-Channel Low-Level Planchet Counter) were calculated for seawater samples taken from eight different regions of the Çanakkale Strait (Şevketiye, Seddülbahir, Lapseki, Kumkale, Burhanlı, Dereliman, Eceabat, and Gelibolu). In the samples, the gross alpha-radiation ranged between 0.064 and 0.046Bq/L and the gross beta-radiation ranged between 14.325 and 10.532 Bq/L. The highest gross alpha-radiation concentration was measured at Gelibolu (0.064 Bq/L) while the lowest (0.046 Bq/L) was measured at Şevketiye. The highest value for gross beta-radiation concentration (14.325 Bq/L) was measured in Seddülbahir, and the lowest value (10.532 Bq/L) was measured in Dereliman. The gross alpha-radiation concentrations measured by the Turkish Atomic Energy Authority in Çanakkale's drinking and utility water ranged between 0.05 and 0.400 Bq/L, and the highest values (0.300 to 0.400Bq/L) were found in the Ezine county. Gross beta-radiation concentrations ranged from 0.05 to 0.500 Bq/L, and the highest values (from 0.400 to 0.500 Bq/L) were recorded in Lapseki province. The gross beta-radiation concentrations in both the sample results and TAEK data were determined to be high in Lapseki and its vicinity. Comparing the mean gross beta- and alpha-radiation concentration values of the Çanakkale Strait with the Bosphorus, the Sea of Marmara and the Black Sea, beta-radiation values in the study area were very high. Gross alpha-radiation results were low in the study area compared to other regions. Evaluating the results against the legal limit threshold, the results were above the legal limit for gross beta-radiation. This result indicates that the water is affected by the rocks through which it passes.

Keywords: Gross alpha radiation; gross beta radiation; Çanakkale Strait; sea water.
*Corresponding author. E-mail: erolkam@yildiz.edu.tr

Submitted: February 19, 2017. **Accepted:** July 13, 2017.

Cite this: Kam E, Önce M, Yümün S. The Origin of the Gross Alpha and Beta Radiation Values of the Waters of Çanakkale Strait (Çanakkale/Turkey). JOTCSA. 2017;4(3):729–38.

DOI: http://doi.org/10.18596/jotcsa.292895.

***Corresponding author. E-mail:** erolkam@hotmail.com.

INTRODUCTION

Radionuclides (U-238, Th-232, K-40, etc.) found naturally in the structure of rocks are dissolved in various ways and mix with the sea environment. Since water helps transport radionuclides, marine ecosystems are heavily influenced by radioactive materials. Radioactivity in sea water is mainly due to the presence of radioactive elements in the Earth's crust (1). The radioactive concentrations of waters passing through volcanic masses are higher than those passing through sedimentary masses (2). Natural sources are significant in radiation dose assessments because the radiation people are exposed to during their lifetimes consists of 85% emitted from natural sources and 15% emitted from artificial sources (3, 4).

Sodium (Na-23), potassium (K-40), calcium (Ca-45), thorium (Th) and uranium (U) found in marine waters are natural radionuclides and produce various types of radiation (5). The most dangerous rays emitted by radionuclides are neutron, gamma, alpha and beta particles. Alpha decay happens when the nucleus spontaneously releases an alpha particle. The alpha particle is a helium nucleus and consists of two protons and two neutrons. Almost all alpha emitters are naturally occurring radioactive materials such as uranium, radium and their isotopes (6) because thorium has low solubility in seawater (7).

There are two types of beta-radiation. The beta (+) particle is identical to the electron and emanates from the nucleus. A beta-particle is (−e) charged, and its mass is equal to 1/7347 of the alpha particle. Beta-particles are more penetrating than alpha-particles (6). These particles released from the radionuclides penetrate the DNA strands – carrying the cell's genetic information – leading to breakage and can cause the generation of chemical toxins. If the damage is not too great, breaks in the DNA can be repaired. However, faults can occur during this repair and chromosomes may form containing false information. These false codes cause morphological changes in living organisms (8). Kam et al. (2010) measured the radon concentrations in the air and the gross alpha and beta radiation concentrations in the drinking waters in the Tekirdağ region (9). The researchers, in their study, measured the concentrations of natural radionuclides in the soil around Çankırı and the surrounding area, the gamma dose rates in the outdoor environment, and the gross alpha- and beta-radiation and indoor radon concentrations in the drinking water (10). Kam et al. (2016) measured the gamma dose values in Kulakçayırı (Istanbul) Lake and evaluated their radioactive properties. It was determined that the gamma dose values in this area of the Black Sea coast not increase substantially and remained at standard values (11).

Yümün (2017) conducted a heavy metal analysis in the drilling and core samples in the western Sea of Marmara to reveal the pollution. The relationship between heavy metal concentrations reported by Yümün (2017) and the radioactivity values obtained in this study was examined regarding their origin (12). Yümün et al. (2016) investigated the foraminifera, ostracods and mollusk communities, and the effects of heavy metals on these aquatic living organisms in İzmir Bay (Karşıyaka, Bayraklı, İnciraltı, and Çeşmealtı) (13). Yümün and Kam (2017) investigated 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 (14).

In this study, the gross alpha- and gross beta-radiation analyses were performed in seawater samples taken from eight different points in the Çanakkale Strait (Fig. 1.)

The results of the seawater analyses made were evaluated by comparing them with legal limits for gross alpha- and beta-radiation concentrations of drinking and utility water in Çanakkale province, as determined by the Turkish Atomic Energy Authority. Furthermore, the results of the analyses carried out in previous seasons in the Sea of Marmara, the Bosphorus, and the Black Sea waters were also compared.

Geological structure and radioactivity in the Area of Investigation

The Middle-Upper Miocene continental and marine sedimentary rocks that collapsed in the Çanakkale basin are exposed along the eastern margin of the Dardanelles Strait. These sediments are located on the Paleozoic schists, marbles, quartzites, Permian-Triassic ophiolites and Eocene volcanic rocks between Çanakkale and Troy. The unit is unconformably overlain by Eocene volcanic and volcaniclastic deposits in the vicinity of Lapseki in the north of Çanakkale. Sedimanter rock units consist of Middle Miocene Sarıyar formation and Upper Miocene Çanakkale formation (15).

It is known that the ratio of natural radionuclide is high in the study area consisting of volcanic and granitic rocks. Because natural radionuclides are abundant in volcanic, phosphate, granite and salt rocks. Particularly granite rocks contain significant amounts of Thorium (16). Ezine and its surroundings are known with whose high radioactivity. The territory of the region contains high rates of Ra-226, Th-232, and K-40. Ezine and its environment are also known for their high radioactivity. The territory of the region contains high rates of Ra-226, Th-232, and K-40 (17).

MATERIALS AND METHODS

Sample collection area

The study area is the Çanakkale Strait, which provides a link between the Turkish maritime system and the Aegean and Mediterranean seas, and is geopolitically important. Çanakkale Strait, which connects Thrace and Anatolia, has a very complex structure in terms of geological and morphological features. Geologically, it runs along the deepest point of a depression formed by Neogene sediments. The basins of both the Bosphorus and the Neogene basement were cut by an Upper Pliocene-age abrasive surface descending towards the axis of the Bosphorus. The Çanakkale Strait was built on the depressions that formed the surface of this erosion and was later buried with its tributaries, to take its current form. The Çanakkale Strait has a length of 61 km, and its width varies from 1.2 to 6 km, with a maximum depth of 82 m and an average depth of 55 m (18).

Sample collection

Seawater samples were taken from the Çanakkale Strait at eight different locations (Burhanlı, Dereliman, Eceabat, Gelibolu, Kumkale, Lapseki, Seddülbahir, Şevketiye) filling 2.5 Lt. plastic bottles; nitric acid was added to fix them at a pH of 2. Samples were collected using the YUMUN 01 drilling platform. Nitric acid prevents the growth of microorganisms in the sample and maintains a constant pH. The sample locations and coordinates are shown in Table 1 and Fig. 1.

Table 1: Core Sample coordinates.

Sample Code	Sample Amount (Lt)	COORDINATE	
		Latitude (X)	Longitude (Y)
1-BURHANLI (Ç.kale)	2.5	463791	4463231
2-DERELİMAN (Ç.kale)	2.5	449212	4443871
3-ECEABAT (Ç.kale)	2.5	445495	4448541
4-GELİBOLU (Ç.kale)	2.5	471306	4478121
5-KUMKALE (Ç.kale)	2.5	436965	4428080
6-LAPSEKİ (Ç.kale)	2.5	473852	4466935
7-SEDDÜL BAHİR (Ç.kale)	2.5	430862	4432732
8-ŞEVKETİYE (Lapseki)	2.5	489498	4471929

Radioactivity measurements

Analyses of the samples were performed at the Çekmece Nuclear Research and Training Center laboratories. Each sample was first filtered, and then a small amount of nitric acid was added to prevent moisture in the sample container (19). Each sample was counted for gross-alpha and gross-beta radioactivity in a low-background gas-flow proportional counter (Berthold, LB770-PC 10-Channel Low-Level Planchet Counter). The measured results were obtained in units of Bq kg^{-1}. The water samples were prepared for radionuclide analyses according to the routine procedure outlined by Karahan et al. (2000) (20).

When evaluating gross alpha radioactivity in the water, attention must be paid to the amount of dissolved matter in the water sample (21).

The low-level counting system is commonly used for measuring environmental samples with low natural background radiation. Its calibration was carried out with standard solutions that contained known ^{241}Am activity for alphas and known ^{90}Sr activity for betas, which were similar to the sample characteristics.

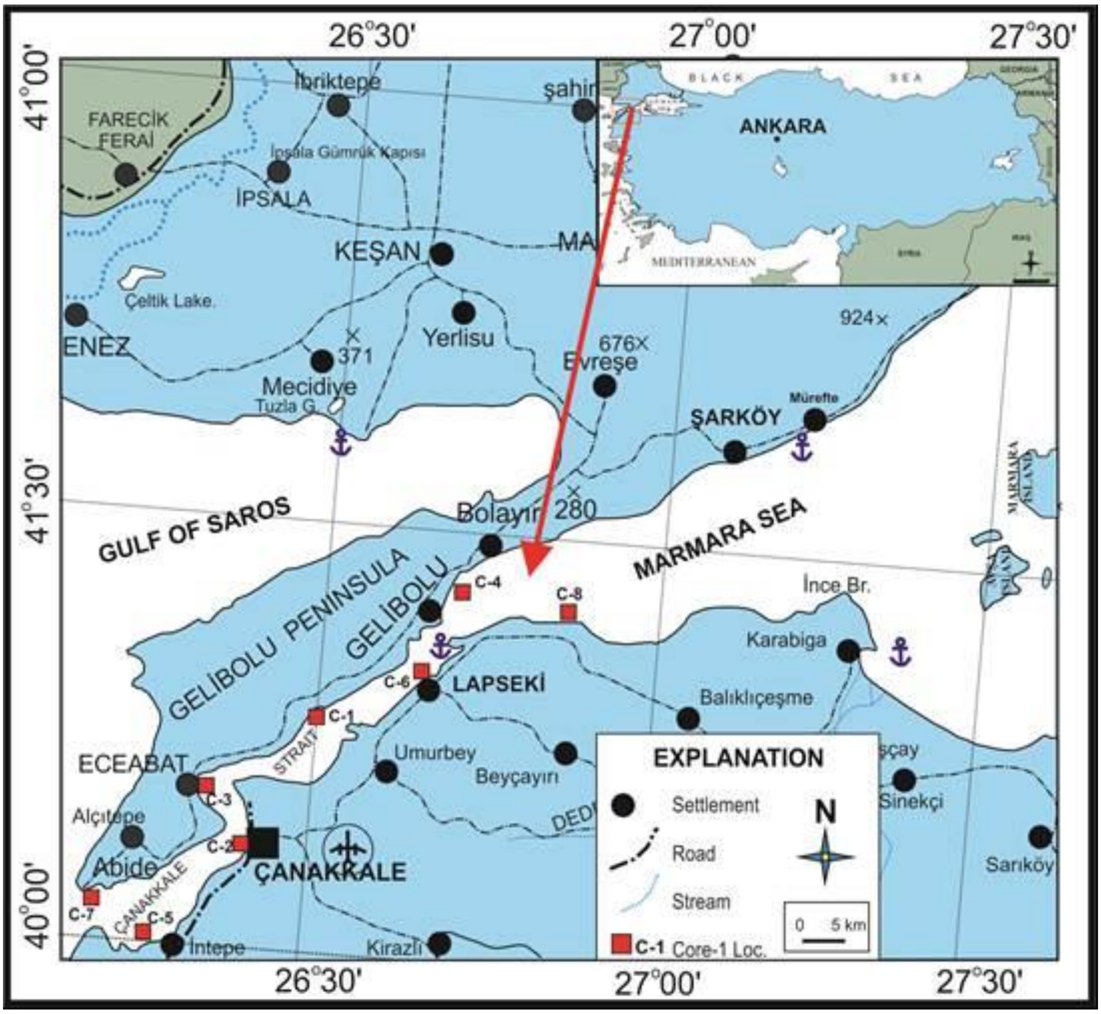

Figure 1: Location map of four points where core samples were taken in the Çanakkale Strait (14)

RESULTS AND DISCUSSION

The gross alpha- and beta-radiation activity values of seawater samples from eight different locations are given in Table 2. In the sea water samples, the average gross alpha- and gross beta-radiation concentration values were 0.046 Bq/L and 14.325 Bq/L, respectively. The highest value for gross alpha-radiation (0.064 Bq/L) was obtained from the sample taken at Gelibolu, while for gross beta-radiation, it was obtained from the sample taken at Lapseki (13.580 Bq/L). The values obtained in the study conducted by the Turkish Atomic Energy Authority for drinking and utility water in Çanakkale province are given in Figure 2. The highest values for the gross alpha-radiation concentration (from 0.300 to 0.400 Bq/L) were in Ezine, whereas the highest values for the gross beta-radiation concentration (from 0.05 to 0.500 Bq/L) were from the Ezine district.

Table 2: Gross alpha and Gross beta radiation values.

Sample Code	Date of Analysis d/m/y	Gross Alpha Bq/L	Gross Beta Bq/L
1-BURHANLI (Çanakkale)	27.11.2015	0.056±0.011	11.914±2.542
2-DERELİMAN (Çanakkale)	27.11.2015	0.055±0.011	10.532±2.398
3-ECEABAT (Çanakkale)	27.11.2015	0.056±0.011	**12.072**±2.559
4-GELİBOLU (Çanakkale)	27.11.2015	**0.064**±0.012	11.687±2.485
5-KUMKALE (Çanakkale)	27.11.2015	0.049±0.011	10.800±2.624
6-LAPSEKİ (Çanakkale)	27.11.2015	0.050±0.011	**13.580**±2.903
7-SEDDÜLBAHİR (Çanakkale)	27.11.2015	0.056±0.011	**14.325**±3.024
8-ŞEVKETİYE (Lapseki)	27.11.2015	0.046±0.011	11.674±2.490
Average Value		0.054±0.011	12.073±2.628
Standard Deviation		0.006±0.00	1.291±0.219

The table for the Water Pollution Control Regulation Classification of continental water resources is given in Table 3.

Table 3: Water Pollution Control Regulation Tables Classification of continental water resources (22,23).

Radioactivity (Bq/L)	Water Quality Classes			
	I (Very good)	II (Good)	III (Medium)	IV (Bad)
Alpha activity	0.5	5	5	>5
Beta activity	1	10	10	10

Table 4: Gross alpha and Gross beta values for the Çanakkale Strait, the Bosphorus, the Sea of Marmara and the Black Sea and their legal status according to the Water Pollution Control Regulations (20)

Locations	Gross – Alpha (Bq/L)	Water Quality Classes	Gross-Beta (Bq/L)	Water Quality Classes
Çanakkale Strait	0.054	I	12.073	IV
İstanbul Strait	0.3	I	5.3	III
Marmara Sea	0.5	I	5.0	III
Black Sea	0.4	I	5.6	III

In terms of gross alpha-radiation values, according to the regulations, waters in the Strait are of Class I water quality, while waters in the Strait regarding beta-radiation values are in Class IV water quality. A comparison of the results of the Çanakkale Strait with the results of the previous years for the Bosphorus, the Sea of Marmara and the Black Sea are given in Table 4. The average gross beta-radiation value for the Çanakkale Strait (12.073 Bq/L) is significantly higher than those of the other three regions (5.3 Bq/L, 5.0 Bq/L, and 5.6 Bq/L). The average gross alpha-radiation value was low.

Periodic sampling is recommended to monitor and continue to assess the changes in gross alpha- and beta-radiation concentrations.

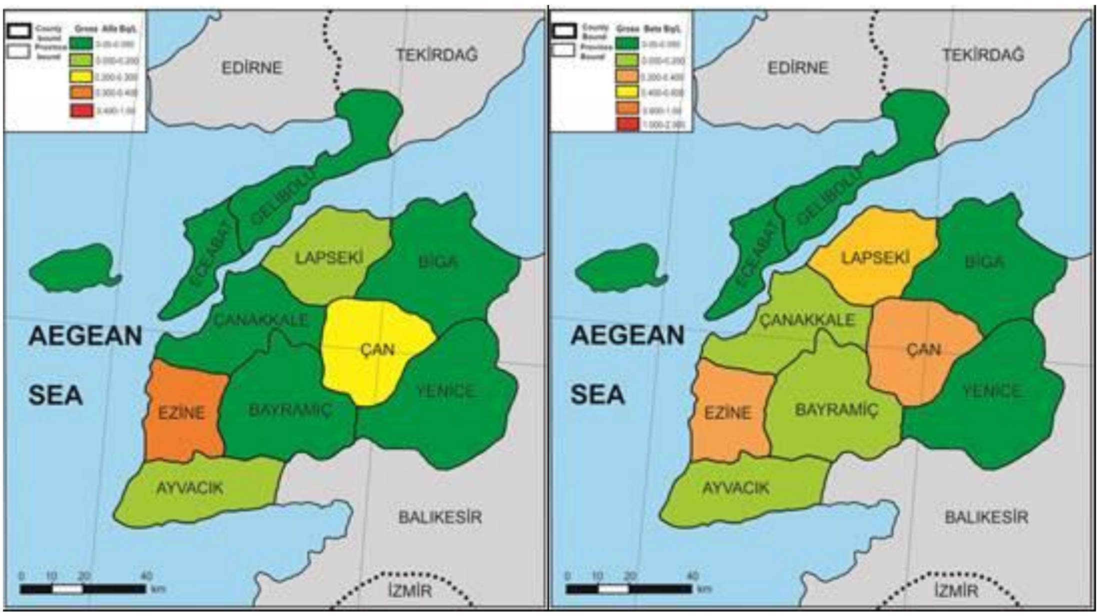

Figure 3: Turkish Atomic Energy Institute Gross Alpha and Beta Values for Çanakkale Strait Drinking and Utility Water (24).

CONCLUSION

This study reveals the radioactivity levels in waters of the Çanakkale Strait. The measurement results were interpreted by comparing them with the gross alpha- and gross beta-radiation values of drinking and utility water according to the TAEK in Çanakkale province. Comparing the sample results and the TAEK data, the gross beta-radiation concentrations were found to be high in Lapseki and its vicinity for both values. The results of the Çanakkale Strait were compared with previous studies conducted in the Bosphorus, the Black Sea and the Sea of Marmara. The gross beta-radiation mean concentration was significantly higher in the study area compared to those in other areas. In terms of water quality, high gross beta-radiation values classify the Strait waters as Class IV quality. The data obtained in this study will constitute the basis for future studies.

ACKNOWLEDGEMENT

The authors would like to thank Yümün Engineering Co. Ltd., which finances the removal of the core samples.

REFERENCES

1. Varol S. Gross Alpha and Beta Radioactivity In Groundwaters. The journal of Engineering Science and Design. 2011; 1-3 101-106. URL: http://sdu.dergipark.gov.tr/download/article-file/195352.

2. Sayre WW, Guy HP, Chamberlan AR. Uptake and Transport of Radionuclides by Stream Sediments. U.S. Geology Survey Professional Paper. 1963; 433-A. URL: https://pubs.usgs.gov/pp/0433a/report.pdf.

3. Kaya A, Karabıdak SM, Kaya S. Radioactivity Measurement of Natural Water Sources In the Area of Bahçecik Village/Gümüşhane-Turkey Gümüşhane University Science Journal. 2016; 6(1) 13-22. DOI: 10.17714/gufbed.2016.06.002.

4. Belivermiş M, Kılıç Ö, Topçuoğlu S, Çotuk Y, Kalaycı G, Peştreli D. Studıesand Further Needed Investıgatıons On Radıoactıve Contamınants In Soıl Samples. X. National Congress of Nuclear Science and Technology. 2009; 6-9.10. 195-200.

5. Acar O, Kalfa MO, Yalçınkaya Ö, Türker AR. Determination and Evaluation of Gross Alpha and Beta Activity Concentrations and Metal Levels in Thermal Waters from Ankara, Turkey. 2013; 37(5), 805-811. DOI: 10.3906/kim-1302-8.

6. Krane S.Kenneth, Introductory Nuclear Physics, John Wiley and Sons. 1955; 173-178. ISBN 13: 9780471805533.

7. Osmond JK, Ivanoich M. Equilibrium-Series Disequilibrium. Applications to Earth Marine and Environmental Sciences, ed. M. Ivanovich. Clarendon Press, Oxford, 1992. ISBN: 0-19-854278-X.

8. Mutlu B, Şen O, Toros H. Effects Of Uv Radiation On Human Health. III. Atmospheric Sciences Symposium. Istanbul Technical University. 2003; 85-89. URL: http://web.itu.edu.tr/~toros/yayinlar/manyetik_alanin_insan_sagligi_uzerine_etki.

9. Kam E, Yarar Y, Bozkurt A. A study of background radioactivity level for Tekirdag, Turkey. Radiat. Prot. Dosim., 2010; 138(1), 40–44.DOI: https://doi.org/10.1093/rpd/ncp178 .

10. Kapdan E, Taksin H, Kam E, Osmanlioğlu E, Karahan G, Bozkurt A. A Study of Environmental Radioactivity Measurements for Çankırı, Turkey, Radiat. Prot. Dosim. 2012; 150(3), 398-404. DOI: https://doi.org/10.1093/rpd/ncr416 .

11. Kam E, Yümün, ZÜ, Önce M, Açıkgöz G. Gamma Dose Rate Values In The Kulakçayırı Natural Lake And The Vicinity (Arnavutköy, İstanbul). Journal of Engineering Technology and Applied Sciences. 2016; 1(1), 1-12. URL : http://dergipark.gov.tr/download/article-file/262974.

12. Yümün ZÜ. The Effect of Heavy Metal Pollution on Foraminifera in the Western Marmara Sea (Turkey). Journal of African Earth Sciences - Elsevier. 2017; 129 346-365. DOI: http://dx.doi.org/10.1016/j.jafrearsci.2017.01.023.

13. Yümün ZÜ, Meriç E, Avşar N, Nazik A, Barut IF, Yokeş B, Sagular EK, Yıldız A, Eryılmaz M, Kam E, Başsarı A, Sonuvar B, Dinçer F, Baykal K, Kaya S. Meiofauna, Microflora And Geochemical Properties Of The Late Quaternary (Holocene) Core Sediments In The Gulf Of Izmir (Eastern Aegean Sea, Turkey). Journal of African Earth Sciences - Elsevier. 2016; 124, 383-408. DOI: http://dx.doi.org/10.1016/j.jafrearsci.2016.09.015.

14. Yümün ZÜ, Kam E. Effects of radionuclides on the recent foraminifera from the clastic sediments of the Çanakkale Strait-Turkey. Journal of African Earth Sciences - Elsevier 2017;131, 179-182. DOI: https://doi.org/10.1016/j.jafrearsci.2017.04.018

15. Atabey E, Ilgar A, Sakıtaş A. Çanakkale Havzasının Orta-Üst Miosen Stratigrafisi, Çanakkale, KB Türkiye. Maden Tetkik Arama Dergisi. 2014; 128,79-97. http://dergipark.gov.tr/download/article-file/111555

16. http://cevre.beun.edu.tr/dersnotu/Fiz341/fiz341cevreselradyoaktivite.pdf

17. Canbaz B. Ezine /Çanakkale Granit Alanının Radyolojik Risk Açısından Değerlendirilmesi. Fen Bilimleri Enstitüsü, Ege Üniversitesi. 2007;97.

18. Artüz LM. Scientific Sea of Marmara. Turkish Bar Association Publications. 2007; 119 (2). ISBN:975-6689--89-8.

19. Taşkın H, Kam E, Bozkurt A. Determination of Gross Alpha and Beta Activitiy Concentrations in Drinking Waters in Bursa Region of North-Western Turkey. Desalination and Water Treatment. 2012; 45,21-25. DOI: 10/5004/dwt.2012.3151.

20. Karahan G, Ozturk N, Bayulken A. Natural radioactivity in various surface waters in Istanbul, Turkey, Water Res., 2000; 34(18), 4367-4370. DOI: 10.1016/j.desal.2010.05.020.

21. Taşkın H, Aslıyüksek H, Bozkurt A, Kam E. Natural radıoactıvıty ın bottled mineral and thermal sprıng waters of turkey. Radiation Protection Dosimetry. 2013; Vol. 157 (4), 575–578. DOI: 10.1093/rpd/nct166.

22. ÇŞB. Water Pollution Control Regulation, Environment and Urban Ministry, Criteria According to Classes of Continuous Water Resources, Annex 1, Tab-1. (25687), 2004

23. OSB. Regulation on Management of Surface Water Quality. Ministry of Forestry and Water Management, Annex -2, Tab-1. (28483), 2012.

24. TAEK, Turkey's Environmental Radioactivity Atlas, Distribution of Soil and Water Radioactivity by Incidence, Ankara, Turkey, 2002. URL: http://www.taek.gov.tr/radyasyon-izleme/turkiye-cevresel-radyasyon-atlasi.html.