Desalination and Water Treatment
www.deswater.com
1944-3994/1944-3986 © 2012 Desalination Publications. All rights reserved
doi: 10/5004/dwt.2012.3151

Taylor & Francis
Taylor & Francis Group

45 (2012) 21–25
July

Determination of gross alpha and beta activity concentrations in drinking waters in Bursa region of north-western Turkey

Halim Taskin[a], Erol Kam[a,*], Ahmet Bozkurt[b]

[a]*TAEK, Cekmece Nuclear Research and Training Centre, Altinsehir Yolu, Halkali, 34303 Istanbul, Turkey*
Tel. +90 212 473 2600 Ext. 1050; Fax: +90 212 473 2634; email: erolkam@hotmail.com
[b]*Faculty of Arts and Sciences, Department of Physics, Harran University, 63300 Sanliurfa, Turkey*

Received 26 July 2011; Accepted 14 December 2011

ABSTRACT

This study intends to radiologically assess the drinking waters from Bursa province of north-western Turkey. Using gross-alpha and gross-beta counting methods, the gross-alpha activity concentrations of 43 drinking water samples were measured as 68.5 mBq dm^{-3} in the range 13–629 mBq dm^{-3}. The gross-beta activity concentrations were determined as 67.1 mBq dm^{-3} in the range 12–455 mBq dm^{-3}. These values lead to average annual effective doses of 14 μSv from alpha emitters and 33.8 μSv from beta emitting radionuclides and are found to be much lower than those recommended for drinking waters by World Health Organization (WHO).

Keywords: Radioactivity; Effective dose; Gross alpha; Gross beta; Water; Bursa

1. Introduction

Radioactive matters that are found in air, soil and water, either naturally or as a result of human activities, make up what is called the background radiation and are main sources of radiation exposure for human beings. The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) estimates the global average human exposure from natural radiation sources as 2.4 mSv y^{-1} and the radionuclides that are present in drinking water are considered to be responsible for a comparatively small portion of this amount [1]. Therefore potential hazards of radioactive substances in water are usually not regarded as a matter of public health concern and the recommended approach adopted by the World Health Organization (WHO) is to set reference dose levels for gross alpha and beta radioactivities instead of assigning individual activity concentration limits for different radionuclides that are present in drinking water [2].

Measurements of natural radioactivity in air, soil and drinking water samples from different geographic locations are continuously carried out in order both to establish a necessary background database and to assess the level of any possible contamination. Some survey studies were performed especially in the northern parts of Turkey which were significantly affected during the Chernobyl accident [3].

The measurements of dose rates in air and activity concentrations in soil samples from around Bursa were carried out previously [4]. This study aims to determine the gross-alpha concentrations and gross-beta concentrations in drinking water samples collected from different locations throughout the province of Bursa.

*Corresponding author.

2. Sample collection area

The province of Bursa is a coastal city located in the northwestern part of the country between the longitudes of 39°35′–40°40′ E and the latitudes of 28°10′–30°10′ N (Peak elevation: 2543 m; Average elevation 100 m above sea level) [5]. It is one of the most densely populated provinces in the country with a population of about 2.1 million (76% living in urban areas). The region spans an area of 10,800 km^2 and is divided into 17 administrative units (districts). The geology of the area shows characteristics of the Pliocene Epoch of Tertiary Era. Almost 48% of the landscape is in the form of plateau while 35% is covered by mountainous terrain. The province is well known for its mild and rainy winters (average rainfall: 674 mm) and arid summers. The year-round average temperature is 14.6°C.

3. Sample collection and radioactivity measurements

In order to measure the radioactivity levels in drinking waters, water samples were collected from selected locations of the study area and were transported to the laboratory in 500 cm^3 plastic bottles. A routine procedure outlined by Karahan et al. [6] was followed to prepare the samples for radionuclide analyses. Each sample was first filtered through a paper, and then transferred to a beaker where a small amount of nitric acid was added to avoid any precipitation on the walls of the container. After slow evaporation to near dryness, the sample was moved to a stainless steel counting planchette to be evaporated to dryness at low temperature. After cooling and weighing for the dry residue, each sample was counted for gross-alpha and gross-beta radioactivities in a low-background proportional counter with gas flow (Berthold, LB770-PC 10-Channel Low-Level Planchet Counter). The system was commonly used for measuring environmental samples with low natural background radiation. The results were obtained in units of mBq dm^{-3}.

The calibration of the low level counting system used in the measurements was carried out with standard solutions that contained known activities of ^{241}Am for alphas and ^{90}Sr for betas which were similar to the sample geometry. The minimum detectable activity (MDA) that could be achieved with the detection system was obtained as

$$\mathrm{MDA}\left(\frac{Bq}{l}\right) = \frac{L_d}{VT\varepsilon 60}$$

where V is the sample volume, T is the duration of the measurements (in min), ε is the counting efficiency [7]. L_d was defined as:

$$L_d = 2.71 + 4.65\sqrt{C_B T}$$

with C_B being the background level in counts min^{-1}. The MDA values were 7 mBq dm^{-3} for alphas and 20 mBq dm^{-3} for betas while the background count rates were 0.04 and 0.5 cpm for alphas and betas, respectively.

4. Results and comparison with literature

The measurement results of gross-alpha and gross-beta activities for the water samples collected in this study are presented in Table 1. The beta activities are generally higher than the observed alpha activities. The gross-alpha activity has an average of 68.5 mBq dm^{-3} (atandard deviation: 120.4 mBq dm^{-3}) and varies between 13 and 629 mBq dm^{-3}. The gross-beta activity has an average of 67.1 mBq dm^{-3} (standard deviation: 68.9 mBq dm^{-3}) and ranges from 12 to 455 mBq dm^{-3}. As shown by the histogram distributions given in Fig. 1, the gross alpha and beta activities obtained in this study are mostly below 100 mBq dm^{-3} and the average values are generally comparable to the data from other parts of Turkey, as well as some international data as seen in Table 2. In addition, they are much lower than those recommended for drinking water by WHO (500 mBq dm^{-3} for alpha activity and 1000 mBq dm^{-3} for beta activity) and therefore no action is generally needed towards reducing the radioactivity in drinking waters from Bursa [2]. It should be noted, however, that two of the samples showed alpha activity concentrations that are higher than WHO's guideline activity and further investigations of these sampling locations based on radionuclide based activity measurements are suggested as a result.

For estimating the total annual effective dose resulting from ingestion of a radionuclide, WHO recommends the use of dose coefficients and gives the values of

Table 1
Gross alpha and gross beta radioactivity levels in drinking waters of Bursa

	Gross alpha (mBq dm^{-3})	Gross beta (mBq dm^{-3})
Number of measurements	43	43
Mean	68.5	67.1
Standard deviation	120.4	68.9
Minimum	13	12
Maximum	629	455
Median	35	54

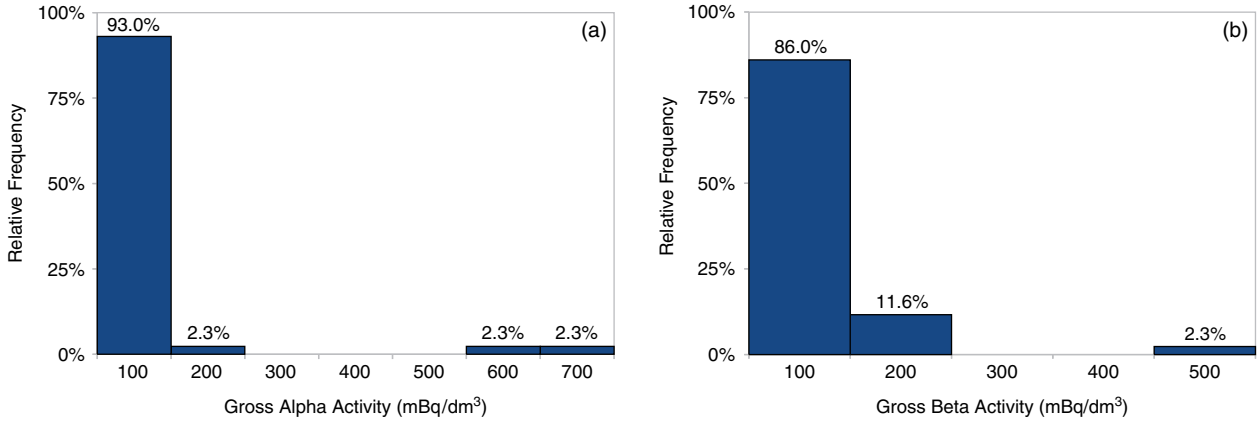

Fig. 1. Histograms of the data for (a) gross alpha, (b) gross beta activity concentrations obtained in this study.

Table 2
Comparison of gross alpha and gross beta radioactivity levels with literature. The data in parentheses are the corresponding ranges

	Gross alpha (mBq dm^{-3})	Gross beta (mBq dm^{-3})
Adana [8]	96	86
Bayburt [9]	63	39
Bursa (this study)	68.5	67.1
Canakkale [10]	59.9 (17.9–296)	84.1 (40.5–199)
Gaziantep [11]	49.3 (6.5–302.6)	128.4 (19.8–418.3)
Giresun [12]	7.1	97.1
İstanbul [6]	22.8 (7–45)	66.4 (20–130)
Kastamonu [13]	8.9 (1.4–26)	271 (16.2–224.1)
Rize [10]	8.3	82.8
Sanliurfa [14]	38 (1.8–432.3)	132.4 (6–924.7)
Trabzon [10]	6.5	100.8
Tekirdag [15]	44	100
WHO action level [2]	500	1000
Central Italy [16]	18.18–128.18	41.57–258.59
Italy [17]	8–349	25–273
Brasil [18]	1–400	120–860
Hungary [19]	35–1749	33–2015
Spain [20]	30–880	40–2280

2.8×10^{-4} and 6.9×10^{-4} mSv Bq^{-1} for ^{226}Ra (an alpha emitter) and ^{228}Ra (a beta emitter), respectively. These coefficients are then multiplied with the measured activity concentrations together with the assumption that an adult, on the average, consumes 2 l of water per day [2]. This procedure will then lead to average annual effective doses of 14 μSv from alpha emitters and 33.8 μSv from beta emitting radionuclides both of which are less than the reference dose level of 0.1 mSv y^{-1} suggesting "no further action". The iso-dose maps of radioactivity in drinking waters for Bursa region can then be constructed as in Fig. 2.

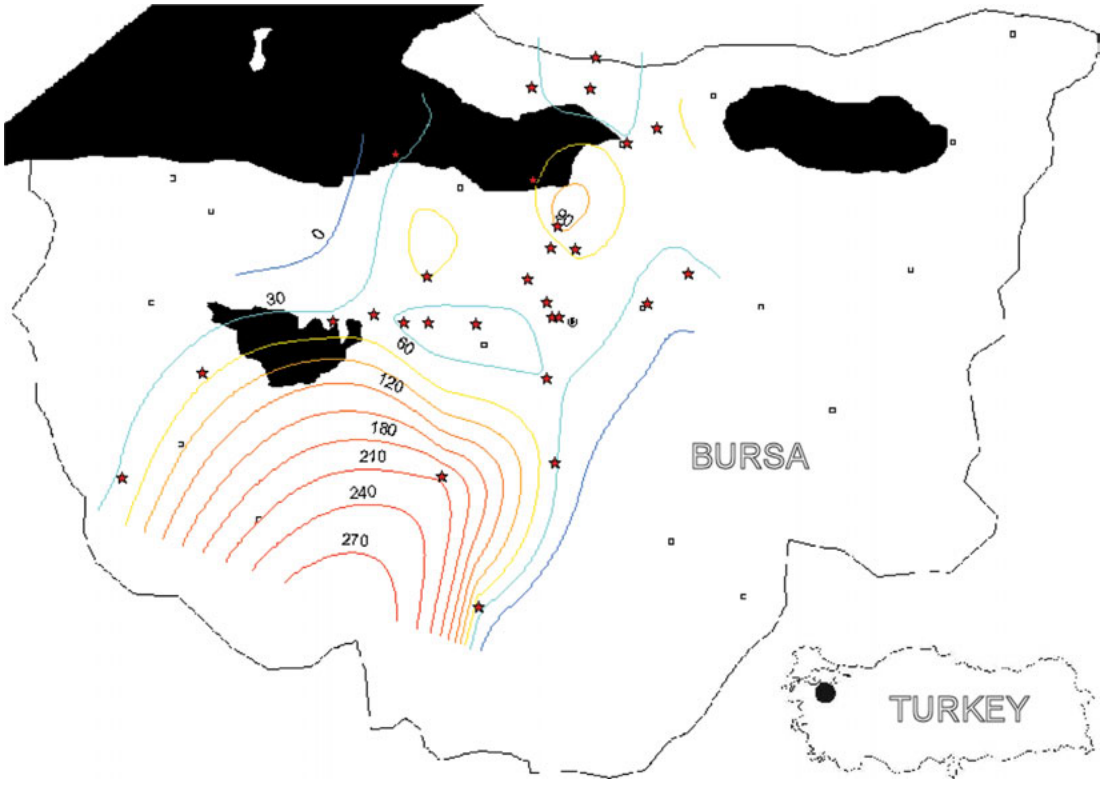

Fig. 2. Contour map of annual effective doses resulting from gross alpha and gross beta radioactivities (μSv y^{-1}) for Bursa.

5. Conclusions

This study presents the radioactivity levels for drinking waters collected from Bursa region located in north-western Turkey. The measured gross-alpha and gross-beta activities are found to be comparable to the data for other Turkish cities. In addition, the obtained activity levels are lower than the recommended limits for drinking water set by World Health Organization (WHO) suggesting that detailed radionuclide analyses of the studied samples are not necessary.

References

[1] UNSCEAR, Sources and effects of ionizing radiation, Report of the United Nations Scientific Committee on the Effects of Atomic Radiation to the General Assembly, United Nations, New York (2000).
[2] WHO, Guidelines for drinking-water quality, 4th edn., World Health Organization, Geneva, Switzerland (2011).
[3] TAEK, Radioactivity and radiation measurements after the Chernobyl accident, Reports of the Turkish Atomic Energy Commission, Ankara, Turkey (1988).
[4] G. Karahan, Risk assessment of baseline outdoor gamma dose rate levels study of natural radiation sources in Bursa, Turkey, Radiat. Prot. Dosim., 142(2–4) (2010) 324–331.
[5] Environmental Status Report (in Turkish), Provincial Directorate of Environment and Forestry, Bursa, Turkey (2006).
[6] G. Karahan, N. Ozturk and A. Bayulken, Natural radioactivity in various surface waters in Istanbul, Turkey, Water Res., 34(18) (2000) 4367–4370.
[7] L.A. Currie, Limits for qualitative detection and quantitative determination. Application to radiochemistry. Anal. Chem., 40 (1968) 586–593.
[8] M. Degerlier and G. Karahan, Natural radioactivity in various surface waters in Adana, Turkey, Desalination, 261 (2010) 126–130.
[9] B. Kucukomeroglu, A. Kurnaz, N. Damla, U. Cevik, N. Celebi, B. Ataksor and H. Taskin, Environmental radioactivity assessment for Bayburt, Turkey, J. Radiol. Prot., 29 (2009) 417–428.
[10] E. Kam, A. Bozkurt and R. Ilgar, A study of background radioactivity level for Canakkale, Turkey, Environ. Monit. Assess., 168 (2010) 685–690.
[11] A. E. Osmanlioglu, E. Kam and A. Bozkurt, Assessment of background radioactivity level for Gaziantep region of Southeastern Turkey, Radiat. Prot. Dosim., 124(4) (2007) 407–410.
[12] N. Damla, U. Cevik, G. Karahan and A.I. Kobya, Gross alpha and beta activities in tap waters in Eastern Black Sea region of Turkey, Chemosphere, 62 (2006) 957–960.
[13] E. Kam and A. Bozkurt, Environmental radioactivity measurements in Kastamonu region of northern Turkey, Appl. Radiat. Isot., 65 (2007) 440–444.
[14] A. Bozkurt, N. Yorulmaz, E. Kam, G. Karahan and A.E. Osmanlioglu, Assessment of environmental radioactivity for Sanliurfa region of southeastern Turkey, Radiat. Meas., 42 (2007) 1387–1391.
[15] E. Kam, Y., Yarar and A. Bozkurt, A study of background radioactivity level for Tekirdag, Turkey, Radiat. Prot. Dosim., 138(1) (2010) 40–44.

[16] D. Desideri, C. Roselli, L. Feduzi and M.A. Meli, Radiological characterization of drinking waters in Central Italy, Microchem. J., 87 (2007) 13–19.
[17] M. Forte, R. Rusconi, M.T. Cazzaniga and G. Sgorbati, The measurement of radioactivity in Italian drinking waters, Microchem. J., 85 (2007) 98–102.
[18] D.M. Bonotto, T.O. Bueno, B.W. Tessari and A. Silva, The natural radioactivity in water by gross alpha and beta measurements, Radiat. Meas., 44 (2009) 92–101.
[19] V. Jobbagy, N. Kavasi, J. Somlai, P. Dombovari, C. Gyongyosi and T. Kovacs, Gross alpha and beta activity concentrations in spring waters in Balaton Upland, Hungary, Radiat. Meas., 46 (2011) 159–163.
[20] M. Palomo, A. Penalver, F. Borrull and C. Aguilar, Measurement of radioactivity in bottled drinking water in Spain, Appl. Radiat. Isot., 65 (2007) 1165–1172.