Radiological Status of Mineral, Spring and Table Waters from Different Regions of Bulgaria

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Abstract

Radiological analysis of mineral waters sampled from springs in the region of Sofia and Velingrad spa resort, and of bottled mineral, spring and a table water from other regions in Bulgaria was carried out as part of the overall monitoring of drinking waters in the country. Natural uranium varied from 0,003±0,001 to 0,023±0,005 mg/l, gross alpha activity – from ≤0,01 to 0,50±0,05 Bq/l and beta activity – from ≤ 0,02 to 0,28±0,06 Bq/l. The concentration of the indicators in all studied waters met the requirements, provided for in the Regulation on mineral, spring and bottled waters in Bulgaria (U ≤ 0.06 mg/l; gross alpha activity ≤ 0.5 Bq/l; gross beta activity ≤ 1 Bq/l). However, alpha activity higher than the more restrictive control level of 0.1 Bq/l, specified in the Regulation for drinking waters, was determined in the mineral water from Ovcha Kupel in Sofia (0,34 Bq/l) and in the bottled mineral water from Devin in the Rhodopes (0,5 Bq/l). Both water samples were further tested for polonium-210 content.

The specific activity of radon-222 measured in the mineral waters sampled from the springs was under the reference levels specified for drinking waters.

In result of the analyses carried out it was concluded the studied waters were not hazardous for human consumption in terms of radiology.

Key words*: radioactivity of waters, natural uranium, radon-222, gross alpha and beta activity*

INTRODUCTION

Bulgaria is characterized by a great variety of mineral waters. Their mineralization is low and the waters are suitable for everyday use as drinking water. In this regard, monitoring of radiological indicators of mineral waters, along with that of drinking water, is essential due to the fact that the main amount of the absorbed dose of radioactive radiation in humans is formed by water consumption.

The ***aim*** of the present study was to study most commonly consumed mineral waters from springs in the region of Sofia city and *spa* resort Velingrad as well as bottled mineral and spring waters from the country, to assess the radioactive dose load on the population.

MATERIAL AND METHODS

Testing Laboratory of Radioecology and Radioisotope Research at ISSAPP "Nikola Pushkarov" is accredited for determination of radioactive elements in waters, soil, plants, food and food products under BDS EN ISO/IEC 17025:2018.

Content of natural uranium was determined by a method based on formation of tetravalent uranium complex with arsenase III and spectrophotometric measurement of the samples at 655 nm wavelength. Radon activity concentration was measured gamma spectrometrically in accordance with BDS EN ISO 13164-2: 2020. The content of gross alpha and beta activity was determined in accordance with the standards BDS EN ISO 9696/2017 and BDS ISO 9697/2019 respectively.

Table 1. Radiological indicators of the studied waters

№	Location	Radon-222	Natural uranium	Gross alpha activity	Gross beta activity
		Bq/l	mg/l	Bq/l	Bq/l
Mineral waters sampled from springs around and in the city of Sofia					
1	Rudartsy	25 ± 5	0,005 ± 0,001	0,03 ± 0,01	≤ 0,02
2	Knyazhevo	10 ± 3	0,003 ± 0,001	≤ 0,01	≤ 0,02
3	Gorna Banya (fountain near the Ring Road of Sofia)	18 ± 4	0,003 ± 0,001	≤ 0,01	≤ 0,02
4	Gorna Banya (fountain at the Bath)	≤ 10	0,004 ± 0,001	≤ 0,01	≤ 0,02
5	Bankya (fountain in the Center of the town)	≤ 10	0,005 ± 0,001	≤ 0,01	0,03 ± 0,01
6	Bankya (fountain next to the bottling center)	≤ 10	0,003 ± 0,001	≤ 0,01	≤ 0,02
7	Central Bath (Sofia city)	25 ± 5	0,005 ± 0,001	≤ 0,01	≤ 0,02
8	Pancharevo	20 ± 4	0,007 ± 0,001	0,05 ± 0,02	0,09 ± 0,02
9	Ovcha Kupel (Recreation Center)	12 ± 3	0,006 ± 0,001	0,34± 0,07	0,28 ± 0,06
Mineral waters sampled from springs in spa resort Velingrad					
10	Chepino (central fountain)	120 ± 10	0,008 ± 0,002	0,04±0,01	≤ 0,02
11	Ladzhene (fountain at the Sanatorium)	51 ± 5	0,006 ± 0,001	≤ 0,01	≤ 0,02
12	Ladzhene (fountain next to the mineral pool)	47 ± 4	0,004 ± 0,001	≤ 0,01	≤ 0,02
13	Fountain in the Central Park of Ladzhene	29 ± 3	0,005 ± 0,001	≤ 0,01	≤ 0,02
Bottled waters					
14	Mineral water - Bankya	-	0,005 ±0,001	0,02±0,01	0,05±0,01
15	Mineral water - Velingrad	-	0,004±0,001	≤0,01	≤0,02
16	Mineral water - Gorna Banya	-	0,004±0,001	≤0,01	≤0,02
17	Mineral water - Devin	-	0,023±0,005	0,50±0,05	0,30±0,06
18	Mineral water - Pirin	-	0,007±0,001	0,05±0,02	0,09±0,03
19	Mineral water - Bachkovo	-	0,002±0,001	≤0,01	0,02±0,01
20	Spring water – Rdodopes	-	0,004±0,001	≤0,01	0,08±0,02
21	Spring water - Bratsigovo	-	0,002±0,001	≤0,01	0,04±0,01
22	Spring water - Rila	-	0,005±0,001	0,02±0,01	≤0,02
23	Table water - Sofia	-	0,003±0,001	≤0,01	≤0,02

RESULTS AND DISCUSSION

Radon

Radon in the mineral waters from Sofia region sampled at the spring is between ≤ 10 ÷ 25 Bq/l. In all water samples it is lower than the parametric value of 100 Bq/l, specified in the national Regulation on drinking water. Radon in waters from spa resort Velingrad is relatively higher reaching 120 Bq/l in the water from Chepino. The consumption of this water on a daily basis is not recommended. Traditionally, the mineral waters in the town are mostly used for balneology.

Uranium

Content of natural uranium in all tested waters does not exceed the maximum permissible value, specified in both the Regulation on mineral waters (0.06 mg/l) and Regulation on drinking water (0.03 mg/l).

Gross alpha and beta activity and total indicative dose

Alpha activity is between ≤ 0.01 (MDA) and 0.5 Bq/l, and beta activity between ≤ 0.02 and 0.3 Bq/l, which is within the control levels (α - 0.05 Bq/l, β – 1 Bq/l), pointed out in the Regulation on mineral waters.

However alpha activity measured in the water from Ovcha Kupel (Sofia region) and in the bottled water from Devin in the Rhodopes exceeded the control level specified for drinking waters.

This relatively higher value of alpha activity in the mineral water from Ovcha Kupel could be probably explained by the deeper and longer circulation of the water in the water-bearing rocks compared to other studied waters from the region of Sofia leading to its higher mineralization. The relationship between amount of salts in dry residue and content of alpha activity in mineral waters is reported by other authors too (Rusconi et al., 2004), the correlation being is stronger for waters with high gross alpha activity and weaker for these with low alpha activity.

Analysis of results obtained for the water from Devin showed that the total content of alpha activity was due the concentration of natural uranium. The water is from the Rhodope mountain, characterized by high uranium content in aquifers built of granites, gneisses and breccias.

Water samples from Ovcha Kupel and Devin were tested for Po-210 alpha-spectrometrically. Polonium content in both waters was lower than the secondary activity concentration of 0.1 Bq/l, specified in the Regulation on Drinking Water.

In case of gross alpha and beta activity below the control levels, the total indicative dose is considered to be lower than the parametric value of 0.1 mSv/year and no additional radiological study is required. The total indicative dose calculated for all studied waters was lower than the parametric value до 0,1 mSv/year.

CONCLUSION

Radiological status of mot commonly consumed mineral waters from the region of Sofia and spa resort Velingrad, as well as of bottled mineral and spring waters from the country was established. Indicators in most of the studied waters met the requirements specified in the national Regulation on mineral waters, as well as the more conservative ones in the Regulation on drinking waters. In two water samples, from Ovcha Kupel (Sofia region) and Devin (the Rhodopes), gross alpha activity exceeded the control level for drinking water, which in the first case was probably due to higher mineralization as result of the deeper and prolonged water circulation in water-bearing rocks, and in the second – due to the higher uranium content, characterizing the region of the Rhodope Mountains.

As a result of the study carried out, it can be concluded that the studied waters are not hazardous for human health in terms of radiology.