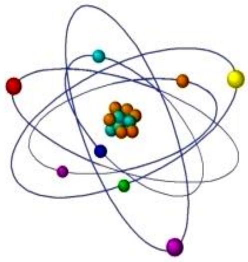
RADON IN SPRING WATER SOURCES IN THE TERRITORY OF KARTLI (GEORGIA)



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ABSTRACT**:** *In the present work it was studied the content of radioactive gas radon - Rn-222 in the number of sources of spring located in some settlements nearby to Tbilisi city (the capital of Georgia) in the territory of so-called Tbilisi and Kartli artesian basins. Research was carried out during the annual period (January-December); samples for measurements in some settlements were selected monthly. Radon detector RAD7 was used for determining radon content. It was established, that radon content in water considerably changes depending on the source location as well as on water type too. So, for example, radon content in various sources of spring water was within the limits from several units of Bq/L up to 100 Bq/L and more. The possibility of influence on various factors on the radon content was analyzed, for example, features of the soil-geological structure, features of water sampling, etc. A comparison with literary data has been carried out.*

Key words: Radon, spring water, activity concentration

INTRODUCTION

Control of a radioactive condition of the environment is one of the most actual problems of modern ecology. Radon is one of three main gases included in the so-called “terrestrial breath”, during which argon-40, helium and radon are constantly escaped from the bowels of the Earth in the atmosphere. Only radon is radioactive among these gases [1]. Radon gets in the water from environmental soil, and also granites, basalts, and sands to which aquiferous layers adjoin. Radon concentration in usually used water is small, but water from some deep wells and artesian wells can contain a lot of radon – from 100 pCi/L up to 1000000 pCi/L [2]. Radon dissolved in water operates in two ways. On the one hand, it together with water gets to the digestive system, and on the other hand, people inhale radon allocated from water by its utilization.

Breathing radon in indoor air can cause lung cancer. Radon decays into radioactive particles that can get trapped in lungs at the inhalation. As they decay further, these particles emit energy impulses that can damage lung tissue and increase the chances of developing lung cancer over the course of a lifetime. Drinking water containing radon represents a risk of developing internal organ cancers, primarily stomach cancer [3].

Results of numerous pieces of research show, that radon content in natural waters in different countries fluctuates in the big ranges. Abdallah et al. showed [4] that radon activity concentration in samples of spring water selected directly in the spring zone (such water type is mentioned further as WSp-1) changes in the range 9.8-49.6 Bq/L with the average value of 29.0 Bq/L; radon concentration in similar samples studied in the work [5] varied from 12.62 to 20.65 Bq/L, and in the work [6] – from 0.15 to 1200 Bq/L with the average value of 98 Bq/L. Radon content in samples of spring water selected far from the spring zone (water type WSp-2) studied in the work [**Error! Bookmark not defined.**] changes in the range from 0.46 to 9.4 Bq/L (average value of 4.7 Bq/L), and in the work [7] – from 8 to 427 Bq/L.

The radon problem in Georgia was not given proper attention. Practically there were no data on radon content in drinking (tap) water. In some author's works [8] there are given data on radon content in drinking (including tap) water in Tbilisi, in the zone of Ureki-Shekvetili, and also radiological doses of radon from water ingestion have been estimated. Some results of radon content research in natural water and soil are resulted in the work [11].

Thus, regular research on the state of radon distribution in the water resources of Georgia is an actual problem. In the present work, some results on radon activity in waters of spring sources in the geographical area of Tbilisi city are given.

PROBLEM STATEMENT

There are several artesian basins in East Georgia some of which are used for reception and supply of the population by drinking water (in particular, Kartli basin is located the Natakhtari complex of the water supply of Tbilisi city by drinking water in which artesian waters are used). These artesian basins feed the numerous springs located on the whole territory of the region. Research of their natural radioactive activity represents doubtless interest from the scientific point of view as well as from the practical point of view. First of all, there are of interest waters of Kartli and Tbilisi artesian basins located to the north and to the south of Tbilisi (Figure 1). In this zone, there are springs that are often used by the population as drinking water.

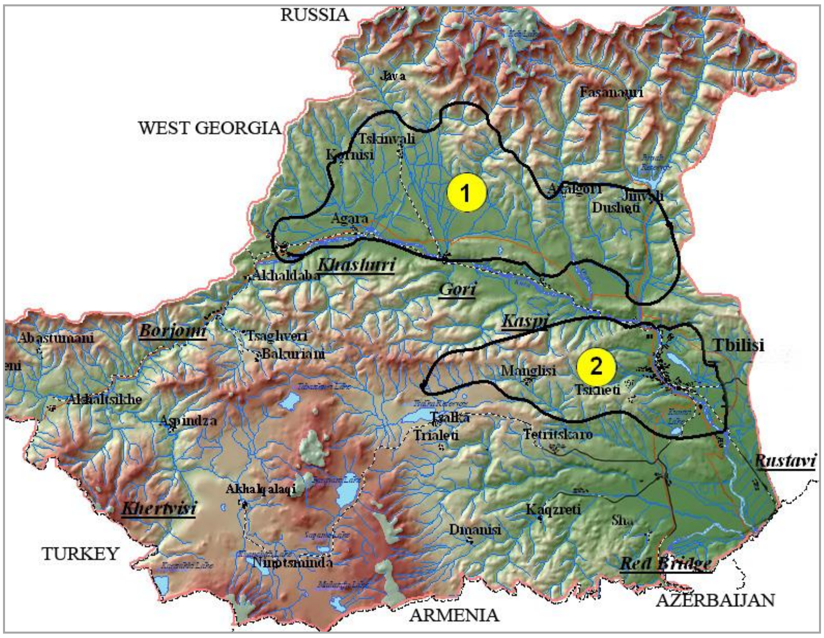


Figure 2. Kartli (1) and Tbilisi (2) artesian basins in East Georgia

The objective of the work was studying of features of radon content distribution depending on geographical factors in surface sources of water (spring), located in Tbilisi and Kartli artesian basins. The first results of carried out research on the water of spring sources are given in the work [12]. In the present publication, there are given and generalized all results of the carried out researches for the period of one calendar year – from January to December.

RESEARCH OBJECTS

Research objects were spring water sources located in the territory of Tbilisi and Kartli artesian basin – in total 24 control points.

During the period from January to December there were selected samples of spring water sources, in particular:

- springs (WSp-1) in which water was selected directly in the spring zone - 10 points;
- springs (WSp-2) in which water was selected far from spring zone – in pipelines, on sufficiently remote distance - from hundred meters up to several kilometers) - 14 points;

In total 134 samples of spring waters were selected and analyzed (*note:* samples from some control points were selected monthly).

METHODOLOGY

Sampling

Sampling was carried out in special glass containers; the volume of the container is 250 mL. Containers were filled with water up to the top and densely closed by a cover. Then the selected water samples were transported to the laboratory for analysis.

Of the three isotopes of radon, the subject of research is Rn-222, because the half-lives of Rn-220 and Rn-219 are much shorter, and they decompose before migrating into soil and rocks, and their amount in the air is insignificant.

Electronic radon detector RAD7 was used for the determination of radon content in water. The RAD7 device uses a method for the registration of radon decay products, namely alpha particles Po-218, Po-2014 and Po-210 (which are formed as a result of decay), based on the use of a solid semiconductor sensor.

The radon measurement process is as follows:

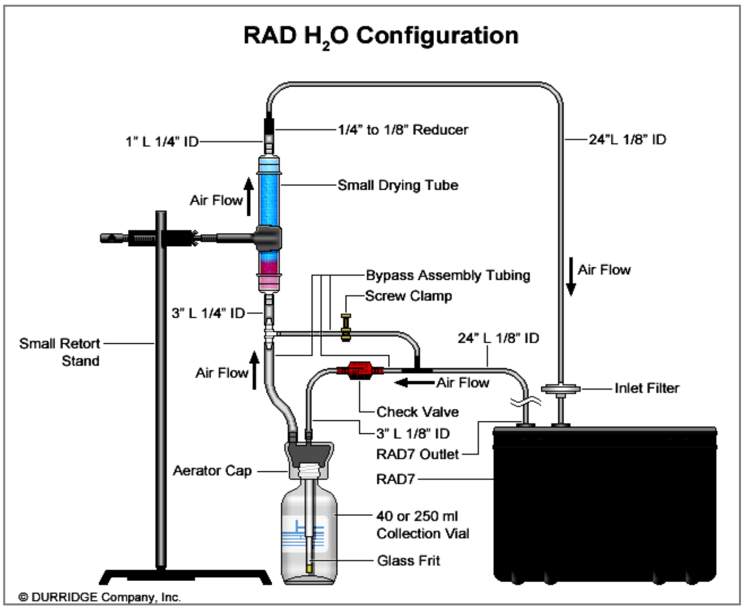


Fig.3. RAD H_2O configuration diagram

A water sample glass container is placed in a circle of closed air pipes (see figure 3). The circle also includes a small desiccant tube, the purpose of which is to dry the air in the closed circle during the process. The duration of the measurement process is specified in the protocol as 30 minutes.

The measurement error of the method does not exceed ± 5%. The device allows the measurement of radon activity in water from 0.2 Bq/L to more than $3.7 \cdot 10^3$ Bq/L [13].

Special multiple measurements were performed to assess the radiation background, using distilled water as a sample. The results obtained on two different detectors showed that the background activity varied in the range of 0.03 - 0.22 Bq/L (average 0.09 Bq/L).

Use of Software CAPTURE v. 4.4.10

Radon concentration measurement data is transferred from the RAD7 device to a computer by using the Capture program. Software CAPTURE v. 4.4.10is a specialized program developed by the manufacturer of RAD7 detectors. CAPTURE is designed to analyze data registered by the RAD7 detector (see figure 4).

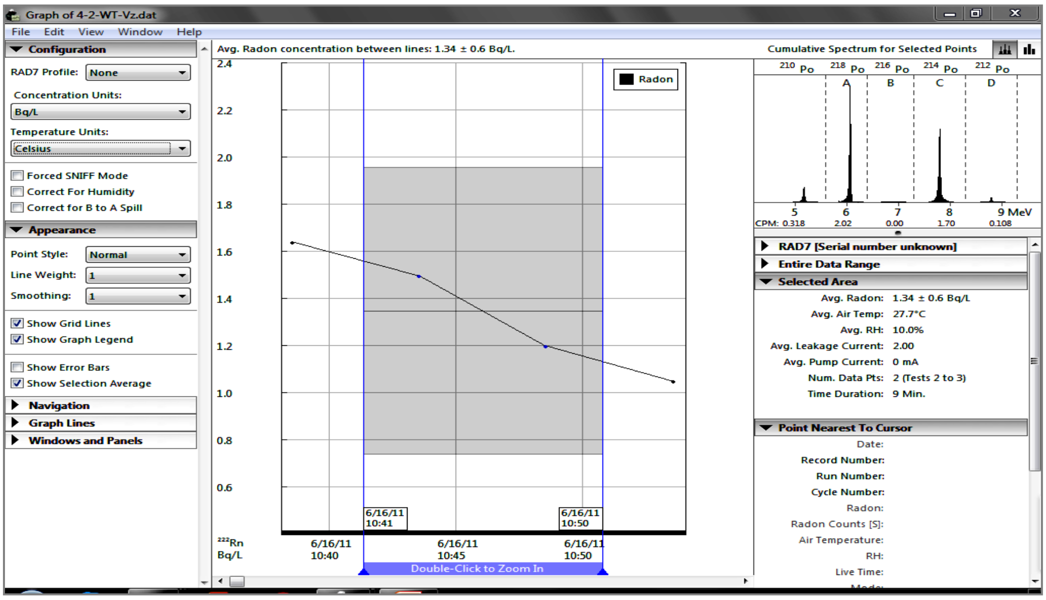


Figure 4. Graphic representation of the results obtained with the RAD7

Processing of the results

For the investigated points taking into account reference level of 11 Bq/L recommended by US EPA [12] and the received results 7 conditional groups of radon activity level in water samples selected in various control points have been established, in particular, in the 1st group (I) there were included control points in which value of radon concentration is very low - did not exceed 0.3 Bq/L (i.e. close to the background), in 2nd group (II) – control points in which it is possible to consider that value of radon concentration is low – in the range of 0.3 - 1.0 Bq/L, in 3rd group (III) – control points in which value of radon concentration can be designated conditionally as typical - in the range of 1.0 - 3.0 Bq/L, in 4th group (IV) – control points in which it is possible to consider that value of radon concentration is above typical – in the range of 3.0 - 10.0 Bq/L, in 5th group – control points in which it is possible to consider that value of radon concentration is high – in the range of 10 - 30 Bq/L, in 6th group (VI) – control points in which it is possible to consider that value of radon concentration is very high – in the range of 30 - 100 Bq/L, in 7th group (VII) – control points in which it is possible to consider that value of radon concentration is ultrahigh – more than 100 Bq/L.

For the characteristic of time history (stability) of radon activity in control points depending on the period (month) of measurements the value of the standard relative deviation of the results received during the year was used. For values of relative standard deviation, no more than 50 % corresponding average value conditionally was accepted as a stable (constant) value of activity concentration (and, accordingly, group of activity) for the given control point. If the value of relative standard deviation exceeded this size, then the value of activity concentration (and, accordingly, group of activity) for the given control point was considered as unstable.

RESULTS

Results of carried measurements are given in Table 1.

Table 1. Generalized monthly activity of radon (A, Bq/L) in spring water, their average (A_{av}), minimal (A_{mn}), maximal (A_{mx}) values, relative standard deviation (RSD), and in the column (Prm) also their averaged values (*aver* – average, *min* – minimal, *max* – maximal)

#	ST	Prm	A, Bq/L												A_{av}	A_{mn}	A_{mx}	RSD
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Bq/L	Bq/L	Bq/L	%
1	TAB-WSp-1	aver	96.3	54.1	33.1	98.8	79.2	75.5	86.3	45.7	63.7	65.9	99.9	68.8	72.3	33.1	99.9	29
2		min		16.7	2.7	49.8	29.8	18.1	19.0	21.9	27.6	9.2	17.2	16.1	20.7	2.7	49.8	59
3		max		110	73	148	129	144	139	91	134	108	163	123	124	72.9	163	21
4	TAB-WSp-2	aver		13.4	11.7	6.0	12.0	8.3	5.4	4.8	7.3	6.5	9.6	7.5	8.4	4.8	13.4	34
5		min		4.0	3.3	0.1	1.1	1.9	0.9	0.3	0.4	0.3	2.9	1.1	1.5	0.1	4.0	92
6		max		27	36	10	21	20	7	8	13	11	13	12	16.2	7.3	35.8	55
1	KAB-WSp–1	aver		7.5	11.1	8.4	6.9	13.3	7.6	8.5	11.1	6.8	12.5	10.9	9.5	6.8	13.3	25
2		min			9.1	5.7	3.7	9.8	5.0	6.6	9.3	5.1	8.1	3.3	6.6	3.3	9.8	36
3		max			13.0	9.8	9.1	16.6	10.3	10.7	12.1	7.9	14.9	14.8	11.9	7.9	16.6	24
4	KAB-WSp–2	aver		9.4	3.8	4.8	2.4	7.7	3.5	5.2	6.3	4.6	7.3	4.2	5.4	2.4	9.4	39
5		min		9.4	3.1	1.7	0.5	5.1	1.6	2.0	3.3	1.8	4.3	3.5	3.3	0.5	9.4	73
6		max		9.4	4.6	10.1	3.7	10.3	5.3	8.3	9.3	7.3	10.2	4.9	7.6	3.7	10.3	33

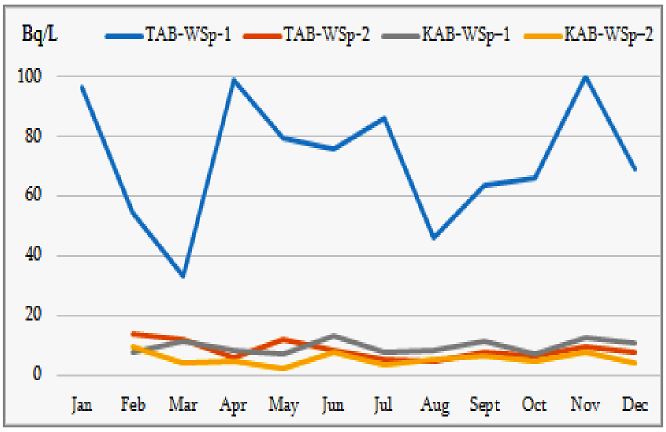
Note: TAB – Tbilisi Artesian Basin; KAB – Kartli Artesian Basin

Apparently from the received results, it is possible to note the following features:

- in Tbilisi artesian basin the highest activity was observed in WSp-1 (163 Bq/L), and the lowest activity (closely to the background) was in WSp-2 (0.1 Bq/L);
- in Kartli artesian basin the highest activity was observed in WSp-1 (16.6 Bq/L), and the lowest activity (closely to the background) was in WSp-2 (0.1 Bq/L);
- values of activity in the same control point depending on the period of measurements are sufficiently unstable; any laws in seasonal dependence were not observed.

ANALYSIS

Apparently from the received data, in the geographical area of Tbilisi city in the territory of Tbilisi and Kartli artesian basins, there was observed a sufficiently big variety of radon activity in spring waters (which covers a range of values from very low 0.1 Bq/L up to ultrahigh – 163Bq/L) (see Table 1, Fig.2).



Observable much lower values for spring water of the second type (selected sufficiently far from the spring site) in comparison with water of the first type (selected directly in the spring location) are, of course, connected with the sufficiently intensive process of radon decontamination in by-pass pipelines (and also, in accumulator tanks).

Rather high values of radon activity observed in some cases in river water, apparently, are connected with their mixing with water from nearby located springs. At a considerable distance from a spring (some kilometers) radon activity in river water is close to background values.

Table 4 shows a comparison of the received results with some literary data. Apparently from the data, the results received in the present work lay within the values received in other publications.

Table 4. Radon content in surface water in different countries.

#	Country (site)	Water type	A, Bq/L			Ref.
			av	mn	mx	
1	Lebanon (Beirut, Mount Lebanon, Beqaa, etc)	WSp-1	29.0	9.8	49.6	[4]
2	Iran (Mashhad)		-	12.62	20.65	[5]
3	Spain (Extremadura)		98	0.15	1200	[6]
4	Georgia (Kartli artesian basin)		9.5	3.3	16.6	Present work
5	Georgia (Tbilisi artesian basin)		72.3	2.7	163	Present work
6	Lebanon (Beirut, Mount Lebanon, Beqaa, etc)	WSp-2	4.7	0.46	9.4	[4]
7	Poland (Walbrzych)		131	8	427	[7]
8	Georgia (Kartli artesian basin)		5.4	0.5	10.3	Present work
9	Georgia (Tbilisi artesian basin)		8.4	0.1	35.8	Present work

CONCLUSIONS

1. It was established, that radon content in spring water in Tbilisi artesian basin varies in a wide range, in particular:
   - in spring water of the first type (samples were selected directly in the zone of spring location - WSp-1) is in the limits from several units of Bq/L (2.7 Bq/L) up to 100 and more (163 Bq/L), with an average value of 72.3 Bq/L;
   - in spring water of the second type (samples were selected from the pipeline at a sufficiently big distance from the zone of spring location - WSp-2) is in the limits from 0.1 Bq/L up to 35.8 Bq/L, with the average value of 8.4 Bq/L;
2. Radon content in spring water in the areal of Kartli artesian basin varies in a wide range:
   - in spring water of the first type (samples were selected directly in the zone of spring location - WSp-1) is in the limits from 3.3 to 16.6 Bq/L, with the average value of 9.5 Bq/L;
   - in spring water of the second type (samples were selected from the pipeline at a sufficiently big distance from the zone of spring location - WSp-2) is in the limits from 0.5 to 10.3 Bq/L, with average value of 5.4 Bq/L;
3. It was carried out analysis in which it was shown that the received results for spring waters can be connected with features of geology of these territories; comparison with literary data has been carried out.

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