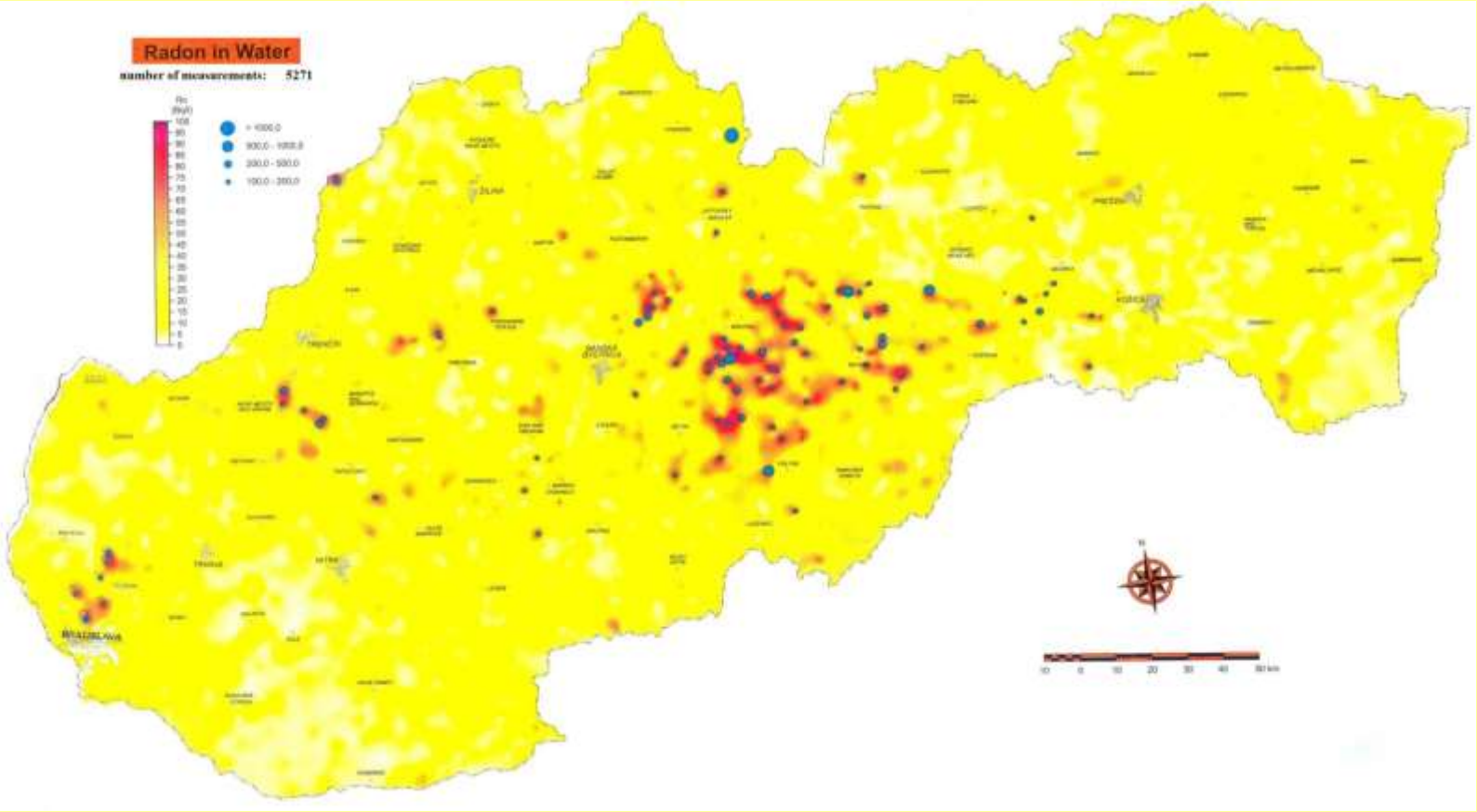
Radon in waters in Slovakia

Karol Holý, Monika Műllerová, Pavol Blahušiak, Iveta Smetanová, Martin Bulko, Radoslav Böhm

Department of Nuclear Physics and Biophysics, Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava, Slovakia

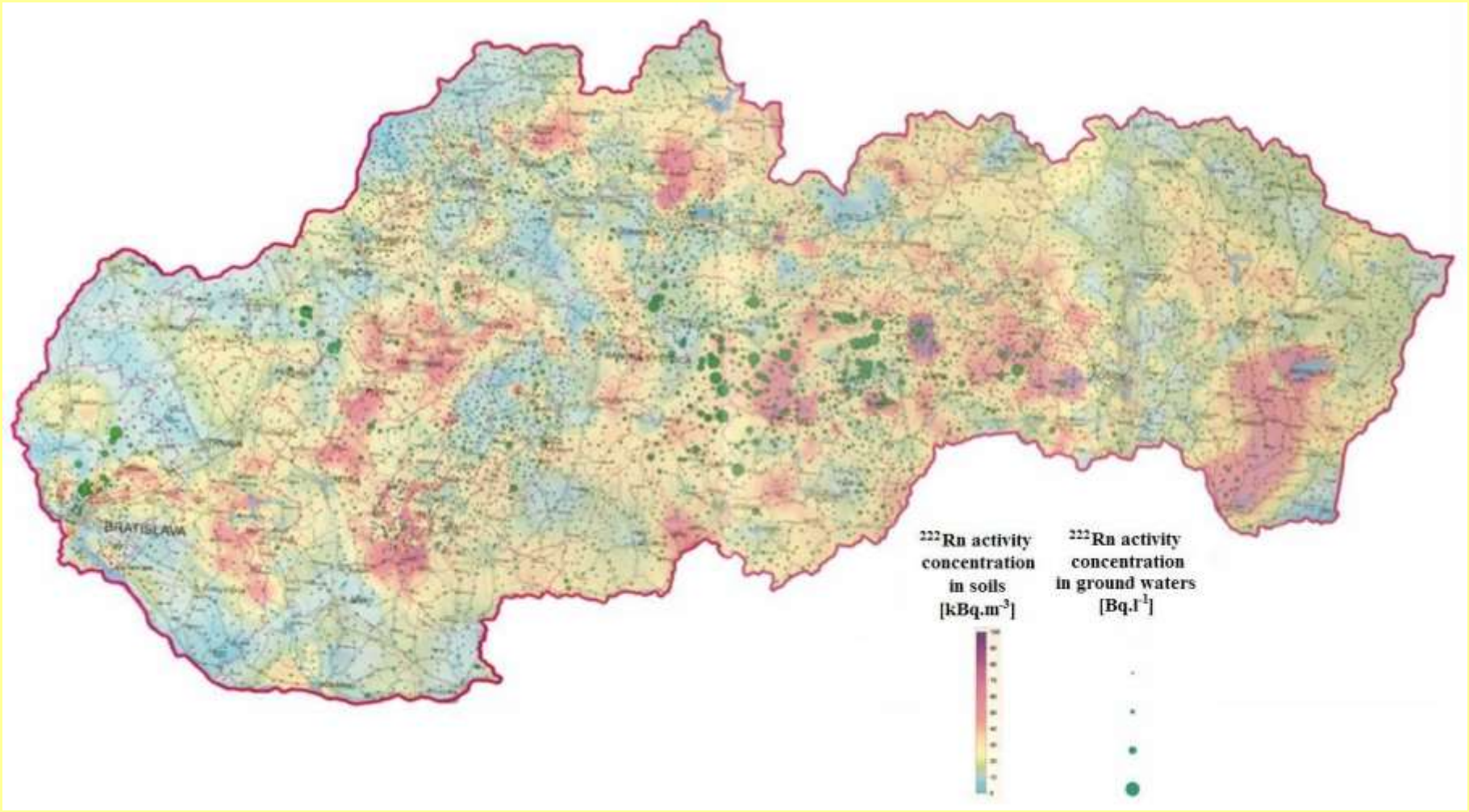
1. Concise information about radon measurements in thermal waters and spas

A. Waters (water springs, mineral and thermal waters, wells, surface waters)
-A large-scale measurement of radon in waters was carried out in the nineties
-The results are published in tables and radon maps



[1] Daniel a kol.: Geochemický atlas Slovenska, Časť IV: Prírodná rádioaktivita hornín, Geologická služba Slovenskej republiky, Bratislava, 1996

Map of radon activity concentration in soil and ground waters



-**Thermal and mineral waters** - the range of measured activities is big

Sampling location	RAC (Bq/ℓ)
Thermal spring Grunfus	3,9 ± 0,6
Thermal spring Ludvig	95,6 ± 11,0
Thermal spring Ondrej	45,3 ± 5,2
Thermal spring Paula	101,5 ± 11,6
Thermal spring Vojtech II	42,9 ± 6,1
Thermal spring Marta	221 ± 25,3
Thermal spring Vilma	136,9
Thermal spring Červený kúpeľ	156,9 ± 18,0
Thermal spring Ľudový	58,6 ± 6,7
Mineral spring Uhličitý	1293,21
Mineral spring „Zuzka“	817,89
Mineral spring „Boženy Nemcovej“	243,23
Mineral spring „Vajcovka“	170,11
St. Ondrej spring	161,91
Mineral spring „Smokovecká kyselka“	113,86
Mineral spring „Bory“	73,05
Mineral spring „Medokýš“	68,71

[2] Ďurecová, Lučivjanský: Prírodná rádioaktivita minerálnych vôd Slovenska, II. ročník konferencie Rádioaktivita v životnom prostredí, Spišská Nová Ves, 2000
[3] Gombala a kol.: Radón v ovzduší kúpeľov stredoslovenského regiónu, IAEA, SK96K0100

Average values of U_{nat} concentration, activity concentration of ^{226}Ra and ^{222}Rn in ground waters of Slovakia

	U_{nat} (mg/ℓ)	**^{226}Ra (Bq/ℓ)**	**^{222}Rn (Bq/ℓ)**
Aritmetic mean	0,0034	0,048	15,51
Geometric mean	0,0027	0,035	9,61
Median	0,003	0,039	9,75

Average values of U_{nat} concentration, activity concentration of ^{226}Ra and ^{222}Rn in mineral waters of Slovakia

	U_{nat} (mg/ℓ)	**^{226}Ra (Bq/ℓ)**	**^{222}Rn (Bq/ℓ)**
Aritmetic mean	0,0045	0,196	29,13
Geometric mean	0,0027	0,063	9,89
Median	0,003	0,060	10,27

Average values of U_{nat} concentration, activity concentration of ^{226}Ra and ^{222}Rn in surface waters of Slovakia

	U_{nat} (mg/ℓ)	**^{226}Ra (Bq/ℓ)**	**^{222}Rn (Bq/ℓ)**
Aritmetic mean	0,0025	0,041	2,15
Geometric mean	0,0019	0,031	0,83
Median	0,002	0,035	1,03

- In present:
  - collection of data within Fractional monitoring system - thermal waters – guarantor: MH SR
  - according to the Slovak law radioactivity of mineral table waters must be monitored

Slovak legislation:

Radon in water:

Type of water supply	**Radon activity concentration**
spring water suitable for infants	20 Bq/ℓ
natural mineral water	100 Bq/ℓ
spring water, bottled water, drinking water	100 Bq/ℓ

Indoor radon in spas:

radon levels defined in the legislation	**Average RAC per year**
Investigation level	400 Bq/m^3
Guideline level	1000 Bq/m^3

***B. Measurements of Rn in spas*: - results are scarce from the nineties**

Spa	Sampling place	Long term measurement: A_{aver} (Bq/m^3)
Spa 1	Therapeutic house 1	30 ± 8
	Therapeutic house 2	439 ± 162
Spa 2	water therapy	106 ± 53
Spa 3	water therapy	101 ± 24
	spring	464 ± 125
Spa 4	Therapeutic house 1	64 ± 9
Spa 5	water therapy	96 ± 31
Spa 6	pool	395 ± 103
	leháreň	142 ± 34
Spa 7	water therapy	980 ± 274
Spa 8	water therapy	32 ± 9
Spa 9	pool	90 ± 44
Spa 10	water therapy	232 ± 58
Spa 11	Therapeutic house 1	1180 ± 330
	Therapeutic house 2	1110 ± 311
	cave	838 ± 226
Spa 12	spring	264 ± 145

[3] Gombala a kol.: Radón v ovzduší kúpeľov stredoslovenského regiónu, IAEA, SK96K0100

C. Measurement methods

The Slovak Technical Standard recommends 2 methods:

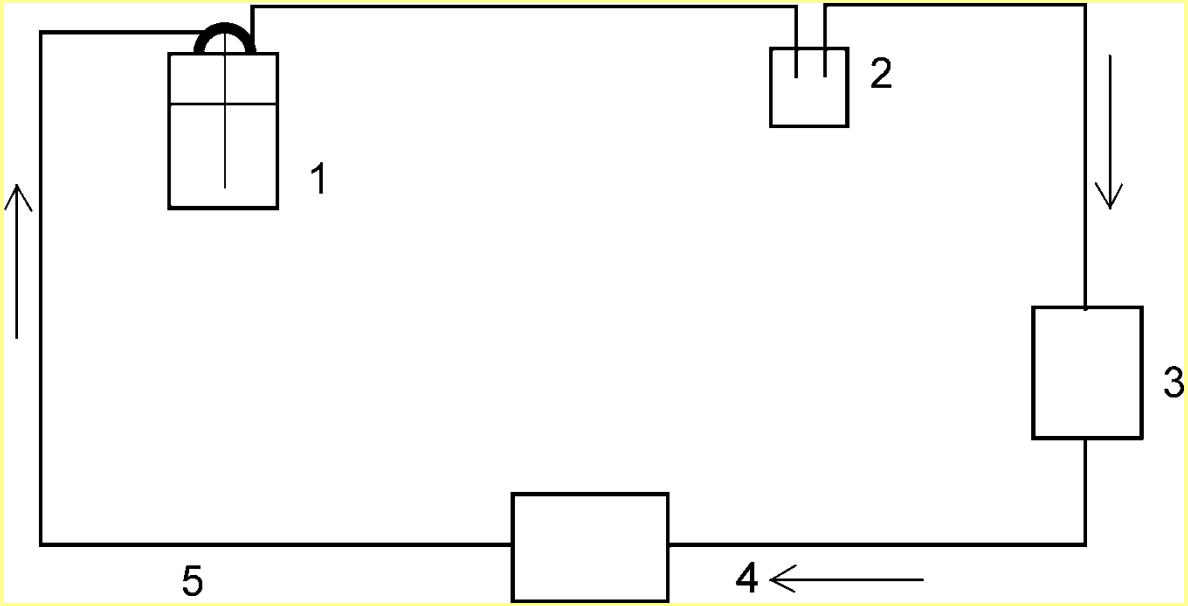
– determination of ^{222}Rn activity concentration by liquid scintillation method

– emanometric determination (^{222}Rn is transferred into a scintillation chamber)

1) Determination of ^{222}Rn activity concentration by liquid scintillation method

The water sample is mixed with a liquid scintillator in the vial. The sample is stored in the dark and after the radioactive equilibrium between ^{222}Rn and its short-living daughters is established, the number of impulses is registered by a scintillation detector.

2) Emanometric determination (^{222}Rn is transferred into a scintillation chamber)



1 - sample container
2 – water trap
3 – air pump
4 - scintillation detector
5 - hoses

Detector and the sample container with a sample are integrated into the circulation circuit (picture). In order to transfer ^{222}Rn, the air is allowed to circulate for 20 min with a flow rate around 1 ℓ/min.

D. Action plan for radon (directive)

- was accepted in Slovakia, but it has not been realized yet

- was a discussion about the directive, but at a general level only

- so called Fractional monitoring system exists:
    - it includes collecting of data about radioactivity (total α and β activity, U_{nat} and ^{222}Rn)

    - frequency of measurements – about once per year – expanded analyses

    - data are not publicly available

- DNPB – preparation of the seminar about the action plan

The present:

problems – spas are non-state facilities, it's difficult to gain access into the spas!

Official requests to the spa management

COMENIUS UNIVERSITY IN BRATISLAVA
FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS
Department of Nuclear Physics and Biophysics
Mlynská dolina F2, 842 48 Bratislava

Dear Mr. Director

Visegrad Fund

In Bratislava, 19.01.2014

Subject: Application for permission of radon measurements

Dear Mr. Director,

I would like to kindly ask you for the permission to perform in your spa facility year-long measurements of radon concentration in thermal waters and in the air of the workplaces where thermal water is used for therapeutic purposes. The reasons for these measurements are explained in detail in the attachment of this letter.

The measurements proposed by us should include:

- sampling of thermal waters for radon analyses for several times a year (4-6 times in total),
- monitoring of radon concentration in the air of workplaces by track detectors for 4 times a year. In each stage, the detectors would be exposed for approximately 3 months. It is assumed that 4-6 detectors would be placed in the workplaces during each stage.

All the results and analyses obtained by us will be given to the management of your spa facility free of charge, and can serve as a base for decisions regarding radiation protection, employees and spa visitors (Regulation of the Government of the Slovak Republic No. 345/2006 of the Collection of Laws, § 34 - 36).

The names of the spa facilities will not be disclosed in our records; each spa facility will only be referred to by a numerical code assigned to it. Also, in order to protect the business interests of your company, the members of the research group conducting measurements and analyses will sign a non-disclosure agreement.

Dear Mr. Director, thank you in advance for permitting the mentioned measurements in your spa facility. I am certain that the proposed collaboration will be mutually beneficial.

Sincerely yours,

Ass.Prof. RNDr. Karol Holý, CSc.
head of Radiation physics section at DNPB CU

Attachment: Reasons for measurement of radon in spa facilities

tel. +421 2 602 95 526, +421 904 986 136 Karol.Holy@fmph.uniba.sk http://radonspas.dnp.fmph.uniba.sk/

Attachment – information about the measurement

Visegrad Fund

Reasons for measurements of radon in spa facilities

(attachment)

Radon (^{222}Rn) is an inert, radioactive gas, occurring naturally as a decay product of ^{226}Ra isotope. Radon is present in all natural materials (soils, waters, rocks, building materials...). High radon concentrations can be found in soil and rock air. The water passing through the rocks is enriched with radon; radon concentration in water can also be high. In general, radon diffuses into the environment from all materials. Concentration of radon (more precisely radon activity concentration) in closed spaces like houses, spa facilities, caves or mines can reach as high as hundreds or thousands of Bq/m^3.

Radon and its radioactive short living decay products are transferred into human lungs by breathing. Lung tissue is irradiated, leading to an increased risk of lung cancer. Radon is classified as a Class A carcinogen and it is the most often cause of lung cancer after smoking. For this reason there is a world-wide effort to minimize the risks related to radon inhalation, and to keep radon concentration in the air of workplaces and residential premises as low as possible.

With the aim to minimize radon related risk, a new EU directive 2013/59 Euratom was accepted. This directive states that EU Member States must prepare and realize so called "Radon action plan". The aim of this plan is to search for increased radon concentrations in residential premises and workplaces, and to take measures leading to the reduction of radon concentration.

A successful solution of this problem requires a correct measurement of radon concentration in various environments and mediums. This gave birth to the idea to harmonize radon measurements among V4 countries. This harmonization initiative includes the creation of common measurement protocols, harmonization of sampling procedures and measurements of radon concentration. Knowledge about the variability of radon concentration in various environments are obtained in order to determine radon-related health risks as accurately as possible.

In 2012, our workgroup focused on the harmonization of measurements of radon concentration in residential buildings. This year we are going to focus on the harmonization of measurements in spa facilities.

In spa facilities, when baths and pools are filled with thermal water, radon located in this water is very effectively released into nearby air. In this air, concentration of radon can vary throughout the year, depending on temperature, pressure and ventilation conditions. Similarly, concentration in thermal water can vary. Unfortunately, little data about this phenomenon can be found in the literature.

In the Slovak legislation (Regulation of the Government of the Slovak Republic No. 345/2006 of the Collection of Laws), concentration of radon in the workplace air of spa facilities is limited by so called "investigation level", which is set to 400 Bq/m3, and by so called "guideline level", which is set to 1000 Bq/m3 (this value should not be exceeded under any circumstances). The values of radon concentration should be obtained on the basis of a year-long monitoring.

Our workgroup concluded that for the harmonization of the measurements, first of all it is important to obtain knowledge about the variability of radon concentration in thermal waters and in workplace air of spa facilities where thermal water is used for therapeutic purposes. During these activites and on the basis of performed analyses we will find out which steps have to be harmonized, and by which manner.

We expect to carry out the following measurements in chosen thermal spa facilities:

- sampling and radon analysys of thermal water samples for 4-6 times a year,
- monitoring of radon concentration by track detectors (see pictures below) in the air of workplaces where thermal water is used for therapeutic purposes for 4 times a year. In each stage, the detectors would be exposed for approximately 3 months. It is assumed that 4-6 detectors would be placed in the workplaces during each stage.

All the results and analyses obtained by us will be given to the management of the spa facility free of charge, and can serve as a base for decisions regarding radiation protection, employees and spa visitors.

Raduet track detector for integral measurements of radon and thoron

RAMARN track detector for integral measurements of radon

Professional continuous radon monitor AlphaGUARD

Thank you for your attention