INTERNATIONAL INTERCOMPARISON MEASUREMENT OF RADON CONCENTRATION IN WATER

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⇨ **INTRODUCTION**

⇨ **PARTICIPANTS AND METHODS**

⇨ **MEASURED THERMAL WATER AND TIMETABLE OF THE INTERCOMPARISON EXERCISE**

⇨ **RESULTS**

⇨ **DISCUSSION**

⇨ **CONCLUSIONS**

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INTRODUCTION

The presentation describes results of the international intercomparison measurement of radon (^{222}Rn) concentration in water, which was held in Teplice, Czech Republic on February 6, 2014, as a part of kick-off meeting of V4 Standard Project ĂRadon in thermal waters and radon risk in chosen thermal water spas in V4 countriesñ, supported by International Visegrad Fund.

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INTRODUCTION

The intercomparison measurement - carried out in the field, i. e. at a selected workplace where the thermal water is used - is not intended for an intercalibration of methods and instruments.

It is designed as an intercomparison of results obtained using different instruments and methods employed in the field in order to assess the ability to interrelate diverse measurements.

Under these circumstances, values are not reported against a standard or reference measurement. Participants results are simply compared to each other, in order to obtain an indication of the collective precision of various measurements.

PARTICIPANTS

- ⇨ **RADON v.o.s., Praha, Czech Republic (CZ);**
- ⇨ **Institute of Nuclear Physics PAN, Laboratory of Radiometric Expertise, Kraków, Poland (PL);**
- ⇨ **Social Organisation for Radioecological Cleanliness, Veszprém, Hungary (HU);**
- ⇨ **Faculty of Mathematics, Physics and Informatics, Department of Nuclear Physics and Biophysics, Comenius University, Bratislava, Slovakia (SK).**

SAMPLING METHODS

CZ: water sample is collected into a pre-evacuated glass cell (125 ml) with a rubber stopper using a needle; radon from the glass cell is transfered into a pre-evacuated glass-type Lucas cell (600 ml); efficiency of the transfer: 0,95;

volume of water sample (ml): 25 ï 50

PL: Ionization chamber method (**ICH**):

water sample is taken to a glass bottle (1 l), filled to the top and closed below the surface of the water; 500 ml of the sample is transfered to the degassing vessel - radon is expelled from the water sample by the AlphaPUMP in a closed gas cycle;

volume of water sample (ml): 500

Liquid Scintillation Counting (**LSC**):

water sample is transfered directly from the source to the 20 ml glass vial with scintilator, using special glass pipette;

volume of water sample (ml): 10

SAMPLING METHODS

HU: water sample is collected into a 300 ml glass bottle with a metal cap; bottle filled to the top; 100 ml of sample is transferred to slender of Water degassing unit (Pylon WG1001), then for a period of 8 to10 minutes a radon free gas (nitrogen) is bubbled through the sample to strip radon from water into an active scintillation cell (270 ml, 300A Pylon);

volume of water sample (ml): 100

SK: water sample is taken to a glass bottles (500 ml), which is filled to the top and closed; before the measurement 7 ml of the water sample is transfered to the degassing vessel (30 ml) by using a burette; quantitative vacuum method is used for the transport of radon from degassing vessel to the Lucas cell (125 ml); whole transfer procedure lasts about 5 minutes; after the transfer, radon remainder in the sample is smaller than 0,3 %;

volume of water sample (ml): 7

MEASURING METHODS

CZ: **Lucas cells** measured in scintillometer (LUK 1, LUK 4A); counting in equilibrium (more than 3,5 h after the transfer; 400 s); verification (calibration) in the Czech Metrological Institute, Praha, 10/2013;

minimal detectable radon concentration (kBq/m^3): ≈ 1

PL: Ionization chamber method (**ICH**):

radon concentration in air is measured in the **ionization chamber** of AlphaGUARD PQ2000PRO; calibration in the Central Laboratory for Radiological Protection; 11/2012

minimal detectable radon concentration (kBq/m^3): 1

Liquid Scintillation Counting (**LSC**):

water sample in the vial with scintillator is closed and mixed for a few minutes to extract radon from water to the scintillator; counting in equilibrium; vials are measured in **liquid scintillation** counter (30 min); TRIATHLER LSC(PB) A/B calibrated by producer in 2007

minimal detectable radon concentration (kBq/m^3): 0.1

MEASURING METHODS

HU: A Grab Radon (Gas Extraction) active Scintillation Cells (GS)

Radon concentration is evaluated by Pylon AB-5 Portable radon monitor photomultiplier, a 300A Pylon active **scintillation cell** (by 270 ml volume and 0,64 cpm/dpm efficiency) and Pylon WG1001 degassing unit by 95% efficiency of degassing and transferring radon from water into cell (efficiency given by Pylon Electronics Inc.); calibration has been done in the Radiochemistry and Radioecology Laboratory, University of Pannonia (certificated radon chamber; known activity of Radium-226 source and Alphaguard PQ2000 PRO as reference), on 8/2013.

After grabbing radon into the cell, a 3 hours waiting time is necessary to reach equilibrium. The decay constant correction factor is calculated due to time between water sampling and measurement;

minimal detectable radon concentration (kBq/m^3): $\approx$ 1.1

MEASURING METHODS

SK: Lucas chambers (brass cylindrical vessels with the flat glass bottom, producted by EMPOS Praha, CZ); for counting, the chambers are connected with scintillation probe and electronics in CAMAC standard; calibration in the Department of Nuclear Physics and Biophysics - calibration of the scintillation cells using a ^{226}Ra standard, 3/2011; calibration of the scintillation probe using a flat ZnS(Ag) detector and a ^{241}Am + ^{239}Pu source, 2/2014;

minimal detectable radon concentration (kBq/m^3): 2

MEASURED THERMAL WATER AND TIMETABLE OF THE INTERCOMPARISON EXERCISE

Thermal water which was used for the intercomparison measurement comes from the source PravŚdlo (Age-old Hot Spring), located in Spa house Beethoven. The thermal water is accumulated in a reservoir below the spa house. Then it si pumped to an underground tank on the slope of a nearby hill. From the tank, water is distributed to the spa-facilities in various bathhouses of Teplice spa.

Water temperature at the source is approximately 41 ^{o}C.

MEASURED THERMAL WATER AND TIMETABLE OF THE INTERCOMPARISON EXERCISE

Basic radiological parameters of thermal water:

Gross alpha activity	0.341 kBq/m^3 (± 14.6%)
Gross beta activity	0.393 kBq/m^3 (± 9,6%)
Gross beta activity after deduction of ^{40}K	0.138 kBq/m^3 (± 9.6%)
Concentration of ^{226}Ra	0.200 kBq/m^3 (± 14%)
Concentration of uranium	0.118 kBq/m^3 (± 14%)

Note: Data are taken from the test report No. 11226/2012 issued by the Institute of Public Health Ústí nad Labem, Czech republic (analysis from December 2012)

MEASURED THERMAL WATER AND TIMETABLE OF THE INTERCOMPARISON EXERCISE

Three different types of samples of thermal water were collected during the intercomparison exercise.

As **the first step**, samples of thermal water were taken directly from the reservoir below the Spa house Beethoven. Water samples were collected below the free water level.

Reported times and depths of sampling:

HU - 9:05, three water samples, depth of 65 - 85 cm below the water level;

PL - 9:40, six water samples, depth of 30 - 40 cm below the water level;

SK - from 9:51 to 9:52, two water samples, one sample from the surface of water, one sample from the depth of 2 m below the water level;

CZ - from 9:59 to 10:01, three water samples, depth of 40 - 50 cm below the water level.

MEASURED THERMAL WATER AND TIMETABLE OF THE INTERCOMPARISON EXERCISE

The second part of the intercomparison measurement was carried out at the workplace of balneotherapy in Spa house Kamenné lázně (Stone Bath) - in room No. 33. Two different ways of sampling were tested there: **sampling from the bath filled with thermal water** and **sampling of running water from the inlet to the bath**.

Sampling from the bath, reported times and depths of sampling:

HU - from 15:00 to 15:01, three water samples, different depths below the water level;

PL - 15:00, six water samples, depth of 30 - 40 cm below the water level;

SK - from 14:58 to 14:59, two water samples, depth of 30 cm below the water level;

CZ - from 14:58 to 15:00, three water samples, depth of about 30 cm below the water level.

Note: Individual participants took samples of water practically simultaneously.

MEASURED THERMAL WATER AND TIMETABLE OF THE INTERCOMPARISON EXERCISE

Sampling from the inlet, reported times:

HU - from 15:07 to 15:09, three water samples;

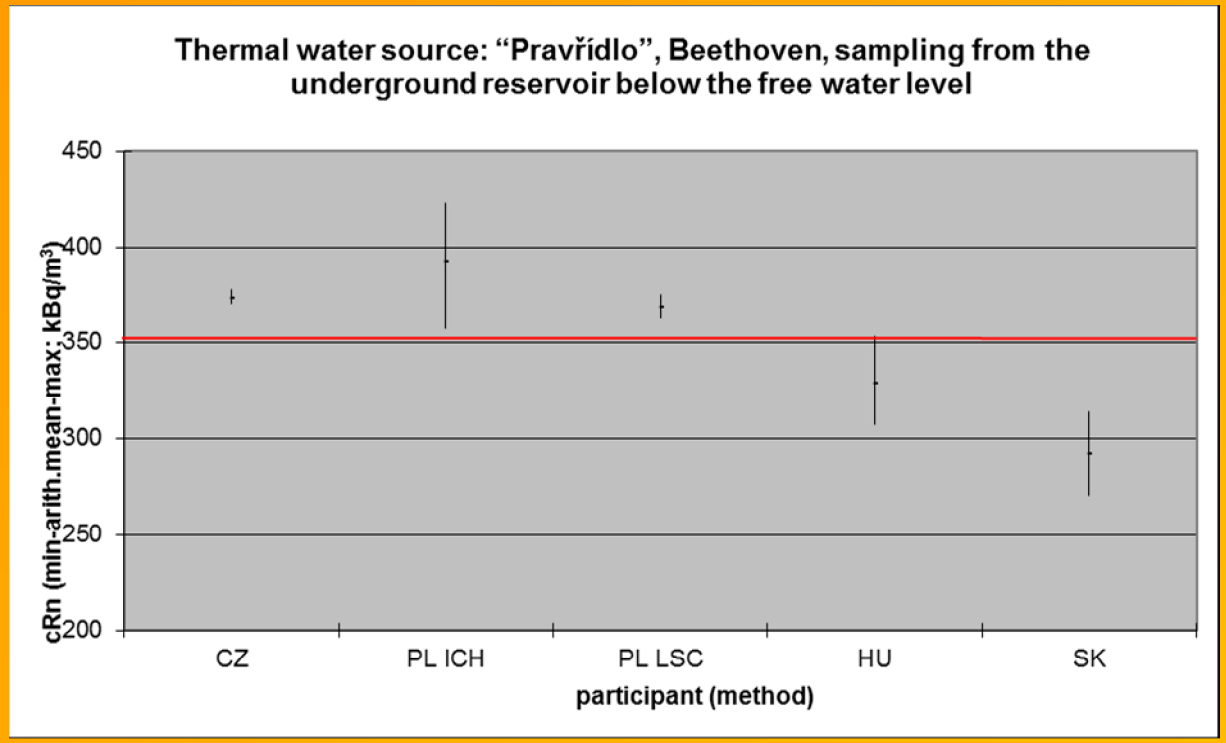
PL - 15:00, six water samples;

SK - from 15:06 to 15:08, two water samples;

CZ - from 15:04 to 15:10, three water samples.

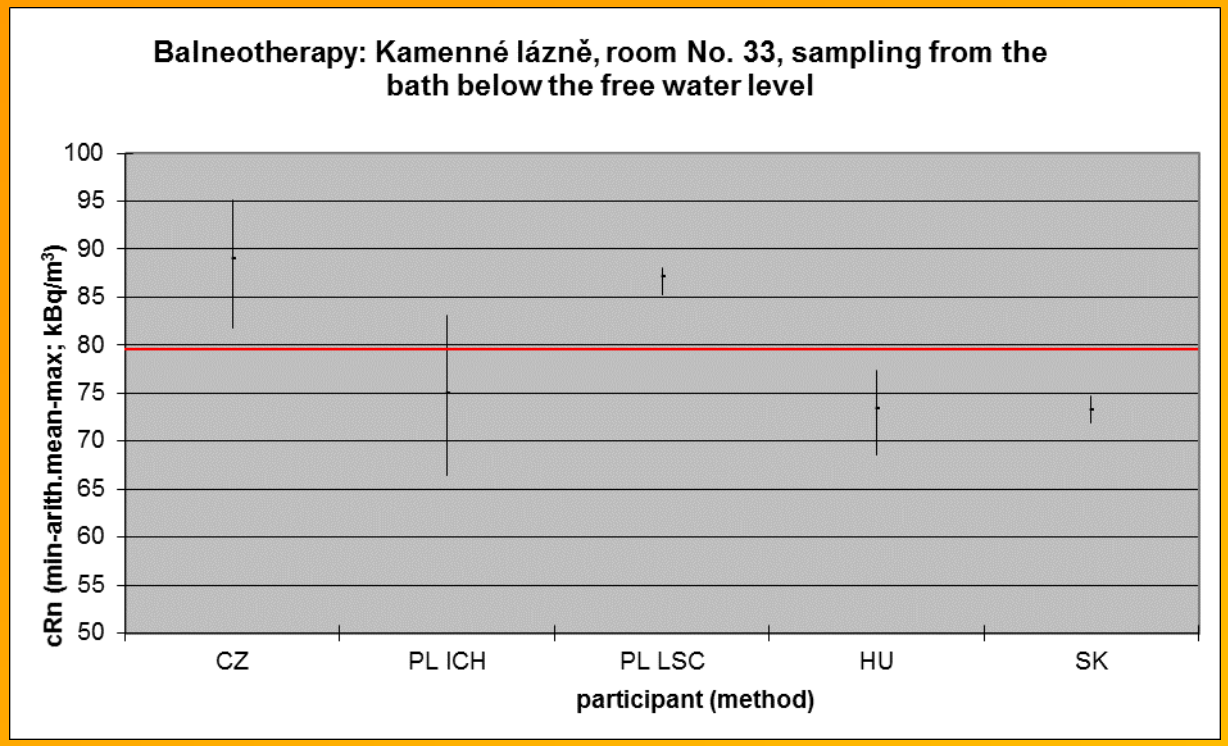
Note: In fact, the individual participants changed during the sampling. Sampling can be thus considered simultaneous.

RESULTS



Note: Red line shows the average of the arithmetic means

RESULTS



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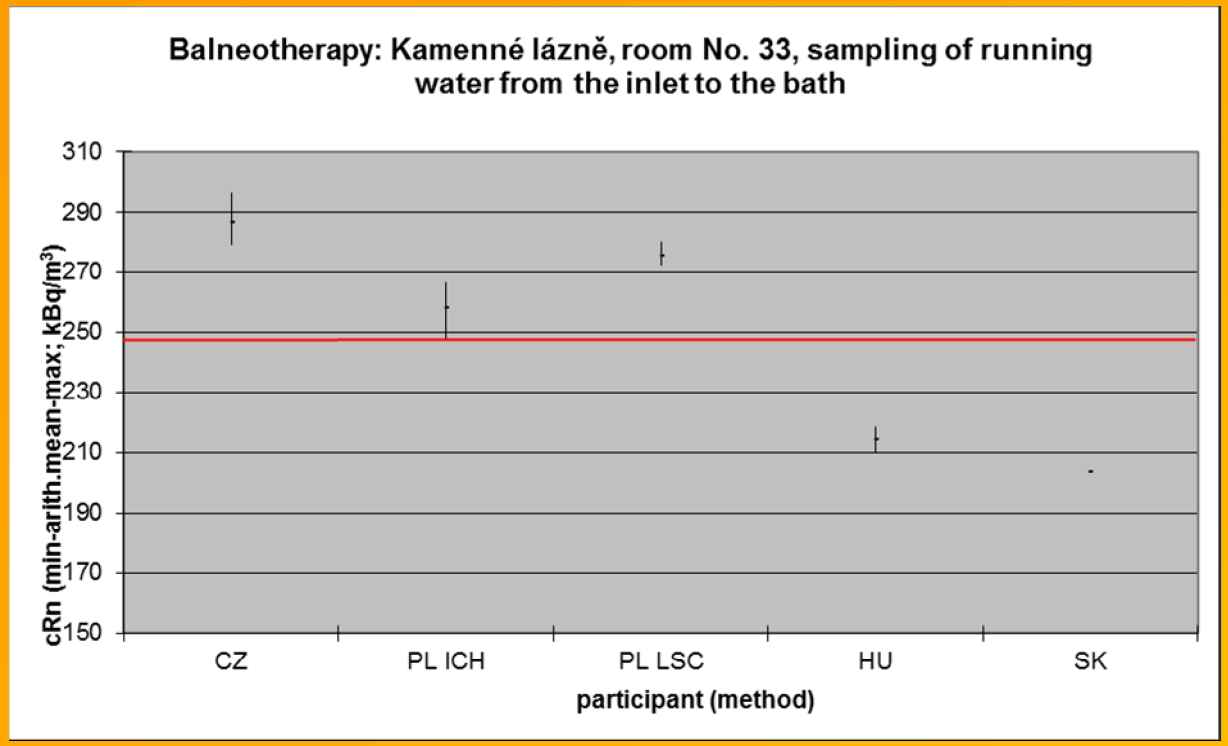
RESULTS



Note: Red line shows the average of the arithmetic means

DISCUSSION

The variability of reported values may be partly influenced by an inhomogeneous distribution of radon in the water in reservoirs. This could be the case of sampling from ñPravÝdloò and from the bath in room No. 33. Moreover, the water samples were taken from different depths below the free water level.

The first part of the intercomparison (sampling from ñPravÝdloò) could theoretically also be affected by **temporal changes of radon concentration in water in the reservoir**, as different participants took their samples sequentially, not simultaneously.

It seems evident that the **differences between participants are more systematic than random**. Values reported by CZ and PL are systematically higher than values reported by HU and SK *(exept results obtained by PL ICH in room No. 33, sampling from the bath below the free water level).*

DISCUSSION

This deviation is independent of the method of sampling. It is therefore likely related to differences in the primary calibration of instruments.

Basic statistical parameters were calculated for two sets of data: for all values obtained by different participants (methods) and for all arithmetic means obtained by different participants (methods).

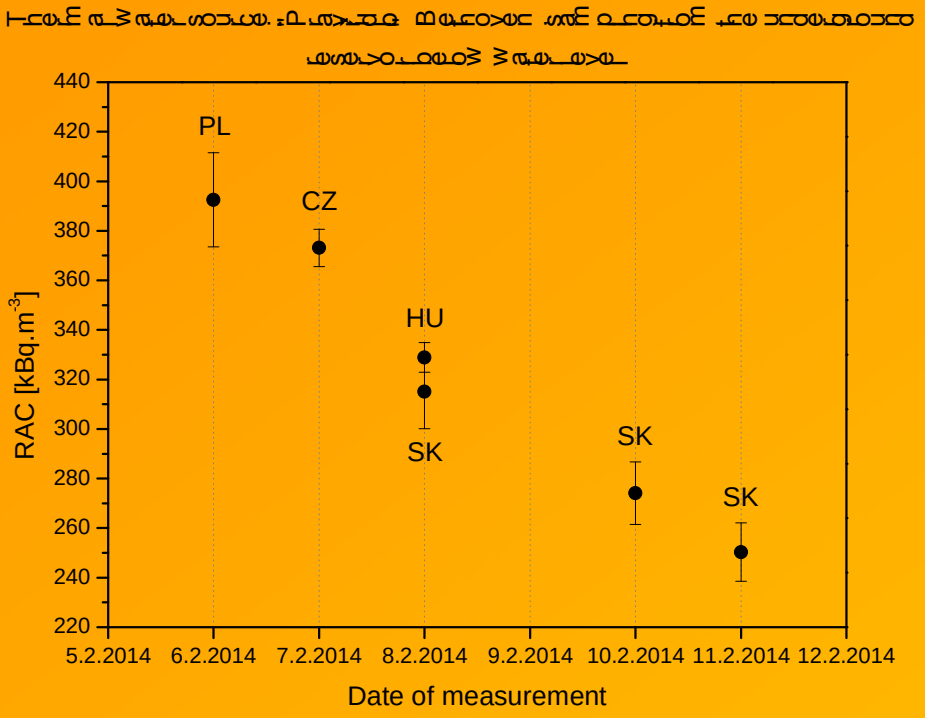
DISCUSSION

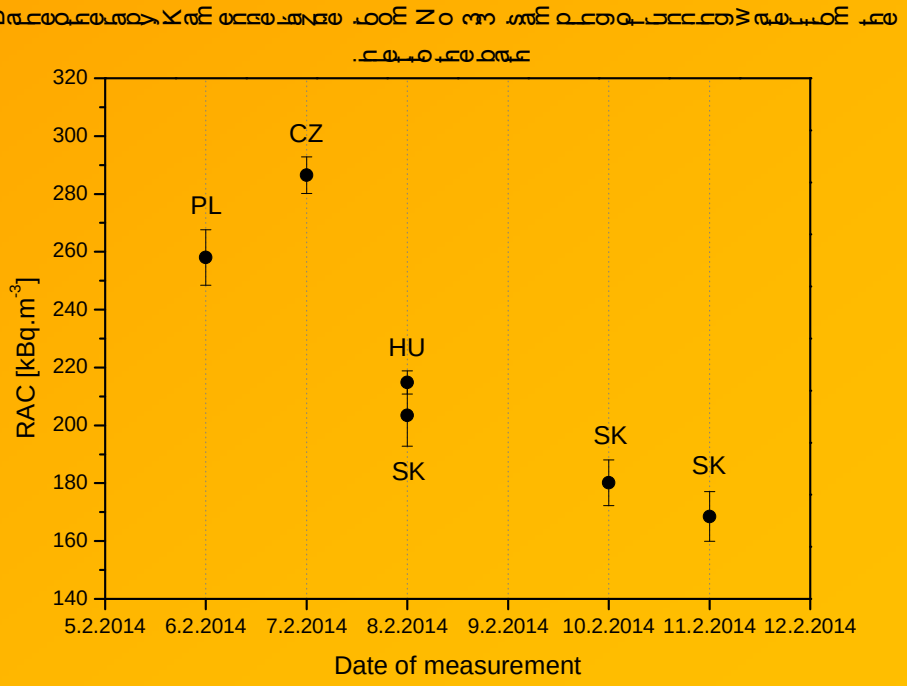
Parameter	All reported values of cRn (kBq/m^3)	Arithmetic means of cRn (kBq/m^3) obtained by different methods
Thermal water source: ñPravŠdloò, Beethoven, sampling from the underground reservoir below the free water level		
Arithmetic mean	355,2	351,0
Standard deviation (SD)	39,2	40,2
SD / arith. mean	0,110	0,114
Minimum	270,7	292,3
Maximum	423,2	392,5
Balneotherapy: Kamenné lázn, room No. 33, sampling from the bath below the free water level		
Arithmetic mean	80,0	79,5
Standard deviation (SD)	8,6	7,8
SD / arith. mean	0,108	0,098
Minimum	66,4	73,3
Maximum	95,2	89,0
Balneotherapy: Kamenné lázn, room No. 33, sampling of running water from the inlet to the bath		
Arithmetic mean	250,7	247,6
Standard deviation (SD)	33,6	36,9
SD / arith. mean	0,134	0,149
Minimum	203,4	203,8
Maximum	296,4	286,6

The dispersion of data was larger when samples of running water were taken from the inlet to the bath (13 - 15%) than in case, when the samples were taken from the reservoir or from the bath (10% - 11%). This fact may indicate some problems with sampling of running water.

DISCUSSION

Another reason for the observed deviations could theoretically be losses of radon from the sample container (bottle) between sampling and measurement.





CONCLUSIONS

Differences in radon concentration in water reported by the intercomparison participants are probably caused by differences in the primary calibration and therefore it could be useful to repeat the intercomparison.

Problems with the tightness of sample containers (bottles) and problems with sampling of running water also cannot be excluded.

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Thank you