Visegrad Fund

Radon in thermal waters and radon risk in chosen thermal water spas in V4 countries

V4 Standard Project

Kick-off meeting

February 5-7, 2014; TEPLICE, CZECH REPUBLIC

Many thanks to Karol, Monika, ...

for your efforts and work to prepare the application of V4 Standard Project with success ☺

Visegrad Fund

PARTICIPANTS

- **Social Organisation for Radioecological Cleanliness**
- **Institute of Radiochemistryand Radioecology at the University of Pannonia**

- **Faculty of Mathematics, Physics and Informatics, Department of Nuclear Physics and Biophysics, Comenius University**

- **RADON v.o.s**

- **Institute of Nuclear Physics PAN (IFJ PAN), Laboratory of Radiometric Expertise**

Institute of Nuclear Physics PAN

The Henryk Niewodniczański
INSTITUTE of NUCLEAR PHYSICS
Polish Academy of Sciences

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LABORATORY OF RADIOMETRIC EXPERTISE
INSTITUTE OF NUCLEAR PHYSICS PAN

PCA
POLSKIE CENTRUM AKREDYTACJI
BADANIA
AB 788

ilac-MRA

UNIA DLA PRZEDSIĘBIORCZYCH
PROGRAM KONKURENCYJNOŚĆ
UNIA EUROPEJSKA
Zakup współfinansowany ze środków Europejskiego Funduszu Rozwoju Regionalnego

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The International Laboratory Accreditation Cooperation

ILAC Mutual Recognition Arrangement

ilac-MRA

ilac global trust
Testing – Calibration – Inspection

POLSKIE CENTRUM AKREDYTACJI
POLISH CENTRE FOR ACCREDITATION

PCA

Sygnatariusz EA MLA
EA MLA Signatory

CERTYFIKAT AKREDYTACJI
LABORATORIUM BADAWCZEGO
ACCREDITATION CERTIFICATE OF TESTING LABORATORY
Nr AB 788

Potwierdza się, że: / This is to confirm that:

INSTYTUT FIZYKI JĄDROWEJ
im. Henryka Niewodniczańskiego
Polskiej Akademii Nauk
LABORATORIUM EKSPERTYZ RADIOMETRYCZNYCH
ul. Radzikowskiego 152, 31-342 Kraków

spełnia wymagania normy PN-EN ISO/IEC 17025:2005

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Akredytacja pozostaje w mocy pod warunkiem przestrzegania wymagań jednostki akredytującej określonych w kontrakcie Nr AB 788

Certyfikat akredytacji ważny do dnia 04.02.2015 r.

Akredytacji udzielono dnia 05.02.2007 r.

DYREKTOR
POLSKIEGO CENTRUM AKREDYTACJI

EUGENIUSZ W. ROGUSKI

Warszawa, 6 grudnia 2013 roku

Polish Centre for Accreditation

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5 .02.2007 ***validity:*** **4.02.2015**

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Laboratory of Radiometric Expertise IFJ PAN

RESEARCH FIELDS:

- ✓ Physics of natural radioisotopes
- ✓ Identification and high-sensitive measurements of gamma isotopes
- ✓ High-sensitive Rn, Tn measurements
- ✓ Investigation of Rn, Tn diffusion process and migration into buildings
- ✓ Calculation and modelling of environmental doses

ACCREDITED METHODS:

- ✓ Measurements of natural gamma isotopes (Ra-226, Th-228, K-40) concentrations in solid samples using low-background gamma spectroscopy
- ✓ Measurements of Rn-222 concentration in liquid samples using α–spectroscopy
- ✓ Measurements of Rn-222 concentration (indoor, outdoor and in soil gas)
  - solid-state nuclear track detector (SSNTD)
  - α– spectroscopy

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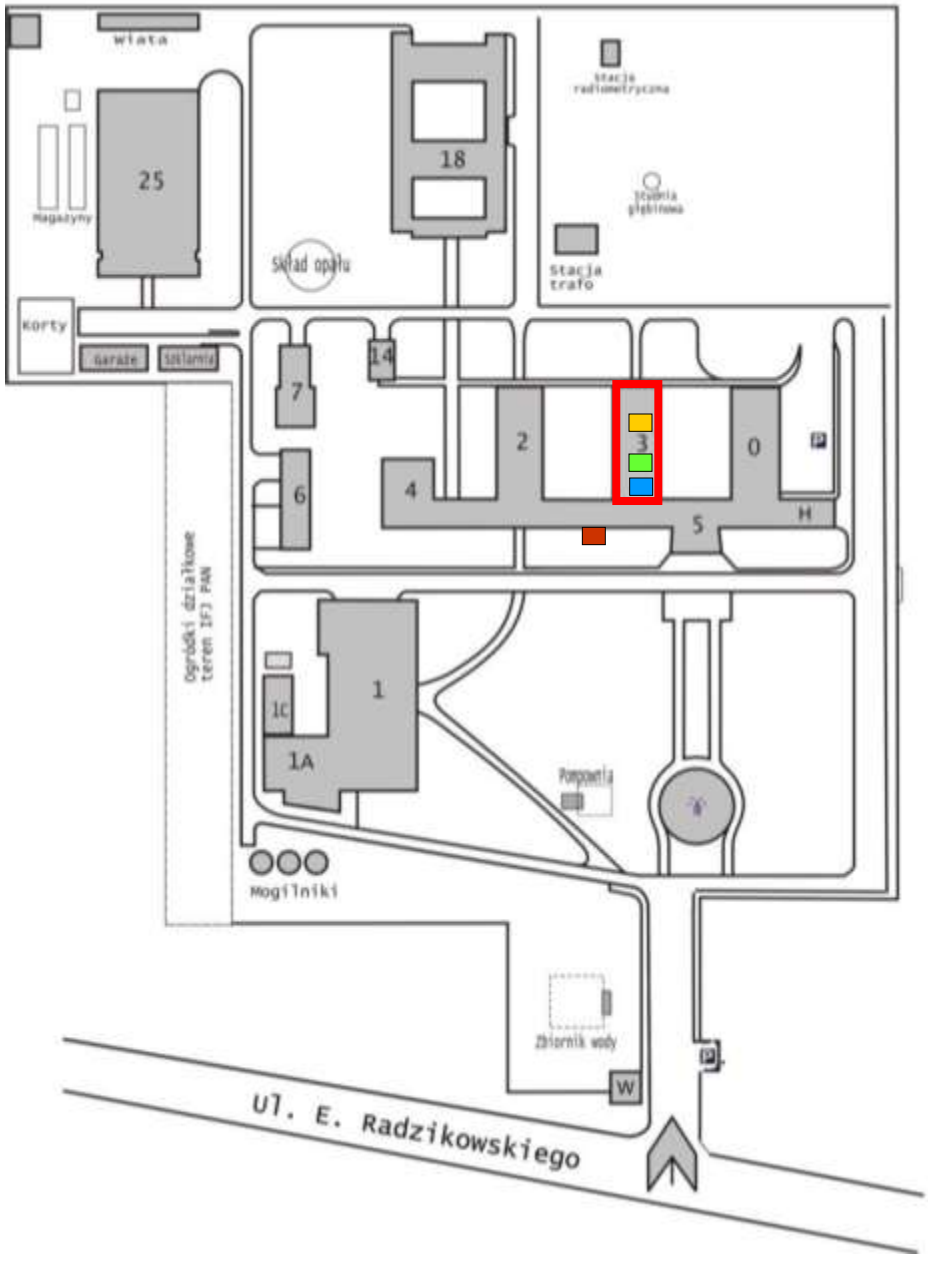
LABORATORIES LER IFJ PAN



Laboratory of Radiometric Expertise IFJ PAN

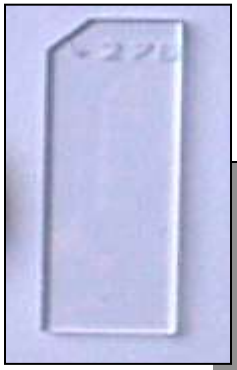
THE RADOSYS SYSTEM 2003

automatic reading of CR-39 detectors

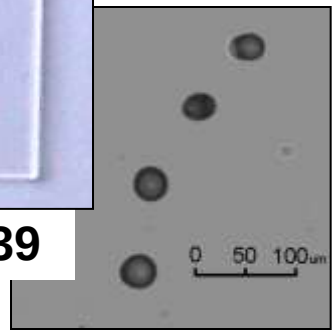
- B&W CCD Camera
- magnification: 100 x
- 12 detectors 60 s/1 detector
- Resolution > 150 tracts / mm^2
- Scanning area:: 47 mm^2
- SQL database engine (PostgreSQL)

RadoBath

- 25% NaOH (sodium-hydroxide) - 5000 g
- Etching temp.: 90 °C
- Etching time: 4 h
- No of detectors: 432



CR-39



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RADON & PROGENY IN AIR

DEVICES FOR RADON MEASUREMENTS

AlphaGUARD PQ2000
AlphaGUARD PQ2000Pro
AlphaGUARD PQ2000Pro

DEVICES FOR RADON AND THORON PROGENY MEASUREMENTS

Radon WL Meter

MODEL WLX (Pylon Electronics INC)

SARAD EQF3220 attachment & unattachmet radon, thoron progeny

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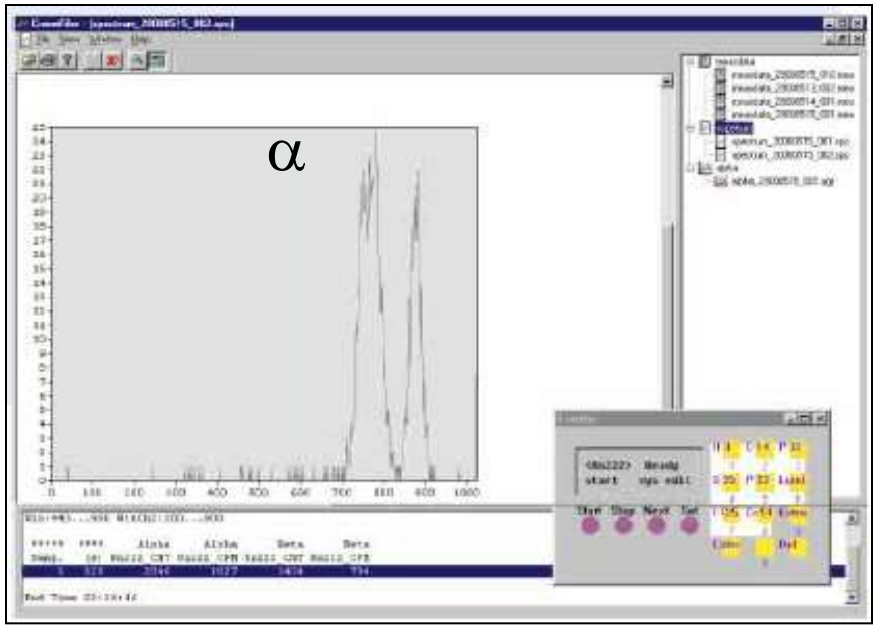
RADON IN WATER - LSC METHOD

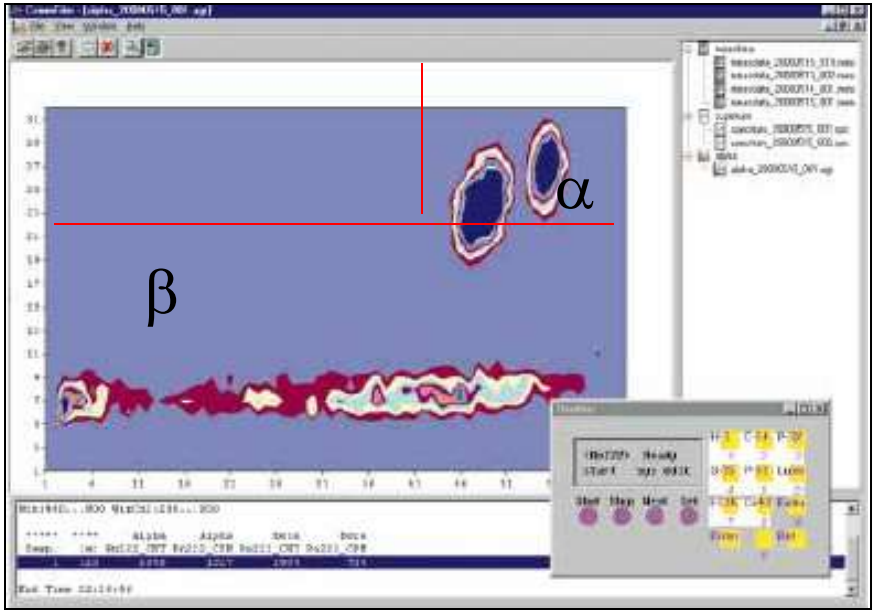
HIDEX

Liquid Scintillation Counter TRIATHLER

Trytium	H-3
Carbon	C-14
Radon	Rn-222
Radium	Ra-226
Uranium	U-238/U234

- ✓alpha / beta separation
- ✓Pb shielding





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RADON IN WATER - LSC METHOD

water sample - 10 ml

Ultima Gold F scintillator - 10 ml

Mixing

Waiting for equilibrium (3 hours)

30 minutes measuring

Counting formula

$$C = \frac{D}{3 * t * V * 0{,}97}$$

C – Radon ^{222}Rn concentration [Bq/L]
D – α decay counts
t – Time of measurement [s]
V – Volume of sample [L]
0,97 – radon extraction factor

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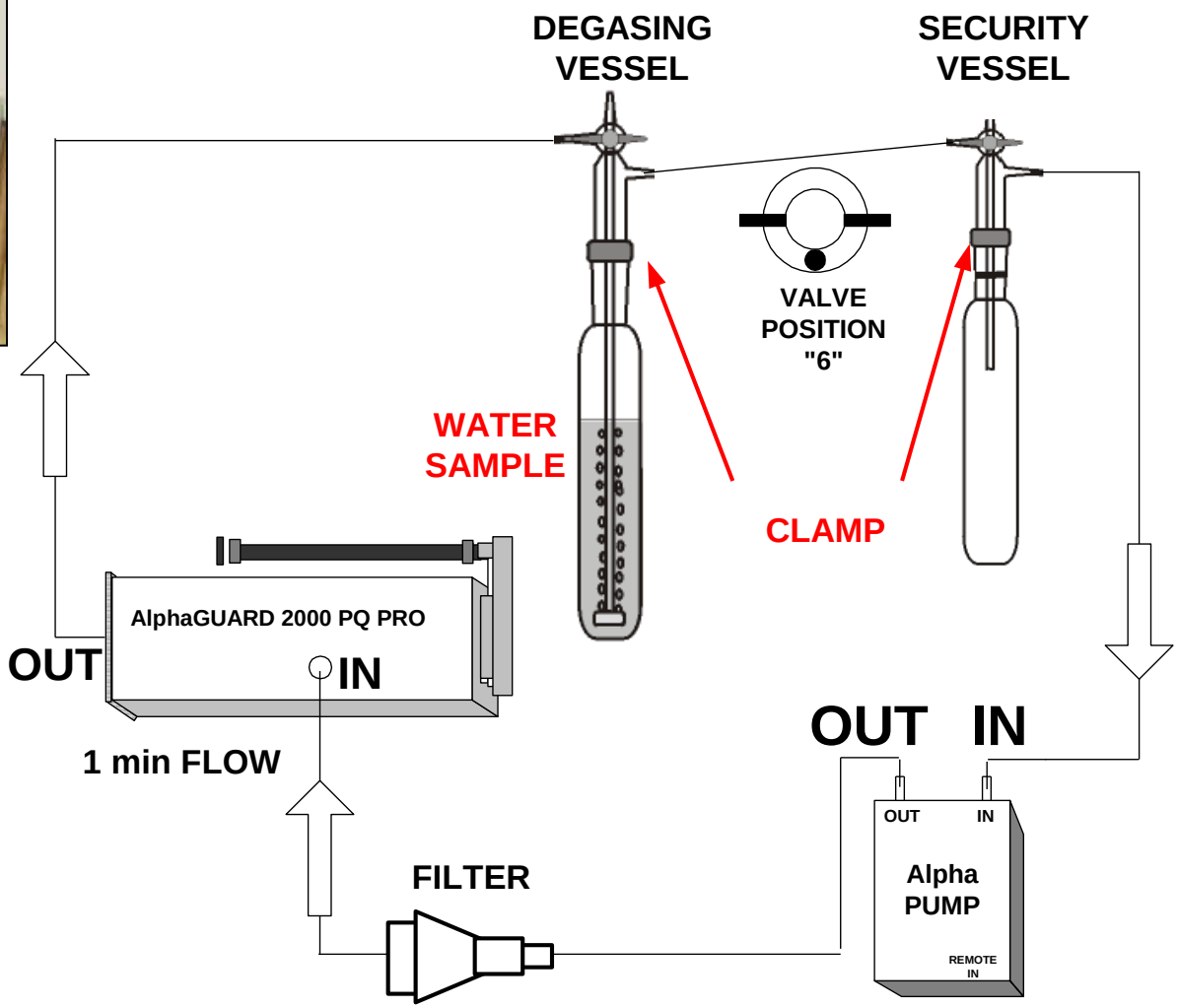
RADON IN WATER - AquaKIT METHOD



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RADON CALIBRATION CHAMBER

CONTROL BOARD

DIGITAL FLOW METER

MASTERFLEX PUMP
Manually controlled (flow rates: up to 3 dm³ / min)

TIMER

- control pump
- time on
- time off
- 7 days in week

MEASUREMENTS IN SERBIA

ELSEVIER

Available online at www.sciencedirect.com
SCIENCE DIRECT®

Journal of Environmental Radioactivity 89 (2006) 249–260

JOURNAL OF ENVIRONMENTAL RADIOACTIVITY

www.elsevier.com/locate/jenvrad

High natural radiation exposure in radon spa areas: a detailed field investigation in Niška Banja (Balkan region)☆

Z.S. Žunić [a], I. Kobal [b], J. Vaupotič [b], K. Kozak [c,*], J. Mazur [c], A. Birovljev [d], M. Janik [c], I. Čeliković [a], P. Ujić [a], A. Demajo [a], G. Krstić [e], B. Jakupi [e], M. Quarto [f], F. Bochicchio [f]

Table 4
Results of radium and radon in water measurements

Sample code	^{226}Ra concentration (Bq dm^{-3})	^{222}Rn concentration (Bq dm^{-3})
W1	0.650 ± 0.015	23 ± 2
W2	0.215 ± 0.010	460 ± 20
W3	0.550 ± 0.020	0.2 ± 0.4
W4	Not measured	570 ± 20
W5	Not measured	510 ± 20
W6	0.046 ± 0.003	0.5 ± 1.6
W7	0.033 ± 0.002	3.0 ± 0.5
W8	0.460 ± 0.015	Not measured
W9	0.038 ± 0.003	Not measured
W10	0.360 ± 0.010	Not measured
W11	0.315 ± 0.010	Not measured
W12	0.039 ± 0.003	Not measured

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INTERCOMPARISON in the past

Contents lists available at SciVerse ScienceDirect

Radiation Measurements

journal homepage: www.elsevier.com/locate/radmeas

Intercomparison measurements of ^{222}Rn concentration in water samples in Poland

Krzysztof Kozak [a,*], Beata Kozłowska [b], Tadeusz A. Przylibski [c], Jadwiga Mazur [a], Anna Adamczyk-Lorenc [c], Kalina Mamont-Cieśla [d], Olga Stawarz [d], Jerzy Dorda [b], Barbara Kłos [b], Mirosław Janik [a], Elżbieta Kochowska [a]

[a] *The Henryk Niewodniczański Institute of Nuclear Physics, Polish Academy of Science, ul. Radzikowskiego 152, 31-342 Kraków, Poland*
[b] *University of Silesia, Institute of Physics, Department of Nuclear Physics and its Application, ul. Uniwersytecka 4, 40-007 Katowice, Poland*
[c] *Wrocław University of Technology, Faculty of Geoengineering, Mining and Geology, Institute of Mining, Division of Geology and Mineral Waters, Wybrzeże S. Wyspiańskiego 27, 50-370 Wrocław, Poland*
[d] *Central Laboratory for Radiological Protection, ul. Konwaliowa 7, 03-194 Warsaw, Poland*

Table 1
Simplified characteristics of "Mieszko" and "Marta" spring water.

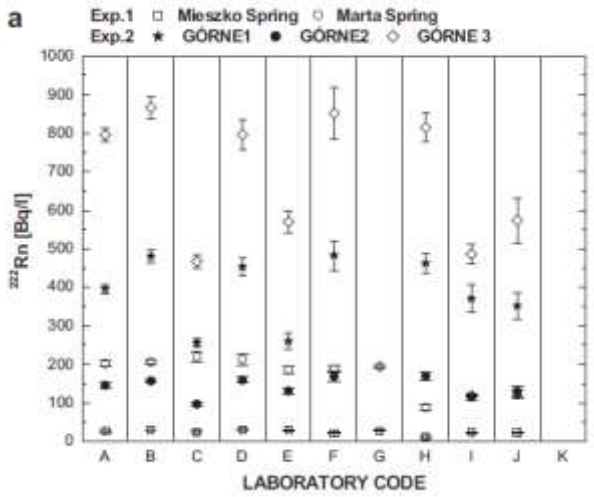
Intake	^{222}Rn concentration [Bq l^{-1}]	Chemical type of water	Temperature [°C]	TDS[a] [g l^{-1}]	CO_2 concentration [g l^{-1}]	Spring discharge [m^3 h^{-1}]
Mieszko	10.4–55.1 (mean = 30.3 for 26 values)	HCO_3–Na	7.3–13.1	2.34–3.82	0.81–2.24	0.16–0.51
Marta	103.6–325.6 (mean = 214.1 for 860 values)	HCO_3–Na–Ca	8.3–14.3	1.13–2.70	1.23–2.15	0.016–0.07

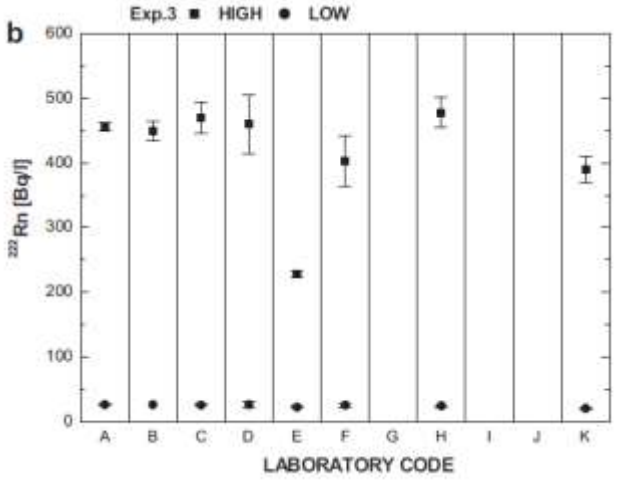
[a] TDS – total dissolved solids.

Table 2
Simplified characteristics of waters from wells: no. 1, no. 2 and no. 3 of "Górne" intake.

Gorne intake	^{222}Rn concentration [Bq l^{-1}]	Chemical type of water	Temperature [°C]	TDS[a] [g l^{-1}]	CO_2 concentration [g l^{-1}]	Spring discharge [m^3 h^{-1}]
Well no. 1	155–614 (27 values)	HCO_3–Na–Mg	8–16	0.15–0.63	0.53–2.54	0.11–1.86
Well no. 2	81–1145 (27 values)					
Well no. 3	137–1170 (1953 values)					

[a] TDS – total dissolved solids.





K.Kozak et al. , Intercomparison measurements of 222Rn concentration in water samples in Poland
Radiation Measurements 47 (2012) 89-95

3. Sampling and measurement methods

One of the most important stages in radon measurement in water is the proper collection of samples in order to minimize radon loss during sampling itself and then during the transportation of samples to the laboratories. The organizers of individual experiments paid particular attention to providing identical conditions for water sampling of any required volume (according to the requirements of each of the applied measurement methods). The sampling time was minimized and usually did not exceed 20 min for each sample. This was especially important in the case of taking groundwater samples since natural conditions may slightly vary in time (Kasztovszky et al., 2000). Some participants collected water samples in bottles which were closed tightly after filling and then brought to the laboratories for measurements. Whereas in the case when the Liquid-Scintillation Counting (LSC) was used, water samples were taken to disposable syringes from which they were quickly transferred to the measurement vials.

K.Kozak et al. , Intercomparison measurements of 222Rn concentration in water samples in Poland
Radiation Measurements 47 (2012) 89-95

5. Conclusions

The aim of this publication was to present the advantages coming from organization and participation in several consecutive intercomparison experiments. The organization of successive comparative experiments of ^{222}Rn concentrations in water brought the expected effect, which was to obtain convergent results by all laboratories. In the 2001 intercalibration measurements, barely 50% of the participating laboratories produced satisfactory results, while in 2003 practically all the laboratories measured radon concentrations comparable within uncertainty limit and close to the estimated reference value. The results of the subsequent intercalibration experiments showed that the liquid-scintillation method seems to be the most reliable technique in measurement both low and high radon activities in water.

In view of indisputable benefits to all laboratories measuring ^{222}Rn concentrations in waters for human consumption, waters regarded as medicinal, groundwaters and surface waters used for geochemical and other research, next experiments of this type are planned in the following years as part of the activities of the Radon Centre – a non-governmental international scientific network. Slightly worse results of the experiments based on groundwater samples suggest that future intercalibration measurements should include both natural waters and laboratory-prepared standard water with known concentrations of radon.

MINERAL WATERS 2007- 2010

LĄDEK ZDRÓJ *(Sudety mountains, SW Poland)*

Jerzy source: 1176 ± 60 Bq/dm^3

Skłodowska-Curie source: 331 ± 17 Bq/dm^3

L-2 Zdzisław bore-hole: 115 ± 21 Bq/dm^3

PIWNICZNA ZDRÓJ, MILIK *(Carpathian mountains, SE Poland)*

P-7 intake: $1{,}1 \pm 0{,}8$ Bq/dm^3

M-4 intake: $2{,}1 \pm 1{,}1$ Bq/dm^3

SLOVENIA

Izvir Toplica source: $4{,}2 \pm 0{,}3$ Bq/dm^3

Hotavlje source: 17 ± 1 Bq/dm^3

GEOTHERMAL WATERS 2006, 2008

BIAŁKA TATRZANSKA *(Tatra mountains, S Poland)*

4,2 ± 1,8 Bq/dm^3

BAŃSKA, near SZAFLARY *(Tatra mountains, S Poland)*

- before heat exchanger

1,0 ± 0,1 Bq/dm^3; 1,2 ± 0,1 Bq/dm^3

- after heat exchanger

2,7 ± 0,2 Bq/dm^3; 2,9 ± 0,2 Bq/dm^3; 2,4 ± 0,2 Bq/dm^3;

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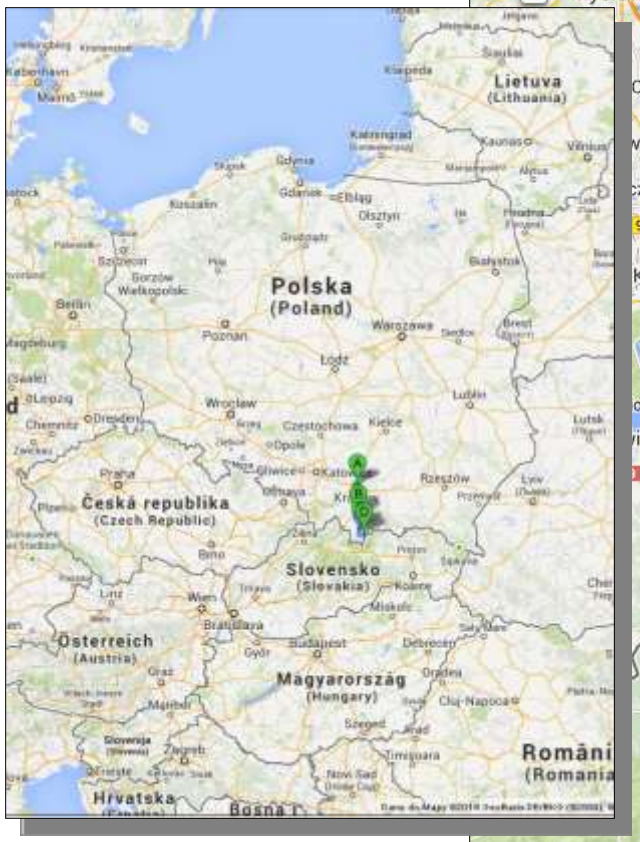
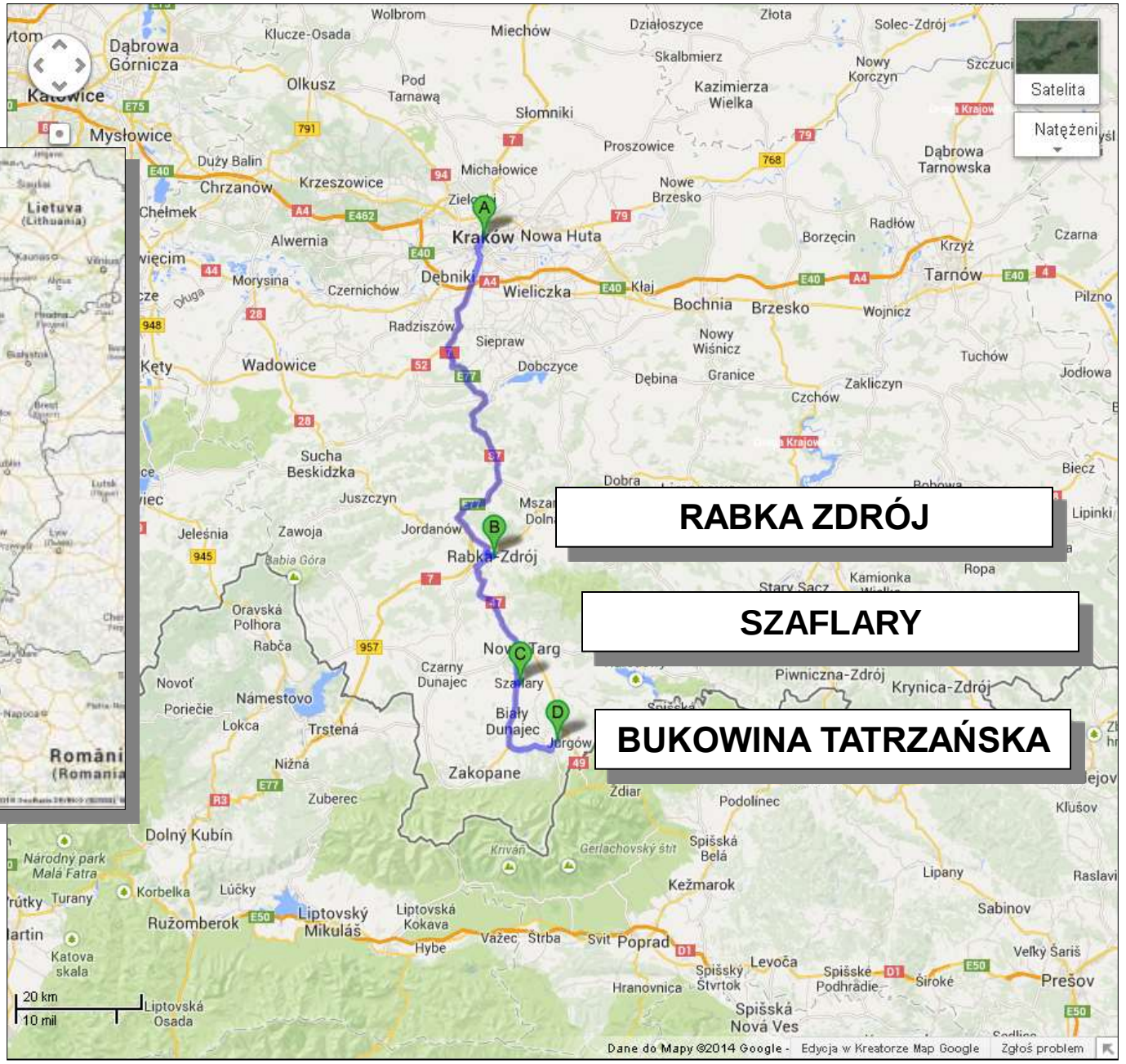
CHOSEN SPAS IN POLAND





RABKA ZDRÓJ

SZAFLARY

BUKOWINA TATRZAŃSKA

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RABKA ZDRÓJ

12 pools (6 in + 6 out)
water temp. 30 °C
start: 2008

http://www.uzdrowisko-rabka.pl

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SZAFLARY

5 pools (2 in + 3 out)
water temp. 30 - 38 °C
start: 2006

http://www.termyszaflary.com

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BUKOWINA TATRZAŃSKA

15 km from Zakopane
12 pools (6 in + 6 out)
water temp. 30 - 36 °C
start: 2008

http://www.termabukowina.pl

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MEASUREMENTS

- start: February 2014 ; stop: November/December 2014 ?
- Radon in water – 2 methods AquaKIT + LSC
  sampling: 4 x year ?
- Active indoor radon measurements
  AG + WL Meter); WLx – PYLON
- Passive indoor radon measurements
  track detectors: 4 exposures ? RAMARN + RSFW

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MEASUREMENTS - questions

- other inside parameters ? (hum., temp.,pressure)
- calculation of average Rn concentration for dose assessment ?
  day/night concentration ! contribution to the „total average”
- spa working hours for workers and what time for patients ?
- location of the detectors in spa ?
- possible problems with owner’s permissions ?