INTERNATIONAL INTERCOMPARISON MEASUREMENT OF SOIL-GAS RADON CONCENTRATION (RIM 2010)

Milan Matolin[1], Martin Neznal[2], Matej Neznal[2]

[1]Charles University in Prague, Faculty of Science, Albertov 6, 128 43 Praha 2, Czech Republic,
e-mail: matolin@natur.cuni.cz

[2]RADON v.o.s., Novakovych 6, 180 00 Praha 8, Czech Republic,
e-mail: radon@comp.cz

- ⇨ **INTRODUCTION: EXPERIENCE FROM PREVIOUS SOIL-GAS RADON INTERCOMPARISON MEASUREMENTS**
- ⇨ **PARTICIPANTS**
- ⇨ **TEST SITES**
- ⇨ **METHOD OF EVALUATION**
- ⇨ **RESULTS**
- ⇨ **CONCLUSIONS**

HISTORY OF SOIL-GAS RADON INTERCOMPARISON MEASUREMENTS (1991 – 2002)

Badgastein, Austria, 1991

CLIFF, K. D. – HOLUB, R. F. – KNUTSON, E. O. – LETTNER, H. – SOLOMON, S. B. (1994): International intercomparison of measurements of radon and radon decay products, Badgastein, Austria, September, 29 - 30, 1991, published by National Radiological Protection Board, Chilton, Didcot, Oxon.

New York, U.S.A., 1995

HUTTER, A. R. – KNUTSON, E. O. (1998): An International intercomparison of soil gas radon and radon exhalation measurements, Health Physics, Vol. 74, pp. 108-114.

Prague, Czech Republic, 1996

NEZNAL, M. – NEZNAL, M. – SMARDA, J. (1997): Intercomparison measurement of soil-gas radon concentration, Radiation Protection Dosimetry, Vol. 72, pp. 139-144.

Buk (near Pribram), Czech Republic, 2002

NEZNAL, M. – NEZNAL, M. (2004): International intercomparison measurement of soil-gas radon concentration, of radon exhalation rate from building materials and of radon exhalation rate from the ground, in Radon investigations in the Czech Republic, edited by I. Barnet, M. Neznal and P. Pacherova (Czech Geological Survey and RADON v.o.s, Prague), Vol. 10, pp. 12-22.

EXPERIENCE:

⇨ „Classical“ field intercomparison measurements are not intended to be used as an intercalibration of methods and instruments. Measured values are not reported against a standard or reference measurement. Participants results are compared to each other, in order to obtain an indication of the collective precision and deviations of various measurements.

⇨ Geological conditions in a depth of soil-gas sampling should be as homogeneous as possible at the test site. If this requirement is not fulfilled, a large variability of measurement results can be expected.

⇨ Incidence of outsider values may strongly influnce the results of the intercomparison measurement.

⇨ Differences connected with primary calibration (i. e. instruments calibration in radon chambers) are usually lower than 10 percent.

EXPERIENCE:

⇨ **Differences on the level of about 20 % seem to be a realistic target for intercomparison measurements of soil-gas radon concentration. If the variability is much larger than 20 %, problems with soil-gas sampling and/or with primary calibration are indicated.**

⇨ **Frequent systematic failures are connected with soil-gas sampling. If the sampling system is not sealed perfectly, the soil-gas samples are diluted by the atmospheric air. The real soil-gas radon concentrations are then underestimated. For testing the applicability of sampling methods, it is useful to choose a test site characterized by medium, or low permeability of soil.**

⇨ **Deviations of measured radon activity concentration in soil gas may be further caused by an imperfect evacuation of detecting chambers (detectors), by an incorrect transfer of soil gas samples into the detector, or by an influence of thoron if it was not eliminated from measured samples.**

EXPERIENCE:

⇨ **Preliminary measurements should be limited at a chosen test site to avoid a destruction of the upper soil layers. This is very important if radon exhalation from the ground surface is measured at the same test site.**

PARTICIPANTS

The intercomparison exercise was attended by participants representing 12 different institutions from 11 countries (Czech Republic, China, Germany, Italy, Luxembourgh, Poland, Republic Of South Africa, Romania, Slovenia, Spain, Sweden) and by the administrator of the reference test sites (Charles University in Prague, Faculty of Science).

20 and 21-09-2010

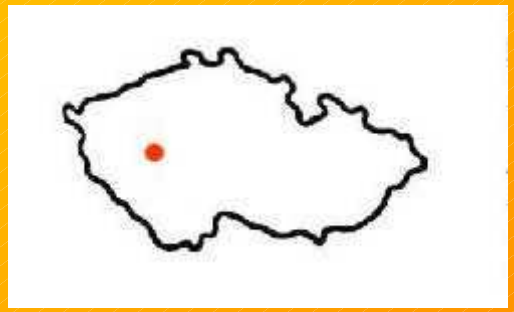
Anonymous evaluation: all data were reported using participants' codes A01, A02, A03,… A13 only.

Different sampling and measuring techniques were used.

TEST SITES

Three natural reference test sites are located about 60 km SW from Prague, near the town Příbram. They are located on meadow areas and they are accessible for cars. At each of the test sites, 15 reference points were marked in a 5 x 5 m grid.

The sites have been used for testing of Czech organizations and private firms dealing with soil-gas radon concentration (radon risk mapping) since 2000. A large database (N = 171 in 2010) containing the information on radon activity concentration in soil gas and its temporal variability is available.



Reference site	c_A ^{222}Rn (kBq/m^3)	Permeab. of soil	Basement rock	Soil	U (ppm)	Terrain	Access for cars
Cetyne	32	L,(M),H	orthogneiss	SL	2.0	meadow	+
Bohostice	52	(L),(M),H	orthogneiss	LS,CS	2.3	meadow	+
Buk	155	H	granodiorite	LS	3.6	meadow	+

METHOD OF EVALUATION

Computer programme TestMOAR

Three steps

Test 1

Comparison with the group

Test 2

Comparison with the group

Charles University in Prague, Faculty of Science
Institute of Hydrogeology, Engineering Geology and Applied Geophysics
Department of Applied Geophysics
128 43 Praha 2, Albertov 6

Assessment of comparison measurement of Rn-222 activity concentration in soil air at reference sites Cetyně, Bohostice and Buk.

Organization: AAA
Street and No.
City/village, postal code

Date of measurement: 10. September 2000

Used symbols: c_A - radon activity concentration in soil air, (kBq/m^3)
t - argument of Student´s distribution

Test 1 - test of differences in c_A measured by organizations at single reference sites

The difference between c_A measured by given organization at single observation points of a reference site and median of c_A data determined by other organizations, including the administrator, at relevant observation points, in the same day, is tested. The difference is significant, if the calculated interval of confidence does not imply zero.

Reference site	*Interval of confidence*	*Ratio of data outside the interval of confidence*
Cetyně	< -5.963; 11.449 >	4/15
Bohostice	< -11.165; 4.912 >	1/15
Buk	< -1.541; 9.701 >	2/15

Test 2 - linear regression and correlation of c_A data measured in the same day at reference sites

Dependence of c_A data measured by given organization (y) on medians (x) of c_A data determined by other organizations, including the administrator, at relevant observations points, in the same day, is expressed by linear regression $y = a + bx$. In ideal case of data coincidence is $a = 0$, $b = 1$. The data acceptable coincidence is not proved, if the calculated t-value of the test criterion exceeds the critical t-value.

Regression parameter	*Calculated t-value*	*Critical t-value*	*Coefficient of correlation*
a = -0.486	0.181	2.695	0.984
b = 1.022	0.788	2.695	

Test 3

Comparison with the radon database

Testing criterion R1/R2 of an ideal value equal to one and acceptable deviations +/- 30 %; R1/R2 <0.7 – 1.3>

Test 3 - comparison of c_A data of an organization with all available c_A data from the reference site, under elimination of radon temporal variations and the level of c_A data of the administrator

Radon activity concentration in soil air at each single reference site is tested by means of a ratio of two parameters R1 and R2. Parameter R1 is the ratio of the c_A mean at the reference site, reported by the organization, to c_A mean, reported by the administrator. Parameter R2 is the average of all available R1 data of preceding measurements at the given reference site. Testing criterion R1/R2 compares the c_A data, reported by the organization, with c_A data of preceding measurements of all organizations. Acceptable deviation from ideal value R1/R2 = 1 is 30 % relatively, R1/R2 < 0.7; 1.3 >.

Reference site	*Parameter R1*	*Ratio R1/R2*
Cetyně	1.050	1.084
Bohostice	0.865	0.917
Buk	0.993	1.018

Ideal value is 1.000

Conclusions

Test 1 and test 2 (both orientative) indicate general coincidence between radon concentration activity reported by your organization and the data reported by organizations participating in the test on the same day. Test 3 shows an agreement of your data with the data of all organizations tested at the reference sites since the year 2000. The procedure of radon in soil air determination, applied by your organization, can be used for radon risk mapping at building sites after the Act No. 18/2002, and the relevant Decree of the State Office for Nuclear Safety No. 184.

Datum

Signature

Seal

METHOD OF EVALUATION (SUMMARY)

Tests 1 and 2 based on comparison of results of the group of participants are more or less indicative.

The most important conclusions are derived from the result of Test 3 based on comparison with reference sites databases, where radon temporal variations are eliminated by data processing.

The method of assessment was proposed and created by the administrator of reference sites. It has been used for a routine evaluation of Czech field intercomparison measurement results since 2000.

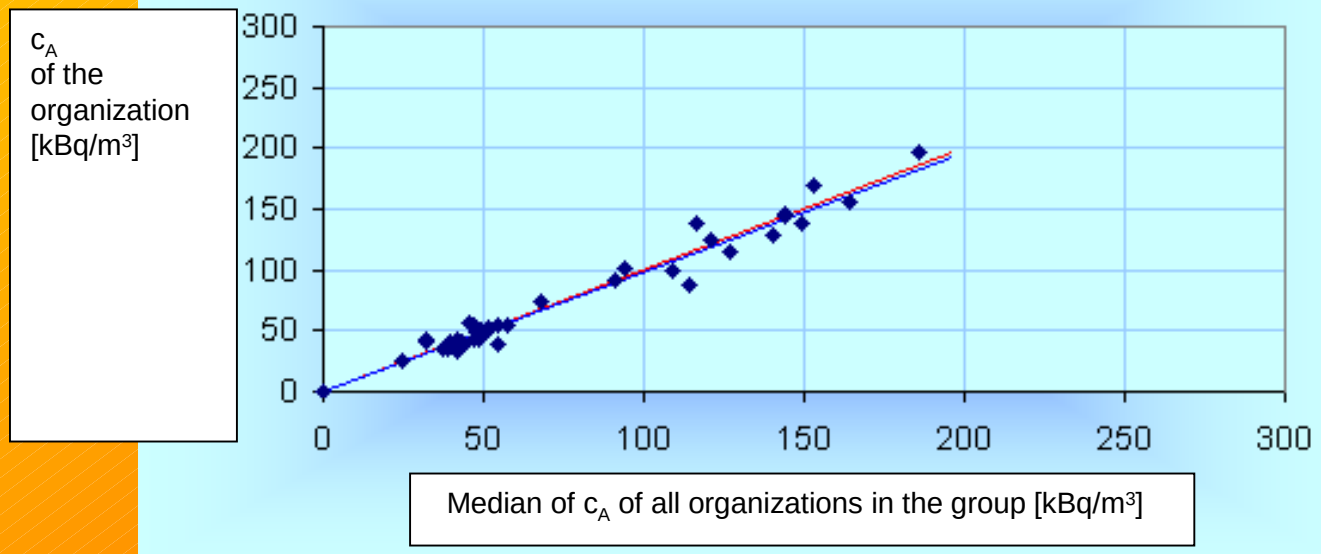
RESULTS

Test No. 2: Linear regression y = a + bx of radon activity concentration reported by an organization (y) at a single station and median (x) of radon activity concentration of the group of organizations at the same station. An ideal data agreement is a = 0, and b = 1. This presumption is rejected if computed t-value is larger than critical t-value. Level of significance α = 1 %.

Tested by Computer programme TestMOAR.

Example of excellent agreement between radon data of an organization and medians of radon data of the group of organizations.

Test 2 – linear regression y = a + bx (blue) between radon activity concentration c_A reported by the organization (y) and medians of c_A (x) of all organizations in the group. Ideal regression line (a = 0, b = 1) is marked red.



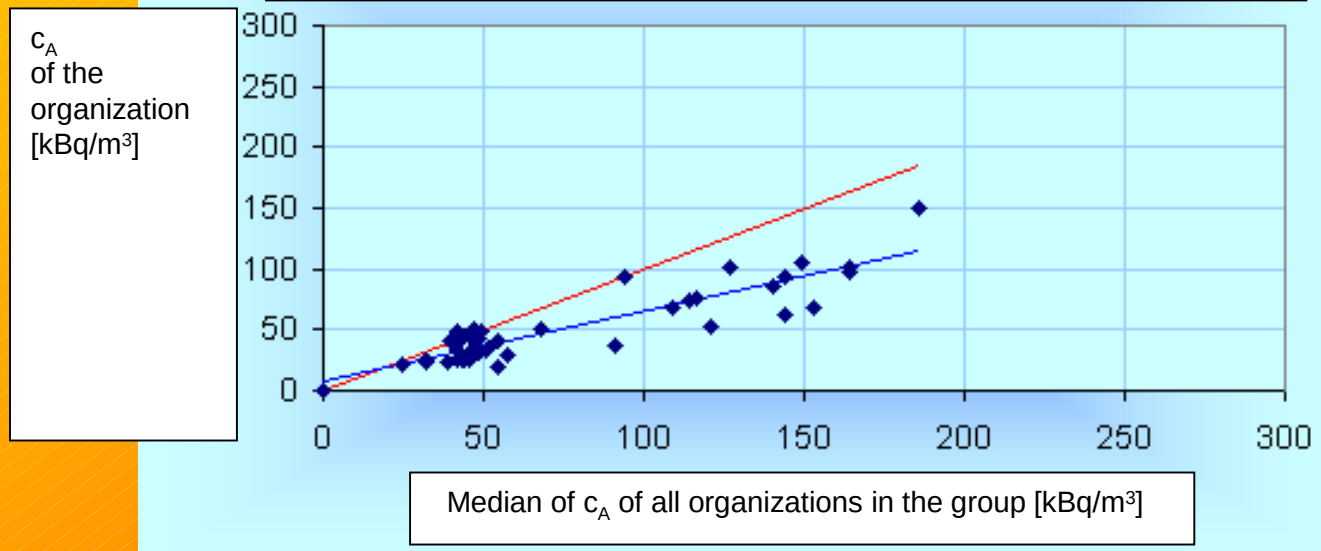
a	=	0,599	ta	=	0,236
b	=	0,984	tb	=	0,542
r	=	0,982	tkrit	=	**2,695**

Test No. 2: Linear regression y = a + bx of radon activity concentration reported by an organization (y) at a single station and median (x) of radon activity concentration of the group of organizations at the same station. An ideal data agreement is a = 0, and b = 1. This presumption is rejected if computed t-value is larger than critical t-value. Level of significance α = 1 %.

Tested by Computer programme TestMOAR.

Example of poor agreement between radon data of an organization and medians of radon data of the group of organizations.

Test 2 – linear regression y = a + bx (blue) between radon activity concentration c_A reported by the organization (y) and medians of c_A (x) of all organizations in the group. Ideal regression line (a = 0, b = 1) is marked red.



a	=	8,389	ta	=	2,150
b	=	0,570	tb	=	9,645
r	=	0,891	tkrit	=	**2,695**

Test No. 3: Comparison of average (AM) radon activity concentration in soil gas at radon reference sites

Normed radon data R1/R2
Criterion R1/R2 ideal value 1.0, acceptable range (0.7; 1.3)
Criterion R1/R2 is applicable for each single reference site
Tested by Computer programme TestMOAR

	Reference site			
	Cetyne	Bohostice	Buk	
Organization	Criterion R1/R2			Average R1/R2
A02	1.135	1.075	1.015	1.075
A03	1.108	1.041	1.275	1.141
A04	1.055	1.021	1.094	1.057
A05	0.795	0.725	0.722	0.747
A06	1.230		0.990	1.110
A07	0.834	0.688	0.662	0.728
A08	1.162	1.023	1.410	1.198
A09	1.094	0.872	1.072	1.013
A10	0.960	0.990	1.041	0.997
A11	0.986		1.021	1.004
A12	1.026	0.970	1.012	1.003
A13	1.482		1.360	1.421

Statistical evaluation of the whole data sets - results of activity concentration in soil gas measurements at radon reference sites Cetyne, Bohostice and Buk

Reference site	Number of observations	Arithmetic mean	Standard deviation	Standard deviation / arithmetic mean
		kBq/m^3	kBq/m^3	
Cetyne	**164**	**41.16**	**12.50**	**0.30**
Bohostice	**144**	**50.44**	**11.21**	**0.23**
Buk	**189**	**134.89**	**40.87**	**0.30**

Note: Detailed results (Main statistical parameters of data sets reported by different participants at different test sites) are presented in Workshop Proceedings.

CONCLUSIONS:

⇨ **The dispersion of data reported by participating organizations includes effects of natural geological inhomogeneity of reference sites - individual points for soil gas sampling were chosen randomly in the surroundings of fixed stations. The dispersion of data is also influenced by various techniques of soil gas sampling, which were used during the intercompariosn exercise, and by differences in used calibration standards and individual proceedures of instrument calibration.**

⇨ **The variability of data, expressed by the ratio of standard deviation vs. arithmetic mean, ranged from 23 to 30 %. Because the variability was higher than 20 %, some problems with soil-gas sampling and/or with primary calibration cannot be excluded.**

⇨ **Despite relatively large radon in soil gas data dispersion, majority of participating organizations fulfilled the criteria of the Test 3 based on comparison with databases (N = 171) of radon reference sites in the Czech Republic.**

⇨ **Radon intercomparison measurements contribute to global radon data standardization.**


Atlas Copco

Thank you

Results of RIM 2012 should be sent to matolin@natur.cuni.cz within 10 days