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INTERCOMPARISON OF RADON IN SOIL INSTRUMENTS AT REFERENCE SITE IN CZECH REPUBLIC

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Abstract
Intercomparison exercises of radon instruments play an important part when it comes to domestic survey as well as international or national mapping in dwellings, soil or water. Therefore, it is of prime interest to improve and standardize technical methods of measurement and also to verify quality assurance through comparison between different instruments and techniques. In the present paper is described the latest intercomparison exercise performed between the Laboratory of Environmental Radioactivity (hereafter called LER) of our department and other 15 different teams around Europe. The test has been held at two radon reference sites located 60 km SW of Prague, Czech Republic.

1. Introduction

Radon comparison measurements at radon reference site serve as verification of field radon measurements performed by single organizations. Radon comparison measurement tests the calibration of instrument, the technique of soil gas sampling, soil gas transfer into the detection chamber, radon measuring procedures, stability of field measurements, elimination of thoron and data processing. Tests are based on the comparison of reported radon (^{222}Rn) activity concentration in soil gas with other participants of comparison measurements and with the database of two reference sites.

Both radon reference sites are located 60km SW of Prague near the city Milin in Czech Republic, Fig.1. The natural radon reference sites Bohostice and Buk have been established in 2000; they are both located on meadows which makes it easy accessible for cars. Each reference site implies 10 stabilized stations, marked by numbers. Separate reference sites differ in radon activity concentration in soil gas; however, radon distribution within the reference site being relatively homogenous, thickness and permeability of soil enabling soil gas sampling at the reference depth of 0.8 m. Geological setting at radon reference sites was investigated by geophysical methods. Temporal radon variations were recorded since 2000 until 2012.

FIGURE 1. Geographical location of the reference site.

2. Materials and Methods

Radon comparison measurement at reference sites was organized for a group of participants. Each group organization measures radon at 10 stabilized stations of each reference site by its own technique. Soil air was sampled from the depth of 0.8 m near to each stabilized station.

Tests are based on comparison of radon data reported by LER with radon data of the participating group and with radon data of a database of the respective reference site. The computer program TestMOAR evaluates the reported radon data. Three tests based on statistics were developed and programmed by the Institute of Applied Mathematics and Computer Techniques, Faculty of Science, Charles University of Prague.

Test No.1 calculates differences between radon activity concentrations at single stations (N = 10) of a reference site, reported by LER and a radon median of radon data reported by the group, which measured radon at identical stations in the same day of measurement.

Test No.2 determines the regression y = a + bx between radon activity concentrations at all measured stations of the two reference sites (N = 2x10 = 20 stations) reported by tested organisations (y) and median (x) of radon data for relevant stations reported by the administrator and all other organisations measuring the same day.

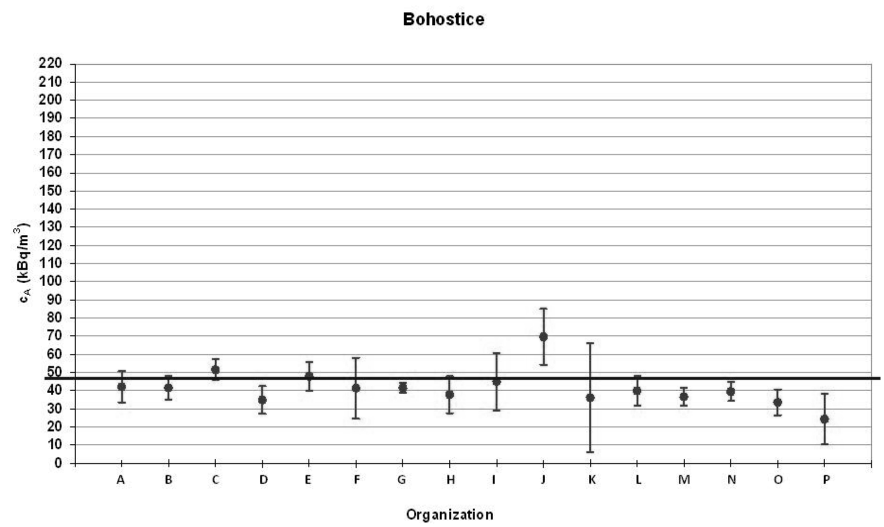
Test No.3 is the comparisons of LER mean radon concentration in soil gas for a single reference site with the radon database of the reference site. At the present (2012), the database of each reference site consists of 198 data sets of successful measurements of different organisations during the period 2000 – 2012. The testing criterion, which has the ideal value equal to one, accepts deviations of standardized radon data in the range of 0.7 – 1.3 (30% relative deviation). Test is performed for every reference site separately. The use of standardized radon data by LER and the database in the Test No.3 eliminates temporal variations of radon activity concentration in soil gas.

All participants were asked to collect soil air samples from three permanently installed 'Neznal' probes (RADON v.o.s.) located near the first three stations and to determine radon concentration in the sample using their own method. In the same time cross-checking: RADON v.o.s. took samples from sampling probes of all participating organizations at the same sampling point using its own sampling system (syringe).

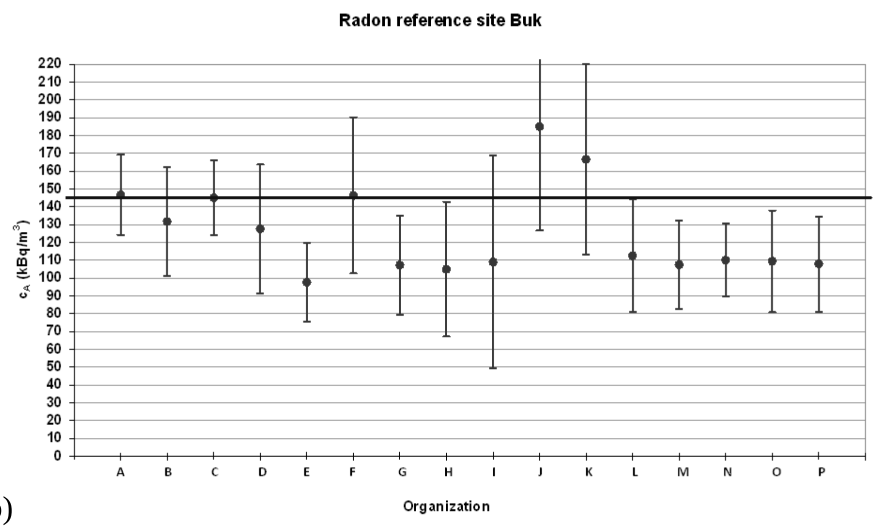
The method used by LER was based on scintillation technique with Lucas cells, namely a LUK 3C, the measuring method and apparatus can be found described elsewhere[2].

3. Results

Each participant received his assessment protocol introducing numerical results of the three tests and a graph of radon data dispersion of the group (marked in codes) for the two reference sites, Fig. 2 and 3. Tests are based on comparison of radon data reported by participating organization with radon data of the group, and with radon data of a database of the respective reference site, Table a). A computer programme TestMOAR evaluated the reported radon data.



(a)



(b)

FIGURE 2 (a) and (b). The arithmetic mean and standard deviations of radon activity concentration in soil gas are reported by the 16 organisations, ours includes

TABLE i). Characteristics of the two reference sites.

Reference site	c_A ^{222}Rn (kBq m^{-3})	Permeab. of soil	Rock	Soil	U (ppm)	Terrain
Bohostice	47	low, medium, high	Orthogneiss	loamy sand, clay sand	2.3	meadow
Buk	146	high	Granodiorite	loamy sand	3.6	meadow

Test No.1 - Test of differences in c_A determined by organization and the group at single stations of three reference sites

A difference between c_A-data reported by the organization and medians of c_A-data reported by all organizations in the group, including the administrator, is tested at each station. The difference is significant, if the computed interval of confidence does not include zero. Level of significance $\alpha = 1$ %.

Reference site	Interval of confidence	Quotient of data outside the interval of
Bohostice	< -7.890 ; 6.520 >	3 / 10
Buk	< -16.946 ; 4.506 >	1 / 10

Test 2 – Linear regression and correlation of c_A data determined by organization and the group at single stations of three reference sites

Linear regression $y = a + bx$ defines the dependence between c_A-data reported by the organization, (y), and medians of c_A-data, (x), reported by all organizations in the group at single stations. An ideal case of 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 $\alpha = 1$ %.

Parameter	Computed t-value	Critical t-value	Coefficient of correlation
a = -1.007	0.231	2.878	0.978
b = 0.969	0.635		

Test 3 – Test of differences between means of c_A reported by the organization and means of c_A-data of all organizations in the database of single reference sites.

Means of c_A-data from single reference sites are tested by test criterion R1/R2. R1 is a ratio of a mean of c_A-data estimated by the organization to a mean of c_A-data estimated by the administrator at given reference site in the same day. R2 is an arithmetical average of R1 values computed from measurements of all organizations since the beginning of measurements at given reference site (2000). Computation of the ratio R1 eliminates temporal climatic variations of c_A at the reference site. Ratio R1/R2 is independent of absolute c_A-values estimated by the administrator. A relative deviation ± 30 % is admissible for the test criterion R1/R2 from ideal value equal to one. Thus, admissible R1/R2 values for each reference site are within the interval < 0.7; 1.3 >.

Reference site	Ratio R1	Ratio R1 / R2
Bohostice	0.948	0.989
Buk	0.767	0.823
Average value		0.906

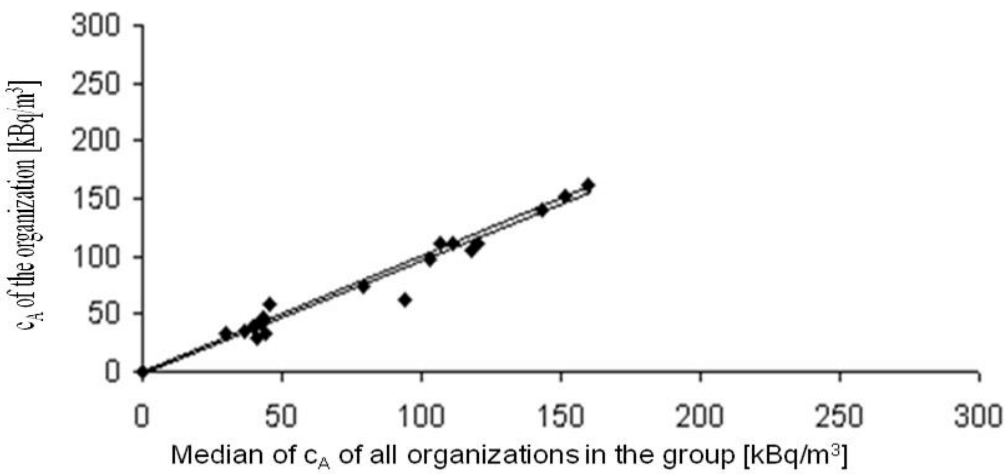


FIGURE 3. Linear regression y = a + bx (lower line) between radon activity concentration c_A reported by LER (y) and medians of c_A (x) of all organizations in the group. Ideal regression line (a = 0, b = 1) is represented by the upper line.

4. Conclusions

Test No.1 and test No. 2 (orientation tests based on the comparison with the group) show for the level of significance α = 1 % a good agreement of LER c_A-data to c_A-data of the group of organizations participating in comparison measurement on the same day. Test No. 3 (the decisive test based on comparison with the databases of radon reference sites) shows good agreement of LER resultant means of radon data at each reference site in comparison with radon data of all successful organizations (N = 217) which measured at radon reference sites since the year 2000 and form a database. After the decisive test No. 3, resultant R1/R2 data fulfil the test criteria and LER radon in soil gas estimates were very well integrated. The procedure of radon estimates agrees with the requirements of radon risk mapping of building sites in the Czech Republic.

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