



Experimental arrangements for indoor radon measurements (two location) and one location for measurement of radon concentration in soil

Introduction

In accordance with ISO/IC 17025:2017 testing laboratory shall have a procedure for monitoring the validity of results that includes regular participation in interlaboratory comparisons. Interlaboratory comparison RADON2021 was organized in order to assess the conformity of different measurement techniques, and then to harmonize methods in case of methodological inconsistencies. Harmonization is of particular importance to neighboring countries, in order to avoid inconsistencies in the classification of radon risk zones along border areas. Six regional laboratories took part in the intercomparison – three from Belgrade and one from Novi Sad, Serbia; one from Podgorica, Montenegro; one from Banja Luka, Bosnia and Herzegovina. All laboratories participated in the indoor radon measurements, while 4 laboratories measured radon in the soil.

Methods

The measurement methods and detectors used were:

- for air
 - EPA 402-R-92-004 – Indoor Radon and Radon Decay Product Measurement Devices Protocols, ch. 3.1. with RAD 7, RTM1688-2 and RadonEye;
 - EPA 520/5-87-005 – 1987 EERF Standard Operating Procedures for Rn-222 Measurement Using Charcoal Canisters, ch. 3.4 using adsorption on charcoal canisters,
 - ISO 11665- 4: Measurement of radioactivity in the environment – Air Radon 222: Part 4: Integrated measurement method for determining average activity concentration using passive sampling and delayed analysis with Electretes, and
- for soil gas
 - ISO 11665-11:2016 Measurement of radioactivity in the environment — Air: radon-222 — Part 11: Test method for soil gas with sampling at depth by using active devices RTM1688-2 and RAD 7.

The measurements were performed in real conditions in rooms where the radon concentration varied following typical daily variation. Indoor radon concentrations were measured at four locations, while radon measurements in soil were performed at one location, all at the Vinča Institute site in the period from October 1 to October 8, 2021. The exposure period was consistent with a typical soil and indoor radon measurement protocols. The radon concentration in the soil was measured at a depth of 80 cm.

Determination of indoor radon concentration and radon concentration in soil; Regional Interlaboratory Comparison – RADON2021

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Statistical analysis

Since all devices used for measurements had similar performances, the robust mean and robust standard deviation were calculated as the mean of all measured radon concentrations and their standard deviation. Before calculation of the reference value, the outliers were excluded. Reference values of indoor radon covered the wide range of concentrations: •(65 ± 9) Bq m⁻³, (519 ± 80) Bq m⁻³, (904 ± 158) Bq m⁻³, (1976 ± 158) Bq m⁻³, while in the soil it was (26060 ± 2350) Bq m⁻³. In order to assess whether there is a statistically significant difference between individual measurement results and the reference value, the Z - test was used.

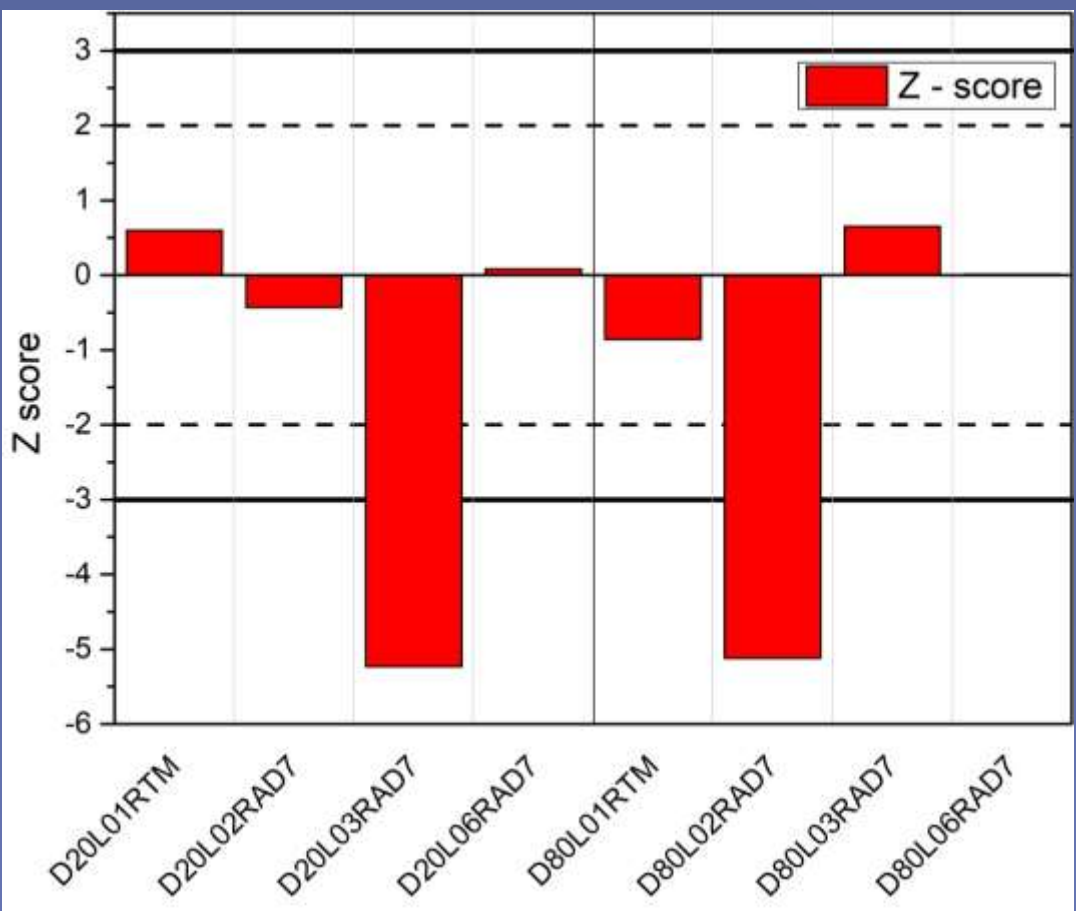
$$Z = \frac{C_{REF} - C_i}{\sqrt{u_{REF}^2 + u_i^2}}$$

where C_{REF} denotes reference value, C_i denotes measured radon concentration, u_{REF} and u_i denote corresponding meaasjurement uncertainties. A criterion for success is:

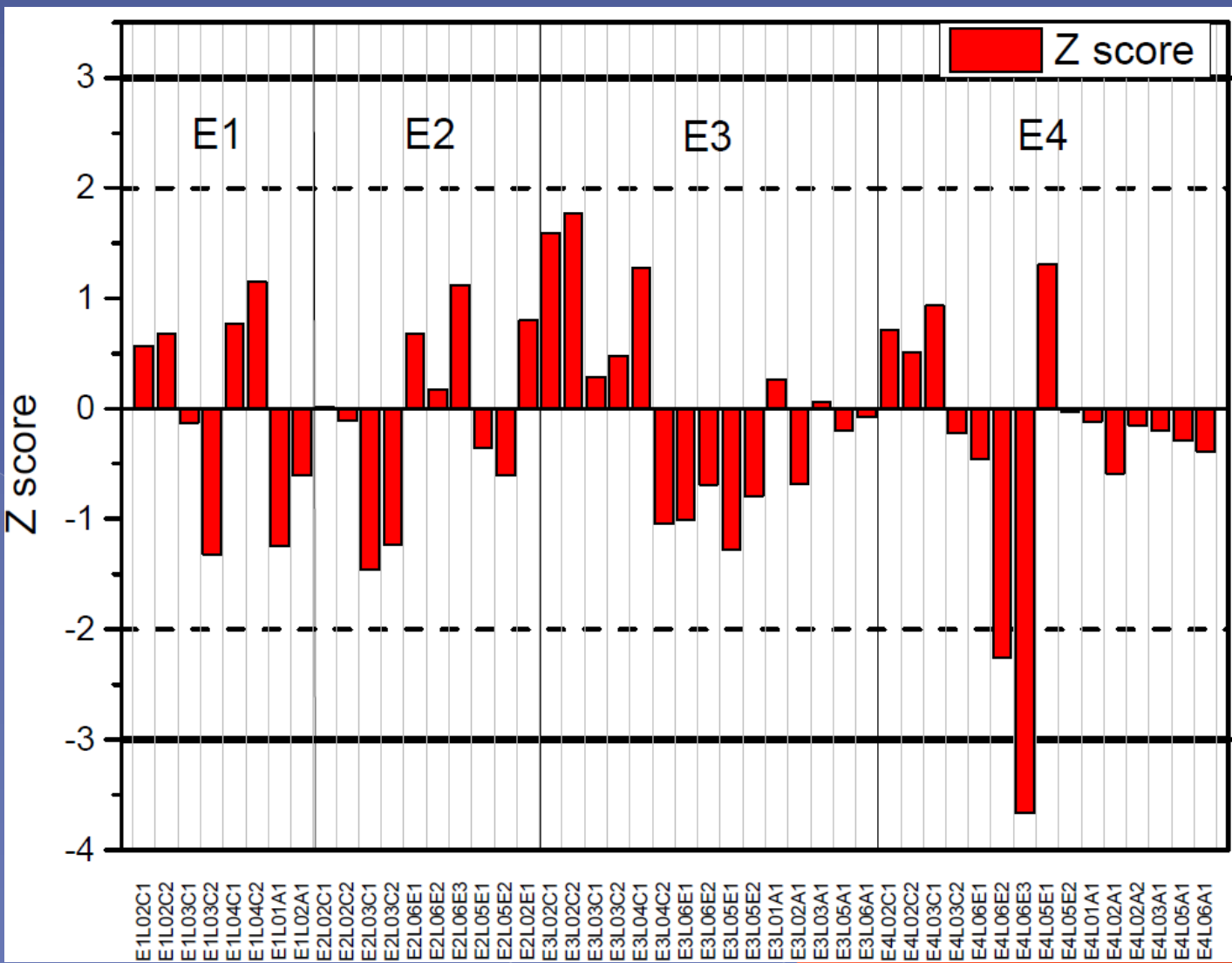
- |z| ≤ 2 the result is satisfactory,
- 2 < |z| < 3 the result is questionable, and
- |z| ≥ 3 result is not acceptable.

Results and Discussion

All results of indoor radon measurements were satisfactory, except in the case of one measurement (for the lowest reference value), when an electret of inadequate sensitivity was used. Three laboratories had satisfactory results of radon concentration measurements in the soil, while the results of one laboratory were systematically lower, with z < -3, which indicated the need for additional analysis of the causes of systematic error and the possible need to change measurement protocols and/or re-calibration of used device.



Z-score results of radon concentration in the soil measurements



Z-score for results of indoor radon measurements for four locations (E1-E4)

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