

NATIONAL INDOOR RADON SURVEYS PERFORMED IN EUROPE: A QUALITATIVE OVERVIEW

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Introduction: Why do we measure radon?

- second cause of lung cancer after smoking
- responsible for 3% - 14% of all lung cancers
- 15000 – 20000 deaths in Europe; 21 000 deaths in USA caused by exposure to radon
- there are regions(dwelling) in which annual average radon concentration exceeds national reference level

Council Directive 2013/59/Euratom

Basic Safety Standards (Article 103) oblige EU member states to:

- establish a radon action plan
- inform public about their radon
- identify Radon Priority Areas (RPA)

“areas where the radon concentration (as an annual average) in a significant number of buildings is expected to exceed the relevant national reference level.”

Introduction: What is the outcome of BSS

- Radon activities and radon surveys therefore were started or repeated in several countries in the last years and are still on-going and maybe will be also increased in the next years.
- For non-EU-member states also IAEA BSS require radon surveys and IAEA guidelines how to perform radon surveys exist (IAEA, 2011).
- IAEA Technical Cooperation Project:
Establishing Enhanced Approaches to the Control of
Public Exposure to Radon



???

Motivation

- European Atlas of Natural Radiation (*De Cort et al., 2011, Cinelli et al, 2019*)
 - collect, validate and report information on radioactivity levels in the environment
- A first overview of indoor radon surveys in Europe (*Dubois 2005*)
 - data reveal heterogeneity of survey strategies, measurement techniques, measurement duration and season
- European map of indoor radon levels using a 10 km x 10 km grid cells (*Dubois et al., 2010*)
- JRC report based on literature review of indoor radon surveys in Europe (*Pantelic et al., 2018*)

Goal:

give qualitative overview of radon surveys with a special attention to the qualitative and conceptual description of surveys, representativeness and QA/QC

Survey design and representativeness

- numerous factors influencing indoor radon
- not feasible to measure radon in all dwellings

Necessary to carefully design survey – representative distribution of radon in dwellings

- truly representative survey – rather difficult
 - complete list of dwellings – seldom available

- each step prone to numerous biases:
 - selection of dwellings: (use of volunteers – oversampling in RPA)
 - choice of measurement technique
 - duration of measurement and **seasonal corrections**...

Niška Banja RPA (*Z. Zunic et al.*)
seasonal factor: 2.7 (year/3m summer)
range: 1.1 – 6.0

Serbian National Rn Survey (Udovicic et al.)
seasonal factor: 0.8 (year/6m heating)
range: 0.5 – 1.4

IAEA Report, 2013 – Review of methodology and measurement techniques

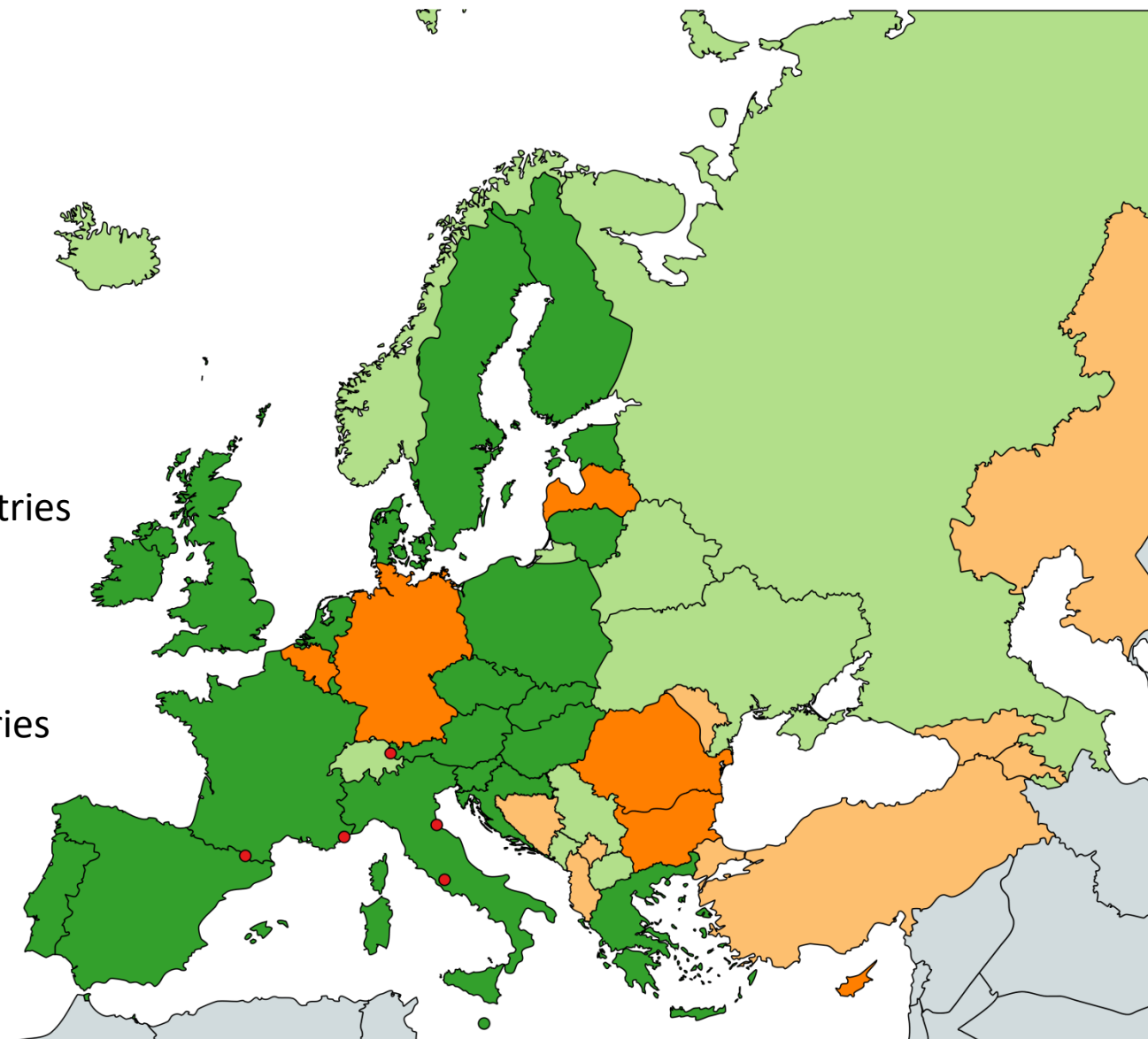
Overview of radon surveys:

Surveys

- National survey - EU countries
- Regional surveys - EU countries
- National surveys - non EU countries
- Regional surveys - non EU countries
- no data exists

National surveys:
22 EU countries
10 non EU countries

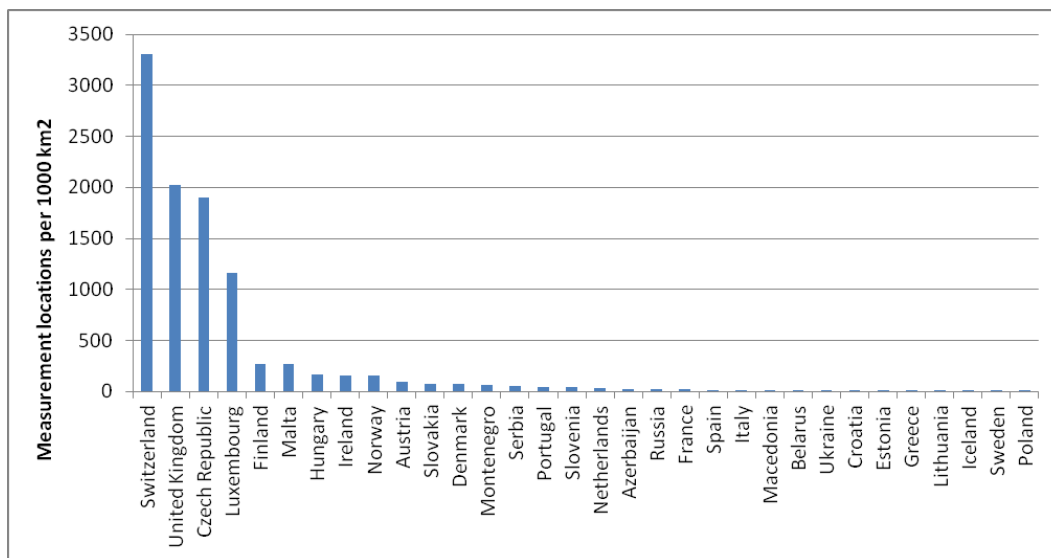
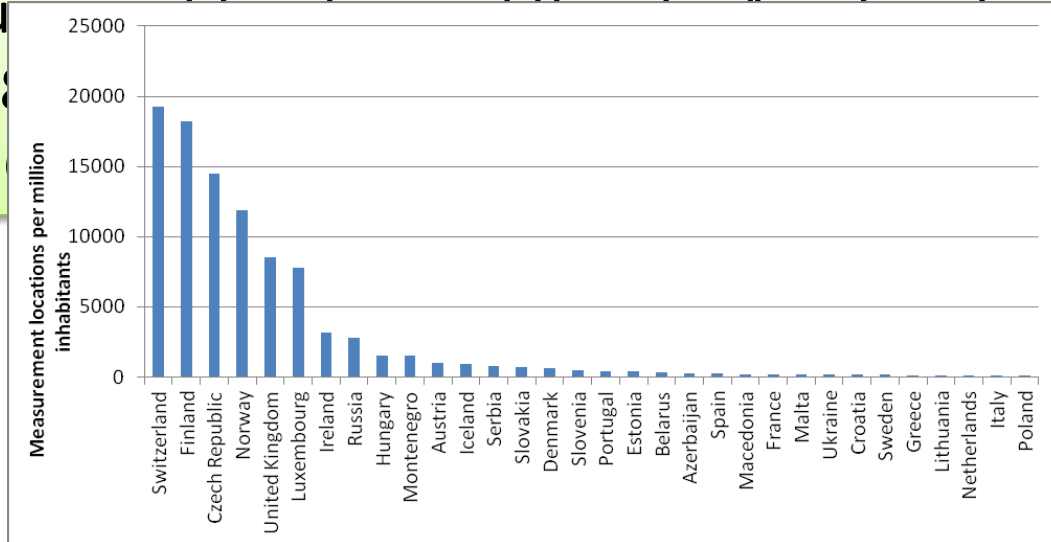
Regional surveys:
5 EU countries
7 non EU countries



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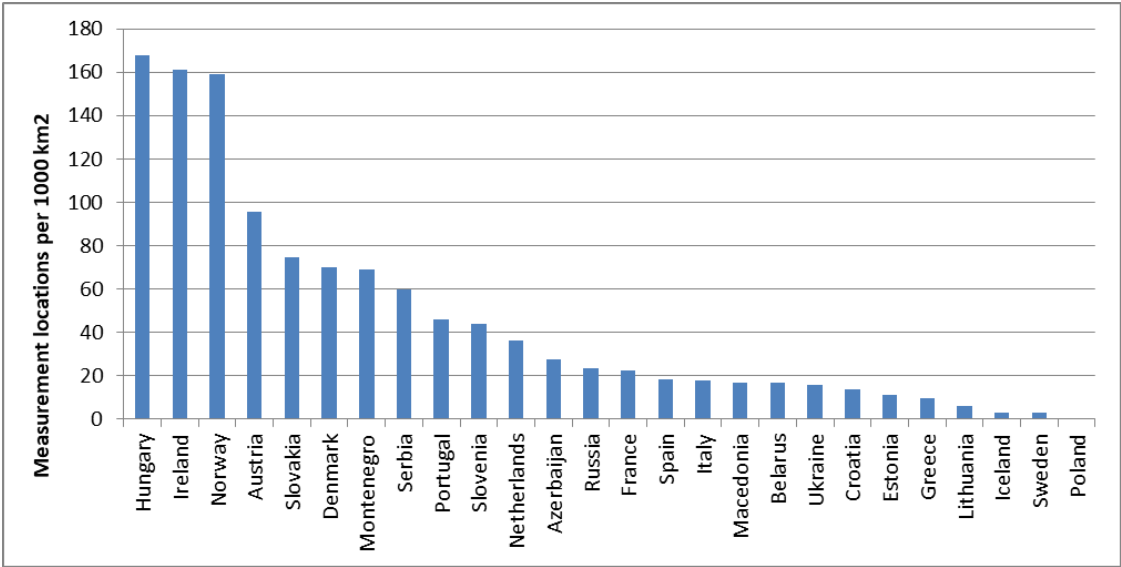
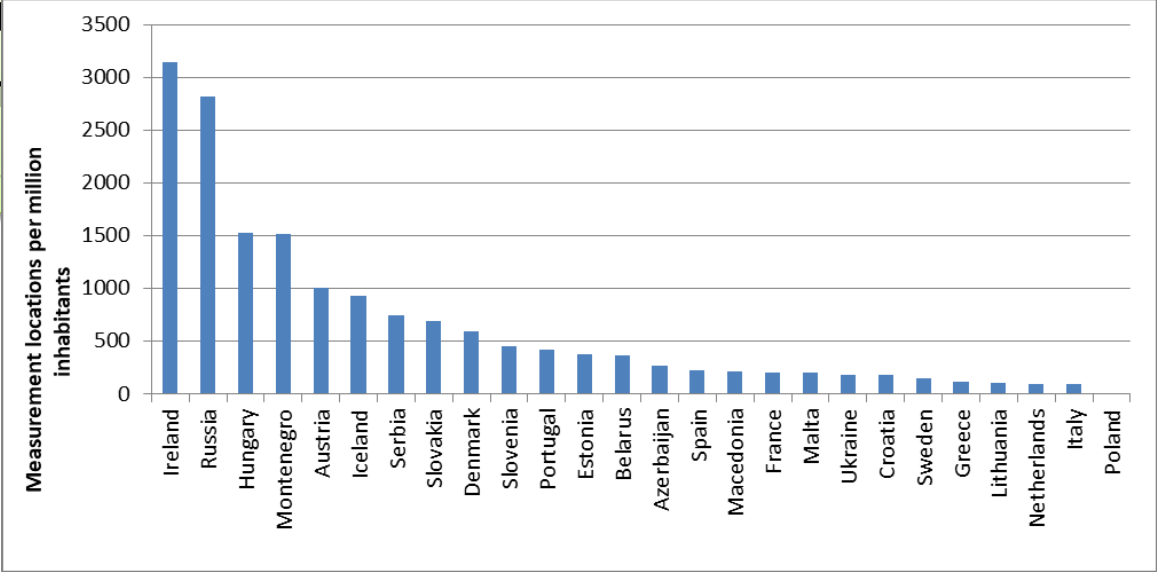
Survey design: density of deployed detectors

- no. of measurements
- ranges from 100 to 1000 magnitudes
- U.K., Russia, Poland way > 50000



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Measurement techniques

- Measurement locations:

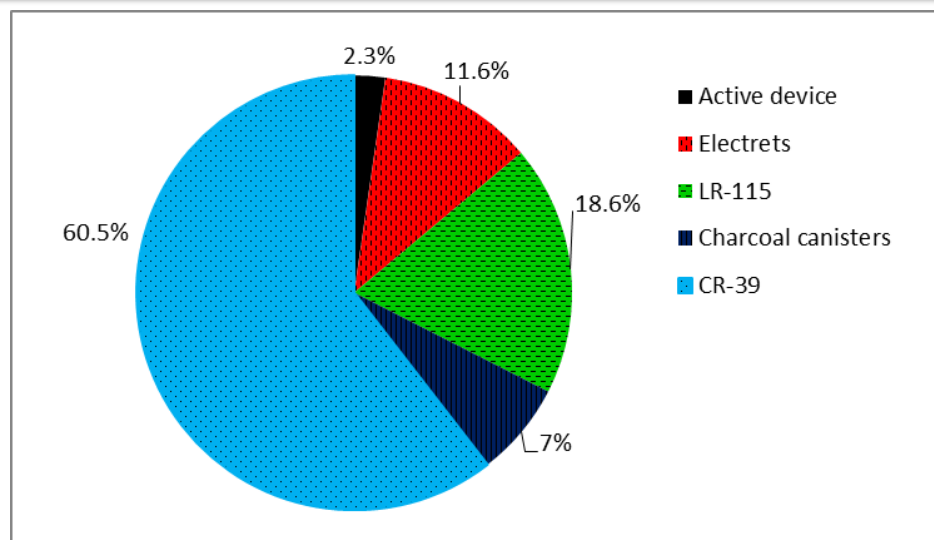
- dwellings (great majority)
- schools, kindergartens
- industrial buildings and workspaces (as a part of the survey)
- swimming pools... (as a part of the survey)

- Sampling strategy:

- based on administrative units
- grid cells: 10x10 km², 5x5km², 1x1km², 0.5x0.5km²
- geological regions
- density correlated with population density or RPA regions
- combination of several requirements
- 10 km x 10 km grid - more prevalent in recent surveys

Measurement techniques

- Types of detectors



- Measurement time:

- covering wide range of time: 48h; a few: days, weeks, months, half/whole year
- different seasons: heating season, no particularly indicated season...

- Applied corrections:

- seasonal: heating season over whole year;
weekly variations and corresponding variation
no corrections at all
- corrections based on wind speed and outdoor temperature

Representativeness

- Detailed analysis of survey representativeness is generally missing
- In few surveys authors only state that survey was representative
- In 1 survey: construction expert was consulted for selection of representative house for each grid cell
- Only in 2 surveys: data were compared with national Census
- In one survey: could results from Rn in schools be representative for general population
- In few surveys: declustering of oversampled area to achieve regional representativeness
- In 1 survey : Representativeness reached by following 4 criteria: surface, population, high radon potential, and lithostratigraphic criterion with random sampling

- Important to avoid mistakes
- Reduce and estimate uncertainties

In many papers QA/QC of radon measurements is described, but proper description of QA/QC in radon surveys is missing

- Reported quality assurance and quality control of radon and/or radon decay products measurements:
 - Periodical calibration (or accreditation ISO 17025): 34 %
 - Intercalibration and intercomparison: 30 %
 - Comparison of the results from different detector systems: 11 %
 - Duplicate detectors: 9 %
 - More than 2 QA/QC procedures: 20 %
 - None: 36 %

Thoron and thoron measurements

- Different sensitivity to Tn - true especially for older types
 - Kfk(Germany,1981): 0.78
 - RadTrak(USA,1991): 0.68
 - NRPB/SSI: 0.05
 - Tn could cause overestimation of Rn concentration
 - >70% of surveys Tn is not mentioned
 - In only a few surveys:
 - Contribution to doses due to Tn
 - Tn measurement in regions with high ^{232}Th
-
- Thoron is mainly measured in regional surveys
 - Large effort of mapping thoron in rural of Balkans (Zunic et al)
 - Identified regions in which Tn contribution could not be neglected

Conclusions:

- Methodologies used in the surveys were very diverse;
- Practically impossible to find two completely same methodologies;
- Often some crucial information regarding Rn survey is missing;
- Therefore, obtaining harmonized data and procedures is/will be quite challenging

- In only a few papers authors have paid attention on representativeness
- Necessary to test to what extent the representativeness of survey was reached

- More detailed qualitative overview of Rn surveys in Europe:

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Thank you for your attention