INDOOR RADON AND SOIL GAS RADON IN THE VICINITY OF NIŠKA BANJA, RADON PRIORITY AREA

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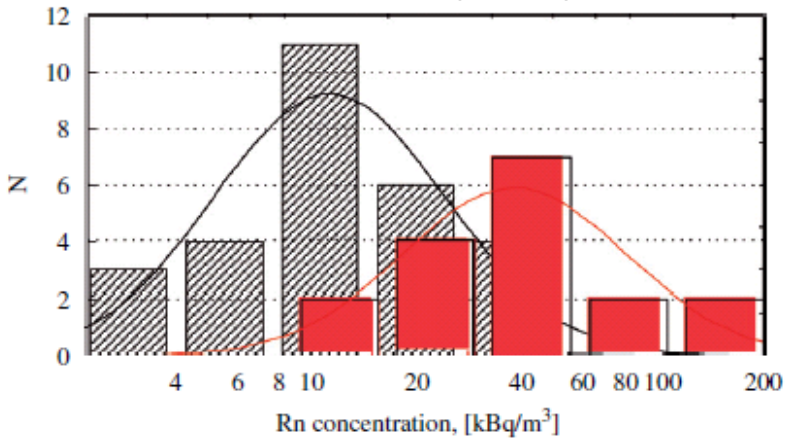
Introduction: Niška Banja

- Identified as a region with enhanced level of natural radioactivity spring deposit (travertine) from water with high ^{226}Ra concentration
- First survey: *(Manic et al., Environ. Int. 32 (2006) 533)*
  - 200 dwellings, charcoal canisters, zone with high ^{222}Rn identified
- Second campaign: (Zunic et al., JER89(2006)249, JER92(2007)165, STE387(2007)269...)
  - ^{222}Rn & ^{220}Rn indoor measurements, outdoor radon measurements,
  - retrospective Rn measurements, soil gas radon measurements
  - Rn in water, indoor, outdoor gamma dose rates
  - 65 houses, >100 rooms;

Some outlines:

- max indoor ^{222}Rn: > 10kBq m^{-3}
- max ^{222}Rn in soil gas > 2MBq m^{-3}
- 2 lognormal distributions: based on two underlying bedrock types (travertine and alluvium)

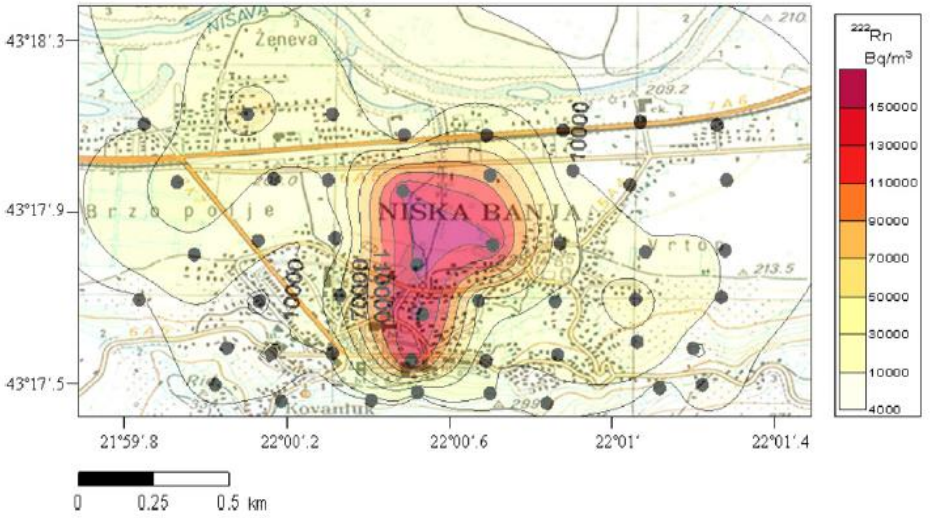
Zunic et al., RM42(2007)1696



Introduction: Niška Banja

- Previous campaigns:
  Although detailed, encompass only settlement of Niska Banja

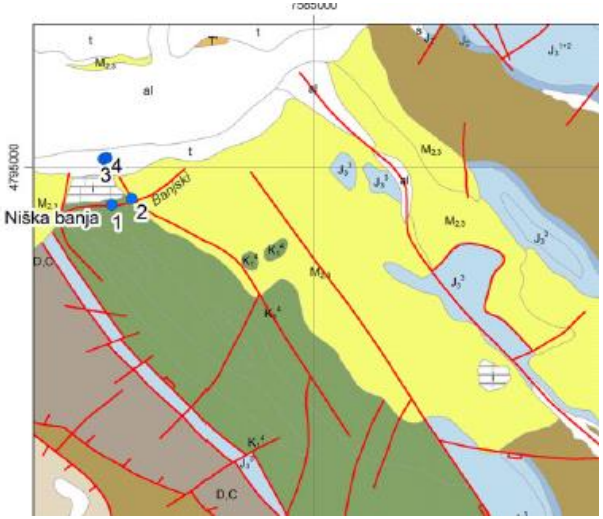
Previous campaign: Niška Banja settlement Rn in soil



Motivation: What to do next?

- Data on lung cancer incidence: on the municipality level
- National Rn survey: a few high indoor Rn locations identified
- Faults NW-SE directions along settlements, connected with NB fault

J. Nikolov; Rad. Meas. 47 (2012) 443-45011



Goal: to perform detailed indoor and soil gas radon mapping of the rest of inhabited settlements in Niška Banja municipality

Methodology: First measurement campaign

- Deployed: 67 CR-39 detectors
- Questionnaire: type of house, floor level, building and floor material, window sealing, heating type, age of the house, existence of hydro-isolation
- 3 months exposure: April – June 2017
- Covering additional inhabited settlements
- Detector distributed by local authorities

Methodology: Second measurement campaign

- Measurements performed in August 2018,
  in or close to houses where CR-39 detectors were deployed

- Soil gas radon measurement:
  - performed with 2 type of devices from 2 Labs:
    - RAD7: 20 measurement points
    - RTM1688-2: 26 measurement points

  } 3 joint measurement points

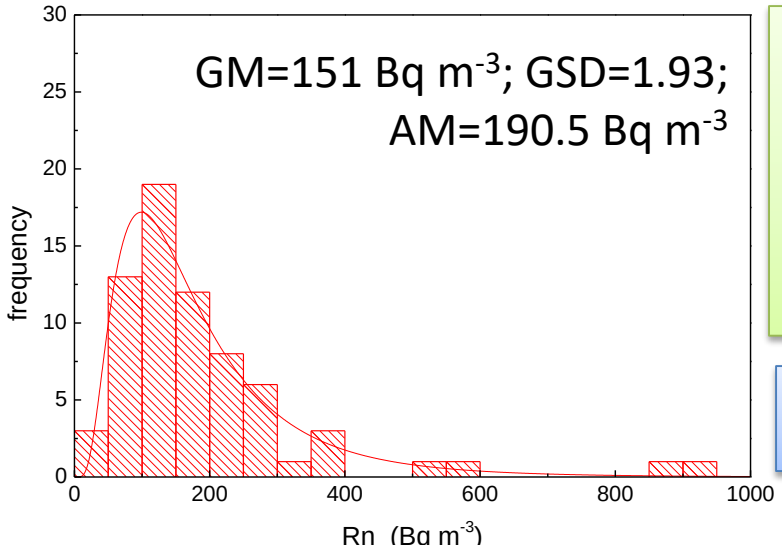
- Indoor radon measurements
  - using charcoal canisters:
    - from 2 Labs: 18 measurement points

- Gamma dose rate measurements:
  - at ground level and 1m above ground

- Soil sample:
  - depth: 30-40 cm (a few profiles: 0-15 cm, 15-30 cm)
  - ^{226}Ra con. by NaI (^{226}Ra, ^{232}Th, ^{40}K by HPGe in progress)

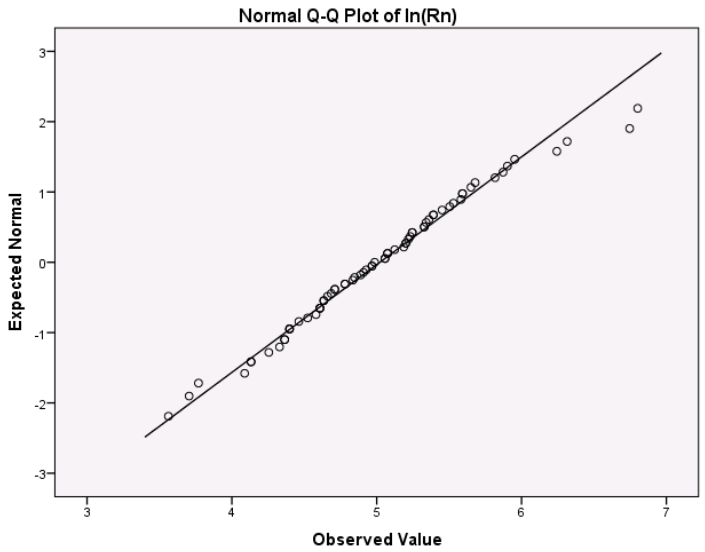
Results: Indoor radon by CR-39 (Radtrak²)

- Applied seasonal factor: 2.71
  (extracted from previous Rn survey Z. Zunic et al.,)

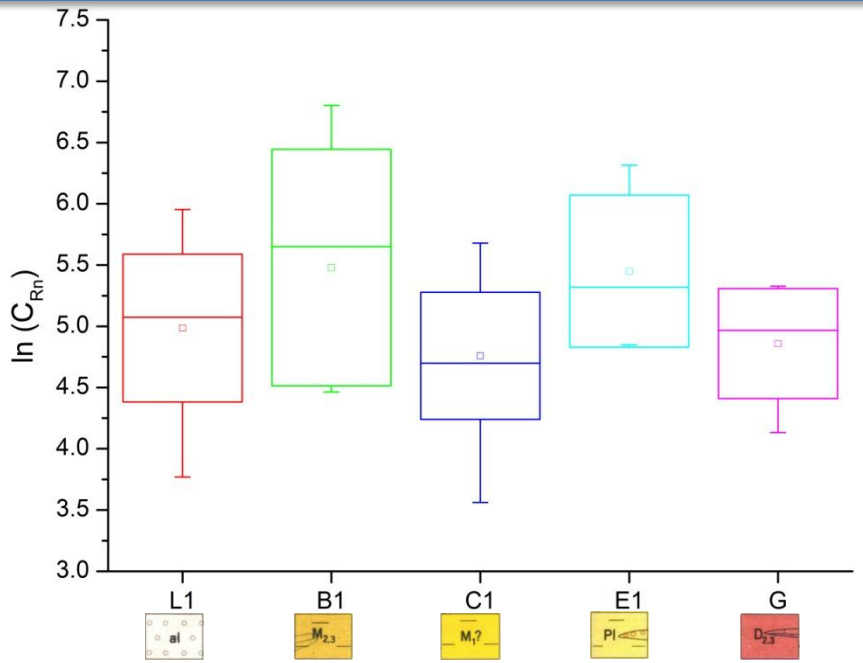


Multiple regression analysis

- Independent variables: 24 dummy, 1 cont.
- Dependent variable: ln(Rn)
- Adjusted R^2=0.22
- Only few denominators significant



Factorial analysis



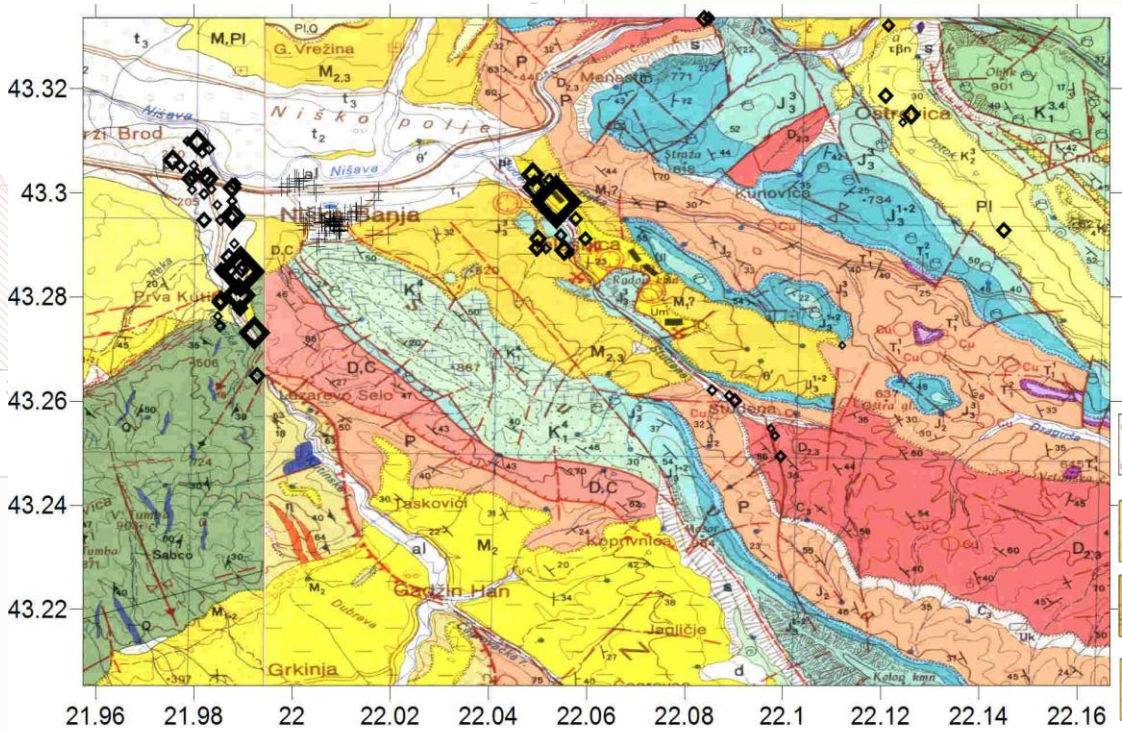
Results: Indoor radon by CR-39 (Radtrak²)

- Applied seasonal factor: 2.71
  (extracted from previous Rn survey Z. Zunic et al.,)

Multiple regression analysis

GM=151 Bq m^{-3}; GSD=1.93;

- Independent variables: 24 dummy, 1 cont.



Alluvinum

Sand, gravel, marl, clay

Middle-Upper Miocene clay with coal, sand, gravel

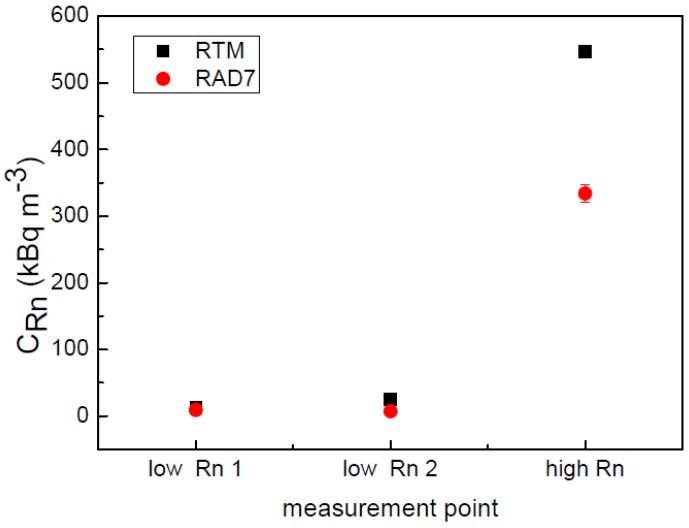
Marl, sandstone, clay with coal and limestone

Devonian-Carboniferous sandstone, phylite and chlorite schist, limestone

Banked and layered limestones and dolomites

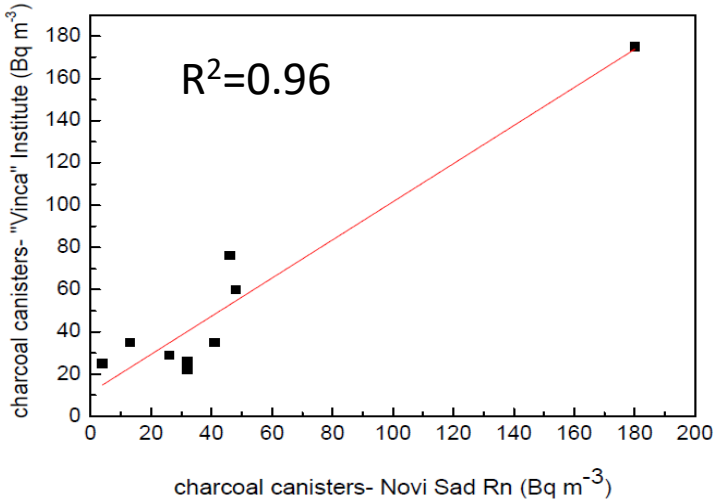
Results: Second measurement campaign

Rn in soil measured with 2 different devices

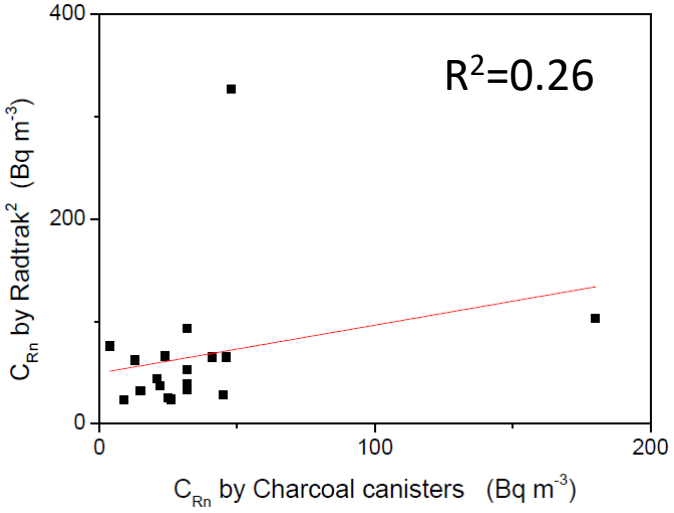


- High correlation between measured results (R^2 = 0.999)
- results from RAD7 systematically lower by 40 % than results from RTM1688-2
- RIM could hopefully provide us the answer to discrepancy ☺

Indoor radon measured by charcoal canisters from 2 institutions

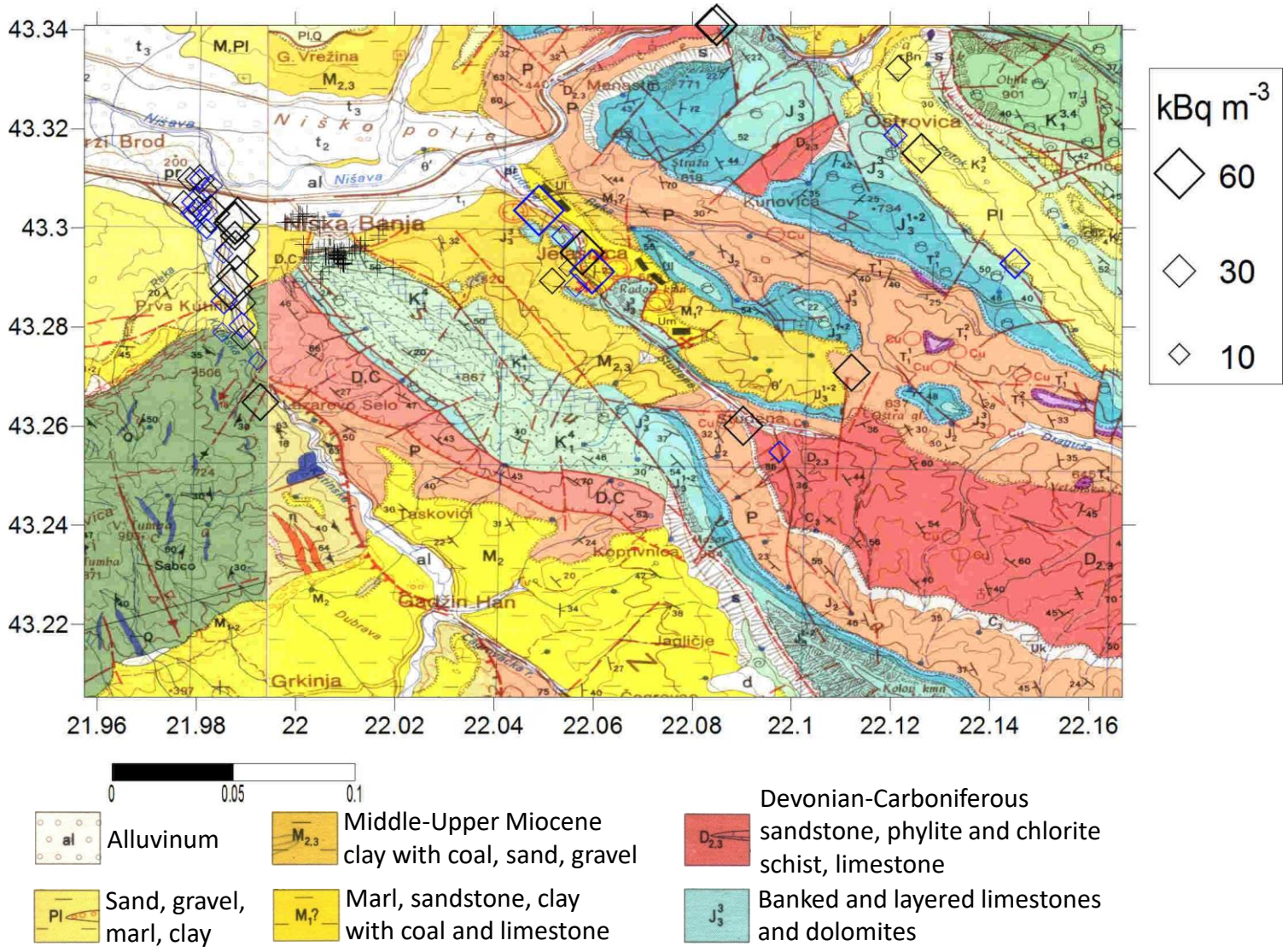


Indoor radon measured by CR-39 and charcoal canisters

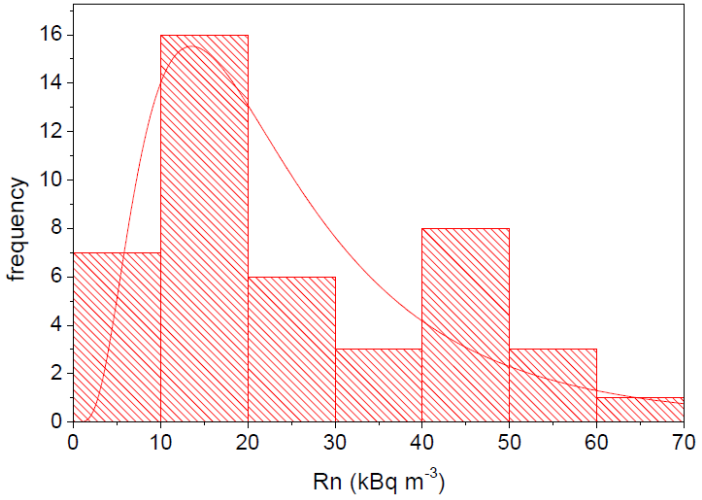


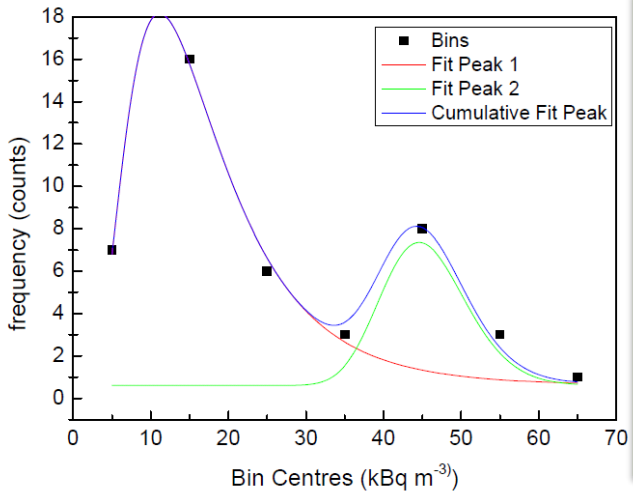
Results: Second measurement campaign

Radon in soil gas

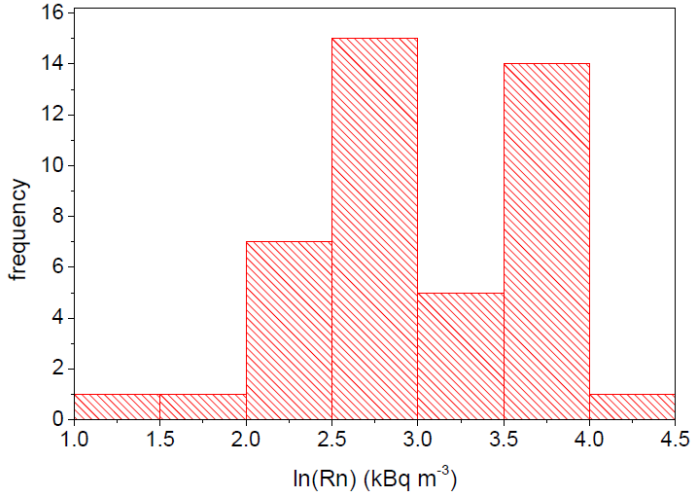


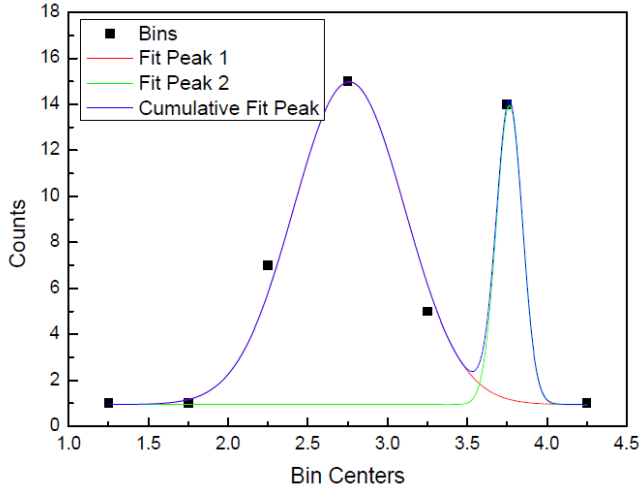
Results: Second measurement campaign





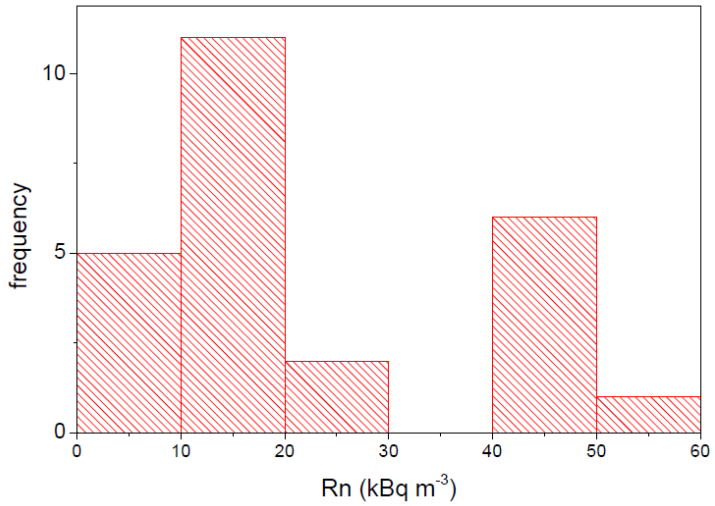
- I peak
  GM: 15.1 kBq m^{-3}
  GSD: 0.6
- II peak
  GM: 45.2 kBq m^{-3}
  GSD: 0.2





Results: Second measurement campaign

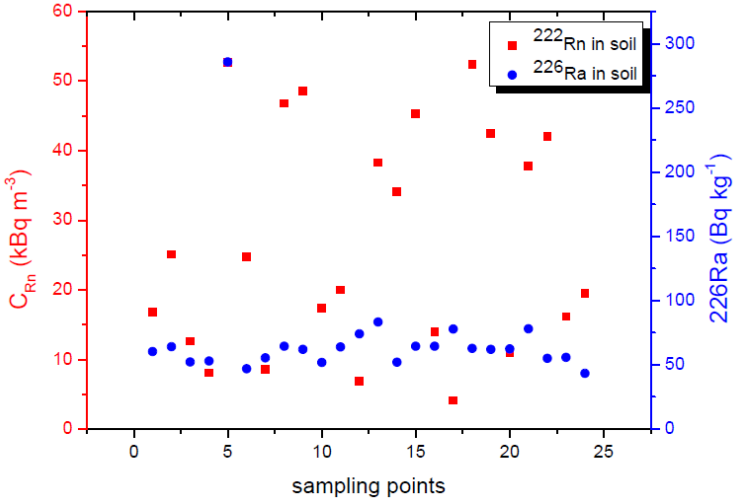
Log-normal distribution of Rn in soil in Alluvium



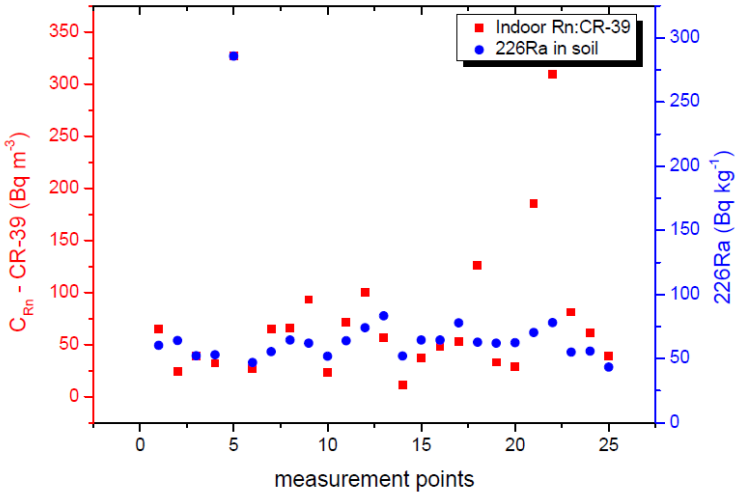
No log normal distribution of Rn in soil observed neither for full sample, nor for specific type of soil

Results: Second measurement campaign

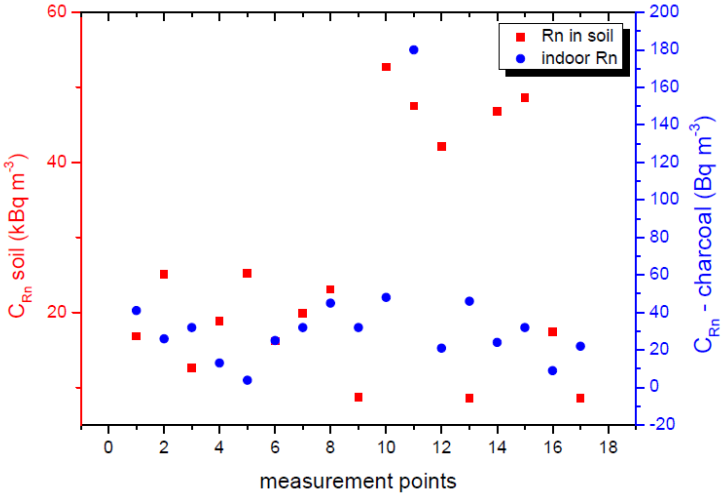
Correlation between Rn and Ra in soil



Correlation between Ra in soil and indoor Rn measured by CR-39



Correlation between soil gas Rn and indoor Rn measured by charcoal



Very weak correlation observed between:

- Rn and Ra in soil (0.34)
- Rn in soil and indoor Rn (0.28 and 0.38)
- indoor Rn (CR-39) and Ra in soil (0.70)

Conclusions:

- Measured indoor and soil gas Rn in the vicinity of NB RPA
- Good correlation between results from 2 Lab. (RIM could provide an answer to discrepancy in soil gas measurements)
- Indoor Rn following lognormal dist.: GM: 151 Bq m^{-3} GSD: 1.93
- No observed dependences between Rn concentration and investigated parameters
- No log normal distribution of Rn in soil observed neither for full sample, nor for specific type of soil
- Weak correlation between Ra in Rn in soil and indoor Rn
- Analysis of terrestrial gamma dose rate in progress

Thank you for your attention !