ZAVOD ZA GRADBENIŠTVO SLOVENIJE

SLOVENIAN NATIONAL BUILDING AND CIVIL ENGINEERING INSTITUTE

# Radon in Slovenia

## Experience in radon mitigation



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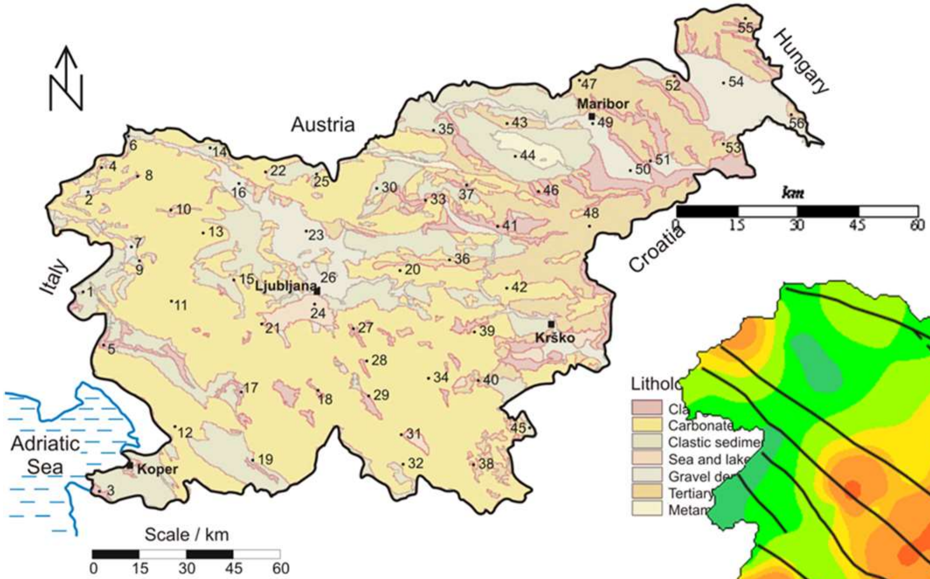
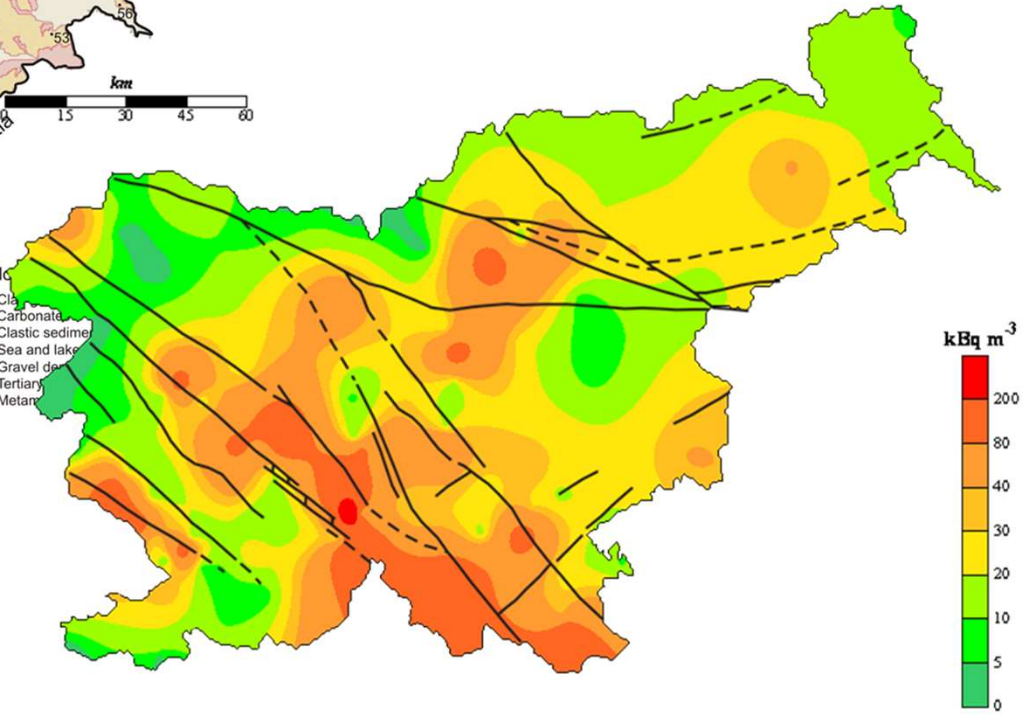
Webinar, 26. 02. 2019

# Slovenia’s geology and radon risk




Source: GREGORIČ, Asta, VAUPOTIČ, Janja, BEZEK, Mateja, ŽVAB ROŽIČ, Petra, LEKOČEVIČ, Nejc, KOBAL, Ivan. Geogenic radon potential in Slovenia. V: SERAFIMOVSKI, Todor (ur.), DOLENEC, Tadej (ur.). Anthropogenic effects on the human environment in the Neogene basins in the SE Europe : proceedings. Ljubljana: Faculty of Natural Sciences and Engineering, Department of Geology; IGCP Committee, 2011, str. 1-8.

# Sources of radon in buildings, considered in case studies

Sources of radon in buildings are found to be either:

- Ground below the footing
- Layer(s) of fly ash on the ground

Not found (in Slovenia):

- Water as a (primary) source of radon in buildings
- Exhalation from building materials

Source: https://stareslike.cerknica.org/2015/06/17/1964-cerknica-nova-sola/

# Legislation in Slovenia

- Radon: legal maximum level of indoor radon average concentration ($C_{Rn}$) is (still) set to 1000Bq/m$^3$, while recommendation is below 300Bq/m$^3$
  - The actual limit is expressed as 6 mSv dose
- Two pieces of legislation in place: more general law (2017) and radon specific regulation (2018)
  - Regulation comes into force in 2021
- Screening is done (priority to radon prone areas first)
  - Immediate response, if $C_{Rn}$ more than 4000 Bq/m$^3$ is found
  - Fast response (within 1 month), if $C_{Rn}$ between 2000 Bq/m$^3$ and 4000 Bq/m$^3$ is found
  - Timed response (normally few months) if $C_{Rn}$ between 1000 Bq/m$^3$ and 2000 Bq/m$^3$ is found
  - Below 1000 Bq/m$^3$ recommendations are given, if necessary
- Actions
  - Immediate action – increase ventilation
  - Systemic action – timing depends on needed mitigation measures

# Building stock we address

-Our team is predominantly oriented towards (large) public buildings, in particular schools and kindergartens

-Such buildings represent a large variety of possible situations with respect to age, architecture, size, terrain, maintenance, etc.

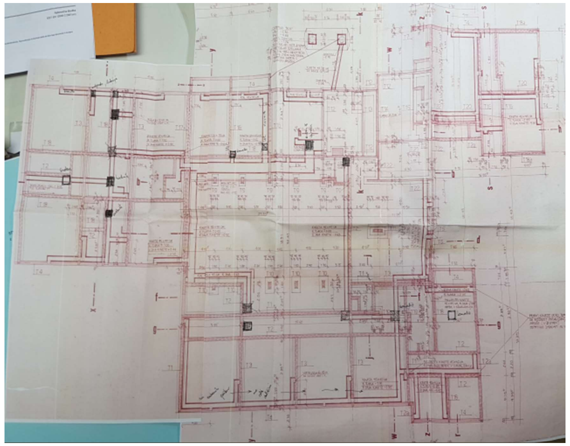
-In general we find problems in buildings built in the 1800s as well as the 1950s and newer; the age of the structure is not a reliable indicator about potential problems

-In Slovenia, there are generally 1000 school buildings, 600.000 family and multifamily houses and 1.200.000 buildings (2 million inhabitants)

-Estimation: about 1% over 1000 $Bq/m^3$ and about 3-4% above 300 $Bq/m^3$

# What we find

- Often poor awareness about radon
- Different attitudes of users in charge – sometimes radon problem is seen as unwanted distraction
- Missing or inaccurate blueprints of buildings
- Significant differences between blueprints and the real situation
- Unknown structures (even if blueprints exist)
- Unknown soil layer composition
- Age-specific building details



# How the process of mitigation is designed

In general our approach always includes:

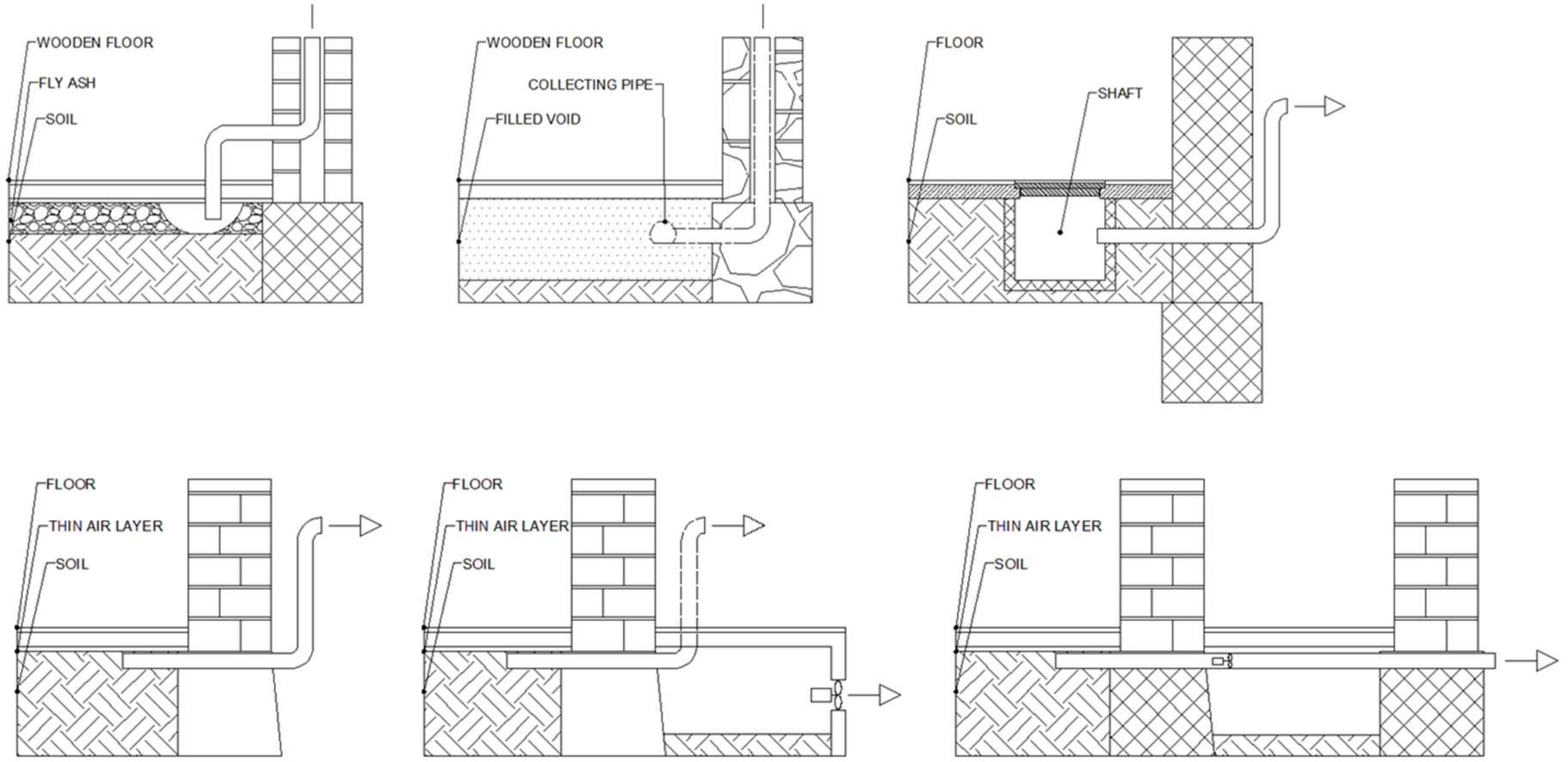
- engaging the user in the problem solving,
- understanding the $C_{Rn}$ measurements,
- identifying possible sources of radon,
- designing the mitigation approach from the radon point of view
  - What is the sub-slab layer permeability (measured / assessed)?
  - Which method (or methods) is the best option; active or passive?
  - In case of ASD (active sub-slab depressurization) – is sealing crucial?
- designing the mitigation approach from the construction point of view
  - Access to the building, structural integrity, water lines, power lines, sewage,…
  - Routing the pipes, exhaust, ventilator (power), and
  - Protection and aesthetical aspects.
- execution of the system,
- monitoring before commissioning (putting into operation), and
- commissioning.

# Approaches to mitigation

Variation of sub-slab depressurization system in practice is high, although the basic principle remains the same.

Final decision is (always) made on-site.

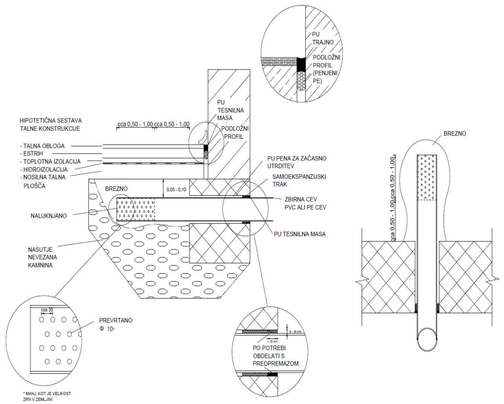
Below: Approaches (used over time) in case studies.



# Mitigation examples

# Case study – case 1

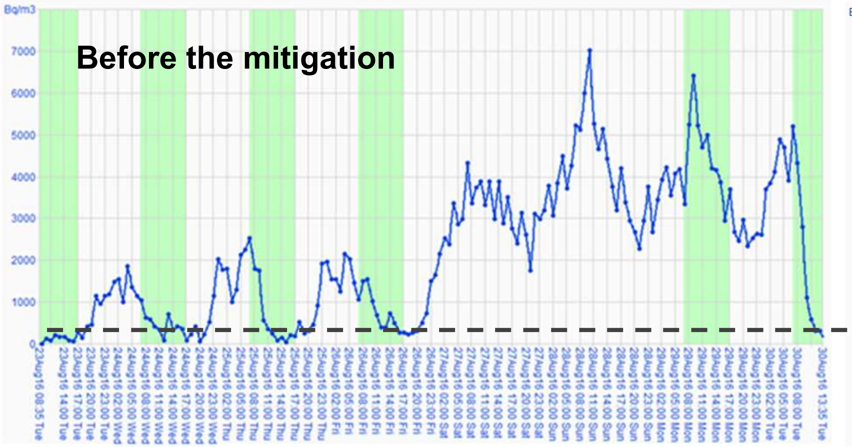
- School, new building (less than 20 years old), elevated concentration measured in one room, likely reason – breaking of the floor structure;
- Screening only – no extensive measurements were done;
- Strong public pressure;
- After initial disbelief that anything has to be done the mitigation was simple.

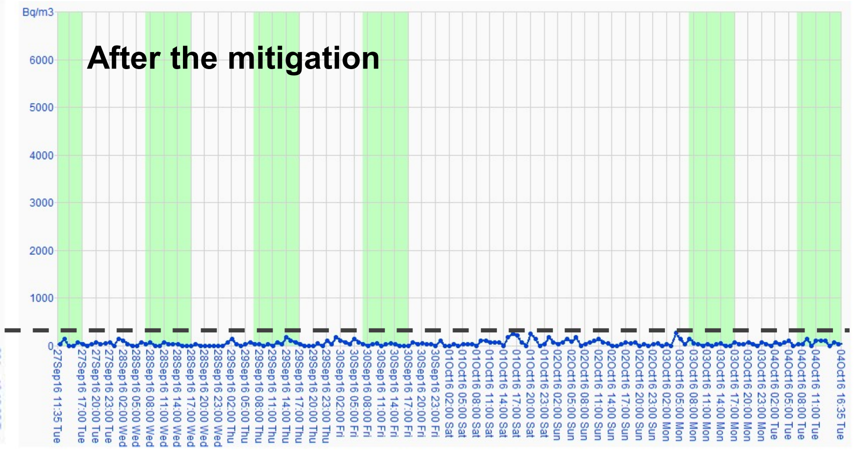


# Results

Simple mitigation and (almost) ideal result

Prior mitigation: 896 ± 120 Bq/m$^3$ (in work hours), after mitigation: 40 Bq/m$^3$ (LLD noise)



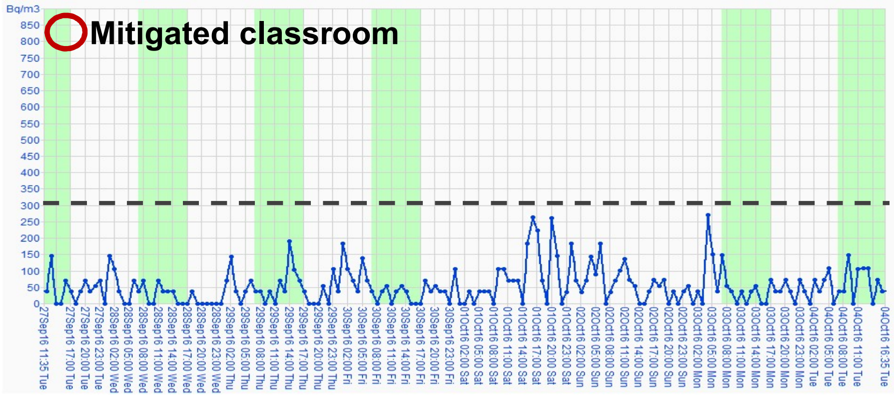



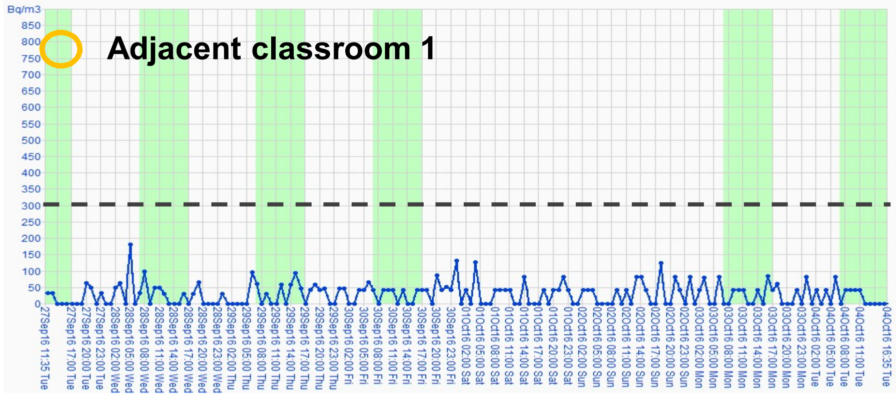
# Results close-up

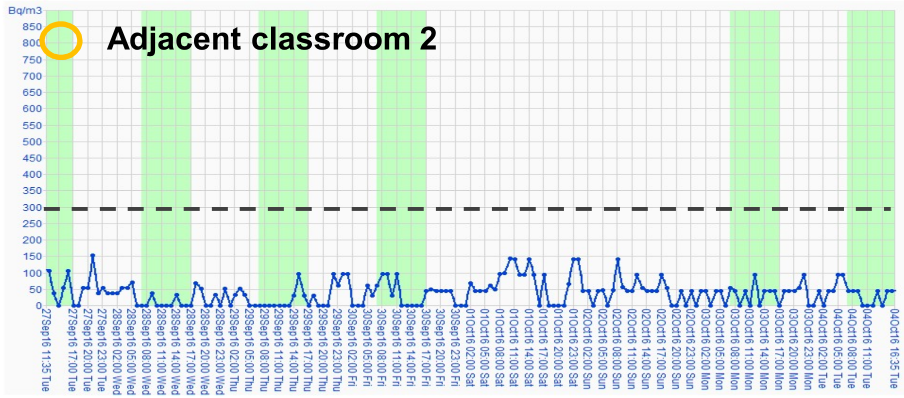
Simple mitigation and almost ideal result.

Because of the exhaust proximity to the window, special care was given to the possibly affected adjacent rooms by taking additional measurements.

No interference was detected.

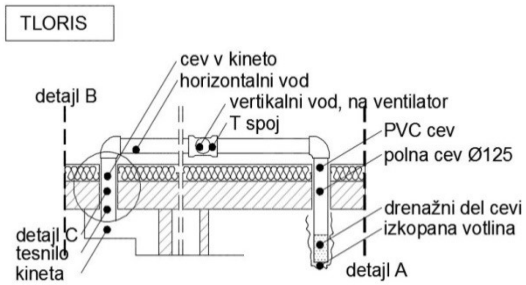


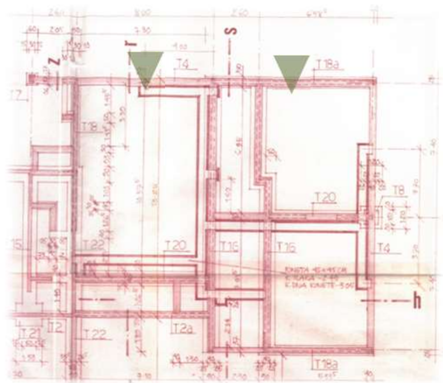



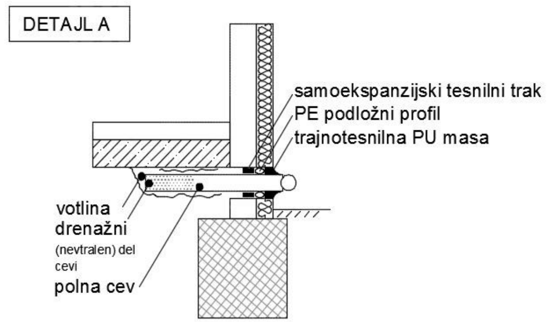



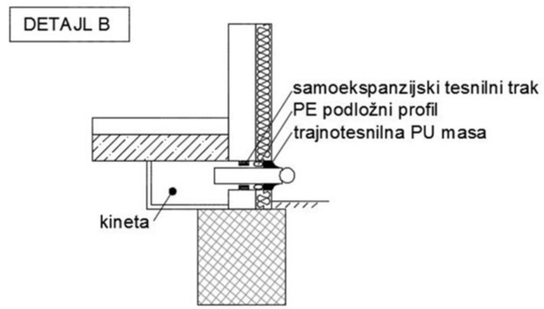
# Case study – case 2

- School, post WWII building, built in the 1950s with additions and reconstructions to the 2000s
- Cascading architecture
- Piping in shafts – three separate branches; possibly large not tightly closed air void
- Blueprints available, but not accurate – verification needed
- Limited cooperation of all parties involved





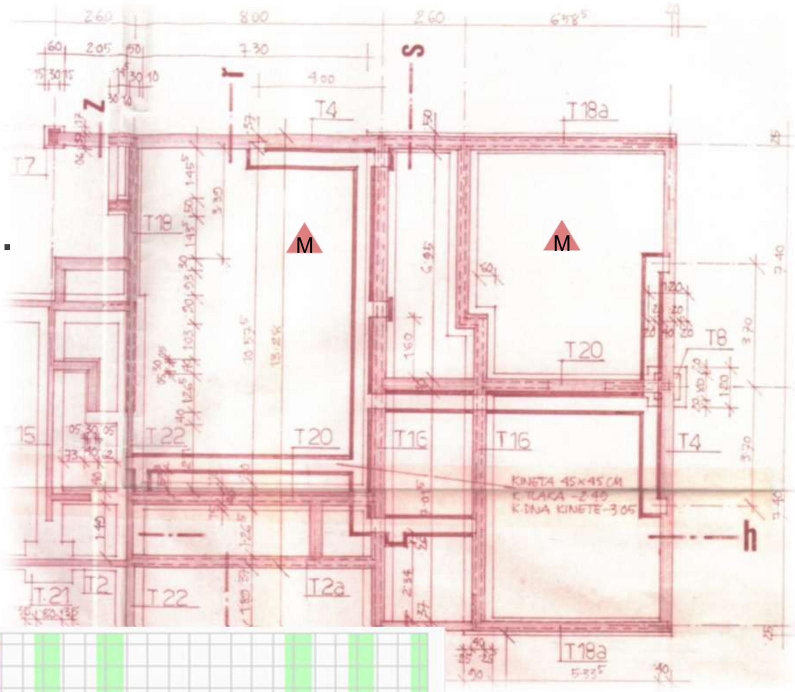



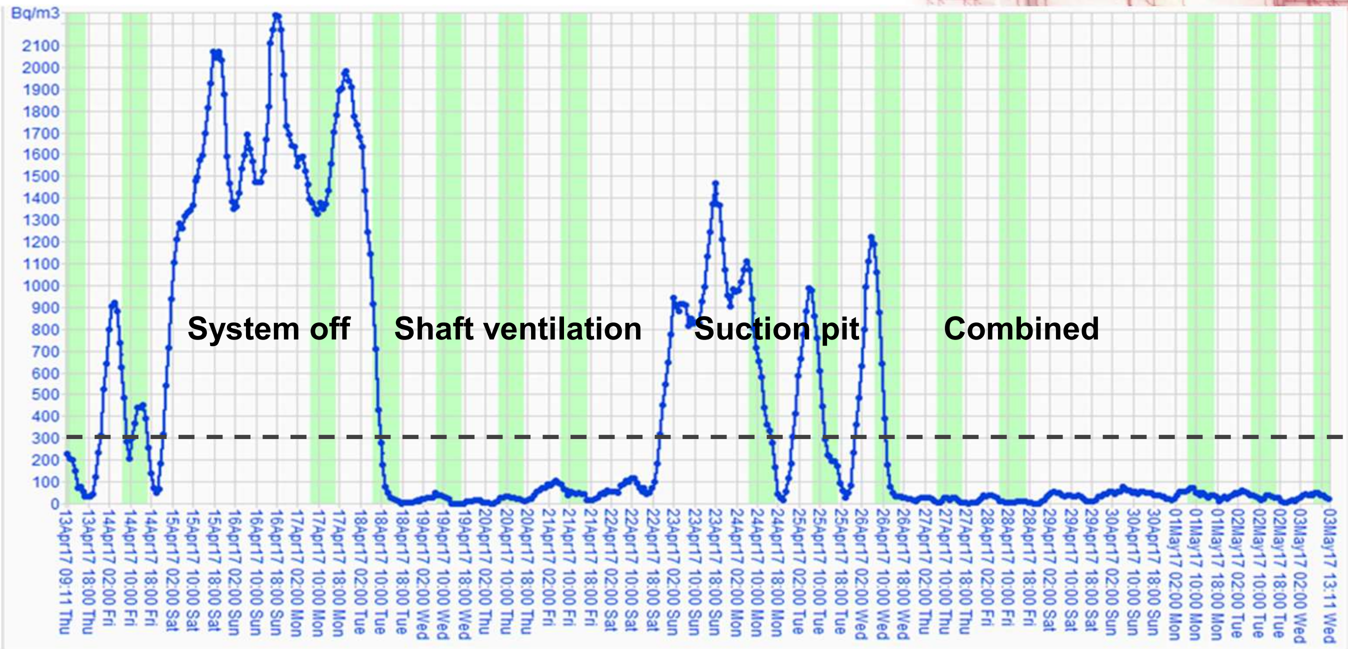
# Results

Building with shaft in ground structure.

Experimental suction pit constructed.

Radon measured in adjacent space (not the space with the suction pit).

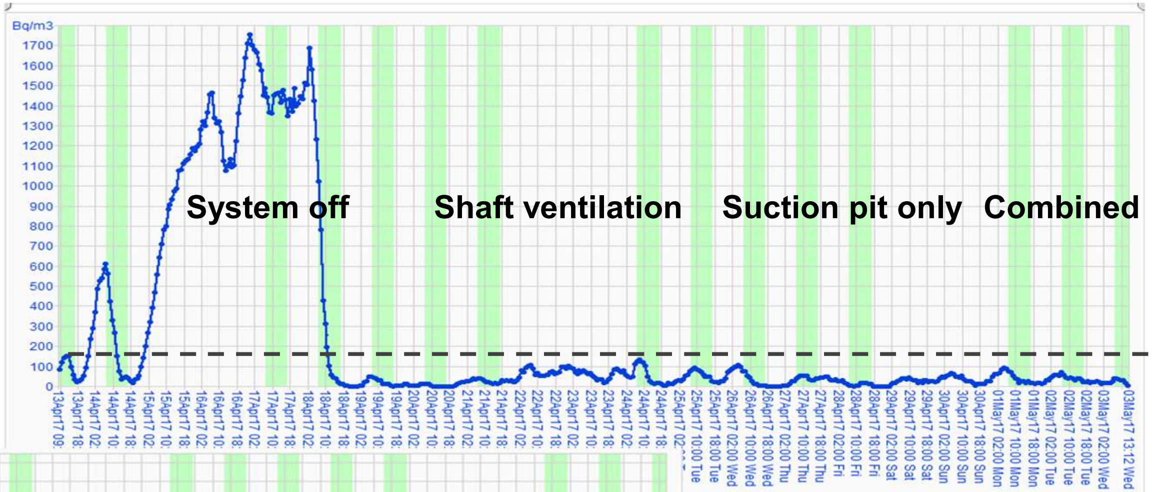


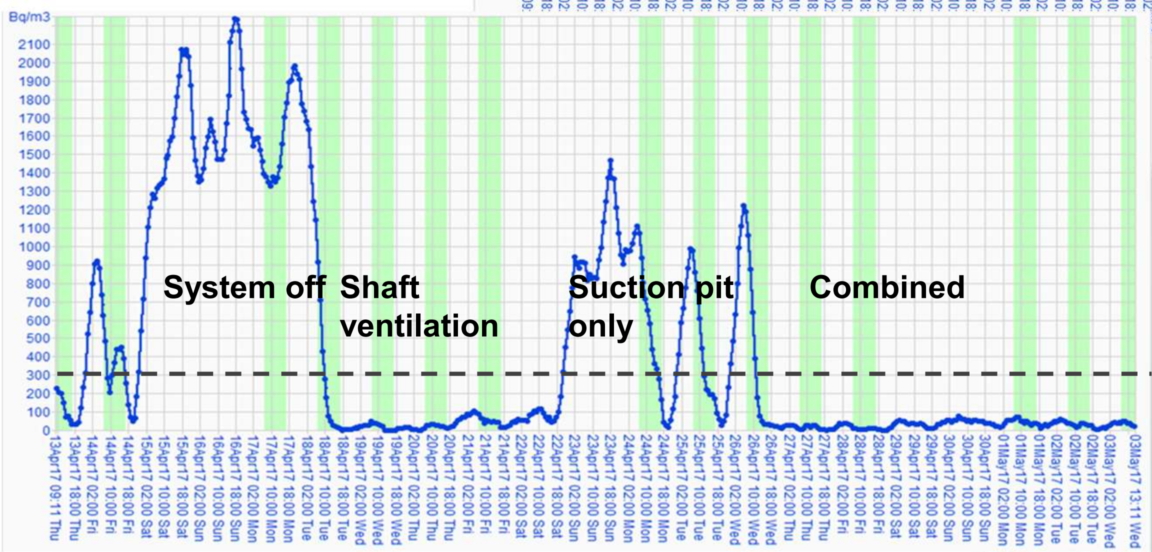
# Results (2)

Influence of the foundation walls clearly demonstrated.

Room with the suction pit

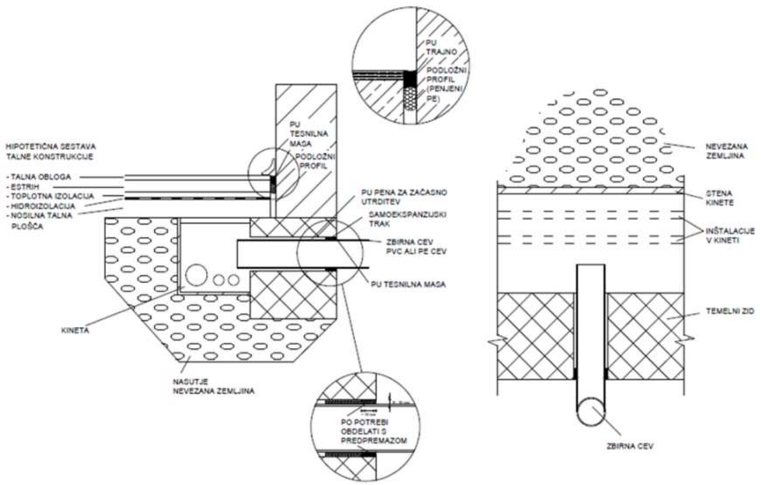



Adjacent room

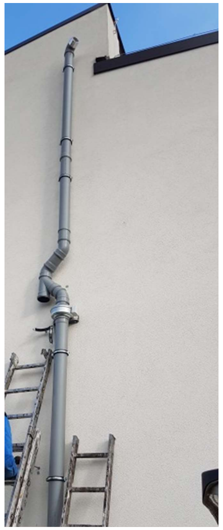



# Case study – case 3

- School, building from the 1950s, retrofitted.
- Extensive measurements were not done prior to the mitigation.
- Problem identified in several classrooms.
- All affected classrooms connected via installation shafts.

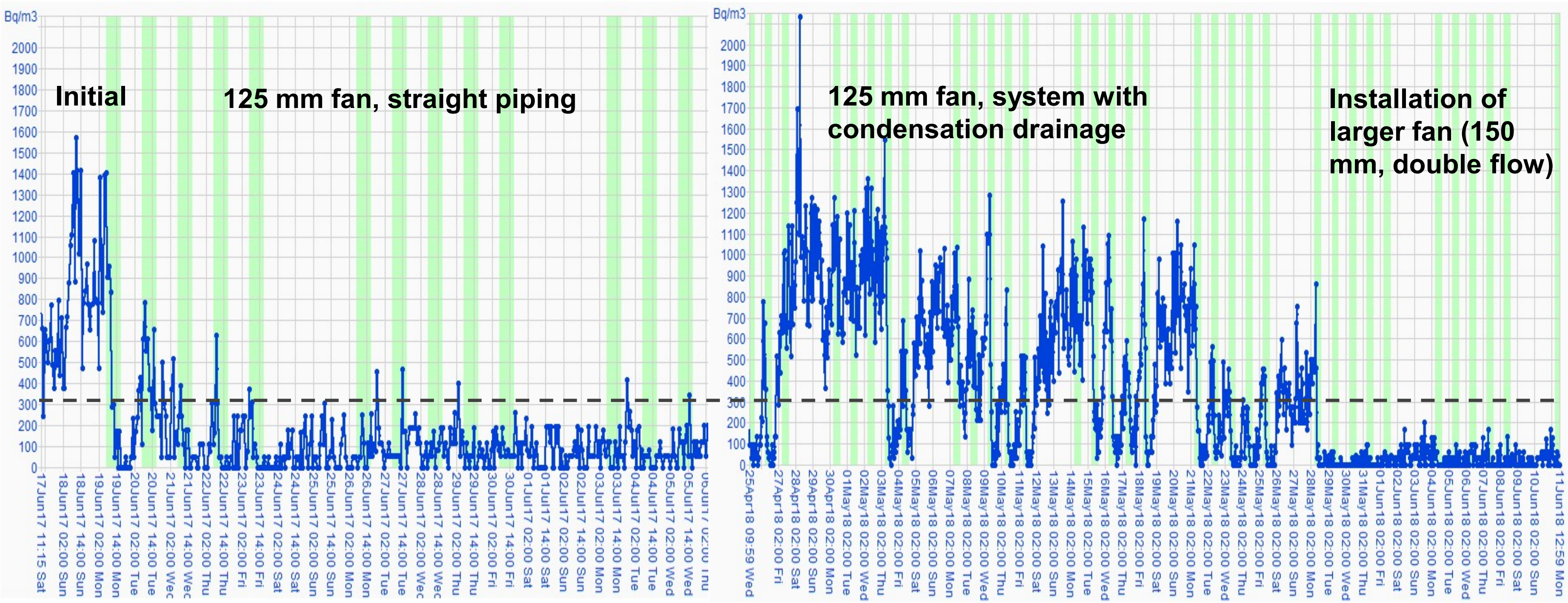





# Results

Secondary effects may influence the system's performance.



# Radon prevention in large public buildings

To avoid problems in known radon prone areas, it is highly recommended to include radon prevention measures in the design.

In reality, due to lack of knowledge and legal requirements, the radon experts are usually called-in too late.

- Case – in Town Idrija
  - Solution with voided floor
  - Problem – heat losses increase (cold floor)
- Case – in Town of Škofja Loka
  - Load bearing slab as footing
  - Installation of gravel layer and collecting pipes
- Case – in Village Črni vrh nad Idrijo
  - Sealing with bitumen foil with aluminium inlay
  - Additional suction pit from the side

# Conclusions

- Radon mitigation in Slovenia is well-established for public buildings, such as schools and kindergartens.
- The principles of the mitigation used can easily be applied to mitigation in single family houses.
- In Slovenia, one basic principle (so far) is always found to be appropriate; the ASD (active slab depressurization) method is proven to reduce radon concentration levels sufficiently, regardless of building age or architecture, *but*
- Every case has its own specific situation; general mitigation principles need adaptation in real applications; errors will occur from time to time, but the general design enables relatively easy fixes in most cases.
- It is very important that proper commissioning is done.
- New building stock should be built radon safe; main hindering element in this task is general radon awareness (in Slovenia).

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# Thank you for your attention

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