Estimating radon mitigation efficiency in the framework of the RESPIRE project

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RESPIRE - Radon rEal time monitoring System and Proactive Indoor Remediation

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LIFE Environment and Resource Efficiency project
LIFE 16 / ENV / IT / 000553 - RESPIRE

REALIZED WITH THE FINANCIAL CONTRIBUTION OF THE EUROPEAN UNION LIFE PROGRAMME

To develop radon mitigation practices by

- Developing Web-GIS based database for
  - Support of local authorities for land-use and health risk assessment
  - Online management and monitoring network for mitigation systems

- Test and evaluate the implementation of a cost-effective and ecological indoor air radon control system: establishing baseline and identifying possible traps and challenges

Type of Buildings

- Dwellings/schools/offices

- Moderate/low radon potential
  - Example of the majority of buildings
  - Passive/hybrid solutions are possible

- Karst areas
  - Very strong temporal (inversion) and spatial variations
  - Specific needs for remediation

- High radon potential
  - Source term is important
  - Soil permeability can greatly influence the mitigation efficiency

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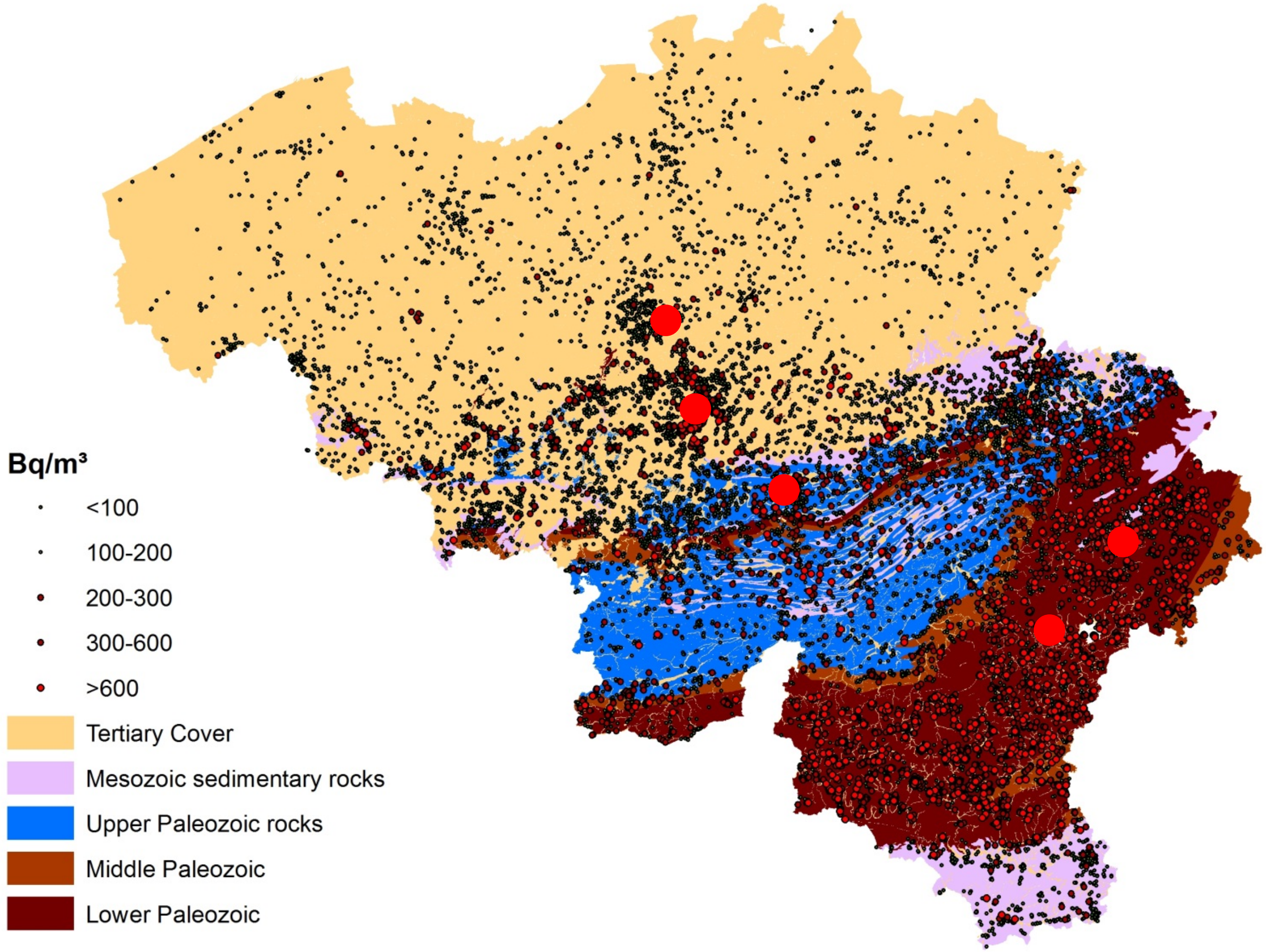
Radon real time monitoring system



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Moderate/low radon potential

Long term radon concentration in the living room (SSNTD for 90 days): 208 Bq/m³

Long term average radon concentration in the basement (active devices for 259 days): 1920 Bq/m³

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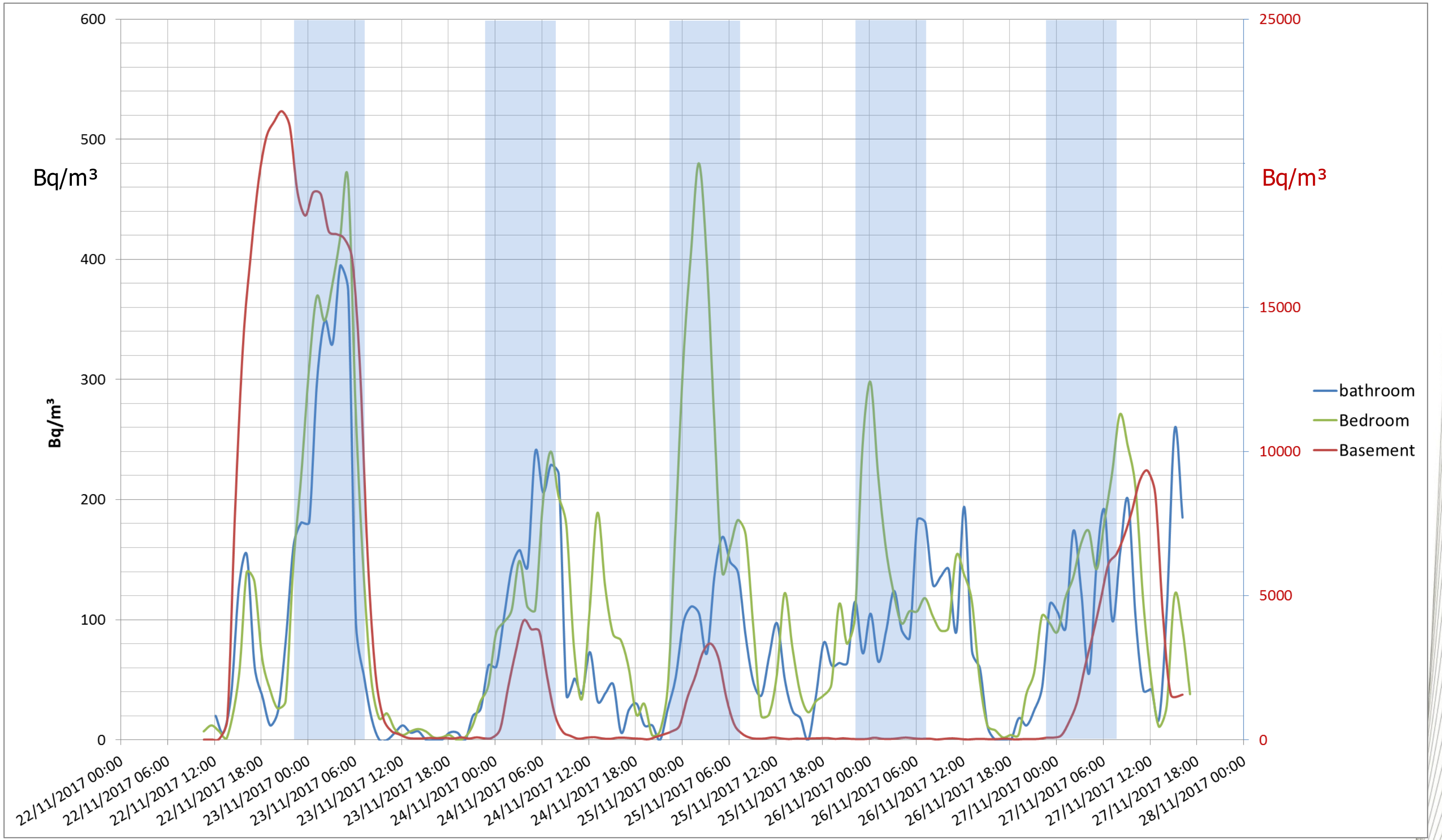

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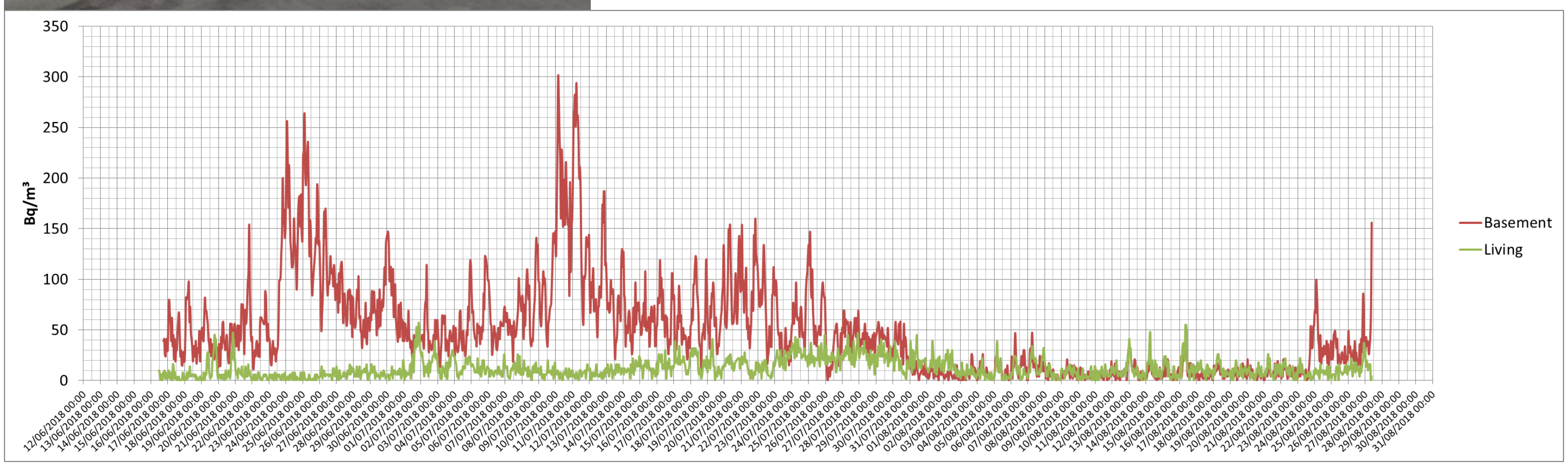
Drainage sump in basement has been closed

	Living room mean Bq/m³	Basement mean Bq/m³
before fan installation (3 months)	208	1920
after fan installation (3 months)	12	75

☞ Follow up in winter



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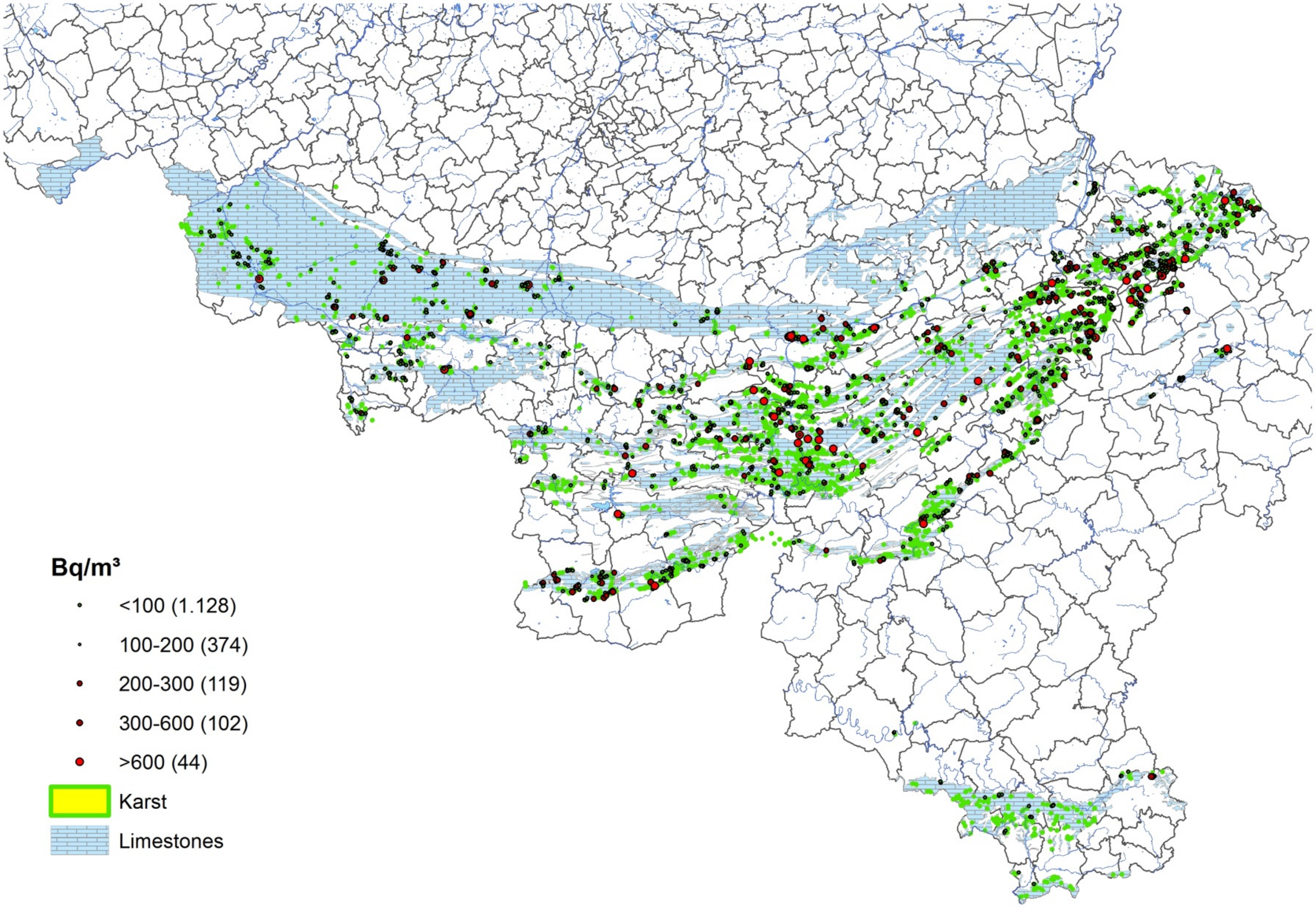
Karst region



Karst:

- carbonate rocks where fractures are enlarged by chemical dissolution to form a network of galleries, conduits and caves

- Forms particular landscapes when part of these galleries collapse

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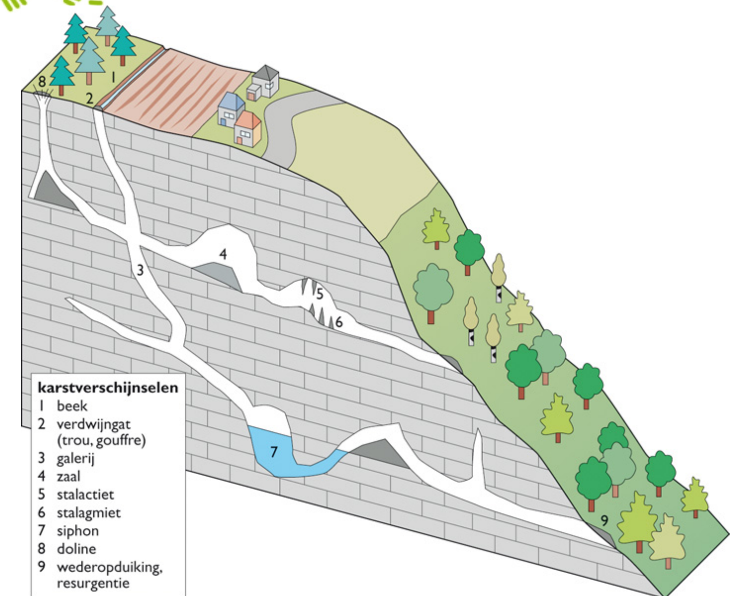
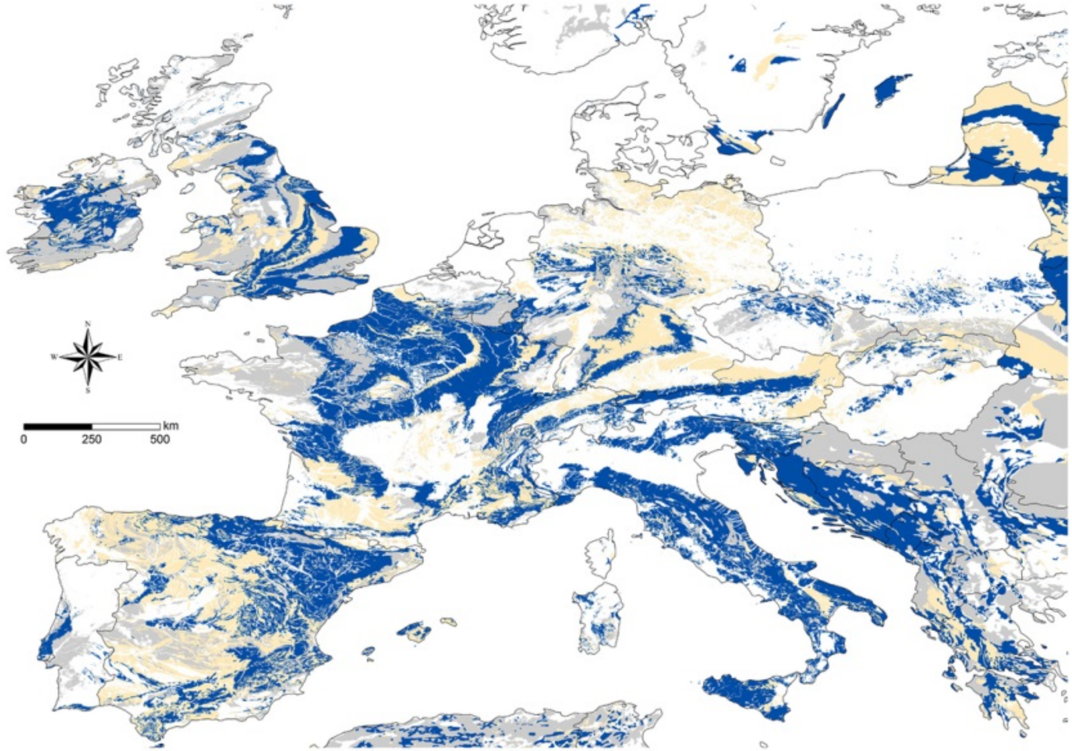
Of particular importance for indoor radon risk due to the potentially high permeability





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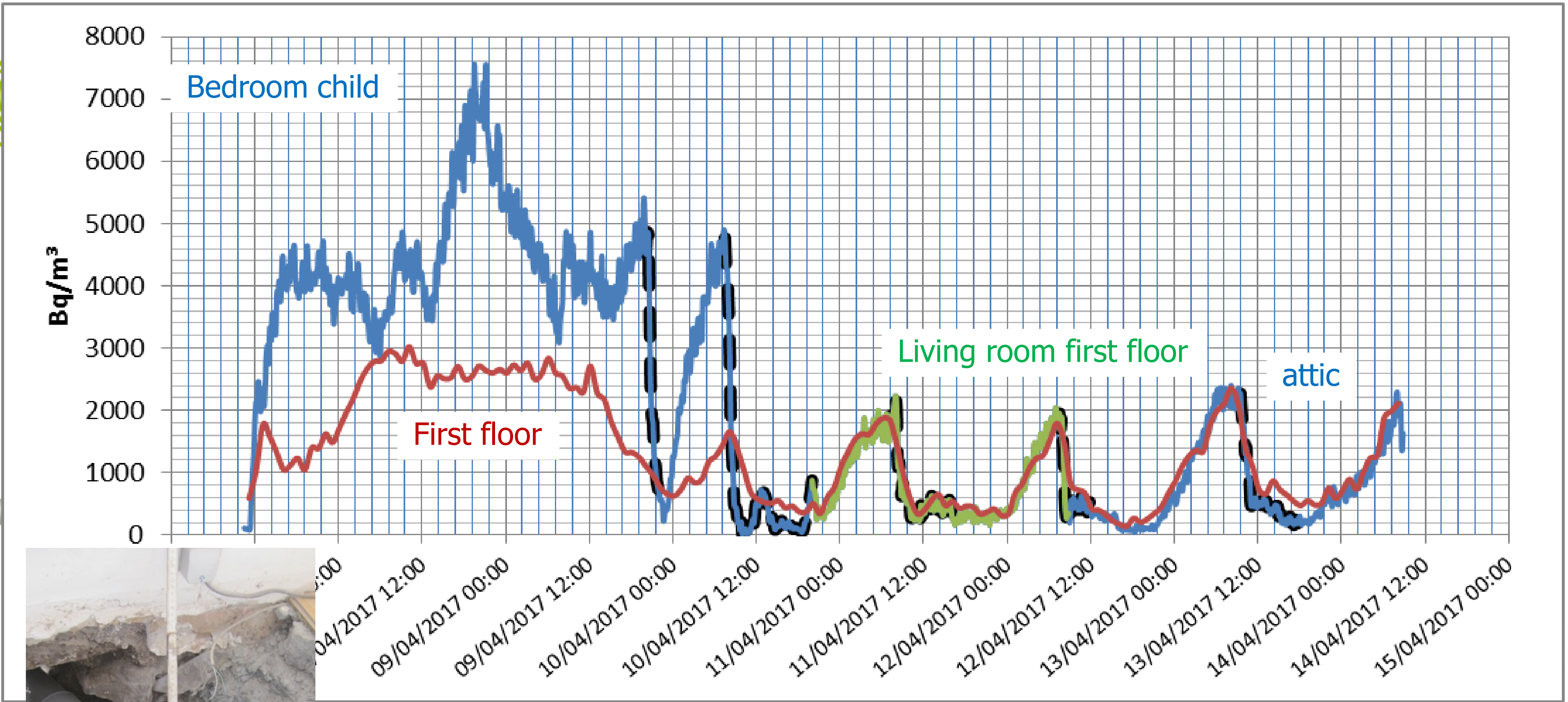
Problems related to karst

- Identify the risk (strong local variations)
- Specific needs for remediation solutions


8000
7000
6000
5000
4000
3000
2000
1000
0
Bq/m³
Bedroom child
First floor
Living room first floor
attic
09/04/2017 12:00
09/04/2017 00:00
09/04/2017 12:00
10/04/2017 00:00
10/04/2017 12:00
11/04/2017 00:00
11/04/2017 12:00
12/04/2017 00:00
12/04/2017 12:00
13/04/2017 00:00
13/04/2017 12:00
14/04/2017 00:00
14/04/2017 12:00
15/04/2017 00:00

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Blower door test

N50 ~7
Natural air changes per hour ~35%

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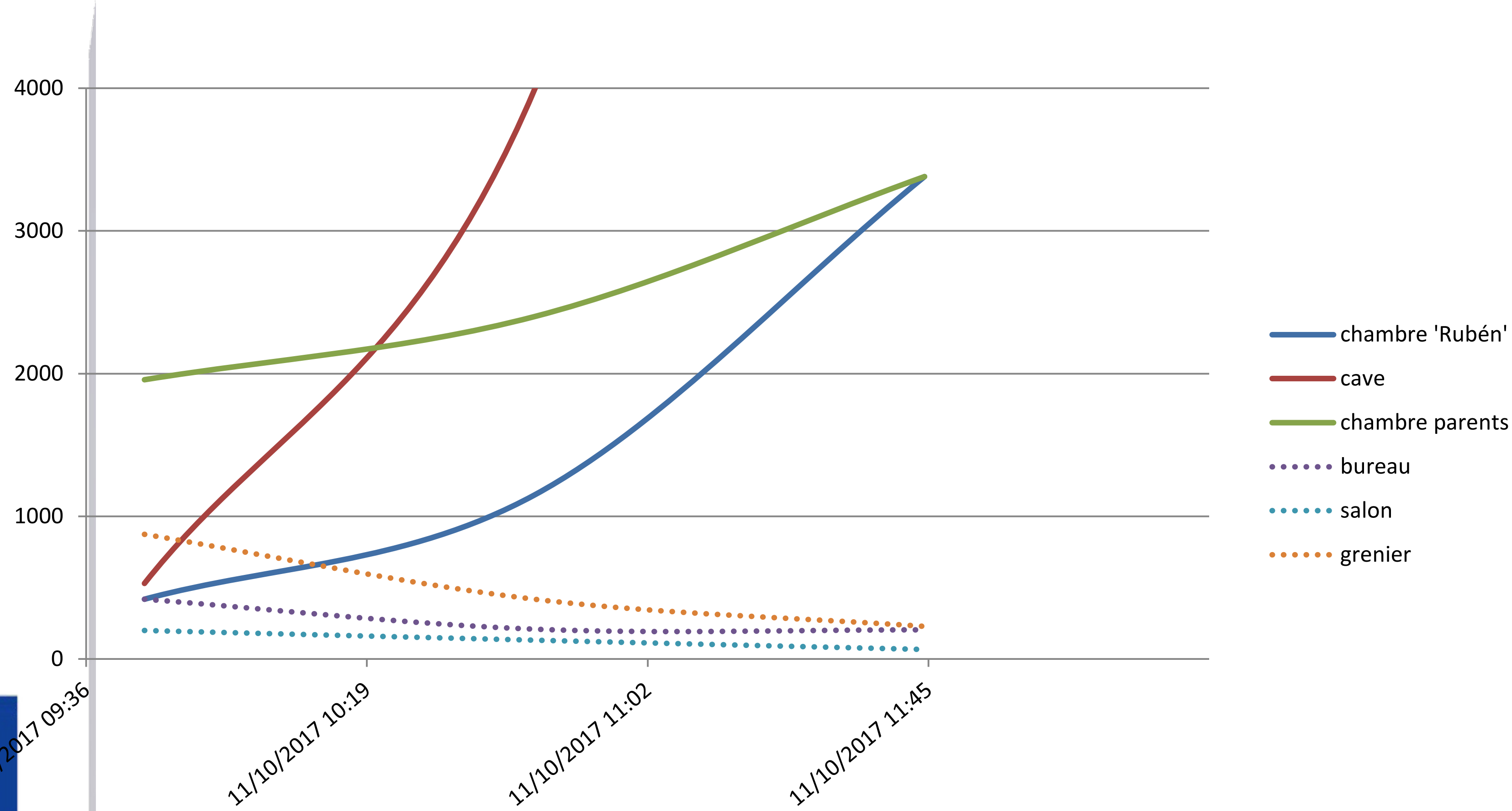
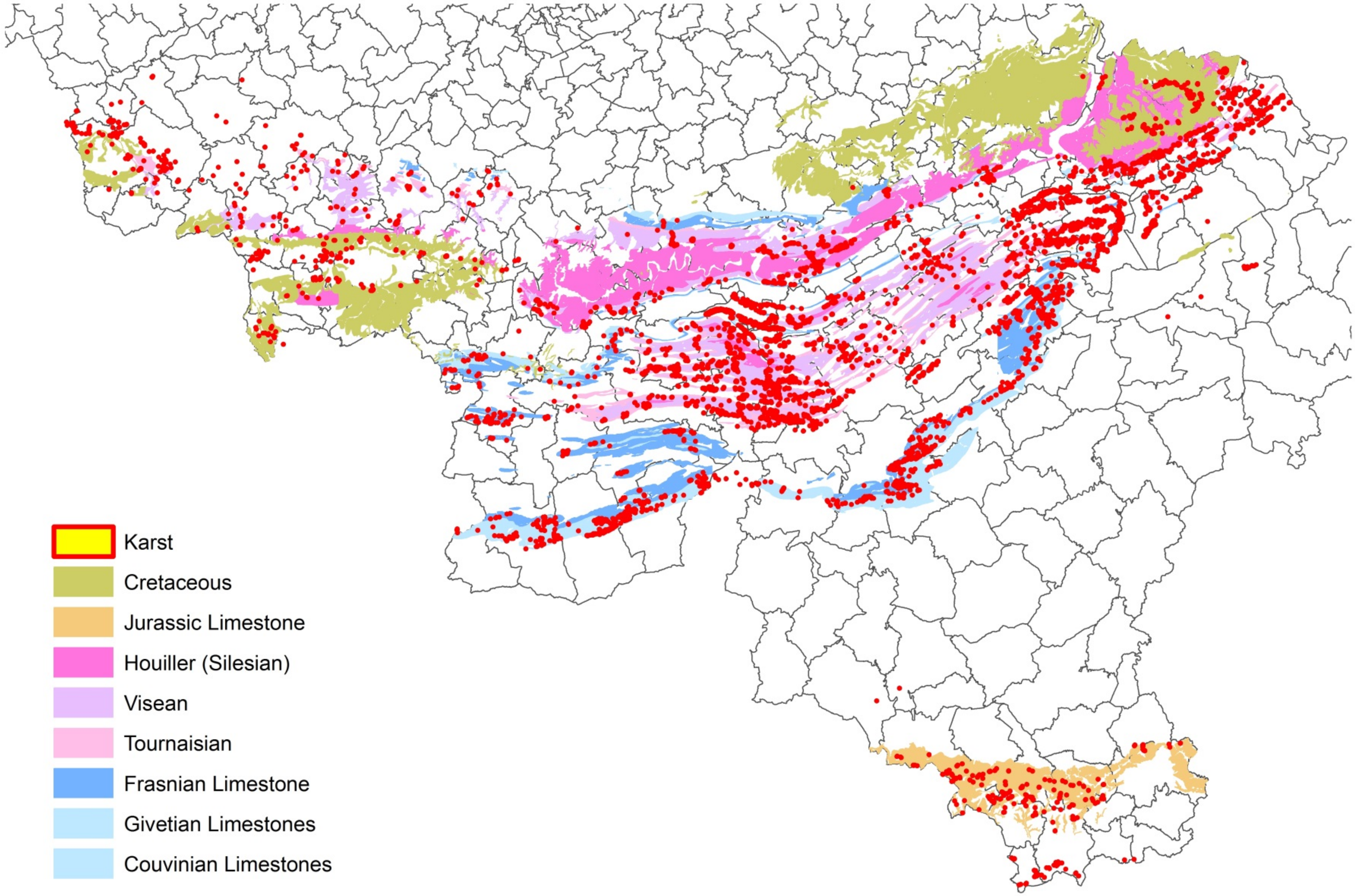
date	Room1	Cellar	Room 2	office	living	attick
11/10/2017 09:45	420	530	1958	420	200	874
11/10/2017 10:45	1150	3990	2400	210	132	420
11/10/2017 11:45	3380	13403	3380	205	67	230




Karst
Cretaceous
Jurassic Limestone
Houiller (Silesian)
Visean
Tournaisian
Frasnian Limestone
Givetian Limestones
Couvinian Limestones

Karst occurs in almost all levels of limestone

Age (Ma)	Period	Series		Stage	remark	GM (Bq/m³)	GSD	t-test P-value	Karst
95	Cretaceous			Cenomanian		58	2,2	0,02	low
190	Jurassic			Sinemurian		64	1,9		low
310	Carboniferous	Upper	Houiller (Silesian)	Westphalian	(coal measures)				
				Namurian	(Chockier hot shales)	57	2,4	0,0002	low
		Lower	Dinantian	Viséan		72	2,8	0,35	high
350				Tournaisian		68	2,6		modest
	Devonian	Upper		Famennian					
				Frasnian		63	2,3	0,001	modest
		Middle		Givetian		77	2,4	0,76	high
				Eifelian	(Couvinian)	76	2,2		modest
		Lower		Emsian	(Burnotian)				
				Pragian	(Siegenian)				
410				Lochkovian	(Gedinnian)				

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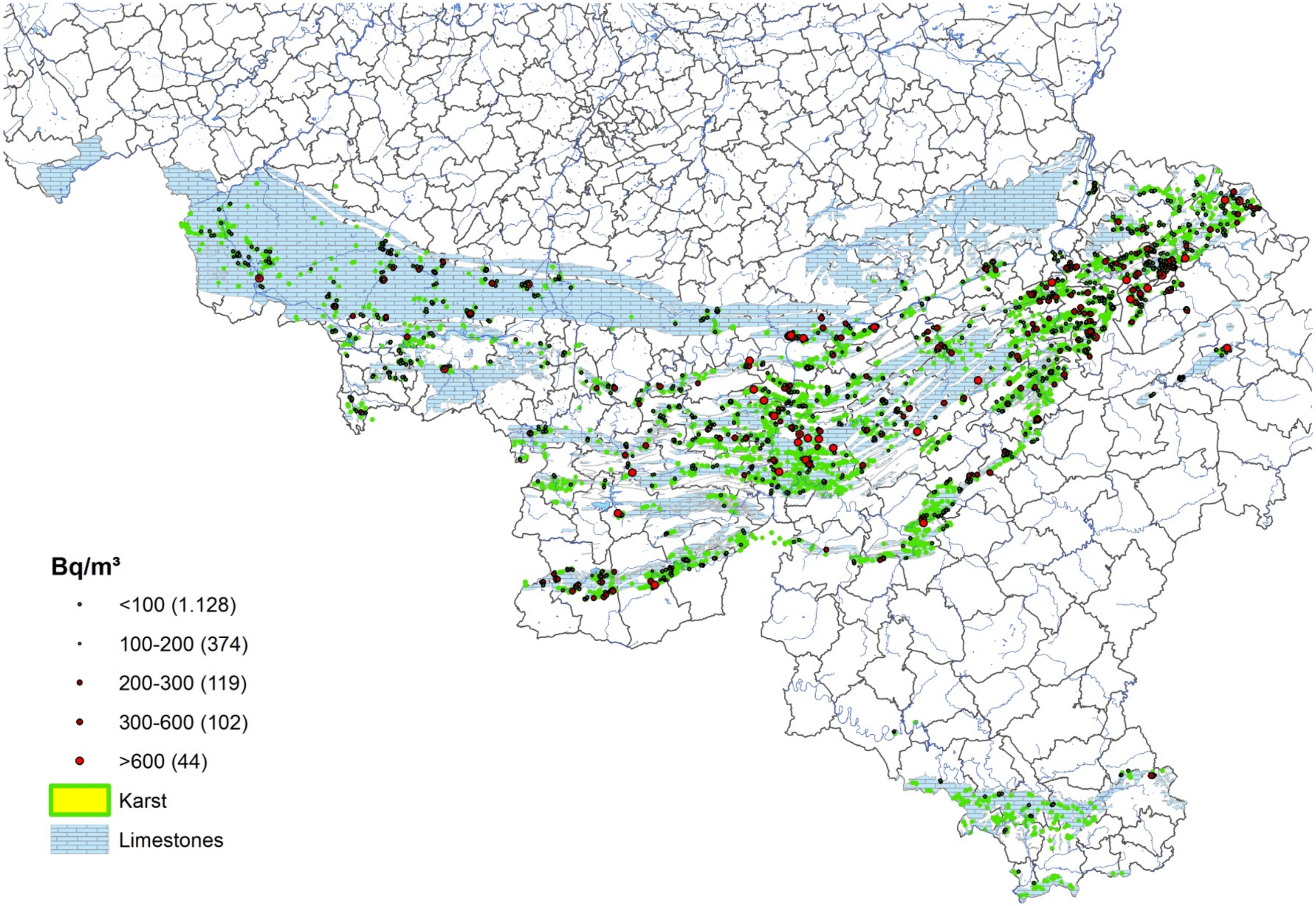
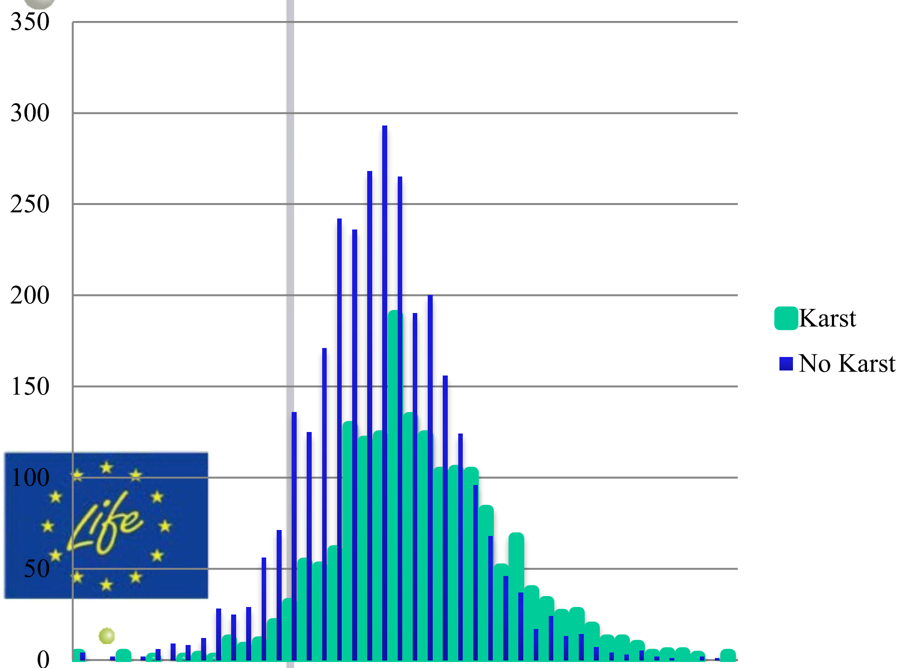

Bq/m³
<100 (1.128)
100-200 (374)
200-300 (119)
300-600 (102)
>600 (44)
Karst
Limestones

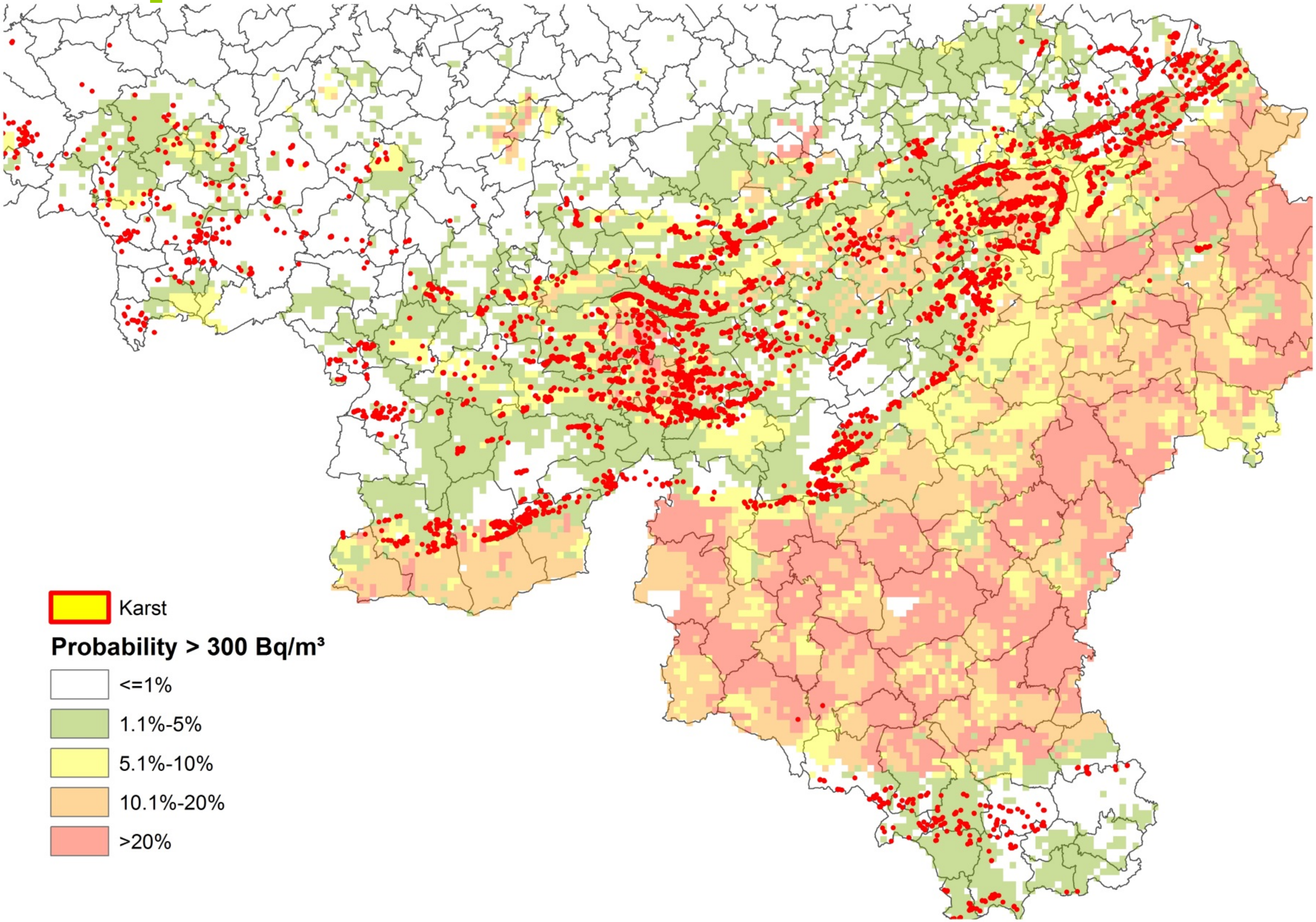
Bq/m³	Proven karst	No proven karst
count	1767	3008
GM	80	59
GSD	2,54	2,31
Median	72	58
Arithmetic mean	132	86
% > 300	8,3	3,0
% > 600	2,5	0,8



t-Test: Two-Sample Assuming Unequal Variances

	Karst	*NoKarst*
Mean	4,38	4,08
Variance	0,87	0,70
Observations	1767	3008
Hypothesized Mean Difference	0	
df	3388	
t Stat	11,209	
P(T<=t) one-tail	5,83E-29	
t Critical one-tail	1,645	
P(T<=t) two-tail	1,17E-28	
t Critical two-tail	1,961	

Improve radon risk map grid squares with info on karst



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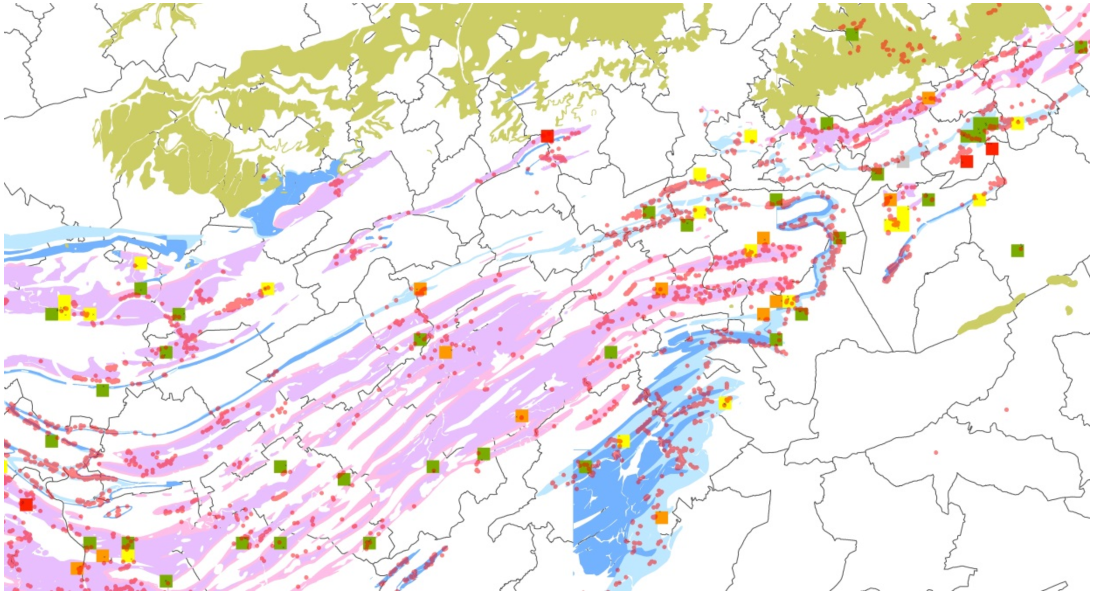
- Select high indoor values near karst (most probably due to karst)
- Isolate the high indoor values on low risk grid squares (based on general geology)



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- 49% of the high indoor values on limestone are found in low risk classes 1 and 2
- For the whole dataset, only 14% of high indoor values are located in low risk classes 1 and 2
- For the high indoor values located on limestones, 71% of the high indoor values are located within 700m distance of proven karst.
- So, the presence of karst could be used to 'upgrade' the local risk in a low risk grid square

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Karst

- Presence of karst increases indoor radon risk, whereas limestone itself represents low to medium risk
- Indoor radon variations are higher in karst regions than outside karst regions
- They can vary greatly in time and space
- The presence of karst can be used to locally ‘upgrade’ the local risk in an overall low risk region
- Problem: not all karst is proven and mapped

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High Radon Potential areas

Characterising dynamics in schools and mitigated schools

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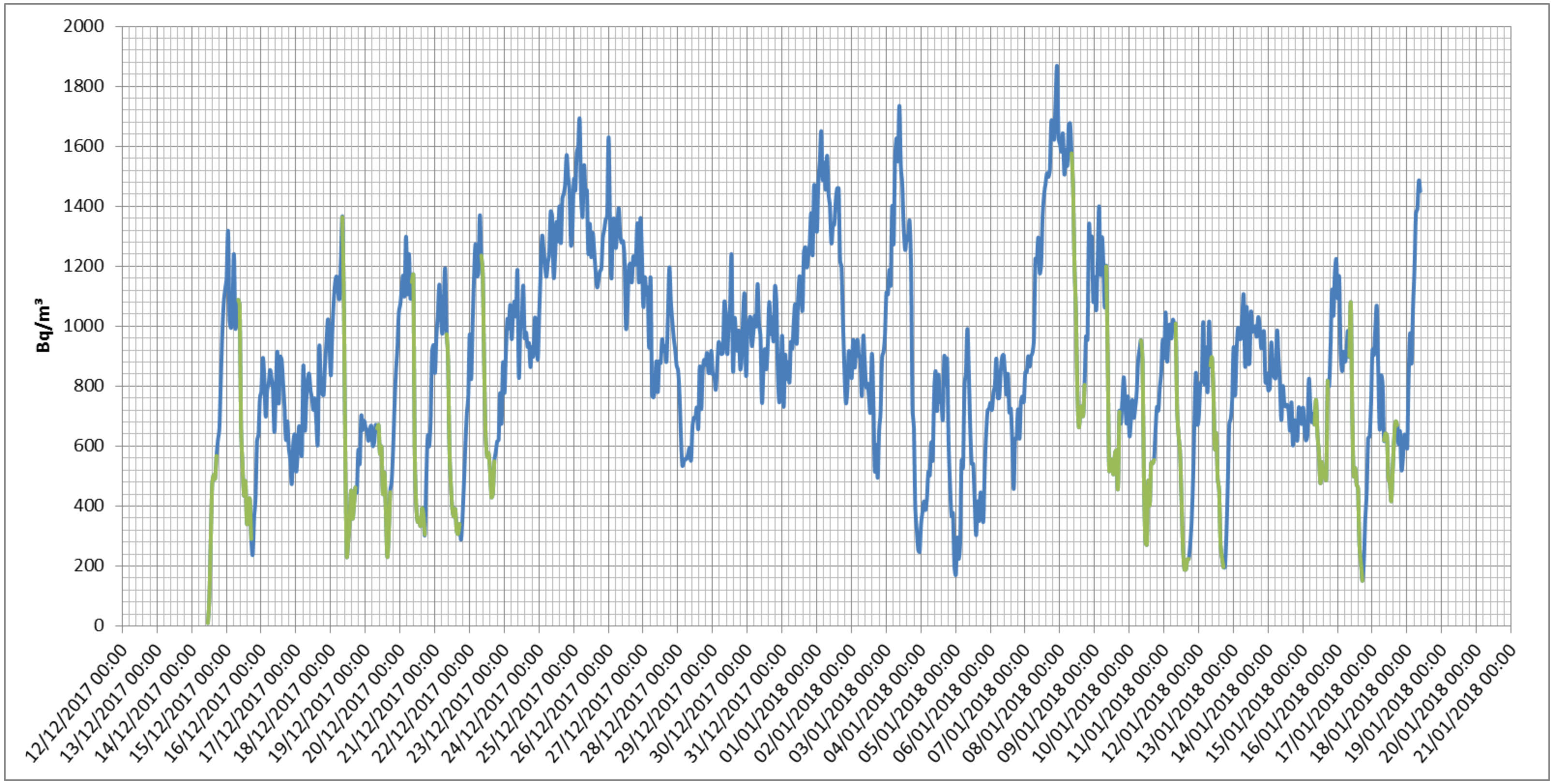

Schools are of particular interest for the application of controlled remediation system due to the strong diurnal variations and weekend/holiday dynamics

CHARACTERISING LARGE BUILDINGS (WORKPLACE OFFICES AND WORKSHOPS)

The identification of radon sources, more specifically through defects in the floor, is a major component of remediation actions, particularly in complex situations which is often the case in workplaces.

<u>Case study</u>: remediation project of an extensive workplace, the activity centre for handicapped persons: 4 buildings with a surface of more than 4.000 m². The main approach for remediation is sub-slab depressurization.
The need for radon sources identification was realized when it appeared that the first gas extractions from the soil were not everywhere enough efficient. The reason was assumed to be radon entry through openings and defects in the floor.

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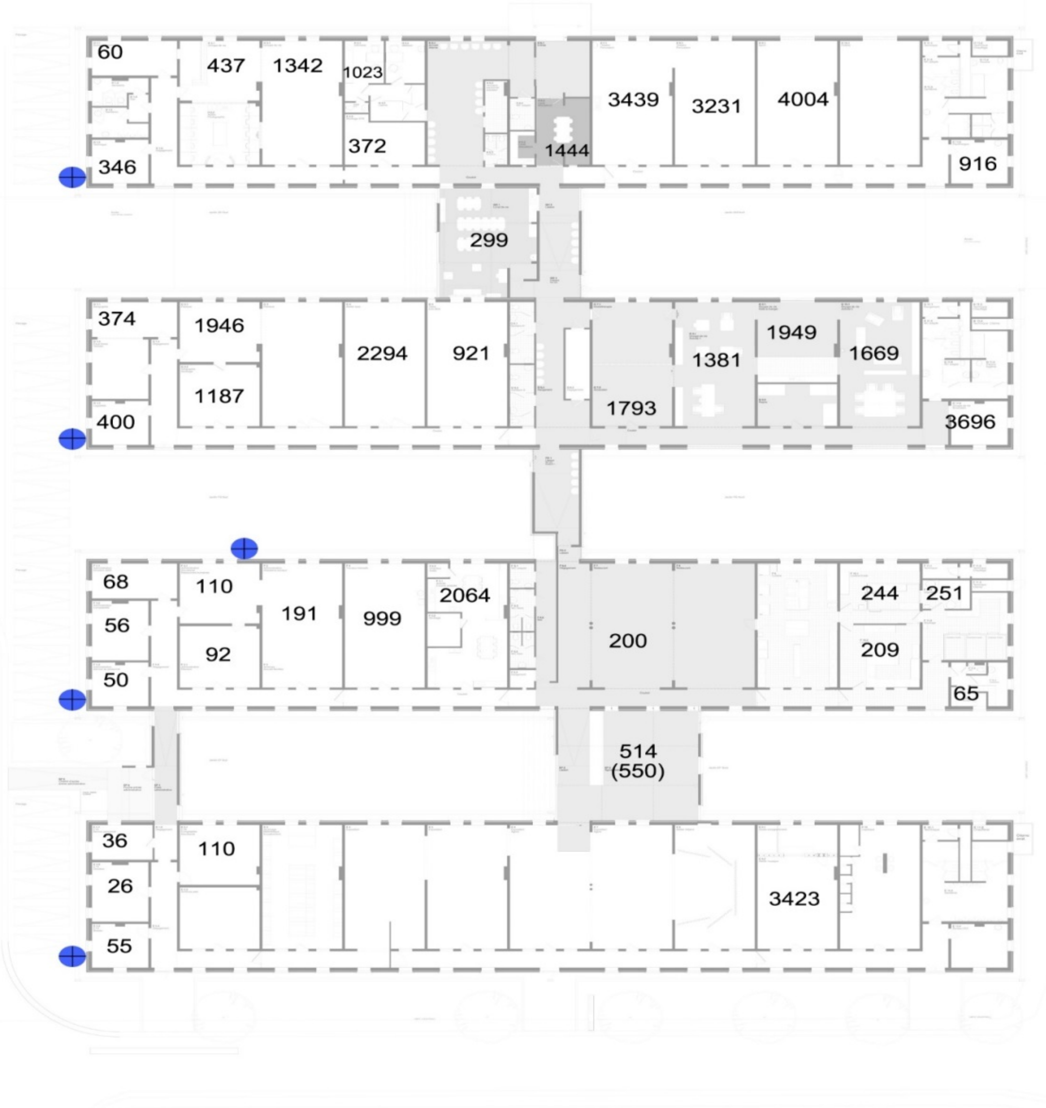
60
437
1342
1023
372
346
1444
3439
3231
4004
916
299
374
1946
2294
921
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400
1793
1381
1949
1669
3696
68
110
191
999
2064
56
92
50
200
244
251
209
65
514
(550)
36
110
26
55
3423

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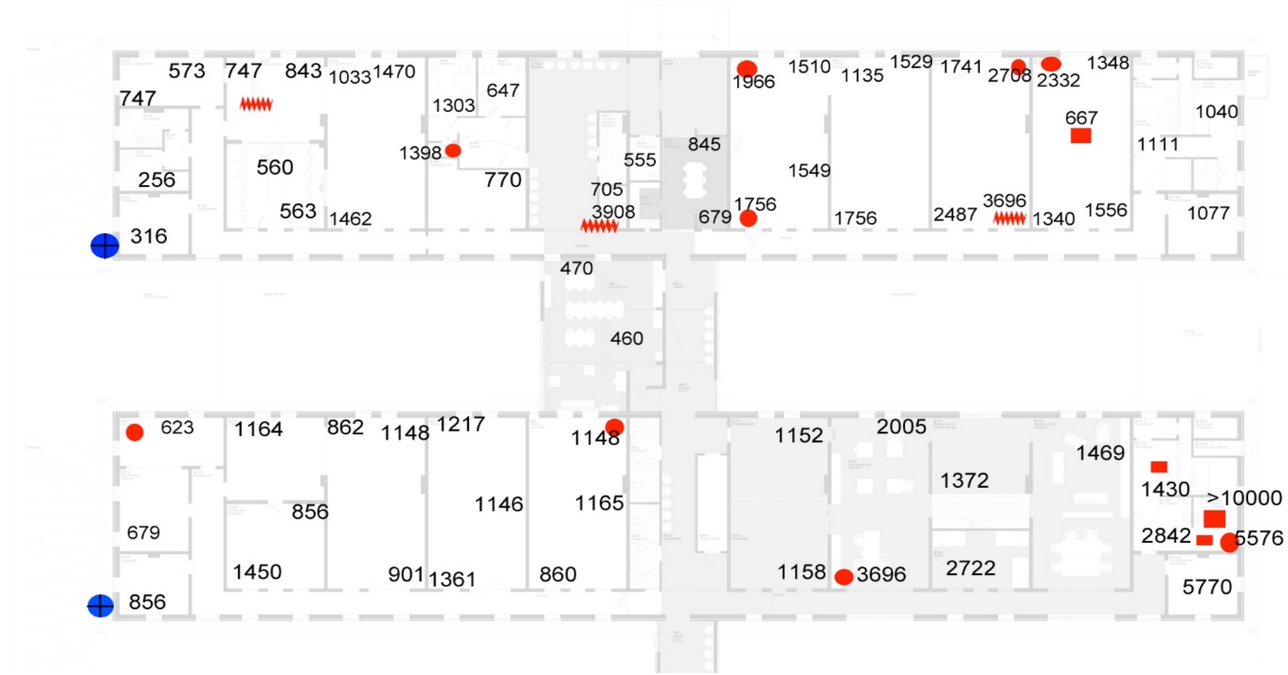

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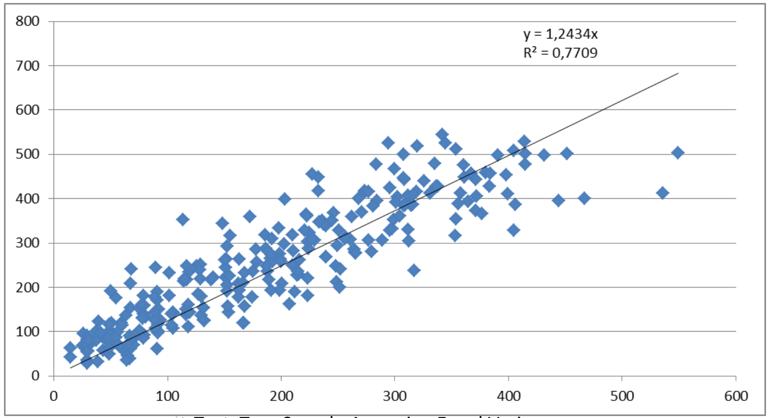
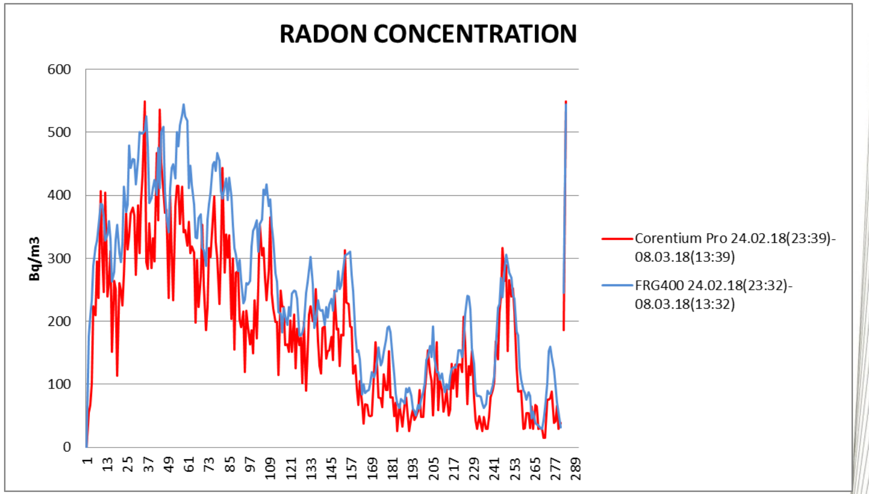
COMPARING DIFFERENT COMMERCIAL RADON MONITORS

Experiment: Two instruments – an AIRTHINGS Corentium Pro and a FTLAB FRD400 – have been placed in a dwelling with moderate radon concentration during several months. Unfortunately both instruments have been staying side by side only during about 2weeks. After this period, the AIRTHINGS monitor remained on the same place, but the FTLAB monitor has been placed in several places. The AIRTHINGS monitor has been registerd during the entire period but the comparison between the registrations done by the 2 instruments could be done only for a period of 2 weeks.

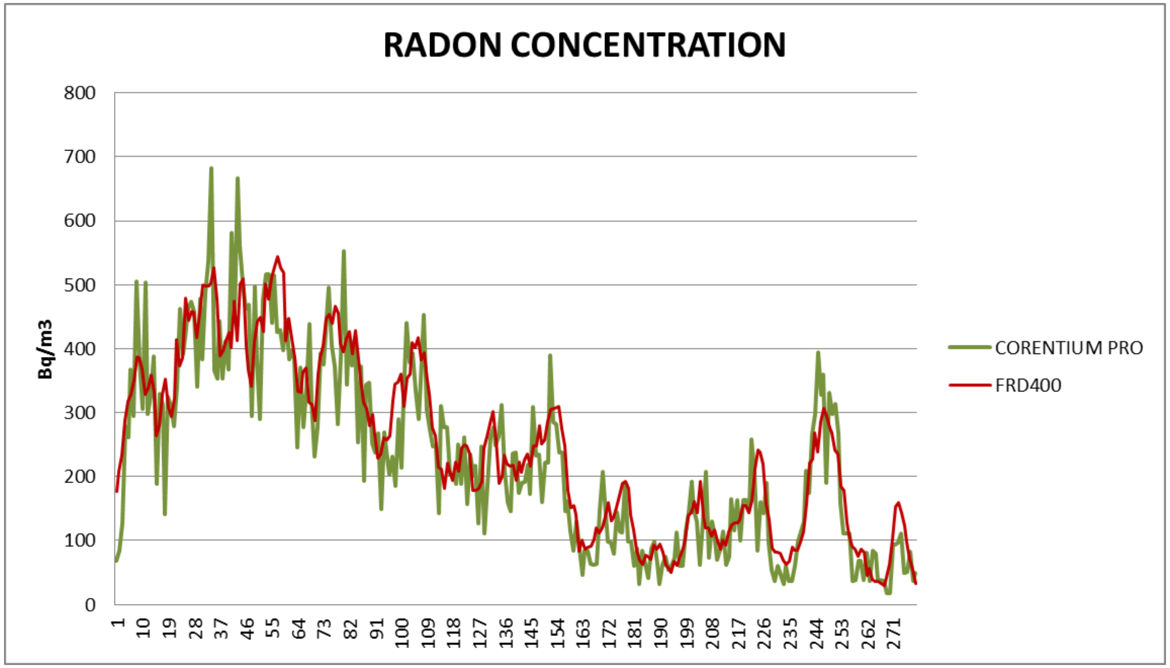


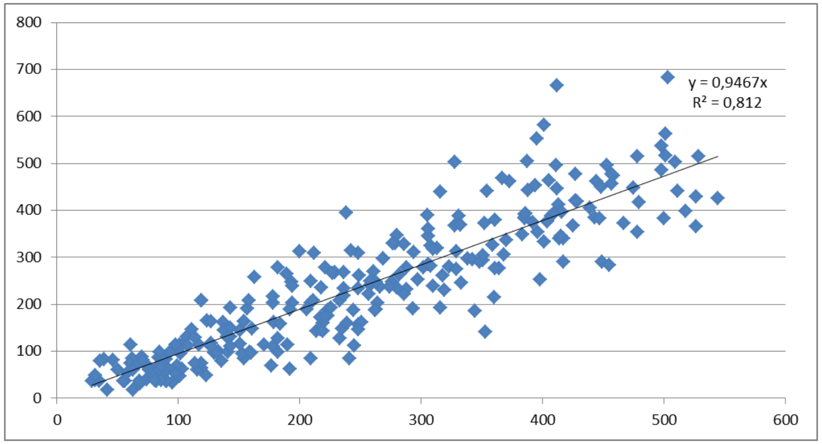


t-Test: Two-Sample Assuming Equal Varianc

	FRD400	RENTIUM P
Mean	246,5998	186,9386
Variance	18560,84	14080,57
Observations	281	281
Pooled Variance	16320,7	
Hypothesized Mean Di	0	
df	560	
t Stat	5,535548	
P(T<=t) one-tail	2,39E-08	
t Critical one-tail	1,647579	
P(T<=t) two-tail	4,77E-08	
t Critical two-tail	1,964209	

After callibration:





t-Test: Two-Sample Assuming Equal Variances		
	FRD400	CORENTIUM
Mean	245,7842	231,4309421
Variance	18424,4	21176,37237
Observations	278	278
Pooled Variance	19800,39	
Hypothesized Mean Diffe	0	
df	554	
t Stat	1,202597	
P(T<=t) one-tail	0,114823	
t Critical one-tail	1,647609	
P(T<=t) two-tail	0,229646	
t Critical two-tail	1,964255	

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Conclusions

- Radon mitigation is a challenge, even outside 'radon priority zones'. For moderate radon levels, (remotely) controlled solution can be of specific interest (economic/ecologically)
- Karst regions significantly increase indoor radon risk, requiring specific diagnostic and remediation techniques
- Workplaces can benefit specifically of (remotely) controlled remediation systems, due to exposure control (rather than concentration)
- Baseline data for different (type of) buildings has been established allowing a sound evaluation/comparison of the RESPIRE radon control system

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Thank you for your attention!

http://www.liferespire.eu/