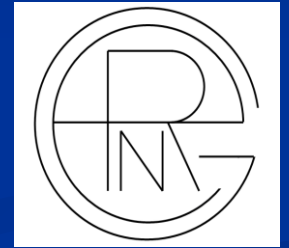


SOME PRELIMINARY RESULTS OBTAINED WHEN INDOOR RADON
MITIGATION METHODS ARE APPLIED



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SOME PRELIMINARY RESULTS OBTAINED WHEN INDOOR RADON MITIGATION METHODS ARE APPLIED

OUTLINE

- TWO RESEARCH PROJECTS
- PREVIOUS WORKS AND RESULTS (1st proj.)
- METHODOLOGY AND WORKING PLAN
- RESULTS
- SUMMARY AND CONCLUSIONS

RESULTS OBTAINED BY THE APPLICATION OF SOME MITIGATION METHODS IN WORKPLACES WITH HIGH INDOOR RADON CONCENTRATION

Two research projects:

1. Radon concentration in working places
2. Remedial or mitigation actions (if needed)

1st RESEARCH PROJECT

HELP PROGRAM FOR CONDUCTING RESEARCH AND DEVELOPMENT ON NUCLEAR SAFETY
AND RADIATION PROTECTION

R+D CSN 2008-2011

Title: **Measurement of radon concentrations in workplaces with particular exposure.**

Duration: **Three years**

Goals: **Monitoring workplaces with expected high concentration of radon in the region of Extremadura (Spain)**

1st RESEARCH PROJECT

MEASURING METHODS

Type of detector	Passive/ Active	Typical uncertainty * (%)	Typical sampling period	Economic cost
Nuclear Tracks	Passive	10 – 25	1 – 12 months	Low
Activated charcoal	Passive	10 – 30	2 – 7 days	Low
Electret	Passive	8 – 15	5 days – 1 years	Average
Electronic integrator	Active	~ 25	2 days - years	Average
Continuos Monitor	Active	~ 10	1 hour - years	High

** Typical uncertainty considering a mean of about 200 Bq/m³*

1st RESEARCH PROJECT

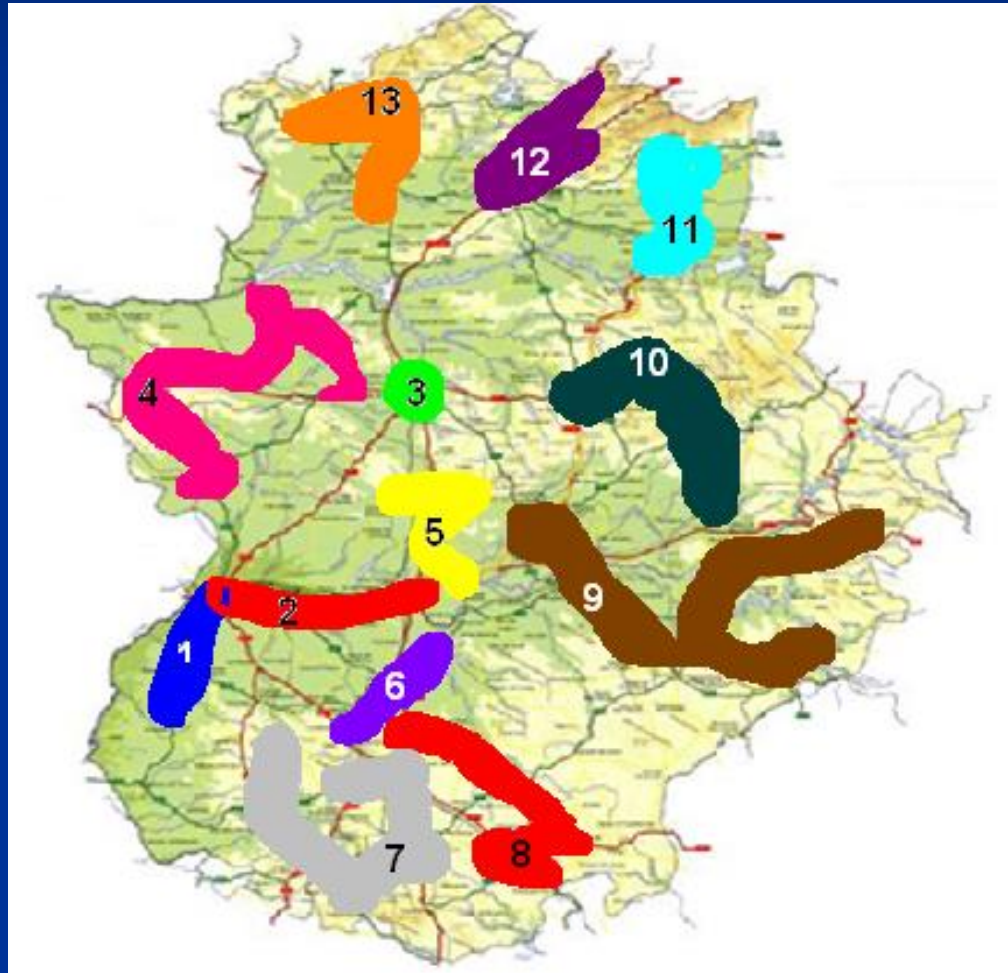
IDENTIFICATION OF PLACES

“Título VII del Real Decreto 783/2001, de 6 de julio”
(Spanish legislation)

- Resorts and spas.
- Caves, tunnels and mines (other than uranium).
- Facilities storing and dealing with water.
- Other underground and surface suspected workplaces.

1st RESEARCH PROJECT

ZONES



1st RESEARCH PROJECT

SAMPLING

Sites	Places	Measurements
Resorts and spas	11	20
Caves, Tunnels and Mines	4	12
Water treatment	2	2
Other	111	170
TOTAL	128	204

	Places	Measurements
Warehouses	20	25
Parkings	7	8
Hotels	5	8
Museums	36	46
University	4	39
Unclassified	39	44
TOTAL	111	170

1st RESEARCH PROJECT

SAMPLING

- Activated Charcoal Detectors.
 - 48 hours.
 - Collected 203 of 204: 99,5 %.
 - Laboratory analysis. “EPA 520/5-005”. Detector NaI(Tl).
- Nuclear tracks detectors CR-39.
 - 3 months.
 - Collected 174 of 194: 89.7 %.
 - External Laboratory analysis. University of Cantabria.



1st RESEARCH PROJECT

CLASIFICACION OF WORKING PLACES

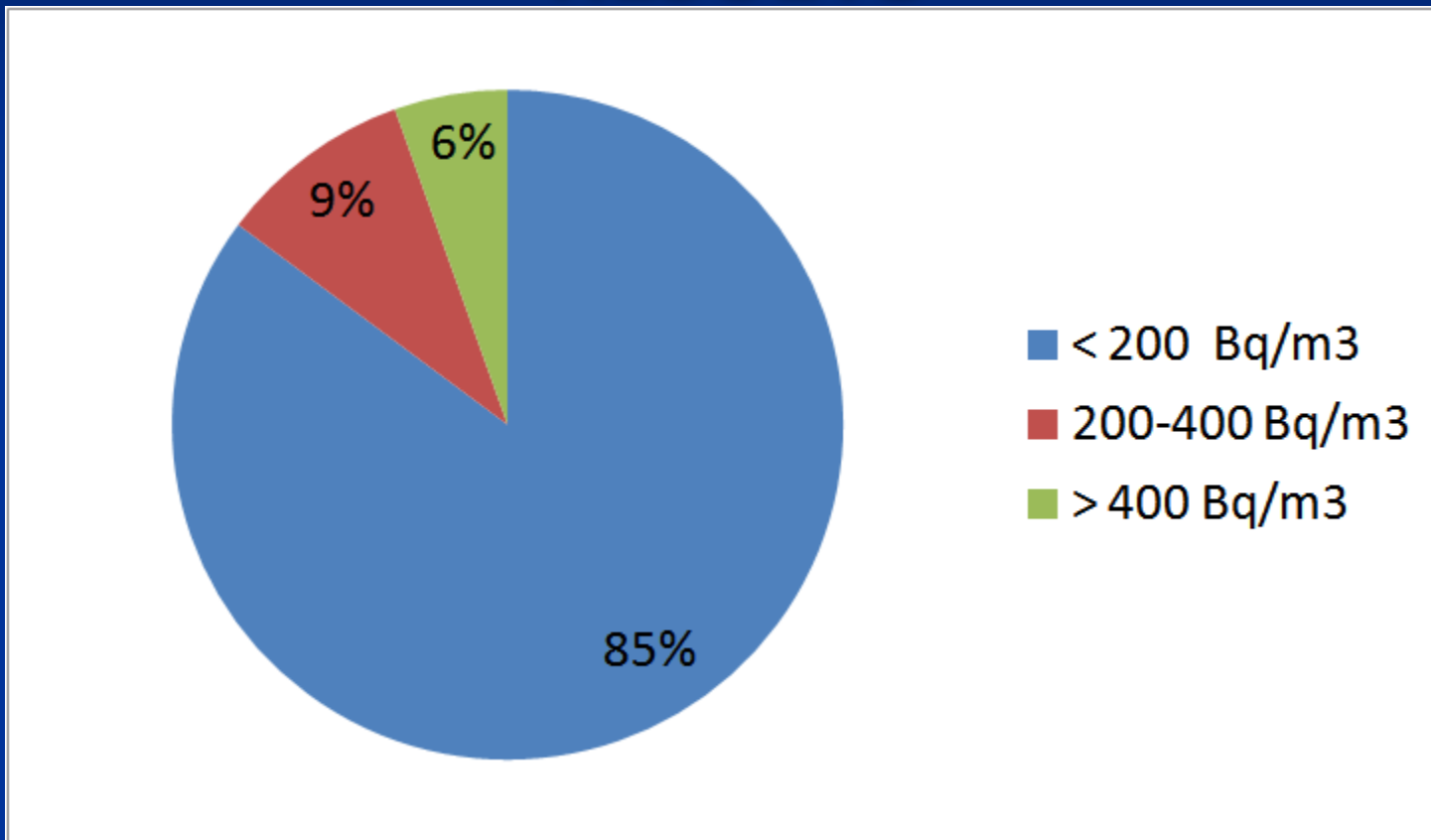
“Título VII del Real Decreto 783/2001, de 6 de julio”
(Spanish legislation)

Let C to be the yearly mean of indoor radon concentration. Then:

- If $C < 200 \text{ Bq/m}^3$ → No actions needed
- If $200 \text{ Bq/m}^3 < C < 400 \text{ Bq/m}^3$ → Single remedial actions recommended
- $C = 400 \text{ Bq/m}^3$ is the level for the protection of workers
- If $400 \text{ Bq/m}^3 < C < 1000 \text{ Bq/m}^3$ → the place is considered with low-level radon activity for professional exposed workers
- For $C > 1000 \text{ Bq/m}^3$ → Significant exposition levels → Compulsory protection actions

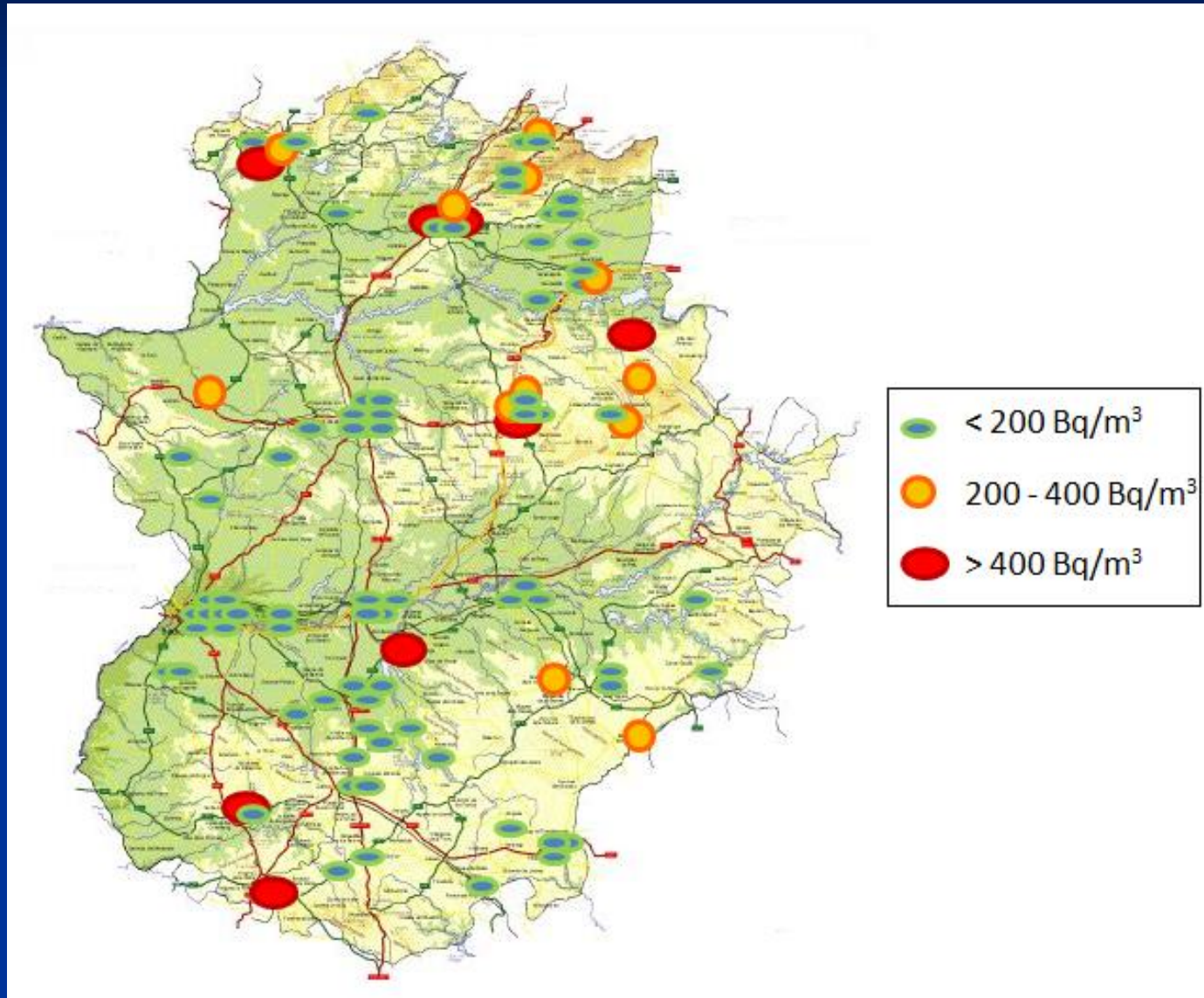
1st RESEARCH PROJECT

RESULTS



Measured places	< 200 Bq/m ³	200-400 Bq/m ³	> 400 Bq/m ³
128	108	12	8

1st RESEARCH PROJECT



1st RESEARCH PROJECT

SUMMARY

- Participation of companies (27 % rejection).
- 15 % (19/128) of the sites above 200 Bq/m³.
- Some interesting facts.
 - 60% (3/5) above 200 Bq/m³ for resorts.
 - 100% (2/2) of the Caves upper than 400 Bq/m³.
 - 0% (0/8) of the water facilities exceeds 75 Bq/m³.
 - UNDERGROUND Places:
 - 100% (7/7) of the parking lots below 20 Bq/m³.
 - 92.3% (12/13) of the warehouses below 100 Bq/m³.
 - SURFACE Places:
 - 20% (6/30) of the museums are over 200 Bq/m³.
 - 17.6% (6/34) from other places are over 200 Bq/m³.

“Radon in workplaces in Extremadura (Spain)”. A. Martín Sánchez, J. de la Torre Pérez, A.B. Ruano Sánchez, F.L. Naranjo Correa. J. Environ. Radioact. 107, 86-91 (2012).

2nd RESEARCH PROJECT

METHODOLOGY AND WORKING PLAN

- In the new R+D project, 4 SURVEYS have been performed
- Track detectors were exposed for 3 MONTHS (1 year total time)

METHODOLOGY AND WORKING PLAN

- The new research project started measuring again in those sites with concentrations greater than 200 Bq/m^3
- New workplaces and also some dwellings (in zones suspected to have great Rn concentrations) were now included.
- Nuclear track detectors (exposed for three months) were used.
- New limits have been defined in the spanish legislation

New Legislation

Instruction IS33 of CSN

Fourth. Radon concentrations in workplaces, the exceeding of which would require the adoption of corrective measures or the installation of monitoring devices

1. The level of the protection of workers against exposure to Rn-222 at their jobs must be 600Bq/m^3 of annual average concentration of Rn-222 during the work day. This is considered to be a reference level, below which the optimisation principle must be applied. This level is also taken to be a level above which the corresponding radiation protection measures must be applied, in case the concentration of radon cannot be decreased after remedial actions have been carried out.

2. It is understood by remedial actions those actions intended to reduce the concentration of radon.

3. In the case of workplaces where members of the public stay for a long time, the intervention level shall be 300Bq/m^3 of annual average concentration of Rn-222.

It is understood by workplace where members of the public stay for a long time that workplace where members of the public might stay for more hours than workers themselves (hospitals, prisons, and so on). Child, primary and secondary education centres fall into this category.

4. The reference levels for the actions indicated in Article 63 of the RPSRI must be the following:

- $< 600\text{Bq/m}^3$: no control is needed.
- $600\text{-}1000\text{Bq/m}^3$: a low level of control must be applied.
- $> 1000\text{Bq/m}^3$: a high level of control must be applied.

5. The limits of Article 9 of the RPSRI are applicable to workers exposed to radon.

METHODOLOGY AND WORKING PLAN

El mapa predictivo de exposición al radón en España

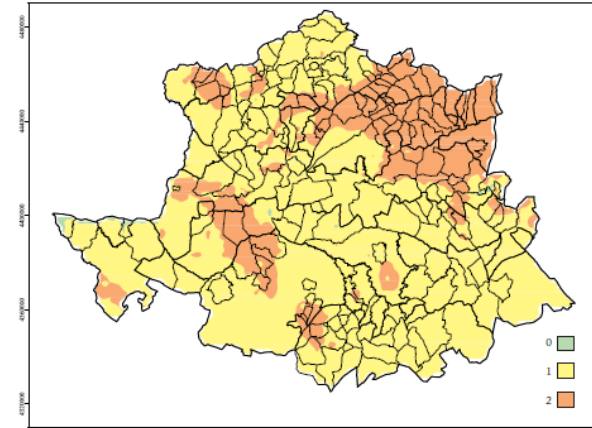
CSN



Colección
Informes Técnicos
38.2013

Cáceres

Categorías de exposición potencial al radón

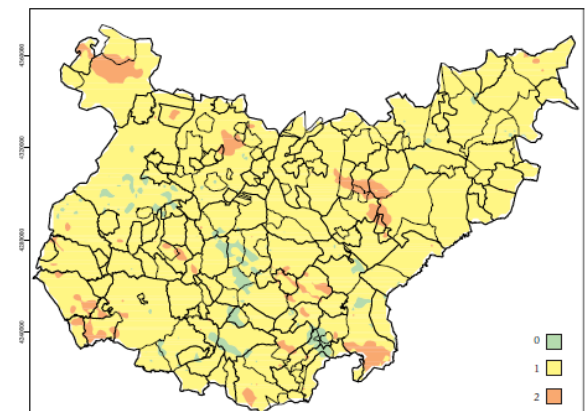


Coordenadas UTM
HUSO 30

0 100 km

Badajoz

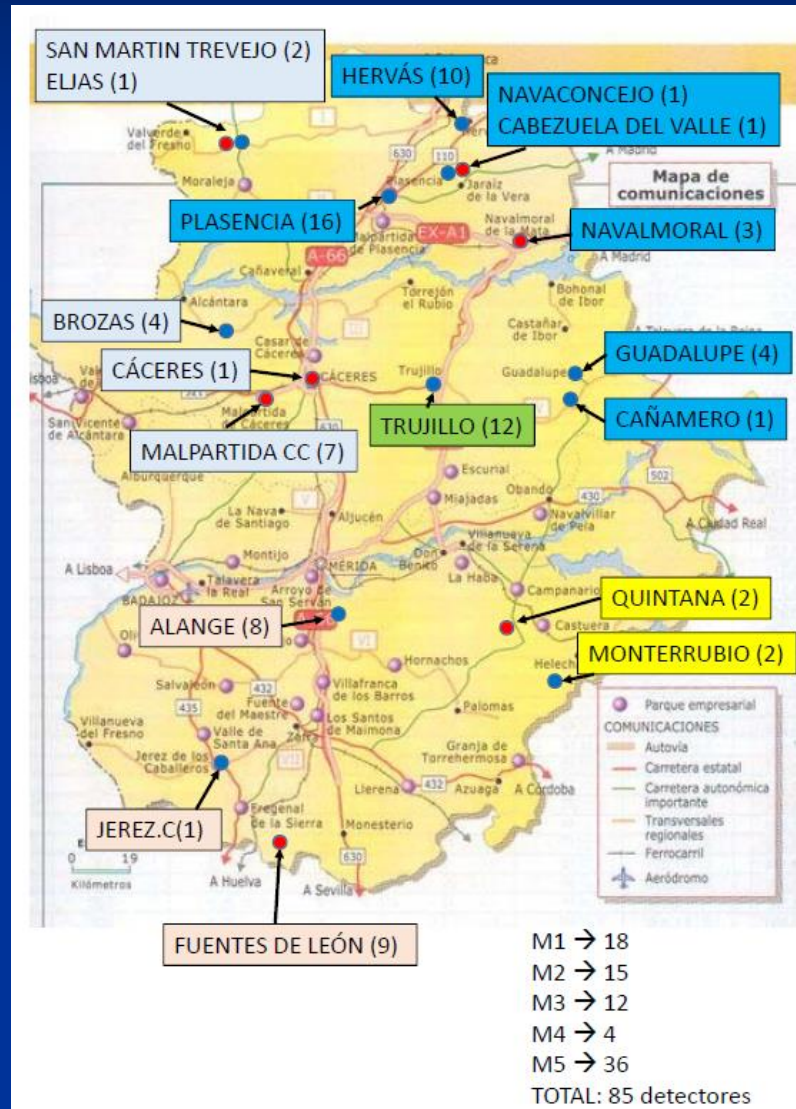
Categorías de exposición potencial al radón



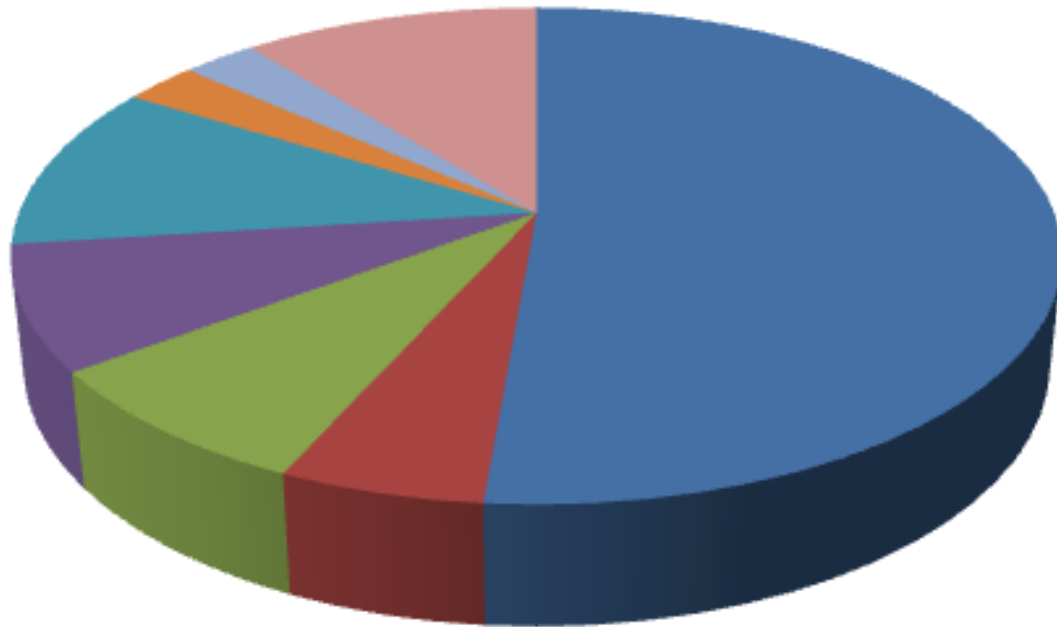
Coordenadas UTM
HUSO 30

0 100 km

METHODOLOGY AND WORKING PLAN



METHODOLOGY AND WORKING PLAN



- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8

1	Museums	19
2	Caves	2
3	Spas	3
4	Schools	3
5	Hotels	4
6	Libraries	1
7	Cellars	1
8	Offices	4
	Total	37

METHODOLOGY AND WORKING PLAN

PROPOSED ACTIONS

- Ventilation (when possible)
- Changing the working place
(inside the same building, when possible)
- Limiting the time of residence of people
- Architectonics actuations

FIRST RESULTS

ANALYZED SITES IN THE 1st PROJECT vs
RESULTS REACHED IN THE FIRST SURVEY
OF THE 2nd PROJECT

	Architec. Actuations	Ventilation	Changing Workplace	Limiting time	No actions
MUSEUMS	2	5	2		10
CAVES				1	1
SPAS		1			2
SCHOOLS		1	2		
HOTELS		2	1		1
LIBRARIES					1
CELLARS			1		
OFFICES			1		3

FIRST RESULTS

ANALYZED SITES IN THE 1st PROJECT vs
RESULTS REACHED IN THE FIRST SURVEY
OF THE 2nd PROJECT

	Architec. actuations	Ventilation	Changing Workplace	Limiting time	No actions
MUSEUMS	1↑1↓	1↑4↓	2↓		1↑2↓4→3-
CAVES				1→	1↓
SPAS		1↓			1↑1-
SCHOOLS		1↓	2↓		
HOTELS		2↓	1↓		1↑
LIBRARIES					1↓
CELLARS			1↓		
OFFICES			1↓		2↑1-

ACTUAL WORKING PLAN

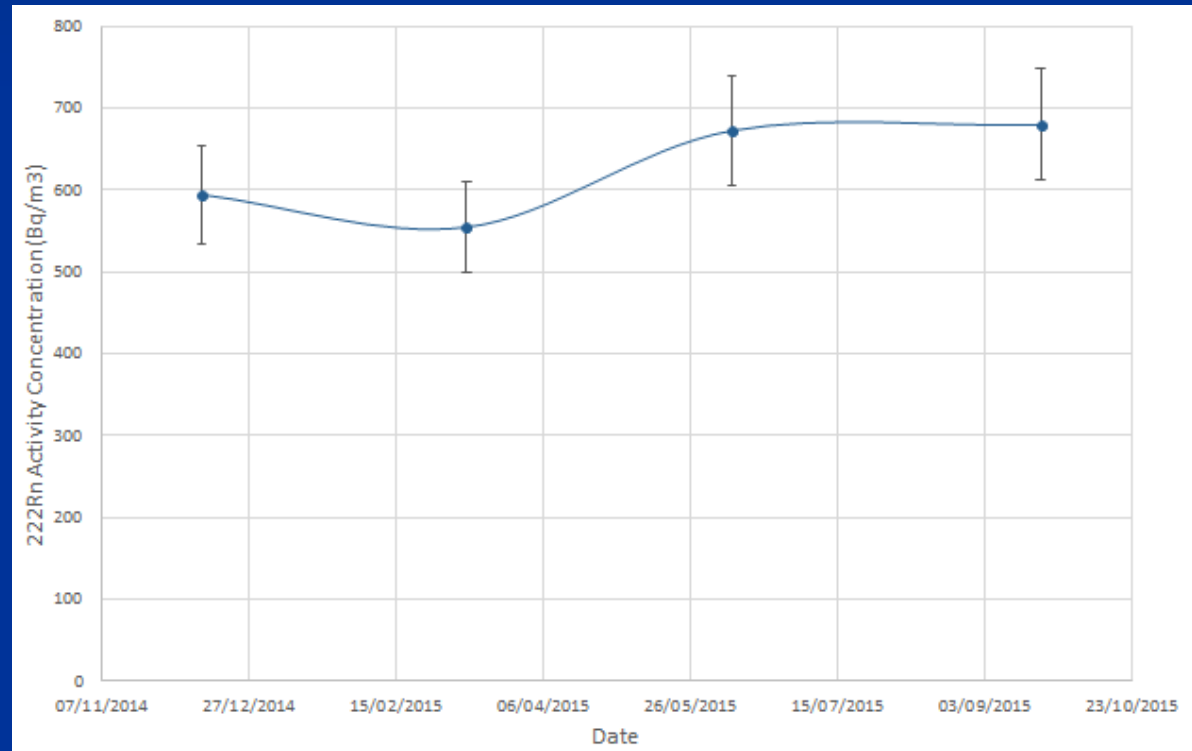
- Some places were discarded by:
 - Low concentration
 - Scarce occupational sites
- Remedial actions were proposed and applied in some cases
- Studies on places with or without applications of remedial actions continued
- Dose on each site are being estimated

SUMMARY

	M1	M2	M3	M4	TOTAL	Rn < 600	600<Rn<1000	Rn > 1000
Meas. No.	79	95	36	30	240	191	38	11
Place No.	31	34	14	10	35	26	6	3
		M1	M2	M3	M4	Total		
Measurem.	Rn<600	70	82	26	13	191		
	600<Rn<1000	7	12	6	13	38		
	Rn<1000	2	1	4	4	11		
	Total	79	95	36	30	240		
		M1	M2	M3	M4	TOTAL (Max value in some survey)		
Places	Rn<600	26	27	9	3	26		
	600<Rn<1000	3	6	3	4	6		
	Rn<1000	2	1	2	3	3		
	Total	31	34	14	10	35		

SOME EXAMPLES:

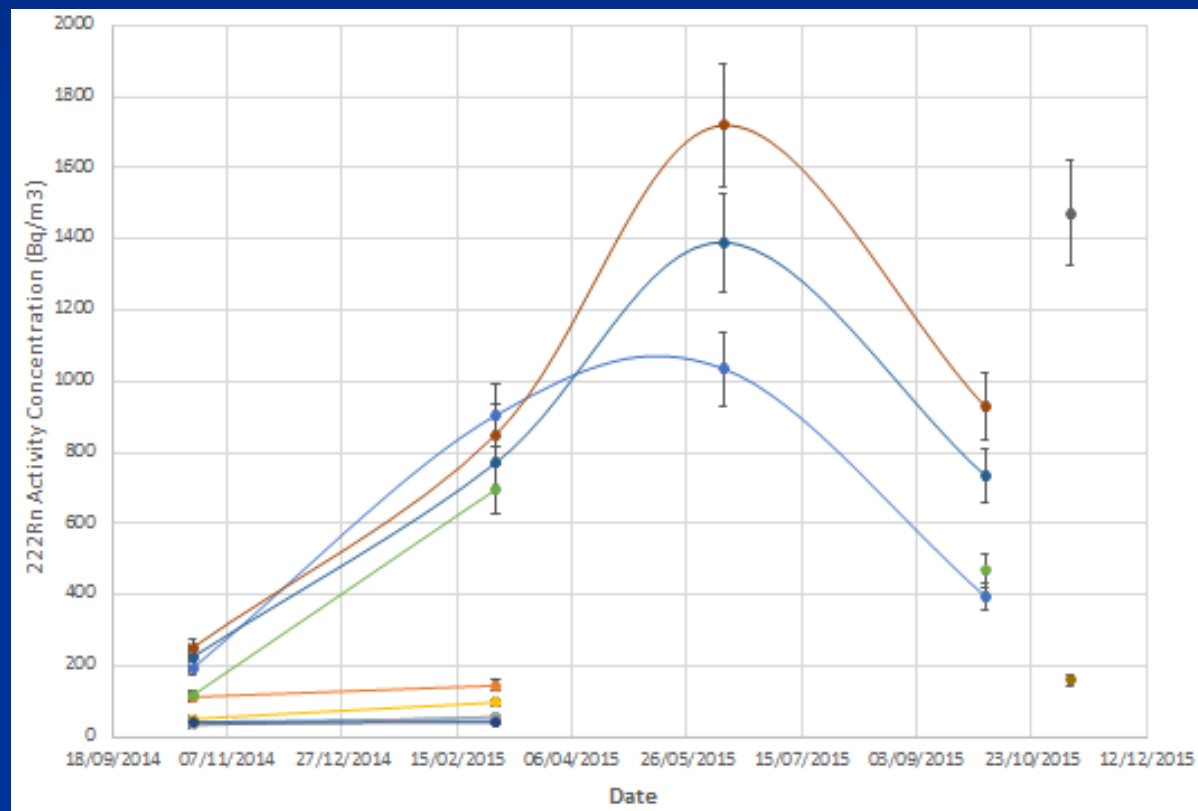
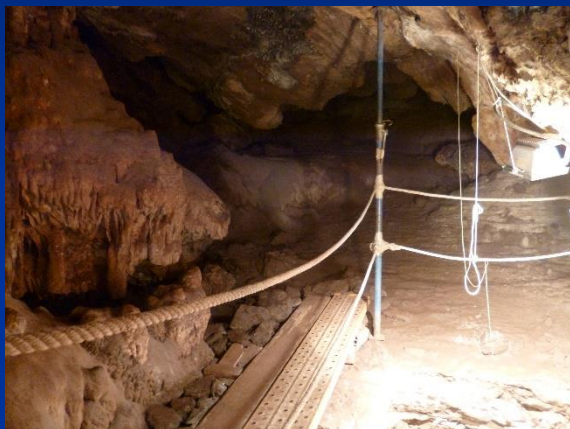
Reception room of a museum



... even with ventilation

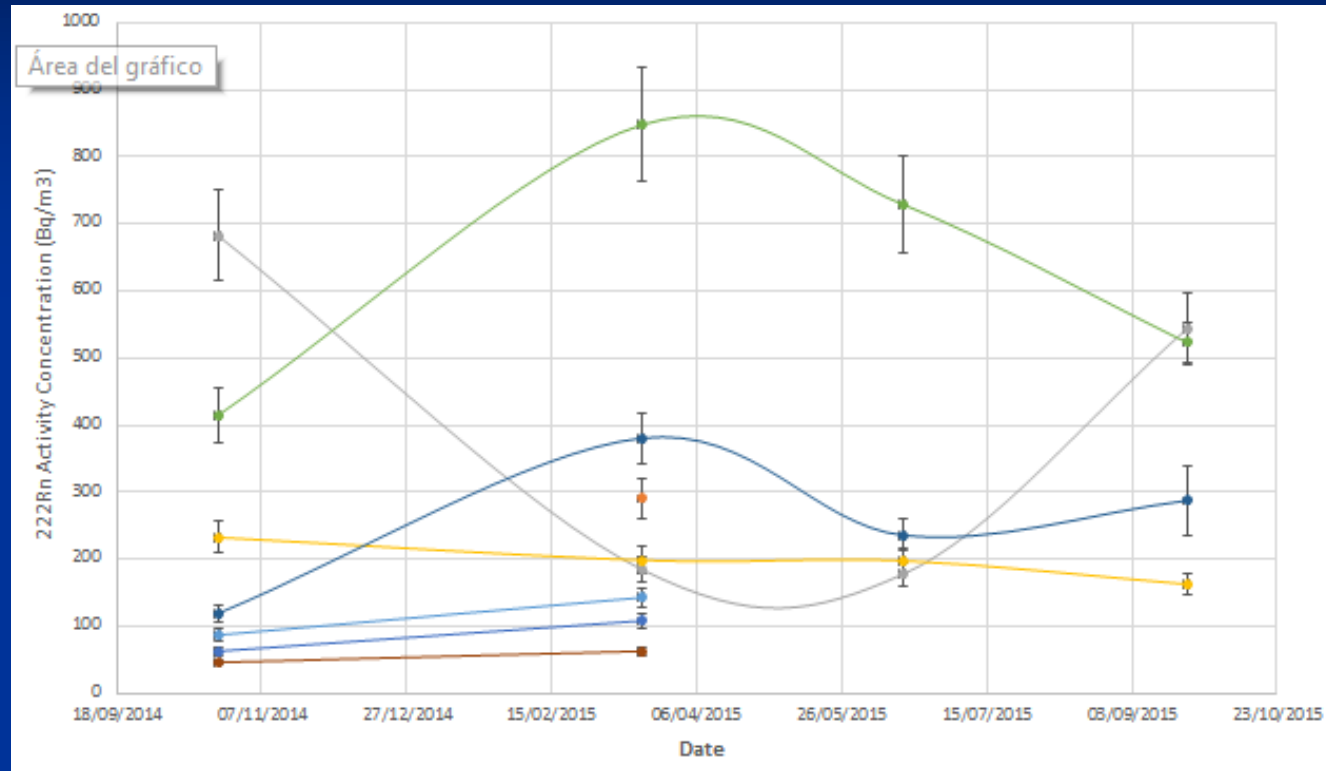
SOME EXAMPLES:

A touristic cave



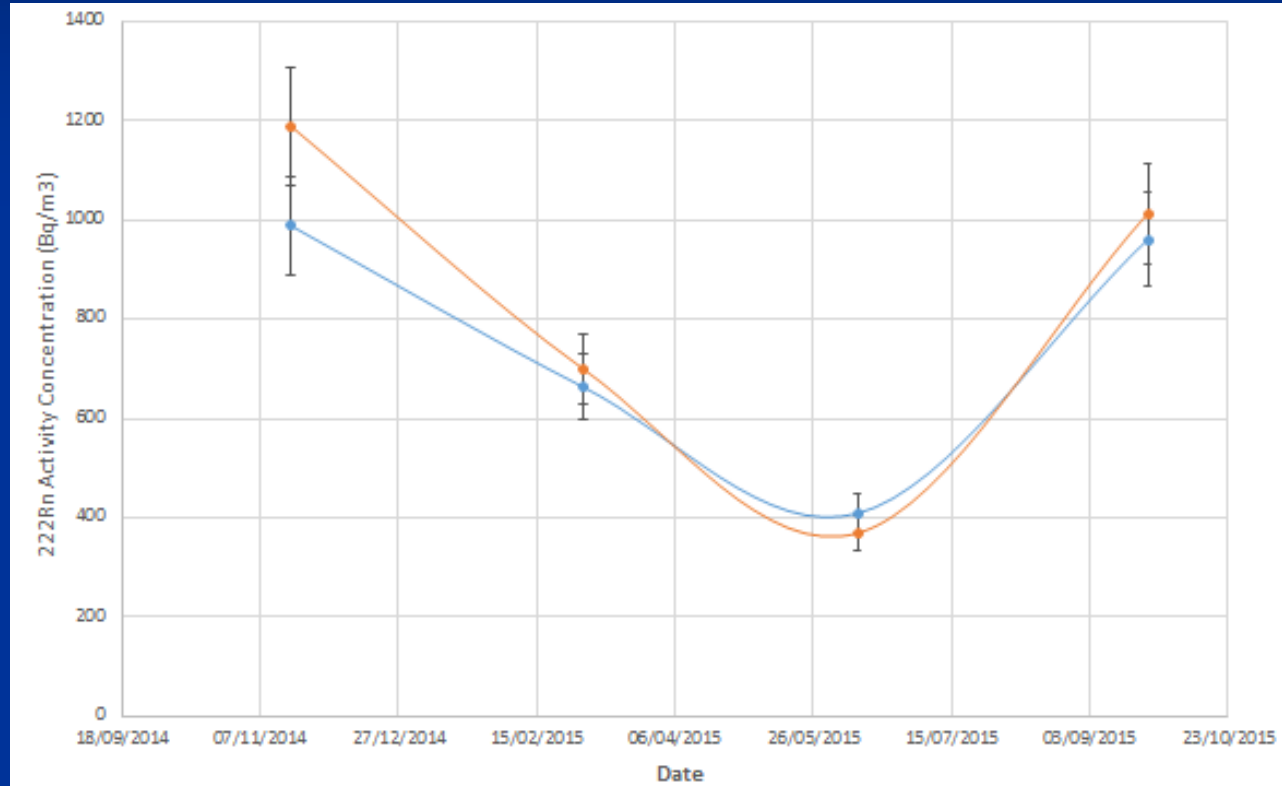
No possible ventilation in this case

SOME EXAMPLES: A Roman spa



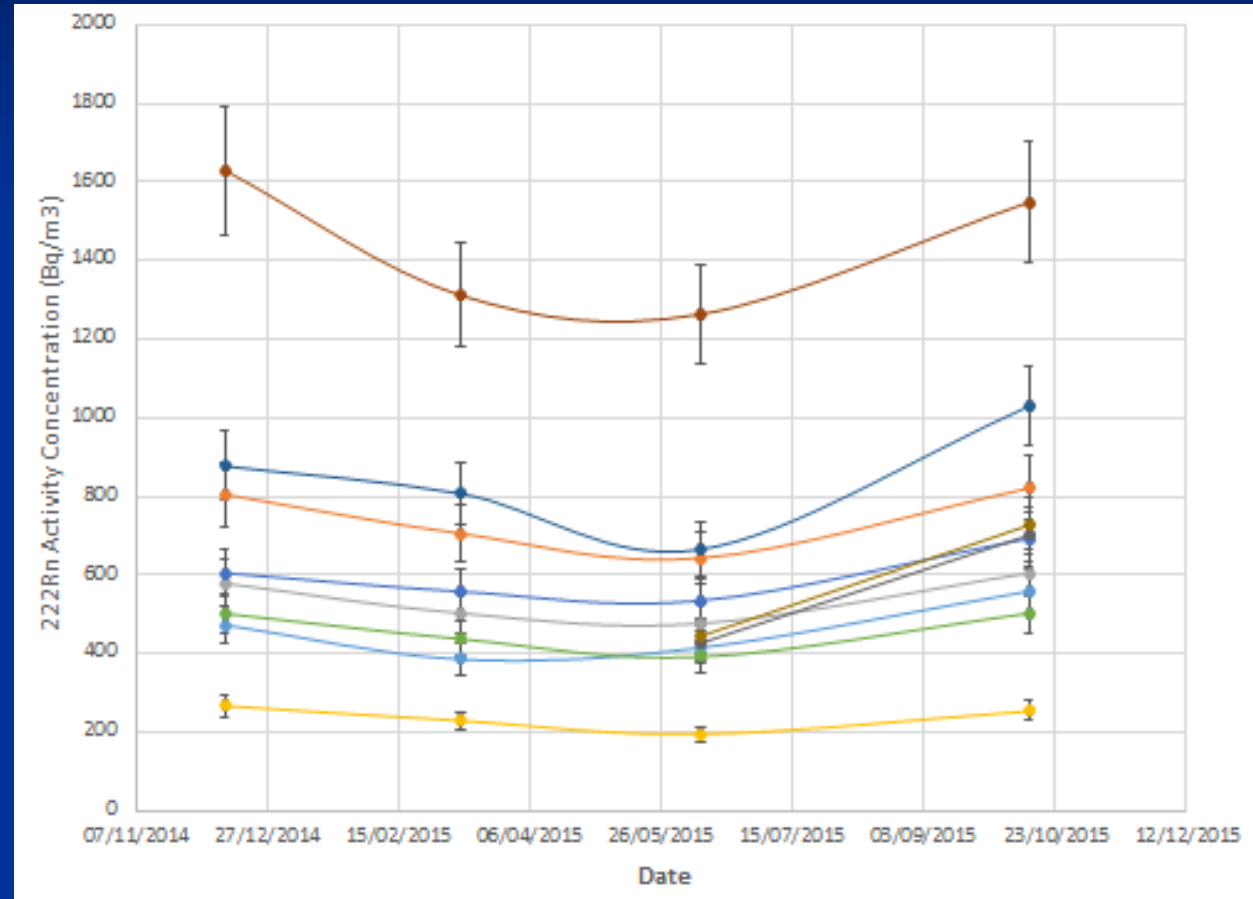
- Reception room : ventilation in hot seasons (grey line)
- Cold water spa: reverse behaviour (green line)
- Rest of dependences: office, massage rooms, hot water spa, etc., without great problems

SOME EXAMPLES: Office room of a museum



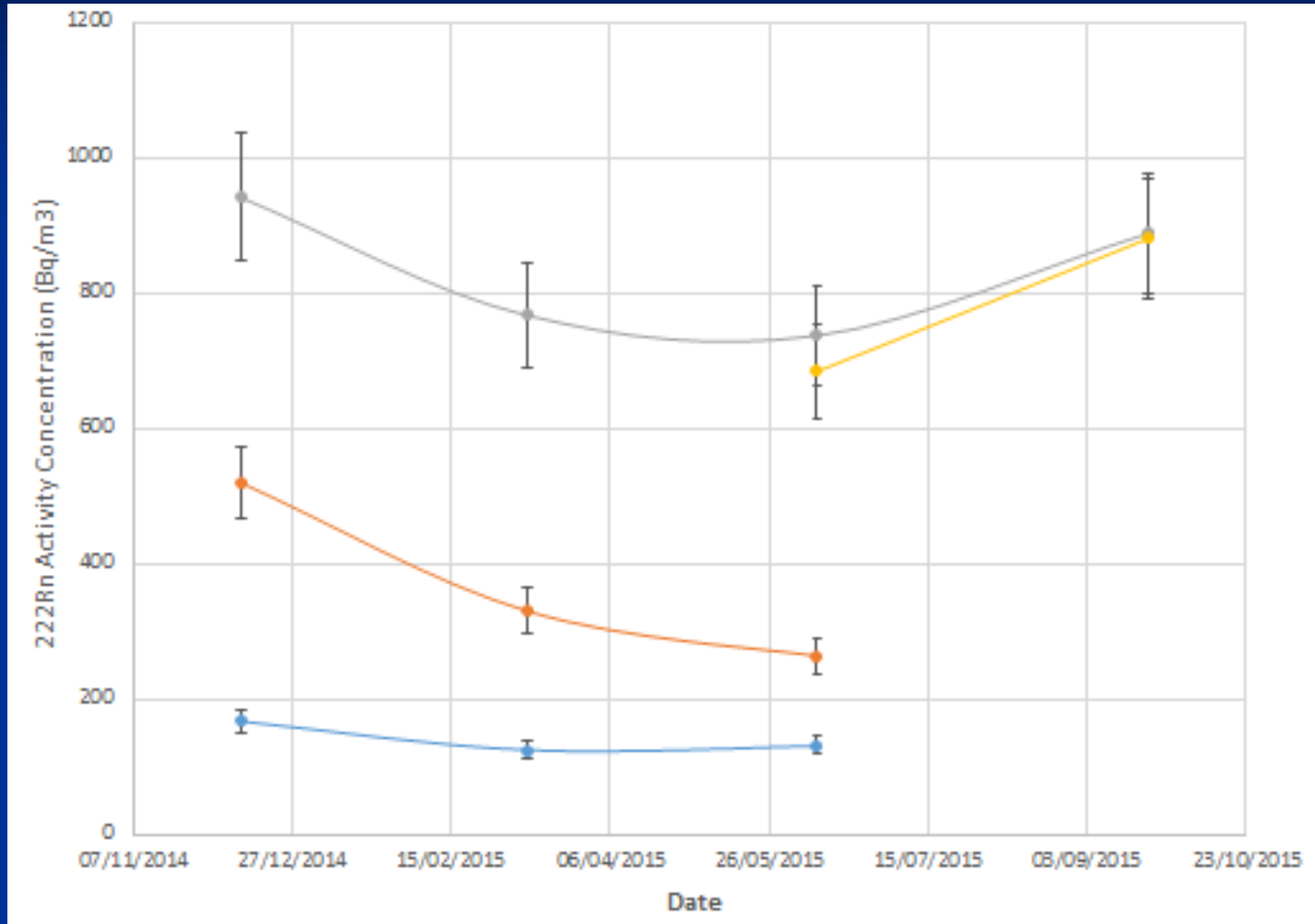
Ventilation in hot seasons

SOME EXAMPLES: Another museum



Even including architectonic actuations

A CASE STUDY: A museum



The reception desk room showed average values of the radon concentration greater than 600 Bq/m³ (grey line)

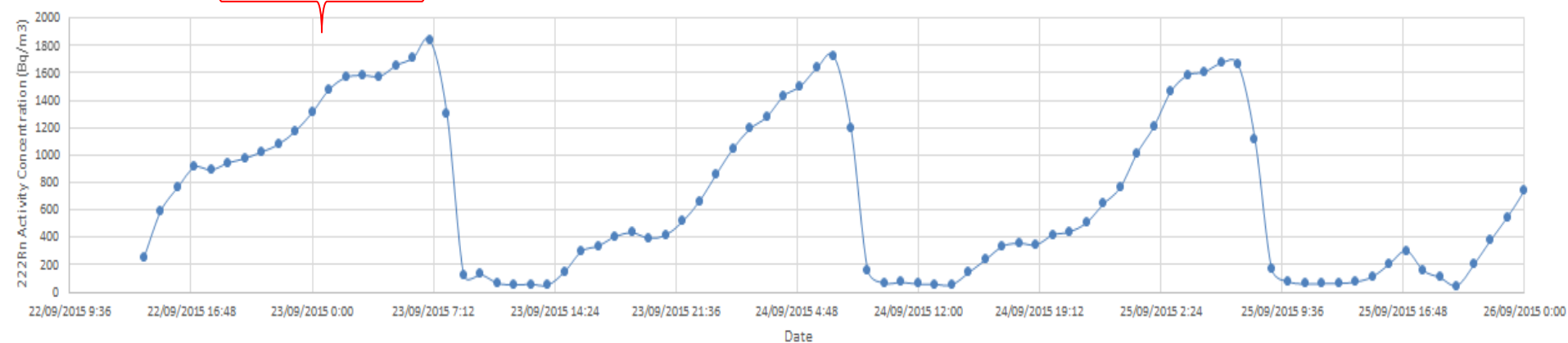
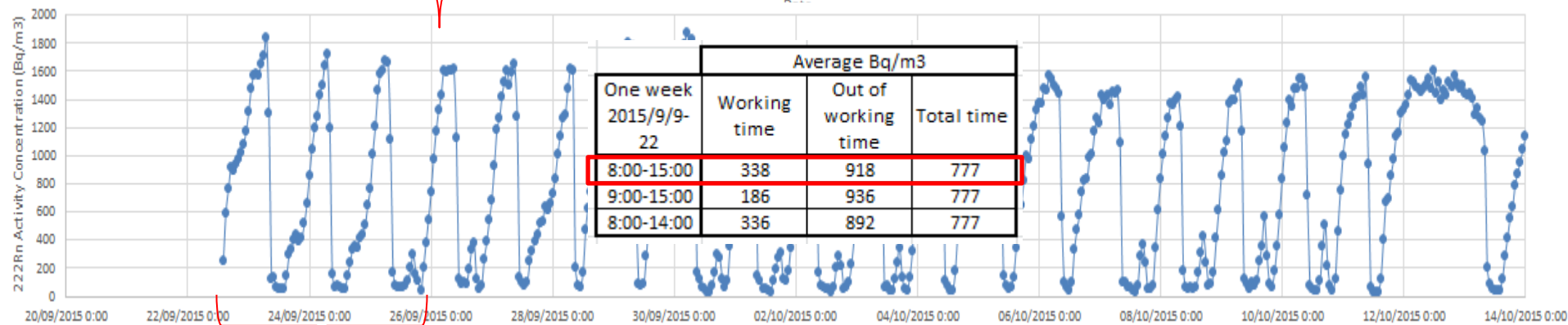
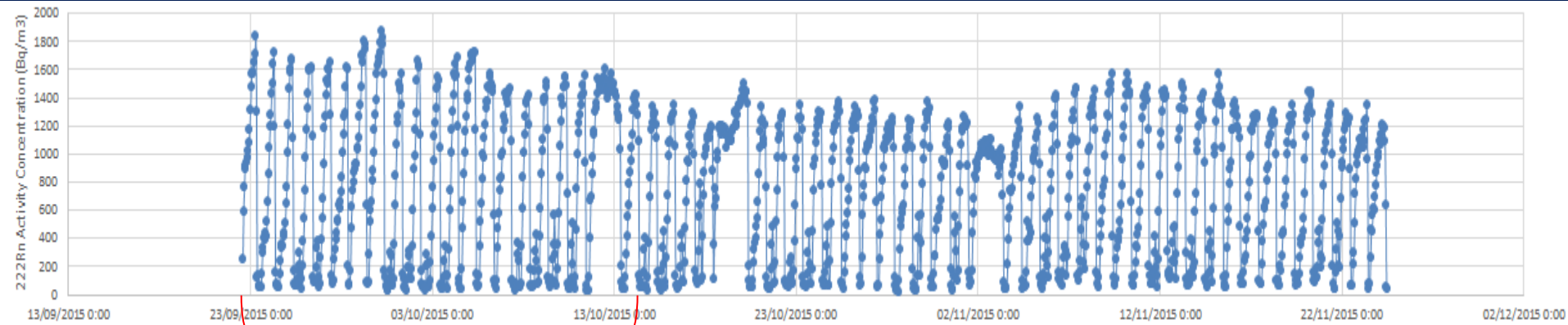
A CASE STUDY: A museum

- Ancient building (historic hospital)
- The reception desk room showed average values of the radon concentration greater than 600 Bq/m^3 (grey line).
- Next door room showed similar concentrations (yellow line).
This room has a (now sealed) well (probably the source of radon).
- Both rooms are semi-undergrounded
- Both rooms have direct communication without any separation gate.
- The room with the well have a little window ($30 \times 80 \text{ cm}^2$) in the upper part, which is opened early in the morning for about 15 min (ventilation).



A CASE STUDY: A museum

A continuous monitor AlphaGuard was then used



SUMMARY AND CONCLUSIONS

- Great variability in the radon concentrations
- Seasonal changes
- Specific “one place – one study” is required
- Difficult extrapolation to other places
- Indicated remedial actions could be not appropriate
- One-year study is recommended for each case
- Hourly variations must be taken into account
- Assessment of dose to the people must be estimated
- New remedial actions must be proposed and applied (if possible)

ACKNOWLEDGEMENTS

GOBIERNO DE EXTREMADURA



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**THANK YOU FOR
YOUR ATTENTION !!!**