Trabajo original de investigación

Proyectos IRART y SMART RAD EN

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Universidad de Cantabria
Octubre 2018

PROYECTO IRART
(2010 – 2013)

- **Introducción, objetivos y diseño del proyecto**
- **Técnicas de medida**
- **Diagnóstico y remedio en casa piloto**
- **Resultados y conclusión**

PROYECTO SMARTRADON
(2016-2020)

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- **Objetivos y diseño del proyecto**
- **Estado actual de desarrollo**

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Programul **Operaţional** Sectorial "**Creşterea competitivităţii** Economice
- co-**finanţat** prin Fondul European de Dezvoltare **Regională** -
"**Investiţii** pentru viitorul **dumneavoastră**"

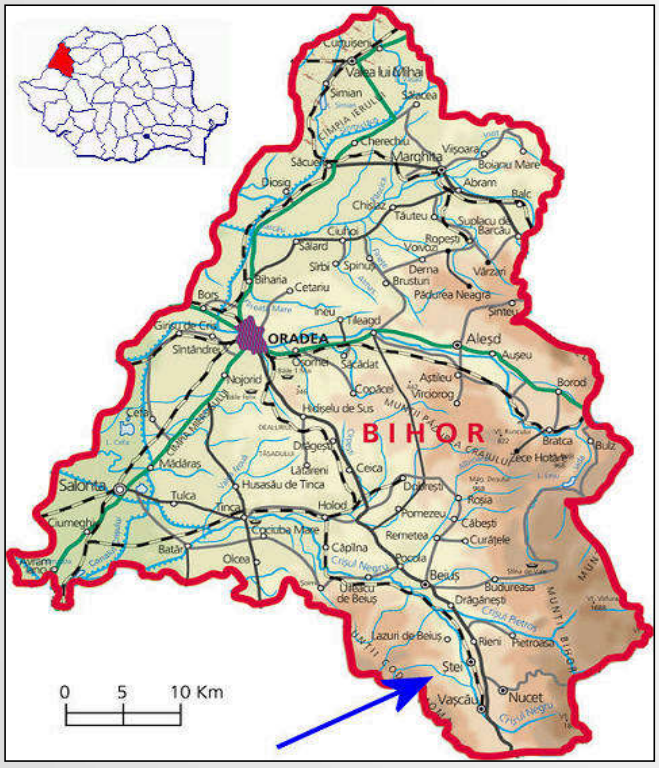
Universitatea **Babeş** - Bolyai din Cluj - Napoca Facultatea
de **Ştiinţa şi** Ingineria Mediului

Implementation Of Radon Remediation Techniques In **Dwellings Of Băiţa Uranium Mine Area** / IRART

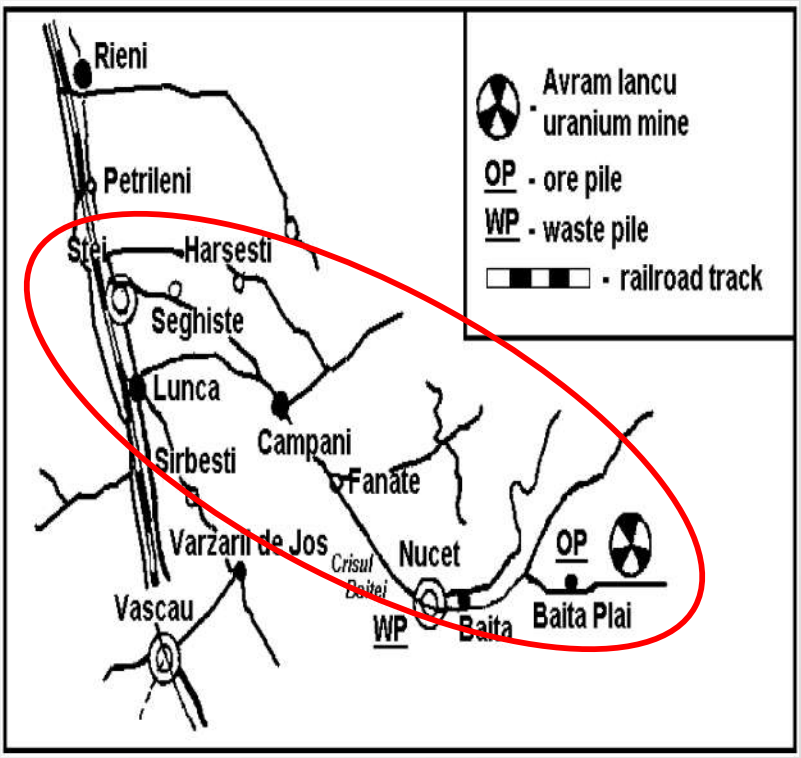
Proiect POS CCE ID 586 - SMIS 12487/ 160/ 15.06.2010
derulat in perioada 15 IUNIE 2010 - 14 IUNIE 2013

LOCATION

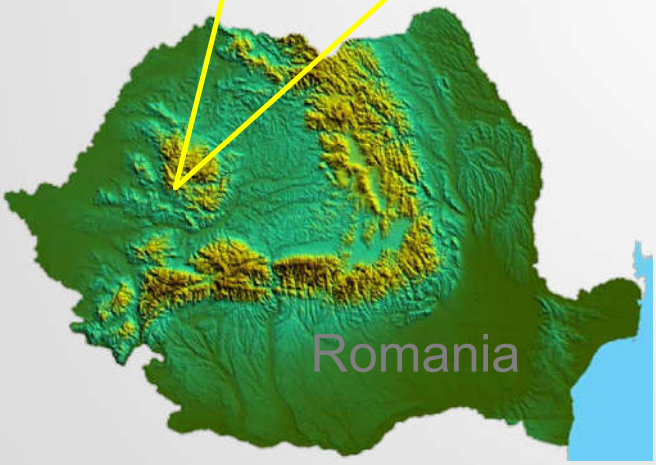
Baita-Stei area: is situated in the northwest of Romania (West Carpathian Mountains) at 120 km southeast of Oradea



Romania /Bihor map and Baita-Stei zone



Investigated Baita-Stei area



BAIȚA PLAI Uranium Mine

- was the largest uranium deposit in the world (open pit mine)

- uranium content: 1-5% in the radiometric sorted material

- in some areas uranium content reaches 30-40% (in pitchblende mineral)

- between 1952-1964 ~20,000 tons of metallic uranium were sent in SU.

- Baita river pass through this deposit, also through the localities:

Baița, Nucet, Fînațe, Cîmpani and Ștei.

Echipa de management

Prof. Dr. Carlos Sainz	Manager de proiect
Prof. Univ. Dr. Constantin Cosma	Director adjunct de proiect
Dr. Ing. Alexandra **Cucoş (Dinu)**	Responsabil de proiect
Ec. Bejenaru Vladimir	**Responsabil cu operațiunile financiare**
Dr. Ec. Florin Pop	Consultant economic
Ing. Dorin Stanciu	Consultant

Echipa de cercetare

Prof. Dr. Carlos Sainz	Director de proiect
Prof. Univ. Dr. Constantin Cosma	Director adj. de proiect
Dr. Ing. Alexandra **Cucoş** (Dinu)	Responsabil proiect
Lect. Dr. Tiberius Dicu	**Cercetător**
Dr. Mircea Moldovan	**Cercetător**
Lect. Dr. Robert Begy	**Cercetător**
Dr. Dan Fulea	**Cercetător**
Drd. Ciprian Cîndea	Asistent cercetare
Drd. Botond Papp	Asistent cercetare
Drd. Bety Burghele	Asistent cercetare

Echipa logistică

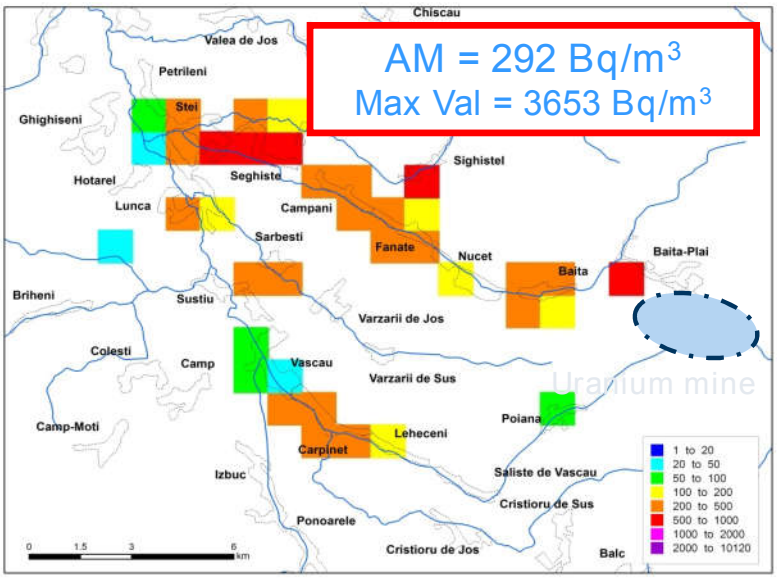
Prorector Prof. Univ. Dr. **Luminiţa** Silaghi-Dumitrescu coordonare strategii
Prorector Prof. Univ. Dr. Cristina **Ciumaş** coordonare strategii
Subing. **Trăian** Boc coordonare *achiziţii*
Ec. Carmen **Ştefan** coordonare aspecte contabilitate
Rodica **Şuta** coordonare - aspecte de resurse umane
Cons Juridic Alexandru **Braşoveanu**
Ec. Ovidiu P**aş**ca

PRELIMINARY RESULTS - FIRST ROMANIAN INDOOR RADON MAP

AM for Romania = 126 Bq/m^3

(excluding **Ştei-Băiţa**)

- ❑ 1998-2010: 2100 integrated measurements of indoor radon CR-39
- ❑ 905 typical houses
- ❑ high Rn concentrations in soil
- ❑ high RP in 85% of houses (200)
- ❑ uranium tailing as building material
- ❑ " RADON PRONE AREA"
- ❑ Basement subsoil main radon source + building materials



The arithmetic mean of indoor radon concentrations in ***Ştei-Băiţa*** radon-prone area, 1x1 km grid cells.

(Cosma C., Cucoş (Dinu) A., Dicu T., Sainz C (2013), Preliminary results regarding the first map of residential radon in some regions in Romania, Radiation Protection Dosimetry, 155(3), 343-350.

Sainz C., Dinu A., C. Cosma et al., (2009), Comparative risk assessment of residential radon exposures in two radon-prone areas, Ştei (Romania) and Torrelodones (Spain), Science of The Total Environment, 407 (15), 4452-4460.

Dinu Alexandra, PhD thesis „Correlations between indoor radon and lung cancer incidence in Ştei-Băiţa Uranium Mine area", 2009)

- **OBJECTIVE 1: Reliable and accurate assessment of population´s exposure to radon in the proposed area**
- **OBJECTIVE 2: Implementation of mitigation methods and techniques to reduce radon concentrations in selected residential houses**
- **OBJECTIVE 3: Assesment of the efficiency of implemented techniques**
- **OBJECTIVE 4: Creation of a spin-off to further extend the previous R&D activities**

DESIGN OF SURVEY

Measurements of radon in houses:

❑ Basic methods
Radon screening by integral methods (nuclear track detectors CR-39, RSK type, RadoSys)
⇨ 2 campaigns of measurements (winter 2010, spring 2011)
⇨ 303 randomly selected houses from interested area
⇨ 3-4 rooms/house
⇨ 2300 measurements (2x1150)

❑ Special methods for radon diagnostics before mitigation in PILOT HOUSE and 20 selected houses with radon level higher than 600 Bq m^{-3}: continual indoor monitoring, radon exhalation measurements (soil and building materials) by gamma and alpha spectrometry, measurements of soil radon and permeability around, gamma dose (DIAGNOSTIC)

❑ Follow-up of mitigation efficiency after mitigation by integrated measurements and continual monitoring

A. Cucoş (Dinu), C. Cosma…, C. Sainz, (2012), Thorough investigation on indoor radon in Băiţa radon-prone area (Romania), Science of The Total Environment, 431, 78–83.

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❑ Integrated Measurements:

⇨ Radosys System
⇨ CR-39 nuclear track detectors

❑ Continuous measurement devices:

ALPHAGUARD PQ 2000, RADIM, RAD7, Radon Scout, RTM 1688-2 Radon/Thoron, Doseman Pro, Ramon

❑ Soil radon measurement:

⇨ LUK 3C scintillation detection with Lucas cells

❑ Gamma dose measurement:

⇨ Gamma Scout

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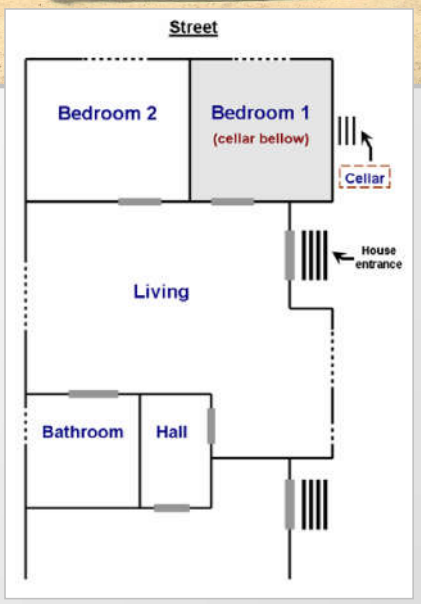
PILOT HOUSE

Radon **diagnostic of the selected pilot house (Fânaţe 116A; Bihor county)**

Room	Annual C Rn (Bq/m^3)
Bedroom 1	889
Bedroom 2	1104
Living	349
Bathroom	395



- The house was constructed in 1976-1978;
- House area of 3198 m²;
- Building material: gravel, sand and slag from the mine area and **Criş-Băiţa river;**
- Investigated area for diagnostic and remediation: 2 bedrooms, 1 living, 1 bathroom, 1 cellar;

PILOT HOUSE: DIAGNOSTIC TECHNIQUES

RADON DIAGNOSTIC MEASUREMENTS
IN HOUSES OF BAITA REGION, ROMANIA

Băiţa 119 – AVRAM DOREL

3.1.1. Inspection of the house

The house Băiţa 119 was built in 1954. Walls are built of red bricks. The house foundation was filled with stones from the mining area. Sand used for coating the house was brought from the mining waste. Recently, the inside was renovated with building materials purchased from the store. Under half of the living is the basement which was also build with stones from the mining waste. All the house, except the half living above the basement - which is made out of wood - has concrete cap. On top of those, the living room has laminated parquet. Bedroom 2 (blue) has varnished floor as does Bedroom 1.

Building materials used for the construction: bricks, stones, sand and ballast from the mining waste; basement - stones from former mining area; Brick, Plait; filling - stones from former mining area; w[illegible] are coupling, zing new and tight.

The measured part of the house is not used for living, at the moment. During diagnostic measurements, the rooms were tempered, uninhabited and mostly closed.

Drinking water used in the house comes from a municipal water supply.

3.1.2. Radon index of the building site

Results of direct in situ measurements of soil-gas radon concentration and of permeability of soil in the surroundings of the house are presented in Table 1.

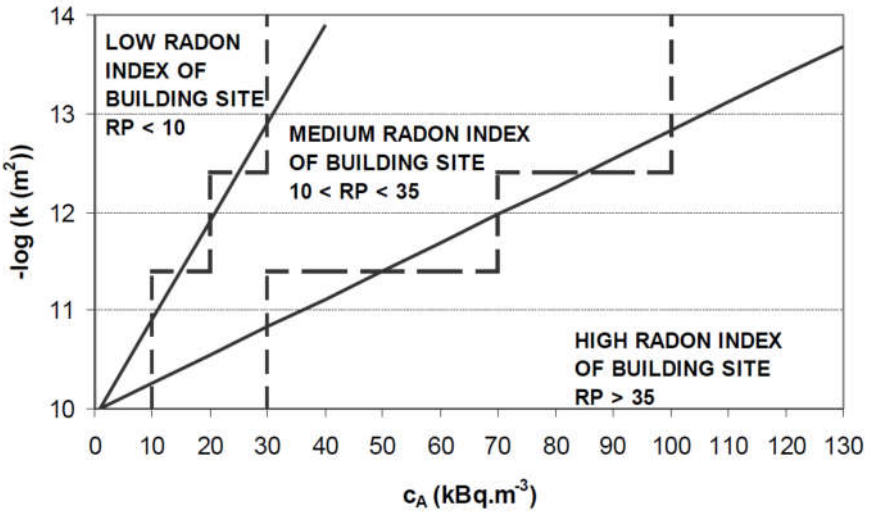
Table 1: Băiţa 119 - Radon index of the building site

Measuring point	c_{Rn} (kBq/m^3)	k (m^2)
1	15.510	3.8E-11
2	13.350	3.1E-11
3	33.030	4.8E-11
4	44.090	3.5E-11
5	9.489	3.9E-11
6	60.140	2.2E-11
7	12.280	1.2E-11
8	0.500	4.5E-12
9	0.500	4.7E-11
10	0.500	2.9E-11
11	52.340	3.4E-11
12	36.910	1.9E-11
Evaluation		
75th percentile	36.9	3.8E-11
RP	85	
Radon index	high (RP ≥ 35)	

RADON INDEX

Rn soil

Permeability



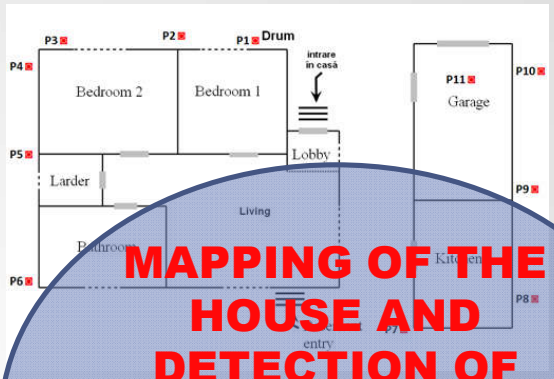


Fig. 1. Location of the sampling points for soil-gas radon concentration measurements.

MAPPING OF THE HOUSE AND DETECTION OF LEAKAGES AND GAMMA ANOMALIES

3.1.3. Detection of leakages in the contact between the subsoil and the building

Results of measurements of radon volume activity (c_{Rn}) in air samples collected in places, where contaminated soil-gas may enter into the house (cracks, etc.), are summarized in Table 2. Location of measuring points is presented in Figure 2.

Table 2: Băiț 119 - Detection of leakages in the contact between the subsoil and the building

Measuring point	Description	c_{Rn} (kBq/m^3)
I	Living – front door threshold, right	0.723±0.12
II	Living – front door threshold, left	0.947±0.230
III	Living – middle of the front wall	1.337±0.774
IV	Living – out corner with the bathroom	1.102±0.293
V	Living – corner with the larder, left	1.207±0.173
VI	Living – corner with the bathroom	1.353±0.192
VII	Living – corner Bedroom 2 with larder	0.974±0.128
VIII	Living – in front of the glazed tile stove	1.217±0,213
IX	Living – Bedroom 1 threshold, left	0,879±0.135
X	Bedroom 2 - right corner, outside wall	0.179±0.047
XI	Bedroom 2 – threshold, right	0.475±0.102
XII	Bedroom 2 – middle of the left wall	0.578±0.101
XIII	Bathroom – crack near the pipe	1.023±0.231
XIV	Bedroom 2 – middle of the right wall	0.673±0.10
XV	Bedroom 1 – under the window, middle of the outside wall	0.973±0.137
XVI	Bedroom 1 – middle of the left wall	0.873±0.150
XVII	Bedroom 1 – in front of the glazed tile stove	0.328±0.110
XVIII	Bedroom 1 – threshold, right	0.579±0.149
XIX	Lobby – left corner	0.578±0.123

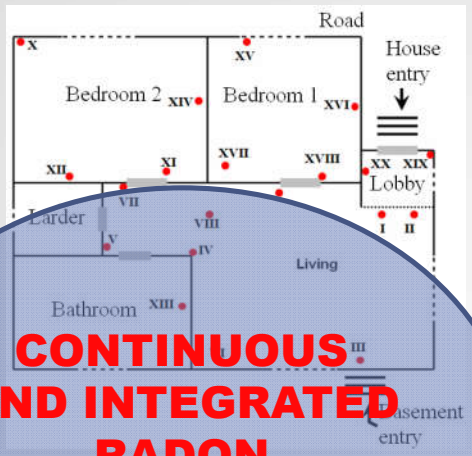
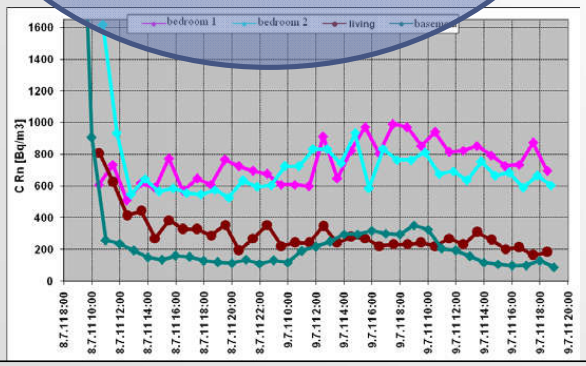


Fig. 2: Băiţa 119, detection of leakages in the contact between the subsoil and the building – location of sampling points

CONTINUOUS AND INTEGRATED RADON MEASUREMENTS

3.1.4. Continual and integral measurements of indoor radon concentration

Results of simultaneous continual and/or integral measurements of indoor radon concentrations in different parts (rooms) of the house are presented in Fig. 3. Average values of indoor radon concentrations are given in Table 3.



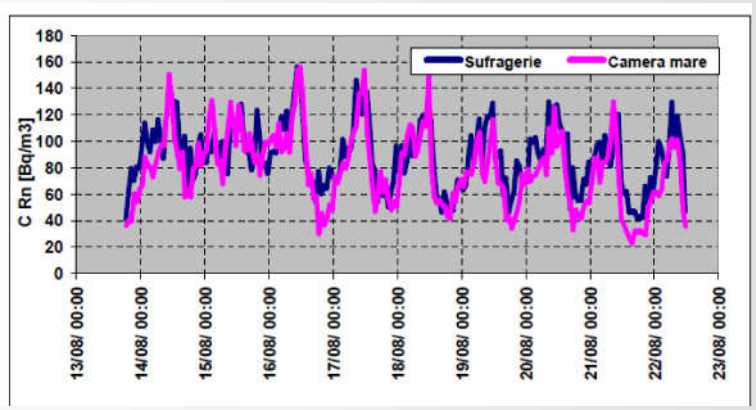
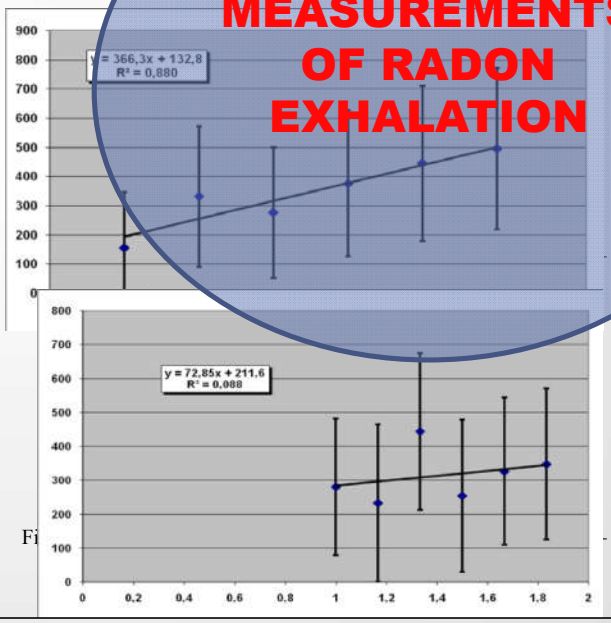


Table 3: Băiţa 119 - Average values of indoor radon concentration (c_{Rn})

Location of sampling	Bedroom 2	Bedroom 1	Living	Basement	Kitchen
Apparatus	Sarad Scout 446	Sarad Scout 447	Sarad Scout 445	Alpha Guard	
Minimum (Bq/m^3)	526	510	164	88	-
Maximum (Bq/m^3)	1617	990	809	3312	-
AM (Bq/m^3)	710.51	744.30	299.57	296.88	-
GM (Bq/m^3)	691.71	733.24	281.21	196.04	-
Track detectors CR39					
Campaign I (Bq/m^3)	-	1353	1070	1325	272
Campaign II (Bq/m^3)	-	508	387	895	110

The exhalation rate from the floor of Bedroom 1 and 2 (ER = 45.46 Bq/m^2/h, respectively 9.04 Bq/m^2/h) was determined based on the data in fig. 4 (Rad7) and fig. 5 (Rad7).

MEASUREMENTS OF RADON EXHALATION



- Rad7).

Fi - Rad7).

A. Radon potential of the building site (RP):

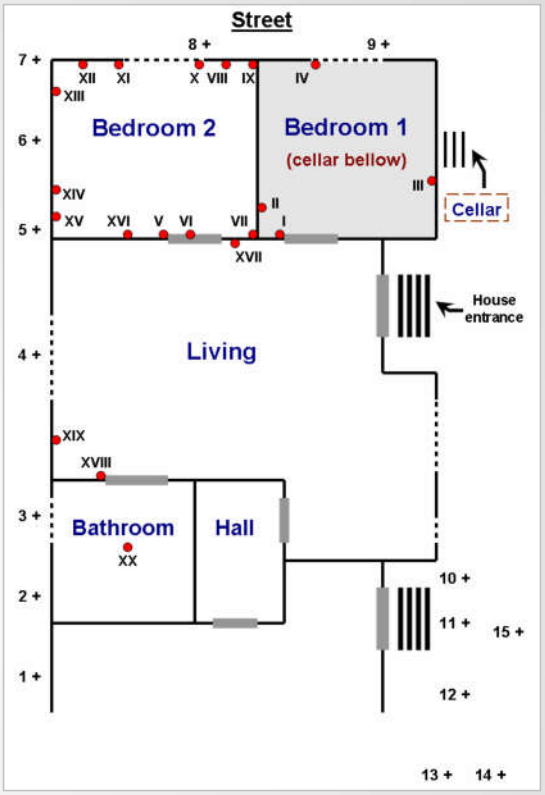
- radon in soil measurements (C Rn [kBq/m^3]) and soil permeability (k [m^2]) around the house in 15 points

statistics	C Rn (kBq/m^3)	k (m^2)
Min	0.3 (p4)	< 5,2E-14
Max	485.3 (p8)	1.6E-11
3th quartile	40.9	9.9E-12

$\Rightarrow$ $C_{Rn,75}$ **şi** k_{75} $\Rightarrow$ RP = ($C_{Rn,75}$-1) / (-log k_{75}-10)

$\Rightarrow$ RP = 40 $\Rightarrow$ high radon risk (RP > 35).

(based on Neznal M. model)



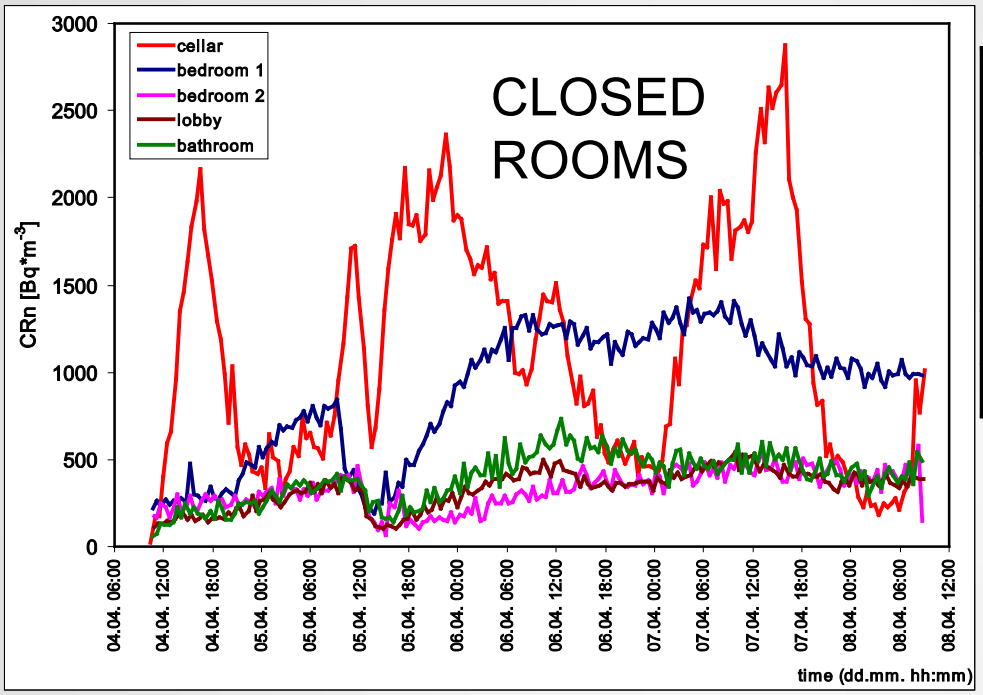
B. Detection of radon leakages from cracks:

- By radon concentration measurements in the contact of the floor and building sub-soil (> 1 kBq·m^{-3})

Description (room)	C_{Rn} [kBq·m^{-3}]
bedroom 1 (4 points)	0.4 - 1.1
bedroom 2 (12 points)	0.7 - 6.7
lobby (3 points)	0.5 - 4.7
bathroom (1 points)	0.5

C. Continous indoor radon measurements:

- Radon concentration measurements in same time in different rooms in the house, by radon monitors:



Room	C_{Rn} Bq·m^{-3}]		
	Min	Max	Mean
cellar	25	2874	1131
bedroom 1	67	578	330
bedroom 2	187	1425	889
lobby	100	546	333
bathroom	56	731	395

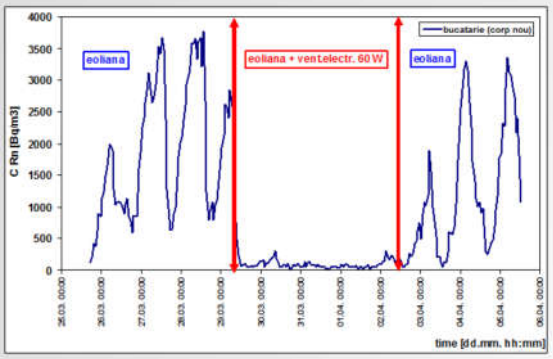
D. Gamma dose rate measurements: - Detection of gamma anomaly:

Description (room)	D [μSv·h^{-1}]
bedroom 2, hot spot near the window	0.74
outdoor wall near the entrance, basement	0.28-0.40

PILOT HOUSE:

TEST OF MITIGATION TECHNIQUES

THE MITIGATION SOLUTION existing buildings
an active sub-slab ventilation system



VENTILATOR/FAN

RADON SUMP

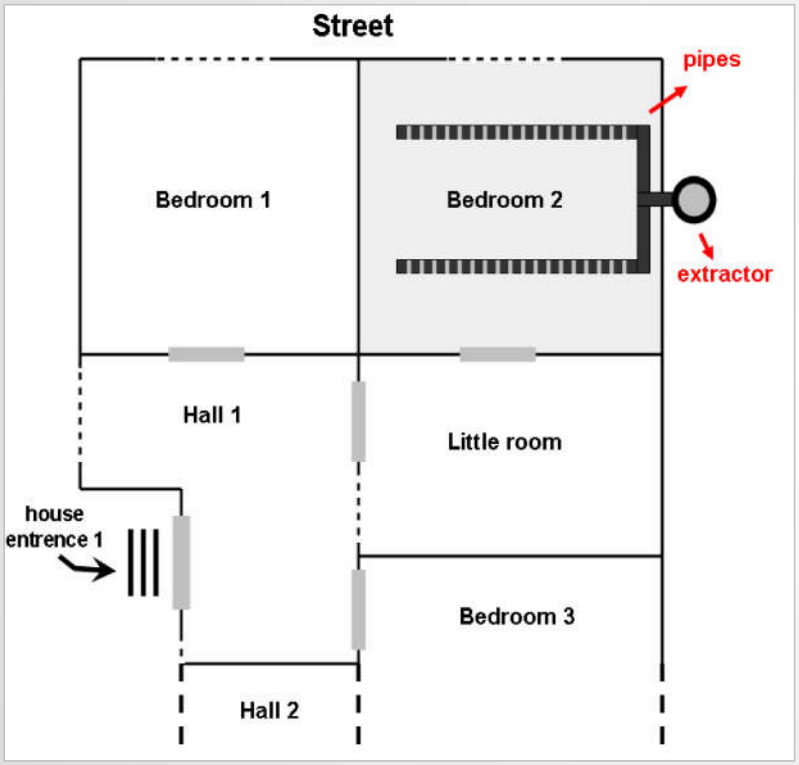
PIPES

MEMBRANE

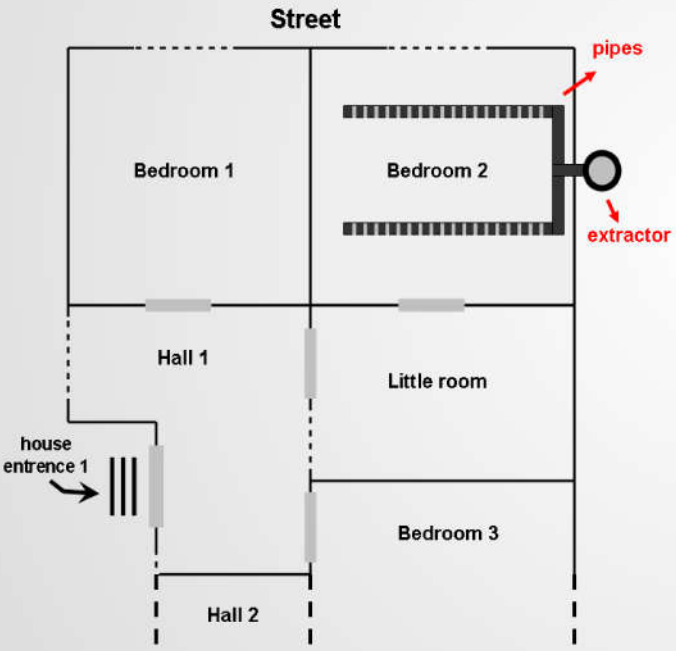
AUTOMATIC SURVEILLANCE SYSTEM

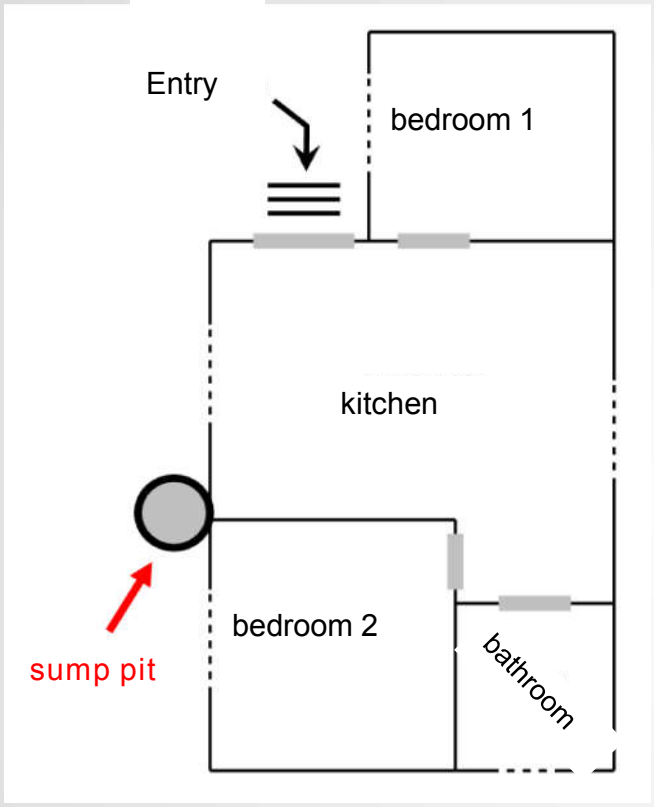
ACCESSORIES

ACTIVE SOIL EXTRACTION/PRESURIZATION

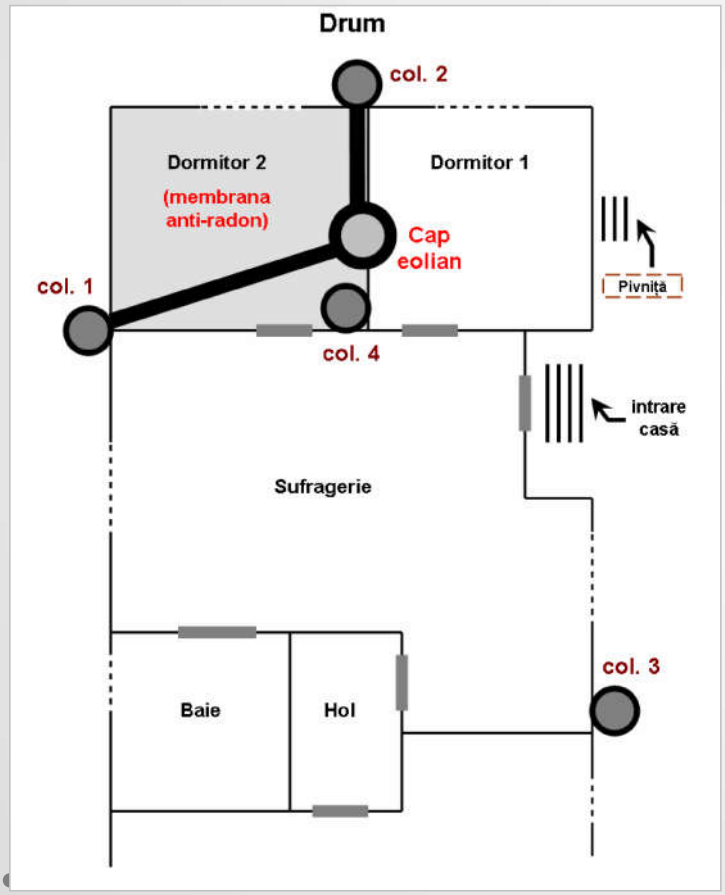


COMBINED MEMBRANE + EXTRACTION



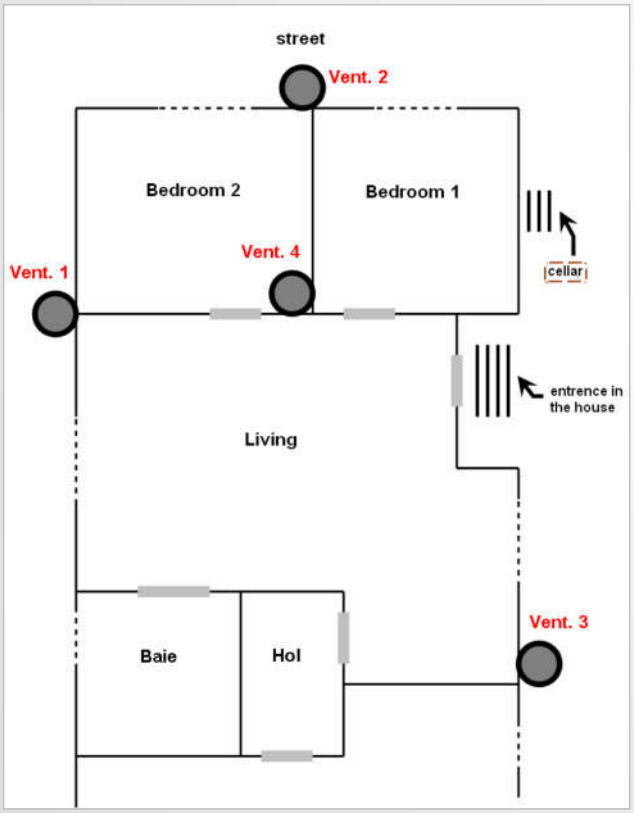

Entry
bedroom 1
kitchen
bedroom 2
bathroom
sump pit

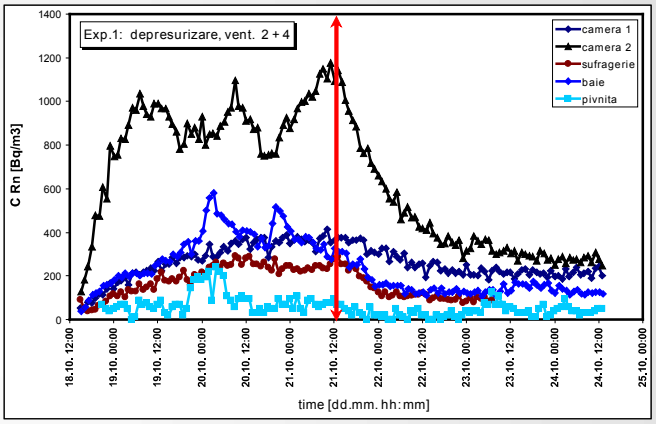
B. Testing the effect of the combination sub-soil extraction techniques (depressurisation by radon extractors, electrical fan of 30 W and eolian) and anti radon membrane ⇒ based on continuous measurements of indoor radon concentrations in periods of accumulation and extraction (min 5+5 days) ⇒ determination the efficiency of the applied techniques;

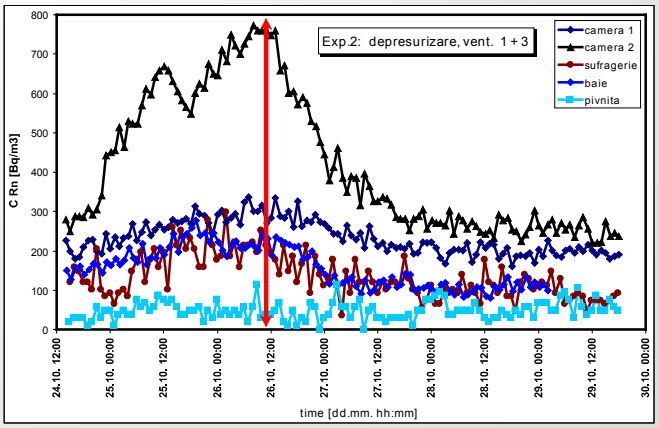


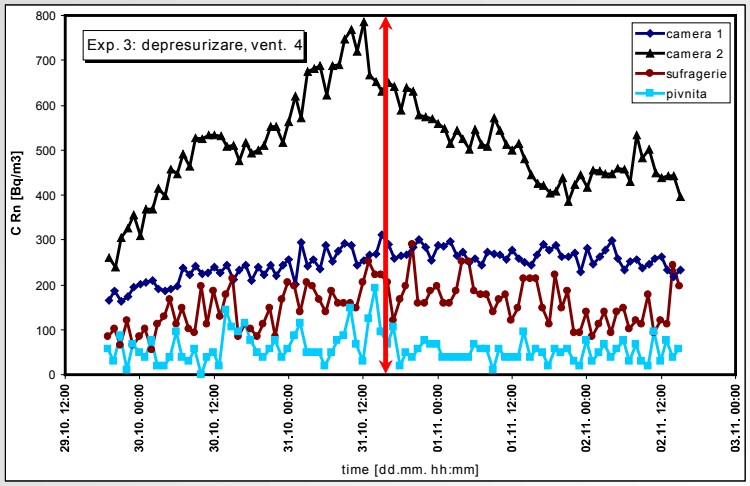
Testing radon remedial techniques in pilot house

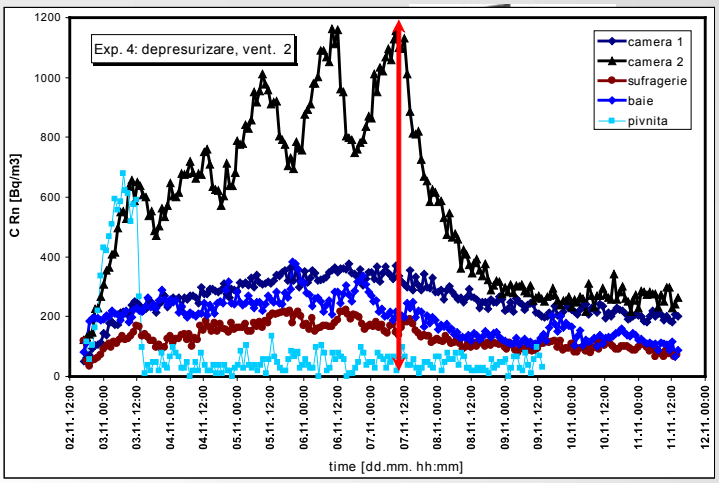
A. Testing SUB-SOIL VENTILATION TECHNIQUES (depressurisation/pressurisation) by radon extractors and electrical fans ⇒ BASED ON CONTINUOUS MEASUREMENTS OF INDOOR RADON CONCENTRATIONS IN PERIODS OF ACCUMULATION AND EXTRACTION (MIN. 5+5 DAYS) ⇒ determination the efficiency of the applied techniques;

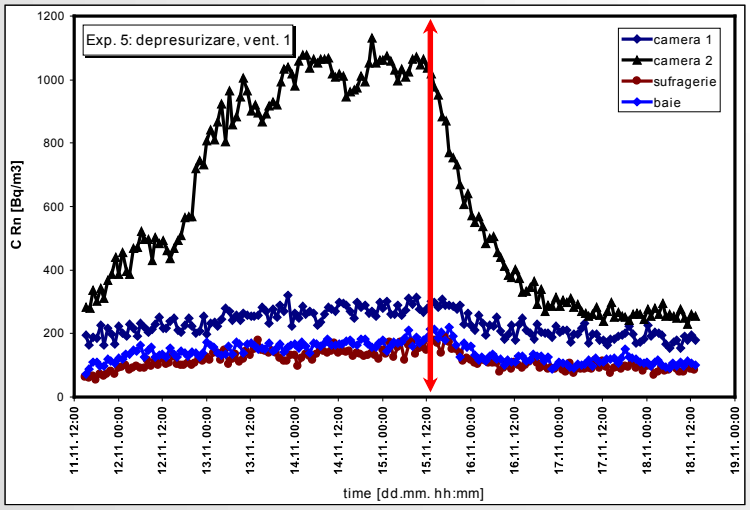


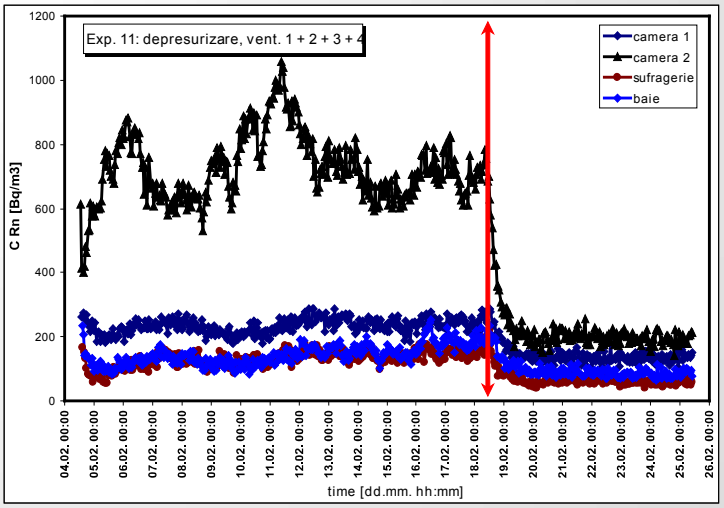




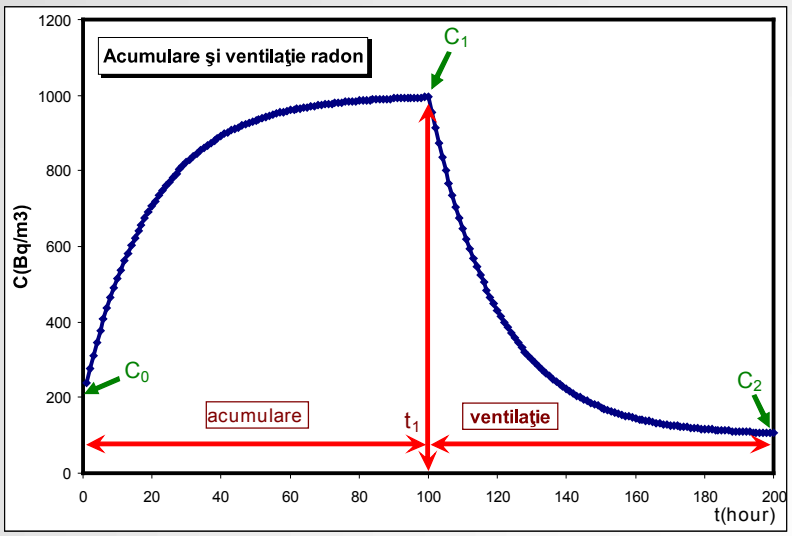

Exp. 3: depresurizare, vent. 4
camera 1
camera 2
sufragerie
pivnita
C Rn [Bq/m3]
time [dd.mm. hh:mm]


Exp. 4: depresurizare, vent. 2
camera 1
camera 2
sufragerie
baie
pivnita
C Rn [Bq/m3]
time [dd.mm. hh:mm]


Exp. 5: depresurizare, vent. 1
camera 1
camera 2
sufragerie
baie
C Rn [Bq/m3]
time [dd.mm. hh:mm]


Exp. 11: depresurizare, vent. 1 + 2 + 3 + 4
camera 1
camera 2
sufragerie
baie
C Rn [Bq/m3]
time [dd.mm. hh:mm]

THEORETICAL MODEL FOR ACCUMULATION AND EXTRACTION PERIODS



C_0 = initial Rn concentration (for accumulation),

C_1 = saturated Rn concentration (for accumulation),

C_2 = Rn concentration for the period of extraction,

t_1 = accumulation time.

RADON REMEDIATION EFFICIENCY:

$$eff = \frac{C_1 - C_2}{C_1}$$

$$R = \frac{C_{before} - C_{after}}{C_{before}} \times 100[\%]$$

where C_{after} and C_{before} are the annual means of integrated radon concentrations before and after remediation

Extraction experiment	room	accumulation			extraction			Eff. (%)
		C0	C1	k1	C1'	C2	k2	
Exp. 1, depressurisation, fans 2+4	Bedroom 1	34	397	0,04	410	206	0,07	48 %
	Bedroom 2	0	943	0,15	1134	275	0,08	71 %
	Living	14	270	0,05	302	90	0,13	67 %
	Bathroom	0	407	0,06	358	133	0,16	67 %
	Cellar	25	90	0,11	130	33	1,03	63 %
Exp. 2, depressurisation, fans 1+3	Bedroom 1	187	376	0,02	324	189	0,05	50 %
	Bedroom 2	191	826	0,04	810	248	0,08	70 %
	Living	101	435	0,01	189	91	0,05	79 %
	Bathroom	125	239	0,05	256	103	0,09	57 %
	Cellar	45		-	49		-	-
Exp. 3, depressurisation, fan 4	Bedroom 1	174	519	0,01	263		-	49 %
	Bedroom 2	240	956	0,02	675	429	0,07	55 %
	Living	143		-	162		-	-
	Cellar	64		-	50		-	22 %
Exp. 4, depressurisation, fan 2	Bedroom 1	69	349	0,03	329	191	0,03	45 %
	Bedroom 2	208	1098	0,02	1117	261	0,08	76 %
	Living	60	188	0,03	193	95	0,09	50 %
	Bathroom	144	261	0,05	253	126	0,08	52 %
	Cellar	46		-	43		-	7 %

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PROYECTO SMARTRADON
(2016-2020)

- Introducción
- Objetivos y diseño del proyecto
- Estado actual de desarrollo

IRART

SELECTED HOUSES (20)

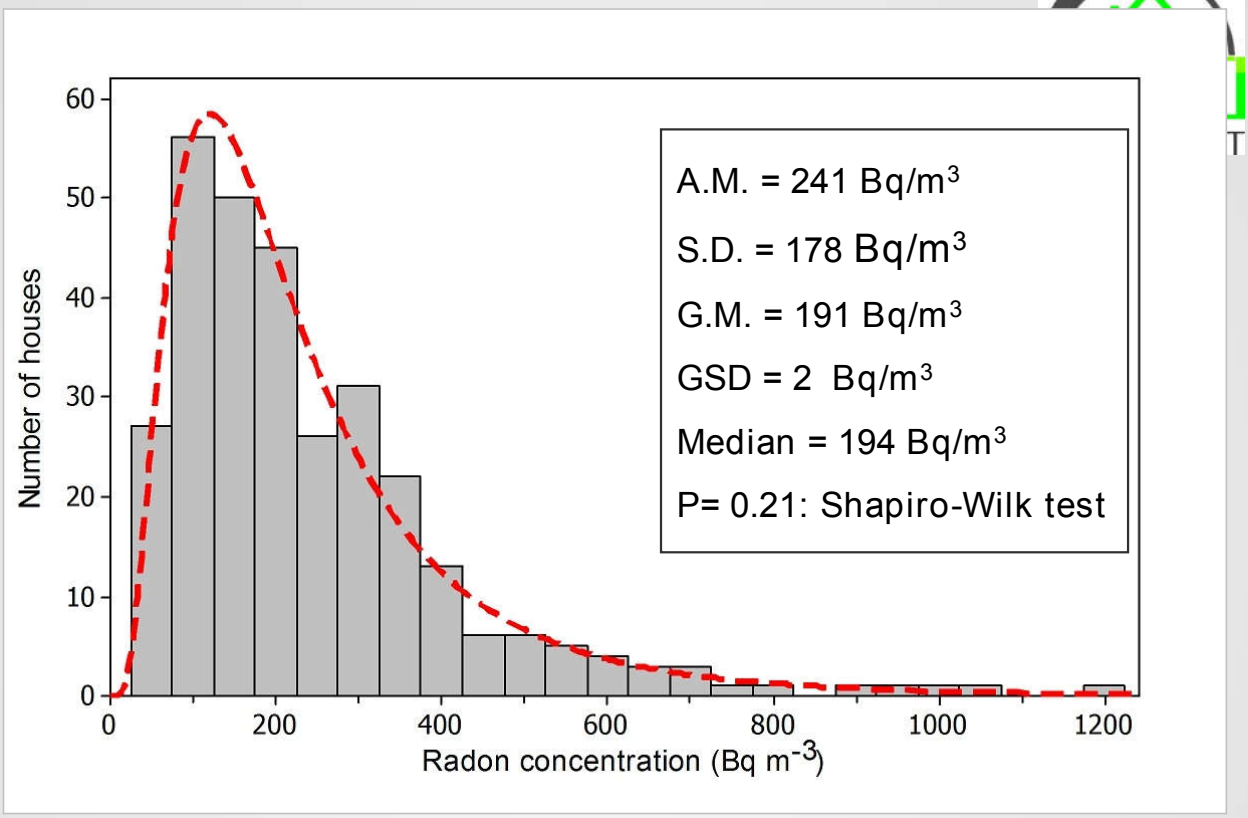
Adress	Owner	Radon potential (RP)	Room	Integrated measurements (Bq/m^3)		
				Winter	Spring	Annual avg.
BĂIȚA 6	Dronca Mihai	119	bedroom	1461	1613	1537
BĂIȚA 75	Lazea Mircea	148	bedroom	1406	909	1157
BĂIȚA 76	Iordache Gh.	99	living room	1452	1188	1320
BĂIȚA 119	Avram Dorel	85	bedroom	1353	508	931
BĂIȚA 138	Petruse Traian	75	living room	901	902	902
BĂIȚA 204	Filip Maria	123	bedroom	1025	774	900
BĂIȚA 206	Lazea Sanda	79	living room	3092	1772	2432
BĂIȚA 213	Lazea Viorel	136	bedroom	1587	1219	1403
BĂIȚA 215	Brasovean Ioan	65,9	bedroom	1357	1002	1180
BĂIȚA 228	Dronca Gheorghe	93	living room	1354	1277	1316
CÂMPANI 57	Dale Floarea	62	bedroom	1013	301	657
CÂMPANI 71	Baic Gheorghe	159	bedroom	751	537	644
CÂMPANI 103	Popa Gheorghe	51	bedroom	869	468	669
CÂMPANI 279	Marta Florian	83	living room	1009	573	791
FÂNAȚE 23	Mot Gheorghe	163	kitchen	1950	1206	1578
FÂNAȚE 189	Popa Ioan	192	bedroom	1392	623	1008
FÂNAȚE 118	Butisca Danut	21	bedroom	1446	1169	1308
FÂNAȚE 136	Muset Dumitru	74	office	3463	1542	2503
FÂNAȚE 202	Aron Vasile	102	bedroom	1107	822	965

a. Descriptive statistics for the radon measurements BY ROOM TYPE within dwellings of **Băiţa**-Stei area.

Type of room	Frequency	AM (Bq m^{-3})	SD (Bq m^{-3})	GM (Bq m^{-3})	GSD (Bq m^{-3})	Median (Bq m^{-3})	Max (Bq m^{-3})	C.V. (%)	% (No> 300 (Bq m^{-3})
Kitchen	247	196	191	141.3	2.2	131	1278	98	18 (44)
Bedroom/ Living	618	273	253	197.1	2.2	196	2016	91	31 (193)
Cellar	233	251	343	151.8	2.5	136	3054	137	22 (52)
Other	30	188	161	133.2	2.4	135	651	86	20 (6)

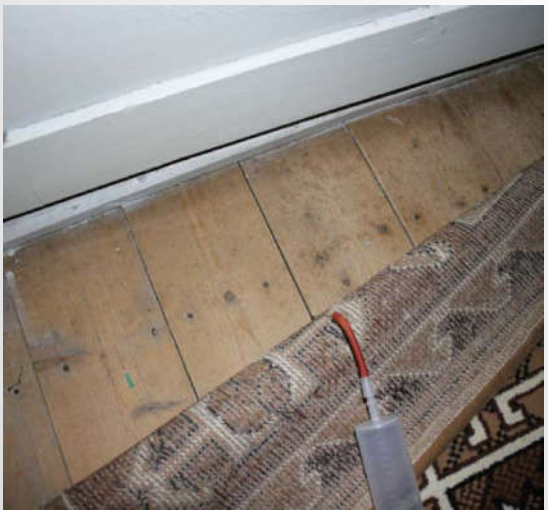
b. Descriptive statistics of indoor radon concentrations in monitored dwellings **of Băiţa**-Stei radon-prone area.

Location	Number of houses	AM (Bq m^{-3})	SD (Bq m^{-3})	GM (Bq m^{-3})	GSD (Bq m^{-3})	Median (Bq m^{-3})	Max. (Bq m^{-3})	C.V. (%)	% (No.) >300 (Bq m^{-3})
Băiţa	131	227	215	162.9	2.2	148	1186	95	22 (29)
Nucet	15	172	87	150.2	1.8	150	337	51	7 (1)
Fânaţe	71	279	172	236.3	1.8	239	1067	62	39 (28)
Câmpani	86	244	121	214.0	1.7	224	593	50	30 (26)
Total	303	241	178	191.4	2.0	194	1186	74	28 (84)



Log-normal distribution of average concentration in 303 houses

A. Cucoş (Dinu), C. Cosma, … C.Sainz, (2012), Thorough investigation on indoor radon in Băiţa radon-prone area (Romania), Science of The Total Environment, 431, 78–83.



EXAMPLE: Protocol study and remediation of Baita 215 house

Parameters of the ground :

c_{A75} = 54,3 kBq.m^{-3}

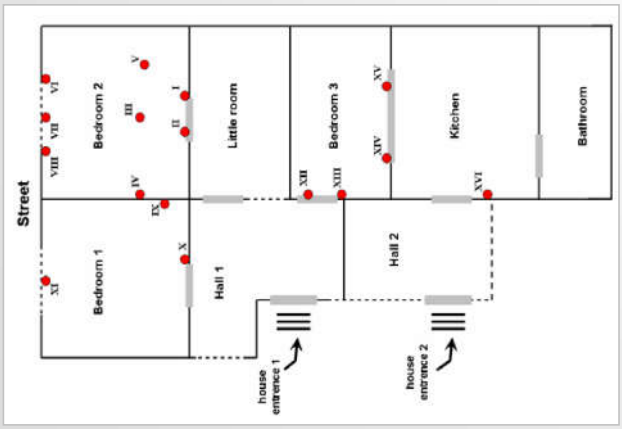
k_{75} = 1.6 10^{-11} m^2

RP = 65,9

high radon index

Average indoor radon: about 1200 Bq.m^{-3} in inhabitable rooms

⇨ very fast fluctuations of indoor radon concentration were observed



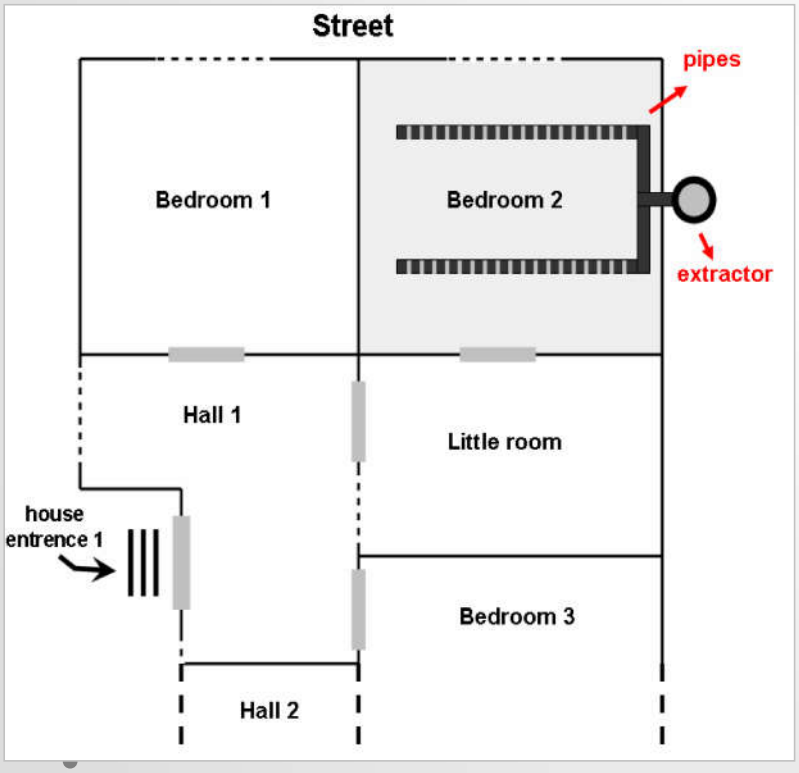
Diagnostic protocol:

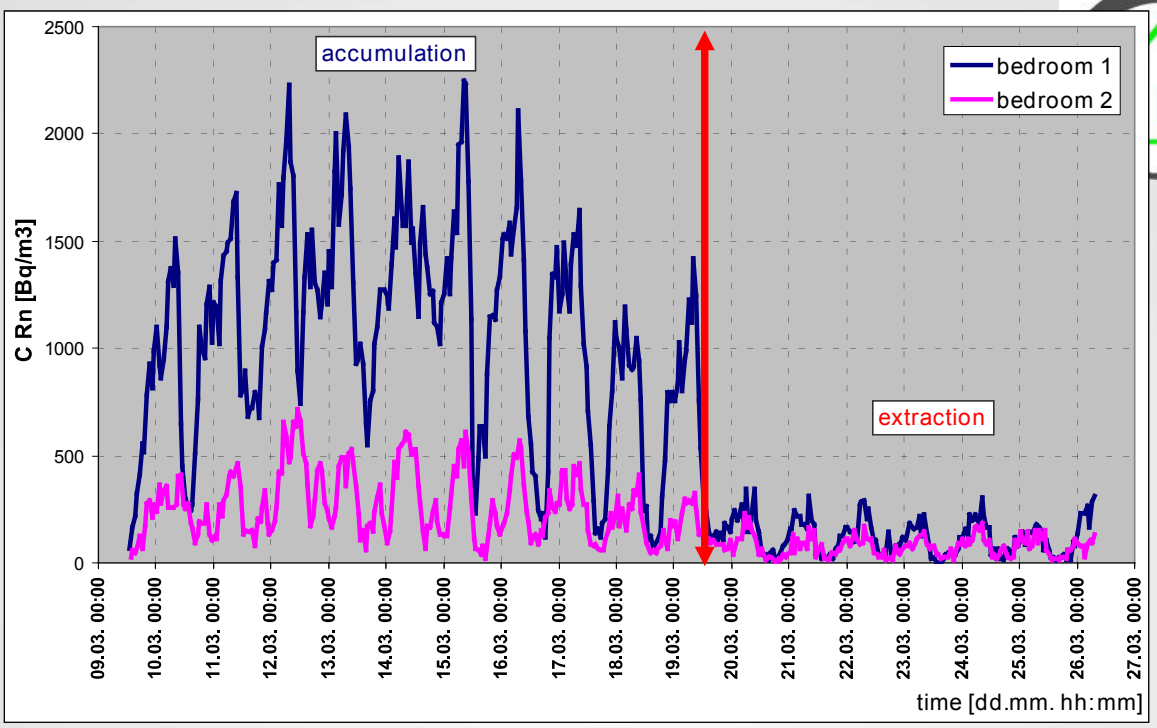
- Radon index of the building site – soil radon measurement and permeability
- Inspection of the house - to find the main entrance radon sources
- Detection of leakages from the floor
- Continuous measurements of indoor radon
- Radon exhalation on the floor
- External gamma radiation

Radon mitigation techniques in 2010-2011

Active soil depressurization :

pipes under the floor, reconstruction of floors and an extractor with a fan
(220 V / 30 W / 110 mc/h)

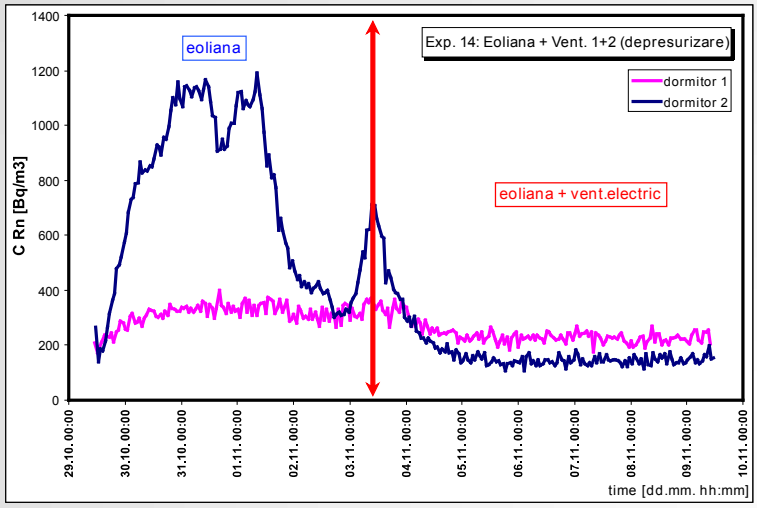


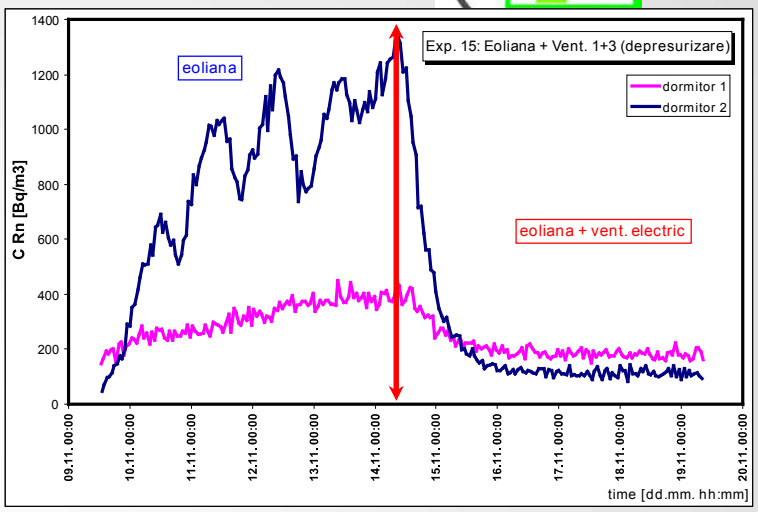


Monitoring of radon concentration during accumulation and DEPRESSURISATION by the fan

Mitigation type	Room	C med.			Eff. (%)
		C before	C after	pres.	
Active soil depressurization	bedroom 1	1102	121	-	89
	bedroom 2	272	77	-	72

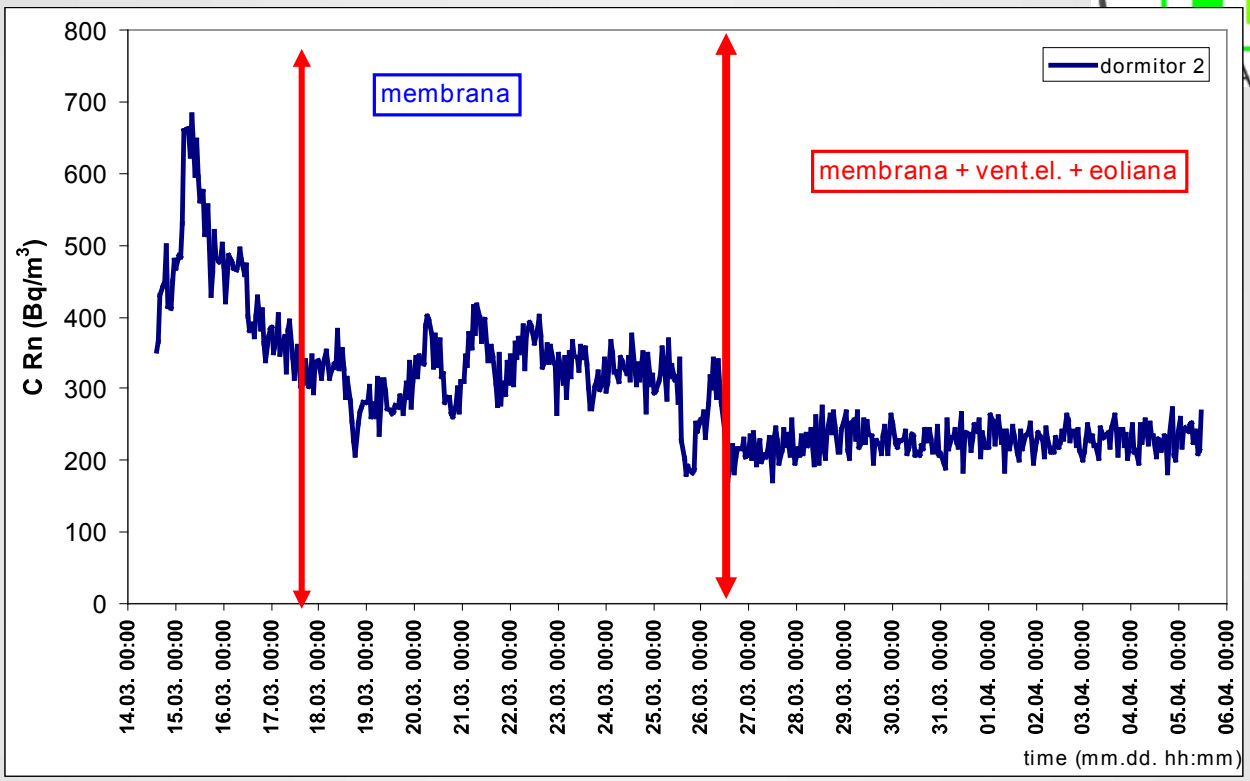
COMBINATION OF SUB-SOIL EXTRACTION TECHNIQUES (DEPRESSURISATION) AND EOLIAN





Experiment	room	C Rn [Bq/m^3]			Eff (%)	
		before	eolian	elect. fan	eolian	elect. fan
Eolian + fans 1+2 (depressurisation)	Bedroom 1	297	280	224	6%	25 %
	Bedroom 2	787	710	144	10%	82 %
Eolian + fans 1+3 (depressurisation)	Bedroom 1	297	300	181	-	39 %
	Bedroom 2	787	800	111	-	86 %

Results of the measurements by the effect of the RADON MEMBRANE and sub-soil extraction (depressurisation) and eolian



Experiment Membrane + (el. Fan + eoliana) Bedroom 2	C Rn [Bq/m³]			Eff (%)	
	before	Membr.	Membr.+ (el.fan+eolian)	Membr.	Membr. + (el.fan+eolian)
	787	351	227	55 %	71 %

Efficiency of the mitigated rooms/houses

No.	House adress	Room	Annual CRn (Bq m^{-3})		Remediation Eff. (%)	Average Remediation Eff. (%) all rooms	Variation range Eff. (%)
			Before remediation	After remediation			
1.	Baita 6	Bedroom	1354	159	88.3	79.0	71.1 - 88.3
2.	Baita 75 A	Bedroom	982	143	85.4	85.3	85.3 - 85.4
3.	Baita 75 B	Living	872	107	87.7	87.7	87.7
4.	**Băiţa 76**	Living	1062	100	90.6	89.5	88.3 - 90.6
5.	Baita 119	Bedroom	761	137	82.0	84.5	80.5 - 82
6.	**Băiţa 127**	Bedroom	948	92	90.3	90.3	90.3
7.	Baita 138	Bedroom	534	113	78.8	78.8	65.6
8.	**Băiţa 204**	Living	771	152	80.4	78.3	75.9 - 80.4
9.	Baita 206	Bedroom	1557	91	94.2	93	83.5-94.2
10.	Baita 213	Bedroom	1205	112	90.7	79.1	67.5-90.7
11.	Baita 215	Bedroom	1010	117	88.4	81.9	75.5-88.4
12.	Baita 228	Bedroom	1059	155	85.3	86.4	79.1 - 85.3
13.	Campani 57	Bedroom	530	91	82.8	82.8	82.8
14.	Campani 71	Bedroom	548	86	84.3	77.0	72.6 - 84.3
15.	Câmpani 103	Living	560	122	78.2	78.2	78.2
16.	**Fânaţe 23**	Kitchen	3389	867	74.4	70.6	66.7 - 74.4
17.	**Fânaţe 59**	Bedroom	1177	214	81.8	65.2	65.4 - 81.8
18.	Fanate 118	Bedroom	1127	77	93.2	90.8	88.4-93.2
19.	Fanate 189	Bedroom	834	219	73.7	72	70.3-73.7
20.	Nucet 9	Bedroom	1958	96	95.1	95.1	95.1
21	Pilot house	Bedroom	1395	174	87.5	76.9	68.7-87.5
				AVERAGE	85.4	81.4	65.4-95.1
				Min	73.7	65.2	
				Max	95.1	95.1	

Remediation technique	Efficiency (reduction factor - %)		Costs (EURO)	
	IRART	RADPAR	**IRART**	RADPAR
Improving natural ventilation	**10-84**	10-50	**2500**	4000
Insulation of floors. Anti-radon barrier	**60-65**	10-60	**1800**	2500
Improving mechanical ventilation	**65-78**	10-60	**2600**	5000
Ventilation methods combined with soil depressurisation	**88-95**	60-99	**3200**	6000

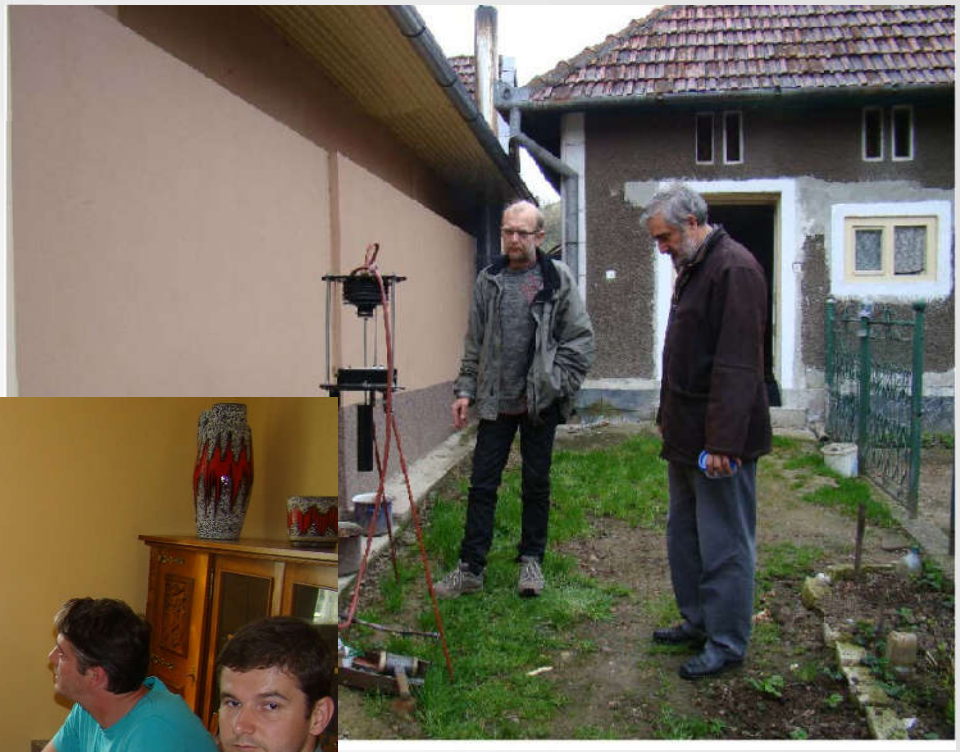
Remediation techniques applied in the IRART project compared with those applied in European countries within the European project RADPAR

Validation INTERNATIONAL EXPERTS

Neznal Brothers

André Poffjin

Luis Quindós



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- Diagnóstico y remedio en casa piloto
- Resultados y conclusión

PROYECTO SMARTRADON
(2016-2020)

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- Estado actual de desarrollo

The project

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Instrumente Structurale 2014-2020

SmartRADON

SMART SYSTEMS FOR CONTROL AND MITIGATION OF RESIDENTIAL RADON LINKED WITH ENERGY EFFICIENCY IN ROMANIA

General objective

Improve the Indoor Air Quality in houses with energy saving systems, thus contributing to increase the safety and health of the population.

URBAN APPROACH: Bucuresti, Cluj Napoca, Iasi, Sibiu and Timisoara.

48 months (2016 – 2020)

Nr. contract: 22/01.09.2016, **cod proiect: ID P_37_229**, **cod MySmis2014+: 103427**

Beneficiar: Universitatea „Babeş-Bolyai" din Cluj-Napoca

Proiect cofinanţat din Fondul European de Dezvoltare Regională prin Programul Operaţional Competitivitate 2014-2020

Introduction

REGULATORY FRAMEWORK

2012/27/EU Directive on Energetic Efficiency

2013/59/EU Directive EURATOM

(TO BE IMPLEMENTED IN 2017 AND 2018 RESPECTIVELY)

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Introduction

SOME CONSEQUENCES…

INDOOR ENERGY EFFICIENCY (IEE)

Reduction of Energy Consumption

Reduction of ventilation (renovation rate of indoor air with fresh outdoor air)

INDOOR AIR QUALITY (IAQ)

Accumulation of indoor air pollutants

Construction material and combustion products (VOC's, CO2, CO, etc..)

Radon (222Rn) concentration

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Introduction

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Instrumente Structurale 2014-2020

Necessity of ”harmonization”...

Integrated measurement system

(CO, CO2, VOC's, Rn, P, t, H)

Automatic Smart System

- **Analyze**
- **Communicate**
- **Take decisions**

The ”radon example”

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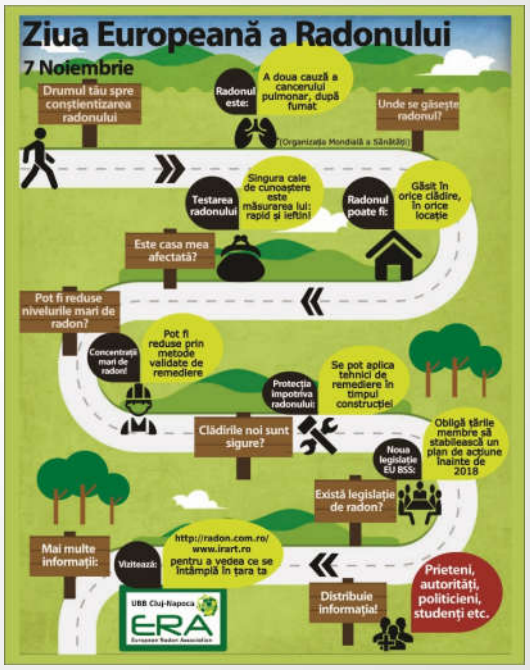
Introduction

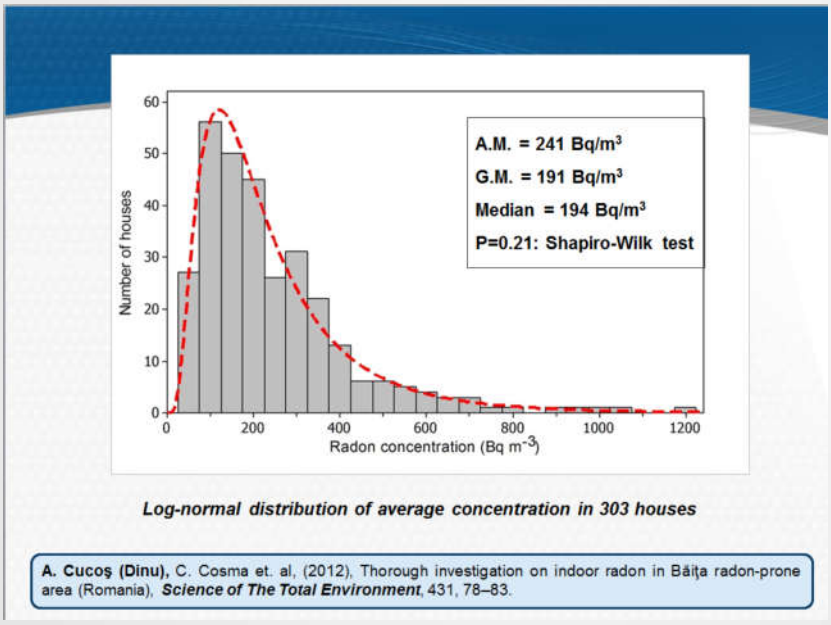
Information/knowledge

Prevention / Diagnosis

Remediation



Introduction



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IRART PROJECT (2010-2013)

We got the information...

Introduction

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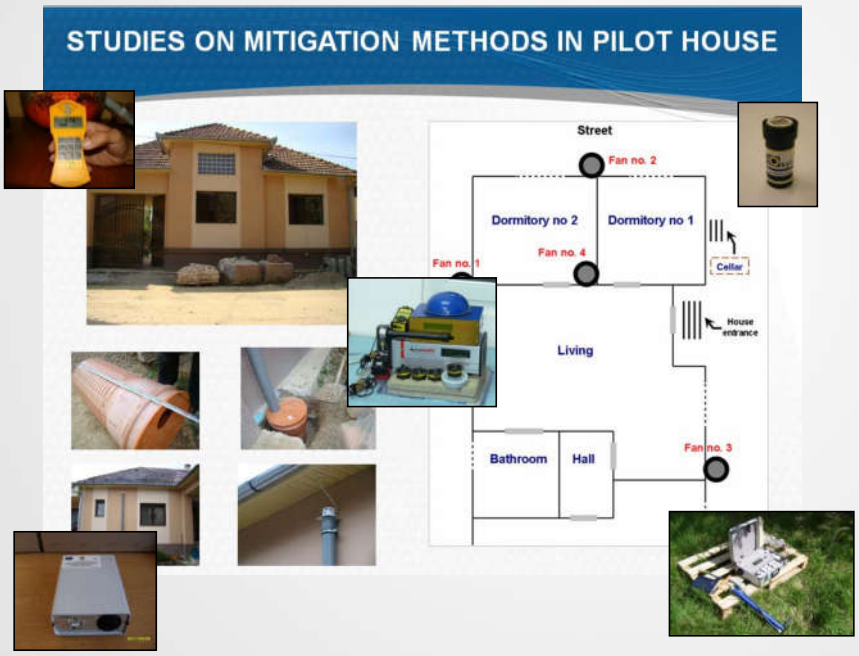
Instrumente Structurale 2014-2020

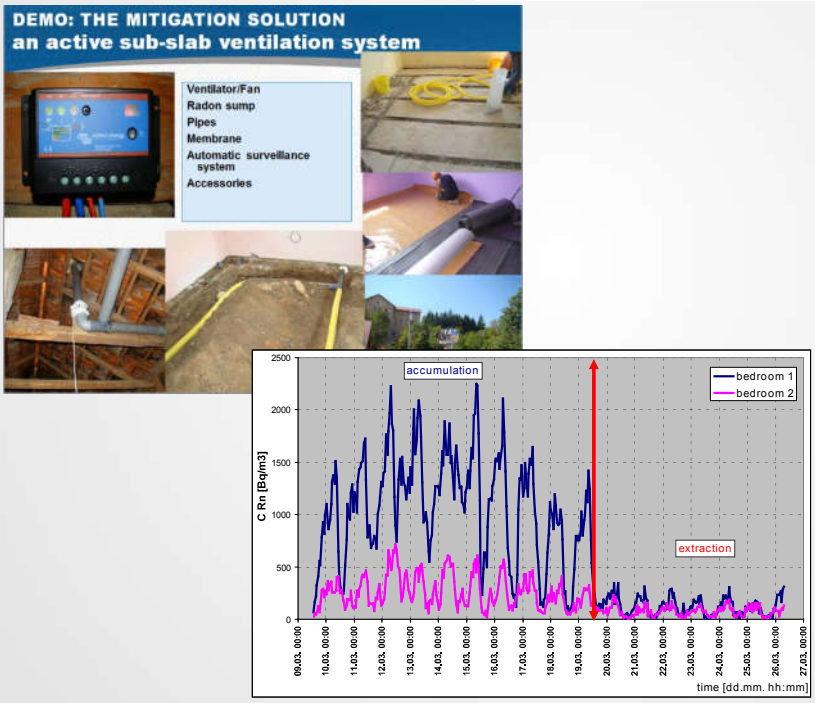


IRART

IRART
PROJECT
(2010-2013)

We made the diagnostic...

Introduction



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Instrumente Structurale 2014-2020

IRART

IRART PROJECT (2010-2013)

... and we reduced radon exposure...

The project

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Instrumente Structurale 2014-2020

MATERIAL RESOURCES

CAPACITIES

- Radon metrology (high quality control)
- Radon diagnosis and remediation
- Risk communication

IRART

Proiect POS CCE ID 586 - SMIS 12487/ 160/ 15.06.2010
derulat in perioada 15 IUNIE 2010 - 14 IUNIE 2013

Rn AND INDOOR AIR QUALITY IN URBAN ENVIRONMENT

SmartRADON

The project

HUMAN RESOURCES

- SCIENTIFIC: 23 researchers
  - UBB (Cluj): 7 + 2 technicians + 3 PhD students
  - UTCB (Bucharest): 3 + 1 PhD student
  - UTC (Cluj): 6 post doc
  - US (Cluj): 1 post doc
  - UC (Santander, Spain)
- FINANTIAL/ADMINISTRATIVE
  - UBB (Cluj)
  - Primainvest (Cluj)

Multidisciplinary team

Communication

Afford complex project

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Instrumente Structurale 2014-2020

1. <u>DEVELOPING INTEGRATED RISK MAPS</u> – **cities Cluj-Napoca, Bucuresti, Iasi, Timisoara, Sibiu**

- **2017**: **RADON SCREENING** - passive monitoring of indoor radon concentration **in 1,000 energy efficient houses** during 1 year
- **2018**: **THE DETAILED EVALUATION OF INDOOR AR QUALITY** (radon, CO_2, CO, VOCs) and **THERMAL CONFORT** (temperature, humidity) in relation to energy efficiency in **100 houses with high exposure to radon (CRn > 300 Bq/m^3)**

2. <u>DEVELOPING A PROTOTYPE SYSTEM FOR CONTINUOUS MONITORING AND REMOTE DATA TRANSMISSION</u> **on radon levels and other household air pollutants - CO_2, CO, VOCs and temperature, pressure and humidity sensors**:
-2018: **100 houses beneficiaries with high exposure to radon (CRn > 300 Bq/m^3)**

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Instrumente Structurale 2014-2020

3. <u>DEVELOPING ENERGY EFFICIENT SOLUTIONS FOR CONTROLLING AND REDUCING EXPOSURE TO RADON AND OTHER HOUSEHOLD AIR POLLUTANTS</u> IN RESIDENTIAL BUILDINGS:

(1) An integrated system for advanced numerical modelling aided by experiment

(2) A prototype system of energy-efficient solutions

-**2019 – 2020**: **10 houses beneficiaries with high exposure to radon (CRn > 300 Bq/m^3)**

4. <u>TECHNOLOGY TRANSFER ACTIVITIES</u>

- Evaluation of efficiency
- Exploitation of results

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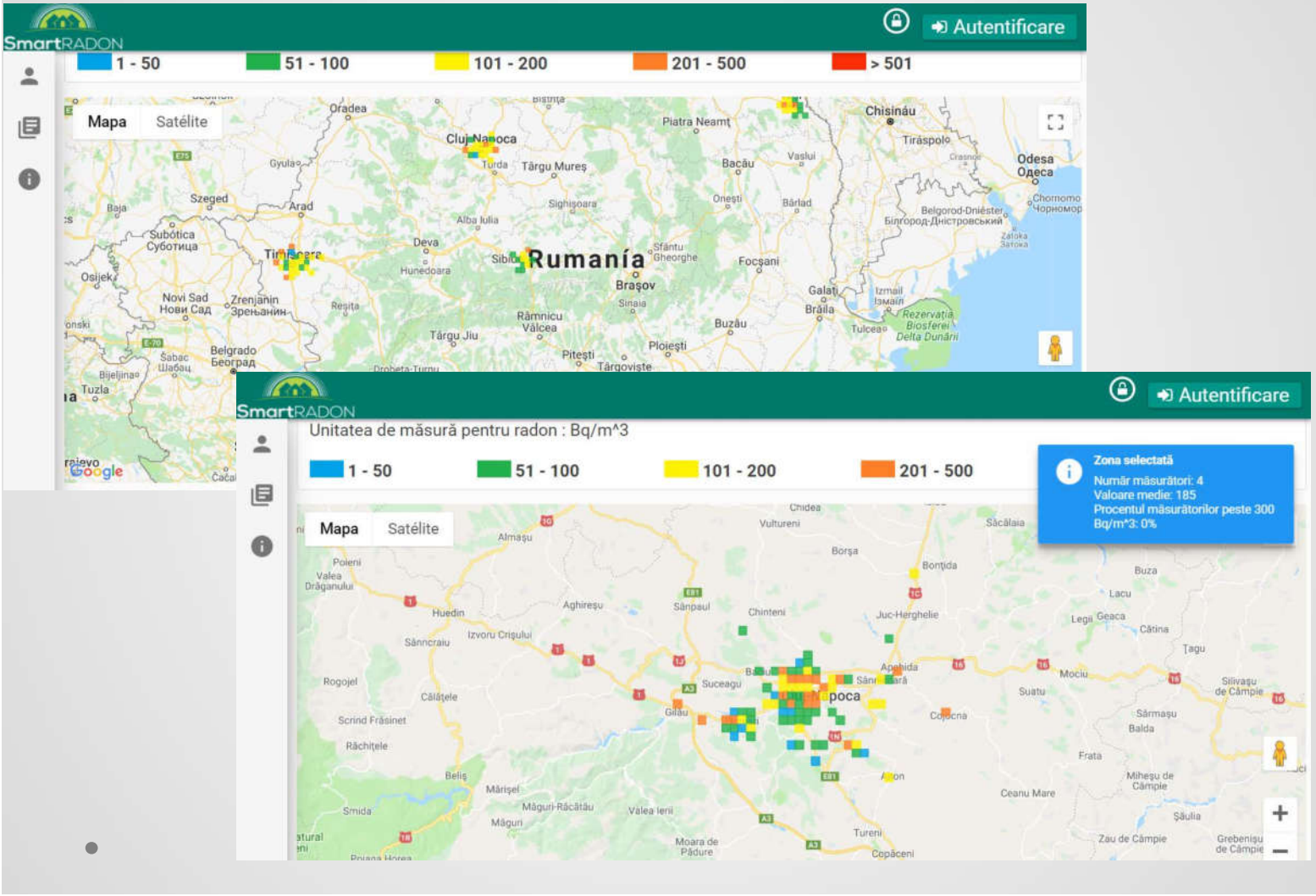
- Diagnóstico y remedio en casa piloto
- Resultados y conclusión

PROYECTO SMARTRADON
(2016-2020)

- Introducción
- Objetivos y diseño del proyecto
- Estado actual de desarrollo

www.smartradon.ro



Soluția 1 (răcire/ventilare/ recuperare căldură)

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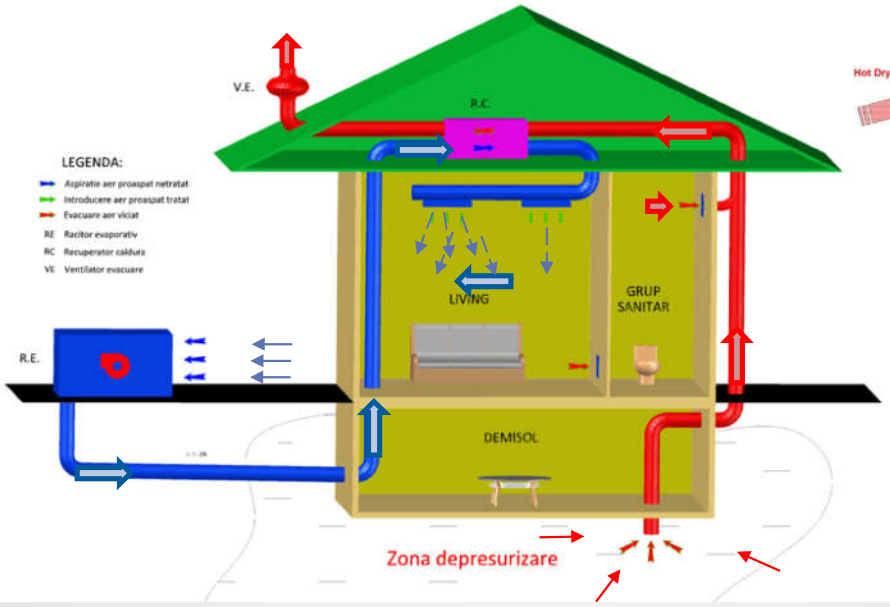
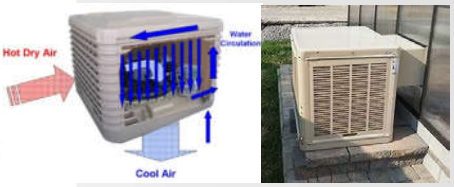
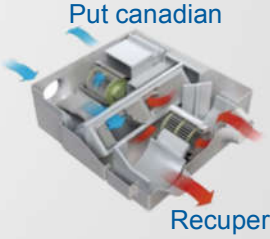
Instrumente Structurale 2014-2020





Racitor evaporativ

Put canadian



Recuperator caldura

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➢ THE PROTOTYPE

- Designed to evaluate INDOOR AIR QUALITY (radon, CO_2, CO, VOC's) and CONFORT (t, H, p) in relation to energy efficiency in 100 houses with high exposure to radon (CRn > 300 Bq/m^3).

- A prototype system for continuous monitoring and remote data transmission.

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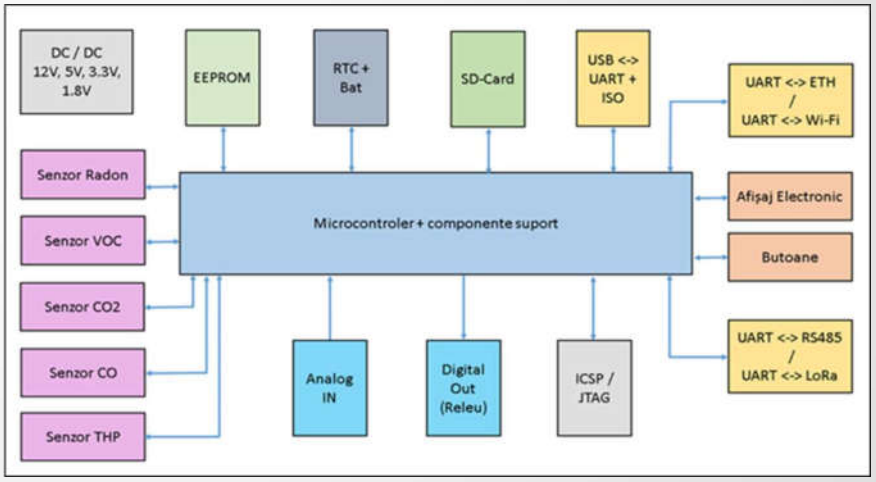
➢ CURENT DEVELOPMENT OF PROTOTYPE

Integrated monitoring system (CO, CO_2, VOC's, Rn, P, t, H)

Automatic "Smart" system:
- Analyze
- Communicate
- Take decisions



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➢ CURENT DEVELOPMENT OF PROTOTYPE

Integrated sensors:

- Radon Sensor (Tesla TSR2): 0 – 50000 Bq/m3, T: 0 - 100℃, H: 0 -100%
- BLOC VOC Sensor (MEMS): 0 – 100 %
- BLOC CO_2 sensor (CDM7160 CO_2): 0 – 4092 ppm
- BLOC Sensor CO (TGS5141 CO): 0 – 18414 ppm
- BLOC THP sensor (ambient temperature, humidity and atmospheric pressure): -40…+85℃; 0-100 RH;

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Instrumente Structurale 2014-2020

SmartRADON

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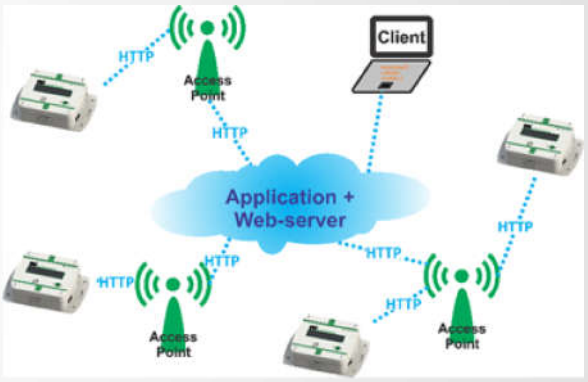
➢ CURENT DEVELOPMENT OF PROTOTYPE

The SMART_RAD_EN monitoring system



Proposed monitoring system communication scheme

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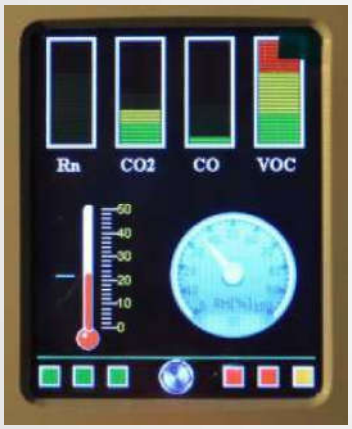
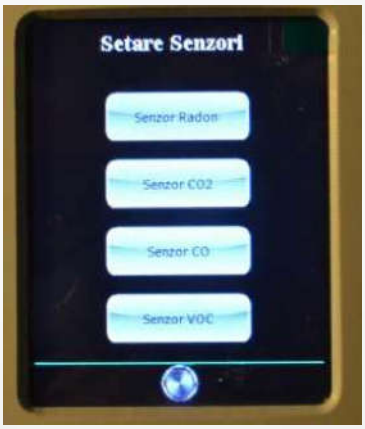
➢ CURENT DEVELOPMENT OF PROTOTYPE





User interface

Mobile app interface

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➢ RESEARCH TESTING - Radon

- Monitoring Radon Activity Concentration in 3 rooms

Exposure	Rn Conc. (Bq/m^3)	Temp. (°C)	rH (%)	P (mbar)
High	1800 ± 550	24 ± 1	32 ± 4	978 ± 2
Medium	430 ± 100	26 ± 2	27 ± 5	956 ± 4
Low	55 ± 20	27 ± 1	30 ± 2	-

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➢ RESEARCH TESTING - CO

7 CO sensors were calibrated

ID Sensor	Theoretical conc. (ppm)	Conc. Before Calibration (ppm)	Conc. After Calibration (ppm)
18	32	24	32.2
87	32	20	32.6
19	32	17	31.8
10	32	20	32
83	32	21	32.4
6	32	27	32.1
9	32	20	32.4

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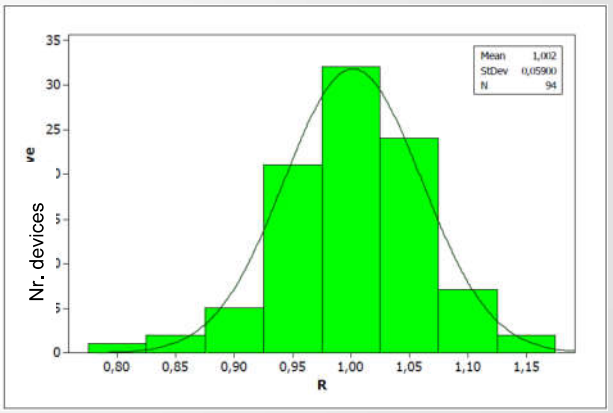
➢ RESEARCH TESTING – CO_2

H (%)	Theoretical concentration (ppm)	Measured concentration (ppm)	R*
0	3365	3145	0.935
40	3365	3357	0.998

*R – Measured concentration / Theoretical concentration



According to the distribution of R only 1 sensor needs to be calibrated

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- The monitoring system will act as a mediator between user behaviour and indoor air quality.

- The owner will be able to understand the effects of his behaviour on indoor air quality and will be able to change his routine in order to increase and maintain indoor air quality to the desired level.

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TO BE CONTINUE… 2020

- PROTOTYPES INSTALATION
- IMPLEMENTATION OF SOLUTIONS
- VALIDATION
- DISEMINATION
- ETC…

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Imposible solo… ¡gracias! multumesc!

LABORATORUL DE ÎNCERCĂRI RADON
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