3th Newsletter, January 2019

LIFE-Respire

Radon r**E**al time monitoring **S**ystem and **P**roactive **I**ndoor **Re**mediation - LIFE16 ENV/IT/000553
Website: www.liferespire.eu, www.liferespire.it

The LIFE-RESPIRE (**R**adon r**E**al time monitoring **S**ystem and **P**roactive **I**ndoor **Re**mediation) project, which started in September 2017, is approaching the end of its first year. The project is realized with the financial contribution of the European Union LIFE programme (LIFE16 ENV/IT/000553).
The main objective of the project is **to demonstrate in 4 areas** (Caprarola, Celleno, and Ciampino in Italy and Jalhay in Belgium) characterised by different Geogenic Radon Potential (GRP), a cost-effective and eco-friendly solution for Rn real-time measurement and remediation **to keep indoor Rn levels below 300 Bq/m^3** (as indicated in European Directive 2013/59/EURATOM). The RESPIRE project will implement an intelligent, adaptable and versatile hybrid Rn remediation system composed of sensors, an Air Quality Balancer (SNAP) and an external additional fan-system (eolian and/or electric) working on positive pressure method. A control model based on a IoT protocol will be also implemented.

The LIFE-RESPIRE geodatabase, consisting of collected continuous and discrete Rn measurements coupled with other geological, geochemical and building characteristics data, will be linked to a WebGIS for easy data management, analysis and visualization by the consortium, and available to the local authorities for land use planning and health risk assessment, helping to prepare relevant national action plans (see Articles 54, 74 and 103 in 2013/59/EURATOM).

This newsletter highlights the mid-term results of the main actions of the project and lists some of the dissemination activities at conferences. Some of the mentioned material is available to the public on the Document section of the LIFE-Respire website.

Any interest and collaboration with the LIFE-Respire Group is appreciated, please contact us!

More information about the purposes of the project can be found in the 1st newsletter and on the LIFE-RESPIRE website.

LIFE-Respire Consortium

CERI-Sapienza: Centre for Research of the Sapienza University of Rome, Italy

CNR-IGAG: Institute of Environmental Geology and Geoengineering of the National Research Council, Rome, Italy

INGV: National Institute of Geophysics and Volcanology, Rome, Italy

FANC: Federal Agency for Nuclear Control, Brussels, Belgium

Elica: Elica S.p.A., Fabriano (AN), Italy

COMUNE DI CAPRAROLA

Comune di Celleno

CITTÀ DI CIAMPINO
CITTA' METROPOLITANA DI ROMA CAPITALE

IN THIS ISSUE

1. Preliminary results (Action A1)

Work on Action A1 has recently been concluded, with the integration and processing of data collected from existing geological and geochemical databases and from RESPIRE field surveys conducted at the project's study sites (Caprarola, Celleno and Ciampino municipalities). Geogenic Radon Potential (GRP) maps (Figures 1 and 2) were obtained by applying Empirical Bayesian Kriging Regression (EBKR), using soil gas radon as the response variable and a number of related proxy variables (i.e., content of the radiogenic parent nuclides, the emanation coefficient of the outcropping rocks, the diffusive ^{222}Rn flux from the soil, the soil-gas CO_2 concentration, the Digital Terrain Model, the permeability of the outcropping rocks, and the terrestrial gamma dose rate of the shallow lithology). The resultant maps have been presented at various international and national conferences (see point 7).

Action A1 also included measurements of dissolved Rn in groundwater, considering that indoor radon can also come from the degassing of tap water having a groundwater origin. Several water samples were collected from springs and domestic/agricultural wells. Hydrochemical characteristics are displayed in Figure 3, while Figure 4 shows that the Caprarola and Ciampino groundwaters are particularly enriched in dissolved radon, generally above the threshold value of 100 Bq/L (D.L. 28/2016) (Figure 4).

2. Permissions for Indoor monitoring in private and public dwellings (Action A2)

Action A2 concerns the collection of all documentation required to obtain public permission for indoor radon monitoring in the participating municipalities.

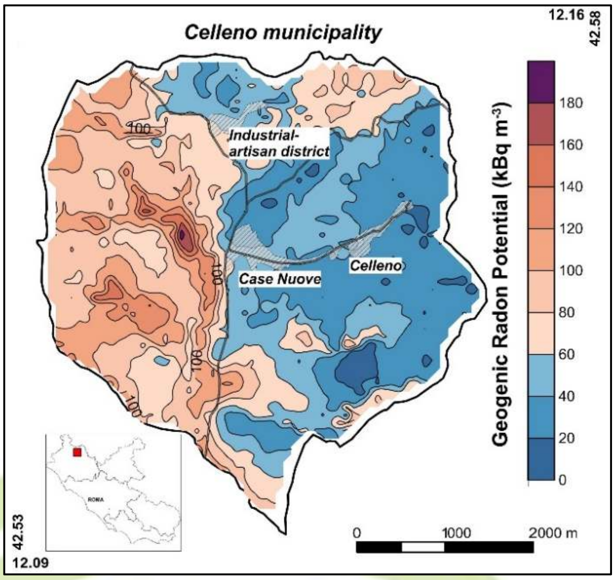


Figure 1. Geogenic radon potential map for the Celleno municipality (Giustini et al., 2019).

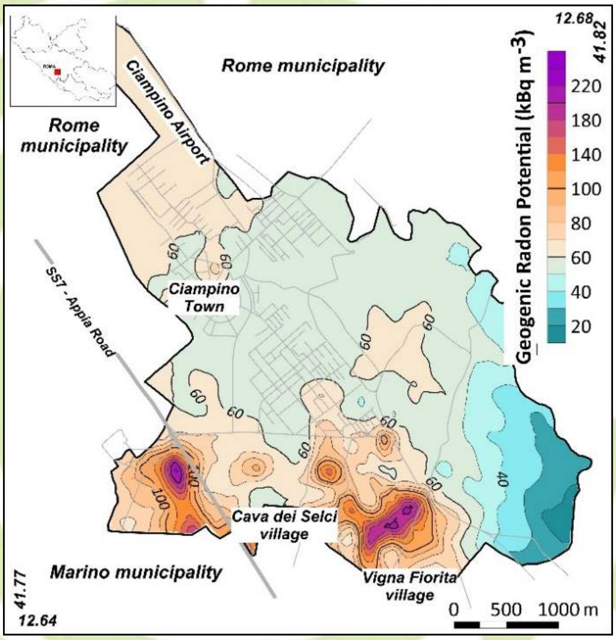


Figure 2. Geogenic radon potential map for the Ciampino municipality.

Owners and local administrations (for public facilities) were contacted individually, during which it was highlighted the importance of their potential participation within an EC-funded LIFE project aimed at improving the health of EC citizens. In this regard, support from the municipalities in terms of contacting individual private home owners and reassuring them about the legitimate activities of the project were fundamental for the successful logistics of this Action.

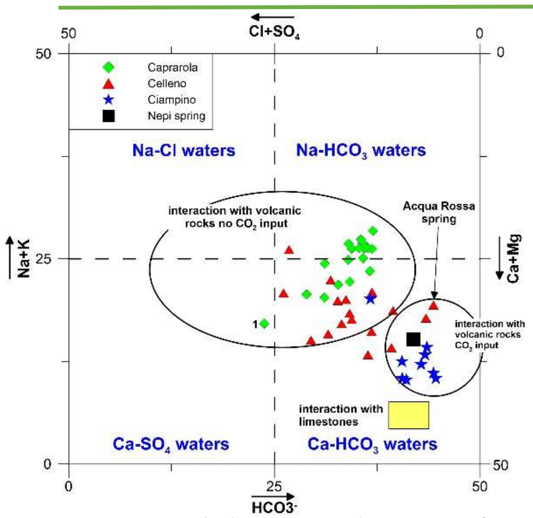


Figure 3. Chebotarev diagram for groundwater collected in the Caprarola, Celleno and Ciampino municipalities.

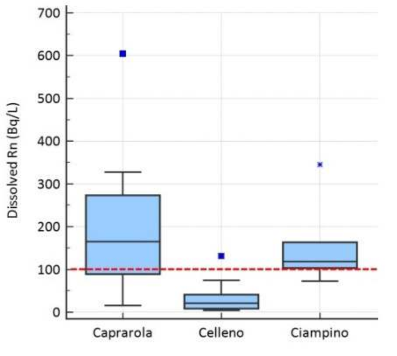


Figure 4. Dissolved radon in groundwater. Dotted red line shows the threshold value of 100 Bq/L (D.L. 28/2016)

3. Prototype assembly and tests(Action B1)

Based on the disappointing results of tests conducted on the RnSS sensor earlier in the project, a second radon sensor, the RD200M, was recently examined to understand if it could better address the technical specifications needed for the monitoring/remediation prototype being developed (Fig. 5). The RD200M consists of an ionization chamber with a measurement range of 0.1 ~ 99.99 pCi/l (0.37 ~ 3700 Bq/m3) and a sensitivity of 30cph / pCi / l (0.81cph / Bq / m3). An interface circuit has been developed to acquire the radon value detected by the sensor and to retransmit it to the SNAP ventilation system every 10 minutes using a radio module (Aurel RTX-MID-3V) operating at 433MHz. Other sensors for the measurement of humidity, atmospheric pressure and temperature were also inserted on the circuit board to correct the response of the RD200M. Two prototypes were connected to a datalogger and tested in a special measurement chamber at the INGV radionuclide laboratory in Rome. The two sensors were exposed to radon concentrations of over 5000 Bq/m^3 (out of scale) and left in acquisition for over a week, during which time the values slowly decreased due to natural decay. The results obtained were very promising (especially in comparison with the previously tested sensor) and in line with the specifications provided by the manufacturer. In particular, changes in relative humidity from 20% to 60% did not appreciably affect the response of the sensors. An on-site test of this prototype version will take place during February in a private house in Celleno.

4. Screening survey using Active Charcoal Collectors (Action B2)

A screening survey using Active Charcoal Collectors (ACC) was performed to determine where indoor radon remediation should be implemented. This low-cost, passive method has been widely used to investigate indoor Rn levels over short time periods (48 hours), with the understanding that they only provide rapid screening results that are needed to decide where elevated Rn values are definitely present and to provide information about the exposure times needed for the longer-term track-etch monitoring method (see point 5 below). New RESPIRE surveys were carried out in the municipalities of Caprarola and Ciampino, while the results of a previous survey were used for screening in Celleno.

Figure 5. Photo of the Respire Monitoring and Remediation System. Electric fan for ventilation (SNAP, © Elica S.p.A.) (1) connected via Bluetooth to the radon sensor (2).

5. Indoor radon long-term monitoring (Action B2)

After initial ACC screening, long-term radon monitoring with passive detectors (Radosys RSK) was carried out in public and private buildings in Caprarola, Celleno and Ciampino municipalities.

After an awareness and information campaign conducted in all three municipalities (Fig. 6), citizens were offered the opportunity to participate for free in the radon monitoring survey of their homes. This initiative was successful and dosimeters were placed in almost 150 private homes and 18 public buildings, including 12 schools. The surveys will be replicated in the same buildings during the spring-summer period to have a wide spectrum of measurement values and to highlight any possible seasonality in the average indoor radon concentrations.

Figure 6. The campaign of awareness and information to citizens of Caprarola municipality.

In addition, a continuous Rn monitoring study was conducted in a cellar of a private house where a concentration of about 30 kBq/m^3 was measured during the screening survey. Rn concentrations were measured in the cellar by a diffusion chamber with a silicon diode (AlphaE, Bertin Instruments) for about 1 month (Fig. 7). Comparison with humidity, atmospheric pressure and temperature changes are in progress.

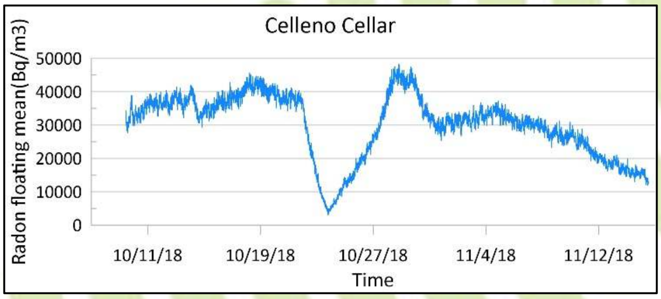


Figure 7. Preliminary results of continuous radon monitoring in a cellar.

6. Development of RESPIRE Web-GIS RadonMap (Action B3)

The first phase of the "Design and implementation of the geographic database" has been completed, with flexibility built into the system to allow for seamless structural modifications that may be necessary in the future due to evolving project needs and results.

Database design involved the definition of information requirements via internal meetings and brainstorming, from which emerged a first structure of the information of interest.

We can group the layers of interest in 5 categories:

- Measurements: this category contains all the measured parameters, including all "outdoor" (i.e., geological, geochemical, etc.) and indoor dataset
- Concentrations of radiogenic elements in soil associated with lithology: representations of specific concentration information on the geographically referenced lithological data
- Interpolated maps: these maps contain continuous representations of specific concentrations of elements, and physical parameters obtained through elaboration of the measured data
- Synthetic maps: results of elaborations
- Base maps

The implemented architecture implemented by the system follows the scheme given in Figure 8.

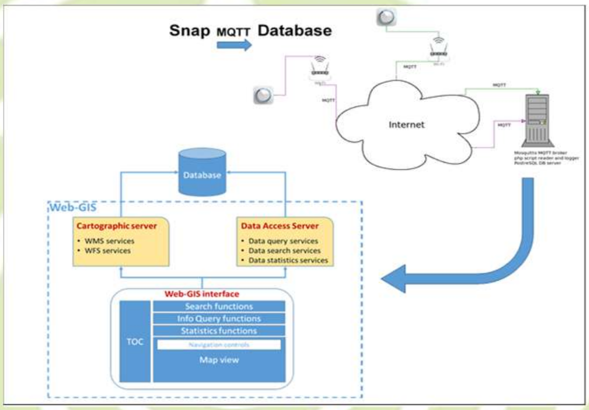


Figure 8. Web-GIS architecture and data integration between SNAP and the database.

We have also implemented data integration between the SNAP and the System database through:

- the Mosquitto server that interprets the messages sent by the Snap via the MQTT protocol
- the software that is responsible for processing and uploading information of interest in the database in such a way as to make it available to the System

In addition, the "Geoserver" mapping server has been created and a first draft of the Web-GIS interface has been created.

7. Replicability potential evaluation and demonstrative case in Belgium (Action B4)

The Ardenne region and surroundings in Belgium has been selected in order to evaluate the efficiency of different remediation systems and the applicability of the RESPIRE approach in different geological (radon potential) settings and different type (and use) of buildings. Three main building types (dwellings, schools, office/public) have been selected in areas with low/medium radon potential (representing the majority of the territory), in karst areas (requiring a specific remediation approach) and in high radon potential zone (with an important source-term).

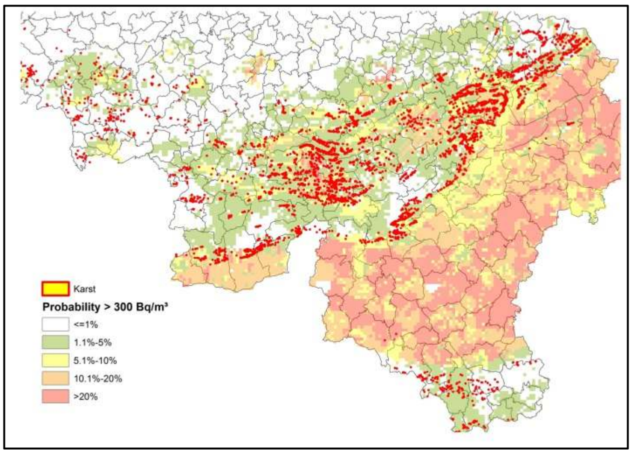
Figure 9. A typical karst landscape influencing the soil-gas dynamics and hence the radon mitigation approaches.

Workplaces (like schools and offices) can benefit greatly from a demand-driven remediation system, controlled by occupation time (working hours) and monitored radon concentration (by a sensor). Important in evaluating the different remediation systems is the characterization (in time and in space) of the different test buildings selected for the project and determine a baseline for future comparisons. In parallel, different type of detectors and continuous radon monitors have been compared and their applicability in terms of response-time and sensitivity have been identified.

There is a clear statistical difference between the buildings measured within 500m distance of a proven karst phenomenon (doline, sinkhole, geomorphological depression) relative to building situated outside a proven karst phenomenon (Fig. 10).

The average (as well the geometric mean (GM) as the arithmetic mean (AM) and the median) is significantly higher for the buildings near the karst.

The same counts for the percentages of buildings that are above the threshold of 300 Bq/m³ (reference level defined by the Euratom Directive 2013/59/euratom.



	Proven karst	No proven karst
Number of measurements	1767	3008
Geometric Mean (Bq/m³)	80	59
GSD	2,54	2,31
Median (Bq/m³)	72	58
Arithmetic mean (Bq/m³)	132	86
% > 300	8,3	3,0
% > 600	2,5	0,8

Figure 10. Distribution and (t-test significant) statistics of the different sample of buildings on karst and outside of the karstic regions.

The statistical spread of the data (here expressed by the geometric standard deviation (GSD) is higher for the buildings near the karst phenomena, since they can result in extremely high radon ingress and related indoor radon concentrations.

Since karstic zones can sometimes contain connected (collapsed or dissolved) zones with high permeability like galleries or fracture zones, the volume of air entering the building can be very high and in the case it is charged with radon, the resulting indoor radon concentration can reach very high levels. Also, due to the temperature effects, the dynamics of radon entry can be the opposite from the normal situation, leading to higher indoor radon concentrations in summer than in winter.

8. Public awareness and dissemination of results (Action D1)

LIFE-RESPIRE results were presented at several conferences:

- National Congress Geosciences for the environment, natural hazard and cultural heritage, Catania (SGI-SIMP 2018).
- 14th International Workshop on the Geological Aspects of Radon Risk Mapping, Prague (GARRM 2018).
- Radon Intercomparison Measurements meeting (RIM 2018), organized as an independent part of the GARRM Workshop.

- The LIFE-Respire Mid Term Conference (11 December 2018). The conference was an opportunity to share the preliminary data of LIFE-RESPIRE, and to make contacts with stakeholders, local authorities and other national and international projects.

The Mid Term Conference was recorded and is available on CD-ROM. Presentations and posters of other events can be found in the Download Section on the LIFE-RESPIRE website.

A further communication and dissemination activity took place to inform stakeholders and local Caprarola authorities of the first results of the project during the 62° Hazelnut Festival on the 26th and 29th of August 2018.

Hazelnut Festival (Caprarola, 26-29 August 2018).

9. Upcoming events

LIFE-RESPIRE presentations are confirmed for the European Geosciences Union conference (EGU 2019) in Vienna, Austria, from 7–12 April 2019.

More details can be found in the News & Events Section on the LIFE-RESPIRE website.

Mid Term Conference (CNR, Rome, 11 December 2018)

Publications

Giustini F., Ciotoli G., Rinaldini A., Ruggiero L., Voltaggio M. (2019). Mapping the geogenic radon potential and radon risk by using Empirical Bayesian Kriging regression: A case study from a volcanic area of central Italy. Science of the Total Environment, 661, 449-464.

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