2nd Newsletter, August 2018

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 main actions conducted in this first year 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 site selection*
2. *Collection of available data*
3. *Intercalibration of Durridge RAD7 for radon measurements in soil gas*
4. *Field surveys for site characterization*
5. *Radon mapping exercise*
6. *Prototype assembly and tests*
7. *Public awareness and dissemination of results (Action D1)*
8. *Upcoming events*

1. Preliminary site selection (Action A1)

In the LIFE-RESPIRE project, the selection of the Italian study sites (Caprarola, Celleno and Ciampino) was based on an analysis of the already available Geogenic Radon Potential (GRP) map of the Lazio region (Ciotoli et al., 2017), in which these 3 sites are characterised by high, medium and low Rn potential, respectively.

Data was collected from existing geological and geochemical databases for the municipalities of Celleno and Ciampino and by conducting new field surveys for this project in the municipality of Caprarola. All the field surveys conducted previously at the Celleno and Ciampino sites were replicated at the Caprarola study site .

For the Belgium site, the radon problem is mainly restricted to the Ardennes region, in the southern part of the country. Based on existing legislation, 35 Ardennes municipalities have a significant number of homes that exceed the present limit of 400 Bq/m^3. The EC Directive 2013/59/Euratom, which has been transformed into Belgian law and has become compulsory by February 2018, defines a new threshold level at <= 300 Bq/m^3 for both dwellings and work places (Figure 1). Almost twice the number of municipalities will be included in the new radon prone area, and the number of dwellings and workplaces concerned will almost double.

2. Collection of available data (Action A1)

The geodatabase of the LIFE-RESPIRE project includes all available data, collected and organised in georeferenced vector (shapefile), raster (grid, tiff, jpg, etc.) layers and datasheet formats in a GIS environment. Data regarding base cartography and thematic maps are freely available from the Open Data website of the Regione Lazio (http://dati.lazio.it/catalog/dataset). The geochemical data come from previous research projects conducted by the Consortium; they include Rn activity and other gases in the soil, Rn flux from soil, soil permeability, Rn dissolved in groundwater and in drinking water (public and/or private), activity concentrations of radionuclides (^{238}U, ^{226}Ra, ^{232}Th and ^{40}K) in soil and rock samples, and indoor Rn measurements collected in public and /or private buildings. For the Belgium site, a soil-gas and permeability measurements on an 1x1 km grid is available for the RESPIRE project. About 5000 indoor radon measurements are available too.

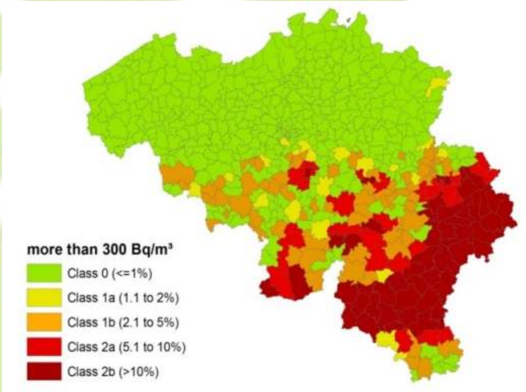

Figure 1. Radon prone areas in Belgium according to the new legislation: >5% dwellings above 300 Bq/m^3.

3. Intercalibration of Durridge RAD7 instruments for radon measurements in soil gas (Action A1)

Before starting field work, all partner's (CERI SAPIENZA, INGV and CNR-IGAG) Rn instruments were inter-calibrated to obtain a homogenous and comparable dataset. All partners use Durridge RAD7 radon monitors to investigate radon concentration in soil gas. The RAD7 is based on the electrostatic collection of short lived radon daughters created inside the detection chamber onto a solid state detector;

discrimination of ^{218}Po allows for a fast response. In particular, i) calibration factors and ii) efficiency trends as a function of absolute water humidity in the soil gas were studied. Regarding the latter, the effect of water content in the soil can be evaluated through the comparison with detectors that are not affected by air humidity (i.e. scintillation cells) (De Simone *et al.*, 2016).

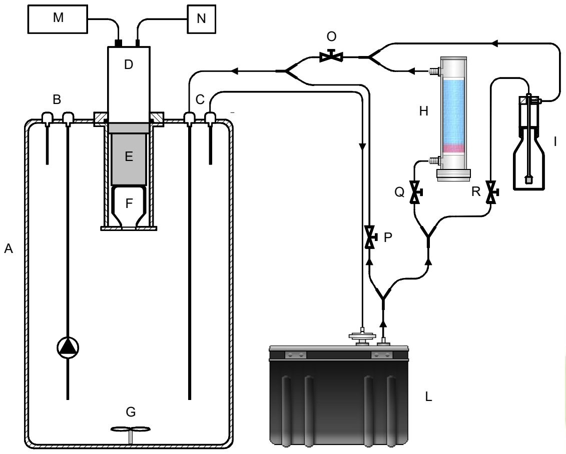

Figure 2. Experimental set-up. A) radon chamber; B) air tight connectors (CPC) to be used when air circulation needs a pump; C) air tight connectors (CPC) when air circulation is guaranteed by an outer device; D) signal processing module; E) photomultiplier; F) scintillating flask; G) fan; H) desiccant column (Drierite); I) humidifying device; L) Durridge RAD7; M) multiscaler, N) low voltage supply; O), P), Q) and R) stopcocks (De Simone et al., 2016).

In order to obtain the dependence of detection efficiency of the RAD7 silicon detector on water content, ad-hoc experiments were designed using a 56 L stainless steel radon chamber equipped with a scintillation cell (ZnS) coupled to a photomultiplier, which is not sensitive to humidity. Radon gas was extracted from a $RaCl_2$ source (2500 Bq) and injected in the chamber (Figure 2). Relative humidity in the system was progressively changed, at a constant temperature, by using the RAD7 pump; the chamber was connected to the drierite drying unit or to a bubbling water bottle for drying or humidifying the closed circuit. When the desired condition was reached, the RAD7 was directly connected in a closed loop to the chamber and the average RAD7 readings were compared with activity concentrations given by the radon chamber at each step.
All the partner's instruments have been tested and ad-hoc corrections have been obtained for each specific RAD7 at different water contents (Figure 3).

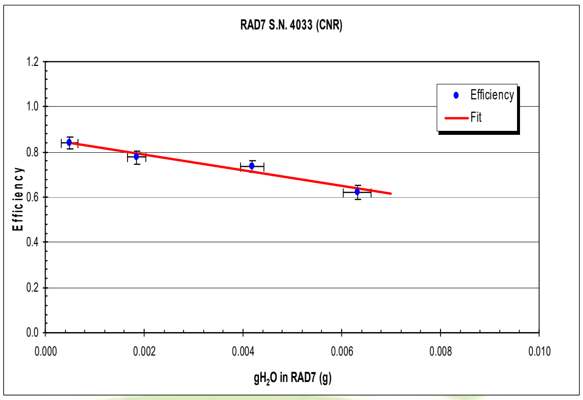

Figure 3. RAD7 S.N. 4033 (CNR) calibration. Efficiency trend as a function of gH_2O and linear data interpolation are shown.

4. Field surveys (Action A1)

Field work was carried out to characterise the natural background of the studied sites in order to construct GRP maps (Figure 4). The field work was mainly conducted in the municipality of Caprarola in order to homogenise dataset among all the 4 studied sites. In particular, field work consisted of:

- Soil gas survey (181 samples and 1191 data analysis)
- Soil permeability measurements (181 measurements)

Figure 4. Soil gas field measurements: radon device (a), multigas sensor (b), flux measurement (c).

- High-resolution gamma spectrometry (16 soil samples and 64 data analysis)
- Indoor Rn pre-screening survey (80 samples in 34 buildings); an ad-hoc questionnaire was filled in by home owners to collect structural information about monitored buildings
- Groundwater sampling at Caprarola and Celleno municipalities (38 samples and 2014 data analysis)
- Gamma ground spectrometry at Caprarola and Celleno municipalities (273 samples).

5. Radon mapping exercise

The mapping of the Geogenic Radon Potential (GRP), is based on the modelling of spatial geological and geochemical proxy data. It is an important task to identify radon-prone areas and provide the local administration with a useful tool for land use planning and strategies aimed at radon health risk reduction. Within of the LIFE-RESPIRE project, different interpolation techniques (Geographically Weighted Regression, GWR and Empirical Bayesian Regression Kriging, EBRK) are applied and compared to map the GRP in the municipality of Celleno, Caprarola and Ciampino. First results have been presented in international and national conferences (Figure 5). The radon mapping exercise is also a task conducted in networking with the MetroRadon project (www.metroradon.eu).

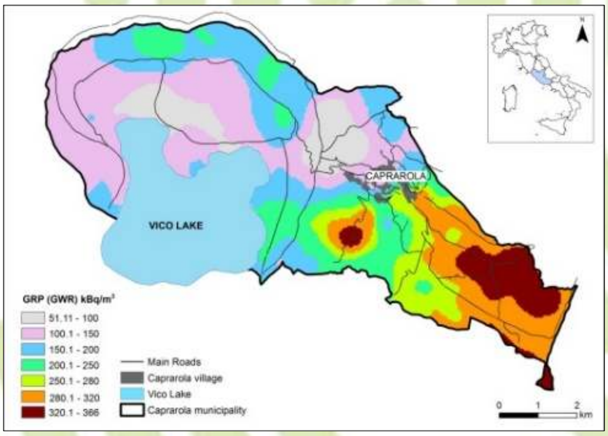

Figure 5. Geogenic radon potential (GRP) map for the Caprarola municipality.

4. Prototype assembly and tests (Action B1)

The prototype of the RESPIRE remediation system was realised using an OEM (Original Equipment Manufacturer) product that is easily adaptable and incorporated in the final device.

After a detailed analysis of the characteristics of the different products on the market, the Radon SS Gas Sensor (EURO-GAS Management Service LTD) was selected for its wide measurement range (0-65000 Bq m^{-3}) and its lowest power supply (3.3V) (Figure 6).

Figure 6. Radon SS Gas Sensor, 1750 pCi/l Rn EURO-GAS Management Service LTD.

The interface circuit board was realised using ORCAD CAPTURE 9.10 software (Figure 7a). The objectives of the circuit are to supply and interrogate the Rn sensor at regular intervals. The measured concentration is then sent to the SNAP fan system on a radio channel (433MHz) by the a digital RF transmitter-receiver. The main power is provided by an external power supply at 5V-1A with a micro USB connector. The radon sensor and its interface board are included in an ad-hoc housing realised using a 3D printer and with front and lateral openings to ensure a suitable air ventilation inside the housing (Figure 7b). The sensors were tested at the INGV laboratories to verify the correct operation of the interface board and the measured values in Bq/m^3.

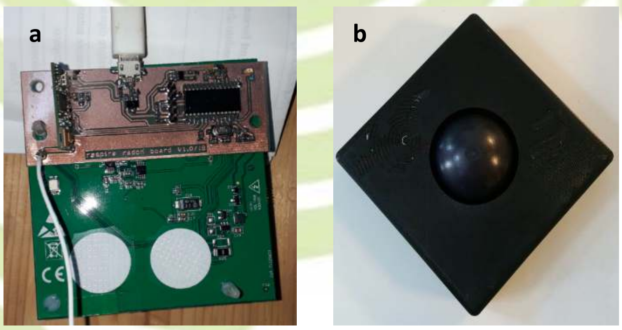

Figure 7. Interface board (29.97 x 77.47mm) (above) overlaid on the Rn sensor board (below) and linked by using a 6 pin connector (a); housing designed ad-hoc and made with a 3D printer (b).

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

Initial LIFE-RESPIRE results were presented at several conferences:.

- 2nd International Workshop on the European Atlas of Natural Radiation (IWEANR 2017) in Verbania, Italy (6-9 November 2017);
- 12th International Conference on Environmental Legislation, Safety Engineering and Disaster Management (ELSEDIMA 2018) in Cluj, Romania (17-20 May 2018)
- Scienza Aperta – Incontri con il pianeta Terra at INGV, Rome (12 May 2018).

First reports are available on the LIFE-RESPIRE website:

- "Report defining the field survey strategy and mapping techniques"
- "A preliminary operative shared protocol for the site selection, mapping techniques and strategy for field surveys"
- "Report on all collected data including natural degassing distribution of Rn at Caprarola municipality".

Presentations and posters can be found in the Download Section on the LIFE-RESPIRE website.

IWEANR 2017 (Verbania, Italy, 6-9 November 2017).

7. Upcoming events

LIFE-RESPIRE presentations are confirmed for several conferences in the coming months, including the National Geosciences Congress for the environment, natural hazard and cultural heritage (SGI-SIMP 2018) and 14th International Workshop on the Geological Aspects of Radon Risk Mapping, Prague (GARRM 2018). A further activity of communication and dissemination will take place to

7. Upcoming events

inform stakeholders and local authorities of Caprarola municipality of the first results of the project within the 62° Hazelnut Festival on 26 and 29 of August 2018. More details can be found in the News & Events Section on the LIFE-RESPIRE website.

Scienza Aperta (INGV, Rome, 12 May 2018)

References

Ciotoli G., Voltaggio M., Tuccimei P., Soligo M., Pasculli A., Beaubien S.E., Bigi S. (2017). Geographically weighted regression and geostatistical techniques to construct the geogenic radon potential map of the Lazio region: A methodological proposal for the European Atlas of Natural Radiation. Journal of Environmental Radioactivity, 166, 355-375.

DeSimone G., Lucchetti C., Pompilj F., Galli G, Tuccimei P., Laboratory simulation of recent NAPL spills to investigate radin partition among NAPL vapours and soil air. Appl. Radiat. Isot, 120, 106-110.

Main Contacts

Sabina Bigi (CERI-Sapienza), Earth Science Department, University of Rome Sapienza , P.le A. Moro 5, 00185 Roma, Italia email: sabina.bigi@uniroma1.it

Giancarlo Ciotoli (CNR-IGAG), Institute of Environmental Geology and Geoengineering, National Research Council, 00015 Monterotondo, Roma, Italia, email: giancarlo.ciotoli@igag.cnr.it

Alessandra Sciarra (INGV), National Institute of Geophysics and Volcanology, Via di Vigna Murata, 00143 Roma, Italia, email: alessandra.sciarra@ingv.it

Boris Dehandschutter (FANC), Federal Agency for Nuclear Control, Rue Ravenstein 36, 1000, Brussels, Belgium, email: boris.dehandschutter@fanc.fgov.be

Mauro Castello, Strategic External Resourcing Area, Elica S.p.A., Via Ermanno Casoli, 2, 60044 Fabriano (AN), Italia email: m.castello@elica.com