4PCAN

D2.7 - Radon impact in lung cancer

October 2024

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List of Abbreviations

VOC: volatile organic compounds

PRCC: Regional Cancer Center

PRLDH: Plovdiv Regional Long Diseases Hospital

CEE: Central East Europe

Deliverable Introduction

Deliverable objective and scope

D.2.7 "Radon impact in lung cancer" focuses on the ninth element of European Code Against Cancer

The task for D.2.7 is twofold:

(a) scoping a review of the literature with regards to radon levels in CEE and what are the limits and measures to reduce human exposure and

(b) building on one of the recent projects of Plovdiv University, Bulgaria (link), aiming at translating the continuous monitoring of radon level in specific communities in Romania and another country within the consortium (to be decided).

To this end, relevant professionals and other communities working or living in subsurface environments with prolonged radon exposure will be identified (ground floors, basements, tunnels, galleries, etc.), together with relevant monitoring infrastructure to be installed. The key enabling factor is the relatively recent commercial availability of radon sensors for dynamic measuring the radon level, which allows automatic gathering of real-time data. Such sensors will be installed in the selected subsurface sites, together with a system for regular medical checks of the people working/living at these sites. This is a preparatory task and if the project is feasible, the implementation will take place during WP5, in the Living-labs.

Content of the deliverable

Indoor radon as second important cause for lung cancer.

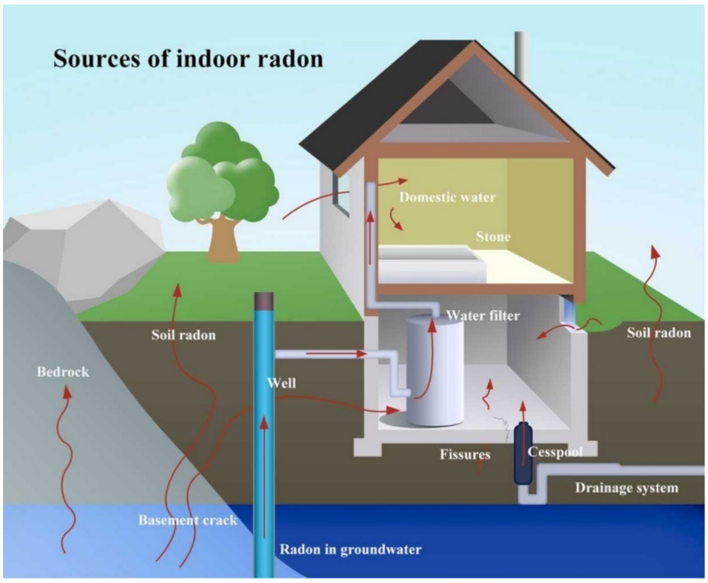
Radon has been found to be the second most important cause of lung cancer after smoking. The excerpt from the articles of Vogeltanz-Holm and Schwartz (2018) briefly summarizes the history of radon as on of the key health hazards:

"In his 1556 textbook on mining, *De Re Metallica* (On Metal Matters), Gregorius Agricola described a wasting disease of miners in the Erzeberge (Ore Mountains) of Germany that "eats away the lungs ... and plants consumption in the body." Three centuries later, German scientists identified this miners' disease as lung cancer (Langård, 2015. Radium was discovered by Marie and Pierre Curie in 1889; the following year, the German physicist Ernst Frederick Dorn demonstrated that radium emitted a radioactive gas, "radon emanation" (later, simply "radon") (McLaughlin, 2012). Epidemiologic studies of radon and lung cancer conducted among miners in the 1950s confirmed Agricola's recognition of lung cancer as an occupational disease. *The recognition that radon levels in some homes approximated those in mines led to epidemiologic studies of residential radon and lung cancer*. These established radon as a cause of lung cancer in the general population, second in importance only to smoking, where it accounts for approximately 21,000 deaths per year in the U.S. (Samet, 2011). (p.3)

Today the main 'paths' for radon entering into houses and working premises are well known. Yet, as recent Chinese study has pointed out, "Understanding the *chemical properties*, *geographical distribution*, *migration patterns*, and *carcinogenic mechanisms* of radon is essential for both the construction of new buildings (prevention) and the management of existing structures (remediation and mitigation)". (Liu et al, 2024)

As shown in the picture below, these are 1) the floors and wall of the building and inflow is higher when the building possess basement or lay directly on the ground surface, 2) pipes of ground water (if sourced by well or other local source) and sewage system, 3) ground and first floors windows.

Figure 1 Sources of indoor radon



(source: Liu, Y. et al., 2024)

From the interviews with the experts, it was pointed out that *type of and materials used in construction of the buildings are also of importance* – the old windows that were not hermetically sealed like modern aluminum and plastic frames allow lower indoor concentration of radon, while modern concrete ground floors (especially with additional insulation) reduce radon inflow. Often this is not enough – the new construction in geologically harmful area should be avoided, and new building technologies should be used:

> "For prevention, buildings should be sited to avoid areas with high levels of geologic radon potential and to use insulating materials, such as special paints and screens, to prevent radon gas from entering indoor spaces from the ground (Szajerski and Zimny, 2020). During the construction phase, air boxes can even be constructed between the ground and the floor/walls where available (Nunes et al., 2022). In terms of mitigation, radon gas concentrations in buildings can be reduced by adding floor ventilation, radon wells, and sub-slab or sump depressurization systems (SSDS) (Riudavets et al., 2022; Khan et al., 2019). This approach is more effective in achieving significant and lasting radon reduction compared to methods like sealing, membranes, or filtration." (Liu et al, 2024)

In addition to location of settlements and type of buildings, behavior pattern related with existing seasonal and daily cycles of indoor radon – for houses and working premises there are firmly established patterns of higher radon level during the night and solder seasons, which however vary according to the geographical latitude (see Elmehdi et al. 2024, Carlo et al. 2023). Preliminary dynamic measurement of indoor radon levels in households by the members of Bulgarian team point to the daily and seasonal patterns that show higher levels during the night period, and higher level during the winter period (see for example https://meter.ac/gs/radon/Rn18/history.html). The different occupational and leisure pattern, as well as patter of everyday activities may significantly influence the overall dose of radon intake by the inhabitants.

That is why the wider availability of radon sensors for dynamic measuring indoor radon open and entire new range of research and policy options. The authors of the study mentioned above call this "…shifting the focus of epidemiological studies from *exposure-response* relationships to *dose-response* relationships [as] … a critical step in optimizing radon exposure risk assessment." (Liu et al, 2024). The shift to "dose-response relationships" means that at the background of certain ground-level radon, specific for given geographic region and largely depending on under-ground geology, surface layers (soil, rock), climate factors, etc., the actual received radon-related radiation may vary significantly because of existing infrastructure and types of buildings, but also because of economic, cultural, and community differences, that influence personal behavior. All this juxtaposed to genetic, metabolic and other biological differences in affected individuals.

Till now one of the few established behavioral patterns was the relationship between radon exposure and passive or active smoking. Now medical and health policy communities are gradually obtaining tools that will help unveiling many other similar interrelationships. The interaction of radon exposure with actual levels of air pollution, or rather the personal intake of air pollutant is such relationship that could be measured simultaneously with new type cheap indoor sensors measuring radon levels together with the levels of nitrogen oxide, volatile organic compounds (VOC), fine particles and some others. [1]

[1] "Once radon is emitted, it migrates upward, accumulates in homes, and decays to radioactive progeny. These freshly generated progeny react with water vapor and atmospheric gases to form highly mobile clusters, which then rapidly attach to air-borne aerosols (Porstendörfer 1994, 2001). The fraction of attached progeny increases with increasing ambient aero-sol concentrations (Porstendörfer 1994). The attached fraction usually composes 90% or more of total radon progeny in a typical room …" (Blomberg et al., 2019:267).

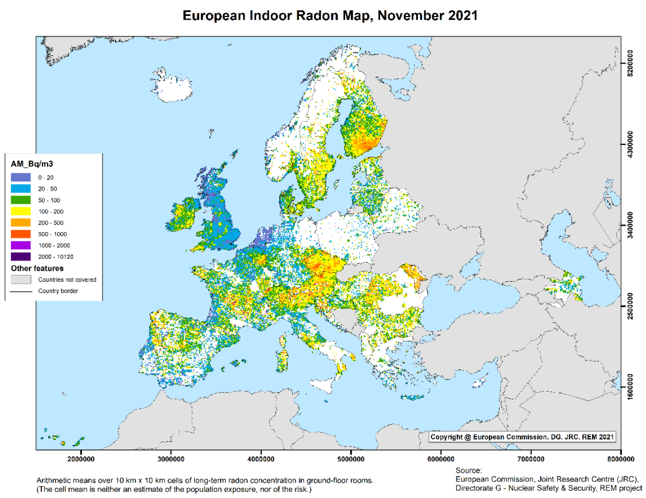
Locating surface radon levels in studied area in Bulgaria and Romania (Arges and Plovdiv Provinces)

This section outlines the known relative level of ground radon emission in Bulgaria and Romania.

The source of ground radon are the breakdown of uranium and thorium in soil (see US EPA's "*Facts about radon*', 2024 edition). Radon is also massively brought to the service during the periods preceding earthquakes, where the surface level can rise significantly (Ghosh et all., 2009, 70-71). We should keep this peculiarity in mind when discussing the difference between sensors measuring overall level or radon for certain period of time (usually six months) and dynamic sensors that provide continuous data for actual radon level.

For Europe, the key source supplying data for ground radon is European Joint Research Center for Radioactivity Environmental Monitoring, which maintain and update the so-called *European Indoor Radon Map,* presenting the ground radon level in each European country, number of measurements per squire unit, etc. The map reveals significant difference between European countries, including between Bulgarian and Romania according to the Becquerel per cubic meter. [2]

Figure 2 European Indoor Radon Map



(source: https://remap.jrc.ec.europa.eu/Atlas.aspx?layerId=3)

[2] The European Indoor Radon Map reports the arithmetic means (AM) over 10 km x 10 km grid cells of annual indoor radon concentration in ground-floor rooms. This grid has been defined by the JRC and uses a GISCO-Lambert azimuthal equal area projection. The input data are provided by national competent authorities (https://remon.jrc.ec.europa.eu/About/Atlas-of-Natural-Radiation/Digital-Atlas/Indoor-radon-AM/Indoor-radon-concentration)

Below we provide two screenshots of the expanded *European Indoor Radon map* for the territories of Bulgaria and Romania, and where we circled the two regions to be studied in 4P-CAN project:

Figure 3 Bulgaria at European Indoor Radon Map

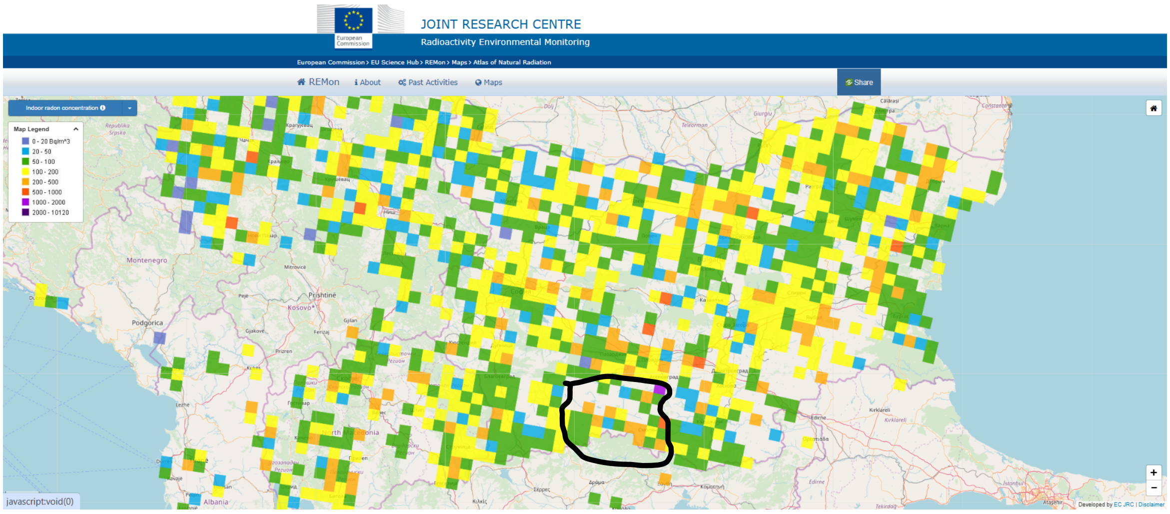
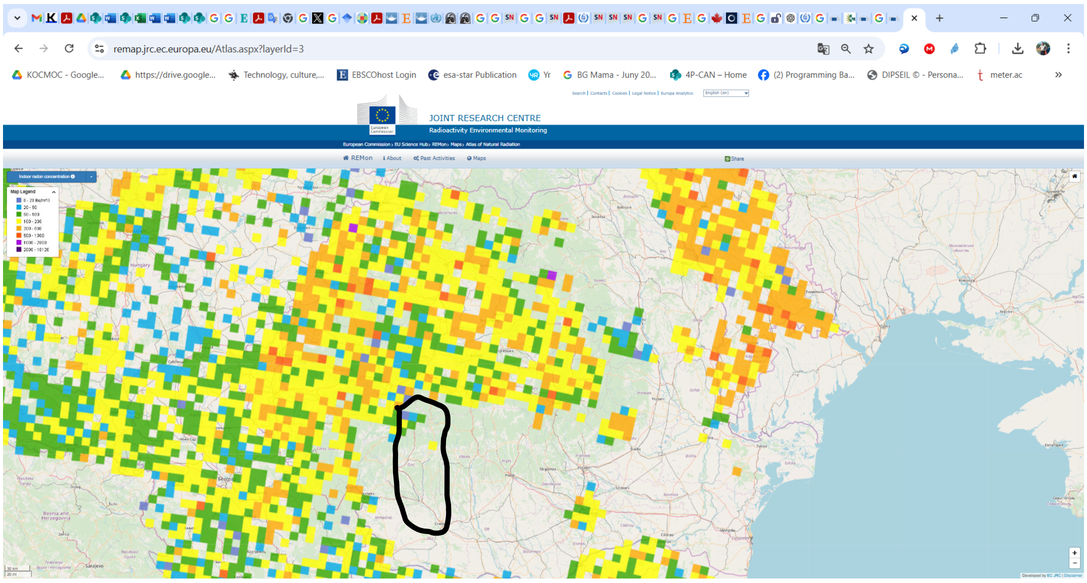


Figure 4Romania at European Indoor Radon Map



It is noticeable the significant difference between the two countries, including between two regions, selected for the study – Arges country in Romania and Plovdiv region (oblast) in Bulgaria.

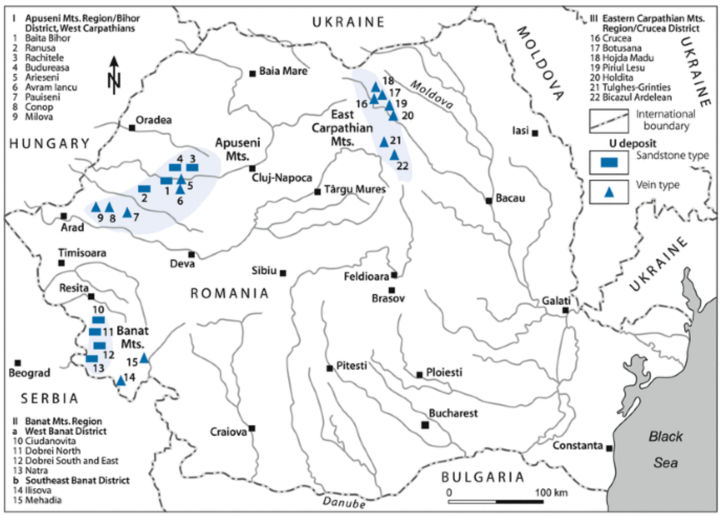
The differences found are supported by the available maps of uranium deposits in two countries. As shown in the map below, "thirty-five uranium-bearing areas containing one or more deposits were identified in Bulgaria... Most deposits are located in the West Balkan Mountains (western Stara Planina), in the western and central Rhodope Massif, and in the ***Thrace Plain,*** while a few deposits occur in the East Balkan, eastern Rhodope, and Sredna Gora Mountains as shown in Fig. 5. (Dahlkamp 2016)

Figure 5 Uranium deposits in Bulgaria

(source: Dahlkamp, F.J. 2016, Figure 2.1)

According to the same source, "uranium deposits are reported from three regions, *Apuseni Mountains* in the Western Romanian Carpathians, *Eastern Carpathian*, and *Banat Mountains*" (Dahlkamp 2016) shown at the map below:

Figure 6 Uranium deposits in Romania

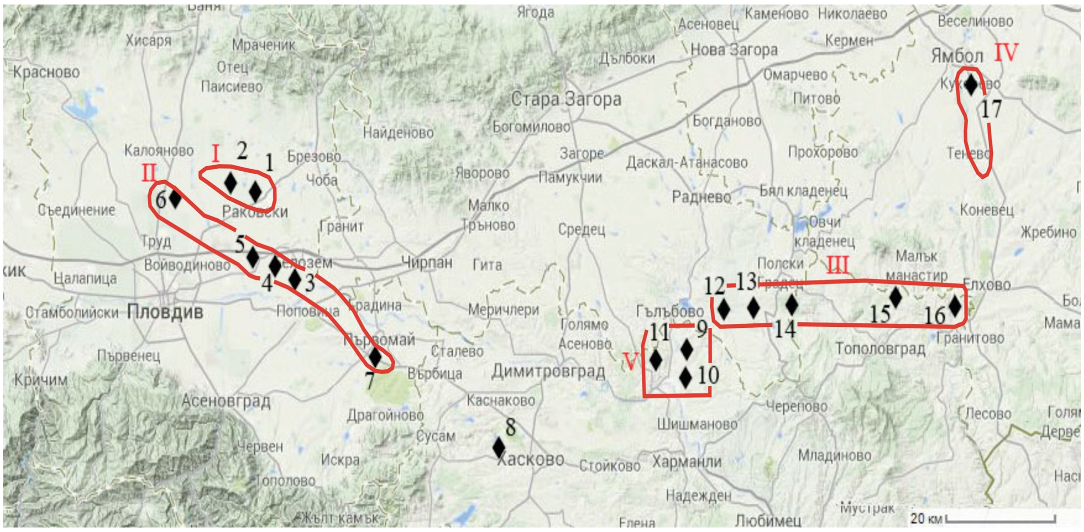


(source: Dahlkamp, F.J. 2016, Figure 12.1)

We see again that Arges county (with center Pitesti) is relatively away form the three main Romanian regions with significant uranium deposits, the Plovdiv province is practically at the center of one of the larges deposits in the country, namely *Thrace plane*.

We found more detailed map, showing the main uranium deposits in Thrace plane in an article from published in 2014 (see below). Plovdiv province comprises the western part of the map with the areas of deposits market with I and II correspondingly:

Figure 7 Uranium deposits in Thrace Plane (Plovdiv region)



(source Dikov, D. and I. Bozhkov 2014).

Based on these finding, the next task of the 4PCAN team was to very the significance of ground radon levels with the actual level of lung cancer in studied region. As seen from above, there are not preliminary evidence about high level of surface radon in Arges county, while the Plovdiv region is located at the center of one of the biggest uranium deposits in Bulgaria. Besides that, several dynamic radon sensor installed in the region by Atanas Terzysiski and his team since 2021 has pointed out higher indoor radon level, sometime exceeding tenfold the establish save levels (see for examples nodes in *Plodiv*, *Rozovetz,* and *Sarnegor* – https://meter.ac/gs/earth/html/current.html). In the section below we outline the preliminary results of secondary study of available statistics from the medical records lung cancer cases from *Plovdiv Reginal Cancer Medical Center* and Plovdiv Lund Diseases Hospital.

Lung cancer occurrence in Plovdiv Region for the period of Locating surface radon levels in studied area in Bulgaria and Romania (Arges and Plovdiv Provinces

We collected medical records for 4649 individual cases of lung cancer in Plovdiv region from *Regional Cancer Center* (PRCC). After check and cleaning the duplicates, the final database comprised 4647 patients. For 4258 it was noted that they had passed away. The remaining 398 persons were considered as alive by 2023 so we could estimate their age too. The table below shows the distribution of the group by age with some additional statistics below (mean, deviation, median, percentiles):

Distribution of initial PRCC database by age

		Count	Column N %
Age at which they died (for 398 there is no data that they died, their age is calculated as of 2023)	up to 40 years	29	0.6%
	41-50 years	195	4.2%
	51-60 years	882	19.0%
	61-70 years	1761	37.9%
	71-80 years	1395	30.0%
	81-90	367	7.9%
	over 90	18	0.4%
	Total	4647	100.0%

	Valid N	Mean	Standard Deviation	Median	Percentile 25	Percentile 75
Age	4647	67	10	68	61	74

We collected second database from Plovdiv *Regional Long Diseases Hospital* (PRLDH), which after cleaning the data comprised 3417 cases. Of these 1915 were from Plovdiv region, and 1502 from neighbor provinces.

We decided to combine the two databases by adding to the initial database from PRCC the 1915 cases from PRLDH. The resulted "All data" base consisted of 6562 cases. After cleaning of duplications there remained 5328 unique case of lung cancer.

Below we present the distribution of 5328 cases according to the municipalities and calculated Incidence index per 1000 inhabitants over 40 years of age and for the entire population (age 0 and above):

Table 1 Patients with lung cancer by municipality in the population over 40 years old

Municipality	Patients 2010-2022	Population 40+ (2016-2022 average)	Lung Cancer Incidence Index
Asenovgrad	479	35376	14
Birch	73	4200	17
Kaloyanovo	105	6833	15
Karlovo	348	28240	12
We scream	73	4208	17
Puppet	46	3861	12
Lucky	23	1750	13
Maritza	245	17829	14
Perushtitsa	48	2643	18
Plovdiv	2,509	181470	14
May Day	308	14235	22
Rakovski	228	13577	17
Rhodopes	253	19507	13
Sadovo	109	8163	13
Sopot	72	5462	13
Stamboliyski	187	10738	17
Union	108	6026	18
Hisaria	114	7433	15
Plovdiv region	5,328	371552	14

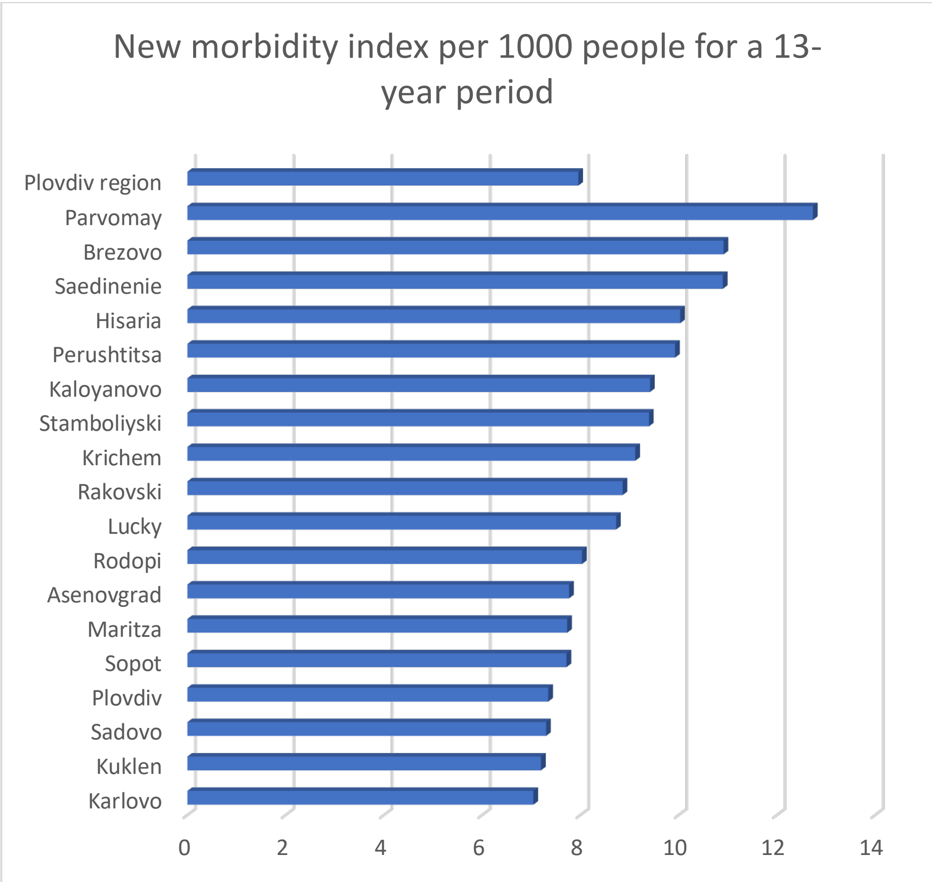
Table 2 Lung cancer patients by municipality for the entire population

Municipality	Patients 2010-2022	Population 0+ period average	Lung Cancer Incidence Index
Asenovgrad	479	61,640	7,8
Birch	73	6,687	10.9
Kaloyanovo	105	11 148	9.4
Karlovo	348	49,408	7.0
We scream	73	8,006	9.1
Puppet	46	6,424	7.2
Lucky	23	2,635	8.7
Maritza	245	31,691	7.7
Perushtitsa	48	4,834	9.9
Plovdiv	2,509	341 498	7.3
May Day	308	24 187	12.7
Rakovski	228	25,732	8,9
Rhodopes	253	31,486	8.0
Sadovo	109	14,927	7.3
Sopot	72	9,329	7.7
Stamboliyski	187	19,901	9.4

Union	108	9,907	10.9
Hisaria	114	11,362	10.0
Plovdiv region	5,328	670 803	7.9

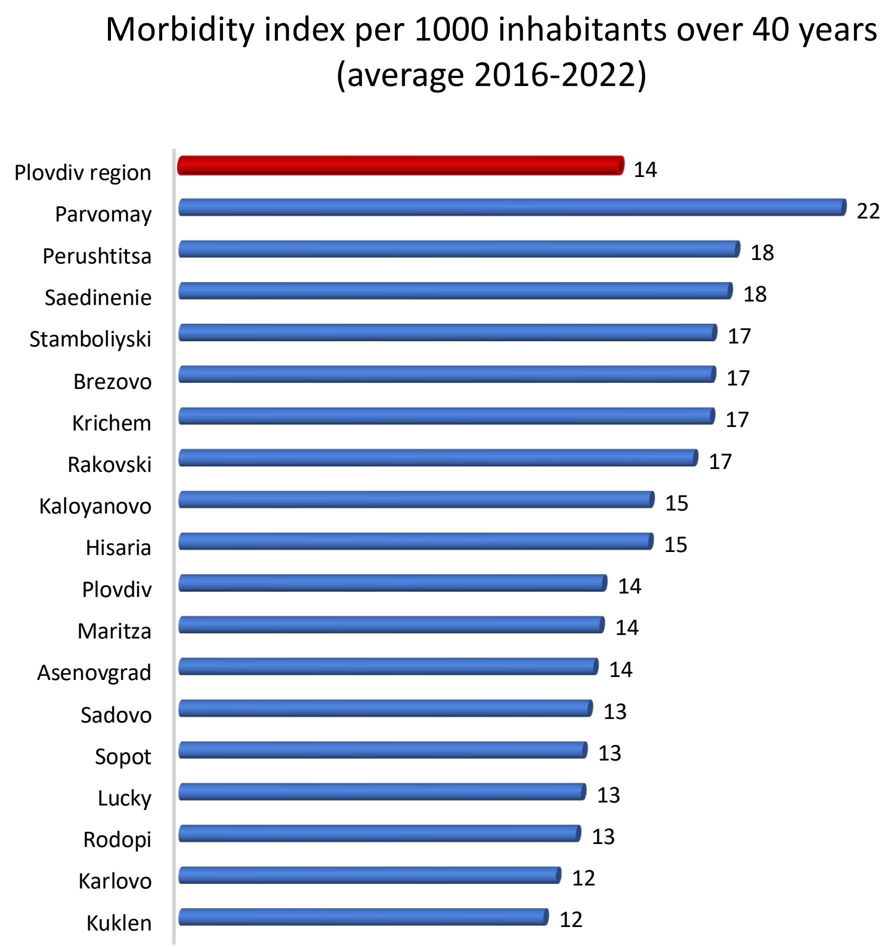
We also prepared two graphs representing morbidity index per 1000 people (for the entire population)

Figure 8 New morbidity index per 1000 people for a 13 years period



Not surprisingly, the two municipalities with highest incidence of lung cancer – *Parvomay* and *Brezovo* are those where the uranium deposits areas I and II from Figure 7 above are located. These became the municipalities where we choose the settlements for Bulgarian Living Lab!

Figure 9 Morbidity index per 1000 inhabitants over 40 years old



Preparations for real life observation of indoor radon levels in the settlements if Romanian and Bulgarian Living Labs with dynamic radon sensors

Within the framework WP2 Deliverable 2.7 Criteria for the selection of households and working premises have been elaborated based on the study of literature, consultations with experts and secondary analysis of (limited) experience in monitoring indoor radon levels with continuous dynamics measurement devices.

The selection of settlements is based on the availability of historical data on the radon level in the regions as outlined in section 2. of the interim report.

Since the radon level is relatively stable in a given area, one sensor in a given household/working premise is relevant to the levels in neighboring households (up to several kilometers depending on the geological conditions underground). Hence in each of the studied settlement in Bulgaria and Romanian no more than 3-5 sensors are needed.

As outlined in section 1 of the Interim report above, the ground radon emission enter building through several channels – ground floor, ground and first floor windows, water pipes (of water is take locally) and sewage system.

Based on preliminary evidence about the low (or unknown) level of ground radon in Arges county (Leresti Municipality) and proven high levels of ground radon in Plovdiv region (Brezovo and Parvomay municipalities) we decided not to search for low-radon level settlements in Plovdiv, but to compare the municipalities in the two countries for the effects of different radon levels.

Also, based on the evidence from the analysis of the literature in section 1, we selected neighborhoods with predominantly private houses/villas up to 2/3 floors will be selected, with the aim of a greater probability of finding people living on the ground/ground floors.

As to the type of building selected, these are to be both new building (built in the last 20 years) or older buildings; building with wooden (old) or plastic/aluminum (relatively new) type of joinery (doors and windows); availability or not of special ventilations system in the building.

Under the supervision of the team of Dr. Atanas Terzyiski the planned 15 radon sensors devices have been produced, which measured not only ground radon levels, but also fine indoor fine particles and VAC elements. In August 2024 the devices have been transferred to the Romanian partners together with instructions for selecting households, installation and use of the devices.

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Experts interviewed :

1) National Institute of Geophysics, Geodesy and Geography, Bulgarian Academy of Sciences: -
   - Assoc. Prof. Petya Trifonova, Ph.D, geophysicist, vise-director of the institute;
   - Assoc.Prof. Emil Oynakov, PhD, seismologist
2) University of Sofia – Assoc. Prof. Ludmil Tsankov, PhD, · Department of Nuclear Engineering
3) Associate Professor Dr. Dimitar Ouzounov, PhD, Schmid College of Science and Technology and the Institute for Earth, Computing, Human and Observing (ECHO) ; Chapman University

Appendix

Radon+ Monitoring Device

About

The device is an IoT gauge that constantly measures the radon volume concentration, ambient temperature, relative humidity and atmospheric pressure. It estimates the VOC and NOx indexes as well as the beta/gamma background radiation. The device is logging the ambient light as well. It transmits the data via the existing wireless network (currently supported is 2.4GHz, WPA2/AES) each 600 seconds to the METER.AC infrastructure. The high-resolution history data then can be downloaded freely from the portal https://meter.ac.

Technical data

Power supply: 5V DC, USB Type B

Operating temperature: -40…60 °C

Radon Volume Concentration: range 1…10^6 Bq/m^3

Air temperature: range -30…50 °C, accuracy ±0.2 °C

Relative humidity: range 0…100 %, accuracy 1%

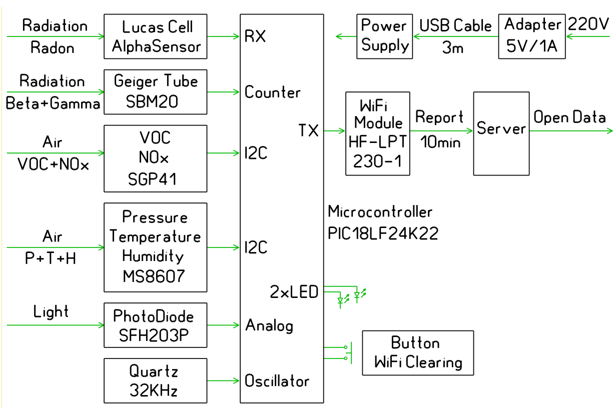
Atmospheric pressure: range 10…2000 hPa, accuracy 0.1 hPa

Background radiation: range 1…200 CPM

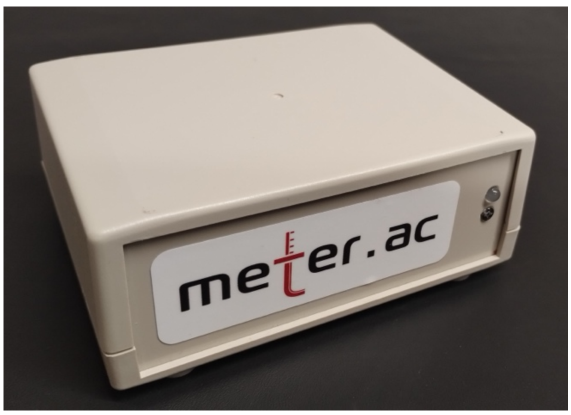
VOC and NOx: range 0…1000 ppm ethanol equivalents

Ambient light: range 0…100% for wavelength 400 nm to 1100 nm

Schematic flowchart of the device



Device view



Embedded sensors

Radon Volume Concentration: RadonTech AlphaSensor
Temperature, Relative Humidity, Atmospheric pressure: TE Connectivity MS8607
Beta/gamma background radiation: SBM-20 Geiger-Muller Tube
VOC and NOx: Sensirion SGP41
Ambient light: Osram SFH 203 P
29 May 2024

Installing the Radon+ Monitoring Device

Wireless configuration

Follow the next steps to configure your Radon+ Monitoring Device to a local wireless network

1. Switch on the device.
2. Connect to its wireless network (SSID: meter.ac, PASS: 0888717141).
3. Go to http://10.10.100.254 (USER: admin, PASS: 0888717141).
4. Replace <u>your SSID</u> with the name of your 2.4 GHz, WPA2/AES network.
5. Replace <u>your password</u> with your network's password and press OK.
6. Restart the device.

Wireless reset

Follow the next procedure for factory reset of the wireless settings

1. Switch off the device.
2. Press and hold the reset button on the bottom panel (single tiny hole).
3. Switch on the device while holding the reset button.
4. Release the reset button once the green led flashes slower.
5. Restart the device

Questionnaire and Selection Criteria for a interview with representatives of the households in settlements where Radon sensors will be installed

Sample – up to 400 people (about 200 in Plovdiv (Bresovo and Parvomai disctrics in Plovdiv) and 200 Leresti district in Arges)**,** which will be reinforced in case of unsatisfactory performance of groups. These should include families with lung cancer patients.

The questionnaire was prepared base on analysis of the methodologies and questionnaires in more than *10 lung cancer surveys*, carried out in USA, UK, and Canada, carried out by Dr. Roman Kalinov. The final version of the questionnaire was based also on specific 4P-CAN objectives.

BLOCK A: SCREENING

A.1. You live (*For the interviewer - see questions C6 and C7! It is important that they simply "live", and that important everyday activities such as cooking, spending free time, tinkering in the garage, workshop, etc. are carried out in the home)* **:**

1. in a single-family house owned only by your family/household
2. on the ground floor - ground floor of a multi-family house, cooperative
3. on the first floor (above a cellar or garage) of a multi-family house, cooperative, apartment block
4. else => TERMINATE INTERVIEW

A.2.How old are you?

To the interviewer: Write age .... and code:

1. Less than 40 years => STOP INTERVIEW
2. More than 40 years

A.3. How would you define this home for yourself?

1. as a basic, I live here permanently => GO TO QUESTION B1

2. as a cottage/summer house

A.4. Do you also come to this accommodation during the winter months?

1. yes
2. no => END THE INTERVIEW

BLOCK B: HEALTH RISKS ARISING FROM THE NATURAL PROPERTIES IN THE AREA

B.1. How do you assess the effect of the natural environment of the area in which this dwelling is located on your health?

1. as very good
2. as good
3. as satisfactory
4. as bad

B.2. Do you know any features of natural environment in this area that could have a negative impact on your health? *(To the interviewer: do not read the answers, just code the answer. More than one answer is possible)*

1. Yes, polluted air (please specify from what ....)
2. Yes, contaminated drinking water (please specify from what ....)
3. Yes , ground radon => GO TO QUESTION B5
4. Yes, another (*what?)* ....
5. No

B.3. Is there ground-level radon in this area, a radioactive gas that is a product of the decay of uranium and other radioactive elements in the earth's bowels?

1. yes
2. no
3. I don't know

B.4. Did you know that radon, especially in high concentrations, is dangerous to health?

1. yes
2. no

B.5. Have you taken measures to reduce the effect of radon on your health?

1. yes, (*what?)* ....
2. no

Radon is an inert gas that does not enter into chemical reactions and reaches the surface and ground air, penetrating the ground floors of homes, and from there it enters the lungs. It is a source of radioactive radiation and is the main second cause of lung cancer after smoking.
We will ask you questions that will allow us to assess the health effects of radon.

BLOCK C: CHARACTERISTICS OF THE DWELLING

C.1. Does the house/building block you live in have: *(each correct answer)*

1. cellars (underground garage)
2. premises in a semi-excavated floor
3. premises on the ground floor
4. premises on the first floor (above the ground floor)
5. premises on the second floor or higher

C.2. What basic material is the home made of?

1. bricks
2. concrete
3. wood / wooden frame with wadding or other filler
4. stone
5. other...

C.3. What basic material is the floor of the ground floor of the building made of?

1. concrete
2. joist
3. other ....

C.4. What is the woodwork in your home? *For the interviewer: If there are different types of windows, what is it in the room where the respondent spends most of the day - living room/living room, bedroom?*

1. wooden joinery
2. plastic (aluminum) joinery

C.5. Do you have an active air ventilation system in the premises of your home? *For the interviewer: Active ventilation means the presence of openings in or above the windows for ventilation; presence of ventilators/expirators - in* *the bathroom, in the kitchen, in other rooms; availability of a special radon removal system .*

1. yes
2. no

C.6. Where is the premises in which you usually carry out the following activities:

	Cellar	Semi-excavated floor	Ground floor	First floor (above ground)	Second floor or higher
1. You spend the active part of the day at home – you work, incl. housework, you rest	1	2	3	4	5
2. You are sleeping	1	2	3	4	5

C.7.How do you most often ventilate the premises in which you usually carry out the following activities:

	Percussively - we open a window, a door wide	We make a current	Through a partially open window, incl. a small window - vent
1. You spend the active part of the day at home - you work, incl. housework, you rest	1	2	3
2. You are sleeping	1	2	3

C.8. In winter, how often do you ventilate the premises in which:

	there is always an open window/vent	2-3 times a day	less often
1. You spend the active part of the day at home - you work, incl. housework, you rest	1	2	3
2. You are sleeping	1	2	3

C.9. Do you ventilate the room you sleep in before going to bed?

1. yes, regularly
2. yes, sometimes
3. no

UNIT D. LIFESTYLE CHARACTERISTICS THAT FAVOR THE DEVELOPMENT OF LUNG CANCER

D.1. Have you ever smoked? *For the Interviewer: Includes manufactured, hand-rolled, filter, unfiltered, flavored tobacco cigarettes*

1. yes
2. no=> GO TO QUESTION D6

D.2.Do you currently smoke?

1. yes => GO TO QUESTION D4
2. no

D.3. When did you quit smoking?

1. 15 or more years ago
2. less than 15 years ago

D.4. On average, how many cigarettes do you smoke/have you smoked per day? ……………

D.5. What is the total number of years you have smoked? …………

D.6. Have you lived and/or worked for a long time (more than 10 years) among smokers?

1. yes, *please explain* ……………………………………………
2. no

D.7. Have you ever been diagnosed with the following diseases:

1. COPD (chronic obstructive pulmonary disease)
2. emphysema
3. bronchitis
4. pneumonia
5. tuberculosis
6. I haven't been

D.8. What do you think the air is like here (around where the house is)?

1. heavily polluted
2. somewhat polluted
3. slightly polluted
4. it is not contaminated
5. I don't know/I can't judge

D.9. Have you lived for 10 years or more in or near a city with a population of more than 100,000?

1. yes
2. no

D.10. Have you ever been diagnosed with a malignancy or cancer other than non-melanoma skin cancer ?

1. yes (*please specify* ………………………………………… ………………………………………………… …………)
2. no

D.11. Has anyone in your family or friends been diagnosed with lung cancer?

1. yes, a blood relative - parents, siblings, children or other blood relatives
2. yes, non-blood relative - spouse, father-in-law, father-in-law, brother-in-law
3. no
4. I don't know

D.12. In the past 6 months, have you had: *(each correct answer)*

1. cough
2. wheezing
3. out of breath
4. coughing up blood

D.13. Have you had a chest CT scan in the last 12 months?

1. yes
2. no

D.14. Have you practiced any of the following professions *(each correct answer)*

1. Asbestos worker
2. Bartender/waiter
3. Ceramic industry worker
4. Chemist
5. Masonry and plastering
6. Plastering and working with plasterboard
7. Painter
8. Glazier
9. work in a manufacturing environment (please specify which industry)
10. Metallurgy
11. Printer/Printer
12. Sandblasting
13. Driving a truck
14. Uranium mining
15. Work in underground mines (ore, coal, etc.)

D.15. To your knowledge, have you been exposed to substances such as radon, silica, cadmium, asbestos, arsenic, beryllium, chromium, diesel fumes, nickel?

1. yes
2. no

E. BLOCK OF QUESTIONS FOR RELATIVES SICK OF LUNG CANCER – for those who answered 1 and/or 2 to question D11

You said you have a relative with lung cancer. We'd like to ask you a few questions about it.

E.1.Is this relative of yours alive?

1. yes
2. no=> GO TO QUESTION E3

E.2. Where does this relative of yours currently live?

1. in our locality => *To the surveyor* : ask for an address to survey him and GO TO QUESTION F1
2. elsewhere

E.3. Where did this relative of yours live (more than one answer)?

1. with us, in our dwelling
2. in another residence in our settlement
3. in another settlement nearby
4. in or near a city of over 100,000 inhabitants
5. elsewhere

E.4. Did he smoke?

1. yes
2. no
3. I don't know

E.5. And was he a passive smoker, ie. been exposed to tobacco smoke for a long time without smoking?

1. yes
2. no
3. I don't know

E.6. What did this relative of yours worked (up to three occupations according to duration)

....

0 I don't know

F. DEMOGRAPHIC CHARACTERISTICS

F.1. Gender (*to be filled in by the interviewer*)

1. a man
2. a woman

F.2. Your education:

1. University (bachelor) and higher
2. Secondary education

3. Basic education or lower

F.3. You are:

1. Actively employed, self-employed
2. pensioner
3. unemployed
4. other .....

F.4. What have you worked (up to three occupations according to duration)

………………..

F.5. How much of the day do you usually spend outside your home (including going to work, shopping, yard work, walking and playing sports outdoors, etc.)?

1. almost all day, i just go home to sleep
2. most of the day
3. the lesser part of the day
4. very little, I only leave the house for a few hours a day