

IRSN

INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Enhancing nuclear safety



Radon

Radon is a naturally occurring radioactive gas that represents a third of the radioactivity received by people in France each year

What do we need to know about radon?

Radon is a naturally occurring radioactive gas. It is generated by the decay of uranium and radium in the earth's crust. It is found in all parts of the earth's surface but is mainly derived from granitic and volcanic subsoils as well as from certain construction materials.

Radon is one of the causes of lung cancer, although it comes far behind the risk of cancer from smoking.

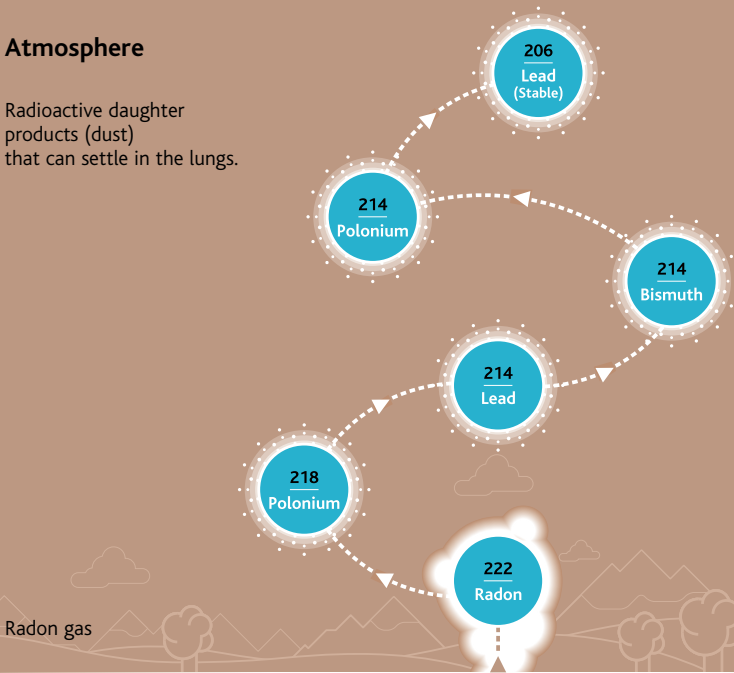
Radon can build up in enclosed areas, particularly in houses.

It is rather simple to reduce radon concentrations in homes:

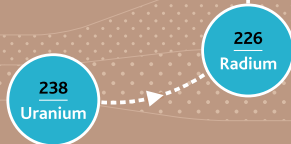
- air and increase ventilation in buildings, basements and crawl spaces,
- improve the airtightness of walls and floors.

Atmosphere

Radioactive daughter products (dust) that can settle in the lungs.



Materials from the earth's crust



Radon: from soil to air.

Contents



- 1 ■ The health risk from radon exposure** p. 2
 - Results of epidemiological studies
 - Results of risk assessments

- 2 ■ Radon in the environment** p. 4
 - Weather conditions
 - Properties of soils and rocks

- 3 ■ Radon in the home** p. 7
 - The campaign to measure radon in French homes
 - How radon enters the home
 - Radon concentration varies depending on the occupation and life styles of people in the house

- 4 ■ Measuring radon** p. 10

- 5 ■ Principles for reducing radon concentrations in homes** p. 11

1

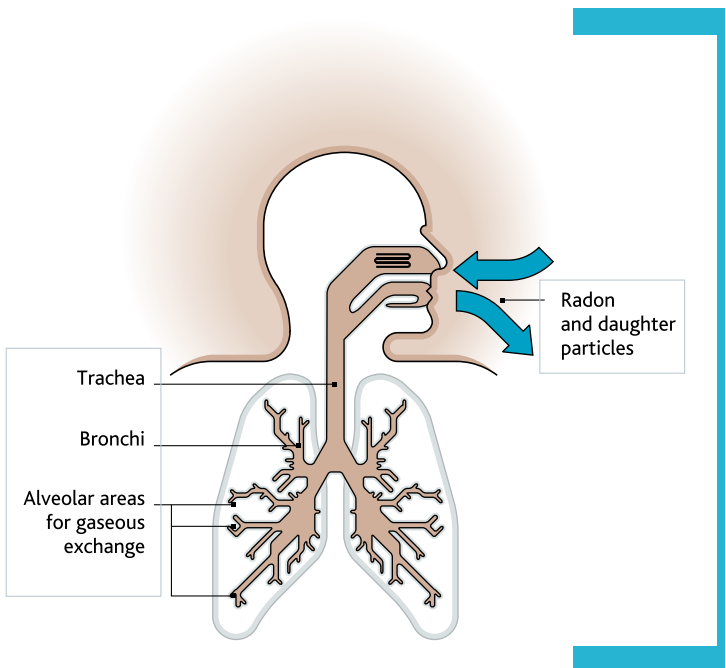
The health risk from radon exposure

□ Results of epidemiological studies

In some parts of the country, the radon accumulated in some homes or other buildings can become a significant source of exposure to ionising radiation for the population.

The risk of lung cancer is behind the vigilance concerning radon in homes or other buildings. Radon and its solid daughter products enter the lungs with the air that is breathed in. These daughter products emit alpha radiation that can lead to the development of cancers.

A number of epidemiological studies conducted recently have confirmed that there is a risk of lung cancer not only with underground miners, but also with the general population. The results of all the epidemiological studies concur, demonstrating an increased risk of lung cancer with the



cumulated exposure to radon and its radioactive daughter products*. The latest results obtained on the general population show that this radon-related risk applies to smokers and non-smokers alike.

The exposure of people to radon in homes can reach exposure levels close to the levels observed in uranium mines in France.

Several international bodies (UNSCEAR, WHO, etc.) are currently preparing a summary of available data that will be used to define a global risk management policy for domestic exposure to radon.

* *Radioactive daughter products: see diagram on the back of the cover page.*

□ Results of risk assessments

There have been many evaluations of the risk of lung cancer from domestic exposure to radon worldwide, especially in the United States, Canada and the UK.

In France, lung cancer kills about 25,000 people every year*. A quantitative evaluation of the health risks associated with domestic exposure to radon conducted in metropolitan France in 2004 revealed that radon could be responsible for certain deaths from lung cancer in a proportion that could be as high

as 10%. These estimates take into account factors such as variations of radon exposure in the entire country, the interaction between radon exposure and smoking as well as the uncertainty that is inherent to calculations of this type. Research is being conducted at the European level to reduce this uncertainty in particular with respect to the quantification of the interaction between smoking and radon.

* *Source: 1999 national mortality data.*

2

Radon in the environment

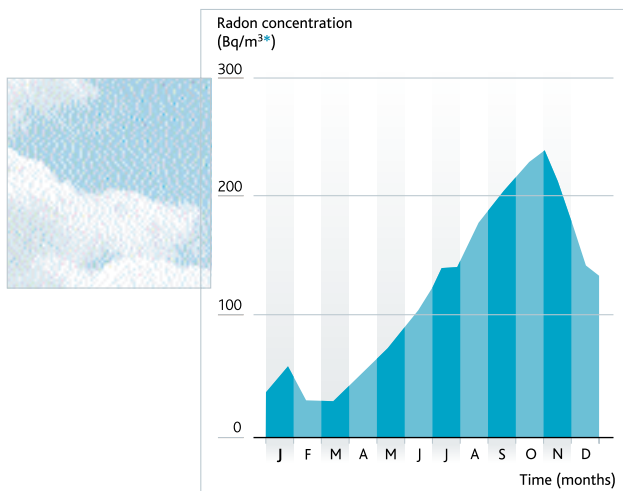
Radon is produced everywhere on the earth's surface from uranium in soil. Its emission to the air depends on two factors:

□ Weather conditions

This is one of the reasons for the difference in radon concentration in time in a given place. Depending on the soil composition, these conditions (wind, sun, rain, cold, etc.) will modify the emission of radon from the soil to the air.

* Bq/m^3
(BECQUEREL PER CUBIC METRE)

One becquerel (Bq) corresponds to one disintegration per second. The Bq/m^3 (or $Bq \cdot m^{-3}$) is the unit of measurement of the radon concentration in the air.



Example of the monthly change in radon levels in the Massif Central.

□ Properties of soils and rocks

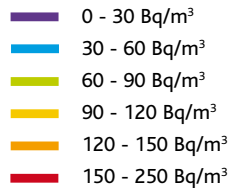
The radon level varies from one place to another in the same region depending on the natural uranium content of the subsoil.

The type of rock is one of the key parameters that affect the emission of radon into the air. Measurements taken along a road, show that concentrations vary from one place to another depending on the geological characteristics (see below).



IGN ordnance survey map no. 31, scale 1:100 000

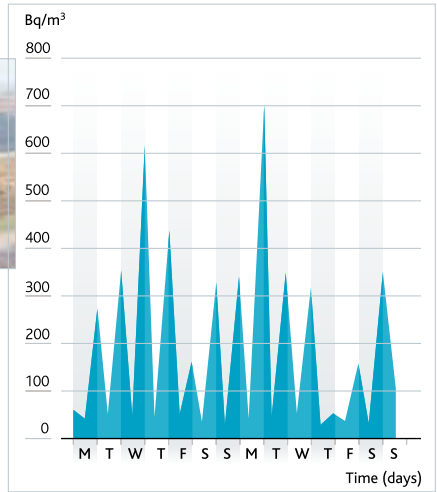
—|—| = 1 km



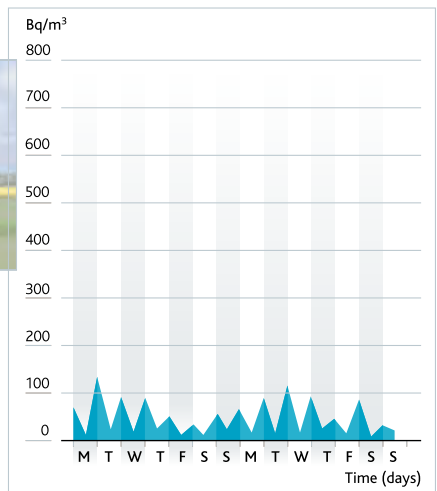
Measurements made at night (the period when the radon concentration in the air is highest).

Note the daily changes in radon levels.

Granitic subsoil: **Brittany**



Sedimentary subsoil: **Greater Paris area**





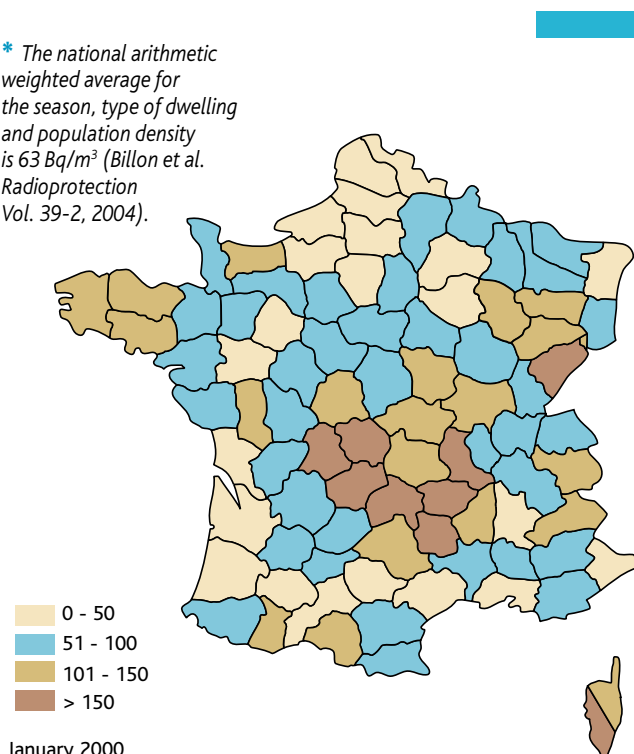
□ The campaign to measure radon in French homes

Geographical distribution by department

IRSN has been carrying out radon measurement campaigns for several years now. As a general rule, granitic subsoils release more radon than sedimentary soils because they have a high

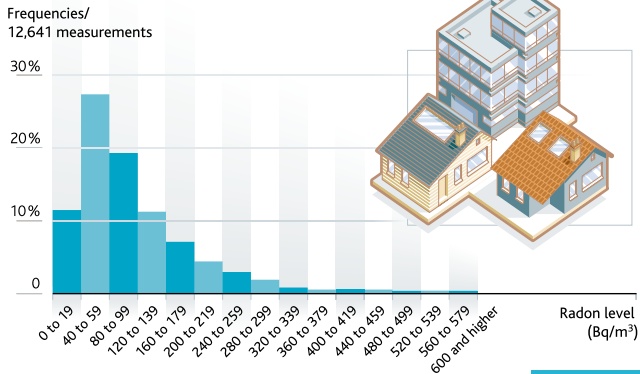
natural uranium content. The average measurement taken in France is 90 Bq/m^3 *, which is higher than the UK average (20 Bq/m^3) and lower than the Swedish average (108 Bq/m^3).

* The national arithmetic weighted average for the season, type of dwelling and population density is 63 Bq/m^3 (Billon et al. Radioprotection Vol. 39-2, 2004).



Average radon concentration
in the air of homes per department (in Bq/m^3)

Radon concentrations vary greatly from one home to another.



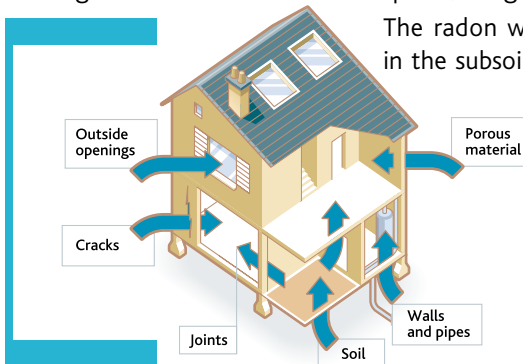
Distribution of radon volume activity in France

- Number of homes measured: 12,641 • Arithmetic mean: 90 Bq/m³
- Minimum: 5 Bq/m³ • Maximum: 4,964 Bq/m³ • Median: 50 Bq/m³
- National arithmetic weighted average for the season, type of dwelling and the population density: 63 Bq/m³
- Number of measurements above 200 Bq/m³: 1,141 or 9.0%
- Number of measurements above 400 Bq/m³: 294 or 2.3%
- Number of measurements above 1,000 Bq/m³: 60 or 0.5%.

□ How radon enters the home

Concentrations can also vary with the characteristics of the building and its ventilation.

Radon may be concentrated in enclosed areas (basement, crawl spaces, living quarters).

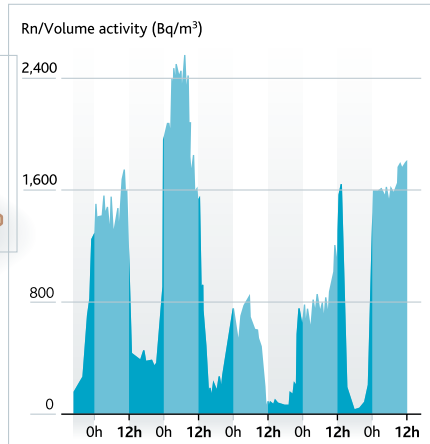


The radon which accumulates in the subsoil and crawl spaces, enters houses through different openings (cracks, piping, etc.).

□ **Radon concentration varies depending on the occupation and life styles of people in the house.**

The radon concentration in a home will vary with each hour in the day depending on the degree and frequency with which doors and windows are opened.

That is why it is important to take a measurement that is representative of the annual average value.



Variations in radon concentration inside the house during the day.

4

Measuring radon

The principle behind a dosimeter is similar to the one used in photography. The alpha particles emitted by radon strike the dosimeter film. A chemical process reveals the impacts on the film. A micro-computer associated with a microscope, connected to a camera recognises these impacts and counts them.



IRSN radon calibration system.

Radon measurements are governed by AFNOR standards that stipulate that the instruments used must be recalibrated to a standard.



Examples of dosimeters used by the IRSN for measuring radon levels in buildings.

WHO TO CONTACT?

If you need any information about the following:

- radon, health risks, measuring equipment and their calibration,
- the list of companies that sell dosimeters,
- your home radon levels, go to the website

www.irsn.fr

*You can also contact your **departmental board of health and social action (DDASS).***

5 Principles for reducing radon concentrations in homes

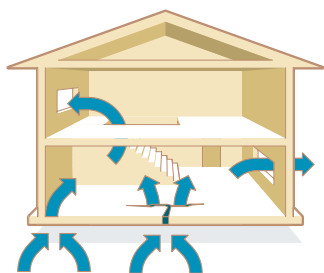


Every one can measure the radon level in their home and act to reduce the pollution level with actions that are often simple and inexpensive. Radon concentration can be reduced in two ways:

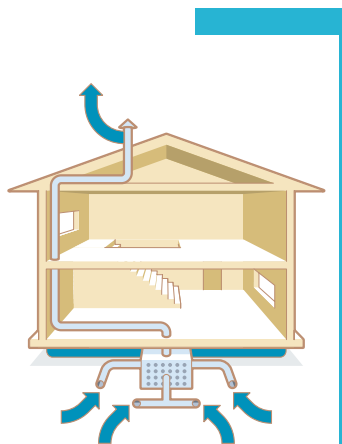
- by preventing radon from coming indoors by ensuring airtightness between the soil and the building (blocking of cracks and pipeways with silicon

glues or cement, laying a membrane on a layer of gravel covered with a concrete slab, etc.) or developing overpressure in the indoor space or a depression in the underlying soil;

- by eliminating, through dilution, the radon present in the building, through natural aeration or mechanical ventilation, thereby improving the renewal of the indoor air.



Airing of living spaces by opening of windows.

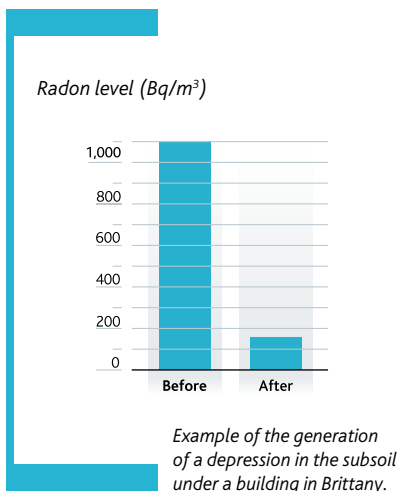


Drainage of radon by generating a depression in the subsoil under the building.

The two types of actions are usually combined.

The effectiveness of a reduction technique must always be checked after it has been used, by

measuring radon levels again. The continuity of the solution chosen must also be checked on a regular basis (approximately every 10 years).



PERSISTENT CONCENTRATIONS

*If radon levels continue to be high, contact the **IRSN, the Nuclear Safety Authority (ASN)** or your **departmental board of health and social action (DDASS)** to know the additional measures to carry out.*

The IRSN

The Institute for Radiological Protection and Nuclear Safety (IRSN) is in charge of the scientific assessment of nuclear and radiological risk. It is a state-funded public establishment of an industrial and commercial nature (EPIC) that carries out research and appraisals for the government and the general public. It is a reference organisation both in France and abroad, with a workforce of over 1,700 people who cover diverse range of disciplines ranging from life sciences to nuclear physics. It carries out research and appraisals in the following fields of expertise:

- protection of persons and the environment against risks from ionising radiation,
- safety of installations and the transportation of radioactive material as well as the protection of these against malicious acts,
- control of nuclear materials and products that may be used in the manufacture of weapons,
- crisis management.

It also contributes to providing the public with information.



Radon

To protect the public from radon-related health risks, the IRSN carries out research on measurement methods, analyses buildings and the environment and assesses the actions to be undertaken.



IRSN certified quality
management system

IRSN

INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Head office
31, avenue de la Division Leclerc
92260 Fontenay-aux-Roses
Registered at the Nanterre Trade and Companies
Register under no. B 440 546 018

Telephone
+33 (0)1 58 35 88 88

Postal address
B.P. 17
92262 Fontenay-aux-Roses Cedex
France

Website
www.irsn.fr