Theremino **System**

About Radon

Radon

Radon is a constituent of the air, since millions of years. We were unaware of its existence, until tools that can detect and measure it, were created. Its presence causes a lot of concern, because of the alarming statistics regarding it links with lung cancer.

Radon is the element 86 in the periodic table - abbreviated "Rn" - an invisible gas, colorless, odorless, non-hazardous by itself, but unstable and therefore radioactive.

Radon isotopes are formed in rocks containing Uranium, Thorium and Radium and passes easily through many substances such as soil, porous rocks, and even plastic. Spread easily in air and water and are carried by them.

Radon and its descendants

Radionuclide	Alternative Name	It comes by:	Time halving	Main emission energy (MeV)		
				Alfa	Beta	Range
Rn-222 (1)	**Radon**	Radium-226 and Uranium-238	3.82 days	5.49	-	-
Po-218 (1)	-	-	3.2 min	6.00	-	-
Pb-214	-	-	26.8 min	-	0.67 / 0.73 / 1.03	0.25 / 0.30 / 0.35
Bi-214	-	-	19.9 min	-	1.51 / 1.54 / 3.28	0.61 / 1.12 / 1.76
Po-214 (1)	-	-	0:16 ms	7.69	-	-
Pb-210	-	-	22.3 years	-	0.17 / 0.63	0.046
Bi-210	-	-	1.5 days	-	01.16	-
Po-210 (2)	-	-	138 days	5.30	-	-
Pb-206	-	-	stable			

Thoron and Actinon

Radionuclide	Alternative Name	It comes by:	Time halving	Main emission energy (MeV)		
				Alfa	Beta	Range
Rn-220 (3)	**Thoron**	Thorium-232	55.6 seconds	**(5)**	-	-
Rn-219 (4)	**Actinon**	Uranium-235	3.96 seconds	**(5)**	-	-

(1) *Highlighted in yellow the three alpha decays of our interest (which are counted by the ion chamber)*

(2) *The disintegrations of Po-210 are far fewer. Their effect is negligible and indistinguishable from random noise.*

(3) *The Thoron has a decay almost 6000 times faster than the Radon and it's easy to produce it, as a descendant of thorium-232. For these reasons, it is often used in laboratory tests, but not important in environmental measures.*

(4) *The Actinon is very rare. It is not measured normally and is not important in environmental measures.*

(5) *Both the Thoron and Actinon decay with alpha emission, but their energy is not specified, as produced mainly by the descendants, not been listed here.*

Indoor and outdoor concentrations

The outdoor concentration of radon **is about one thousandth of its concentration in the soil**. This can be demonstrated by placing a bucket upside down on the bare ground, with a measuring device inside. The radon emanating from the ground, is collected in the bucket, until reaching an equilibrium condition. The monitor will indicate **a radon concentration,** that is **hundreds of times higher than in the surrounding air.**

A house with foundations, walls, floors and a roof can be considered **similar to an upturned bucket** and traps radon, especially if all the windows are closed. In these conditions, radon may become 10 to 100 times more concentrated than outside.

Living in developed countries we spend most of the time indoors. At work, at school, or at home, you are easily exposed to radon concentrations, high enough to endanger health.

Water concentrations

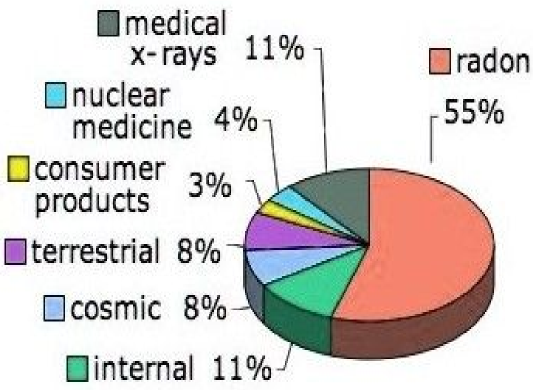
Not all drinking water containing radon. If the water comes from a surface source such as a river, lake, or reservoir, much of the radon is released into the air or decades before reaching the taps at home. Radon is only a problem if water is pumped from wells and comes directly from the aquifer. However, not all deep sources, contain radon.

Currently there are no legal limits for the concentration of radon, in the water. Current regulations of some aqueducts, set a limit of 4000 Bq/m3 (100 pCi/l), while some, proposed laws to reduce the level of radon in drinking water, below 10000 Bq/m3 (300 pCi/l)

Dangers of Radon

Radon gas, is actually the second leading cause to lung cancer, after tobacco smoking, in Italy (ISPESL - National Institute for Prevention and Safety at Work - Publication "Radon in italia.pdf")

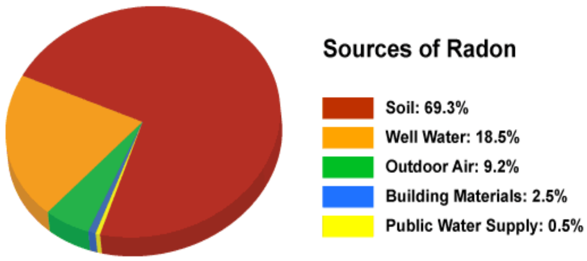
The exposure to radon, is one of main causes of tumor, being responsible of roughly half of the total radiation absorption, of the whole human population. It is considered one of the main causes of lung cancer, after cigarette smoking. The International Agency for Research on Cancer (IARC) has classified radon among the most carcinogenic products (class 1).



This important hazard, has been much neglected until now, even if its dangers are well known since long time. How much radon is widespread in homes and Its importance on our health, are causes of concern and completely understood just a few years ago. Just recently, radon's importance is understood, and its presence in homes not underestimated.

Humanity has always been exposed to some sort of radioactivity of natural origin. Today this exposure has increased, since we live mainly in closed, poorly ventilated spaces. The most important proportion of radiation absorbed, is mainly derived from the exposure to radon, in the air of the environment we live.

The presence of dissolved radon in drinking water and it's ingestion, causes a minimal risk for stomach cancer. The main risk related with the presence of radon in drinking water, is due to the transfer of radon into the air.



Radon spreads easily from water to air. When concentrations are particularly high, water (for example in the shower) helps to significantly increase the concentration of radon in the air.

Radon concentration (Approximate)		Number of people dying from lung cancer (*) (Per 100 people)	
Bq/m3	**pCi / L**	**No Smoking**	**Smoking**
1500	40	10	60
750	20	4	26
400	10	1	15
300	8	-	12
150	4	-	6
75	2	-	3
50	1.25	-	2
15	0.4	-	1

(*) According to data collected by the U.S. Agency EPA (Environmental Protection Agency) in the research "Lifetime risk of lung cancer deaths from EPA Assessment of Risks from Radon in Homes (EPA 402-R-03-003)"

Maximum levels according to the law

The Environmental Protection Agency (EPA) has declared that a radon level of less than 150 Bq/m3 (4 pCi/l) has little or no risk to health.

EPA has also issued some recommendations for specific actions to be taken, where there is a higher concentration level. These include follow-up testing of the other rooms in the house. However, as in the final analysis there is no absolute acceptable level established scientifically, it is up to the homeowner to decide what level of radon is acceptable to his house.

Reports of comparison of risks published, indicate that a radon concentration of 1,000 Bq/m3 (30 pCi/l) results in approximately the same cumulative risk as smoking two packs of cigarettes a day.

Biological mechanisms

The health threat of radon is indirect. When humans breathe alpha particles contaminated air, produced by the disintegration of radon and its descendents, they are exposed to chromosomal damage in the thin layers of lung tissue. This damage is a potential cause of lung cancer, especially when combined with the effects of cigarette smoking.

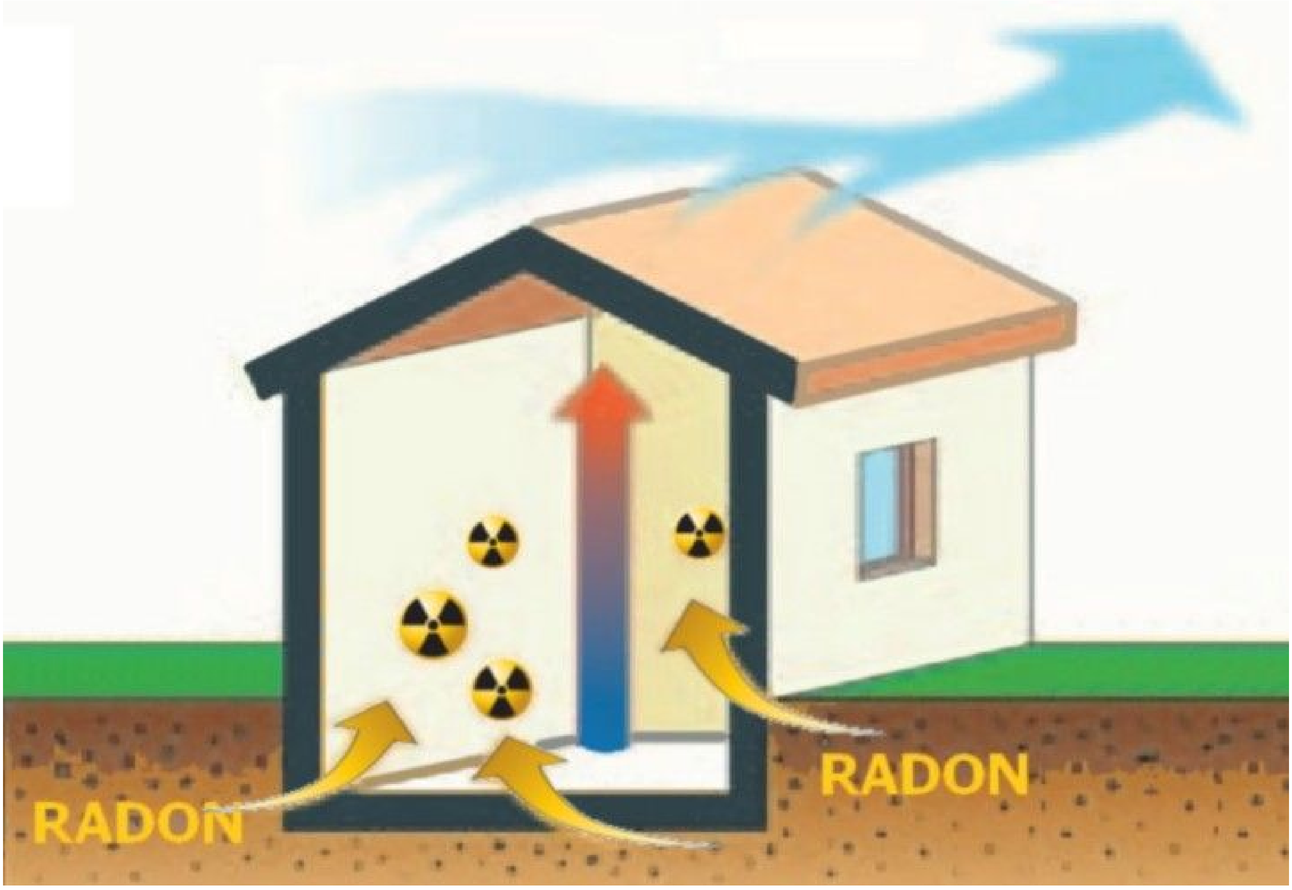
Most of radon 222 (5.5 MeV) that is inhaled or exhaled directly, diffuses into the bloodstream, where its alpha-emitting emissions do little harm. However, short-lived radon descendents as Polonium-214 and Polonium-218, emit alpha particles of higher energy (6 MeV and 8 MeV), which are capable of damaging the more sensitive human tissue.

Atoms of radon may disintegrate in turn, forming polonium, bismuth and lead. These products "of decay", are radioactive and associate easily with the aerosol of the air we breathe. The decay products, accumulate gradually in closed spaces. During breathing, they can penetrate lungs, deposit on the lung tissue, irradiating it, in some cases starting a carcinogenic process.

How radon enters homes

Radon's concentration in the atmosphere, varies according to seasonal and daily variations of temperature and atmospheric pressure.

The concentration of radon indoor is on average, 10 times higher than that found outdoors. Radon seeps into the ground through cracks in walls and floors, cables passages or pipes.



The main cause of the presence of radon in homes, is decreased pressure between the living areas and the ground. Decreased pressure is caused by wind and by differences in temperature, higher in winter when buildings are heated. The effects of this depression, results in the aspiration of air from the soil, with its radon content. The aspiration of radon is facilitated by openings such as chimneys, windows, skylights, as well as air extraction systems for the kitchen, bathroom, etc. ..

Even without pressure difference between indoor air and the soil, radon can penetrate easily (but more slowly) due to diffusion. The diffusion occurs according to Fick's law: "Two volumes of air, having different concentrations of pollutants, tend to dilute, reaching homogeneous concentrations".

Points of entry of radon

1 Walls

2 Sockets (through the tubes of the electrical system)

3 Wells

4 Pipe

5 Ground Floor

6 External openings (windows and exterior doors)

7 Internal openings

8 Porous materials (walls and floors underground)

9 Fireplaces

10 joints between walls and floor

11 Cracks and fissures

Curie and Becquerel conversions

Conversion Tables

Bq/m3	pCi / l
0.5	0.013
1	0.027
2	0.054
5	0.135
10	0.27
20	0.54
50	1.35
100	2.7
200	5.4
500	13.5
1000	27
2000	54
5000	135
10000	270
20000	540
50000	1350
100000	2700

pCi / l	Bq/m3
0.01	0.37
0.02	0.74
0.05	1.85
0.1	3.7
0.2	7.4
0.5	18.5
1	37
2	74
5	185
10	370
20	740
50	1850
100	3700
200	7400
500	18500
1000	37000
2000	74000

Simple conversions

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1 Curie = 37 GigaBequerel

1 pCi = 0.037 Bq

1 Bq = 27.02 pCi

By the time (minutes and seconds)

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1 Bq = 1 CPS (one disintegration per second)

1 Bq = 60 CPM

1 pCi = 0.037 CPS

1 pCi = 2.22 CPM

With the volume (1 cubic meter = 1000 liters)

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1 pCi/l = 37 Bq/m3

1 Bq/m3 = 0.02702 pCi/l

Concentrations of radon

Conversions in parentheses, from Bequerel per cubic meter to picocuries per liter, are approximated with a ratio of 40, instead of 37, to obtain the usual values rounded to multiples of 1, 2, 4, 5

Maximum levels recommended by the EPA

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For buildings to be built: 150 Bq/m3 (4 pCi/l)
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Maximum levels according to the European legislation (recommended)

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For existing buildings:    400 Bq/m3 (10 pCi/l)
For buildings to be built: 200 Bq/m3 (5 pCi/l)
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Maximum levels according to some regulations

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Working ambients     = 800 Bq/m3 (20 pCi/l)
Basement with radon  = 400 Bq/m3 (10 pCi/l)
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Outdoor radon concentration

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From 5 to 10 Bq/m3 (from 0.2 to 0.4 pCi/l)
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Orders of magnitude in scale with picoCurie and Bequerel

pCi/liter	Bq/m3	pulse/min	pulses/second	outcome
0.01	0.4	0.02	-	(Note 1)
0.1	3.7	0.2	-	don't worry
1	37	2	0.03	check often
10	370	22	0.3	get worried
100	3700	220	3	do something immediately
1000	37000	2200	33	(Note 2)

(Note 1) A concentration so low, lower than the outside air, is measurable only if the ion chamber doesn't work properly or if it is sealed in a container insulated to radon for about ten days.

(Note 2) Google searching for "radon graph" (in images mode) you can check hundreds of graphics. Almost no one, shows values over a few hundred pCi/l

Characteristics of materials

Solubility coefficients characteristic of radon in different materials (20 ° C, 1 atm)

Material	Solubility coefficient
Water	0.25
Air	1
Polyethylene	5-10
Rubber, silicone	10-50
Ethylic alcohol	6
Acetone	6
Benzene	13
Toluene	13
Xylene	13
Chloroform	15
Ether	15
Hexane	17

Water-resistance of building materials

Material	Impermeable to radon
HDPE foil 1.5 mm	yes
PVC alloy 1 mm	yes
Polymer bitumen 4 mm	yes
Epoxy resin 3 mm	yes
Paint 0.2 mm	no
Cement 100 mm	no
Stone 150 mm	no
Plastic 100 mm	no
Bricks 150 mm	no

Radon diffuses through the EP, in fact the passive dosimeters with LR-115 film are housed in a box, which is then inserted into a sealed PE bag, ready for the exposure (it is exposed this way, sealed). Each exposure is generally accompanied by a blank proof carried out in parallel on the same batch of dosimeters, then saved. For the preservation, envelopes are made, cutting and folding the aluminum plastic where you will put the complete dosimeter, then closed by heat sealing the flaps.

Main features of the Radon

Atomic number	86
Atomic weight	222
Color	colorless
Density at 1 bar and 0 ° C	9.73 gr./Lt
Solubility in water at 1 atm. and 20°C	230 cm3/kg
Boiling point at 1 atm.	- 62 °C