“Research about the quantity of Radon in our everyday places”

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Abstract

The idea of our project comes from our school (Collegio Ballerini); the idea is to detect the main sources of Radon (Rn-222) in order to discover eventual endangered zones.

Previous studies\(^1\) have shown that Rn is more concentrated in basements, granite-built structures and shafts\(^2\).

Radon is a radioactive noble gas coming from the decay of Uranium radioisotopes U-238 found in soil and in building materials. Its halving time is 3.8 days and it decades by emitting \(\alpha\) radiations\(^3\).

We put CR-39 glasses in several locations\(^4\) exposed to Rn emissions; the target places were chosen among the ones which were presented by students after their scholar researches held during the summer 2015.

The aim of the research is to figure out wether the Radon level of the places is legal according to the Italian laws\(^5\).
Introduction

As multiple researches have demonstrated that radon can deal severe damage to human organism (due to its Alfa decay), it has been registered as the second most common cause of lung cancer, according to the UN World Health Organization (the first one is smoking): Alfa particles are able to modify human DNA and could be introduced to human body by inhalation or ingestion. Due to this reason, Italian laws have established a limit of Rn level in every building\(^5\).

Radon is a noble naturally produced by the radioactive decay of Uranium and Thorium. Radon itself has a relatively short half life\(^6\). Radon is present in the ground, underwater (especially in aquifers), building materials or laval stones. These materials can emit Rn in its gas form, so it’s more likely to be found in underground and close locals, such as basements. This process is analogue to the one that makes Radon decay products, known as “Radon daughters”, common as the noble gas itself.

The aim of this research is to calculate the presence of Radon in different Italian locations and buildings in order to have just a vague idea of the level in those places and, if possible, to make a comparison between the results.

Materials

- 0,5 L of distilled Water
- 1 microscope
- 1 PC
- Ice
- application Motic Educator
- 24 CR-39 glasses 20x35x0,8 mm
- 24 expansion chambers
- 1 Becker
- 1 fryer
- 120 g of NaO
Methods

- Fix each CR-39 to an expansion cell.
- Place the cells in the chosen places. (fig. 1)
- Let each CR-39 untouched for at least 6 months. This will allow alfa radiation cause enough microscopic holes in the glass to let the be checkable by passing through it.
- Remove CR-39 glasses and bring them to a LAB in order to study them.
- Prepare the solution that will enlarge the holes on the glasses in the following way:
  - Put 0,5L of still water in the beaker
  - Mix into the water 120g of NaOH, in order to create a 6N, thermostatic, solution.
- Remove the little plastic layer from CR-39 glasses, then put them inside the solution (in our case, we didn't stick glasses to an apposite beaker, but it would be better to do so)
- Put the solution inside the fryer for about 5 hours and a half in the fryer.
- When the CR-39 glasses are extracted, holes deriving from alfa radiations (i.e. from Radon gas) will be expanded, so that they can be observed by microscope, at a gradation of 40x.
- After a preliminary division of the glasses in 10 parts will allow to get more precise informations.
- By an equation that considers previous empirical dates, it will be possible to go up to the quantity of radon concentration (Bq/m³) (fig. 2)

<table>
<thead>
<tr>
<th>LOCAL</th>
<th>FLOOR</th>
<th>UTILIZATION</th>
<th>EXPOSITION TIME (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old well</td>
<td>- 1,17 m</td>
<td>Water collection</td>
<td>194</td>
</tr>
<tr>
<td>New well</td>
<td>-1,47 m</td>
<td>Water collection</td>
<td>194</td>
</tr>
<tr>
<td>External stock (granite company)</td>
<td>0</td>
<td>Poorly attended</td>
<td>189</td>
</tr>
<tr>
<td>Internal stock (granite company)</td>
<td>0</td>
<td>Poorly attended</td>
<td>179</td>
</tr>
<tr>
<td>Cellar</td>
<td>-1</td>
<td>Poorly attended</td>
<td>186</td>
</tr>
<tr>
<td>Old core of Caspoggio</td>
<td>0</td>
<td>Uninhabited</td>
<td>160</td>
</tr>
</tbody>
</table>

Fig. 1
Some of the places utilized, with the respective data
Results

<table>
<thead>
<tr>
<th>LOCAL</th>
<th>RADON AVERAGE (Bq/m³)</th>
<th>ERROR AVERAGE (Bq/m³)</th>
<th>REFERENCE LEVEL (Bq/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Old well</td>
<td>335</td>
<td>64</td>
<td>500</td>
</tr>
<tr>
<td>New well</td>
<td>2579</td>
<td>403</td>
<td>500</td>
</tr>
<tr>
<td>External stock (granite company)</td>
<td>322</td>
<td>27</td>
<td>500</td>
</tr>
<tr>
<td>Internal stock (granite company)</td>
<td>204</td>
<td>56</td>
<td>500</td>
</tr>
<tr>
<td>Cellar</td>
<td>142</td>
<td>12</td>
<td>400</td>
</tr>
<tr>
<td>Old core of Caspoggio</td>
<td>108</td>
<td>28</td>
<td>400</td>
</tr>
</tbody>
</table>

Fig. 2
The radon level in places with the respective reference levels set by law

Fig. 3
Comparison between radon average and references level
Discussion

Before arguing about the results revealed, it is fair to remind the maximum level of radioactivity concentration caused by Radon in indoor places recommended by the EU and approved by the 241/2000 law:

- 200 Bq/m$^3$ in recently built houses
- 400 Bq/m$^3$ in antiquated houses
- 500 Bq/m$^3$ in workplaces

As specified on the ARPAV website (Agenzia Regionale per la Prevenzione e Protezione Ambientale del Veneto) there is no amount of radon considered "safe" for the human health, but the law levels quoted before are reasonable thresholds not to be overtaken in order to prevent as more cancers as possible.

The possibility to come upon lung cancer increases with the quantity of radon absorbed by the human body; a study reported on the ARPAV website points out statistically how many people are supposed to come upon lung cancer if exposed to a certain amount of radon in a lifetime.

In particular 17 people out of 1000 will get a cancer if living in an house with 200 Bq/m$^3$, 34 people out of 1000 if the concentration level is 400 Bq/m$^3$.

As the amount of people out of 1000 supposed to come upon cancer increases proportionally to the radon concentration, we can establish that with a concentration of 500 Bq/m$^3$ 43 people could get cancer.

Among all the places in which we put the dosimeters, the one expected to host the higher concentration of radon was the granite quarry (internal deposit, external deposit and inner office) as this material is widely known to be a grand emitter of radon.

If we compare the results revealed in the granite deposits and we compare them with the datas from the various cellars, we see that the average radon concentration in deposits (244 Bq/m$^3$) is higher than the average in cellars (176 Bq/m$^3$) by 68 Bq/m$^3$.

Clearly there is more radon concentration in granite deposits than in cellars. However, if we consider the maximum level of radioactivity concentration caused by Radon in indoor places recommended by the EU, we see that the difference between max level in workplaces and average deposits level is larger than the one between the max level in houses and average cellars level (256 Bq/m$^3$ for deposits against 24 Bq/m$^3$ for cellars -if the houses are new- or 224 Bq/m$^3$ -if the houses are old).
So we can conclude that the company examined did a great effort in lowering the radioactivity with effective aeration systems, reducing the radon concentration by 256 Bq/m^3 below the maximum level recommended.

An other proof that the aeration system is hugely effective is the concentration of radon in the office, the lowest among the datas (64 Bq/m^3 and 69 Bq/m^3).

If a granite quarry manages to keep this radon level (averagely 244 Bq/m^3) although the high radon emissions, a similar aeration system in a cellar could almost zero the risk of coming upon lung cancer because of radon radiations, however, disinformation about the risks and high prices restrain the improvement of home health safety.

A very last consideration can be done over the different aeration systems: the natural and the artificial one.

We put 4 dosimeters in 2 different types of granite deposits: one indoor and one outdoor.

The results were unexpected, as normally we would imagine the outdoor deposit to have the list radon concentration, as it is more aerated; on the contrary the results are:

- Outdoor concentrations: 322 Bq/m^3 and 256 Bq/m^3
- Indoor concentrations: 204 Bq/m^3 and 195 Bq/m^3

It is clear that the indoor deposit is provided with an artificial aeration system, more efficacious than the natural one.
Conclusion

Even if our experiment hadn't followed a standard schedule, i.e. lots of misurations for each single place, we achieved enough informations about Rn level in the observed places. Moreover, we've been able to compare those informations and judge the results in a precise way. Anyway, this experimentation can be improved: by placing more glasses in each place, and by a careful observation of the physical phenomena that may interfere with our process: even if Rn is the major source of alfa radiations, we have no way to be sure that it is the only one detected by our glasses.

We can state for sure, once again, that places subjected by an intense air circulation are less likely to obtain dangerous Radon levels; it is reassuring that almost none of the checked places do not cross over that level (the only exception is an abandoned house).

Definitely, by considering our results we can claim our job to be successful.

References

2) Radon is generated by the radioactive elements present in all the constituents of the earth’s crust
3) α radiations are the particles consisting of 2 protons and 2 neutrons, produced by the decay of a non-stable nucleus.
4) Mountain; basement of an abandoned house; granite; cellar; wells.
5) In Europe the recommendation 90/143 / Euratom of 21/02/90 that has been in force recommends for existing residential buildings an action threshold of 400 Bq / m³, for the new ones of 200 Bq / m³. http://www.provincia.bz.it/agenzia-ambiente/radiazioni/legislazione-radon-temi.asp
6) The most stable isotope, 222Rn, has an half-life of 3.8 days.