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Research paper

Radon gas as a constructive element in the chilean pacific coast the case of a manor house in Viña del mar (valparaíso).

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Abstract

The presence of radon gas in buildings is an indicator of indoor air quality. The study presented analyses the amount of radon gas in the city of Viña del Mar in the Valparaiso region (Chile), in a manor house that currently serves as the Center of Advanced Studies at the Univer-sidad de Playa Ancha. Radon gas is an element considered highly harmful to people by various scientific agencies in the field of medicine and health, including the World Health Organization (WHO). The main effect of the presence of radon in the human environment is the risk of lung cancer. This radioactive gaseous element is present in almost all construction materials, and in the land where buildings are located. This article provides the measurements made by the Center of Advanced Studies of the Universidad de Playa Ancha and analyses the levels obtained according to their danger to humans. These values have been used as comparisons to analyse the differences in the presence of this gas between the Chilean Pacific coast and Europe. The values have been analysed with respect to the requirements that are currently being implemented.

Keywords: *Radon Gas; Environment; Healthy Architecture; Construction Materials; Chilean Construction*

1. Introduction

1.1. Radon gas in the environment

Radioactivity is a physical phenomenon by which the unstable isotopes of certain chemical elements are able to lose energy and transform into other, more stable isotopes. During this process, radiation is emitted in the form of electromagnetic waves (X-rays and gamma rays) or particles (alpha, beta and neutrons).

This type of radiation is called ionizing because when it enters matter, it usually removes electrons from the surrounding atoms by a process known as ionization. If the matter is biological tissue with a high water content, the ionization of water molecules can give rise to so-called free radicals that have a high chemical reactivity, sufficient to alter important molecules that are part of the tissues of living beings. These alterations may include chemical changes in DNA, the basic organic molecule that forms part of the cells that make up our body [1]. These changes can lead to biological effects, including abnormal cell development. These alterations may be more or less serious depending on the dose of radiation received. [2].

Three-quarters of the radioactivity in the environment comes from natural elements. In this sense, radon is the major source of natural radioactivity and the public health problem generated by its concentration and that of its descendants in drinking water or inside buildings, has made people aware that what until now was considered a negligible background has to be determined, at least, for its correct evaluation [3].

Radon gas is produced as a result of the breakdown of uranium and thorium in rocks. The amount of this gas that accumulates in a building depends on its location, the materials that have been used in its construction and our way of life (ventilation and time in a room). Radon emanates from rocks and is concentrated in enclosed areas, so it is highly recommended that homes and workplaces be properly ventilated.

Radon concentrations in a building vary substantially with geographic location. Given the large number of factors involved, it is very difficult to predict whether the levels of this gas will be high in a particular dwelling; however, it is possible to make reliable predictions about the areas where high concentrations of this gas are most likely to be found.

1.2. Radon gas in chile

Despite the fact that the presence of radon is quite significant in many territories, posing a certain risk to the health of a large number of citizens, the fact is that regulation of this gas is very recent or even non-existent in certain countries. The intense concern about radon in the United States has been slow to become widespread in Europe and South America, but this phenomenon is gradually beginning to be considered with the existence of various international and European organisations responsible for the study and control of radioactivity. Organizations that, for some years, have been concerned about this issue through the generation of documents urging the different countries to adopt concrete measures in relation to radiation and advising their own legislative development, generating a progressive standardization [4], [5].

During the month of July 2017, an investigation was conducted in the Chilean city of Viña del Mar (Fig. 1). This research was part of an agreement between the Centre of Advanced Studies of the Universidad de Playa Ancha and the Department of Architectural Construction of the University of Alicante [6]. The purpose of this study was to determine the presence of this gas inside Chilean buildings to compare them with similar European buildings.

Fig. 1: Location of the Peaceful Coastal City of Viña Del Mar. (Google Maps Imagen).

The construction studied on the radon gas indicator present in the interior was a 19th century manor house in the city of Viña del Mar, on the Chilean Pacific coast. This building currently serves as the headquarters of the Universidad de Playa Ancha and the former premises have been converted into research laboratories and management offices. (Fig. 2).

Fig. 2: Image of the Building Studied, Located in Traslaviña 450 Street in The City of Viña del Mar. It Currently Serves as the Center of Advanced Studies for the Universidad De Playa Ancha.

2. Methodology

The air quality study conducted with radon gas as an indicator was conducted using Ion Chamber Ionic Electret (CIE), a system that combines a chamber (plastic box of known volume) with a device or electret. CIE chambers are passive devices that function as integrator detectors to measure the average radon gas concentration during the measurement period. The electret works both as an electric field generator and as a sensor in the ion chamber. The radon gas, but not the disintegration products, enters the chamber by diffusion through an inlet equipped with a filter. Radiation emitted by radon and its disintegration products formed inside the chamber ionizes the air contained inside the chamber by reducing the detector surface voltage. A calibration factor then relates this voltage drop to the radon concentration in the space studied. Fig. 3 shows the elements used in one of the areas measured during the study.

Fig. 3: Image of the Ionic Chamber of Electrete Placed in One of the Zones of Measurement.

Sampling of the amount of radon gas was initiated on 30 June 2017 and lasted 12 days. Two basic premises were taken into account when selecting the measurement sites: closed rooms with little ventilation and the possibility of being without transit of persons during the measurement days. The storage of the elements had to be adapted to the needs of the sites and the people working there.

The manor house studied generally has good ventilation conditions since all the rooms have external windows and the movement of people generates continuous movement. The study was conducted in early summer in South America, although temperatures remained constant over the 12 days: between 8 and 20ºC. The only day that precipitation occurred was the 4th of July, although it was very light.

Fig. 4 shows the six sites studied: Environmental laboratory, Environmental laboratory coordinator office, Philosophy office, Ethology Laboratory, Laboratory coordinator office and Office general management investigation.

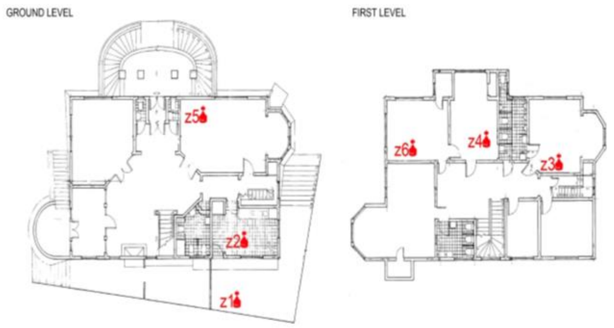

Fig. 4: Location of the Measurements Taken Inside the Building under Study.

3. Results

The averages of the results obtained from the amount of radon gas inside the building were those represented in Table 1. As can be seen in the survey, six measurements were taken at each of the six sites to test the results. The mean radon gas concentration measured in Bq/m3 is represented.

Table 1: Summary of Measurements Made at the Center of Advanced Studies of the Universidad De Playa Ancha

Zone		Samples	Average radón level (Bq/m^3)
1	Environmental laboratory	6	194,92
2	Environmental laboratory coordinator office	6	212,20
3	Philosophy office	6	160,14
4	Ethology Laboratory	6	134,93
5	Laboratory coordinator office	6	174,46
6	Office general management investigation	6	435,64

Fig. 5 represents the results obtained graphically by means of a Box Plot with the deviations obtained at each of the six measuring points. The results in the first five areas are similar. The six-measurement zone corresponding to the Office general management research is the one with the highest presence of radon gas, with an average of more than 400 Bq/m3.

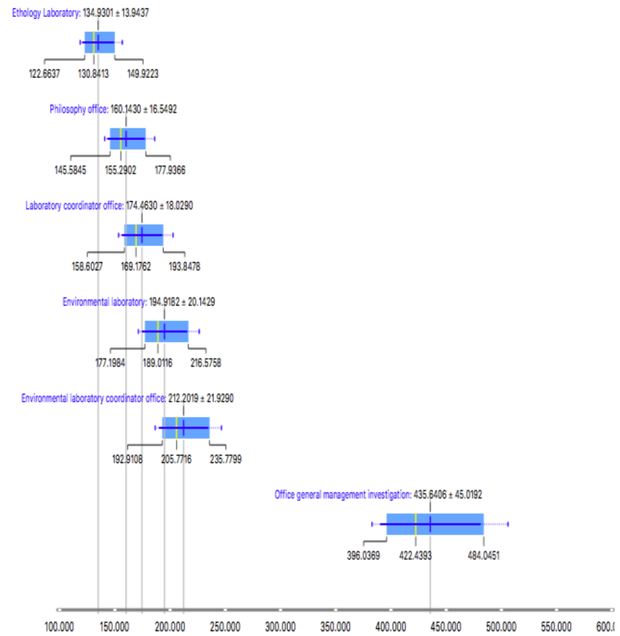

Fig. 5: Box Plot Zones Measures in the Building. Represented in (Bq/M3).

4. Discussion of results

The results obtained in the different measurements are compared with the 100 and 300 Bq/m3 recommended by the European directive 2013/59/EURATOM of the year 2014 updating the suggested as recommended maximums by the European Atomic Energy Commission in 1990 [7] and the 100 Bq/m3 exposure to residential radon recommended by WHO in the Handbook on Indoor Radon (WHO handbook on indoor radon: a public health perspective) of the year 2009 [8]. Therefore, the 100 Bq/m3 is considered as the first threshold from which the permanent monitoring of the gas presence measurement corresponds and the level of 300 Bq/m3 as the threshold from which corrective ventilation measures must be taken.

From the data extracted from the study, the concentration of radon gas inside the building is interpreted, conditioned by the differences in ventilation produced by the air currents caused mostly by ventilation. On the other hand, radon results can be variable within the same room in the same building, as stated by different studies that have addressed the issue [3], [9], [10]; for this reason, the variations in the measurements between the different measurements obtained are obtained.

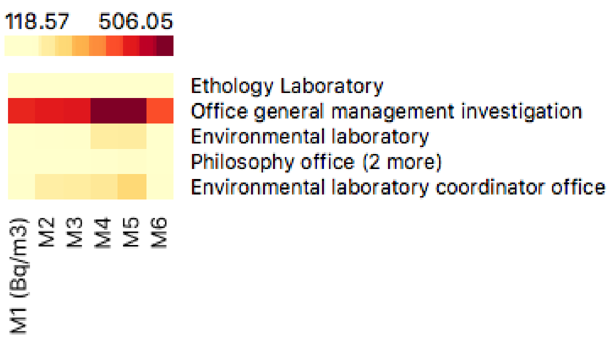

Fig. 6: Heat Plot of the Different Measurement Zones.

From the results obtained during the study in the Chilean manor house studied, a comparison is made between the different places measured with a short camera and a short electrete (used type of the CIE). As shown in Table 1 of the results, the values of radon gas in the air of the first five zones are similar (between 130 and 220 Bq/m3). The measuring zone six corresponding to the Office general management investigation have the highest presence of radon gas, with an average of more than 400 Bq/m3. Figure 6 shows the results with a Heat Plot.

5. Conclusion

In order to draw the conclusions, the purpose of the directive 90/143/EURATOM has been to, where the European Union recommends a target radon gas level at the design stage of 100 Bq/m3 maximum for new buildings and a level of immediate action from 300 Bq/m3 for indoor spaces from which measurements should be carried out in places used by people. Although these values should not be taken as safe when they are less than 100 Bq/m3, whether it can be interpreted as a frontier from which to begin to pay attention and try to minimise the values obtained by incorporating a more efficient form of air renewal and establishing more efficient construction methods to accumulate less radon gas.

The first five measurement zones have obtained values between 100 and 300 Bq/m3, should therefore be taken into account and be subject to periodic review. The maximum amounts of radon obtained inside the building were 435 Bq/m3, in zone 6 of the Office general management investigation. These values must be taken into account to improve ventilation, either by manual or mechanical means.

Predictive maps must be specified in their application through technical building codes but in most countries, including Spain, the Technical Building Code does not yet consider the dose of radon that can house at most one building and how to dispose of it [11]. At present, Chile does not have a specific regulation on this pathology of construction either.

Radon gas is harmful to human health, becoming a highly carcinogenic element, and therefore new regulations must incorporate this aspect as a control element. In view of the results set out in this article, the need for and compliance with measures (construction, ventilation, etc.) has been established. For limiting the presence of radon gas in buildings, especially in enclosed spaces used by people. In all cases, radiological studies on radon exposures in work and leisure settings should be carried out on a mandatory basis. All this regardless of the type of terrain on which the buildings are built and the type of materials used.

6. Author contributions

The work presented here was developed in collaboration among all authors. All authors have contributed to, seen and approved the manuscript.

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