International Journal of Engineering & Technology, 7 (4.5) (2018) 393-395

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

The Radon Gas in Underground Constructions. Railway Tunnel of Alicante (Spain)

Carlos Rizo Maestre[1]*, Servando Chinchón Yepes, Victor Echarri Iribarren[3]

[1]*University of Alicante*
[2] *University of Alicante*
[3] *University of Alicante*
**Corresponding author E-mail:carlosrm@ua.es*

Abstract

The presence of radon gas in constructions is an indicator of air quality. The study presented analyzes the amount of radon gas in the Railway Tunnel in Alicante. This infrastructure is very important for the city due to its social importance in facilitating urban mobility. radon gas is an element considered highly harmful to people by different 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 environment of the human being is the risk of contracting lung cancer. This radioactive gaseous element is present in almost all building materials, and in the land in which the buildings are implanted. In this article the measurements made in the tunnel are provided and the levels obtained are analyzed according to their danger to humans. In Spain, the Technical Building Code (CTE) still does not contemplate the dose of radon that can hold a maximum of one building and how to contain it.

Keywords: *radon, characterization of materials, environment, healthy architecture, building materials, sustainability*

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. The process involves the emission of radiation 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 penetrates into matter, it tends to pull electrons from the surrounding atoms through a process known as ionization. In the case that the material is biological tissue with a high water content, the ionization of water molecules can lead to so-called free radicals that have a high chemical reactivity, enough to alter important molecules that are part of the tissues of living beings. Among these alterations can be included chemical changes in DNA, the basic organic molecule that is part of the cells that make up our body [1]. These changes can lead to the appearance of biological effects, including the abnormal development of cells. These alterations can be more or less serious depending on the dose of radiation received [2].
Three quarters of the radioactivity in the environment comes from the natural elements. In this sense, radon is the largest source of natural radioactivity and the public health problem that generates its concentration and that of its descendants in drinking water or in the interior of buildings, has made us aware of that what until now was considered a negligible fund has, at least, to be determined for its correct evaluation [3].
radon gas is produced because of the decay of uranium and thorium contained 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). The radon emanates from the rocks and is concentrated in closed places, so it is highly recommended that homes and workplaces are properly ventilated.
The concentrations of radon in a building vary substantially with the geographical situation. Given the large number of factors involved, it is very difficult to predict if the levels of this gas will be high in a specific home; On the other hand, it is possible to make reliable predictions about the areas where there is a higher probability of finding homes with high concentrations.



Fig. 1: Image of the tunnel during the data collection phase. The image corresponds to the tunnel on its way through Mount Benacantil.

The Railway Tunnel of the Metropolitan Transport of Alicante that passes through the slopes of Mount Benacantil, is a modern construction of the 21st century, which serves to connect the city center of Alicante with the northern zone.

Copyright © 2018 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

1.2. The Luceros-Marq Railway Tunnel

The Luceros-Marq Railway Tunnel is next to the Serra Grossa Tunnel, one of the most important civil works carried out in the 21st century in the city of Alicante. This infrastructure connects the Marq-Castillo stations, at the foot of Mount Benacantil, with the station of Luceros, although in the future its pretensions are to reach Renfe's own railway station and serve as a connection to the city with travelers arriving from all of Spain. The route of the tunnel passes under the Avenues of Alfonso X el Sabio, of the Station and of Jaime II until entering the Benacantil Mountain (Fig. 1), reaching to be located fifteen meters below the level zero of the street.

2. Methodology

The study of the air quality carried out with radon gas as an indicator was made using an Electrete Ionic Chamber (EIC) sensor, a system that combines a camera with a device that works at the same time as generator of an electric field and sensor. In Fig. 2, shows the elements used in each of the areas measured in the study.



Fig. 2: Equipment used during the study. The elements that compose it are the meter, a tamper-resistant box, a camera with a short space of time, along-time camera, a short electret (blue) and a long one (red).

The sampling of the amount of radon gas was initiated in December 2015 and had a different duration for each of the chosen places, being finalized in July 2016. For the election of the measurement sites, two were considered fundamental premises: closed rooms with little ventilation and the possibility of remaining without people's transit during the measurement days. The deposit of the elements had to adapt to the needs of the places and their custodians.

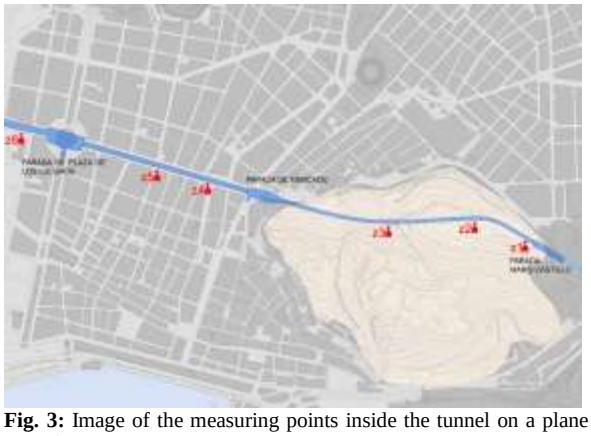


Fig. 3: Image of the measuring points inside the tunnel on a plane of the city of Alicante where Mount Benacantil stands out.

The Tunnel of Mount Benacantil, has good ventilation conditions, for the measurements Ionic Chamber of Electrete was used. Fig. 3 shows the arrangement of the cameras inside the tunnel studied, for which special attention was paid to the movement of trains and mechanical elements by the renewal of air produced inside it.

3. Results and Discussion

The measurements obtained from the amount of radon gas inside the tunnel were low (Table 1); The large air extraction equipment placed along with the movement of the trains coming from the outside, make the air is renewed continuously which leads to the low presence of radon gas.

Table 1: Font Specifications for A4 Papers

	Place	Sample	Radon average (Bq/m3)
Zone 1	65 m Marq	1	19,08
Zone 2	155 m Marq, 610m Mercado	2	12,63
Zone 3	424 m Marq, 340m Mercado	6	75,99
Zone 4	105 m Mercado, 420m Luceros	2	27,88
Zone 5	265m Mercado, 270m Luceros	3	20,53
Zone 6	66 m Luceros, Renfe direction	2	182,00

The results obtained in the different measurements are compared with the 400 Bq/m3 that the European Commission for Atomic Energy recommended not to exceed in 1990 [4] and the 100 Bq/m3 of exposure to residential radon recommended by the WHO in the publication Handbook on Indoor radon (2009 WHO Handbook on indoor radon: a public health perspective) [5]. At present, the incidence of radon gas in people continues to be studied to establish gas values and under what conditions improvement measures must be taken. To extract the results of the study, the two previously mentioned values are considered, considering those below 100 Bq/m3 normal, between 100 and 400 Bq/m3 to be taken into account and those higher than 400 Bq/m3 places in which should intervene [6].

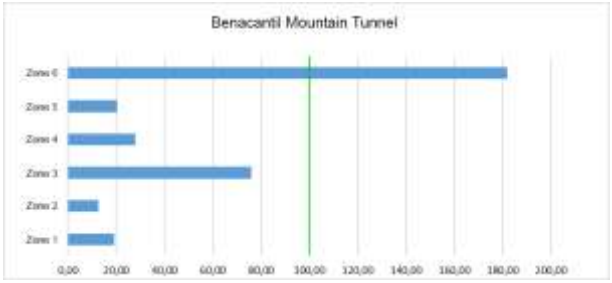


Fig. 4: Comparative bar graph of the results obtained in the tunnel, measured in Bq/m3. In green reference of 100 Bq/m, the reference of 400 Bq/m3 does not appear because it is low values.

In the Tunnel of Monte Benacantil, of the six zones that were studied during the eight days that the measurement was carried out, all the values were much lower than those that could be considered susceptible to be solved. The only place that turned out to be somewhat higher, with an average of 182 Bq/m3, was the section of the tunnel that connects the current Luceros stop with the future Renfe stop (Zone 6). This section is in disuse since the trains do not circulate and the air extraction systems are not connected being the amount of air renewed minor. In the future, when connecting to the Renfe stop, the train transit and the ventilation measures themselves will probably improve the accumulated radon gas values. For the representation of the results, from the summary tables we present a comparative graph of the average radon gas value by zones in Bq/m3 is made in Fig. 4.

4. Conclusion

Radon gas is detrimental to human health becoming a highly carcinogenic element and therefore, new construction regulations are working to incorporate this point as an element of control. The biggest source of this gas is the land, being the constructions with low protection measures or underground susceptible to accumulate greater amounts of this gas. The new constructive forms make the buildings more and more hermetic and prevent the renewal of the air. Other factors to consider are the temperatures when they are extreme since they facilitate the accumulation of the gas by the difference of pressure and the precipitations that facilitates the ionization of the places.

The Luceros-Marq Tunnel that passes through the foothills of Mount Benacantil, has a high air renewal inside produced by both the movement of trains and extraction systems and therefore the accumulation of radon gas inside is low. In view of the results presented in this paper, the need and compliance of ventilation measures to contain the presence of radon gas in the building, especially in closed spaces used by people, is verified. As reflected in Technical Report of the Nuclear Safety Council [6], radiological studies on radon exposures in underground workplaces and leisure facilities (including public car parks, mines, metro, museums, tourist caves, etc.) should be carried out compulsorily. All this regardless of the type of rock on which the constructions are based and the type of materials used.

Acknowledgement

The authors thank the University Institute of the Water and the Environmental Sciences of the University of Alicante the facilities provided for this work.

References

[1] United Nations. Scientific Committee on the Effects of Atomic Radiation., Sources and effects of ionizing radiation : United Nations Scientific Committee on the Effects of Atomic Radiation : UNSCEAR 2000 report to the General Assembly, with scientific annexes. United Nations, 2000.

[2] Consejo de Seguridad Nuclear, Dosis de Radiación. Editor Consejo de Seguridad Nuclear, 2010.

[3] J. J. J. L. Llerena Cristobo, Medición de la concentración de gas 222Rn en el interior de edificios. USC. Departamento de Física de las Partículas, 2006.

[4] 90/143/EURATOM, "Recomendación de la comisión EURATOM, de 21 de febrero de 1990, relativa a la protección de la población contra los peligros de una exposición al radón en el interior de edificios," 1990.

[5] H. Zeeb, F. Shannoun, and W. H. Organization, "WHO handbook on indoor radon: a public health perspective," 2009.

[6] M. García-Talavera San Miguel, J. L. Martín Matarranz, R. Gil de Mingo, J. P. García Cadierno, and E. Suárez Mahou, El mapa predictivo de exposición al radón en España. Editor Consejo de Seguridad Nuclear, 2013.