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Detection and importance of the presence of Radon Gas in Buildings

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***Abstract*—Radon is a type of radioactive gaseous element that is considered as an extremely harmful element to people's health by the World Health Organization (WHO). The study is radon gas within the framework of construction. Radon is a radioactive element that is present in building materials as in all fields where human construct the buildings. This element is present both in the lives of people and according to the World Health Organization is an element of risk in cancer formation in the body of human beings. The purpose of the article is to list the different forms of radon entry into buildings and the different exposure level representing the land or the materials and construction techniques, which are developed with houses. In Spain, the Technical Building Code (CTE) still does not provide the dose of radon can contain up a building and as contain, unlike other countries with different laws at the level of health and in terms of building, have tools and engaged in trying to curb the existence of radon inside buildings.**

***Index Terms*—Radon gas, Constructive Sustainability, Building materials, healthy architecture**

I. Sizes and Units

In this article we will use the following scientific nomenclature:

-Bq: It is the activity of a quantity of radioactive material with core decay per second. It is Equivalent to a nuclear disintegration or transformation per second.

-Bq / m^3: when it comes to the activity concentration of a material either in liquid or gaseous medium. An example is the concentration of radon in the air (222Rn).

-Sievert (Sv): Unit dose. A Sievert is equal to one joule per kilogram. Because of the immensity of this unit, doses in millisievert (mSv) are usually employed.

-Half-Life (T) is the time required for half of the cores of an initial sample of a radioisotope for disintegration.

-Average doses: is defined as the number of doses received by different bodies in a given period of time. Its unit of measurement is the Sievert (Sv)

II. What is Radon?

Radon is a chemical element with symbol Rn that belongs to the group of noble gases. In the periodic table it is the atomic number 86. The average mass is 222, therefore, has 136 neutrons. Usually it is found in gaseous form in which it is colorless, odorless and tasteless. In solid form it has a reddish appearance. It belongs to the noble gases and is a radioactive element. Radon is a product of the decay of radium (Ra-226).

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Radon accounts for the third part of radiation received throughout our lives. The major pathway into the human body is the respiratory system with a ninety percent. The other ten per cent corresponds to through the digestive system [5].

III. What are noble gases?

The noble gases make a group chemical elements with similar properties under standard conditions, are monatomic gases, odorless, colorless with very low chemical reactivity.

They are members of the group 18 of the periodic table.

The seven gases that include this group are: helium (He), neon (Ne), argon (Ar), krypton (Kr), xenon (Xe), radon (Rn) and Ununoctium (Uuo).

The noble gases are explained by modern theories of atomic structure and only react to certain extreme external conditions. They are chemically stable, inert and do not interact with other elements.

IV. What is Radioactivity?

Radioactivity is the emission or transmission of energy as electromagnetic waves or subatomic particles through space or through a material medium, even in a vacuum.

It is a physical phenomenon where some chemical elements, called radioactive, have a process in their cores that emit radiation with properties that modify and interfere in other mediums or elements.

V. How is Radon formed?

Radon comes from the decay chains of uranium (U-228 and U-235) and thorium (Th-232), i.e., it is found halfway between the main elements of the chain and the stable elements or non-radioactive isotopes located at the end of the chain.

Radon has a half-life of 3.8 days, i.e., the amount of radon in a given space, is reduced by half in this time, it is in this way the this chemical element is measured in the environment.

Uranium as well as thorium are elements found in most rocks and soils of the planet, in proportional doses, which experts call ppm (parts per million of a given material). The concentration of these two elements in rocks depends on the type, being the Granitic those containing the most, followed by clays that also have a high content. Rocks derived from sands as well as Basaltic rocks have a negligible content of radon.

VI. How is radon measured?

Radon can be measured in two ways, the existing radon in the air in a given space or the Radon that affects humans.

Sievert (Sv) is mentioned when dealing with the effect it has on humans. The Sievert is a type of measurement that determines the biological effect a quantity of an element causes, in this case radon to a particular/specific organ, the

most affected organ in this case is the lung, followed closely by digestive organs.

On the other hand, we talk about units of Becquerels (Bq) when dealing with the amount of decay that occurs in one second. Thus, by measuring the density units of Becquerels (Bq/m^3) the amount of radon in the environment in a given space is established.

VII. How does Radon affect our health?

The factor that causes cancer is not known, science has not yet proven that certain particles when subjected to radiation, undergo DNA mutation in their cells. Radon, as a radioactive chemical element, can cause cancer.

The World Health Organization (WHO) along with the International Agency for Research on Cancer (IARC) and the Environmental Protection Agency (EPA), consider the presence of radon in the environment as the main risk of human lung cancer.

Radon affects our health causing a mutation in the DNA cells that can lead to cancer. For smokers, radon is more detrimental as the particles left behind in the body, are more likely to adhere to radon and therefore more difficult to remove [6].

Recommendation 90/193 concerning the population against the dangers of radon exposure within buildings in 1990, recommends an annual level of 400 Bq/m^3 for existing buildings and 200 Bq/m^3 for new buildings.

The International Atomic Energy Agency (IAEA) speaks of corrective measures in homes that are in the average levels of radon between 200 and 600 Bq/m^3 per year and above 1000 Bq/m^3 in the workplace. The WHO recommends proceeding in a straightforward manner beginning at 200 Bq/m^3 per year and urgently at 400 Bq/m^3 levels.

The World Health Organization (WHO) declared Radon a carcinogenic element due to its relation with lung cancer in 1986. Many research teams have reached conclusions on the relation between the level of radon in their lives and the risk of developing lung cancer.

Although radon is considered the cause of between 3% and 14% of deaths from lung cancer, the presence of high doses of radon gas in the lives of people is not taken into account as the cause for developing cancer.

The various ills as result of exposure to radiation of any kind, and the level to which they affect humans, depend on many conditions; exposure time, the intensity of radiation, the irradiated body or the irradiated dose.

The Spanish National Security Council (CSN) places the average dose received by a person in Spain over one year at 2.41 mSv, of which approximately 50% comes from radon, other radiation sources may be terrestrial/ground radiation produced by different materials, cosmic radiation or the one produced by our own body. As the study is a mean approach and the perception resulting from a statistical analysis, it is considered that the values are quite different due to the different exposures of people at their place of residence, activity or lifestyle.

VIII. Radon in life

Radon is found in terrestrial soils and materials used in developing the architecture and buildings. As a gas, radon moves freely through the air we breathe and is able to move through the ground pores and penetrate into living spaces, the reason for being a peril to life.

Radon is present in the daily lives of people both in their homes and on the ground [7]. Various studies show the amounts of radon present in homes, as the aforementioned study by Beatriz Piedecausa in cave homes in Crevillente [4]. Other studies mention the dangers of the presence of radon in buildings, not only in homes, but in workspaces as well [8].

Even though a consensus has not been reached, the concern of the scientific world is evident regarding its prevention and the level of alertness against this risk. Currently the Spanish community is in a process of decision making to take action in this respect [6].

IX. Radon in building

Radon is present in nature and therefore the environments surrounding human beings. Construction materials used as well as the different soils/grounds/terrains used by mankind today generate an amount of Radon depending on the chemicals used in the production, that is, if the said material has among its chemical elements some of the chains that form Radon during their decomposition such as uranium or thorium, they will end up forming Radon along the process.

At the time of building a house in an environment we should consider two things, the amount of radon that exists in the ground or environment and the added amount of radon that building materials employed will bring.

The document "Radiation Protection 112" considers that only the elements and materials cause 20% of the radiation from Radon in homes with which it is made. Hence, the environment and location are regarded as the maximum sources of Radon at 80%. Therefore, if a measurement of Radon in a house is 240 Bq/m^3, it is construed that 48 Bq/m^3 are from the materials used for building and the other 192 Bq/m^3 are due to the land.

X. How can Radon be prevented?

The most accepted way to prevent the accumulation both in homes and places of human mobility is ventilation: if cross-ventilation is established within a space and is able to renew the air, radon will not accumulate in such a drastic manner and can be removed [9].

Radon, being present on the ground, especially in granitic rocks, there is a very high uranium content existence in many places where buildings stand. Accordingly, the solution to this problem is to apply constructive barriers as constructive elements that endow the building with greater protection from Radon[10].

Various companies that deal in the matter commercialize these constructive elements. These companies offer systems that provide air chambers and protective barriers for walls and elements of contact with ground.

XI. How to measure radon for the study

There are different ways to measure radon, depending on the equipment used and the time required; usually such devices have a standard rule of more amount of time, more reliable the results are:

Temporary methods of collection of an air sample at a given time and subsequent analysis in the laboratory

Continuous real time analysis with devices

Field measures with sampling devices

The study has a team of temporary methods; the Eperm system for this study by the Water and Environmental Sciences Institute of the University of Alicante has an apparatus from RadianSA.

Eperm is a Radon measurement system featuring plastic chambers of known volume, that serves as a vessel, together with an electrically polymer that works as an electroconductor. The chambers have an inlet, which serves as a selective membrane that permits the entry of gas. The chambers are fitted to a so-called detector named electret that is electrically discharged when ionized molecules come in contact with the element.

The Eperm system analyzes the results based on the time during which the samples have been collected, that is, the more time employed, more reliability in the results. Due to recommendations of such systems and the data obtained in the studies in samples from 5 to 7 days that have been conducted to date, it is considered efficient.

XII. Data collection

Currently the study is in the period of application of permits for the collection of new data and execution of a database. The data obtained so far have been the calibration of apparatus and for testing trials.

The aim is to establish a database that has existing results of Radon in the city of Alicante, to map out the different areas and building types of the area and their Radon measurements. Similar studies as the ones conducted by Dr. Piedecausa are proposed. The places that have been proposed for consideration are:

The Castle of Santa Barbara, one of the most important elements of the city with the highest number of visits and of great interest due to its more than thousand years of history.

San Fernando Castle, another major castle in the town of Alicante.

The Civil War shelters of the City of Alicante built during the Spanish Civil War, between 1936 and 1939 various shelters were built to accommodate the population during the bombings that occurred throughout the country.

The Pipes and water tanks of the city of Alicante are considered important as part of the study as the water stored tins them is for human consumption.

The Public Schools of Alicante, with similar architectural styles, are considered important in the proposed study to be carried out

These are the working lines on which the firm is resolved to continue its research with the aim of documenting a database Radon status of the City of Alicante. The agreements between the University of Alicante and the City council to promote sustainable development of the city favor such agreements.

XIII. Future paths for research

Scientists studying Radon (medicine, chemistry, architecture...), from the effects in humans to the protection against this element, have different objectives to minimize the effects of this element in the population [11].

Establish a set of rules providing radon measurement in a given area to produce a map of the different types of housing and under what conditions the accumulation of radon is higher.

Choose the areas with most relevant doses of Radon and elucidate the results, establishing the conditions for accumulation of the element.

Establish remedial measures for buildings that gather higher levels of radon and be able to reduce the possible harmful causes to health.

Establish new construction techniques involved from the time of beginning of construction of a building so that they are not just patches but elements that are involved in the entire architectural process.

Create a knowledge base of the measures taken in the different areas to establish the various measures that have been under taken in each of them.

The Radon as a carcinogen, causes a number of DNA mutations that cause cancer, therefore, one of the most important research lines within the scientific community is to understand why this mutation occurs, the internal process cells go suffer.

XIV. Conclusions

Various conclusions have been reached from the studies carried out for the thesis of Carlos Rizo Maestre as well as conclusions of the investigations conducted by different teams and the experimentation accomplished by data collection. Accordingly, it can be concluded that:

Radon is a hazardous element to health and can cause cancer.

Radon is found in almost all areas and existing building elements.

According to the measurements taken, people are well below the normal levels hazardous to health.

There are technical resources/means to prevent accumulation of radon, hindering the entrance of the gas in buildings.

The Most effective way of eliminating the gas is to create cross ventilation to allow air renewal and allow the eradication of the gas inside buildings.

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