O 119. A SNEAKY GAS ALL OVER OUR LIVES; RADON

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ABSTRACT: Radon gas, a radioactive substance, can be found almost anywhere in nature due to uranium. Because radon is released in the radioactive decay chain of uranium, it is not caused by human activities. It is the second most common cause of lung cancer after smoking. Radon, which does not appear to be dangerous in open areas, poses a high risk in closed areas and houses. The radon level in soil, air and water should be in accordance with international safety standards. It is important that the ground surveys of the buildings to be constructed be performed well and that the radon levels are determined correctly. When necessary, it is important for the human health to isolate the connection of the building with the soil floor. All building materials used in the construction and insulation of the building are suitable to be preferred by low-radiation ones. The smell, color and taste of radon cannot be felt; it is a dangerous inert gas that triggers the risk of lung cancer. For this reason, the greatest measure to be taken by the governments is to raise awareness and educate the public about the health problems that may be caused by this gas and the damages caused by the radon gas.

Keywords: Radioactive elements, inert gases, radon gas, human health, lung cancer

1. INTRODUCTION

Radon was first discovered by F. E. Dorn in 1900 and was isolated in 1908 by William Ramsay and Robert Whytlaw-Gray (Wilkening, 1990; Mc Laughlin, 2012; Parsons, 2003). Colorless, odorless and tasteless, Radon is the last member of the noble gases in the VIIIA group of the periodic table (Erees and Yener, 1999). Radon is a gas with an atomic weight of 222 atoms and defined by the symbol Rn, which is radioactive in nature. The boiling point is -62 °C and the melting point is -71 °C (Ferreira and Lobo, 2007; Smits et al. 2018; Tufaner, 2018).

Radon has 27 isotopes; the most important of these are radioactive gases known as radon (Rn^{222}), thoron (Rn^{220}) and actinon (Rn^{219}) (Szabó et al., 2014; Appleton, 2007). Especially, Rn^{222} is considered in the measurements because of their very short half-lives and very small quantities. It is known that the amount of radon in nature is 20 times higher than the amount of thoron.

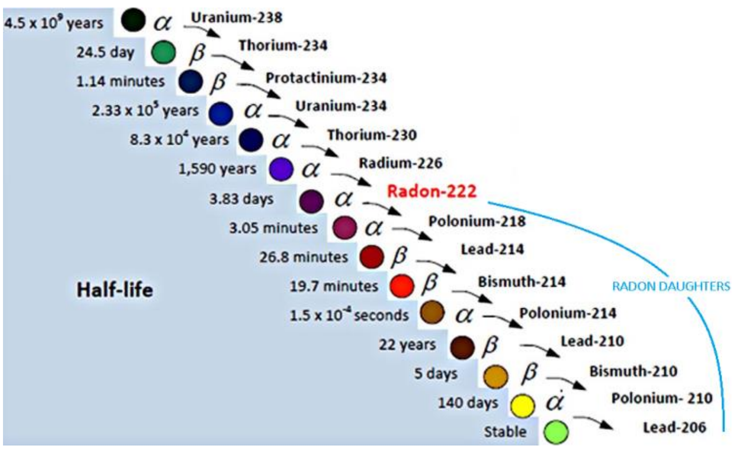
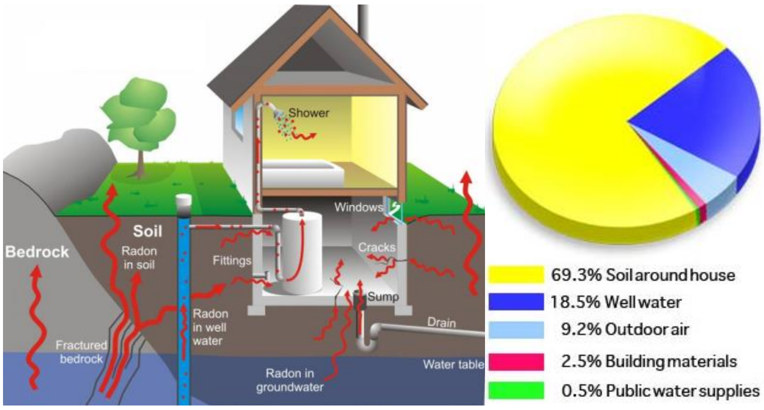


Figure 1. Radioactive elements and their half-lives in the radioactive decay chain of uranium

Radium (Ra^{226}) is formed as a result of the radioactive decay of natural uranium (U^{238}) on earth. Radioactive decay of radium (Ra^{226}) with a half-life of 1600 years results in unstable radon gas (Rn^{222}) (Pérez-Moreno et al., 2019). This gas is subjected to radioactive degradation by emitting alpha particles

(${}_2^4\alpha$; helium nuclei) and beta particles (${}_{-1}^{0}\beta$) until it stabilizes. This decomposition results in short half-life and solid radioactive decay products. These are known as radon strains or radon daughters (figure 1). The last of many radioactive elements formed in the radioactive decay cycle is the stable Pb^{206}. Together with radon; all radioactive elements in the uranium decay chain can be found in rock, soil and water and can be released from all natural surfaces. The increase in the amount of radon in the gas content released from the bottom of the earth towards the surface can be considered as an important predictor of earthquake. Although the half-life of the radon is very short (3.8 days), 50% of the radiation in the natural environment is due to this element (figure 2) (Smits et al. 2018; Field, 1999; Ivanova et al., 2019).

(A)


(B)

Figure 2. Radon oscillation paths **(A)**; Radon resources **(B)**

2. REGIONS WHERE RADON GAS IS PRESENT IN THE WORLD

Variations in the amount of radon gas may be seen depending on the seasons and various factors (Prasad et al., 2016). Radon and its daughters can be found hanging in the air in high amounts in caves and rocks where uranium is present, the amount of which can vary from year to year and even from day to day. Especially in places where there are some geological structures such as granite and volcanic rocks, the high amount of radon can sometimes be detected even in drinking water (Poortinga et al., 2008; Baixeras et al., 2001). Radon and its daughters are invisible derivatives that are found in large quantities in tunnels, caves, mines, subway lines, shopping centers, factories, schools and offices, parking areas, spas and hot springs and structures in the earthquake zone (figure 3) (Swakon´ et al., 2005; Doi and Kobayashi, 1996). It has been reported that the amount of radon is lower in places with sedimentary rocks. The fact that the amount of radon in the earth is infiltrating into buildings, which are the living spaces of people, presents serious dangers.

The majority of the radon source in the buildings is the soil and rocks at the base of the building. Radon and other gases rise along the ground and are trapped under the building. These trapped gases create great pressure. In our homes that are our living spaces, the air pressure is generally lower than that in the soil. Due to this high pressure at the bottom of the building, gases leak from the floor and walls of the building into the houses through the cracks and cavities. Radon gas can also leak into the houses through the wall cavities of the plumbing pipes in the building. Especially, it is seen that the amount of radon is higher in the basement and ground floors of the houses due to its being a heavy gas. In addition, radon gas can also be transported to houses with building materials used in the construction of the building (Al-Jarallah, 2001).

Figure 3. Different regions in terms of excess radon gas

3. NEGATIVE EFFECTS OF RADON GAS ON HUMAN HEALTH

Short-lived radon and radioactive decay products that cannot be detected without special devices are present as suspended particles in the air. They penetrate the human body through breathing but do not chemically bind to tissues. Since the solubility in tissues is very low. However, they may be trapped in the lungs in the form of radioactive aerosols and adversely affect human health by increasing radiation dose in the bronchial epithelium. When the alpha particles emitted during radioactive decay hit a surface, their energy is absorbed by the surface. Human skin is thick enough not to be affected, but alpha particles can strongly affect lung cells. This may result in cell damage and, in the future, lung cancer (Erees and Yener, 1999). Radon-induced lung cancer is estimated to be approximately 10-15% of all lung cancer cases (figure 4). This does not mean that anyone exposed to radon gas will develop lung cancer. Already the risk of lung cancer is higher in smokers (Poortinga et al., 2008). Radon and cigarette have a "synergistic" effect; that is, the damage caused by exposure to both is greater than the damage caused by the two separately. It can be said that the workers in the mines are in the highest risk group due to the high amount of radon they are exposed to (Lubin and Boice, 1997). Similarly, many people who use spas and caves for health often face the same risk. However, since the amount of radon in open areas is very low, no adverse effects on health are observed. Thus, except for the high level of radon, the cancer-causing effect of it is directly related to how much time a person spends in confined spaces and, of course, whether he smokes or not.

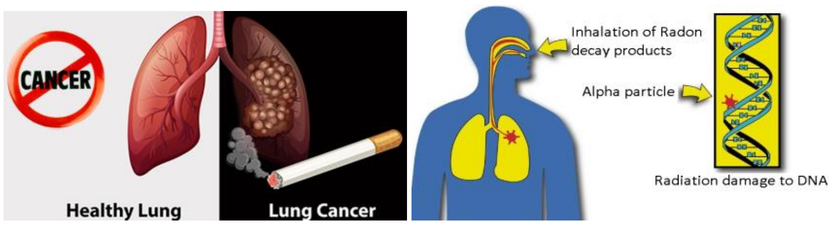


Figure 4. Lung cancer effects of radon

4. RADON LEVELS ALLOWED BY SOME HEALTH ORGANIZATIONS

It is the fundamental duty of all humanity to protect and raise public awareness against radiation. Therefore, national and international radiation protection institutions have been established in many regions of the world. The International Commission on Radiological Protection (ICRP), which was established in Stockholm in 1928, is the first to carry out studies. In radiation protection, there are many international organizations like; the United Nations Effects of Atomic Radiation Scientific Committee (UNSCEAR), the International Atomic Energy Agency (IAEA), the European Atomic Energy Community (EURATOM), Turkey Atomic Energy Agency (TAEK), the International Radiation Units Commission (ICRU), the World Health Organization (WHO), International Standards Organization (ISO) (Costa, 2014; Calmet, 2014; Ivanova et al., 2019). The permissible radon level in homes and workplaces is determined by these organizations. According to the IAEA Basic Safety Standards, the recommended levels for radon are determined in the range of 200 to 600 Bq/m^3, while the amount of radon according to ICRP should be <300 Bq/m^3 in homes and <1000 Bq/m^3 in workplaces. The amount of radon in the same habitats was reported by TAEK to be <400 Bq/m^3 in houses and <1000 Bq/m^3 in workplaces respectively (Kürkçüoğlu and Tozun, 2015; Tufaner, 2011). As can be understood, there are limits to the amount of radon determined by each country as well as international standards and there are differences between these values even though they are close to each other. In case the said radon limit values are exceeded, warnings are made by the national and international organizations to take measures to reduce the amount of radon and the necessary recommendations are forwarded to the relevant units.

5. PRECAUTIONS FOR RADON

The construction areas should be analyzed thoroughly, and it should be determined whether the surface is suitable for radon levels and whether the new buildings will be isolated from radon should be taken into account (Darby, et al., 2001). The houses used should be ventilated frequently and the cracks in the basement and ground floors should be repaired. In particular, the floors below the third floor of the buildings should be investigated in terms of radon gas and necessary precautions should be taken. In addition, the control and supervision of the functioning of the ventilation systems of the buildings should be done periodically. Care should be taken not to establish residential areas in locations where international radon gas levels are exceeded. Construction of buildings should be allowed particularly in areas away from earthquake risk areas. Or the floor area where the building will be built must be isolated from radon gas.

6. CONCLUSION AND SUGGESTIONS

Since Radon is colorless, odorless and cannot be detected without special devices, it is necessary to be protected from this gas by taking necessary precautions in living areas. In particular, ground surveys of long-term homes and workplaces should be carried mandatorily out with care. The preparation of a report by the relevant management units on whether the ground is suitable for constructing a building in terms of radon gas is the basic element in protecting human health. Radon, which is a radiation hazard, is a harmful gas that can adversely affect human health and trigger the risk of lung cancer. Therefore, it is helpful for countries to keep their radon levels within the standards set by the World Health Organization. In fact, it is necessary to bring in the expert units in order to determine the radon level and maintain the amount of this gas at a constant level. Personnel trained as specialists in the field of radon gas should be on duty and the construction of buildings should only be allowed with proper ventilation systems.

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